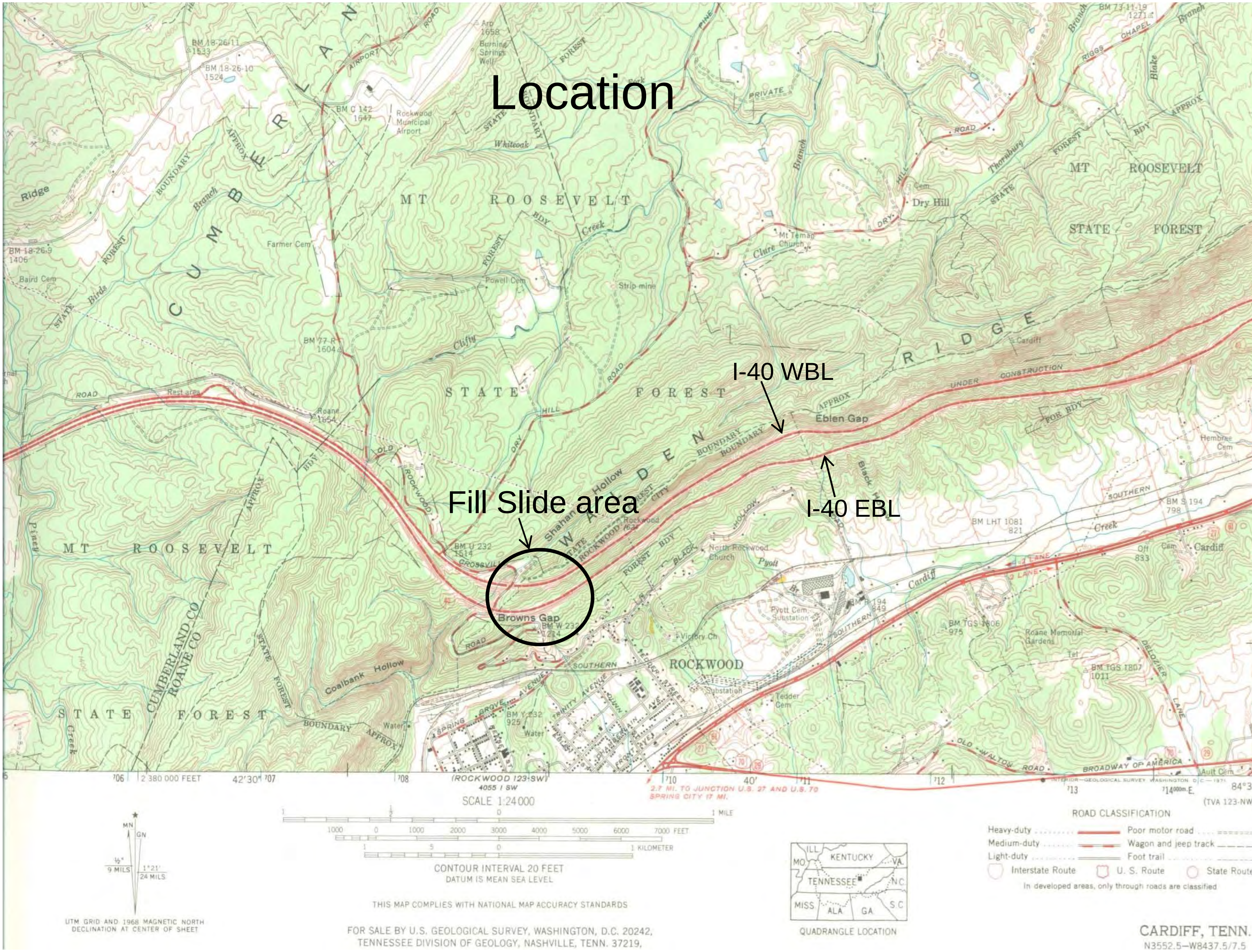
I-40 Fill Slide, Roane Co. Tennessee

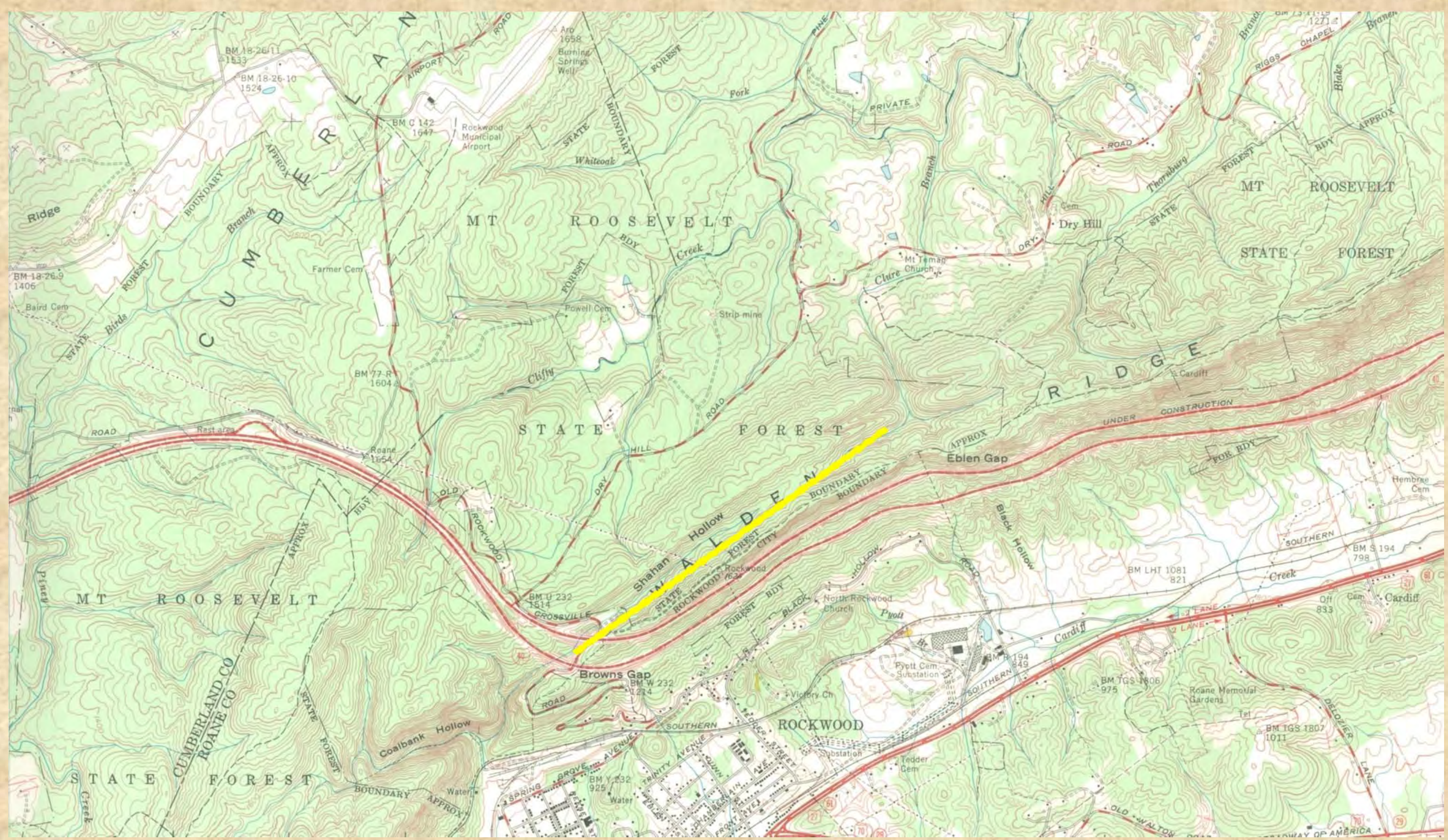
BY: Lori McDowell, PE

TDOT, Geotechnical Engineering

Location


I-40 WBL
I-40 EBL
Fill Slide area
Browns Gap
Eblen Gap
ROCKWOOD
Rockwood Municipal Airport
Dry Hill
Cardiff
MT ROOSEVELT STATE FOREST
WALDEN RIDGE
CUMBERLAND
CUMBERLAND CO
ROANE CO
SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242,
TENNESSEE DIVISION OF GEOLOGY, NASHVILLE, TENN. 37219,
QUADRANGLE LOCATION
ROAD CLASSIFICATION
CARDIFF, TENN.
N3552.5—W8437.5/7.5

Geology



CUMBERLAND
MT ROOSEVELT
STATE FOREST
Rockwood Municipal Airport
Farmer Cem
Powell Cem
Strip mine
Whiteoak
Clifty
Creek
Fork
Dry Hill
Mt Teman Church
Clure
Thoreburg
RIDGE
Cardiff
UNDER CONSTRUCTION
Eblen Gap
WALDEN
Shahan Hollow
Black Hollow
Browns Gap
Coalbank Hollow
CUMBERLAND CO
ROANE CO
North Rockwood Church
Pyott Cem
Substation
Victory Ch
ROCKWOOD
Tedder Cem
Roane Memorial Gardens
Hembree Cem
Piney
Ridge
Baird Cem
Birds
Branch
Rest area

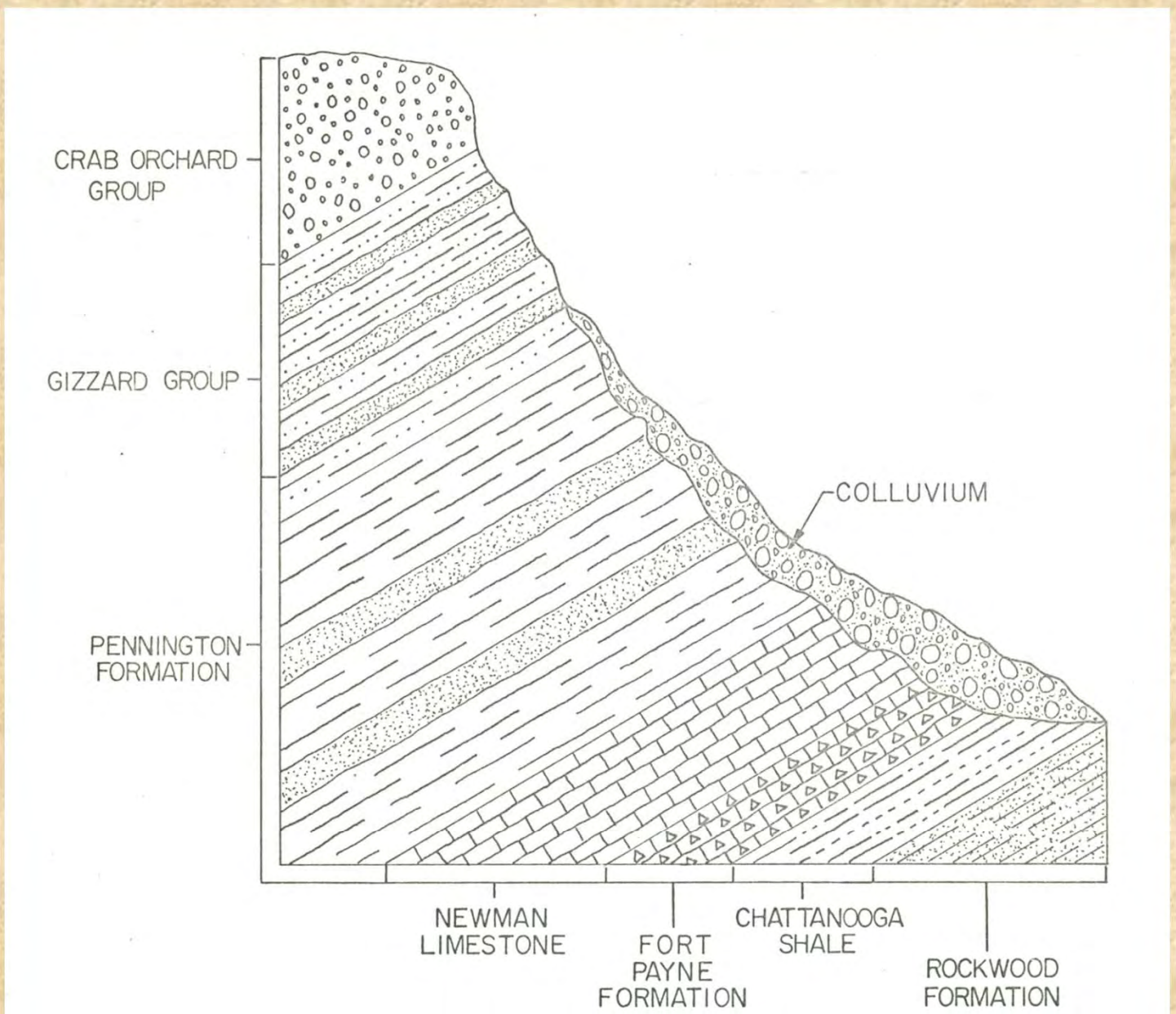
Geologic Layering

Colluvium / gravity deposited material

Sandstone

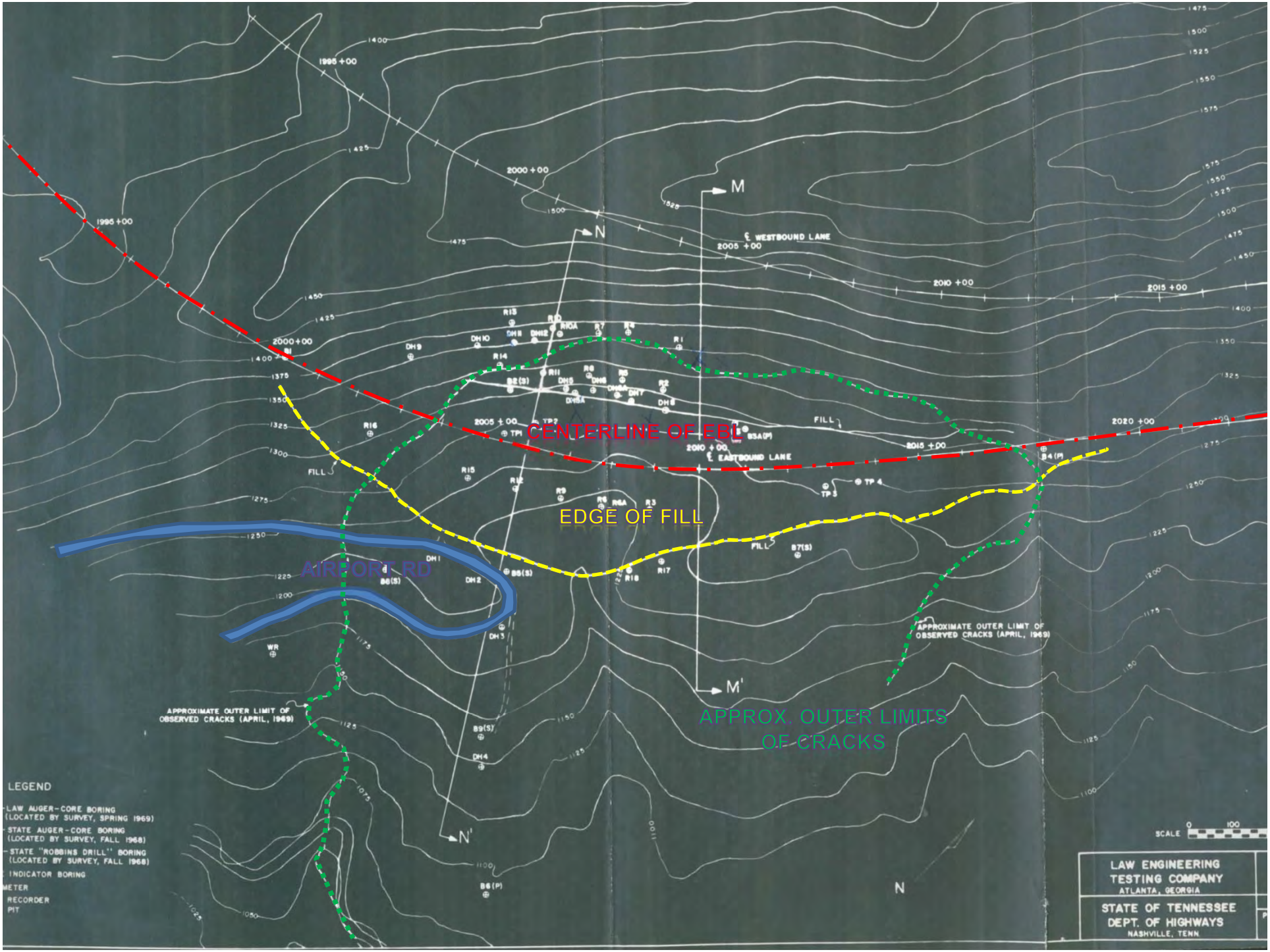
Shale interval (weak) – Pennington fromation

Limestone – Newman Limestone


CRAB ORCHARD GROUP
GIZZARD GROUP
PENNINGTON FORMATION
COLLUVIUM
NEWMAN LIMESTONE
FORT PAYNE FORMATION
CHATTANOOGA SHALE
ROCKWOOD FORMATION

Chronology of Site

- Construction started in Mid May 1967
- Removal of “undesirable material” in August of 1967.
- Fill material for that section of roadway started in late August of 1967.
- In January of 1968 landslide movements were first noted and March 7, 1968 work was halted.


CENTERLINE OF EBL
EDGE OF FILL
APPROX. OUTER LIMITS OF CRACKS
AIRPORT RD
APPROXIMATE OUTER LIMIT OF OBSERVED CRACKS (APRIL, 1969)
APPROXIMATE OUTER LIMIT OF OBSERVED CRACKS (APRIL, 1969)
℄ WESTBOUND LANE
℄ EASTBOUND LANE
1995 +00
2000 +00
2005 +00
2010 +00
2015 +00
2020 +00
M
M'
N
N'
FILL
LEGEND
LAW AUGER-CORE BORING (LOCATED BY SURVEY, SPRING 1969)
STATE AUGER-CORE BORING (LOCATED BY SURVEY, FALL 1968)
STATE "ROBBINS DRILL" BORING (LOCATED BY SURVEY, FALL 1968)
INDICATOR BORING
METER
RECORDER
PIT
SCALE 0 100
LAW ENGINEERING TESTING COMPANY ATLANTA, GEORGIA
STATE OF TENNESSEE DEPT. OF HIGHWAYS NASHVILLE, TENN.

First attempts at Remediation

- Installation of drainage facility
  - (April 8, 1968) A ditch on the upper side of the EBL approximately 607 feet in length, 15-20 feet deep and 10-12 feet wide with a perforated 8-inch corrugated metal pipe inside the ditch, topped with crushed stone, and a 42 inch cross-drain.

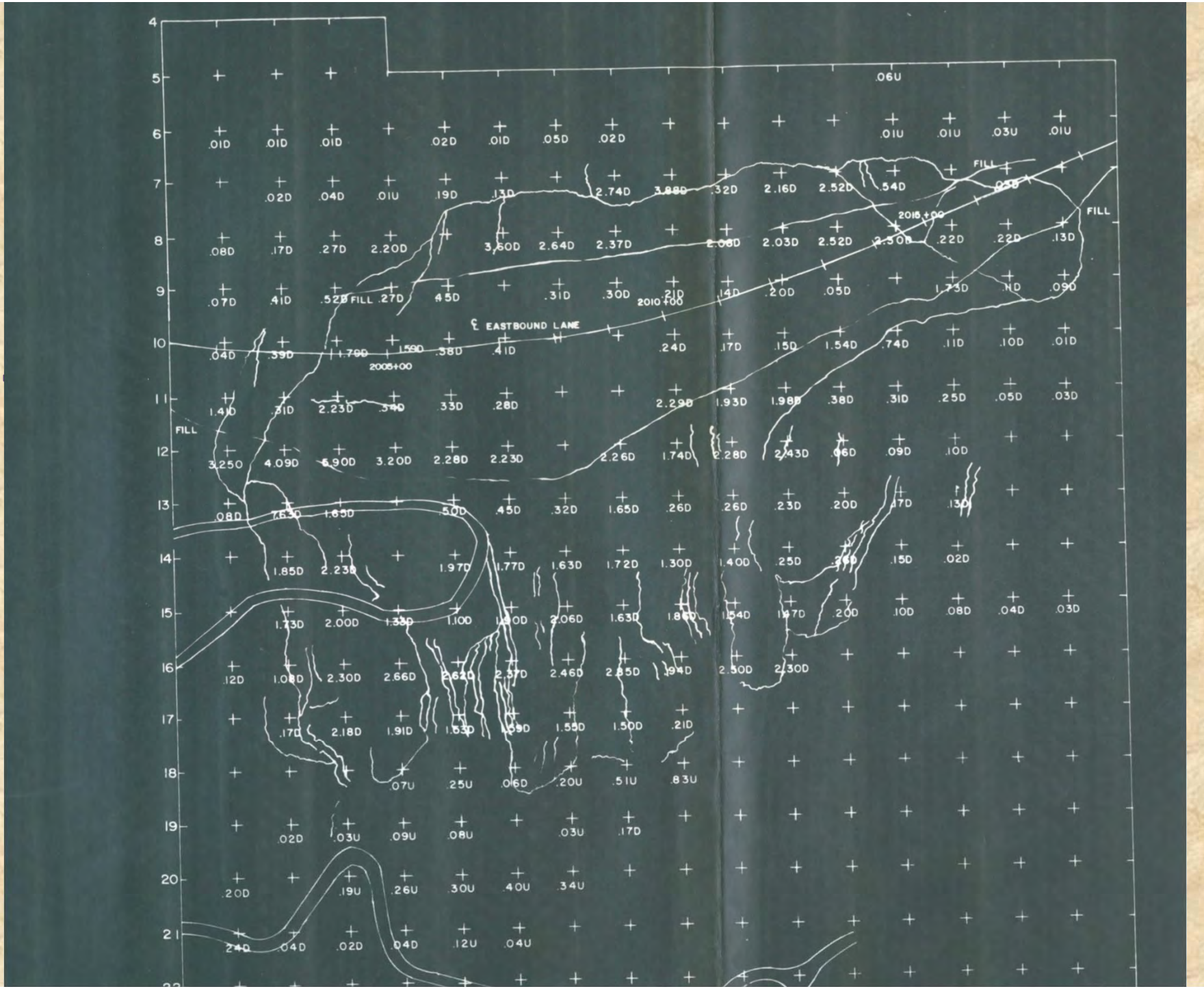
R1

After which, construction continued but movement was still noted.

  - (June 1968) Drilled shafts 35-40 ft. deep and 3 ft. in diameter filled with crushed stone were placed at the toe of the fill for a length of 200 ft.

R2

In August of 1968 the 42 inch pipe had failed and was removed.

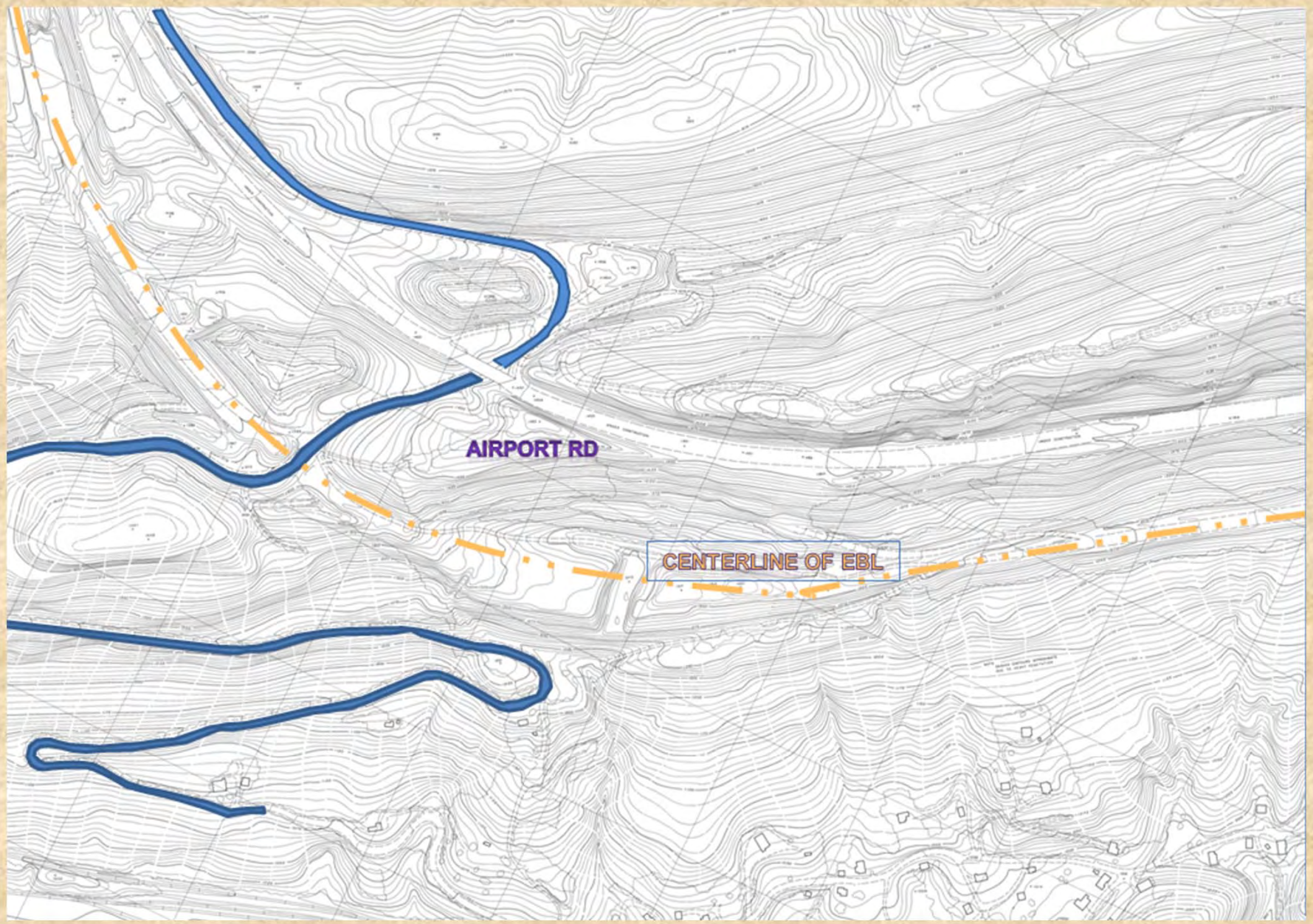

FILL
FILL
FILL
2018+00
2010+00
2005+00
℄ EASTBOUND LANE

- In October of 1968 Law Engineering Testing Co. was contracted to determine failure mechanism and present recommendations.

I2 – Used aerial photographs and full stereoscopic examination

I3 – Subsurface investigation - nine borings in which six slope inclinometers were installed within and also four sealed piezometers were installed. Ground water levels monitored for all.

I4 – Seismic activity monitoring


AIRPORT RD
CENTERLINE OF EBL

Law Engineering Findings

- There was evidence of movement in the past before any construction was done.
- There was an old gulley that bisected the slide that formed the headwaters of Black Creek
- The whole area has a high water table
- Possibility of different layers of aquifers due to the fracturing of the rocks.
- There is more than one slide happening along the whole slide, but one failure surface was identified.

Law Engineering Findings

- The original slope originally had a factor of safety of around 1.0.
- The main cause for the movement of the slope is ground water.
  - High water table in the fill
  - Possibility of more than one aquifer due to geology layering
  - Possible sealing/"pinching" of seeps or springs under fill
  - Noted movement of slide increased after heavy rain or snow melting

Law Engineering Findings

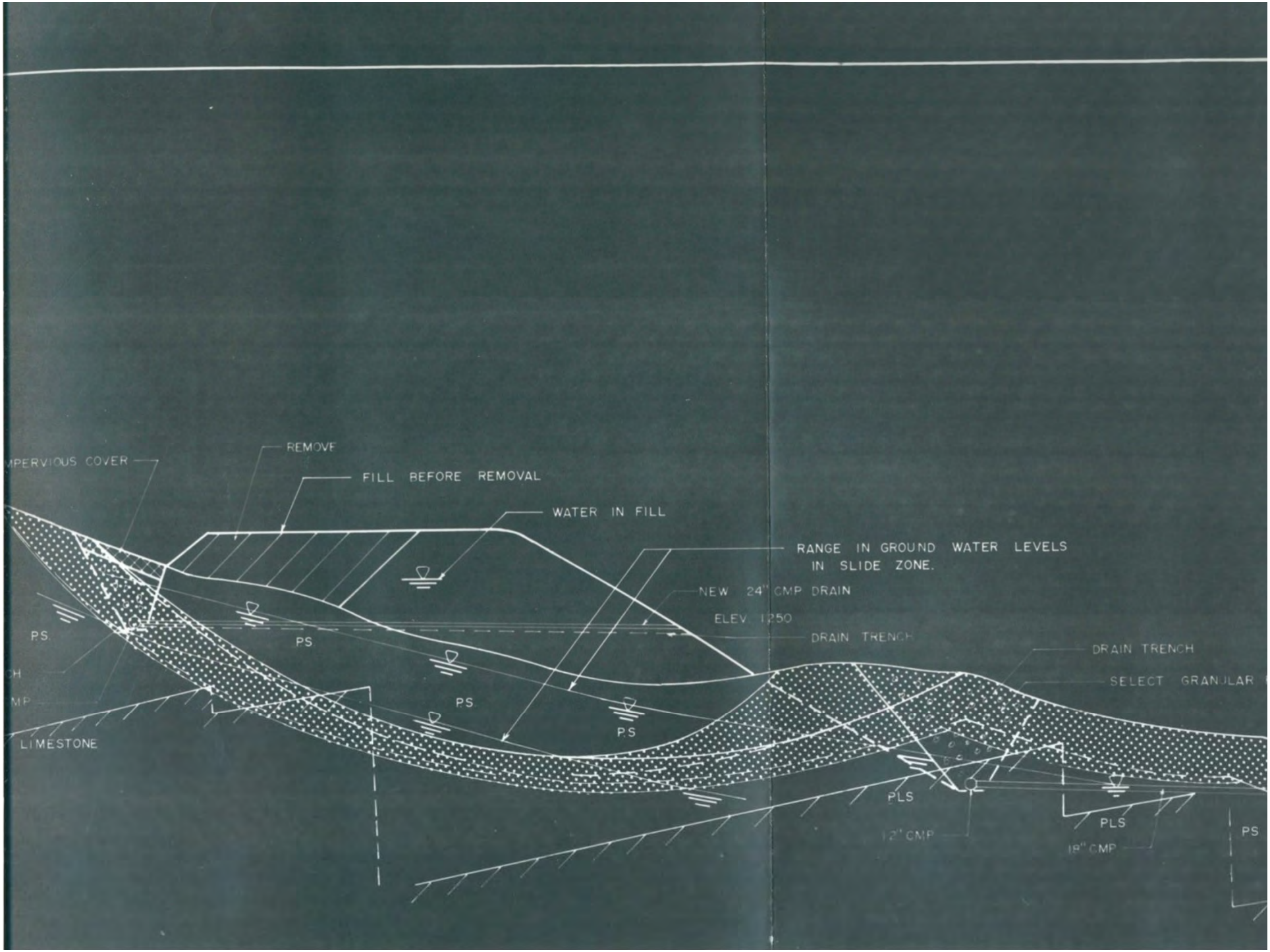
- Three primary factors:
  1) Unstable structure of the Pennington shale
  2) The large unbalanced weight of the fill within the slide zone.
  3) Ground water pressure within the Pennington Formation.

Methods of Stabilizing Slope Recommended by Law Eng.

1) Remove all weak Pennington Shale
2) Reduce weight of fill and lower grade
3) Use of a Retaining Structure
   a) Buttress
   b) Line of Drilled Shafts
   c) In the form of a retaining wall
4) Bridging area of Failure
5) Shifting roadway horizontal into hillside (cut).
6) Drainage - deep drainage and horizontal drains

- From July 1968 to February 1969, the average movement of the slide was noted to be between 0.3 ft. to 0.5 ft. along the slope and increased in speed from February to May 1969 to a 2’-3’ lateral movement.
- In October of 1969 plans were started for Remediation – Minimal solution chosen which was lowering the grade of roadway and installing 44 horizontal drains.

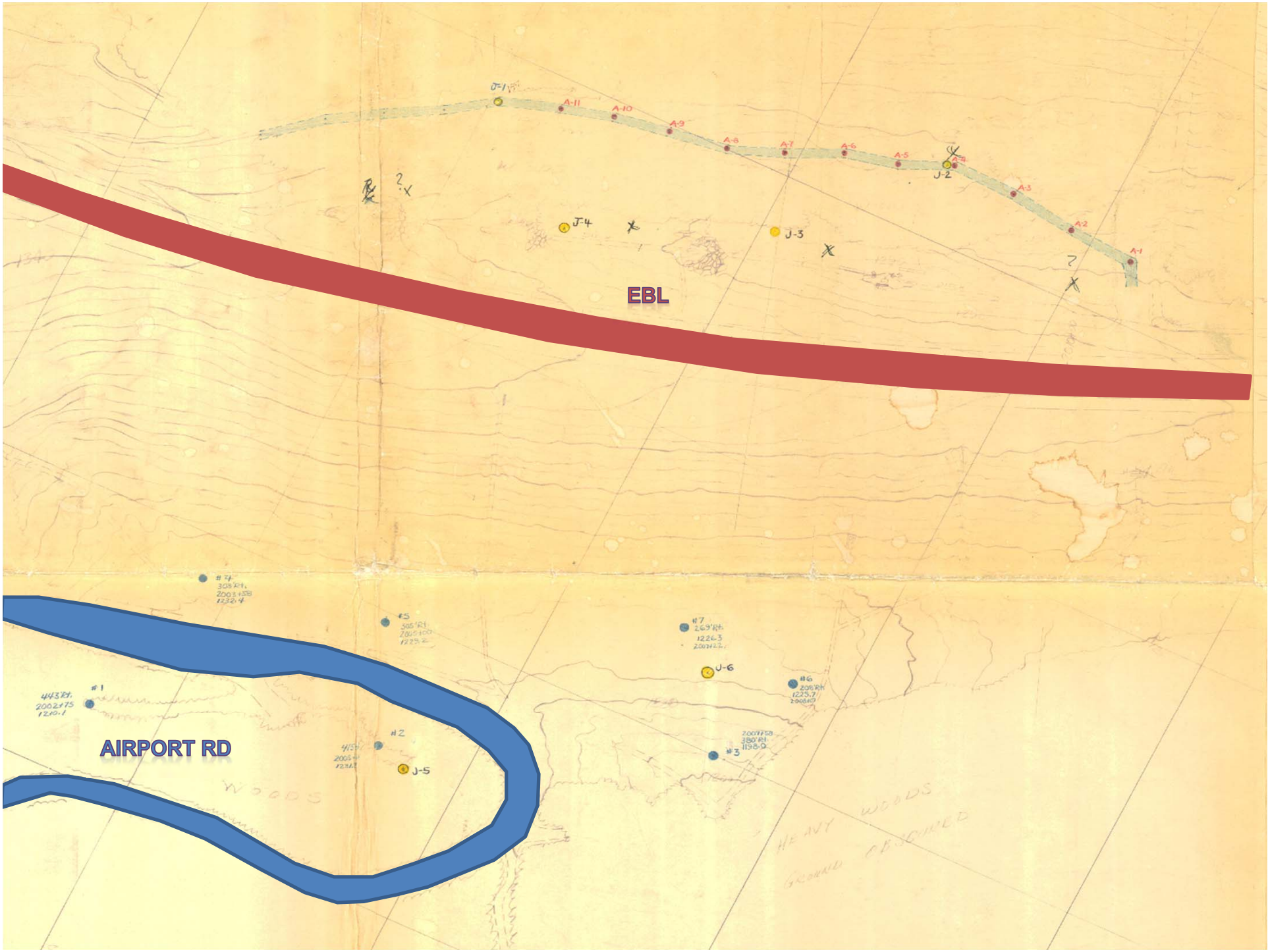
R3


REMOVE
MPERVIOUS COVER
FILL BEFORE REMOVAL
WATER IN FILL
RANGE IN GROUND WATER LEVELS
IN SLIDE ZONE.
NEW 24" CMP DRAIN
ELEV 1250
DRAIN TRENCH
DRAIN TRENCH
SELECT GRANULAR
P.S
P.S
P.S
P.S
P.S
LIMESTONE
PLS
PLS
12" CMP
18" CMP
PS


Rock Buttress

I5

- Between March-April 1974, there was an installation of 7 Slope inclinometers at the toe of the embankment and an observation well in the median and about 4 more located along the slope.
- On August 19, 1974, the last portion of the East Bound Lane of I-40 through the state of Tennessee is open to public.


EBL
AIRPORT RD
J-1
J-2
J-3
J-4
J-5
J-6
A-11
A-10
A-9
A-8
A-7
A-6
A-5
A-4
A-3
A-2
A-1
#1
#2
#3
#4
#5
#6
#7
WOODS
WOODS

- Movement noted through the slope inclinometer readings for the year of 1974 had a max movement of 3” horizontally and 6”-8” vertically
- Between September 1975 to December 1975 33 additional drains were installed at two pads in a fan pattern at the centers of each ravine.

R6
I6

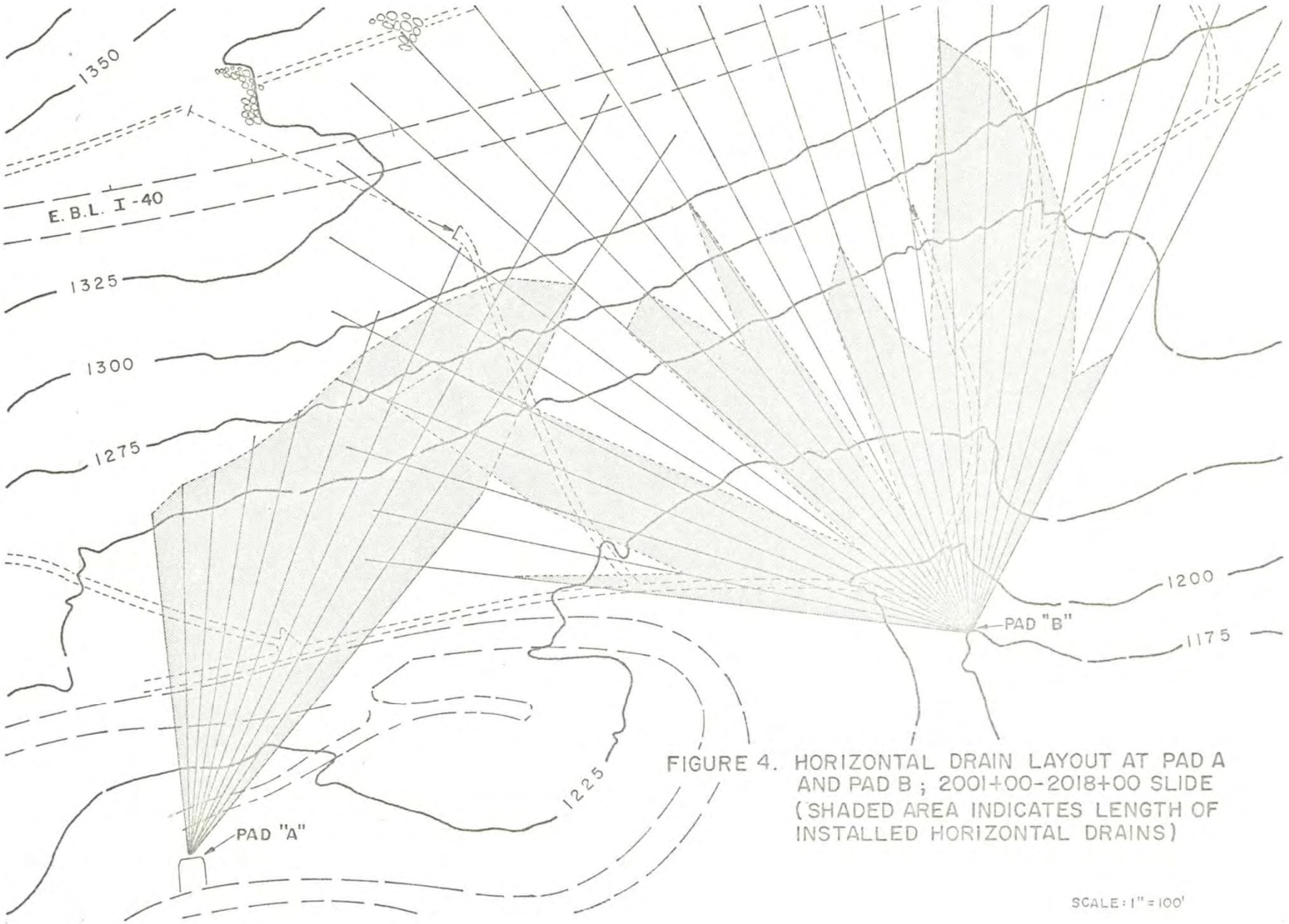


FIGURE 4. HORIZONTAL DRAIN LAYOUT AT PAD A AND PAD B ; 2001+00-2018+00 SLIDE (SHADED AREA INDICATES LENGTH OF INSTALLED HORIZONTAL DRAINS)

SCALE: 1" = 100'

Horizontal Drain Outlet as of 5-19-2003

Horizontal Drain Outlet as of 6-9-09

Stream created by horizontal drains

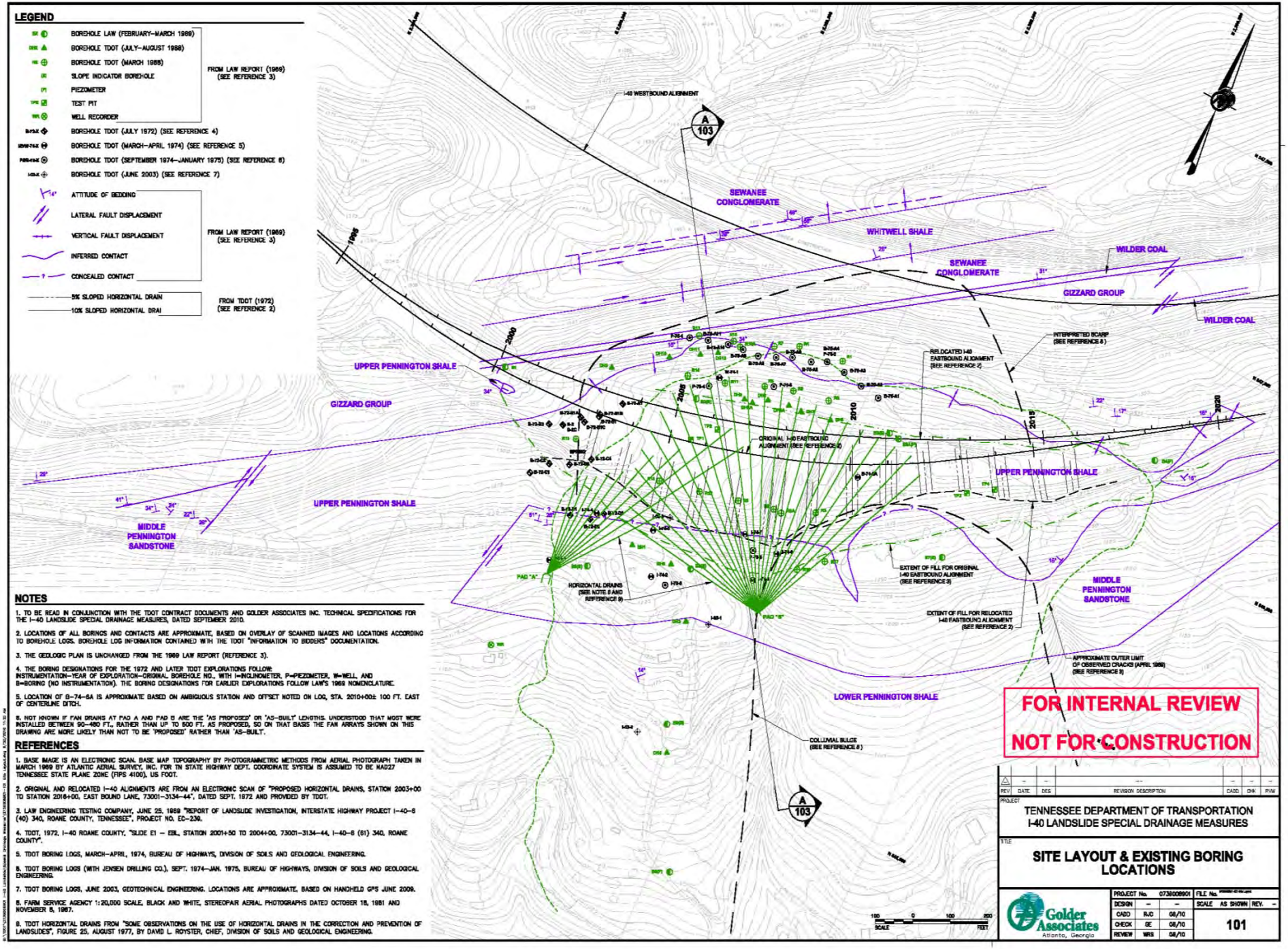
Due to slowing in movement, from 1977 to 1994 the only requirements for the area was an overlay of asphalt when needed.

In 1994, the Geotechnical Engineering section was requested by Maintenance to review the slide area.

- In 1994 to 1995, more horizontal drains were installed along the toe of the fill and down slope of the two pads.
- In June of 2003, three additional slope inclinometers were installed and data has been collected since.
- Rate of movement was averaging 0.1 to 0.2 inches per year from 2003 through 2009. Between 2009 and 2010, the rate of movement had increased to 0.6 inches for the year

R7

I7



NOTES

1. TO BE READ IN CONJUNCTION WITH THE TDOT CONTRACT DOCUMENTS AND GOLDER ASSOCIATES INC. TECHNICAL SPECIFICATIONS FOR THE I-40 LANDSLIDE SPECIAL DRAINAGE MEASURES, DATED SEPTEMBER 2010.

2. LOCATIONS OF ALL BORINGS AND CONTACTS ARE APPROXIMATE, BASED ON OVERLAY OF SCANNED IMAGES AND LOCATIONS ACCORDING TO BOREHOLE LOGS. BOREHOLE LOG INFORMATION CONTAINED WITH THE TDOT "INFORMATION TO BIDDERS" DOCUMENTATION.

3. THE GEOLOGIC PLAN IS UNCHANGED FROM THE 1969 LAW REPORT (REFERENCE 3).

4. THE BORING DESIGNATIONS FOR THE 1972 AND LATER TDOT EXPLORATIONS FOLLOW: INSTRUMENTATION–YEAR OF EXPLORATION–ORIGINAL BOREHOLE NO., WITH I=INCLINOMETER, P=PIEZOMETER, W=WELL, AND B=BORING (NO INSTRUMENTATION). THE BORING DESIGNATIONS FOR EARLIER EXPLORATIONS FOLLOW LAW'S 1969 NOMENCLATURE.

5. LOCATION OF B-74-6A IS APPROXIMATE BASED ON AMBIGUOUS STATION AND OFFSET NOTED ON LOG, STA. 2010+00± 100 FT. EAST OF CENTERLINE DITCH.

6. NOT KNOWN IF FAN DRAINS AT PAD A AND PAD B ARE THE "AS PROPOSED" OR "AS–BUILT" LENGTHS. UNDERSTOOD THAT MOST WERE INSTALLED BETWEEN 90–400 FT., RATHER THAN UP TO 800 FT. AS PROPOSED, SO ON THAT BASIS THE FAN ARRAYS SHOWN ON THIS DRAWING ARE MORE LIKELY THAN NOT TO BE "PROPOSED" RATHER THAN "AS–BUILT.

REFERENCES

1. BASE IMAGE IS AN ELECTRONIC SCAN. BASE MAP TOPOGRAPHY BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPH TAKEN IN MARCH 1969 BY ATLANTIC AERIAL SURVEY, INC. FOR TN STATE HIGHWAY DEPT. COORDINATE SYSTEM IS ASSUMED TO BE NAD27 TENNESSEE STATE PLANE ZONE (FIPS 4100), US FOOT.

2. ORIGINAL AND RELOCATED I–40 ALIGNMENTS ARE FROM AN ELECTRONIC SCAN OF "PROPOSED HORIZONTAL DRAINS, STATION 2003+00 TO STATION 2016+00, EAST BOUND LANE, 73001–3134–44", DATED SEPT. 1972 AND PROVIDED BY TDOT.

3. LAW ENGINEERING TESTING COMPANY, JUNE 25, 1969 "REPORT OF LANDSLIDE INVESTIGATION, INTERSTATE HIGHWAY PROJECT I–40–6 (40) 340, ROANE COUNTY, TENNESSEE", PROJECT NO. EC–239.

4. TDOT, 1972, I–40 ROANE COUNTY, "SLIDE E1 – EBL, STATION 2001+50 TO 2004+00, 73001–3134–44, I–40–6 (61) 340, ROANE COUNTY".

5. TDOT BORING LOGS, MARCH–APRIL, 1974, BUREAU OF HIGHWAYS, DIVISION OF SOILS AND GEOLOGICAL ENGINEERING.

6. TDOT BORING LOGS (WITH JENSEN DRILLING CO.), SEPT. 1974–JAN. 1975, BUREAU OF HIGHWAYS, DIVISION OF SOILS AND GEOLOGICAL ENGINEERING.

7. TDOT BORING LOGS, JUNE 2003, GEOTECHNICAL ENGINEERING. LOCATIONS ARE APPROXIMATE, BASED ON HANDHELD GPS JUNE 2009.

8. FARM SERVICE AGENCY 1:20,000 SCALE, BLACK AND WHITE, STEREOPAIR AERIAL PHOTOGRAPHS DATED OCTOBER 18, 1981 AND NOVEMBER 8, 1987.

8. TDOT HORIZONTAL DRAINS FROM "SOME OBSERVATIONS ON THE USE OF HORIZONTAL DRAINS IN THE CORRECTION AND PREVENTION OF LANDSLIDES", FIGURE 25, AUGUST 1977, BY DAVID L. ROYSTER, CHIEF, DIVISION OF SOILS AND GEOLOGICAL ENGINEERING.

FOR INTERNAL REVIEW

NOT FOR CONSTRUCTION

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	PVW
–	–	–	–	–	–	–

PROJECT

TENNESSEE DEPARTMENT OF TRANSPORTATION
I-40 LANDSLIDE SPECIAL DRAINAGE MEASURES

TITLE

SITE LAYOUT & EXISTING BORING LOCATIONS

Golder Associates
Atlanta, Georgia

PROJECT No.	073800901	FILE No.	
DESIGN	–	–	SCALE AS SHOWN REV. –
CADD	RJC	08/10	
CHECK	GE	08/10	101
REVIEW	WRS	08/10	

- In May of 2008, Golder Associates was hired to analyze and assess the history and provide recommendations for repairing the Major fill slide.

Two recommendations made in Phase I

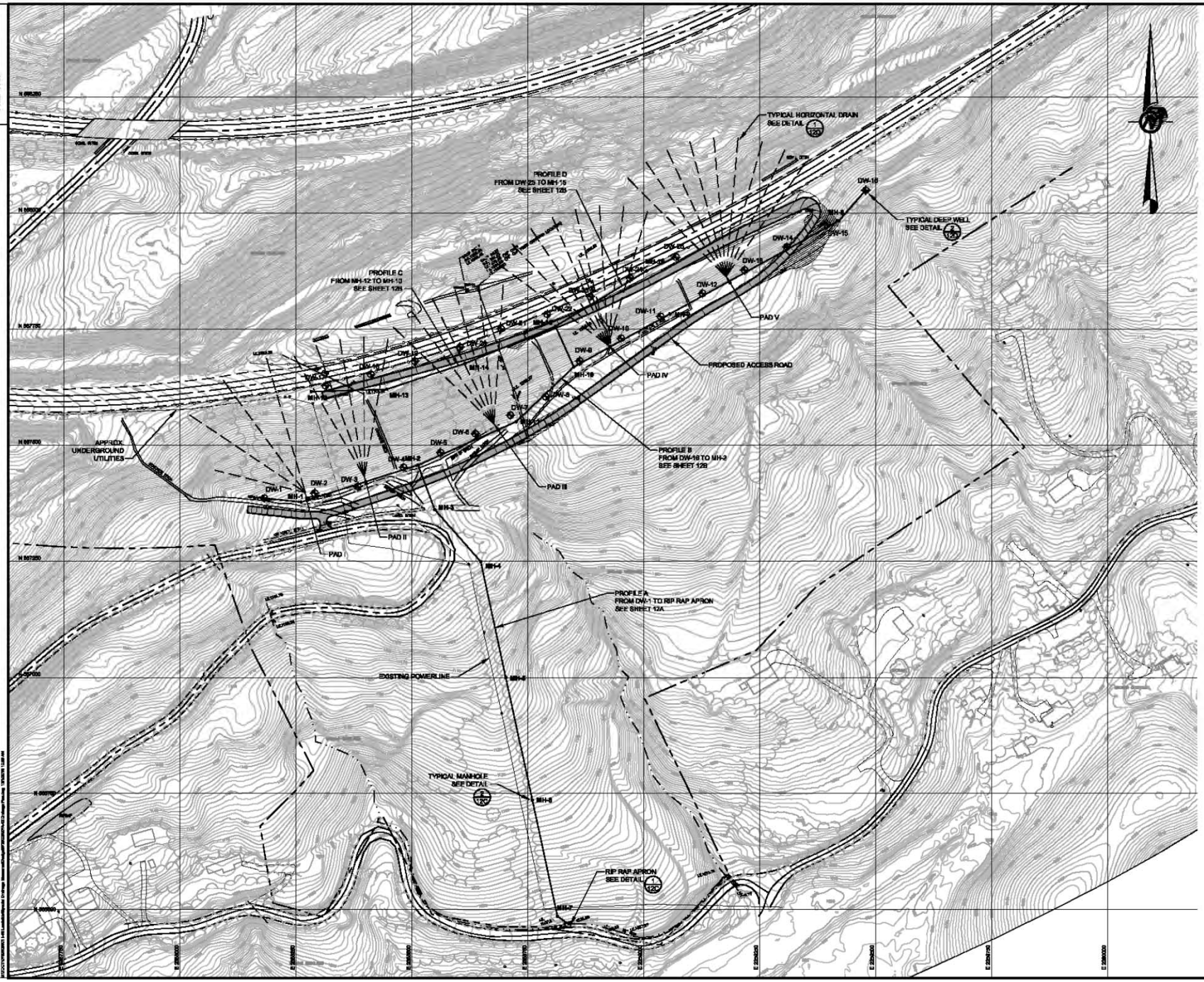
1) Monitoring equipment- seven inclinometers were installed with piezometers located at possible aquifier depths, along with a weather station.

  – Current data shows that movement increases with rainfall.

2) Construction of a drainage system to alleviate some of the water pressure within the slope

R8 - Includes a proposal of 25 wells with regulated pumps with drain pipes linked to remove water from the slope without allowing it to re-infiltrate the surface, 4 piezometer standpipes, and 5 pads with between 4 and 9 horizontal drains at each pad.

TENNESSEE D.O.T.
DESIGN DIVISION
FILE NO.



PROPOS

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PROPOS

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MH-12
MH-13
MH-14
MH-15
MH-16

LEGEND

PRO

MH-1 PRO

12" I

PRO

REFERENCES

1. BASE MAP AND ACCESS
HUTCHESON, INC.

DRAF

Golde
Associa
Atlanta, Ge

- As to date- the slope inclinometers were completed in early 2011 and have been monitored since.
- The rate of movement from march to april was 0.25 inches and slowed thru the summer weather. The peizometer data shows the fluctuation of the water table.
- The construction of the drainage system is to start in August of 2011.

From a review of the data and reports, remediation of the slope is going to be very expensive and unique to the situation.

Any Questions?