LANDSLIDE STABILIZATION USING MICROPILES STATE ROUTE 837 WASHINGTON COUNTY, PENNSYLVANIA

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STATE ROUTE 837
LANDSLIDE STABILIZATION
Washington County, PA

Presentation Outline

- Project Background
- Slope Movement Diagnosis
    - Site Reconnaissance
    - Literature Review
    - Subsurface Investigation
- Design Summary
- Construction Overview

PROJECT BACKGROUND

STATE ROUTE 837
LANDSLIDE STABILIZATION
Washington County, PA

Project Stakeholders

Owner: Commonwealth of Pennsylvania,
Department of Transportation

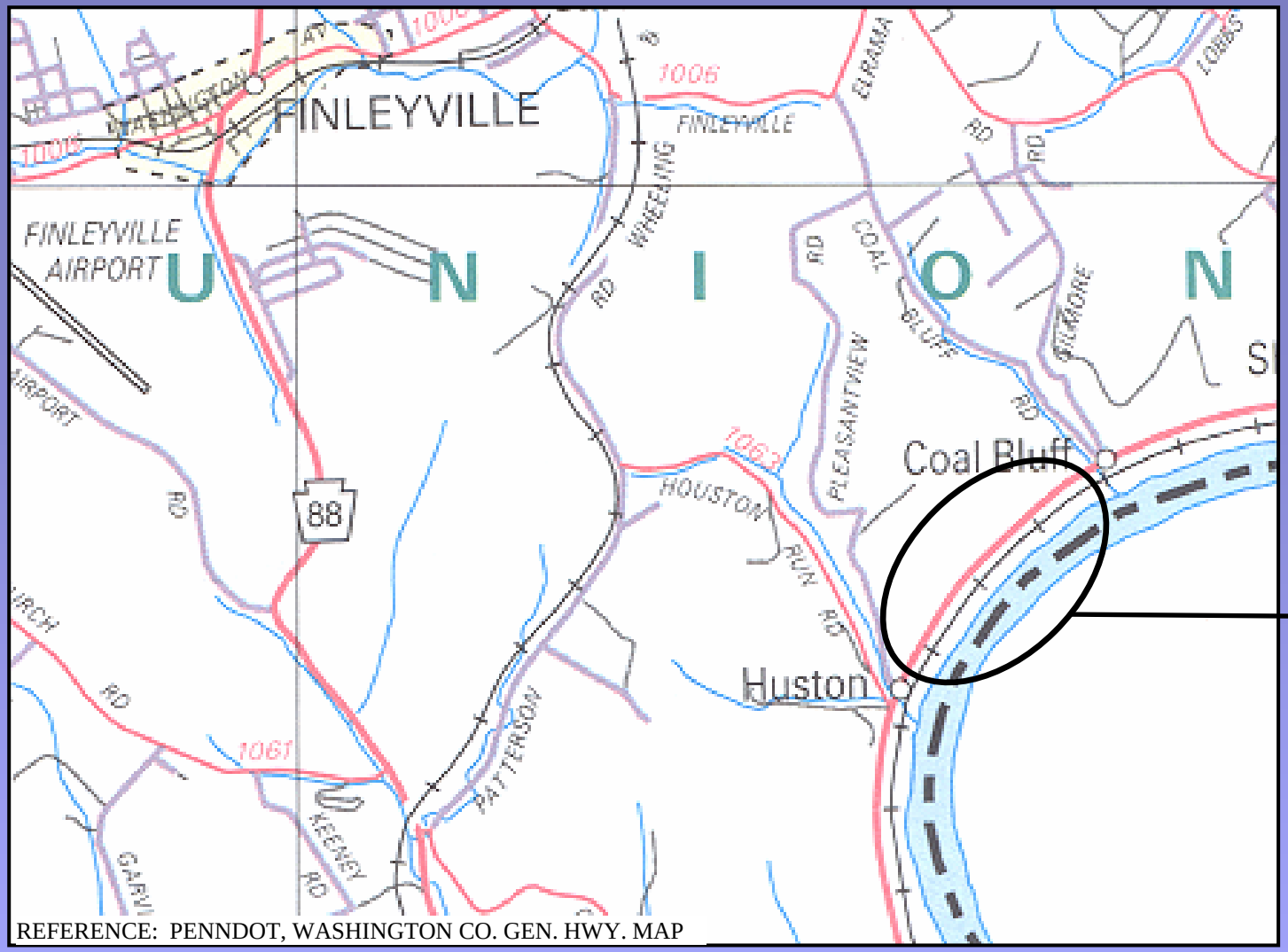
- Designer: Gannett Fleming, Inc.

STATE ROUTE 837
LANDSLIDE STABILIZATION
Washington County, PA

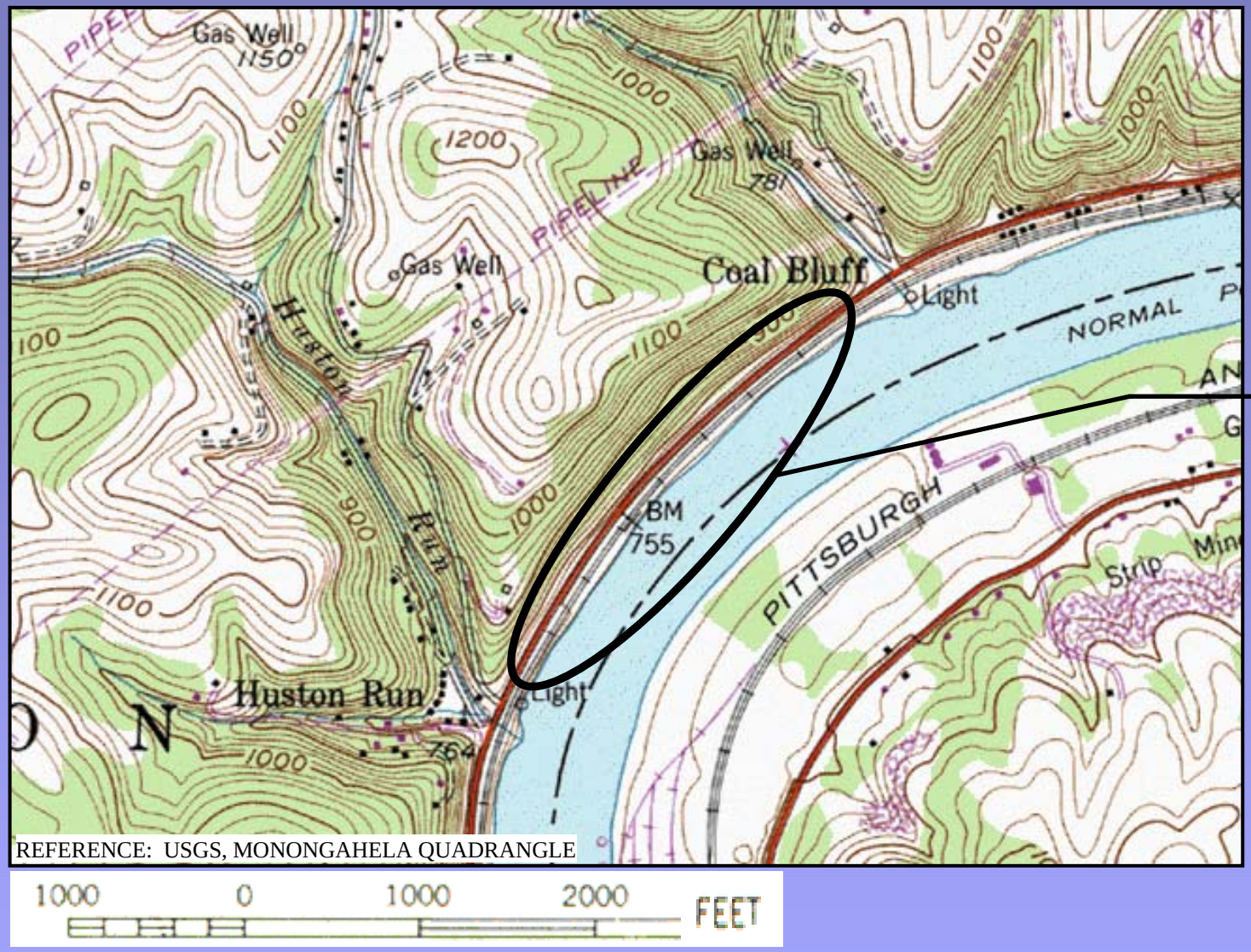
Project Location

- Union Township, Washington County, PA
- 20 miles south of Pittsburgh
- On the Valley Wall of the Monongahela River

PROJECT SITE



REFERENCE: PENNDOT, WASHINGTON CO. GEN. HWY. MAP



REFERENCE: USGS, MONONGAHELA QUADRANGLE

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SITE RECONNAISSANCE

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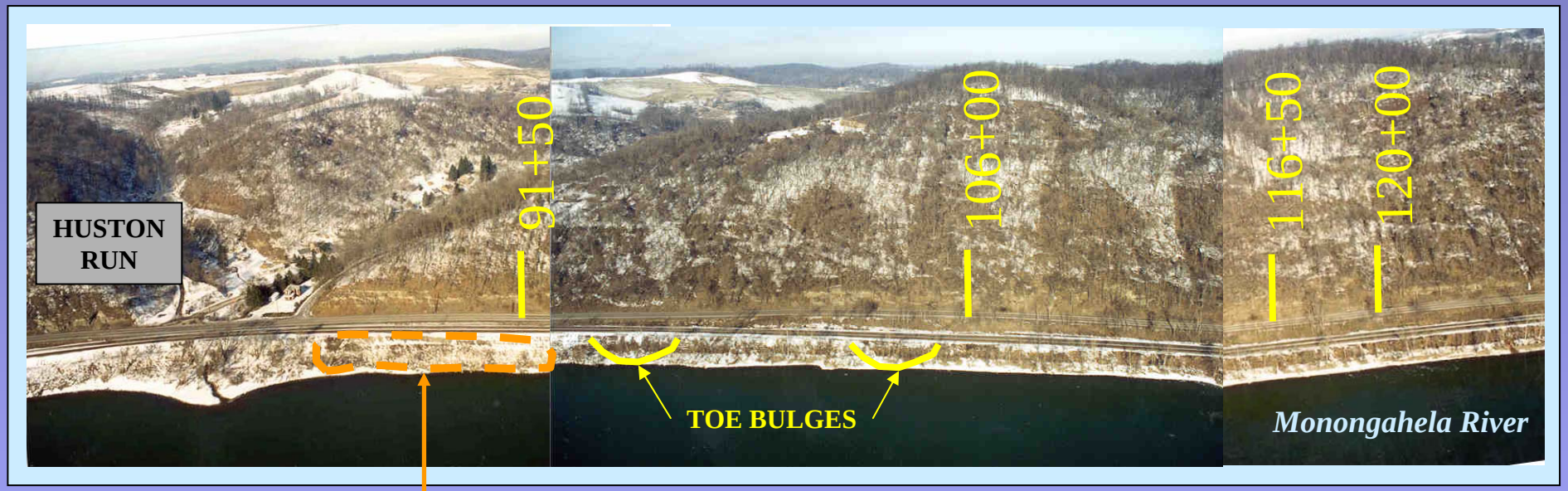
Site Reconnaissance Summary

- Distressed pavement
  - Patching
  - Depression/displacements and cracking
- Non-functioning roadway drainage systems
- Toe bulges in soil below the adjacent RR
- Past landslide remediation efforts by the RR
- Outcrop of the Pittsburgh coal seam

SOUTHERN SLIDE

NORTHERN SLIDE



ROCK EMBANKMENT PLACED BY RR

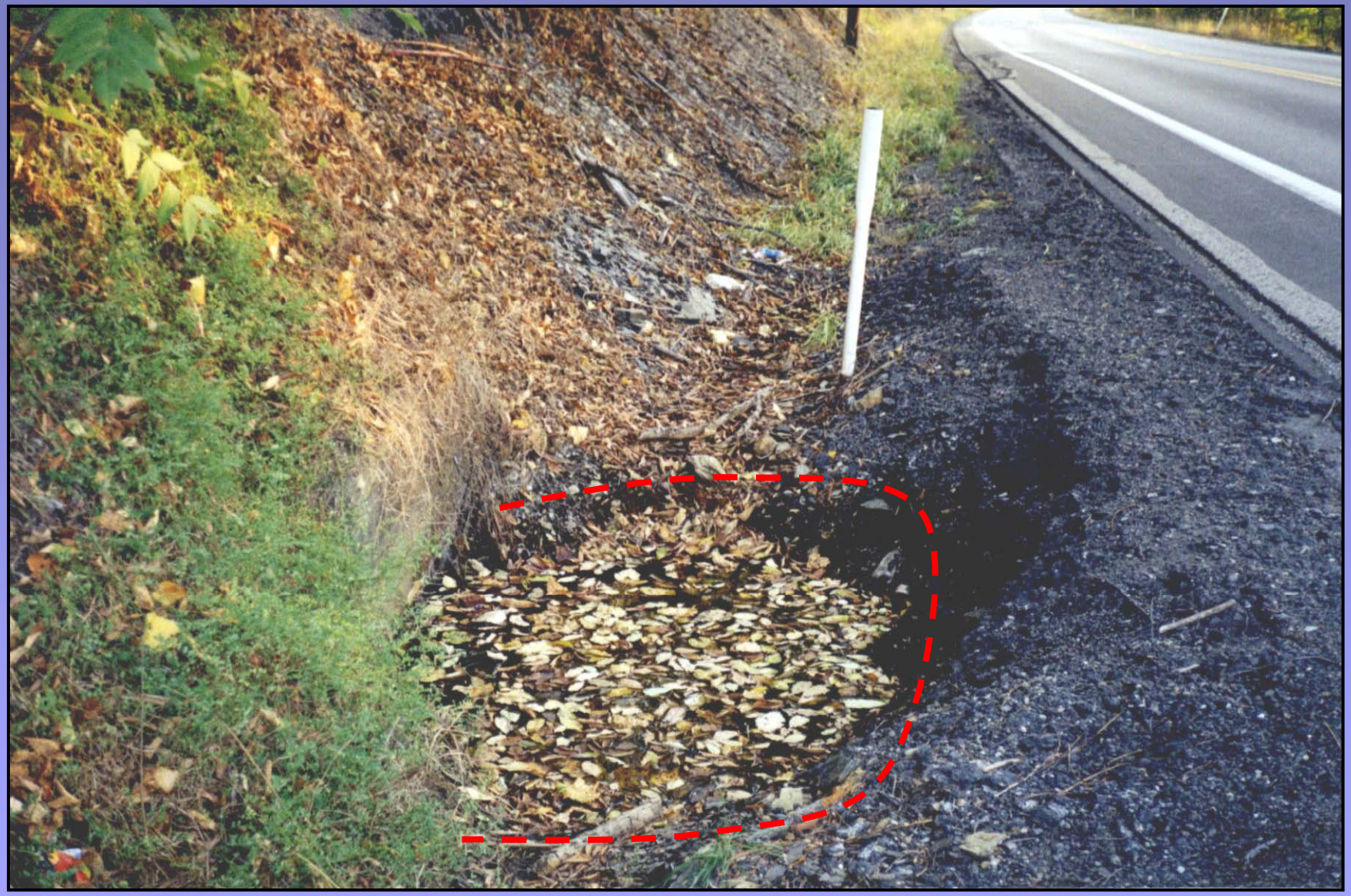

ROUGH
ROAD

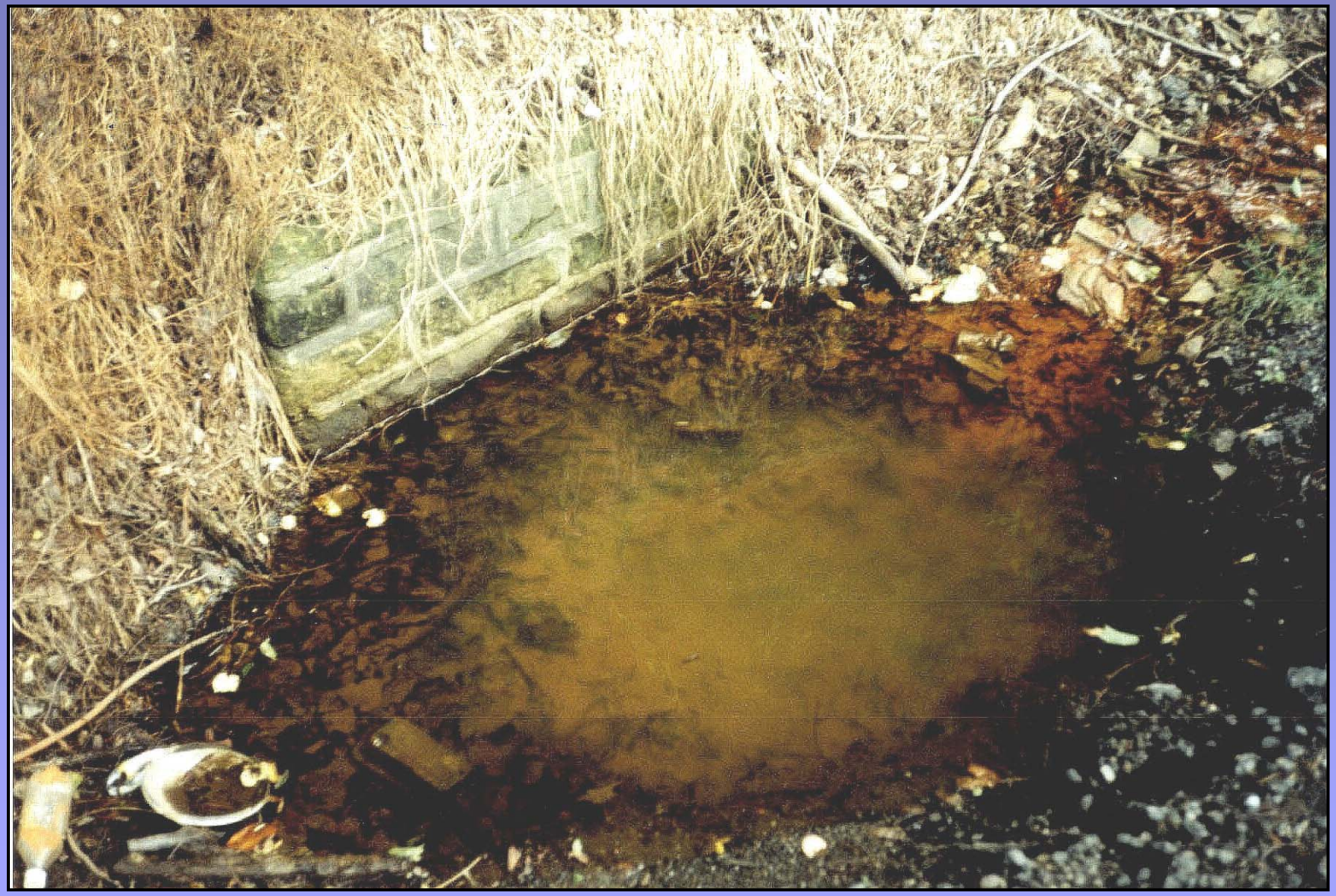

APPROXIMATE STATION 100+50


APPROXIMATE STATION 100+50


APPROXIMATE STATION 118+00

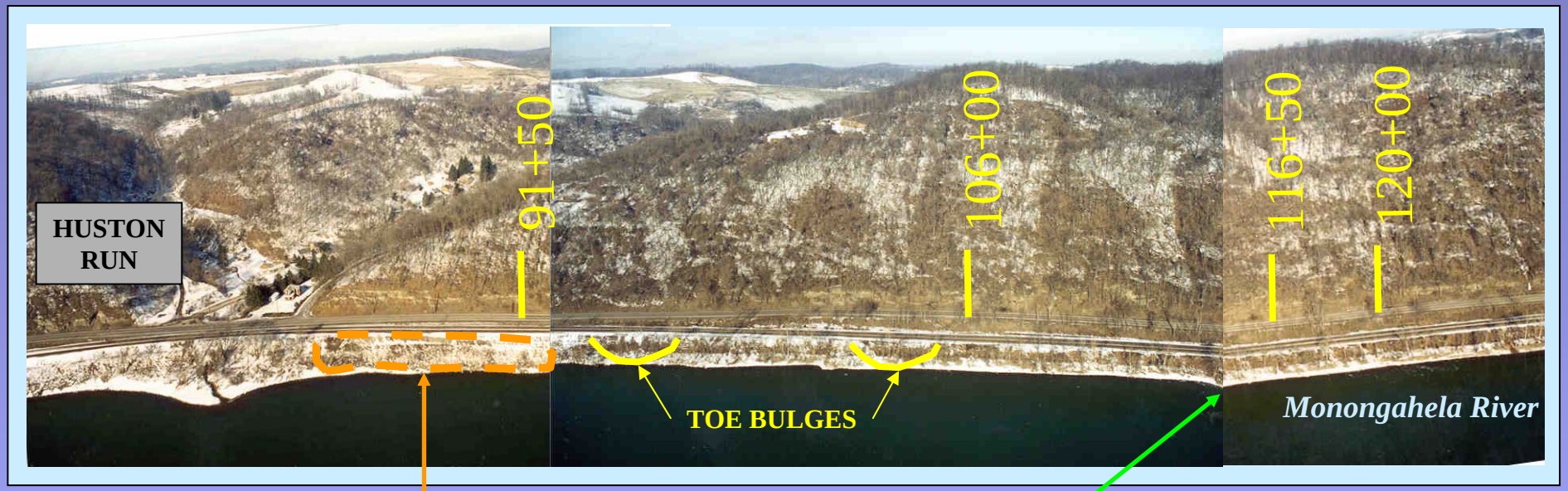

APPROXIMATE STATION 118+00





SOUTHERN SLIDE

NORTHERN SLIDE



ROCK EMBANKMENT PLACED BY RR

SITE OF FORMER COAL TIPPLE


PITTSBURGH COAL OUTCROP


MINE SEAL
CLOGGED DRAIN

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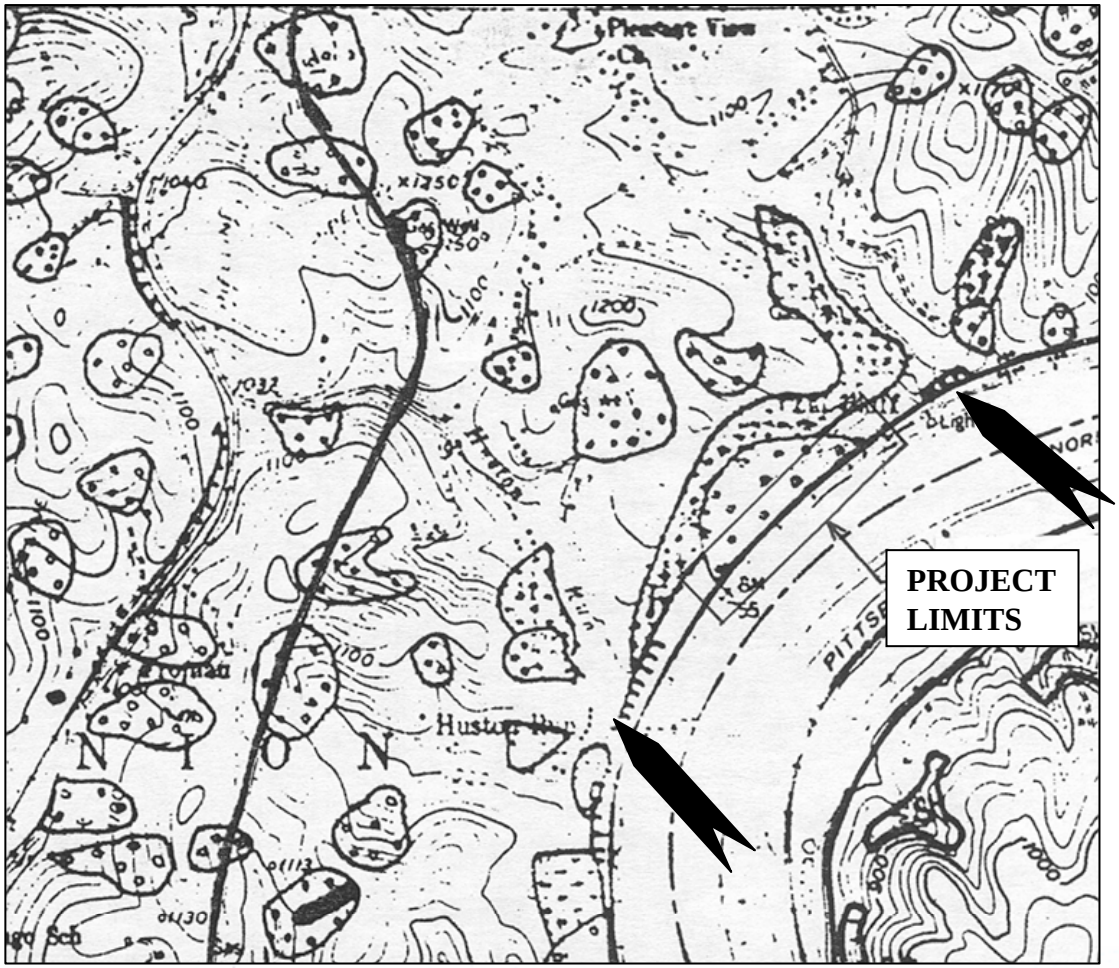
LITERATURE REVIEW

STATE ROUTE 837
LANDSLIDE STABILIZATION
Washington County, PA

Geologic Literature Summary

- Ancient landslide area
- Pittsburgh coal seam mined beneath adjacent areas of land
- Near the axis of the Duquesne-Fairmont syncline



ACTIVE OR RECENTLY ACTIVE LANDSLIDE

Complex landslide composed of earthflow, debris slide, earth and rock slump. Identified from historical records, and from scars, debris and other field evidence. Ground extremely unstable; sliding accelerated by excavation, loading and changes in drainage conditions. May include areas with several active slides too small to be shown separately. Questioned where doubtful.

OLD LANDSLIDE

Area of extensive hummocky ground caused by earthflow and earth and rock slump. Lacks clear evidence of active sliding. Relatively stable in natural, undisturbed state, generally not affected by small structures properly sited in areas away from the edge of the toe; can be reactivated by extensive, rapid excavation, loading, and changes in ground water and surface water conditions. Area of old landslide probably includes recent ones not identified from field evidence or otherwise documented. Upslope boundary of landslide generally defined by modified scarp, but downslope (toe) may be gradational and not well defined. Questioned where doubtful.

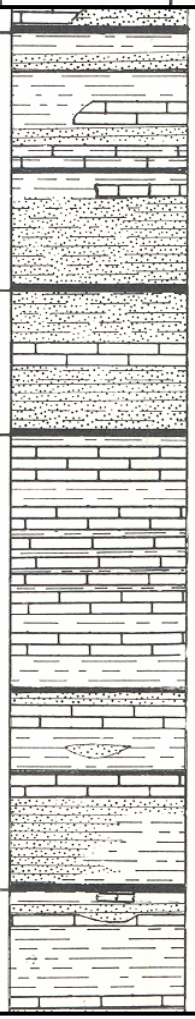
SOIL AND ROCK SUSCEPTIBLE TO LANDSLIDING

SCALE 1:24 000

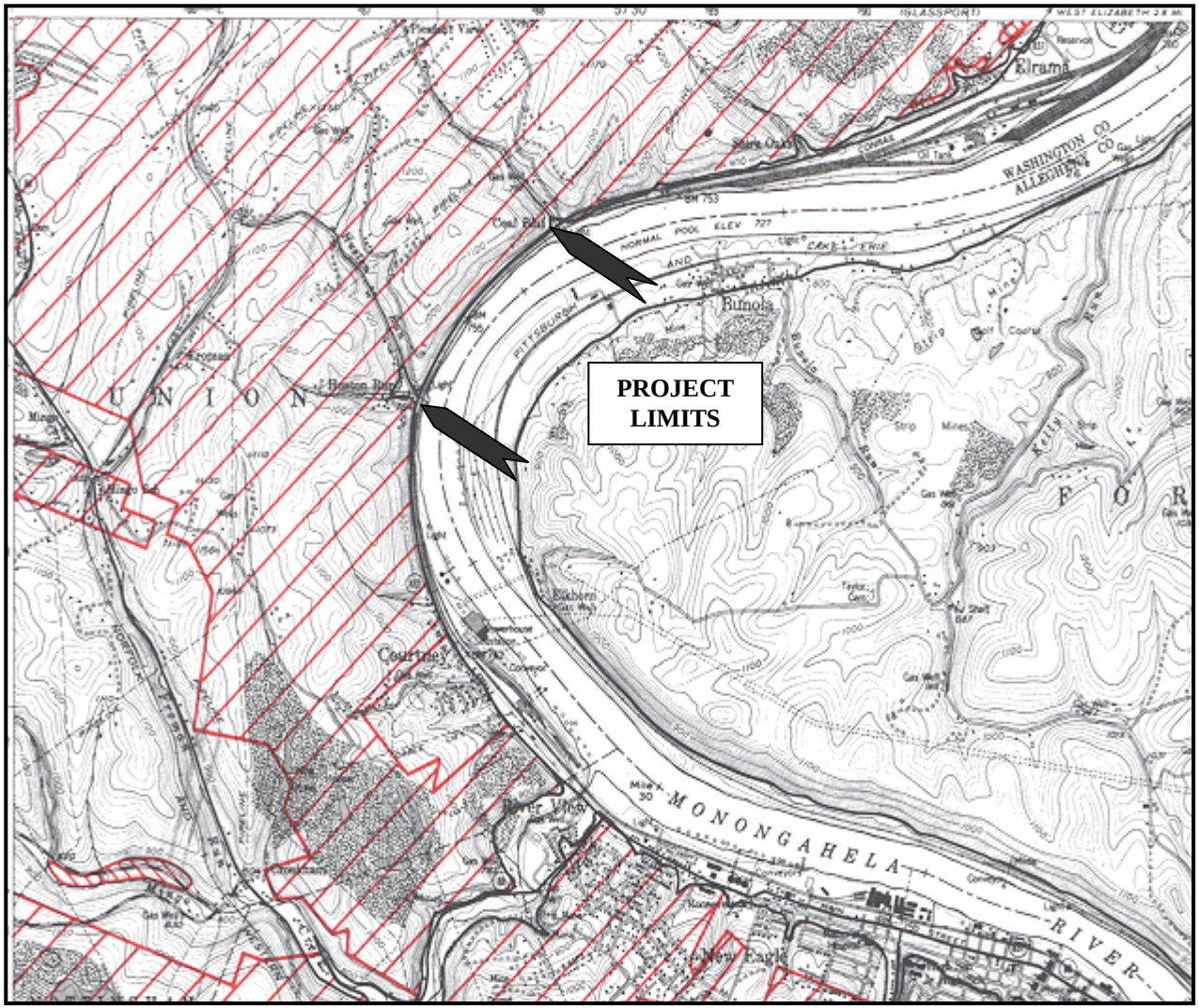
1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

System	Group (Symbol)	Thickness in Feet	Formation (Symbol)	Columnar Section	Members, Beds and Other Minor Units
Pennsylvanian and Permian			Waynesburg (ℙPwb)		Washington coal Little Washington coal Waynesburg sandstone Waynesburg "A" coal Waynesburg coal
	Monongahela (ℙm)	350	Uniontown (ℙu)		Waynesburg limestone Uniontown sandstone Uniontown coal
			Pittsburgh (ℙpg)		Benwood limestone Sewickley coal and sandstone Fishpot limestone Redstone coal Redstone limestone Pittsburgh sandstone Pittsburgh coal Upper Pittsburgh limestone Lower Pittsburgh limestone

PROJECT INTERVAL

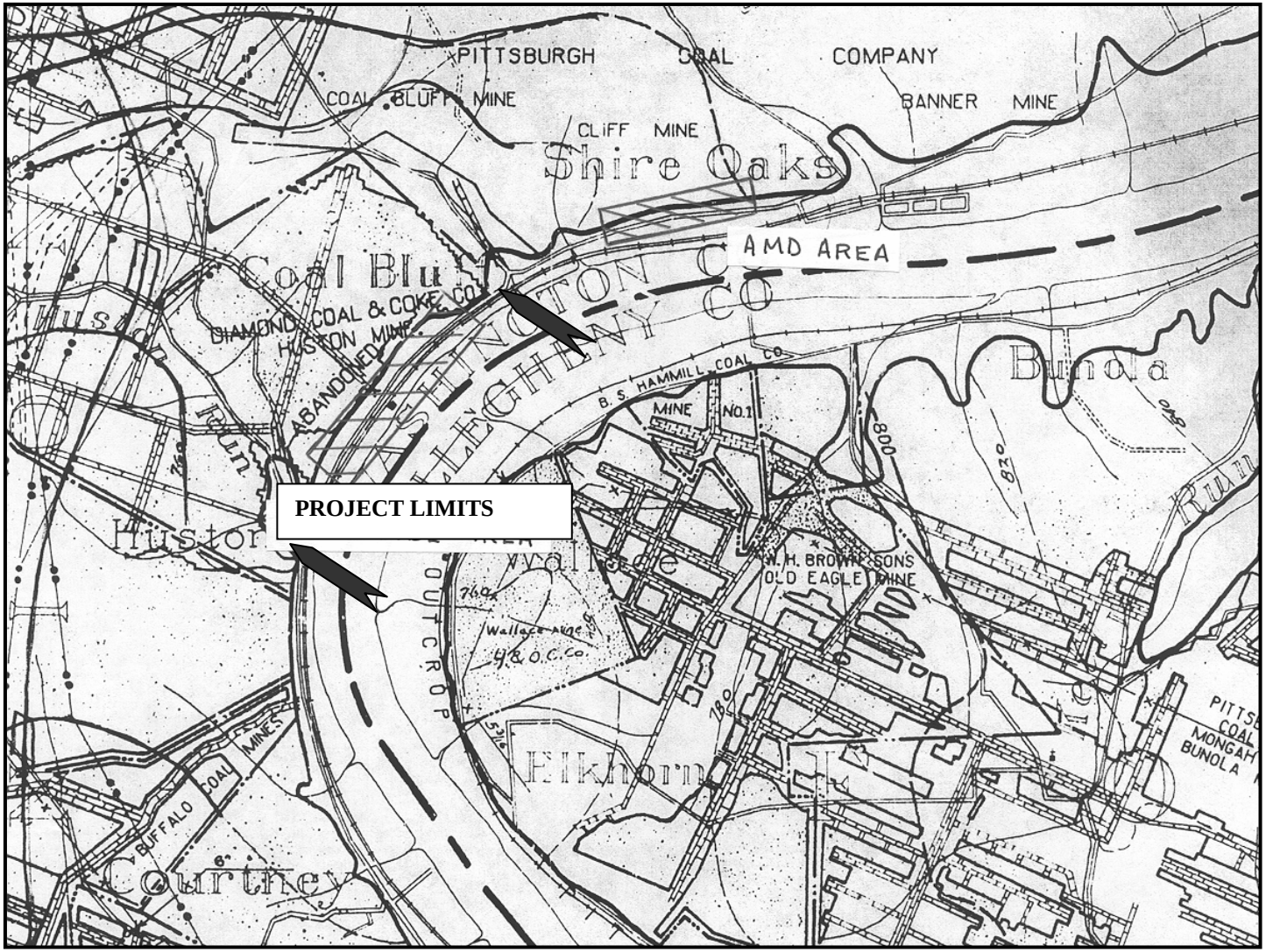


Explanation

Mined-out areas

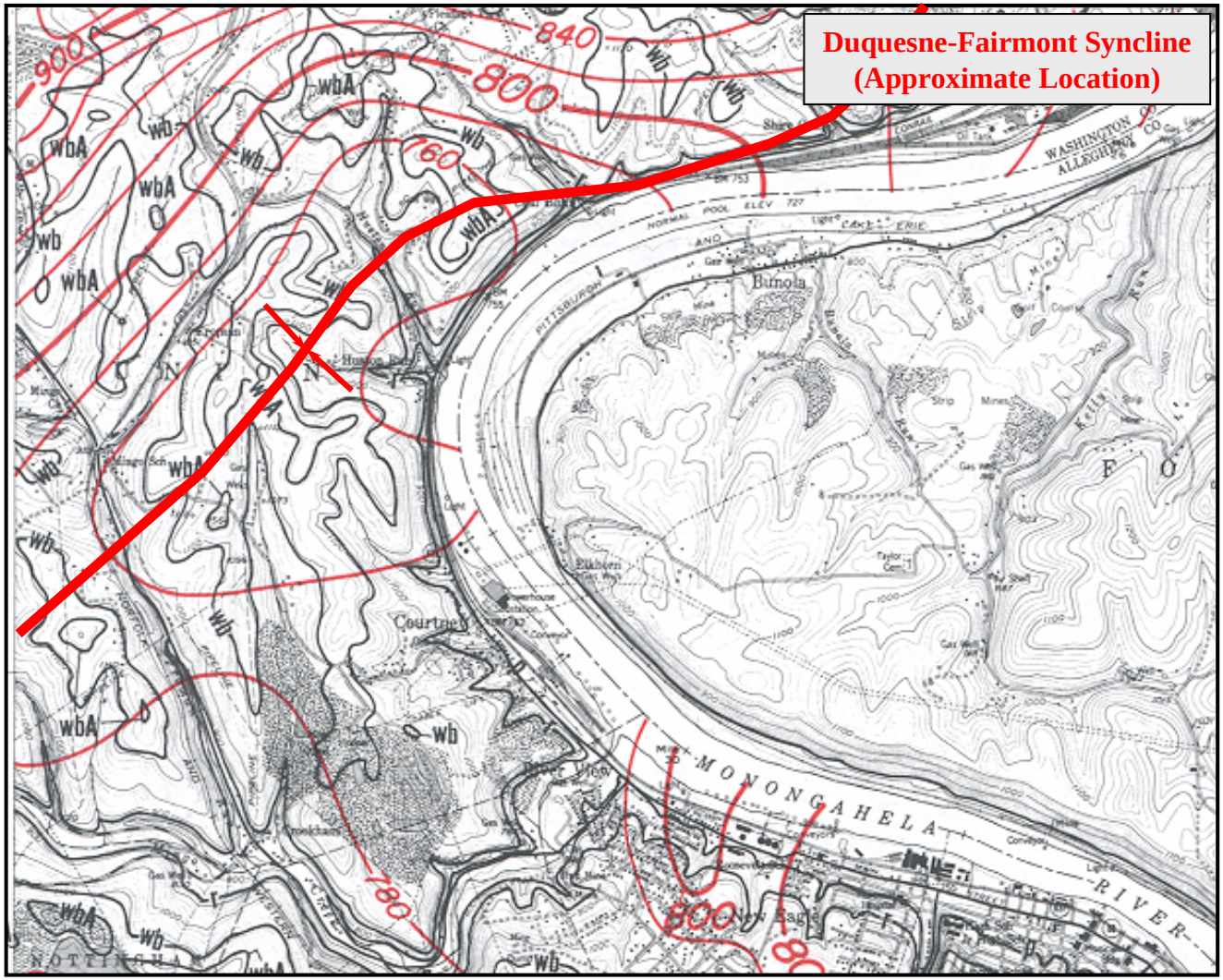
0 1 2 3 4 5 KILOMETRES

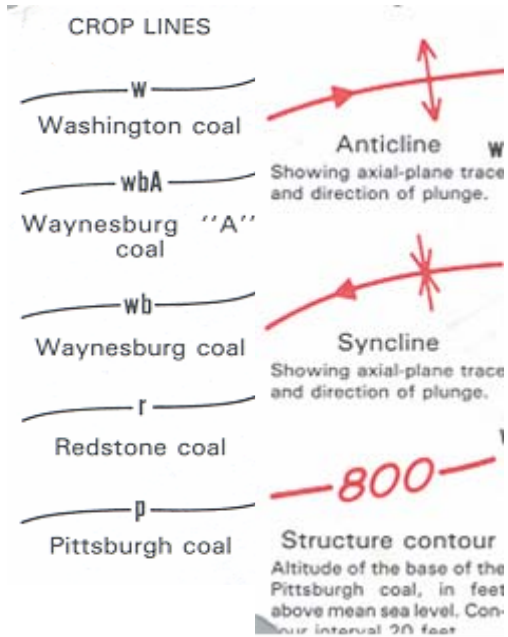
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

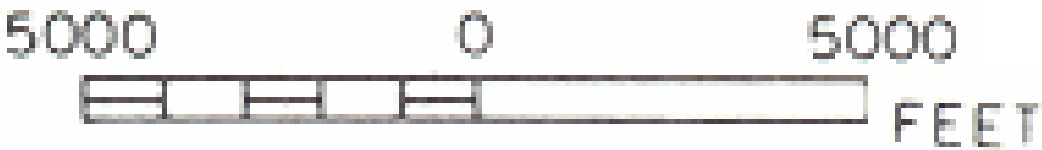


0 1 2 3 4 5 KILOMETRES

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL


Duquesne-Fairmont Syncline
(Approximate Location)
900
840
800
760
780
wbA
wb
Burnola
Courtney
MONONGAHELA
RIVER
PITTSBURGH
WASHINGTON
ALLEGHENY
CO


CROP LINES
w
Washington coal
wbA
Waynesburg "A" coal
wb
Waynesburg coal
r
Redstone coal
p
Pittsburgh coal
Anticline
Showing axial-plane trace and direction of plunge.
Syncline
Showing axial-plane trace and direction of plunge.
800
Structure contour
Altitude of the base of the Pittsburgh coal, in feet above mean sea level.


5000
0
5000
FEET

STATE ROUTE 837
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DESIGN SUMMARY

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<u>Subsurface Investigation(s)</u>

- Limited information available from past studies
  - 8 borings
  - 3 inclinometers

- 40 additional borings
  - 4 inclinometers
  - 4 piezometers

- Laboratory test data
  - SPT samples: classification and moisture content
  - Shelby tubes: direct shear strength
  - Bedrock core samples: uniaxial compressive strength

ENGINEERS FIELD BORING LOG

BORING NO:	GF-40
SHEET	1 OF 1
DATE: START	12-03-01
END	12-03-01
O.G. ELEV	769.0 ft

PROJECT NAME: S.R. 0837, SECTION 21R LANDSLIDE COUNTY: WASHINGTON
STATE ROUTE NO.: 0837 SECT.: 21R SEGMENT: -- OFFSET: --
STATION: 103+50 OFFSET FROM CENTERLINE: 12.0 ft RT
INSPECTOR (SIGNED): G. Toth DRILLERS NAME/ COMPANY: R. McElfresh / SITE-Blauvelt Engineers, Inc.
EQUIPMENT USED: CFE 55, Truck Rig
DRILLING METHODS: NQ Wireline with Water
CASING SIZE: - DEPTH: - WATER: DEPTH: Dry TIME: 1100 DATE: 12-03-01
CHECKED BY: WAH DATE: 1-15-02 DEPTH: Dry TIME: 1115 DATE: 12-04-01
NOT ENCOUNTERED ☐

DEPTH (FT.)	SAMPLE NO. AND TYPE / CORE RUN	BLOWS / 0.5 FT. ON SAMPLER	RECOVERY (FT.)	RECOVERY % / RQD %	POCKET PENT or TORVANE (TSF)	USCS / AASHTO	H2O CONTENT	DESCRIPTION		REMARKS
				100				0.0 to 0.8 ASPHALT (Binder)	El. 768.2	
								0.8 to 1.8 ASPHALT (Wearing)	El. 767.2	
								1.8 to 2.2 ASPHALT (Binder)		
								2.2 to 2.6 ASPHALT (Wearing)		
								2.6 to 2.8 ASPHALT (Binder)		
								2.8 to 3.5 ASPHALT (Wearing)		
								3.5 to 4.6 ASPHALT (Binder)		
5.0	R-1		5.0	-				4.6 to 5.9 ASPHALT (Wearing) Deteriorated 5.3-5.6'	El. 765.1	
				100				5.9 to 6.5 ASPHALT (Binder)	El. 762.5	
								6.5 to 6.9 CONCRETE	El. 762.1	
7.3	R-2		2.3	-				6.9 to 7.3 ASPHALT (wearing)	El. 761.7	
								END OF BORING @ 7.3 ft		

MORE THAN 7' OF ASPHALT

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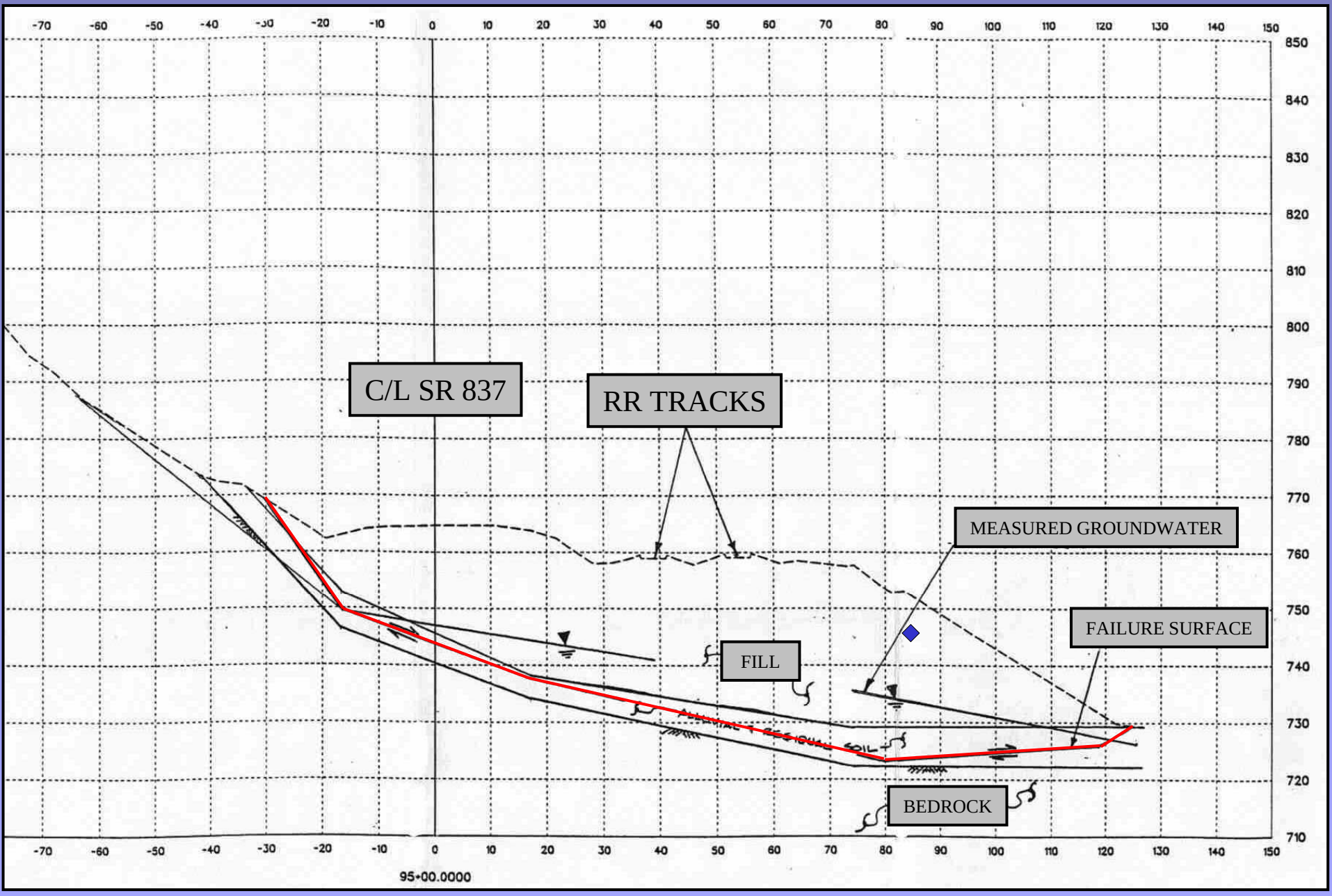
Analyses

- Subsurface model created based upon site survey, boring data, piezometers and laboratory test data
- Failure plane identified by inclinometer and boring data in native soil near the top of bedrock


C/L SR 837
RR TRACKS
MEASURED GROUNDWATER
FAILURE SURFACE
FILL
BEDROCK
95+00.0000

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Analyses (continued)

- Failure of existing slope modeled by back analysis
  - FS slightly less than 1.0 achieved
  - Rediscovered some pitfalls of back analysis (i.e., water levels)

Soil Strength Parameters:

• FILL MATERIALS:	$\phi = 30°$;	c = 100 psf;	γ = 110 pcf
• COLLUVIUM:	$\phi = 14°$;	c = 100 psf;	γ = 130 pcf

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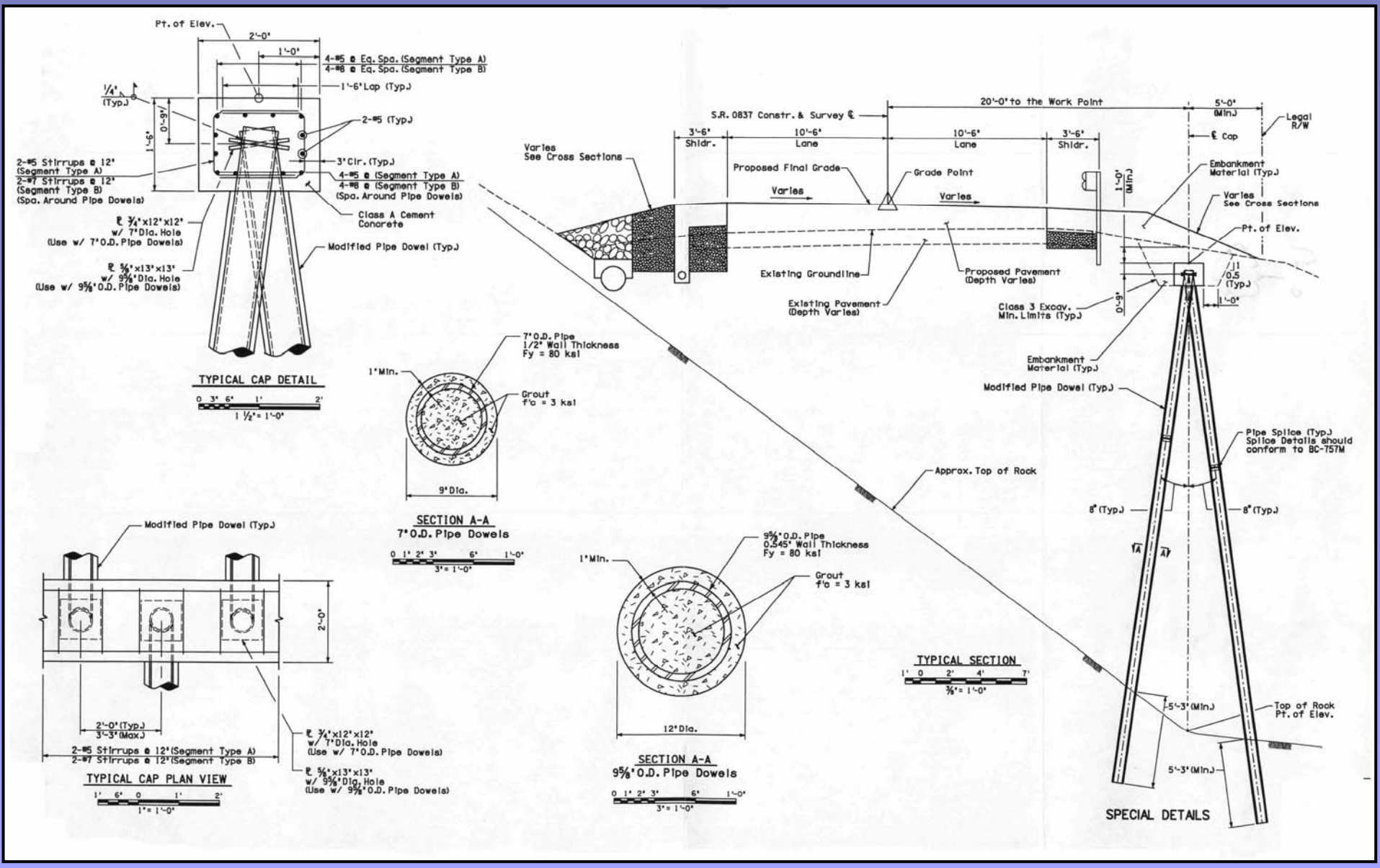
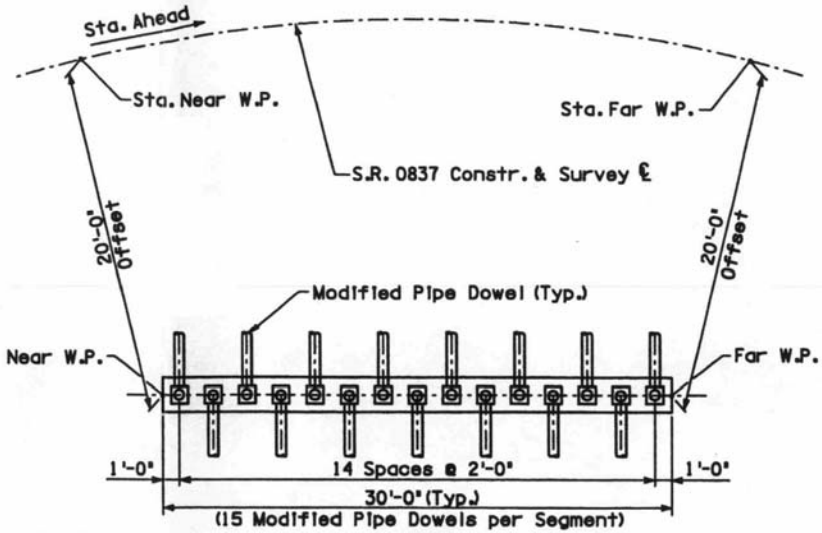
Analyses (continued)

- Remedial alternatives considered
  - Horizontal drains – deemed inappropriate
  - Excavation and replacement – required detour
  - Anchored soldier pile wall – requires ROW acquisition
  - Tangent caisson wall – $6-7 million

- Ultimately, micropiles were selected
  - Relatively quick construction
  - No need for additional ROW
  - Administratively simpler – buried reinforcement

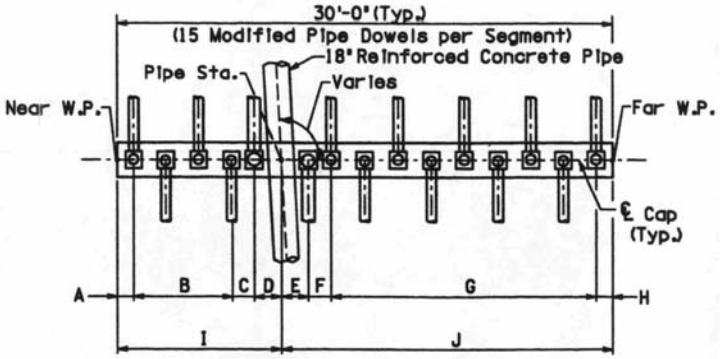


Net load due to landslide mass: 25.7 kips/foot



TYPICAL PLAN - SEGMENT TYPE A

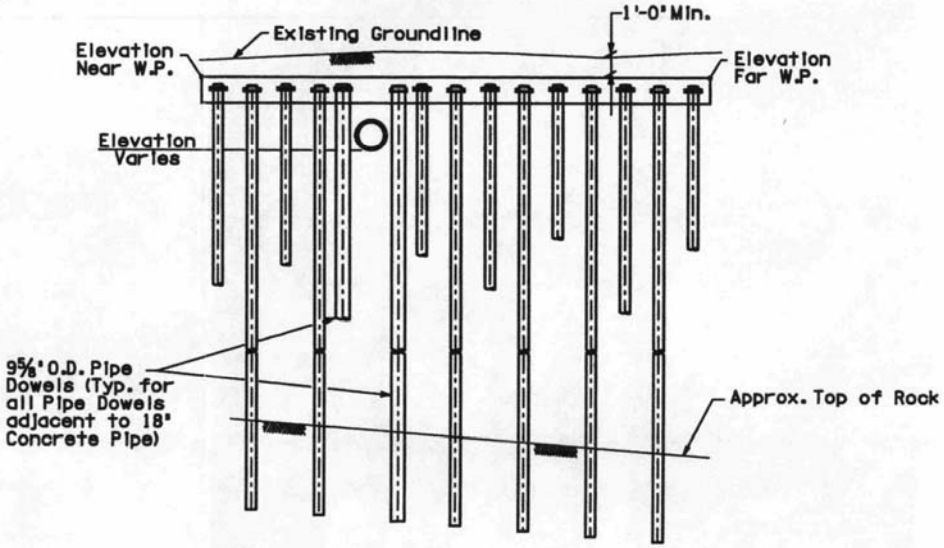
5' 2½' 0 5' 10'
1" = 5'-0"



* For dimensions and spacings see layout data below.

TYPICAL PLAN - SEGMENT TYPE B

5' 2½' 0 5' 10'
1" = 5'-0"



TYPICAL ELEVATION - SEGMENT TYPE B
(SEGMENT A SIMILAR)

5' 2½' 0 5' 10'
1" = 5'-0"

GENERAL NOTES - MODIFIED PIPE DOWEL SYSTEM:

1. Provide materials and workmanship in accordance with specifications, Publication 408M, 2000 and contract Special Provisions.
2. Design Specifications:
   AASHTO LRFD Bridge Design Specifications 1998, and as supplemented by "Design Manual, Part 4" April 2000 Edition.
3. Design Live Loads:
   PHL-93 (Live Load Surcharge).
4. The centerline of each segment is defined as a straight line between work points
5. All work performed outside the PennDOT Right-of-Way should be coordinated with the Railroad in accordance with the project specifications.
6. For Typical Section and additional Details see sheet ___ of ___.
7. Material Properties:
   - Use Class A Cement Concrete in the Cap
   - Use 3 ksi Grout for the Modified Pipe Dowels
   - Use Grade 60 Reinforcing Steel Bars in the Cap
   - Use 80 ksi Pipe for the Modified Pipe Dowels
   - Use 36 ksi Steel for all Top Plates.

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Analyses (continued)

- Concurrent reestablishment/improvement of site drainage
- Approximate final cost of $3.5 million

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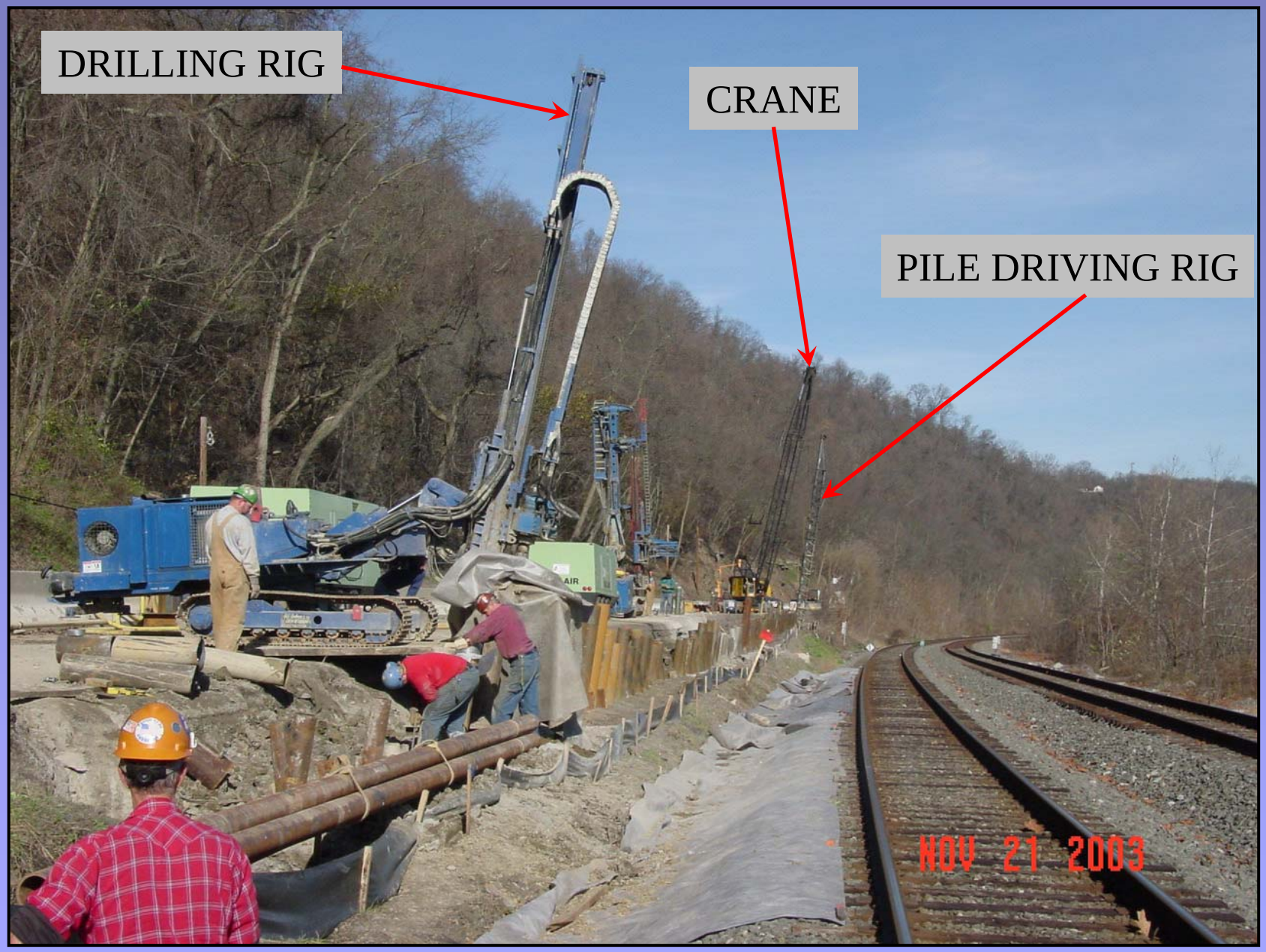
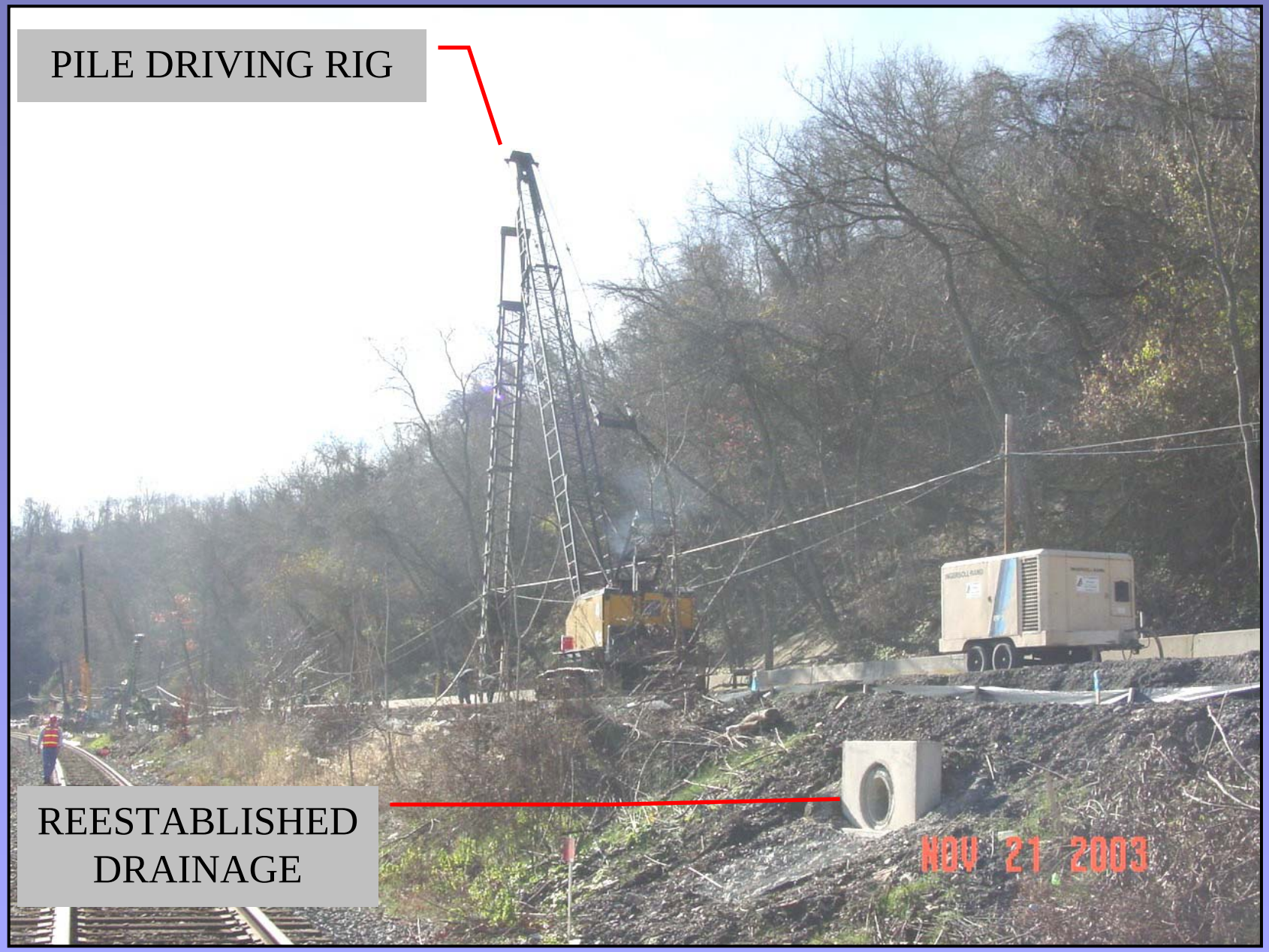
CONSTRUCTION OVERVIEW


DRILLING RIG
CRANE
PILE DRIVING RIG
NOV 21 2003


NOV 21 2003


PILE DRIVING RIG
REESTABLISHED DRAINAGE
NOV 21 2003

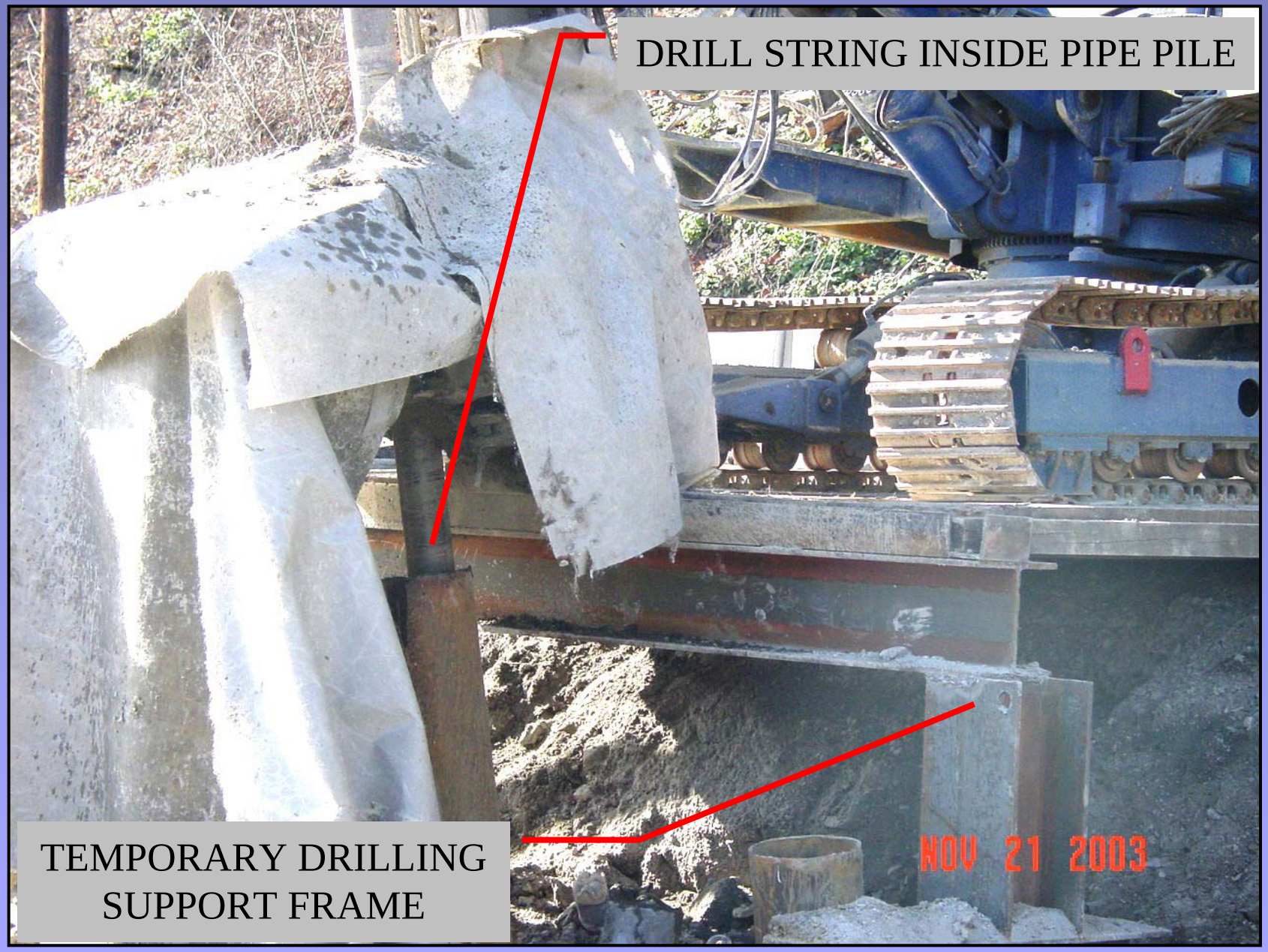

NOV 21 2003


INSTALLED
PIPE PILES
NOV 21 2003


5
NOV 21 2003


NOV 21 2003


HBR 505 D
NOV 21 2003


DRILL STRING INSIDE PIPE PILE
TEMPORARY DRILLING SUPPORT FRAME
NOV 21 2003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01.07.2005 10:39