

**SURFACE AND SUBSURFACE INFORMATION SUMMARY
ABERDEEN LANDSLIDES
ALDEN ROAD, BELMONT STREET,
AND COUNCIL CREST
ABERDEEN, WASHINGTON**

Submitted to:

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1.0 SUMMARY

The following summary is presented for introductory purposes and, as such, should be used only in conjunction with the full text of the report.

- **Project Description:** The report addresses three landslide sites in Aberdeen, Washington, located near the following roadway intersections: Alden Road at Friedlander Road; Belmont Street at Robert Gray Boulevard; and Council Crest at Eighth Street. The landslide locations are shown on the enclosed Location Map (Figure 1). These three landslides occurred on 29 December 1996, below City roadways, and extended from the roadway down into relatively steep ravines. This report provides surface and subsurface information to be used in conjunction with the project manual and plan set.
- **Exploratory Methods:** We explored subsurface conditions by means of three borings advanced at strategic locations across each of the project sites. We also conducted site reconnaissance and landslide mapping of each site. Concurrent with these field studies topographic surveys of each site were performed by Parametrix, under subcontract to us.
- **Subsurface Conditions:** The subsurface conditions in our explorations at the three sites were relatively consistent. The site soils consisted of landslide debris, mantling fill soils/residual soil and/or weathered bedrock soils or both, which overlies bedrock of the Montesano formation at depth. The geologic cross-sections presented for the three sites in Figures 3, 6, and 9 display the subsurface conditions encountered in our explorations.
- **Landslide Assessment:** The slope failures appear to be compound slides consisting of rotational sliding in the upper soils followed by translational sliding along the dipping bedrock surface. Evidence of erosion and flow of the slide debris is also present. Saturation of the upper soils appears to have triggered the landslides that were already marginally stable. The existing slopes are only marginally stable in their current condition.

2.0 PROJECT DESCRIPTION

The project consists of three landslide sites in Aberdeen, Washington, located near the following roadway intersections:

- Alden Road at Friedlander Road;

- Belmont Street at Robert Gray Boulevard; and
- Council Crest at Eighth Street.

The landslide locations are shown on the enclosed Location Map (Figure 1).

The Alden Road site consists of a main landslide scar approximately 50 to 60 feet in width bordered upslope by Friedlander Road to the east, a residence and landscaped yard to the north, a power line easement to the south, and a drainage ravine downslope to the west. The Belmont Street site consists of a main landslide scar approximately 55 to 65 feet in width bordered upslope by Belmont Street to the south, undeveloped native vegetated sloping parcels to the east and west and a drainage ravine downslope to the west. The Council Crest site consists of a main landslide scar approximately 65 to 75 feet in width bordered upslope by Council Crest to the east, a residence and adjacent gravel drive to the north, a residence and landscaped yard to the south and a drainage ravine downslope to the west with a residence at the base of the area. The enclosed Site and Exploration Plans (Figures 2, 5, and 8) illustrate these site boundaries and adjacent existing features.

We understand these three landslides each occurred on 29 December 1996 below city roadways, with failure extending from the roadway edge down into relatively steep ravine areas. The cause of failure at each of these sites is believed to be related to blockage of storm drainage by snow, followed by rapid snow-melt and heavy rains resulting in focused runoff down these ravines. Each of the landslides appear to be a combination of erosion and soil failure due to saturation and loss of shear strength.

The overall project plan includes geotechnical and related design services necessary for repair of the landslide areas. Items included for design included surveying, geological reconnaissance and mapping, geotechnical exploration, geotechnical engineering, and cost estimates.

This report provides a summary of surface and subsurface information available for the three landslides. The report is intended to be used in conjunction with the Aberdeen Street Embankment Restoration project manual and plans. This information was originally presented as part of AEE's *Geotechnical Engineering Assessment*, dated 8 August 1997, which presented recommendations regarding repair of the landslides.

3.0 EXPLORATORY METHODS

We explored surface and subsurface conditions at the project site in two phases: a subsurface exploration phase during 23 through 27 June 1997, and a field mapping phase during 16 and 17 July 1997. Our field exploration and testing program comprised the following elements:

- A visual surface reconnaissance of the Alden Road, Belmont Street and Council Crest landslide sites;
- Field mapping of surface features of the Alden Road, Belmont Street and Council Crest landslide sites;
- Six hollow-stem auger borings, two at each site (designated B-1 and B-3) advanced at strategic locations across the sites;
- Three hand borings, one at each site, (designated B-2) advanced at a strategic location on the Alden Road, Belmont Street and Council Crest sites;
- Thirty-three moisture contents performed on selected soil samples obtained from strategic depths beneath the Alden Road, Belmont Street and Council Crest sites;
- Six grain size with hydrometer analyses (two from each site) performed on selected soil samples obtained from strategic locations beneath the three sites;
- One 200-Wash analysis performed on a selected soil sample obtained from beneath the Belmont Street site;
- A review of published geologic maps and seismologic literature.

Table 1, below, summarizes the approximate functional locations, surface elevations, and termination depths of our nine subsurface explorations, and Figure 2 (Alden Road), Figure 5 (Belmont Street), and Figure 8 (Council Crest) depict their approximate relative locations. Appendix A of this report describes our field exploration procedures and boring logs, and Appendix B describes our laboratory testing procedures and results.

TABLE 1			
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS			
Exploration	Functional Location	Surface Elevation (feet)	Termination Depth (feet)
Alden Road			
B-1	Main body of slide	125	20½
B-2	Toe of slide	114	7½
B-3	Alden Road	148	45½
Belmont Street			
B-1	Main body of slide	266	21½
B-2	Toe of slide	255	4
B-3	Belmont Street	283.5	45½
Council Crest			
B-1	Main body of slide	184	21
B-2	Toe of slide	170	6½
B-3	Council Crest	203	50½
Elevation datum: Mean Sea-Level			

The specific number, locations, and depths of our explorations were selected in relation to the existing and proposed site features, under the constraints of surface access, underground utility conflicts, and budget considerations. Parametrix, Inc. was subcontracted to survey site features and our boring locations and provide AEE with a topographic map of the Alden Road, Belmont Street and Council Crest sites. Consequently, the data listed in Table 1 and the locations depicted on Figures 2, 5 and 8 should be considered accurate only to the degree permitted by our data sources and implied by our measuring methods.

It should be realized that the explorations performed for this evaluation reveal subsurface conditions only at discrete locations and actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have begun. If significant variations are observed at that time, we may need to modify the embankment restoration design to reflect the actual site conditions.

4.0 SITE CONDITIONS

The following sections of text present our observations, findings, and interpretations regarding development, utility, surface, soil, groundwater, landslide and seismic conditions at the project site. Descriptive logs of our subsurface explorations and graphic results of our laboratory tests are included in Appendix A and Appendix B, respectively, of this report.

4.1 Development Conditions

The Alden Road site is currently undeveloped with the exception of a gravel path and landscape area that was partially damaged during the landslide event. The site area appears to have served as a drainage to direct runoff down to the ravine area to the west.

The Belmont Street site is currently undeveloped and serves as a stormwater drainage basin with a 12-inch diameter culvert outfall at the west side of the area.

The Council Crest site lost a portion of paved roadway to the east and a gravel drive accessing a future development to the north. In addition, the site serves as a stormwater drainage basin with a 6-inch diameter culvert outfall at the south side of the area.

4.2 Utility Conditions

The Alden Road site has an 18-inch diameter storm drain culvert, and outfall located north of the landslide area. The storm sewer collects runoff from a ditch at the N.E. intersection of Alden Road and Friedlander Road and directs the water to the west to the outfall. A sanitary sewer generally runs along the east side of Friedlander Road. Overhead power lines run north-south along Friedlander Road to the power line easement south of the site.

The Belmont Street site has an exposed 3-inch diameter gas line along the upslope south bank of the landslide scarp. A power pole slid into the ravine area during the landslide event and was disconnected and removed from the area. A 12-inch diameter storm drain culvert and outfall at the west side of the site drains runoff from a catch basin at the west side of Belmont Street.

The Council Crest site has a 6-inch diameter storm drain culvert and outfall at the upslope bank of the south landslide scarp. A catch basin collects runoff from Council Crest and directs the flow to the outfall. A sanitary sewer pipeline is at the east side of Council Crest aligned in a north-south direction. We understand the landslide removed a portion of roadway and impacted a sanitary sewer pipeline which was capped and visible at the east bank of the landslide scarp. Overhead power and telephone lines are located near the center of the landslide in a north-south alignment.

4.3 Surface Conditions

The landslide scar and debris path to the ravine bottom for the three landslide sites were generally cleared of surficial vegetation during the earth movement. Currently the upper main landslide scarp and landslide area for the three existing landslide sites are covered with reinforced plastic to prevent additional erosion and sediment loss. Vegetation on the slopes adjacent to the landslide scars include moderate size trees including fir, cedar, hemlock, and alder. Surface brush consists of native vegetation including blackberry brambles, salal, surface grasses, skunk cabbage and wild flowers. The three landslide sites contain mounds of displaced material within the landslide scar areas which moved downslope during the landslide events. The surface conditions and features discussed in this section are shown on the *Site and Exploration Plans* (Figures 2, 5, and 8).

Alden Road

The Alden Road site topographic relief from the top of the slope at Friedlander Road (elevation 150 feet) to the ravine bottom (elevation 40 feet) is approximately 110 feet. The topographic relief for the upper main landslide area is on the order of 30 feet. The Alden Road upper main landslide is approximately 50 to 60 feet in width.

At the Alden Road site we observed open parallel cracks in the asphalt pavement atop Friedlander Road east of boring B-3 and the main landslide scarp, generally indicative of movement. An intact 3- to 4-foot-diameter stump within the upper landslide scarp approximately 10 feet below the top of the slope appears to have been filled over possibly during road construction. Moderate groundwater seepage was observed at the base of the stump near elevation 130 feet. Additional seepage was observed atop the sandstone bedrock at approximate elevations of 108 and 94 feet. We also observed additional ongoing creep on the slopes on the north and south sides of the landslide scar with scarps of 1 to 4 feet. Trees growing in a skewed manner, generally indicative of ongoing movement, were noted on the slopes. Sandstone bedrock exposures were observed downslope with bedding dipping generally downslope to the west from 37 to 55 degrees. At approximately elevation 80 feet a near vertical 35 foot high sandstone bluff extends downward to the base of the ravine at elevation 40 feet.

Belmont Street

The Belmont Street site topographic relief from the top of the slope at Belmont Street (elevation 284 feet) to the ravine bottom (elevation 232 feet) is approximately 52 feet. The topographic relief for the upper main landslide area is on the order of 27 feet. The Belmont Street upper main landslide is approximately 55 to 65 feet in width.

At the Belmont Street site two storm water lines drain surface water into the ravine area including a 12-inch diameter corrugated metal pipe (CMP) and a 4-inch ADS pipe. As previously mentioned, an exposed gas line was observed in the bank of the upper scarp area

and should be rerouted prior to any work on the slope. Moderate groundwater seepage was observed at approximate elevations of 260 and 252 feet along the ravine area. Landslide scarps (up to 4 feet in height) and surficial creep was observed on the east and west sides of the main landslide scar. Downed trees and rootballs and skewed tree growth were observed along the slope areas. Sandstone bedrock exposures were observed downslope with bedding dipping generally downslope to the north approximately 15 degrees. A drainage channel was observed further downslope to the north which merges with the main creek at approximately elevation 233 feet.

Council Crest

The Council Crest site topographic relief from the top of the slope at Council Crest (elevation 210 feet) to the ravine bottom (elevation 40 feet) is approximately 170 feet. The topographic relief for the upper main landslide area is on the order of 30 feet. The Council Crest upper main landslide is approximately 65 to 75 feet in width.

At the Council Crest site a 6-inch diameter CMP storm drain directs surface water from a catch basin into the south side of the ravine area. The outfall empties over the slope. Moderate groundwater seepage was observed at approximate elevation of 170 and 160 feet along the ravine area. Landslide scarps (up to 4 feet in height) and surficial creep was observed predominantly on the south side of the main landslide scar. The north side of the ravine was cleared and logged recently and was covered with low lying surface brush and slash debris. Skewed tree growth indicative of ongoing creep was mainly observed along the south side of the ravine area. Sandstone bedrock exposures were observed downslope with variable bedding planes, including dips of 20 degrees to the southeast and 26 degrees to the northeast. A fracture or joint was observed with a dip of 60 degrees to the west. A drainage channel from the north merges with the main ravine downslope near an elevation of 130 feet. A geotextile silt fence with upslope straw bales was noted across the ravine channel near an elevation of 160 feet.

4.4 Soil Conditions

Regional geology of the three site areas for Alden Road, Belmont Street, and Council Crest includes bedrock, colluvium and landslide deposits. The Geologic Map of Washington — Southwest Quadrant, 1987, classifies the bedrock in the three site areas as marine sedimentary rocks of the Miocene of Tertiary age known as the Montesano formation. The Montesano formation consists of a coarse-to fine-grained silty sandstone, siltstone and mudstone which is orange-brown when weathered and blue-gray when fresh. The three site areas are located on the west flank of the Aberdeen syncline. The dip of the Montesano formation is indicated to be roughly 30 degrees to the south.

The subsurface conditions in our explorations at the three sites were relatively consistent. The site soils consisted of landslide debris, mantling fill soils/topsoil and/or weathered bedrock

soils or both, which overlies bedrock of the Montesano formation at depth. The geologic cross-sections presented for the three sites in Figures 3, 6, and 9 display the subsurface conditions encountered in our explorations. The subsurface soil conditions for each site are discussed briefly below.

Alden Road

Our on-site explorations, borings B-1 through B-3, revealed fairly uniform soils conditions (Figure 3). Borings B-1 and B-2 encountered very soft, saturated, sandy silt with some organics, landslide debris to depths of 7 and 5 feet, respectively. In boring B-1 these soils mantled 1 foot of medium-dense, wet, gray silty sand before encountering the dense to very dense, moist, silty fine sand (weathered sandstone). Boring B-1 penetrated 6 feet of weathered bedrock before encountering a very dense, moist, silty fine sand (sandstone) to the full depth of our exploration of 20½ feet. In boring B-2 the landslide debris soils overlaid 1½ feet of very loose, saturated bluish-gray, silty sand followed by ½ foot of soft, wet, black sandy silt with some organics (relic topsoil) to a depth of 7 feet before encountering the dense to very dense, silty fine sand (weathered sandstone). Boring B-2 was terminated in the weathered bedrock at 7½ feet.

In boring B-3 our exploration encountered 6 inches of asphalt over 2 inches of base course mantling, very soft, wet, sandy silt with some clay and organics to 3 feet in depth. These soils overlaid a very loose, moist, silty fine sand to 10½ feet in depth. These upper soils are interpreted to be fill. Between 10½ to 14½ feet our boring penetrated a loose to medium-dense, moist, silty fine sand with some clay (weathered sandstone) before encountering the very dense, moist, silty fine sand with some clay (sandstone) to the full depth of our exploration of 45½ feet. A saturated, silty sand zone was encountered roughly between 36 and 38 feet within this stratum.

Belmont Street

Our on-site explorations, borings B-1 through B-3, revealed fairly uniform soil conditions (Figure 6). Boring B-1 encountered medium-stiff to stiff, moist to wet, sandy silt with organics to 6 feet in depth. These soils overlie a medium-dense to dense, silty sand with some clay (weathered sandstone) to 12½ feet in depth. The boring then penetrated 1½ feet of hard, wet, silt to 14 feet. These soils overlie a dense, moist to wet, silty sand with some clay (weathered sandstone) to the full depth of our exploration of 21½ feet. In boring B-2, a very soft, wet to saturated, silty sand with some organics (slide debris) at 2 feet mantles 1 foot of loose, wet, silty sand. Our exploration encountered a dense to very dense, wet, silty fine sand with some clay (weathered sandstone) to the full depth of our exploration of 4 feet.

In boring B-3 we encountered 6 inches of asphalt overlying 6 inches of base course which mantled a very loose to loose, wet, silty fine sand with some clay to 9½ feet in depth, interpreted as fill. These soils overlie a medium-dense, moist to wet, silty fine sand with some

clay (weathered sandstone) to a depth of 18 feet. Below this depth our exploration encountered interbeds of very dense, moist, silty fine sand with some silt and hard moist silt with some sand to sandy (sandstone/siltstone) to the full depth of our exploration, 45½ feet. A saturated, silty sand zone was encountered roughly between 41 to 44 feet within this stratum.

Council Crest

Our on-site explorations, borings B-1 through B-3, revealed fairly uniform soil conditions (Figure 9). Borings B-1 and B-2 encountered a very soft to soft sandy silt with some organics (landslide debris) to depths of 1 foot and 4 feet, respectively. These soils mantled a medium-dense, moist to wet, silty fine sand with some clay to depths of 5 and 5½ feet, respectively, before encountering dense, moist, silty fine sand with some clay (weathered sandstone). Boring B-2 was terminated in these dense soils a depth of 6½ feet. In boring B-1 these dense soils continued to a depth of 9½ feet where they overlie a very dense, moist, silty fine sand with some clay (sandstone) to the full depth of our exploration of 21½ feet.

In boring B-3 we encountered 6 inches of asphalt over 9 inches of base course mantling, very soft, wet sandy silt to 4½ feet in depth. These soils overlie a very loose to loose, damp to moist, silty fine sand with some clay to a depth of 9½ feet. These upper soils are interpreted to be fill. Beneath these soils we penetrated a medium-dense, damp to moist, silty fine sand with some clay (weathered sandstone) to 27 feet in depth where we encountered a very dense, moist silty fine sand with some clay (sandstone) to the full depth of our exploration, 50½ feet. A saturated silty sand zone was encountered roughly between 32 to 34 feet within this stratum.

Table 2 below summarizes the approximate thicknesses, depths and elevations of soil deposits encountered in our subsurface explorations.

TABLE 2 APPROXIMATE THICKNESSES, DEPTHS, AND ELEVATIONS OF SOIL LAYERS ENCOUNTERED IN EXPLORATIONS					
Exploration	Thickness of Landslide Debris/Fill Soils (feet)	Thickness of Loose to Medium- Dense Silty Sand (feet)	Thickness of Weathered Sandstone (feet)	Depth of Sandstone/ Siltstone (feet)	Elevation of Top Sandstone/ Siltstone (feet)
Alden Road					
B-1	7	1	6	6½	118½
B-2	7	½	N/E	N/E	N/E
B-3	3	7½	4	31	133½
Belmont Street					
B-1	0	6	6½	9	253½
B-2	2	1	1	N/E	N/E
B-3	2	7½	8½	27½	265½
Council Crest					
B-1	0	1	8½	11½	174½
B-2	4	1½	1	N/E	N/E
B-3	1½	8	17½	23½	176
Elevation Datum: Mean Sea Level surveyed by Parametrix, Inc.					
N/E = Not encountered with depth of exploration					

Our laboratory tests revealed that soils at all three sites were very similar and determined to be a silty-fine sand with some clay, and have fines (silt and clay) contents ranging from 30 to 47 percent. We interpret these soils to be currently near or above their optimum moisture contents, and to be highly sensitive to moisture content variations. Table 3, below, summarizes our laboratory test results.

TABLE 3 LABORATORY TEST RESULTS FOR GRANULAR SOILS				
Soil Sample	Moisture Content (percent)	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)
Alden Road				
B-3 S-5	26	0	70	30
B-3 S-10	15	0	66	34
Belmont Street				
B-1 S-5	19	0	57	43
B-3 S-4	31	0	53	47
Council Crest				
B-1 S-4	18	0	63	37
B-3 S-3	36	0	58	42

The testing procedures used to attain our laboratory results are discussed in Appendix B. Our laboratory test results are also presented in Appendix B.

4.5 Groundwater Conditions

At the time of our explorations (23 through 27 June 1997) we observed groundwater depths ranging from near the surface for perched groundwater conditions at each site and groundwater at depths ranging between 32 to 42 feet at the three sites.

Table 4, below, summarizes the approximate groundwater depths and elevations observed in our explorations for each site. Because our explorations were performed during an extended period of generally wet weather, these groundwater measurements may closely represent the yearly average levels; somewhat higher levels probably occur during the winter and spring months. At all times of the year, groundwater levels would likely fluctuate in response to precipitation patterns, off-site construction activities, and site utilization.

TABLE 4 APPROXIMATE DEPTHS AND ELEVATIONS OF GROUNDWATER ENCOUNTERED IN EXPLORATIONS			
Exploration	Depth of Groundwater (feet)	Elevation of Groundwater (feet)	Date of Measurement
Alden Road			
B-1	½	124 ½	23 June 1997 (ATE)
B-2	2	112	25 June 1997 (ATE)
B-3	36	112	26 June 1997 (ATE)
Belmont Street			
B-1	12 ½	253 ½	24 June 1997 (ATE)
B-2	1 ½	253 ½	25 June 1997 (ATE)
B-3	41	242 ½	27 June 1997 (ATE)
Council Crest			
B-1	2 ½	181 ½	23 June 1997 (ATE)
B-2	1 ½	168 ½	25 June 1997 (ATE)
B-3	32	171	26 June 1997 (ATE)
N/E = not encountered within depth of exploration ATE = at time of exploration			

4.6 Landslide Conditions

Our observations revealed that the landslides at the Alden Road, Belmont Street, and Council Crest were relatively similar at each site. The landslides involved a wedge of soil approximately 10 to 15 feet thick and roughly 50 to 70 feet wide from the main scarp narrowing down to 35 to 50 feet wide at the toe of the slide in the drainages below the roadways. The landslides removed one lane of asphalt paving from the Alden Road and Council Crest sites, and removed the shoulder area of the roadway next to the asphalt paving at the Belmont Street site.

It was reported that all three landslides occurred on 29 December 1996. The landslide failures extended from the edge of the roadways and into one lane, down to the relatively steep ravine areas. It is believed that the slope failure of the sites is related to blockage of the storm drainage systems by snow, followed by rapid snow-melt and heavy rains resulting

in focused runoff down the ravines. Each of the landslides appear to be a combination of erosion and soil failure due to the saturation and loss of shear strength of the fill and residual soils mantling the weathered sandstone (bedrock).

4.7 Seismic Conditions

Based on our analysis of subsurface explorations and our review of published geologic maps, we interpret the intact native soil and rock conditions (below the fill and slide debris) to correspond to a seismic profile type I, as defined by the 1996 AASHTO manual entitled *Standard Specifications for Highway Bridges*. Earthquake maps included with this same manual indicate that a bedrock site acceleration coefficient of about 0.10 is appropriate for an earthquake having a 10 percent probability of exceedance in 50 years (corresponding to a magnitude of 7.5 and a return interval of 475 years).

5.0 CLOSURE

The interpretations and conclusions presented in this informational summary are based, in part, on the explorations that we performed for this study; therefore, if variations in the subgrade conditions are observed at a later time, we may need to modify this summary report to reflect those changes. Also, because the future performance and integrity of the project elements depend largely on proper initial site preparation, drainage, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process.

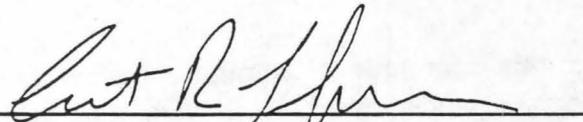
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3 September 1997

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We appreciate the opportunity to be of service on this project. If you have any questions regarding this summary report or any aspects of the project, please feel free to contact our office.

Respectfully submitted,

AGRA Earth & Environmental, Inc.



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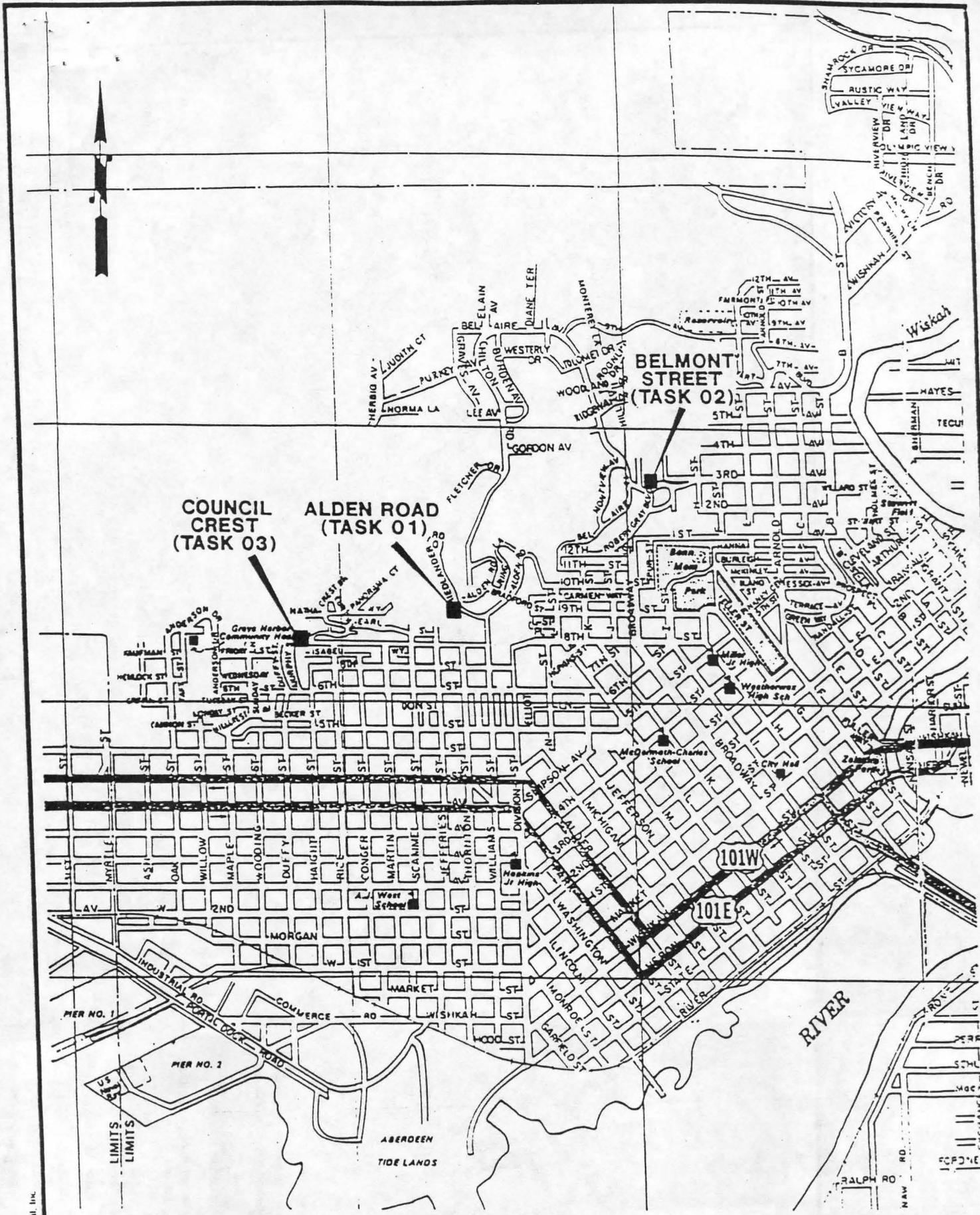


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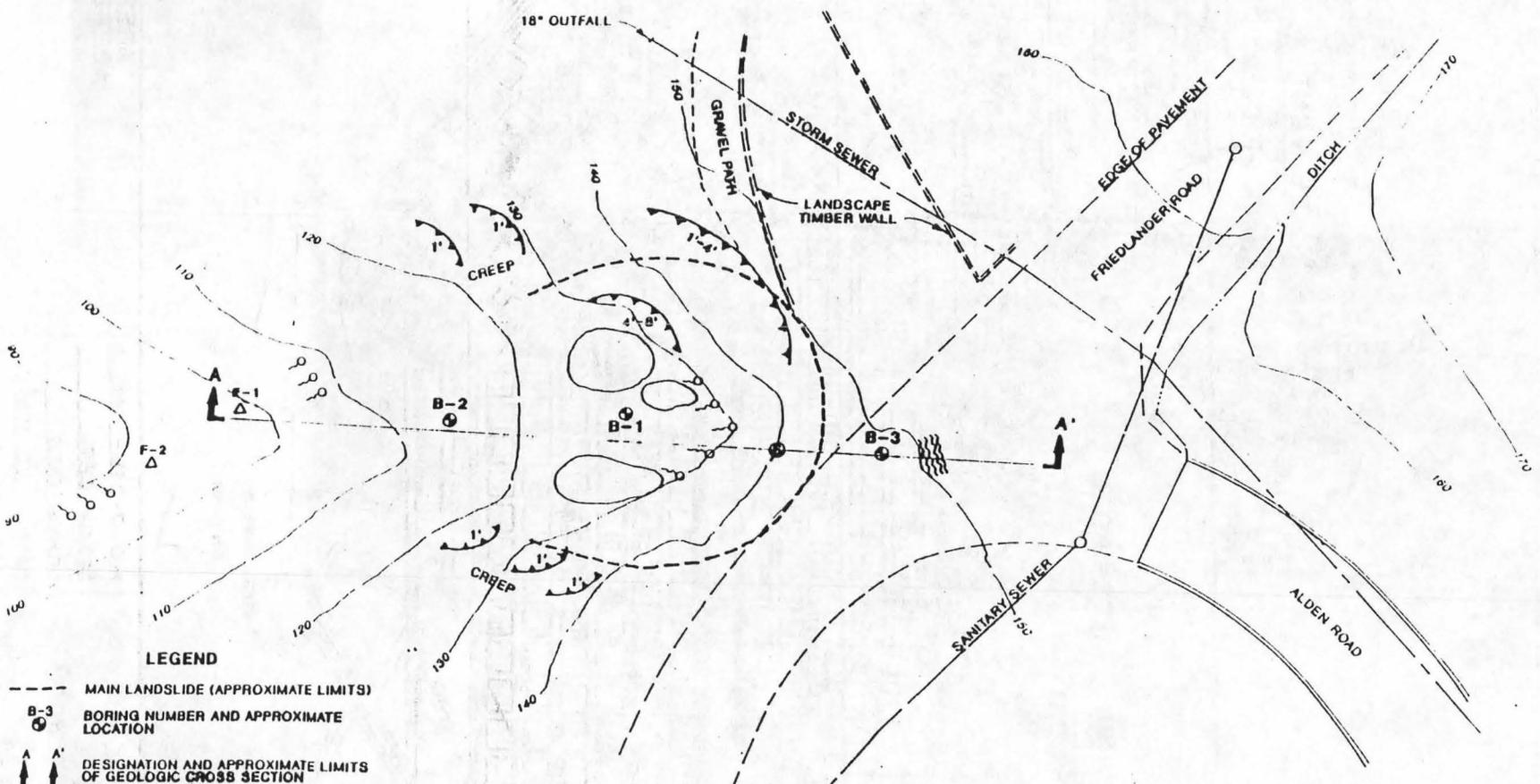
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 DATE JUL 1997
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**ABERDEEN LANDSLIDES
 ABERDEEN, WASHINGTON**

LOCATION MAP

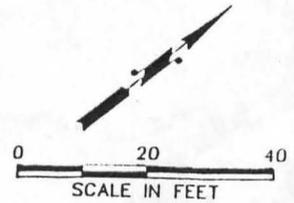
FIGURE 1



LEGEND

- MAIN LANDSLIDE (APPROXIMATE LIMITS)
- B-3 BORING NUMBER AND APPROXIMATE LOCATION
- A-A' DESIGNATION AND APPROXIMATE LIMITS OF GEOLOGIC CROSS SECTION
- 100 EXISTING GROUND SURFACE CONTOURS
- ||||| CRACKS IN ASPHALT
- SEEPAGE
- ⊙ STUMP (IN PLACE)
- 1' LANDSLIDE SCARP AND HEIGHT (APPROXIMATE)
- DISPLACED MATERIAL
- F-3 FEATURE - BEDROCK EXPOSURE

F-1 STRIKE N25W/DIP 38°W
 F-2 STRIKE N25E/DIP 65°W
 F-3 STRIKE N15W/DIP 37°W

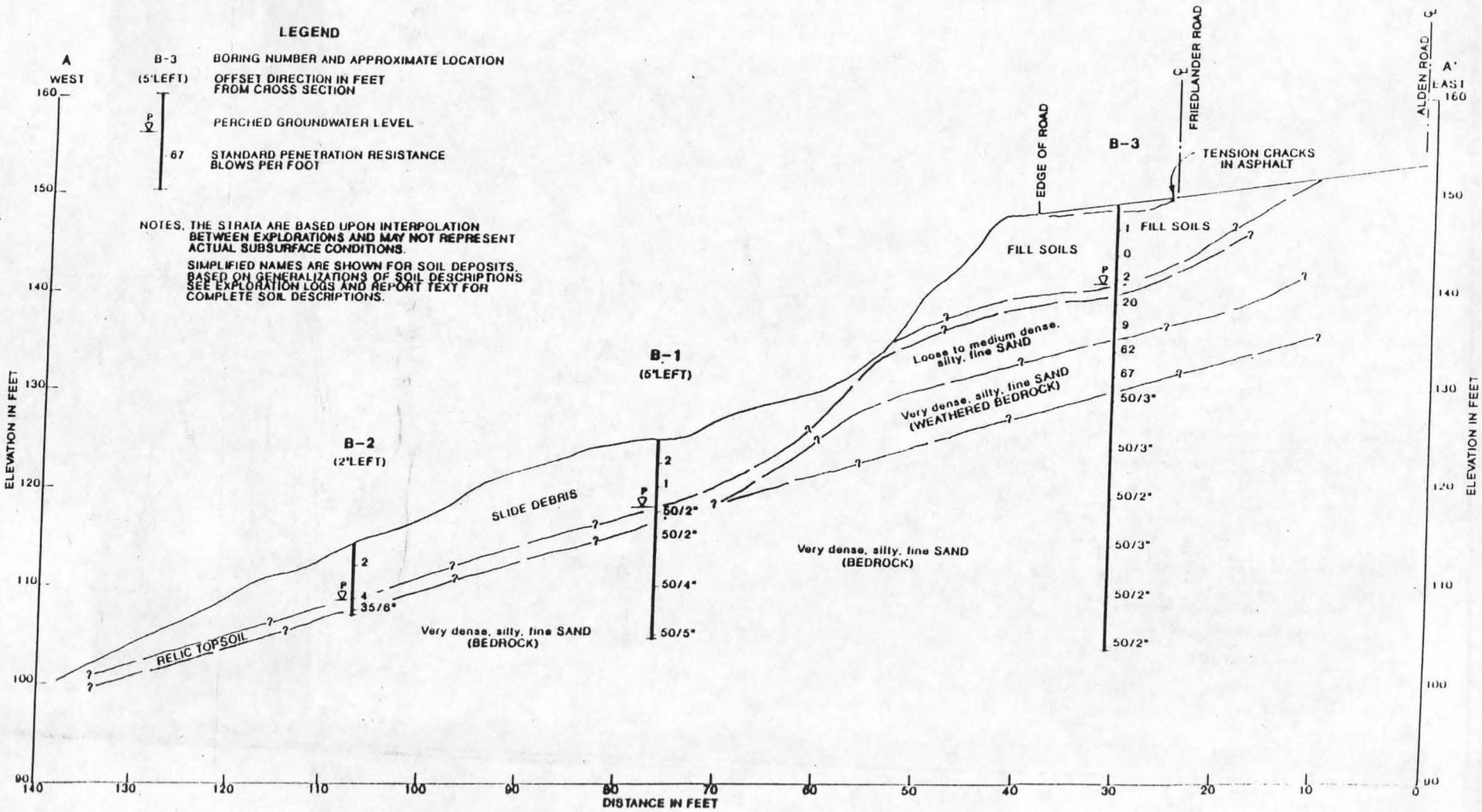


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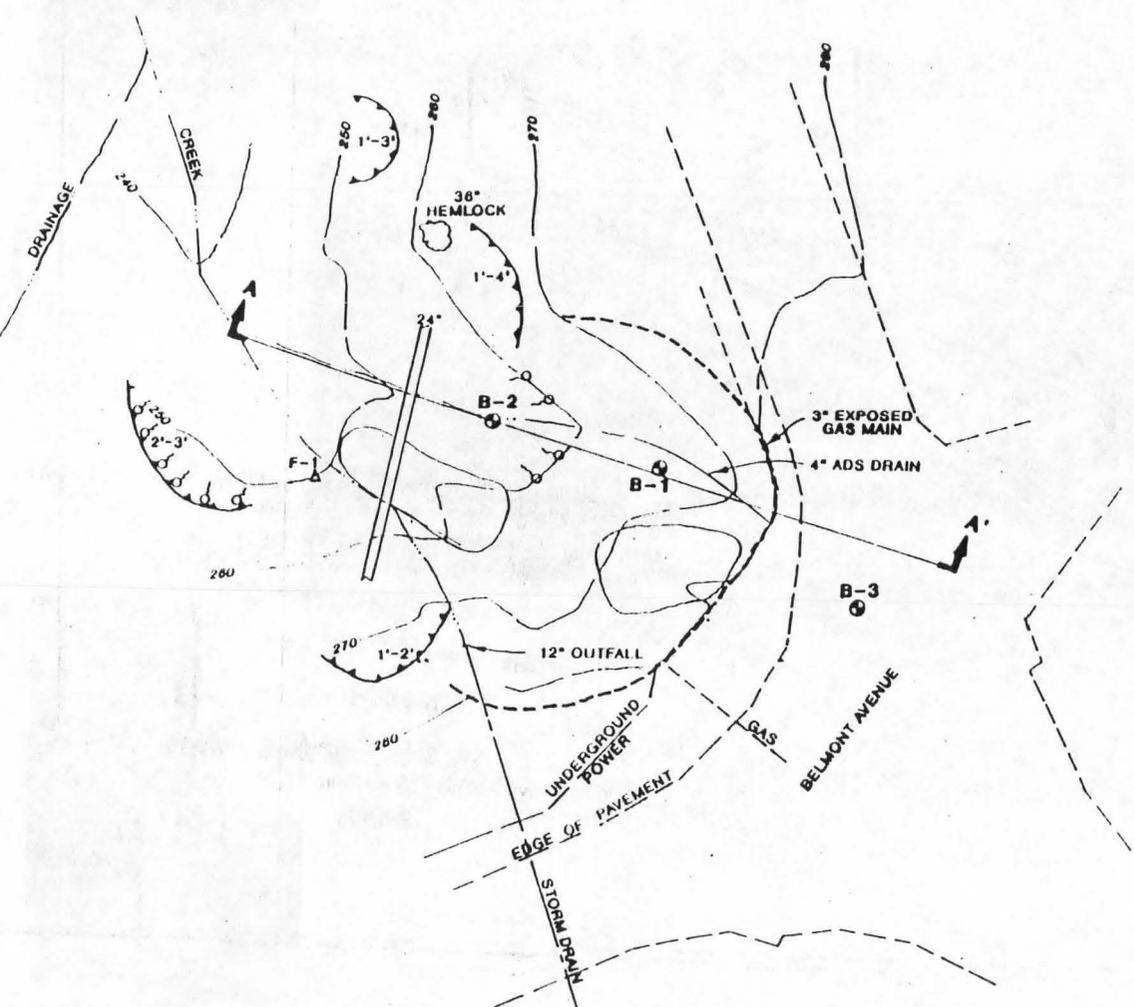
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 DATE JUL 1997

ABERDEEN LANDSLIDES
ALDEN ROAD (TASK 01)
ABERDEEN, WASHINGTON
 SITE & EXPLORATION PLAN

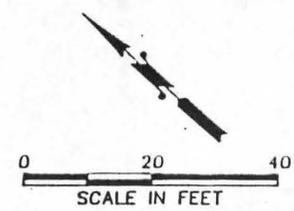
FIGURE 2



<p>AGRA Earth & Environmental 11335 NE 122nd Way, Suite 100 Kirkland, Washington, U.S.A. 98034-6918</p>	W.O. 7-21M-11883-A DESIGN HWB DRAWN DMW DATE JUL 1997 SCALE 1"=10'	ABERDEEN LANDSLIDES ALDEN ROAD (TASK 01) ABERDEEN, WASHINGTON GEOLGIC CROSS SECTION A-A' FIGURE 3
---	--	---



- LEGEND**
- MAIN LANDSLIDE (APPROXIMATE LIMITS)
 - B-3 BORING NUMBER AND APPROXIMATE LOCATION
 - A-A' DESIGNATION AND APPROXIMATE LIMITS OF GEOLOGIC CROSS SECTION
 - 160- EXISTING GROUND SURFACE CONTOURS
 - O- SEEPAGE
 - DOWNED TREE
 - 1'- LANDSLIDE SCARP AND HEIGHT (APPROXIMATE)
 - DISPLACED MATERIAL
 - F-1 FEATURE - BEDROCK EXPOSURE
F-1 STRIKE E-W/DIP 15°N

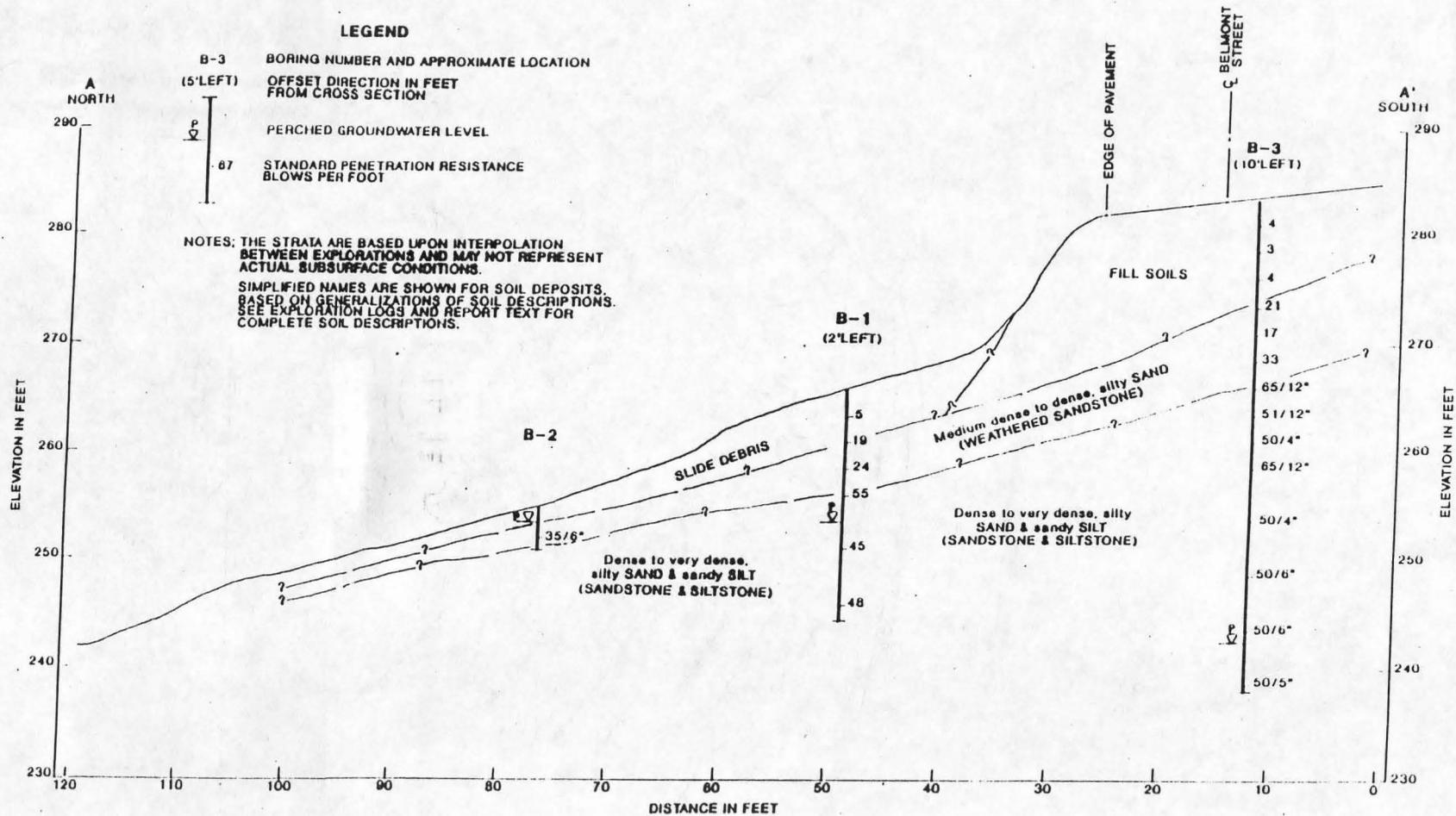


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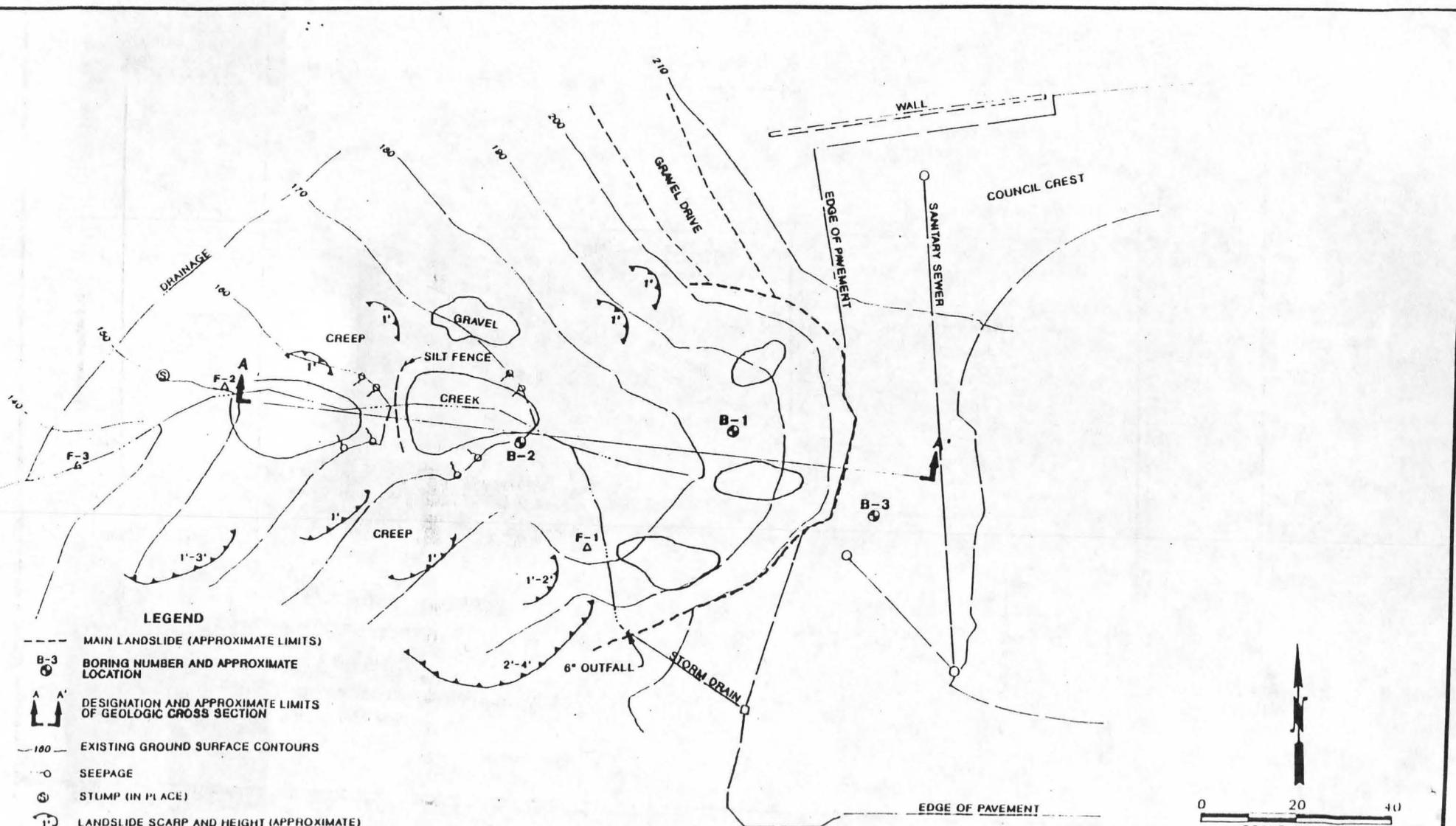
WO. 7-21M-11893-A
 DESIGN CRT
 DRAWN DMW
 DATE JUL 1997
 SCALE 1"=20'

ABERDEEN LANDSLIDES
BELMONT STREET (TASK 02)
ABERDEEN, WASHINGTON
 SITE & EXPLORATION PLAN

FIGURE 5



<p>AGRA Earth & Environmental 11335 NE 122nd Way, Suite 100 Kirkland, Washington, U.S.A. 98034 6918</p>	W.O. 7-91M-11693-A	<p>ABERDEEN LANDSLIDES BELMONT STREET (TASK 02) ABERDEEN, WASHINGTON</p> <p>CROSS SECTION A-A'</p> <p>FIGURE 0</p>
	DESIGN CRT	
	DRAWN DMW	
	DATE JUL 1997	
	SCALE 1" = 10'	



LEGEND

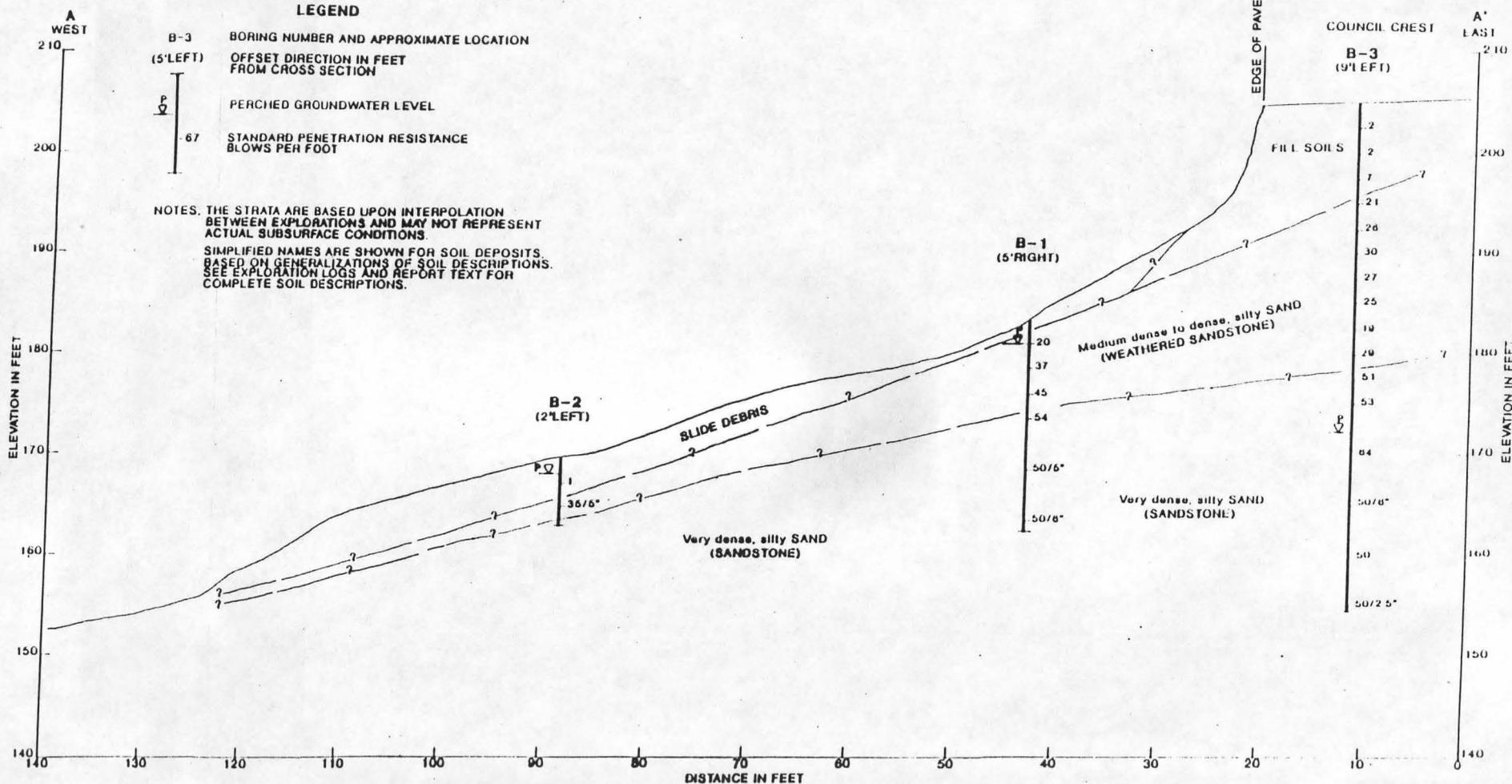
- MAIN LANDSLIDE (APPROXIMATE LIMITS)
- B-3 BORING NUMBER AND APPROXIMATE LOCATION
- A-A DESIGNATION AND APPROXIMATE LIMITS OF GEOLOGIC CROSS SECTION
- 100 --- EXISTING GROUND SURFACE CONTOURS
- SEEPAGE
- ⊙ STUMP (IN PLACE)
- 1' LANDSLIDE SCARP AND HEIGHT (APPROXIMATE)
- DISPLACED MATERIAL
- F-3 FEATURE - BEDROCK EXPOSURE
- F-1 STRIKE N50E/DIP 20°SE
- F-2 STRIKE N40W/DIP 26°NE
- F-3 STRIKE N20E/DIP 60°W

DATE: 6-24-87

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WO. 7-91M-11893-A
DESIGN CRT
DRAWN DMW
DATE JUL 1987
SCALE 1"=20'

ABERDEEN LANDSLIDES
COUNCIL CREST (TASK 03)
ABERDEEN, WASHINGTON
SITE & EXPLORATION PLAN
FIGURE 8



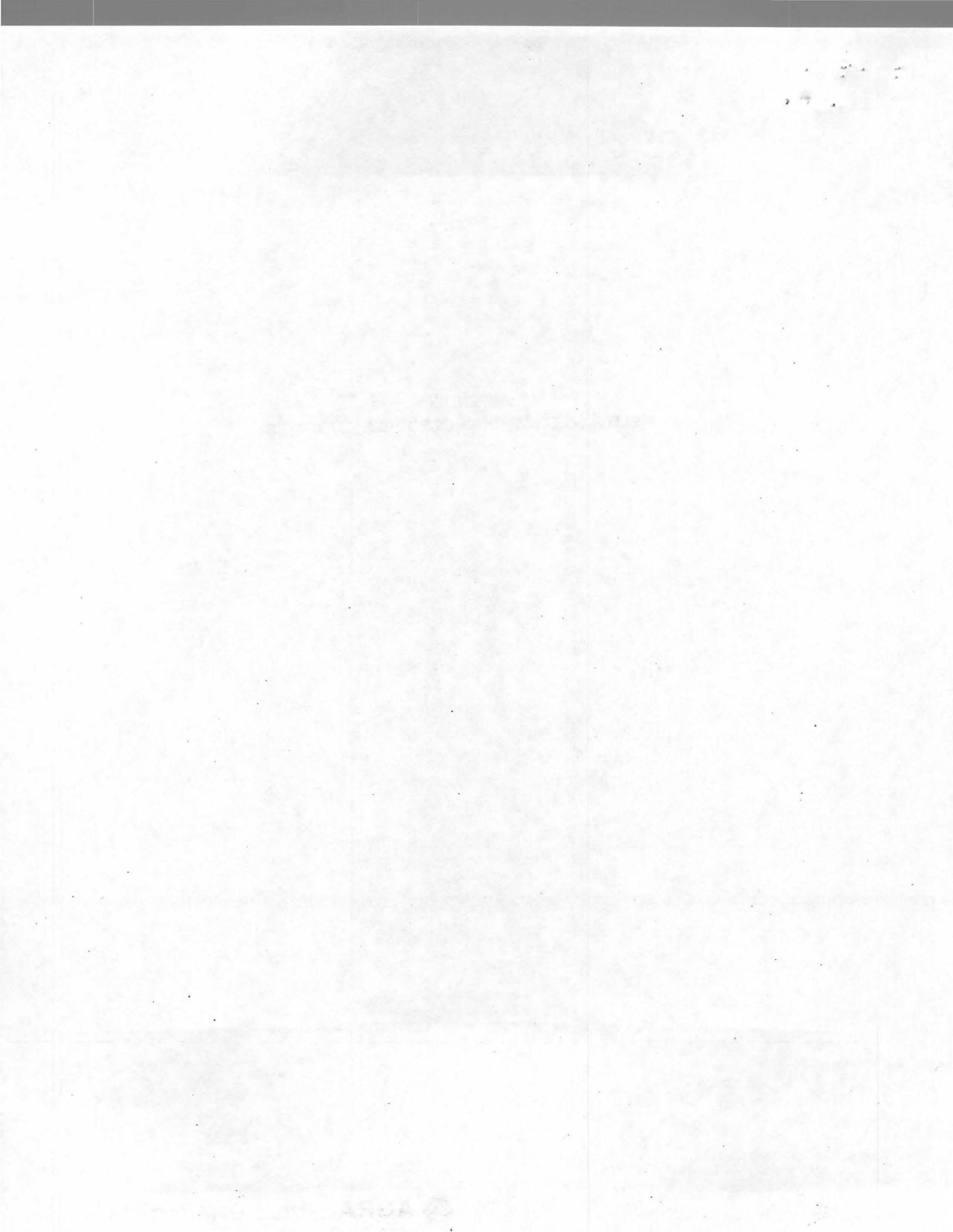
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WO. 7-91M-11893-A
 DESIGN HWB
 DRAWN DMW
 DATE JUL 1997
 SCALE 1" = 10'

ABERDEEN LANDSLIDES
COUNCIL CREST (TASK 03)
ABERDEEN, WASHINGTON
GEOLOGIC CROSS SECTION A-A'

FIGURE 9

APPENDIX A
FIELD EXPLORATION PROCEDURES AND LOGS



APPENDIX A
FIELD EXPLORATION PROCEDURES AND LOGS
7-91M-11693-A

Our field exploration program for this evaluation included six borings, and three hand borings advanced at the project sites. The following paragraphs describe our procedures associated with these explorations. Descriptive logs of our explorations are enclosed in this appendix.

Soil Boring Procedures

Our exploratory borings were advanced with a hollow-stem auger, using a truck-mounted and skid-mounted drill rig operated by an independent drilling firm working under subcontract to AEE. A geologist from our firm continuously observed the borings, logged the subsurface conditions, and collected representative soil samples. All samples were stored in watertight containers and later transported to our laboratory for further visual examination and testing. After each boring was completed, the borehole was backfilled with a mixture of bentonite chips and soil cuttings, and the surface was patched with asphalt or concrete (where appropriate).

Throughout the drilling operation, soil samples were obtained at 2½- or 5-foot depth intervals by means of the Standard Penetration Test (SPT) per ASTM:D-1586. This testing and sampling procedure consists of driving a standard 2-inch-diameter steel split-spoon sampler 18 inches into the soil with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count." If a total of 50 blows is struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The enclosed *Boring Logs* describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth is depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted.

Hand Boring Procedures

Our exploratory hand borings were advanced with a 3-inch-diameter hand auger operated by an AEE geologist, who logged the subsurface conditions and obtained representative soil samples. All samples were stored in watertight containers and later transported to our laboratory for further visual examination and testing. After each hand boring was completed, we backfilled the borehole with soil cuttings and tamped the surface.

The relative density of granular soils and relative consistency of cohesive soils were generally estimated according to the drilling resistance encountered in each borehole. However, at certain depths, we determined the density or consistency by means of a Portable Penetration Test (PPT), which is similar to the Standard Penetration Test (SPT) per ASTM:D-1586. This testing and sampling procedure consists of driving a standard 2-inch-diameter steel split-spoon sampler 12 inches into the soil with a 40-pound hammer free-falling 24 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Portable Penetration Resistance, or "PPT blow count." If a total of 50 blows is struck within one 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting PPT blow count was then converted to a Standard Penetration Resistance, or "SPT blow count," by means of energy correlations.

The enclosed *Hand Boring Logs* describe the vertical sequence of soils and materials encountered in each hand boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Our logs also indicate the approximate depth of any groundwater encountered in the boreholes, as well as all sample numbers and sampling locations.

Aberdeen Landslides -

7-91M-11693-A

PROJECT: Alden Road

W.O.

Task 01

BORING NO. 8-1

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 1 of 1
					Standard	Blows per foot	Other	
0	Location: Toe of upper landslide Approximate ground surface elevation: 125 feet							TESTING
0 - 5	Very soft, wet to saturated, brown-black-blue gray, sandy SILT with some organics, wood and trace clay (Landslide Debris)			ATD				
5			S-1		▲	●		
5 - 10	Medium dense to dense, wet, blue-gray, silty SAND		S-2		▲	●		
10	Dense to very dense, moist, tan-brown, silty SAND (Weathered Sandstone)		S-3				50/2"	▲
10 - 15			S-4			●	50/2"	▲
15	Very dense, moist, tan-brown, whitish and dark brown, silty SAND (Weathered Sandstone)		S-5				50/4"	▲
15 - 20			S-6				50/5"	▲
20 - 20.4	Boring terminated at approximately 20.4 feet							
20.4 - 30								

LEGEND

- 2.00-inch O.D. split spoon sample
- ▨ Grain size analysis
- Perched groundwater level at time of drilling
- Hydrometer analysis



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Drilling method: HSA

Hammer type: Cathead

Date drilled: 23 June 1997

Logged by: CPT

PROJECT: Aberdeen Landslides - Alden Road

7-91M-11693-A

W.O.

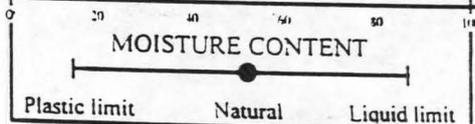
Task 01

HAND BORING NO. B-2

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 1 of 1
					Standard	Blows per foot	Other	
0	Location: 30' SW of B-1 Approximate ground surface elevation: 114 feet							TESTING
0 - 5	Very soft, wet, blue-gray, brown, black, sandy SILT with some organics (Landslide Debris) Becomes wet to saturated, blue-gray, brown		S-1	P ATD	▲	●		
5 - 7.5	Very loose, saturated, blue-gray, silty SAND Soft, wet, black, sandy SILT with some organics Dense to very dense, wet, blue-orange-tan, silty SAND (Weathered Sandstone)		S-2A S-2B			●	▲	100/6" 35/6"
7.5 - 30	Hand boring terminated at approximately 7.5 feet							

LEGEND

- 2.00-inch O.D. split spoon sample
- Grain size analysis
- P Perched groundwater level at time of drilling
- Hydrometer analysis



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7-91M-11693-A

PROJECT: Alden Road

W.O.

Task 01

BORING NO. B-3

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 1 of 2
					Standard	Blows per foot	Other	
0	Location: Top of slide in road Approximate ground surface elevation: 148 feet							TESTING
0-5	6" Asphalt over 2" base course over loose, moist to wet, silty, gravelly SAND (Fill) Very soft, wet, brown, sandy SILT with some clay and organics							
5-10	Very loose, moist, mottled orange in orangish tan, silty, fine SAND with trace to some clay and scattered organics		S-1					
			S-2					
			S-3					
10-15	Medium dense, moist, mottled orange in orangish tan, silty, fine SAND with trace to some clay Loose, damp to moist, mottled orange in orangish tan, silty, fine SAND with trace to some clay		S-4					
			S-5					
15-20	Very dense, damp, mottled orange in orangish tan, silty, fine SAND with trace to some clay (Weathered Sandstone)		S-6				62/12"	
			S-7				67/12"	
20-25	Highly oxidized bedding plane of 70 degrees at 20.5 feet		S-8				50/3"	
25-30	Very dense, damp to moist, orangish tan, silty, fine SAND with trace to some clay (Weathered Sandstone)		S-9				50/3"	

LEGEND

- 1 00-inch O.D. split spoon sample
- Grain size analysis
- Perched groundwater level at time of drilling
- Hydrometer analysis



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7-91M-11693-A

PROJECT: Alden Road

W.O.

Task 01

BORING NO. B-3

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 2 of 2 TESTING
					Standard	Blows per foot	Other	
30	Location: Top of slide in road Approximate ground surface elevation: 148 feet Very dense, damp to moist, orangish tan, silty, fine SAND with trace to some clay (Sandstone)		S-9		10	20 30 40 50	50/3'	
35	Becoming moist Dense, saturated, tan, silty, fine to medium SAND		S-10	P ATD	●		50/2'	
40	Very dense, moist, orangish tan, silty, fine SAND with trace to some clay (Sandstone)		S-11				50/3'	
45			S-12				50/2'	
Boring terminated at approximately 45.5 feet								
50								
55								
60								

LEGEND

-  2.00-inch O D split spoon sample
-  Grain size analysis
-  Perched groundwater level at time of drilling
-  Hydrometer analysis



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7-91M-11693-A

PROJECT: Belmont Street

W.O.

Task 02

BORING NO. B-1

DEPTH (feet)	SOIL DESCRIPTION Location: <i>Toe of upper landslide</i> Approximate ground surface elevation: <i>266 feet</i>	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE				Page 1 of 1
					Standard	Blows per foot		Other	
0	<i>Medium stiff to stiff, moist to wet, orangish tan-brown, sandy SILT with trace organics</i>		S-1		10	20	30	40	TESTING
5					<i>Medium dense to dense, moist, reddish-orange-brown, silty SAND with some 0 to 20 degree sand laminae (Weathered Sandstone)</i>		S-2		
10	S-3		20	30					40
15			S-4						20
15	<i>Hard, wet, blue-gray, sandy SILT with some clay interbedded with SAND with some silt</i>				P ATD		20	30	40
20			<i>Dense, moist to wet, blue-gray, greenish and whitish, silty SAND with some 0 to 20 degree sand laminae and some clay (Weathered Sandstone and Siltstone)</i>				S-5		20
25	S-6				20	30			40
30			<i>Boring terminated at approximately 21.5 feet</i>						

LEGEND

- [2.00-inch O.D. split spoon sample
- 3 Perched groundwater level at time of drilling
- ATD
- Hydrometer analysis
- Grain size analysis
- 200 wash (percent fines shown)



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Drilling method: HSA

Hammer type: Cathead

Date drilled: 24 June 1997

Logged by: CRT

Aberdeen Landslides -
Belmont Street

7-91M-11693-A
Task 02

HAND
BORING NO. B-2

PROJECT:

W.O.

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 1 of 1
					Standard 10	Blows per foot 20 30 40	Other 40	
0	Location: 30' NW of B-1 Approximate ground surface elevation: 255 feet							TESTING
	Very soft, wet to saturated, tan-brown, sandy SILT with some organics Loose, to medium dense, wet, orangish tan-brown, silty SAND Dense to very dense, wet, orangish tan-brown, silty SAND with some 0 to 20 degree silt laminae (Weathered Sandstone)			p ATD		35/6'	▲	
5	Hand boring terminated at approximately 4 feet			S-1			●	100/6' ▲
10								
15								
20								
25								
30								

LEGEND

- I 2.00-inch O D split spoon sample
- Perched groundwater level at time of drilling
- Hydrometer analysis
- Grain size analysis
- 200 wash (percent fines shown)



Aberdeen Landslides -

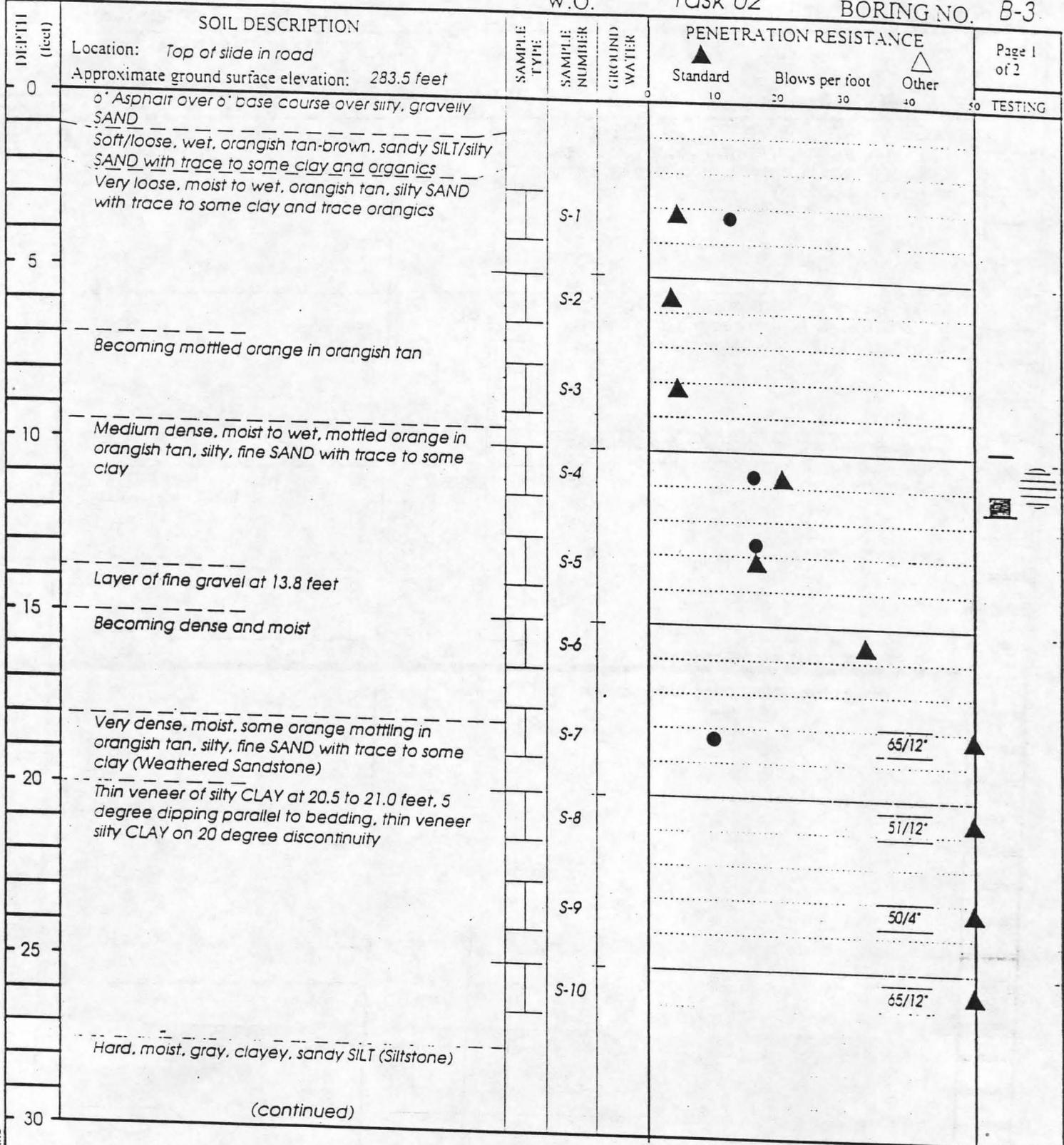
7-91M-11693-A

PROJECT: Belmont Street

W.O.

Task 02

BORING NO. B-3



LEGEND

- 2.00-inch O.D. split spoon sample
- Perched groundwater level at time of drilling
- Hydrometer analysis
- Grain size analysis
- 200 wash (percent fines shown)



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Drilling method: HSA

Hammer type: Mechanical

Date drilled: 27 June 1997

Logged by: HWB

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TESTING

Page 1 of 2

Aberdeen Landslides -

7-91M-11693-A

PROJECT: Belmont Street

W.O.

Task 02

BORING NO. B-3

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 2 of 2			
					Standard	Blows per foot	Other				
30	Location: Top of slide in road Approximate ground surface elevation: 283.5 feet				0	10	20	30	40	50	TESTING
	Hard, moist, gray, clayey, sandy SILT as above		S-11			●			50/4"	▲	55
	Very dense, moist, light to medium gray, silty, fine SAND with trace to some clay and trace organics at 31 feet (Sandstone)										
35	Very hard/very dense, moist, light to medium gray, sandy SILT/silty SAND with bedding at 36.3 feet on 20 degree dip (Siltstone/Sandstone)		S-12						50/6"	▲	
40	Very dense, moist, light gray, silty, fine SAND with trace to some clay and volcanic ash clasts (Sandstone)		S-13	P ATD					50/6"	▲	
	Becoming wet										
45	No volcanic ash in sample at 45 feet		S-14						50/5"	▲	
	Boring terminated at approximately 45.5 feet										
50											
55											
60											

LEGEND

-  2.00-inch O.D. split spoon sample
-  Grain size analysis
-  Perched groundwater level at time of drilling
-  200 wash (percent fines shown)
-  Hydrometer analysis



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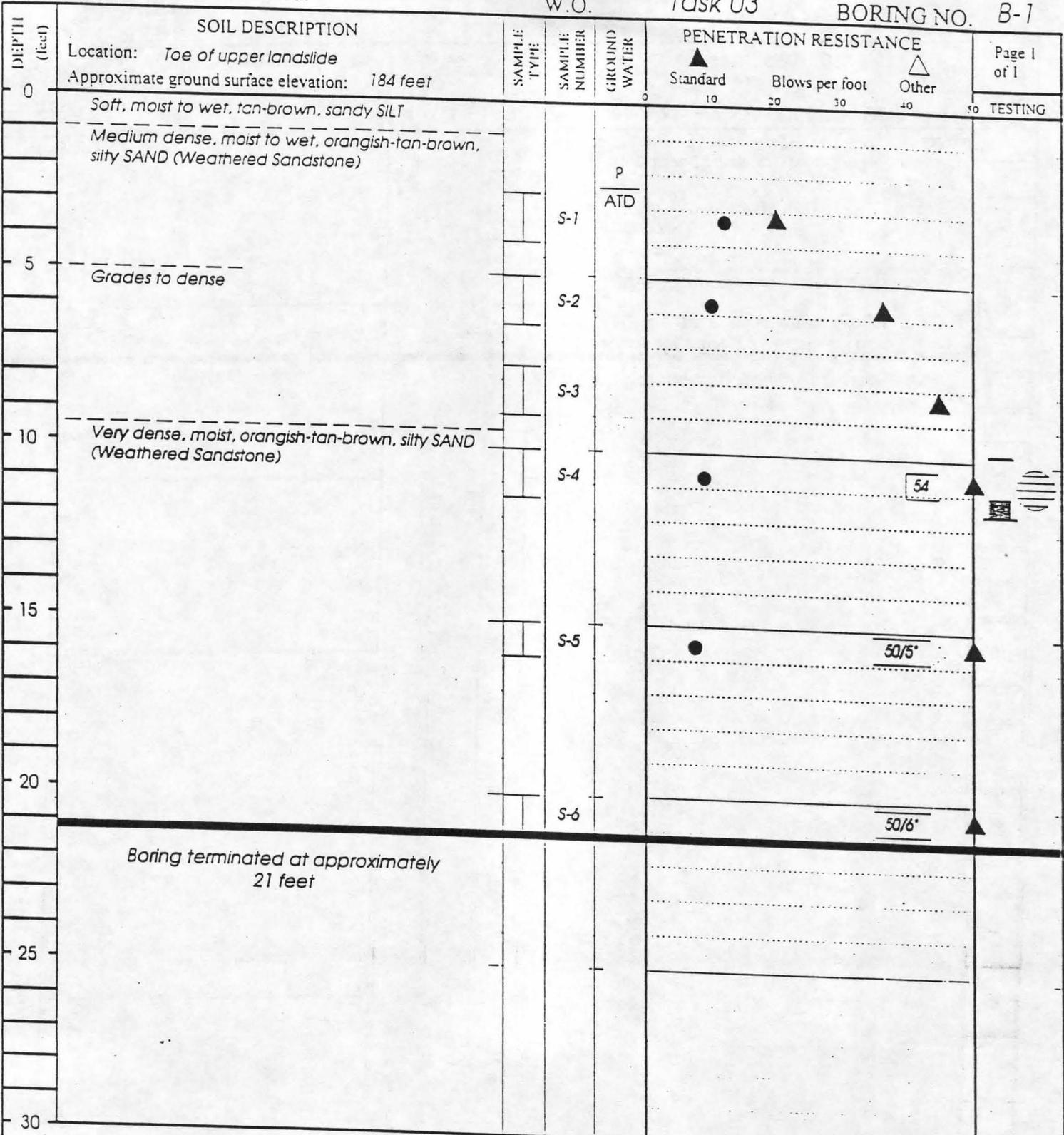
7-91M-11693-A

PROJECT: Council Crest

W.O.

Task 03

BORING NO. B-1



LEGEND

1 00-inch O D split spoon sample

Grain size analysis

Perched groundwater level at time of drilling

Hydrometer analysis



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Drilling method: HSA

Hammer type: Cathead

Date drilled: 23 June 1997

Logged by: CRT

Aberdeen Landslides -
Council Crest

7-91M-11693-A
Task 03

HAND
BORING NO. B-2

PROJECT:

W.O.

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 1 of 1	
					Standard ▲	Blows per foot	Other △		
0	Location: 45' W of B-1 Approximate ground surface elevation: 170 feet				10	20	30	40	TESTING
	Very soft, wet, blue-gray, sandy SILT with some wood and organics (Landslide Debris)								
	----- Becomes wet to saturated, brown-gray								
			S-1	P ATD	▲				
5	Medium dense, wet, tan-brown, silty SAND								
	----- Dense to very dense, moist to wet, silty SAND with some sand laminae (Weathered Sandstone)		S-2			35/5		100/5	
	Hand boring terminated at approximately 6.5 feet								
10									
15									
20									
25									
30									

LEGEND

2.00-inch O D split spoon sample



Grain size analysis

Perched groundwater level at time of drilling

Hydrometer analysis

MOISTURE CONTENT

Plastic limit Natural Liquid limit



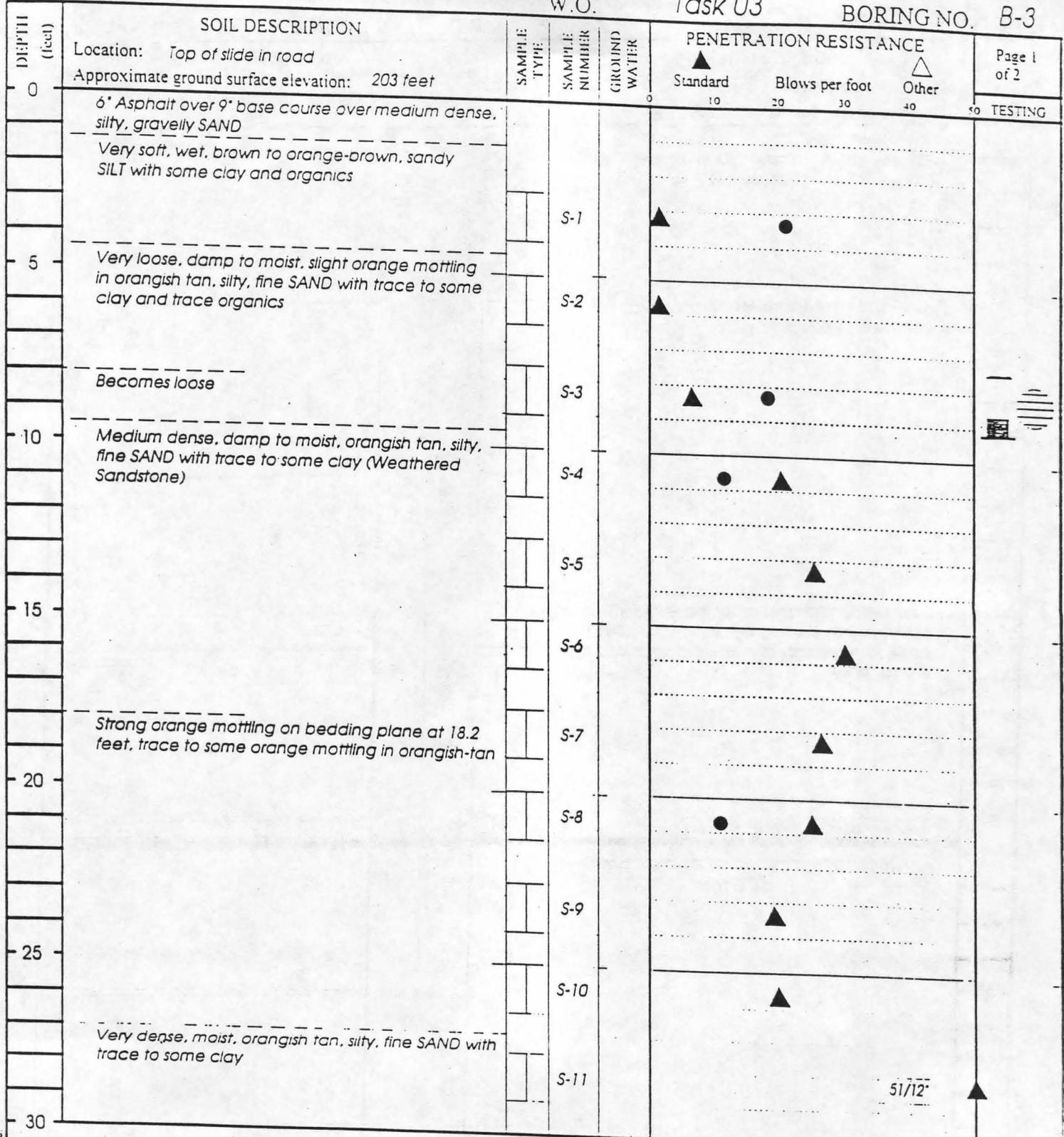
AGRA
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Aberdeen Landslides -
 PROJECT: Council Crest

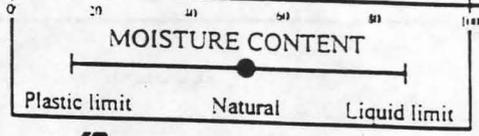
7-91M-11693-A

W.O. Task 03 BORING NO. B-3



LEGEND

- 2.00-inch O.D. split spoon sample
- Perched groundwater level at time of drilling
- Hydrometer analysis
- Grain size analysis



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7-91M-11693-A

PROJECT:

W.O.

Task 03

BORING NO. B-3

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE			Page 2 of 2
					Standard	Blows per foot	Other	
30	Location: Top of slide in road Approximate ground surface elevation: 203 feet				▲		△	TESTING
	Very dense, moist, trace orange mottling in orangish tan, silty, fine SAND with trace to some clay (Weathered Sandstone)		S-12				53/12'	
				p ATD				
35	Wet sand stringer present in this interval, not detected in SPT samples		S-13		●		64/12'	
40			S-14				50/6'	
45	Very dense, damp to moist, trace to some orange-buff mottling in orangish tan, silty, fine SAND with trace to some clay and rip up clast at 45.2 feet (Sandstone)		S-15				50/12'	
50	Veneer of silty CLAY at 50.5 feet		S-16				50/2.5'	
	Boring terminated at approximately 50.5 feet							
55								
60								

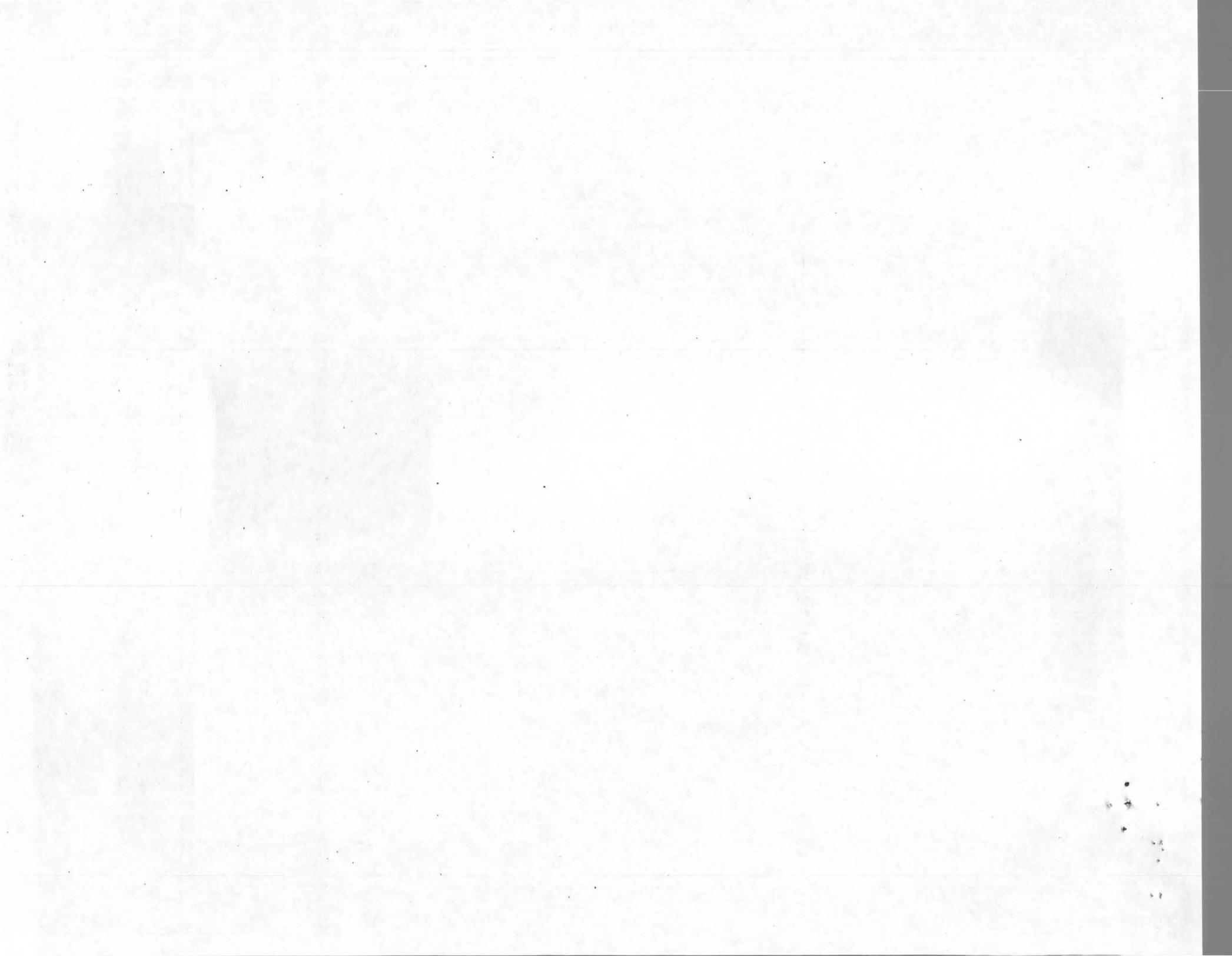
LEGEND

- 2.00-inch O D split spoon sample
- Perched groundwater level at time of drilling
- Hydrometer analysis
- Grain size analysis



APPENDIX B
LABORATORY TESTING PROCEDURES AND RESULTS





APPENDIX B
LABORATORY TESTING PROCEDURES AND RESULTS
7-91M-11693-A

Our laboratory testing program for this evaluation included numerous visual classifications, thirty-three moisture content determinations, six grain size with hydrometer analyses, and one 200-Wash analysis. The following paragraphs describe our procedures associated with each type of test. Graphical results of certain laboratory tests are enclosed in this appendix.

Visual Classification Procedures

Visual soil classifications were conducted on all samples in the field and on selected samples in our laboratory. All soils were classified in general accordance with the United Soil Classification System, which includes color, relative moisture content, primary soil type (based on grain size), and any accessory soil types. The resulting soil classifications are presented on the exploration logs contained in Appendix A.

Moisture Content Determination Procedures

Moisture content determinations were performed on representative samples to aid in identification and correlation of soil types. All determinations were made in general accordance with ASTM:D-2216. The results of these tests are shown on the exploration logs contained in Appendix A.

Grain Size Analysis Procedures

A grain size analysis indicates the range of soil particle diameters greater than the U.S. No. 200 mesh sieve size included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM:D-422. The results of these tests are presented on the enclosed grain-size distribution graphs and were used in soil classifications shown on the exploration logs contained in Appendix A.

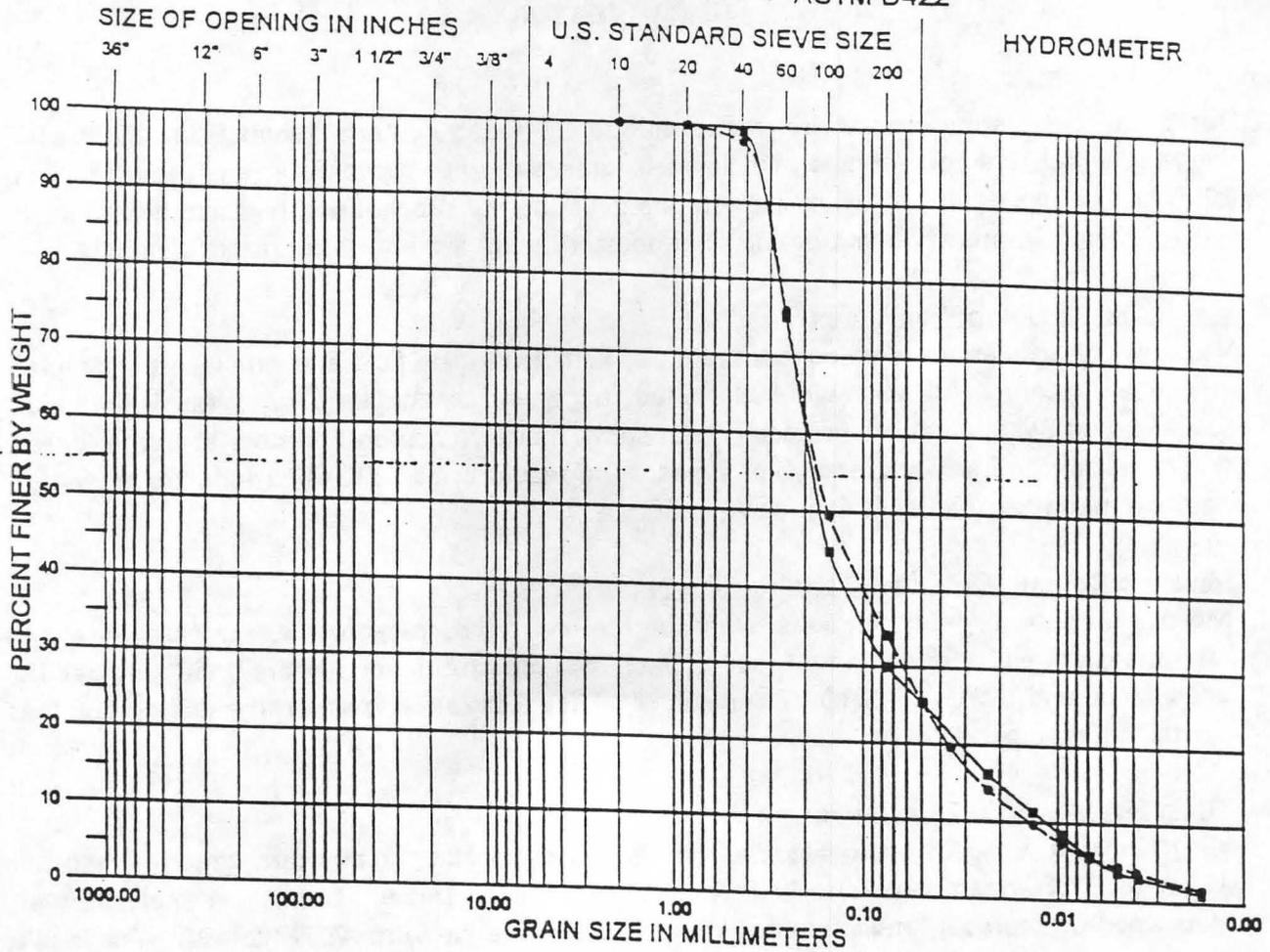
200-Wash Analysis

A 200-wash is a procedure in which the fine-grained soil fraction is separated from the sand and gravel by washing the soil on a U.S. No. 200 sieve. A 200-wash was performed on selected soil samples obtained from our test pits in general accordance with ASTM:D-1140. The results of these analyses were used in soil classifications shown on the test pit logs in Appendix A and are presented in this appendix.

Hydrometer Analysis Procedures

A hydrometer analysis indicates the range of soil particle diameters less than the U.S. No. 200 mesh sieve size included in a particular sample. Hydrometer analyses were performed on representative samples in general accordance with ASTM:D-422. The results of these tests are presented on the enclosed grain-size distribution graphs and were used in soil classifications shown on the exploration logs in Appendix A.

GRAIN SIZE DISTRIBUTION ASTM D422



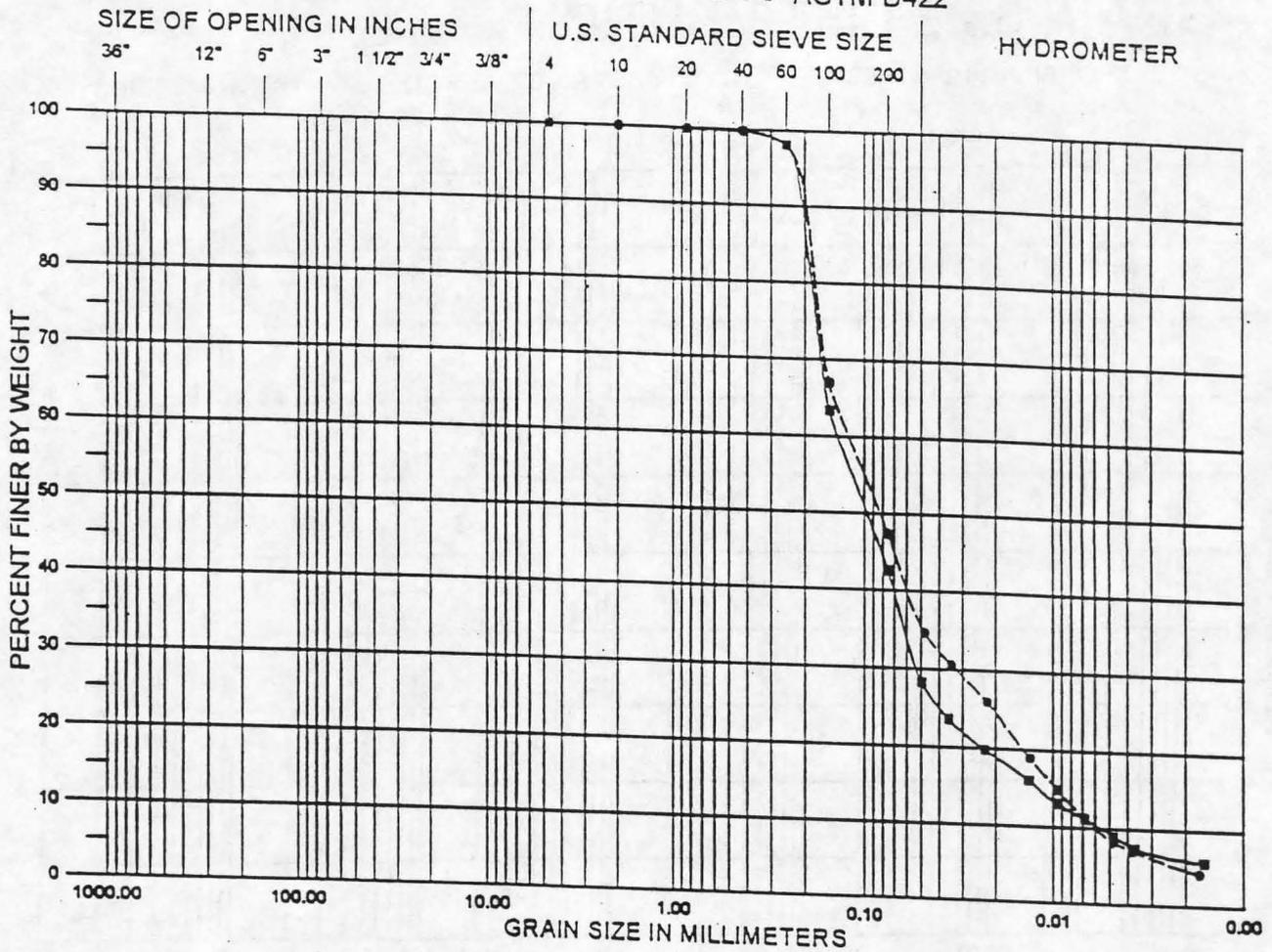
BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Exploration	Sample	Depth	Moisture	Fines	Soil Description
■-■-■-■-■	B-3	S-5	12.5-14.0'	26%	30% Silty SAND, trace clay
●-●-●-●-●	B-3	S-10	30.0-30.8	15%	34% Silty SAND, trace clay
✖-✖-✖-✖-✖					
▲-▲-▲-▲-▲					

Project: Aberdeen Landslide Alden & Friedlander
 Work Order: 7-91M-11693-A Task 1
 Date: 7-2-97

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