



SHORE EROSION STUDY Technical Report

Appendix 9

SHORELINE EROSION AND BLUFF STABILITY ALONG LAKE MICHIGAN
AND LAKE SUPERIOR SHORELINES OF WISCONSIN

DOUGLAS AND WESTERN BAYFIELD COUNTIES
WISCONSIN POINT TO BARK BAY

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COASTAL ZONE
INFORMATION CENTER

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appendix 9

WISCONSIN
COASTAL MANAGEMENT

This report has been prepared through the cooperative efforts of the Wisconsin Geological and Natural History Survey, the University of Wisconsin (Madison, Milwaukee, Parkside, and Extension), the Wisconsin Department of Natural Resources, and the Office of Coastal Management, Wisconsin Department of Administration. Assistance was further provided by Owen-Ayres and Associates.

This report is being reproduced quickly and in a limited quantity for dissemination to local governments and interested parties.

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INTRODUCTION

This Appendix provides detailed information on shoreline conditions for the Lake Superior shoreline between Wisconsin Point and the mouth of Bark River. The order of informational materials in the Appendix is from west to east. The shoreline has been broken down into reaches and by geographic sections within these reaches. (figure 1). Each reach has a general description followed by the detailed information for the geographic sections within that reach.

For each geographic section, a more detailed narrative is presented along with a map and two types of bluff profiles. Shown on the map are the locations of measured profiles, and subsection divisions that are described separately. Engineering data such as safety factor, the confidence level of this safety factor, and the distance the slope must retreat before a stable slope angle is obtained (assuming no further wave erosion at the toe) are also given. The subsection descriptions include the materials, condition, failure mechanisms, and degree of vegetative cover of the beach, toe, and bluff within the section. The measured profiles, from bluff top to water's edge, are presented. These profiles show stratigraphy, slope angles, circles of failure, and calculated safety factors for these sites. Finally, a longitudinal profile of the shoreline of the section, showing the locations and stratigraphy of the measured profiles is given. Section data were collected in the summer of 1979.

Location of geotechnical borings is indicated on Figure 1 at the beginning of the Appendix. Detailed information pertaining to these boreholes are included in the Appendix where they occur within the reaches.

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A text describing the borehole site, a location map, and several measured profiles are included. Where data were available, the engineering properties and the borehole log are also given. Geotechnical data were obtained during the summer of 1978.

The measured profiles, the safety factors, and the stability lines will all change through time so some caution is appropriate when utilizing this information.

The meaning of abbreviations used in the Appendix is given below. For more detailed description of the methods used in compiling the data, regional interpretations, and conclusions about the engineering characteristics and types of slope failure taking place refer to the main report (Shoreline Erosion and Bluff Stability Along Lake Michigan and Lake Superior Shorelines of Wisconsin) available from the State Planning Office and the Wisconsin Geological Natural History Survey.

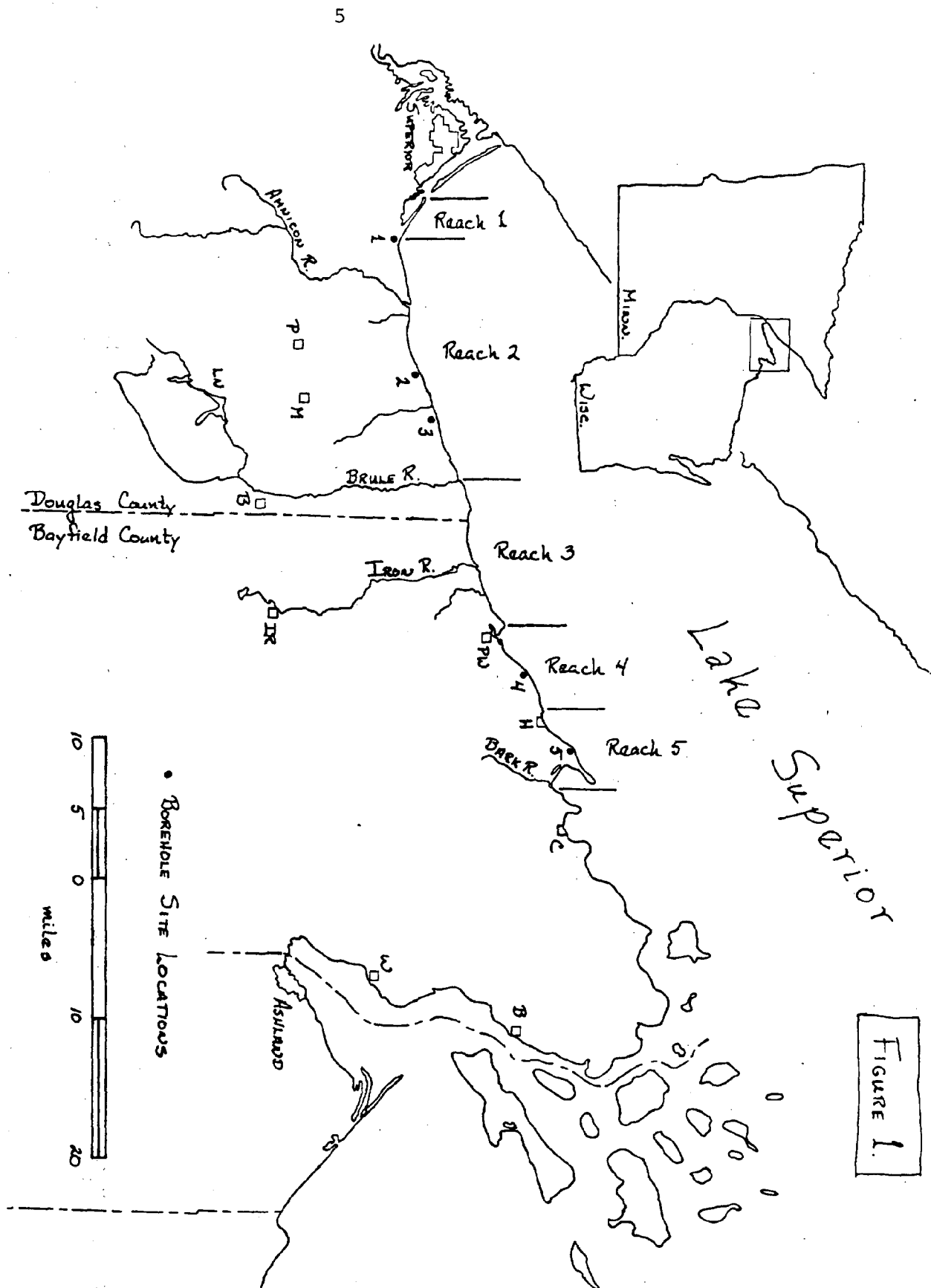
Symbols Used
(used as nouns and adjectives)

b	brown	br	bedrock
bd	boulders	dbr	disturbed bedrock
c	clay or clayey	rst	red sandy till
co	coarse		
f	fine		
g	gravel		
m	medium		
p	pebbles		
r	red		
s	sand		
si	silt		
t	till		
y	cobbles		

SF Factor of Safety
 A - unsatisfactory (1.00)
 B - questionable (1.00-1.25)
 C - satisfactory (1.25)

Conf. Confidence Level
 A - high confidence - at borehole
 B - medium confidence - near borehole
 stratigraphy visible
 C - low confidence - away from borehole,
 stratigraphy questionable

SL Stability line - the distance slope
 must retreat to attain a stable
 slope angle. This assumes no erosion
 at toe and unchanged conditions of
 nature of material and water table.



GEOLOGY

Detailed stratigraphic investigations of the bluffs along the Wisconsin shoreline of Lake Superior reveal the presence of three till units. The oldest till unit is composed of the Jardine Creek till, which can be distinguished by its sandy loam texture (average: 61% sand, 24% silt, 15% clay). This till unit is underlain by Precambrian sandstone throughout the study area. The till is exposed in the bluffs between the Iron River and Port Wing and on Bark Point. It is present just below lake level in the western part of the study area. This till was derived from bedrock.

The next youngest till units is composed of the Hanson Creek till. This till can be distinguished by its clay texture (average: 10% sand, 32% silt, 58% clay), its relatively browner color (5YR 3/4), and the complex intermingling patterns of red and gray color bands within it. This till also has a lower plasticity index (38) and higher standard penetration resistance (21) than the clay facies of the Douglas till unit (45 and 14, respectively). This till unit is exposed in the bluffs from Wisconsin Point to the Iron River and is absent east of the river. This till was derived from lake sediments deposited during the retreat of ice that deposited the Jardine Creek till.

The youngest till unit is composed of the Douglas till. Two textural facies are present within this unit -- the clay facies (average: 10% sand, 26% silt, 64% clay) and the clay-loam facies (average: 40% sand, 27% silt, 33% clay). In addition, this till can be distinguished by its characteristic red color (2.5 YR 4/4) and its occurrence as the surficial unit of the Lake Superior plain. The clay facies is exposed

in the bluff from Wisconsin Point to Port Wing while the clay-loam facies extends from Port Wing to Bark Bay. This till was derived from lake sediments deposited during the retreat of ice that deposited the Hanson Creek till.

In addition to these tills a deposit of sand and gravel that comprises nearly all of the bluffs between Port Wing and Herbster and a deposit of fine-sandy silt between Bardon and Haukkala Creeks are significant bluff constituents.

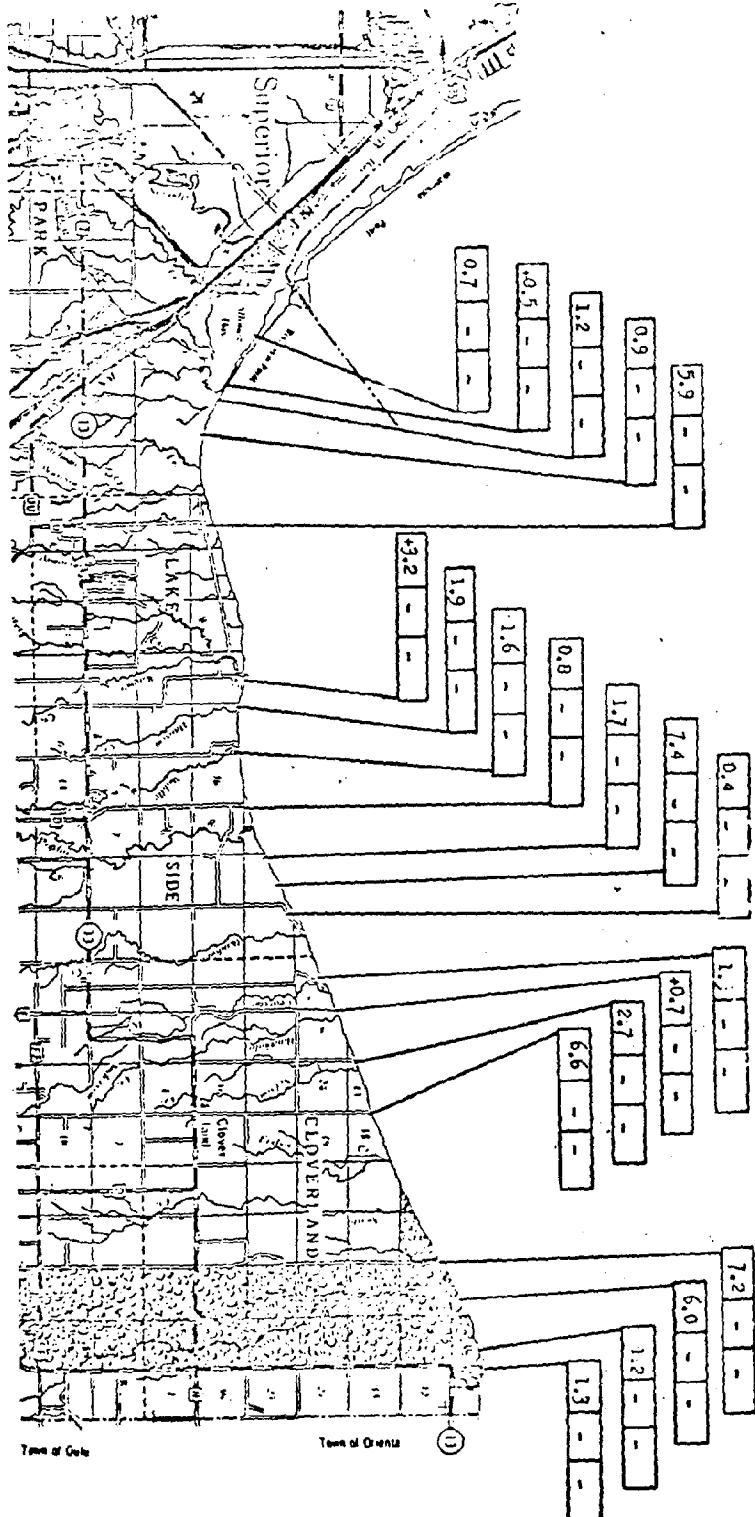
Thus there is evidence in northwestern Wisconsin suggesting at least three episodes of glacial activity during Late Wisconsinan time. These episodes are indicated by the presence of the three till units exposed in the bluffs along the Lake Superior shoreline. Although lakes filled the western end of the basin after each of the till units were deposited, no lake sediments were observed overlying the youngest unit, the Douglas till unit.

The till units are tentatively correlated with till units described in Minnesota by Wright (and others, 1970) based on lithologic similarities, stratigraphic relationships, and geographic occurrence. The Jardine Creek till unit is correlated to sandy till units deposited during the St. Croix and Automba phases in Minnesota; the Hanson Creek till unit to the clayey till units deposited during the Split Rock phase; and the Douglas till unit to the clayey till units deposited during the Nickerson phase.

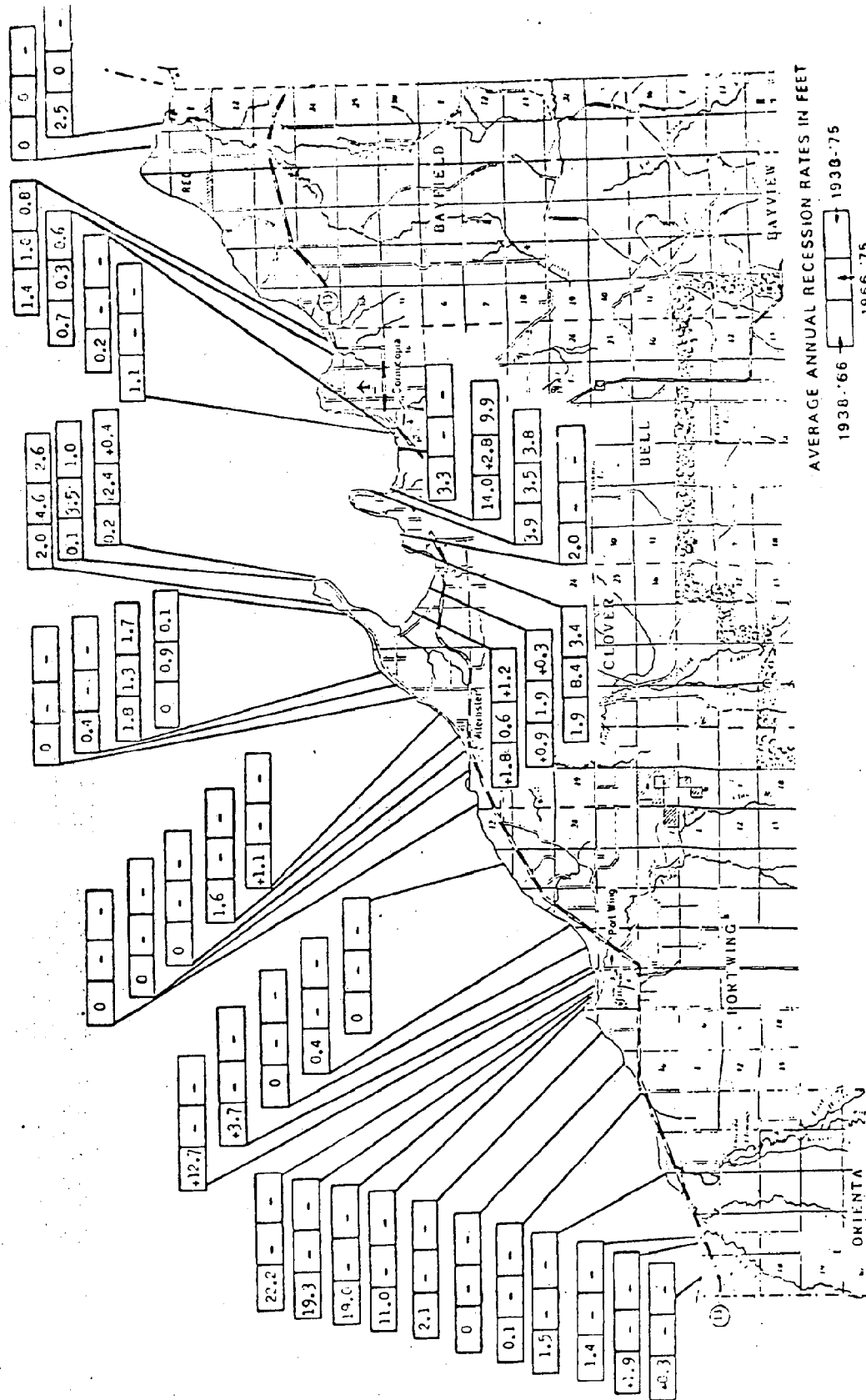
Because they are based on dates from organic materials that could be contaminated, the ages of the phases described by Wright (and others, 1973) may be too old. Based on more conservative reasoning, the glacial

glacial episodes recorded in the study area probably occurred between 14,000 and 12,000 yrs BP. They may be as young as 10,200 yrs BP.

The Lake Superior basin is presently undergoing glacial rebound or uplift in response to the unloading of the ice mass. This uplift, however, is not occurring uniformly across the basin. The northeast is rising at a faster rate than the southeast. As a result, the basin is being tilted and the water in the lake is rising against the Wisconsin shoreline. This differential uplift has, in part, contributed to erosion processes along the Wisconsin shoreline since waves can more directly act against coastal bluffs and beaches.



AVERAGE ANNUAL RECESSION RATES IN FEET
 1930-'66 - 1938-'75
 1966-'75
 - data not available



Reach 1

Reach 1 extends from the Minnesota-Wisconsin state line, 3.4 miles to the eastern end of Wisconsin Point. This reach includes Sections 28, 27, 34, and 35 of Township 48 North, Range 13 West in Douglas County. Geologically, this reach is a portion of the bay mount bar which separates Lake Superior from Allouez Bay. Together with Minnesota Point, this bar is the longest fresh water spit in the world and provides natural harbor protection for the ports of Superior and Duluth.

Wisconsin Point is composed of sandy material which has been transported to the western end of the Superior Basin by the littoral currents which trend east to west. The sand is derived from the erosion of shorelines to the east. Beaches are sandy and range from as much as 300 feet wide near the Superior Entry to near zero at the eastern end of this reach.

Erosion in this reach varies greatly. The western-half of Wisconsin Point has a stable shoreline, and in some places is experiencing accretion. The area of maximum accretion occurs at the western end where the jetties of the Superior Entry block the littoral movement of material. The eastern half of the reach is eroding at a rate of approximately 1 foot per year.

The land is entirely owned by the City of Superior and Douglas County with recreation being the major land use. A sanitary landfill is located in the western section of the reach in an area of active erosion. Alternatives for the protection of the landfill are being investigated at the present time. The only shoreline protection structures in this reach are the jetties at the Superior Entry.

Borehole Site 1

Borehole Site 1 is located between Reaches 1 and 2, within the corporate boundaries of the City of Superior. Sections 35 and 36 of Township 49 North, Range 13 West comprise this 2.1 mile site. This study area includes Wisconsin Point (the bay mouth bar which separates Lake Superior from Allouez Bay) and the western portion of the red clay bluffs which dominate much of the Douglas County shoreline.

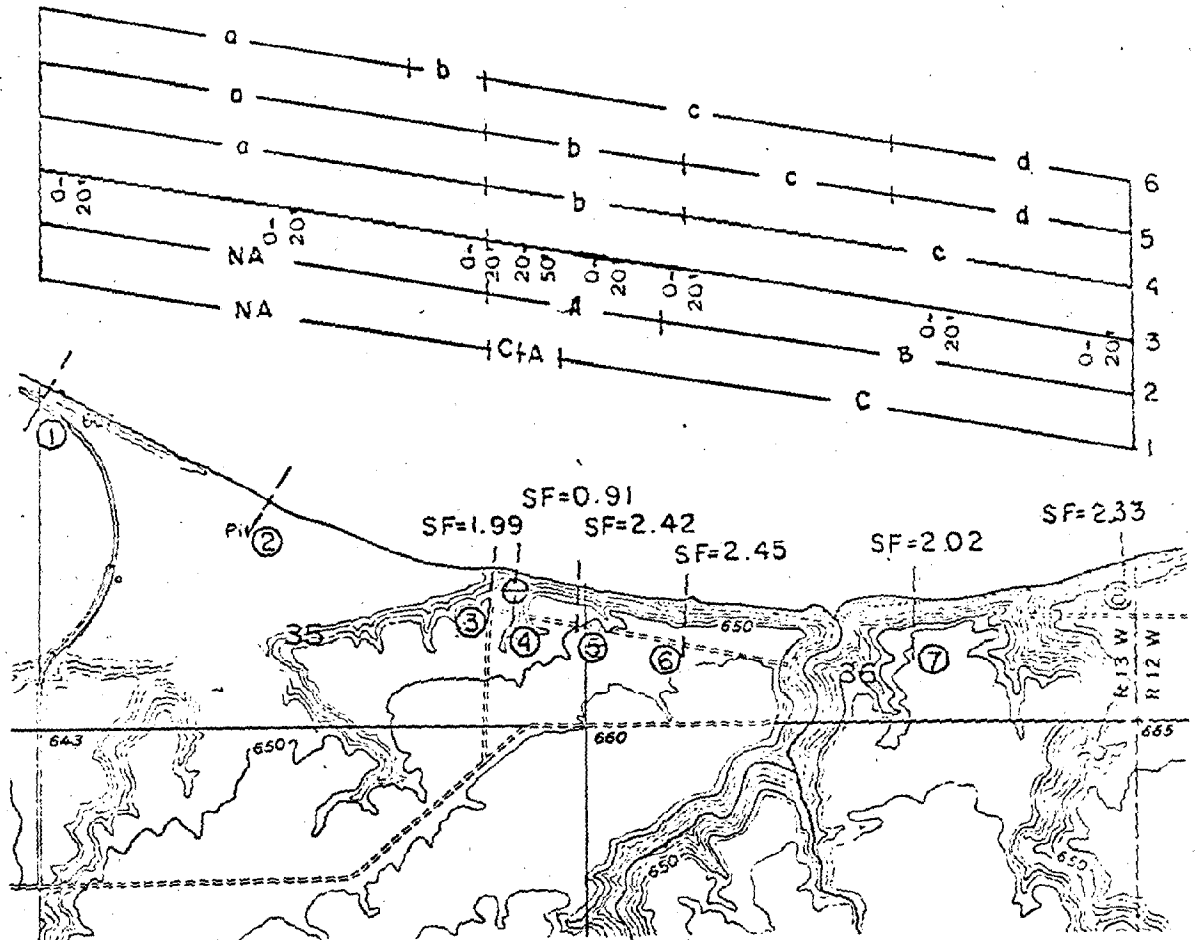
Wisconsin Point occupies nearly all of Section 35. Sand dunes 10 to 15 feet in height are present in the western portion and a wetland is located between Wisconsin Point and the mainland (see Profile 1 and 2). Beach widths in Section 35 decrease from 75 feet in the west to zero in the east.

The bluffs located in the eastern portion of Section 35 and in Section 36 average 50 to 60 feet in height. Two stratigraphic units are identifiable within the bluff face: an upper, redder clay unit and a lower, browner clay unit. This lower layer is exposed at the bluff toe east of Dutchman's Creek to the end of the reach. This browner unit has a higher silt content and a greater percentage of cobble to boulder size clasts. The clay units located in this study area extend eastward through Douglas County and into western Bayfield County.

The role of vegetation in bluff stabilization is well illustrated in this study area. In section 35 and the western 1/4 of Section 36, flows and shallow slides are prevalent where vegetation is absent. Rotational slumping, however, appears to be unaffected by the presence of vegetation (see Profiles 6 and 8).

Beach widths along the bluffs vary from in excess of 150 feet at the western end to less than 20 feet in the east. The beach environment is highly dynamic along this coast. To illustrate, within a period of one year beach widths in some locations increased from zero to 165 feet (see Profile 4). This change is due, in part, to decreasing lake levels combined with the

amount of sand in the littoral system.

**SAFETY FACTOR (SF)**

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-at boreholes (high confidence)
- B-near boreholes with stratigraphy visible
- C-no stratigraphy visible (low confidence)

- 6 BEACH
- 5 TOE
- 4 BLUFF
- 3 STABILITY LINE
- 2 CONFIDENCE LEVEL
- 1 SAFETY FACTOR

APPROXIMATE SCALE
1 inch = 1500 feet

Borehole Site 1

Bluff:

- a) None
- b) 0 to 20% vegetation with shallow slides, flows, and slumps
- c) 90% vegetation with occasional slumping

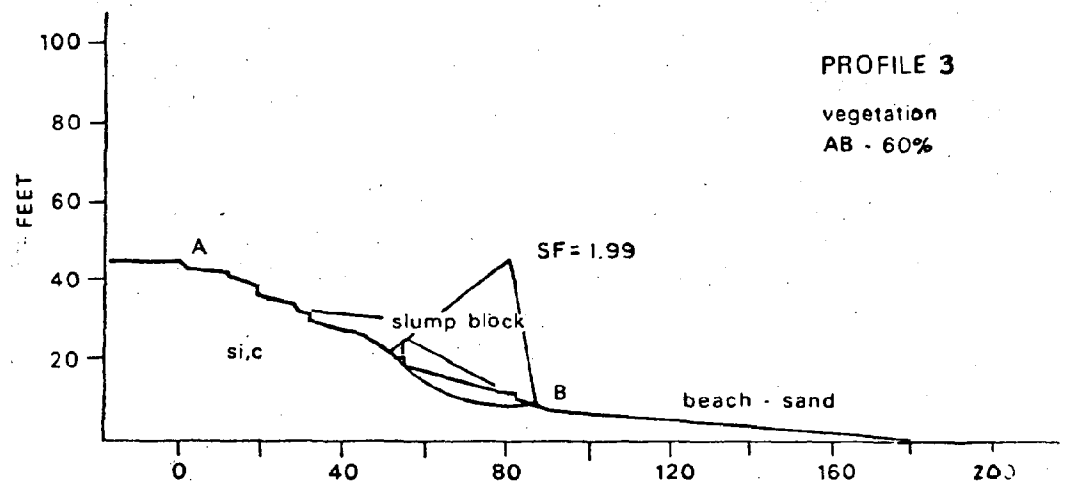
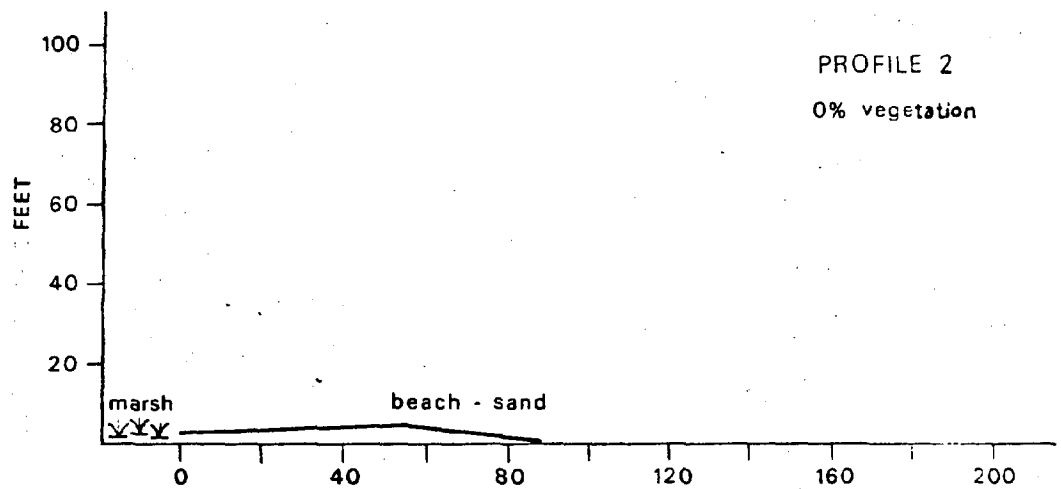
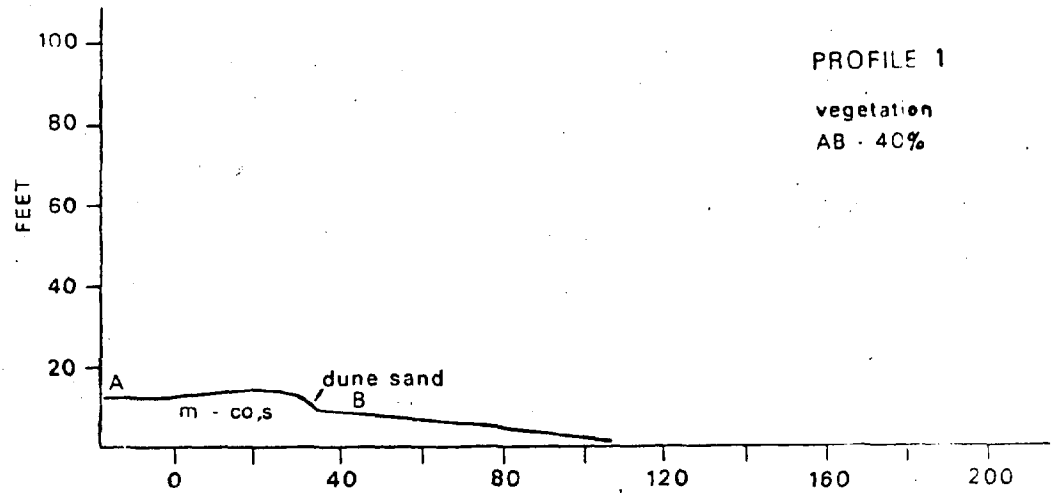
Toe:

- a) None
- b) Flow terraces and slump debris
- c) 100% vegetation
- d) Wave cut. Silty-clay exposed

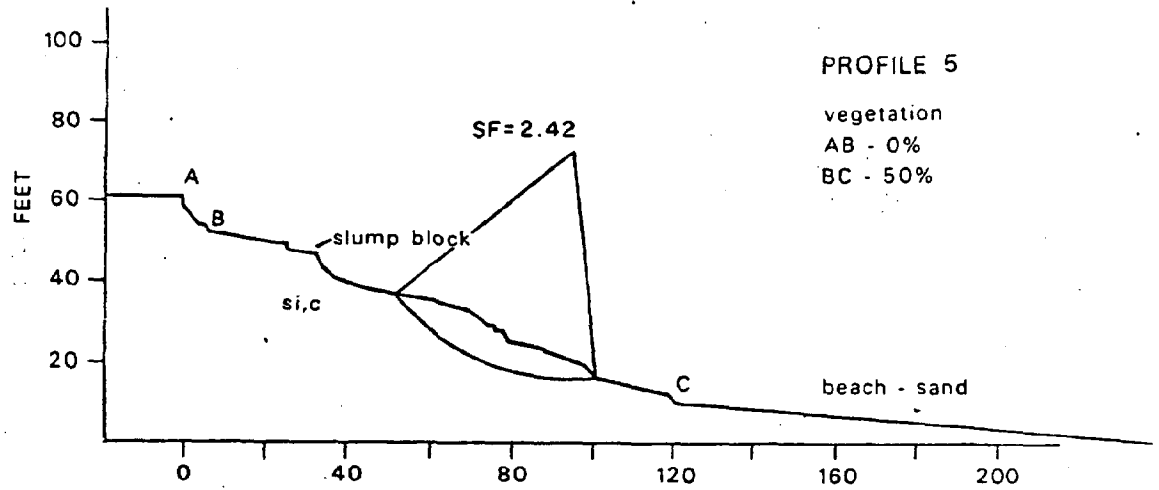
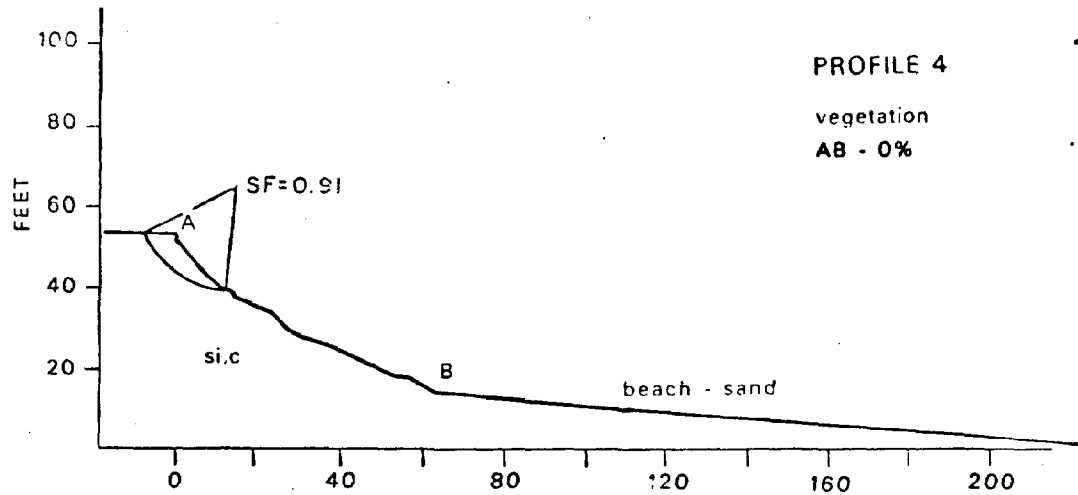
Beach:

- a) 40 to 90 feet, sand
- b) No beach marsh
- c) 45 to 165 feet, sand with some gravel
- d) 15 to 30 feet, sand

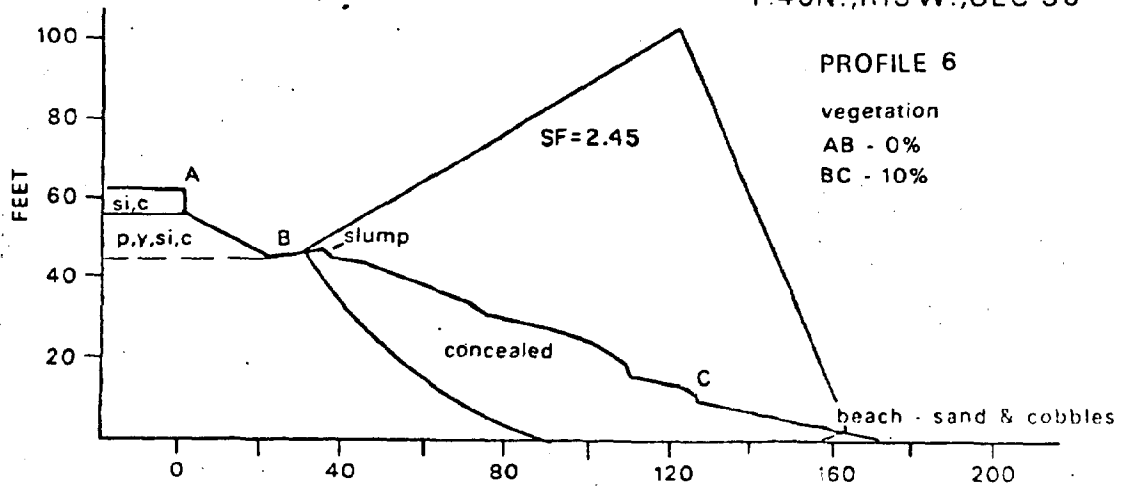
T.49N.,R13W.,SEC 35



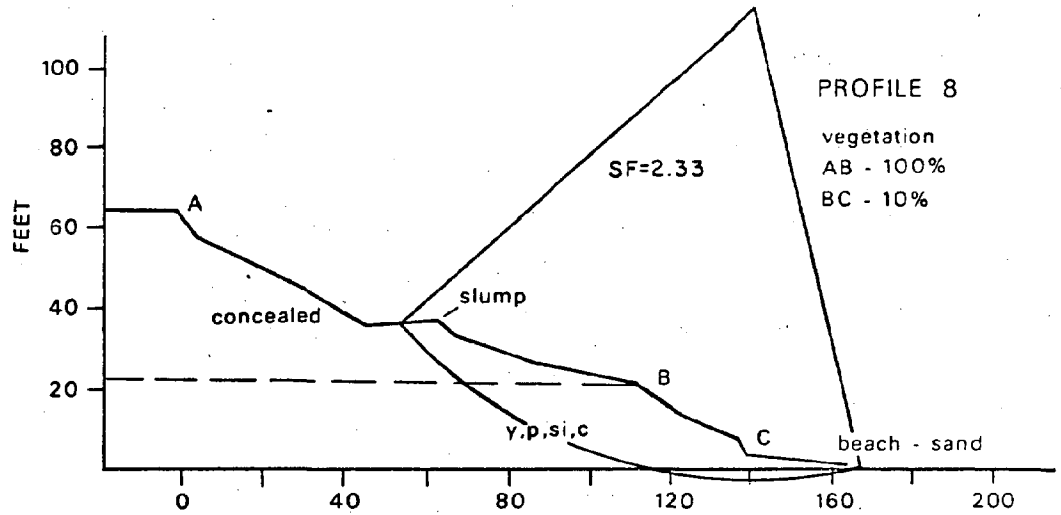
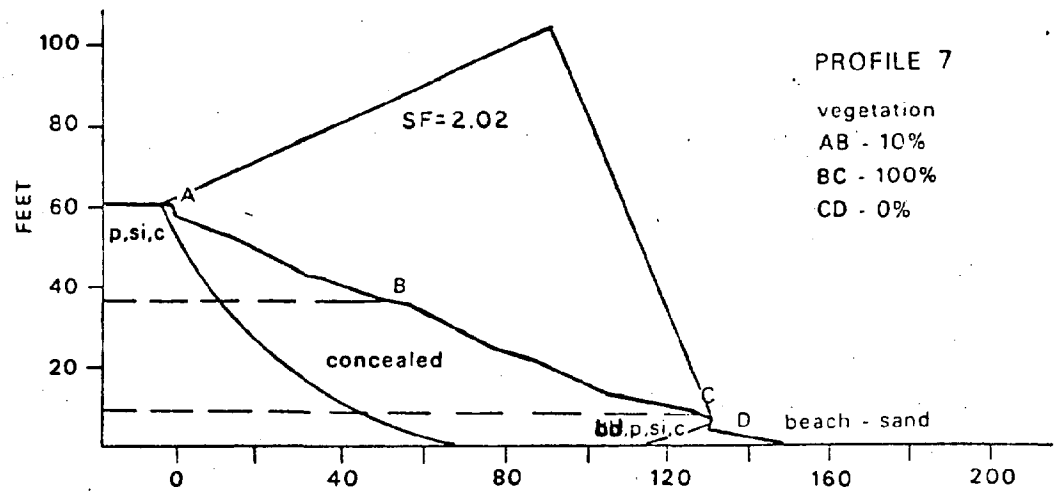
T49N.,R13W.,SEC 35.



T.49N.,R13W.,SEC 36



T49 N., R13 W., SEC 36



LOCATION

SGT-1 T49N R13W Sec. 35

Depth (ft.)	Blow Count (split spoon) 10 20 30 40 50 60 70 80 90 100	Pocket Penetrometer (kg/cm ²) 1 2 3 4 5	w _n	γ_d gm/cm ³	w _L	I _p	% Clay	% Clay & Silt	ϕ' degree	c' kg/cm ²	Description of Soil
5	10 20 30 40 50 60 70 80 90 100	1 2 3 4 5	30.5	1.82	66	36	62.0	93.0			clay, red, silty, trc. sand (CH)
10											
15											
20			34.2	1.82	77.5	47.3	67.0	90.0			
25			40.6	1.82	65.4	28.9	79.0	96.0	33.0	0	clay&silt,lt. gray, trc. grvl. (CL&ML)
30											
35											
40											
45											
50			29.1	1.88	36.0	13.8	18.0	95.0	28.0	0.08	
55											
60											
65											
70											
75											
80											
85											
90											
95											
100											
105											
110											
115											
120											

EOB 50.0

Reach 2

Reach 2 extends from the eastern end of Wisconsin Point to the mouth of the Bois Brule River. The reach includes approximately 18 miles of shoreline in Sections 35 and 36 of Township 49 North, Range 13 West, Sections 31, 32, 33, 34, 27, 35, 25, and 36 of Township 49 North, Range 12 West, Sections 30, 29, 28, 21, 22, 23, 14, and 13 of Township 49 North, Range 11 West, and Sections 18, 17, 8 and 9 of Township 49 North, Range 10 West in Douglas County. The entire shoreline is made up of high bluffs composed mainly of two clay units. Bluffs average 50 feet in height with a maximum of 80 feet. Three miles west of the Bois Brule River the bluff begins to decrease in height from 50 feet to 30 feet near the mouth of the river.

Erosion rates of 1 to 7 feet per year have been measured along this reach of shoreline. The only portions which appear to be stabilized are near the mouths of rivers and streams. These streams are actively down-cutting in their headwater reaches, but the mouths are drowned. Some carrying large quantities of sediment into Lake Superior. Beaches serve as a protective barrier to wave action at these locations. Where no stream is present, beaches are narrow or absent. Waves can easily cross these beaches and directly attack the bluff toe. Toe erosion over-steepens the bluffs and triggers slides and rotational slumping. Excessive rainfall commonly saturates the upper layers of the clay, decreasing soil strength. As a result, flows and shallow slides are the dominant erosion mechanisms during wet periods.

The land is entirely privately-owned with the exception of the easternmost 1.3 miles of shoreline which is part of the Brule River State Forest.

The majority of the land is undeveloped with access to the shoreline limited to a few section line roads and roads which lead to stream mouths. A park and public boat landing at the mouth of the Bois Brule is maintained by the State of Wisconsin.

Only three structures are located within this reach. A timber groin and sunken barge are located at the east side of the Amnicon River. These structures are completely deteriorated and non-functional. Just west of Bardon Creek, a poured concrete groin has developed a beach along its western side.

Section 35, T 49 N, R 13 W

The section is located at the base of Wisconsin Point. Along the western third of the shoreline, a moderately-wide, sandy beach is present. Behind most of this beach subsection is the city of Superior's old landfill. The next third of the beach is characterized by the addition of sand to the beach by the deposition of material in long-shore transport. Inland from this beach subsection is a marsh. The last subsection is marked by a forty foot bluff along the shoreline. The bluff is naturally protected by a wide, sandy beach; however, the bluff itself has not stabilized. Failure is predominantly by shallow sliding, but occasional deeper slides are present. The bluff material is red clay, most of which has slumped. The toe is also composed of slumped, red clay. Vegetative cover is quite poor and is restricted to clumps of sod and occasional small alders moving downslope on slump blocks. Because of its easy access and proximity to Superior, this last subsection is heavily used.

Sec. 35, T 49 N, R 13 W

Bluff:

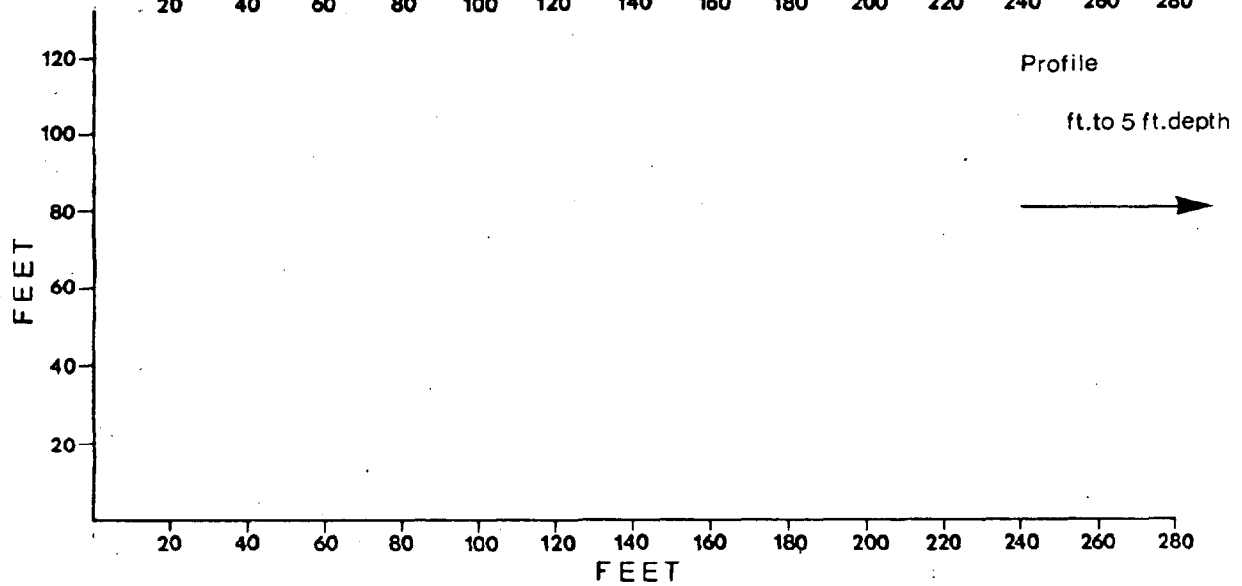
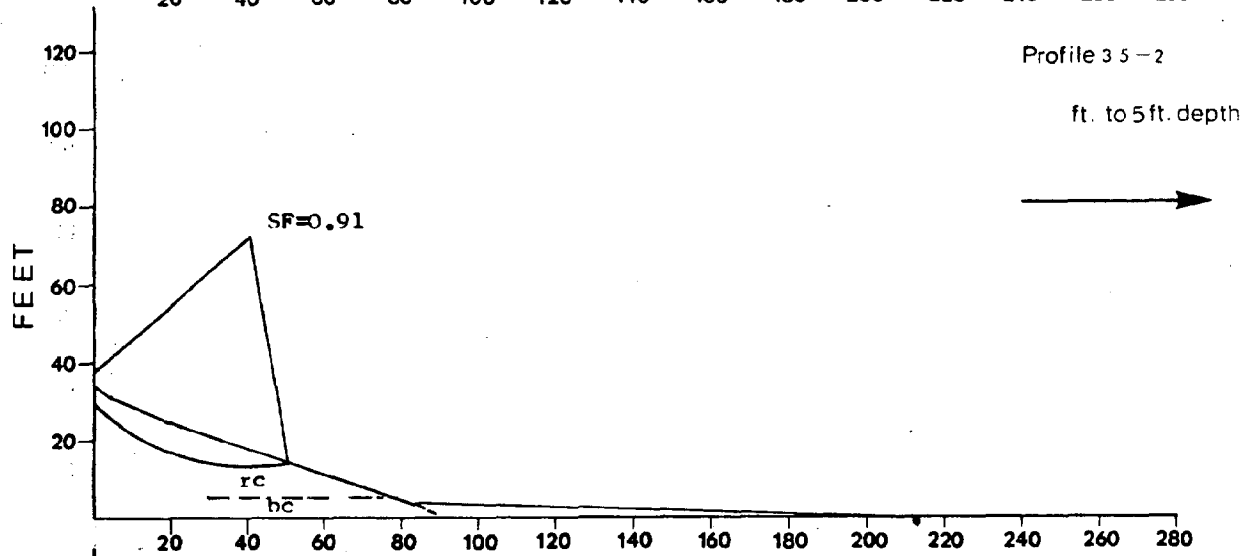
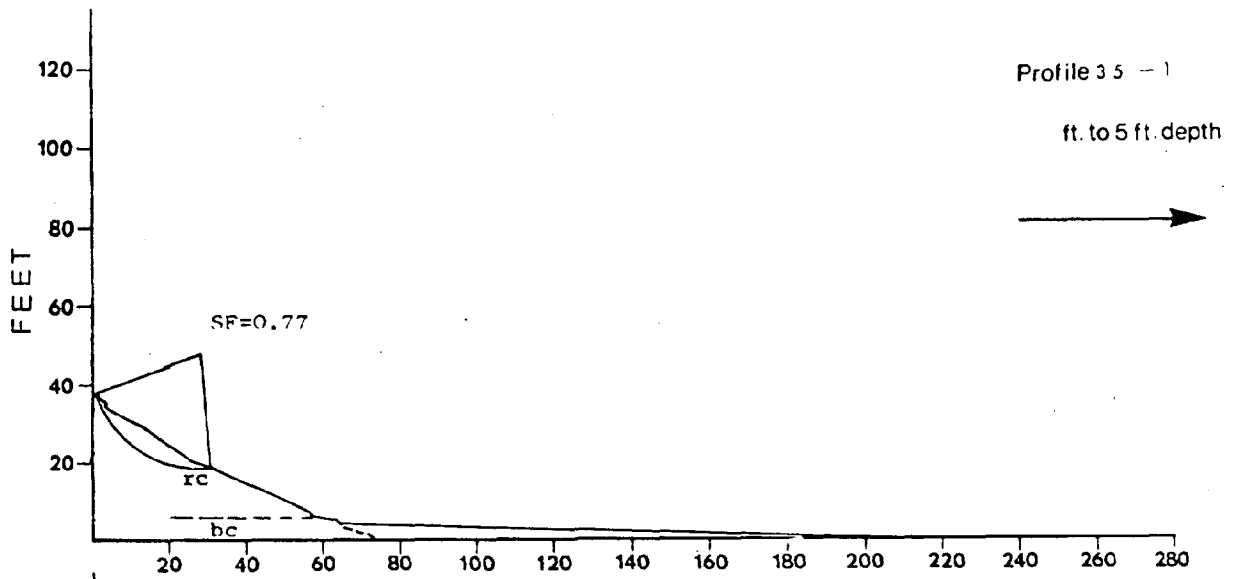
- a) absent
- b) 40 ft; broadly scalloped crest; shallow sliding with occasional moderately deep slides; 10-20% grass, horsetails, some small alders; slumped red clay

Toe:

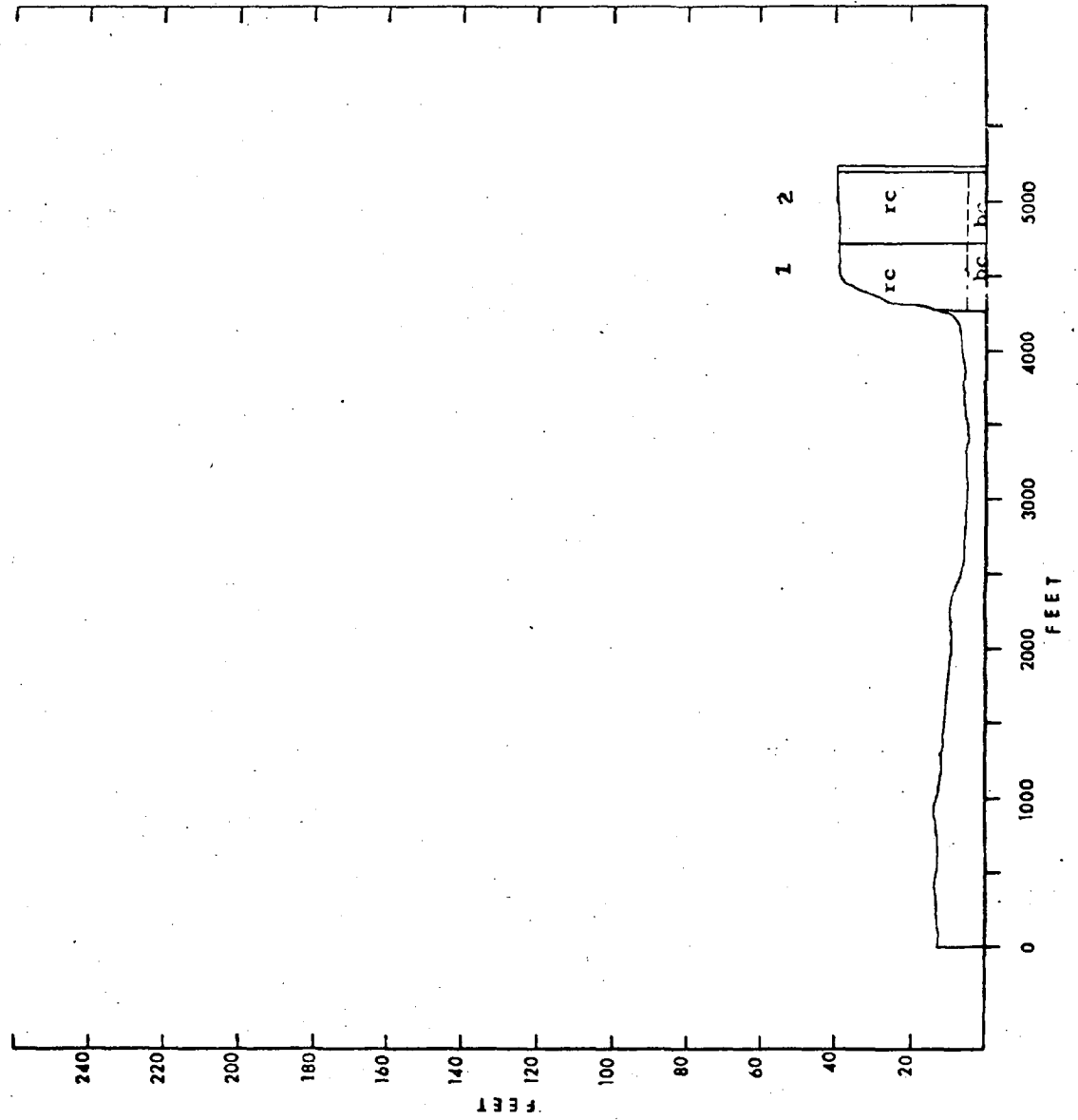
- a) absent
- b) slumped red clay, protected, partially vegetated with grass and horsetails

Beach:

- a) spit
- b) spit backed by lagoon
- c) 100-150 ft wide; coarse sand with scattered cobbles throughout width and with a concentration of pebbles and granules near the water's edge



T. 49 N., R. 13 W., Sec. 35



Section 36 T 49 N, R 13 W

The section is located a mile east of Wisconsin Point and is bisected by Dutchman Creek. The bluff is 50 ft. high, except at the streams, and extends throughout the section. At its western end, the bluff is failing by shallow sliding. It is poorly vegetated - grass and alder being restricted to slump blocks moving downslope - and is composed of red clay. The rest of the bluff shows only minor evidence of recent instability. It is well-vegetated with birch, alder, and grass that conceal the bluff materials. West of Dutchman Creek, the sandy beach is wide enough to protect the toe. Eastward, the beach thins considerably and the toe, composed of slumped red clay, shows marked instability. Where the beach is absent, a 10-12 ft. toe scarp is present; renewed bluff instability is expected in these areas. The beach west of Dutchman Creek is heavily used due to its proximity to Superior and ease of access.

SEC 36 T49N R13W

SAFETY FACTOR

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes

(high confidence)

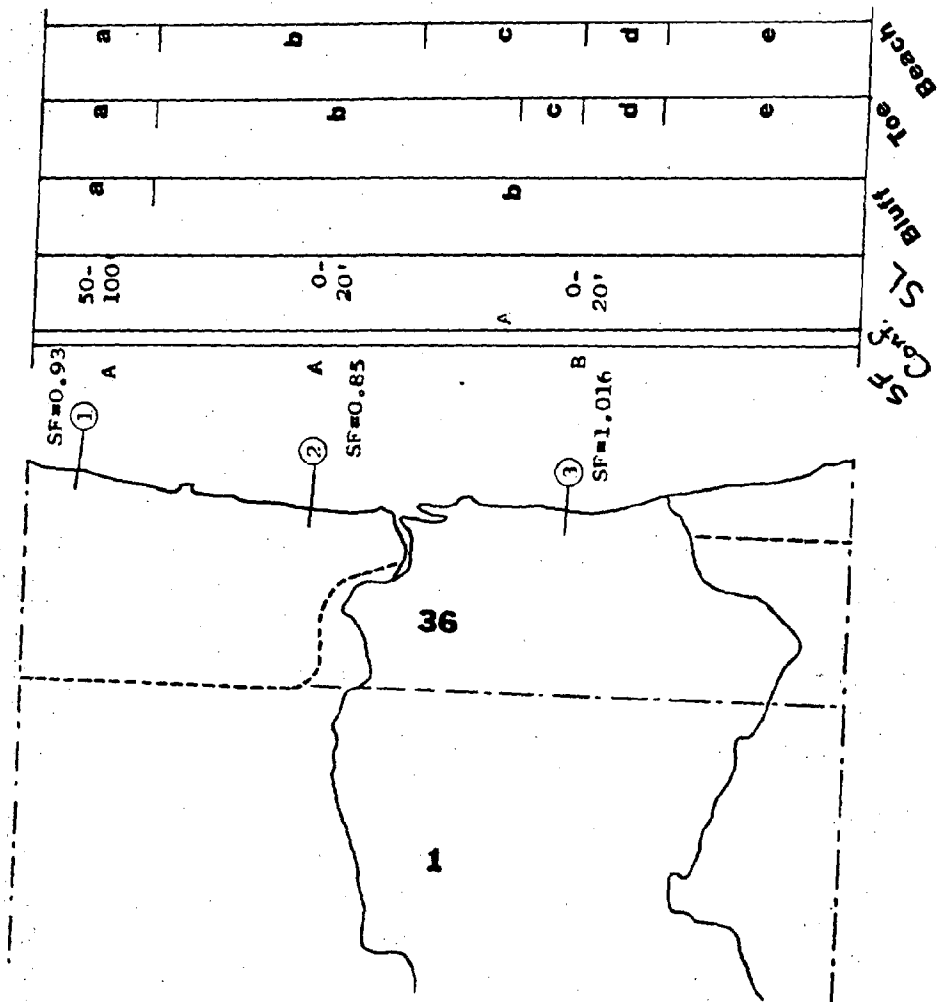
B-near boreholes

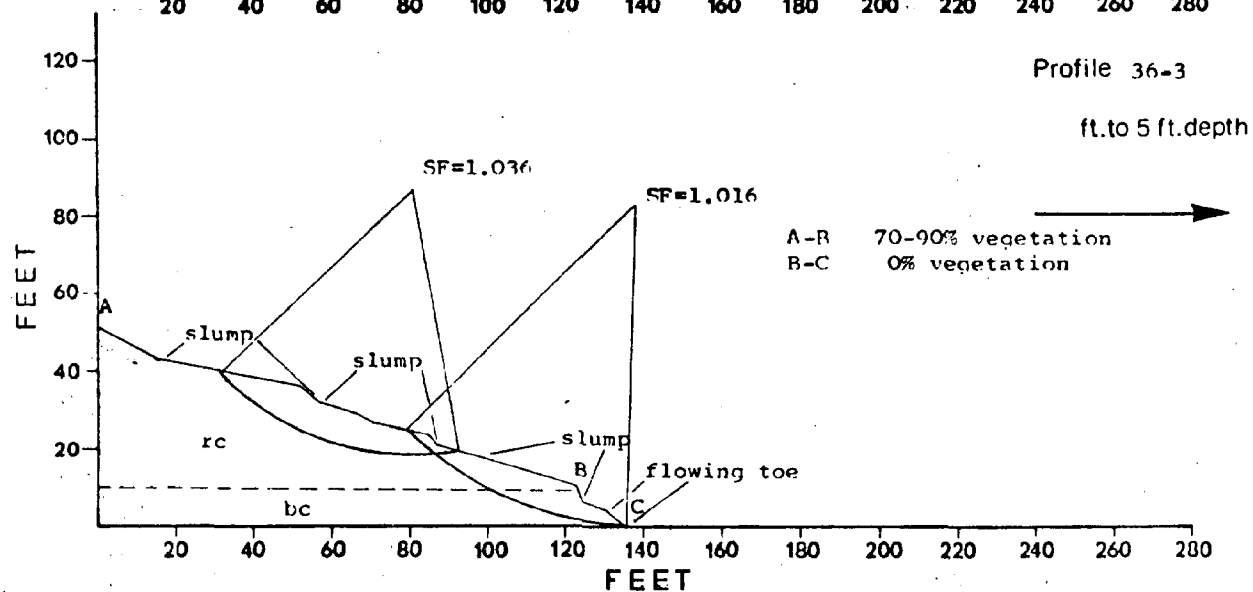
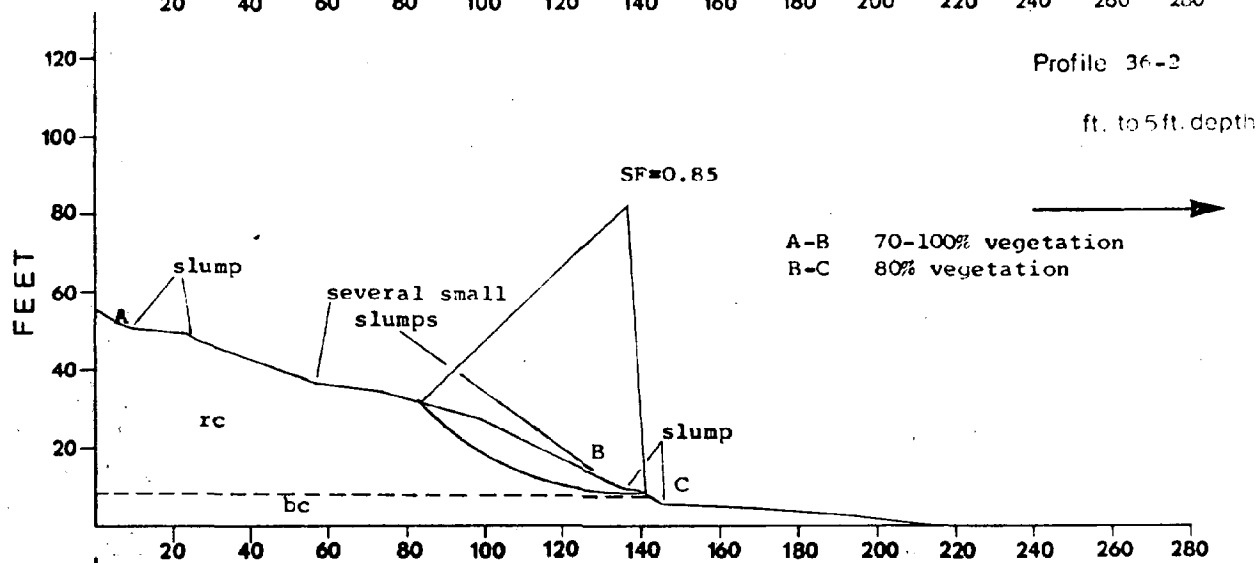
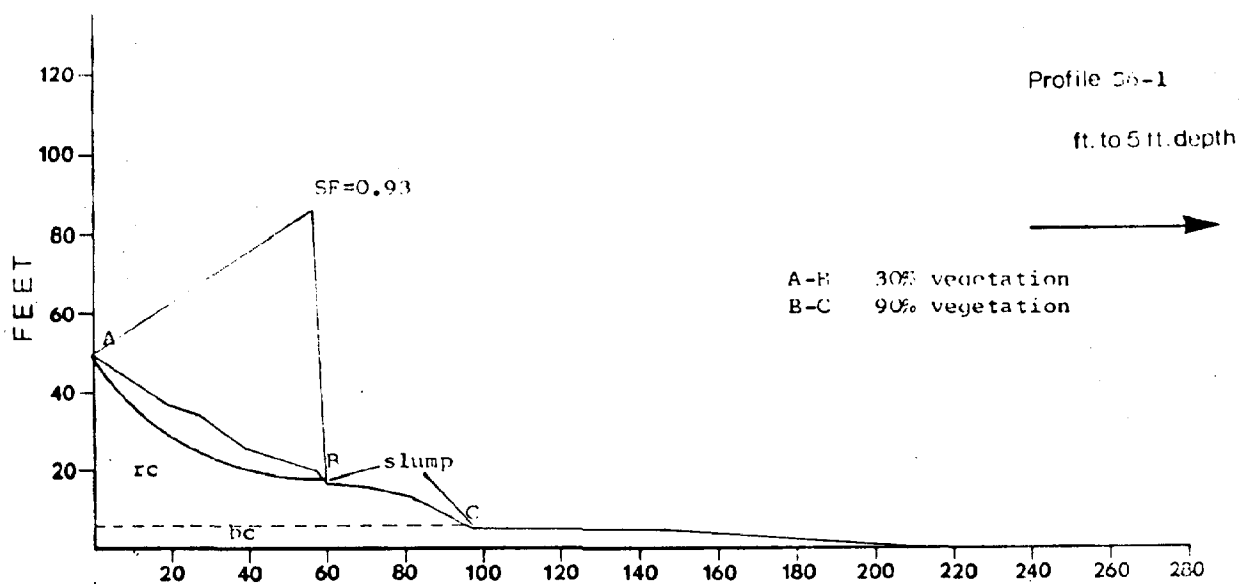
stratigraphy visible

C-no stratigraphy

visible (low

confidence)





Sec. 36, T 49 N, R 13 W

Bluff:

- a) 45-50 ft high; crest scalloped; numerous shallow slides; vegetation (30-60%) confined to clumps of alder and grass on slump blocks; clay
- b) 45-55 ft high dropping to 4-6 ft at streams; crest generally subdued; well-vegetated (90-100%) with birch, alder and grass; fairly stable of late, clay

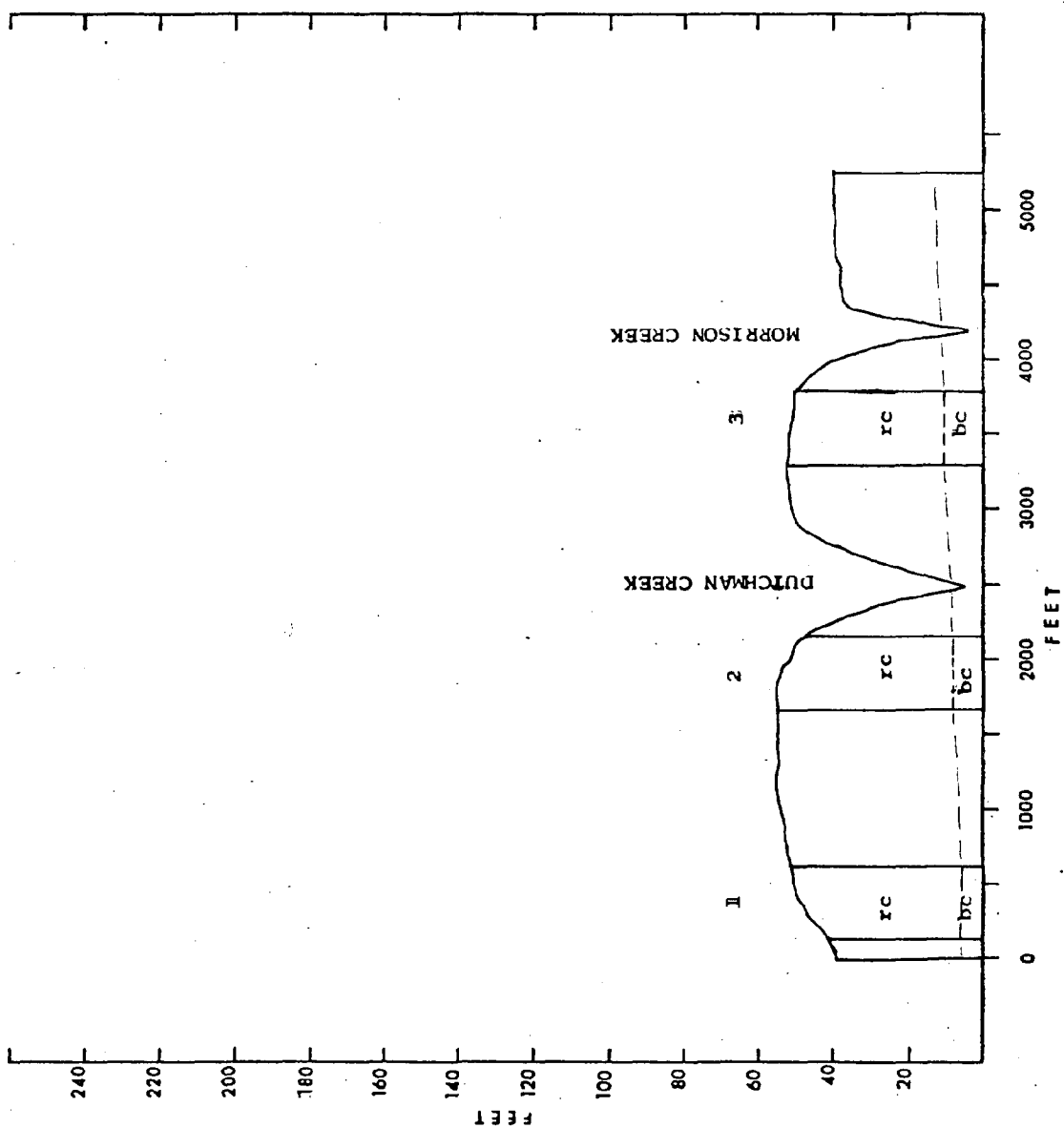
Toe:

- a) red clay; slumped; protected by beach
- b) clay, slumped, protected, vegetated with alder and grass or scarped at large slump blocks
- c) clays, slumped, partially protected, failing for 10 ft vertically by shallow sliding with 2-3 ft scarps at base unvegetated
- d) clays, slumped, unprotected from waves, failing by shallow sliding and mudflows with 8-12 ft scarps at base, unvegetated
- e) clays, slumped, partially protected, failing for 10 ft vertically by shallow sliding with 2-3 ft scarps at base unvegetated

Beach:

- a) very wide (145-150 ft) narrowing evenly eastward to wide (85-90 ft) coarse to medium sand with cobbles scattered over whole width and with a concentration of pebbles and cobbles 30 ft wide at water's edge
- b) wide (80-90 ft); uniform width; coarse to medium sand with few scattered cobbles over whole width and with a conclusion of pebbles and cobbles 15-20 ft wide at water's edge
- c) very wide (150-180 ft) narrowing steadily to absent, coarse to medium sand; concentration of pebbles and cobbles 15-20 ft wide at water's edge; approximately 20-30 ft of back beach near stream is vegetated for 250 ft eastward.
- d) mostly absent (0-5 ft) wholly within wash/swash zone sand with occasional cobbles or boulders
- e) narrow (20-30 ft) wider west of stream (40-50 ft); coarse-medium sand; minor concentration of pebbles and cobbles 5-6 ft near water's edge - concentration increases greatly eastward

T.49N., R. 13W., Sec. 36



Section 31, T 49 N, R 12 W

The section lies just outside the city limits of Superior, WI, 3 miles to the west of the mouth of the Amnicon River. Most of the bluff of this section is comprised of slumped red clay. A brown clay can be seen in the banks of a small creek to the eastern end of the section, but its extent and influence on the bluff is unknown. The bluff height rises steadily and evenly towards the east from 40 to 55 ft. except where it drops to meet the three small creeks that enter the Lake. Changes along the bluff face are most noticeable in the character of the vegetative cover. Where vegetation is up to 90%, birch and alder with occasional firs are predominant and slope failures appear subdued. These subsections alternate with areas where vegetation is less than 50% and small slumps and shallow slides characterize the bluff face. The vegetation that occurs here is in the form of clumps of sod, with or without trees, which are slowly sliding down slope. Along much of the bluff a 20 foot wide beach protects the toe of the bluff from continuous wave erosion except during intense storms. Where slumps and flows have extended across the beach, the waves are actively eroding at the toe. This section contains two private homesites, but most of the shoreline is undeveloped and used only occasionally.

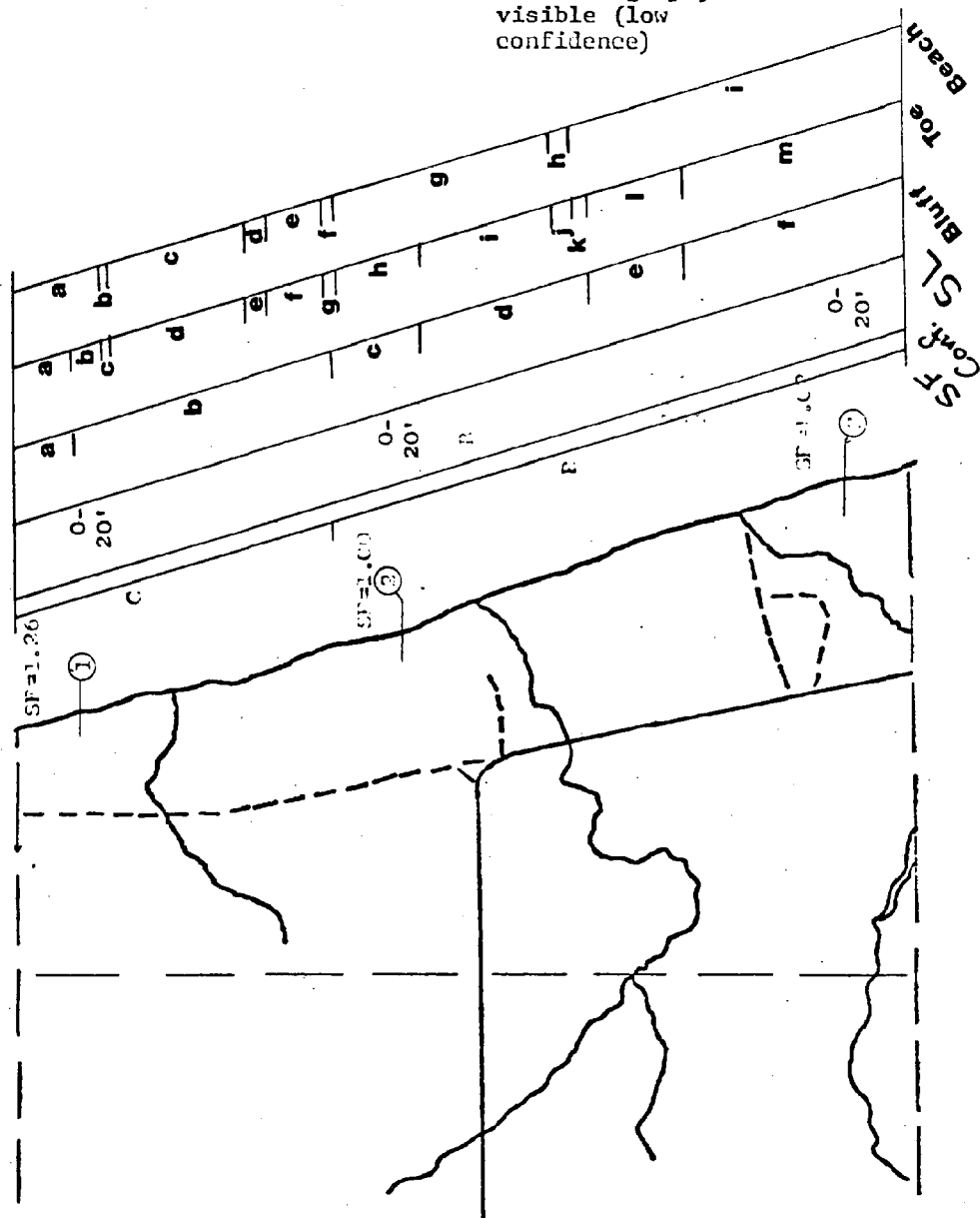
SEC31 T49N R12W

SAFETY FACTOR

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



Sec. 31, T 49 N, R 12 W

Bluff:

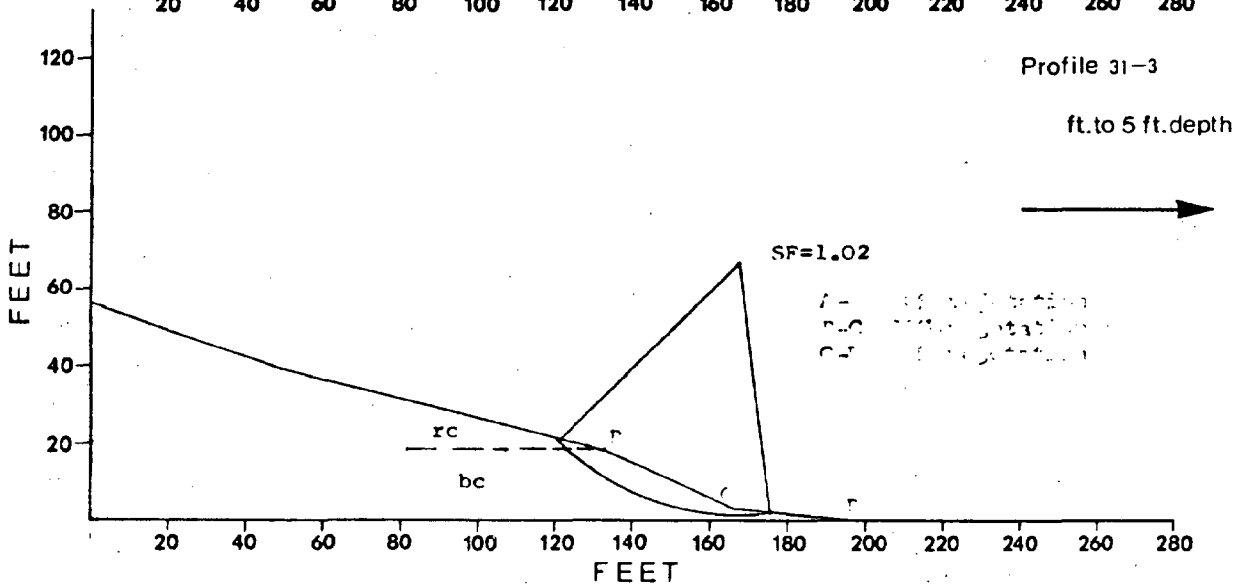
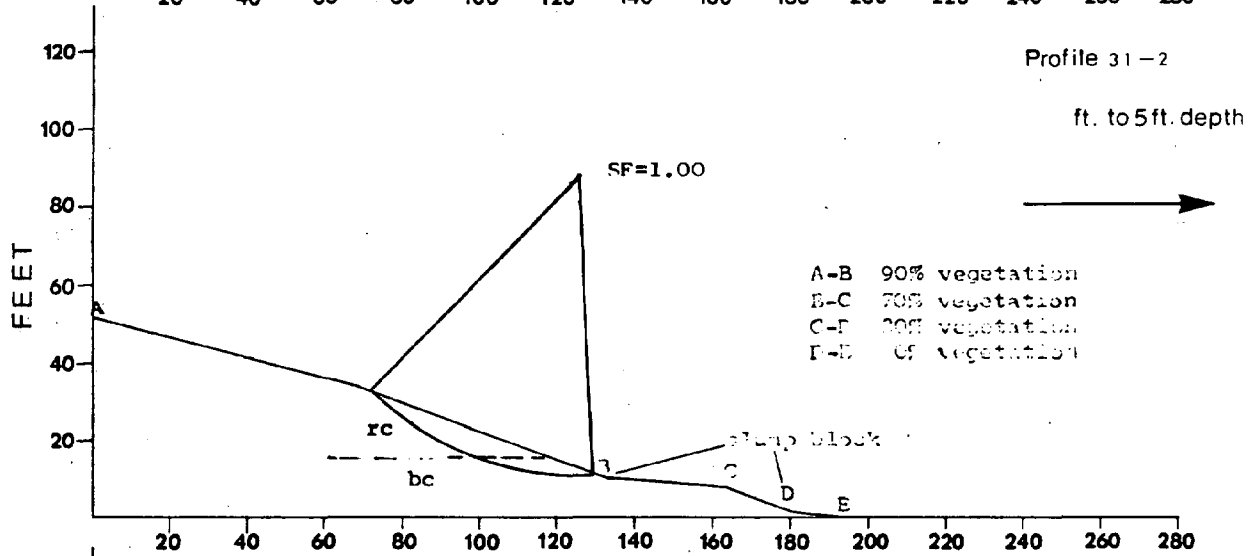
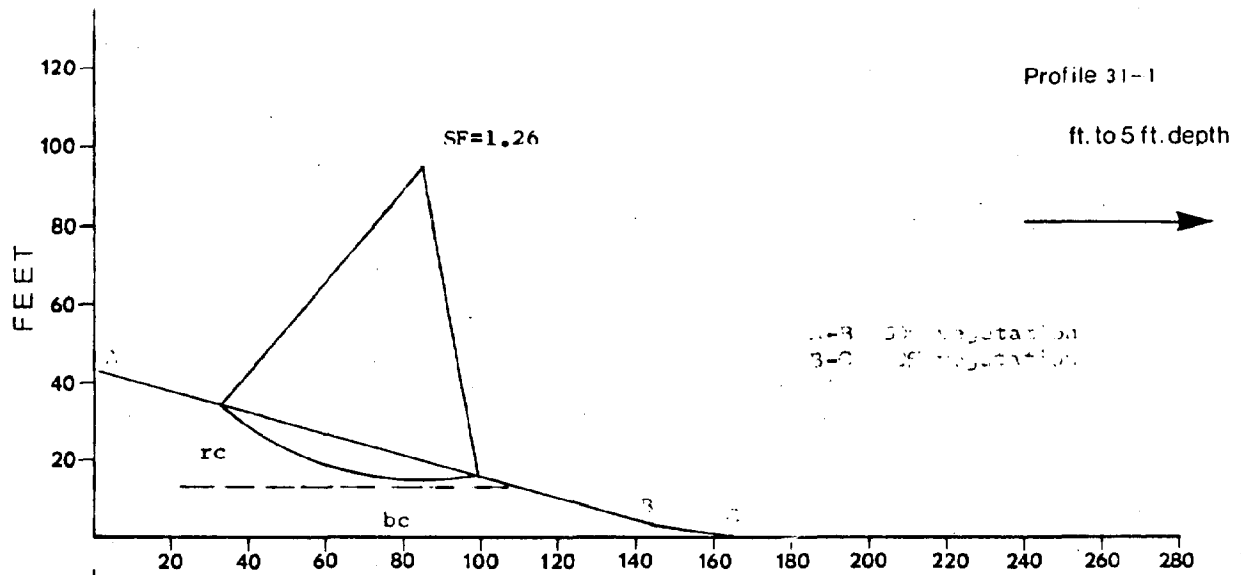
- a, c, and e) 50-90% vegetated with birch, alder, occasional fir, with horsetails in wet or locally failed places; predominantly red clay slumped; medium scale rotational slumps and shallow slides; bluff crest rises from 40 ft to 50 ft eastward; rounded but commonly showing a scarp and cut by 1-5 ft ravines.
- b, d, and f) 10-40% vegetated with alder; birch with grass in clumps moving downslope, horsetails in wet areas; red clay, slumped; bluff surface straight and failing; bluff height 40' rising to 55' to the east

Toe:

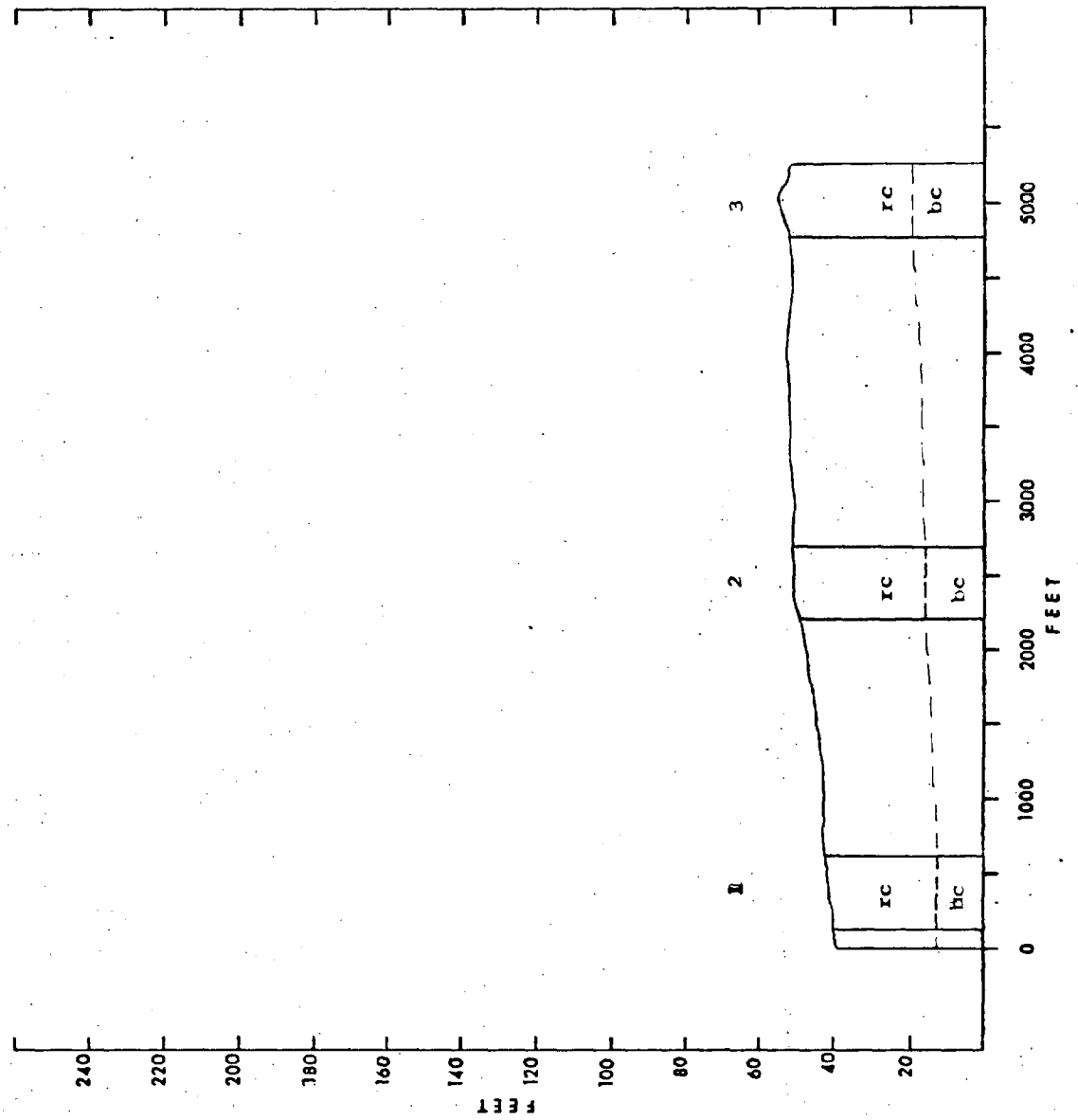
- a, h and l) Moderately well- to well-vegetated; slumped red clay. rounded or, in places, a small scarp, protected from wave attack except during large storms
- b, d, f, i, k, and m) Little or no vegetation; slumped red clay; rounded or producing mudflows; protected from wave attack except during large storms
- c, e, g, and j) Little or no vegetation: slumped red clay; mudflows and eroded clay surfaces; unprotected

Beach:

- a, c, e, g, and i) Medium sand, with pebble concentration 3' from shore with occasional boulders; 15-20' wide; driftwood accumulation at back of beach
- b, d, f, and h) Covered, beach absent



T.49N., R.12 W., Sec. 31



Section 32 T 49 N R 12 W

The section is located two and a half miles west of the mouth of the Amnicon River. The western half of the beach is discontinuous, generally 20 ft. wide and sandy; but it is occasionally covered by slumped red clay. The bluff behind this beach subsection is 50 ft. high and the crest is finely scalloped. Failure is by shallow sliding and the moderate vegetation (30-60%) is restricted to slump blocks moving downslope. The bluff materials are slumped clays, redder at the top of the bluff and browner at the toe. The toe is protected except where failure has pushed it out over the beach. The eastern half of the section has no beach; the toe, of slumped clay, is unprotected from wave action. The bluff here is 50 ft. high and the crest is more subdued and rounded. It is well-vegetated (80-90%) with alder, birch, grass and horsetails. Most of the slope appears fairly stable, but a fresh scarp at mid-slope was often noted. This renewed instability is no doubt due to the instability of the toe, which is failing by shallow sliding and flowing, producing a 10-12 ft. scarp in the slumped clay. At the eastern end, the bluff instability has extended back to the crest. The vegetative cover has nearly been destroyed (0-10%) and consists of clumps of alder and grass moving downslope on slump blocks. Here the bluff materials are clearly slumped clays. The shoreline of this section appears to be largely unused.

SEC32 T49N R12 W

SAFETY FACTOR

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVEL

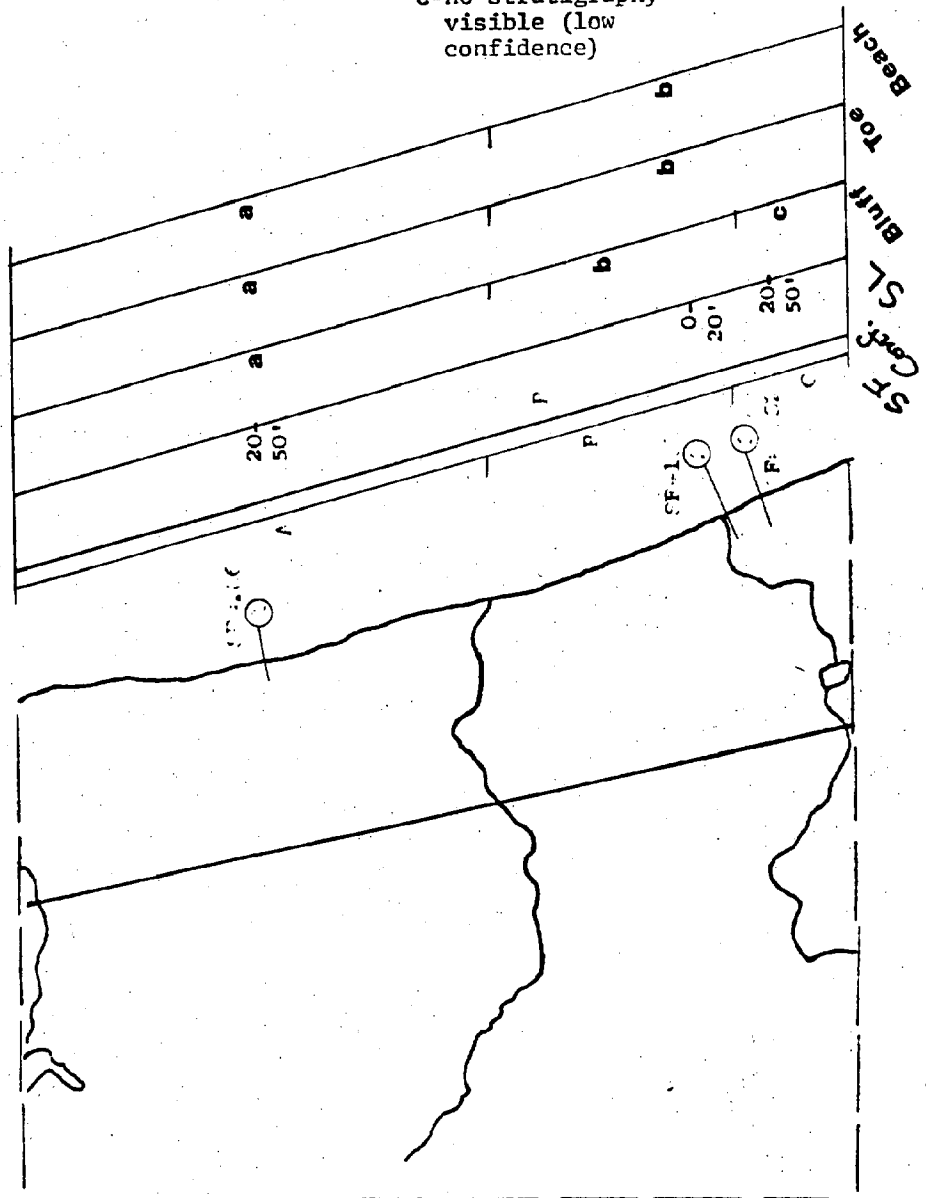
A-boreholes

(high confidence)

B-near boreholes

stratigraphy visible

C-no stratigraphy

visible (low
confidence)

Sec. 32, T 49 N, R 12 W

Bluff:

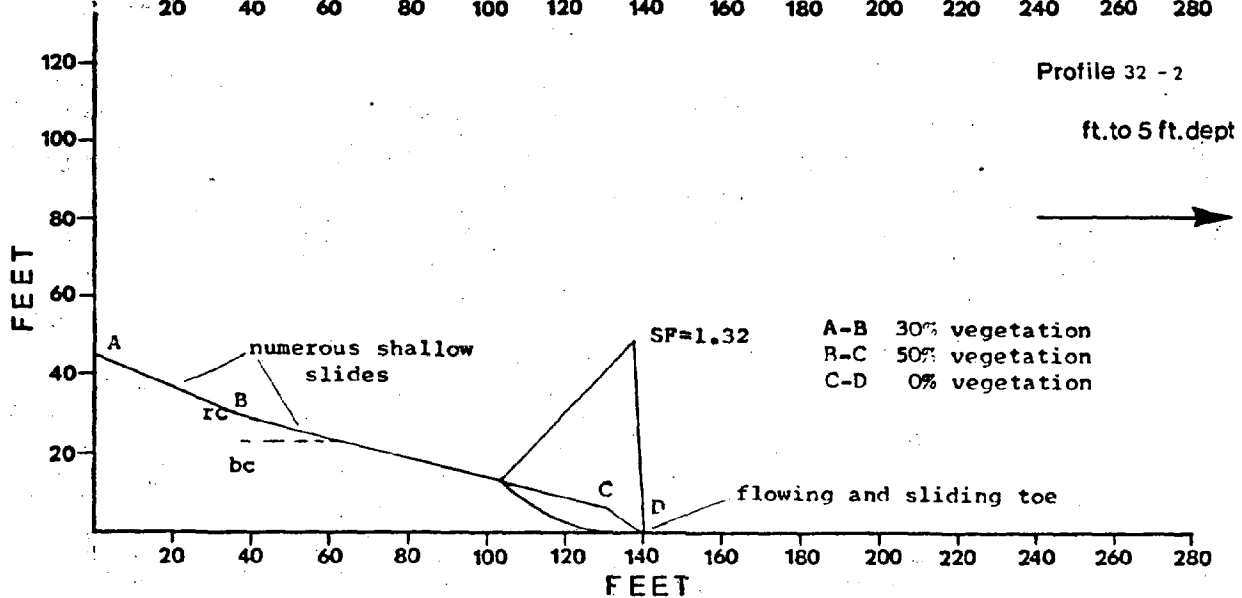
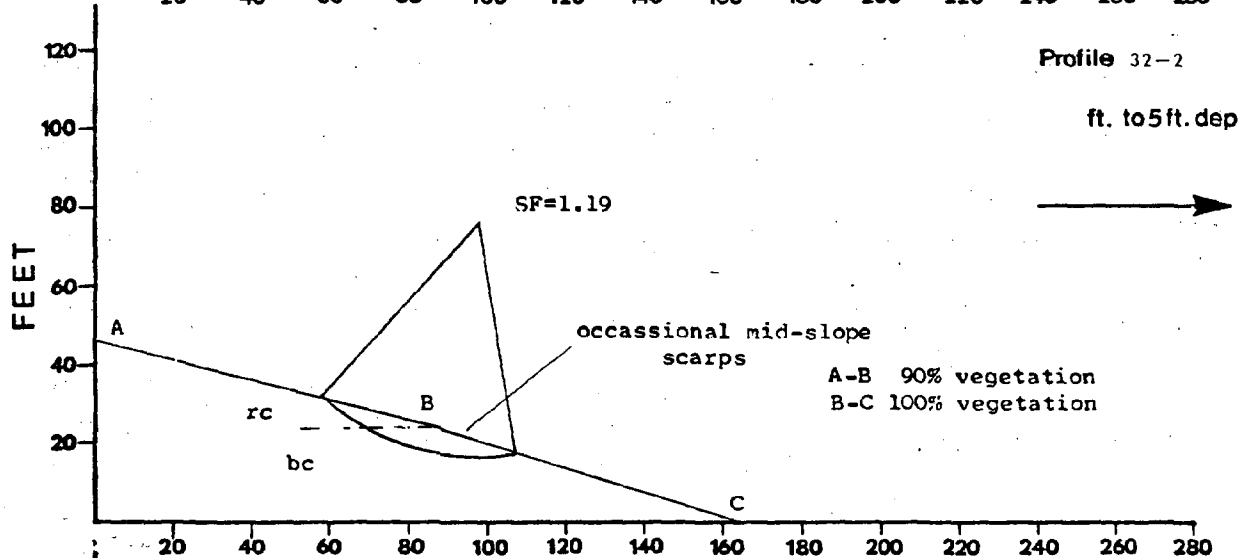
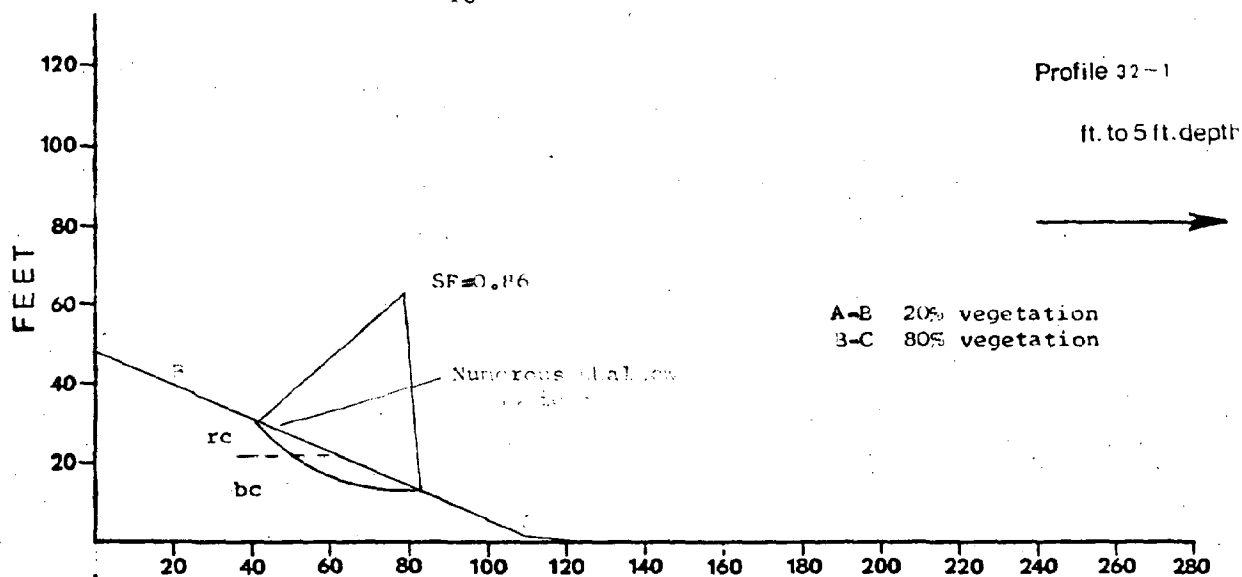
- a) 45-50 ft high; crest scalloped; shallow slides; vegetation (50-60%) restricted to clump on actively moving slump blocks; clay
- b) 45-50 ft high; crest subdued; well-vegetated (80-90%) with alder, birch, some conifer, grass, moss, and horsetails toward the toe; fairly stable of late but fresher a-mid-slope scarp was often noted, clay
- c) 45-50 ft high, crest newly scalloped; vegetation being destroyed (0-10%); shallow slides, clay

Toe:

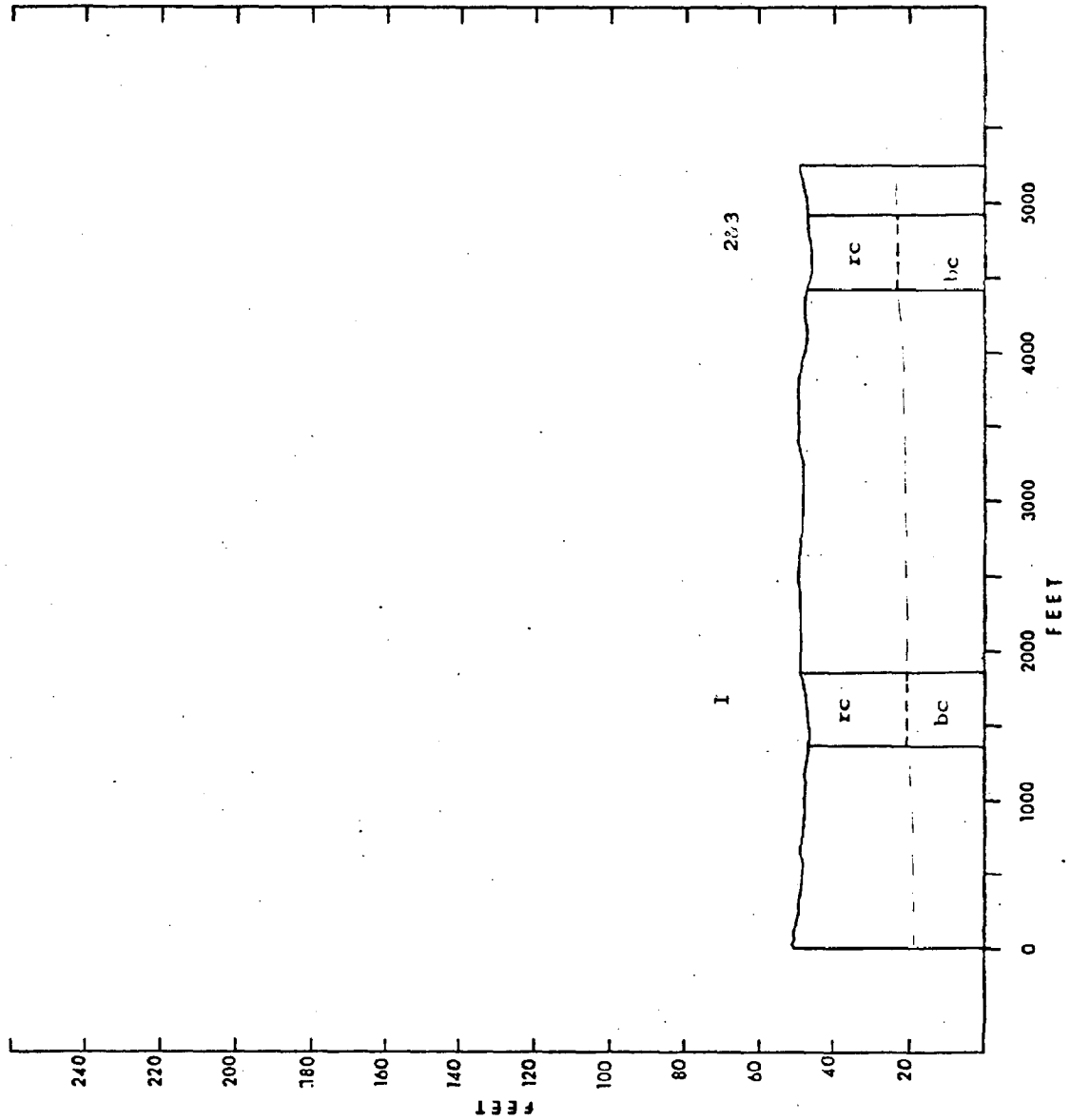
- a) mixed-colored clay (red-brown-gray); slumped; generally protected from wave action
- b) red and brown clay; slumped; under wave attack; failing for 12 ft vertically by shallow slides and mudflows

Beach:

- a) discontinuous (covered by slumped clay occasionally) 0-20 ft; coarse to medium sand with occasional large boulders and pebbles and cobbles at waterline; pebble and cobble concentration decreases to absent eastward
- b) mostly-absent 0-5 ft; wholly within wash-swash zone; sand with occasional large boulders



T. 49 N., R. 12 W., Sec. 32



Section 33 T 49 N, R 12 W

The section is located one and a half miles west of the mouth of the Amnicon River. The beach is present only rarely within this section. Where present it is at most 20 ft. wide and is composed of sand, often interfingered or perhaps underlain by clay like that in the toe. The bluff is 50 ft. high and only a very short subsection is well-vegetated and lacking fresh scarps. Failure is by shallow to moderately deep slides and by flows originating on the upper half of the bluff. In one subsection the bluff is actually vertical! Here, failure is by block fall. There appear to be two materials in the bluff - an upper red clay, which is less stable, and a lower browner clay, which seems to be stronger. A subtle break in slope can often be noted at the contact. The toe in this section is almost entirely unprotected from wave action. The toe material is the brownish clay, probably in situ. The shoreline of this section is rarely used.

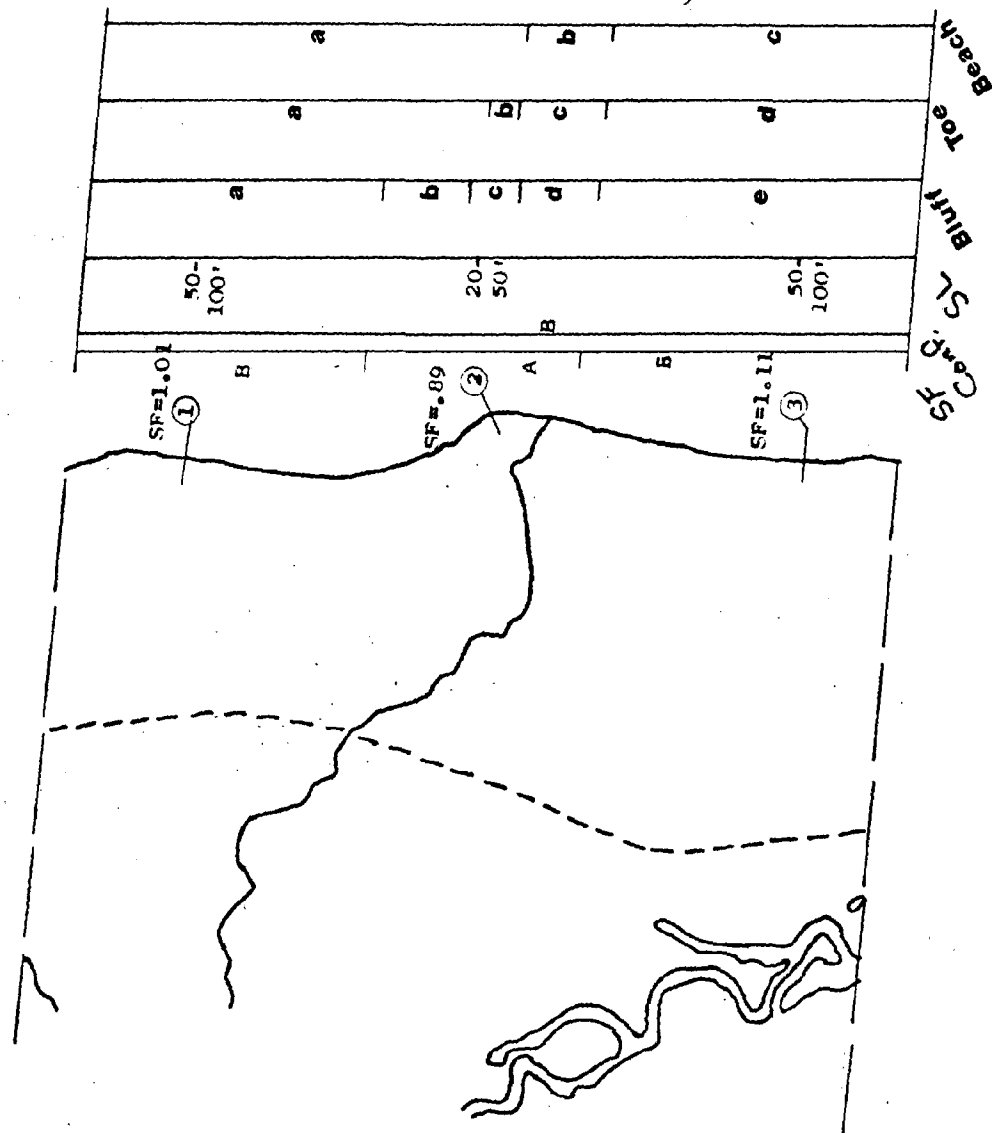
SEC33 T49N R12W

SAFETY FACTOR

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVELA-boreholes
high confidence)B-near boreholes
stratigraphy visibleC-no stratigraphy
visible (low
confidence)

Sec. 33, T 49 N, R 12 W

Bluff:

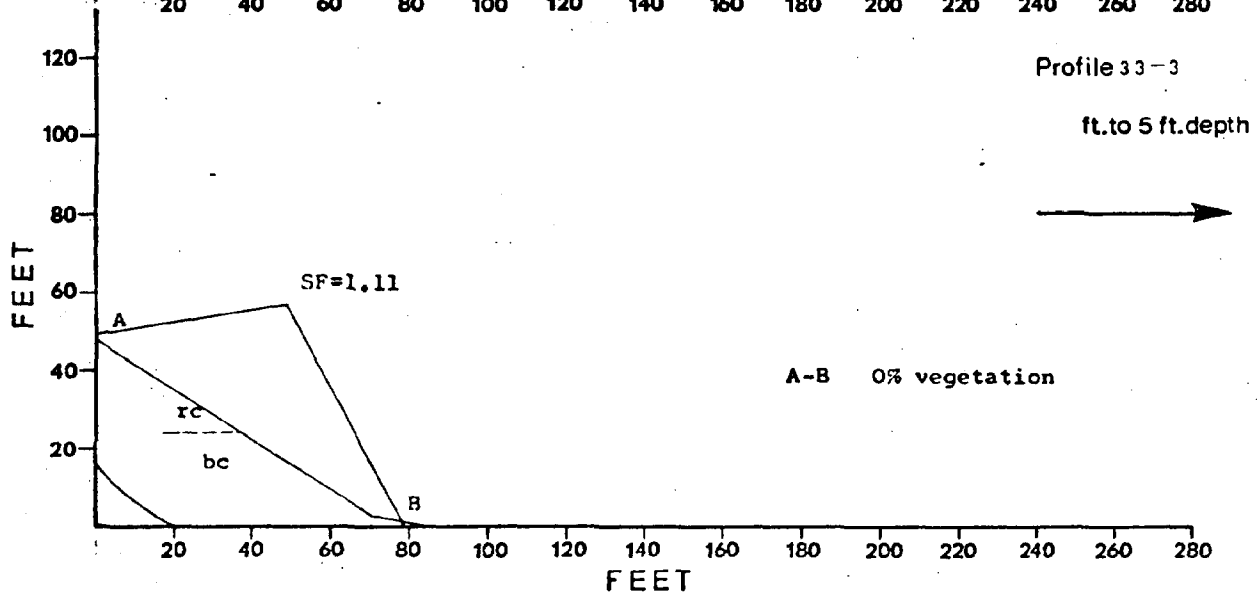
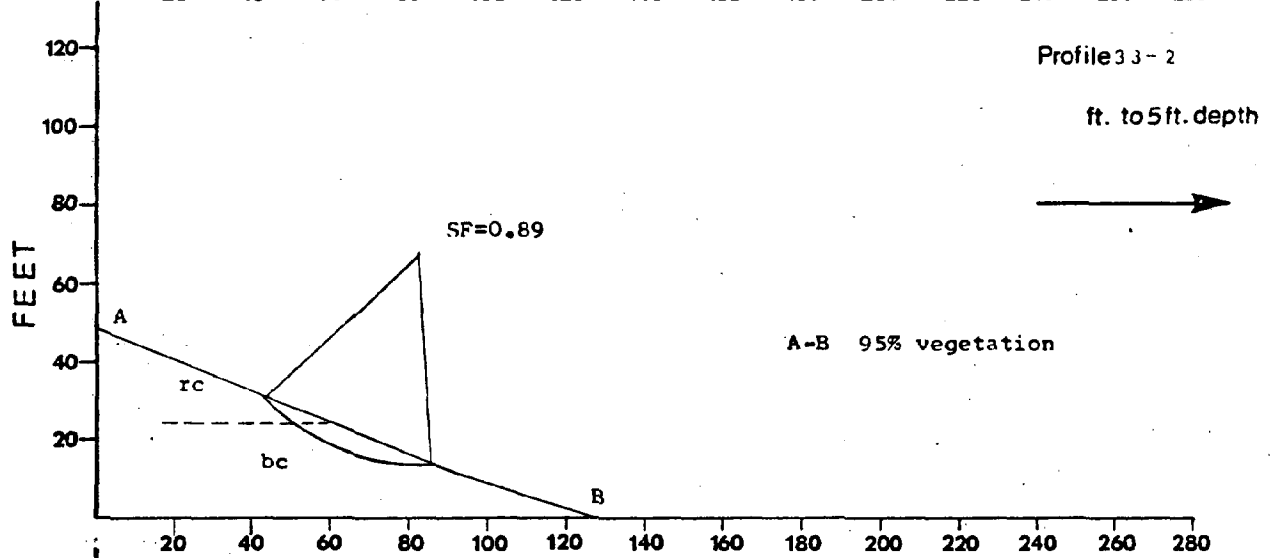
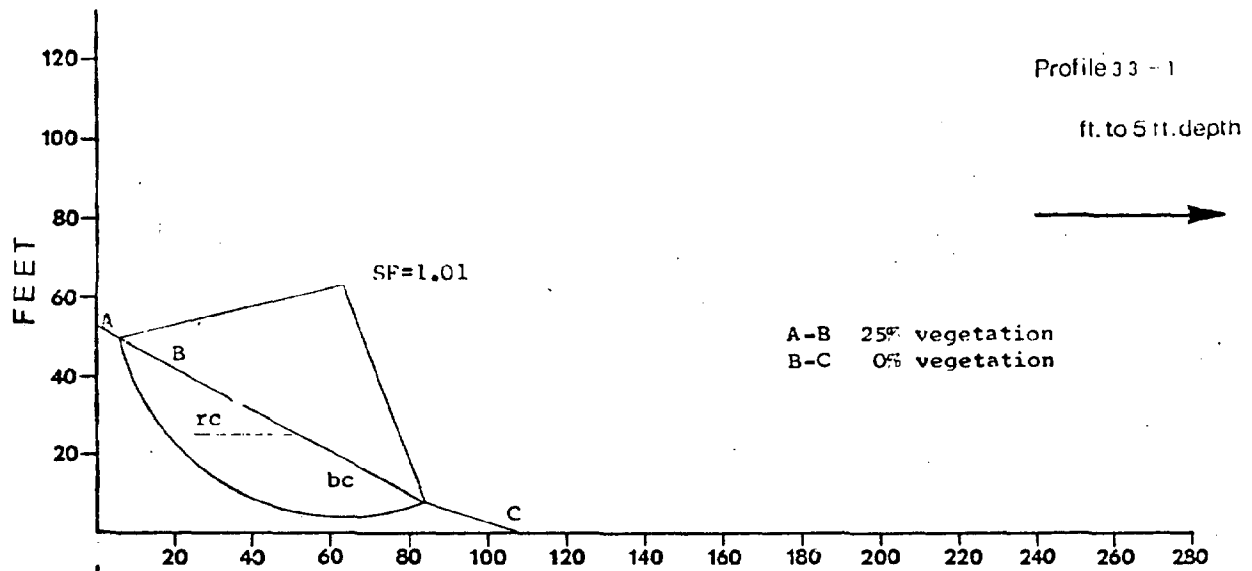
- a) 50 ft high; scalloped crest; shallow slides and flows; vegetation on slump blocks only 0-20%, red clay over brown clay with red clay slumping over stronger brown clay
- b) 50 ft high; scalloped crest; shallow slides; vegetation 80-90% on upper slope transitional between subsections a and c; probably same materials as subsection a.
- c) 50 ft high; subdued crest; only a very few shallow slides; vegetation 90-100%; materials the same as subsection a
- d) 50 ft high; linear crest with very steep scarp; block-fall and very deep rotational slumping; no vegetation, two-fold stratigraphy, red clay over brown clay
- e) 50 ft high; scalloped crest; shallow slides and flows; vegetation on slump blocks only 0-20%, red clay over brown clay with red clay slumping over stronger brown clay

Toe:

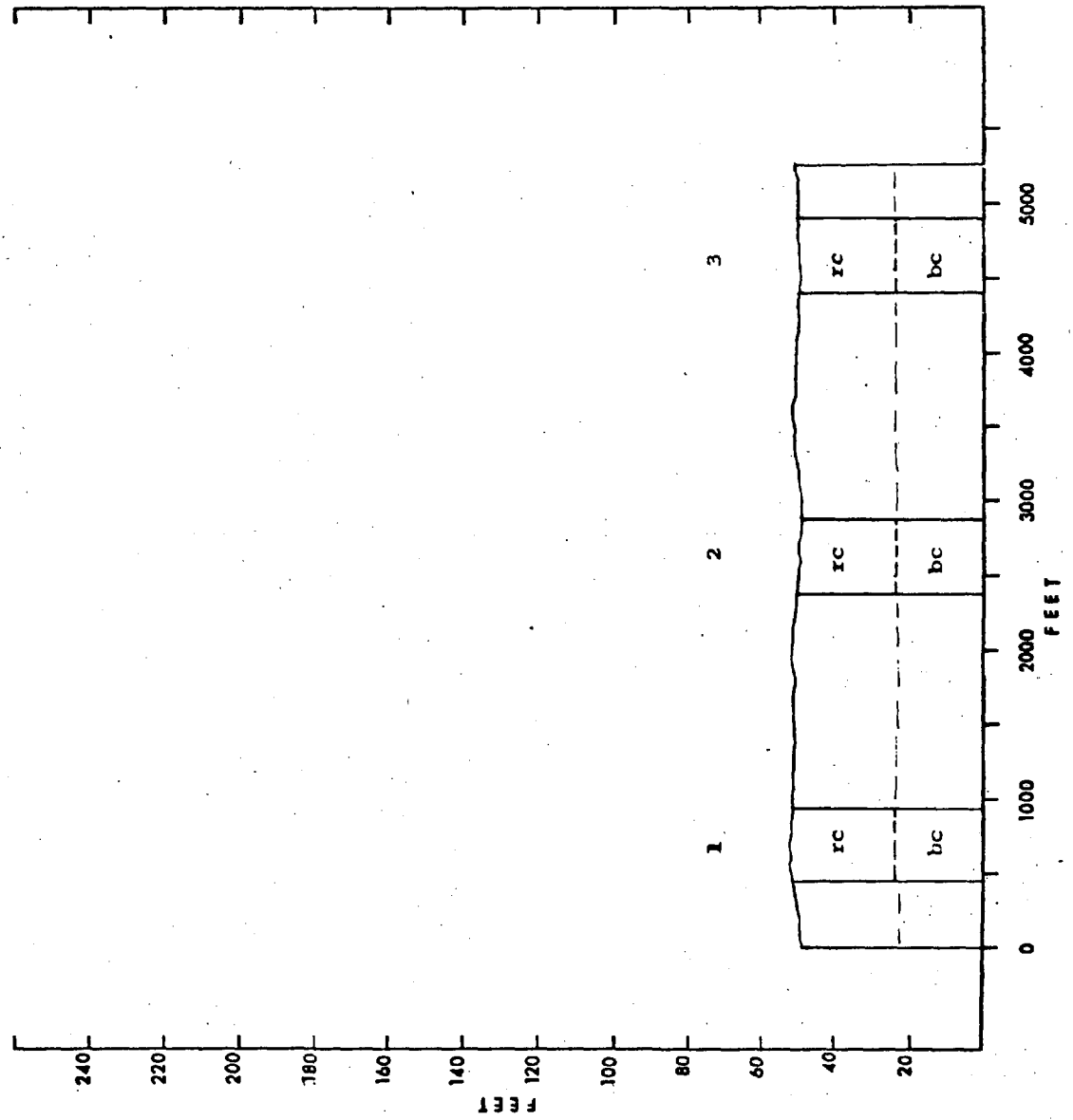
- a) slumped or in situ clay (brownier in color); mostly unprotected; scarp 2-18 ft high.
- b) protected slumped clay covered by vegetation
- c) unprotected slumped clay ("talus pile" from Bluff (d))
- d) slumped or in situ clay (brownier in color); mostly unprotected; scarp 2-18 ft high

Beach:

- a) discontinuous; mostly absent; if present up to 20 ft wide coarse sand with pebbles, cobbles and occasional boulders
- b) absent
- c) discontinuous, mostly absent; if present up to 20 ft wide coarse sand with pebbles, cobbles and occasional boulders



T.49 N., R. 12 W., Sec. 33



Section 34/27 T 49 N, R 12 W

This section is bisected by the mouth of the Amnicon River. There is very little beach west of the Amnicon; but beginning with the 100 ft. wide spit built westward across the river, a good sandy beach is present eastward for approximately half a mile. The bluff west of the river is fairly uniform, being 33-60 ft. high. It is poorly vegetated, and is actively failing by shallow sliding with some flowing from the upper part. The materials are a red clay, which seems weaker and prone to flowing, over a browner clay, which seems stronger. This difference in strength is frequently revealed by a marked break in slope at the contact, as well as the generally convex-upward profiles. This difference in strength is also shown in the nature of the bluff east of the river. East of a small creek, the bluff is only 15-25 ft. high and is composed wholly of the brown clay; it holds a 50° slope and the crest is near the shore. As the bluff rises above 25 ft., the slope angle decreases to about 30° and the crest recedes greatly from the shore. The mode of failure changes from blockfall to shallow sliding and flowing. The toe is composed mostly in situ brown clay with some slumped red clay. It is unprotected west of the Amnicon and generally protected east of it. The western portion is used by hunters and perhaps by the Camp Amnicon programs, while good access and a public landing insure frequent use on the east side.

SEC 34/27 T49N R12W

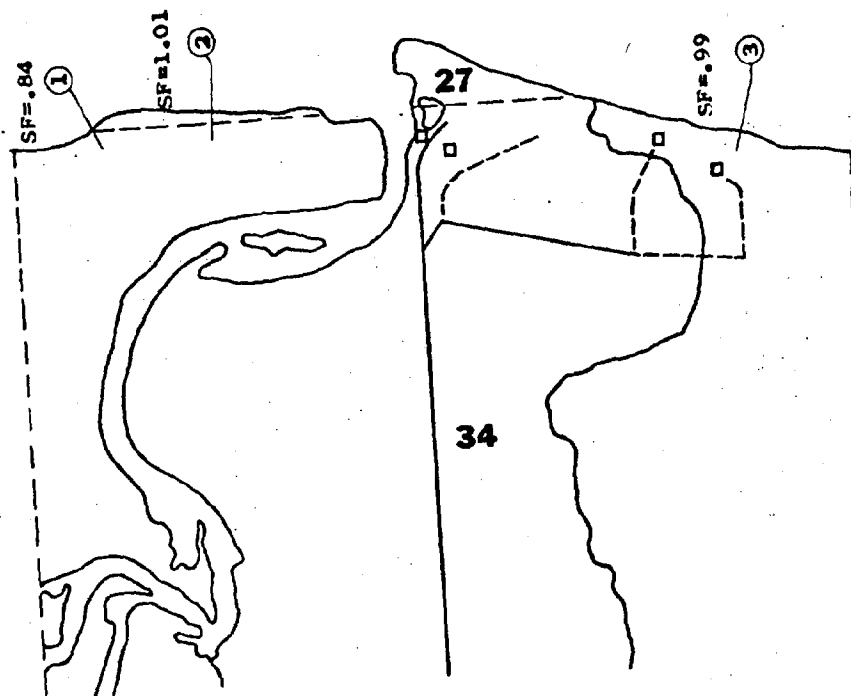
SAFETY FACTOR

- A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
 high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)

SF Conf. SL Bluff Toe Beach									
a	b	c	d	e	f	g	h	i	j
a	b	c	d	e	f	g	h	i	j
a	b	c	d	e	f	g	h	i	j
20-50'									
		50-100'							
				B					
A		B							



Sec. 27/34, T 49 N, R 12 W

Bluff:

- a) 55 ft crest scarped, shallow and moderately deep sliding, some flow from upper part; slumped clay (red over brown); vegetated 0-20% alder and grass
- b) 55 ft crest rounded, shallow slides; slumped clay; vegetation 70-80% alder, birch, grass horsetails
- c) 55-60 ft dropping at the very eastern end toward 15-20 ft; crest scarped, shallow slides and flows; vegetated 0-10% tree-clumps; break-in-slope evident at red clay-to-brown clay contact
- d) 15-20 ft falling to 0 ft eastward, minor shallow sliding; 70-90% vegetation, birch alder, grass.
- e) absent - Amnicon River
- f) rising to 60 ft and dropping back to 0 ft; scarped, shallow slides; - vegetation 60-70% alder-brick-grass
- g) absent-stream
- h) rising quickly to 12 ft then gently to 25 ft; blockfall (50° slope) 0% vegetation; brown clay
- i) 50-55 ft, rising from 25 ft; shallow slide, some flow; vegetation 20-30% clumps, alder, grass; two clay units

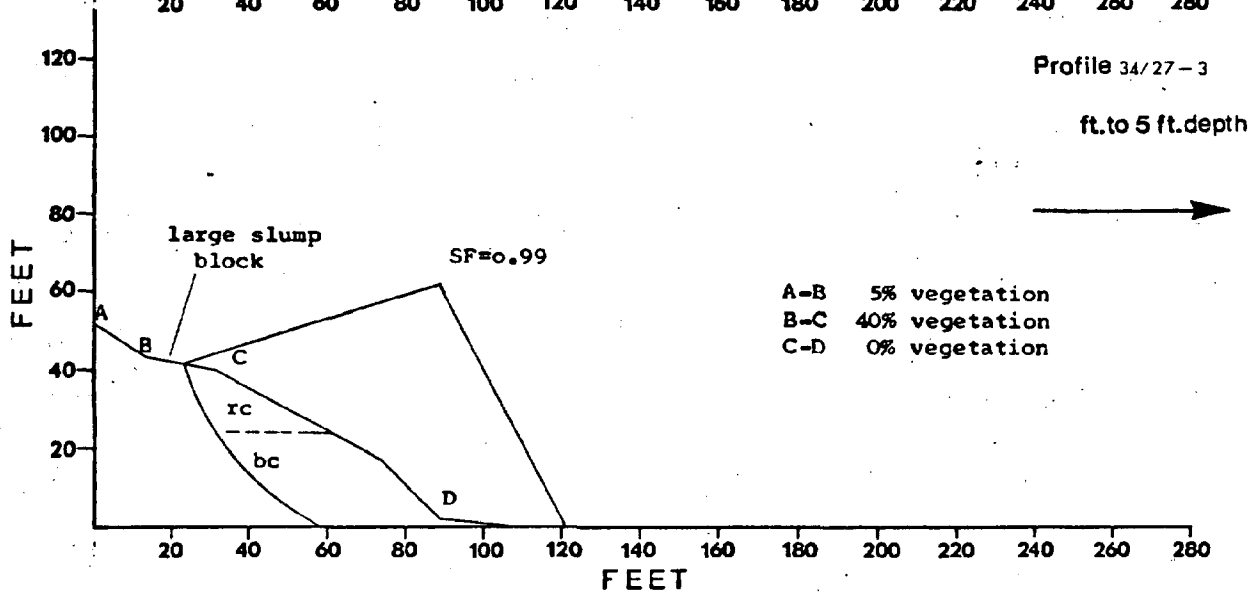
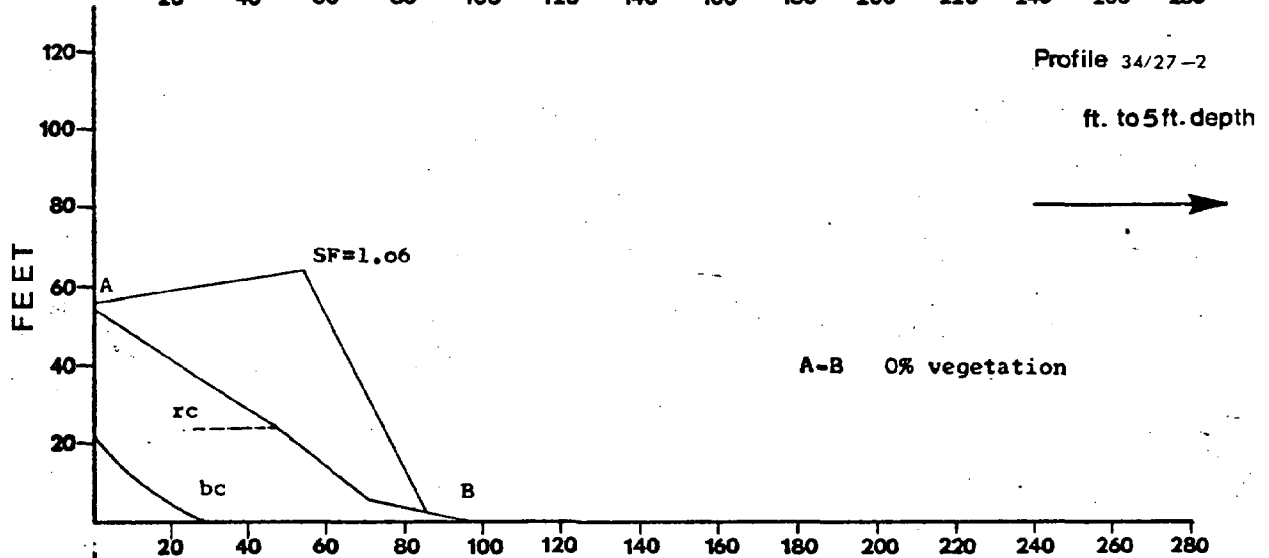
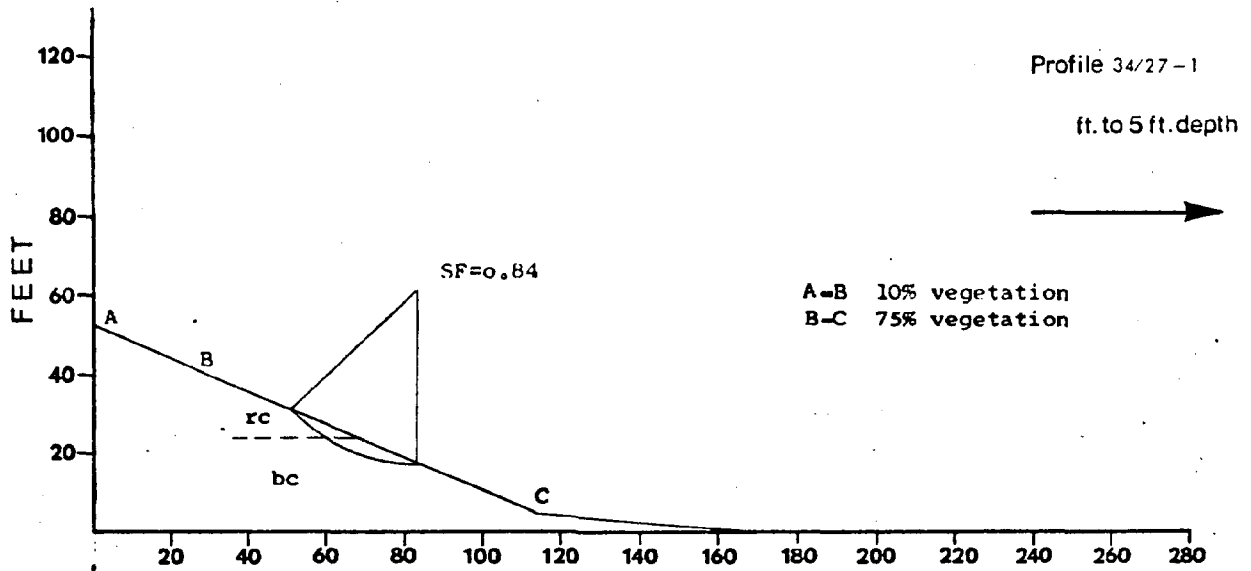
Toe:

- a) unprotected in situ (brown) clay with some slumped (red) clay
- b) protected and vegetated slumped clay
- c) unprotected in situ clay
- d) protected vegetated (0-20%) slumped clay
- e) absent - Amnicon River
- f) moderately protected slumped or in situ clay
- g) absent-stream
- h) protected in situ clay
- i) partially protected in situ clay

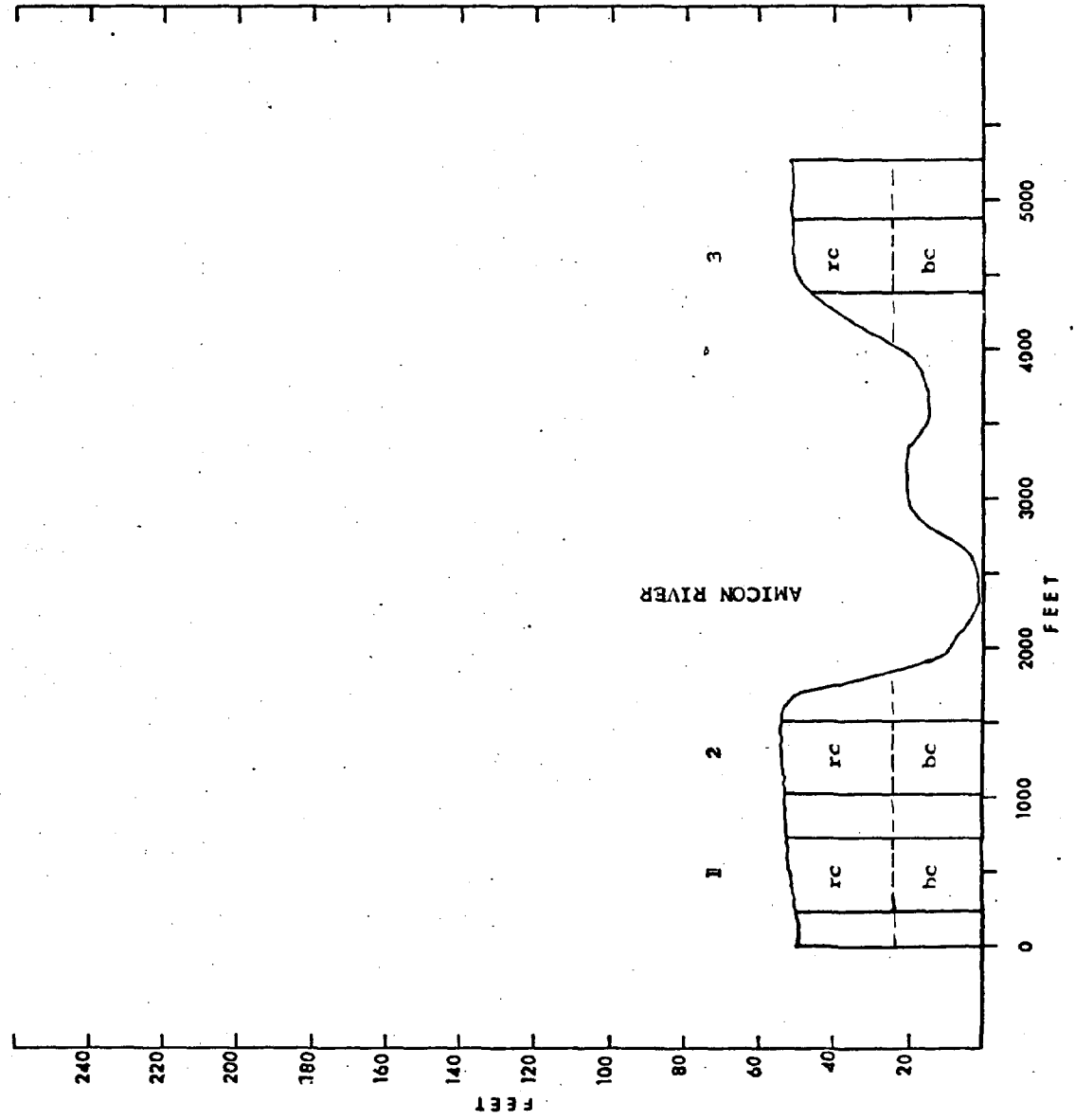
cont.

Beach:

- a) absent- toe water
- b) maximum of 80 ft; 0 ft at both ends; coarse sand with cobbles scattered-pebbles concentrated near water
- c) absent
- d) 0-5 ft widening eastward to 50-60 ft at river coarse sand with pebbles and granules concluded near water
- e) spit and beach 80-100 ft wide; coarse sand with some boulders and cobbles at water
- f) 20-30 ft; coarse sand with scattered cobbles; occasional concentration of pebbles and granules at water
- g) 0-10 ft discontinuous; coarse sand, boulders frequent



T. 49 N., R. 12 W., Sec. 34/27



Section 35 T 49 N, R 12 W

This section is located between the valleys of Hanson Creek and Middle River inclusive, a half a mile east of the Amnicon River. A good sandy beach, usually about 60 ft. wide, is present throughout most of the section. The bluff is quite discontinuous because of the streams which intersect the shoreline with wide valleys. Where well-expressed, the bluff is 55 ft. high, moderately vegetated, and failing by shallow sliding with some flowing from the upper part. The bluff materials are a brown clay overlain by a red clay but the brown clay is rarely exposed. Near the streams, the bluff height rises and falls quickly, to and from approximately 30 ft.. It is very well vegetated with little evidence of instability. A well graded slope is present at the west side of the Middle River. The toe is protected by the wide beach and is composed of slumped red clay, with infrequent exposures of in situ brown clay. There is public access at the west side of the Middle River, but no landing is present. Use is probably moderate to infrequent.

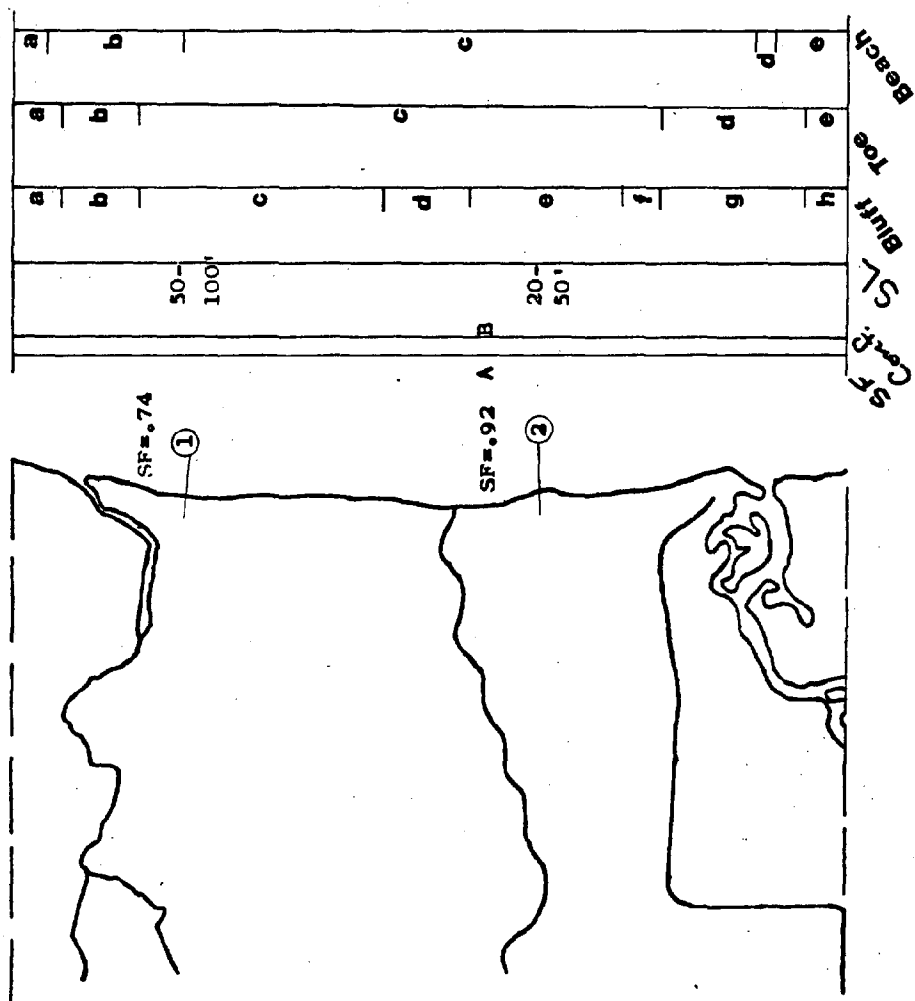
SEC35 T49N R12W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 35, T 49 N, R 12 W

Bluff:

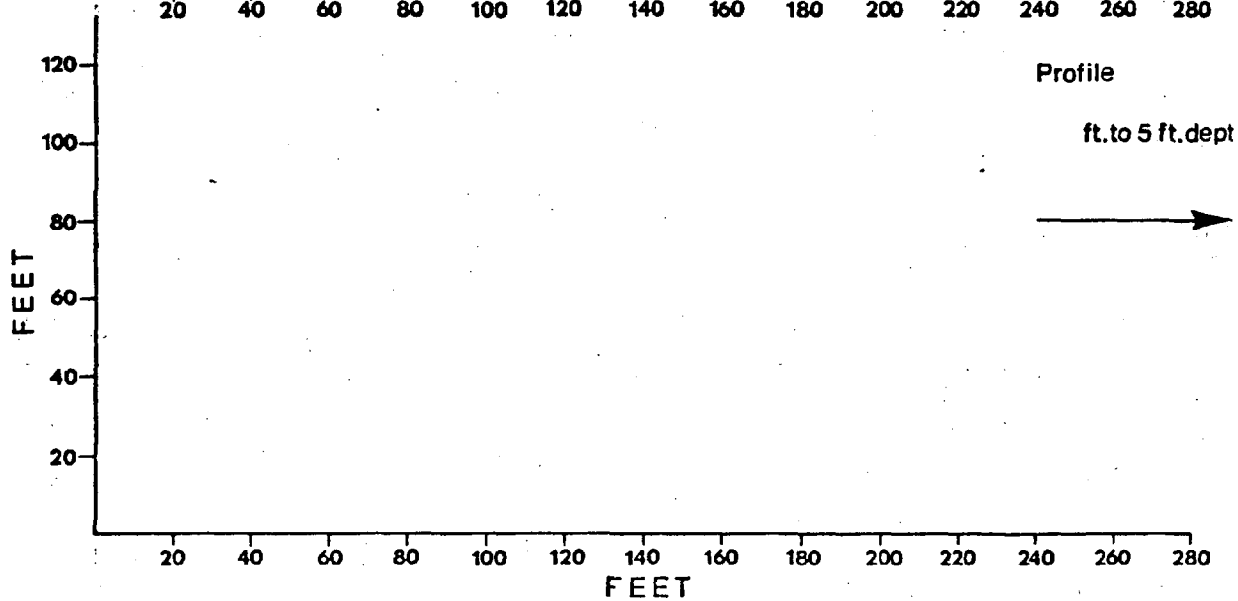
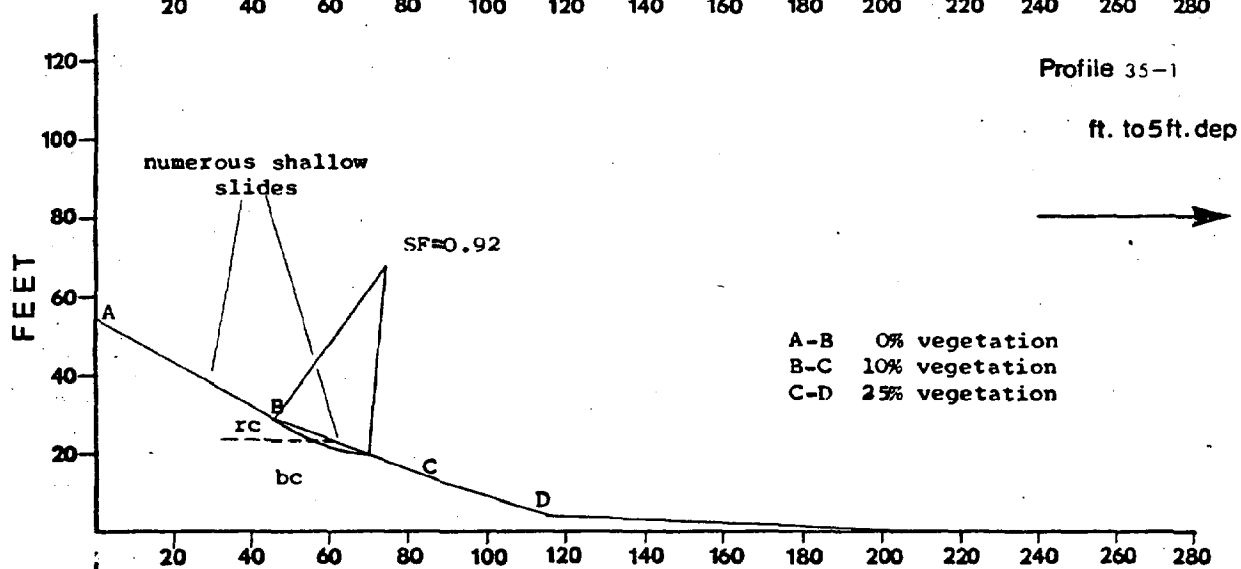
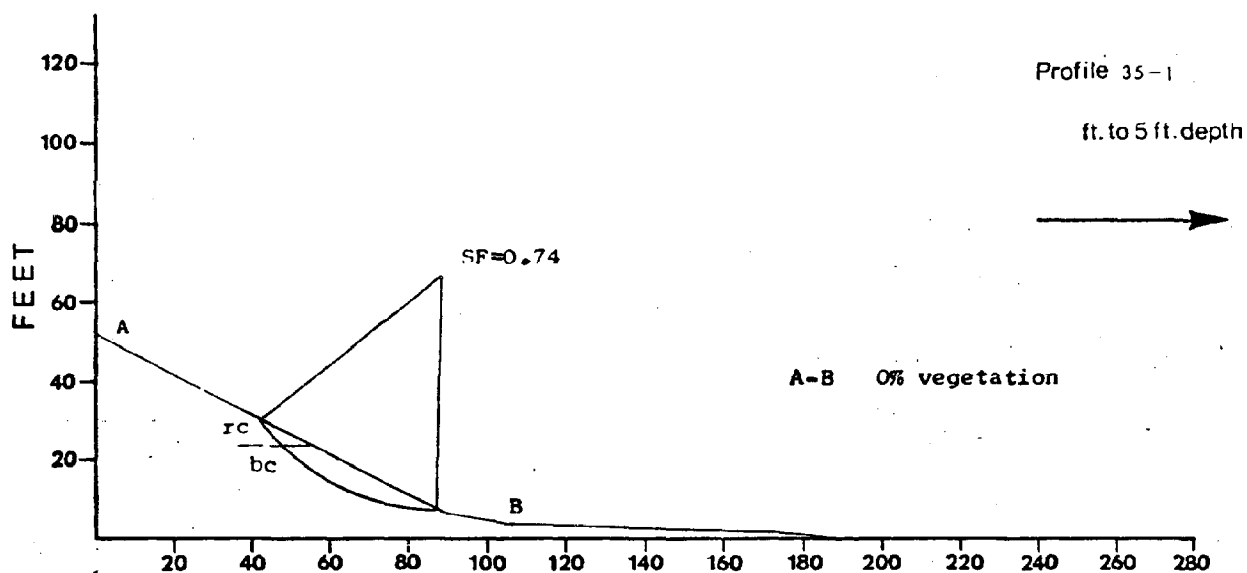
- a) 50 ft dropping to 0 ft; shallow slide and block fall; 0% vegetation, red and brown clay
- b) absent
- c) rising to 50 ft; eastward shallow slides; flows from top 0-5 to 40-50% alder and grass; two clay units
- d) 30 ft falling to 0 ft; no failure seen; vegetation 95-100%, birch, alder, grass, horsetails
- e) 50-55 ft; shallow sliding and flows from top; vegetation usually 0-20% alder grass slumped clay
- f) 30 ft falling to 0 ft; no failure seen; vegetation 95-100%, birch, alder, grass, horsetails
- g) absent gentle graded slope - well vegetated
- h) 0 ft rising to 30 ft; shallow slides and some block fall; 10-20% tree-clumps and horsetails, slumped clay

Toe:

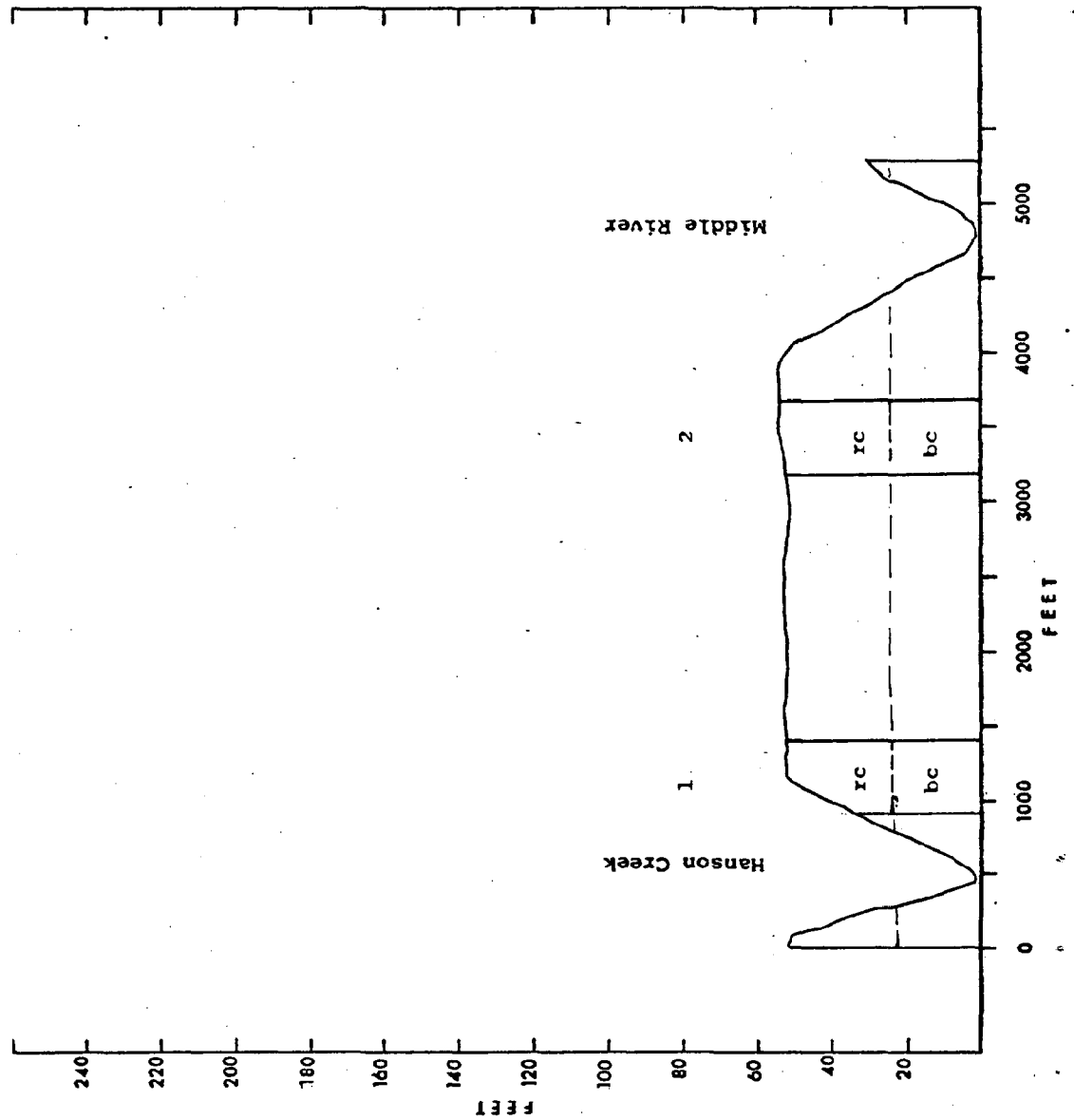
- a) unprotected, in situ brown clay
- b) absent
- c) protected slumped clay, vegetated
- d) absent; gentle graded slope - well vegetated
- e) protected slumped clay

Beach:

- a) mostly absent; interfingering with clay flows
- b) 40 ft coarse sand with pebbles concentrated near water
- c) 60 ft; coarse sand, pebbles near water
- d) absent Middle River
- e) 60-80 ft coarse sand; pebbles near water; includes spit



T.49 N., R.12 W., Sec.35



Section 36/25, T 49 N R 12 W

This section is bounded on the west by the Middle River and on the east by the Poplar River Road. Throughout the section, the bluff is composed of red and brown clay. The brown clay is beneath the red clay stratigraphically, and occasionally exposed at the toe. At two locations, coarse sand with gravel lenses is exposed in the lower 15 ft. of the bluff; however, this sand is not laterally extensive and makes up only a small percentage of the bluff. The bluff face consists of alternating subsections of differing vegetative cover. The well-vegetated parts include thickets of small alder with poplar and birch. In these subsections, the slumps and shallow slides that have occurred are subdued and vegetated although a scarp at the crest is common. The less vegetated reaches consist of alder and birch rooted in sod clumps moving slowly downslope. Medium scales slumps and shallow slides occur in the last vegetated subsections more frequently. Occasional large slump blocks, now forming the toe, have carried a large amount of vegetation and red clay down slope. Ponding may be present at the backs of the blocks as shown in RP 36/25-2. Except at either end of the section, where it is between 20 and 50 feet wide, the sandy beach is narrow, of variable width, and in many places consists only of a swash zone. Thus the toe, of slumped clay, is unprotected from wave action. Access to this section is fair and it is used only occasionally.

SEC36/25 T49 N R12 W

SAFETY FACTOR

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes

(high confidence)

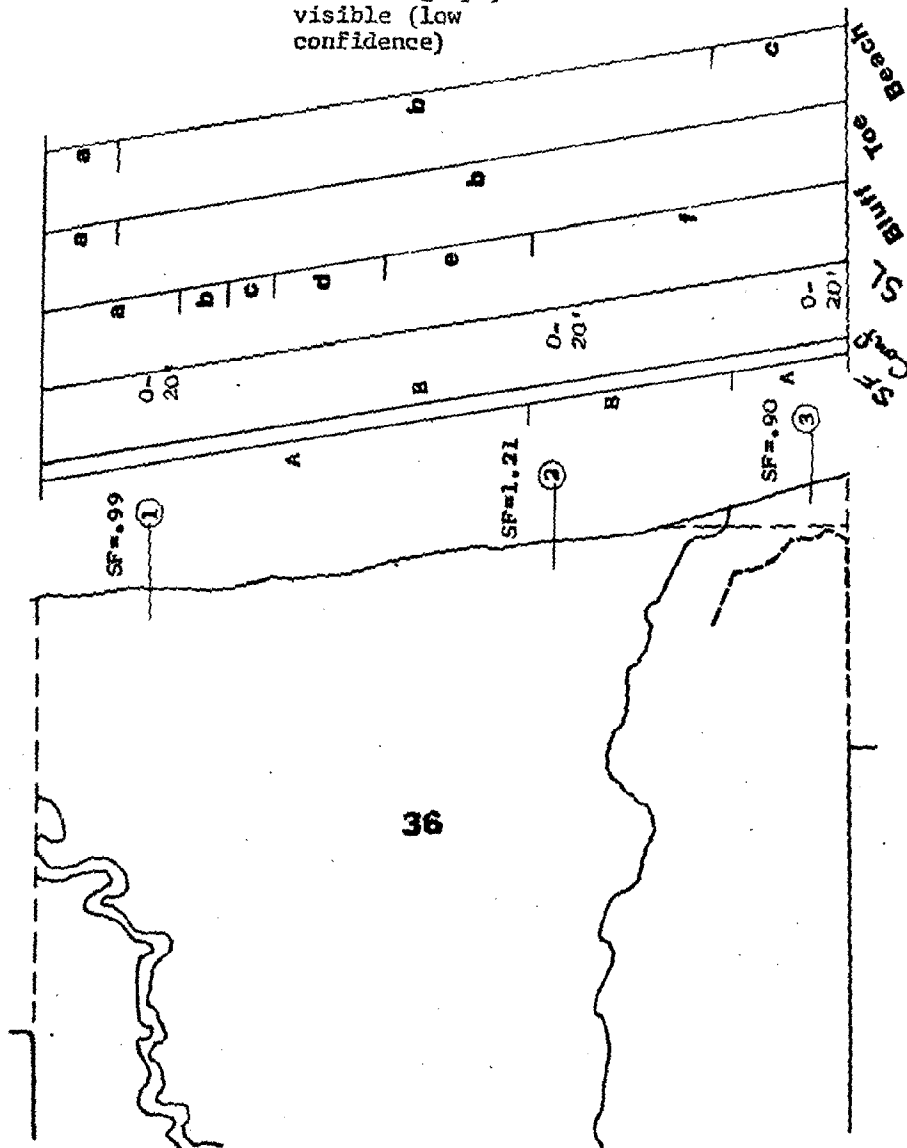
B-near boreholes

stratigraphy visible

C-no stratigraphy

visible (low

confidence)



Sec. 36, T 49 N, R 12 W

Bluff:

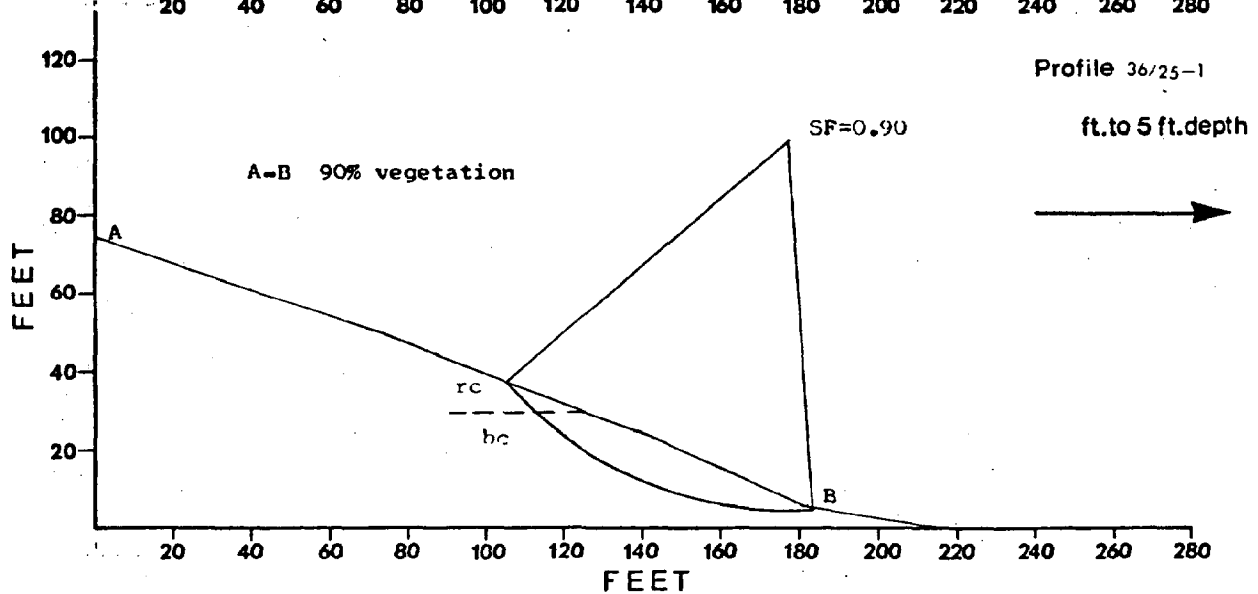
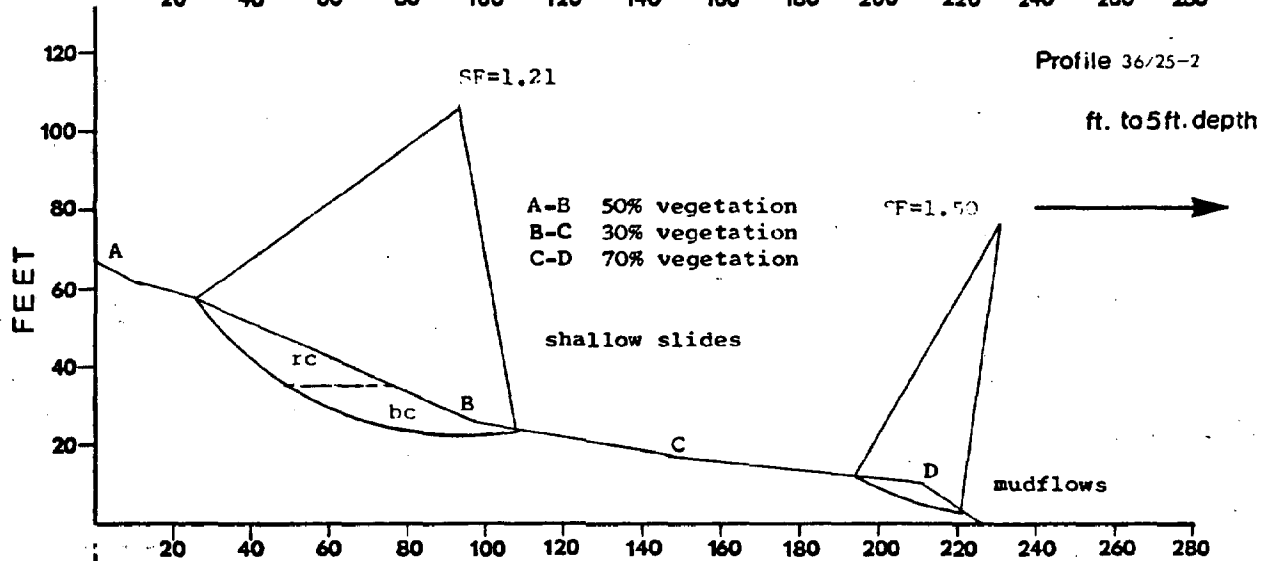
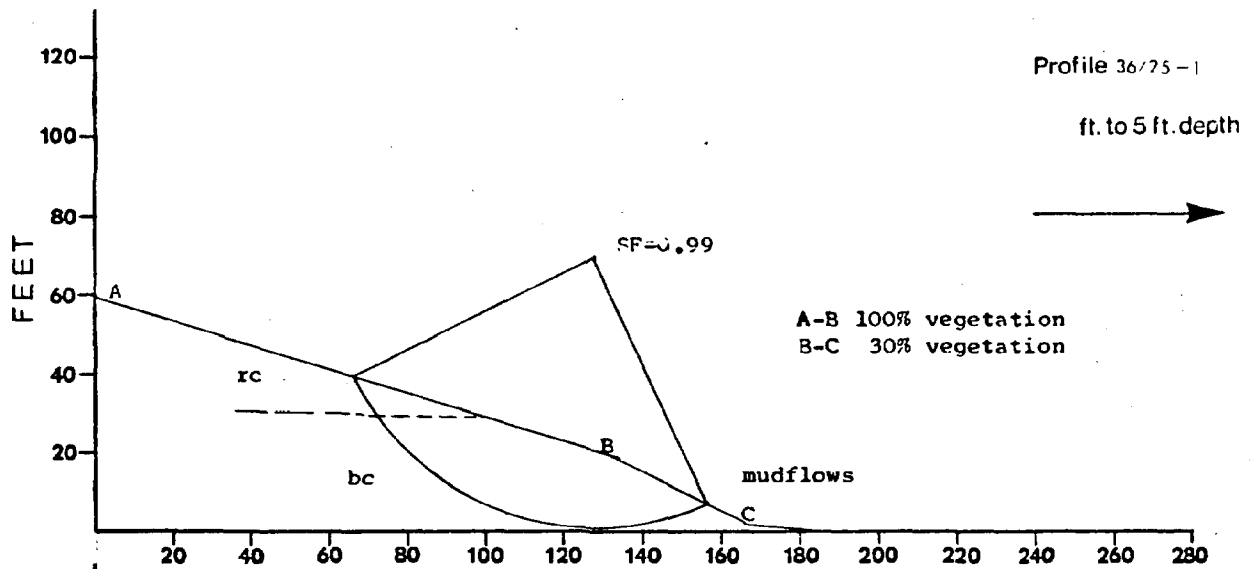
- a) 90-100% vegetation; with alder, grass with occasional birch and conifer; slumped red clay with brown clay occasionally exposed in slumped toe; subdued slump blocks; crest scarp 60 ft high with even crest
- b) 30% vegetation; with grass and small trees in clumps moving downslope; slumped red clay, shallow slides, large rotation slump at base; crest scarp; 55 ft high with even crest
- c) 90% vegetation with poplar, alder, birch and occasional conifer; slumped red clay; subdued medium scale slumps and slides; 60 ft high even crest, similar to (a)
- d) 30-50% vegetation; in clumps of alder and birch moving downslope; slumped red clay with brown streaked clay occasionally exposed at base; medium scale rotational slumps and shallow slides; crest scarp; 60-65' high with even crest
- e) 90% vegetation with poplar, alder, birch and occasional conifer; slumped red clay; subdued medium scale slumps and slides; 60-65' high with even crest
- f) 30-60% vegetation with birch and alder with grass in clumps moving downslope, Horsetails on recent failures; red clay with brown and red clay towards base; shallow slides, bluff height 65-75 ft and constant except where it drops to meet a creek.

Toe:

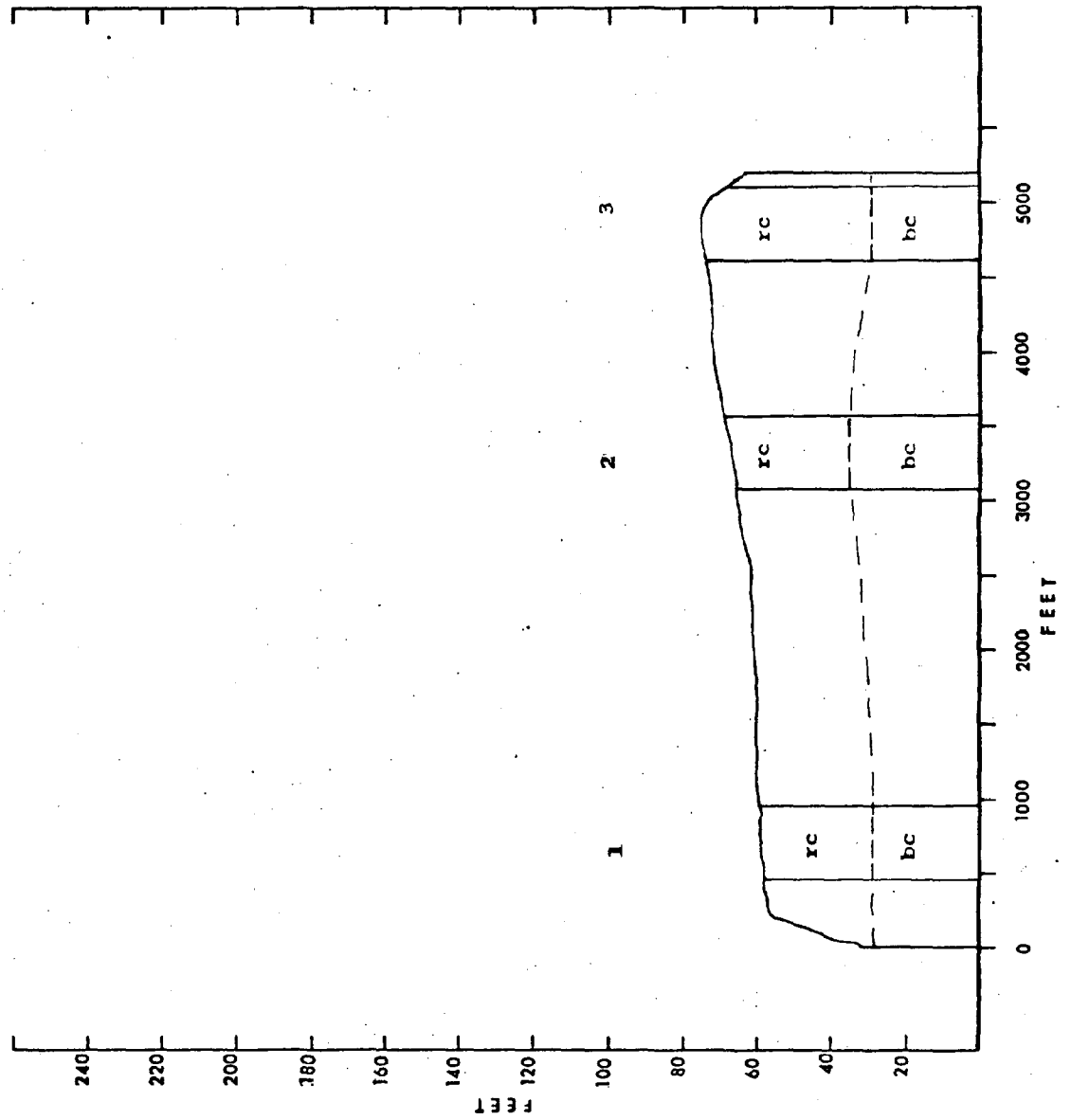
- a) 50% vegetation with horsetails and clumps of alder, birch and grass; slumped red clay; protected from waves
- b) 0-10% vegetation; flowing and/or slumping red clay with some brown clay; toe hit by storm waves, or in places, presently at water level

Beach:

- a) narrows to the east from 50' to 15', sandy with concentration of pebbles and granules 10' from shore
- b) 3-15' wide; sandy with scattered pebbles; in places beach consists only of swash zone
- c) 20-50' wide; sandy with pebble concentration 10' from shore



T.49 N., R.12 W., Sec. 36/25



Section 30, T 49 N R 11 W

The section lies immediately east of Poplar River Road in Lakeside Township and is bisected by the Poplar River. Throughout the section, red clay is a major constituent in the bluff, with 20 ft. brown clay present stratigraphically below the red clays. The brown clay is only observed in the occasional mudflows and slumps at the toe or in ravines. The western portion of the bluff, is actively failing with small scale slumps and shallow slides. In this subsection, vegetative cover is only 30%, consisting of clumps of birch and alder moving downslope. The bluff is moderately steep (24°) increasing nearly vertical just east of the Poplar River. The remainder of the eastern part is better vegetated, up to 70% cover with the slumps and slides more subdued. The toe, comprised of slumped red and brown clay, is protected from wave erosion by a wide sandy beach, except in one or two subsections. Access is fair for the western half but poor for the eastern half, so public use is rather infrequent.

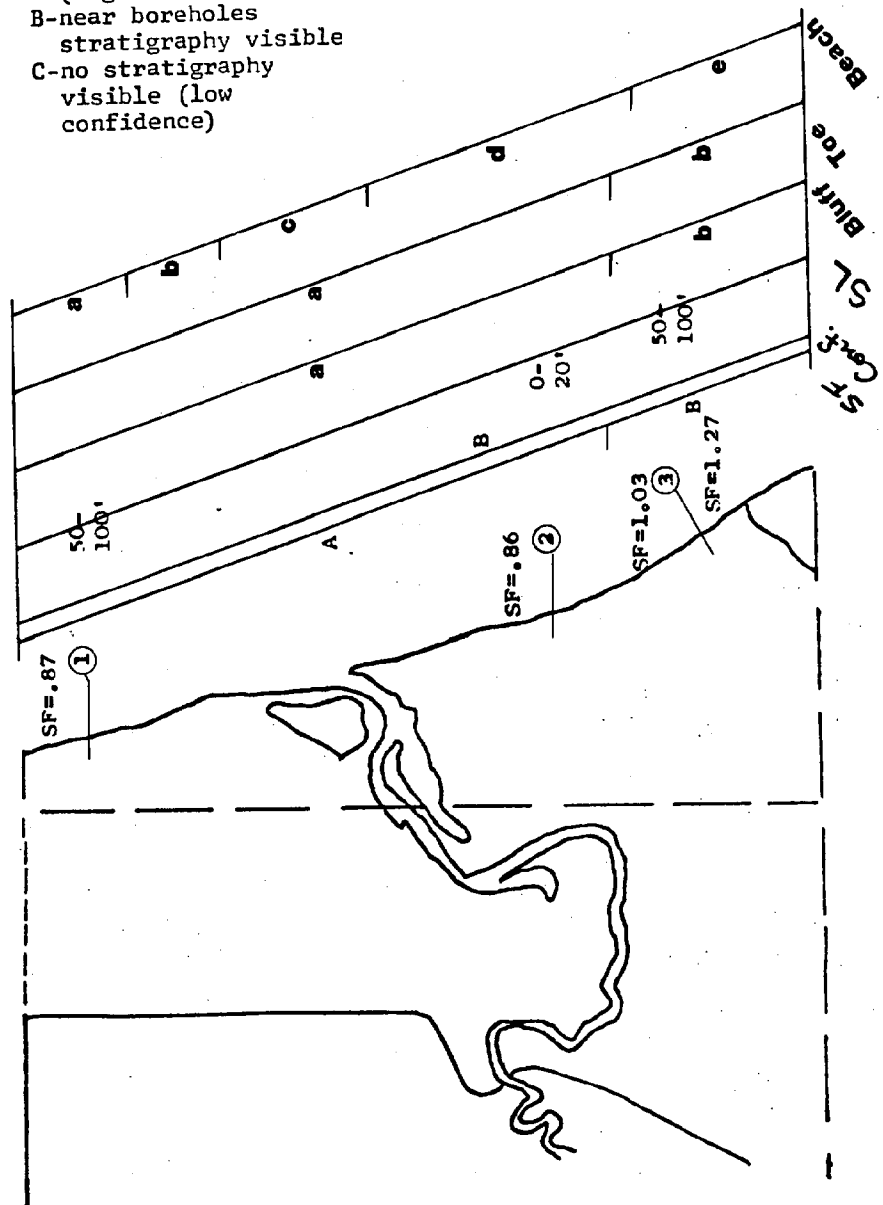
SEC30 T49N R11W

SAFETY FACTOR

- A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
 (high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



Sec. 30, T 49 N, R 11 W

Bluff:

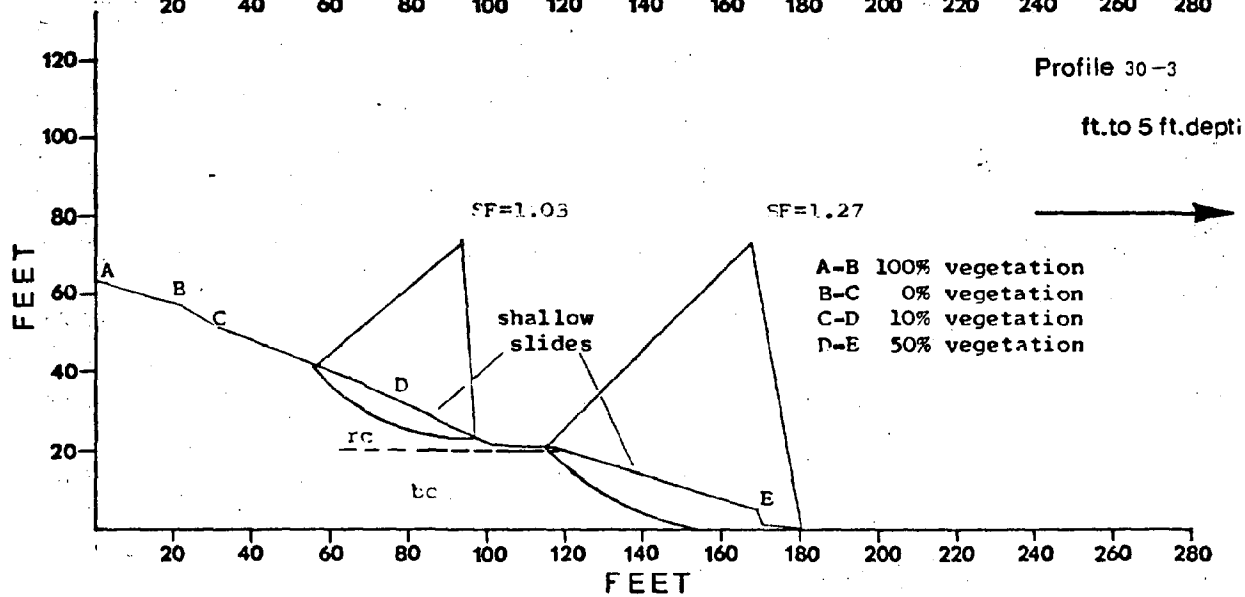
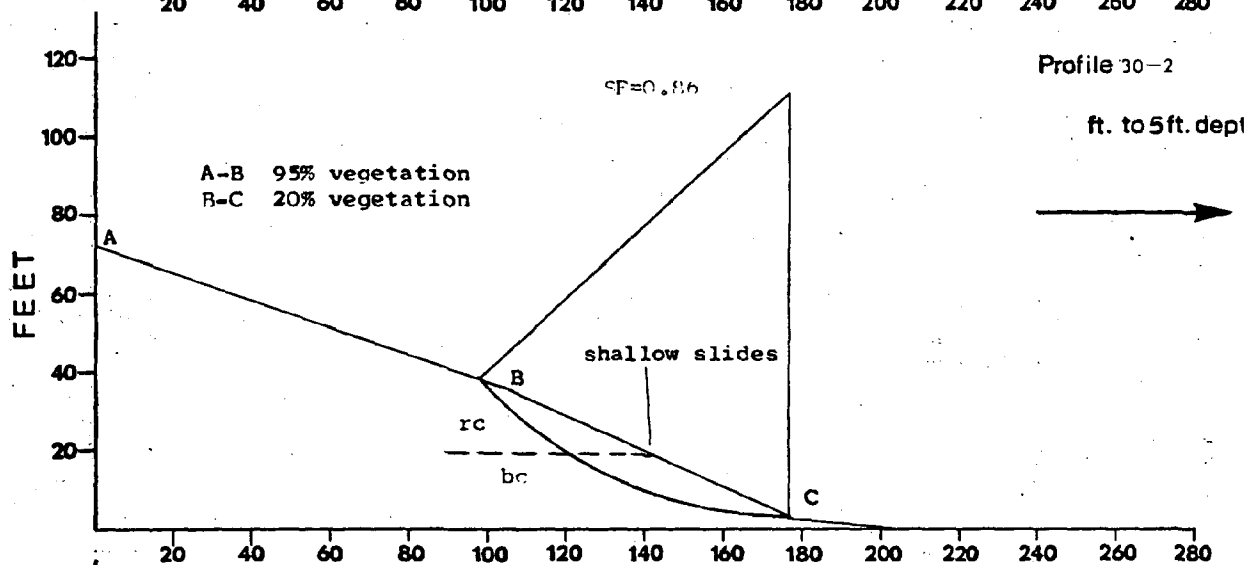
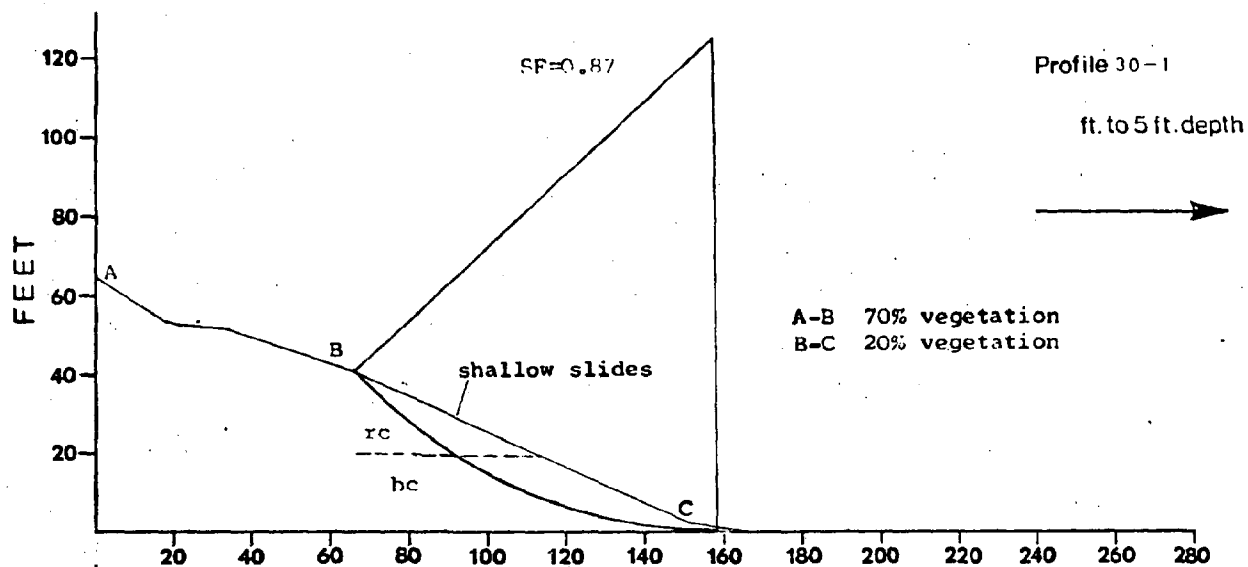
- a) 30% vegetation with birch and alder in clumps moving downslope; slumped red clay with some brown clay exposed at base; small scale slumps and shallow slides; bluff height 60-65 ft; vegetation increases and bluff height drops at the Poplar River and small creeks; occasional upper part of bluff is well vegetated
- b) 40-70% vegetation with alder and birch; slumped red clay with brown clay at base; subdued slumps and shallow slides; bluff height even at 60-65'

Toe:

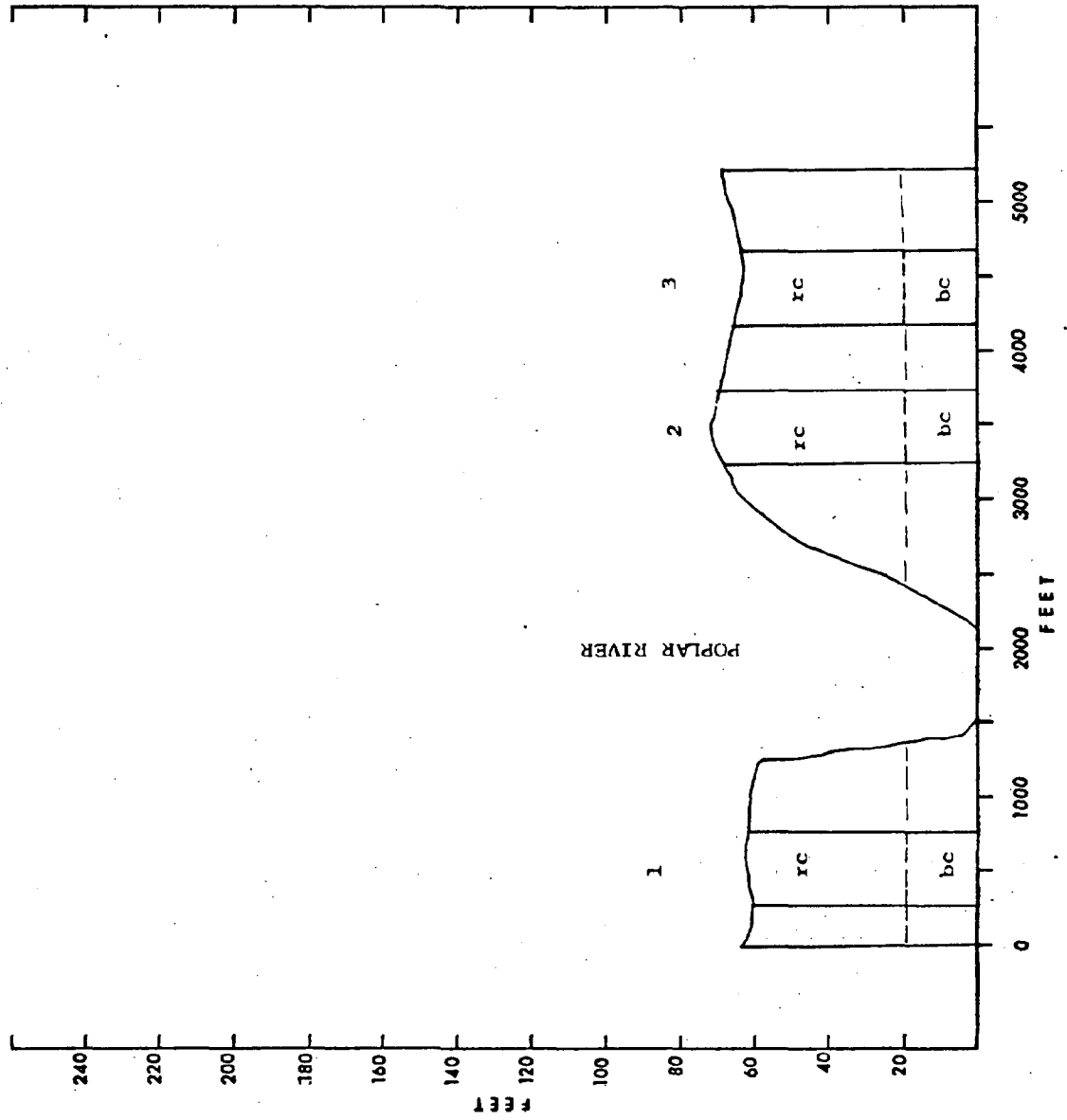
- a) Poorly vegetated; red clay or brown clay; flowing or slumping; waves hit toe during storms
- b) Moderately vegetated red or brown clay; rounded crests occasionally flowing, toe hit by waves during storms

Beach:

- a) 30' wide; sand with pebbles at shore
- b) 3-15' wide; width variable; sandy with pebbles; beach occasionally consists only of swash zone
- c) 30-50' wide; sandy with pebbles at shore; extensive driftwood towards Poplar River
- d) 10-20' wide; width fairly even; sandy
- e) 0-15' wide; width variable; sandy with occasional cobbles and numerous slumped trunks



T. 49 N., R. 11 W., Sec. 30



Borehole Site 2

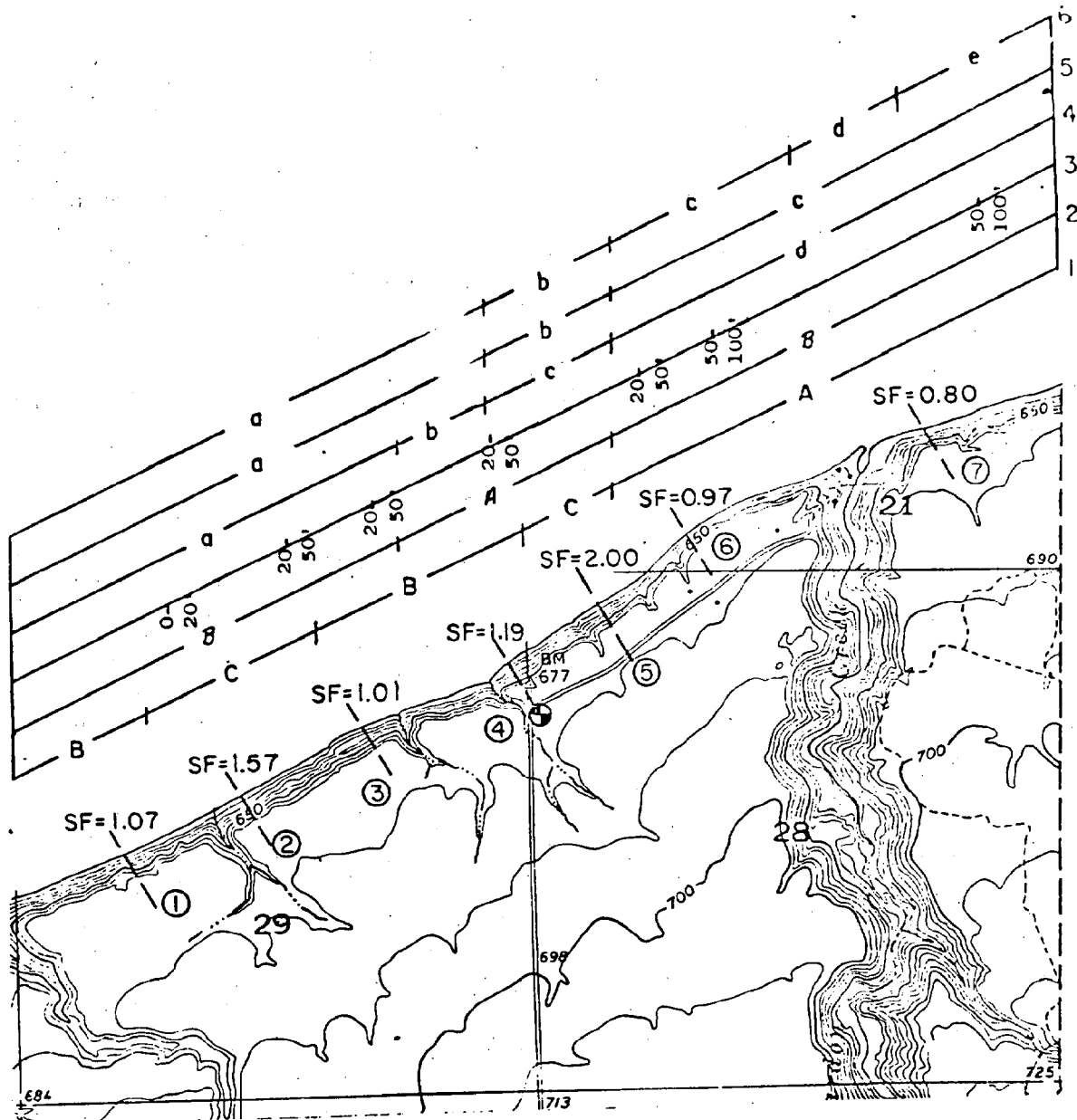
Borehole Site 2 is located in Reach 2. It begins 0.5 miles east of the Poplar River and ends 0.5 miles east of Bardon Creek. The site includes 2.2 miles of shoreline in Sections 29, 28, and 21 of Township 49 north, Range 11 west in Douglas County. This study area is comprised of high bluffs with actively eroding slopes. The bluffs average 70 feet in height and are dissected by several gullies and streams.

Bluffs in Section 29 and the western half of Section 28 are composed of the two clay units identified at Site 1. The lower, browner clay unit is exposed only in the lower 20 feet of the bluff face. Cobbles and boulders eroded from this unit help to identify its location. A third stratigraphic unit appears in the eastern half of Section 28 and continues into Section 21. It is a well-sorted, dark-brown sandy silt deposit that is exposed in the lower bluff profile. This unit is very compact, obtaining slope angles as high as 60 degrees (see Profiles 6 and 7).

Erosion in the western three-quarters of Section 29 occurs in the form of shallow translational slides and flows. Surface water has played, and is playing, an important role in eroding these Douglas County bluffs. Cirque-shaped basins are created by drainage patterns which channel surface water across the bluff. As a result, the vegetation on these slopes has been stripped by this active erosion. A distinct change in erosional mode occurs in the eastern quarter of Section 29. Massive rotational slump blocks, sometimes encompassing the entire bluff, have been observed. The western half of Section 28 appears to be relatively stable since the bluffs remain fully vegetated and there is little evidence of slope failure. East of these stable bluffs, bluff profiles change dramatically. In this area,

the bluff toe is composed of the sandy silt overlain by the browner clay. The differential strength of these two soil units has resulted in a distinct break in slope (see Profiles 6 and 7). Erosion of the sandy silt unit occurs in the form of shallow translational slides while the clay unit experience rotational slumping, and flows. Redder clay from previous slumps often covers the lower units.

Beaches along Study Area 2 are generally narrow, (averaging 10 to 20 feet), but wider beaches occur near streams and fullies (see Profile 4). Beaches are often covered by debris from recent slope failures.



SAFETY FACTOR (SF)
 A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL
 A-at boreholes
 (high confidence)
 B-near boreholes with
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)

6 BEACH
 5 TOE
 4 BLUFF
 3 STABILITY LINE
 2 CONFIDENCE LEVEL
 1 SAFETY FACTOR

APPROXIMATE SCALE
 1 inch = 1500 feet

Borehole Site 2

Bluff:

- a) No vegetation, with shallow slides and flows
- b) No vegetation, with massive slumping
- c) Full vegetated, no erosion
- d) No vegetation, steep slopes greater than 45°, with translational slides, and slumping present

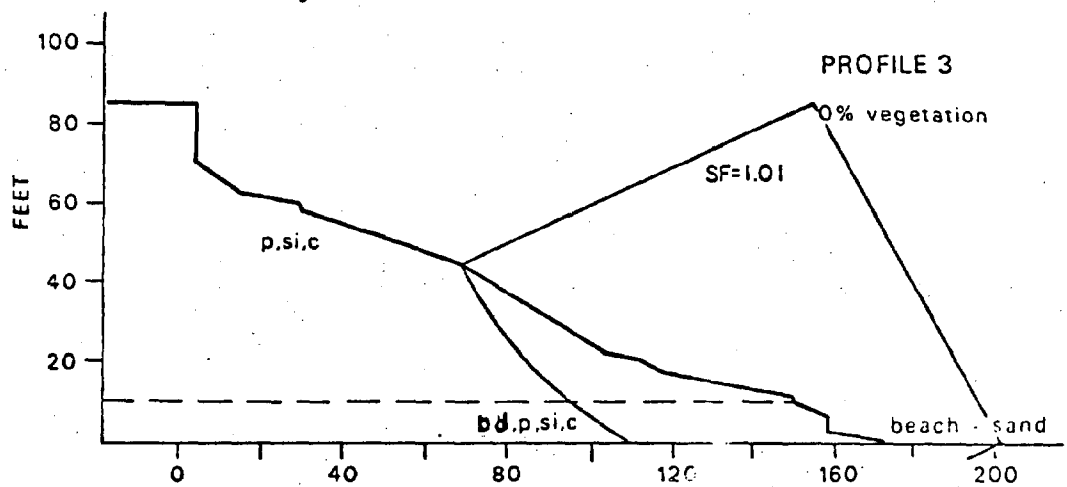
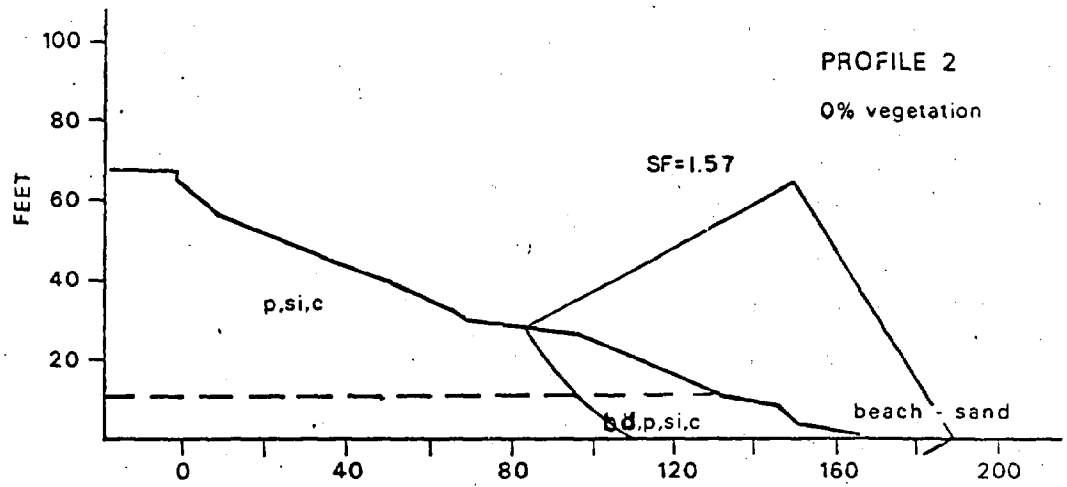
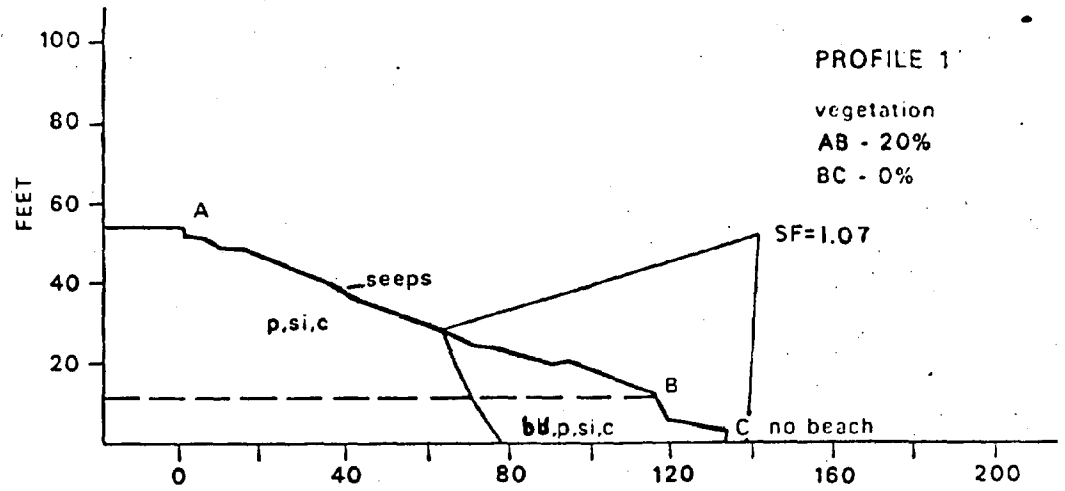
Toe:

- a) Flow and slump debris
- b) Fully vegetated
- c) Very steep wave cut toe, sandy silt exposed

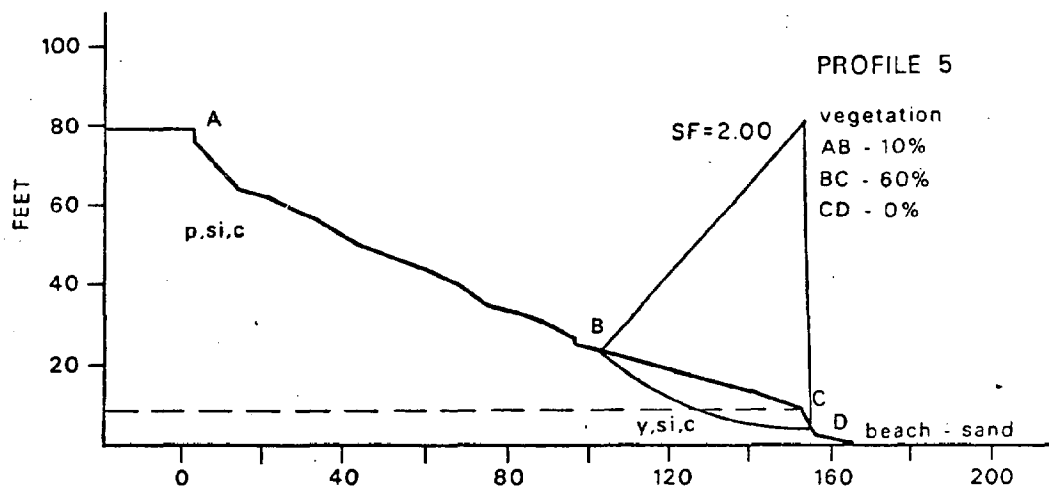
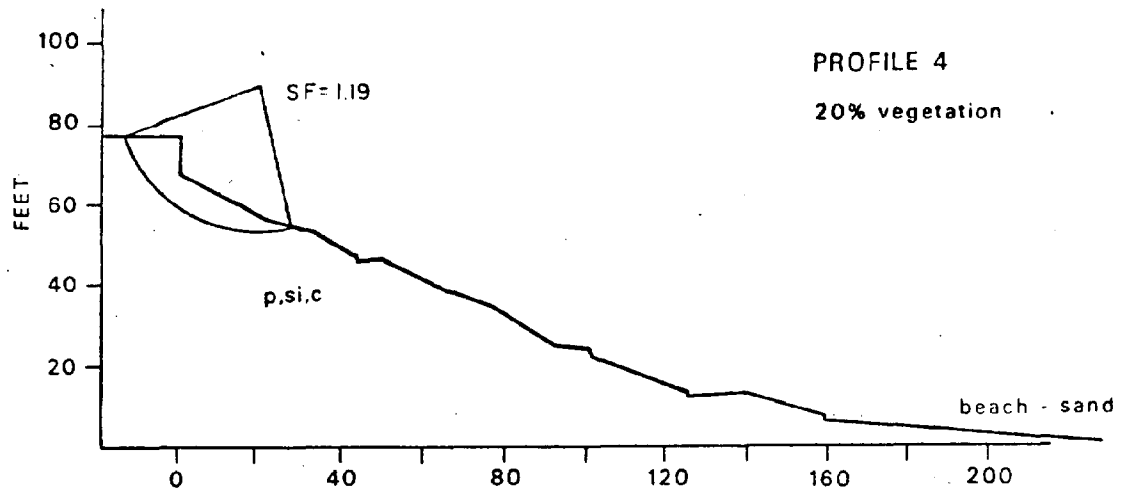
Beach:

- a) 0 to 20 feet, sand
- b) 30 to 70 feet, sand
- c) 10 to 20 feet, sand
- d) 20 to 50 feet, sand
- e) 10 to 20 feet, sand

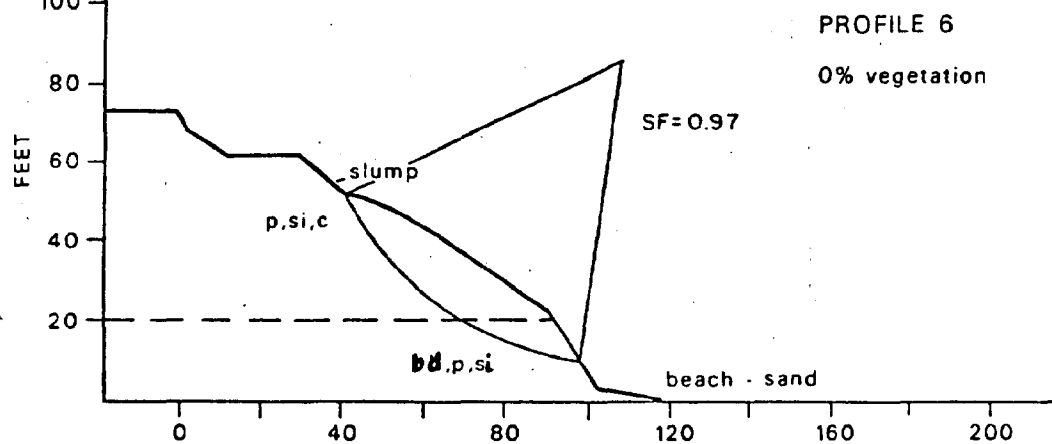
T.49N.,R11W.,SEC 29



T.49N.,R11 W.,SEC 28



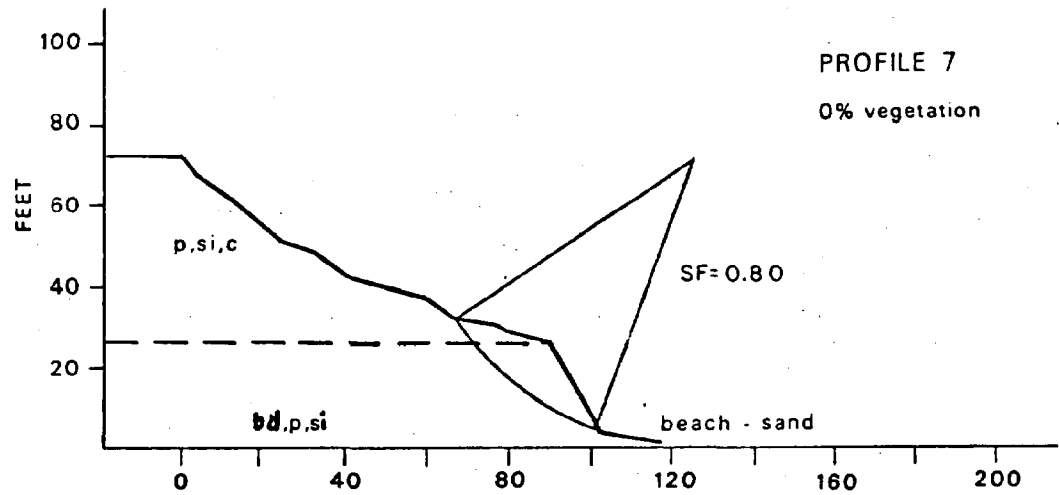
T.49N.,R11 W.,SEC 21



T.49N.,R11 W.,SEC 21

PROFILE 7

0% vegetation



Section 29, T 49 N R 11 W

The section lies a half a mile to the east of the Poplar River and is bounded on the east side by Peterson Road. Throughout the section, the bluff is comprised of red clay, with approximately 20 ft. of brown clay at the base of the bluff. The brown clay is usually covered and exposed only in ravines. The bluff height is constant at 70-75 feet. Large slump blocks are responsible for moving large masses of material from the bluff. These blocks are now at the toe, actively being eroded by wave action. The exposed bluff face above the slump block exhibits shallow slides and clumps of sod with individual trees moving down slope. No indigenous vegetation has been able to establish itself on these slopes. Where large slumps have not occurred, the toe is usually a low rounded step of a former mud flow. In these localities, a wide sandy beach is present. In slumped areas, beach width is highly variable and occasionally consists only of the swash zone. As access is not very good, the section gets little public use.

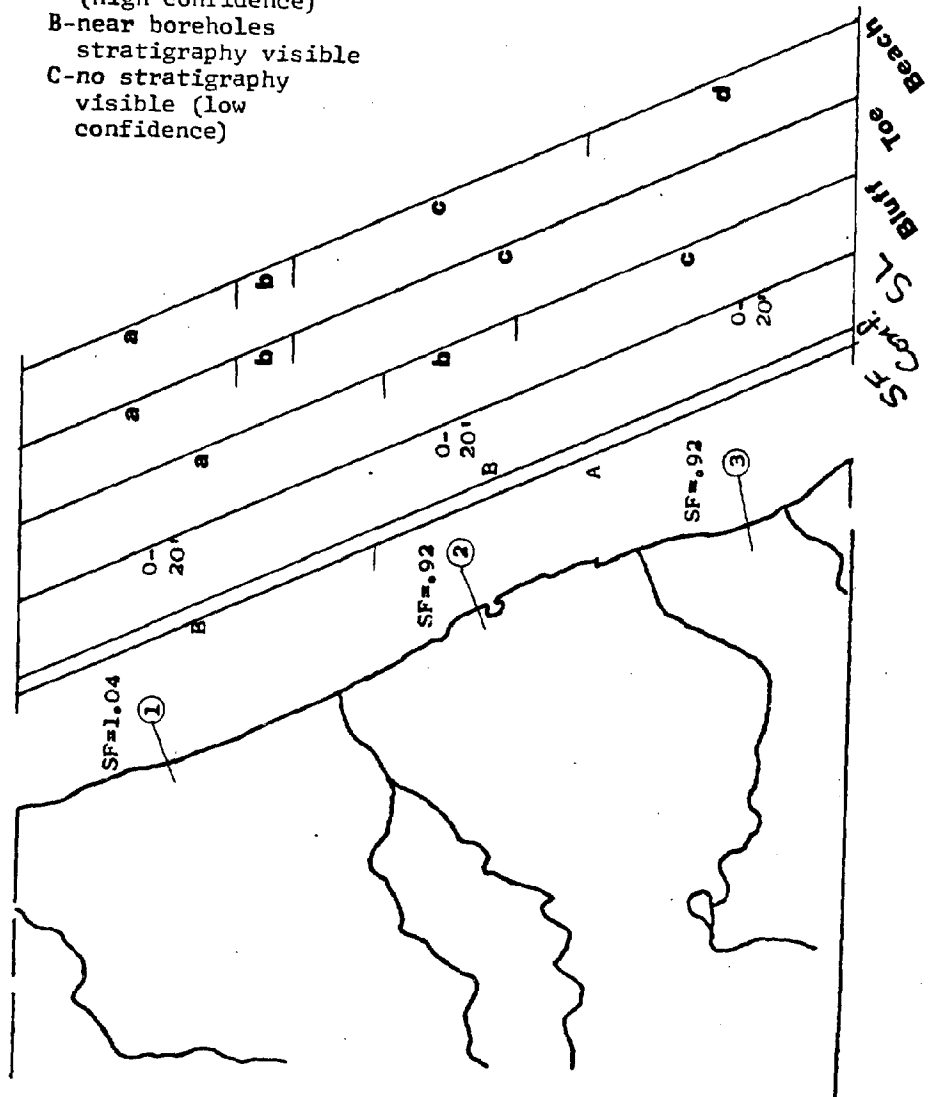
SEC29 T49 N R11W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 29, T 49 N, R 11 W

Bluff:

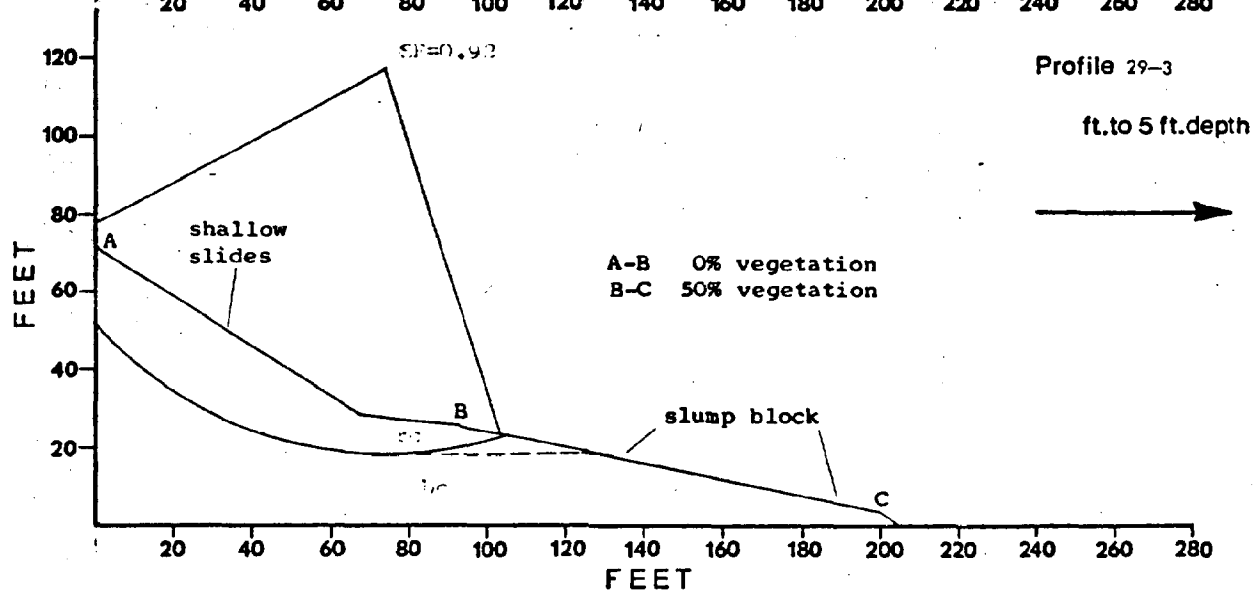
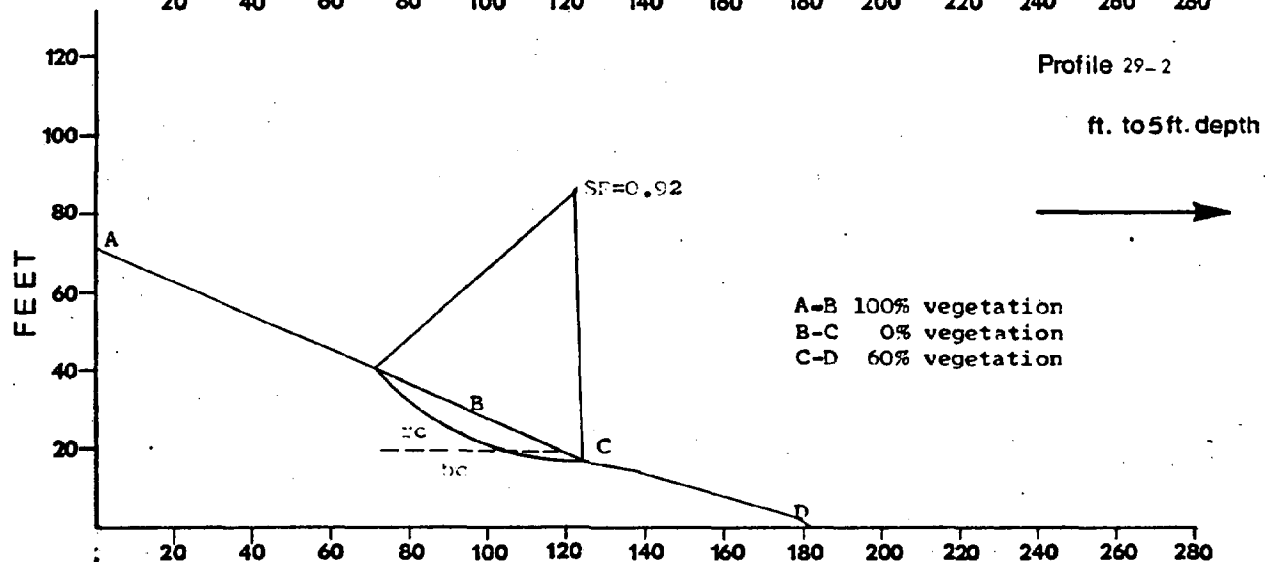
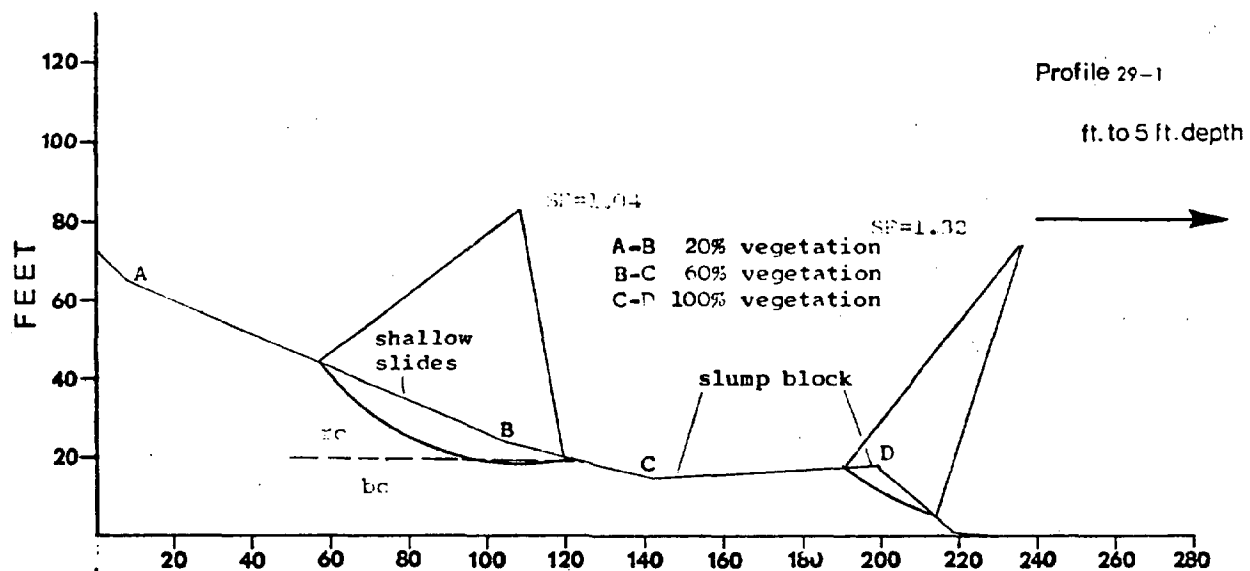
- a) upper 2/3 40% vegetation with birch and grass clumps in shallow slides, lower 1/3, 90-100% vegetation with birch and alder; large slump block; red clay
- b) 60-100% vegetation with birch, alder, and horsetails; red clay; hummocky surface with occasional scarp
- c) largely unvegetated except for slump blocks and three clumps; red clay; shallow slides and slumps

Toe:

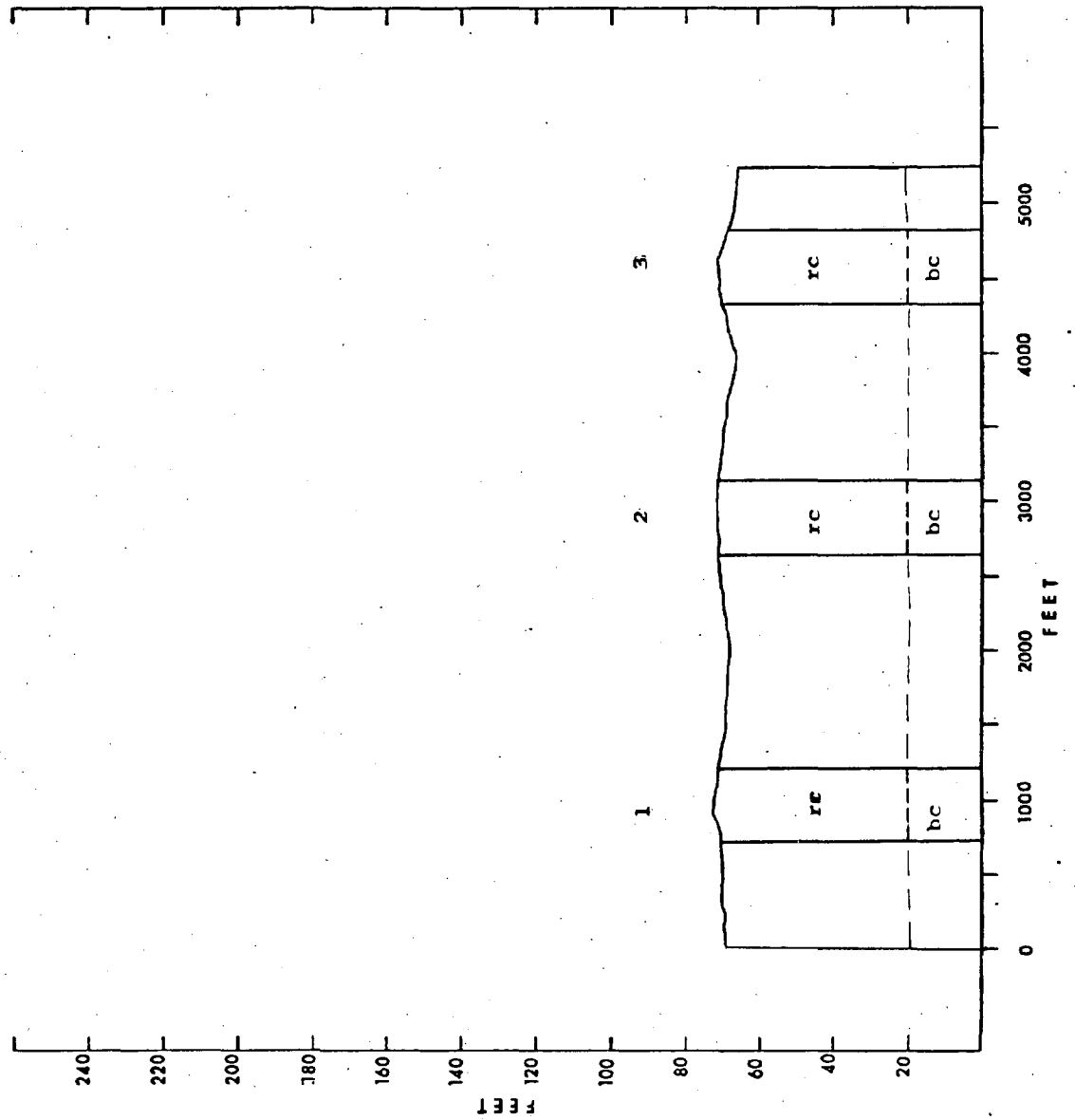
- a) Low 3-15'; wave eroded, slumped red clay
- b) low 3; rounded, protected, slumped red clay
- c) Low 3-15' scarp of slumped red clay; may be unprotected when beach is absent

Beach:

- a) 0-10' wide; width variable; sandy few pebbles, patches of cobbles
- b) 15-20' wide; sandy with pebbles near shore
- c) 0-15' wide, width variable; sandy with pebbles near shore
- d) 15-20' wide; sandy with pebbles near shore



T. 49 N., R. 11 W., Sec. 29



Section 28/21, T 49 N R 11 W

The section lies to the east of Peterson Road and is bisected by Bardon Creek. De Vries Road runs parallel to the shoreline along the bluff top west of Bardon Creek. Red clay is a major constituent of the bluff. Beneath this material lies 20 feet of brown clay. Toward the western end, a brown silty material appears in a ravine 10 ft. above the lake level. Its upper contact with the brown clay rises to the east until it is 20 ft. above the lake surface. Though covered many places east of Bardon Creek, this silty unit forms a prominent bench in the slope profile as seen in RP 28/21-3. Throughout the section, shallow slides are the dominant form of failure. This material accumulates at the toe to be eroded by waves. Where the silty unit forms a bench, the sliding material forms chutes, flowing over the bench and fanning out at the base into a lobe. The beach is sandy and of variable width. It widens at the mouth of Bardon Creek and is absent where flows and slides have covered it. Vegetation is very sparse throughout the section and consists only of trees and sod slumped from the crest. A few summer cottages abut DeVries road but none have developed access to the shore. At the end of DeVries, a cottage with several smaller buildings is present right on the lake. A cement pier and some boulder rip-rap have been constructed here. Public use is limited by poor access.

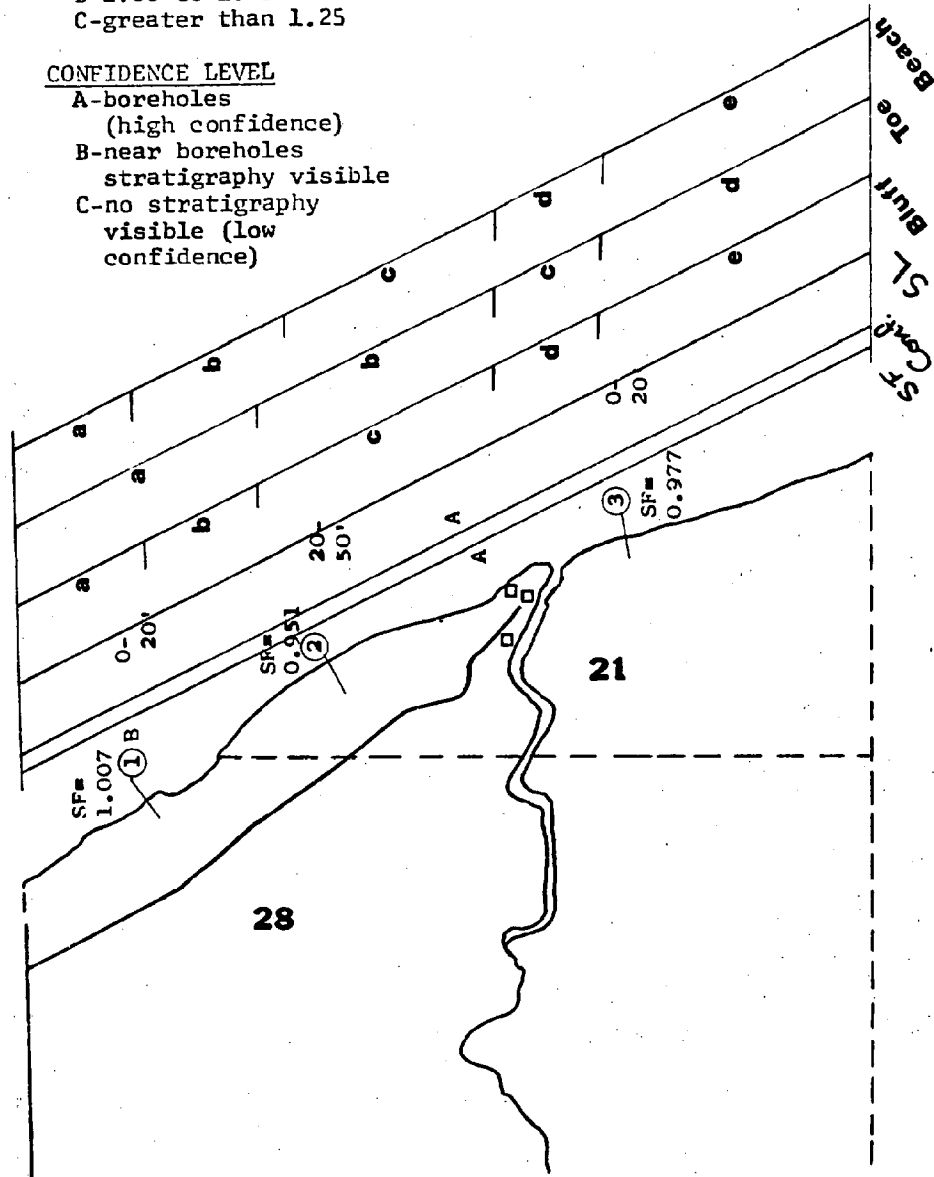
SEC28/21 T49N R11W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 28/21, T 49 N, R 11 W

Bluff:

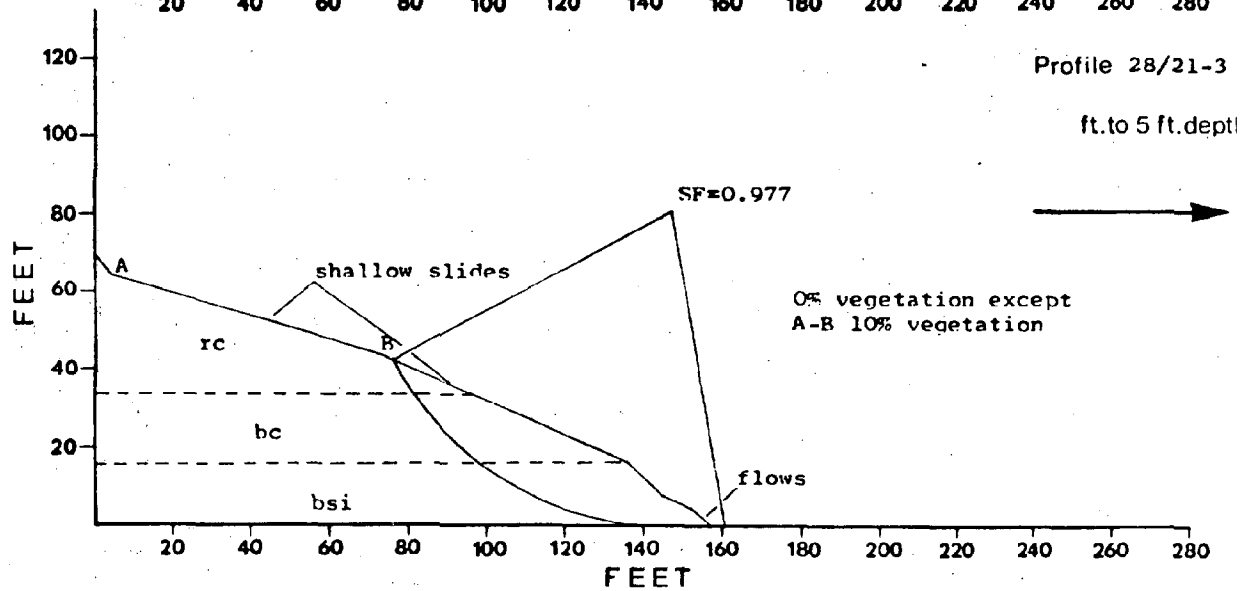
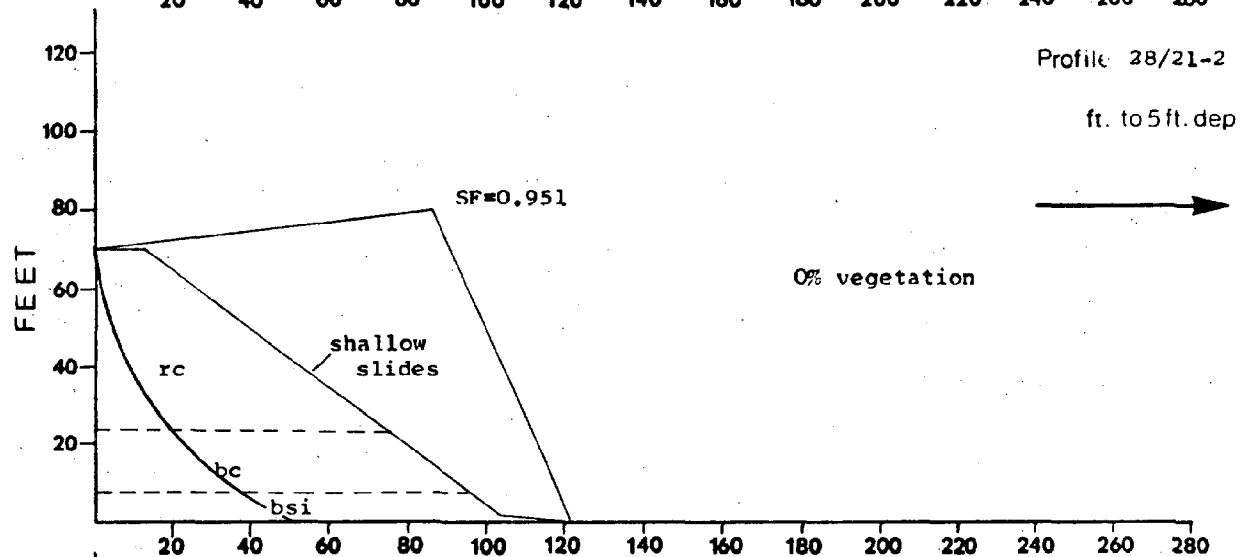
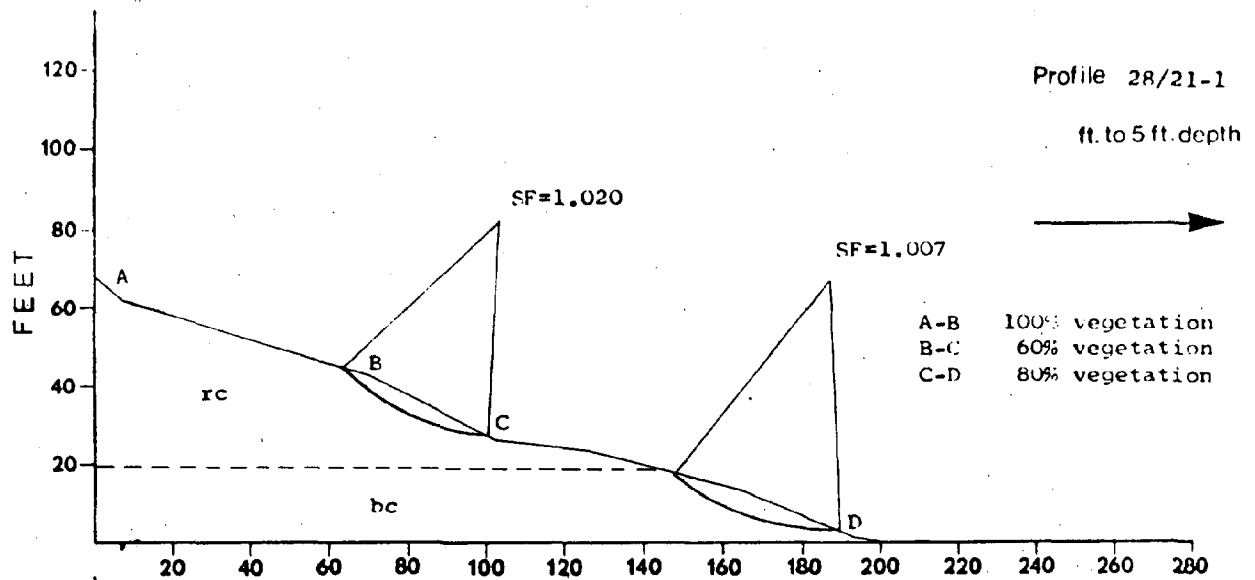
- a) 90-100% vegetation with birch, alder, and occasional conifer; red clay over 20' of brown clay; slumps subdued and vegetated with occasional new scarps and flows; 65-70' high, even crest
- b) 30% vegetation with birch and sod in clumps in upper portion and horsetails covering lower slope; red clay over brown clay; small slumps, shallow slides and mudflows; 65-70' with even crest
- c) 10% vegetation with occasional birch and sod clumps; red clay over 20' of brown clay over 10' of brown silt; slope very steep with shallow slides and mudflows; 70-75' with even crest
- d) bluff absent- Bardow Creek
- e) 10% vegetation with sod clumps; red clay 35', over 20' of brown clay over 20' of brown silt; shallow slides and mudflows; silt forms prominent steep slope; 70-75' high with even crest

Toe:

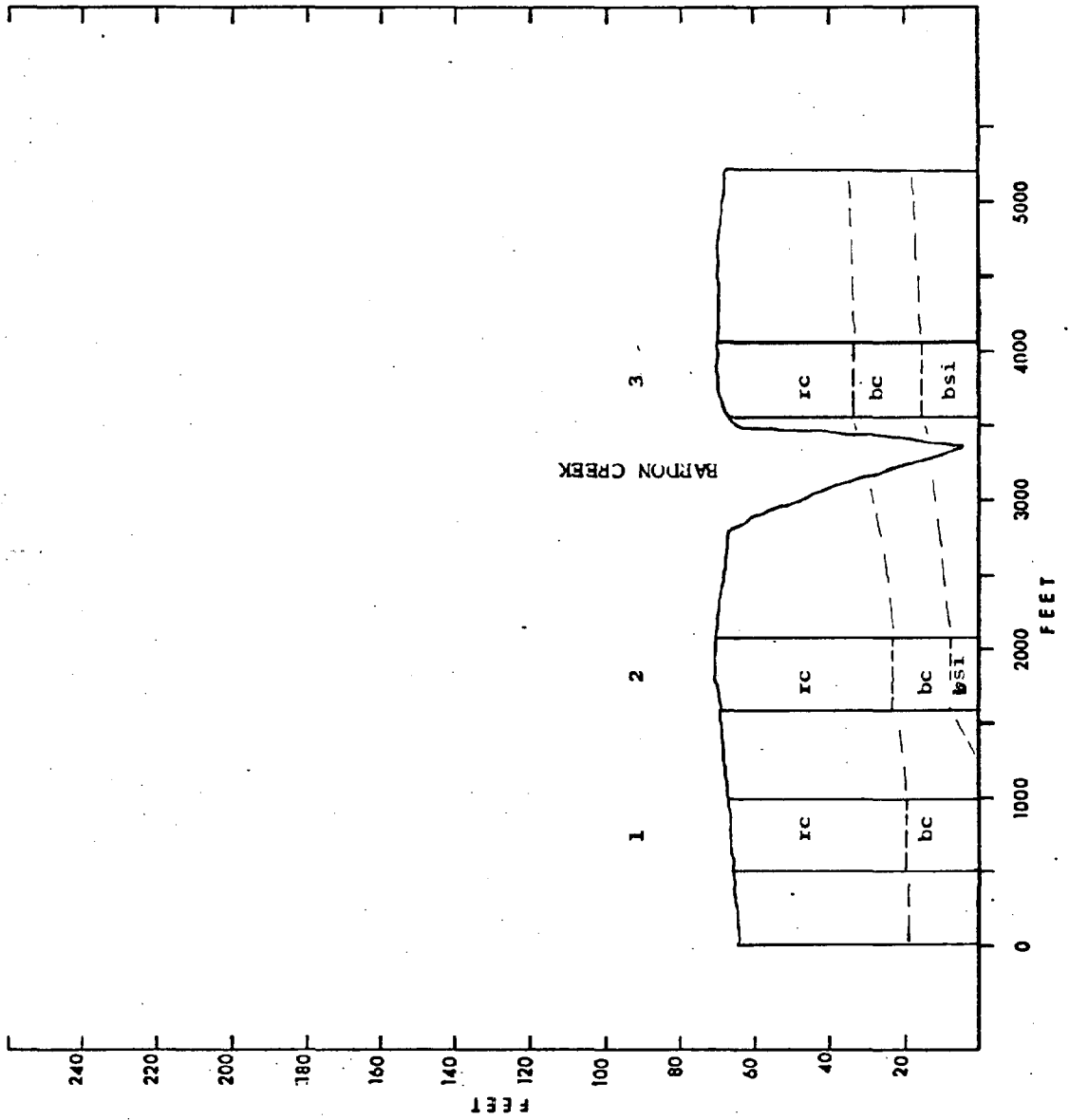
- a) 3-5 ft; slumped red clay; horsetails and sod clumps; wave protected
- b) rounded, un-vegetated, slumped red clay of mudflows; in places hit by wacks
- c) toe absent-Bardon Creek
- d) slumped red clay, mudflows, un-vegetated, un-protected from waves

Beach:

- a) 20-25' wide; sand with scattered pebbles; width constant
- b) 8-15' wide; sand with scattered pebbles
- c) 0-8' wide; width variable; sandy with log litter and occasional boulders
- d) 8-50' wide; widens at mouth of Bardon Creek; sandy
- e) narrow sandy swash zone or beach absent: scattered driftwood



T. 49 N., R. 11 W., Sec. 28/21

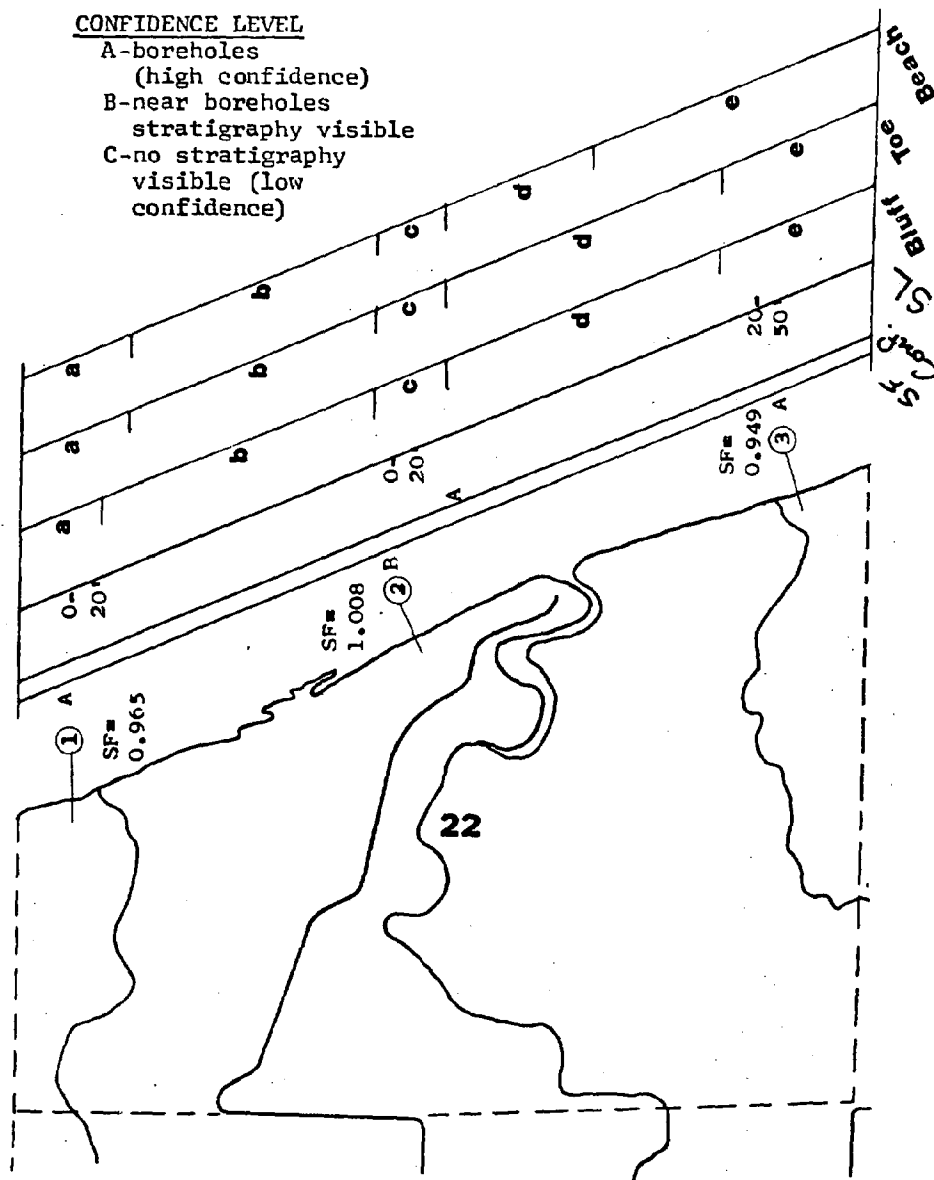


Section 22, T 49 N R 11 W

The section lies 8 miles north of the town of Maple and is bisected by Pearson Creek whose mouth may be reached by Beck's Road. The deposits which make up the bluff are, from the top, 30 ft. of red clay, 20 ft. of brown clay, and 20 ft. of a brown silty material. The clay is fairly uniform whereas the character of the silty unit is variable, ranging from a homogenous sandy silt with occasional pebbles in the western end, to 30 ft. of sand with bands of red clayey sand in the eastern end. The silty unit does not fail readily and has a gulleyed appearance when not covered. It is moderately resistant and forms a steep face as can be seen in RP 22-1 and RP 22-3. The clays above are occasionally steep slope formers (RP 22-1), but more commonly exhibit shallow slides and flows. Often, where the silty unit is present as a bench, clay material will flow over it, forming a slide chute, and fan out at the toe. Vegetated sod clumps with trees are also carried over the bench. The bluff face is devoid of any indigenous vegetation, and what little there is consists of clumps of sod with trees that have pulled away from the failing bluff crest. The beach is wide and sandy at the creek mouth where the toe is fairly stable. But in the intervening areas, beach width is variable, narrow, and occasionally absent. The toe is often unprotected and being eroded. Access is good to the west half by Becks Road and the beach is used when present. To the east, the bluff is less accessible because of Pearson Creek.

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



Sec. 22, T 49 N, R 11 W

Bluff:

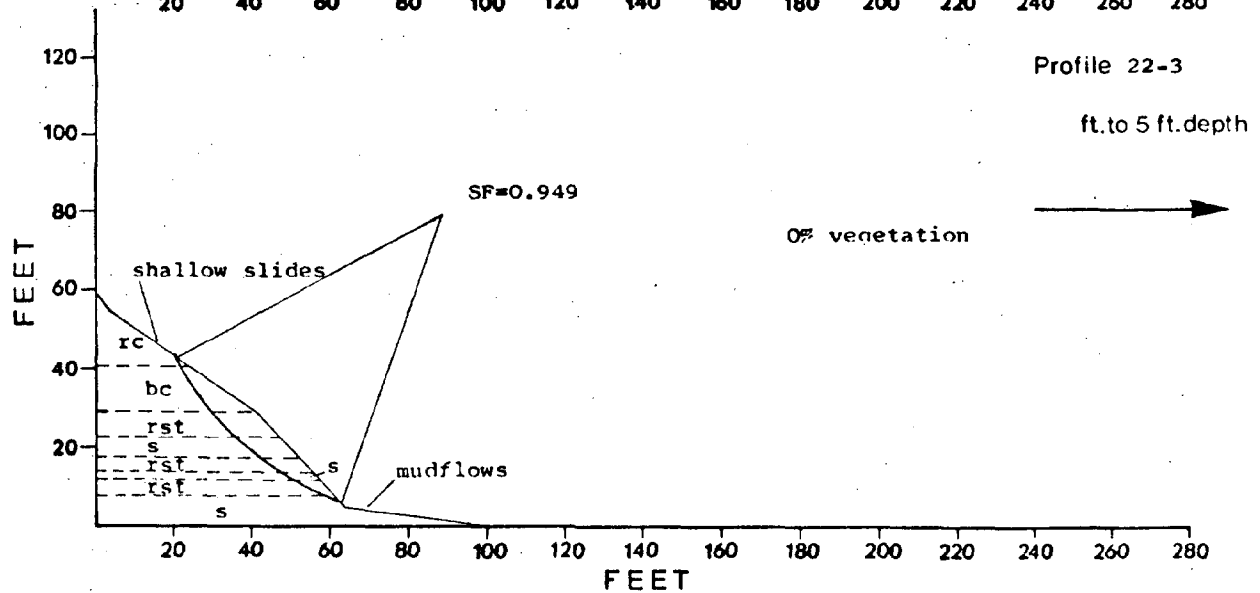
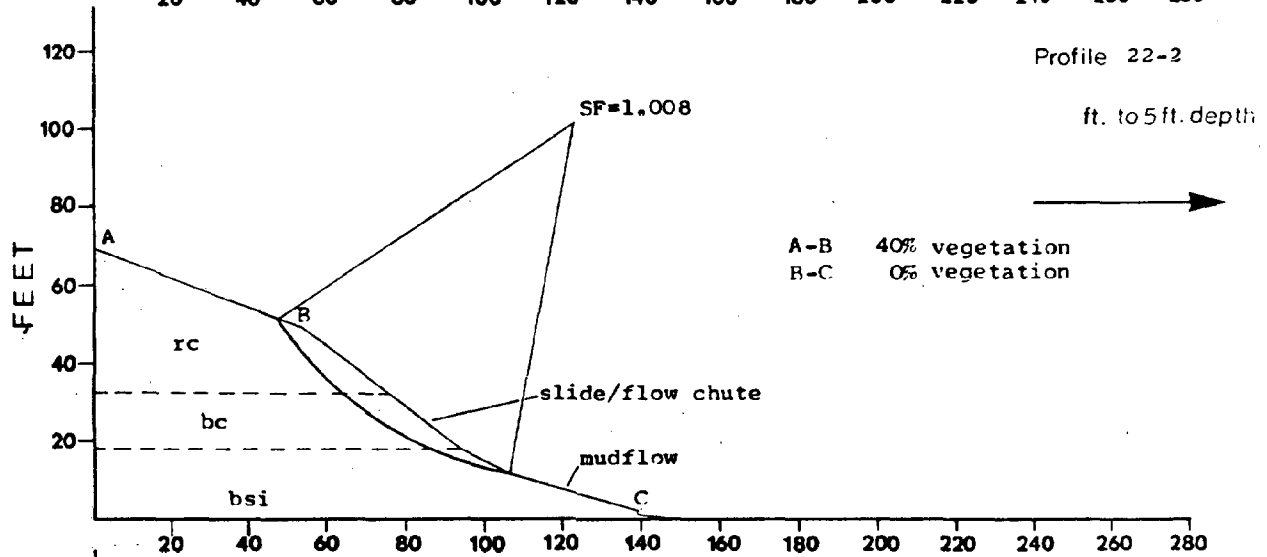
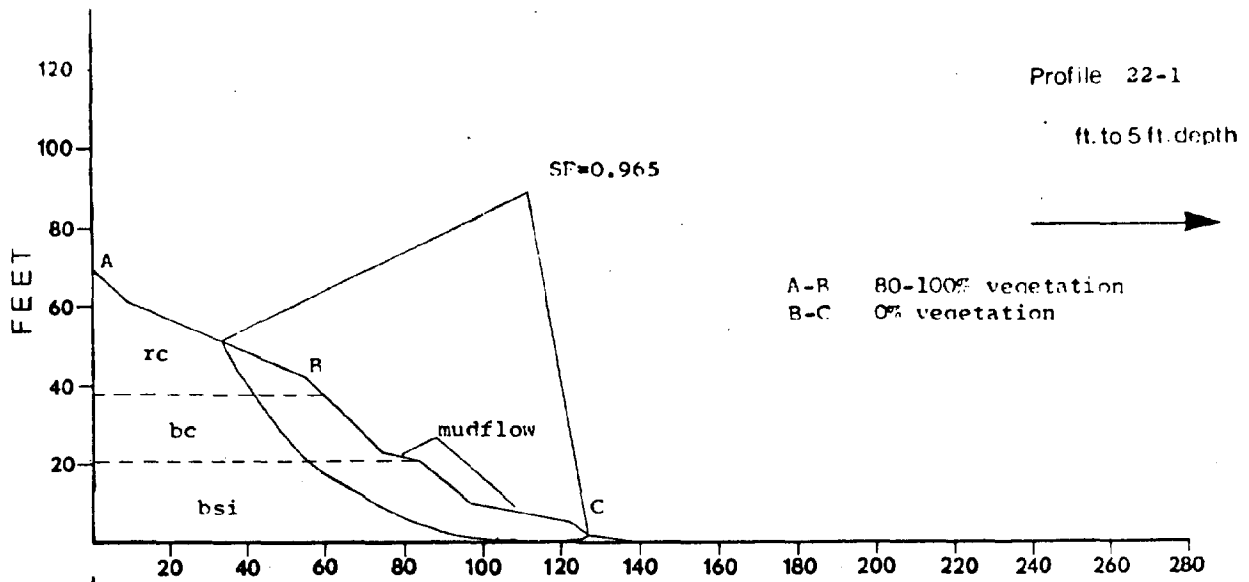
- a) 10-20% Vegetation, clumps of sod with alder; red clay over brown clay over 20' of brown silt: Shallow slides and mudflows, flows leave chutes on hillside and lobes at base where they fan out; silt forms bench which may be obscured; 70-75' high with even crest
- b) 30-60% vegetation; small alder and grass in clumps with horsetails predominating on the lower slopes; red clay overlying shallow slides predominate with occasional scarps; brown silt outcrops but does not influence slope angle: 70-75' high, fairly even crest
- c) 40% vegetation in upper slope with alder; lower slope unvegetated; brown and red clay over brown silt; shallow slides and mudflows; flows leave chutes on slope and lobes at base where they fan out; silt forms bench; 65-70' high
- d) 30-60% vegetation; horsetails with alder clumps; shallow slides; crest has scarp; does not form bench; red clay over silt 40-45' high with even crest
- e) 10% vegetation, occasional birch or alder clump; red and brown clay over sand with sandy till intermixed and at base; shallow slides in clay and eroded face in sand; crest scarp occasionally vegetated; 60' high with fairly even crest

Toe:

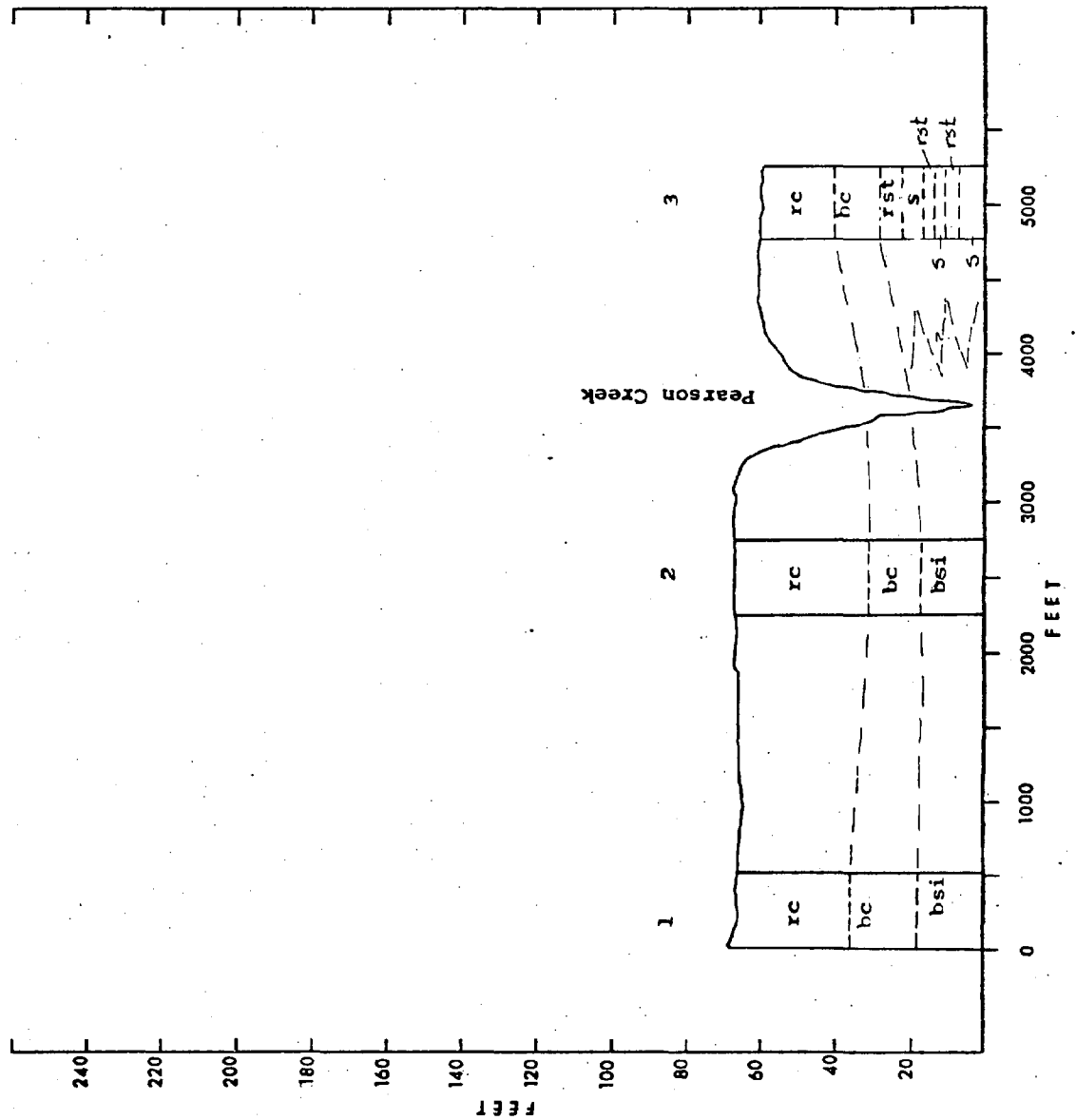
- a) unvegetated protected lobes of red clay that have flowed over silt unit
- b) slump blocks of red clay; vegetated on backs; protected but occasionally unprotected
- c) unvegetated; protected flow lobes of red clay
- d) vegetated horsetails; slumped red clay; protected
- e) unvegetated; protected flow lobes of red clay

Beach:

- a) 10-25' wide, sandy with scattered pebbles; occasionally absent due to extensive flows
- b) 3-8' wide, width variable; sandy; occasionally absent due to slump blocks and mudflows
- c) 10-25' wide; sandy, with scattered pebbles
- d) 40-50' wide; sandy, cobbly in swash zone and 20' back



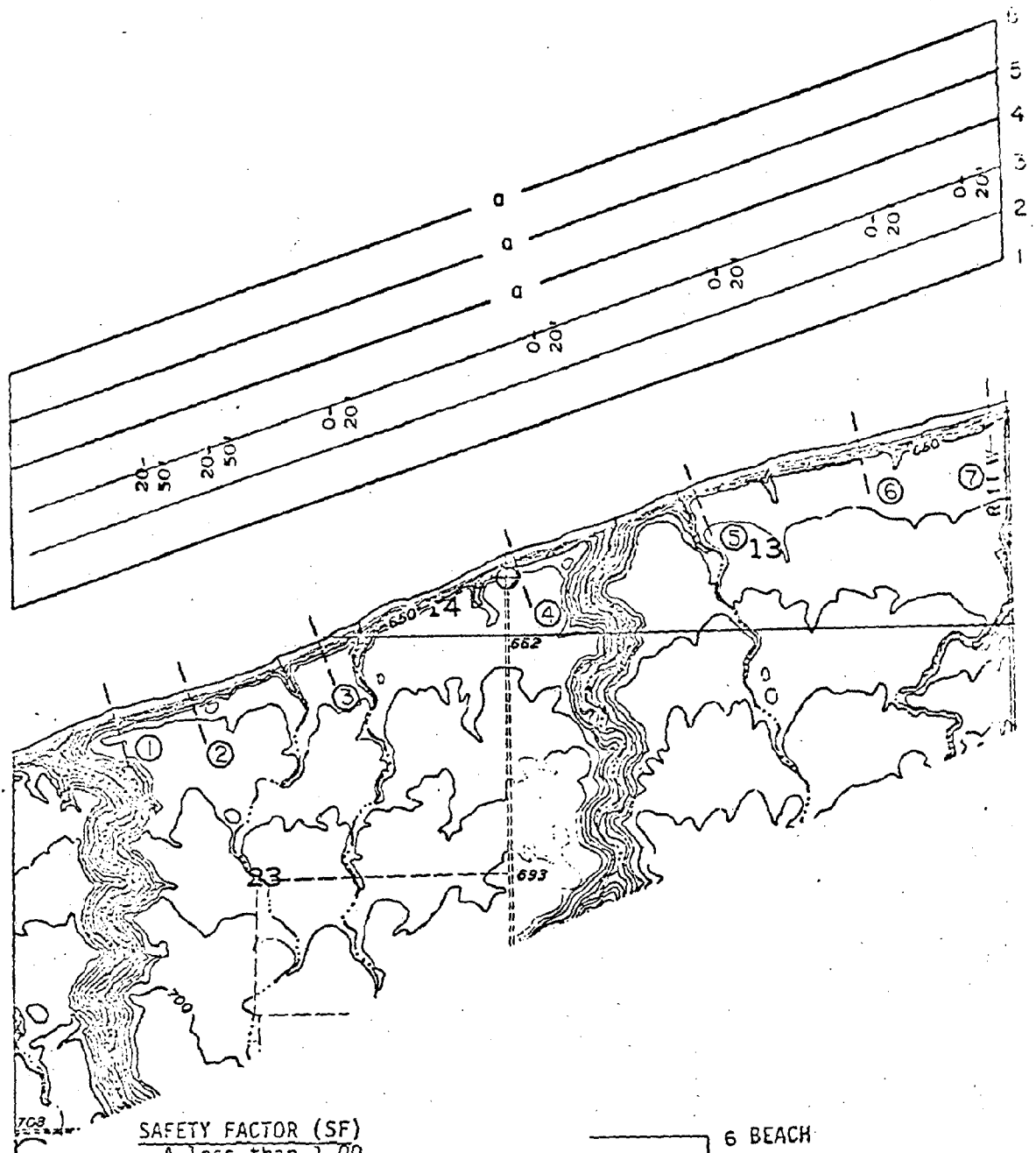
T.49 N., R.11 W., Sec. 22



Borehole Site 3

Borehole Site 3 is located in Reach 2 and extends from west of Haukkala Creek to a point midway between Nelson and Fisher Creeks. This study area includes 2.2 miles of shoreline in Sections 23, 14, and 13 in Township 49 north, Range 11 west in Douglas County. The shoreline is dominated by erodible bluffs which range from 50 to 65 feet in height. Haukkala Creek, Nelson Creek, and three unnamed streams dissect these bluffs.

The bluffs at this site have geological units similar to those identified at Site 2 one mile to the west. In the western end of the site, the two clay units are underlain by a unit of well-sorted sand (see Profile 1). Further to the east, the lower, browner clay is intermittently exposed at the bluff toe. The two-clay units are occasionally separated by a thin lense of sand (see Profile 2). Gray clay, which may represent an inclusion within the silty-clay soils, is present at one location within the study area (see Profile 6). Bluff failures primarily in the form of large-scale rotational slumps result from the continual erosion of the bluff toe (see Profiles 1 and 4). Beaches, generally less than 10 feet in width, provide little protection from this wave action. The removal of vegetation by large-scale rotational slumping has increased the susceptibility of the site to translational slides and saturated earth flows.



SAFETY FACTOR (SF)

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-at boreholes
(high confidence)
- B-near boreholes with
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)

- 6 BEACH
- 5 TOE
- 4 BLUFF
- 3 STABILITY LINE
- 2 CONFIDENCE LEVEL
- 1 SAFETY FACTOR

APPROXIMATE SCALE
1 inch = 1500 feet

Borehole Site 3

Bluff:

- a) 80% to 100% vegetation except where large scale rotational slumping has occurred, flows and translational slides present locally.

Toe:

- a) Wave cut with local slump blocks and flow terraces

Beach:

- a) 0 to 10 feet, sand; greater than 30 feet near streams, and gullies.



vegetation
AB - 10%
BC - 70%
CD - 0%

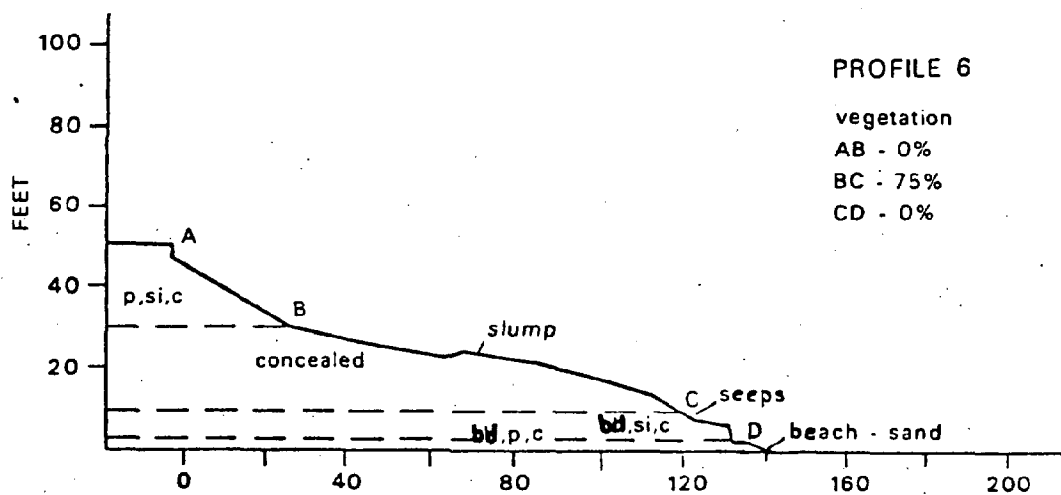
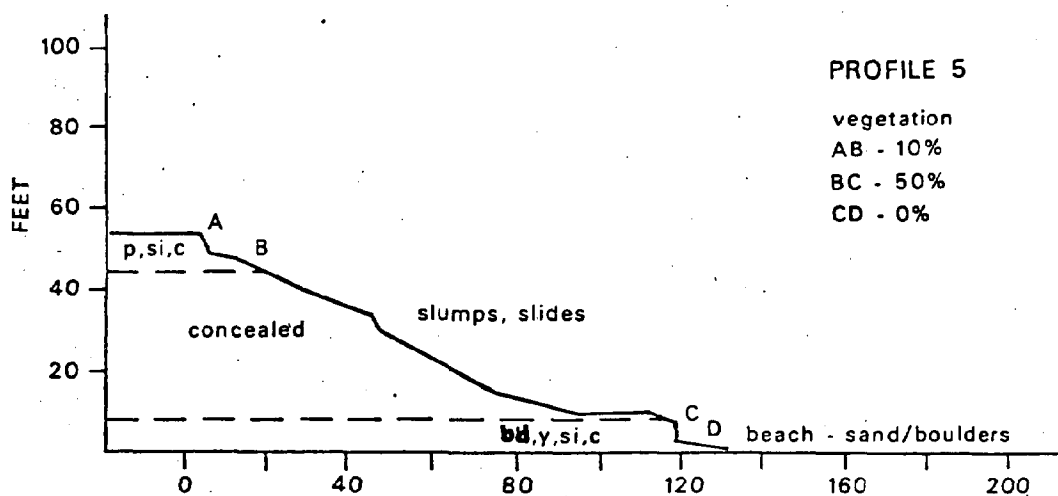
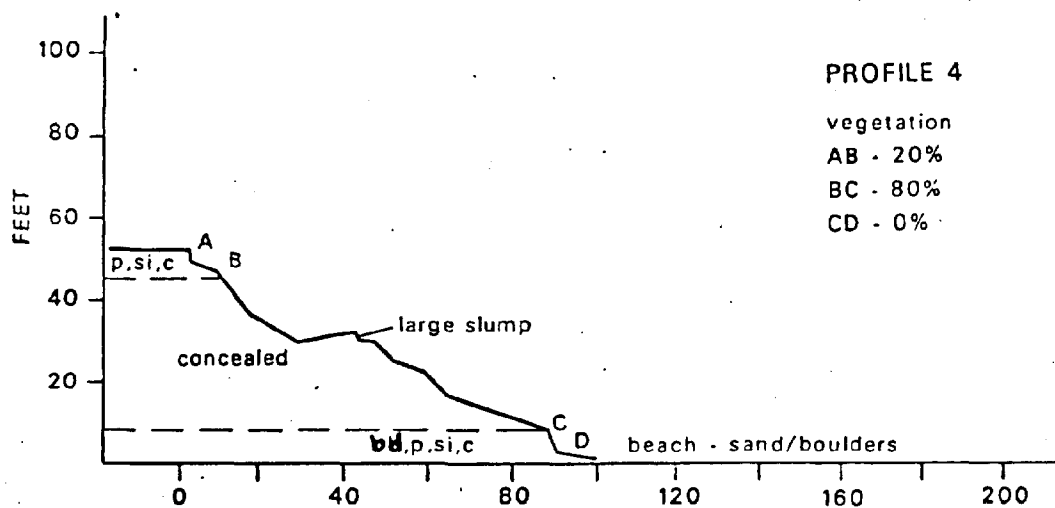


vegetation
AB - 90%
BC - 10%

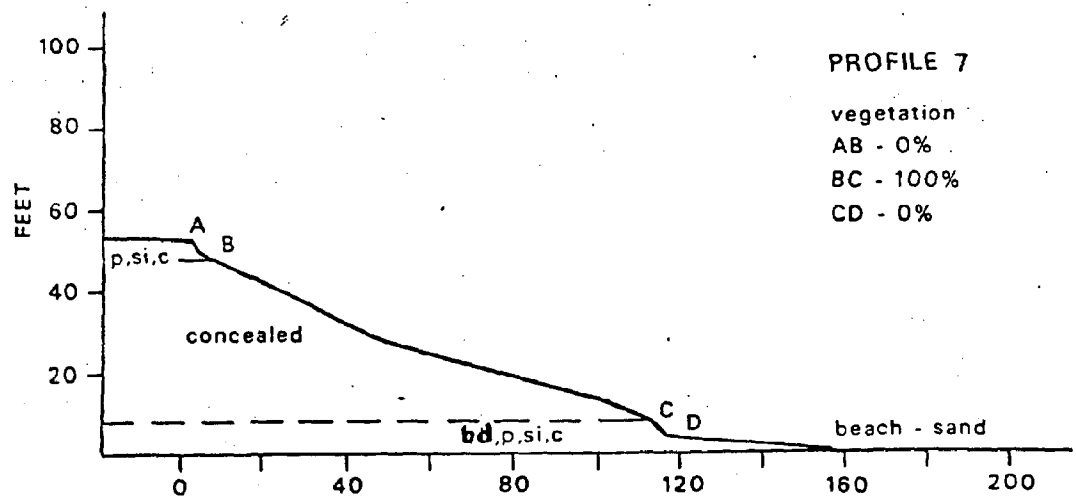


vegetation
AB - 80%
BC - 0%

T.49N.,R11 W.,SEC 13



T.49N.,R11 W.,SEC 13



Section 23/14, T 49 N R 11 W

This section is located to the west of Windy Lane, a road which meets Highway 13 one mile west of Cloverland. The section is bisected by Haukkala Creek. In this section, the bluff height slowly decreases steadily from 55 ft. to 45 ft. Similarly, a silty unit, which occurs in the sections to the west, become less visible to the east and is absent by the center of the section. The silty unit here contains a large amount of sand. Failure in this unit is uncommon and, when exposed, has an eroded appearance. The overlying 20 ft. of brown clay and 30 ft. of red clay are similar in type of failure. Occasionally, a large rotational slump occurs, but shallow slides are more common. -In the more vegetated reaches, occasional scarps are noticeable, signifying renewed failure. In the western third, vegetation is sparse and consists of horsetails, and trees and grasses being rafted down from the failing crest by shallow slides. In the remainder of the section, though not entirely stable, grass and alder cover 80-90% of the hummocky bluff face. In some subsections the beach is wide and the toe is mostly protected. In the other subsections, the beach width is variable and often absent, leaving the toe unprotected from wave erosion. Access to the shore in the section is poor. No development is present at this time along the bluff.

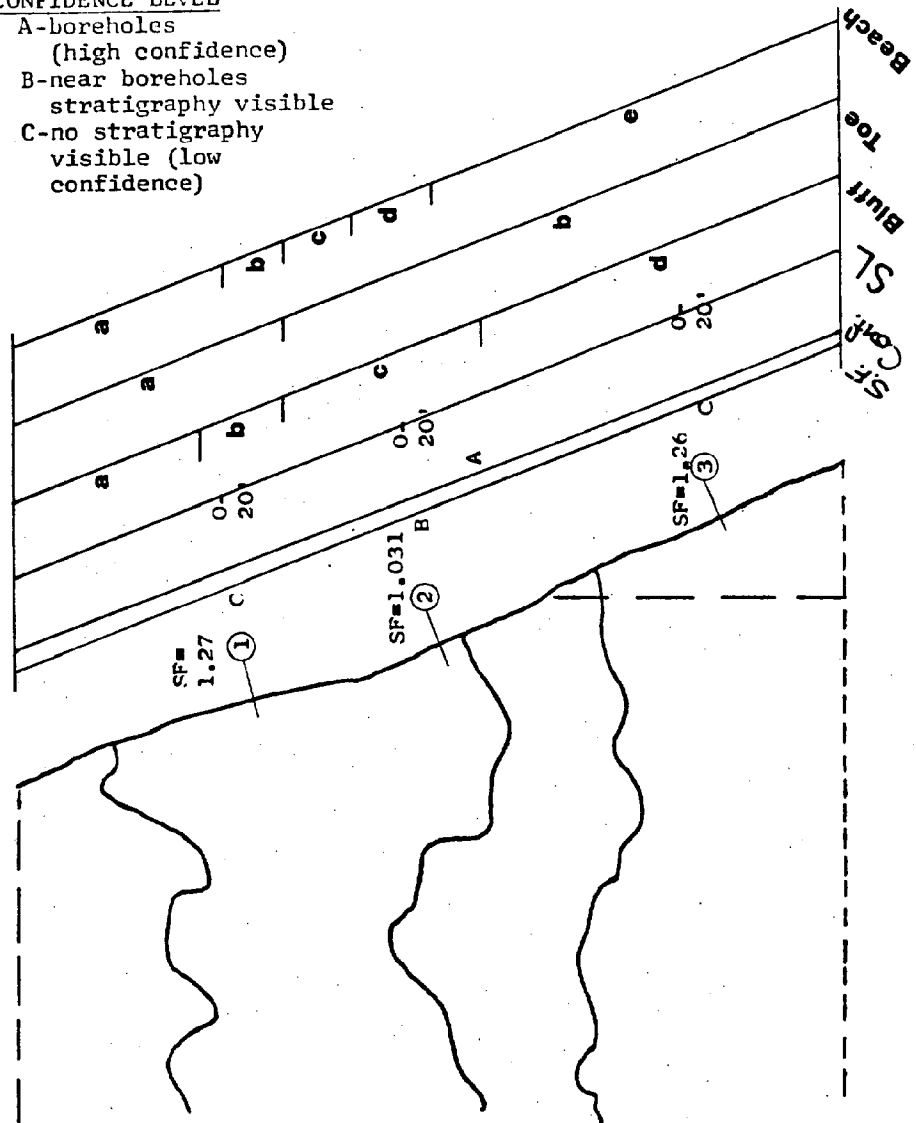
SEC 23/14 T49 N R11 W

SAFETY FACTOR

- A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
 (high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



Sec. 23/14, T 49 N, R 11 W

Bluff:

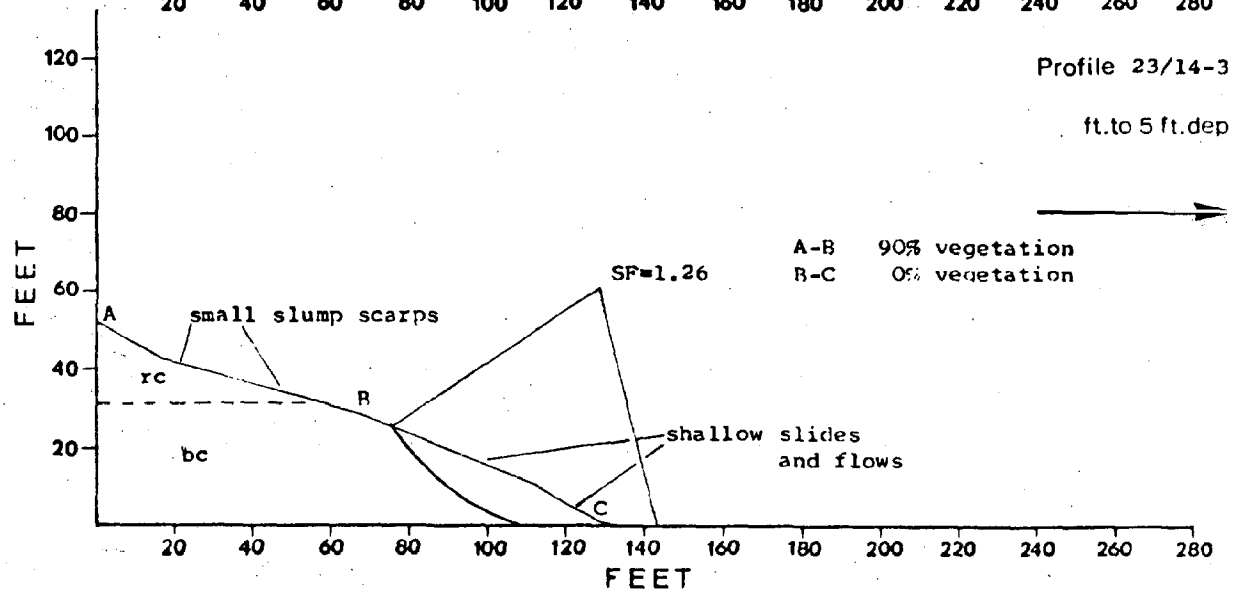
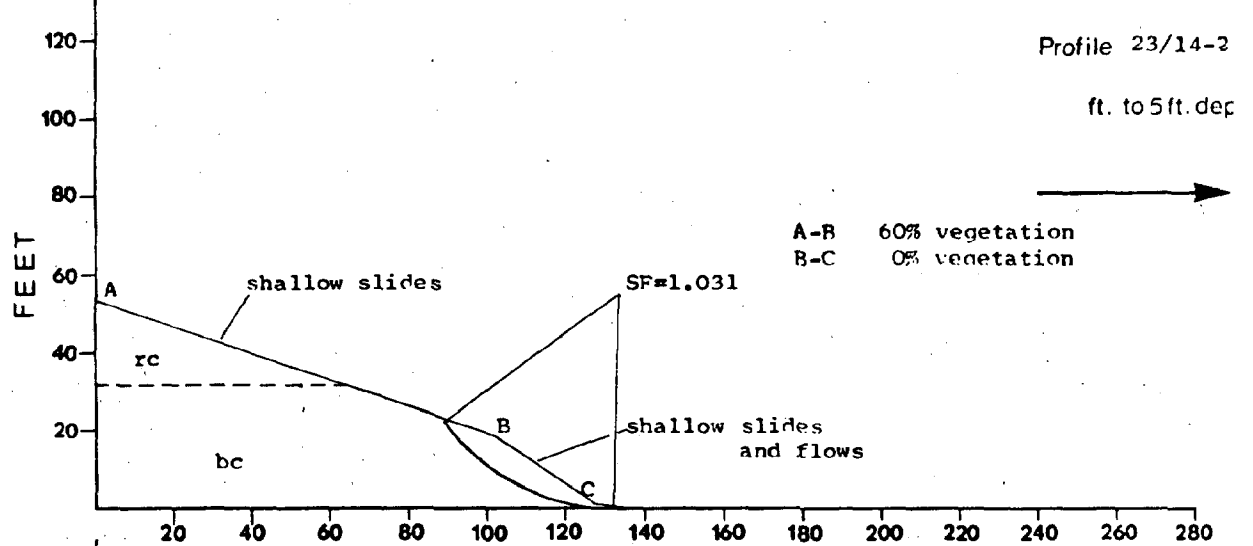
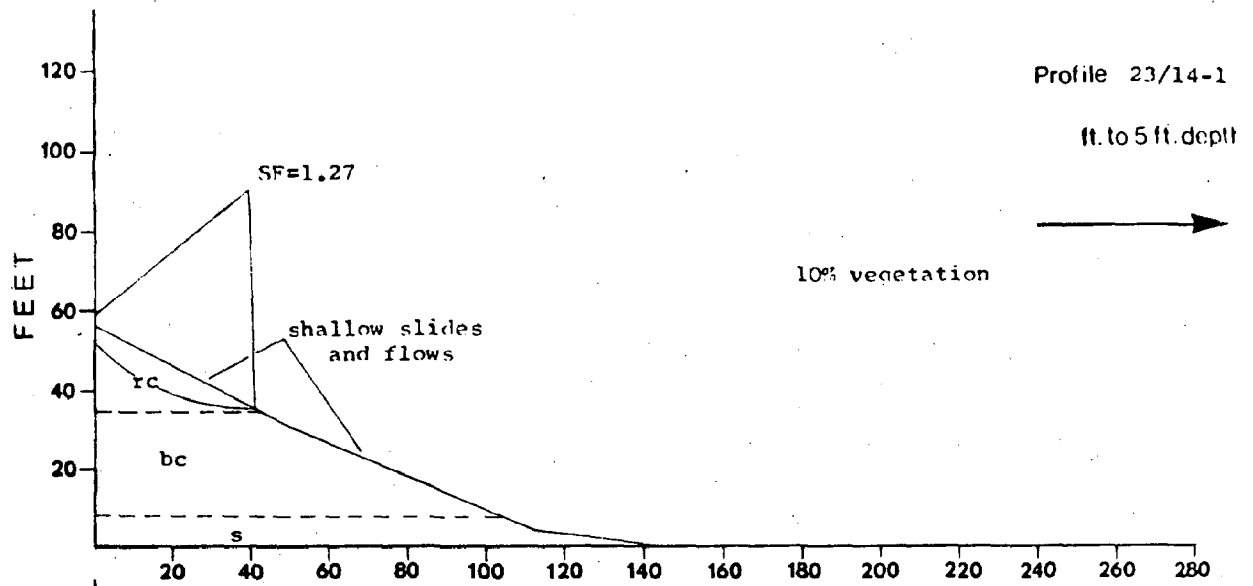
- a) 10-20% vegetation with occasional alder or birch clump; red to brown clay over sand with till; shallow slides and mudflows; 55-60 ft high; crest fairly even; sand with till forms bench.
- b) 10% vegetation; with grass tufts and birch clump; steep failing slope; red to brown clay over sand with till; 60-65' high
- c) 80-90% vegetation; horsetails and alder; hummocky rounded bluff face; clay over sand with till (?); even crest 55-60'
- d) 50% vegetation with grass birch and alder, red over brown clay: shallow slides with scarps common: 50-55' with even crest

Toe:

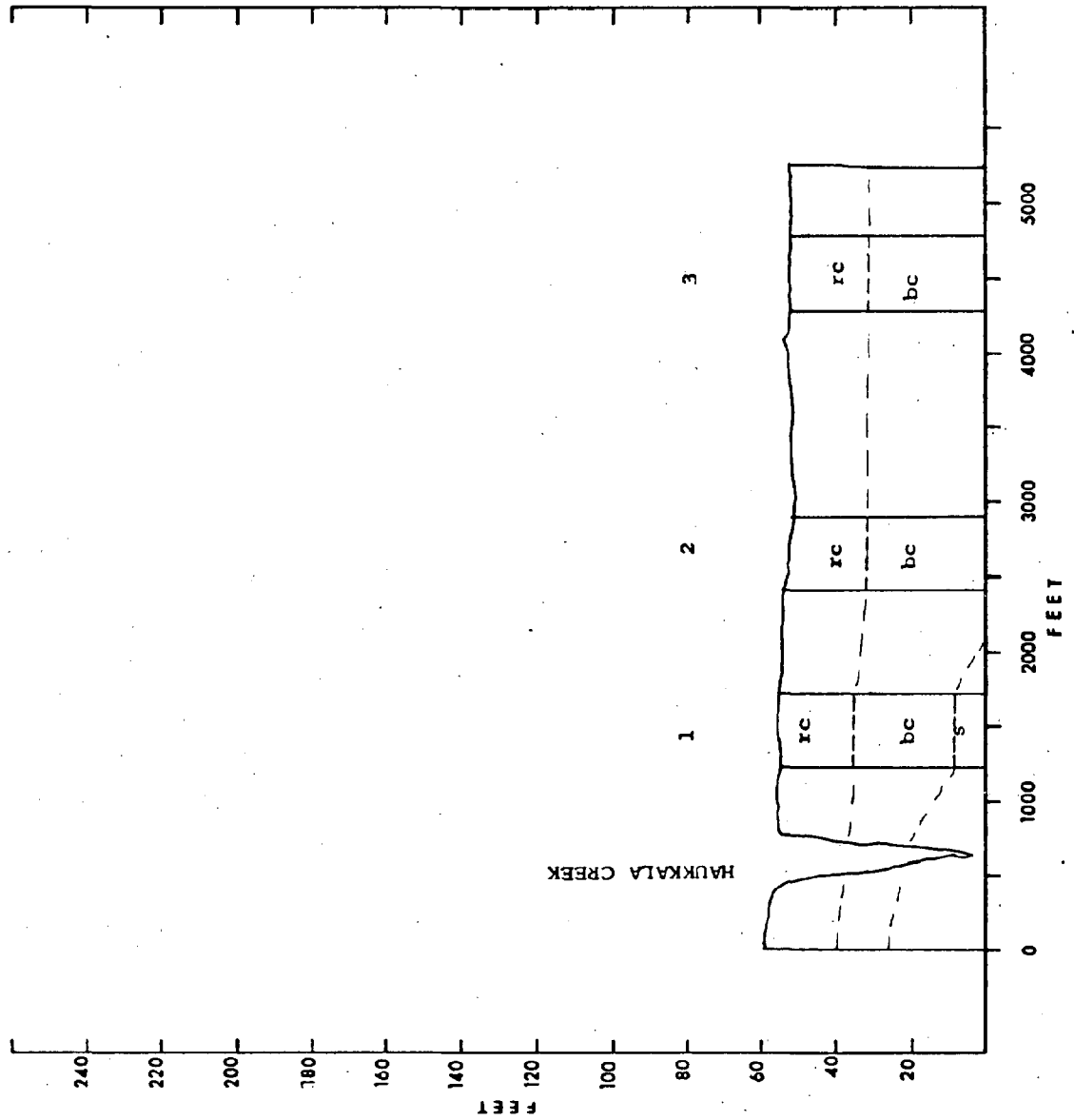
- a) unvegetated protected lobes of mudflow red clay that have flowed over sand with till bench
- b) rounded, slumped red clay, unprotected with occasional tree clumps

Beach:

- a) 3-8 wide; sandy with cobbles and boulders; occasionally absent
- b) 20-30' wide; sandy with scattered pebbles; lots of driftwood
- c) 3-8' wide; sandy with occasional boulders; occasionally absent
- d) 20' wide; sandy with pebbles at shore
- e) 3-8' wide; sandy with occasional boulders, occasionally absent



T.49 N., R. 11W, Sec. 23/14



Section 13, T 49 N R 11 W

The section is located four miles west of the mouth of the Brule River. The beach is not present throughout the section, being absent or nearly so for about a quarter of a mile in the middle. West of this it begins at 15-20 ft. in width widening to 40 ft. Eastward it reappears at 10-20 ft. for the remainder. When present, it is sandy and boulders are quite frequent throughout. The bluff declines slowly from 50-55 ft. in the west to 30-40 ft. in the east and is moderately to well vegetated throughout. It is failing by two mechanisms. At the west end, repeated shallow sliding predominates, producing an evenly-sloped hummocky surface. At the east end, failure is by large, single-block sliding of moderate depth; this produces a broadly stepped profile. A long subsection in the middle shows elements of both mechanisms. The bluff is composed of a red clay, mostly slumped, covering a brown clay which underlies it. The toe is poorly to partially protected on the average and is composed of slumped red clay. Although there is reasonable access to the section, use seems to be limited.

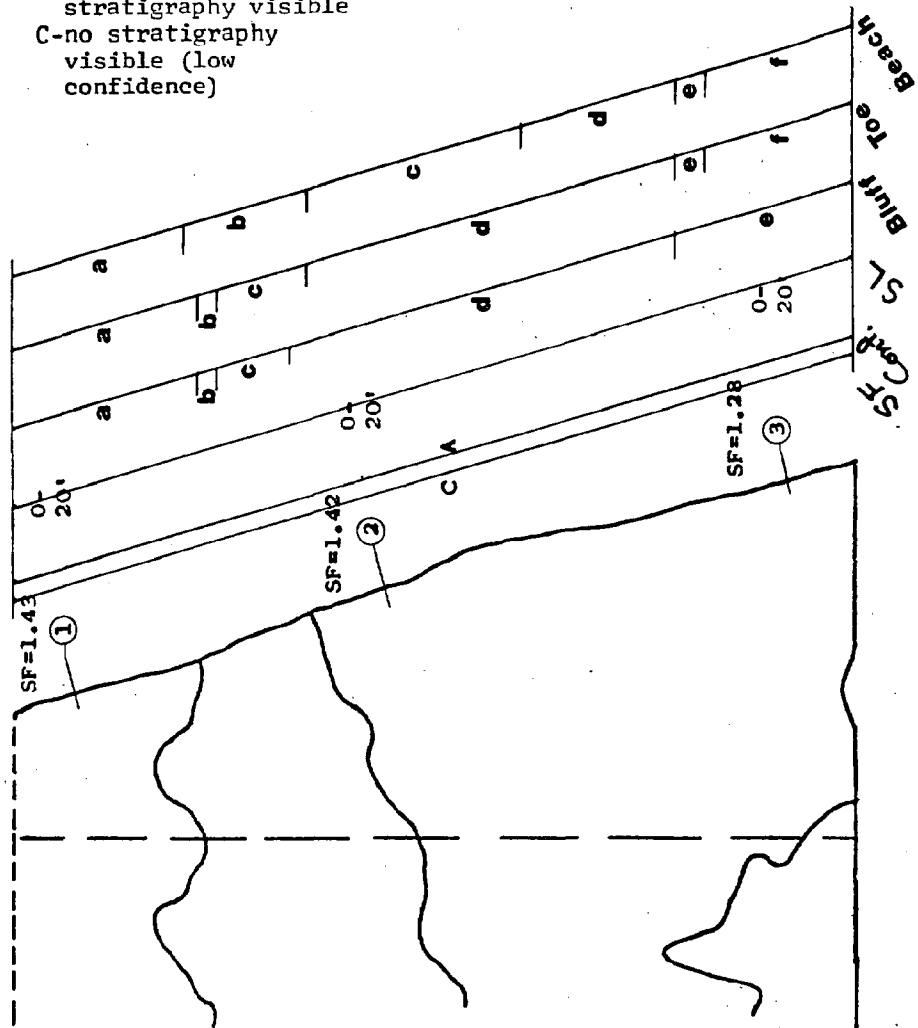
SEC 13 T49N R11W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 13, T 49 N, R 11 W

Bluff:

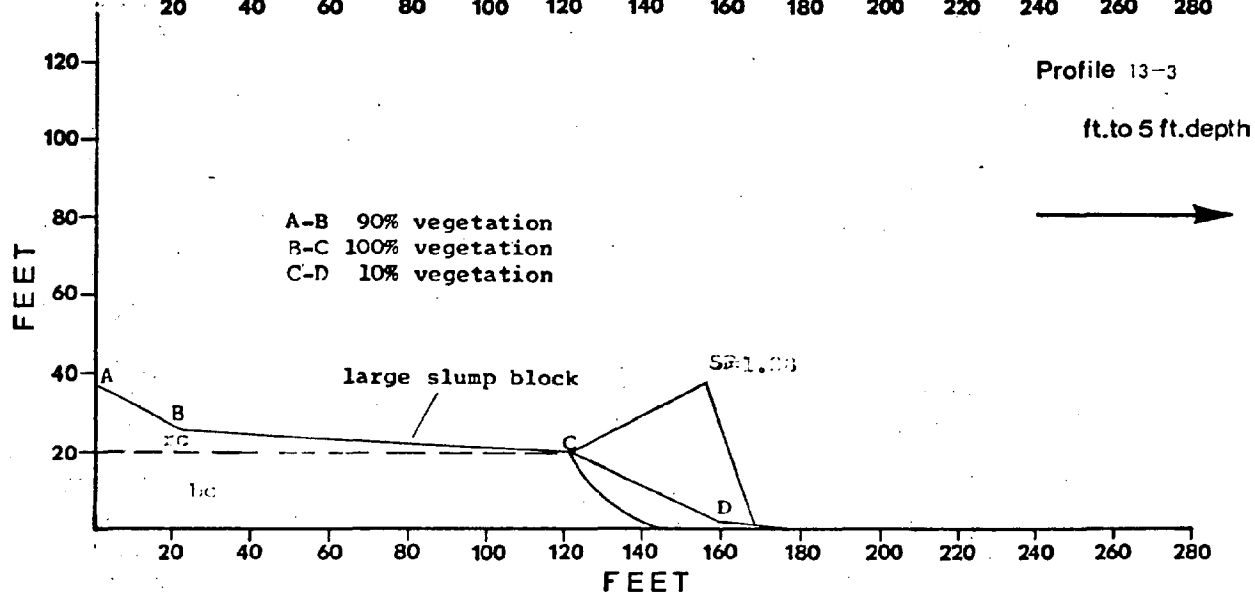
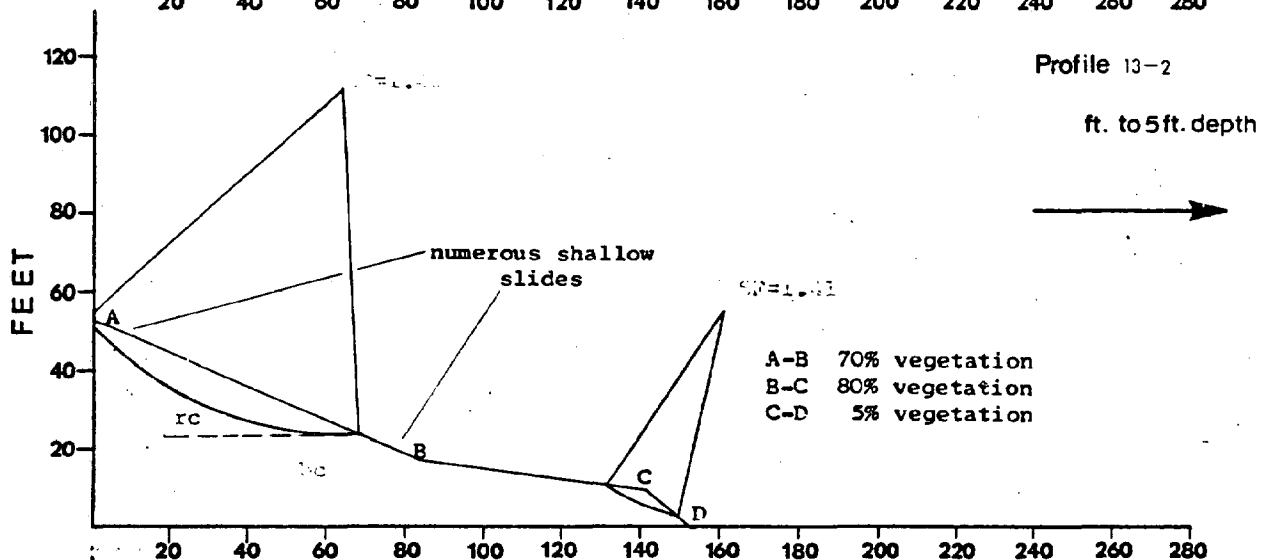
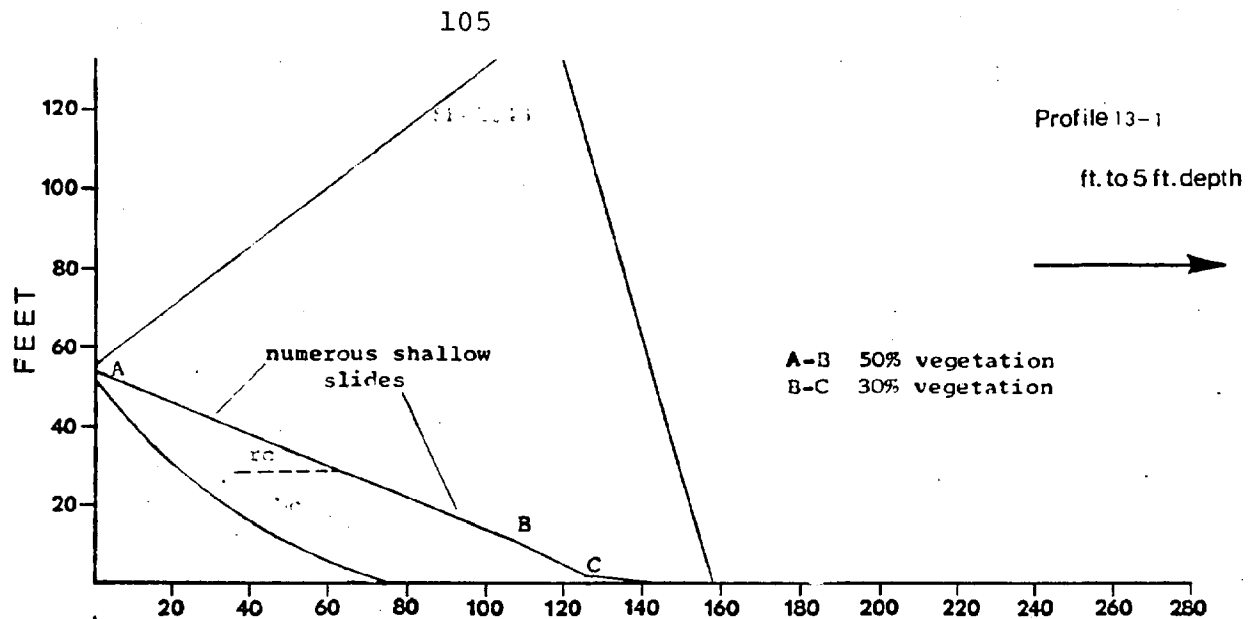
- a) 50-55 ft; crest scalloped and scarped; shallow sliding slumps; 70-90% alder and grass silty clay over clay
- b) absent-estuary
- c) 50-55 ft; single block slide with shallow failure above and below; 60% alder and grass; slumped silty clay over clay
- d) 40-50 ft. declining to east; crest scarped and scalloped; poorly expressed single block failure; numerous shallow failures - hummocky; vegetated 40-80% birch, alder and grass, horsetails; silty clay over clay
- e) 35-40 ft; broadly scalloped; single-block moderately-deep slide, shallow sliding on main and toe scarps; vegetated 70-90% alder and grass

Toe:

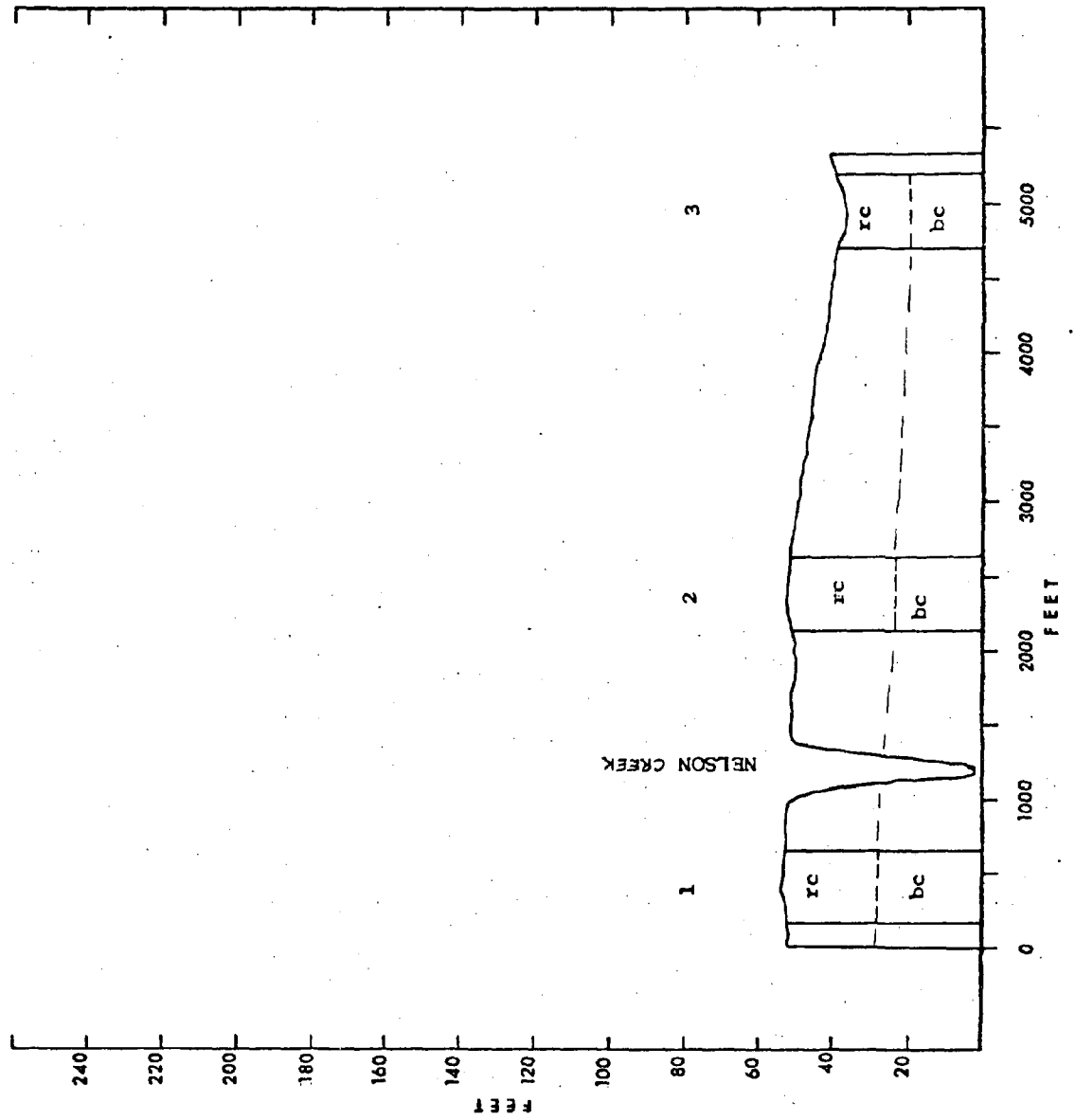
- a) partially protected, slumped silty clay
- b) absent-estuary
- c) protected, rounded slumped silty clay
- d) poorly protected, slumped silty clay - in situ clay
- e) unprotected, slumped silty clay and in situ clay
- f) partially protected, silty clay and in situ clay

Beach:

- a) 15-20 ft; discontinuous, coarse sand with boulders offshore
- b) 40 ft; coarse sand with pebbles boulders at water
- c) 0-5 ft; coarse sand, boulders offshore under waves
- d) 15-20 ft, discontinuous; coarse sand, boulders offshore
- e) absent-boulders
- f) 10-15 ft; coarse sand boulders offshore



T.49 N., R. 11 W., Sec. 13



Section 18, T 49 N R 10 W

This section is located three miles west of the mouth of the Brule River. There is a beach present along most of the section. To the west it is sandy and discontinuous, 10-20 ft. wide with boulders offshore. It widens to the east to 60-70 ft. The bluff is 50 ft. high at the west end, drops to 35 toward the middle, and rises to 40-45 ft. at the east end of the section. It is well-vegetated except near the stream mouths, where the bluff is usually much steeper than elsewhere. Failure is by many processes and is quite varied spatially. It is usually marked by a single slump block 10-20 ft. deep across its top. The slide may be anything from shallow to moderately deep. The top of the block is frequently hummocky and ponded, and it may be tilted forward or backwards. The long scarp above the block may be hummocky and well-vegetated or actively sliding and flowing. The front of the block forms the toe and is usually scarped and failing by sliding and flowing. The bluff is composed of a red clay, which contain a fair amount of silt. A browner clay is occasionally exposed near the toe, but the contact is obscured by the failure. The toe is composed mostly of slumped clay and its degree of protection is directly related to the width (or absence) of the beach. There is good access at the west end of the section, but use appears limited.

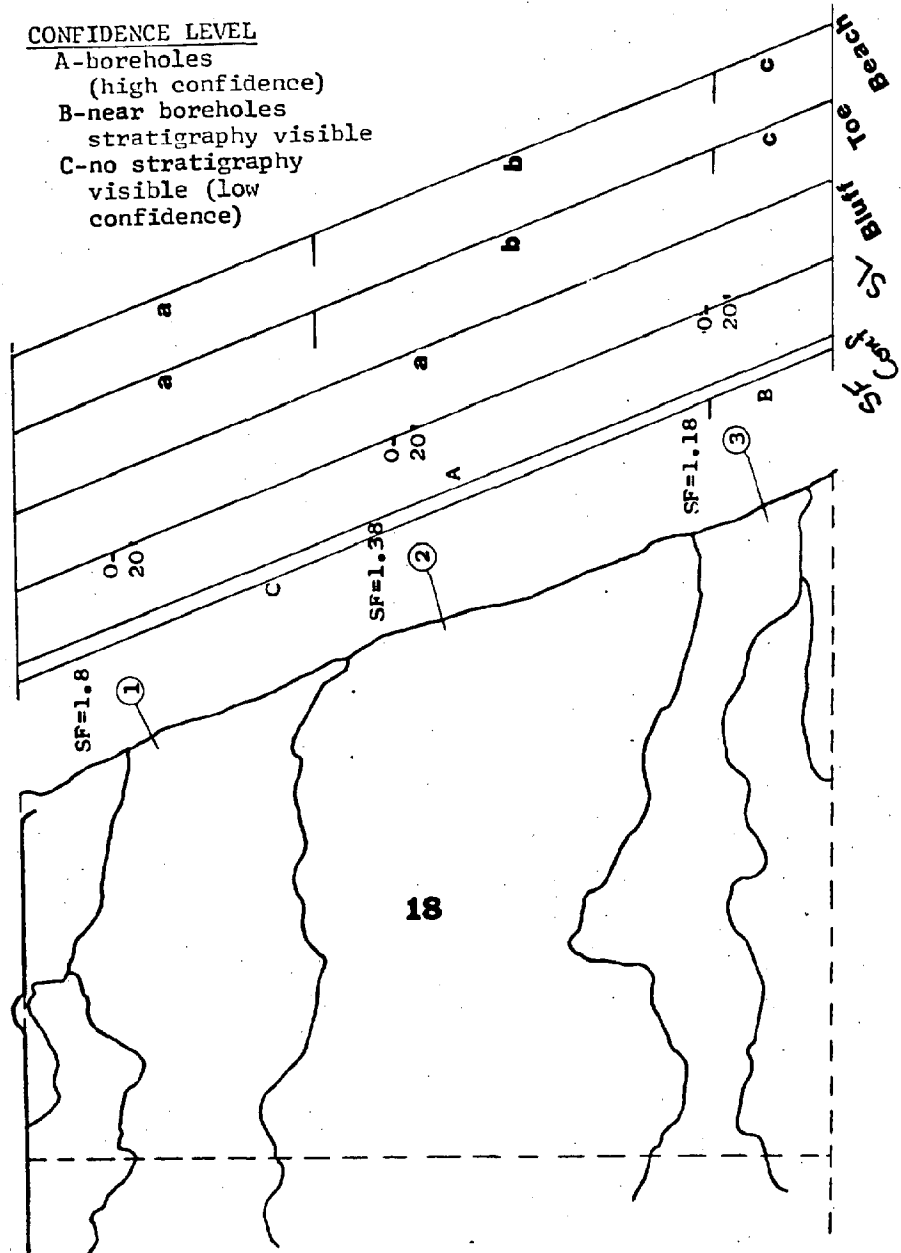
SEC 18 T49N R10W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 18, T 49 N, R 10 W

Bluff:

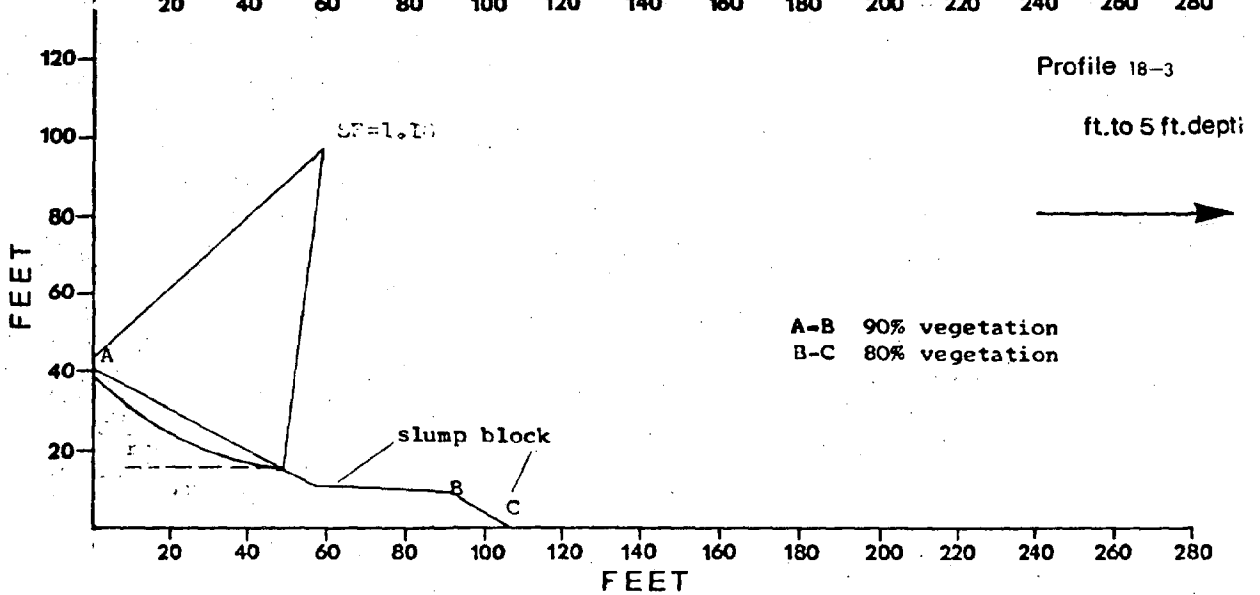
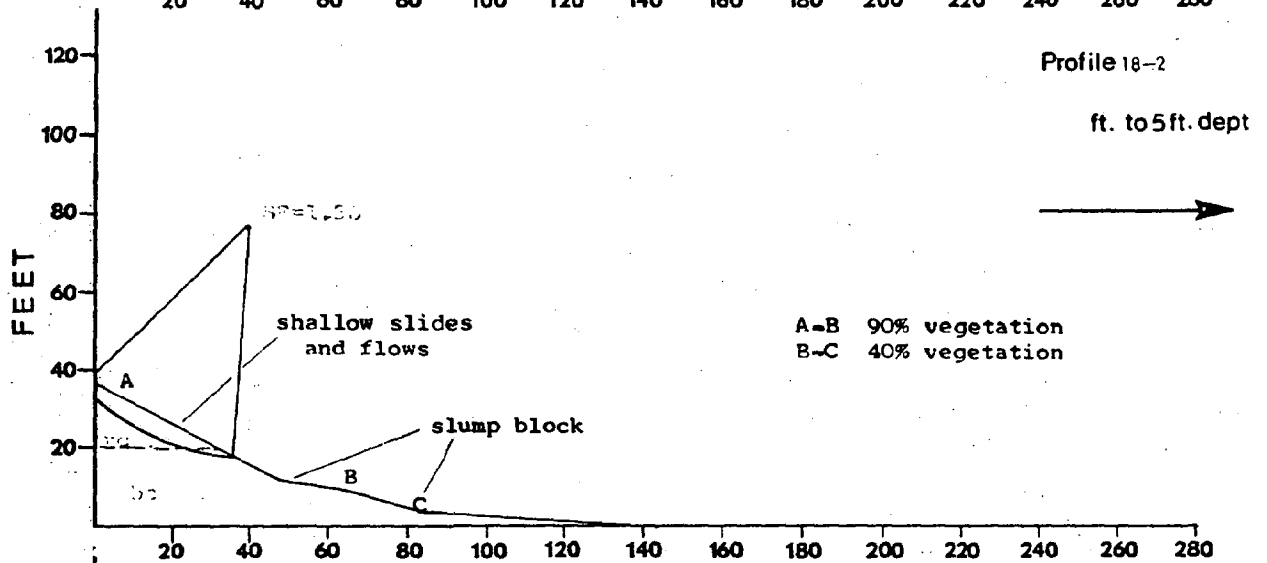
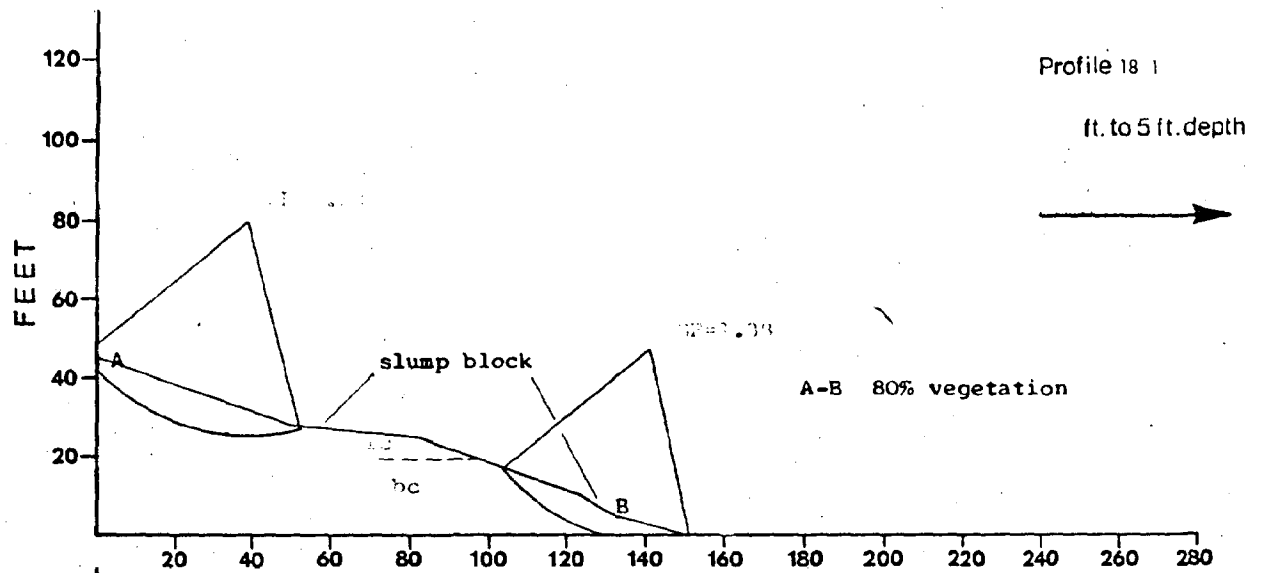
- a) 50 ft at west, dropping to 35 in middle and rising back to 40 ft at east; crest broadly scalloped, both scarped and rounded; failure is by many processes and is quite varied spatially: large rotational slumps, slides and flows on slump scarp; brown silty clay; birch, alder, grass, moss and horsetails.

Toe:

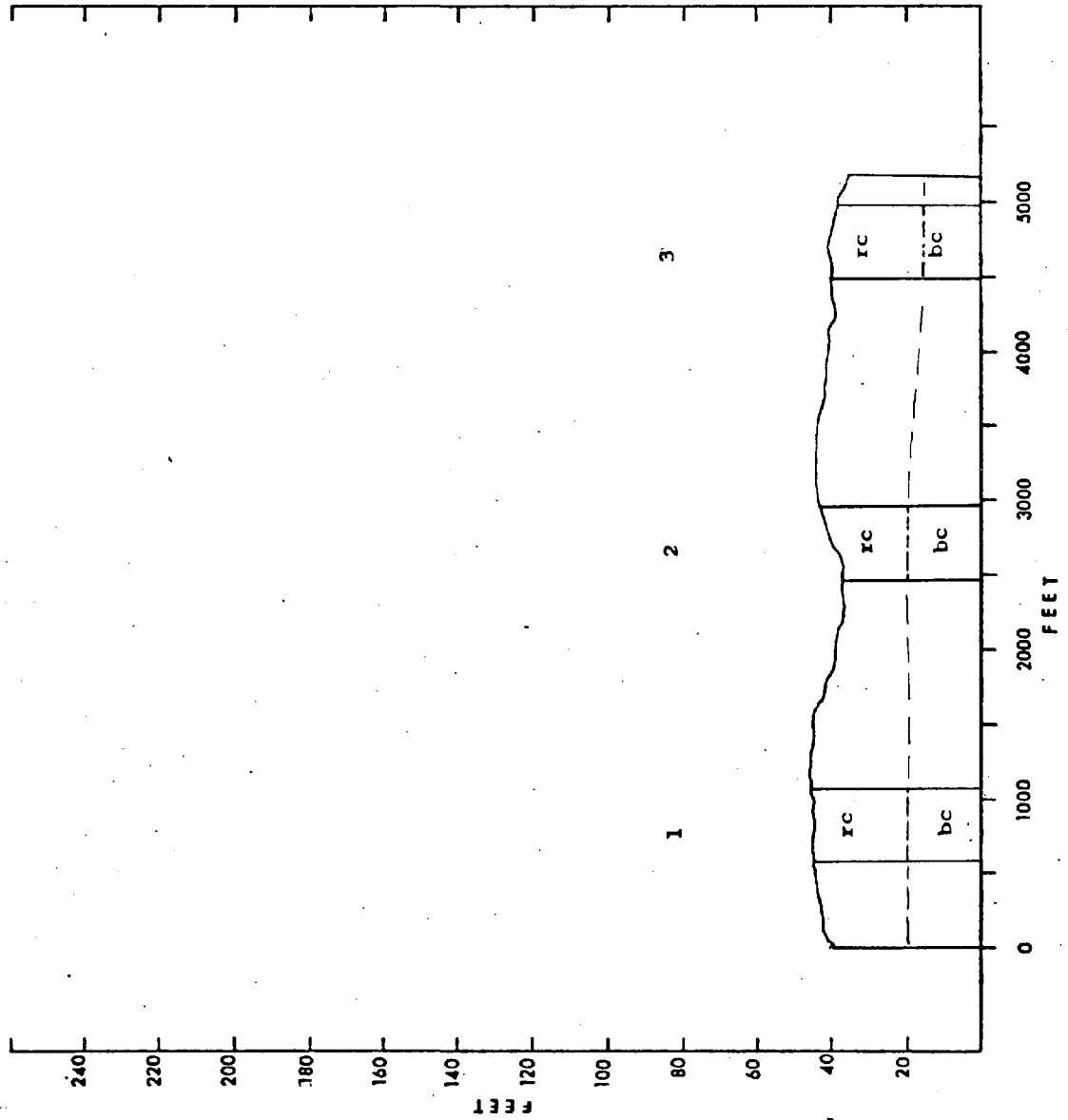
- a) partially protected, but may be either rounded and vegetated or scarped and flowing; slumped silty-clay
- b) protected, rounded and vegetated but occasionally scarped and flowing; slumped silty-clay
- c) unprotected, scarped and flowing

Beach:

- a) 10-20 ft, discontinuous coarse sand with boulders frequent offshore
- b) 60-70 ft; coarse sand with boulders frequent offshore
- c) absent; boulders offshore



T. 49 N., R. 10 W., Sec. 18



Section 17/8, T 49 N R 10 W

This section is located 2 miles west of the mouth of the Brule River. West of Smith Creek the beach is either absent or frequently interrupted. Where present in these subsection, it is sandy, 10-20 ft. wide with boulders offshore throughout. A 40-60 ft. wide sandy spit is built across the Smith Creek estuary, some of which is vegetated. East of Smith Creek the beach narrows to 20-30 ft. The bluff is 35-40 ft. high and moderately to well-vegetated throughout. Failure is by shallow sliding with blocks of varying size and number, and by flowing. In the eastern half, there is a single, large block, and the sliding is perhaps the deepest here. There is additional sliding and flowing above and below this block. Between this subsection and Smith Creek, the sliding becomes quite shallow and is much mixed with flowing. East of Smith Creek, numerous shallow slides are present above a subdued larger block. The bluff is composed of a red clay, which is underlain by a brown clay. The toe is unprotected where the beach is absent, partially protected elsewhere; but it is only wholly protected east of Smith Creek. It is composed of slumped clay. Access to the section is quite poor.

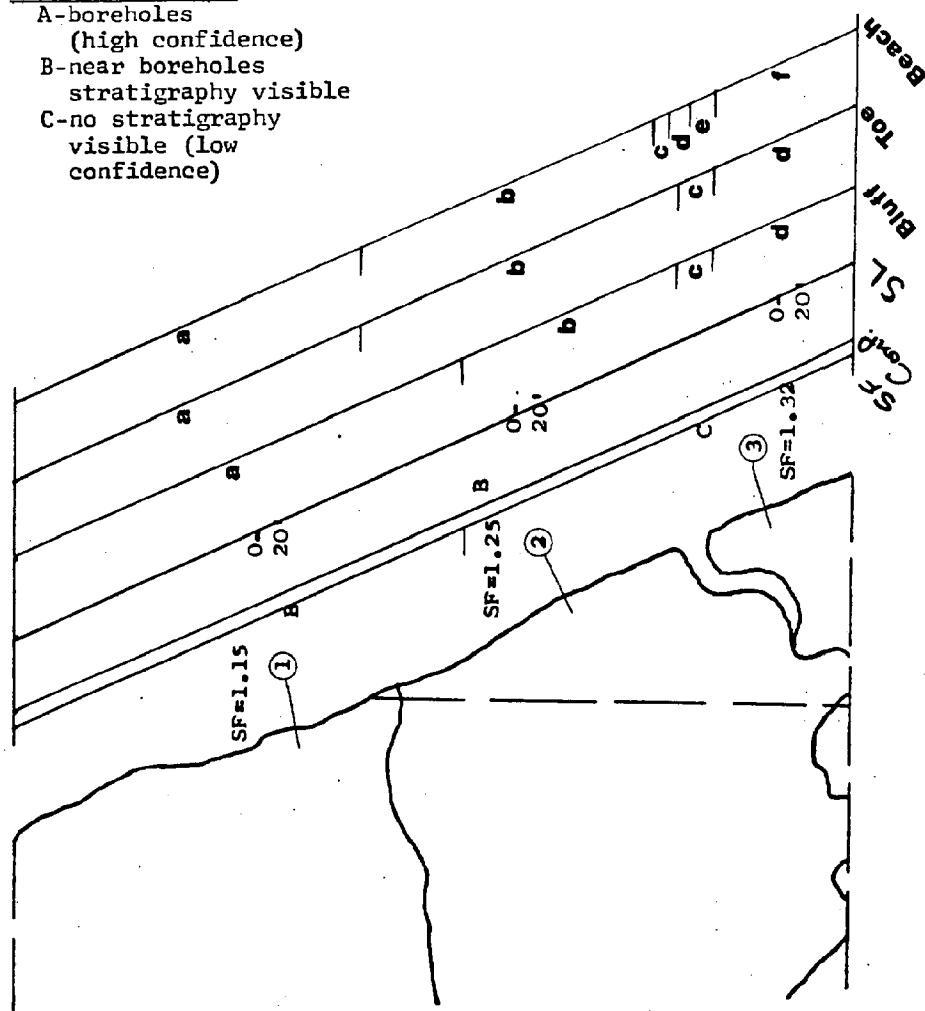
SEC 17/8 T49 N R10 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 17/8, T 49 N, R 10 W

Bluff:

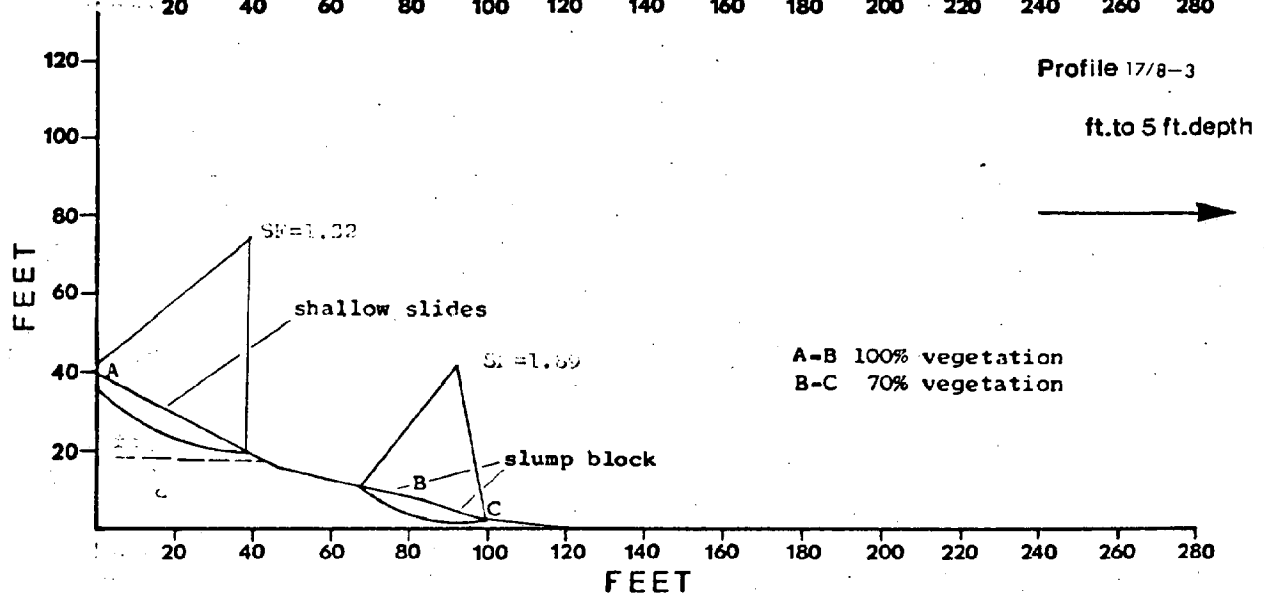
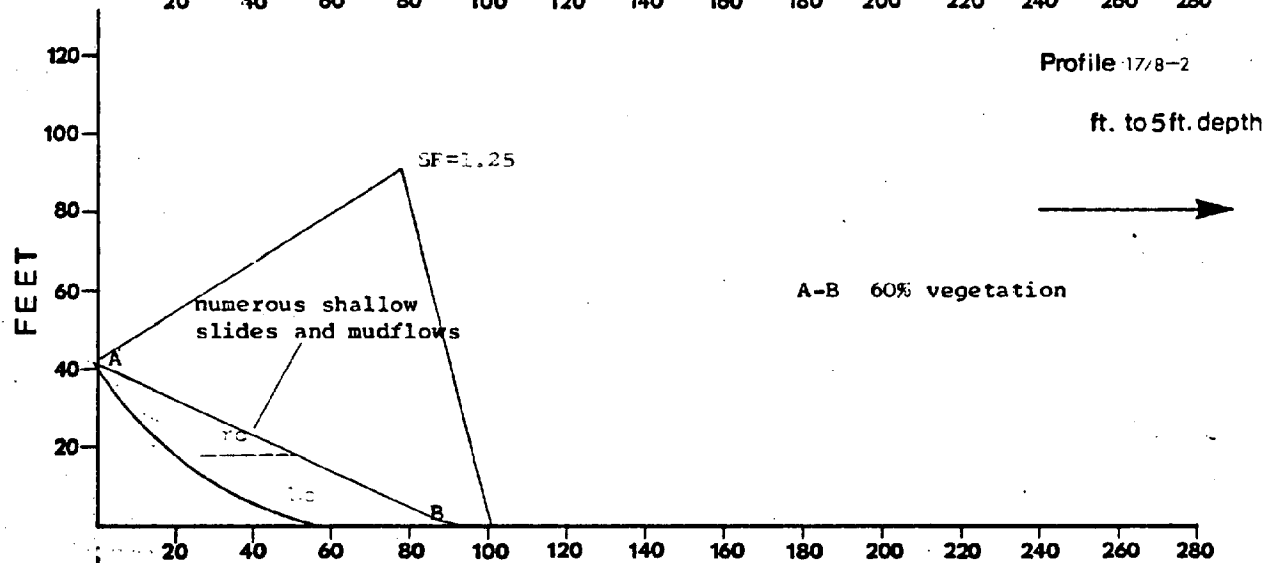
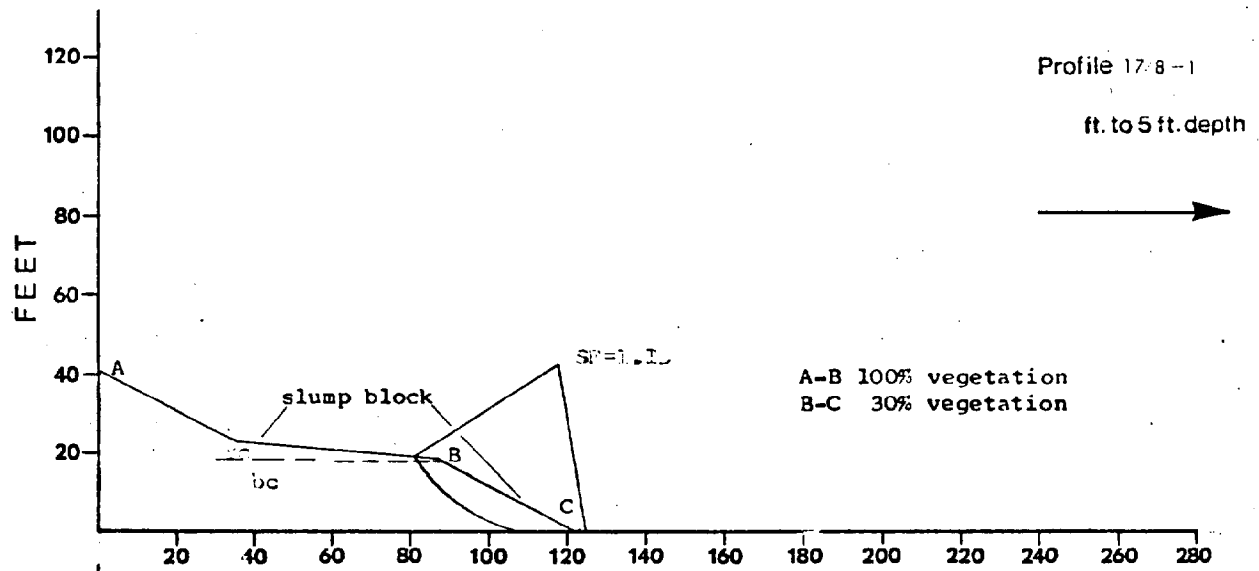
- a) 35-40 ft; crest broadly scalloped, scarped or rounded; single moderately deep slide, shallow sliding and flowing on main scarp and toe; vegetation 70-90%, birch, alder, grass, horsetails; red-brown silty clay, mostly slumped
- b) 35-40 ft. crest scalloped and scarped; shallow sliding and flowing, lacks large single block failure; vegetation 40-60%, alder and grass moving down slope; silty clay
- c) absent - Smith Creek; boulders offshore
- d) 40 ft; crest scalloped, rounded; failing by single block, shallow slide, with sliding and flowing above; vegetation 80-90%, birch, alder, grass, silty clay

Toe:

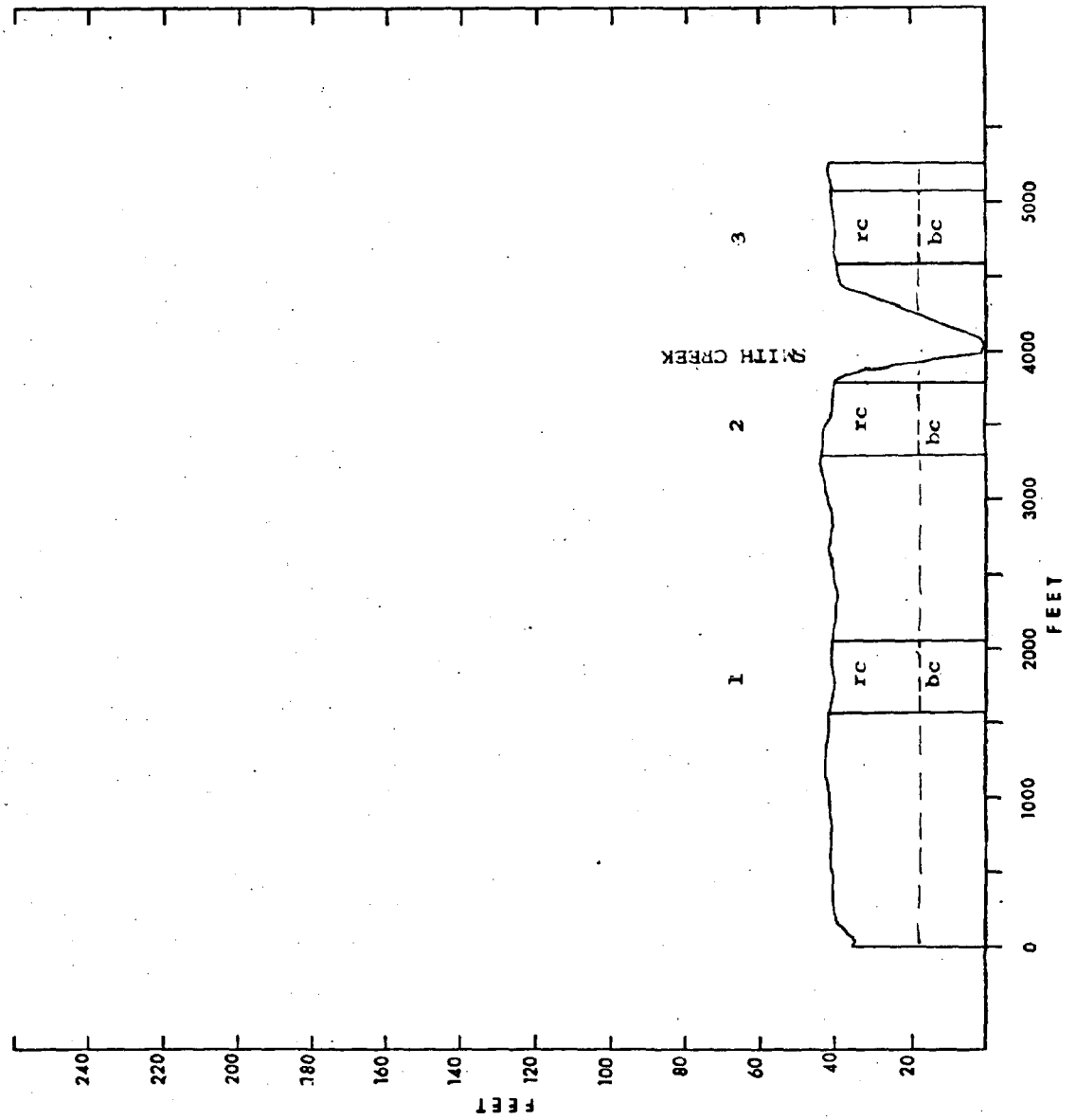
- a) unprotected, scarped, flowing and sliding, slumped silty clay
- b) generally protected, often scarped, flowing and sliding, slumped silty clay
- c) absent - Smith Creek; boulders offshore
- d) protected; slumped silty clay, rounded and vegetated

Beach:

- a) absent, boulders offshore
- b) 10-20 ft; coarse sand often interrupted by toe-flows, boulders offshore
- c) absent - Smith Creek; boulders offshore
- d) 5-10 ft; coarse sand, 2-3 ft wave-cut face at water-line
- e) 40-60 ft. back half vegetated; 2-3 ft. wave-cut face 25 ft from water-line; coarse sand with concentration of pebbles near water, boulders
- f) 20-30 ft; coarse sand occasionally interrupted; concentration of pebbles near water: a .5ft wave-cut face 6-8 ft from toe, boulders



T. 49 N., R. 10 W., Sec. 17/8



Section 9, T 49 N R 10 W

This section is located just west of the mouth of the Brule River. A sandy beach 30 ft. wide, is present along the western half of the shoreline. It then becomes narrower (15-20 ft.) is often interrupted and then widens quickly to 80 ft. The bluff is 40 ft. high to the west declining 35 ft. just west of the estuary after which it is absent. Subsections to the east and west ends are moderately to well vegetated and failing such that one large slump block is well preserved. Shallow sliding of much smaller blocks occurs on the scarp above the block while the scarped toe is more prone to flowing. A short subsection toward the middle is more poorly vegetated and is failing by numerous shallow slides and flows of small scale. The bluff is composed of a red clay, which is underlain by a browner clay. In places medium-coarse sand interbedded with silts and clays may be found between them. These relationships are partially obscured by the slumps and vegetation. The toe is scarped and composed of slumped and in situ clay along the western three-quarter. The eastern quarter is well-rounded and vegetated. There is good access to the very small western-most portion of the shore but the estuary is unpassable at present.

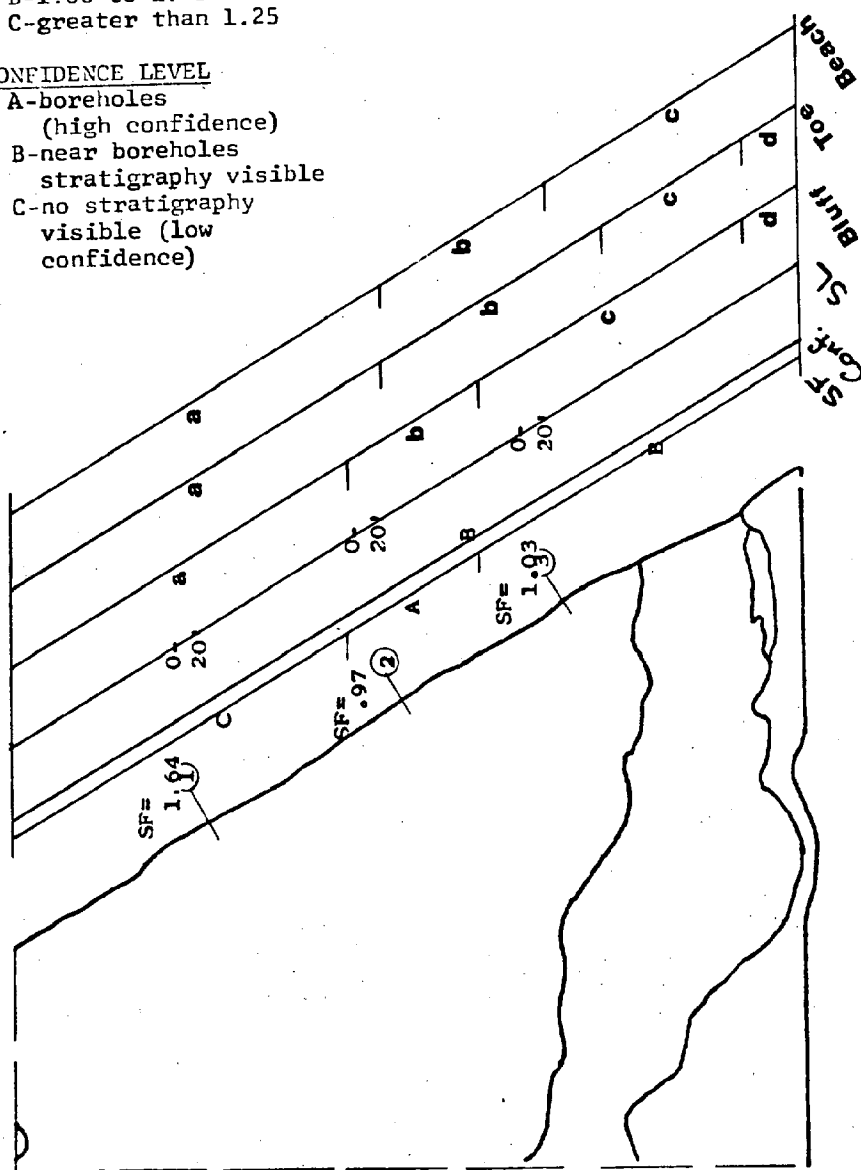
SEC 9 T49N R10W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 9, T 49 N, R 10 W

Bluff:

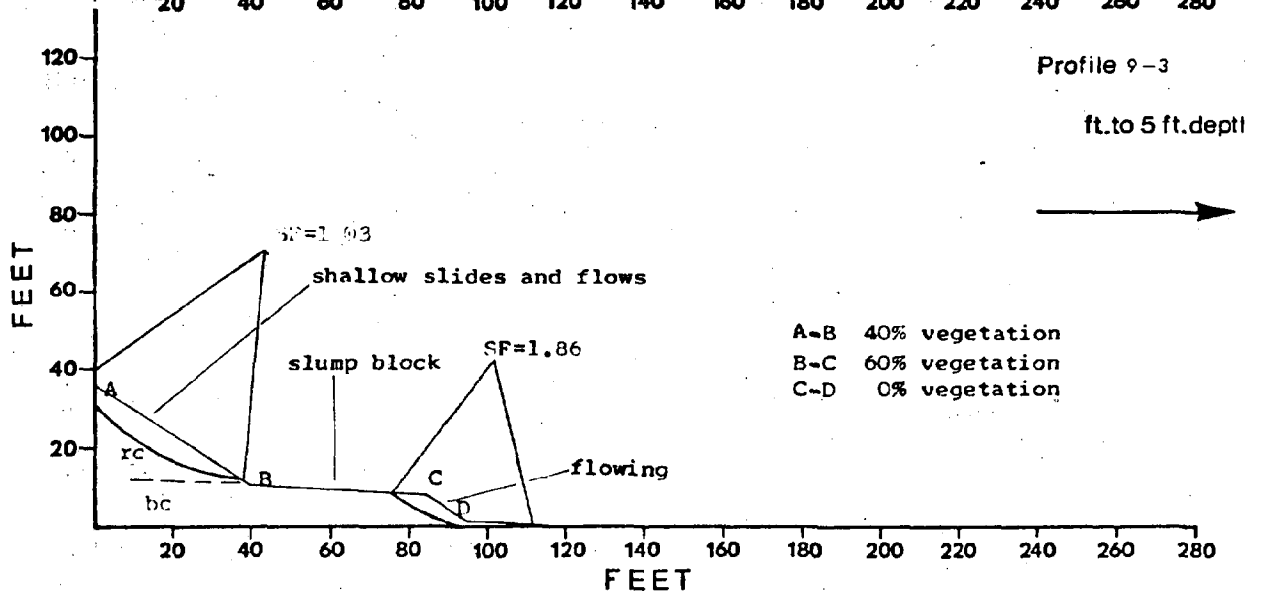
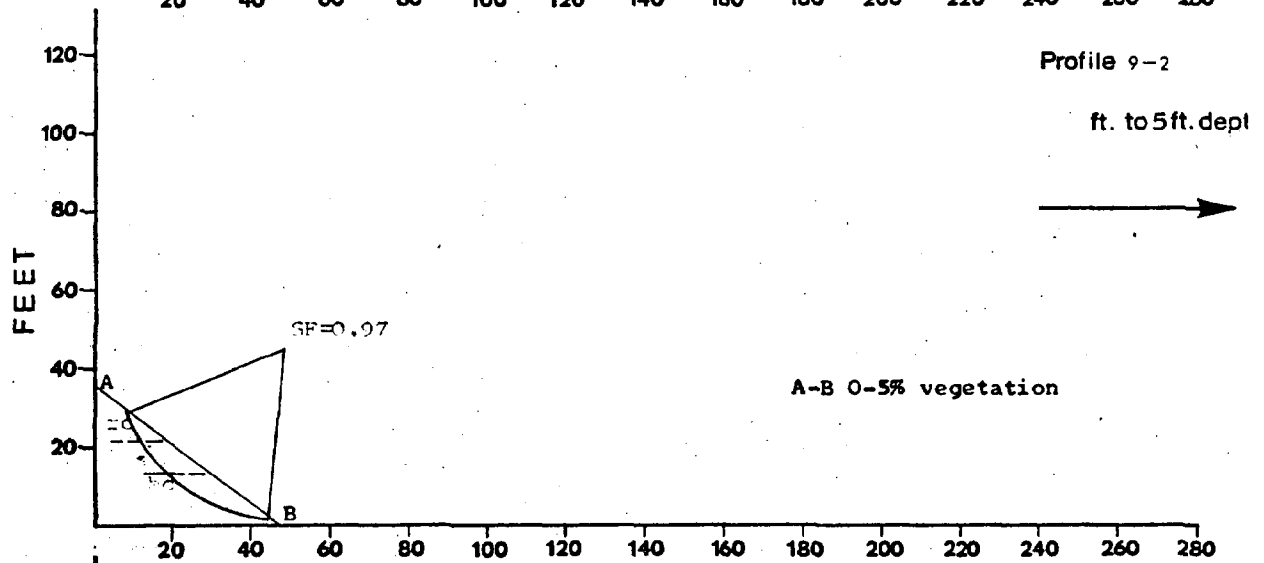
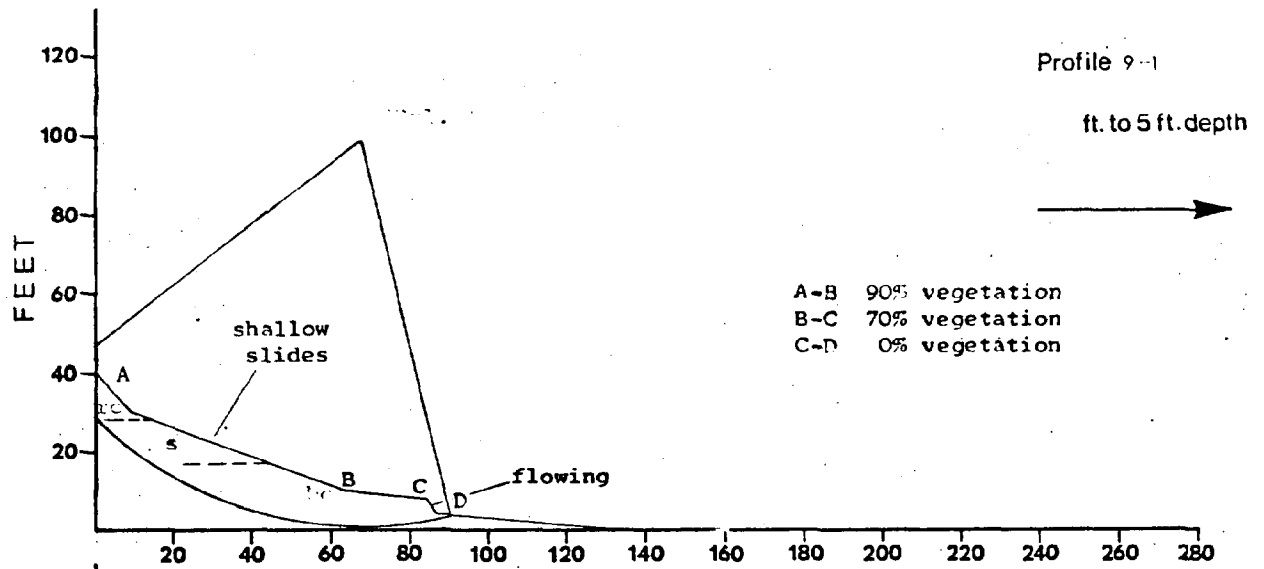
- a) 40 ft; crest broadly scalloped, rounded; single-block shallow slide with flowing and shallow sliding on main and toe scarps; 90% vegetated, birch, alder, grass, horsetails; silty clay gradational to clay, with a clean sand occasionally between
- b) 35 ft; crest scalloped, scarped; shallow sliding and flowing; poorly vegetated 0.5% on moving blocks; silty clay over clay, sometimes gradational sometimes with sand in-between
- c) 35 ft; crest broadly scalloped, single-block shallow slide with flowing and shallow sliding on main scarp and most of toe; moderately well vegetated, 50-60% alder, grass, horsetails; silty clay gradational to clay with occasional sand layers.

Toe:

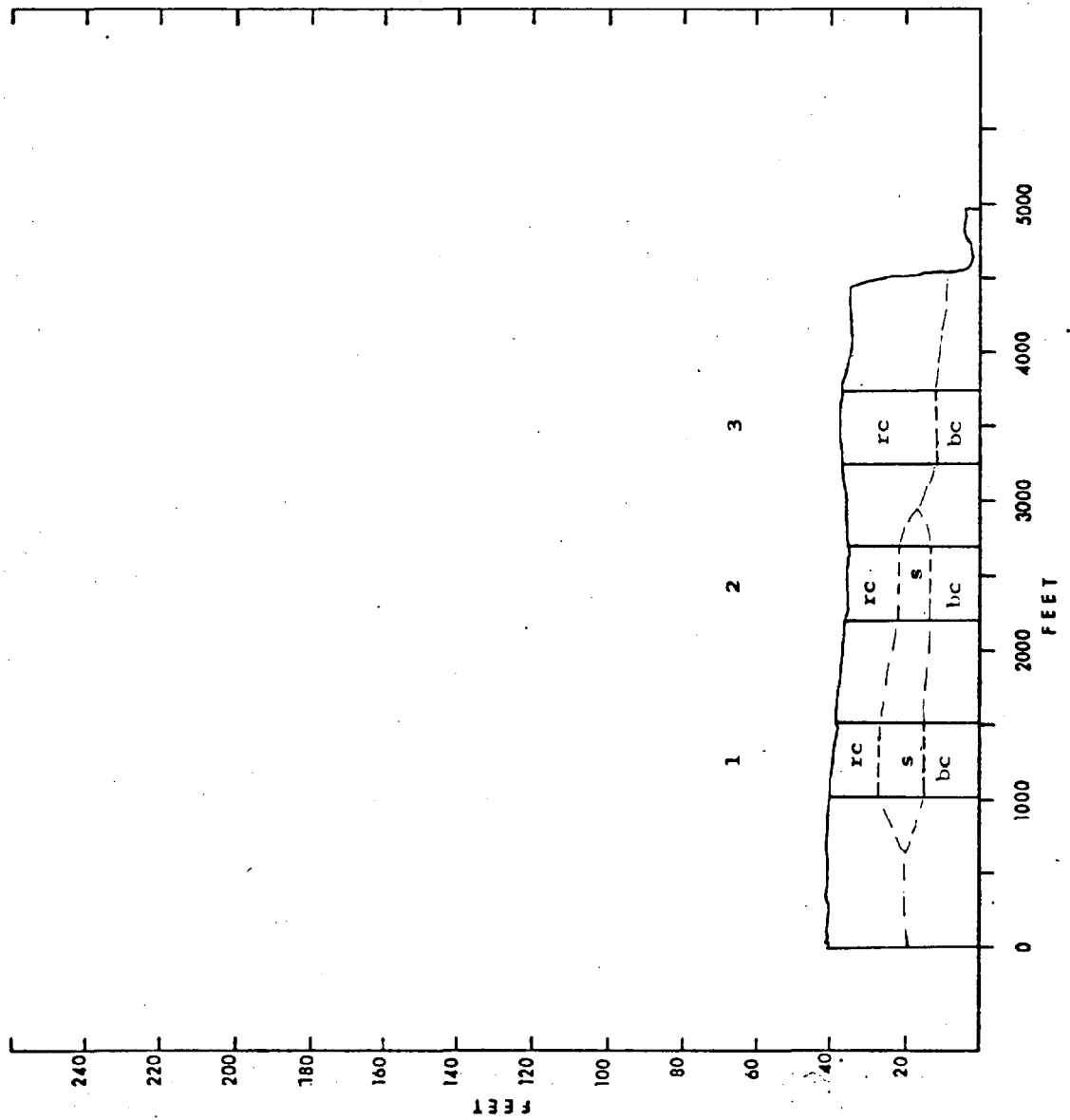
- a) Protected, flowing, slumped
- b) poorly protected, scarped and flowing, slumped silty clay
- c) protected, mostly rounded, slumped silty clay

Beach:

- a) 30 ft; coarse sand with some pebbles at water; .5 ft. wave-cut face close to toe; boulders offshore
- b) discontinuous, interrupted frequently, 10-15 ft. coarse sand with boulders offshore
- c) 20-80 ft; broadest just west of stream and across estuary coarse sand with pebbles near water; 2-3 ft wave-cut face often present.



T.49 N., R. 10W., Sec. 9



Reach 3

Reach 3 extends approximately 9.5 miles from the Bois Brule River to Quarry Point, one mile west of Port Wing. This reach includes Sections 10, 3, 2, and 1 of Township 49 North, Range 10 West, in Douglas County, Sections 6, 5, and 4 in Township 49 North, Range 9 West, Sections 33, 34, 35, 36, and 25 in Township 50 North, Range 9 West, and Sections 30 and 19 in Township 50 North, Range 8 West in Bayfield County. Bluffs are generally less than 30 feet high in the reach. Between the Brule and Iron Rivers the redder clay unit composes most of the bluffs. Between the Iron River and Quarry Point a thin cap of the redder clay overlies a sandy loam and/or lenses of well sorted sand. Bedrock crops out at the toe of the bluff from Jardine Creek eastward.

Erosion along this reach of shoreline has become a serious problem at several locations. Shore protection for State Highway 13 has been required at a location 6.5 miles west of Port Wing between Reefer Creek and Iron River. The U.S. Army Corps of Engineers, in cooperation with the Wisconsin Department of Transportation, has established a demonstration site to test low cost structural protection methods. In addition to Highway 13, several homes are being threatened by erosion. Recession rates averaged 1.5 to 2.0 feet per year between 1938 and 1966. Locally, erosion rates have been much higher. Bluff retreat of 27 feet was measured over a 13 month period at the Corps of Engineers demonstration site (Sterrett, 1978).

Beaches, where present, are less than 10 feet wide and composed of sand and gravel. These narrow beaches provide very little protection from wave attack. Erosion of the bluff face is largely the result of shallow slides triggered by oversteepened slopes and saturated earth flows. Very little rotational slumping has been observed within this reach.

With the exception of the western two miles of shoreline, part of the Brule River State Forest, all land is under private ownership. State Highway 13 provides excellent access and much of the shoreline has been subdivided for seasonal and year-round homes. Even though several homes are being threatened by erosion, no privately-owned shore protection structures are found within this reach.

Section 10/3 T 49 N, R 10 W

The section lies just west of Brule Point in Brule River State Forest. The western half is cut by the Brule River and the shoreline characteristics show the river's influence. Access is excellent along Brule River Road. A parking lot with picnic facilities lies at the end of the road near shore, a small park operated by the DNR. There is no bluff along the shore at the eastern end. Here sandy spits have prograded, protecting the bluff and forming a marshy area behind. A profile across the present spit is shown in RP 10/3-1. In the remainder of the section, a very low bluff is present, rarely exceeding 20 ft. The materials in the bluff are dominantly red clay but others are present. Medium to coarse sands occurs below the red clay in varying thicknesses occasionally comprising much of the bluff. At the toe and lying under the sand (where the sand is present), a brown clay is occasionally exposed, and beneath that in just a few small outcrops is a red sandy till. The bluff height is low enough that major failures are uncommon. Instead, the toe is undercut by wave action and the surface vegetation and sod slowly slide downslope. Where sand comprises much of the bluff, mass wasting phenomena are replaced by rill erosion. The beach is variable in width and particle size. It is mostly sandy although certain subsections are bouldery and cobbly. Where the beach is absent, wave action is directly eroding the toe. Because of the good access, this reach is used frequently. Since it is a state forest, no housing development has occurred along the bluff crest.

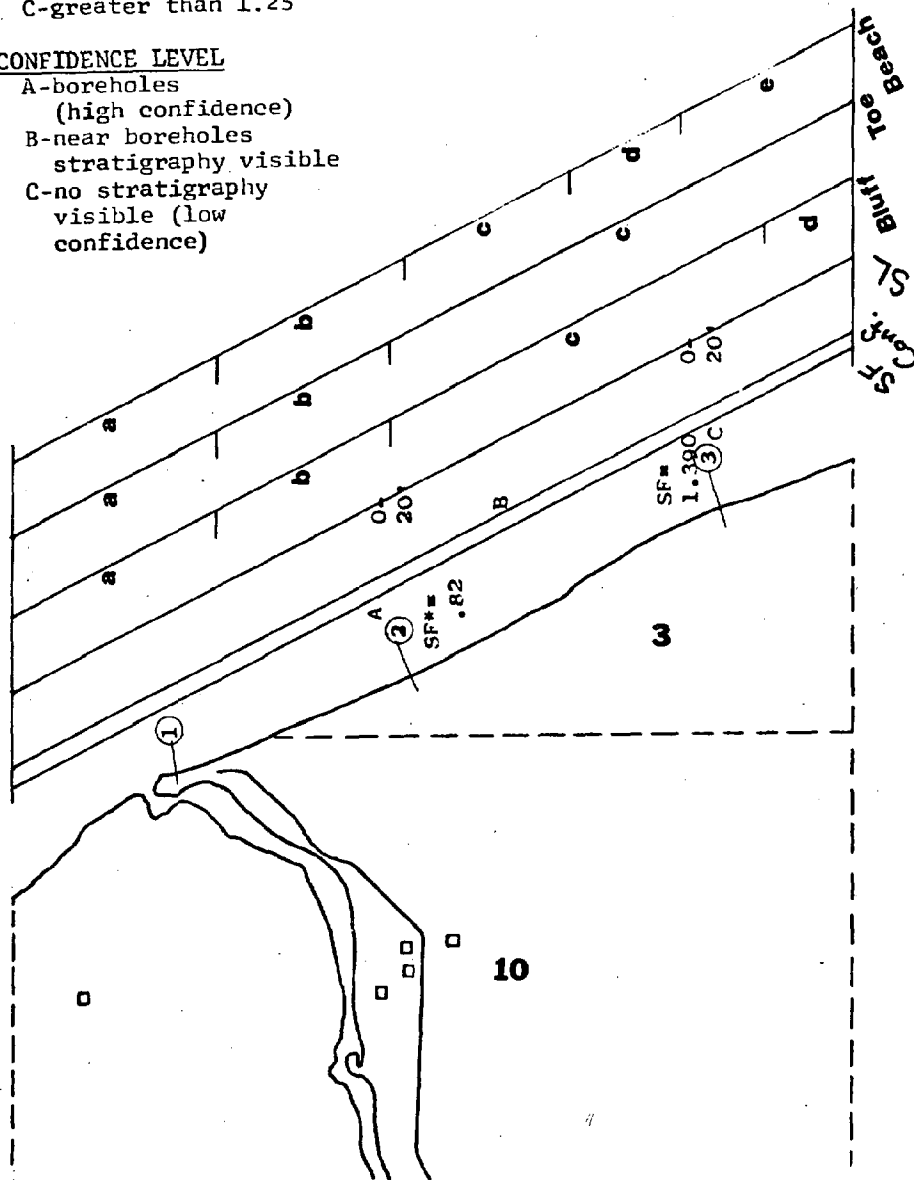
SEC 10/3 T49 N R10 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 10/3, T 49 N, R 10 W

Bluff:

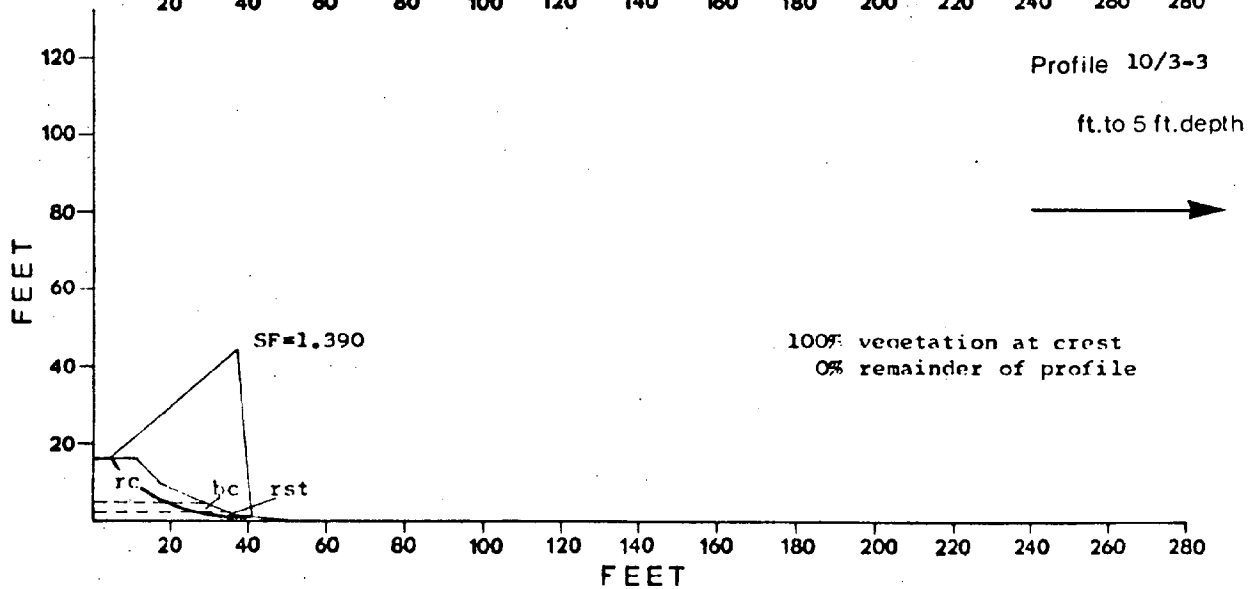
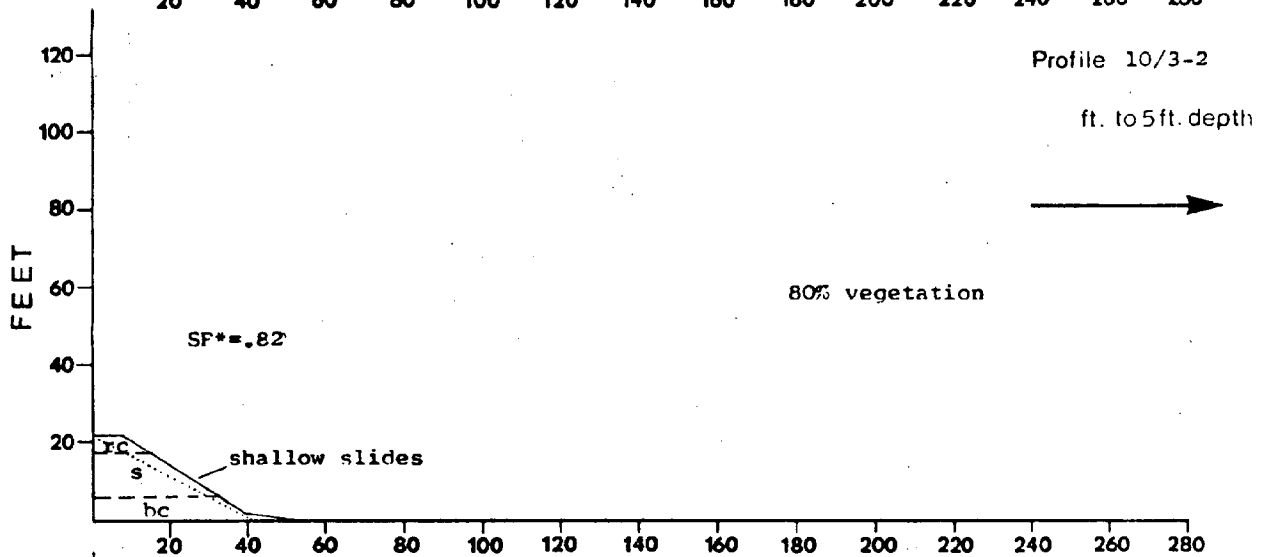
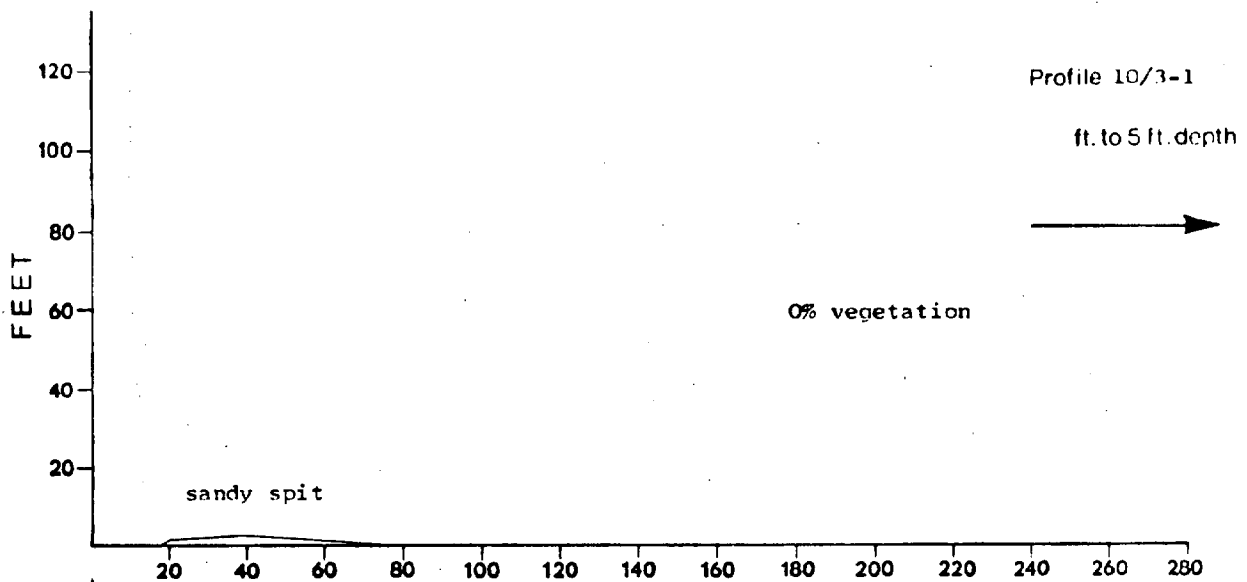
- a) No Bluff; sandy spits at shore with marsh behind; stable vegetated slope lies well behind beach
- b) 100% vegetation with conifer and alder; fairly hummocky surface with occasional scarp; red clay over red sandy till; 20-25' high with even crest
- c) unvegetated except for occasional tree clump; red clay with thick sand in places over red sandy till; shallow slides or eroded; 20' high with even crest
- d) 40% vegetated with birch clumps; red clay over till; small slumps and shallow slides; 20' high

Toe:

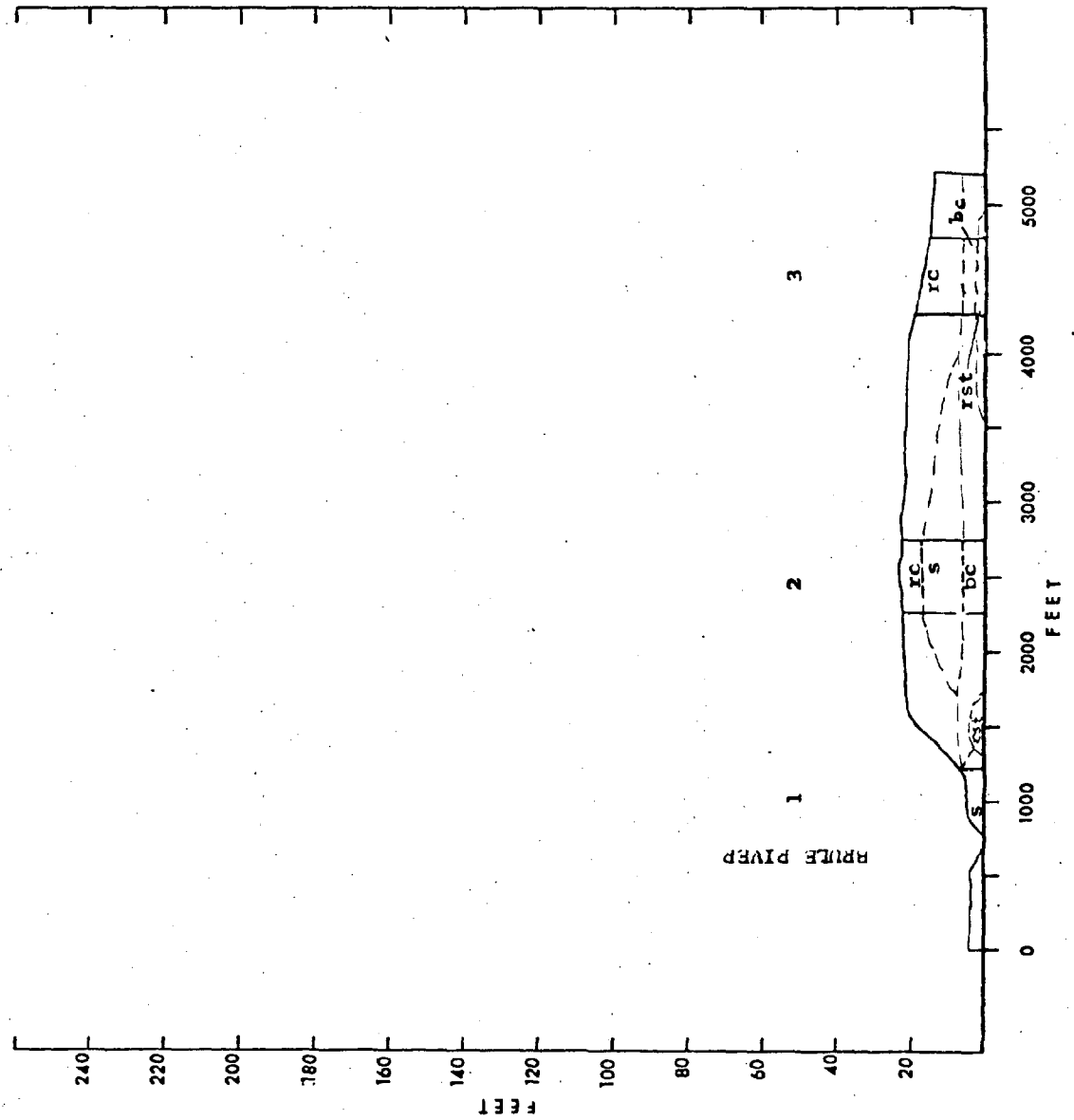
- a) No Bluff
- b) vegetated rounded slump block toe; forms step 2.5' high; unprotected
- c) occasionally

Beach:

- a) sandy spits; pebble concentration along shore
- b) 3-8 ft. sandy with scattered boulders; locally beach is cobbly
- c) 20 ft.; sandy
- d) 3-8 ft.; sandy with scattered boulders
- e) 10-20 ft.; sand, boulders, cobbly in places, coarse sand along shore



T.49 N., R.10 W., Sec. 10/3



Section 2, T 49 N, R 10 W

This section is located just west of Brule Point, about one mile east of the Brule River. A sandy beach is present spordically along the shoreline. Subsections of 15-20 ft. in width alternate with subsections of 15-20 ft. in width alternate with subsections of near or total absence. The beach is quite wide just east of the stream estuary which bisects the section, but it narrows steadily thereafter. The bluff is 15-20 ft. high at the western end and declines slightly to 10-15 ft. at the estuary. Following a subsection of no bluff (graded, gentle slope) it rises again to 10-15 ft. and then more slowly to 15-20 ft. It is failing by shallow sliding and flowing; but the degree of activity, as indicated by the amount of vegetation, varies. Subsections with 80-100% vegetation alternate with subsection having 20-40%. The bluff is composed of clay, mostly slumping. The toe is composed of slumped clay and its degree of protection relates directly to the width (or absence) of the beach. There is reasonable access to the middle of the section by an unimproved dirt road, but use seems to be infrequent.

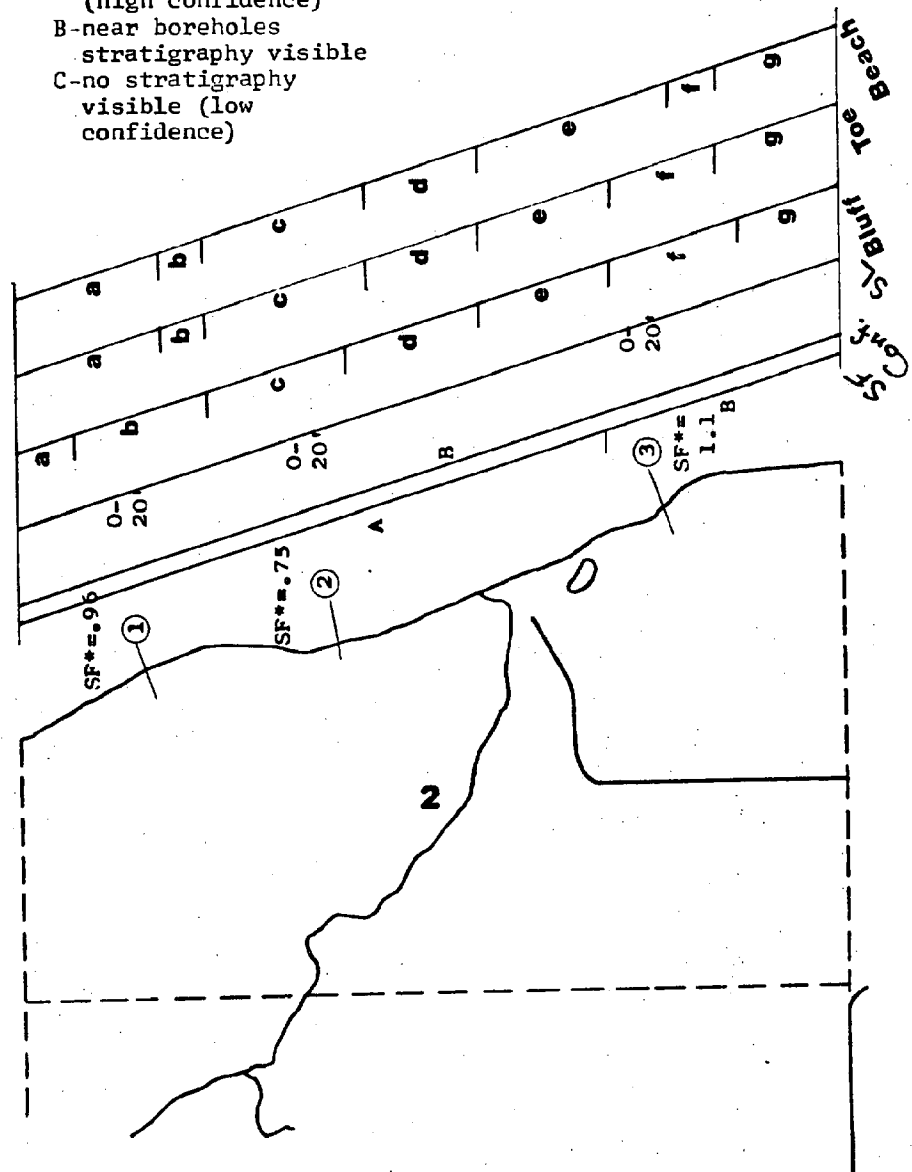
SEC 2 T49N R10 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 2, T 49 N, R 10 W

Bluff:

- a) 15-20 ft; shallow slides; vegetation 80% alder, birch, grass; red clay
- b) 15-20 ft; scarped crest; shallow slides and flows; vegetation 10%, birch clumps; red clay
- c) 15-20 ft; crest scarped, shallow slides and flows; vegetation 20%, birch and alder clumps; red clay
- d) 10-15 ft; crest scarped; shallow slides with good blocks; vegetation 60-70%, alder, poplar, grass; red clay
- e) absent graded slope very low gradient
- f) rising quickly to 10-15 ft.; shallow slides with little movement; vegetation 90-100% grass, alder, birch red clay
- g) 15-20 ft; crest scarped; shallow slides; vegetation 30-50% grass, alder poplar birch; red clay

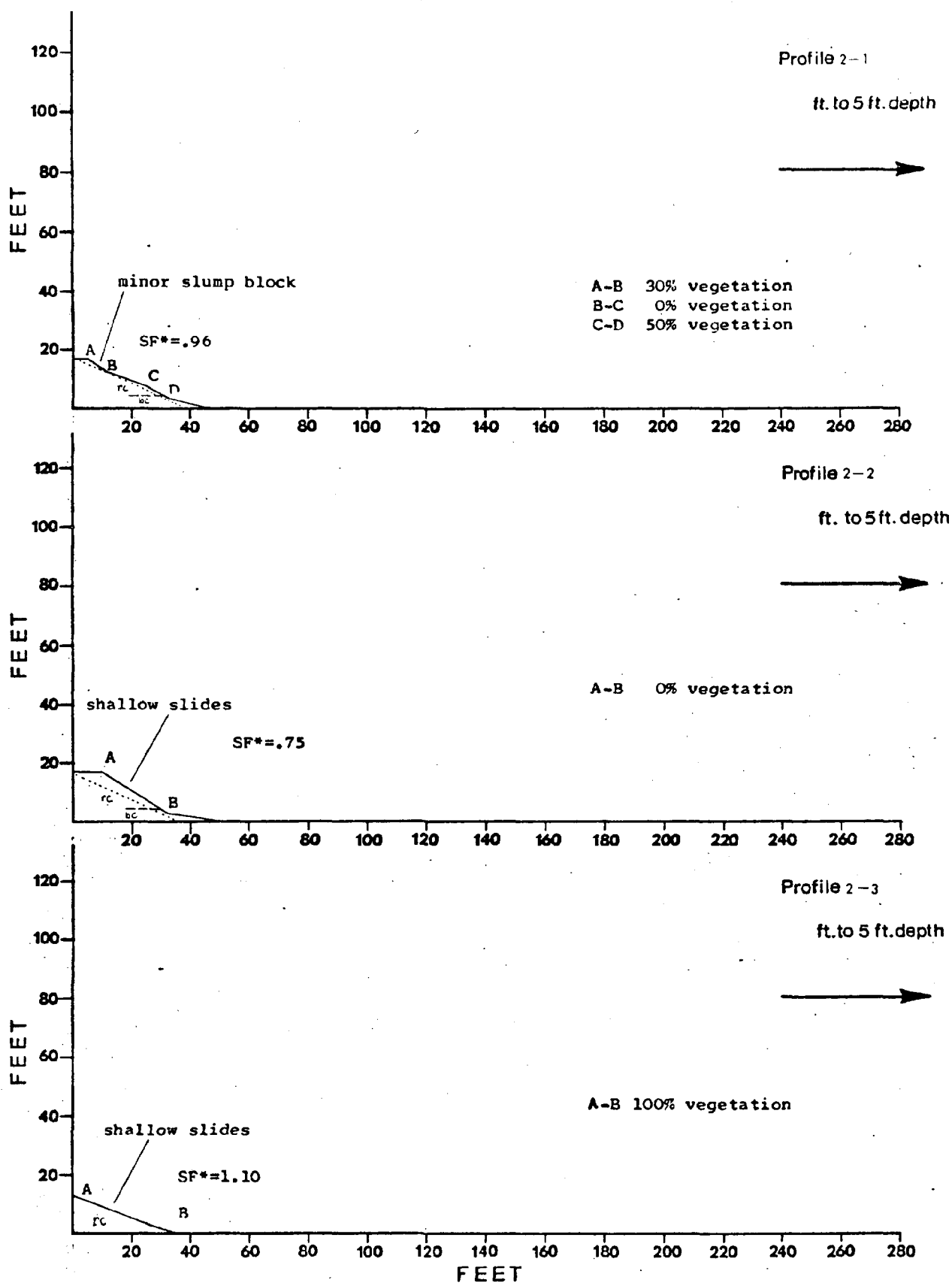
Toe:

- a) protected slumped red clay
- b) unprotected, slumped red clay
- c) mostly protected slumped red clay
- d) unprotected, slumped red clay
- e) absent graded slope very low gradient
- f) mostly protected, slumped red clay
- g) 0-5 ft mostly absent; coarse sand with scattered pebbles

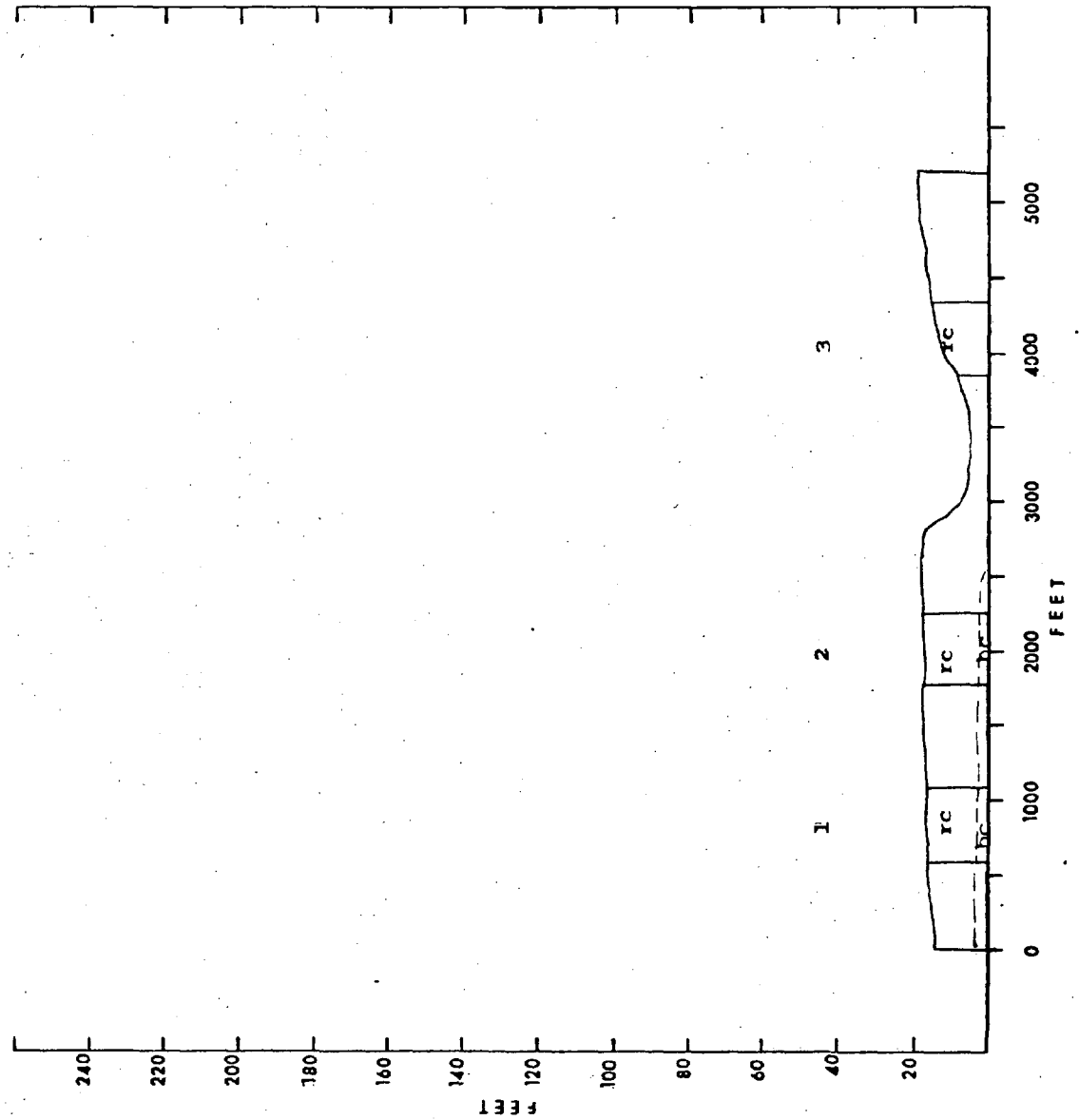
Beach:

- a) 15-20 ft; coarse and magnetite sand, pebbles at water
- b) absent
- c) 10-15 ft; coarse sand with cobbles and boulders scattered
- d) 0-5 ft; mostly absent, coarse sand
- e) 80 ft narrowing eastward to 10 ft; coarse sand with pebbles and cobbles at water
- f) 5-10 ft. often interrupted; coarse sand with many cobbles throughout

g) 0-5 ft. mostly absent; coarse sand with scattered pebbles



T.49 N., R. 10W., Sec. 2



Section 1, T 49 N R 10 W

This section lies on the eastern side of Brule Point and is the eastern-most section of the shoreline in Douglas County. Throughout the section, the bluff materials consist predominantly of red clay. In two isolated locations, a browner clay of similar texture occurs, but does not influence in the vegetation or failure style. In the western part of the section where vegetative cover is 100%, the bluff is stable and has a smooth, moderately steep profile. Farther east, vegetation decreases and the clay is failing in small rotational slumps and shallow slides. These slides scallop the bluff crest and carry sod clumps and trees down slope. In the eastern-most portion, the bluff may be unvegetated and very steep with shallow slides and flows. The crest of the bluff lies 20-30 ft. above the lake and is fairly even, rising steadily towards the east. The toe of the bluff is unvegetated, except for the western portion and the occasional sod clump brought down from the crest. It is composed of slumped red clay. It is protected by a wide sand beach except in a few subsections where waves attack the toe directly. The shoreline, here, is undeveloped and is used seldom. Access is poor and only from unimproved dirt roads which lie in the adjoining sections.

SEC1 T49N R10W

SAFETY FACTOR

A-less than 1.00

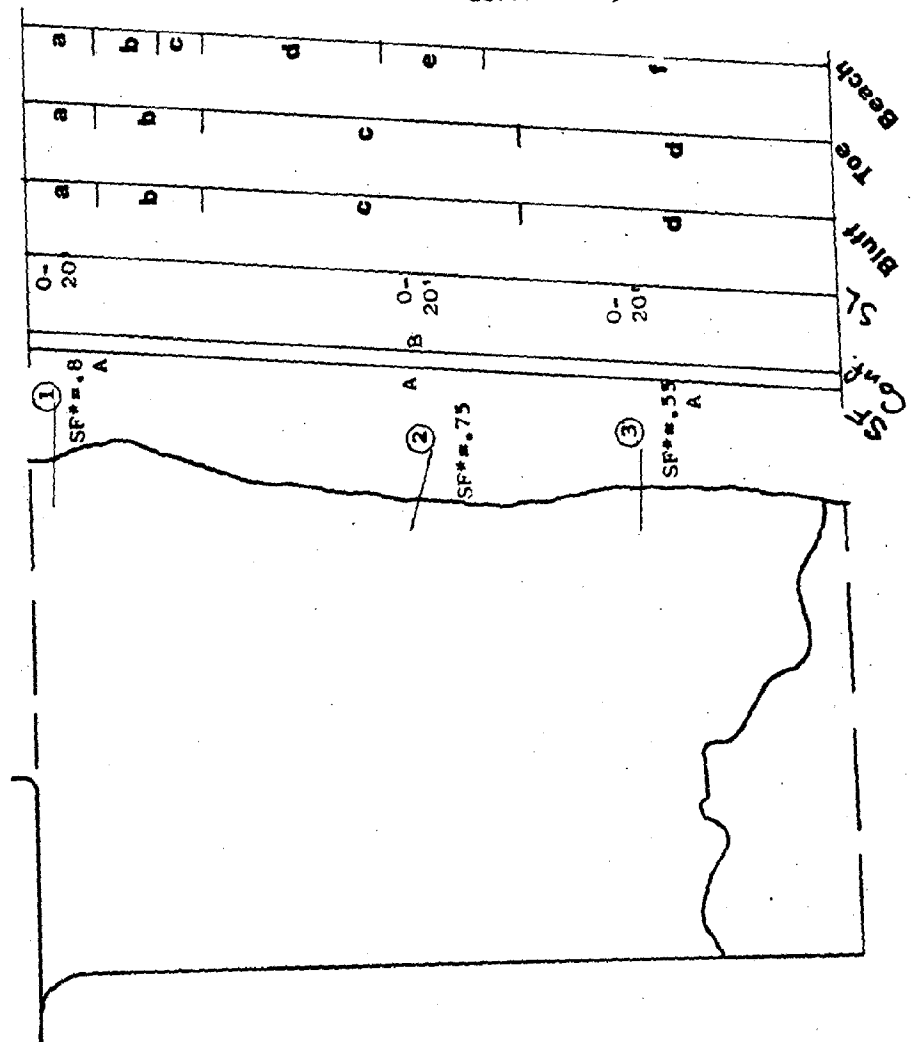
B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVEL

A-boreholes

(high confidence)

B-near boreholes
stratigraphy visibleC-no stratigraphy
visible (low
confidence)

Bluff:

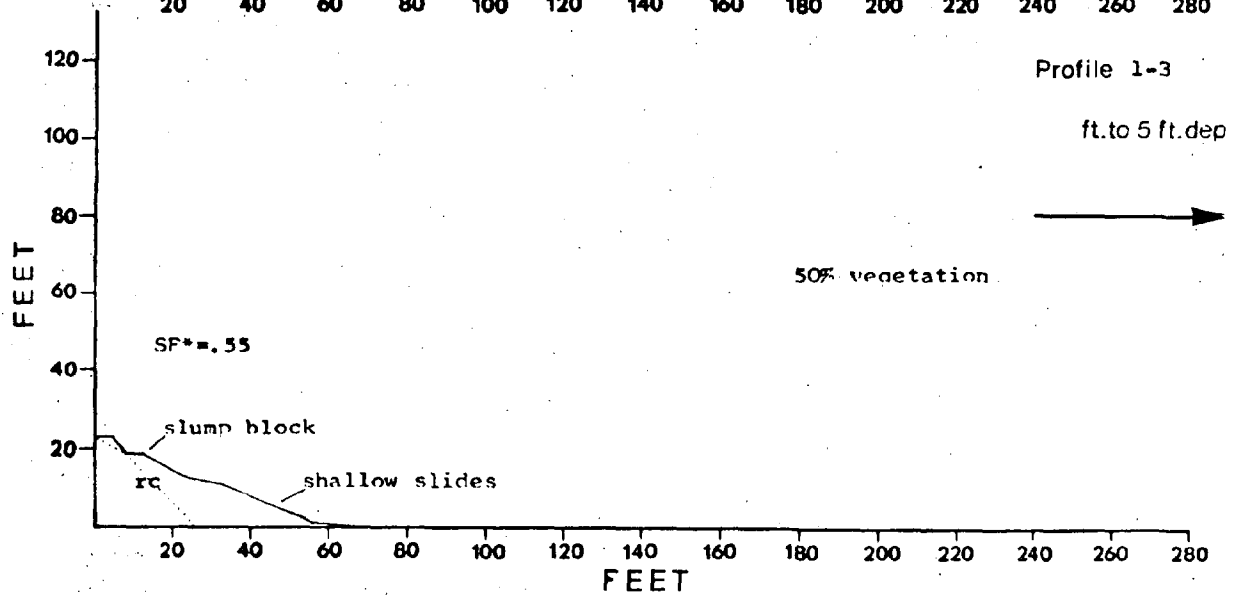
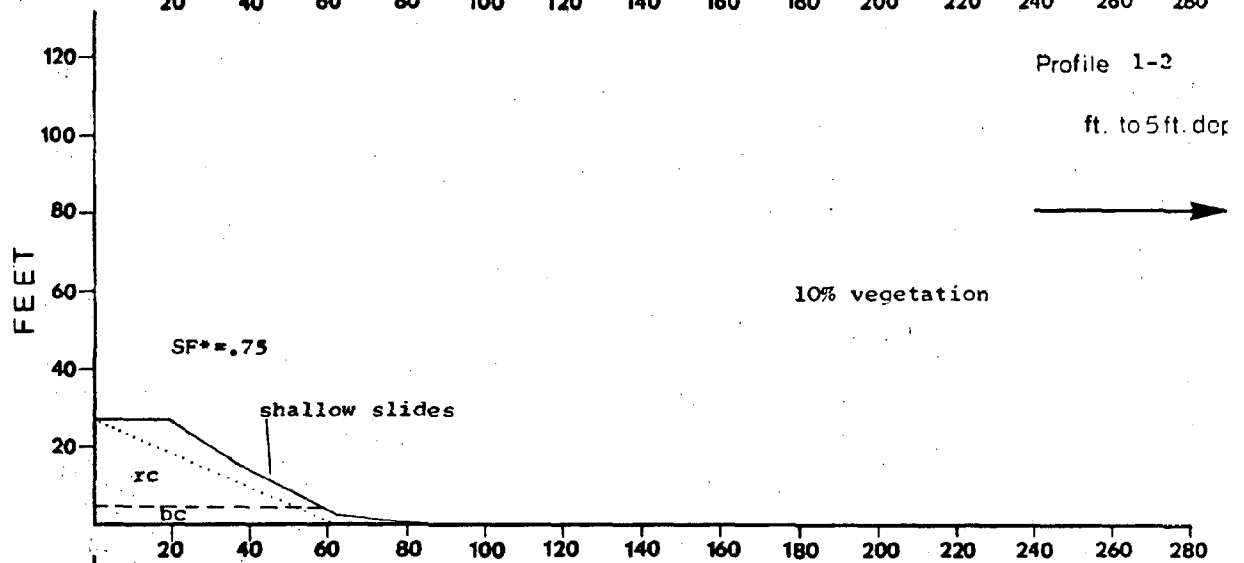
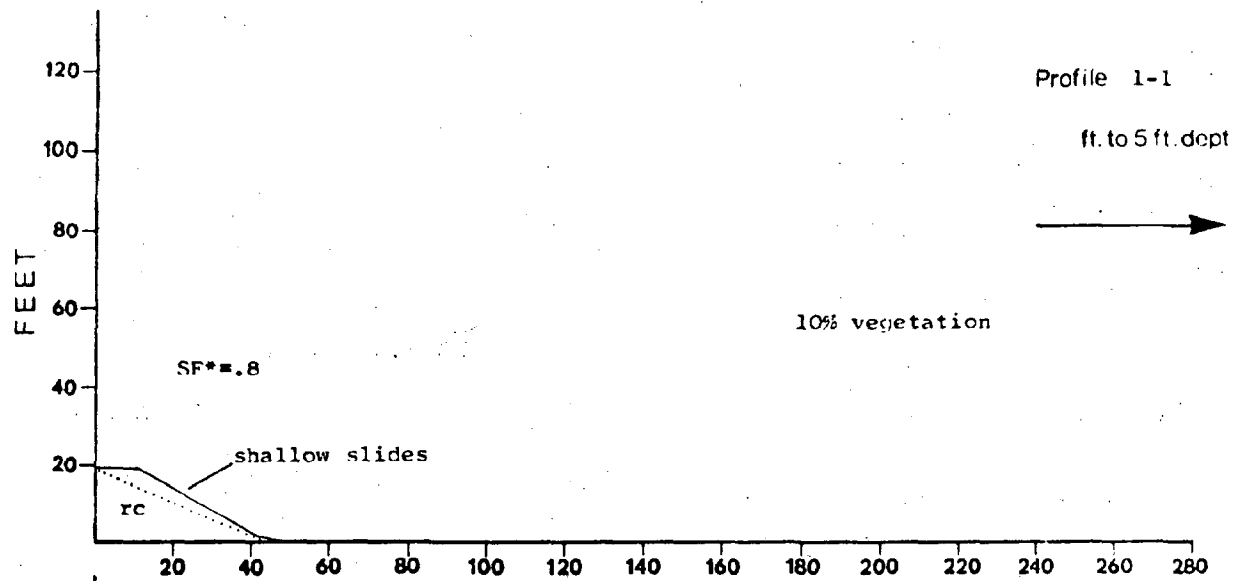
- a) 10% vegetation, sod clumps; shallow slides in red clay; 18 ft. with root-bound crest
- b) 100% vegetation; grass sod with birches, smooth stable slope in red clay; 20' with even crest
- c) 10-40% vegetation with sod and birch in clumps; shallow slides with occasional rotational slump; 20-30' high rising steadily to the east
- d) 0-50%; well vegetated where small slumps predominate; no vegetation in near vertical scarps; red clay; 20-30' irregular crest.

Toe:

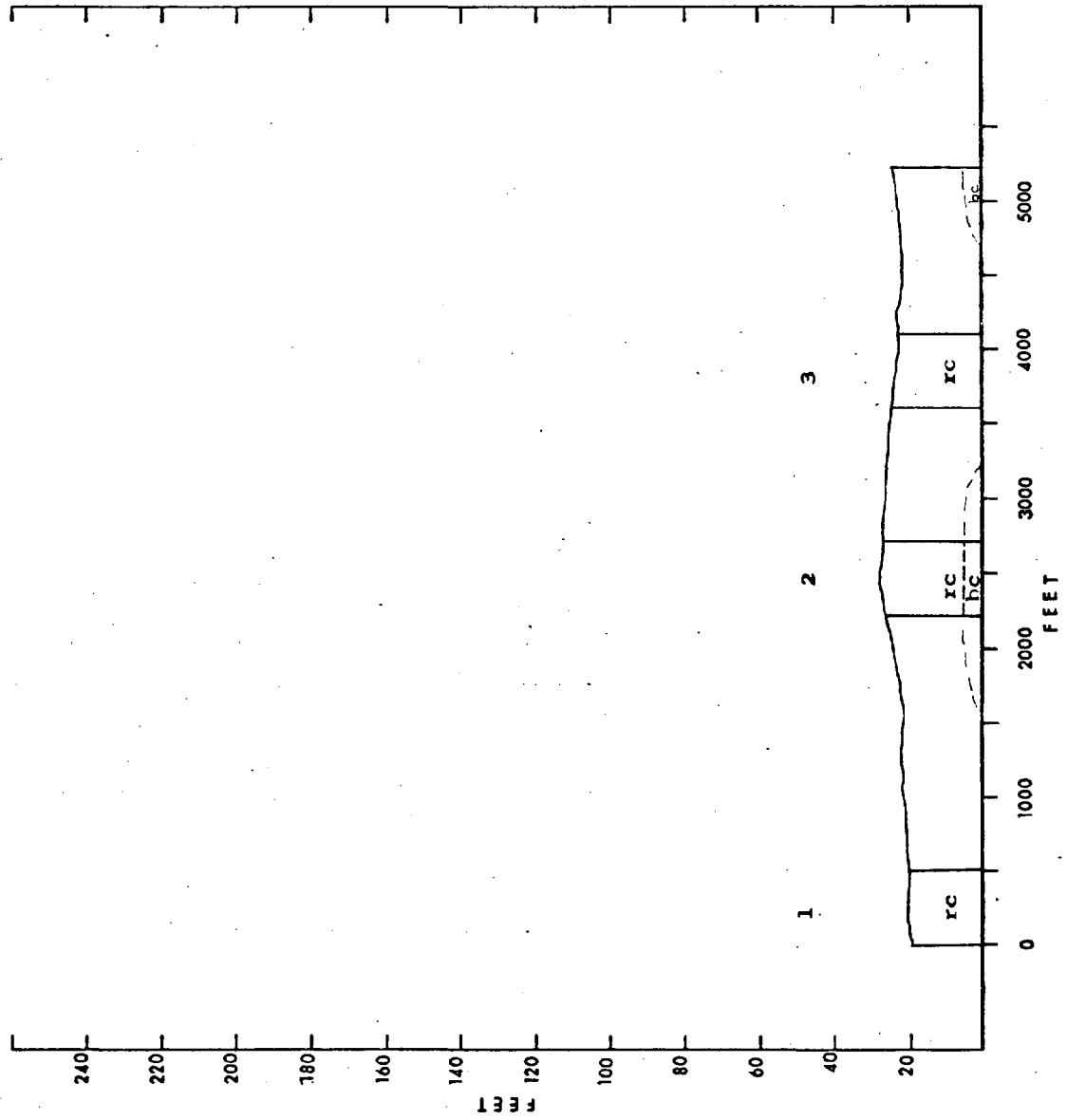
- a) slumped red clay, unvegetated, occasional unprotected
- b) 1-2' step of red clay, protected
- c) unvegetated slumped clay; forms small scarp when occasionally unprotected
- d) unprotected slumped red clay

Beach:

- a) 3-10 ft.; sand
- b) 30 ft.; sandy, no pebbles
- c) 20 ft. sandy
- d) 0-5 ft, swash zone occasional; sandy
- e) 20-30 ft., sandy, no pebbles
- f) 0-10 ft, sandy with occasionally covering slumps



T. 49 N., R. 10 W., Sec. 1



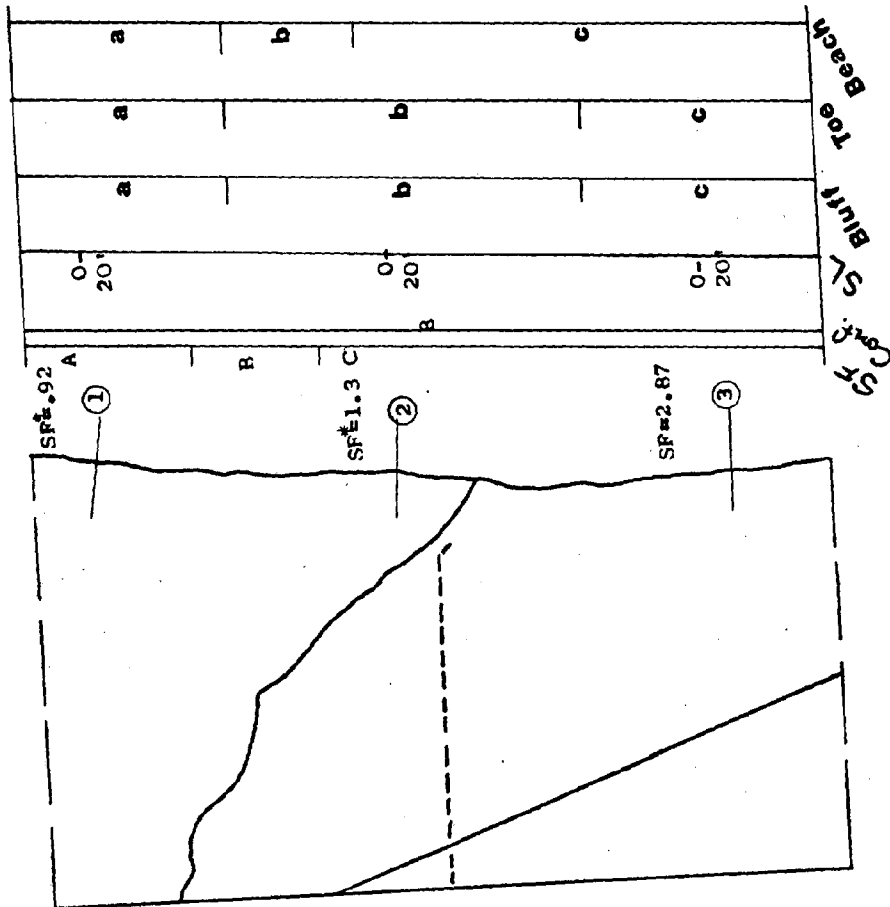
Section 6, T49N, R9W

This section is the westernmost section in Bayfield County. The bluff throughout is composed of 15 to 20 feet of red clay over 5 feet or less of brown clay which is exposed occasionally at the toe. This material is failing in shallow slides and sliding tree clumps producing a hummocky surface. Medium scale rotational slumps occur occasionally. Bluff height is fairly consistent at 30 feet. The amount of vegetative cover increases from 10-30% in the west to 100% in the east and consists primarily of birch and alder with grass. The toe is made of red clay that has slid downslope and is protected throughout by a wide (15-30 feet) sandy beach. Access to the shoreline is possible along a dirt road from highway 13. Though the land surface affronting the lake has been cleared in the past, it is returning to a natural state. No homes occur and the shoreline is infrequently used.

SEC 6 T 49 N R 9 W

SAFETY FACTOR
 A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL
 A-boreholes
 (high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



Sec. 6, T 49 N, R 9 W

Bluff:

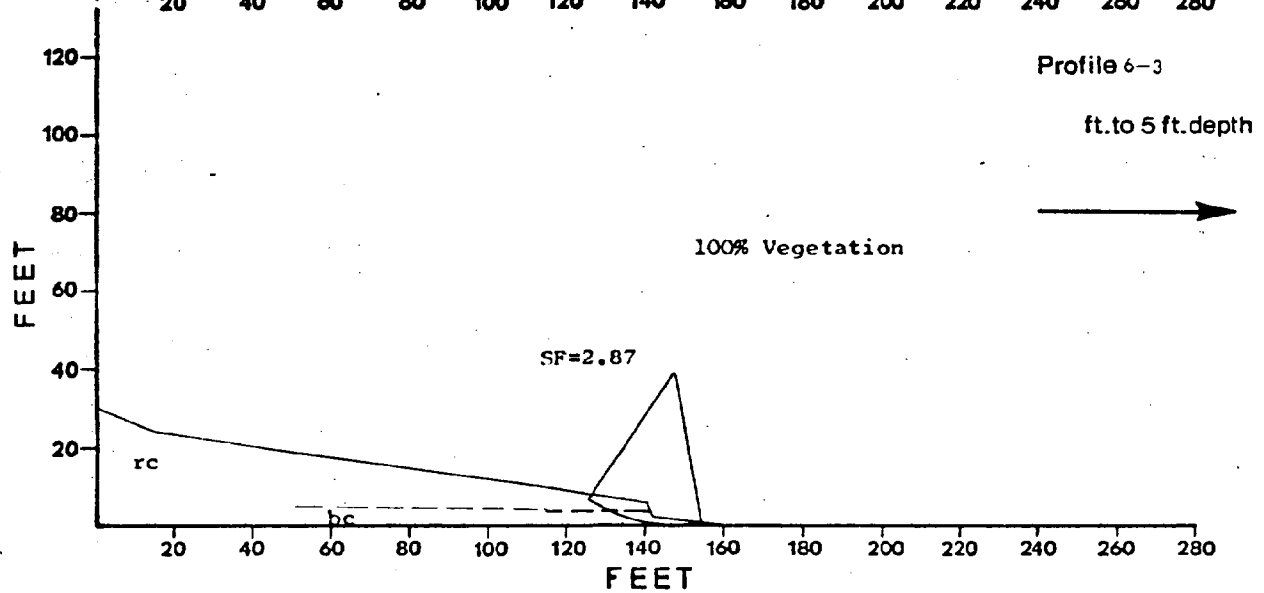
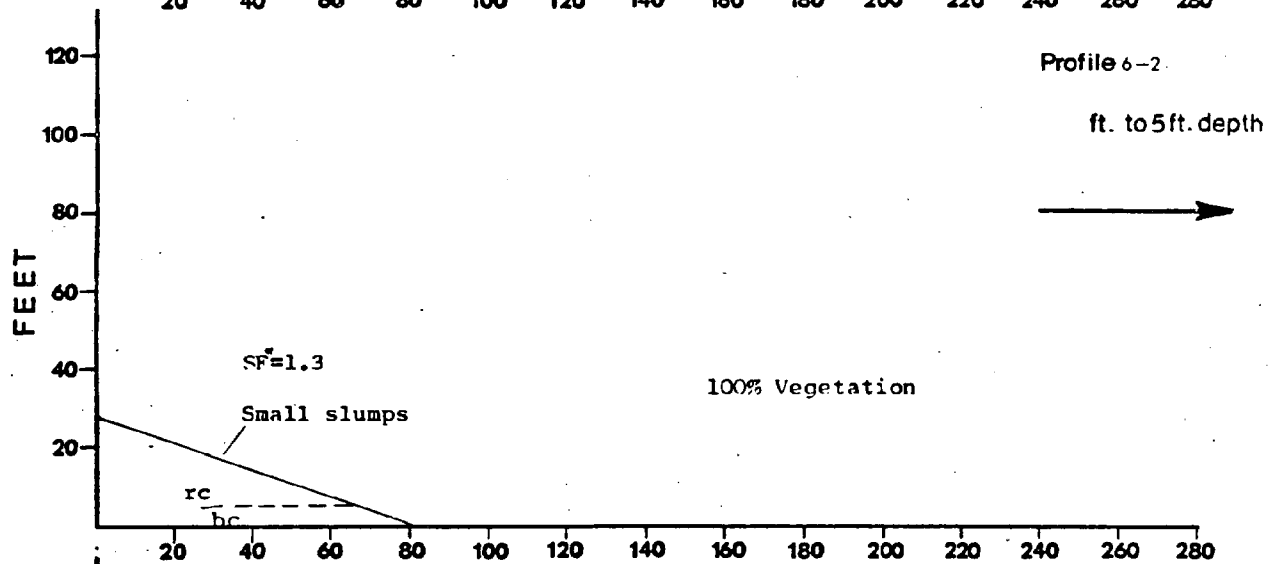
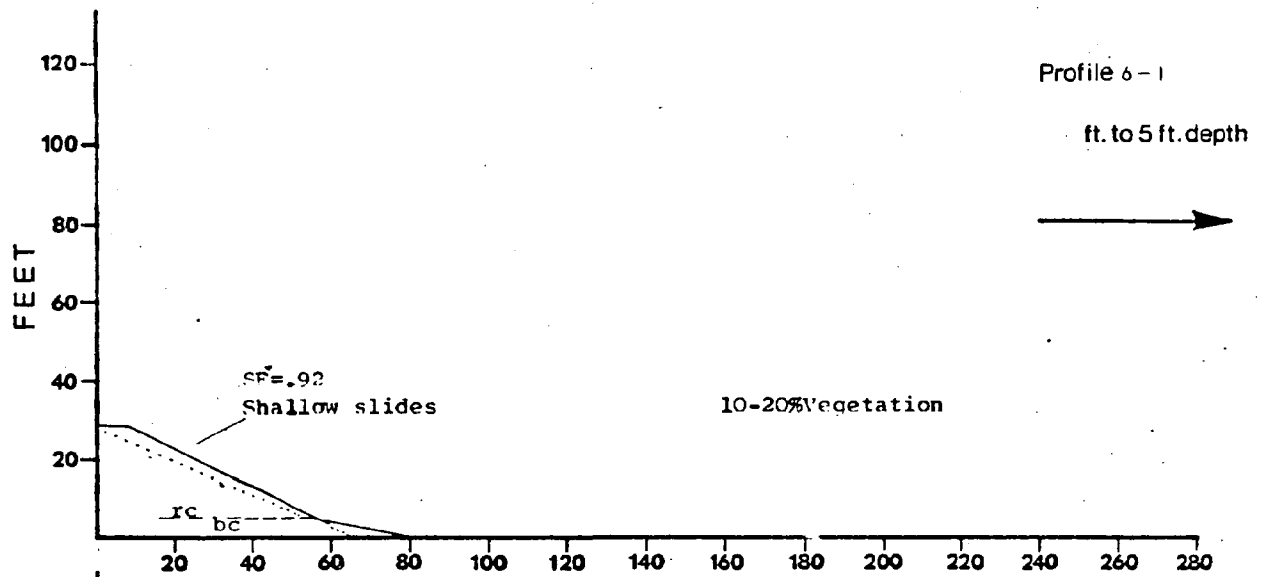
- a) 10-30% vegetated, shallow slides moving sod clumps; red with occasional brown clay at base; 30' high
- b) 40-80% vegetated, variable types, alder and birch predominate shallow slides and medium scale rotational slumps in red clay; 20-30' high
- c) 100% vegetated; alder and grass, low sloping hummocky surface in red clay; 30' high

Toe:

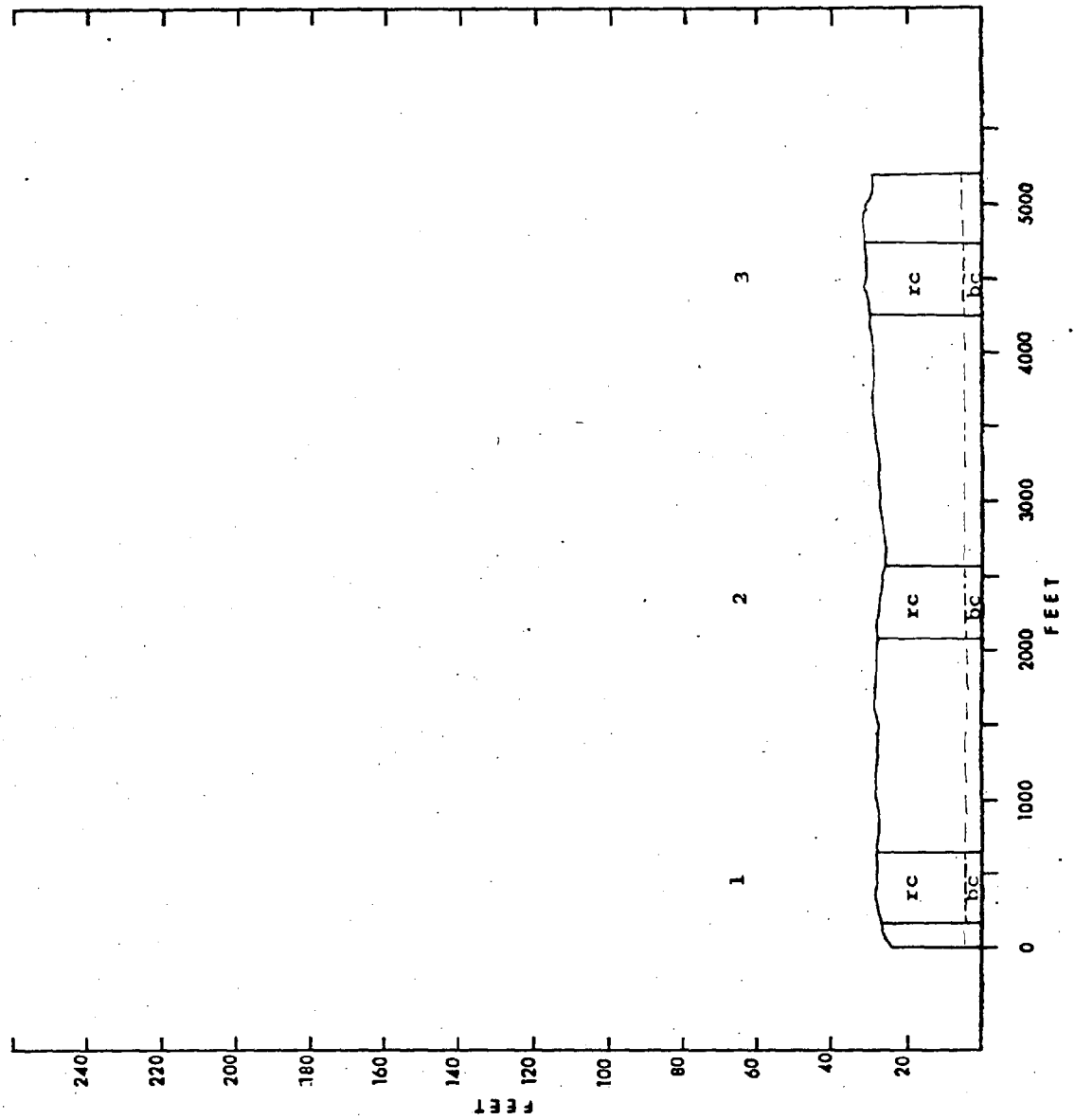
- a) slumped red clay, protected
- b) slumped red clay; occasionally unprotected
- c) continuation of bluff slope

Beach:

- a) 30' wide; sand with pebbles at shore
- b) 5-15' wide, width variable; sand
- c) 30-40' wide, sand with pebbles at shore



T.49 N., R. 9 W., Sec. 6



Section 5, T49N, R9W

This section occurs near the western end of Bayfield County and is bisected by Fish Creek. State Highway 13 lies within 1/4 mile throughout the section. The bluff is 25 to 30 feet high and is composed of 15 to 20 feet of red clay over 5 feet of brown clay. The bluff is fairly stable, its rounded, hummocky appearance indicating no major recent movement. Failure has occurred more recently east of Fish Creek where the bluff-top has been cleared near a small cottage. The bluff is well-vegetated throughout with birch and alder forest. The bluff toe is protected by a wide (15-25 feet) sandy beach. At the extreme east end of the section, the Corps of Engineers has levelled the bluff and rip-rapped the toe with a variety of materials (see subsection description) as a shoreline protection demonstration. A dirt road just west of Fish Creek provides access to the shoreline. One cottage is present but shoreline use is minimal.

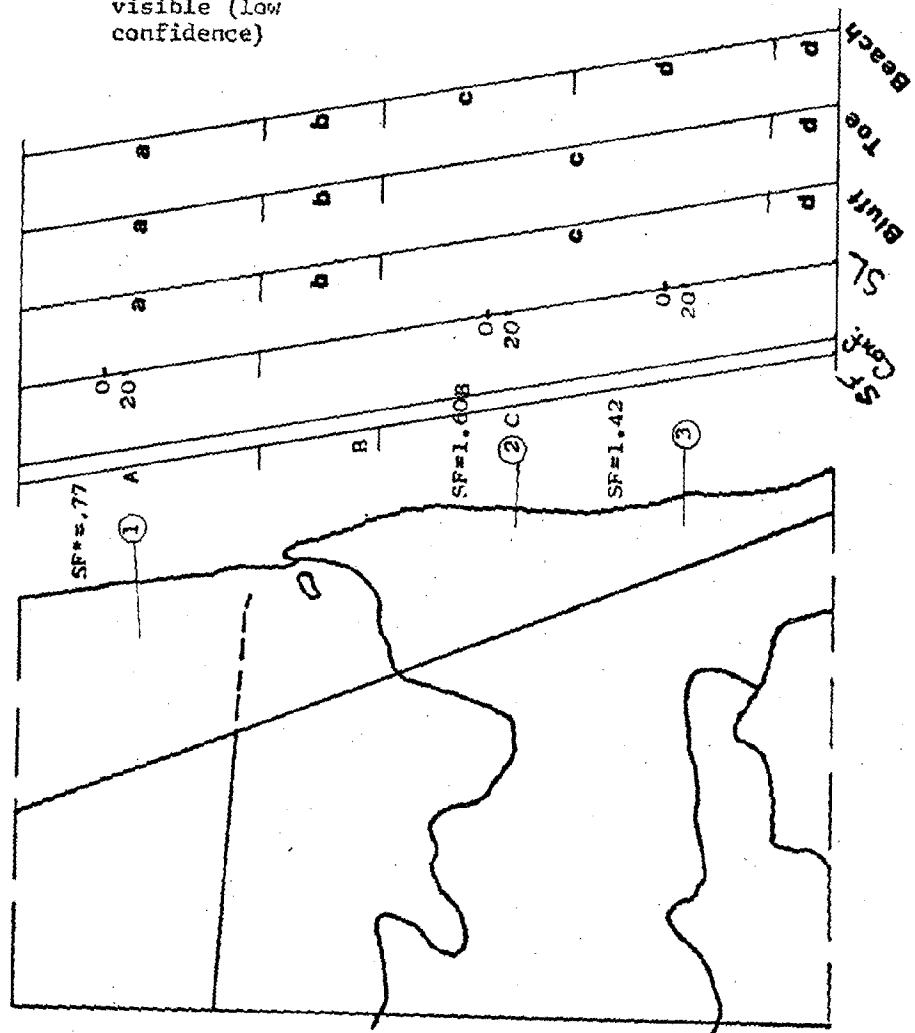
SEC 5 T49N R9W

SAFETY FACTOR

- A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
 (high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



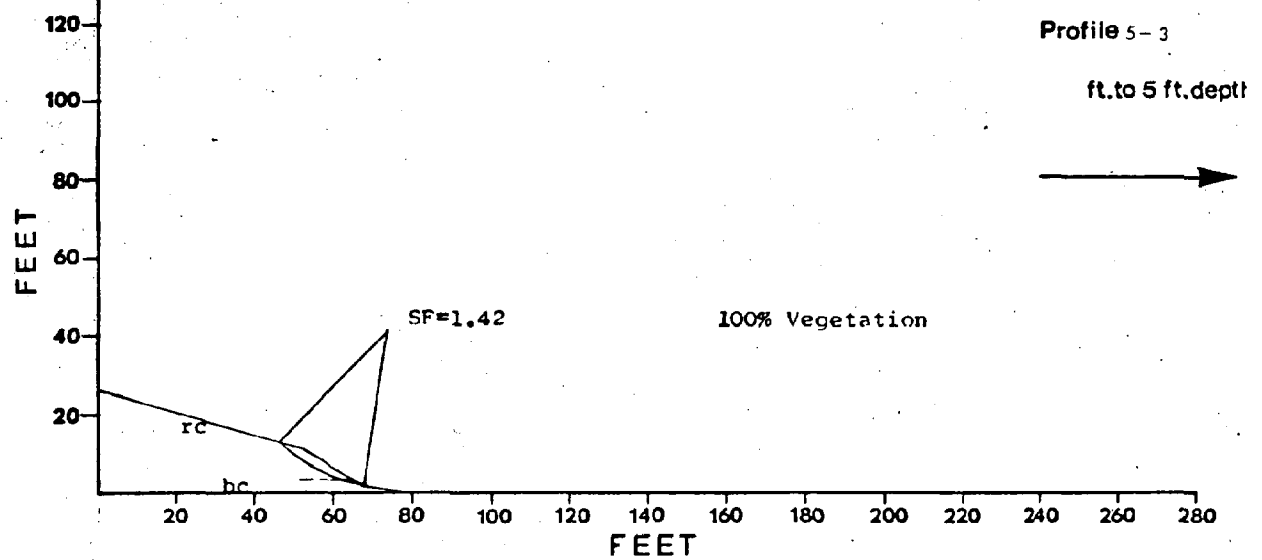
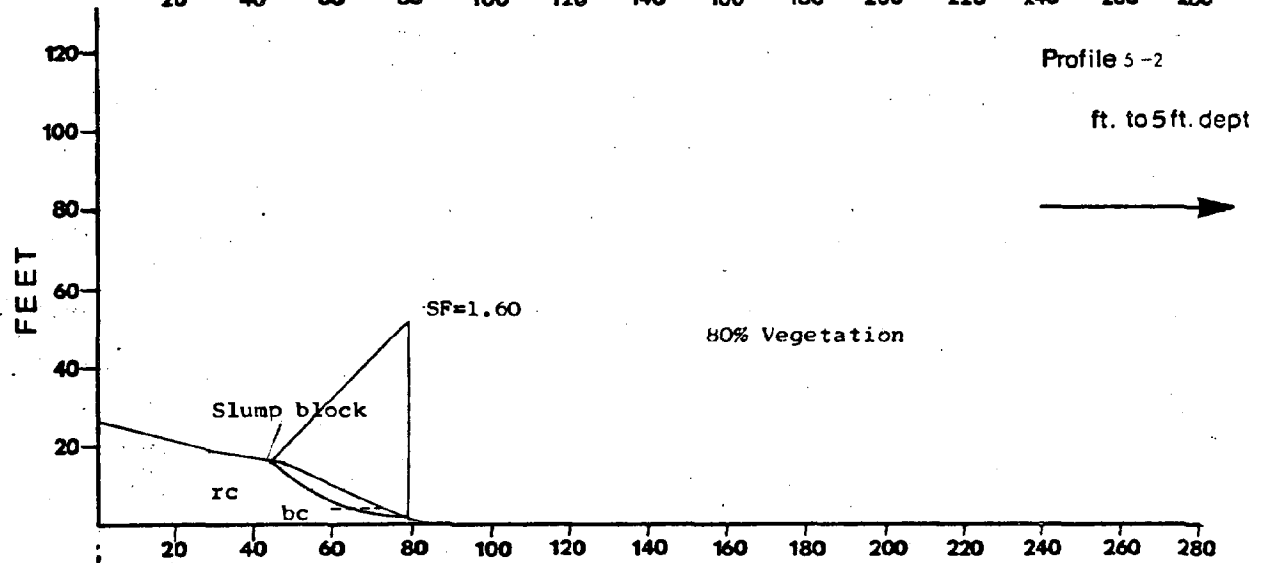
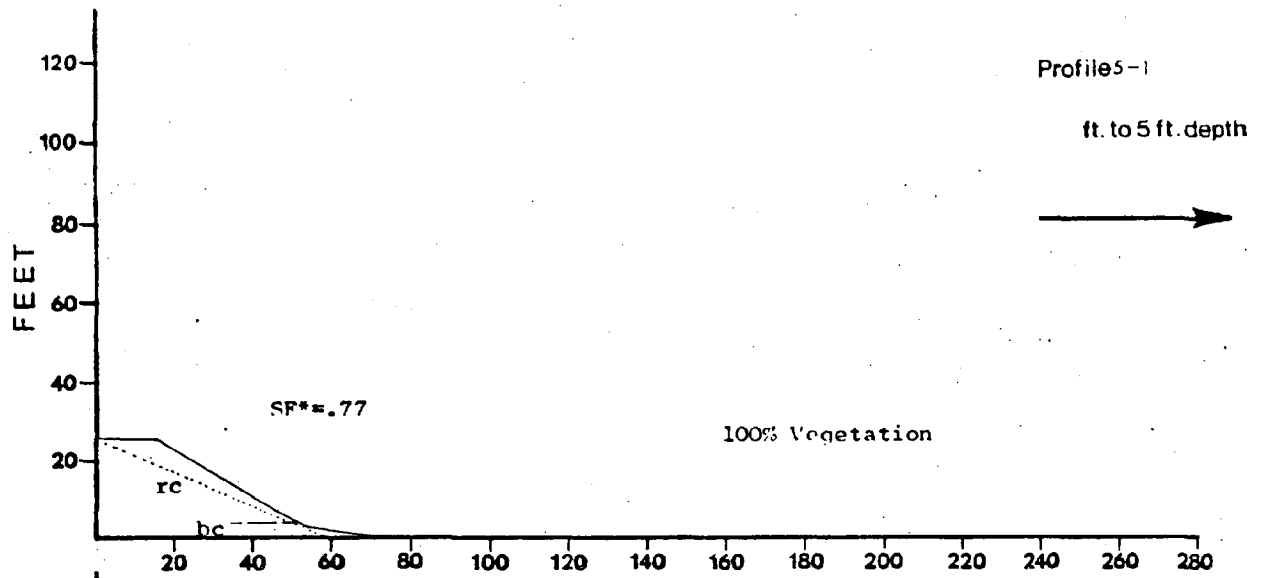
Sec. 5, T 49 N, R 9 W

Bluff and Toe:

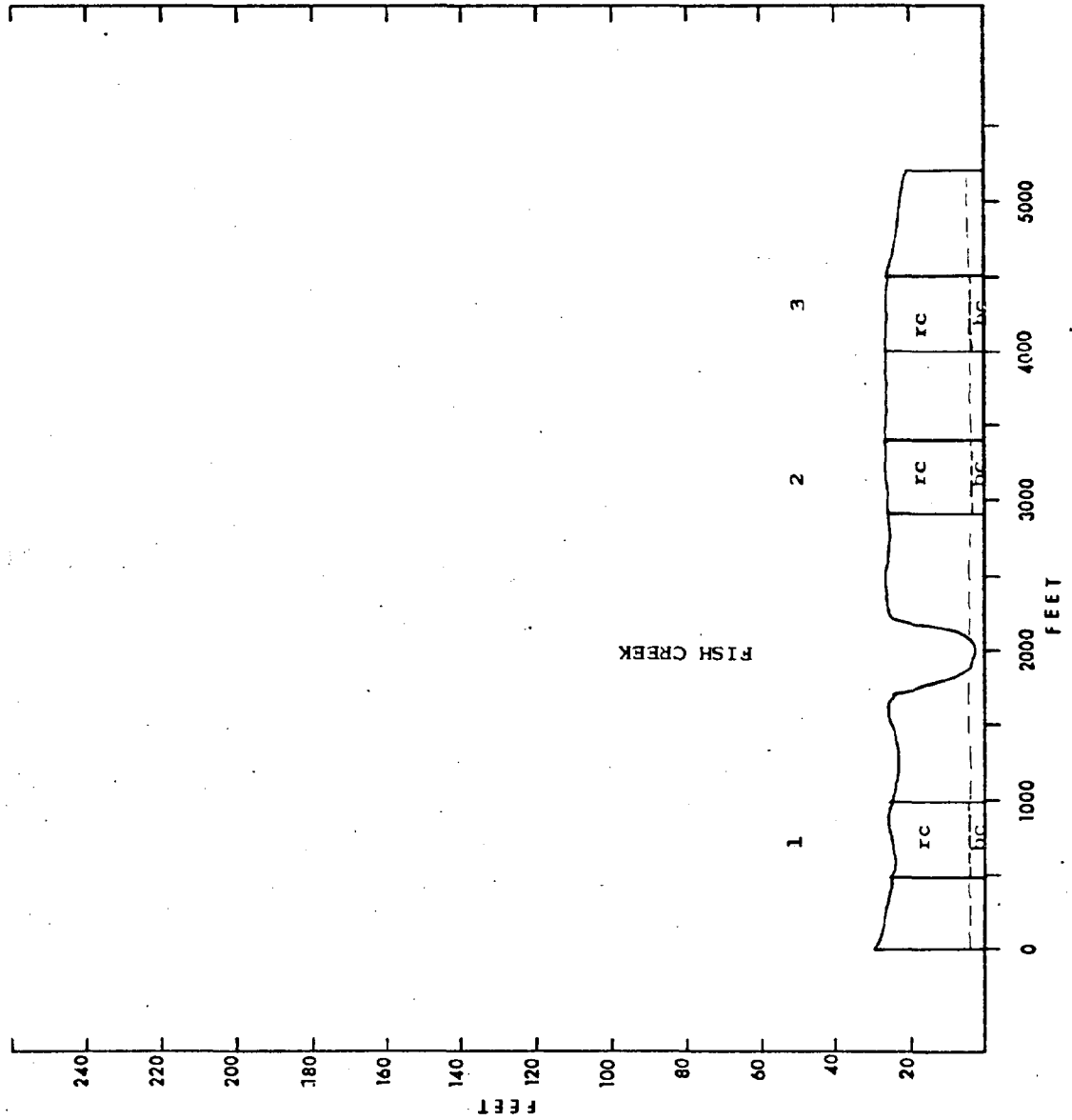
- a) 100% vegetated in alder and birch forest; smooth to slightly hummocky surface in red clay; fairly stable; 20-25' high of even crest
- b) no bluff, Fish Creek with low lying lateral terraces
- c) 100% vegetated in alder and birch forest; hummocky surface with occasional slumps, red clay, 30' high with even crest
- d) Corps of Engineers rip-rap study; 500' wide; bluff leveled at low slope and the following sequence of materials are found at toe (west to east)
 - Boulders
 - Concrete ribbed blocks
 - Boulders
 - Interlocking cinder blocks
 - Boulders
 - Interlocking cinder blocks
 - Boulders
 - Bolted automobile tires
 - Boulders
 - Fence of I-Beam frame and railroad ties

Beach:

- a) 20-25' wide; sand with pebbles
- b) 15-20' wide sandy
- c) 15-20' wide sandy
- d) 10-15'; sandy, pebbly with cobbles and scattered boulders
- e) (see bluff subsection 'd')



T.49 N., R. 9 W., Sec. 5



Section 4, T49N, R9W

This section lies 5 miles to the west of Port Wing near the western end of Bayfield County. The bluff is 20 to 25 feet high and is composed primarily of red clay (15-20 feet) over brown clay (<5 feet). This material is failing in shallow slides and sod clumps moving down slope. Vegetative cover is highly variable, ranging from 0 to 100% depending on the failure activity along a given portion of the shoreline. Vegetation consists of birch, alder, shrubs, and grass predominantly. The bluff is protected throughout by a 5 to 25 foot sandy beach. Towards the east end, boulders occur occasionally on the beach. Half of a dozen cottages are located along the bluff top but use of the shoreline is minimal. The section is bisected by Reefer Creek and State Highway 13 lies within 1/4 mile throughout the section.

6.

6.



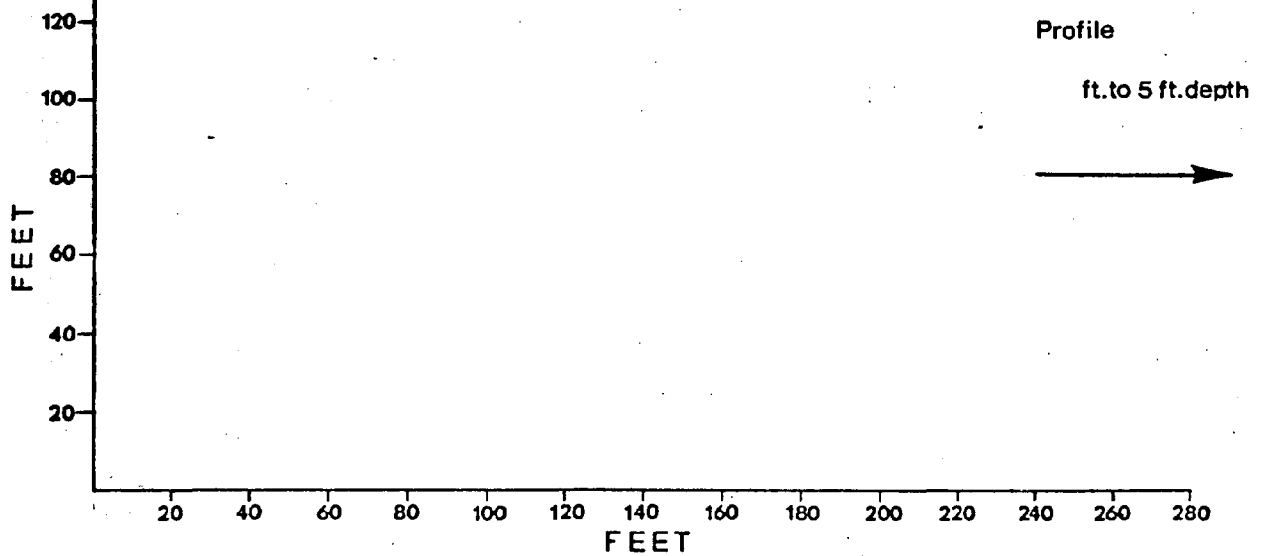
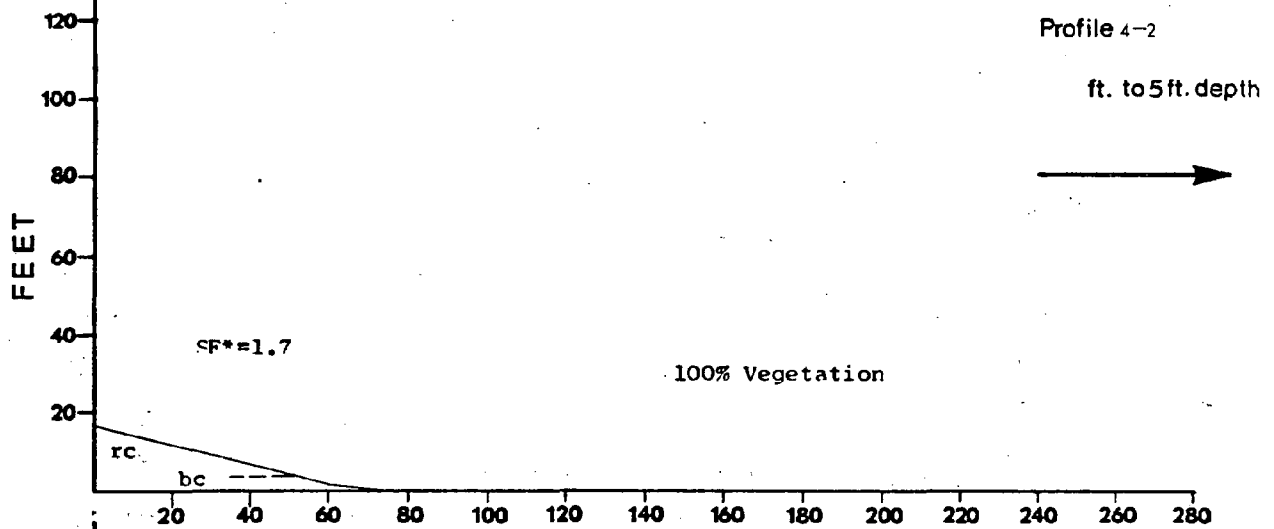
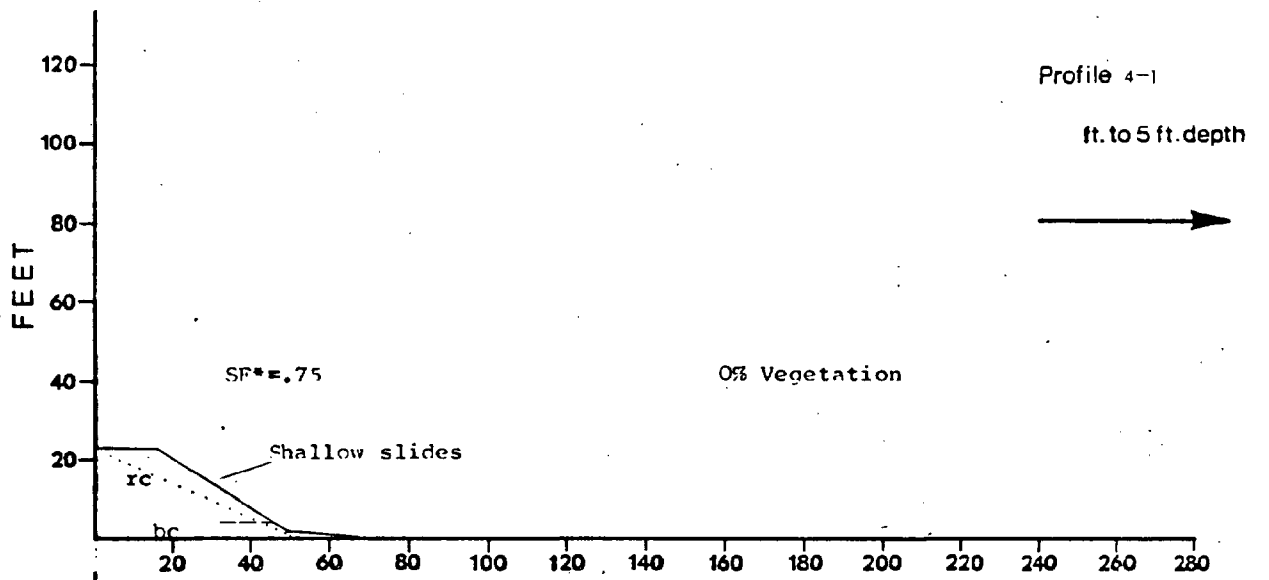
Sec. 4, T 49 N, R 9 W

Bluff & Toe:

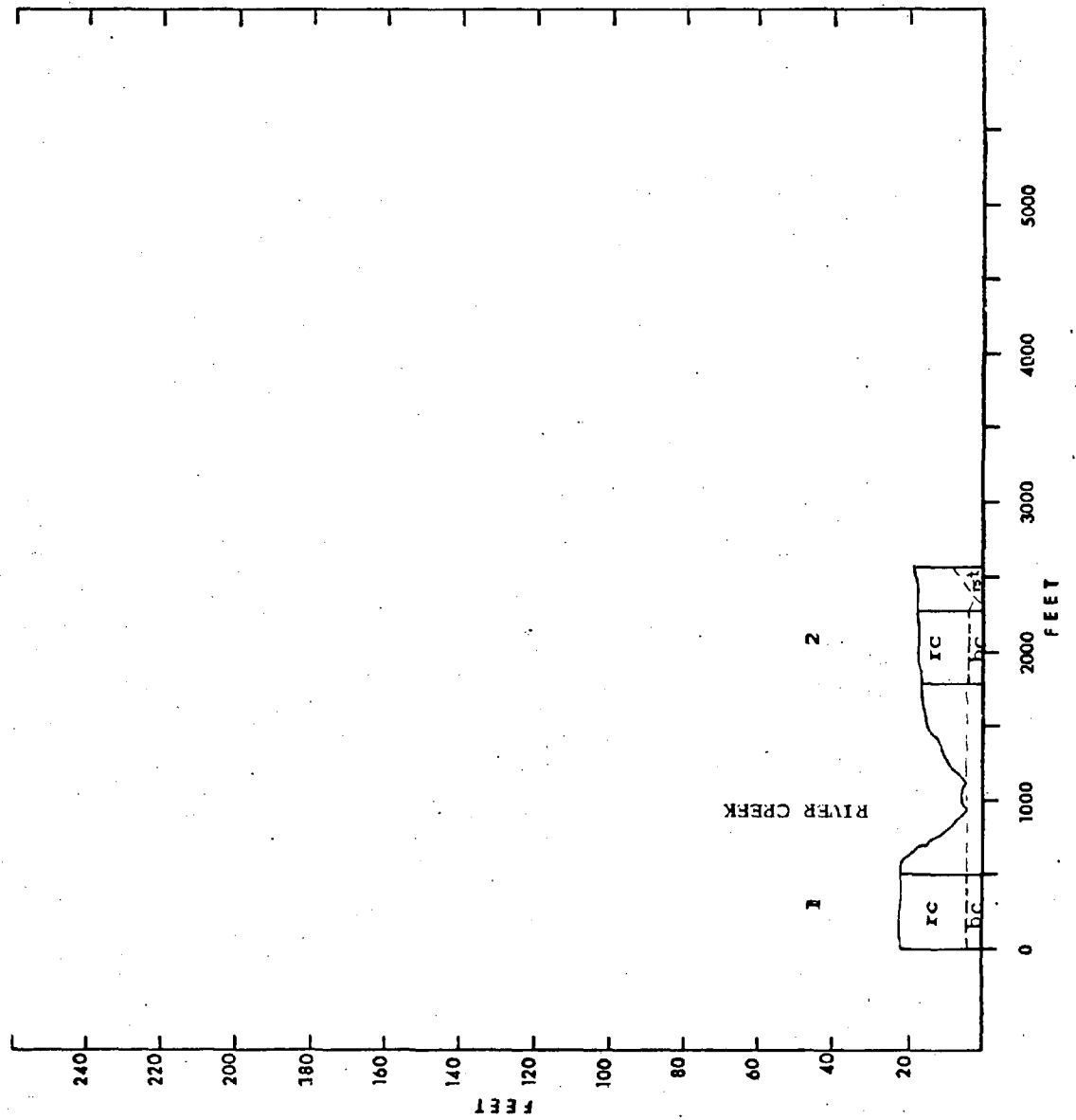
- a) 20-40% vegetated, tree and sod clumps moving down steep (60%) slope in red clay; 20-25' high
- b) No bluff; Reefer Creek
- c) 0% vegetated; shallow slides in steep red clay with brown clay at base; 20' high
- d) 100% vegetated; shrubs and birch, shallow slides and small scale rotational slumps; 20' high
- e) 40-60% vegetated with tree clumps and grass moving downslope, shallow slides, red clay, 20-25' high

Beach:

- a) 20-25 ft.; sand with occasional pebbles
- b) Reefer Creek; sand spits
- c) 5-20 ft; sand with occasional boulders



T.49 N., R.9 W., Sec.4

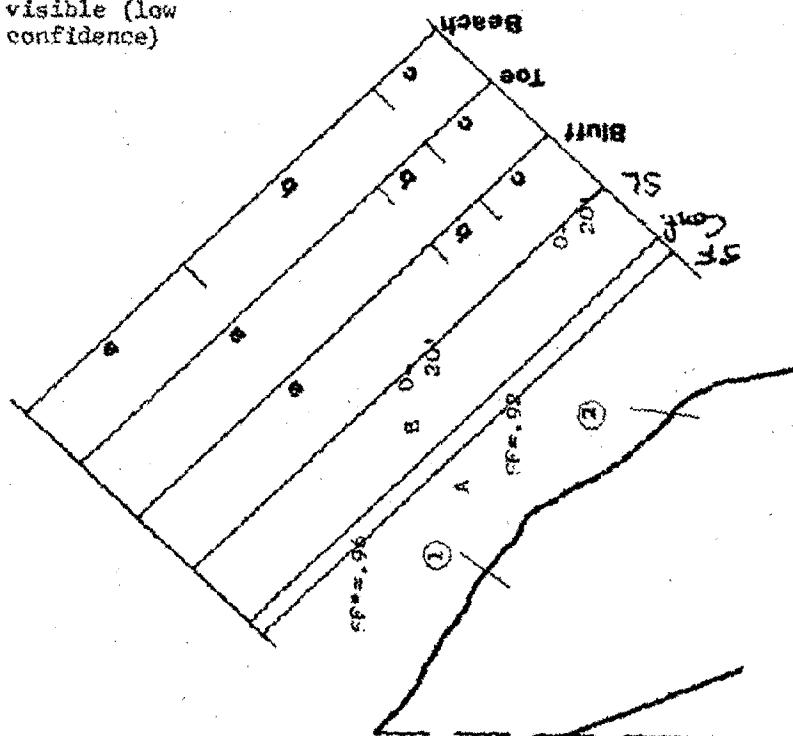


Section 33, T 40 N, R 9 W

This section lies 5 miles west of Port Wing near the west end of Bayfield County. The section is bounded on the east by the Iron River. The bluff is 15 to 20 feet high and is composed mostly of red clay. The stiffer and slightly more silty brown clay, which is present to the west of this section, is absent here. Also, bedrock, which is Precambrian red sandstone of the Bayfield Group and absent to the west, is present for the first time in this section. Medium scale rotational slumps and shallow slides are the predominant failure type. Vegetative cover is variable depending on failure activity and includes birch, fir, and grass. A wide beach (20 to 40 feet) occurs at the east end of the section but elsewhere the beach is either narrow, absent, or replaced by bedrock. Thus, in places, waves freely attack the bluff toe. The shoreline is accessible at its eastern end from State Highway 13 but is probably rarely used.

A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



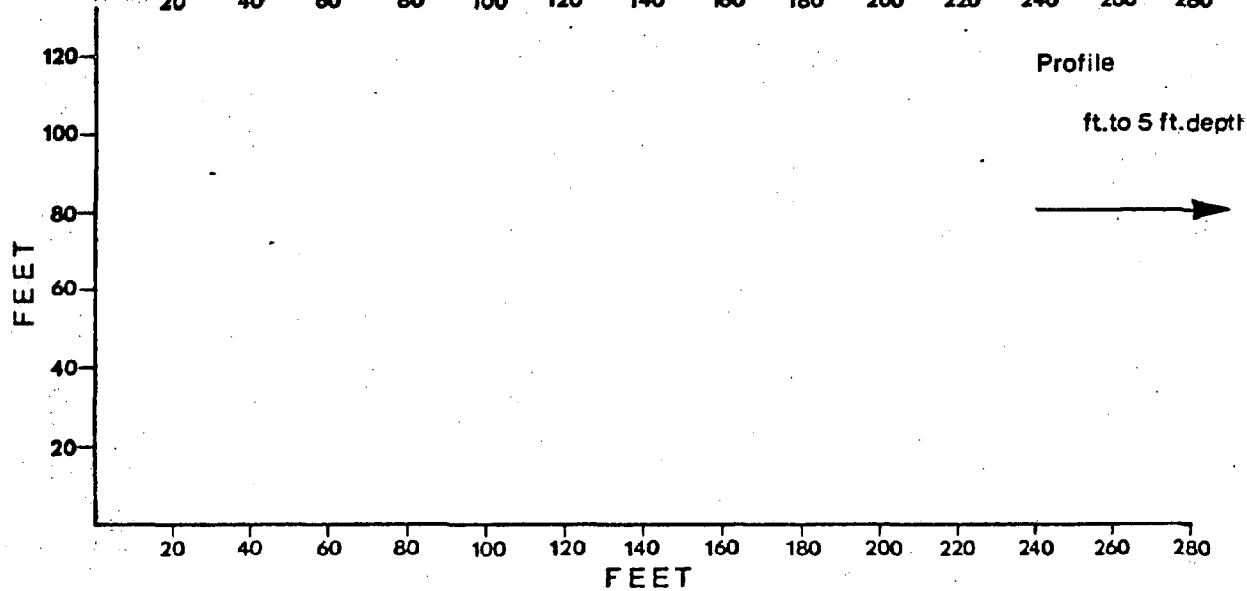
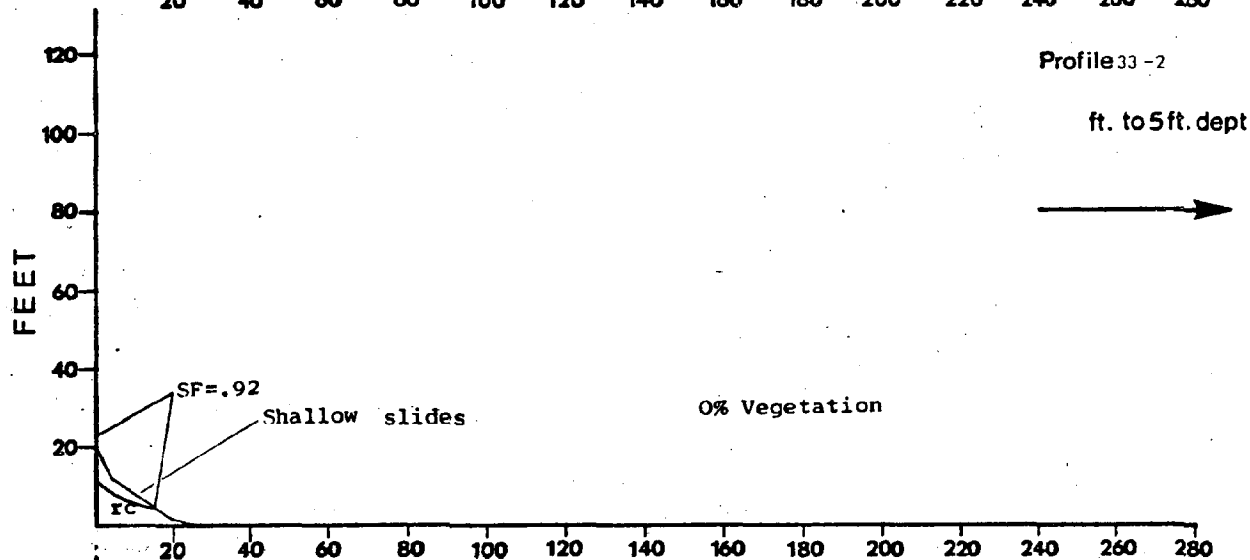
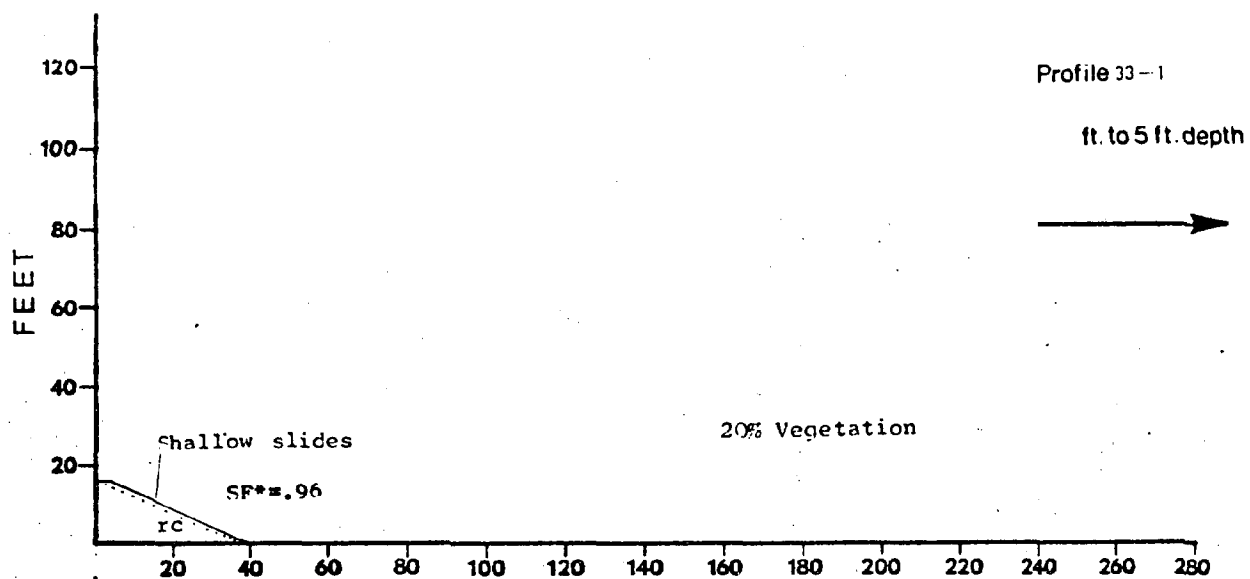
Sec. 33, T 50 N, R 9 W

Bluff & Toe:

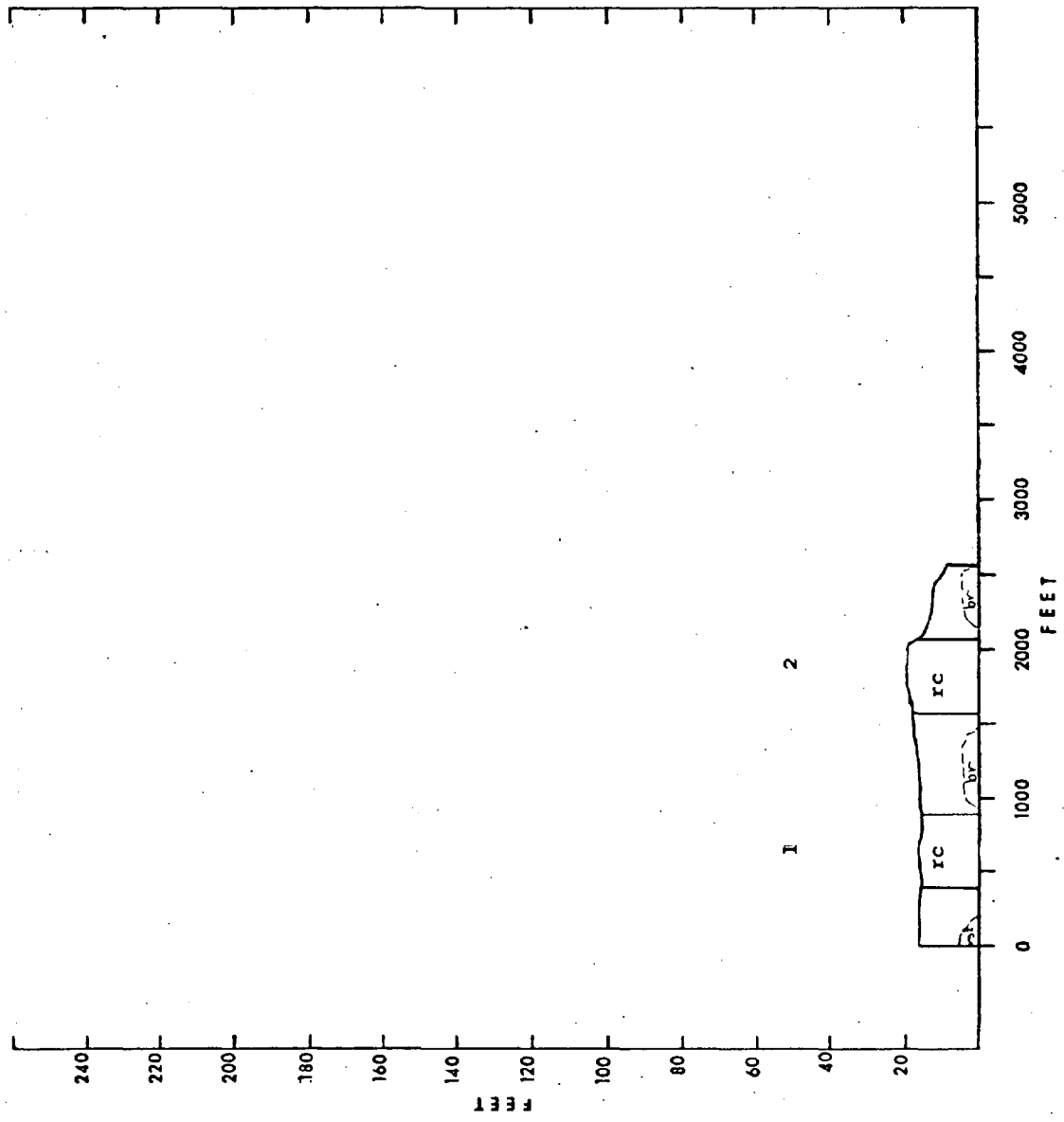
- a) 80-100% vegetated, birch and firs; Medium scale rotational slumps in red clay over 1-10' feet of red clayey sand; 20-25' high with even crest; bedrock at toe in west half.
- b) 10% vegetated, birch clumps sliding downslope; shallow slides in shallow slides in red clay with bedrock occasionally at toe; 20' high
- c) 40-50% vegetated, birch and sod clumps; small slumps; no bedrock at toe; 15-20' high tapering off to east

Beach:

- a) 0-10 ft; sandy with boulders; boulder concentration increases to the east
- b) 0-5 ft.; cobbly and bouldery; beach often replaced by bedrock 1'-5' exposed
- c) 20-40 ft, widening towards east and Iron River; sand with pebbles; no bedrock



T.50 N., R. 9 W., Sec. 33



Section 34, T50N, R9W

This section lies 4 miles to the west of Port Wing, Wisconsin and the Iron River flows into Lake Superior at its west end. The stratigraphy is more complex here than to the west. Throughout the section, red clay occurs at the top of bluff and makes up the whole bluff towards the western end. In the middle portion of the section, two-thirds of the bluff is made up of sand with occasional interbeds of red clay. This unit forms a pronounced break in slope. At the extreme eastern end, a red sandy-loam till occurs cropping out at the bluff toe. The bluff height is 20 to 35 feet rising steadily to the east. Failure is primarily by small slumps and shallow slides which carry clumps of sod downslope. Vegetation is sparse consisting of birch and grass in the western end. Towards the east, vegetation is absent except for occasional sod clumps. The beach is narrow and sandy with cobbles and boulders. The width is not sufficient to protect the bluff from wave attack during intense storms. The entire section shows signs of past or present development. Numerous access roads and homesites have been constructed, but the shoreline itself probably sees little concentrated use.

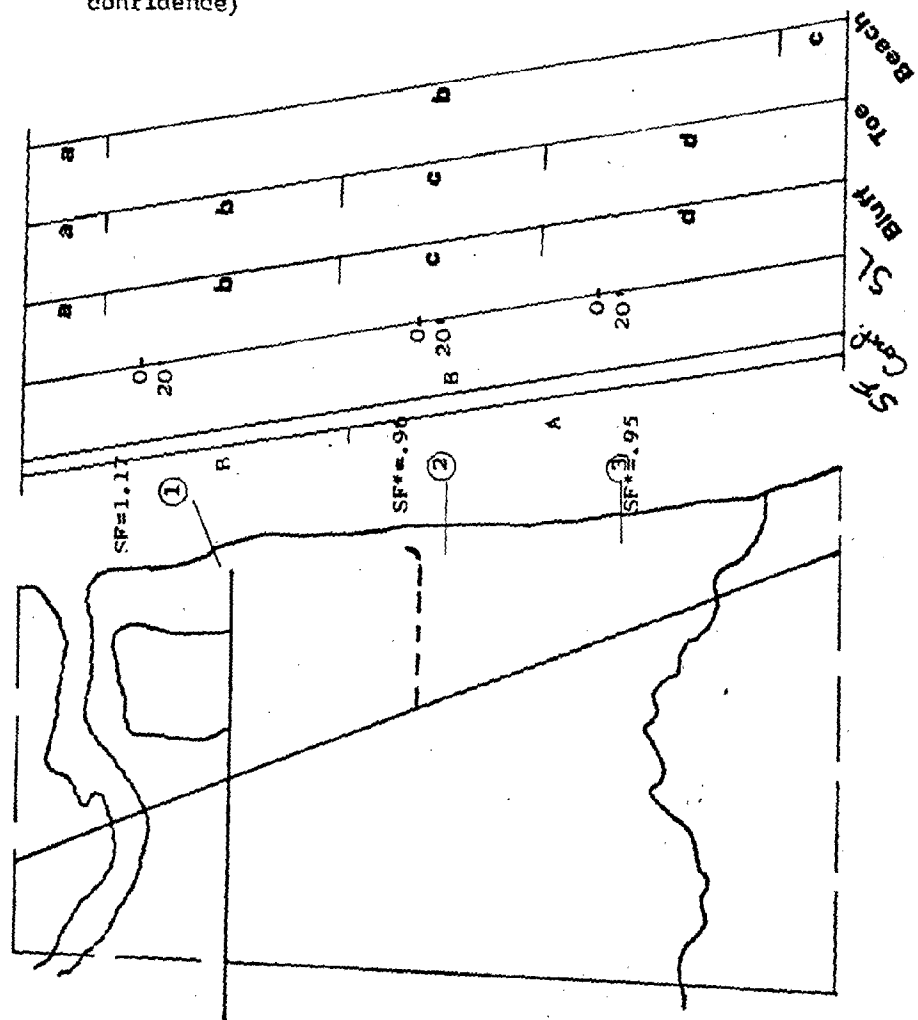
SEC34 T 50 N R 9 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



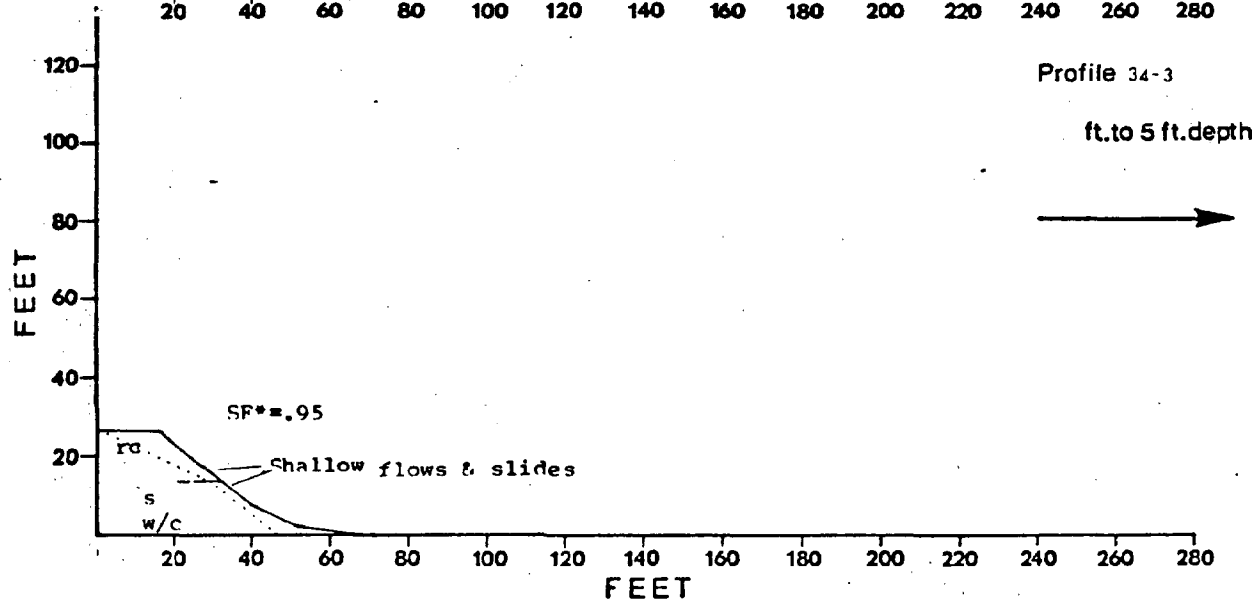
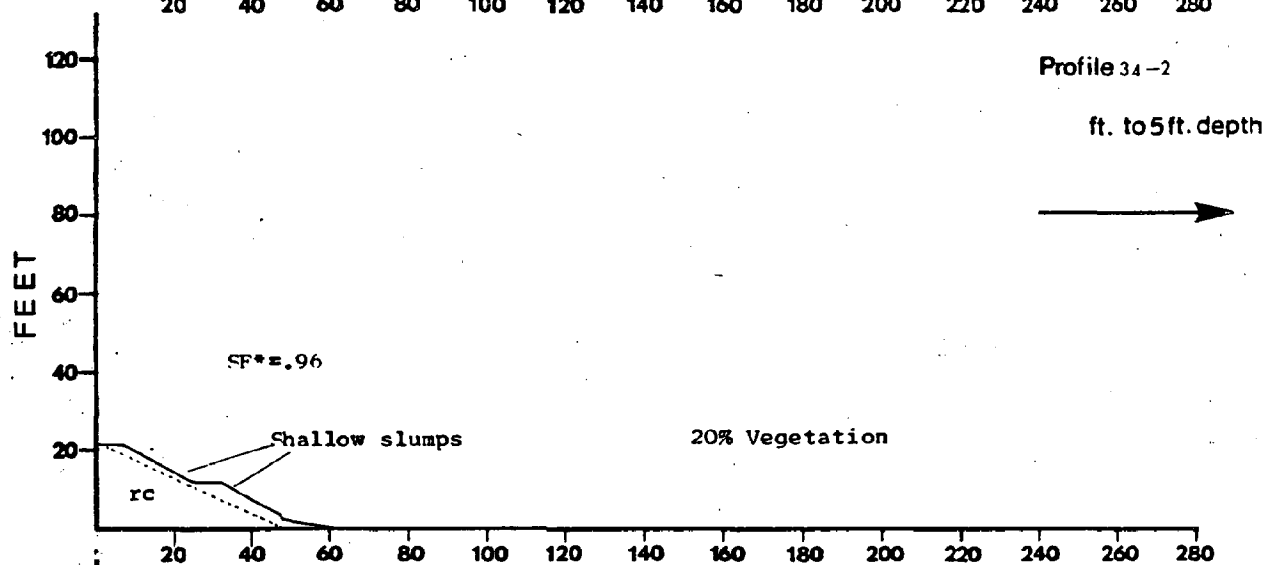
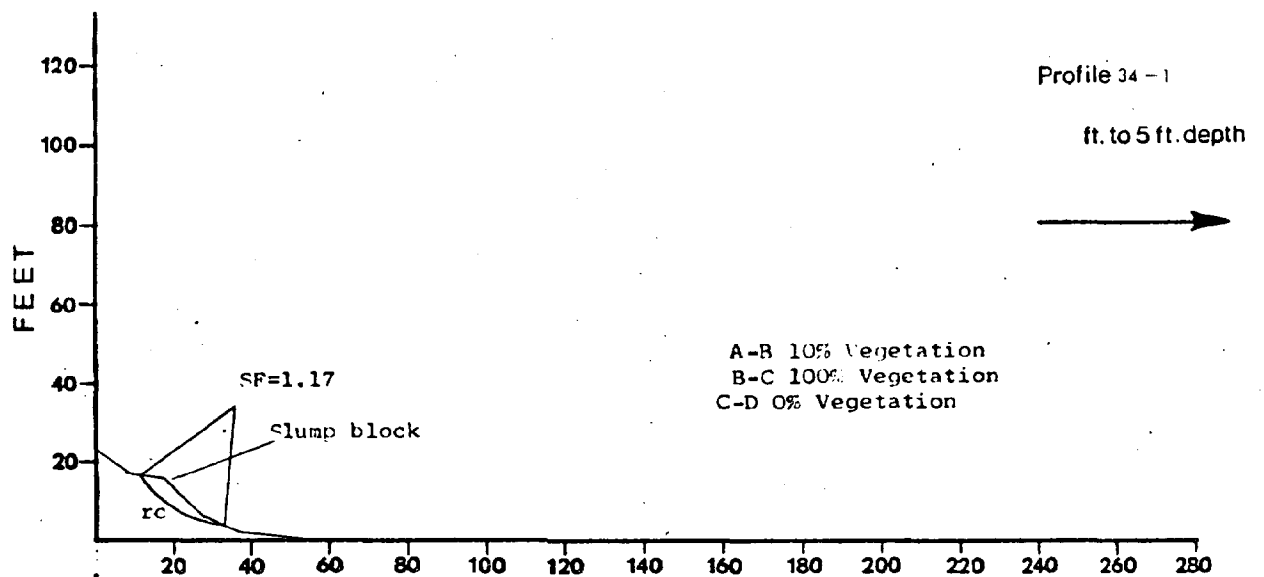
Sec. 34, T 50 N, R 9 W

Bluff and Toe:

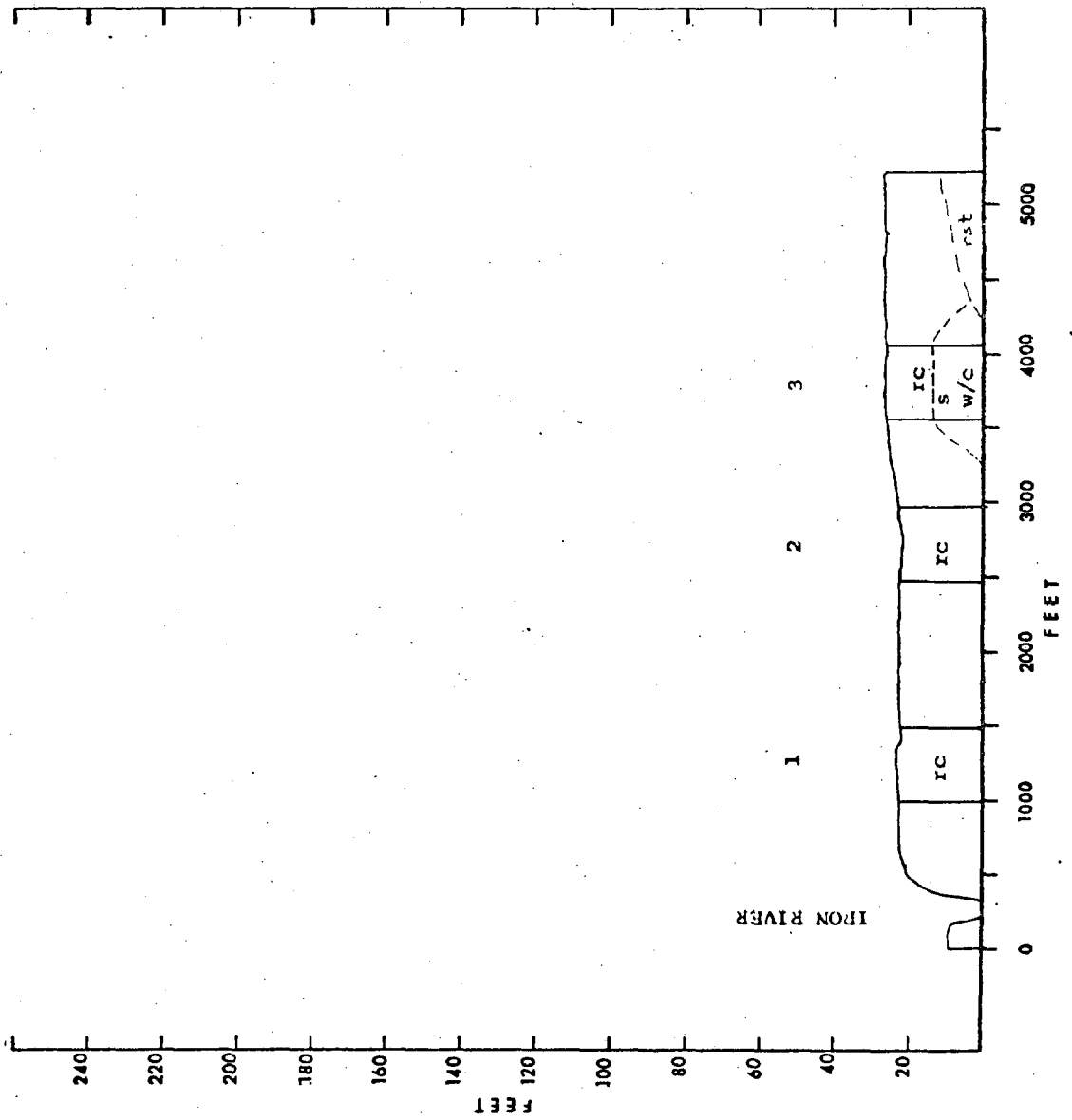
- a) No bluff, Iron River
- b) 40% vegetated; birch and grass; red clay; small slumps and shallow slides; 20' high
- c) 40% vegetated grass; red clay over 2 ft. of clayey sand till; long narrow shallow sod blocks sliding downslope; 20-25' high
- d) 0% vegetated, occasional tree clumps in east end where crest is vegetated; red clay over sand; shallow slides and flows; 30-55' high, sand forms break in slope

Beach:

- a) Iron River; 50' sand beach to west, cobbly swash zone to east
- b) 15'-20 ft., occasionally absent; sandy with cobbles and scattered boulders immediately off shore
- c) 5-10 ft., sand and cobbles with boulders



T.50 N., R.9 W., Sec. 34



Section 35, T50N, R9W

This section lies three miles west of Port Wing and one mile east of the Iron River. Jardine Creek and a small restaurant (the Quarry Inn) are located near the eastern end of this section. The stratigraphy consists of red clay over red sandy-loam till throughout the entire length of the shoreline. At the eastern end, bedrock outcrops at the bluff toe. Above the bedrock lies a zone of breccia composed of broken-up sandstone presumably as a result of fracturing by overriding ice. Bluff height is even at 20 feet. Erosion of the bluff is by rill and wave erosion w/small shallow slides. No large scale failures were observed. The bluff is unvegetated except for occasional clumps of sod moving downslope. Boulders, eroded from the sandy till, dot the predominantly sandy, narrow beach. The bluff top is fairly well developed for Lake Superior with several cottages, a restaurant, and a wayside off of State Highway 13. Access to the beach is easily made from any of these sites.

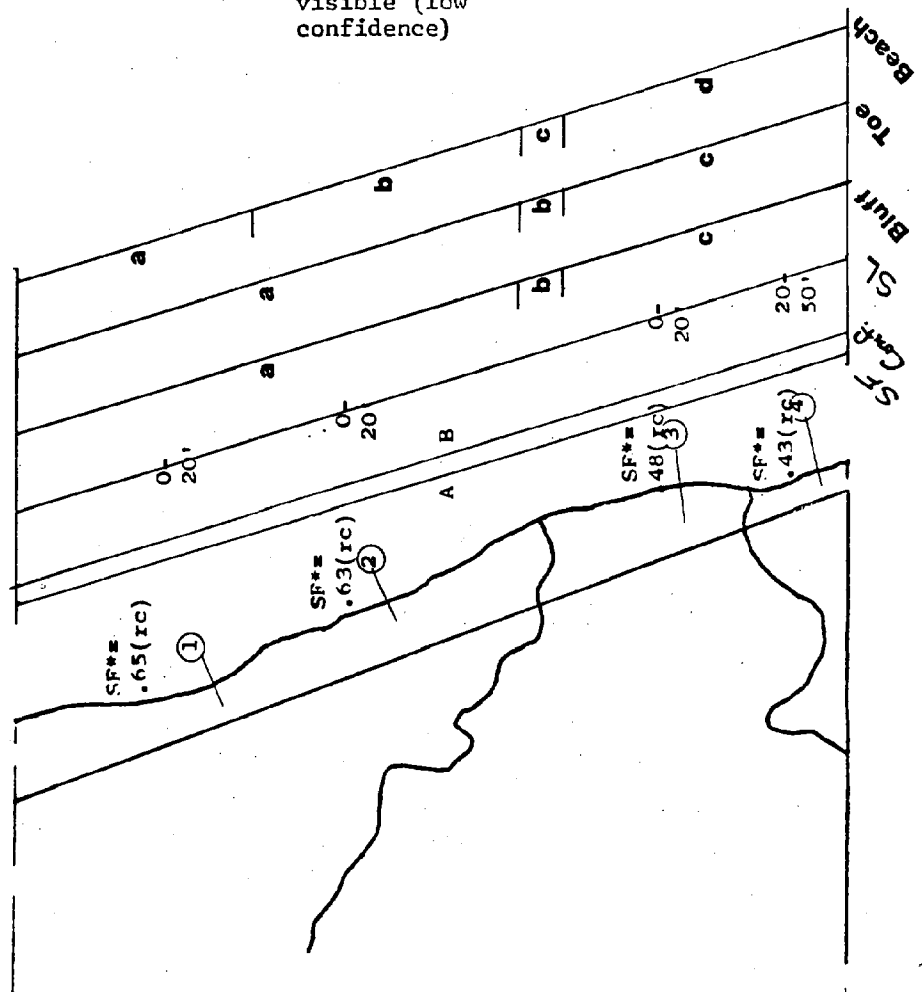
SEC35 T50N R9W

SAFETY FACTOR

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVELA-boreholes
(high confidence)B-near boreholes
stratigraphy visibleC-no stratigraphy
visible (low
confidence)

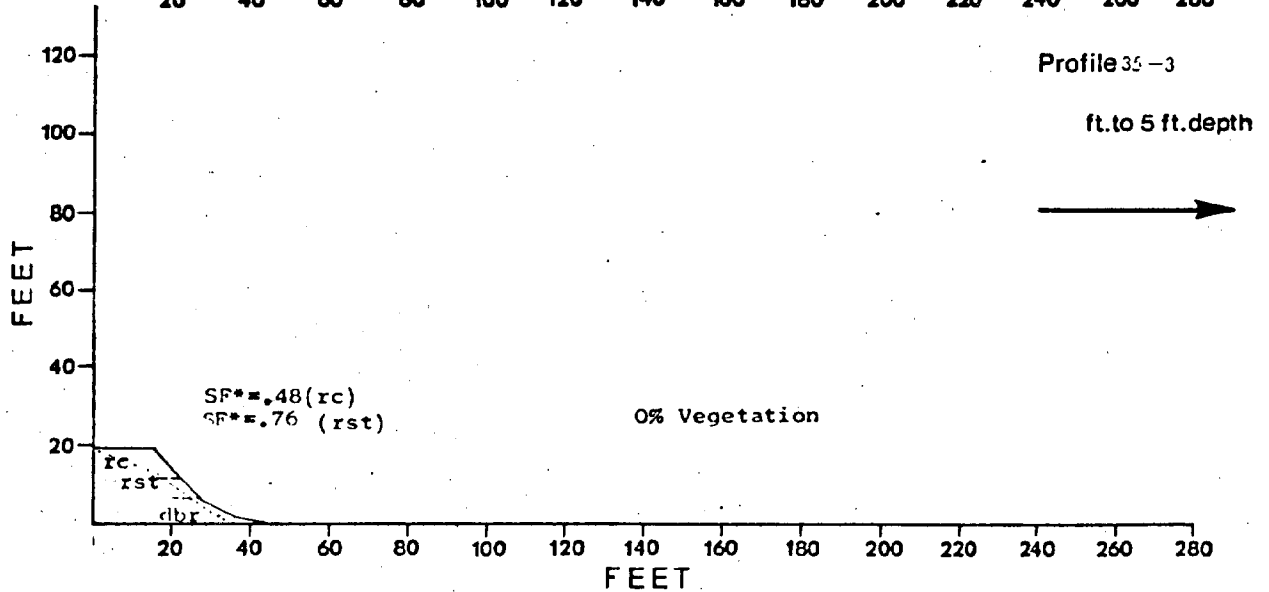
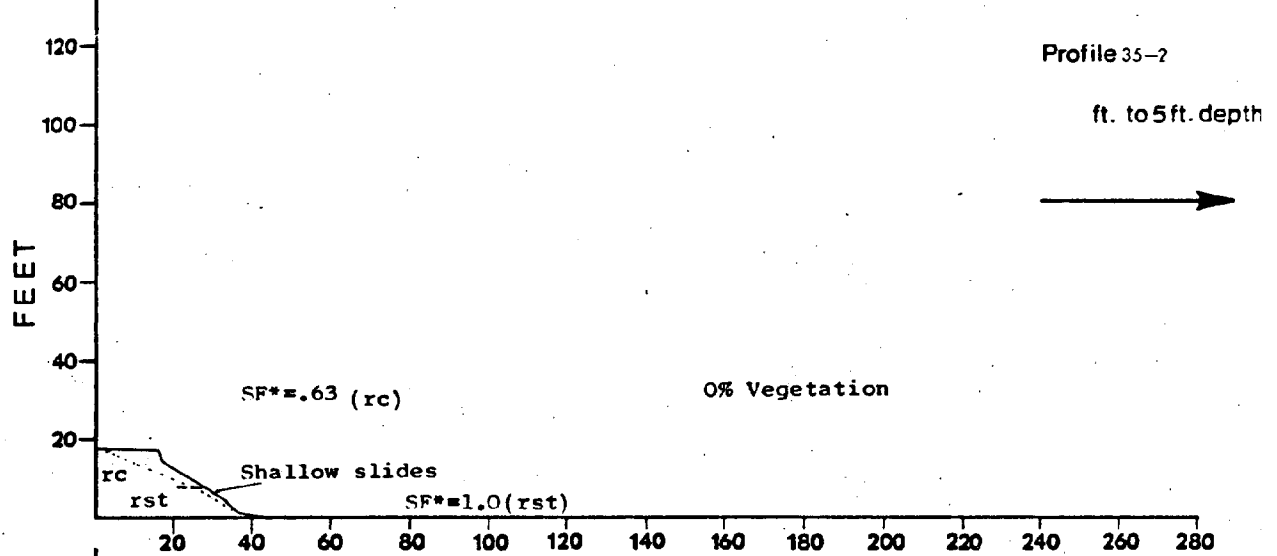
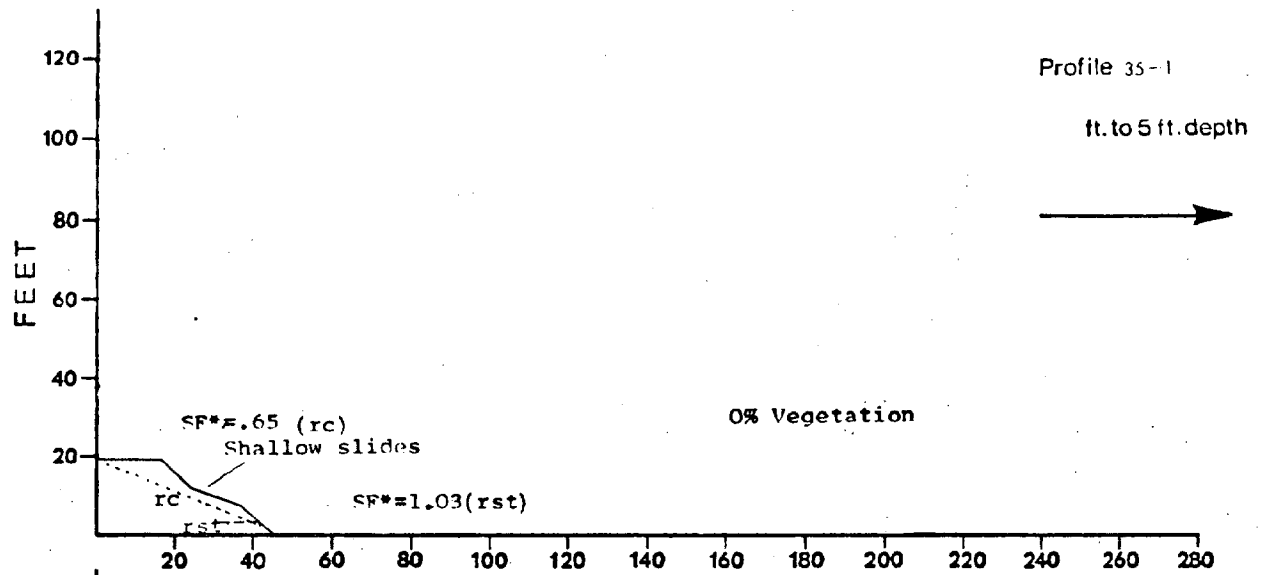
Sec. 35, T 50 N, R 9 W

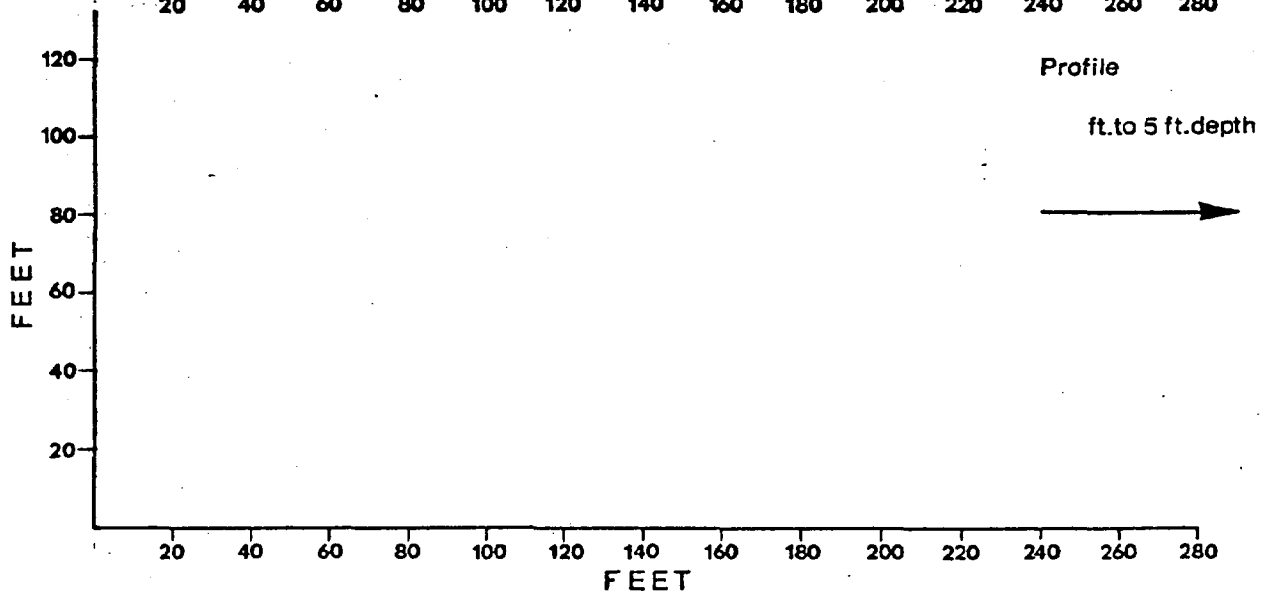
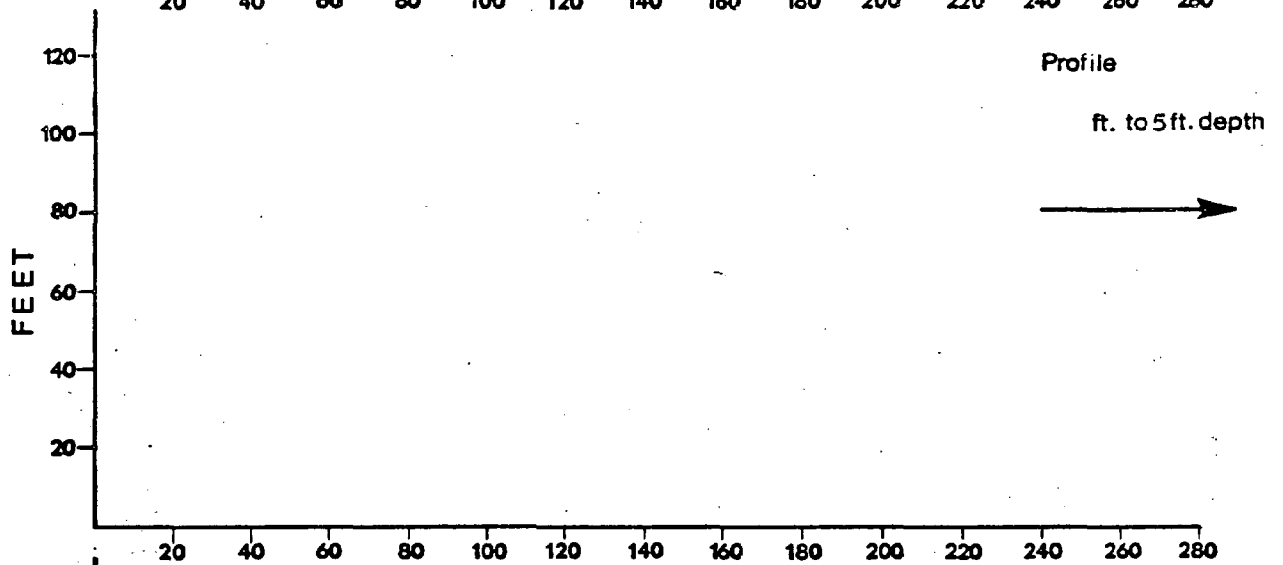
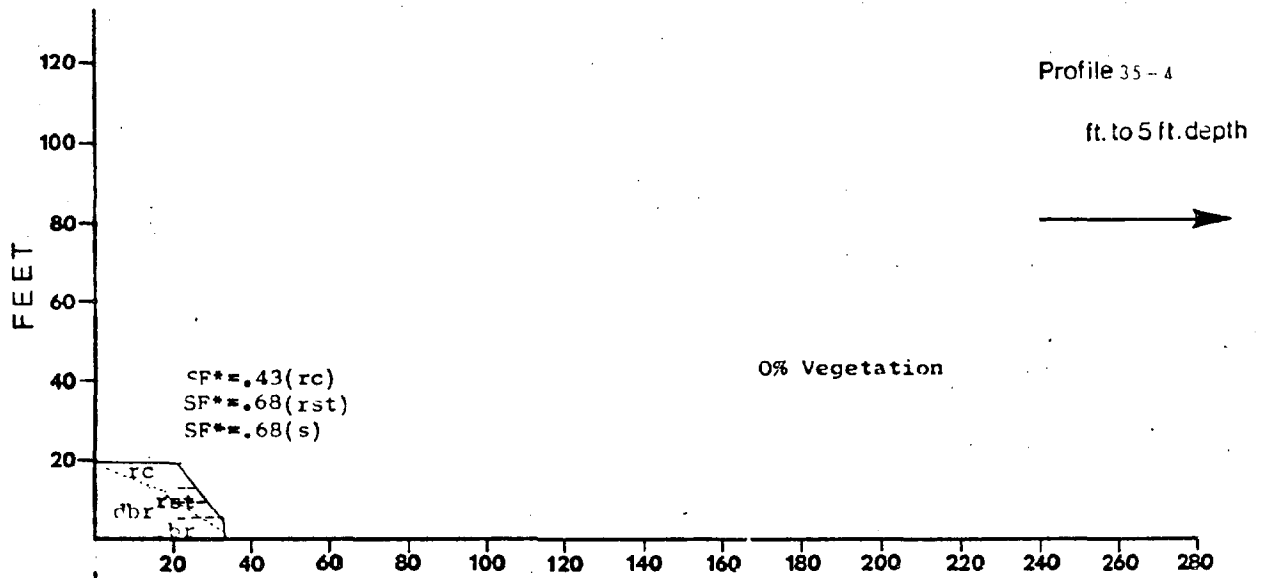
Bluff and Toe:

- a) 0-20% vegetated, sod and birch clumps, red clay over red sand till; till forms a break in slope; 20-30 feet.
- b) Jardine Creek, no bluff
- c) 0% vegetated red clay, sandy till, disturbed bedrock over bedrock rilled with slides; 20' high; > 100% slopes

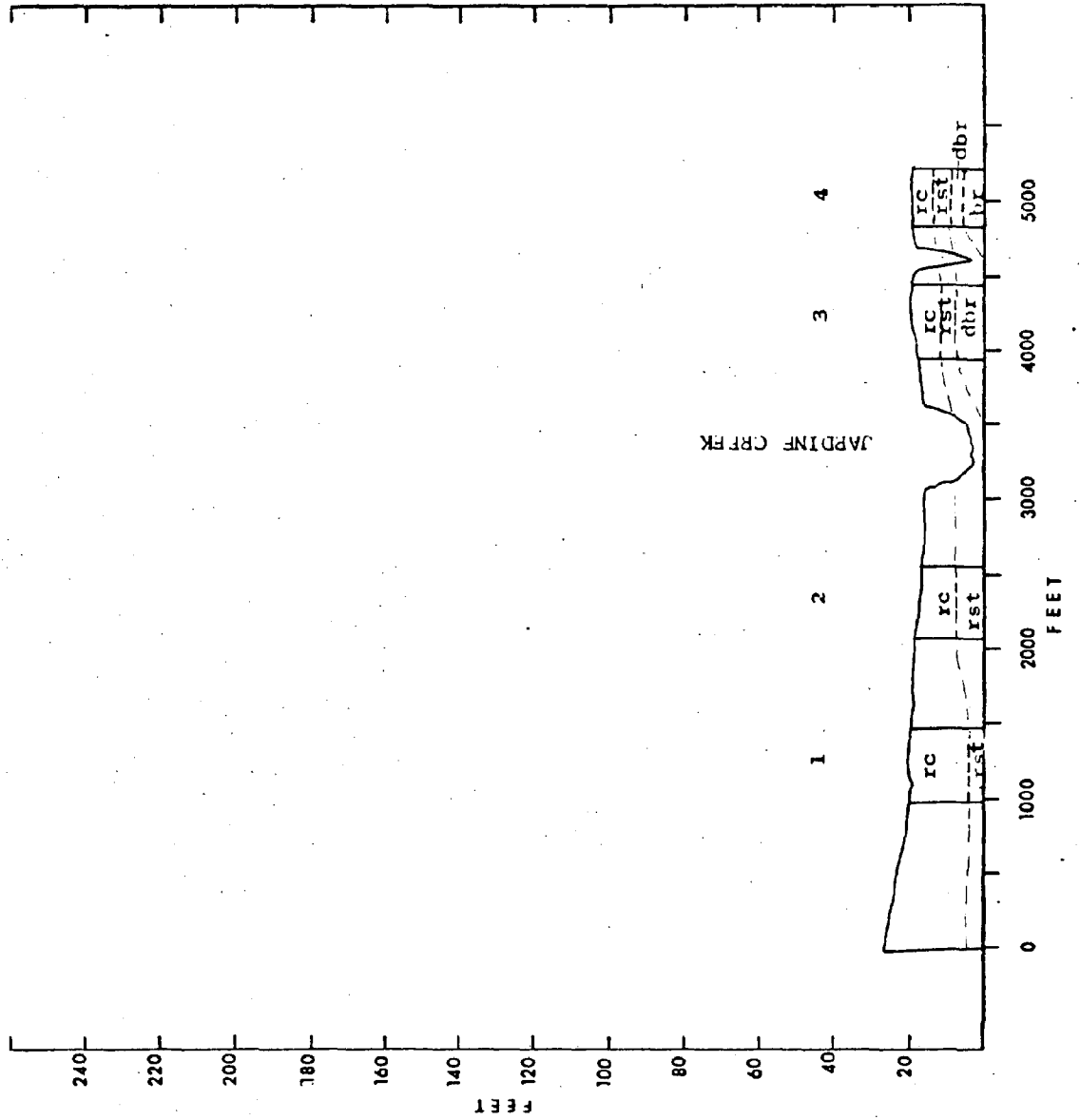
Beach:

- a) 15 ft.; sandy with occasional boulders
- b) 5 ft; cobbly and sandy with occasional boulders
- c) Jardine Creek
- d) 10 ft; cobbles and boulders





T. 50 N., R. 9 W., Sec. 35



Section 36/25, T50N, R9W

This section lies two miles west of Port Wing. The stratigraphy throughout is highly variable with several units. Red clay occurs at the bluff top through the entire section. In the western third, this red clay overlies a red sandy-loam till which in turn overlies bedrock. Occasionally the bedrock has a brecciated appearance. Red clay over bedrock dominates the middle third. Here bedrock composes one-half to two-thirds of the entire bluff. The remaining eastern third has red clay over bedded sand and gravel with bedrock occurring occasionally at the toe. The bluff varies in height from 20 to 35 feet. Vegetation is sparse with the exception of occasional sod clumps that have moved downslope. Erosion is primarily by rilling and wave action with shallow slides. Little development has occurred along the bluff top with the exception of a few cottages. Access to the beach is from Kukor Road located at the eastern end of the section.

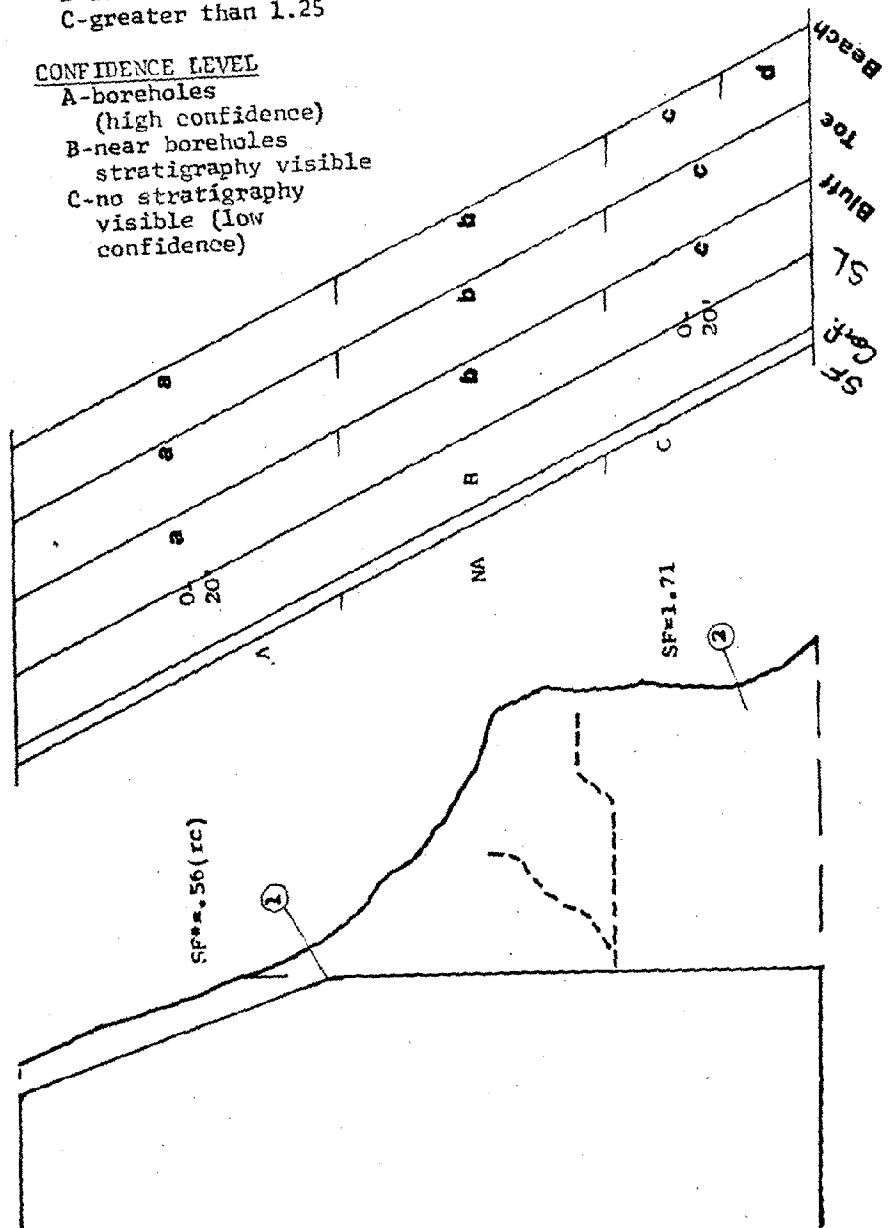
SEC 36/25 T50N R9W

SAFETY FACTOR

SAFETY FACTOR
A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

CONFIDENCE LEVEL
A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



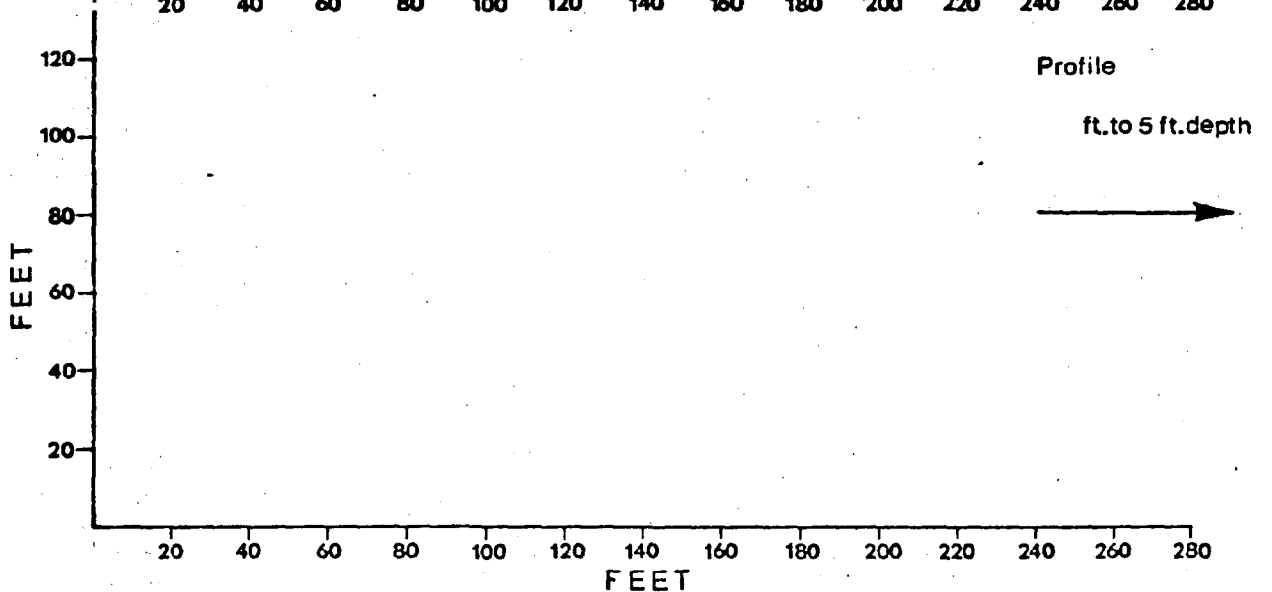
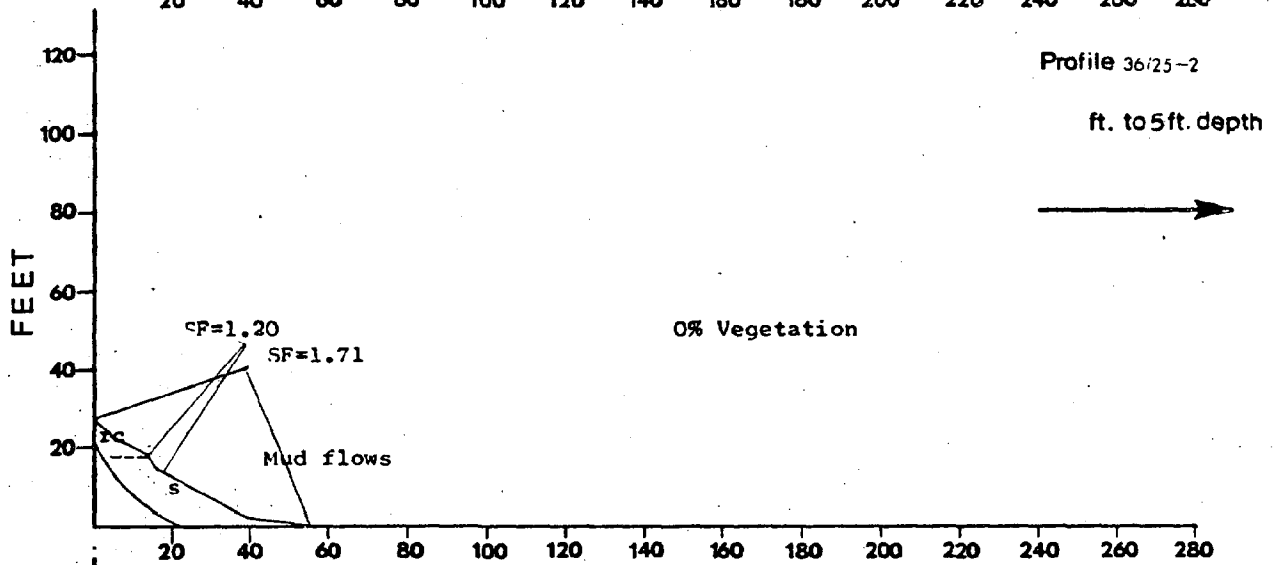
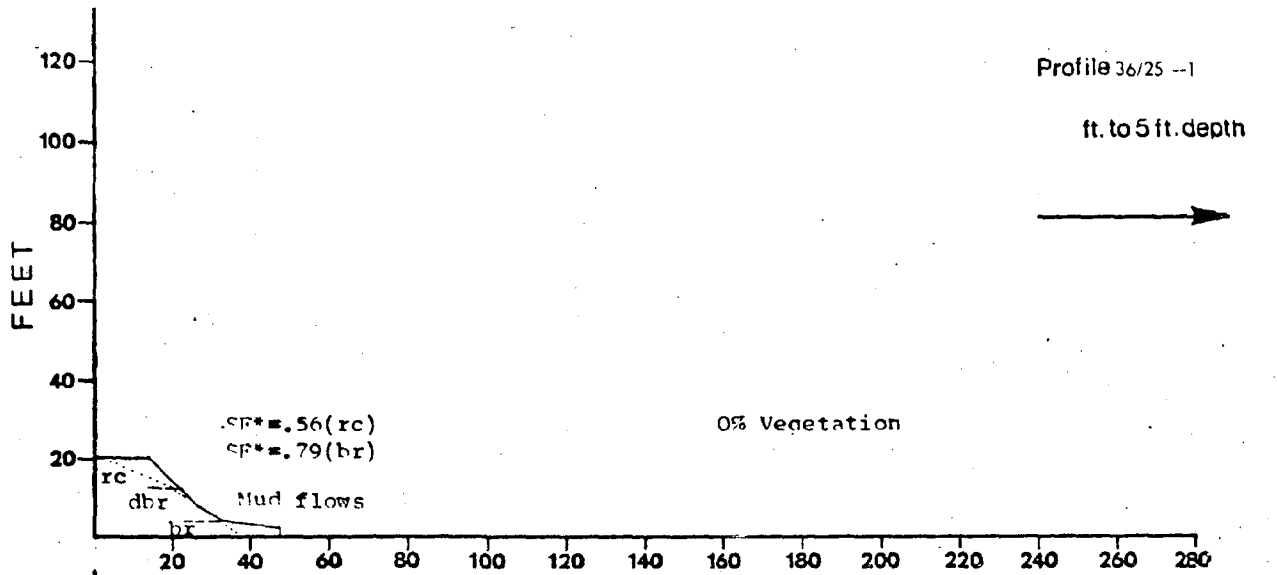
Sec. 36/25, T 50 N, R 9 W

Bluff and Toe:

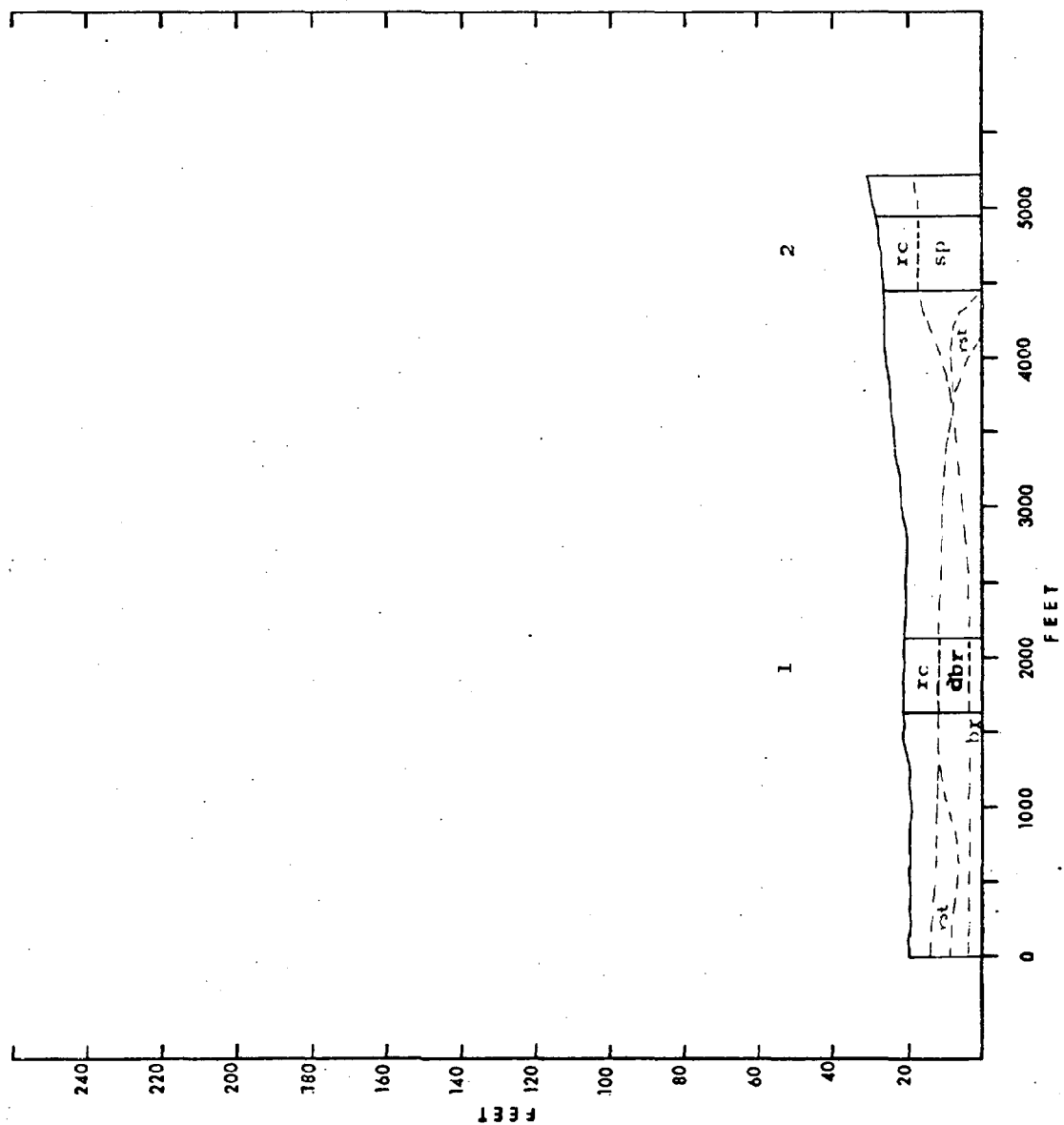
- a) 0-20% vegetation, birch clumps; red clay over disturbed bedrock occasional cobbly sandy till; eroded with clay flows; bedrock in toe and occasional wave beaten; 20-25 ft.
- b) 0% vegetation; red clay over bedrock; 20' with Bedrock up to 15'
- c) 0-10% vegetation, tree clumps; red clay over fine sand and gravel; rilled with shallow flows; 20-30' high

Beach:

- a) 5-20'; cobbly with occasional sandy stretches and scattered bedrock outcrops
- b) bedrock with occasional small sand pockets
- c) 20-30'; sand and pebbles with scattered boulders and cobbles
- d) 5'; cobbles and boulders



T.50 N., R. 9 W., Sec. 36/25



Section 30/19, T50N, R8W

This section lies just one mile west of Port Wing. Quarry Point, the site of an abandoned sandstone quarry, occurs at the east end of the section. The entire shoreline in this section is dominated by bedrock. Locally sand and gravel may overlies the bedrock, and red clay occurs at the top of the bluff throughout. The bluff height is 20 to 30 feet high with bedrock making up one-to two-thirds. Rilling and some mudflows occur in the red clay but the protection of the bluff by the bedrock toe allows the unconsolidated portion of the bluff to become somewhat stabilized. Beaches are present only in bedrock recesses. Vegetation is 10 to 20% with shrubs and occasional tree clumps. Several summer homes have been built along Kukor Road in the western half of the section. The eastern half is largely undeveloped. Access to the shoreline is easy along Kukor Road and at Quarry Point.

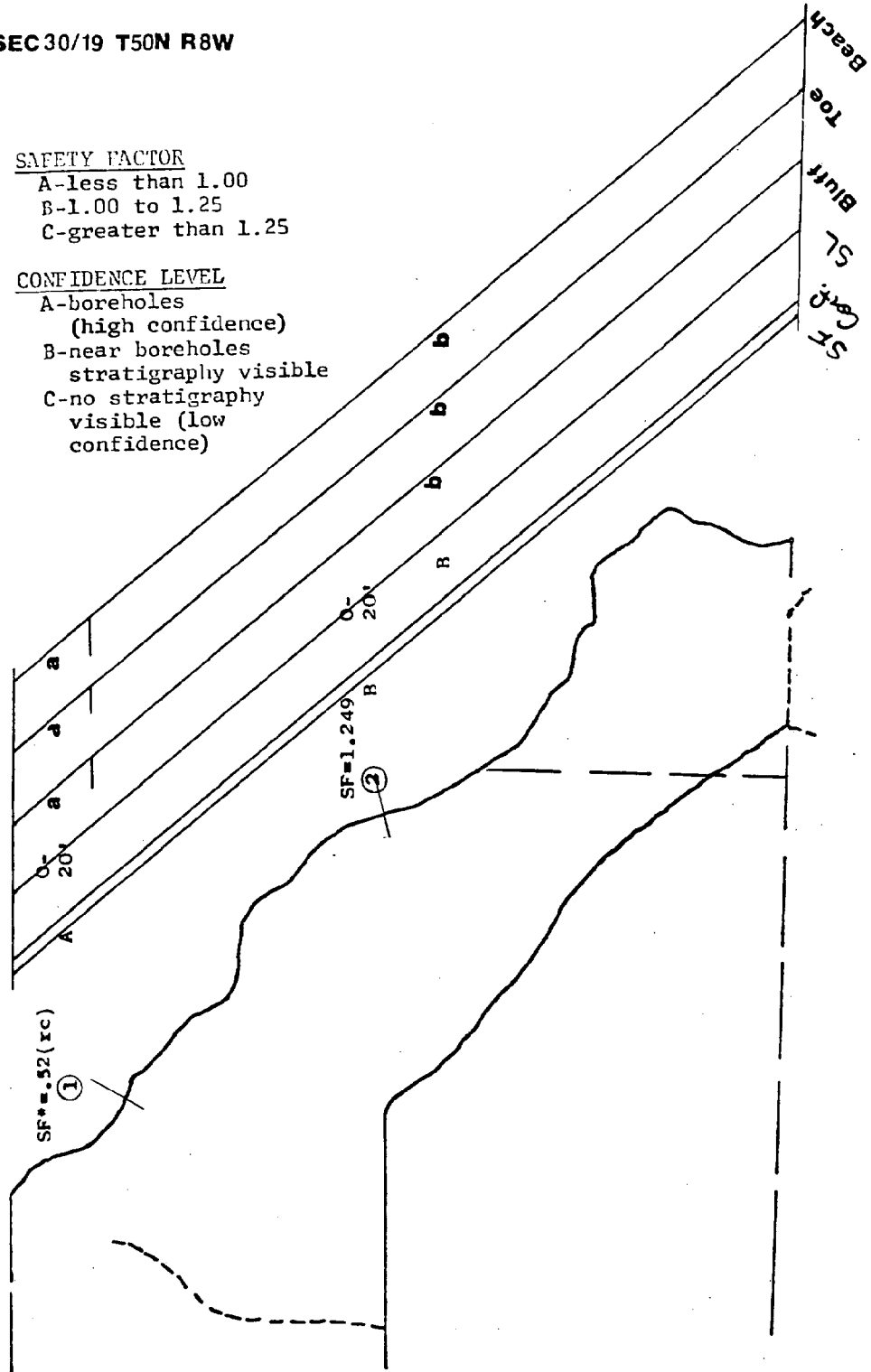
SEC 30/19 T50N R8W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



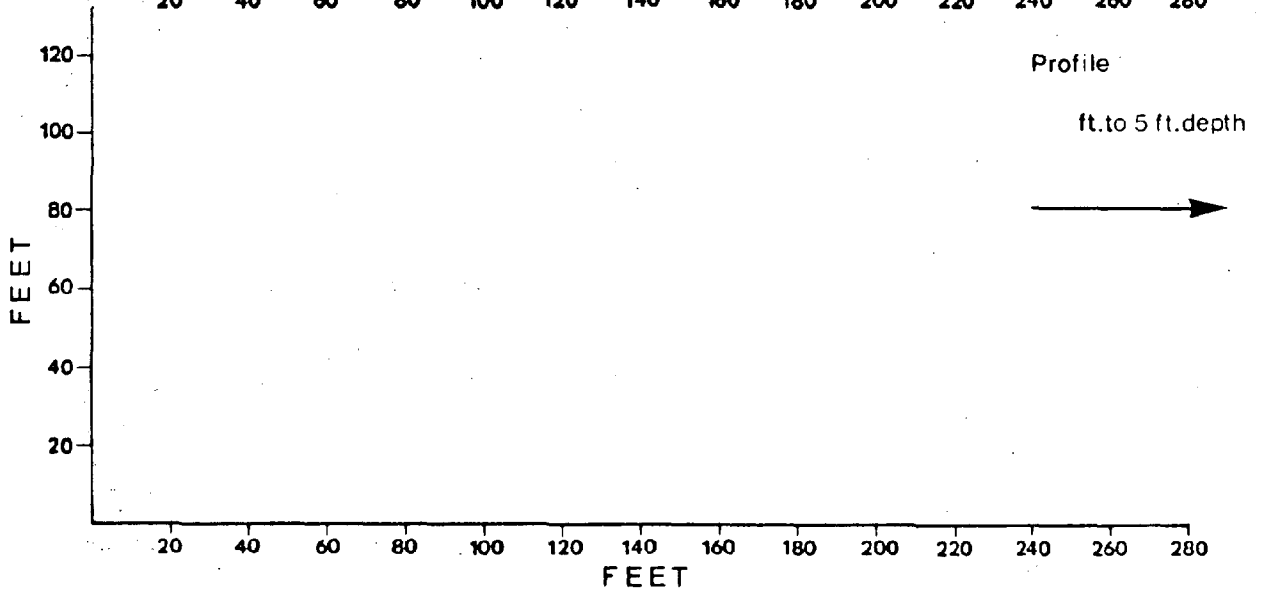
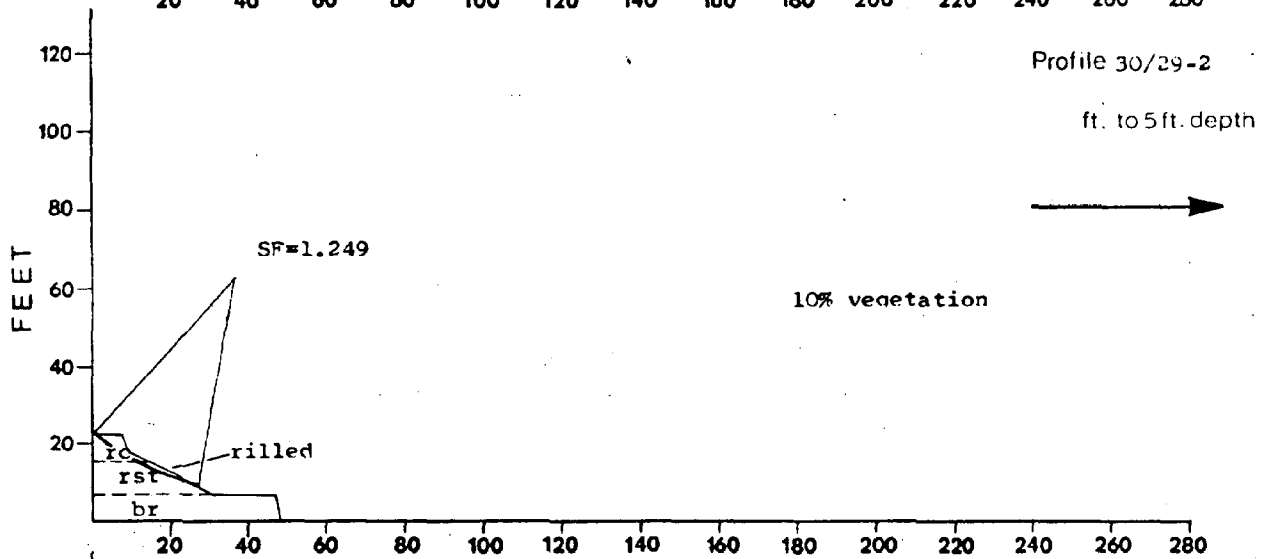
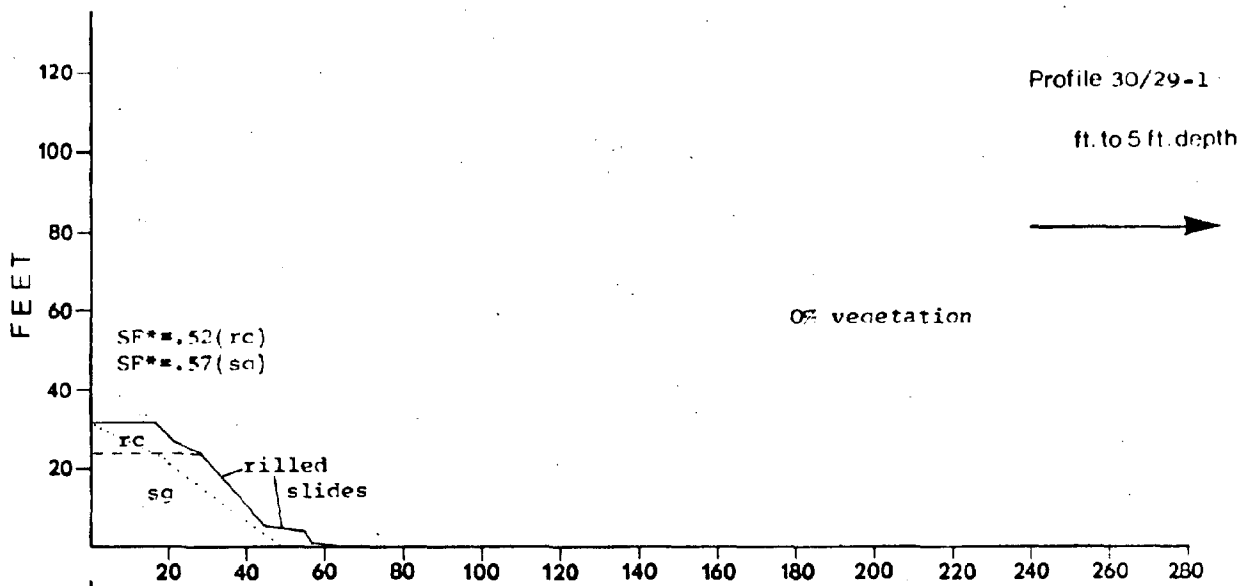
Sec. 30/19, T 50 N, R 8 W

Bluff and Toe:

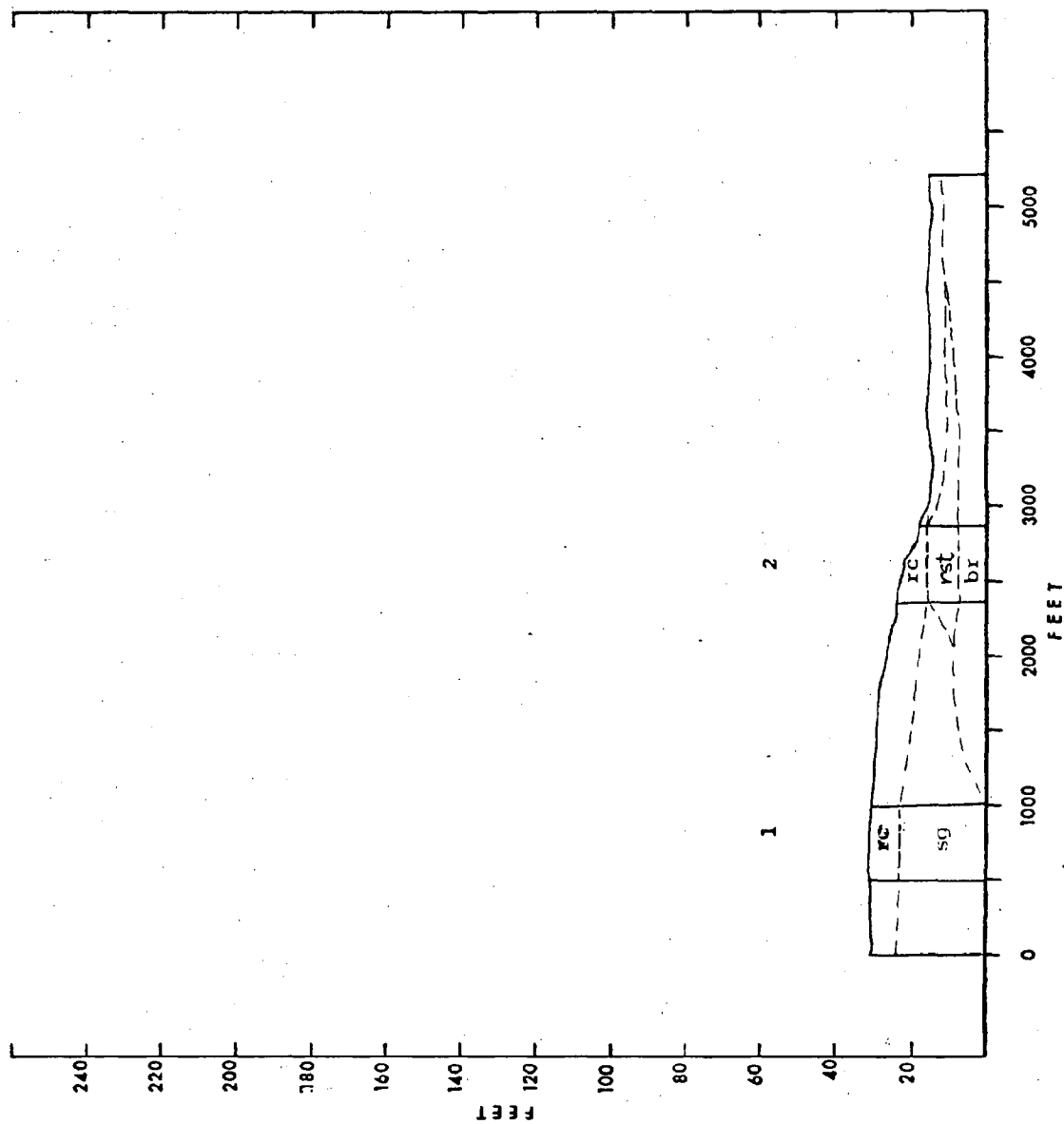
- a) 10-20% vegetation, shrubs in ravines and occasional tree clumps; shallow slides and rilling; red clay over sand with gravel lenses; bedrock occasionally at toe and hit by waves; bluff steep 25-30' high
- b) bedrock dominated bluff with up to 10' of unconsolidated material (red clay and/or sand with gravel) resting on 5-15' of exposed bedrock; 20' high with little vegetation

Beach:

- a) 5-25'; sandy and cobby with scattered boulders and occasional bedrock
- b) bedrock at water level with occasional cobbly pocket beaches



T.50 N., R. 8 W., Sec. 30/19



Reach 4

Reach 4 starts at Quarry Point one mile west of Port Wing and extends 7 miles eastward to a sandstone outcrop one mile west of the Village of Herbster. This reach includes Sections 11, 12, 14, 15, 19, 20, 21, and 22 of Township 50 North, Range 8 West, and Sections 6 and 7 of Township 50 North, Range 7 West in Bayfield County. The geology of the shoreline changes significantly within this reach. A two-mile sand spit is found along the western edge of Reach 4. This sand spit forms a bar around the mouth of the Flag River. Bluffs reoccur west of the sand spit and gradually rise to a height of nearly two hundred feet. The bluffs are primarily composed of sand and gravel, and capped with a discontinuous layer of clay-loam. Sandstone bedrock is exposed at the bluff toe at several locations.

Beaches between Quarry Point and the Flag River are sandy and narrow. East of the Flag River the beaches are sandy and very wide near the harbor jetties, and decrease in width towards the east. Beaches along the bluffs are generally less than 10 feet in width and composed of cobbles and boulders. Where sandstone is exposed at the base of these bluffs, no beach is present.

Erosion rates along this shoreline vary significantly. Between Quarry Point and the jetties at the mouth of the Flag River, recession rates in excess of 20 feet per year have been measured. East of the jetties the beach has accreted as much as 12 feet per year. This variation is caused by the jetties which block the westerly littoral transport of sediment, thereby starving beaches to the west and creating a surplus of sand on the eastern

side of the jetties. Along the high bluffs, erosion is very spotty. Approximately one-half of the bluffs are well vegetated and show little active erosion while other portions are void of vegetation and actively receding. Erosion of the bluffs occurs in the form of translational slides and flows. No large-scale rotational slump blocks are present along this shoreline. Where bedrock is exposed at the base of the bluffs, the toe is protected from wave action and little or no erosion is present.

The land within this reach is entirely under private ownership. Access to the shoreline is impossible along the high bluff shoreline. The upland areas are undeveloped with the exception of a few year-round residences. Excellent access is available at Port Wing and a small boat harbor is located at the mouth of the Flag River. Between Quarry Point and the Flag River the shoreline is undeveloped. East of the river to the high bluff shoreline, a moderate amount of development has occurred, including several seasonal and year-round homes. The only shore protection structures along this reach are the steel-sheet jetties at the mouth of the Flag River.

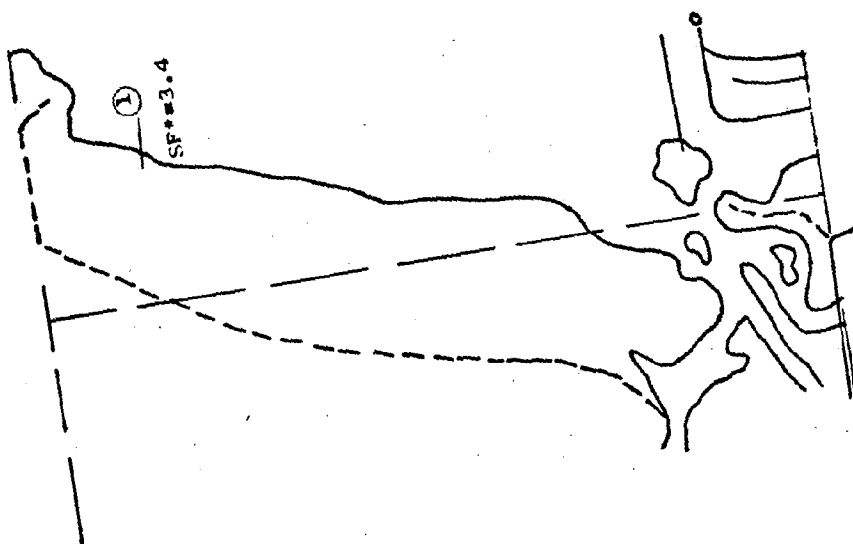
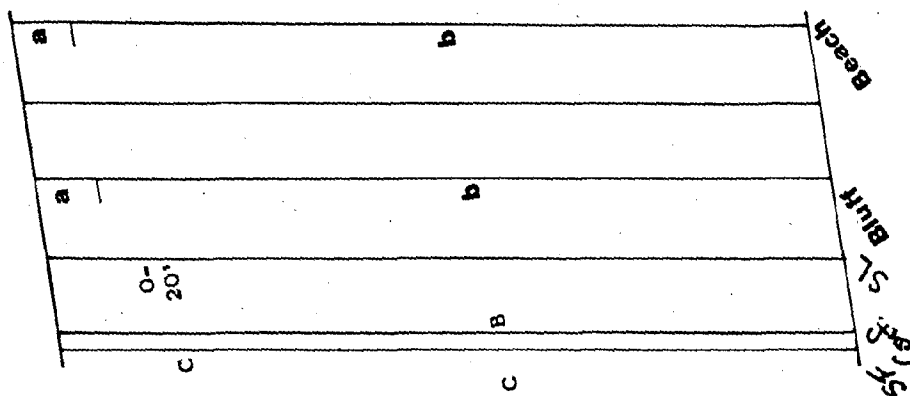
Section 20, T50N, R8W

This section is located just west of Port Wing. Except for a low, wave-attacked bedrock bluff (10 ft. high) at the extreme western end of the section, the shoreline is a 15 ft. wide, medium sand beach. The active beach is backed by a 50-ft. wide zone of vegetated beach ridge and the Bihor Lake marsh. The harbor of Port Wing is partially within this section and there is access to the beach at the western end.

SEC20 T 50 N R 8W

SAFETY FACTOR
 A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL
 A-boreholes
 high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



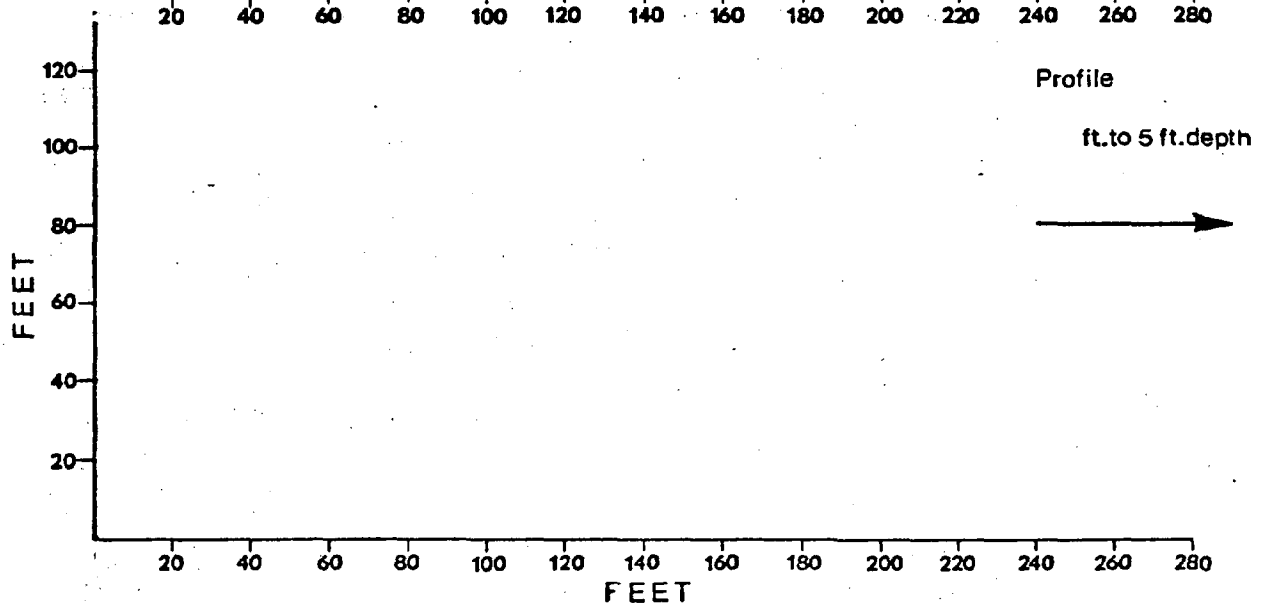
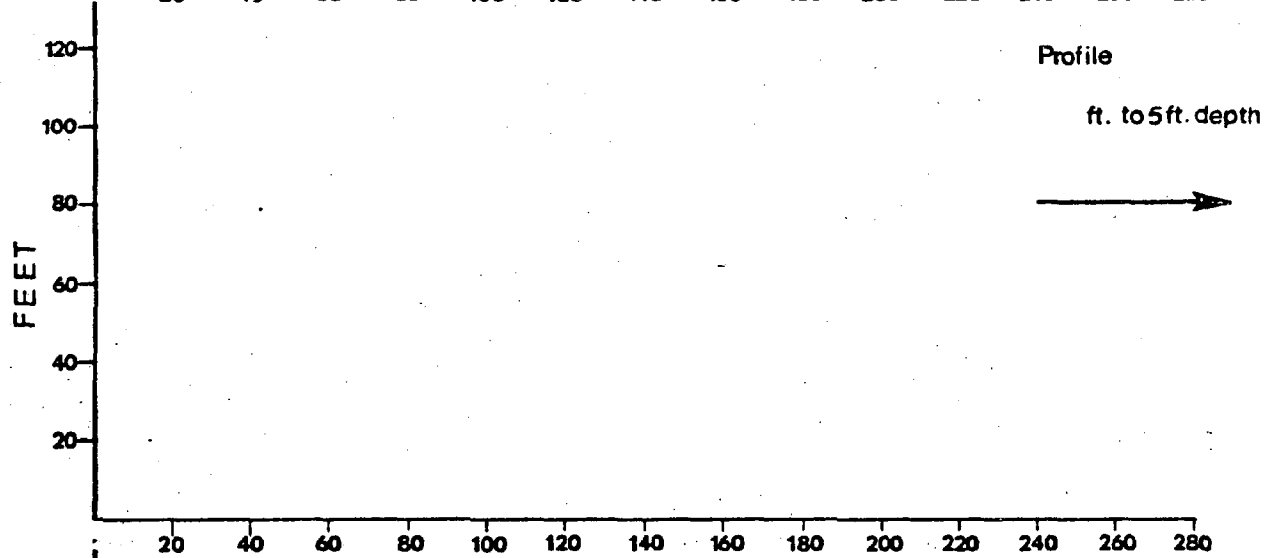
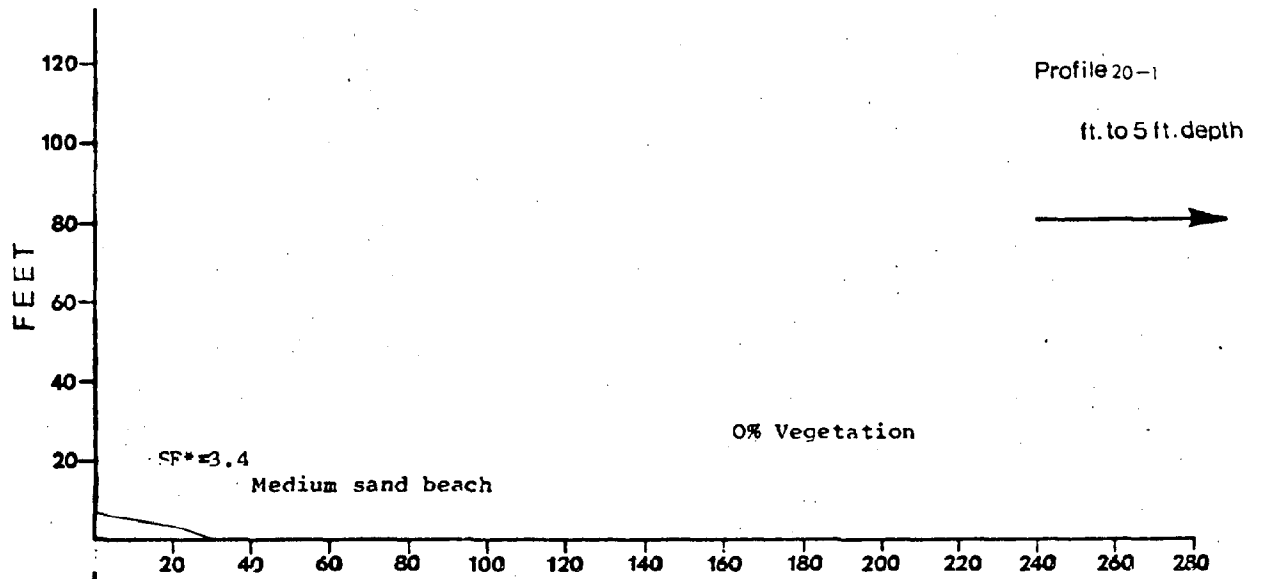
Sec. 20/29, T 50 N, R 8 W

Bluff:

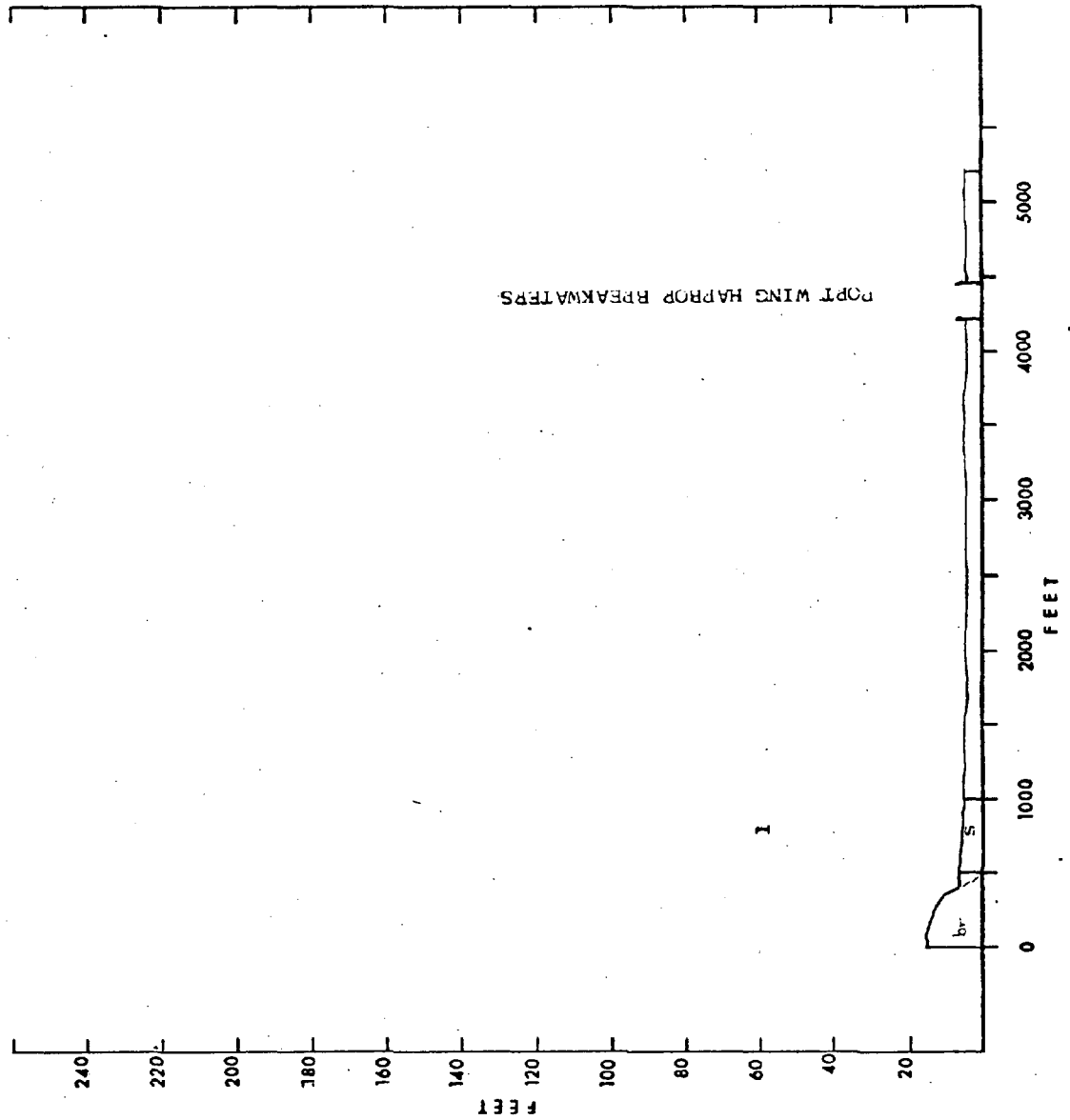
- a) Low bench of red sandstone, 10' high and wave attacked
- b) no bluff

Beach:

- a) beach absent
- b) wide beach; 15' with steep sand berm, with 50' of grass backed by trees behind beach. Breakwater and light at eastern end for Port Wing Harbor



T. 50 N., R. 8 W., Sec. 20



Section 21, T50N, R8W

This section is located just east of Port Wing. The shoreline is characterized solely by a beach ridge, backed by a marsh. The unvegetated (active) beach is 15 ft. wide and composed of medium to coarse sand. The harbor at Port Wing is partially within this section.

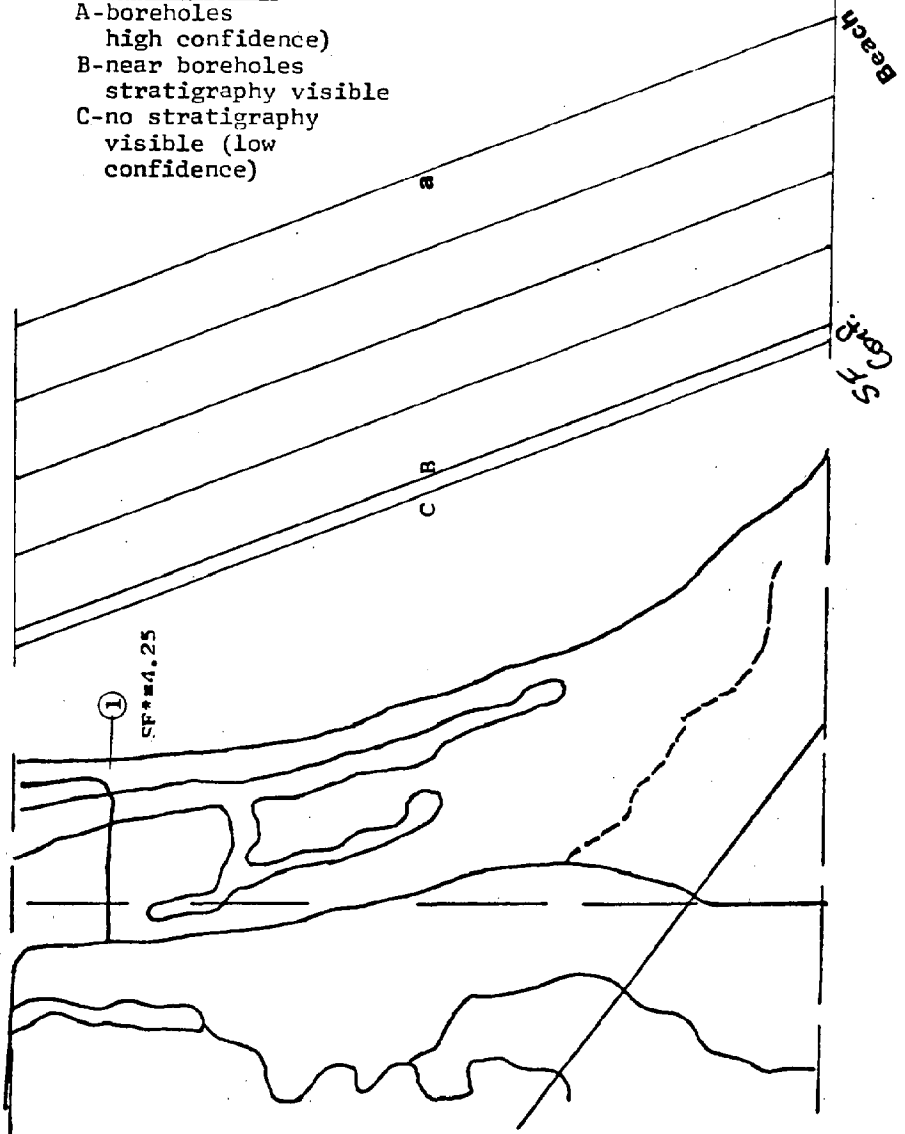
SEC21 T 50 N R 8 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)

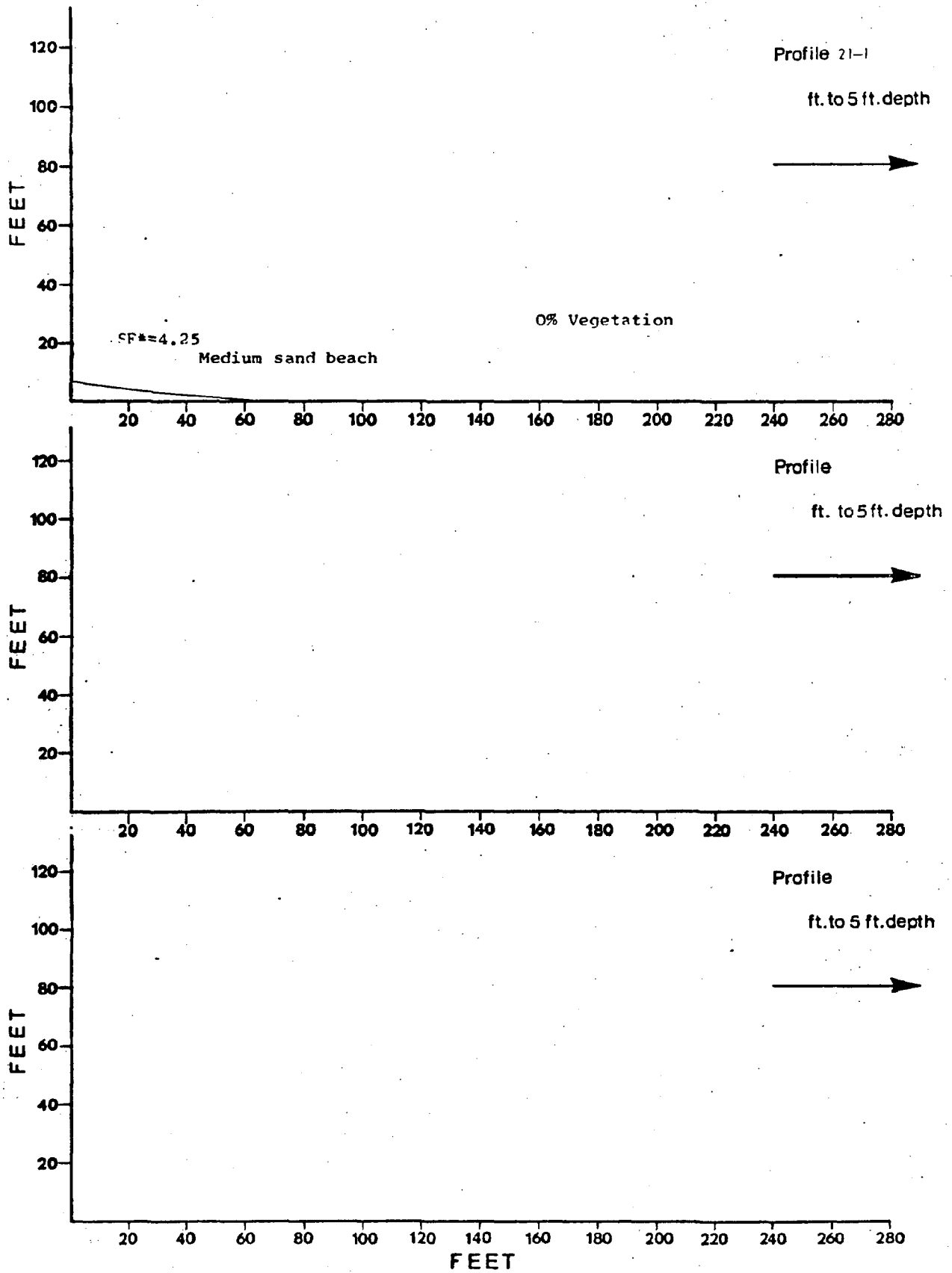


190

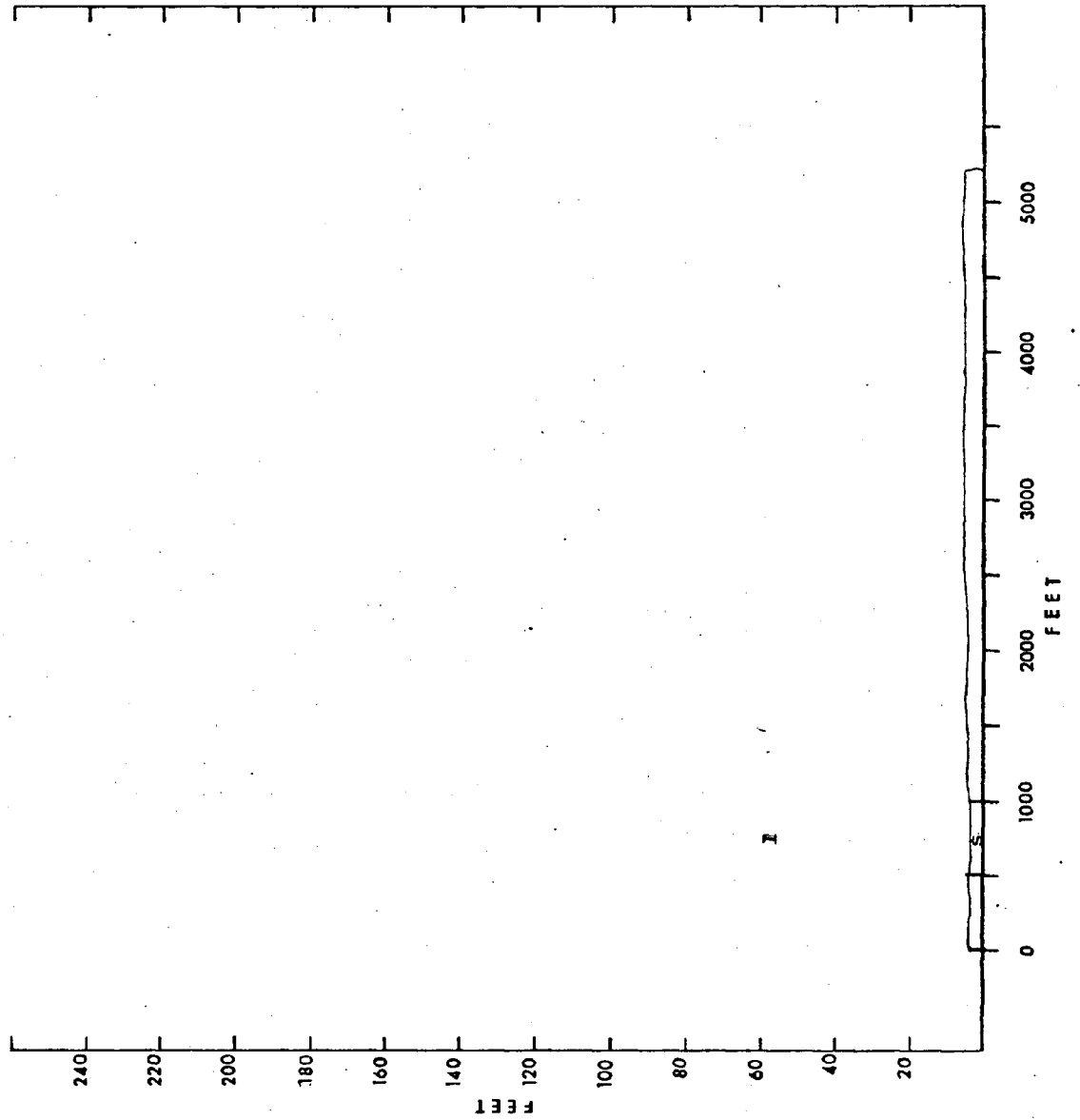
Sec. 21, T 50 N, R 8 W

Beach:

a) 15 ft; no bluff; long sandy beach; backed by grass bordering marsh



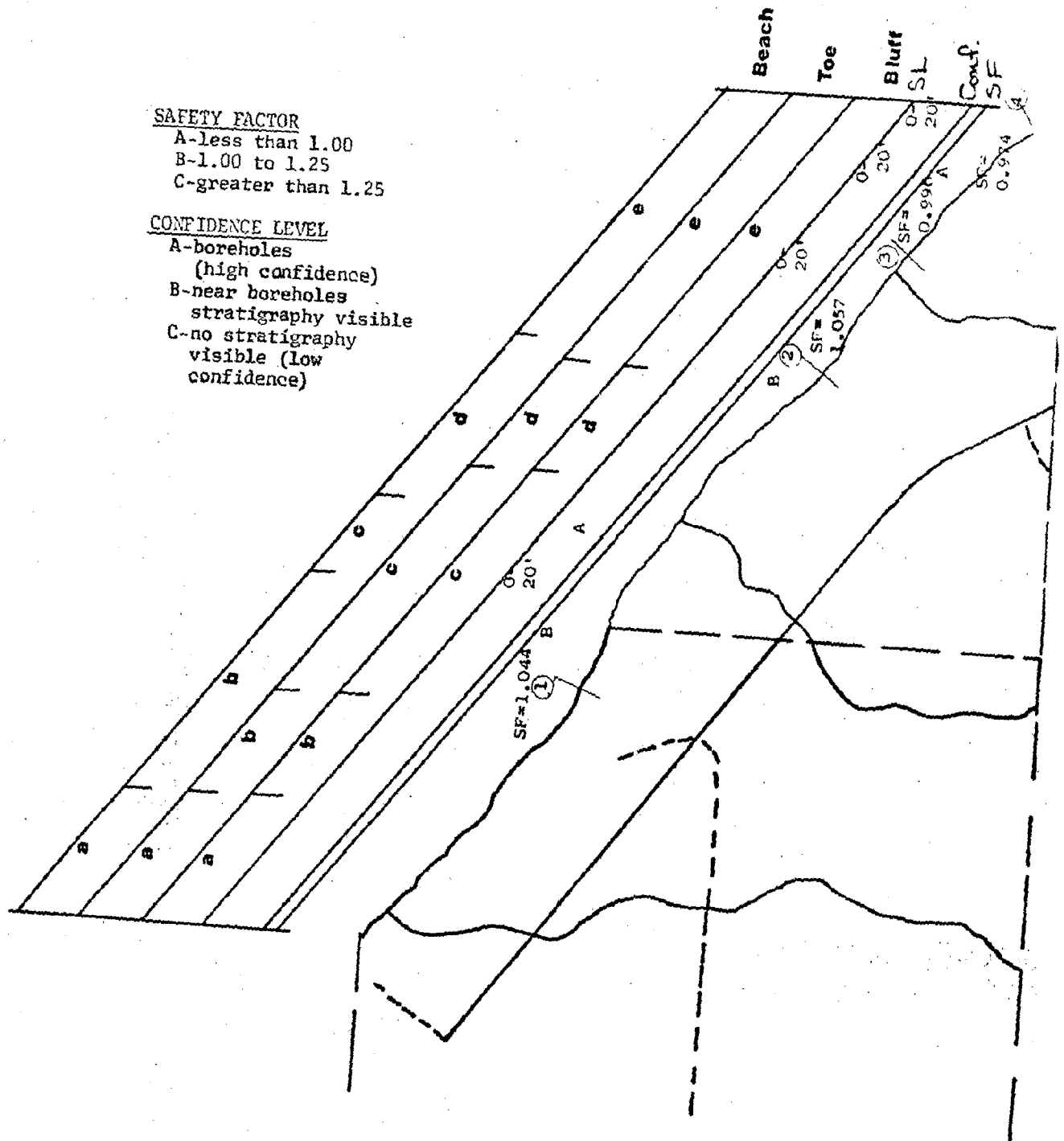
T. 50 N., R. 8 W., Sec. 21



Section 22/15, T50N, R8W

Section 22/15 lies immediately to the east of Port Wing. Marked changes in stratigraphy and bluff characteristics from those seen to the west occur in this section. The bluff rises abruptly from a 5 feet beach ridge at the section's western end to 60 feet after one-quarter mile. By the east end of the section the bluff height has reached 80 feet. The bluff is capped with a sandy clay to clay loam unit 3 to 5 feet thick. Most of the material found in the bluff beneath this clay consists of sand with occasional gravel lenses. Towards the eastern end, medium thick beds of sandy clay occur within the sand, and usually have seeps associated with them. Most of the bluff is stable and well forested. Large seep failures occur at a couple locations. Much of the bluff is protected from wave action by a sandy, cobbly beach although during storms, waves probably attack the toe. This section contains four private homesties, but most of the shoreline is undeveloped and largely inaccessible.

SEC 22/15 T50N R8W



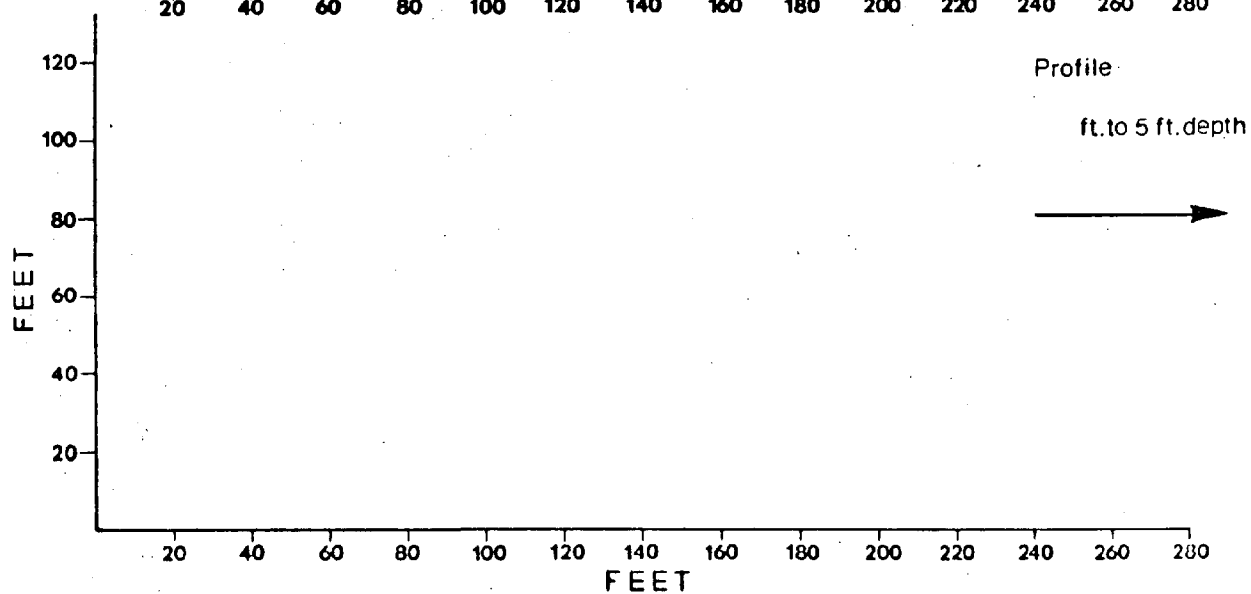
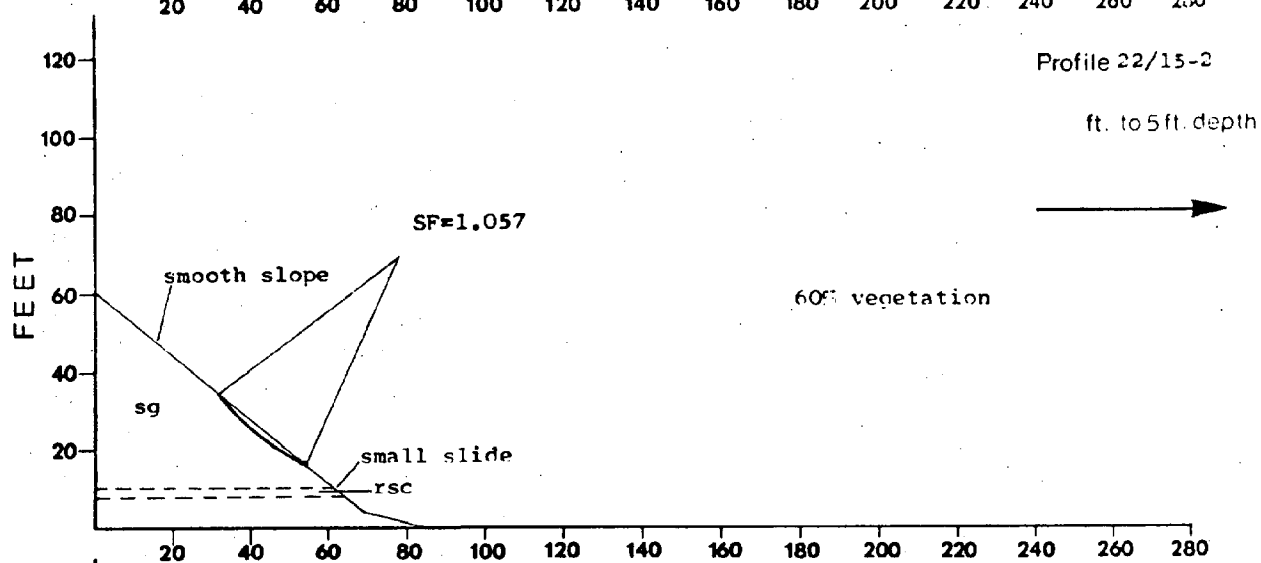
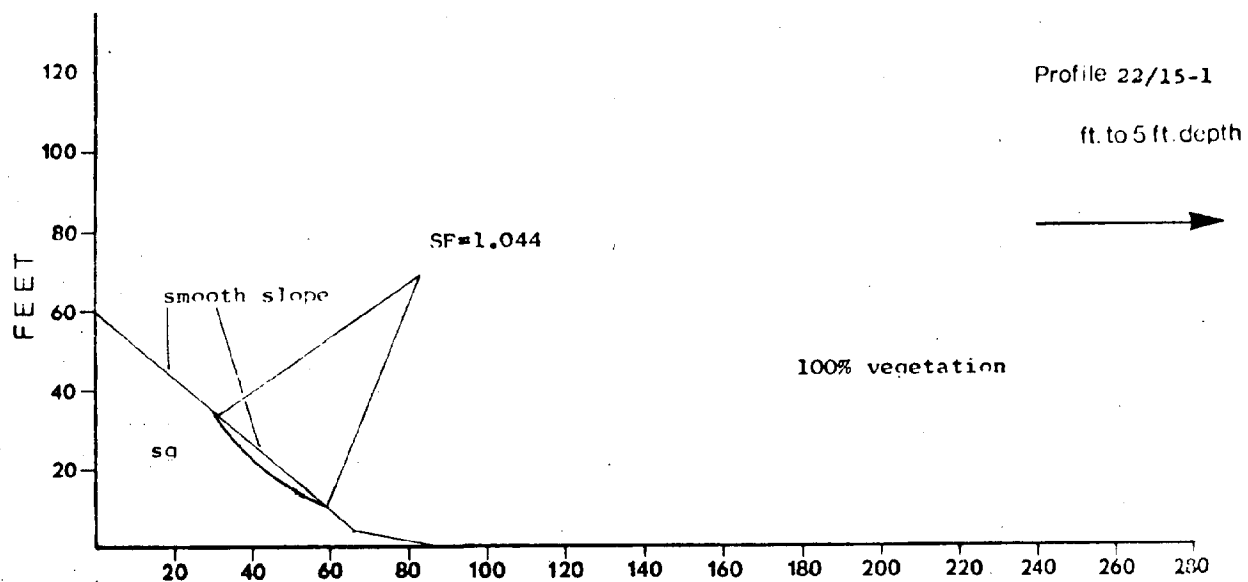
Sec. 22, T 50 N, R 8 W

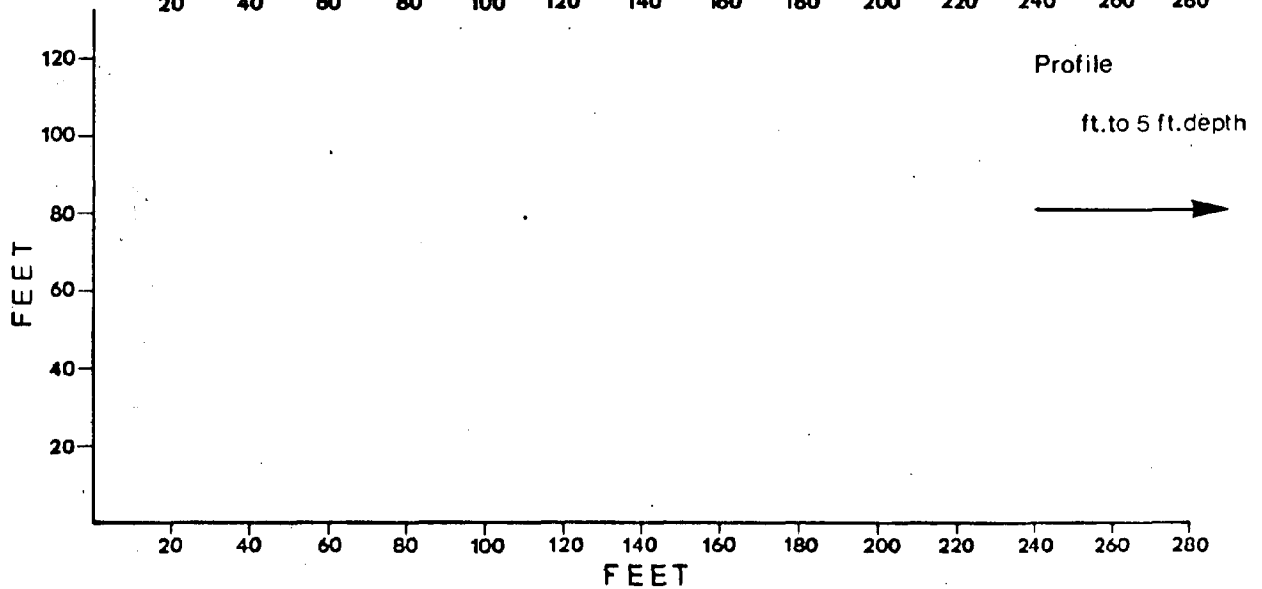
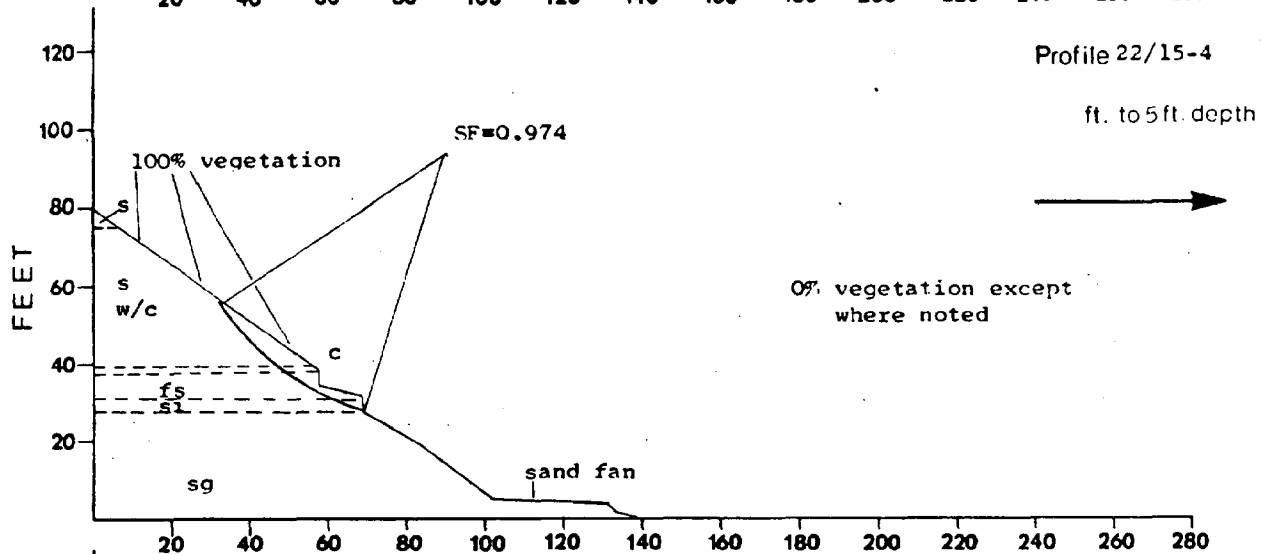
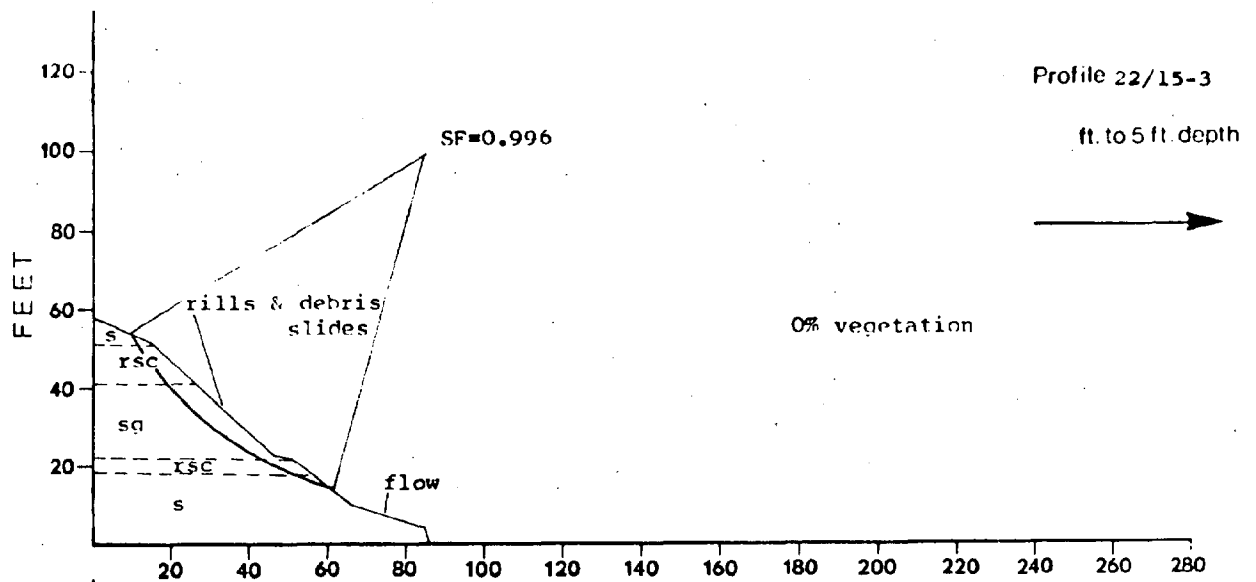
Bluff and Toe:

- a) no bluff
- b) 100% forested in fir and birch; rises to 30' steadily eastward; stable slope in sand and gravel
- c) bluff is sand and gravel cut by ravines and seep failures with debris slides which form fans at toe; rilling, gullying, and sand flows on none-vegetated bluff face; bluff alternates 100% forested with 0 vegetation; 60 ft with irregular crest
- d) 100% forested, fir and pine, smooth slope in sand and gravel; 60' high
- e) sand and gravel with occasional indurated sand layers with seeps; 80' high; patchy exposures; 100% forested otherwise

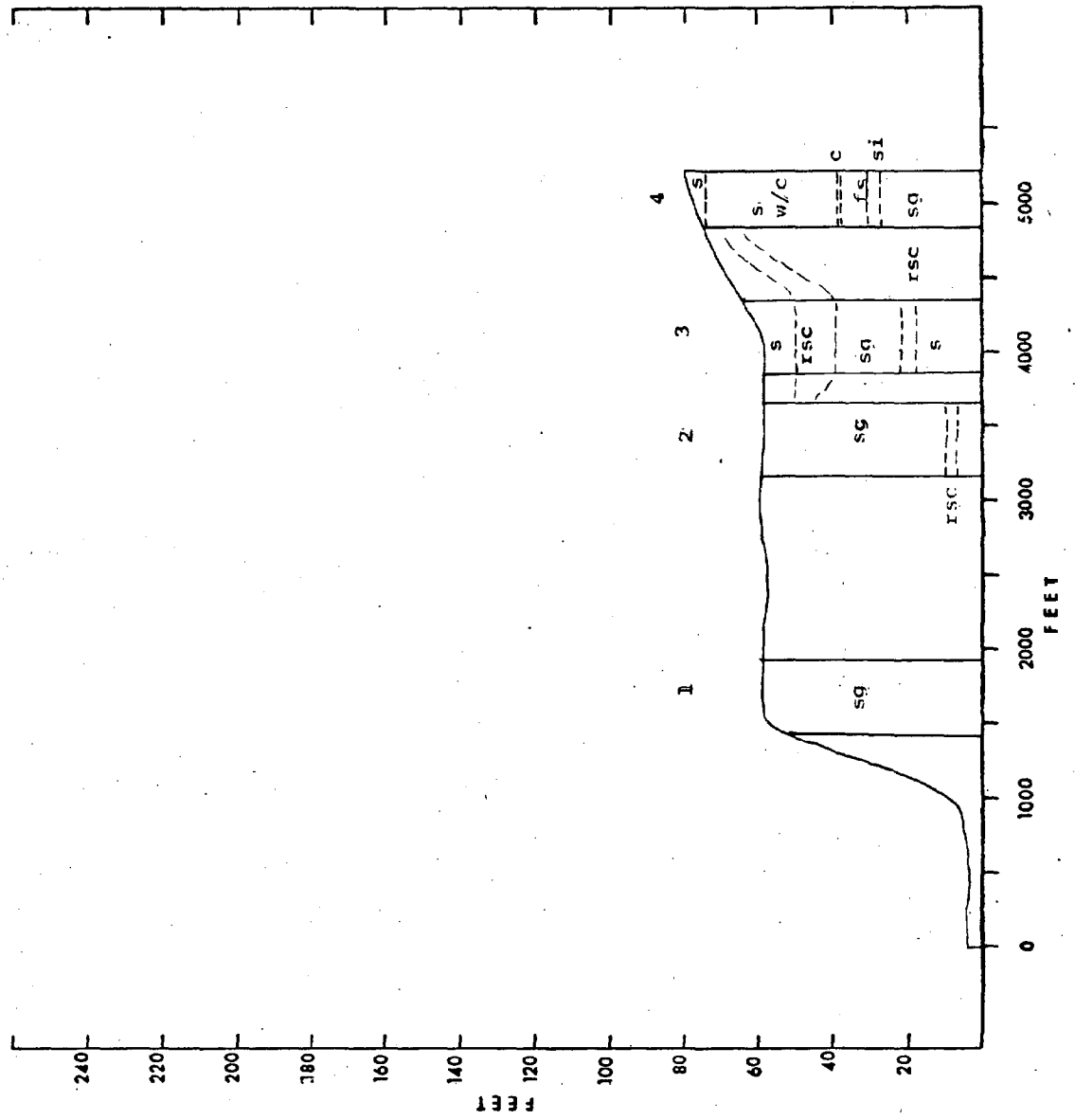
Beach:

- a) 15 ft sandy, pebbles at shore
- b) 10 ft cobbles with sand at shore and more cobbles immediately of shore
- c) 20'; sandy, pebbles at shore
- d) 20'; even width; cobbles
- e) 5'; cobbles with numerous slumped trees





T.50N., R. 8 W., Sec. 2/15

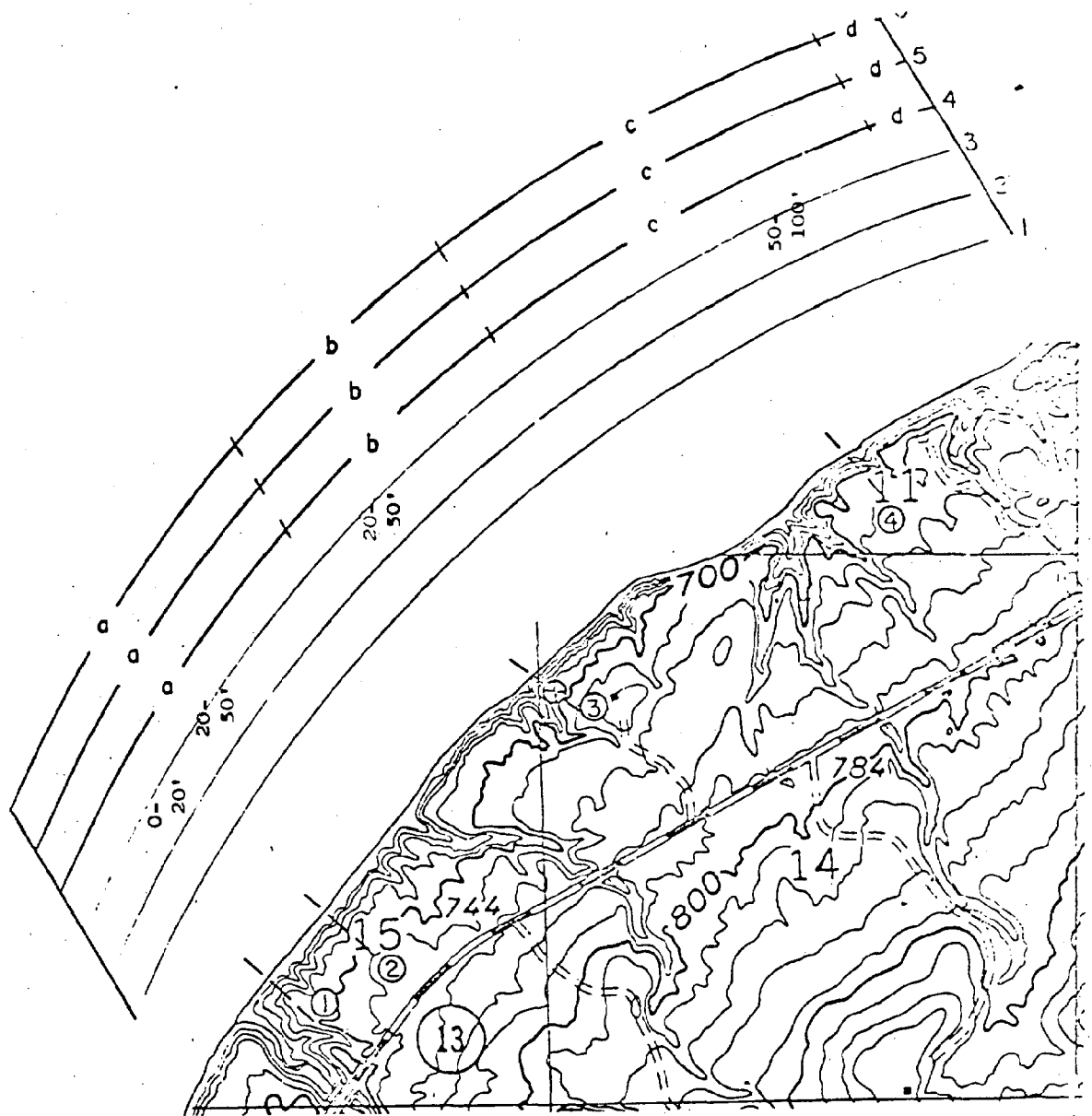


Borehole Site 4

Borehole Site 4 is located within Reach 4 and begins 1.9 miles east of the Port Wing harbor. This study area includes 2.1 miles of shoreline in Sections 15, 14 and 11 of Township 50 north, Range 8 west in Bayfield County. It is a high bluff area with bluffs ranging from 60 to 120 feet. The face of the bluffs have been dissected by numerous gullies and intermittent streams which gives the bluff face a "flat iron" appearance.

The composition of the bluffs in this study area are much different than those to the west. Bluffs are composed predominantly of well-sorted sand and gravel. Clay-loam (less than 10 feet thick) caps the sand in some locations. Precambrian sandstone is exposed at the bluff toe in the northeast portion of Section 15, the southwest portion of Section 14 and the northeast end of the study area in Section 11.

Beaches along this coast are generally less than 20 feet wide and composed of cobble to boulder-sized clasts. Where bedrock is exposed at the bluff toe the beach is often absent (see Profile 3). Although translational slides are the primary mechanism of erosion, sheetwash and rill erosion are also evident in this study area. The aerial distribution of erosion is very irregular. Bluffs which are actively eroding and void of vegetation are often adjacent bluffs which are fully vegetated on slopes greater than 45 degrees (Profile 2). This pattern does not appear to be modified by the presence of bedrock at the bluff toe. This pattern appears to indicate that bluff failures are not initiated by wave attack at the bluff toe, but erosional agents acting on the upper half.

SAFETY FACTOR (SF)

A-less than 1.00

B-1.00 to 1.25

C-greater than 1.25

CONFIDENCE LEVELA-at boreholes
(high confidence)B-near boreholes with
stratigraphy visibleC-no stratigraphy
visible (low
confidence)

- | | |
|---|------------------|
| 6 | BEACH |
| 5 | TOE |
| 4 | BLUFF |
| 3 | STABILITY LINE |
| 2 | CONFIDENCE LEVEL |
| 1 | SAFETY FACTOR |

APPROXIMATE SCALE
1 inch = 1500 feet

Borehole Site 4

Bluff:

- a) Steep slopes, greater than 45°. Vegetation generally restricted to ravines, translational slides present.
- b) Bedrock, well vegetated
- c) Steep slopes. Vegetation limited to ravines, gullying and translational slides present.
- d) Bedrock, well vegetated

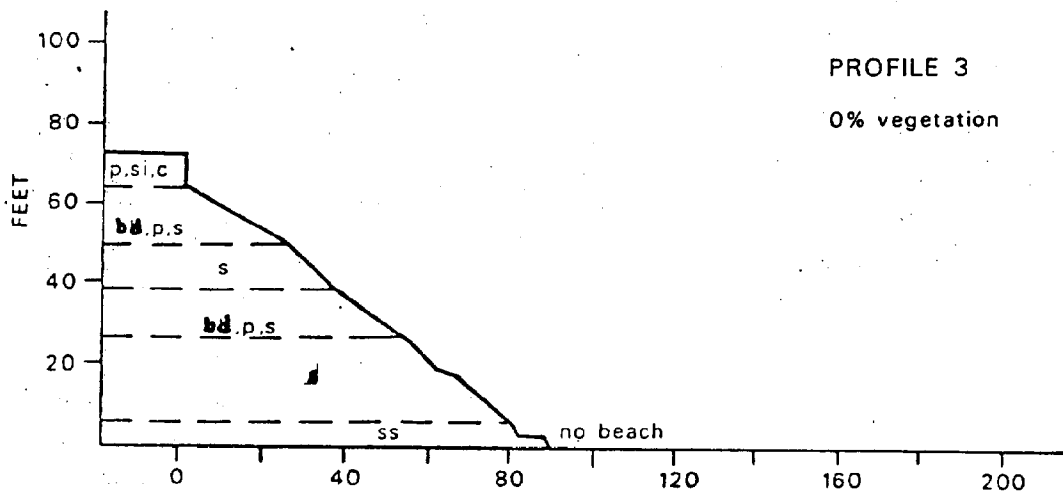
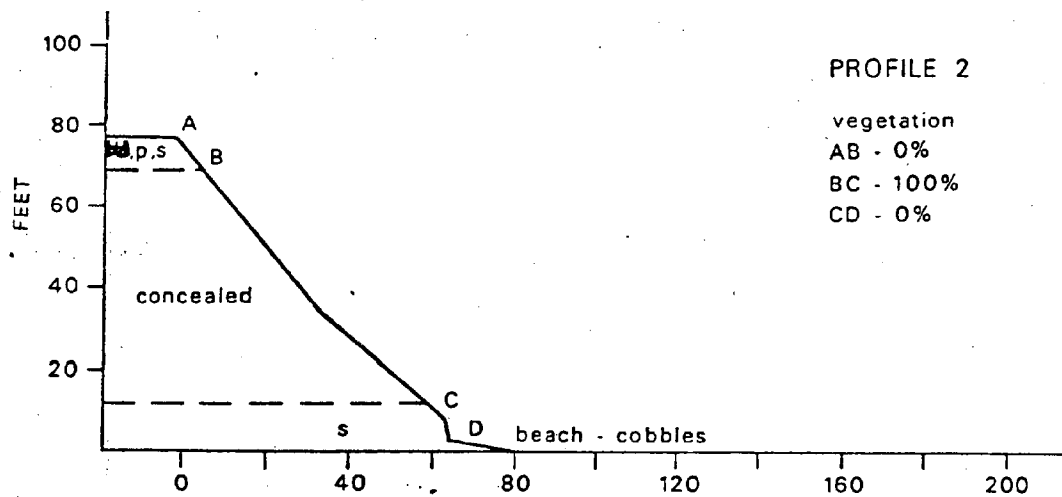
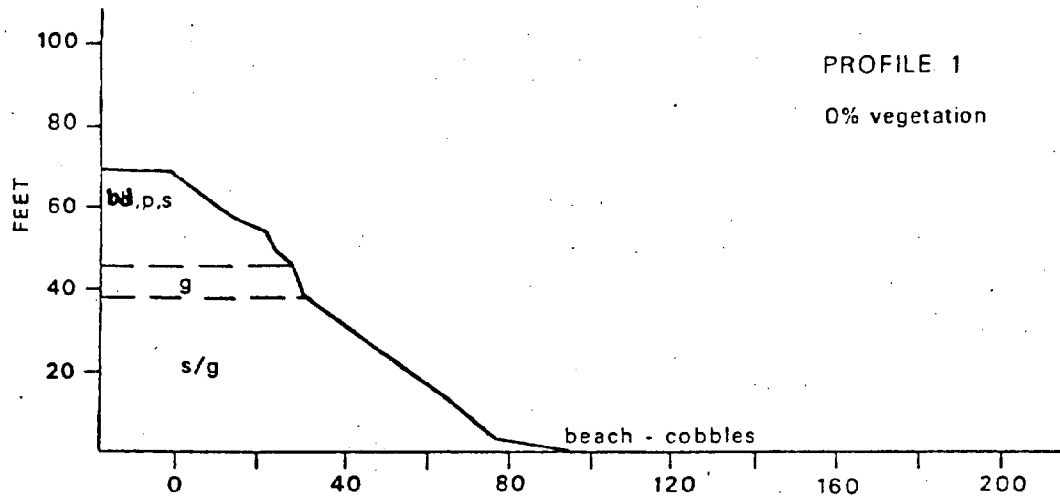
Toe:

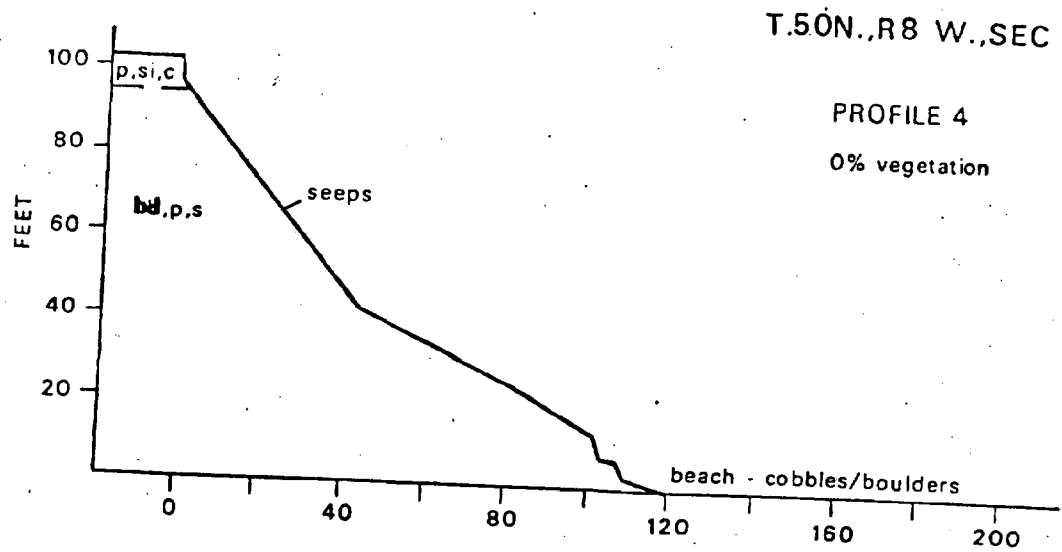
- a) Wave cut exposing bluff material.
- b) Generally fully vegetated with sandstone exposed
- c) Wave cut exposing bluff material
- d) Fully vegetated with sandstone bedrock exposed

Beach:

- a) 15 to 20 feet, cobbles and boulders, wider near gullies.
- b) 0 to 10 feet, cobbles, boulders, and/or bedrock.
- c) 10 to 20 feet, cobbles and boulders, wider near gullies.
- d) 0 to 10 feet, cobbles, boulders, and/or bedrock.

T.50N., R 8 W., SEC15





Section 14/11, T50N, R8W

The section lies three miles west of the town of Herbster. Most of the bluff in this section consists of sand with gravel. But the stratigraphy may be complicated locally by lenses of red sandy clay which are not vertically or laterally extensive. The bluff rises steadily to the east from 75 ft. to 140 ft. interrupted occasionally by small creeks entering the lake. Where the bluff is nonvegetated, shallow sand flows and rills develop. However, most of the bluff is well vegetated in forest. Occasionally, seep failures occur producing long narrow gullies and sand fans at their base. Seeps are usually associated with the clayier beds within the sand. Beaches are narrow and cobbly, widening where the bluff faces more northeasterly. During intense storms, waves attack the bluff toe directly. The beach and the land along the bluff top is totally undeveloped. The steepness and height of the bluff discourage use of the shoreline in this section.

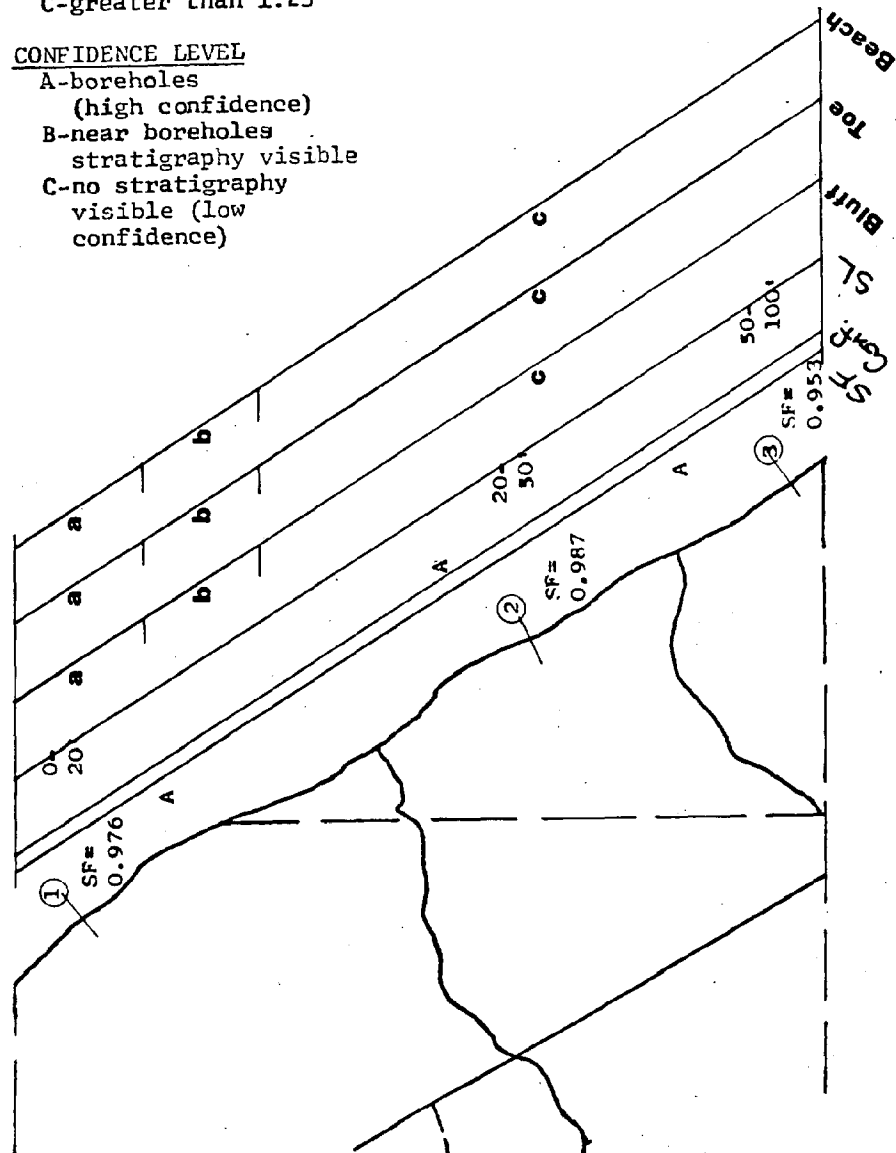
SEC 14/11T50N R 8W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 14/11, T 50 N, R 8 W

Bluff:

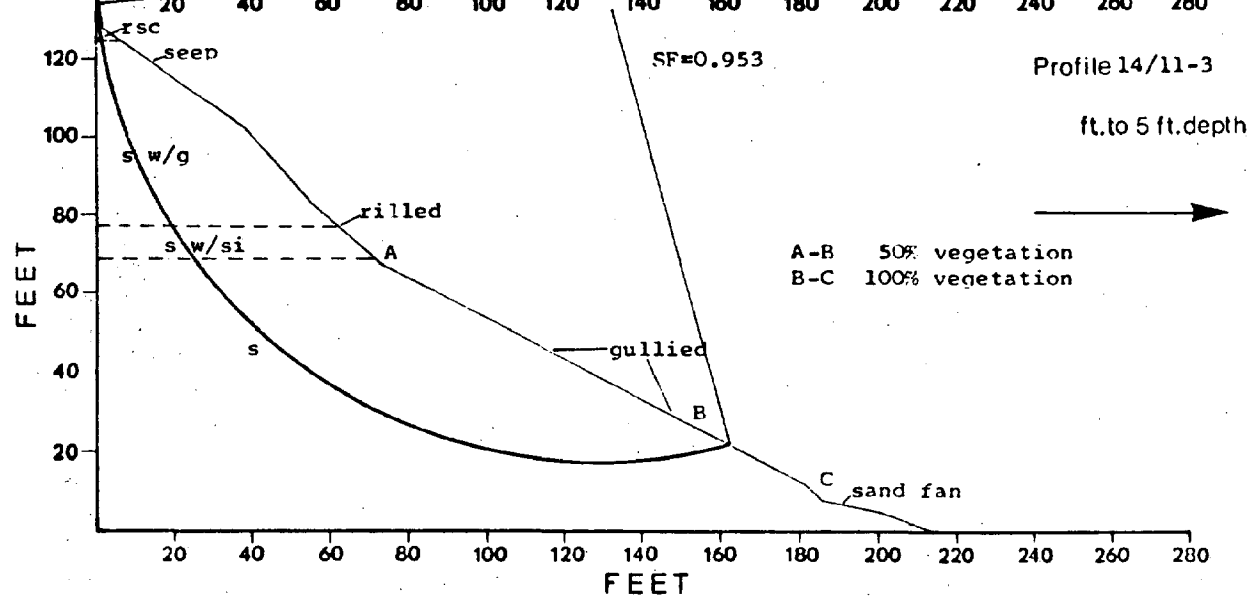
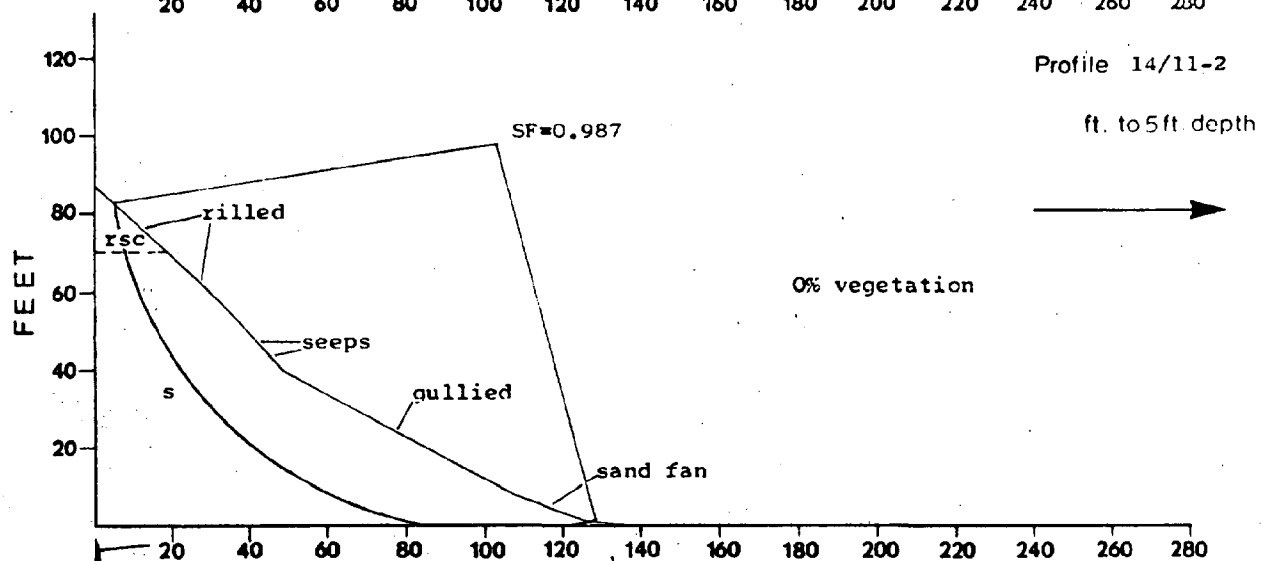
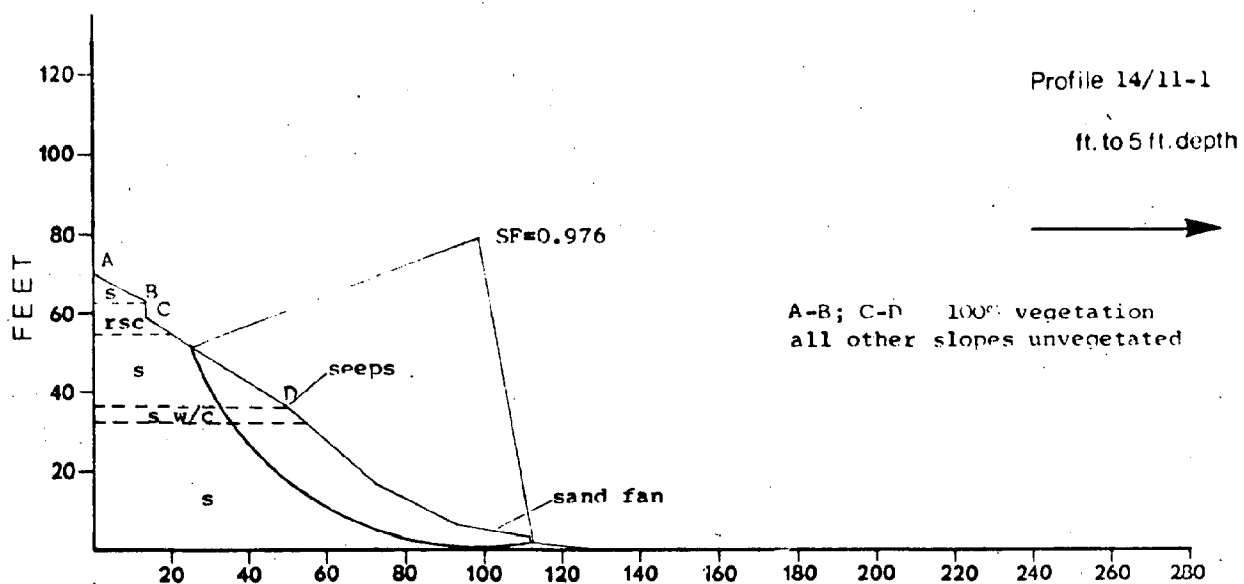
- a) bluff mostly forested with scattered patches of non-vegetated bluff face; sand with discontinuous silty or clayey beds which are often indurated with seeps; shallow sand flows and rills on exposed face. Occasional seep failures producing long narrow gullies with fans at base; 75-80' high with irregular crest
- b) 100% Vegetated, forested; few scarps, smooth slope; sand with some gravel and occasional clay layers in upper slope which produces seeps, 100' high
- c) 0-100% vegetated sand with red clay at top of bluff and occasional gravel lenses; rilling, gulling and seep failures where non-vegetated; steep 125 -140 ft seeps where sand is silty or clayey

Toe:

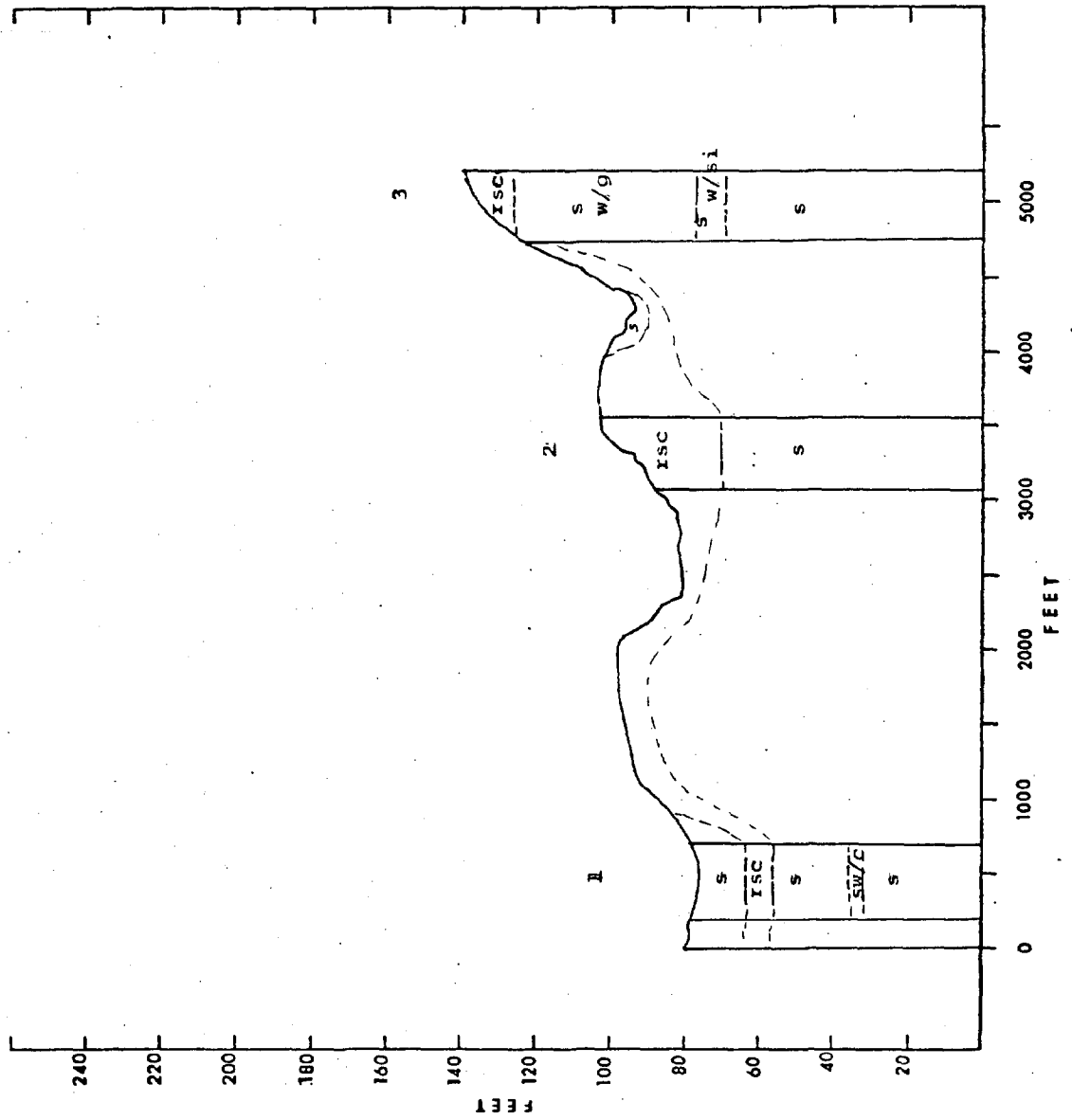
- a) sand fans below failures; vegetated, bedrock at extreme W end
- b) sand fans
- c) sand fans below failures; "talus" of slid sand; vegetated

Beach:

- a) 5-10'; cobbles with sand; occasional covered by sand fan; numerous slumped trees
- b) 20-25; sand with cobbles; sand spits at creek
- c) 10-15 ft; sand and cobbles; sand at creeks



T.50 N., R. 8 W., Sec. 14/11



Section 12, T50N, R8W

This section is located 2 miles west of Herbster. The bluff is 140 ft. high at the western end of the section and the height decreases gradually to 120 ft. at the eastern end. The bluff is cut by a number of very large gulley systems, but all of the streams are intermittent. The bluff is composed almost entirely of sand and gravel with a thin, discontinuous cap of clay loam. In addition to rilling and gulleying, seep failures are common and act to keep the gulleys from stabilizing. Except for the active gulleys, the bluff is generally well-vegetated. At the shoreline, cobbly beaches with a coarse sand matrix, 20-40 ft. wide, alternate with bedrock outcrops 4-8 ft. high.

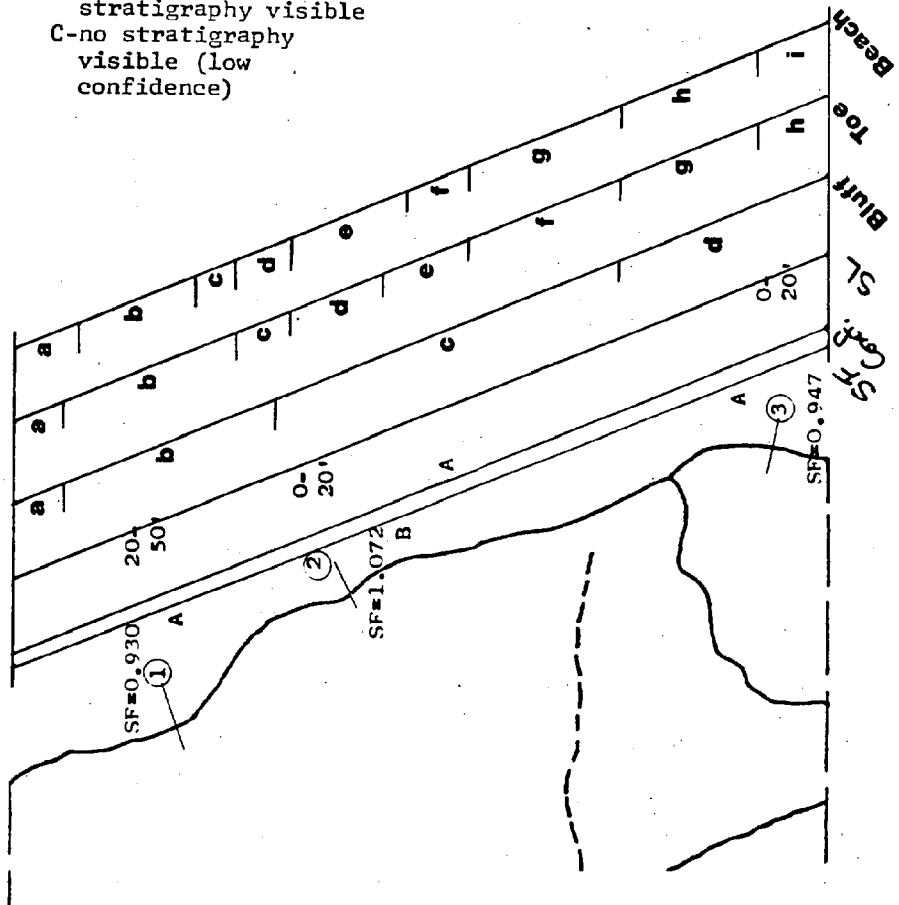
SEC12 T50N R8W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 12, T 50 N, R 8 W

Bluff:

- a) 140-150 ft; sand and gravel; seeping and rilling/gulleying; vegetation variable 0-100%, tall birch, alder, fir and thick undergrowth
- b) 140-150 ft; sand with occasional gravel lenses; narrow seep failures which open up laterally at creast; vegetated 60-100% tall birch, fir and alder, thick undergrowth
- c) 120-130 ft; sand; seeping; rilling; dry flows; vegetation mostly 0% some 50-90% tall birch, cedar and fir with undergrowth
- d) 140 ft dropping at stream, then rising, as a series of ridges oblique to shoreline, to 120-140 ft.; sand with gravel lenses; gulleying and dry flows; vegetation mostly 100% tall birch, cedar and fir; some 10-20% vegetated slum blocks

Toe:

- a) vegetated sand
- b) partially vegetated and partially failing sand
- c) 6-8 ft bedrock
- d) vegetated sand, partially failing
- e) 4-6 ft bedrock
- f) vegetated sand, partially failing
- g) 4-6 ft and up to 25 ft of bedrock
- h) vegetated sand, partially failing

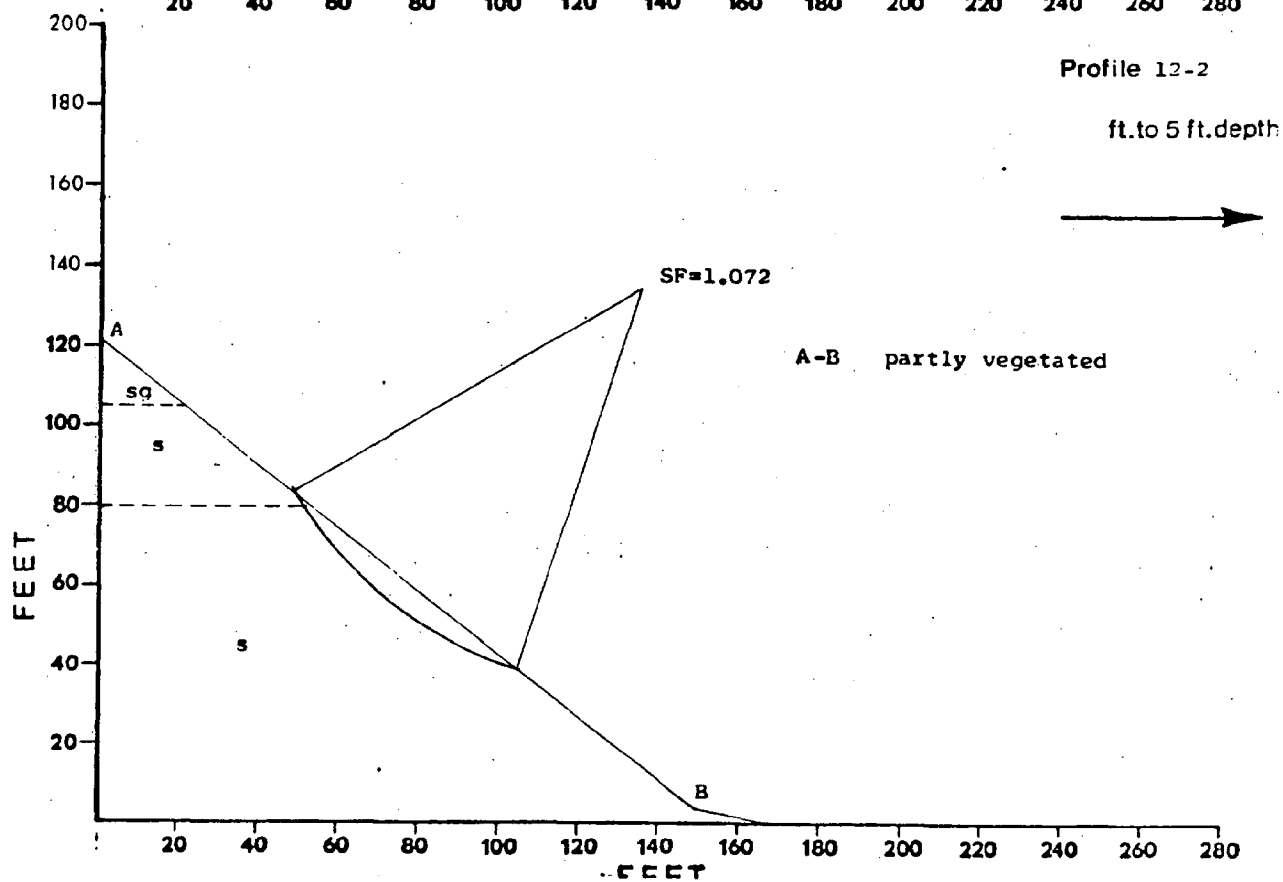
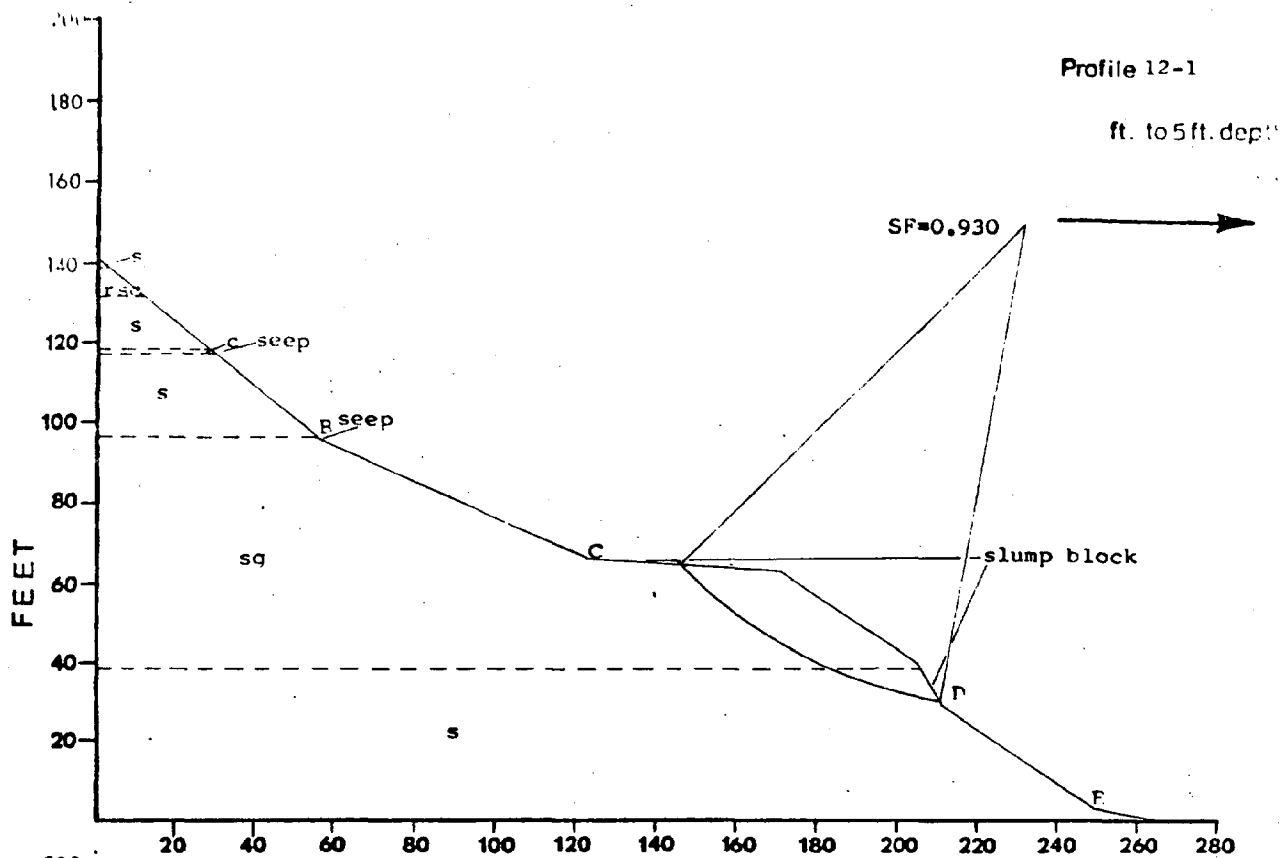
Beach:

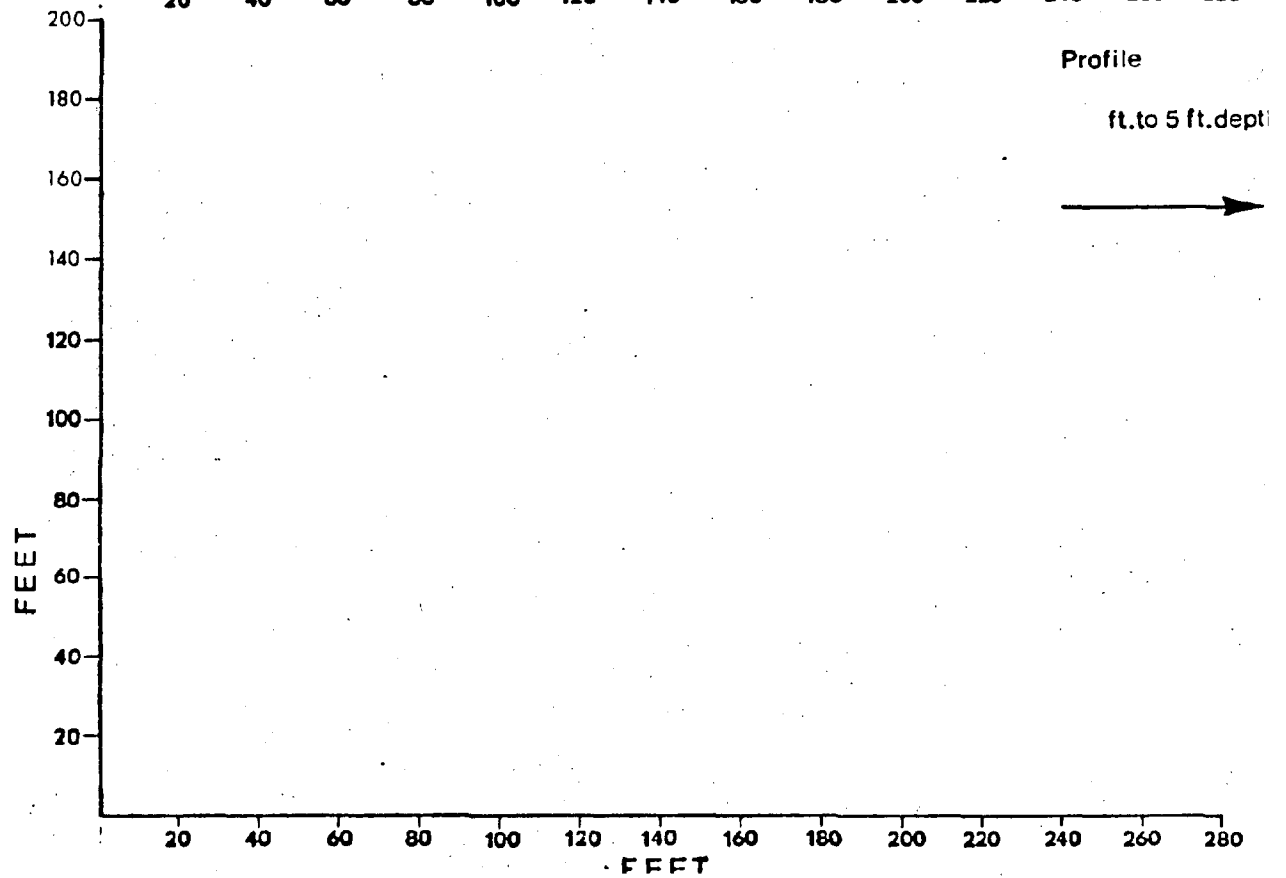
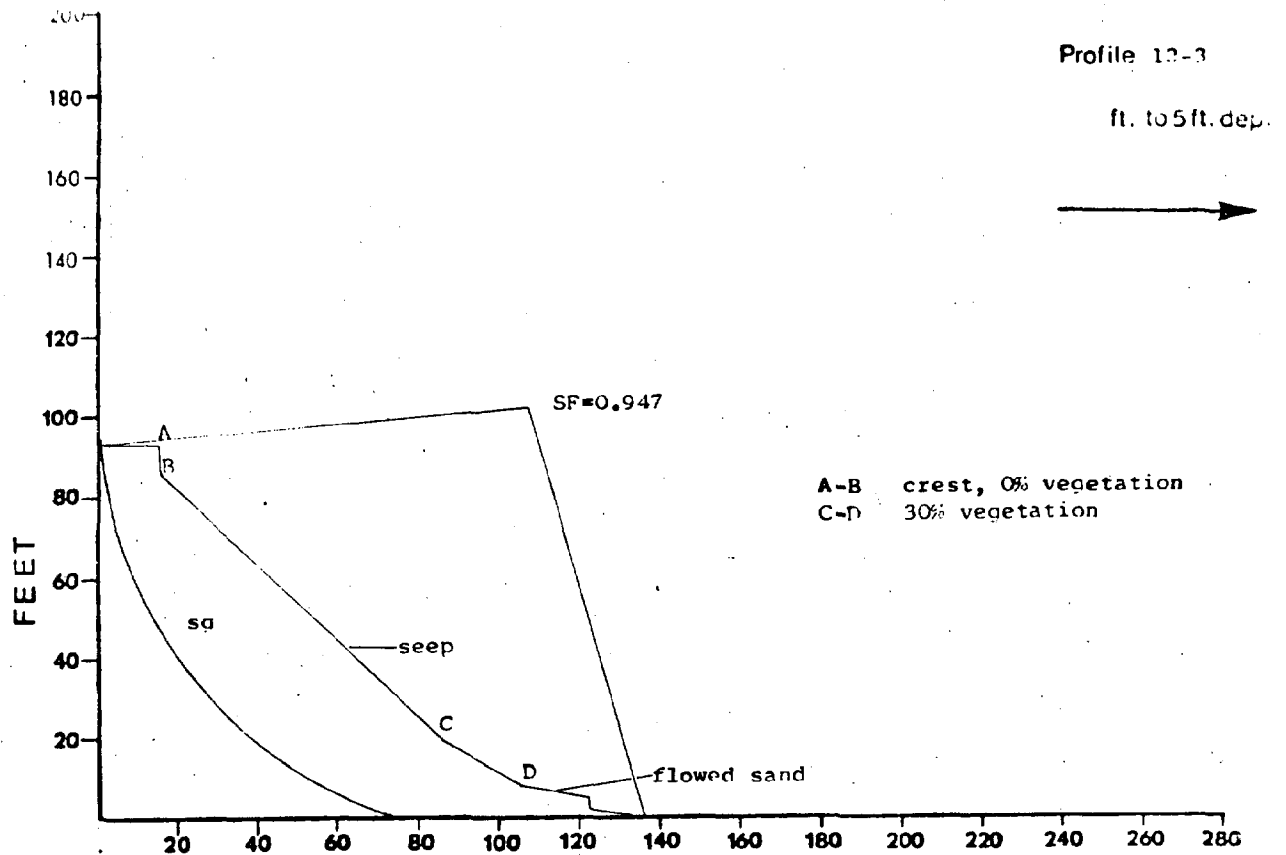
- a) 20-30 ft; cobbles and boulders with coarse sand matrix
- b) 20-40 ft; coarse sand with cobbles at toe
- c) 20-5 ft; cobbles with pebbles and boulders
- d) bedrock with occasional 0-10 ft coarse sand
- e) 20-30 ft; cobbles and boulders with coarse sand matrix
- f) bedrock
- g) 20-30 ft; cobbles and boulders with coarse and matrix

cont'd.

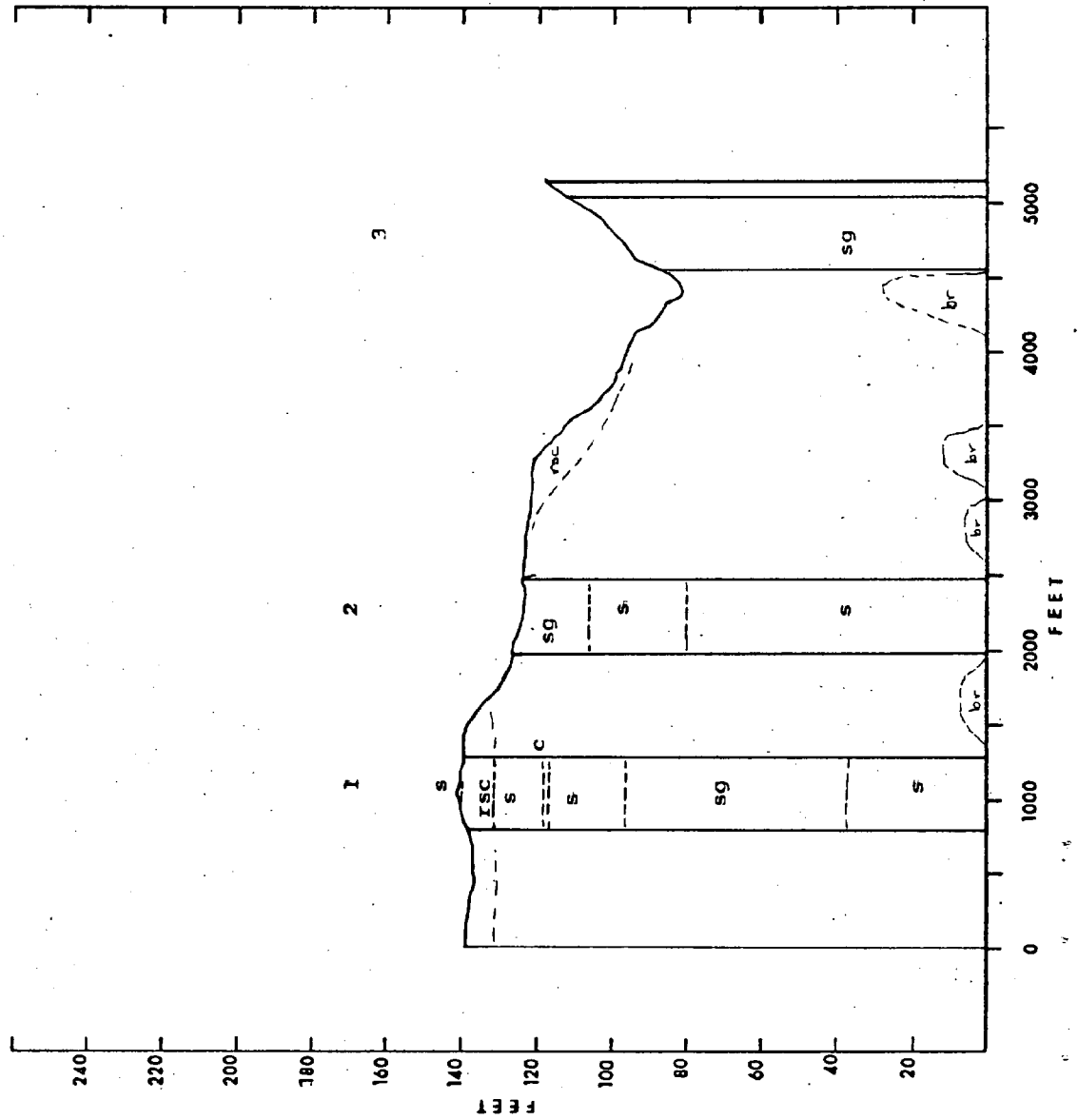
h) bedrock

i) 15-20 ft; coarse sand with cobbles at toe





T.50 N., R. 8 W., Sec. 12



Section 7/6, T50N, R7W

This section is located a mile west of Herbster. The bluff height rises from 120 ft. at the western end to 170-180 ft., which is the bluff height of most of the western half of the section. As the shoreline bends northward, the bluff height decreases to 70 ft., which is the bluff height for the eastern half of the section. The higher bluff is composed almost entirely of sand with a thin discontinuous cap of clay loam. Bedrock occurs occasionally at the toe. Bedrock comprises the lower half of the 70 ft. bluff with sand making up the rest. At the very eastern end the bluff is composed of clay loam over silt loam over sand. Most of the failure is by rilling and gulleying with some shallow sliding. The bluff is moderately to well vegetated. In the western end of the section, the beach alternates between 15-20 ft. of coarse sand and bedrock outcrops. The beach of the eastern half of the section is all bedrock except the very eastern end which is 45-60 ft. of coarse sand and granules.

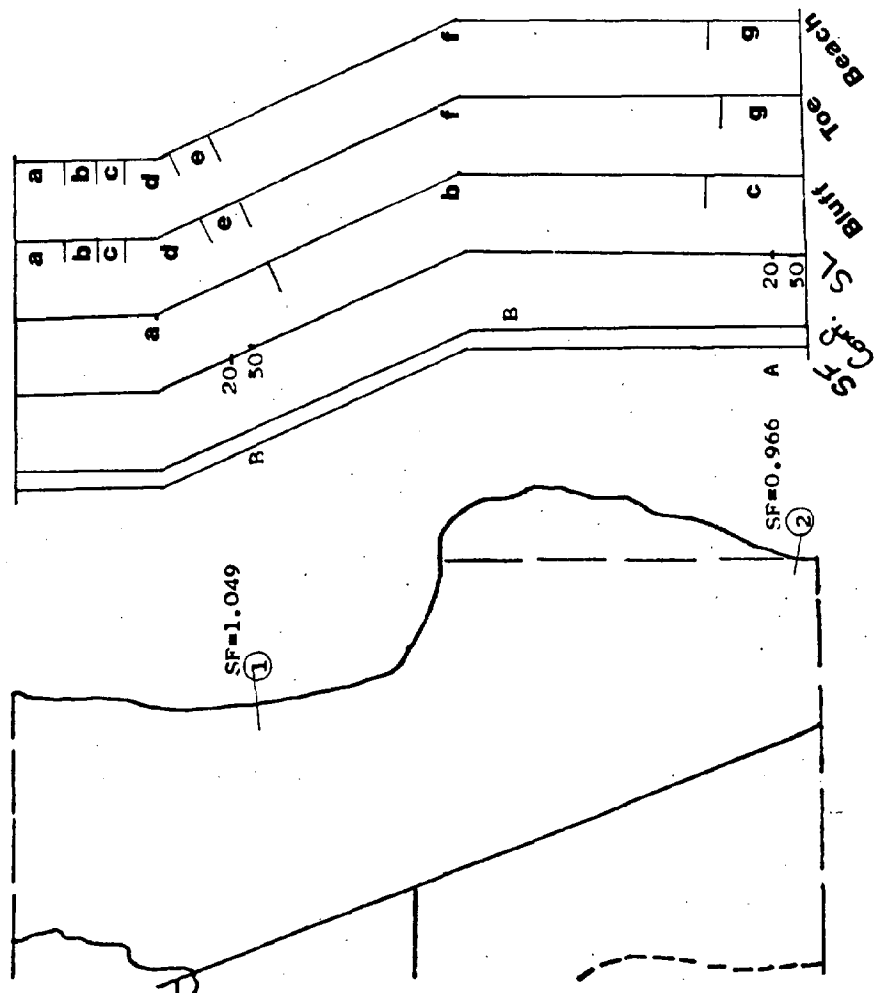
SEC 7/6 1 50 N R7 W

SAFETY FACTOR

- A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



Sec. 7/6, T 50 N, R 7 W

Bluff:

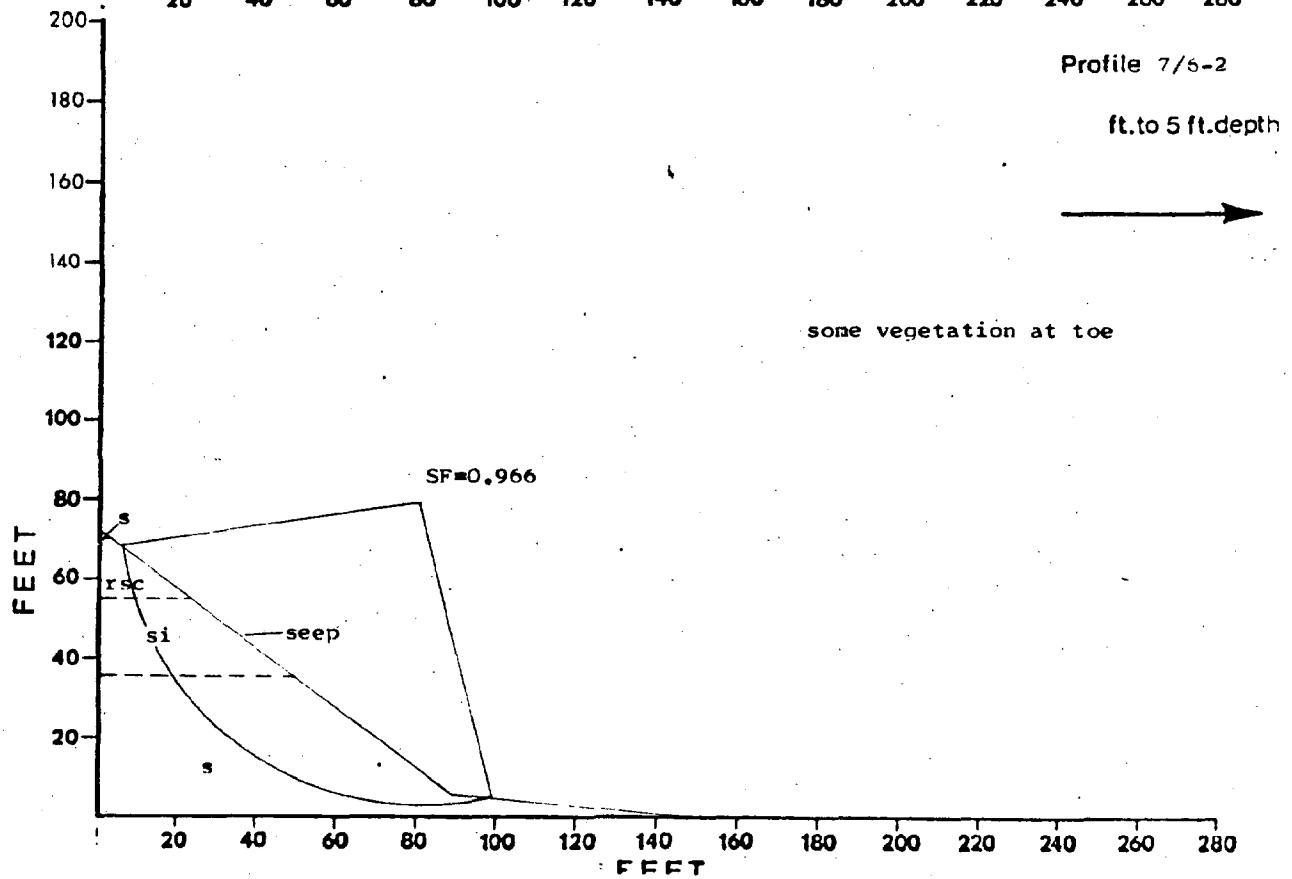
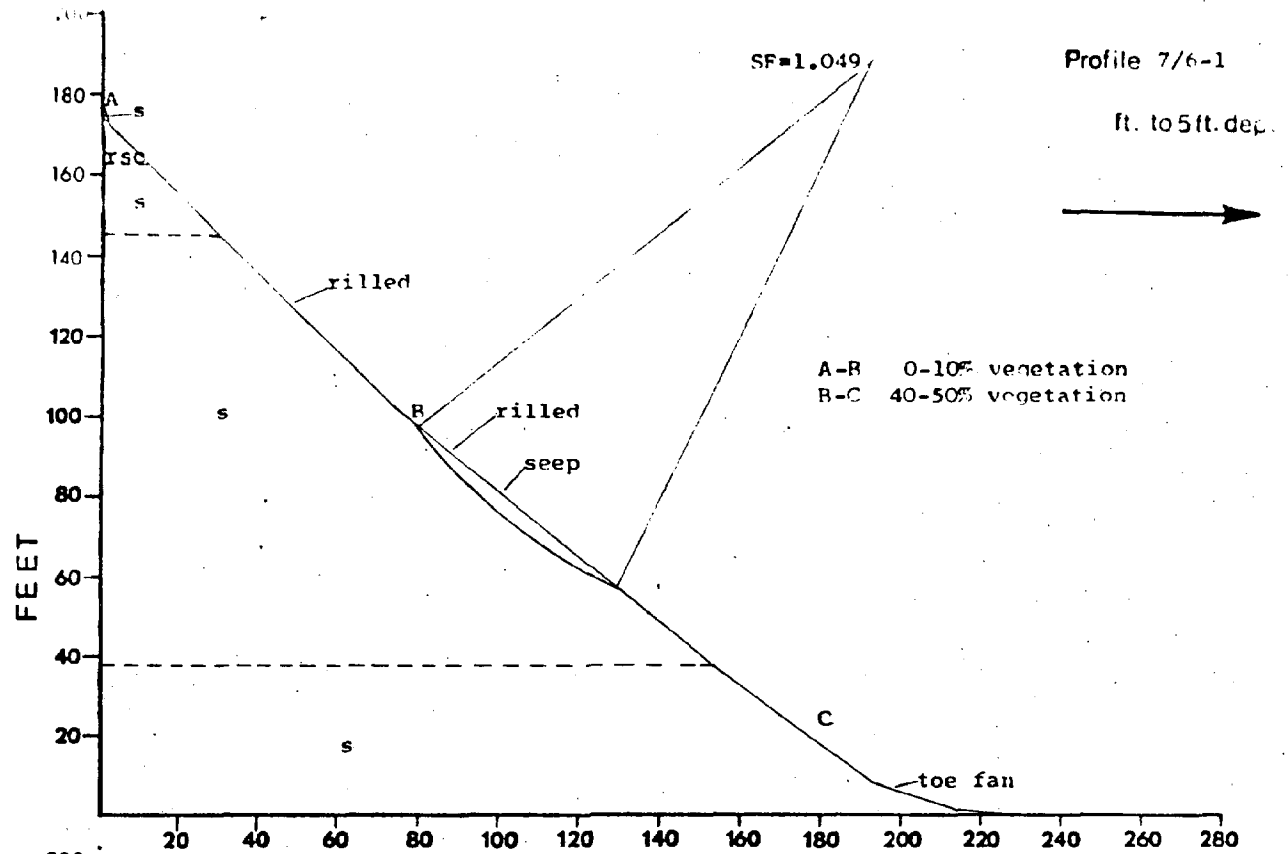
- a) 180 ft dropping to 100 after northward bend; sand with gravel lenses; rilling and gulleying; vegetation as little as 0-10%; half to two-thirds is 70-90% tall birch and cedar with undergrowth
- b) 100 then 70 ft after eastward bend; sand and gravel over bedrock the latter is 1/2 of bluff height; ~~there are~~ watercourses graded to rock lip; occasional failure by block fall; vegetation 100% birch, cedar, fir, alder along the top of the bluff.
- c) 70 ft; bedded sands and silts; shallow sliding and gulleying; 40-70% vegetated; clumps moving downslope, birch and alder

Toe:

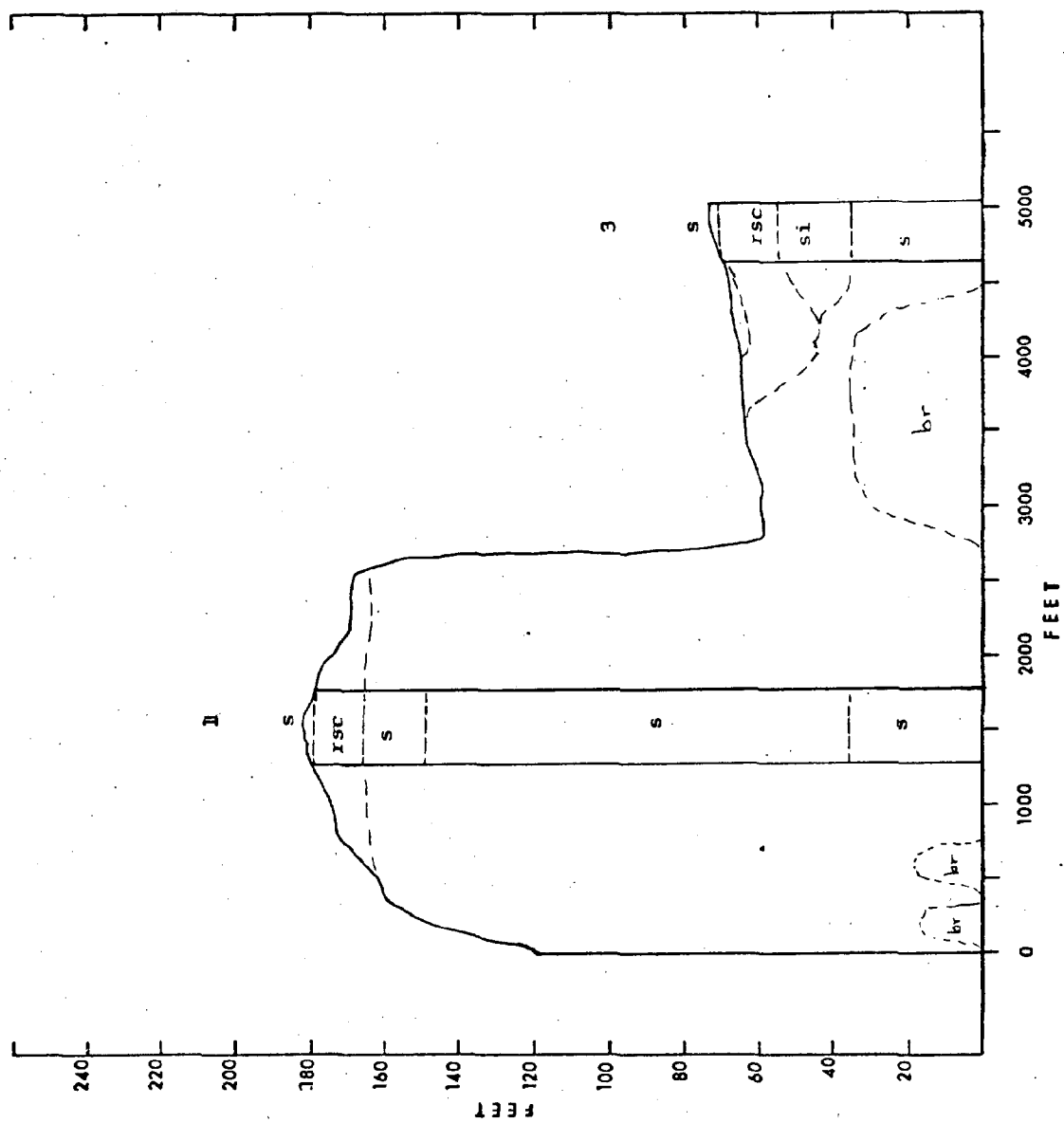
- a) 15-18 ft bedrock
- b) sand, protected
- c) 15-18 ft bedrock
- d) sand, protected
- e) sand, poorly protected
- f) 4-40 ft bedrock
- g) sand, protected

Beach:

- a) bedrock
- b) 15-20 ft; coarse sand with occasional cobbles and pebbles
- c) bedrock
- d) 20-25 ft; coarse sand
- e) 1-2 ft; cobbles and boulders; bedrock just underwater
- f) bedrock
- g) 45-60 ft; coarse sand, pebbles at shore, granules in swash zone



T.50 N., R. 7 W., Sec. 7/6



Reach 5

Reach 5 extends from a sandstone outcrop one mile west of the Village of Herbster along 7 miles of shoreline to the mouth of Bark River. This reach includes Sections 6, 5, 4 and 1 of Township 50 North, Range 7 West and Sections 33, 34, 27, 26, 23, 24, 25, 36, and 36 of Township 51 North, Range 7 West in Bayfield County. The morphology of the shoreline is very similar to that of Reach 3. The bluff at the western end of the reach is 70 feet in height and decreases in height toward the Cranberry River at which point a low, sandy spit is present. East of the river, the bluffline rises to an elevation in excess of 150 feet halfway between Herbster and Bark Point. Bluff heights then decrease from this maximum to 15 feet along the neck of Bark Point. The high bluff areas are composed largely of sand and gravel with a thin veneer of clay-loam near the bluff top. The low bluffs near Herbster and Bark Point are primarily composed of clay-loam overlying a sandy-loam. Precambrian sandstone bedrock is present at the tip of Bark Point.

Beaches vary greatly in width and composition throughout the reach. At the mouth of the Cranberry River in Herbster, a sandy beach in excess of 50 feet is present while along the bedrock shorelines no beach exists. Most of the shoreline has a very narrow beach, often less than 10 feet wide, composed of gravel to cobble-sized clasts. The spit and beach at the mouth of Bark River are also wider than 50 ft.

Erosion is a serious problem along much of this shoreline. In the Village of Herbster, the low clay bluff is being eroded at a rate of 1 to 2 feet per year. A section of the road along the water front has recently been relocated, and several other portions of the road are presently being threatened. The high bluffs east of Herbster are eroding at

approximately the same rate as the low bluff. To date, bluff erosion has not caused serious problems since very little development has occurred along the bluff edge. However, severe surface water erosion in the form of gulying is threatening both homes and roads. Sand and gravel, the principal bluff constituents, are extremely susceptible to stream erosion. Because the clay loam which is found near the surface has very low permeability, erosion from surface water runoff remains a continual problem. In addition, some land development activities have served to heighten erosion potential along high blufflines. The combination of rapid runoff, a steep gradient to the lake, the erodibility of the sand and gravel, and man's activities have produced dramatic problems. For example, along the Bark Point Road, several very large gullies, some threatening the road have developed as a result of surface water channelization.

Except in the Village of Herbster where the Town of Clover maintains a lake front park and the mouth of the Cranberry River which is owned by the State of Wisconsin, the shoreline is under private ownership. This reach of shoreline is moderately well developed. Seasonal and year-round homes are numerous from Herbster to Bark River. Only two shore protection structures are present: a non-functional timber jetty at the mouth of the Cranberry River and a timber pier groin which is in excellent condition in front of a resort in the Village of Herbster.

Section 8/5, T50N, R7W

This section is located at the town of Herbster and is bisected by the Cranberry River. The bluff is 55-60 ft. high at the western end of the section and becomes steadily lower eastward until it is replaced by a beach ridge, which extends to the eastern end of the section. The bluff is composed primarily of sand and has a thin capping of clay loam. The western end of the bluff is well-vegetated and fails by dry flows and gulleying. The lower bluffs (less than 25 ft.) are less vegetated and shallow slides occur frequently. The beach is uniformly 20-30 ft. wide and is composed of coarse sand and granules, probably derived from the bluff. The beach to the east of the Cranberry River is heavily used by the residents of Herbster and tourists.

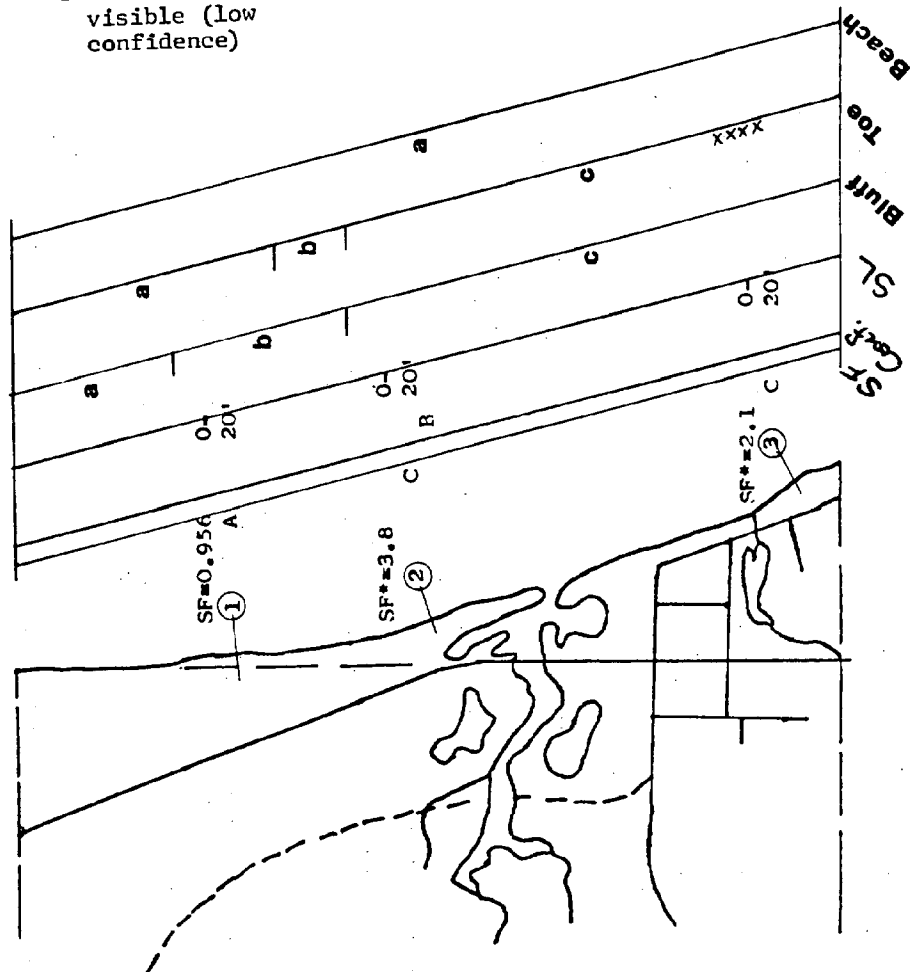
SEC8/5 T50N R 7W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 8/5, T 50 N, R 7 W

Bluff:

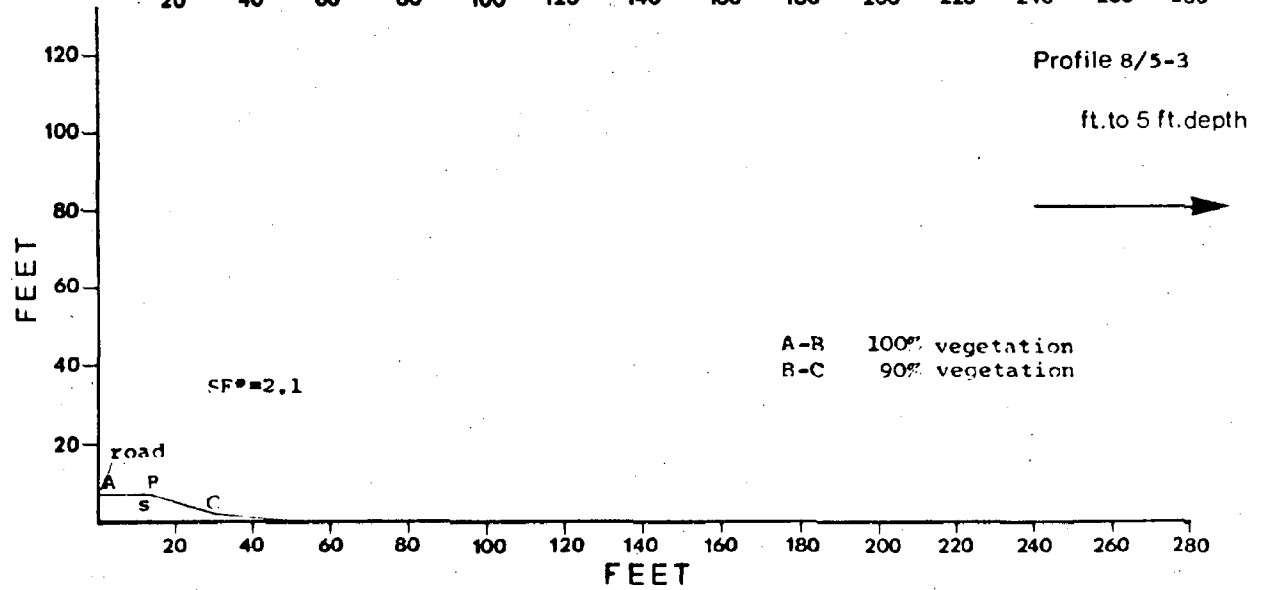
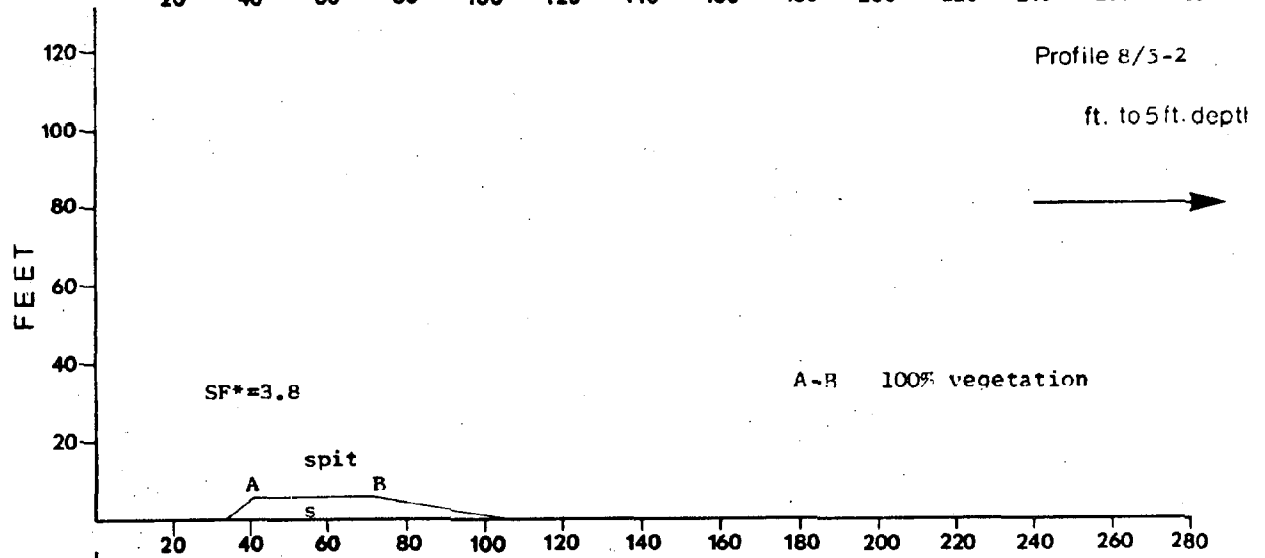
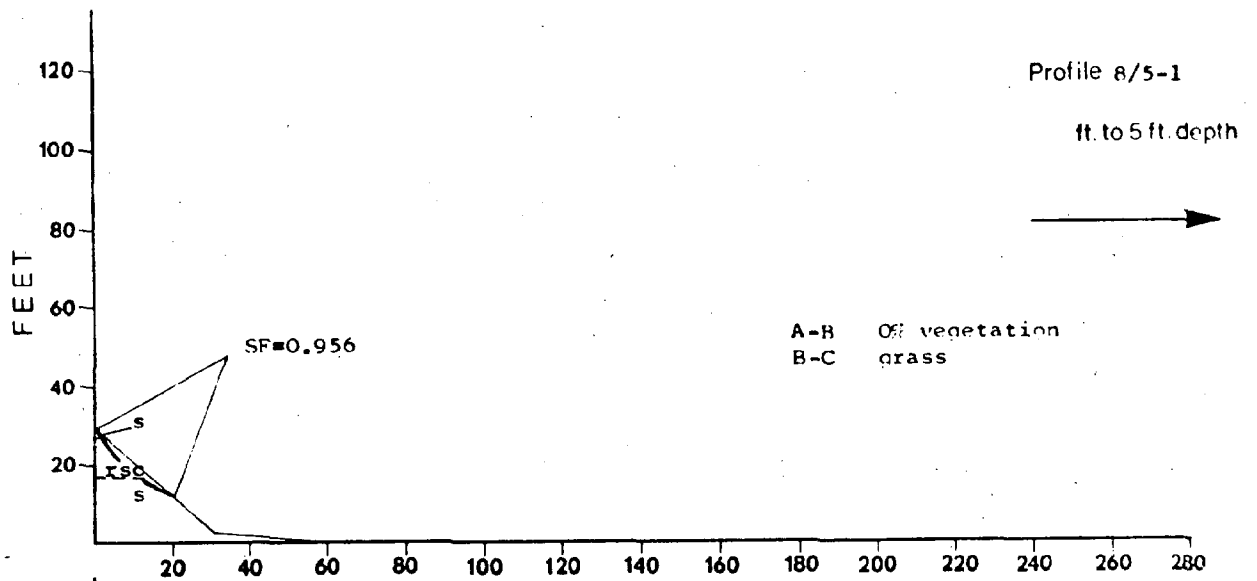
- a) 55-60 ft height drops to 30-35 at east end; sand, some clayey sand; gulleying and flowing; 80-100% vegetated birch, alder, cedar
- b) 25-30 ft - dropping to 0 ft eastward; clayey sand over sand; shallow sliding; 20% vegetated
- c) absent

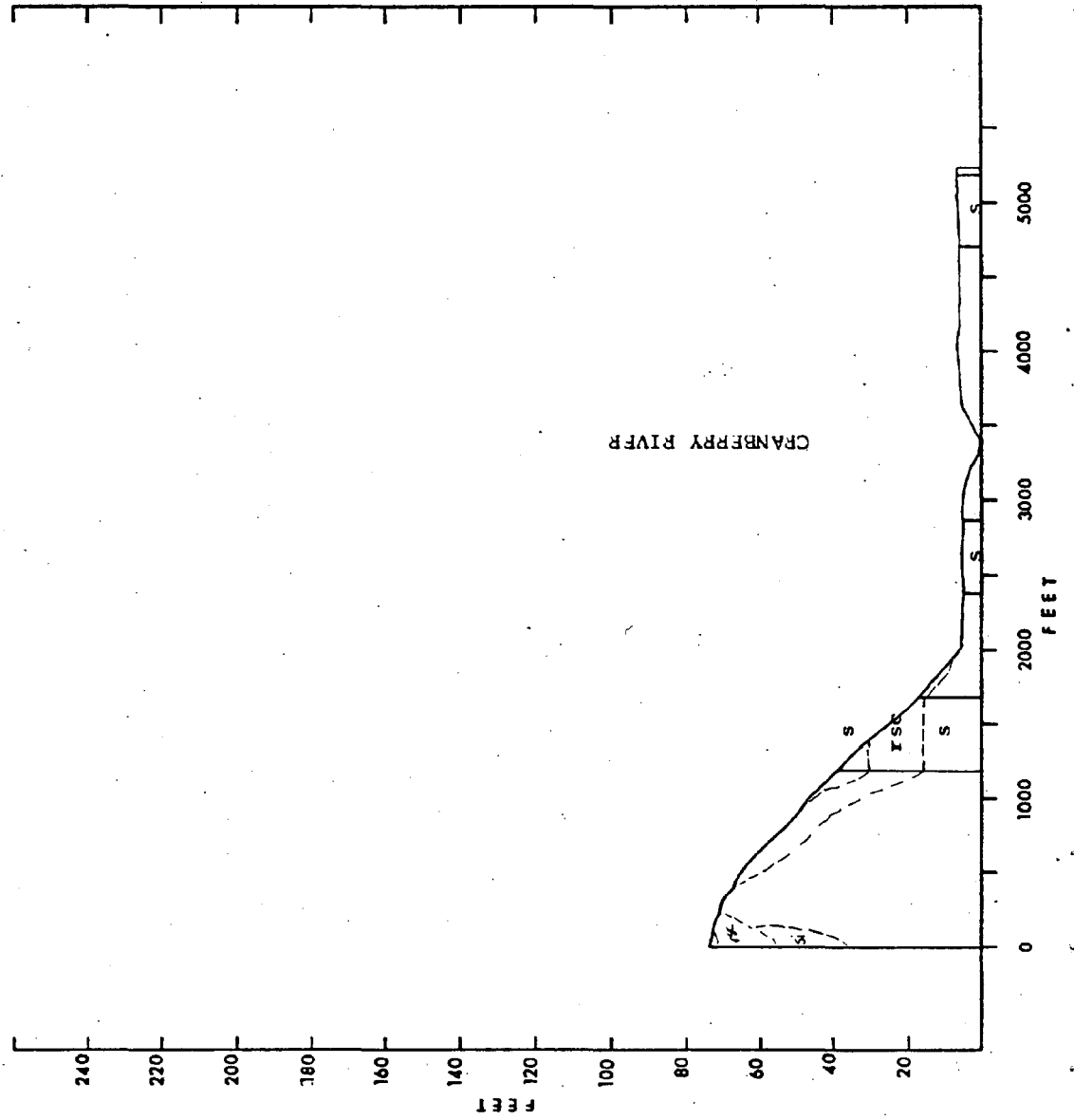
Toe:

- a) protected sand
- b) protected clayey sand
- c) absent; or beach sands as ridge; xxxx rip-rap

Beach:

- a) 20-30 ft; coarse sand; pebbles at shore, granules in swash zone





Section 4/33, T50/51N, R7W

The western end of this section represents the eastern limits of the Village of Herbster, Wisconsin. The bulk of the material in the bluff is made up of sand with gravel. The coarseness of this material varies along the shoreline. At the top of the bluffs lies a persistent red clay to clay loam unit. Translocation of clays from this unit has produced a clayey sand unit immediately below the upper capping unit. Towards the middle of the section, a brown silt-rich, till-like material occurs for a couple tenths of a mile in the bluff. The bluff height is greatest towards the middle of the section where it is 50 ft. The bluff drops steadily to 25 ft. at the eastern end. At the western end, the bluff is absent for 1/4 mile. Here, a sand berm, which has been rip-rapped, protects a local road from wave attack. Vegetation is up to 100% and consists of birch, pine and shrubs. Where vegetation is more patchy, rilling and gulleying is eroded the exposed material. The beach is cobbly and narrow throughout and does not serve to protect the bluff toe from wave attack during intense storms. Homesites occur continually along the bluff and a few include access to the beach by stairs. Most use is limited to the easily accessible, sandy beach which lies at the western end of the section. Here the presence of the town of Herbster, a camping area, and a small resort encourage use of the beach.

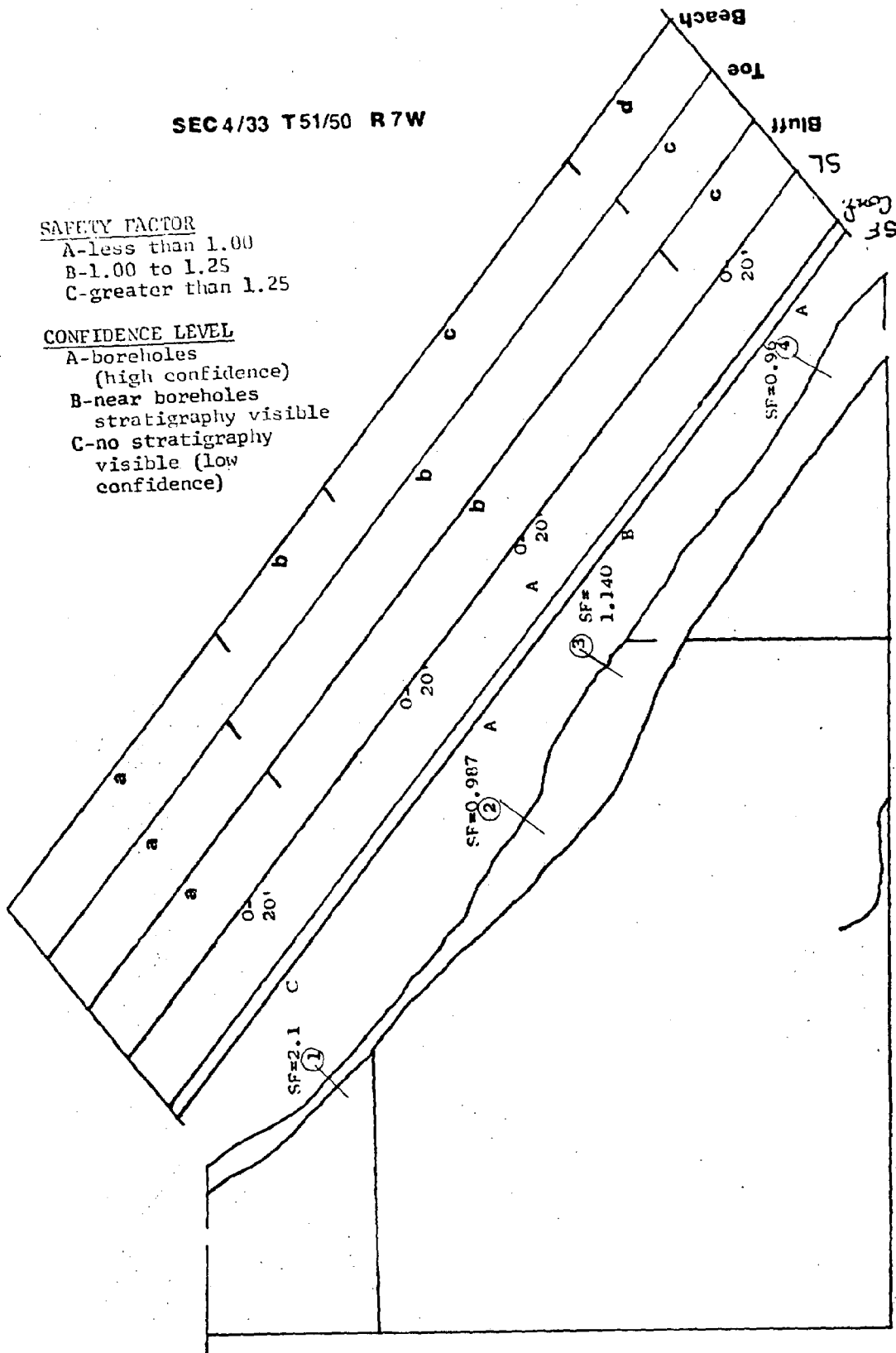
SEC 4/33 T 51/50 R 7W

SAFETY FACTOR

- A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
 (high confidence)
 B-near boreholes
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)



Sec. 4/33, T 50/51 N, R 7 W

Bluff:

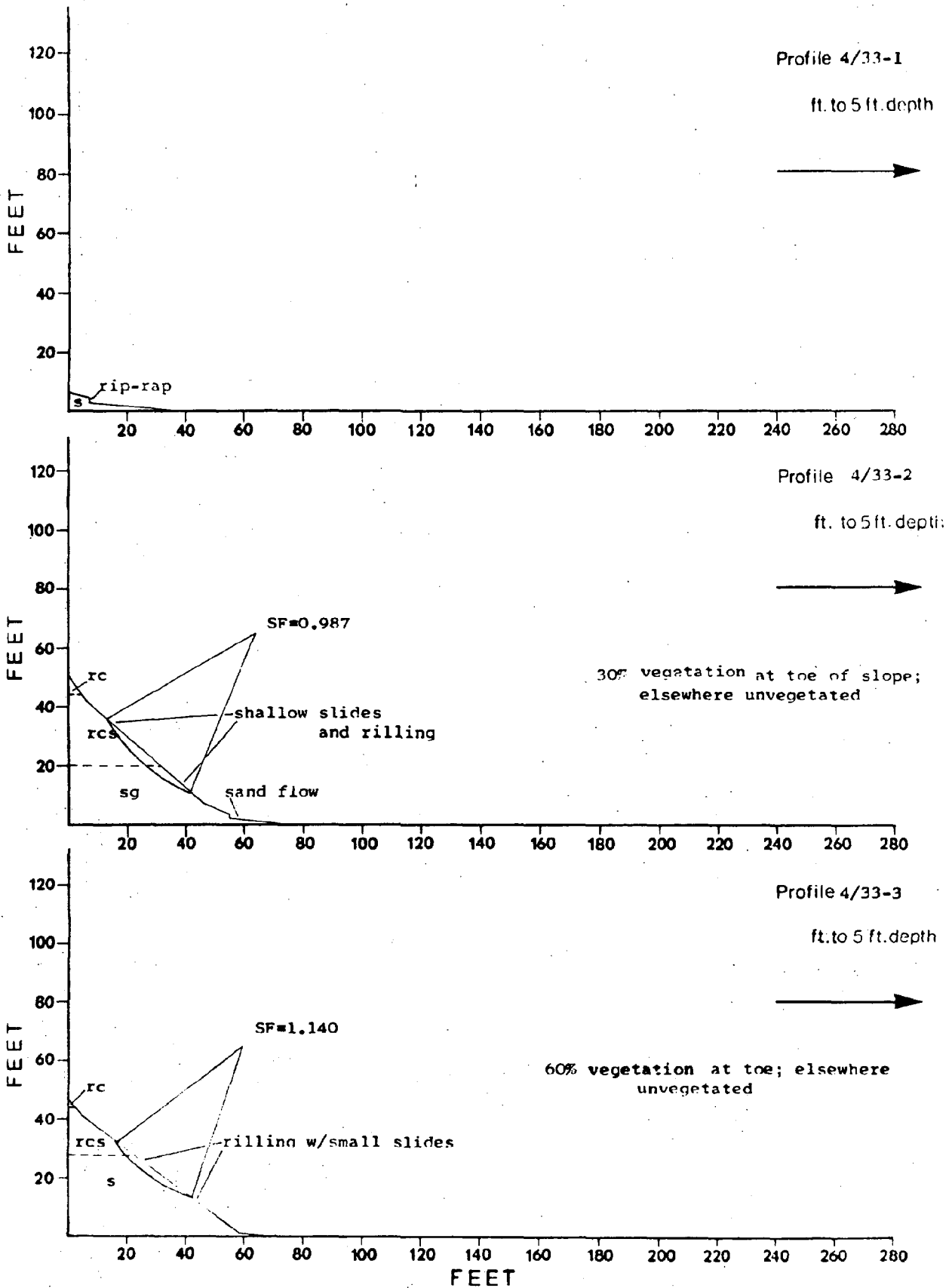
- a) no bluff; small rip-rapped 2-4' rise behind beach, vegetation with grass and shrubs
- b) bluff rises eastward to 40 ft, 100% birches and pines with shrubs in clay over clayey sand over sand and gravel, occasional shallow slides, brown sandy silt occurs at toe over limited beach
- c) 25-35' bluff in sandy clay (5-8') over sand with gravel; 80% vegetated, trees; eroding by slope wash and occasional shallow flows

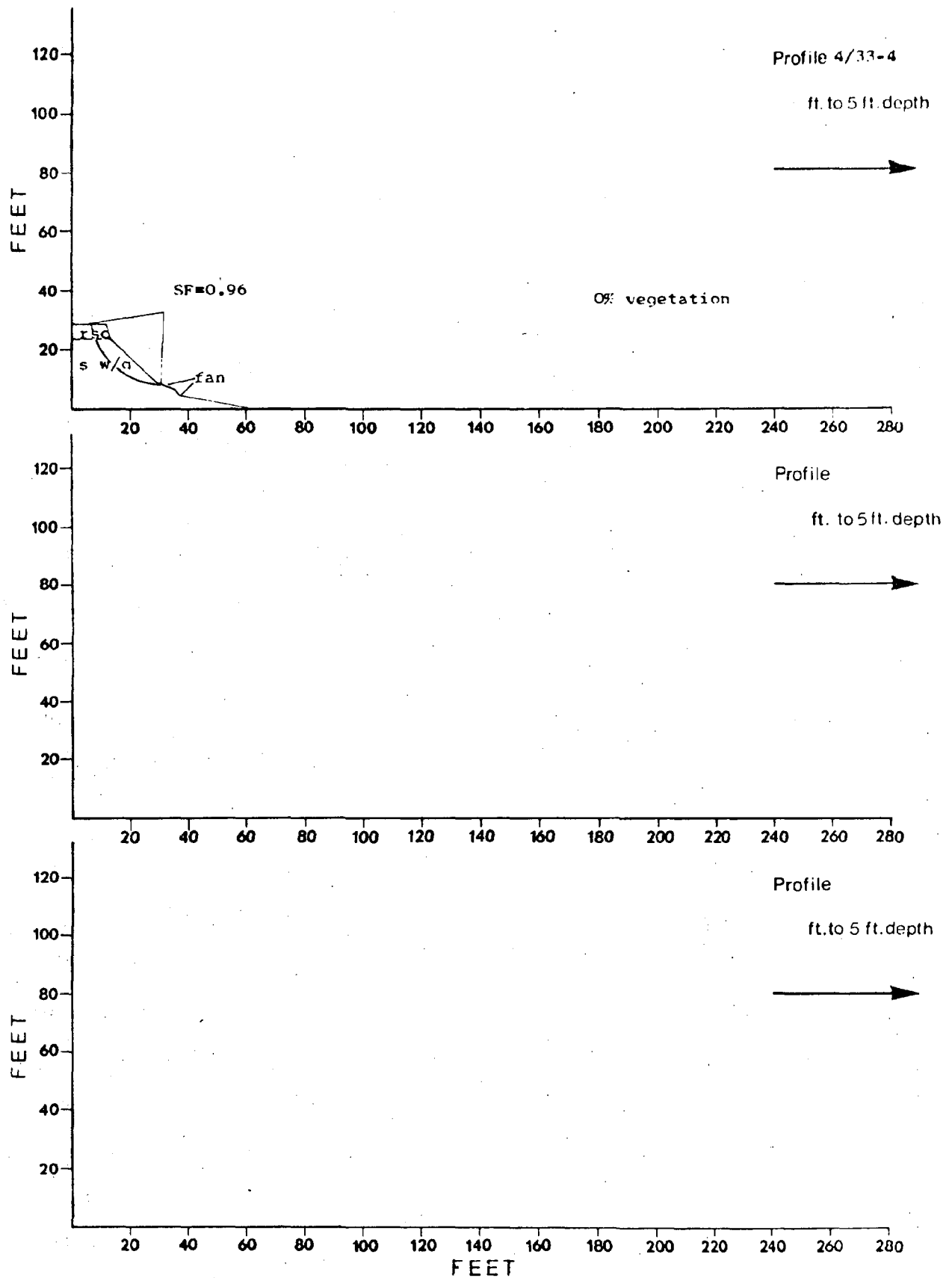
Toe:

- a) no bluff, occasional rip-rap; protected
- b) vegetated, protected
- c) vegetated, protected some talus cones of swamped debris

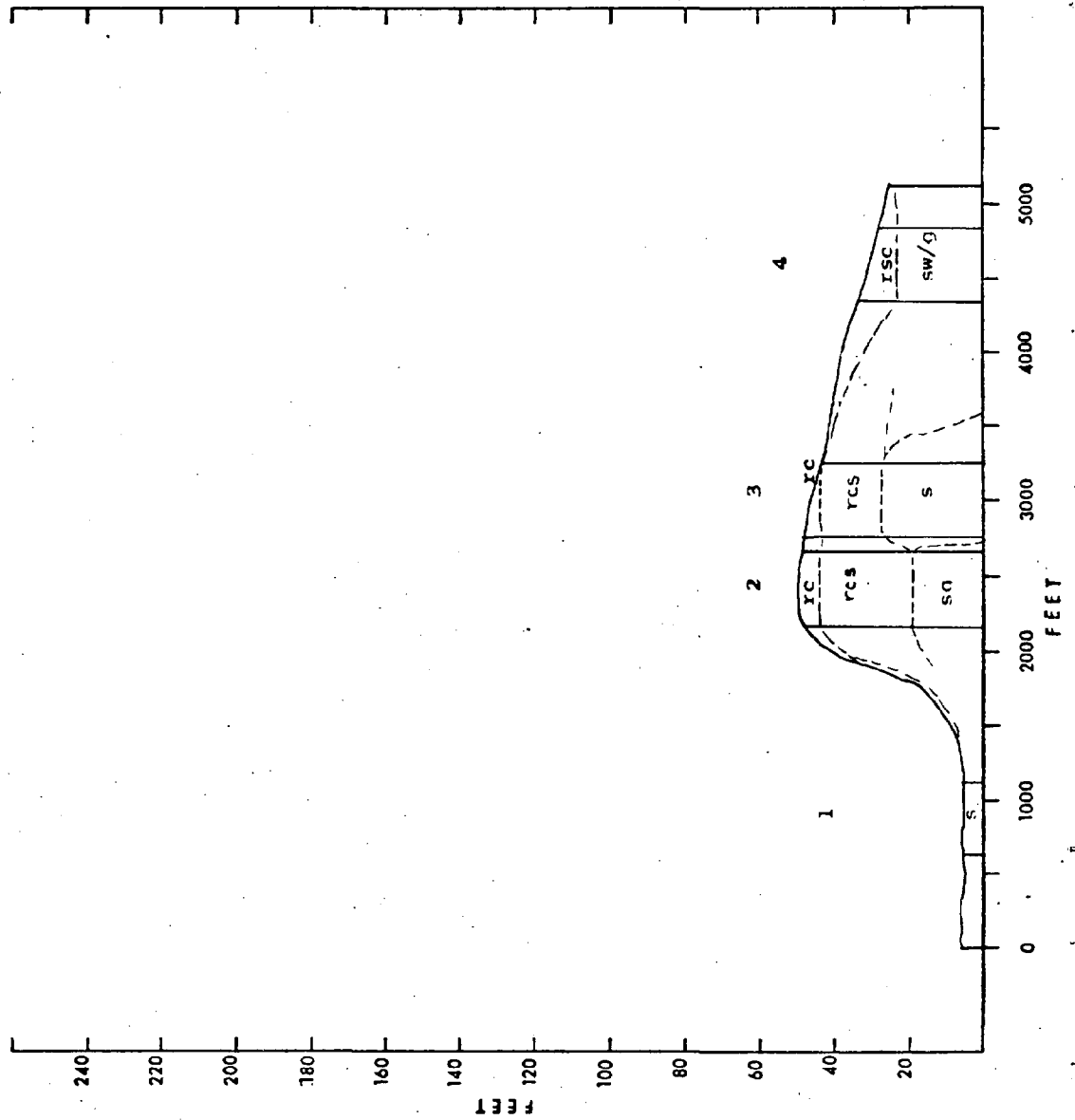
Beach:

- a) 20' wide; sandy with occasional culvert; two piers
- b) 15' wide; cobbles and pebbles with scattered boulders
- c) 5' wide; cobbles of scattered boulders
- d) 10-20' wide; cobbles and pebbles; occasional boulders





T.51/63N., R. 7 W., Sec. 4/33

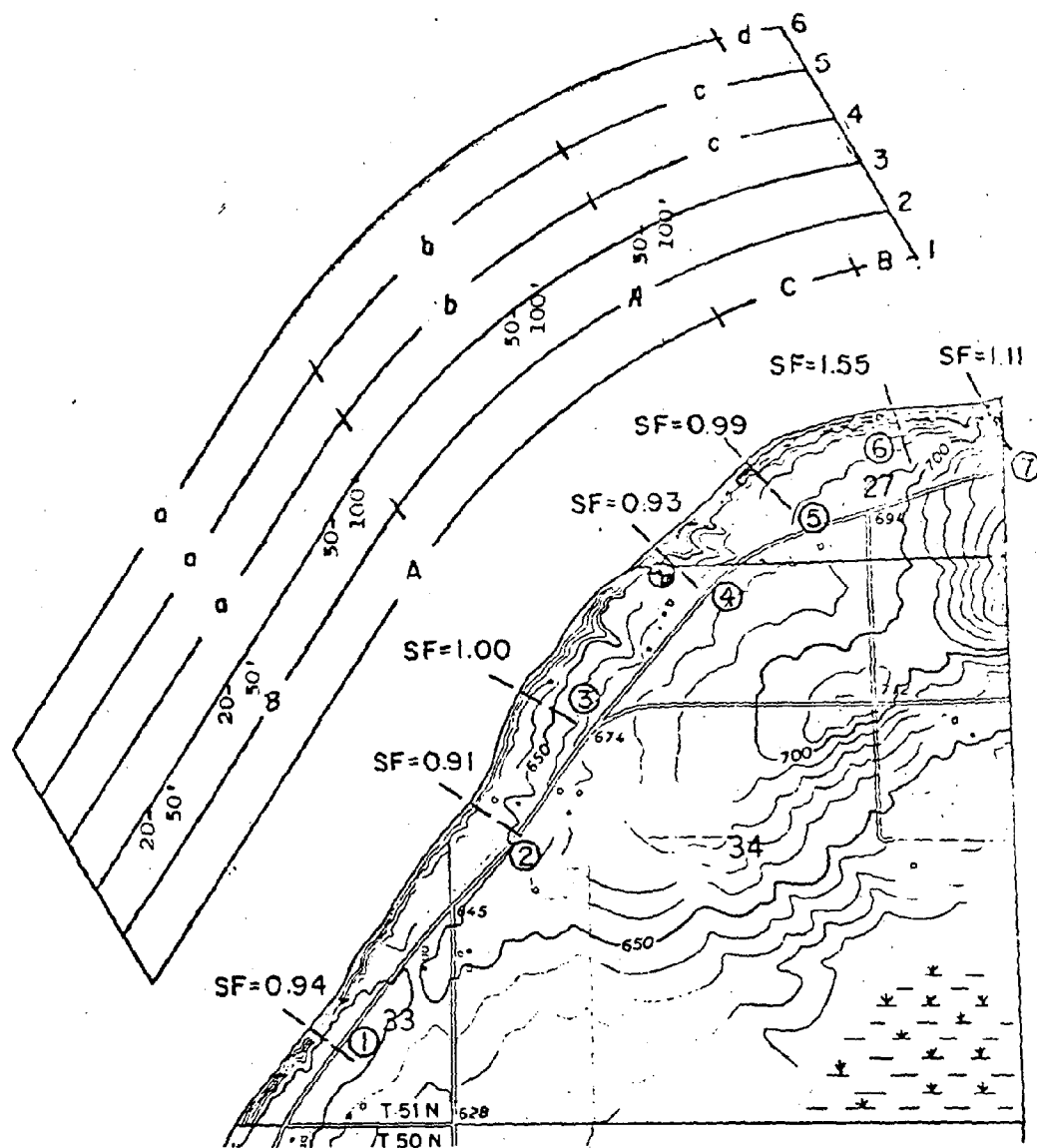


Borehole Site 5

Borehole Site 5 is located half-way between the Village of Herbster and Bark Point in Reach 5. This study area begins 1.2 miles east of the Village of Herbster and includes 2.0 miles of shoreline in Sections 33, 34, and 27 of Township 51 north, Range 7 west in Bayfield County. The shoreline is composed of bluffs which generally increase in height from 25 feet in the southwest to 85 feet in the northeast. Beaches fronting these bluffs are 10 to 30 feet wide and composed of cobbles. Some isolated "pocket" sand beaches are also found in Reach 5.

Bluff composition is similar to that of Site 4, mostly well sorted sand and gravel. Sand is well compacted and obtain slope angles in excess of 50° in many locations. Red-brown clay-loam is found overlying the sand discontinuously. In Profile 6, a stony silt-loam unit is exposed at the toe of the bluff. Sandstone is exposed at one location between Profiles 6 and 7 in Section 27.

Erosion along this coast occurs as the result of direct wave attack on the bluff toe. These slopes fail by translational slides and flows. A second form of coastal erosion at this site is gullying. Numerous ravines dissect the bluff face and are actively being enlarged by surface water drainage. One gully north of Profile 4 is being enlarged at a rapid rate as the result of land management practices. A roadside ditch is channeling large volumes of storm water into the gully which, in turn, erodes bluff soils. Without some corrective measures, the road may become endangered over the next three years.



SAFETY FACTOR (SF)
 A-less than 1.00
 B-1.00 to 1.25
 C-greater than 1.25

CONFIDENCE LEVEL
 A-at boreholes
 (high confidence)
 B-near boreholes with
 stratigraphy visible
 C-no stratigraphy
 visible (low
 confidence)

6 BEACH
 5 TOE
 4 BLUFF
 3 STABILITY LINE
 2 CONFIDENCE LEVEL
 1 SAFETY FACTOR

APPROXIMATE SCALE
 1 inch = 1500 feet

Borehole Site 5

Bluff:

- a) 25% to 40% vegetated with shallow slumping, translational slides, and seeps present.
- b) Steep slopes greater than 45°; zero vegetation, translational slides, and gullying present.
- c) 50% vegetation generally near gullies; translational slides, gullying, and seeps present.

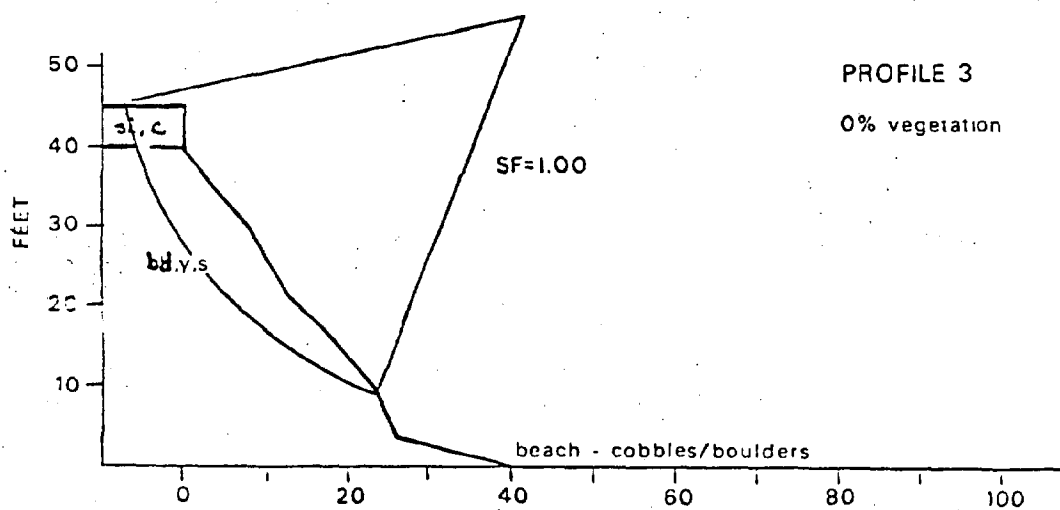
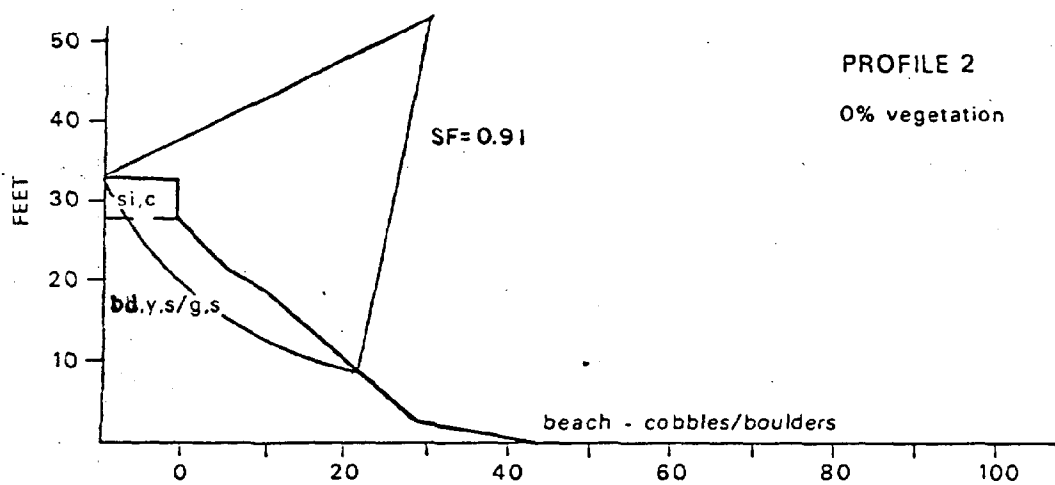
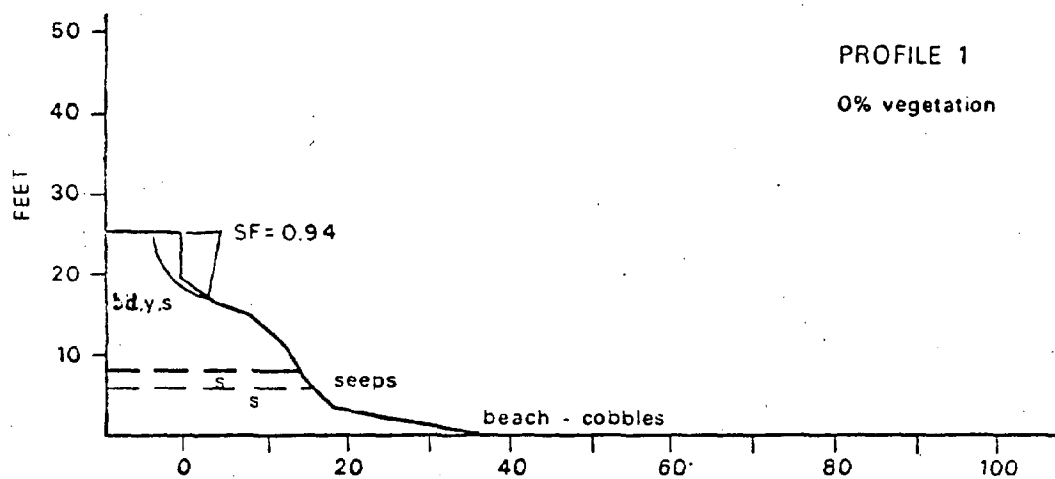
Toe:

- a) Covered with debris from slope failure.
- b) Steep faced wave cuts exposing bluff material.
- c) Covered with debris from slope failure.

Beach:

- a) 10 to 20 feet, cobbles and boulders, wider near gullies.
- b) 20 to 30 feet, sand and gravel.

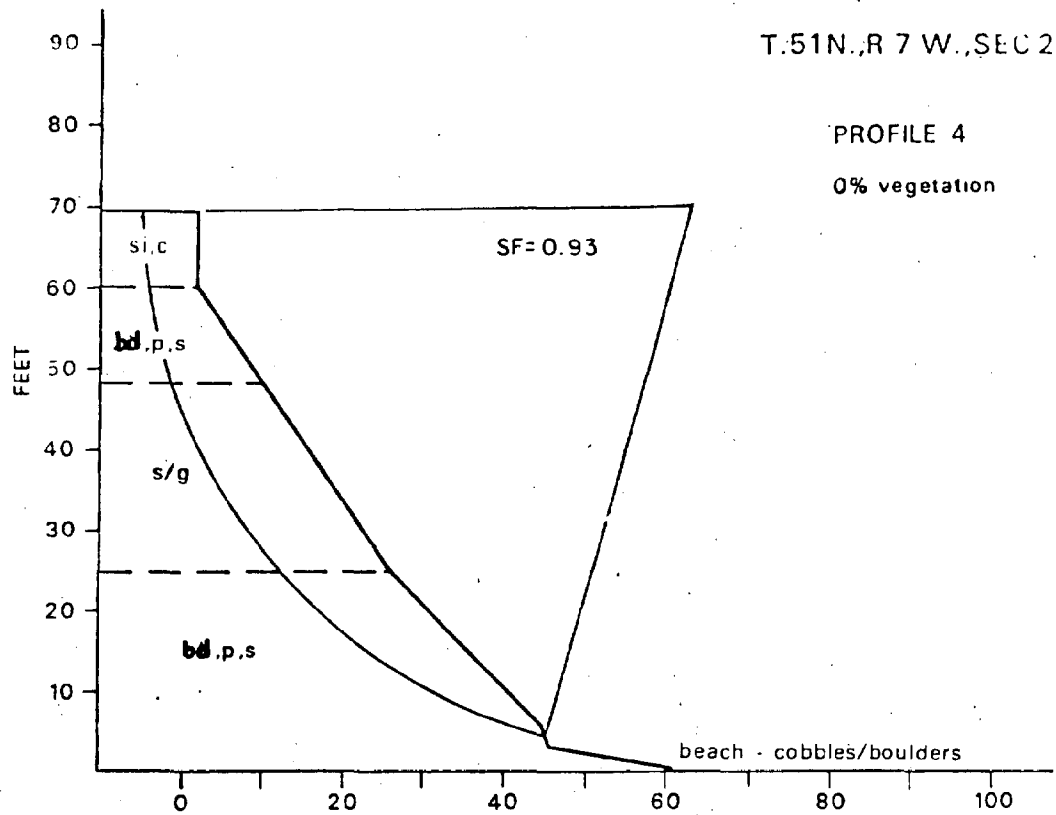
T.51N..R 7 W.,SEC33/34



T.51N., R 7 W., SEC 27

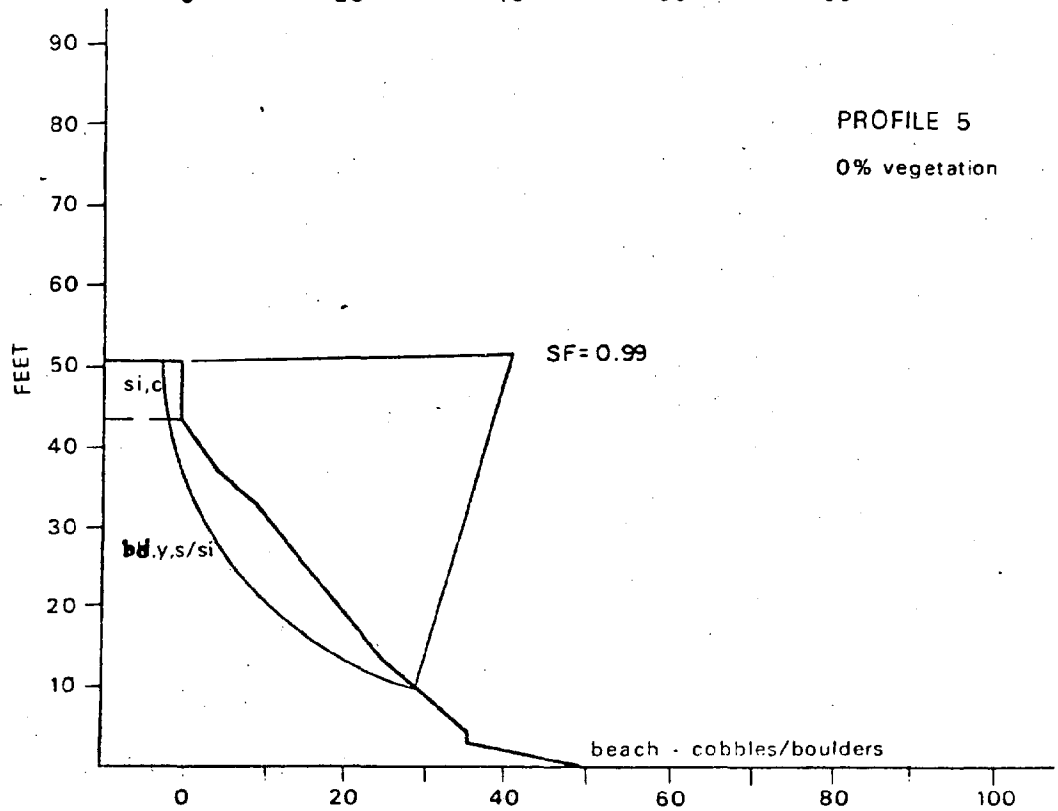
PROFILE 4

0% vegetation



PROFILE 5

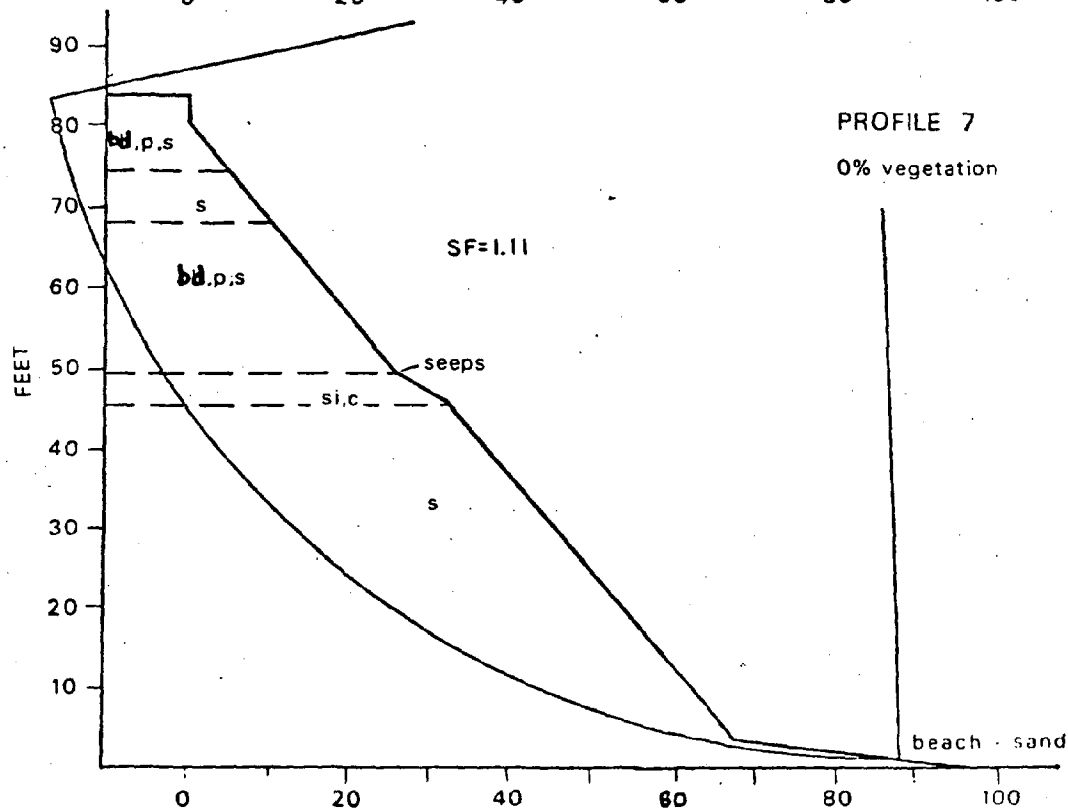
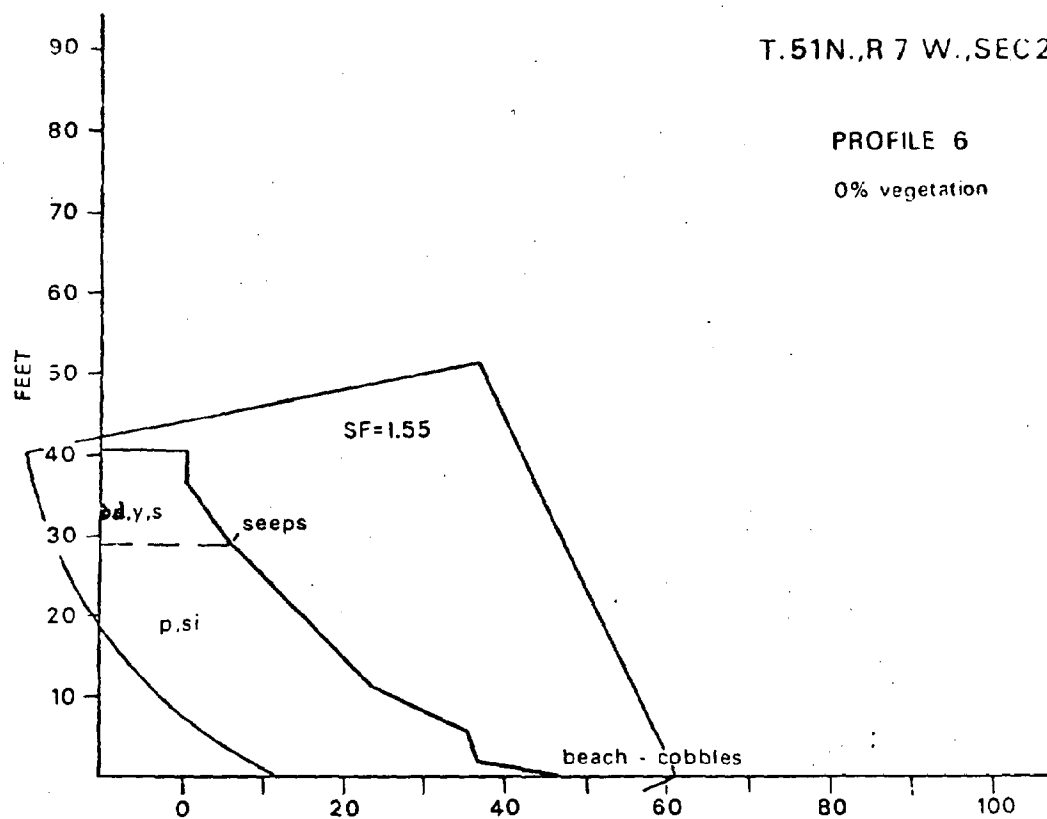
0% vegetation



T.51N.,R 7 W.,SEC27

PROFILE 6

0% vegetation



LOCATION

SGT-6 T51N R7W Sec. 27

Depth (ft.)	Blow Count (split spoon)	Pocket Penetrometer (kg/cm ²) 1 2 3 4 5	w _n	Y _d gm/cm ²	w _L	I _p	% Clay	% Clay & Silt	φ' degree	c' kg/cm ²	Description of Soil
5			15					20	38	0	sand, redbn, so.silt(SM-SP)
10			12					20	40	0	sand, redbn
15			15					20	40	0	silty, so. clay
20			10					20	40	0	so. grvl. & cobble (SM)
25											
30											
35											
40											
45											
50											
55											
60											
65											
70											
75											
80											
85											
90											
95											
100											
105											
110											
115											
120											

EOB 45.0

Section 34/27, T51N, R7W

This section lies along the western side and forming the base of Bark Point. Herbster lies just one mile to the west. The bluff materials are made up of predominately sand with gravel. At the top of the bluff, a sandy clay to clayey sand unit occurs throughout the section. The sand in places is poorly sorted and contains enough clay that when dry, forms nearly vertical cliffs. Erosion occurs in these reaches primarily by slope wash. Elsewhere, sand and debris flows, block falls, and/or rilling occurs. The bluff rises evenly from 25 ft. at its western end to 60 ft. near the eastern end. At the eastern section line, the bluff top rises sharply to nearly 120 ft. The bluff is 80-100% vegetated except for occasional exposures and the stretch towards the western end of nearly vertical cliffs. The beach is narrow and cobbly and does not protect the toe of the bluff during intense storms. Bedrock is exposed in a very limited exposure toward the eastern end. The bluff top is partially developed with occasional small cottages or farm buildings. Access to the beach is poor and evidence suggests that it is used seldom.

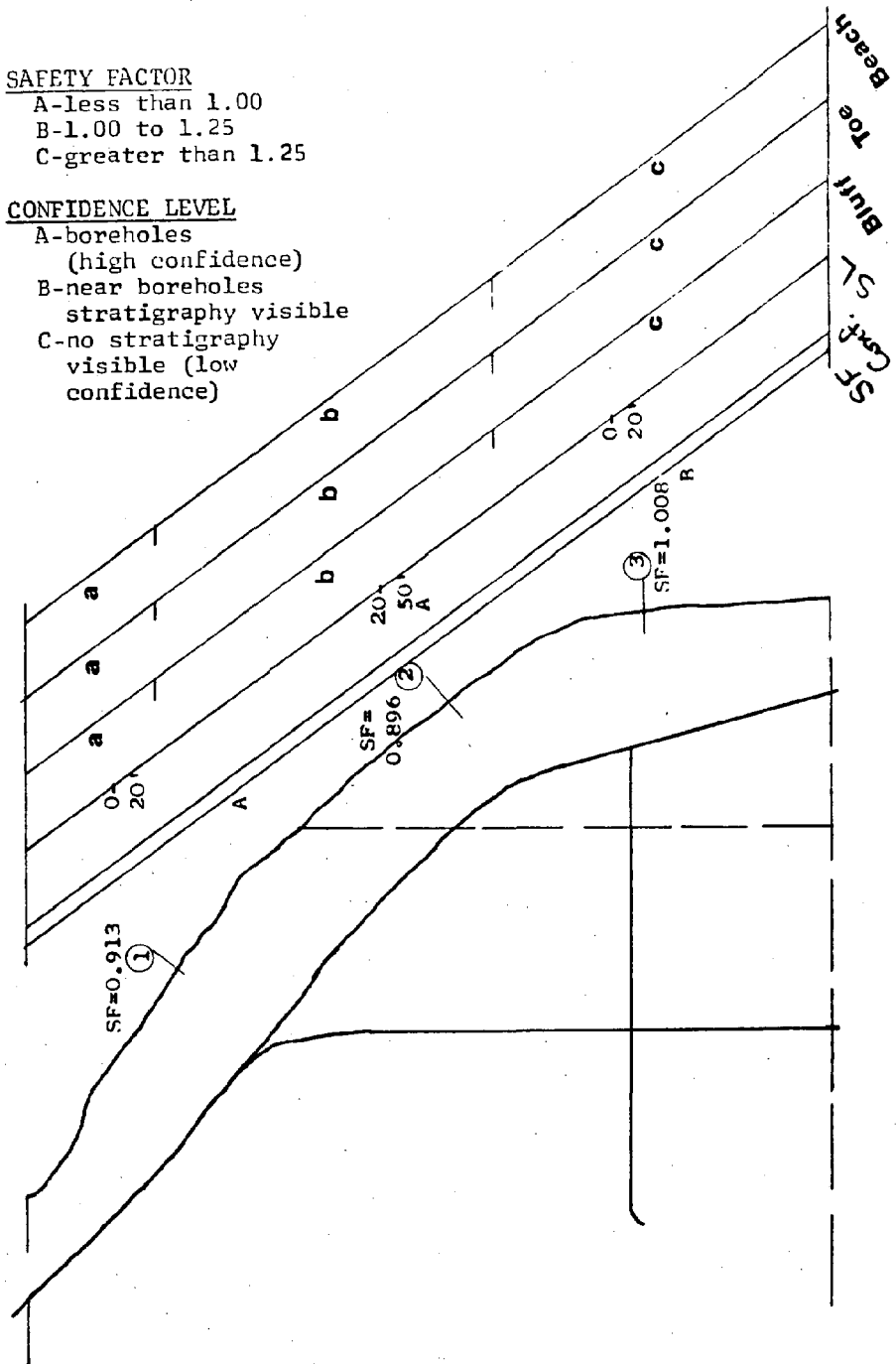
SEC 34/27 T 51N R 7W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Sec. 34/27, T 51 N, R 7 W

Bluff:

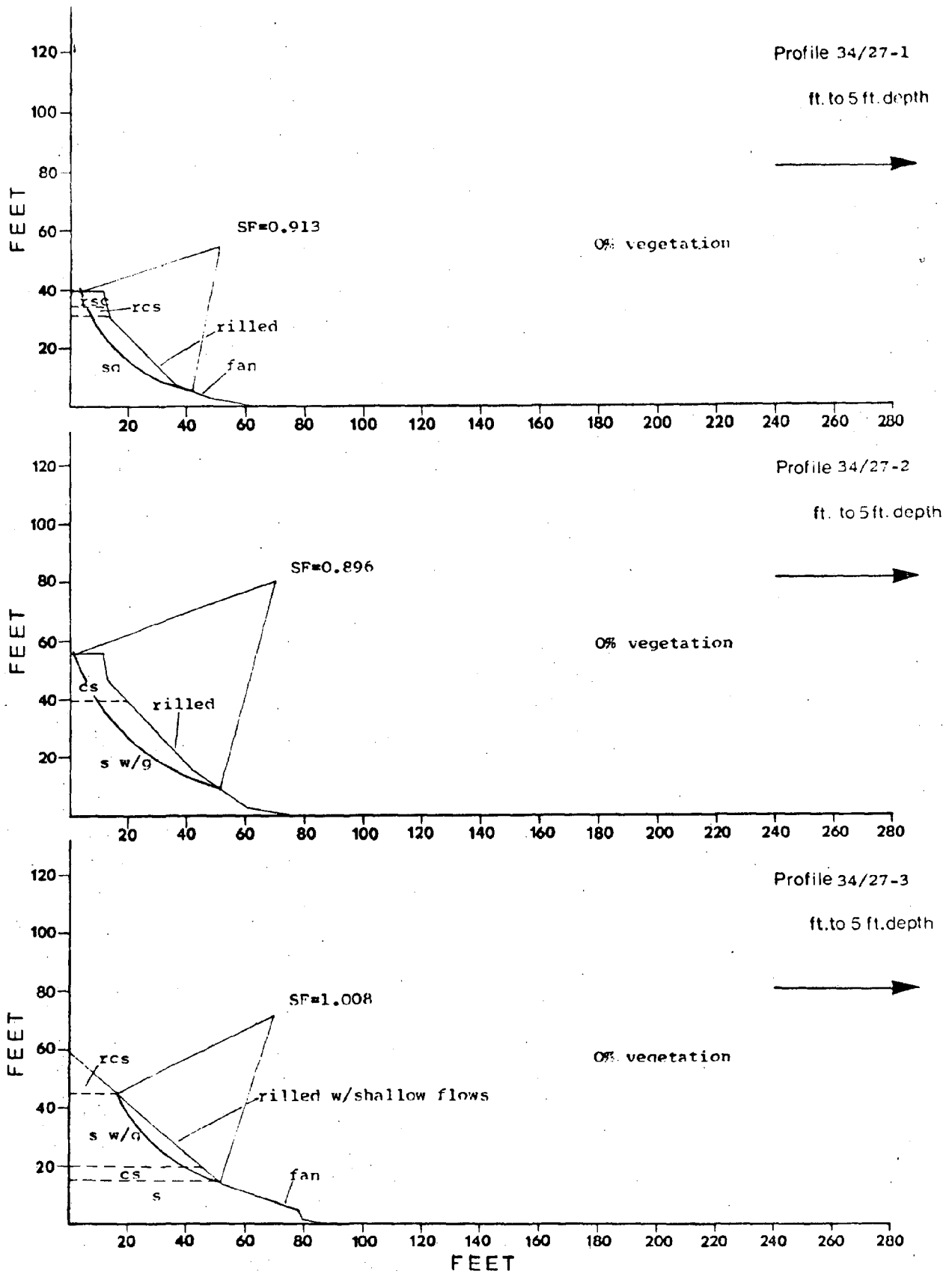
- a) 25-40' high bluff; red clayey sand with clay on top and occasional clean sand beds throughout; 60-80% in birch and shrubs; occasional shallow slides
- b) steep (45°-90°) slopes in hard dry poorly sorted sand; eroded by slope wash, occasional debris flow, and block falls; usually 3-4' of sandy clay at top with overhanging poor bound crest. Farther east, seep failures occur; 40-50' high
- c) steep high bluff in sand and clayey sand; sandy clay occasionally at crest; 60' high; Densely vegetated on scarp and in ravines but no vegetation on scarp faces; shallow sand flows and rilling

Toe:

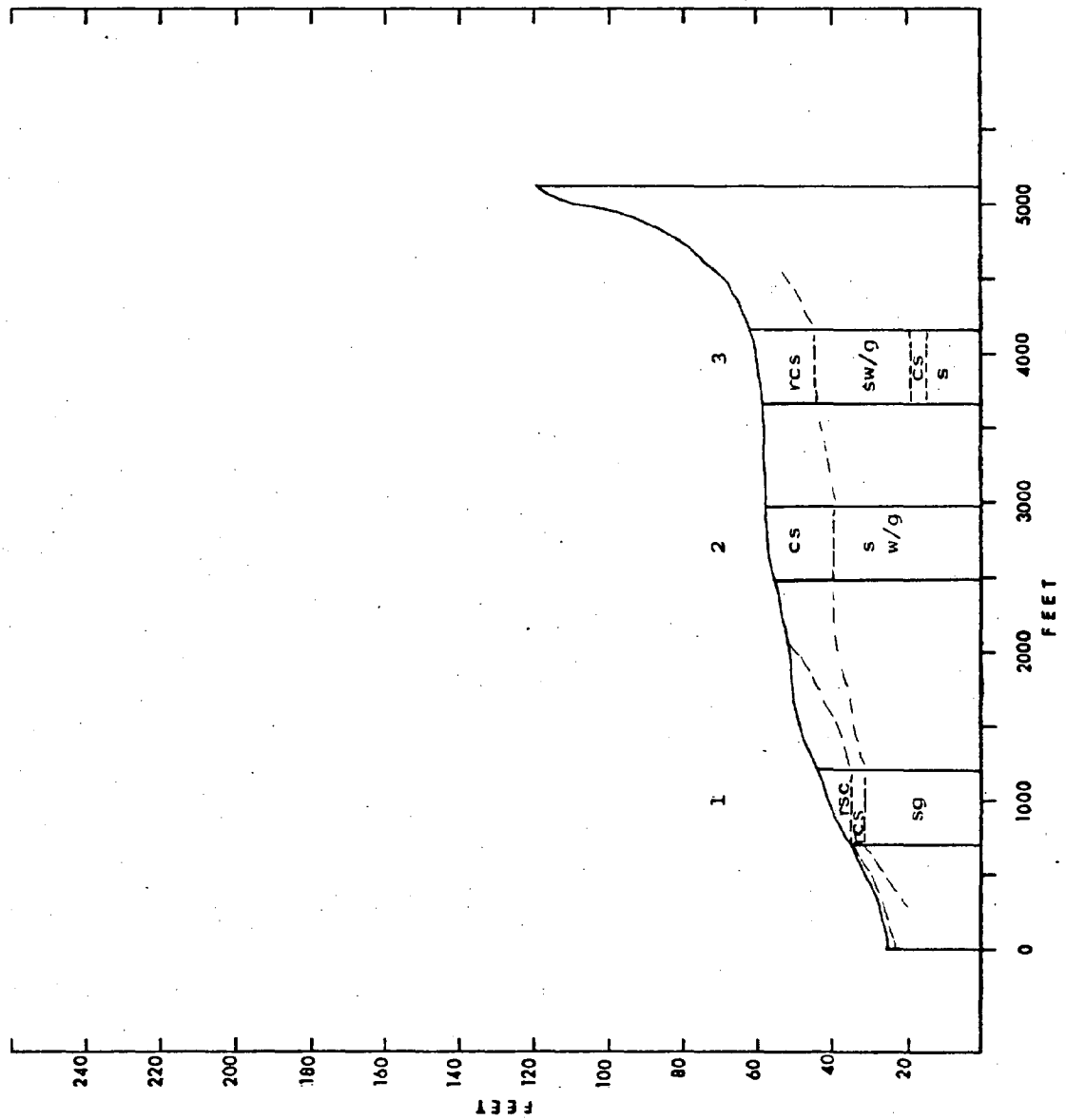
- a) occasional unprotected toe; well vegetated occasional with small fans of slumped material
- b) sand talus and flow fans; protected and sparsely vegetated
- c) toe occasionally unprotected; flow fans

Beach:

- a) 0-5 ft wide; sand over cobbles; numerous slumped trees; occasionally absent
- b) 10-20 ft; cobbles with sand and scattered boulders
- c) 3-10 ft; variable, sandy and cobbly; numerous fallen trees



T. 51 N., R. 7 W., Sec. 34/27



Section 26. T51N, R7W

(Northeast-facing)

This section is located at the base of Bark Point, approximately 3 miles from Herbster. The bluff is 125 ft. high at the western end of the section, rises to 140 ft., and then decreases steadily to around 10-15 ft. The higher bluffs are composed mostly of sand, with some silty layers, capped by a thin clay loam. A stony silt loam is exposed at the toe at the western end of the section. These higher bluffs are moderately to well vegetated with mature alder, birch, fir, and cedar. Failure is largely shallow slides with some rilling and gulleying. The low bluffs are composed of clay loam over a discontinuous laminated clay over sandy loam. The bluff face is fairly steep and fails in shallow slides and flows. The beach is 15-25 ft. wide at the western end and is composed of coarse sand, probably derived from the bluff. Eastward, the beach thins becomes more cobbly and eventually pinches out. There are a number of cottages on top of the higher bluffs but the beach appears to be seldom used.

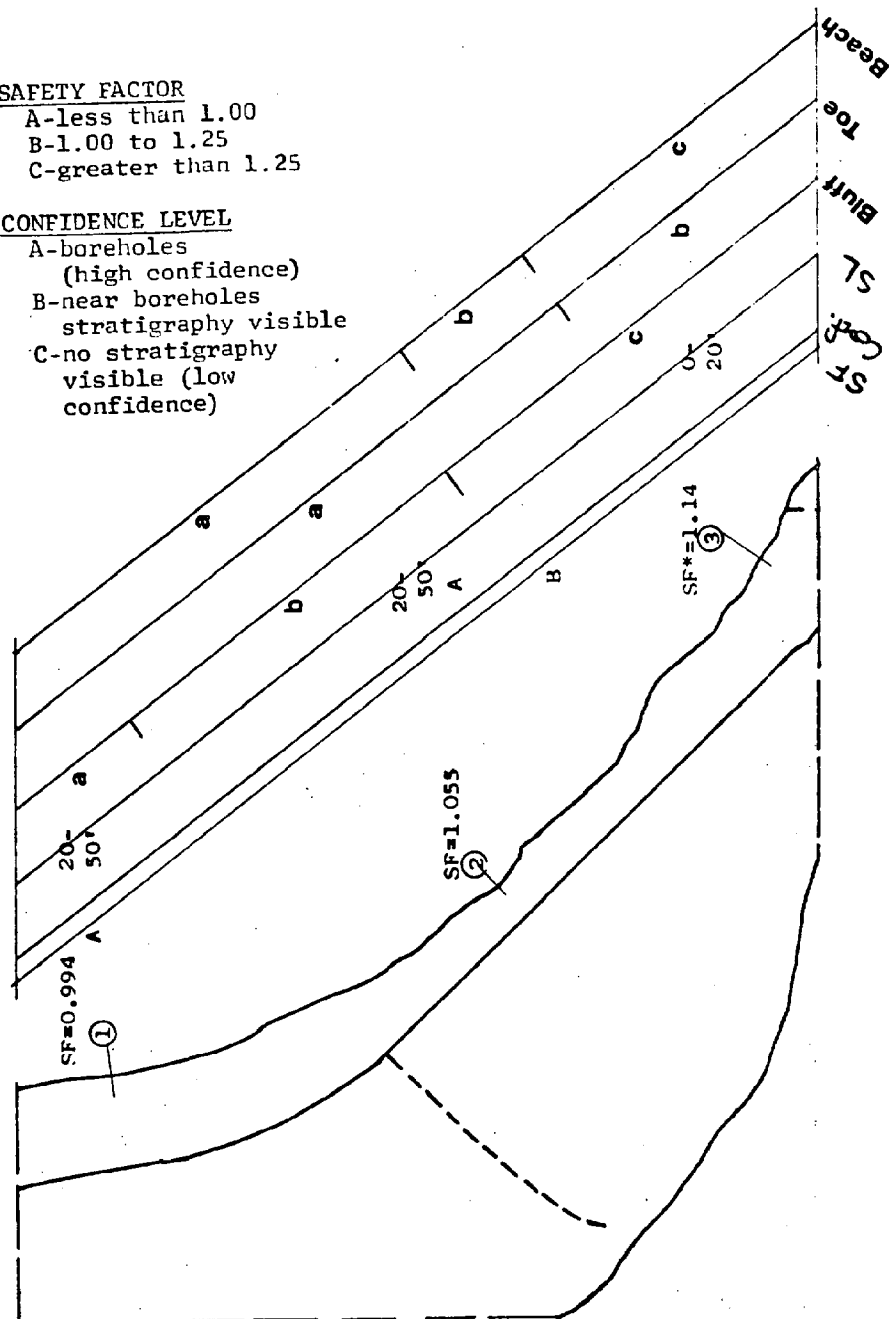
SEC 26 T 51 N R 7 W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Section 26/23, T 51 N, R 7 W. northwest-facing shoreline

Bluff:

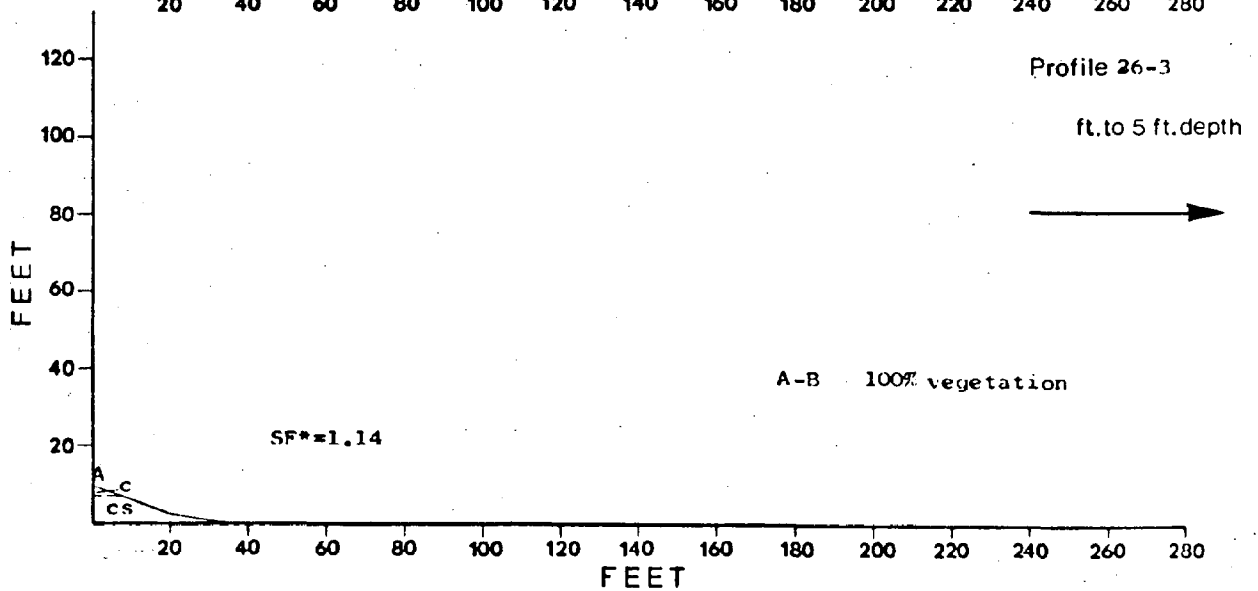
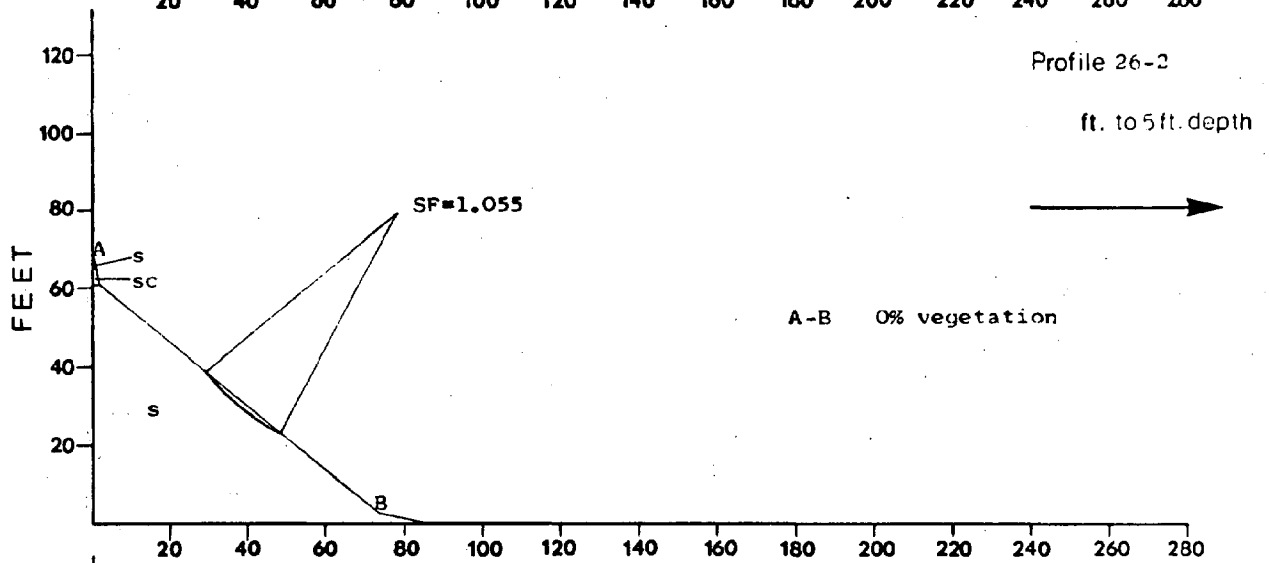
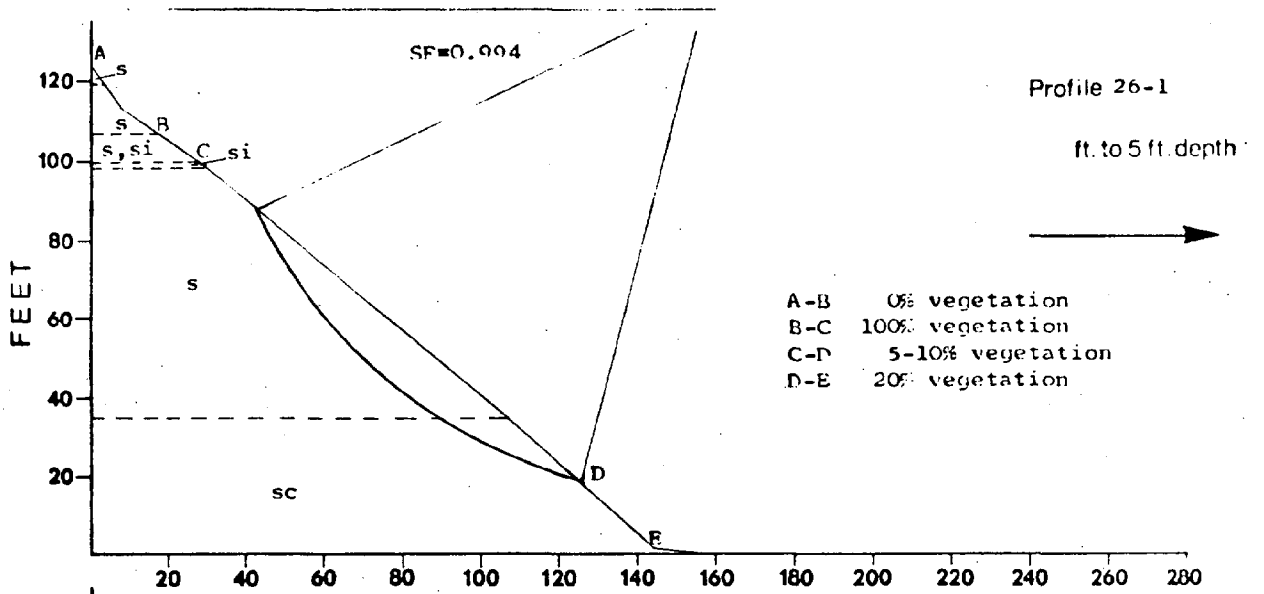
- a) 125-140 ft. falling to 100 ft "eastward"; some shallow slump and surface flows, rilling and gulleying; vegetation - usually 90-100% alder fir and cedar; where failing, 0-20%; loose sand over silt loam
- b) 100 ft. falling to 15 ft steadily; shallow slides and surface flows and gulleying; vegetation usually 40-50% alder, birch, fir and cedar; often 100% or 0%; clay loam over sand
- c) 15-10 ft. even height; shallow slides; vegetation 30-40% as above; clay loam over discontinuous laminated clay over loamy sand

Toe:

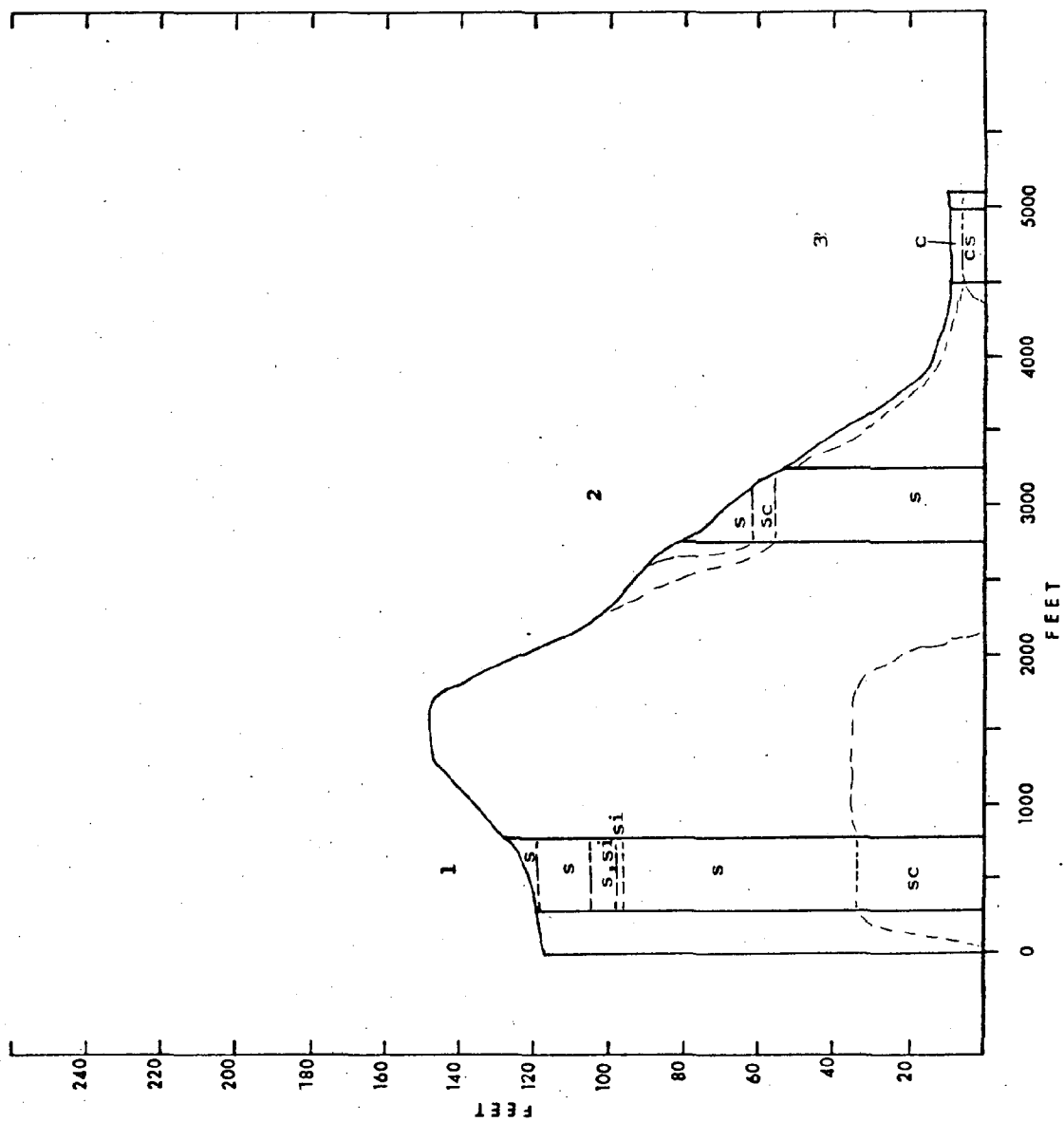
- a) protected sand or sandy clay; mostly in situ
- b) unprotected clayey sand, in situ

Beach:

- a) 15-25 ft; coarse sand, with pebbles at water and cobbles at toe occasionally
- b) 15 ft cobbles and boulders with coarse sand at water occasionally
- c) 0-2 ft; cobbles and coarse sand; mostly absent



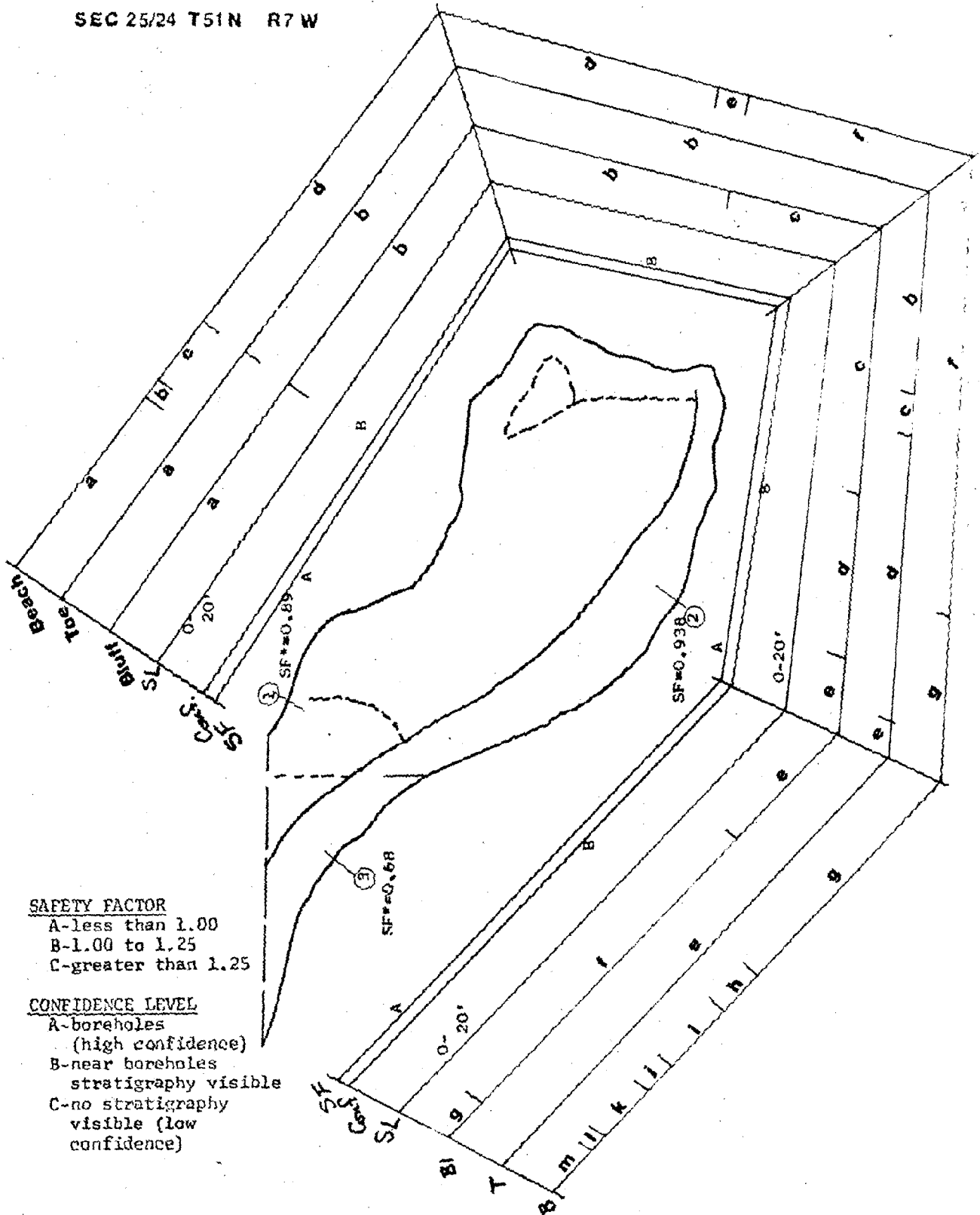
1



Section 24/25, T51N, R7W

This section forms the bulk of Bark Point. The bluff ranges from 10-15 ft. to as high as 30 ft. with the greater heights occurring around the tip of the point. The lower bluffs along either side of the point are composed of clay over clayey sand; around the end of the point, bedrock rises to form the toe of the bluff. The bluff face is typically steep and failure is by rill-wash and shallow sliding. The beach ranges from 5 to 20 ft. in width and is often interrupted by slide debris. The beach is composed predominately of cobbles, with some boulders and a coarse sand matrix. One landowner has constructed some wooden cribs and a concrete retaining wall in an attempt to forestall the erosion of his property. This is one of the more densely developed areas on the western side of the Bayfield Peninsula

SEC 25/24 T51N R7W



Sec. 24/25, T 51 N, R 7 W

Bluff:

- a) 10-15 ft rising northeastward to 20-25 ft; shallow slides of bluff top vegetation clumps, some rilling; 30-50% vegetation, clumps of birch, alder and fir, or horsetails; clay with sand over laminated clay over clayey stony sand and occasionally over loamy stony sand
- b) 20-25 ft; blockfall, some shallow sliding off crest; 0% vegetation; mostly bedrock; 2-4 ft. of clayey stony sand on top.
- c) 15-20 ft; shallow sliding off bluff top, rilling; 20-30% clumps of slumped birch, poplar; clay with sand over laminated clay over clayey stony sand over bedrock toe
- d) 20 ft rising to 30 southward; shallowing sliding, rilling in clay; bedrock rises and consisted up to 1/2 of bluff and upper clay units may be absent
- e) 30 ft falling to 15 ft southward; shallow slides off bluff top, some rilling; 30-50% vegetation, birch, alder, and fir, or horsetails; clay with sand over laminated clay over clayey stony sand
- f) 10-15 ft; shallow sliding off crest; vegetation variable, mostly 10-20% slumped clumps, birch and poplar, occasional 100% meadow grasses and vines; clay units over clayey stony sand
- g) 3-5 ft. little failure noted; 80-100% birch, poplar, fir, cedar

Toe:

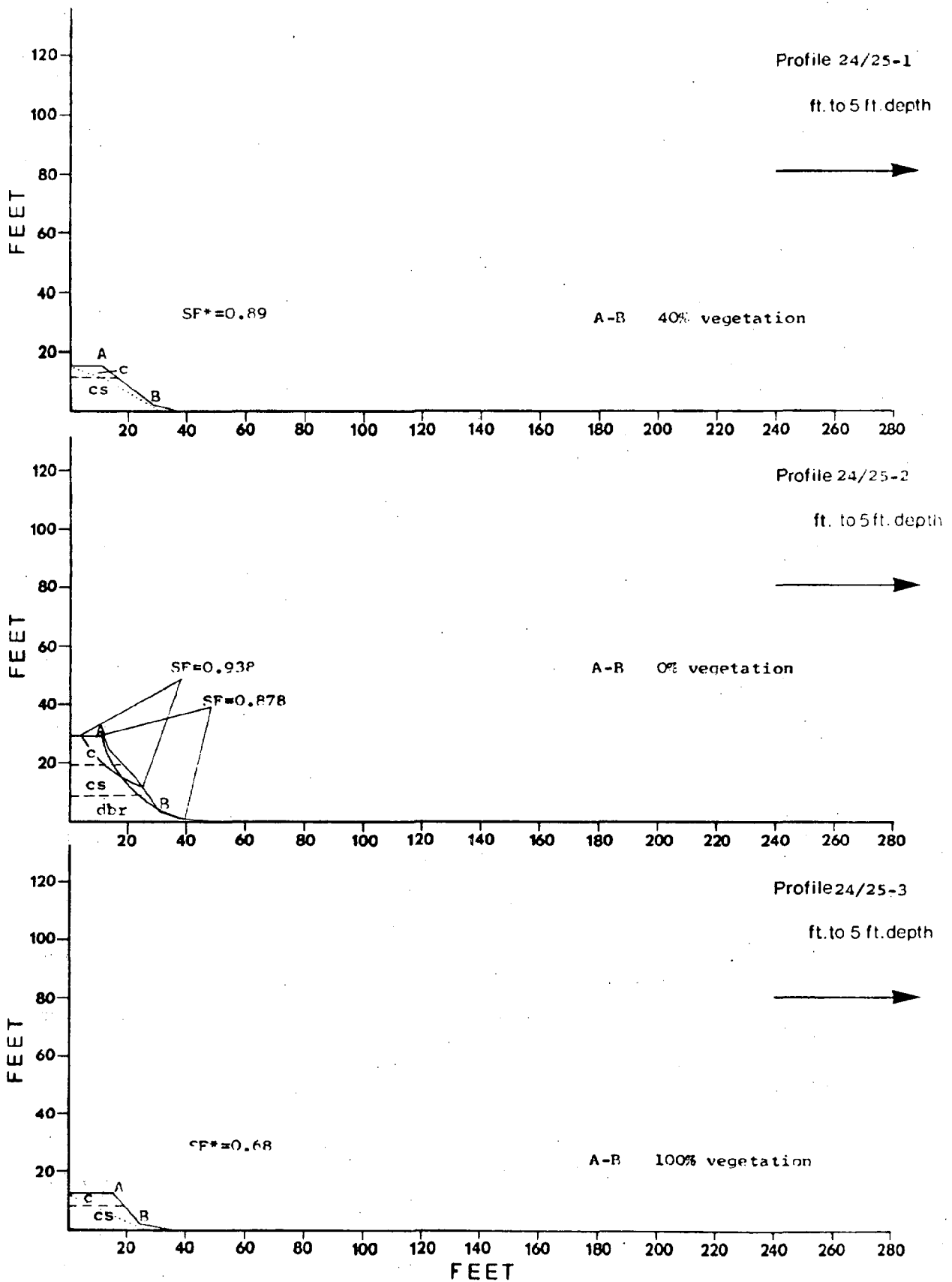
- a) mostly protected, slumped clayey sand
- b) bedrock
- c) protected by rip-rap over clayey sand
- d) bedrock
- e) mostly protected, slumped clayey sand

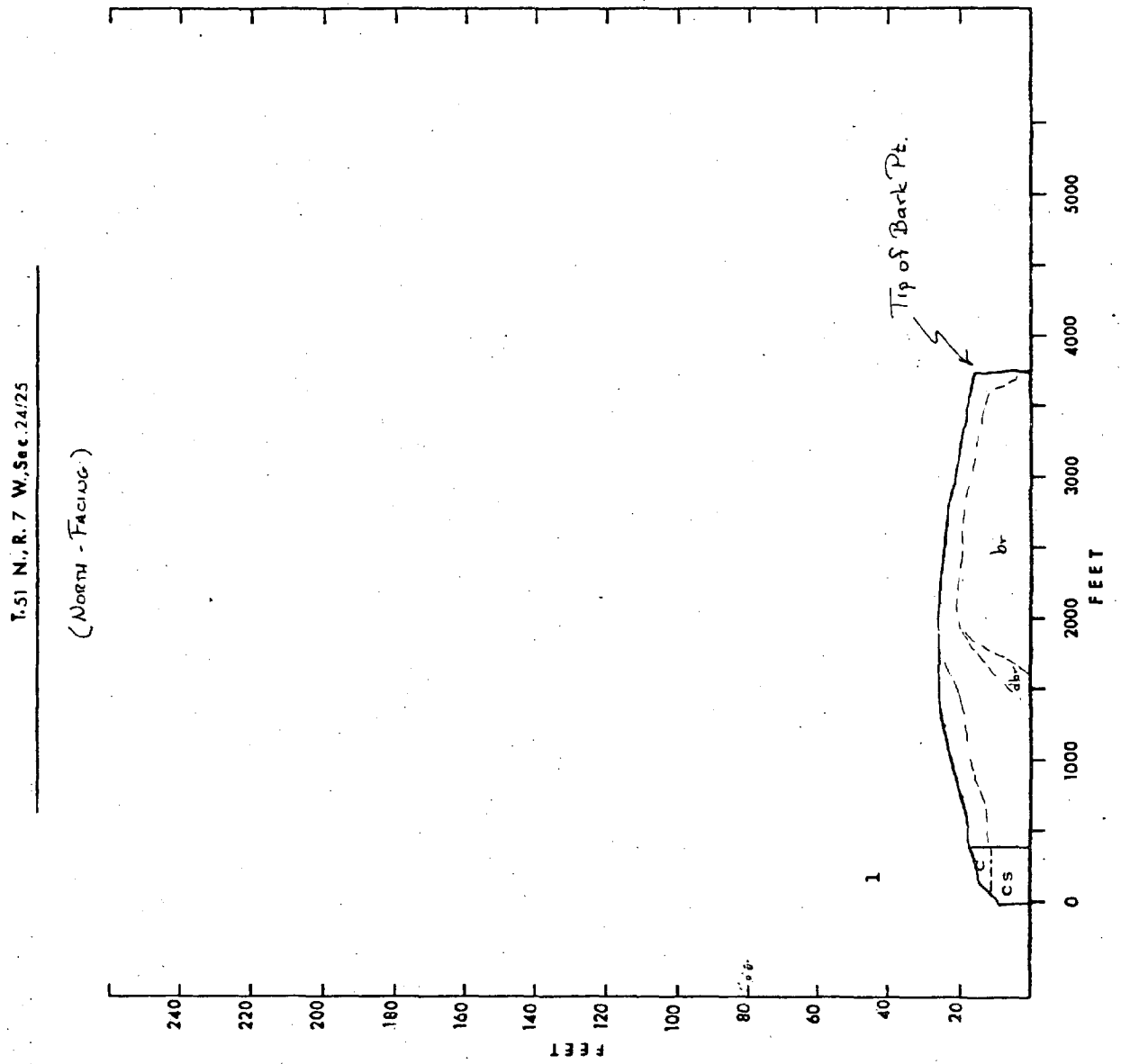
Beach:

- a) 5-15 ft cobbles with boulders; often interrupted by slide blocks
- b) 10-20 ft coarse sand with cobbles
- c) 5-15 ft cobbles with boulders; often interrupted by slide blocks
- d) bedrock - no beach
- e) 5-15 ft cobbles with boulders; often interrupted by slide blocks

Cont'd.

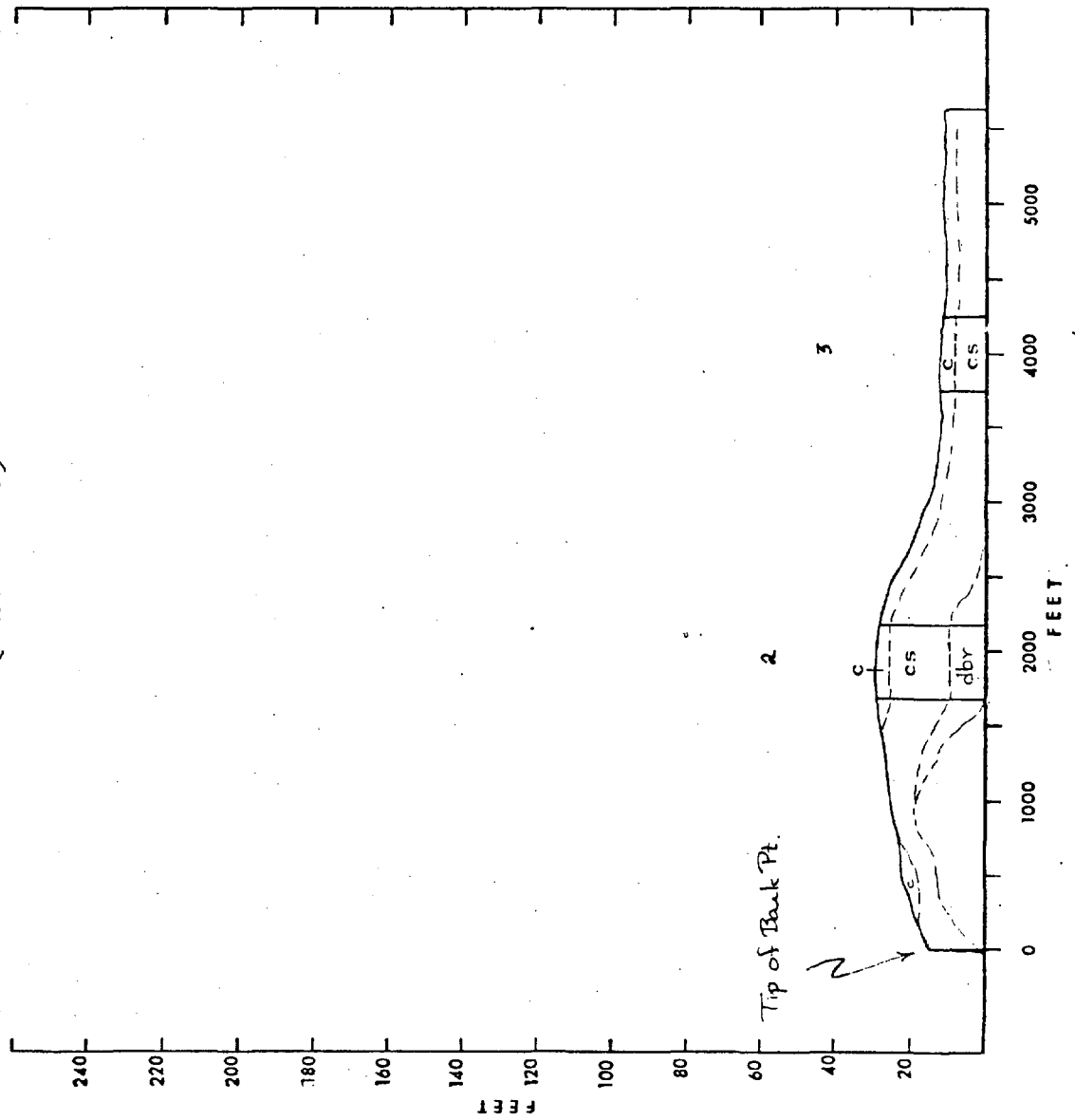
- f) bedrock- no beach
- g) 5-15 ft cobbles with boulders; not as interrupted by slide blocks
- h) 10-20 ft coarse sand with cobbles and two concrete and wood piers
- i) 5-15 ft cobbles with boulders; less interrupted by slide blocks
- j) 10-20 ft coarse sand with cobbles and one pier at south end
- k) 5-15 ft cobbles with a short portion cribbed with wood and less interrupted by slide blocks
- l) 10-20 ft coarse sand with two piers, a retaining wall between and a wood crib at south end
- m) 5-15 ft cobbles with boulders; less interrupted by slide blocks





151 N., R. 7 W., Sec. 24/25

(EAST-FACING)



Section 26, T51N R7W

(Southeast facing)

The section is located at the base of Bark Point. There is bluff present throughout, rising from less than 5 ft. at the northern end of the section to 30-40 ft. at the southern end. Most of the section has a 10-15 ft. bluff with a poorly vegetated, nearly vertical face. The bluff is composed of clay overlying clay-sand overlying sand and gravel, and fails by shallow sliding or rill-wash. Most of the beach is 10-15 ft. wide and composed of boulders and cobbles with a coarse sand matrix. At the southern end of the section it narrows to a maximum of 5 ft. and is occasionally interrupted by slide debris.

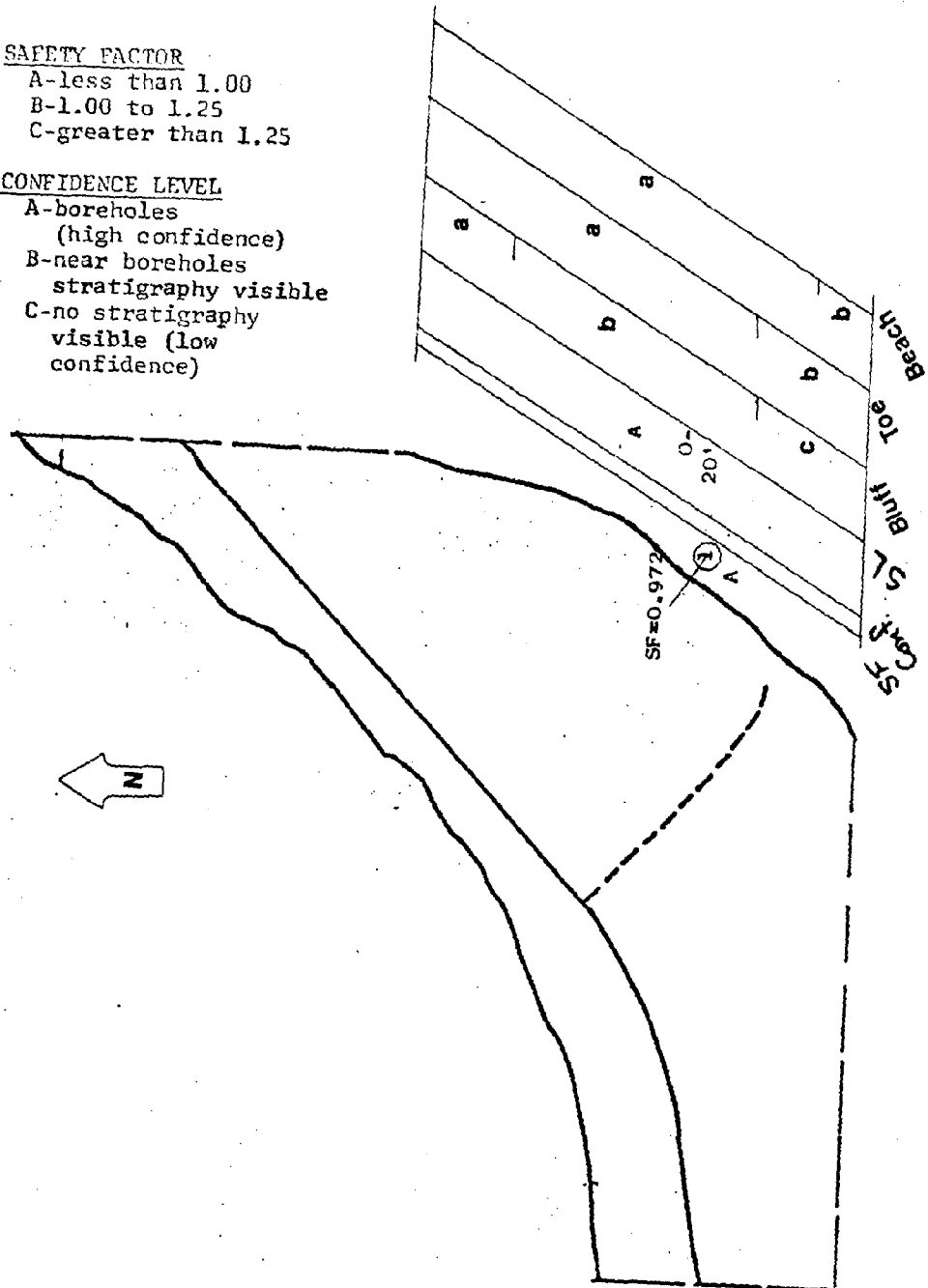
SEC 26 T51N R7W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low confidence)



Section 26/23, T 51 N, R 7 W southeast-facing shoreline

Bluff:

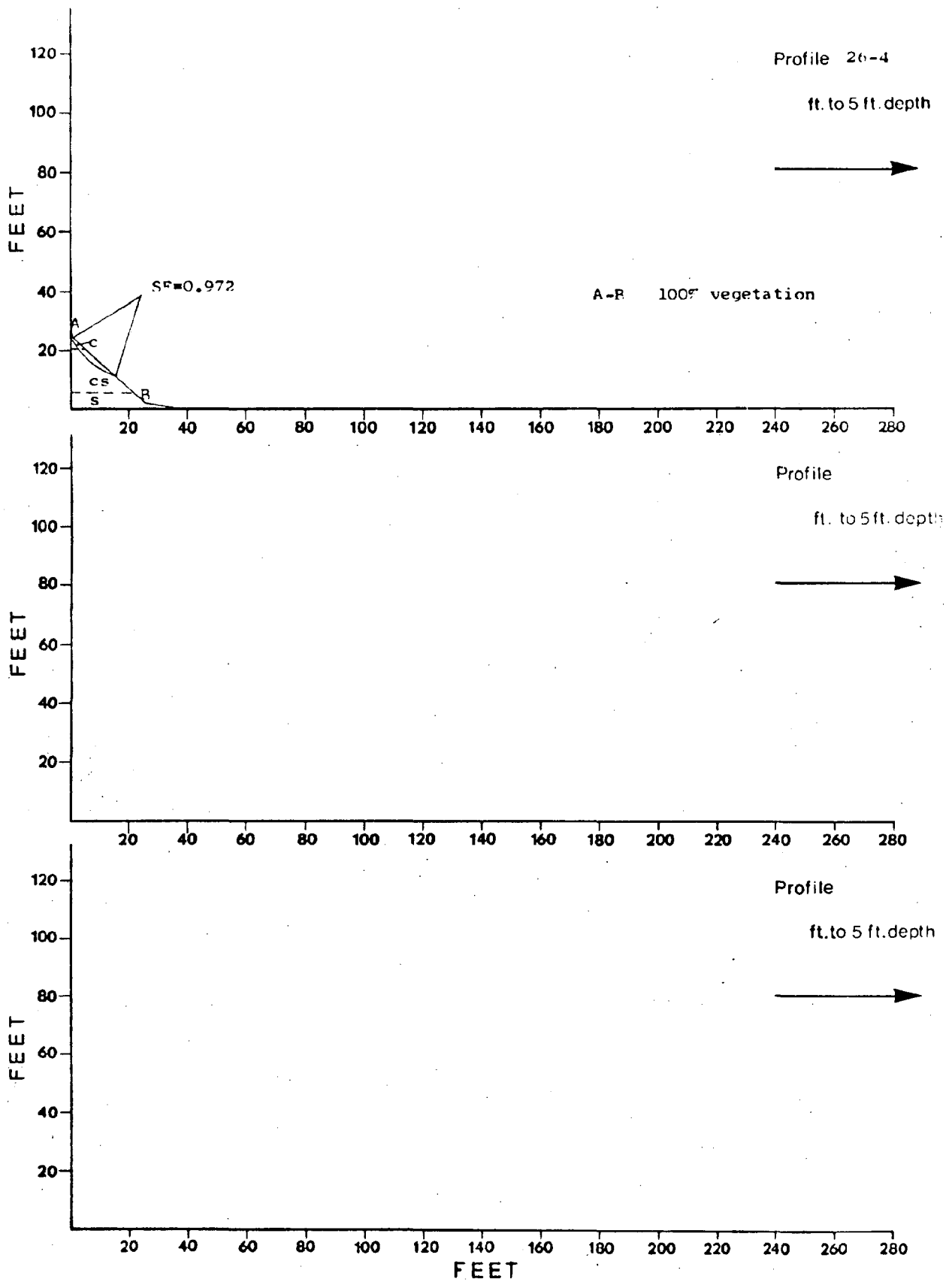
- a) \leq 5 ft; mostly well-graded and vegetated (100%) with poplar and birch and cedar; clayey sand
- b) 10-15 ft rising to 25-30 ft southwest-ward; clay over clayey sand; shallow sliding and rilling; 0-10% large trees fallen over
- c) 30-40 ft; clay over sand over clayey sand: occasional shallow slides associated with seeps; vegetated mostly 100% birch, cedar, poplar, fir: 0% on failures

Toe:

- a) protected clayey sand
- b) slumped clayey sand or sand

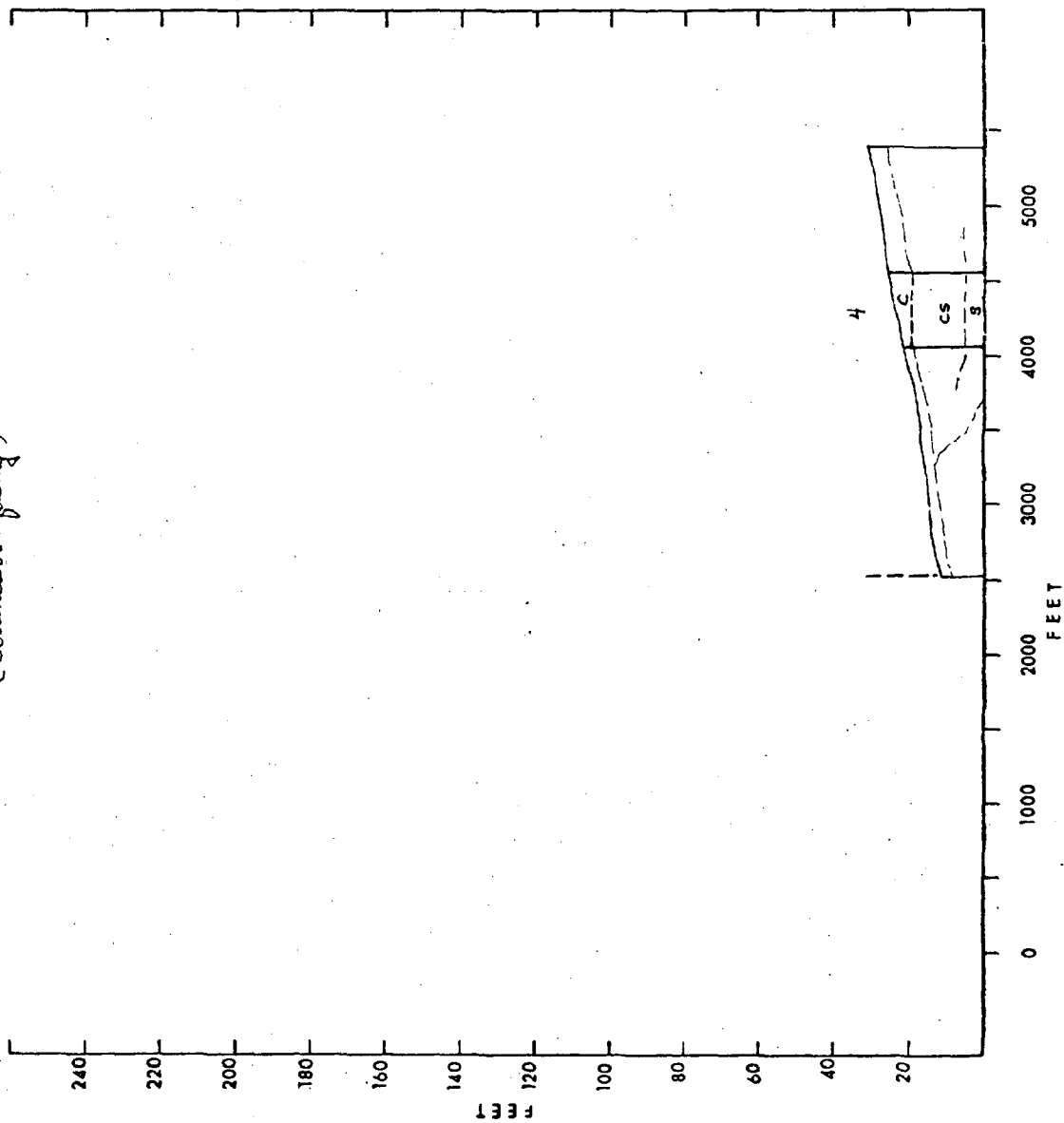
Beach:

- a) 10-15 ft; cobbles with boulder and occasional coarse sand matrix
- b) 0-5 ft; cobbles; interrupted by blocks from failures



T. 57 N., R. 7 W., Sec. 26

(Southeast-facing)



Section 35/36, T51N, R7W

The section is located at the eastern side of the base of Bark Point and the southern end of Bark Bay. There is a 30-40 ft. bluff, composed of clay overlying clayey sand, present for a short distance from the northern end of the section. The bluff is well-vegetated with birch, poplar and cedar, but some shallow-slide failures do occur. The bluff height drops rather rapidly to nothing and is replaced by a beach ridge (backed by a lagoon and marsh) that comprises 80% of the section shoreline. Where the bluff is present there is a 5-10 ft. wide cobble beach. Elsewhere the beach is 20-30 ft. wide and is composed of medium sand. There are a number of small, summer cottages along the beach ridge but there is no access to this area by road.

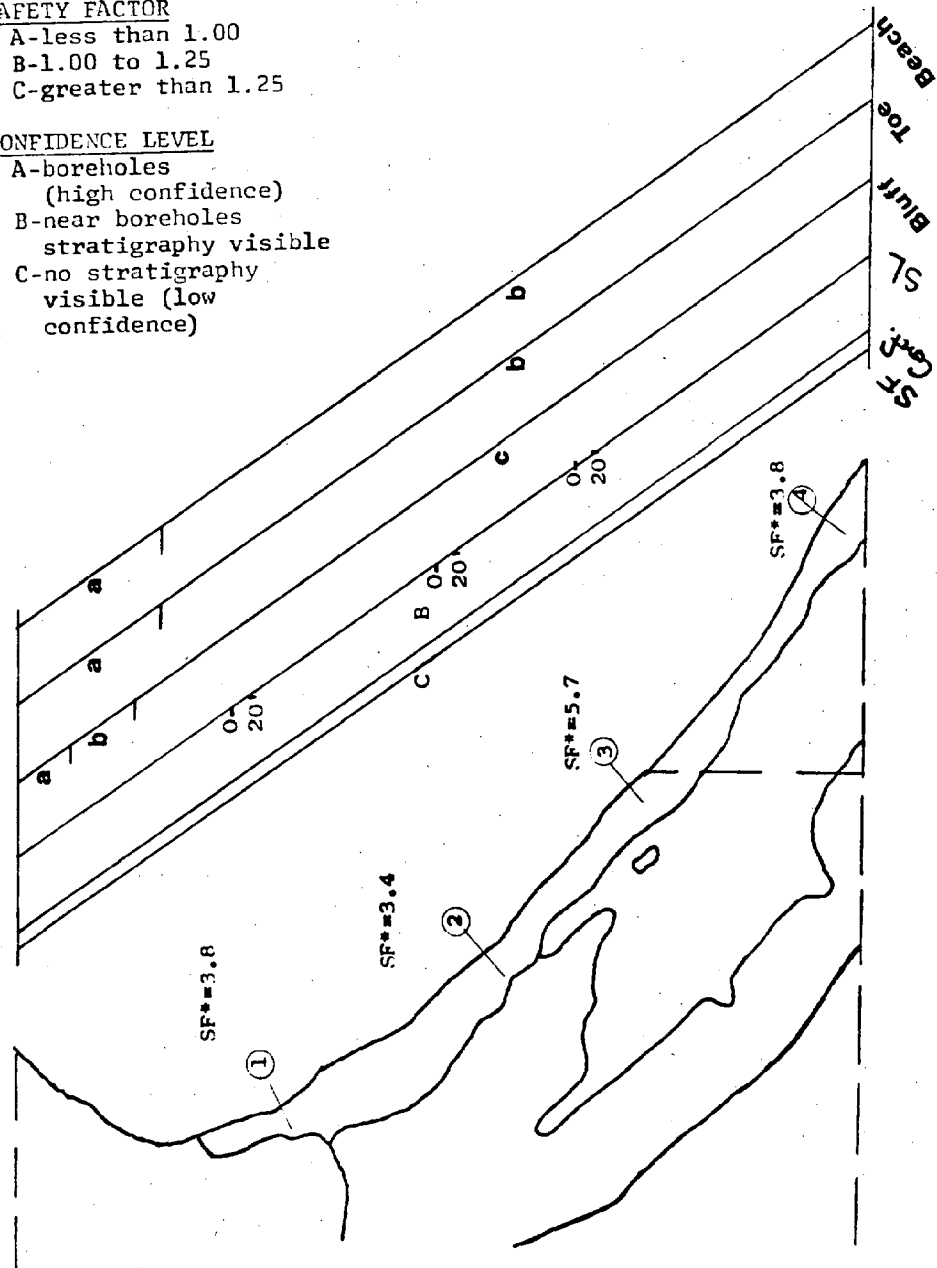
SEC 35/36 T. 51N R7W

SAFETY FACTOR

- A-less than 1.00
B-1.00 to 1.25
C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
B-near boreholes
stratigraphy visible
C-no stratigraphy
visible (low
confidence)



Sec. 35/36, T 51 N, R 7 W

Bluff:

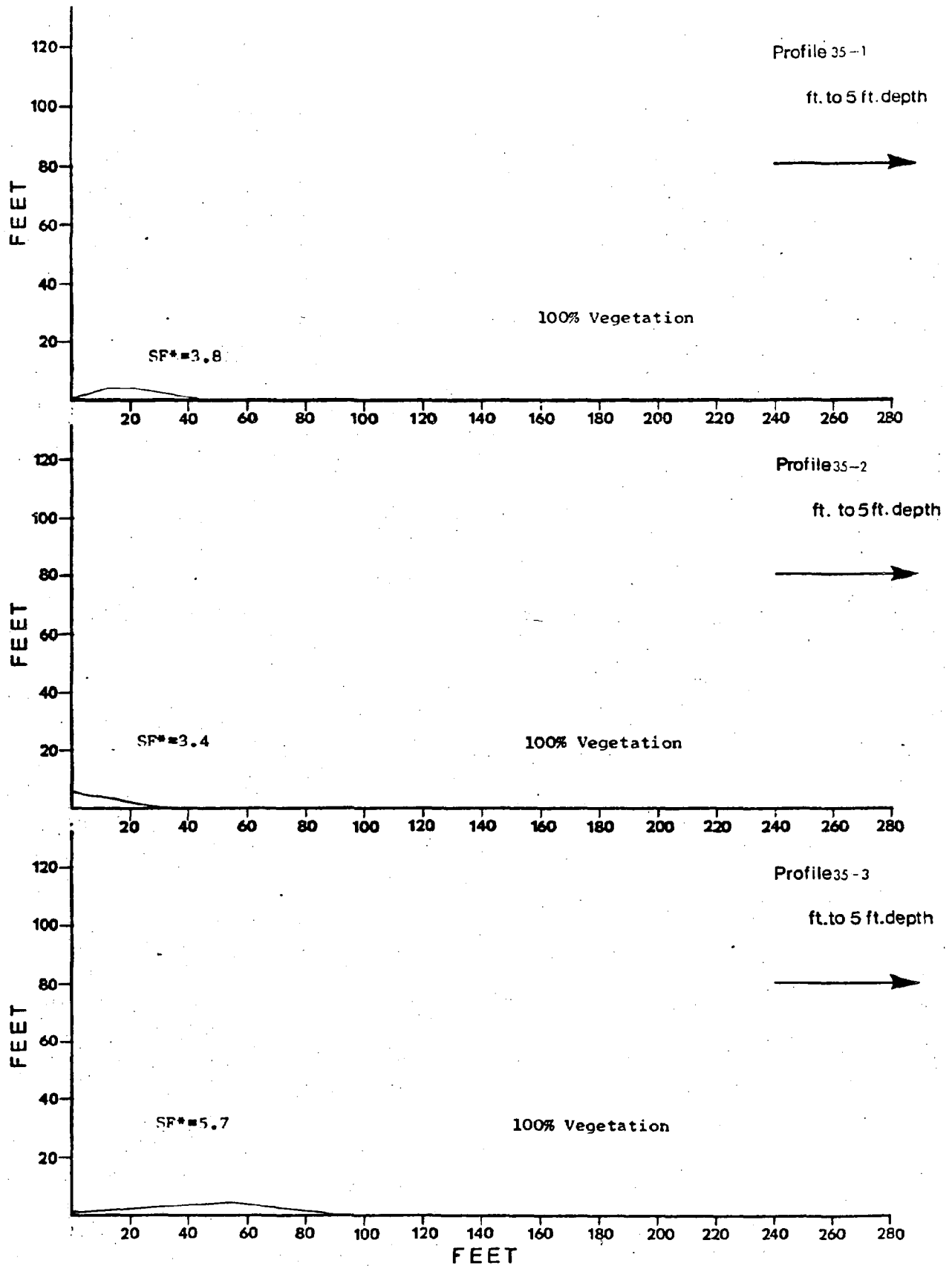
- a) 30-40 ft.; clay, sand, clayey sand; occasional shallow sliding; mostly 100% vegetated birch, poplar, cedar
- b) falling to 0 ft; no failures; 100% vegetated
- c) absent; beach ridge

Toe:

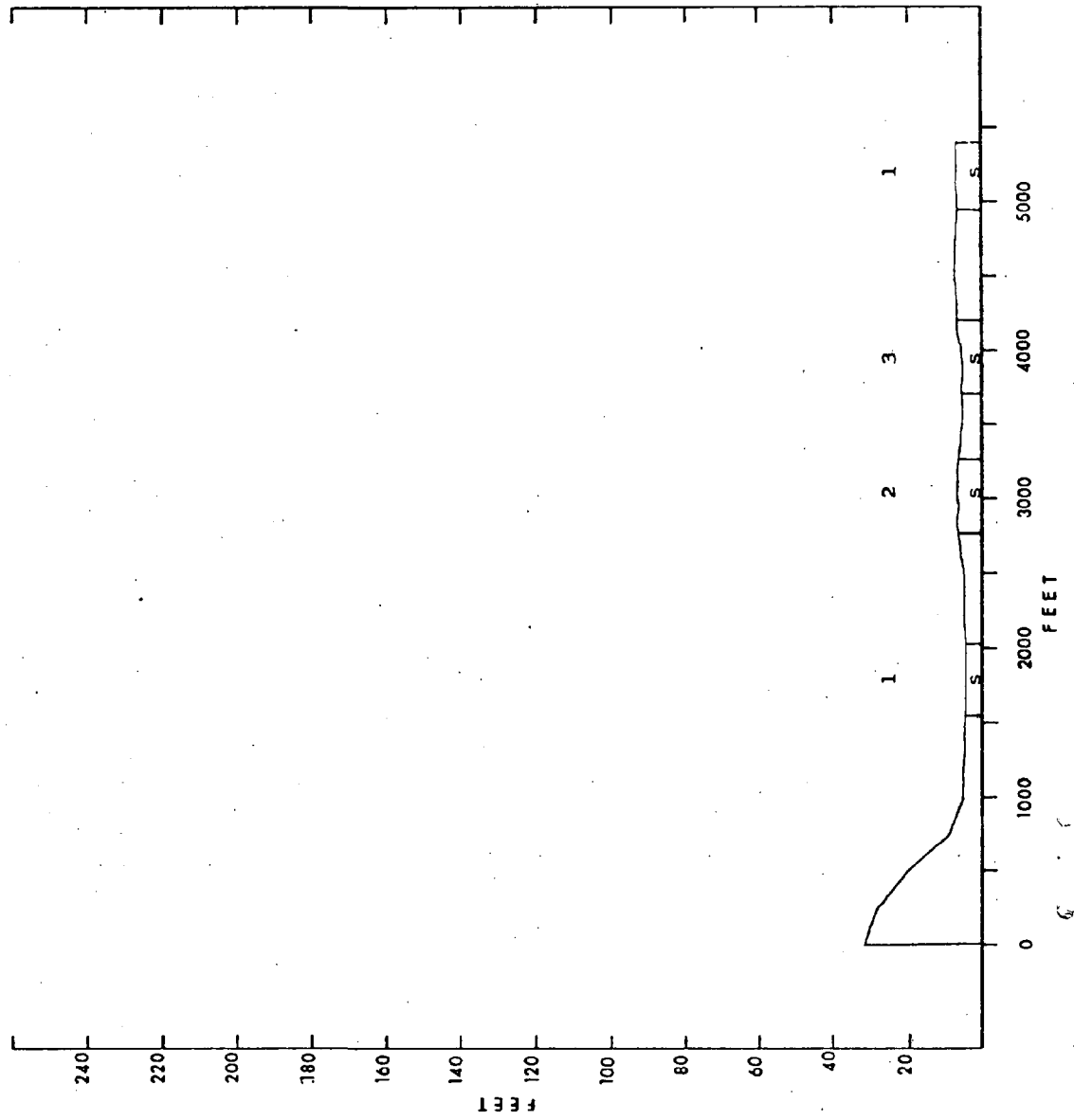
- a) vegetated, birch, poplar, cedar
- b) absent; beach ridge

Beach:

- a) 5-10 ft; cobbles with sand matrix
- b) 20-30 ft; medium sand



T. 51 N., R. 7 W., Sec. 35/36



Section 1, T50N, R7W

The section is located at the southern end of Bark Bay. The mouth of the Bark River is at the eastern end of the section. A moderately well-vegetated beach ridge, backed by a marsh and lagoon, extends throughout the section. The beach itself is 20-30 ft. wide and is composed of medium sand. There are a number of small summer cottages along the beach ridge, but there is no access by road to this area.

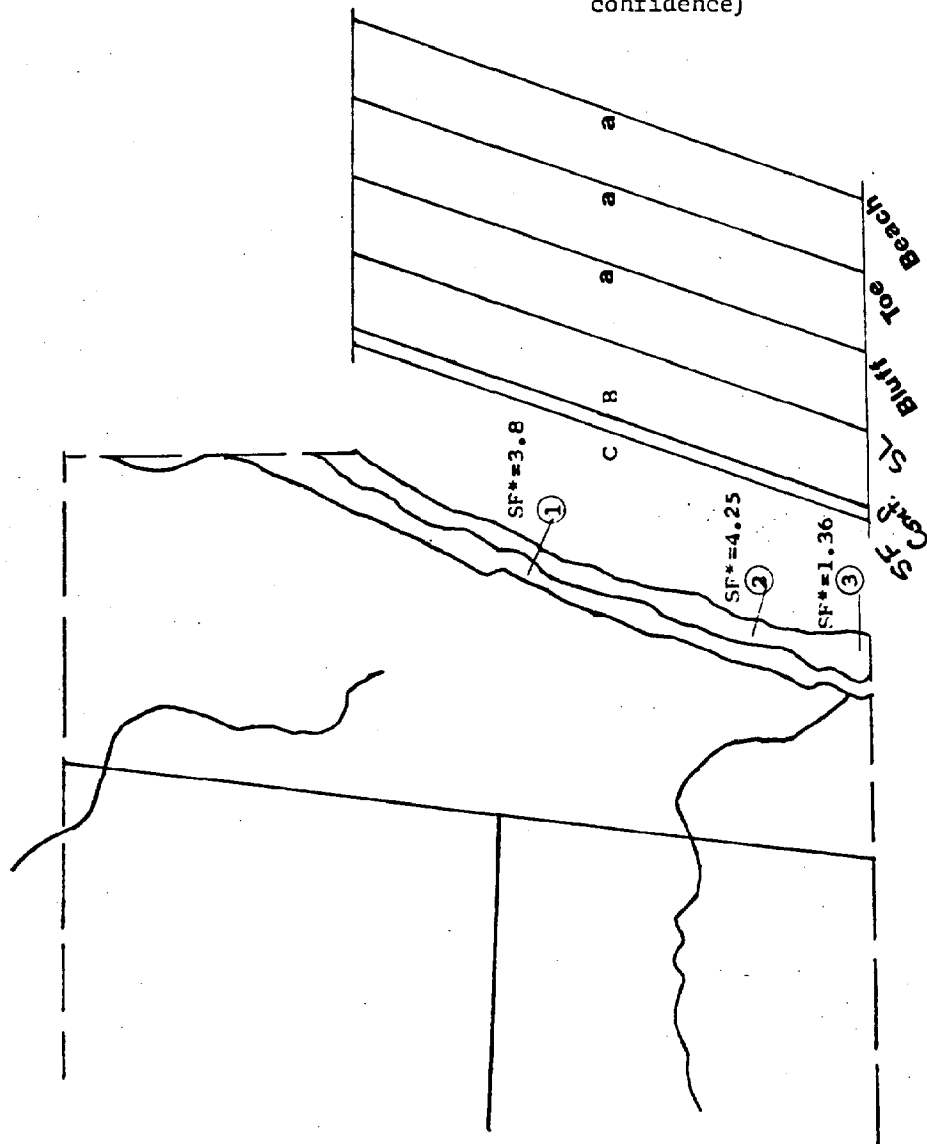
SEC1 T50N R7W

SAFETY FACTOR

- A-less than 1.00
- B-1.00 to 1.25
- C-greater than 1.25

CONFIDENCE LEVEL

- A-boreholes
(high confidence)
- B-near boreholes
stratigraphy visible
- C-no stratigraphy
visible (low
confidence)



Sec. 1, T 50 N, R 7 W

Bluff:

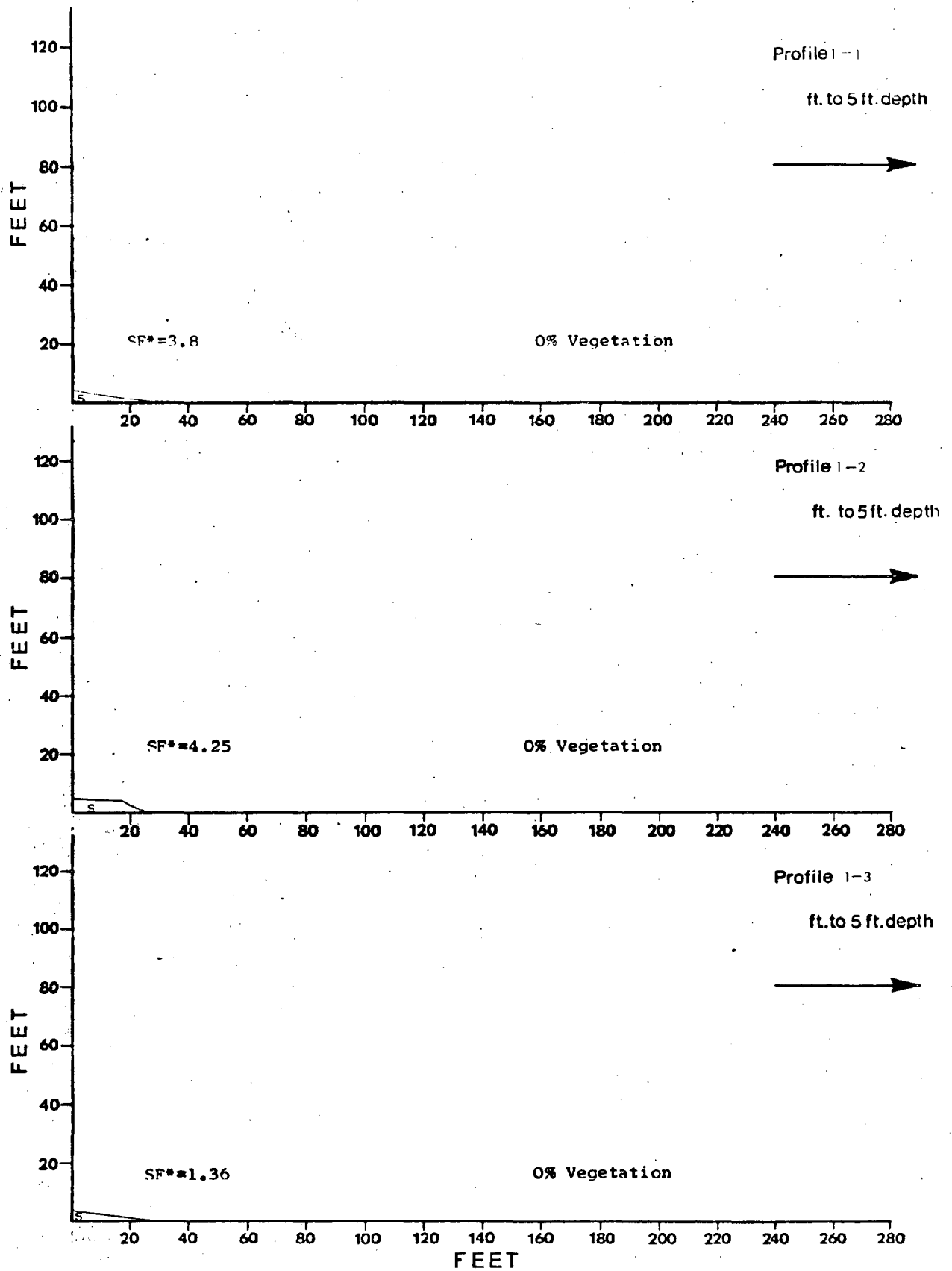
- a) absent; beach ridge; 50-100% vegetated; maple, fir, pine, cedar, birch, poplar, shrubs and gasses and horsetails

Toe:

- a) absent; beach ridge

Beach:

- a) 20-30 ft; medium sand; some horsetails on backbeach



T. 50 N., R. 7 W., Sec. 1

