P. MACHIBRODA ENGINEERING LTD.

GEOLOGY OF THE FORESTRY FARM TRUNK SEWERS LINE, SASKATOON

Report 0047-002   August 25, 1980

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

October 3, 1980

P. Machibroda Engineering Ltd.
2331 Millar Avenue
Saskatoon, Sask.

Attention: Mr. Paul Machibroda

Dear Mr. Machibroda:

I plan to continue my research of the geology of the Saskatoon area with the anticipation of writing scientific papers on the subject. During this study, I will be involved with members of the University of Saskatchewan and the Saskatchewan Research Council who plan to conduct geophysical and analytical analyses on the tills and stratified deposits.

I request permission to add the logs obtained during my recent study for your firm on the "Geology of the Forestry Farm Trunk Sewers Line, Saskatoon" to my data bank. Permission is also requested to use this information in future research and consulting, to give copies of the testhole information to my collegues, and to conduct laboratory analyses on the samples obtained during this study.

Your firm would be acknowledged in any paper written on the subject, and you would receive a copy of the material published.

Sincerely yours,

E.A. Christiansen

E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087
SASKATOON, SASKATCHEWAN, CANADA
S7K 3S9

PHONE 374-6700

August 25, 1980

P. Machibroda Engineering Ltd.
2331 Millar Avenue
Saskatoon, Saskatchewan

Attention: Mr. Paul Machibroda

Dear Mr. Machibroda:

Enclosed are eight copies of Report 0047-002 on the "Geology of the Forestry Farm Trunk Sewers Line".

Sincerely yours,

E.A. Christiansen

SUMMARY

The Forestry Farm Trunk Sewers trench will be excavated in the following deposits:

(1) surficial Sand and Silt on the upland near the South Saskatchewan River,

(2) slickensided and fractured clay and silt in the Lacustrine Clay, Silt, and Sand unit,

(3) soft Ablation Silt and till of the Battleford Formation,

(4) boulder pavement at the base of the Battleford Formation,

(5) dry and wet Intertill Sand between tills of the Battleford and Floral Formations,

(6) hard, jointed and unjointed, silty Upper Till of the Floral Formation,

(7) possibly in silt and sand in the upper part of the Sutherland Valley fill,

(8) dry and wet sand in the Forestry Farm Aquifer,

(9) unjointed Middle Till of the Floral Formation,

(10) jointed, clayey till of Unit 3 of the Sutherland Group, and

(11) jointed and unjointed, sandy till of Unit 2 of the Sutherland Group.

RESPONSIBILITY

In site investigations where both geologists and geotechnical engineers are involved, it is understood that the geologist is responsible for defining the geologic units and processes, whereas the geotechnical engineer is responsible for determining the engineering properties and defining the dimensions of the earth materials to the scale relevant to the engineering analyses required for the intended use.

LIMITATION

The geologic logs are believed to represent the geology at the specific sites at the time studied. Except at the borehole sites where geologic logs are available, the geologic contacts are inferred and represent either straight lines to guide the eye from one log to another or models that are believed to best fit the information available.

TABLE OF CONTENTS

Text | Page

Text

Illustrations

Appendices

1. INTRODUCTION

1.1 Terms of Reference and Objective

On May 7, 1980, E.A. Christiansen Consulting Ltd. was commissioned by P. Machibroda Engineering Ltd. to provide a geologic section along the proposed Forestry Farm Trunk Sewers Line from the South Saskatchewan River to the Forestry Farm. On June 10, 1980, it was decided to extend this investigation to the vicinity of the Highway 5 overpass east of Sutherland.

1.2 Location

The location of the geologic section along the proposed Forestry Farm Trunk Sewers Line, the Sutherland Valley, and information pertinent to this valley and long section are shown in Drawing 0047-002-01.

1.3 Previous Work

The geology and groundwater resources of the study-area were dealt with regionally by Christiansen (1967a) and in greater detail by Christiansen (1970) and Meneley (1970). Papers on collapse structures (Christiansen, 1967b), Pleistocene stratigraphy (Christiansen, 1968a,b), and the history of deglaciation (Christiansen, 1979) are the bases for the discussions of these subjects.

A geologic study of the Meewasin Bridge site and the Forestry Farm area for the City of Saskatoon through Clifton Associates Ltd. (E.A. Christiansen Consulting Ltd., 1979, 1980) provided the framework for the present study.

1.4 Present Study

This study is based on information from the Saskatchewan Research Council, Clifton Associates Ltd., P. Machibroda Engineering Ltd., and from 7 testholes drilled, sampled, and electric logged for the purpose of this investigation. Samples were obtained by a Williams MF power auger at 1 to 2 m intervals and by a Failing 1500 rotary drilling rig (Fig. 1) at 5 - foot intervals.

Samples from 6 augerholes (Boreholes 2,3,4,8,16,20; Drawings 0047-002-01, 02) were logged by E.A. Christiansen Consulting Ltd. (Appendix 1). The augerhole log at Borehole site 11 was provided by P. Machibroda Engineering Ltd. and was used to more precisely define the base of the Upper Till of the Floral Formation (Drawing 0047-002-02). The remainder of the augerhole logs will appear in the P. Machibroda Engineering Ltd. geotechnical report and are shown in Drawing 0047-002-01 and 02 to facilitate the comparision of the geologic and geotechnical interpretations.

The testhole samples were collected by the driller (Fig. 1B) and placed in sample pans (Fig. 2A). From these pans, samples were selected, washed, and placed in muffin tins for drying (Fig. 2B). The oven-dried, augerhole samples (Boreholes 2,3,4,8,16,20; Drawings 0047-002-01,02) and the testhole samples were described by E.A. Christiansen with the aid of hydrochloric acid to test for carbonates, a Munsell Color Chart, and a hand lens. Based on these geological descriptions and field logs, the augerhole logs were compiled (Appendix 1), and on the bases of geologic logs, driller's logs, and electric logs, the testhole logs were compiled (Appendix 1). Tills from 4 testholes (Boreholes 1,22,23,29; Drawings 0047-002-01,02) were submitted for total carbonate analyses to differentiate these tills.

A

B

Figure 1. Test drilling program:
(A) test drilling equipment at Borehole No.1 and
(B) driller examining cutting samples taken from drilling fluid.

A

B

Figure 2. Cutting samples: (A) cutting samples in pan and muffin tin and (B) cutting samples in muffin tin (see 25-cent piece for scale).

2. GEOLOGY

2.1 Introduction

The bedrock and glacial deposits along the Forestry Farm Trunk Sewers Line include the Bearpaw Formation and Empress, Sutherland, and Saskatoon Groups.

2.2 Bearpaw Formation

The Bearpaw Formation is the bedrock below the Forestry Farm Trunk Sewers Line and is composed of 80 m of gray, noncalcareous, marine clay and silt which becomes sandy toward the upper part of the Formation (Borehole 14, Appendix 1).

2.3 Empress Group

The Empress Group, which was named by Whitaker and Christiansen (1972), is composed of 0-7 m of interbedded sand and till in the vicinity of the South Saskatchewan River (Borehole 1, Drawing 0047-002-02). This deposit is believed to be a bedrock valley fill.

2.4 Sutherland Group

2.4.1 Introduction

The Sutherland Group, which was named by Christiansen (1968a), is composed of 3 tills: Unit 1,2, and 3. This study has established the top of this Group as the base of exploration for future geologic investigations along the Forestry Farm Trunk Sewers Line.

2.4.2 Unit 1

Unit 1 is composed of 30 to 35 m of gray to dark gray, slightly calcareous till. In Borehole 25, the lower 11 m of this unit is composed of interbedded gray, noncalcareous sand, silt and clay which is interpreted as disturbed bedrock.

2.4.3 Unit 2

Unit 2 is composed of 0 to 50 m of gray, calcareous, sandy, bouldery till which is olive in color where oxidized in the upper part of the unit. Unit 2 is missing at Borehole 25 where it has been removed by the erosion which formed the Sutherland Valley.

2.4.4 Unit 3

Unit 3 is composed of 0 to 13 m of olive gray and gray, mottled, gypsiferous, slightly calcareous, clayey till. The Unit is almost entirely oxidized and jointed presumably because of desiccation. The oxidation in the upper part of Unit 2 is interpreted as oxidation which has taken place downward from the original top of Unit 3 rather than representing a separate interval of weathering.

2.5 Saskatoon Group

2.5.1 Introduction

The Saskatoon Group, which was named by Christiansen (1968a), includes the Floral and Battleford Formations and the Surficial Stratified Drift.

2.5.2 Floral Formation

The Floral Formation, which was named by Christiansen (1968a), includes the Middle Till, Forestry Farm Aquifer, Sutherland Valley Fill, Upper Till, and Intertill Sand.

The Middle Till is composed of 1 m of gray, calcareous till (Borehole 23, Drawing 0047-002-02, Appendix 1). The Lower Till and the Lower Sand of the Forestry Farm Aquifer, which are present north of the Forestry Farm (E.A. Christiansen Consulting Ltd., 1980), are not present along the Forestry Farm Trunk Sewers Line.

The Forestry Farm Aquifer, which is the Upper Sand of the Aquifer north of Sutherland, was encountered only in Borehole 23 (Drawing 0047-002-02). The Aquifer is composed of 8 m of sand which grades from fine grained in the upper part of the unit to very coarse-grained sand with a basal pebble zone in the lower part of the unit. This sand is considered to be interglacial in origin (SkwaraWoolf, 1980).

The Sutherland Valley Fill is composed of 0 to 20 m of gray, calcareous clay, silt, sand,and gravel becoming coarser grained with depth. The lower contact is distinct, whereas the upper contact is gradational with the overlying Upper Till. The gravelly nature of the lower fill suggests a fluvial rather than glacial erosion origin for the Sutherland Valley. Fluvial valleys commonly have lag concentrates of coarser material in their bottoms derived from the erosion of till, whereas glacially eroded depressions commonly have till on the glacially eroded surface. The progressive increase in particle size of the fill with depth suggests the Sutherland Valley Fill was derived from a retreating glacier.

The Upper Till is composed of 0 to 23 m of gray, calcareous, silty till, the upper part of which is oxidized and jointed with iron oxide coatings on the surfaces of the joints. The fact that the lower contact is gradational with the underlying silt-fill in the Sutherland Valley suggests part of this fill was eroded by the glacier and incorporated into the Upper Till.

The Intertill Sand is composed of 0 to 1 m of sand which lies in an intertill position between Floral and Battleford Formations. The sand occurs in Boreholes 8 and 16 (Appendix 1) but is too thin to be shown in Borehole 8 (Drawing 0047-002-02). Because of the intertill nature of this thin sand, it has the potential of being widespread in the Forestry Farm area but probably in a discontinuous pattern.

2.5.3 Battleford Formation

The Battleford Formation is composed of 0 to 6 m of gray, calcareous, sandy, soft, unjointed, and unstained till. The upper part is oxidized to a light-brownish gray and grayish brown color. The lower contact is marked by a boulder pavement whose boulders were flattened and striated by glacial erosion (Fig. 3).

2.6 Surficial Stratified Drift

2.6.1 Introduction

The Surficial Stratified Drift includes the Ablation Silt; Lacustrine Clay, Silt, and Sand; and the Sand and Silt units.

2.6.2 Ablation Silt

The Ablation Silt occurs at the base of the Surficial Stratified Drift directly on the Battleford Formation. It is composed of 0 to 1 m of light-brownish gray, strongly calcareous, soft, laminated, jointed silt. The gradational nature of this unit with the underlying soft sandy till of the Battleford Formation and its distinct contact with the overlying Lacustrine Clay suggests this silt is ablation material produced by the melting glacier rather than being brought into glacial Lake Saskatchewan by the North and South Saskatchewan Rivers (Fig. 4). Because the Ablation Silt is not mappable at the scale used in Drawing 0047-002-02, it has been included in the Lacustrine Clay, Silt, and Sand unit. The Ablation Silt, however, is shown in Appendix 1 (Boreholes 16,20,23,29,30).

Figure 3. Boulder pavement between Floral and Battleford Formations north of Tisdale, Saskatchewan. This pavement was exhumed by water erosion in a ditch along Highway 35. Notice flat-topped, striated in-situ boulders formed by glacial deposition and erosion.

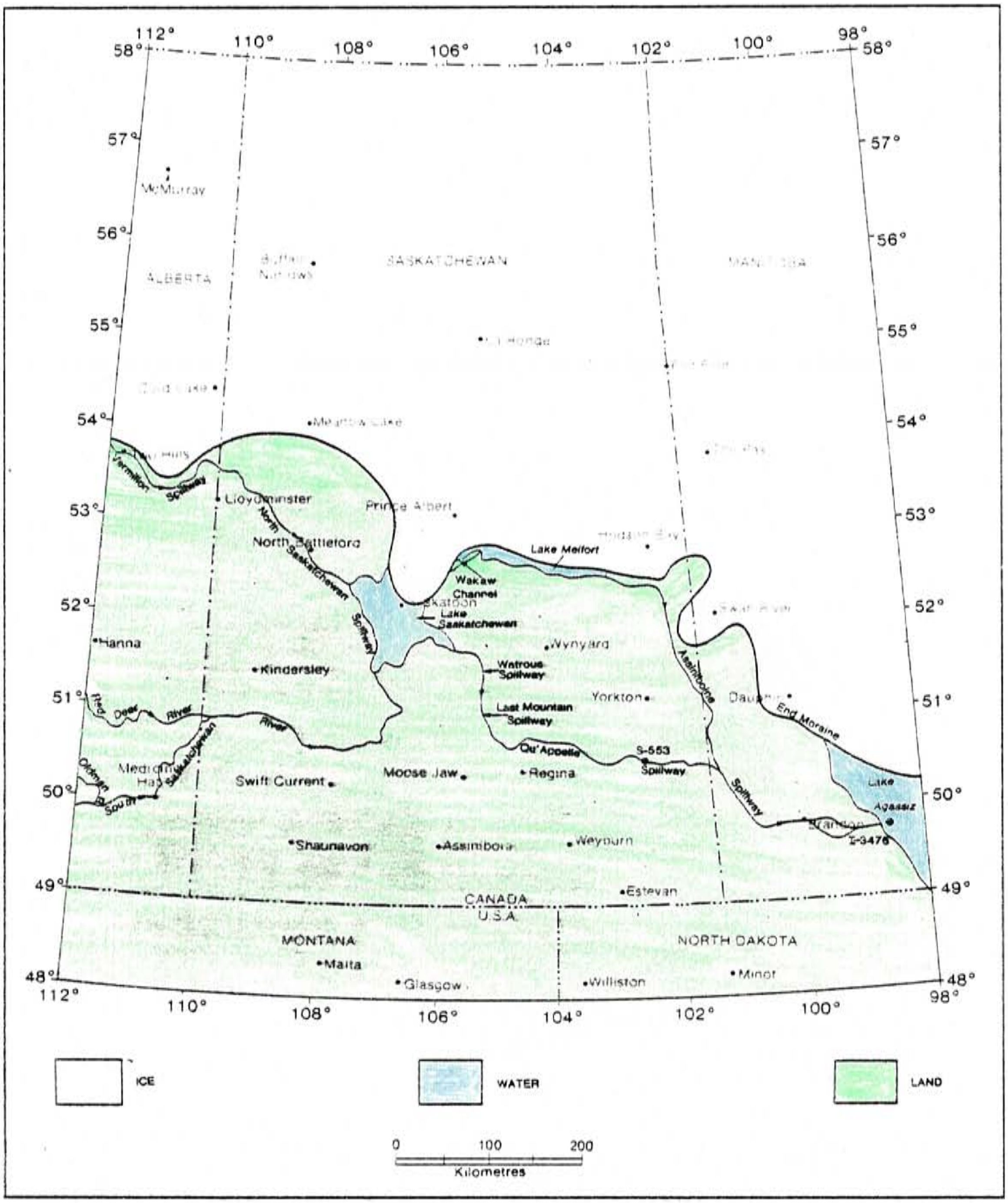


Figure 4. Phase 6 of the history of deglaciation of southern Saskatchewan and adjacent areas about 12,000 years ago. From Christiansen (1979).

2.6.3 Lacustrine Clay, Silt, and Sand

The Lacustrine Clay, Silt, and Sand is composed of 0 to 10 m of gray, grayish brown, and olive gray, calcareous, locally gypsiferous, interbedded, clay, silt, and very fine-to fine-grained sand. Boreholes 22,24,27,29 (Drawing 0047-002-02) show a lower silt and clay layer, a middle silt and sand layer, and an upper silt and clay layer. These deposits were laid down in glacial Lake Saskatchewan by the North and South Saskatchewan Rivers. (Fig. 4).

As the lake level fell during the retreat of the glacier, the shoreline of Lake Saskatchewan moved northward and coarser-grained sands and silts were laid down on the previously deposited finer-grained clays and silts by the process of regressive offlap (Christiansen, 1979). As the glacier re-advanced to the position shown in Figure 4, the shoreline moved southward and silts and clay were laid down on the previously deposited sands and silts by the process of transgressive onlap.

As the glacial ice melted, the Ablation Silt; Lacustrine clay, silt, and sand; and ablation till of the Battleford Formation were let down on the lodgement till of this Formation or on the Floral Formation. During this collapse,the Lacustrine Clay, Silt, and Sand unit was slickensided and fractured (Fig. 5).

2.6.4 Sand and Silt

The Sand and Silt unit is composed of 0 to 7 m of light-brownish gray and grayish brown, calcareous, sand and silt with pebble layers (Boreholes 1,2,3,4,8; Drawing 0047-002-02; Appendix 1). These sediments are interpreted as deltaic deposits laid down on previously cut terraces along the South Saskatchewan River when the glacier re-advanced to the position shown in Figure 4. Locally, very fine-grained silty

A

B

Figure 5. Deformed lacustrine silt and clay. (A) Slickensided and (B) fractured lacustrine silt and clay in a sewer trench near the stockyards in Saskatoon formed by collapse when the underlying stagnant, glacial ice melted.

sand is part of the Sand and Silt unit. This massive, silty sand is of wind-blown origin (Christiansen, 1970) and is believed to be the origin of the surface sand at Borehole 1.

3. GEOLOGIC PROCESSES

3.1 Introduction

Collapse caused by the dissolution of salt and the melting of glacial ice, glacial and fluvial erosion, and regressive offlap and transgressive onlap are the main processes that have been operative during and since deposition of the bedrock and glacial deposits along the Forestry Farm Trunk Sewers Line. Collapse caused by the dissolution of salt and glacial and fluvial erosion will be discussed in more detail, whereas the other two processes are discussed in sufficient detail under the heading "Lacustrine Clay, Silt, and Sand".

3.2 Collapse Caused by Dissolution of Salt

According to Christiansen (1967b), the bedrock along the Forestry Farm Trunk Sewers Line has collapsed more than 100 m as a result of the dissolution of Devonian salt. Recent, unpublished information suggests the last collpase may have taken place in the Forestry Farm area immediately before or during the deposition of Unit 1 of the Sutherland Group which is restricted to the collapsed area.

Although the bedrock in the vicinity of Saskatoon has collapsed more than 100 m, disturbed sediments were not encountered. Test drilling during the last 10 years in collapsed areas of Saskatchewan has revealed few if any disturbed sediments. It is concluded, therefore, that collapse has had little effect on the sediments of the Forestry Farm area. Because the Forestry Farm Trunk Sewers Line overlies an area of little or no Devonian salt, future collapses are much less likely here than in adjacent areas which are underlain by more than 100 m of salt.

3.3 Glacial Erosion

Glaciers erode, transport, and deposit earth materials. Missing beds attest to glacial erosion, and tills record deposition of glacial material. Glacial erosion occurs near the margin of glaciers where bedrock and glacial deposits are eroded from the ice-thrust depressions and are carried upward in the glacier along diverging flowlines (Fig. 6). Christiansen and Whitaker showed the depression east of Tyner, Saskatchewan (Fig. 7) is and ice-thrust depression formed by glacial erosion.

Glacial erosion is used to explain the origin of the upward facing concave surfaces which form the lower contact of till units in several localities along the Forestry Farm Trunk Sewers Line (Drawing 0047-002-02). The missing beds in the Sutherland Valley Fill and the gradational contact between this Fill and the overlying Upper Till of the Floral Formation between Boreholes 11 and 22 (Drawing 0047-002-02) also attest to glacial erosion prior to deposition of the Upper Till. Examination of Drawing 0047-002-02 shows glacial erosion was most active in the Sutherland Valley Fill where the lacustrine sediments were less resistive to erosion than the surrounding tills.

3.4 Fluvial Erosion

Between the deposition of the Forestry Farm Aquifer and the Upper Till of the Floral Formation, the Sutherland Valley was eroded through the Forestry Farm Aquifer, the Middle Till of the Floral Formation, and Unit 3 of the Sutherland Group into Unit 2 of this Group (Drawing 0047-002-02). The bottom of this valley is about 10 m lower in elavation than the South Saskatchewan Valley. The pattern of the Sutherland Valley (Drawing 0047-002-01) and the gravelly deposits on the valley

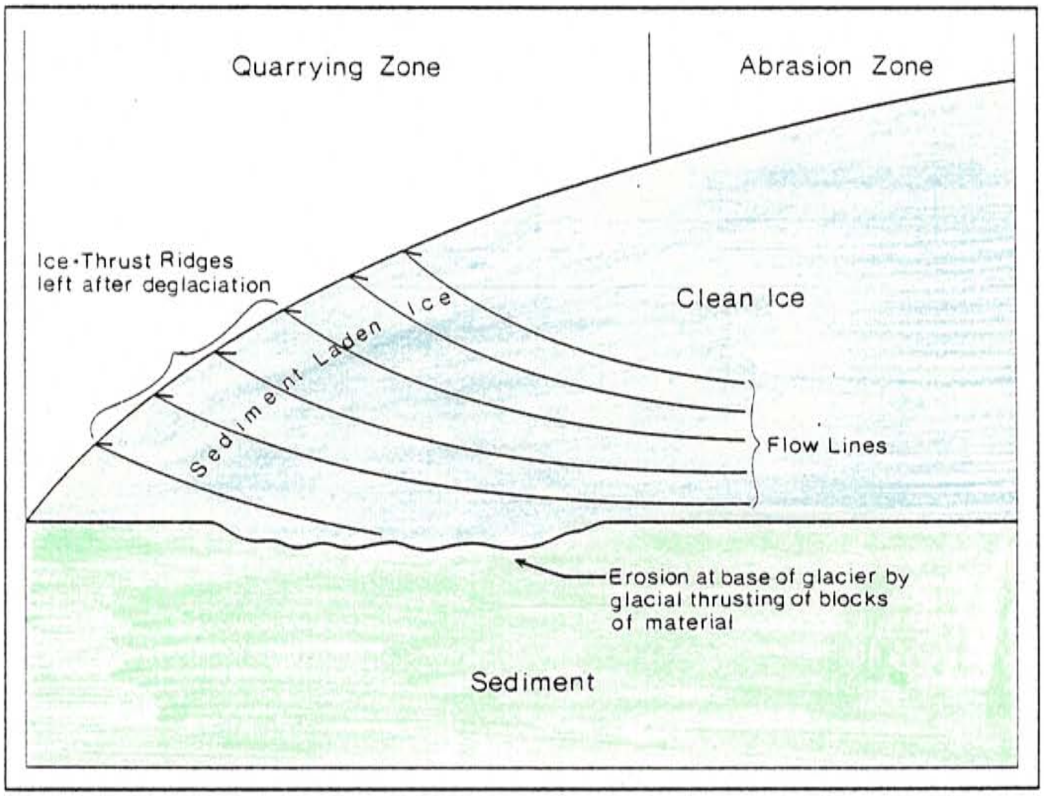


Figure 6. Schematic diagram showing the process of glacial erosion. From Christiansen and Whitaker (1976).

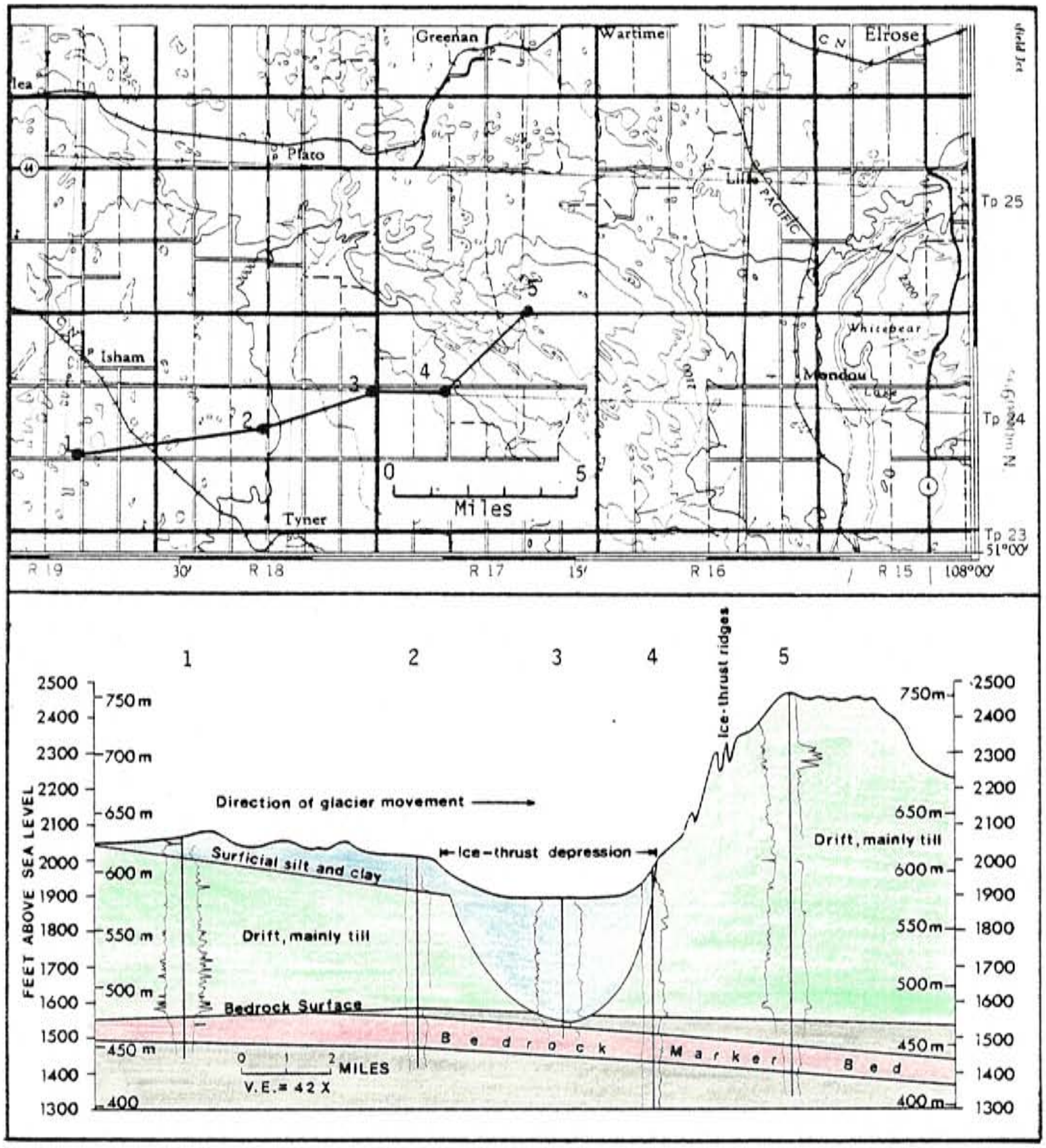


Figure 7. Omission of beds in an ice-thrust depression east of Tyner, Saskatchewan. From Christiansen and Whitaker (1976).

floor, which are similar to stony deposits on the floor of the South Saskatchewan River Valley, suggest the Sutherland Valley is a valley formed by fluvial erosion rather than an ice-thrust depression formed by glacial erosion.

During deglaciation, the South Saskatchewan River Valley and its terraces were formed. The valley was cut through the Saskatoon Group of sediments and Unit 3 into Unit 2 of the Sutherland Group (Drawing 0047-002-02).

4. GEOLOGIC HISTORY

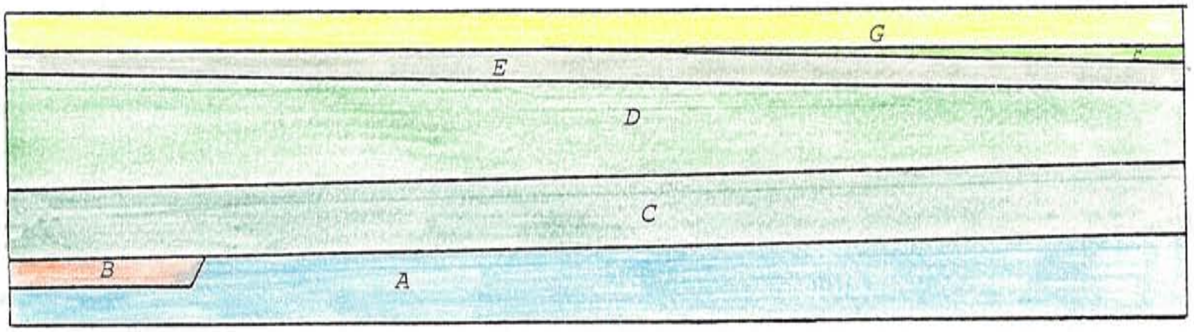
4.1 Introduction

The geologic history between Boreholes 1 and 23, Long Section AA' (Drawing 0047-002-02) is shown in 6 phases, in which the history is depicted in sketches (Fig. 8) based on this long section. The purpose of this history is to give a chronological explanation of the observations presented in the previous chapters and to check the stratigraphic interpretations shown in Long Section AA'.

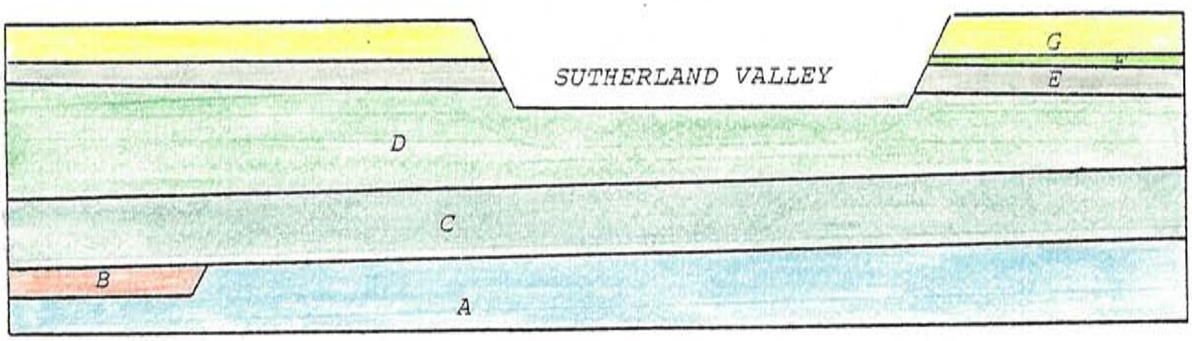
4.2 Phase 1

During Phase 1 (Fig. 8), a valley was cut into the Bearpaw Formation (A) and filled with interbedded sands and till of the Empress Group (B). This was followed by deposition of Units 1,2, and 3 of the Sutherland Group (C,D,E.) which were deposited either during different glaciations or during major retreats and re-advances of the same glacier as suggested by the major difference in lithology of these three tills.

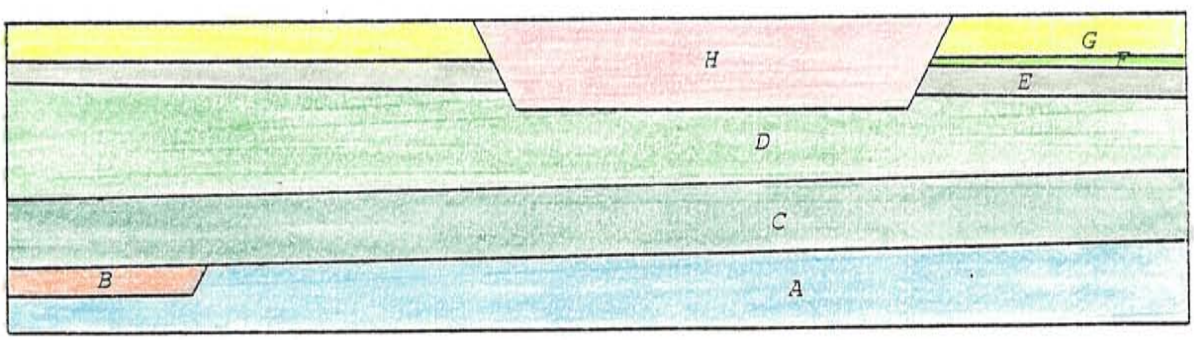
Between the deposition of Unit 3 (E) of the Sutherland Group and the Middle Till (F) of the Floral Formation, Unit 3 and the Upper part of Unit 2 of the Sutherland Group (E,D) were subjected to weathering



Phase 1. Deposition of Empress Group (B); Units 1,2, and 3 of the Sutherland Group (C,D,E); and the Middle Till and Forestry Farm Aquifer of the Floral Formation (F,G).



Phase 2. Fluvial erosion of the Sutherland Valley.

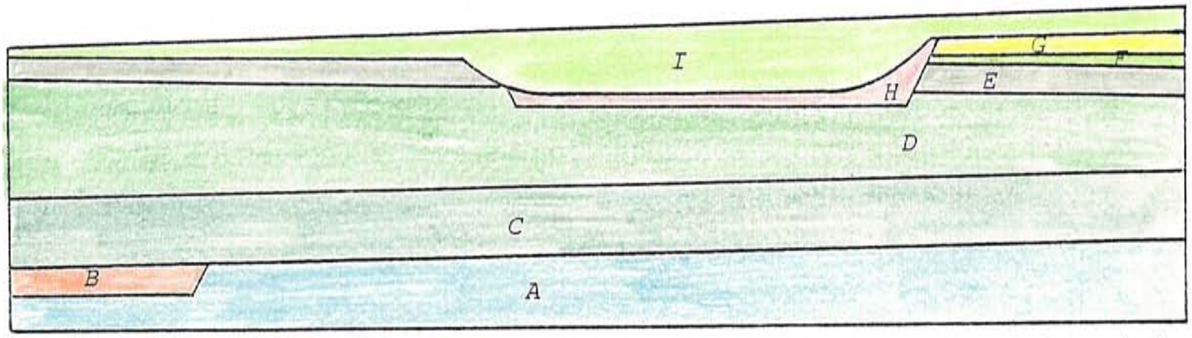


Phase 3. Deposition of the Sutherland Valley Fill (H).

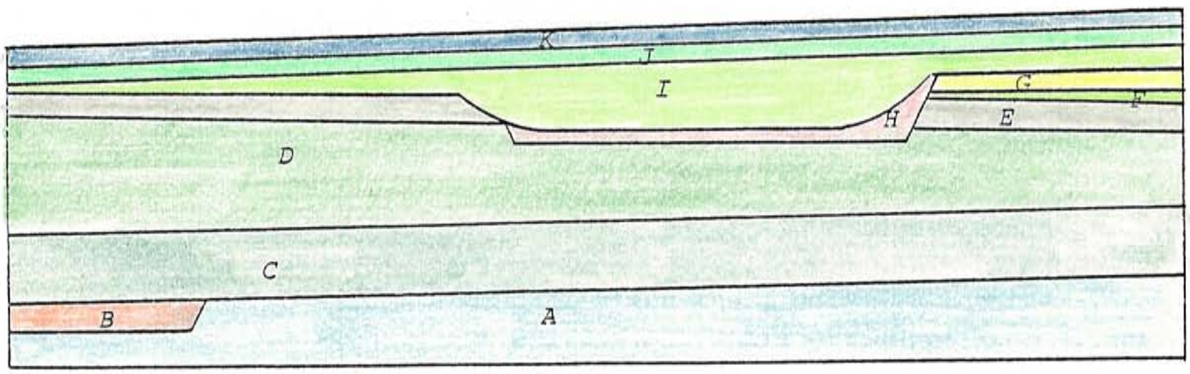
(A) Bearpaw Formation; (B) Empress Group; (C) Unit 1, (D) Unit 2, (E) Unit 3, Sutherland Group; (F) Middle Till, (G) Forestry Farm Aquifer, (H) Sutherland Valley Fill, Floral Formation.

Figure 8. Geologic history of the Forestry Farm Trunk Sewers Line.

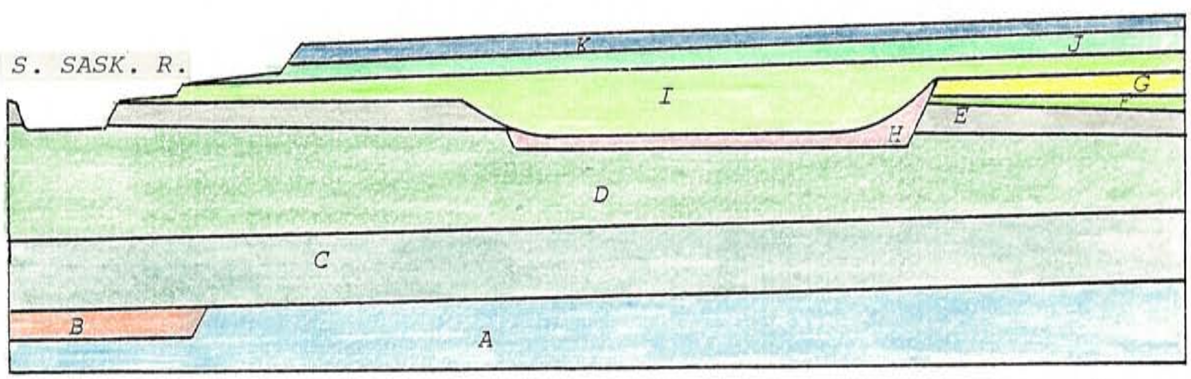
continued on next page



Phase 4. Glacial erosion of the Sutherland Valley Fill (H) and deposition of the Upper Till (I) and Intertill Sand (too thin to be shown) of the Floral Formation.



Phase 5. Glacial erosion of the Upper Till (I) of the Floral Formation and deposition of the Battleford Formation (J), Ablation Silt (too thin to be shown), and Lacustrine Clay, Silt, and Sand (K).



Phase 6. Fluvial erosion of the South Saskatchewan River Valley and deposition of Sand and Silt unit on valley terraces (too thin to be shown).

(A) Bearpaw Formation; (B) Empress Group; (C) Unit 1, (D) Unit 2, (E) Unit 3, Sutherland Group; (F) Middle Till, (G) Forestry Farm Aquifer, (H) Sutherland Valley Fill, (I) Upper Till, Floral Formation; (J) Battleford Formation; (K) Lacustrine Clay, Silt, and Sand.

during which the tills were jointed and oxidized. This weathering interval came to a close during the first of three glaciations during which the Floral Formation was deposited. The Lower Till of the Floral Formation was either not deposited along Long Section AA' (Drawing 0047-002-02) or was removed by glacial erosion prior to deposition of the Middle Till (F) of the Floral Formation. During the retreat of the glacier that deposited the Middle Till, sand and gravel (G) was deposited which was reworked during the interval between its deposition and the overlying Upper Till (I) of the Floral Formation to form a fossiliferous (SkwaraWoolf, 1980), recumbent folded (Hendry and Stauffer, 1975), interglacial deposit known as the Forestry Farm Aquifer (G).

4.3 Phase 2

During Phase 2 (Fig. 8), the Sutherland Valley was fluvially eroded through the Forestry Farm Aquifer and the Middle Till of the Floral Formation (G,F) and through Unit 3 into Unit 2 of the Sutherland Group (E,D). The gravel and very coarse-grained sand on the valley floor was left behind as a lag deposit derived from the erosion of sand and gravel (G) and till (F,E,D).

4.4 Phase 3

During Phase 3 (Fig. 8), the Sutherland Valley was filled with clay, silt, and sand (H) which becomes finer grained upward. This decrease in grain size and the black streaks in the silts (organic matter?) suggest the fill was initiated during the retreat of the glacier that deposited the Middle Till and continued into the interglacial interval between the depositon of the Middle and Upper Tills of the Floral Formation (F,I).

4.5 Phase 4

During Phase 4 (Fig. 8), the Sutherland Valley Fill (H) was eroded by the glacier that subsequently deposited the Upper Till (I) of The Floral Formation.

During the retreat of the glacier that deposited the Upper Till (I), the Intertill Sand was laid down. During the interval between the deposition of this sand and the Battleford Formation, the sand and upper part of the Upper Till were subjected to weathering, and the till was oxidized and jointed.

4.6 Phase 5

During Phase 5 (Fig. 8), the Battleford Formation (J), Ablation Silt, and Lacustrine Clay, Silt, and Sand unit (K) were deposited.

The last glacier, which deposited the Battleford Formation, advanced across the study-site about 20,000 years ago (Christiansen, 1968b) and was retreating from the site about 12,000 years ago (Christiansen, 1979). During this advance the Intertill Sand and Upper Till (I) of the Floral Formation were eroded, and the boulder pavement was laid down discontinuously over the area. During the retreat, the soft, sandy till of the Battleford Formation and the Ablation Silt were released from the ice where they came in contact with the Lacustrine Clay, Silt, and Sand (K) deposited in Lake Saskatchewan which inundated the glacier.

4.7 Phase 6

When the shoreline of Lake Saskatchewan receded north of the study-site, the South Saskatchewan River eroded the terraces southeast of the river. As the shoreline receded northward through the study-site, the middle silt and sand unit was deposited on the lower silt and clay layer by the process of regressive offlap. When the glacier re-advanced to the position shown in Figure 4, the shoreline transgressed southward through the study-site, and the upper silt and clay was deposited on the middle silt and sand unit by the process of transgressive onlap. It was during this re-advance that the river terraces were covered with deltaic deposits of the Sand and Silt unit.

As the glacier retreated and Lake Saskatchewan fell, the South Saskatchewan River continued to downcut until it reached its present level about 10,000 years ago (Christiansen, 1979, p. 931). As the river downcut, it eroded into the Sutherland Valley (Drawing 0047-002-01) and lowered the groundwater head in the valley fill. The meander of the river at its confluence with the Sutherland Valley (Drawing 0047-002-01) may have been caused, at least in part, by the softer fill in the Sutherland Valley. After the terraces were eroded, wind-blown silts were deposited on the study-site.

5. GEOTECHNICAL CONSIDERATIONS

5.1 Introduction

This chapter is restricted to geotechnical considerations from a geological viewpoint only and are presented as suggestions for the consideration of the geotechnical engineer who is responsible for applying the geologic framework in solving the geotechnical problems.

5.2 Boulder Pavement

A boulder pavement (Fig. 3) occurs discontinuously between the Floral and Battleford Formations and was encountered in numerous testholes drilled in the Forestry Farm area.

5.3 Jointing

Open desiccation joints occur in the oxidized parts of the Sutherland Group and the Upper Till of the Floral Formation and extend a few metres into the underlying unoxidized tills. Joints were not observed in the oxidized Battleford Formation but are common in the Ablation Silt and clays and silts of the Lacustrine Clay, Silt, and Sand unit.

5.4 Consolidation

Tills of the Sutherland Group and Floral Formation were consolidated by glaciers, whereas the Battleford Formation and Surficial Stratified Drift were not. The Battleford Formation and Ablation Silt were released from the glacier as it melted and the Lacustrine Clay, Silt, and Sand and the Sand and Silt units were deposited in Lake Saskatchewan and by the South Saskatchewan River respectively; consequently, the unconsolidated nature of these deposits.

5.5 Fractures

In Borehole 20 (Drawing 0047-002-02, Appendix 1) fractured till with heavy light-olive brown iron oxidized coating on the blocks occurs between 9.6 and 11.2 m. This fracturing, which has caused this blocky structure, is thought to have formed by repeated desiccation as the groundwater table fluctuated in this zone.

5.6 Collapse Structures

Although the bedrock has collapsed more than 100 m in the Forestry Farm area (Christiansen, 1967b) as a result of the removal of Devonian salt, there is no evidence the sediments that will be excavated from the Forestry Farm Sewers Trench were disturbed by this process.

During the collapse of the Lacustrine Clay, Silt, and Sand as the glacier melted, these sediments were slickensided and fractured (Fig. 5). Because of these structures, earth material may slump from the walls into the bottom of the trench.

5.7 Groundwater

Groundwater occurs in the sands and gravels at the base of the Sutherland Valley Fill, in the Forestry Farm Aquifer, and in the Intertill Sand (Drawing 0047-002-02). Although the aquifer in the Sutherland Valley Fill may not be penetrated by the proposed trench, the groundwater head may be high enough to cause problems. Because these aquifers are all intertill in origin, they can be expected to be extensive and to produce considerable amounts of water. Piezometers have been installed in these aquifers by P. Machibroda Engineering Ltd. who will deal with the geotechnical considerations of these aquifers in their consulting report.

6. LITERATURE CITED

Christiansen, E.A. 1967a. Geology and groundwater resources of the Saskatoon area (73B), Saskatchewan. Saskatchewan Research Council, Geology Division, Map 7.

Christiansen, E.A. 1967b. Collapse structures near Saskatoon, Saskatchewan, Canada. Canadian Journal of Earth Sciences, v.4, p. 757-767.

Christiansen, E.A. 1968a, Pleistocene stratigraphy of the Saskatoon area, Saskatchewan, Canada. Canadian Journal of Earth Sciences, v.5, p. 1167-1173.

Christiansen, E.A. 1968b. A thin till in west-central Saskatchewan, Canada. Canadian Journal of Earth Sciences, v.5, p. 329-336.

Christiansen, E.A. 1970. Geology. *In* Physical environment of Saskatoon, Canada. *Edited by* E.A. Christiansen. NRC Publication 11378, Ottawa, Canada.

Christiansen, E.A. 1979. The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas. Canadian Journal of Earth Sciences, v.16, p. 913-938.

Christiansen, E.A. and Witaker, S.H. 1976. Glacial thrusting of drift and bedrock. *In* Glacial Till. *Edited by* R.F. Legget. Royal Society of Canada, Special Publication 12, p. 121-130.

E.A. Christiansen Consulting Ltd. 1979. Geology of the Meewasin Bridge Site, Saskatoon, Saskatchewan. Consulting Report 0037-001 for Clifton Associates Ltd.

E.A. Christiansen Consulting Ltd. 1980. Geology of the Forestry Farm area, Saskatoon. Consulting Report 0040-002 for Clifton Associates Ltd.

Hendry H.E. and Stauffer, M.R. 1975. Penecontemporaneous recumbent folds in trough cross-bedding of Pleistocene sands in Saskatchewan, Canada. Journal of Sedimentry Petology, v.45, p. 932-943.

Meneley, W.A. 1970. Groundwater resources. *In* Physical environment of Saskatoon, Canada. *Edited by* E.A. Christiansen. NRC Publication 11378. Ottawa, Canada.

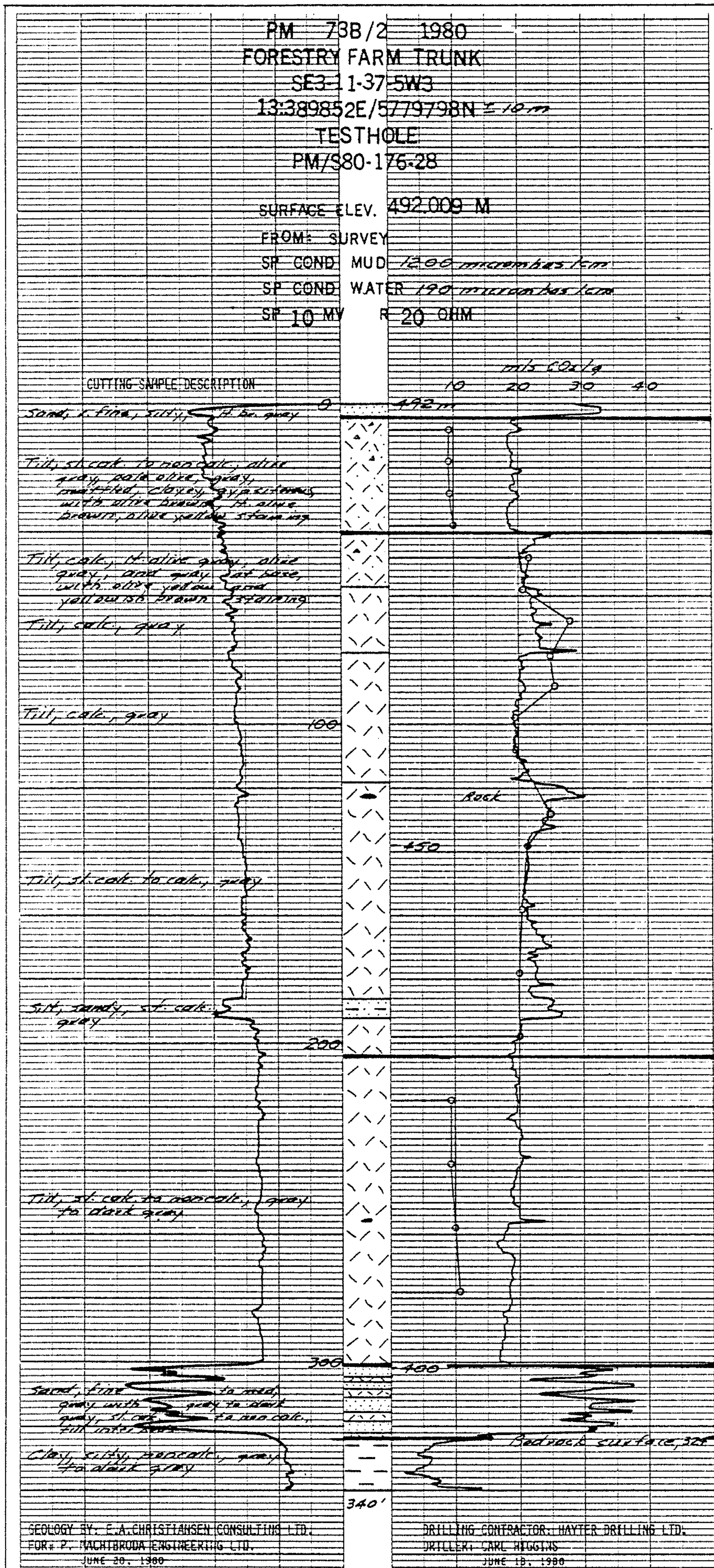
SkwaraWoolf, T. 1980. Mammals of the Riddell Local Fauna (Floral Formation, Pleistocene, Late Rancholabrean), Saskatoon, Canada. Natural History Contributions No. 2, Saskatchewan Culture and Youth, Museum of Natural History.

Whitaker, S.H. and Christiansen, E.A. 1972. The Empress Group in southern Saskatchewan. Canadian Journal of Earth Sciences, v.9, p. 353-360.

Appendix 1. Geologic logs.

BOREHOLE 1

S80-128



SAND AND SILT

UNIT 3, SUTHERLAND GROUP

UNIT 2, SUTHERLAND GROUP

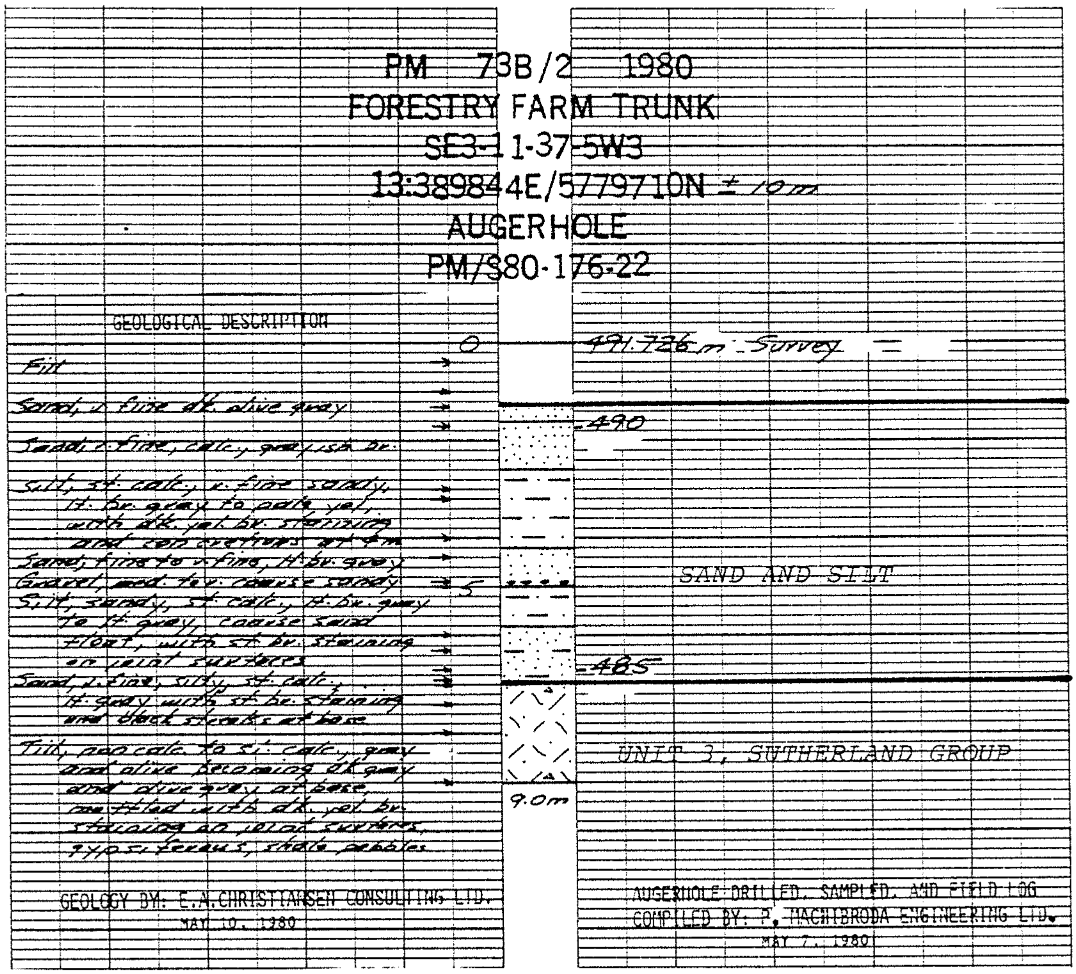
UNIT 1, SUTHERLAND GROUP

EMPRESS GROUP

BEARPAW FORMATION

BOREHOLE 2

S80- 122



BOREHOLE 3
S80-121

PM 73B/2 1980
FORESTRY FARM TRUNK
NW15-2-37-5W3
13:389906E/5779632N ± 10 m
AUGERHOLE
PM/S80-176-21

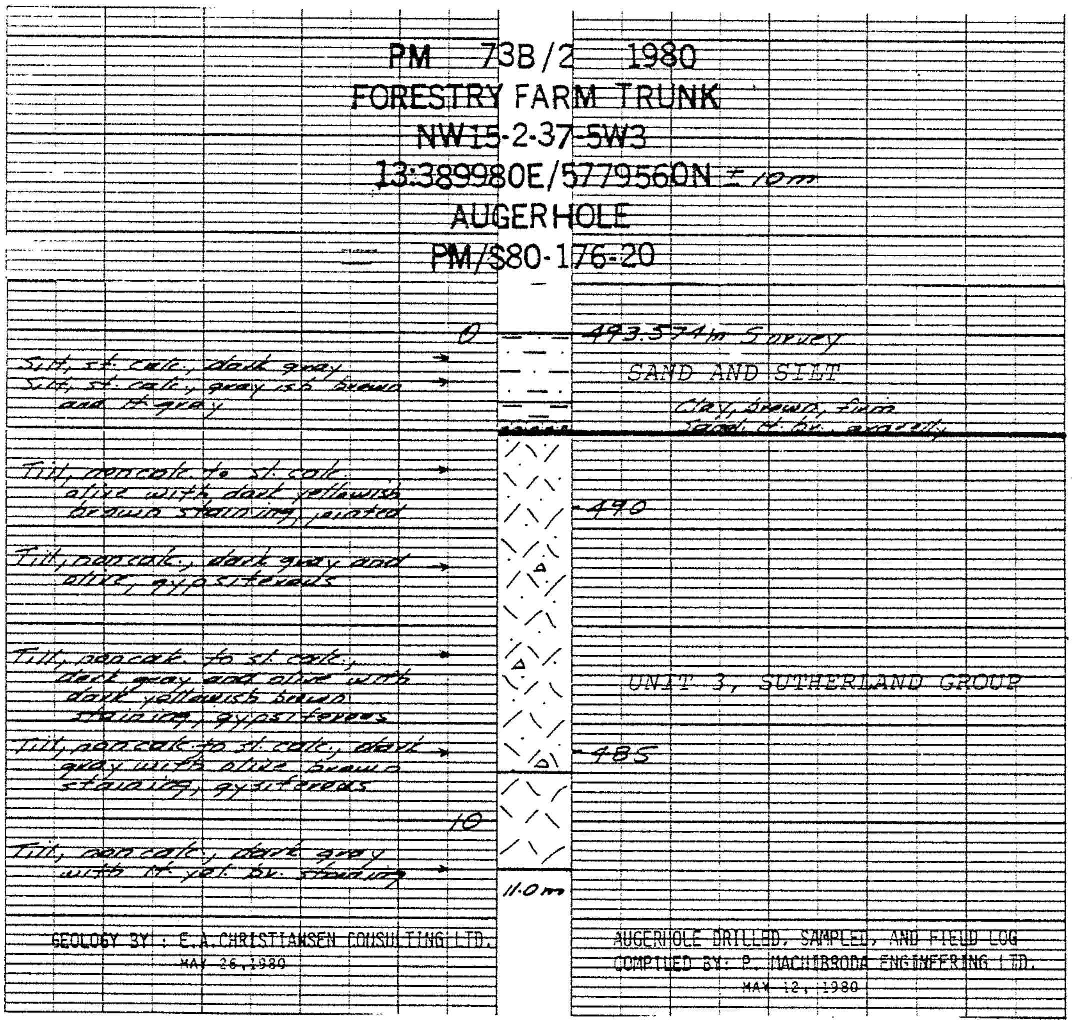
Description	Depth (m)	Elevation / Unit
	0	493.473 m Survey
Sand, silty, v. fine st. calc. grayish brown		SAND AND SILT
Sand, v. fine, calc., grayish brown, friable		
Till, calc., grayish brown with olive brown staining		UPPER TILL, FLORAL FORMATION
Till, sl. calc., olive with olive brown staining, gyp.		490
Till, noncalc. to sl. calc., olive with olive brown staining		
Till as above with veinlets of gypsum crystals		UNIT 3, SUTHERLAND GROUP
Till, sl. calc., gray to dark gray with dark yellowish brown staining		485
	10	
Till as above with lt. olive brown staining and shale pebbles	10.6 m	

GEOLOGY BY: E.A. CHRISTIANSEN CONSULTING LTD.
MAY 26, 1980

AUGERHOLE DRILLED, SAMPLED, AND FIELD LOG COMPILED BY: P. MACHIBRODA ENGINEERING LTD.
MAY 13, 1980

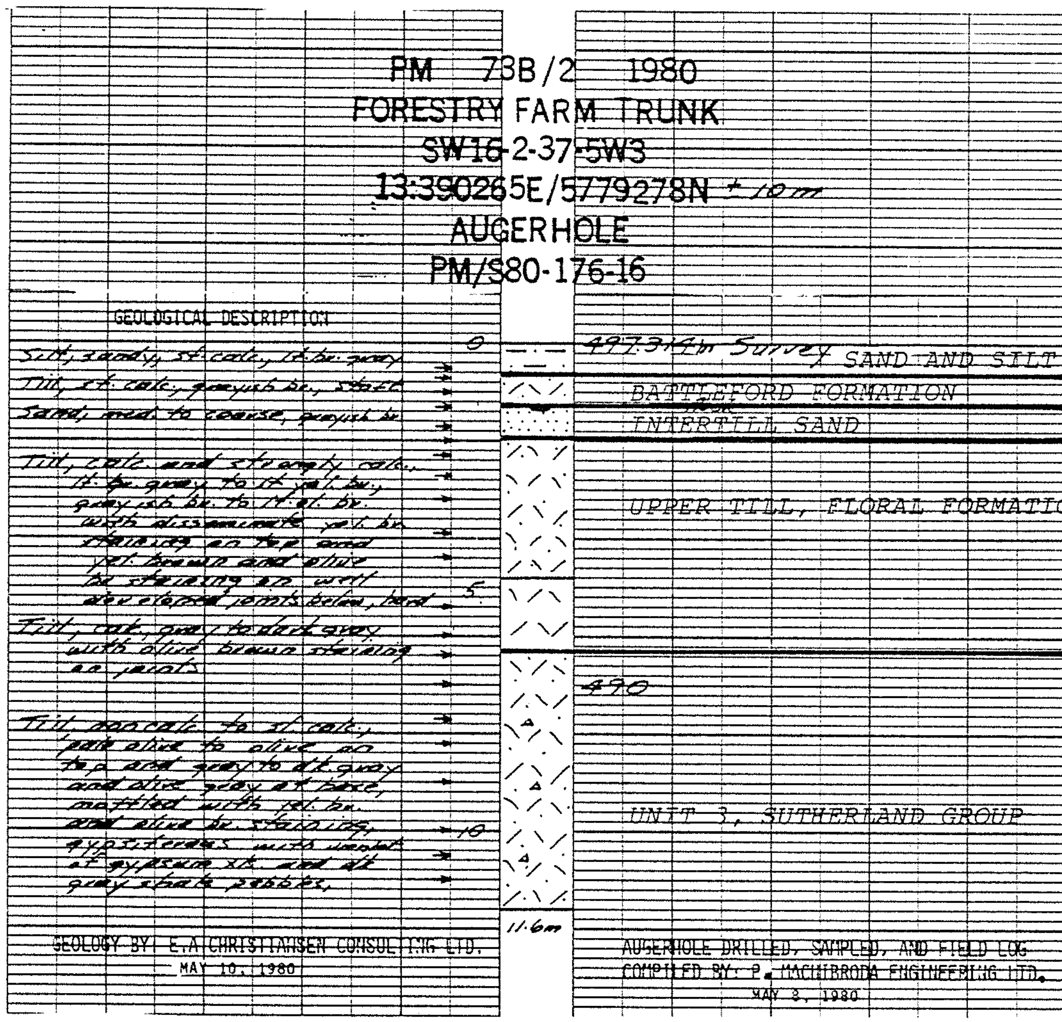
BOREHOLE 4

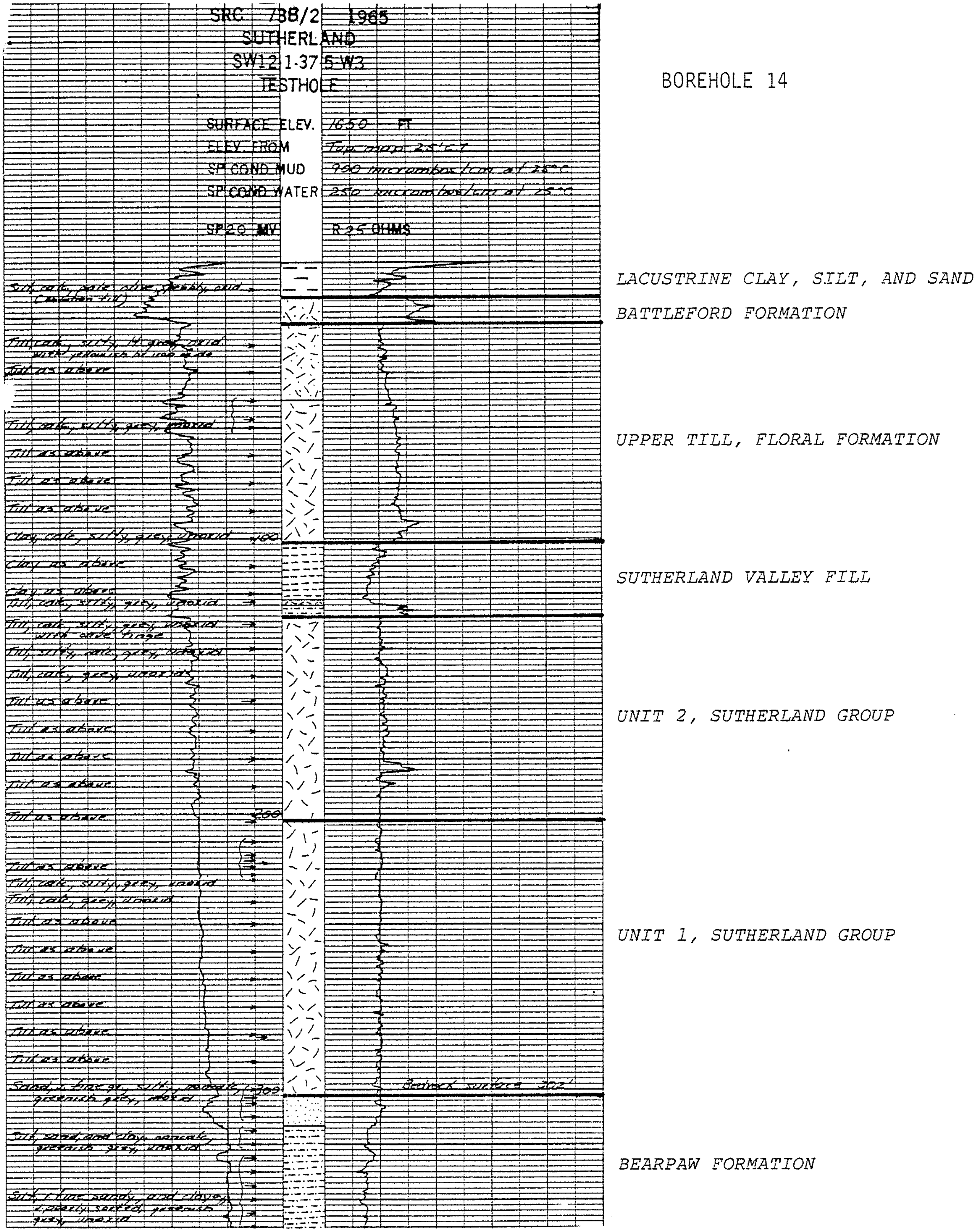
S80-120



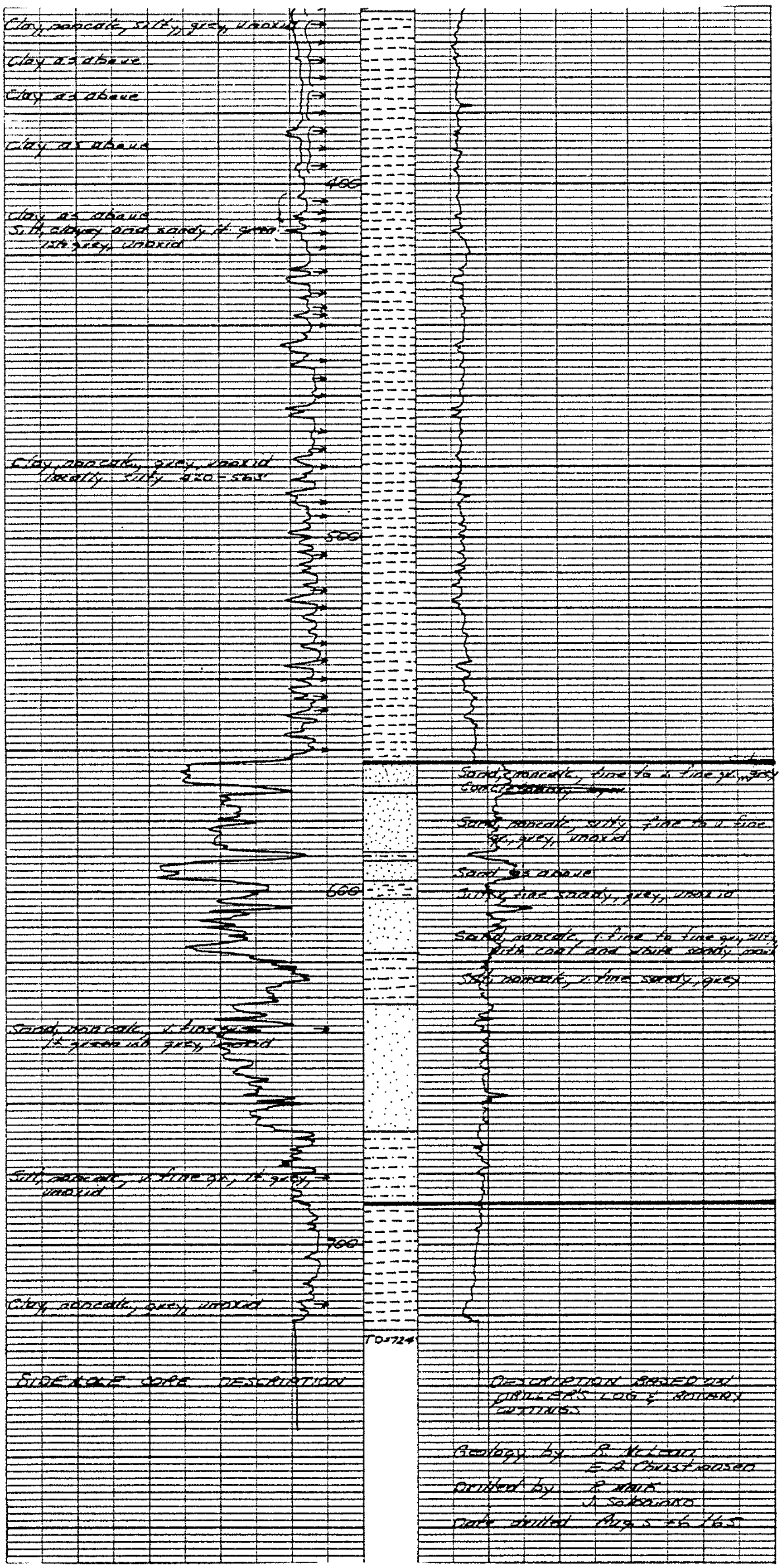
BOREHOLE 8

S80-116




SRC 73B/2 1965
SUTHERLAND
SW12 1-37 5 W3
TESTHOLE
SURFACE ELEV.
ELEV. FROM
SP COND MUD
SP COND WATER
SP 20 MV
R 25 OHMS
BOREHOLE 14
LACUSTRINE CLAY, SILT, AND SAND
BATTLEFORD FORMATION
UPPER TILL, FLORAL FORMATION
SUTHERLAND VALLEY FILL
UNIT 2, SUTHERLAND GROUP
UNIT 1, SUTHERLAND GROUP
BEARPAW FORMATION

BOREHOLE 14 continued



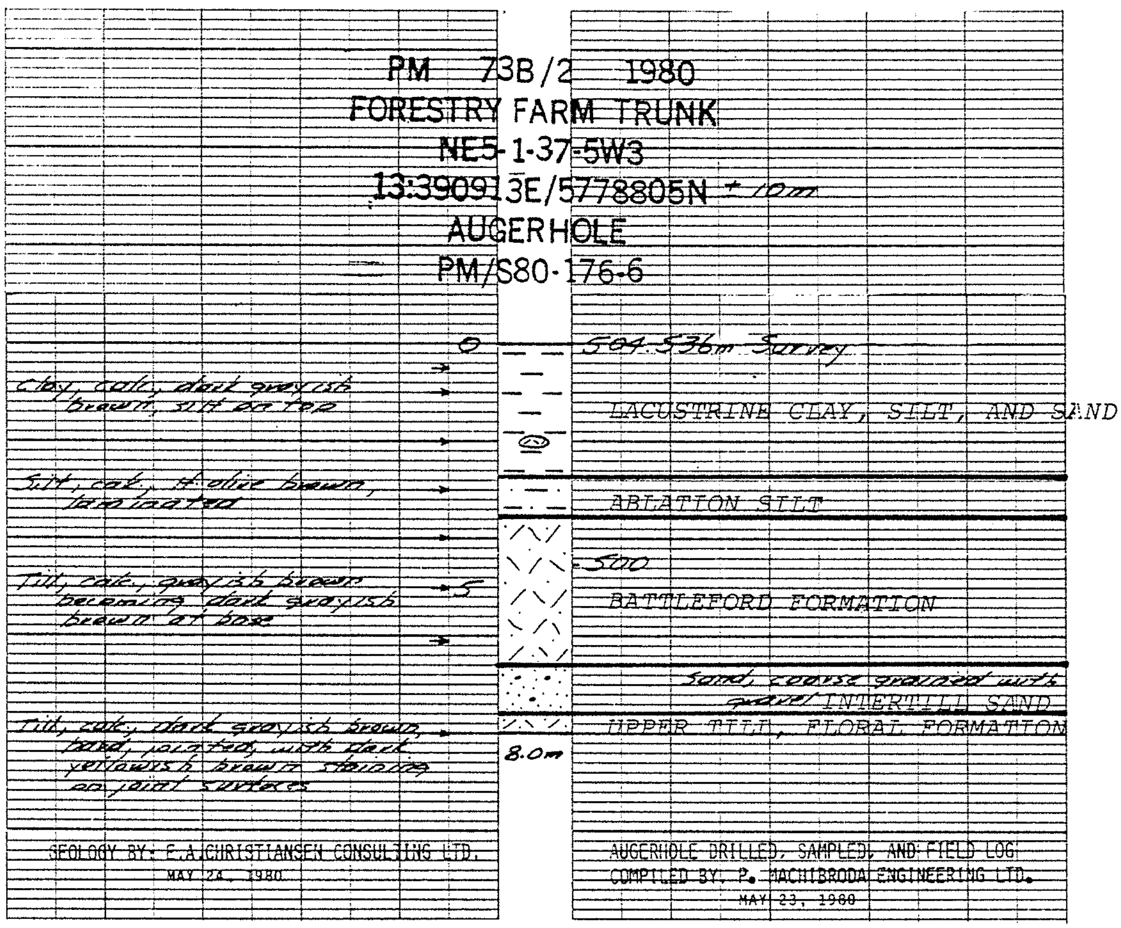
BEARPAW FORMATION

JUDITH RIVER FORMATION

LEA PARK FORMATION

BOREHOLE 16

S80-106



BOREHOLE 20

S80-102

PM 73B/2 1980

FORESTRY FARM TRUNK

NE6-1-37-5W3

13:391301E/5778800N ± 10m

AUGERHOLE

PM/S80-176-2

SAMPLE DESCRIPTION

0 — 504.996m Survey

LACUSTRINE CLAY, SILT, AND SAND

Clay, silty, st. calc., grayish brown to dk grayish brown

Clay, calc., gray br. to dk grayish br.

Clay, silty, calc., grayish brown, gypsiferous

ABLATION SILT

Silt, st. calc. to calc., pale olive laminated, jointed with yel brown staining on joints

Clay and silt, varved, st. calc. and calc., grayish br. and lt. br. gray, laminated and jointed with st. br. staining

5 — 500

BATTLEFORD FORMATION

Till, calc., sandy, grayish brown to lt. br. gray, unstained and unjointed except for part of unit, soft becoming gray and lt. yel. br. at base

Rocks

Till, calc., silty, lt. br. gray and gray with dk brown staining on well developed joint surfaces, hard

10 — 495

Till, st. calc., gray, blocky with heavy dk olive brown staining on surfaces of blocks

Probably formed where groundwater table fluctuates

UPPER TILL, FLORAL FORMATION

Till, silty, st. calc., gray with olive gray staining on joint surfaces

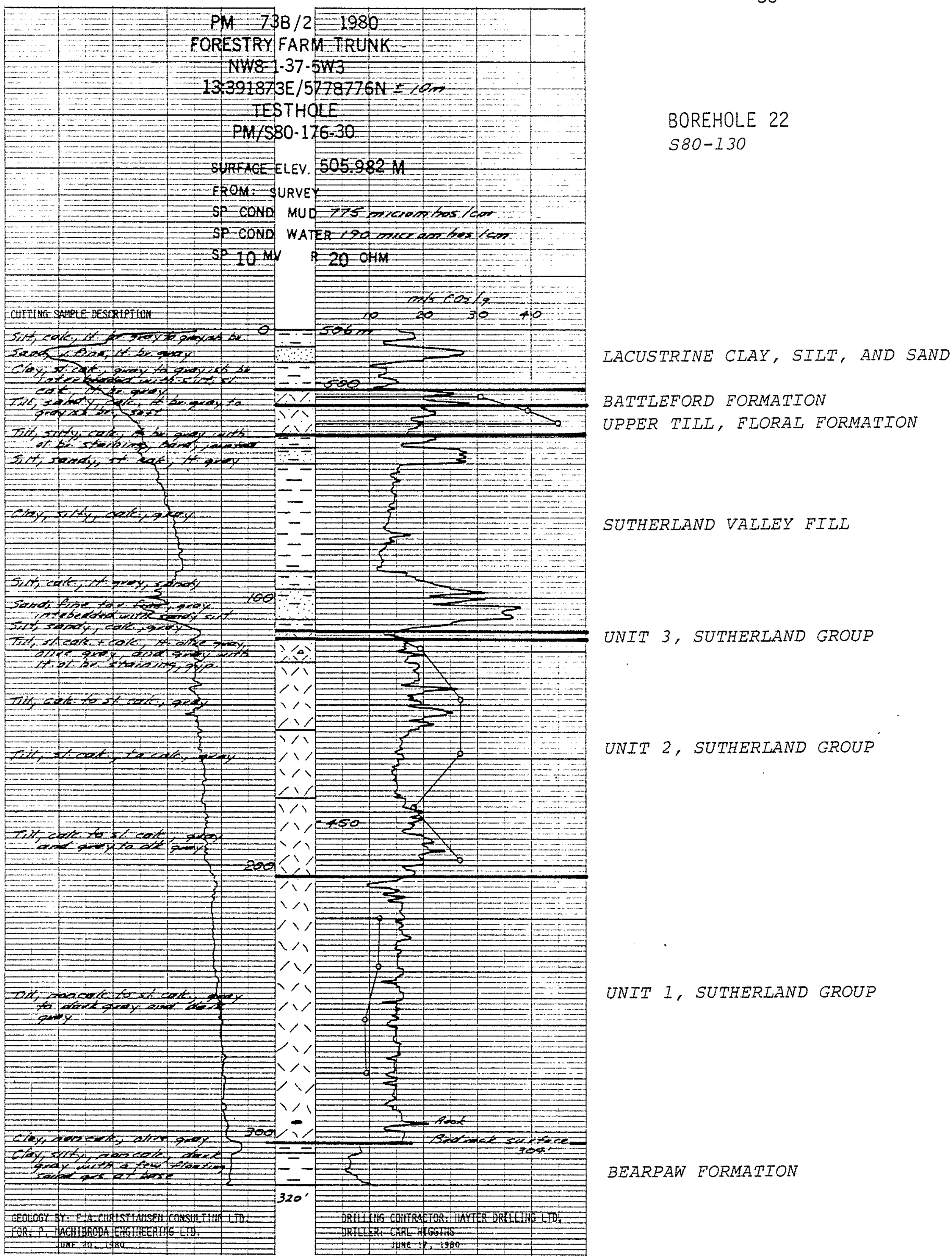
15 — 490

Till, silty, sandy at 16m, gray st. calc.

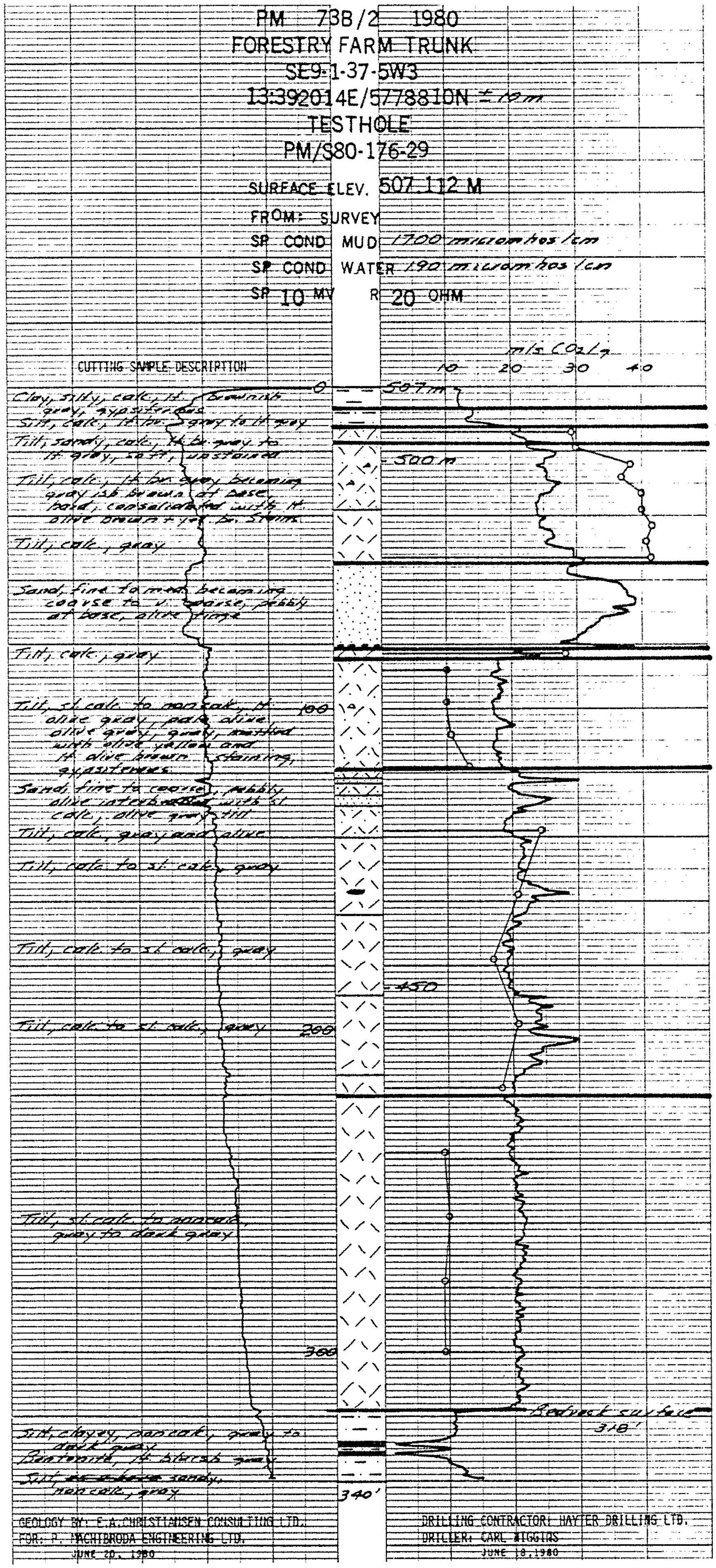
16.4m

GEOLOGY BY: E.A. CHRISTIANSEN CONSULTING LTD.
MAY 10, 1980

AUGERHOLE DRILLED, SAMPLED, AND FIELD LOG COMPILED BY: P. MACHIBRODA ENGINEERING LTD.
MAY 10, 1980


PM 73B/2 1980
FORESTRY FARM TRUNK
NW8-1-37-5W3
13:391873E/5778776N ± 10m
TESTHOLE
PM/S80-176-30
BOREHOLE 22
S80-130
SURFACE ELEV. 505.982 M
FROM: SURVEY
SP COND MUD 775 micromhos/cm
SP COND WATER 190 micromhos/cm
SP 10 MV R 20 OHM
CUTTING SAMPLE DESCRIPTION
mls CO2/g
10 20 30 40
0
506m
590
450
100
200
300
320'
Silt, calc., lt. br. gray to grayish br.
Sand, v. fine, lt. br. gray
Clay, sl. calc., gray to grayish br. interbedded with silt, sl. calc., lt. br. gray
Till, sandy, calc., lt. br. gray to grayish br., soft
Till, silty, calc., lt. br. gray with ol. br. staining, hard, jointed
Silt, sandy, sl. calc., lt. gray
Clay, silty, calc., gray
Silt, calc., lt. gray, sandy
Sand, fine to v. fine, gray interbedded with sandy silt
Silt, sandy, calc., gray
Till, sl. calc. + calc., lt. olive gray, olive gray, and gray with lt. ol. br. staining, gyp.
Till, calc. to sl. calc., gray
Till, sl. calc. to calc., gray
Till, calc. to sl. calc., gray and gray to dk. gray
Till, noncalc. to sl. calc., gray to dark gray and dark gray
Clay, noncalc., olive gray
Clay, silty, noncalc., dark gray with a few floating sand grs. at base
Rock
Bedrock surface 304'
LACUSTRINE CLAY, SILT, AND SAND
BATTLEFORD FORMATION
UPPER TILL, FLORAL FORMATION
SUTHERLAND VALLEY FILL
UNIT 3, SUTHERLAND GROUP
UNIT 2, SUTHERLAND GROUP
UNIT 1, SUTHERLAND GROUP
BEARPAW FORMATION
GEOLOGY BY: E.A. CHRISTIANSEN CONSULTING LTD.
FOR: P. MACHIBRODA ENGINEERING LTD.
JUNE 20, 1980
DRILLING CONTRACTOR: HAYTER DRILLING LTD.
DRILLER: CARL HIGGINS
JUNE 17, 1980

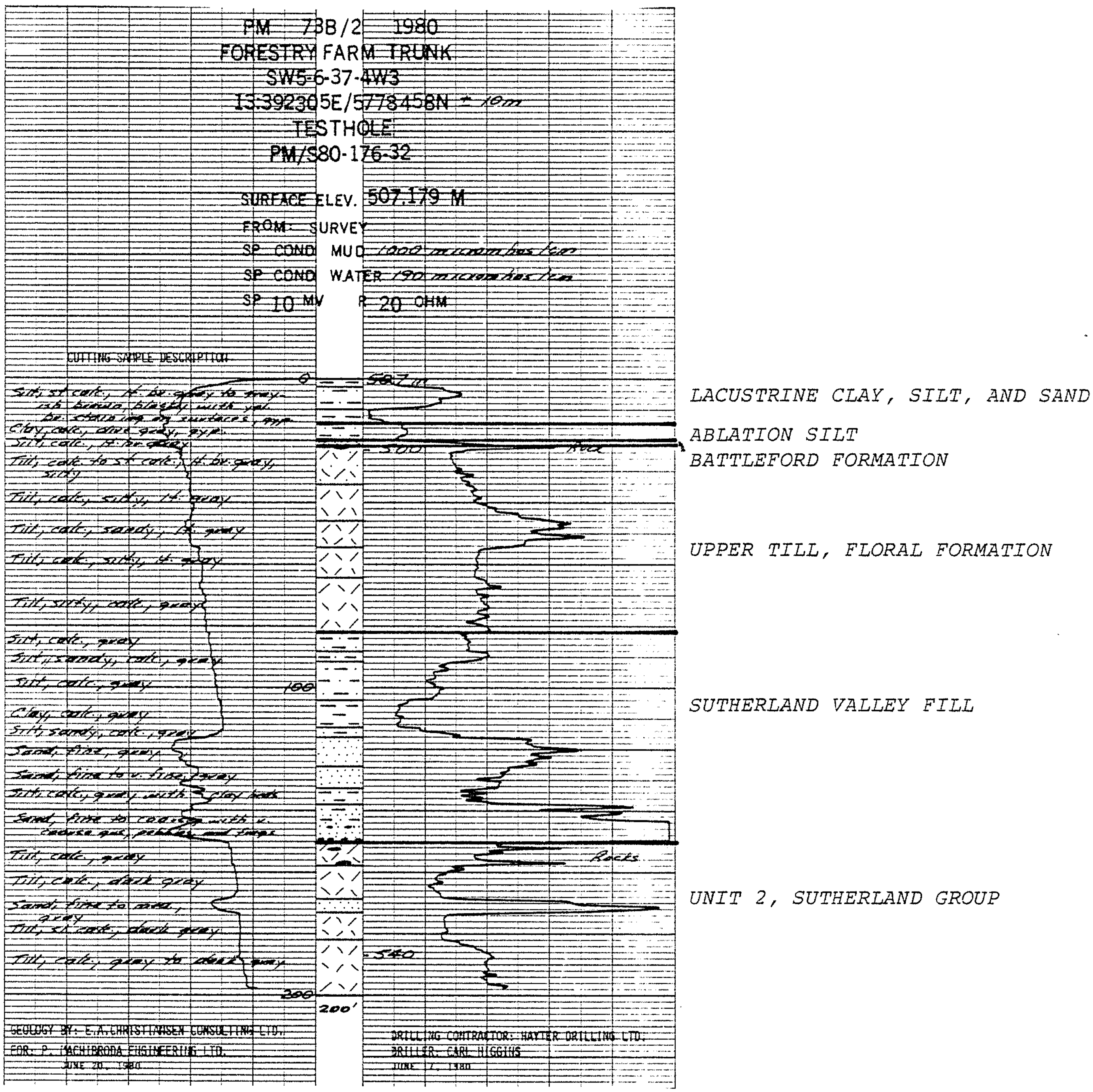
BOREHOLE 23
S80-129



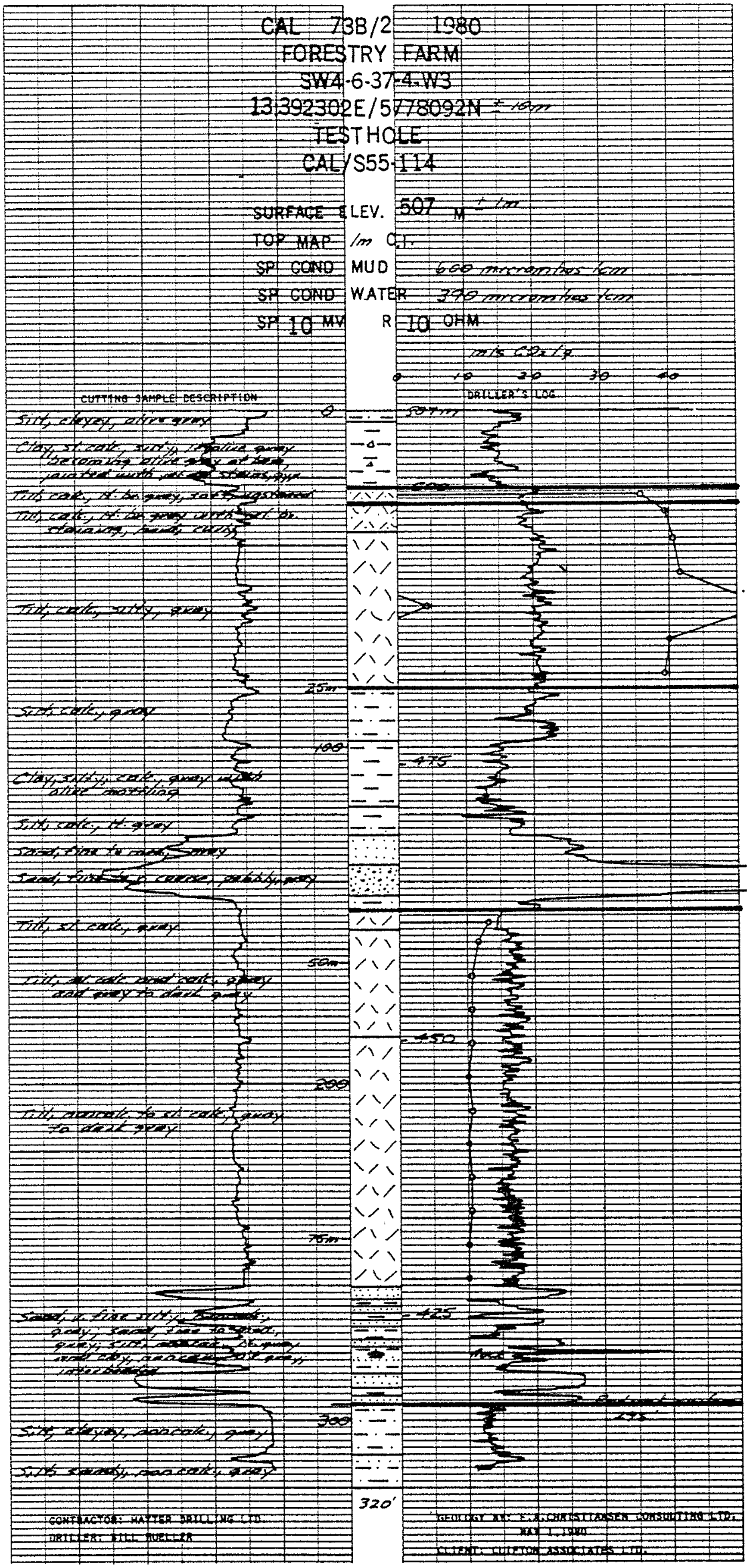
LACUSTRINE CLAY, SILT, AND SAND
ABLATION SILT
BATTLEFORD FORMATION
UPPER TILL, FLORAL FORMATION
FORESTRY FARM AQUIFER
MIDDLE TILL, FLORAL FORMATION
UNIT 3, SUTHERLAND GROUP
UNIT 2, SUTHERLAND GROUP
UNIT 1, SUTHERLAND GROUP
BEARPAW FORMATION

BOREHOLE 24

S80-132



BOREHOLE 25



LACUSTRINE CLAY, SILT, AND SAND

BATTLEFORD FORMATION

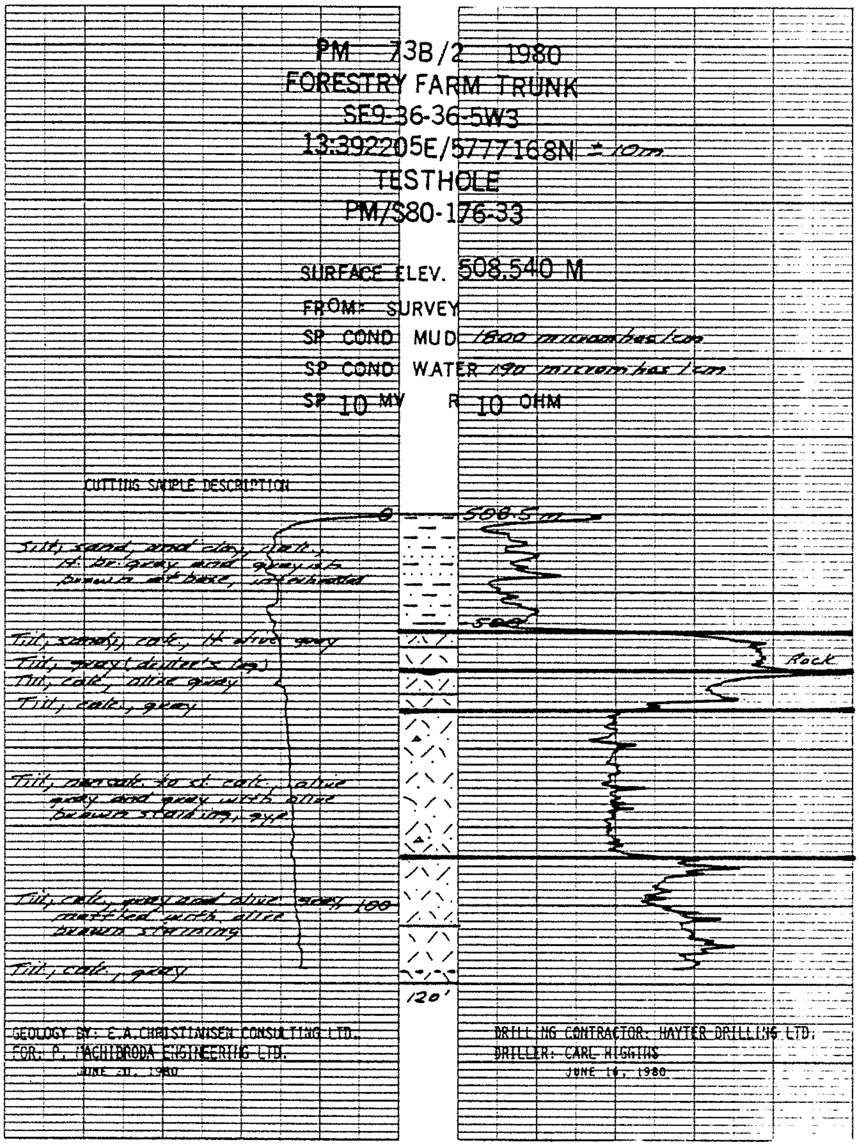
UPPER TILL, FLORAL FORMATION

SUTHERLAND VALLEY FILL

UNIT 1, SUTHERLAND GROUP

BEARPAW FORMATION

BOREHOLE 27
S80-133



LACUSTRINE CLAY, SILT, AND SAND

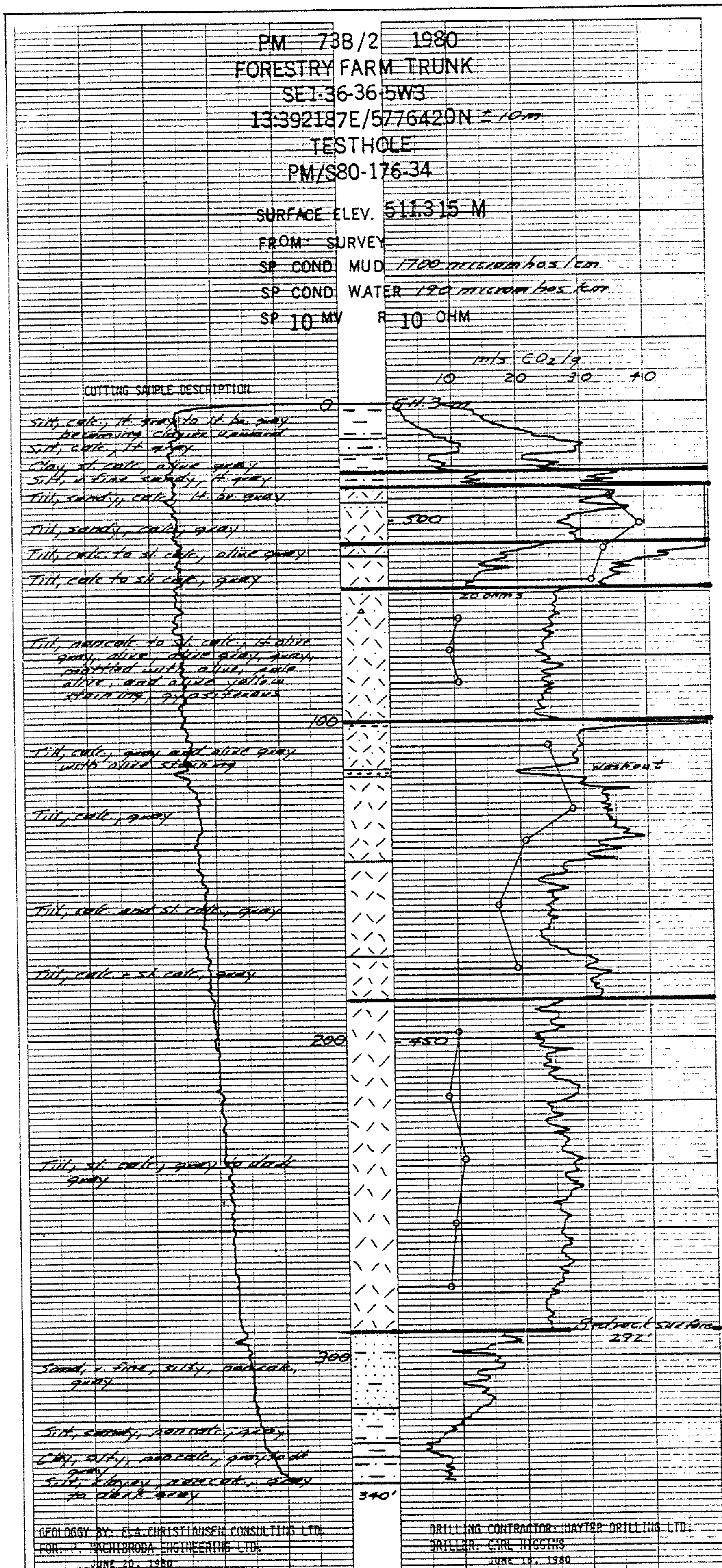
BATTLEFORD FORMATION

UPPER TILL, FLORAL FORMATION

UNIT 3, SUTHERLAND GROUP

UNIT 2, SUTHERLAND GROUP

BOREHOLE 29
S80-134



LACUSTRINE CLAY, SILT, AND SAND

ABLATION SILT

BATTLEFORD FORMATION

UPPER TILL, FLORAL FORMATION

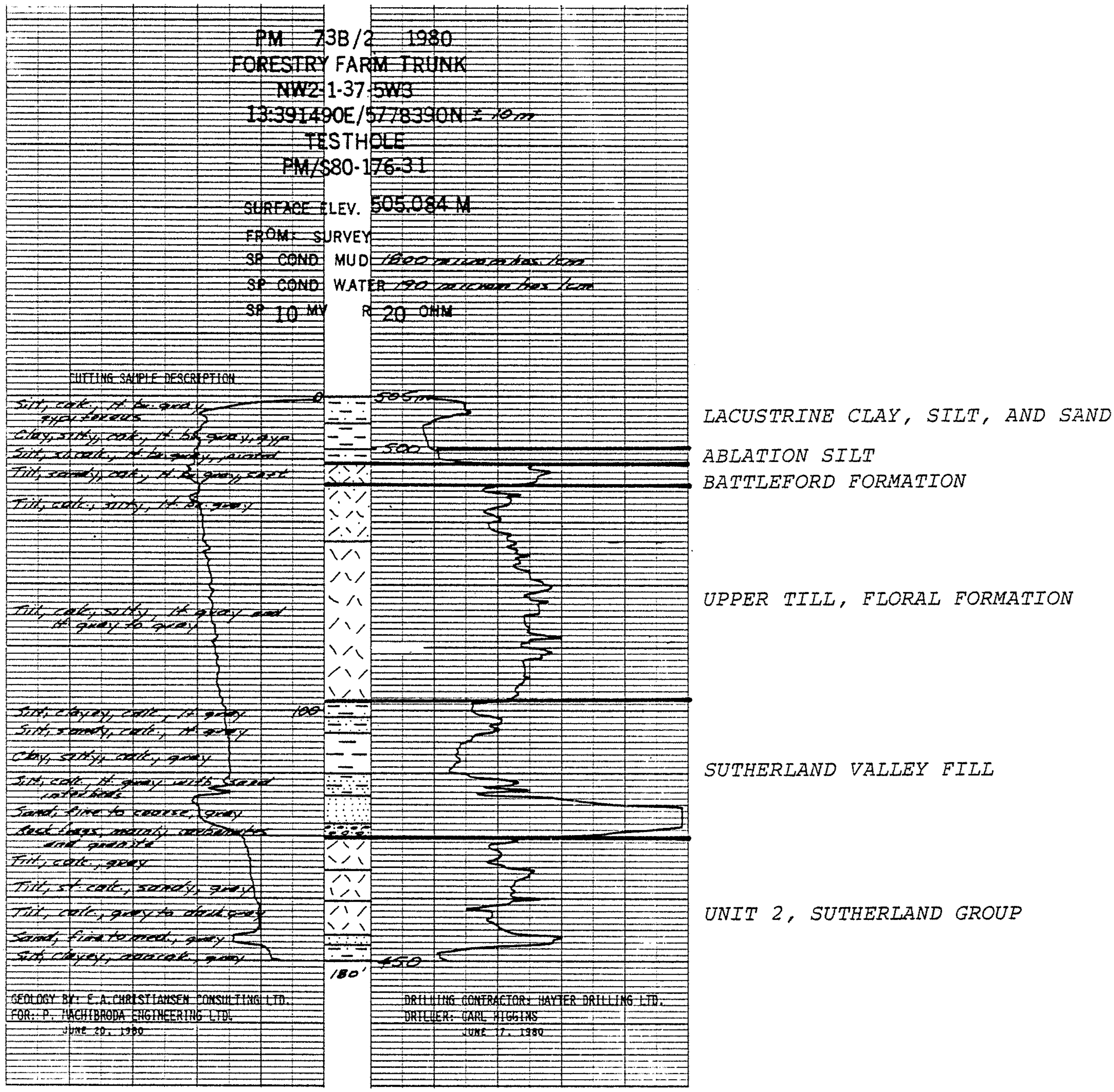
UNIT 3, SUTHERLAND GROUP

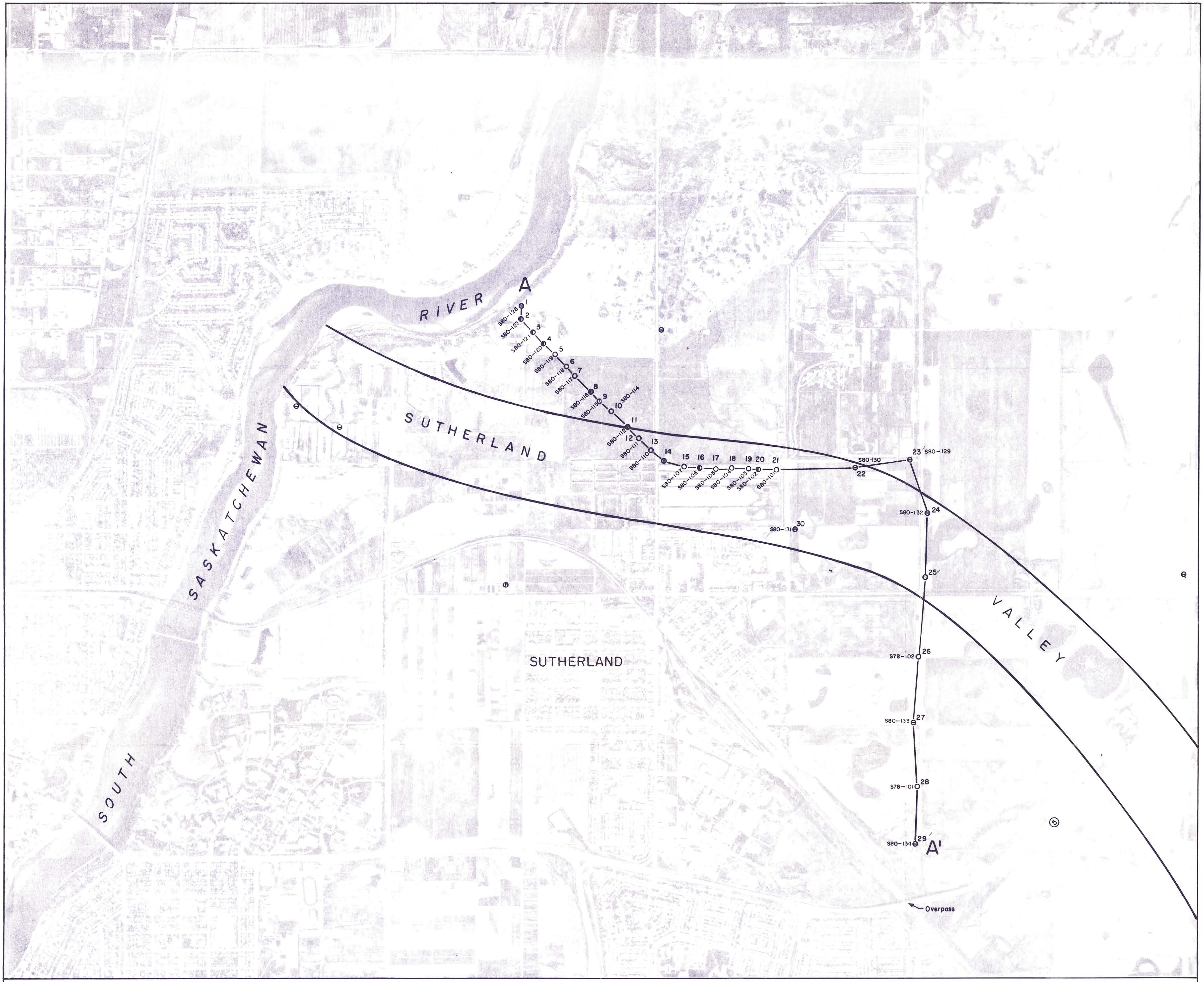
UNIT 2, SUTHERLAND GROUP

UNIT 1, SUTHERLAND GROUP

BEARPAW FORMATION

BOREHOLE 30
S80-131





BOREHOLE CATEGORIES

TESTHOLES
- Electric logs, cutting samples, and cores
- Electric logs and cutting samples

Augerholes
- Geologic logs (double vertical line in Drawing 0047-002-02)
- Geotechnical log (single vertical line)
- Geotechnical logs not used in Drawing 0047-002-02 (see P. Machibroda Engineering Ltd. consulting report)

LOCATION OF LONG SECTION AA' ALONG THE PROPOSED FORESTRY FARM TRUNK SEWERS LINE

Base provided by the Engineering Department, City of Saskatoon

E.A. CHRISTIANSEN CONSULTING LTD.
CONSULTING GEOLOGIST
Box 3087
Saskatoon, Sask.
S7K 3S9
Phone: 374-6700

Drawing No. 0047-002-01
Drawn By E. A. Christiansen
Date July 17, 1980

DRAWING 0047-002-02. LONG SECTION ALONG PROPOSED FORESTRY FARM TRUNK SEWERS LINE.

SEE DRAWING 0047-002-01 FOR LOCATION OF CROSS SECTION AND FOR LOCATION AND CLASSIFICATION OF INFORMATION.

HORIZONTAL CONTROL BY MEASUREMENT FROM CULTURAL REFERENCE AND VERTICAL CONTROL BY LEVEL SURVEY PROVIDED BY WATER AND SEWER DIVISION, ENGINEERING DEPARTMENT.

DRAWING 0047-002-02. LONG SECTION ALONG PROPOSED FORESTRY FARM TRUNK SEWERS LINE.

SEE DRAWING 0047-002-01 FOR LOCATION OF CROSS SECTION AND FOR LOCATION AND CLASSIFICATION OF INFORMATION.

HORIZONTAL CONTROL BY MEASUREMENT FROM CULTURAL REFERENCE AND VERTICAL CONTROL BY LEVEL SURVEY PROVIDED BY WATER AND SEWER DIVISION, ENGINEERING DEPARTMENT.