SASKATCHEWAN HIGHWAYS AND TRANSPORTATION

GEOLOGY OF THE DEER CREEK BRIDGE AREA

Report 0135-002 Feb. 10, 1992
February 10, 1992

Saskatchewan Highways and Transportation
Geotechnical and Material Branch
Humford House - 7th Floor
1855 Victoria Avenue
Regina, Saskatchewan
S4P 3V5

Attention Mr. R.A. Widger:

Dear Mr. Widger:

Re: Geology of the Deer Creek bridge area.

Enclosed is one copy of Report 0135-002 on the "Geology of the Deer Creek bridge area". I have an additional copy for Karl Sauer which I can give him with your permission. If you should require more copies, please let me know.

Sincerely yours,

E.A. Christiansen  P.Eng, P.Geol.
OB LIQUE AERIAL PHOTOGRAPH SHOWING DEER CREEK BRIDGE, DEER CREEK LANDSLIDE IN OPPOSITE BANK, ABANDONED FERRY CROSSING, AND BOREHOLES 1201, 1202, 1203, 1204
SUMMARY

The North Saskatchewan River valley was eroded through the Saskatoon, Sutherland, and Empress Groups into the bedrock Lea Park Formation at the Deer Creek landslide and bridge site. The preglacial Rex valley, in which sand and gravel of the Empress Group was deposited, trends eastward and passes through most of the Deer Creek landslide. It may be possible to stabilize this slide by pumping water from the Empress Group.

The thick landslide debris in the North Saskatchewan River valley at the Deer Creek bridge site and the deep-seated movement at 460 m in slope indicator 9 suggest the valley was eroded to the 460 m level and subsequent filled with landslide debris. Movement at 460 m is continuing and is probably the reason for the displacement of Pier 2. Movement along the Deer Creek landslide shear zone in the upper part of the Lea Park Formation has resulted in displacement of Pier 3.
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1. INTRODUCTION

1.1 Objectives

The objectives, as set forth in "Project proposal 0135-001", are to compile geological logs and draw a cross section along the North Saskatchewan River across the Rex valley. Concern about the possibility of deep-seated movement at Pier 2, prompted updating of the Deer Creek landslide and bridge cross section and drawing a longitudinal section along the North Saskatchewan River to provide the basis for historical modelling of the North Saskatchewan River valley. In order to record the geology, define the shear zone, and model the possible deep-seated movement at the Deer Creek landslide and bridge site, a report was also added to the proposal.

1.2 Location

The location of the Deer Creek area and the Deer Creek landslide and bridge site are shown in Drawing 0135-002-01 and 03.
1.3 **Previous Work**

Previous work on the bedrock and glacial geology pertinent to this study includes a map of the geology and groundwater resources (Christiansen and Whitaker 1973) and a letter report and cross section across the Deer Creek landslide and bridge site (E.A. Christiansen Consulting Ltd. 1990).

1.4 **Present Study**

The present study includes a map and cross section A-A' of the Deer Creek area (Drawings 0135-002-01, 02), a map and cross section B-B' of the Deer Creek landslide and bridge site, and a longitudinal section C-C' along the North Saskatchewan River (Drawings 0135-002-03, 04, 05). The report includes a graphical presentation of the history of the North Saskatchewan River valley which proposes an explanation for the possible deep-seated movement at Pier 2.

2. **STRATIGRAPHY**

2.1 **Introduction**

The stratigraphy of the Deer Creek bridge area is based on
logs in Appendices 1 and 2 and on cross sections A-A' and B-B' (Drawings 0135-002-02, 04) and longitudinal section C-C' (Drawing 0135-002-05). The base of exploration of the Deer Creek bridge area is the Mannville Group (Drawing 0135-002-02), whereas the base of exploration of the Deer Creek landslide and bridge site is the Upper Colorado Group and the gamma-ray marker (Drawing 0135-002-04). The base of exploration for boreholes 1205 to 1209 (Appendix 1) is the bedrock surface. Borehole 1207, however, was terminated in a clayey till. The sediments studied in the Deer Creek bridge area belong to the Cretaceous and Quaternary Systems.

2.2 Cretaceous System

2.2.1 Introduction

The Cretaceous System, in ascending order, includes the Mannville, Colorado, and Montana Groups (Fig. 1, Drawing 0135-002-02).
Figure 1. Stratigraphic chart.
2.2.2 Mannville Group

The Mannville Group, which is an extensive aquifer and heavy oil reservoir in west-central Saskatchewan, is composed of sand, silt, and carbonaceous material. This Group was included in the study because of its possible effect on the porewater pressure in the Lea Park Formation of the Deer Creek landslide (Sauer, personal communication).

2.2.3 Colorado Group

The Colorado Group includes a lower and upper unit. The Lower Colorado Group is composed of 115 to 135 m of noncalcareous, gray, marine clay, whereas the Upper Colorado Group is composed of about 70 m of calcareous, petroliferous, dark gray, marine clay. The lower and upper parts of the Upper Colorado Group are composed of the Second White Speckled shale and the First White Speckled shale, respectively.

2.2.4 Montana Group

The Montana Group is represented by the Lea Park Formation
in Drawing 0135-002-04. The formation is composed of 100 to 115 m of noncalcareous, gray, marine clay. Where the contact between the Upper Colorado Group and the Lea Park Formation cannot be determined in geophysical logs, the units are combined (Drawing 0135-002-02).

2.3 Quaternary System

2.3.1 Introduction

The Quaternary System, in ascending order, includes the Empress, Sutherland, and Saskatoon Groups (Fig. 1, Drawings 0135-002-02, 04).

2.3.2 Empress Group

The Empress Group is composed of stratified sediment between bedrock and the oldest till (Whitaker and Christiansen 1972). A complete Empress Group consists of a lower preglacial unit and an upper proglacial unit. In the Deer Creek bridge area, the preglacial (Eocene, Fig. 1) component of the Empress Group is missing; consequently, the Tertiary System (Fig. 1) is not discussed. The Empress Group is composed of less than one metre to 5 m of mainly
sand and gravel. This group is of particular interest because of possibility of stabilizing the Deer Creek landslide at the bridge site by draining groundwater from this sand and gravel aquifer (Sauer, personal communication).

2.3.3 Sutherland Group

The Sutherland Group is composed of deposits between the Empress and Saskatoon Groups (Christiansen 1968a). The Sutherland Group is composed of a lower sandy till and an upper clayey till. The sandy till is less than one metre to 7 m thick and pinches out at borehole 1202 (Drawing 0135-002-04). The clayey till is less than one metre to 12 m thick and pinches out at borehole 1201. Most of the thinning of the landslide is accounted for by Sutherland Group.

2.3.4 Saskatoon Group

The Saskatoon Group is composed of deposits between the Sutherland Group and the present-day land surface (Christiansen 1968a). The Saskatoon Group is composed of Intertill sediments, Floral and Battleford Formations,
Terrace sediments, and River sediments (Fig. 1, Drawing 0135-002-04).

The Intertill sediments are composed of less than one metre to 42 m of sand and gravel (Drawing 0135-002-02, 04). The unit is placed in the Saskatoon Group because its unoxidized sand and gravel overlies oxidized clayey till of the Sutherland Group (Drawing 0135-002-04, log 14).

The Floral and Battleford Formations (Christiansen 1968a, 1968b) are composed of less than one metre to 40 m of till. Local occurrences of stratified drift lying on till are included in this unit. Tills of the Floral and Battleford Formations are differentiated from tills of the Sutherland Group by carbonate content, texture, and electrical resistance. Tills of the Floral and Battleford Formations have higher carbonate and sand contents and higher electrical resistance than the clayey till of the Sutherland Group (Drawing 0135-002-04).

The Terrace sediments represent North Saskatchewan River sediments laid down when the river flowed at a higher level. The sediments are composed of less than one metre to 9 m of sand and silt in the west bank of the present-day river and 2 m of gravel overlain by 7 m of sand in the east bank (Drawing 0135-002-04).
The youngest sediments (River sediments) occur on the bottom of the present-day North Saskatchewan River. These sediments are composed of less than one metre to 2.5 m of sand. This sand-fill is anomalously thin at the Deer Creek bridge compared to the Meridian bridge and Maidstone bridge where the sand thicknesses are 24 m and 19 m, respectively (Drawing 0135-002-05).

3. SLOPE INSTABILITY AT DEER CREEK BRIDGE

3.1 Introduction

Both deep-seated and shallow slope instability occur at the Deer Creek bridge site (Drawing 0135-002-04). Deep-seated movement is occurring at 460 m in slope indicator No. 9 near log 16, and shallow slope instability is taking place along a shear zone in the upper part of the Lea Park Formation here called the "Deer Creek landslide".

3.2 Deep-Seated Movement

The thick landslide debris in the North Saskatchewan River (Drawing 0135-002-05), the movement of Pier 2 which is deeper than the shear zone in the more shallow Deer Creek
landslide, and the softened zones in the Lea Park Formation below this shear zone suggest a deep-seated movement is occurring at the Deer Creek bridge site. This conclusion was confirmed by the analysis of slope indicator No. 9 by D. Charleson (personal communication through E.K. Sauer) who showed that deep-seated movement is taking place at 460 m.

3.3 Deer Creek Landslide

The shear zone of the Deer Creek landslide is in the upper part of the Lea Park Formation (Drawing 0135-002-03, 04). The shear zone is at 485 m (S.I.5, log 21 at base of Pier 3), at 484 m (S.I.1, log 18), at 486 m (mylonitic zone in core, log 17), at 490 m (S.I.8, log 20), and at 496 m (S.I.9, near log 16).

The surface of the Deer Creek landslide drops from 555 m at the top of the upper scarp to 484 m at the toe of the landslide. The landslide wedge is 46 m thick at the upper scarp and pinches-out in the vicinity of Pier 2, for a length of 440 m. All stratigraphic units in the landslide thin towards the North Saskatchewan River; however, more of the thinning occurs in the sandy till and clayey till units of the Sutherland Group which pinch-out in the direction of
landslide movement. The surface of the landslide which slopes at an angle of 6 degrees, exhibits a prominent upper scarp and numerous smaller scarps (gravity faults), ridges (horsts), and swales (grabens) formed as a result of extension (Christiansen and Sauer 1984, Stauffer et al. 1990).

The movement of Pier 3 is the result of movement of the Deer Creek landslide on a shear zone at the base of the Pier at 485 m. Pier 3 may be affected also by deep-seated movement at 460 m.

4. HISTORY OF THE NORTH SASKATCHEWAN RIVER VALLEY AND SLOPE INSTABILITY

4.1 Introduction

The history of the North Saskatchewan River valley and the accompanying slope failures are shown in five phases (Fig. 2), based on an extended version of cross section B-B' (Drawing 0135-002-04). Location of the extended cross section B-B" is shown in Drawing 0135-002-01.
Figure 2. History of the North Saskatchewan River valley.
4.2 **Phase No.1**

Phase No.1 is the stratigraphic model that existed after the withdrawal of the Battleford glacier but before development of the North Saskatchewan River valley.

4.3 **Phase No.2**

Between Phase Nos. 1 and 2, the valley was eroded to the level of the terrace east of the present river. Because the valley penetrated the Lea Park Formation during Phase No.2, slope instability may have occurred but is not shown in this phase.

4.4 **Phase No.3**

Between Phase Nos.2 and 3, the former valley was incised to 460 m. The thick sand-fills in the North Saskatchewan River valley at Meridian bridge, Maidstone bridge, and Battleford (Drawing 0135-002-05) and movement at 460 m in slope indicator 9 are the reasons for placing the maximum depth of the valley at 460 m at the Deer Creek bridge site.
4.5 Phase No.4

During Phase No.4, a major landslide took place along a shear zone at 460 m. The landslide moved across the deeper incised valley and filled it with landslide debris which is presumed to be at least 12 m thick according to the projected base of the sand-fill between Meridian bridge and Maidstone bridge (Drawing 0135-002-05). The thickness is inferred to be 24 m thick, the base of which is presumed to correspond with the 460 m slip surface in slope indicator 9.

In Drawing 0135-002-05, the thalweg was drawn through the bedrock surface at Battleford and the 460 m level of Deer Creek bridge and projected under the Meridian bridge. The sediment between the thalweg and the base of the sand-fill is inferred to be landslide debris.

4.6 Phase No.5

Phase No.5 represents present-day conditions of slope instability at the Deer Creek bridge site. Deep-seated movement is continuing and is apparently affecting Pier 2. Most of the movement, however, is probably in the Deer Creek landslide that is affecting Pier 3.
5. REX VALLEY

According to Christiansen and Whitaker (1973), Rex valley can be traced from the siding of Rex near the Alberta-Saskatchewan border, north of Lloydminster, to the Deer Creek bridge site. Bedrock surface elevations from more recent borehole information were added to Drawing 0135-002-01, and the 500 m contour line was drawn. This contour line confirms the conclusion of Christiansen and Whitaker (1973) that the Rex valley underlies the Deer Creek bridge site.

The Empress Group in logs 10 and 14 (Drawings 0135-002-02, 04) and in log 1208 (log 26, Appendix 2) indicate that the Rex valley is a fluvially eroded bedrock valley at the Deer Creek bridge site. The sand and gravel in log 11 (Drawing 0135-002-02) overlies till and, therefore, it must be a younger valley fill deposit.

6. ACKNOWLEDGMENT

Dr. E.K. Sauer contributed a great deal to this report through many conferences and several field trips to the Deer Creek bridge site.
7. LITERATURE CITED


Appendix 1. Index of logs.

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* Logs in Appendix 2
Appendix 2. Geological logs.
LOG 18

SHT 734/12 1968
DEER CREEK BRIDGE
S.I. NO.1
NE-09-28-52-25-M9
1259150E/5921000N
SLOPE INDICATOR
457.295, 795.457, 105.744, 105.744
ELEVATION 1641.13 FT.
SURVEY
SP COND NUG
SP COND GREEN SP 20 MV 20 CM

SIGNED BY J. SKINNER
ENGINEER
JUL 19, 1948

SIGNED BY R. G. CHRISTENSEN
CONSULTING ENGINEER
SEP 15, 1948

E.A. Christiansen Consulting Ltd.
LOG 21

SHT 73-F/12 1968
DEER CREEK BRIDGE
PIER NO. 3
NE-09-28-52-25-W3
12:591550E/593100N
COREHOLE

STATION 25 +98.5\' 7.2\' RT. C.L.

CORE DESCRIPTION BY SHER.

SAND, FINE, CALC., OXID.

SAND, FINE AND SILT, CALC., OXID.

NO SAMPLE DESCRIPTION AVAILABLE.

S.I. INDICATOR DEFLECTION 445k
CLAY, NONCALC., BK., UNOXID.
CLAY, NONCALC., BK., UNOXID.
CLAY, NONCALC., BK., UNOXID.

MOISTURE CONTENT GREATER THAN
CLAY, NONCALC., BK., UNOXID.
CLAY, NONCALC., BK., UNOXID.
CLAY, NONCALC., BK., UNOXID.

DRILLED BY
SASK. HIGHWAYS AND TRANSPORTATION
18/12/66 AND 21/12/68

LOG COMPILRED BY
E.A. CHRISTIANSSEN CONSULTING LTD.
JANUARY 18, 1992

E. A. Christiansen Consulting Ltd.
**LOG 22**

**SHT 73-F/12 1968**
**DEER CREEK BRIDGE**
**PIER NO.2**
**SE-16-28-52-25-W3**
**12:591650E/5931050N**
**COREHOLE**

**CORE DESCRIPTION BY SHT**

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**NORTH SASKATCHEWAN RIVER:**

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**DRILLED BY**
**SASK. HIGHWAYS AND TRANSPORTATION**
16/12/66 AND —/12/68

**LOG COMPILED BY**
**E.A. Christiansen Consulting Ltd.**
**JANUARY 18, 1992**

_E.A. Christiansen Consulting Ltd._
LOG 24

SHT  73-F/12  1966
DEER CREEK BRIDGE
NO.700
SW-13-27-52-25-W3
12.591800E/59.31100N

COREHOLE

N. ABUTMENT STATION 50 + 60' ON C.L.

CORE DESCRIPTION BY SHT

SAND+SILT, CALC., DK. GR. BR.

SAND, MED.-CO. AT BASE.

BOULDERS

CLAY, NONCALC., Y. DK. GR.

CLAY, NONCALC., Y. DK. GR.

CLAY, NONCALC., Y. DK. GR.

CLAY, NONCALC., Y. DK. GR.

DIAGRAM

CORE MATERIAL

DIRED MATERIAL

UNOXID., STIFF - BEDROCK SURFACE

UNOXID., SOFT-STIFF

UNOXID., HARD

LOG COMPILED BY
E.A. CHRISTIENSEN CONSULTING LTD.
JANUARY 20, 1992

E. A. Christiansen Consulting Ltd.

SASK. HIGHWAYS AND TRANSPORTATION
OCTOBER 15, 1966
DRAWING 0135-002-03. MAP OF DEER CREEK LANDSLIDE AND BRIDGE SHOWING LOCATION OF CROSS SECTION B-B'.
SASK. DEPT. HIGHWAYS
CS. 3-18
DEER CREEK BRIDGE
NE 28-52-25 W3

HOLE No. 10004
APR. 45.1990

Driller J. SWITZER

E. Legged by F. ZABDIEN

SURFACE ELEV. 1734.3 FT.
SP COND. WATER: mmhos/cm at 50 °C
SP COND. MUD: mmhos/cm at 50 °C

VEER SCALE 1" = 20FT
SP e: mmhos/cm
H: ohms/m

15

0 529

20

500

40

61m

60