APPENDIX B

Geotechnical Engineering Report

GEOTECHNICAL ENGINEERING REPORT

Preliminary Geotechnical Study
Upper Southeast Salt Creek Sanitary Trunk Sewer
Lincoln Wastewater System
Lincoln, Nebraska

PREPARED FOR

EA Engineering, Science, and Technology
121 South 13th Street
Suite 701
Lincoln, NE 68508

May 28, 2004

PREPARED BY

HWS
Solutions Through Service

HWS Consulting Group
825 J Street, Box 80358
Lincoln, NE 68501-0358
402.479.2200 Fax: 402.479.2276
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May 28, 2004

Mr. Dale Schlautman
EA Engineering, Science, and Technology
12 1 South 13th Street
Suite 701
Lincoln, Nebraska 68508

REFERENCE: Preliminary Geotechnical Study
Upper Southeast Salt Creek Sanitary Trunk Sewer
Lincoln Wastewater System
Lincoln, Nebraska

Dear Mr. Schlautman:

The City of Lincoln, Nebraska plans to construct a trunk sewer line that is about 1.3 miles in length. This sewer will run approximately parallel to the BNSF Railroad tracks from approximately 1 mile NNW of the intersection of 27th Street and Rokeby Road to about ½ mile SSE of the intersection of 27th Street and Rokeby Road. The sewer will cross under the BNSF Railroad tracks at two locations, via trenchless construction, such as utility tunneling, pipe jacking, or microtunneling. The remaining portion of the sewer will be installed by means of open cut trenching.

As requested, HWS Consulting Group Inc. (HWS) has performed a subsurface exploration and a preliminary geotechnical study of the subsurface soils at the referenced site. The purpose of these services was to address geotechnical issues for the preliminary design of the proposed sanitary sewer. This report summarizes the findings of the subsurface exploration and the preliminary geotechnical study.

SUBSURFACE EXPLORATION

A program of Dutch friction-cone soundings, test borings, and soil sampling was performed at the project site on May 7, 2004. Three (3) Dutch friction-cone soundings were made at the site. Four (4) exploratory borings were taken to depths of between 7 and 30 feet below the existing grade to establish the general subsurface conditions of the area under consideration. Three of these borings were made immediately beside the three soundings.

The Dutch friction-cone soundings were performed with a mechanical penetrometer in accordance with ASTM D 3441-98, Standard Method for Deep, Quasi-Static, Cone, and Friction Cone Penetration Tests of Soil. The mechanical penetrometer operates incrementally, using a set of inner rods to operate a telescoping penetrometer tip and to transmit the components of penetration resistance (cone bearing and friction sleeve resistance) to the surface for

measurement. The plot of the test data identifies the relative positions and thicknesses of hard and soft layers.

The borings were made in accordance with ASTM D 1452-80 (Reapproved 2000), Standard Practice for Soil Investigation and Sampling by Auger Borings. A machine-driven, continuous flight auger having a diameter of 6 inches was used to advance borings 1,2, and 4 for sampling. Access with the drill rig was not possible at boring locations 3a and 3b, therefore, these two borings were advanced used a hand auger and a Backsaver soil probe. All bore holes were stable and casing was not required. Water level readings were made in the auger borings at times and under conditions stated on the boring logs.

Several small disturbed soil samples were obtained and were examined in the laboratory by a member of HWS' professional engineering staff to supplement the field identification.

The vicinity map and the boring location plan are presented in Appendix A. The penetration diagrams (see Appendix B) present the results of the Dutch friction-cone soundings. The boring logs (refer to Appendix C) present the data obtained in the subsurface exploration. The logs include the surface elevations, the approximate depths and elevations of major changes in the character of the subsurface materials, visual descriptions of the materials in accordance with the criteria presented in Appendix D, and groundwater data. The approximate locations of the soundings and borings are shown in Appendix A.

Elevations (approximate) at the sounding and boring locations were determined by survey with reference to points that HWS' Survey Department located and elevated prior to the subsurface exploration. These reference points are presented below. The elevations are with reference to USGS datum (NAVD88).

- **Boring 1.** Top of manhole cover, located east of the railroad tracks and on the south side of the ditch; elevation = 1 1 85.4 feet.
- **Boring 2.** Control point # 174; elevation = 1 194.5 feet.
- **Borings 3a and 3b.** Control point #182; elevation = 1203.6 feet.
- **Boring 4.** Top of railroad bridge deck; elevation = 1 194.8 feet.

GEOLOGY AND SITE CONDITIONS

The city of Lincoln lies in the Dissected Till Plains section of Nebraska, a part of the Central Lowland province of the Interior Plains physiographic division[1]. The project site is located in the southern portion of Lincoln, and is situated in both alluvial bottomlands and a loess mantled terrace adjacent to Salt Creek. Dakota sandstone is exposed in a railroad cut north of borings 3a and 3b. Refusal of hand sampling equipment-presumably on Dakota sandstone-occurred at boring locations 3a and 3b at depths of 7.3 and 7.6 feet, respectively, below existing grade. In the Lincoln area, the upper portion of the Dakota sandstone is known to have beds of both shale and ironstone.

[1] Physiographic Provinces of North America, Map by A. K. Lobeck, 1948; The Geographical Press; Columbia University, New York

The subsurface materials encountered at the boring locations are briefly described below in descending order of occurrence. Detailed descriptions are provided in the boring logs, which are presented in Appendix C.

Soil Zone	**Description**
Modern Alluvium	Silty sand, low plasticity, 50 to 60 % fine to coarse sand, wet, loose, extends from the ground surface to a maximum depth of 0.9 feet, encountered at boring 3b.
Topsoil	Lean clay, medium plasticity, 0 to 25% fine sand, wet, medium stiff to stiff, extends from the ground surface to a maximum depth of 3 feet, encountered at borings 2, 3a, and 4.
Alluvium	Fat clay, lean to fat clay, lean clay, silty sand, 0 to 70% fine sand, low to high plasticity, wet to saturated, stiff to very stiff and medium dense, extends from the ground surface, or underlies the topsoil, to a maximum depth of the depth explored, encountered at borings 1 and 4.
Subsoil	Fat clay, lean clay, high to medium plasticity, 0 to 15% fine sand, wet, stiff, underlies the topsoil and extends to a maximum depth of 4 feet, encountered at borings 2 and 3 a.
Lower-Subsoil	Lean clay, medium plasticity, wet, stiff to very stiff, underlies the subsoil and extends to a maximum depth of 5.5 feet, encountered at boring 2.
Peoria Alluvium	Fat clay, lean to fat clay, lean clay, sandy lean clay, clayey sand, silty sand, 0 to 80% fine to medium sand, low to high plasticity, medium stiff to very stiff, moist to saturated, underlies the Peoria and extends to a maximum depth of the depths explored, encountered at borings 2,3a, and 3b.
Dakota Sandstone (assumed)	Assumed to underlie the Peoria alluvium, Dakota sandstone is exposed in a railroad cut section northwest of borings 3a and 3b; borings 3a and 3b are assumed to have reached refusal on Dakota sandstone.

Groundwater was encountered at elevations ranging from 1 17 1.9 to 1 179.9 feet (5.2 to 2 1.8 feet below existing grade). The water table could be expected to fluctuate several feet depending on surface drainage, rainfall, vegetation, temperature, and other factors.

DISCUSSION

1. General soil Conditions. The soils encountered at borings B-1, B-2, and B-4 generally consisted of medium stiff to very stiff clay soils. Open cut trenching is expected to be a suitable construction method, except at the BNSF crossings where trenchless construction would be utilized. At borings B-3a and B-3b, refusal of the hand sampling equipment occurred at elevations 1 190.2 and 1 186.8 feet (7.3 and 7.6 feet below existing grade), respectively. The refusal was assumed to be on Dakota sandstone because sandstone is evident in the railroad cut located immediately northwest of borings B-3a and B-3b. Boring B-3a was made on the bank of a small creek and B-3b was made within the creek.

2. Groundwater. As previously discussed, groundwater was encountered at elevations ranging from 1 17 1.9 to 1 179.9 feet (5.2 to 2 1.8 feet below existing grade). Table 1 presents groundwater data at the five boring locations.

TABLE 1
Groundwater Data

Boring No.	Groundwater Elevation, ft.	Groundwater Depth*, ft.	Distance the Water Table is Above or Below the Proposed Flow Line, ft.
1	1171.9	5.2	0.5 below
2	1172.7	21.8	4.2 above
3a	**	**	**
3b	**	**	**
4	1179.9	8.4	6.6 above

*Below existing grade.
** Groundwater was not encountered to the depths of the borings (7.3 feet [elevation 1190.2 feet] at B-3a and 7.6 feet [elevation 1186.8 feet] at B-3b).

3. Trenchless Construction. Trenchless installation methods (for example, utility tunneling, pipe jacking, and microtunneling) will likely be used at the two railroad crossings. A brief summary of the soil and groundwater conditions at the trenchless locations is presented in Table 2. It should be noted that bedrock (Dakota sandstone) will likely be encountered during trenchless construction on the east side of the tracks in the vicinity of borings 3a and 3b.

TABLE 2
Brief Description of Soil and Groundwater Conditions At Trenchless Locations

Location	Boring No.	Groundwater*	General Soil Conditions
BNSF Tracks	1	0.5' above	Stiff to very stiff lean and fat clays.
West Side of BNSF Tracks	2	4' below	Medium stiff to very stiff lean and fat clays.
East Side of BNSF Tracks	3a, 3b	**	Soft to stiff lean clays overlying presumably Dakota sandstone.

*Approximate distance that the water table is above or below the proposed flow line of the sewer.
**Groundwater was not encountered to the depths of the borings (7.3 feet [elevation 1190.2 feet] at B-3a and 7.6 feet [elevation B 186.8 feet] at B-3b).

4. Bank Erosion. In the vicinity of boring 2, the currently proposed alignment of the sewer line is approximately 120 feet from the nearest bank of a meander of Salt Creek. Concern has been expressed that future bank erosion by Salt Creek might endanger the proposed sewer line. EA Engineering indicated that the flow line of the sewer would be approximately 26 feet below existing grade. The soils encountered at boring 2 consisted of medium stiff to very stiff lean and fat clays. Aerial photographs dated 1956 show that the stream channel is in approximately the same location as its current location. The flow line elevation of the channel could be compared to the sewer line flow elevation to help determine if bank erosion could become a future problem.

5. Applicability of Recommendations. The recommendations presented in this report are based in part upon HWS' analyses of the data from the Dutch friction-cone soundings and soil borings. The penetration diagrams, boring logs, and related information depict subsurface conditions only at the specific sounding and boring locations and at the time of the subsurface exploration. Soil conditions may differ between the soundings and exploratory borings and might change with the passage of time. The nature and extent of any variations between the sounding and boring locations or of any changes in soil conditions (e.g., drying of soil) might not become evident until excavation and construction of the trunk sewer project have begun.

HWS should be contacted if any questions arise concerning this report or if changes in the preliminary nature, design, or location of the sewer line are planned. This report shall not be reproduced, except in full, without the written approval of HWS Consulting Group Inc.

Submitted By

HWS CONSULTING GROUP INC.

Prepared by:

Joshua M. Letts
Engineering Geologist

Reviewed by:

Doyle B. Petersen, P.E.

REGISTERED PROFESSIONAL ENGINEER
DOYLE B. PETERSEN
E-5528
5-28-04
STATE OF NEBRASKA

JML/jml
Enclosures
#52-34-1702.0200 (#52-84-3099)
USESCTS2.doc
Orig. & 2 pc.: EA Engineering, Science, and Technology

APPENDIX A.

VICINITY MAP AND BORING LOCATION PLAN

VICINITY MAP

Preliminary Geotechnical Study
Upper Southeast Salt Creek Sanitary Truck Sewer
Lincoln Wastewater System
Lincoln, Nebraska

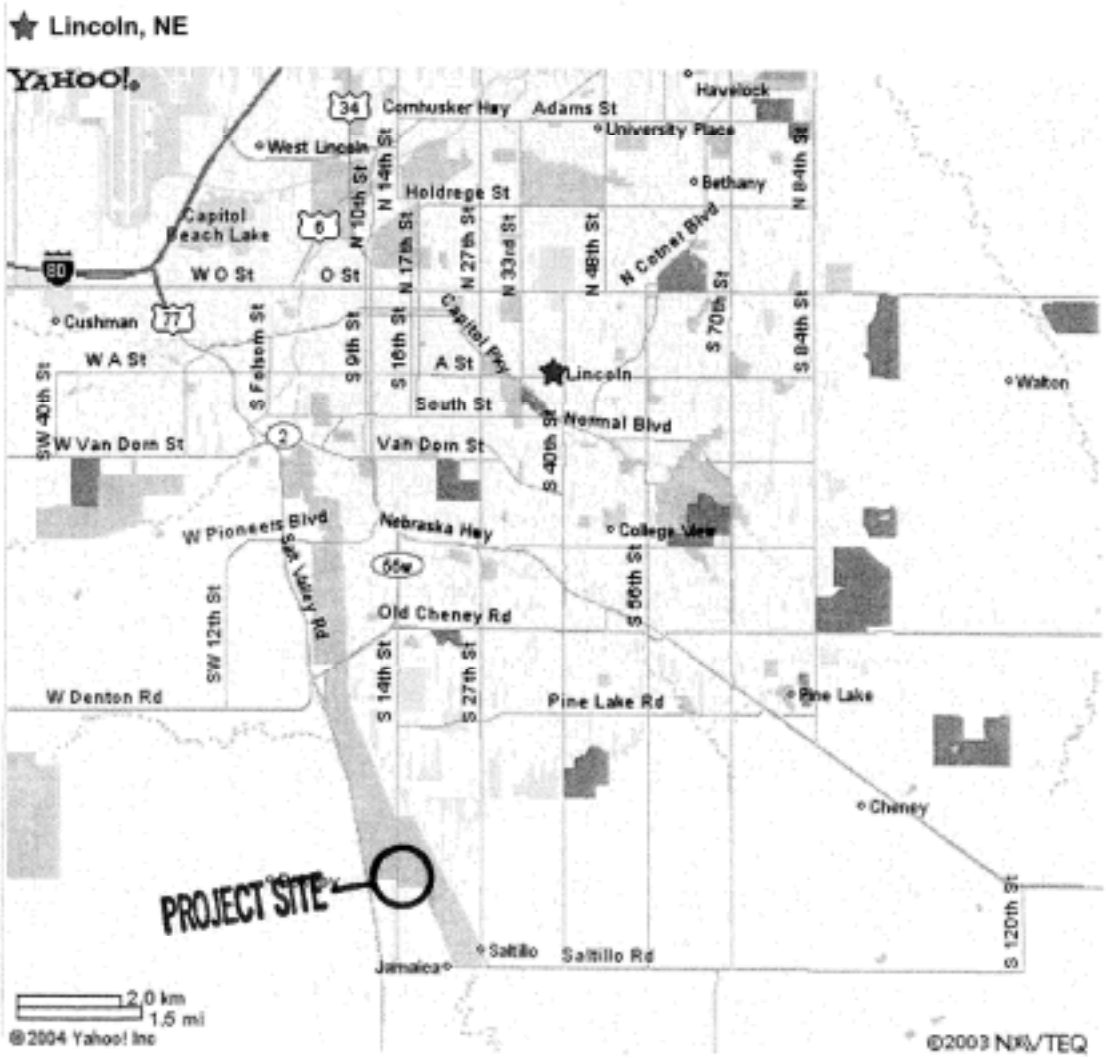
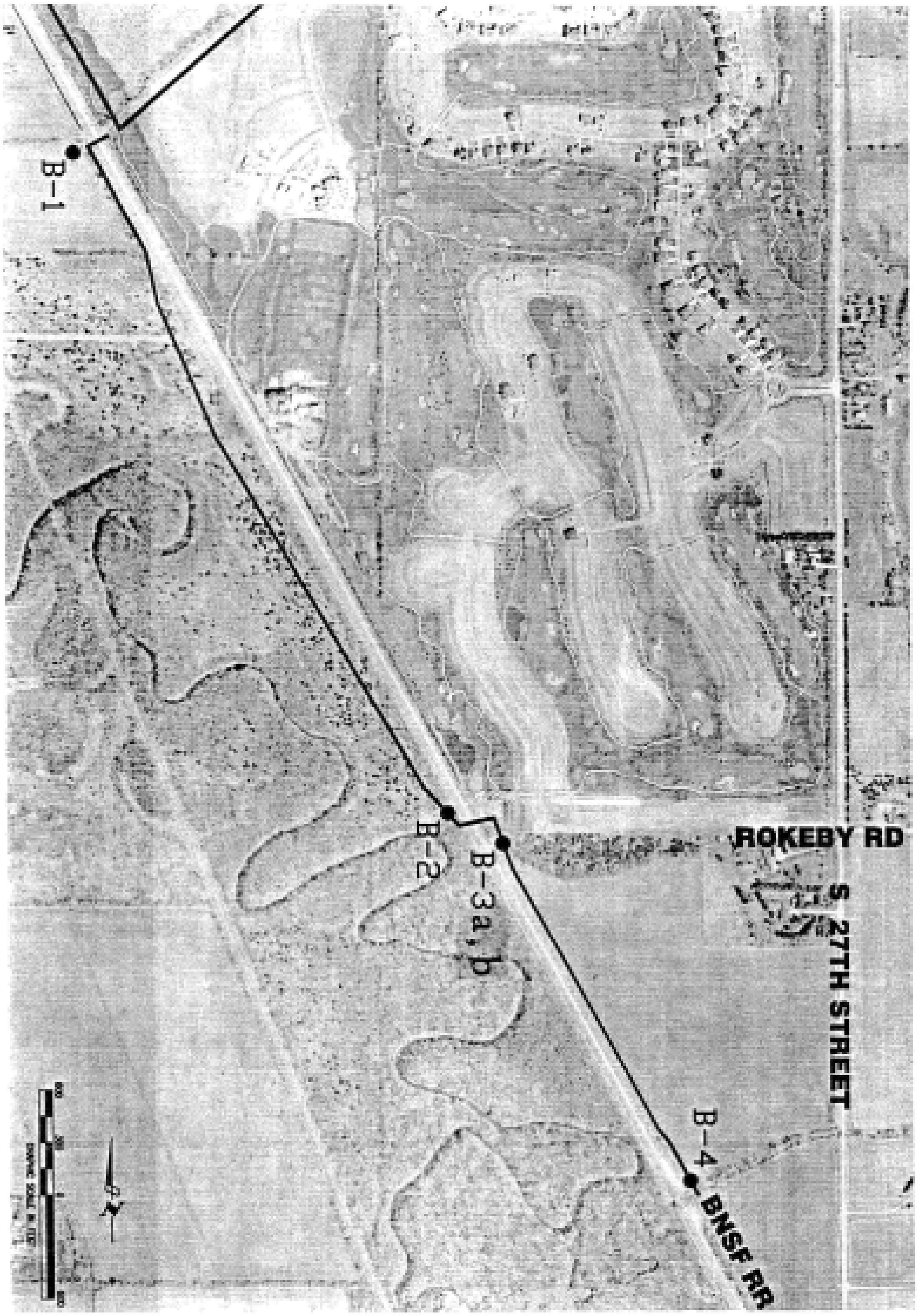


Figure A-1



EA ENGINEERING, SCIENCE, AND TECHNOLOGY

UPPER SOUTHEAST SALT CREEK
TRUNK SEWER PRELIMINARY STUDY
LINCOLN, NEBRASKA

SURVEY DATA POINTS
AND
GEOTECH DATA POINTS

PROJECT MGR.	DESIGNED BY	DRAWN BY	CHECKED BY	DATE	SCALE	PROJECT NO.	FILE NAME	DRAWING NO.	FIGURE
DJS	-	HSL	DJS	APRIL 2004	AS SHOWN	13540.06	-	-	-

APPENDIX B.

DUTCH FRICTION-CONE PENETRATION DIAGRAMS

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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Preliminary Geotechnical Study**
Upper Southeast Salt Creek Sanitary Trunk Sewer

SOUNDING NO.: **S-1**
LOCATION: **B-1**
SURFACE ELEVATION: **1177.1 feet**

DATE: **May 7, 2004**
TESTED BY: **SP**
RECORDED BY: **MS**

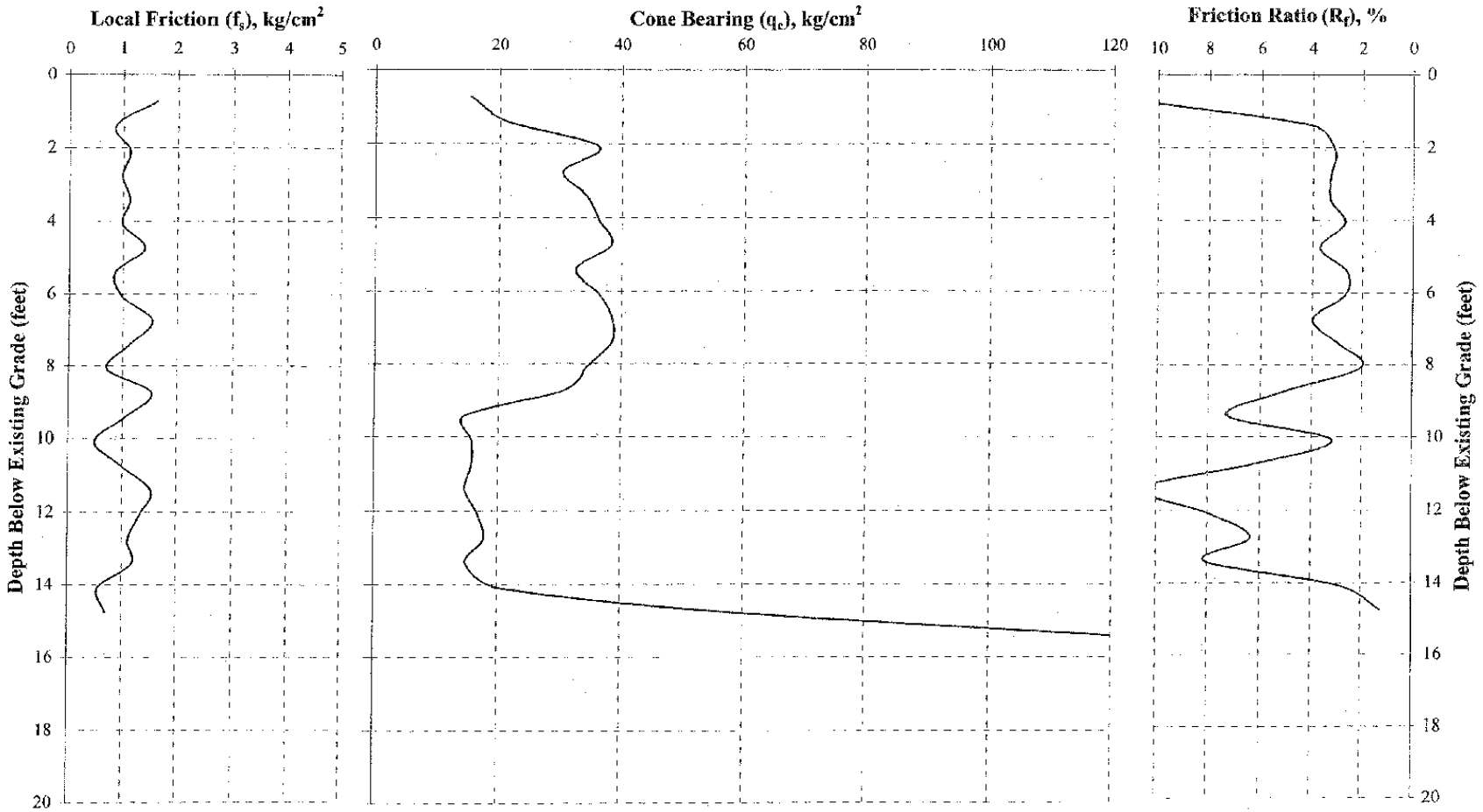

Figure B-1a

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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Preliminary Geotechnical Study**
Upper Southeast Salt Creek Sanitary Trunk Sewer

SOUNDING NO.: **S-2**
LOCATION: **B-2**
SURFACE ELEVATION: **1194.5 feet**

DATE: **May 7, 2004**
TESTED BY: **SP**
RECORDED BY: **MS**

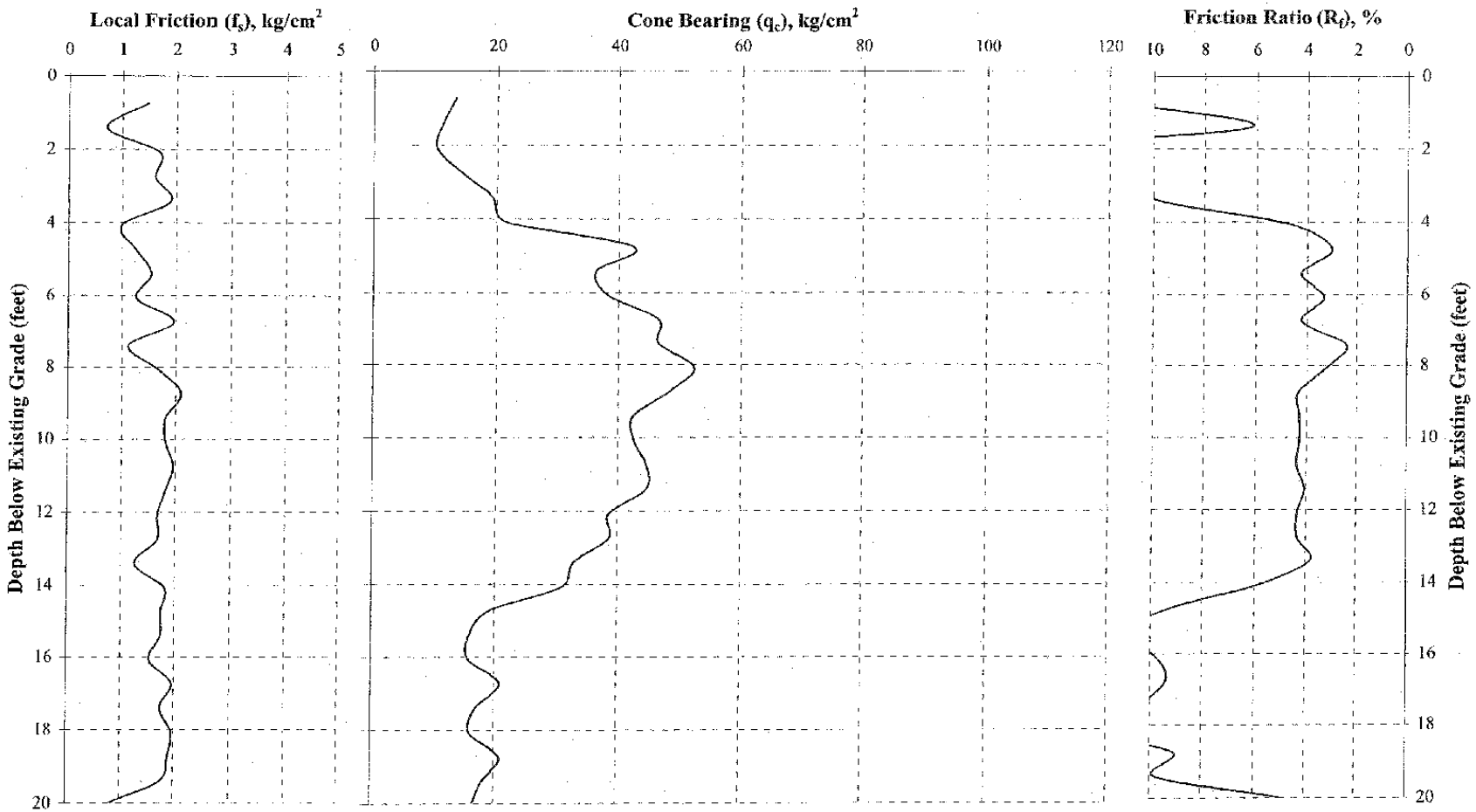

Figure B-2a

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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Preliminary Geotechnical Study**
Upper Southeast Salt Creek Sanitary Trunk Sewer

SOUNDING NO.: **S-2**
LOCATION: **B-2**
SURFACE ELEVATION: **1194.5 feet**

DATE: **May 7, 2004**
TESTED BY: **SP**
RECORDED BY: **MS**

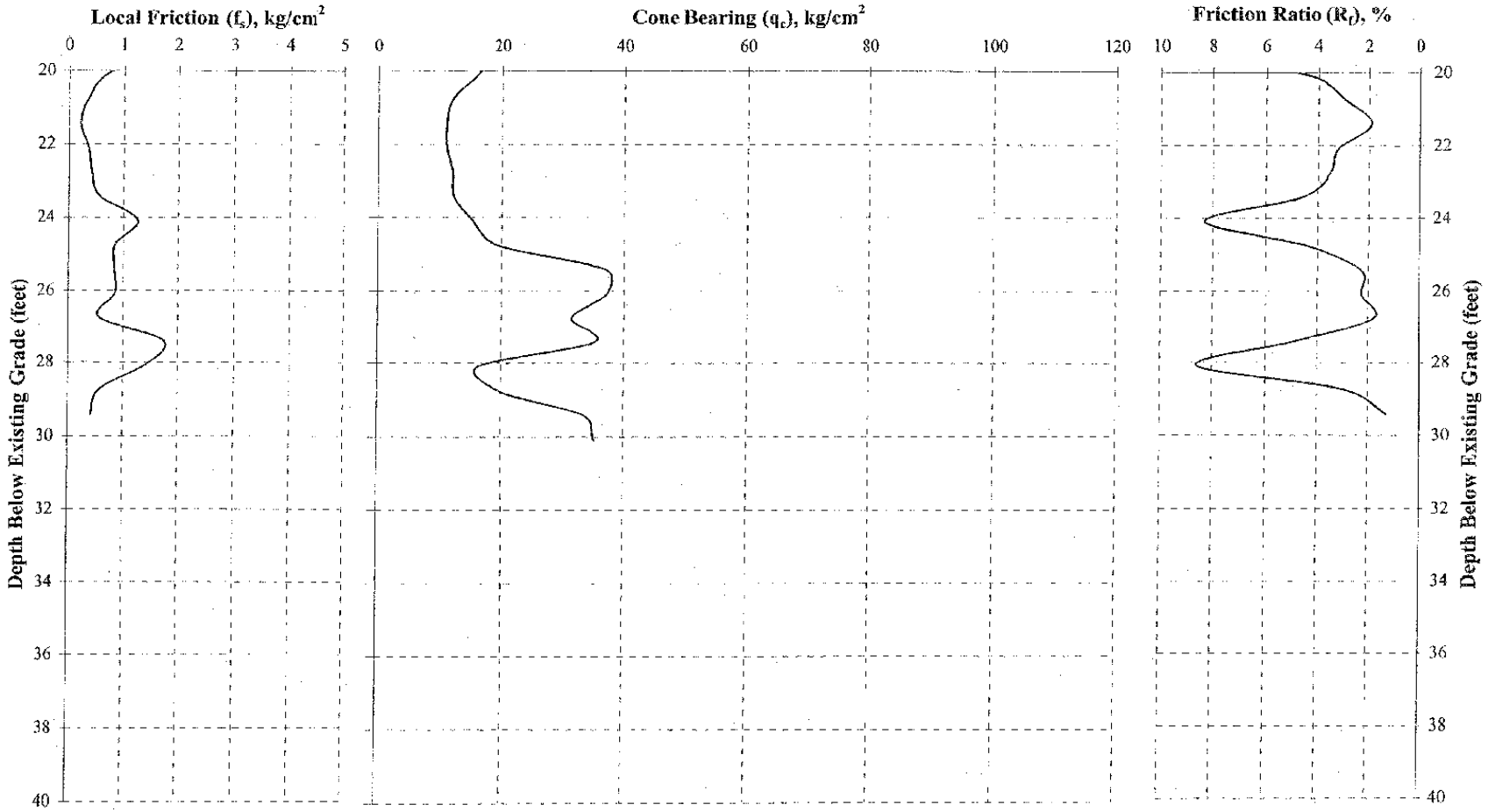

Figure B-2b

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PENETRATION DIAGRAM OF DUTCH FRICTION-CONE PENETROMETER

PROJECT: **Preliminary Geotechnical Study**
Upper Southeast Salt Creek Sanitary Trunk Sewer

SOUNDING NO.: **S-4**
LOCATION: **B-4**
SURFACE ELEVATION: **1188.3** feet

DATE: **May 7, 2004**
TESTED BY: **SP**
RECORDED BY: **MS**

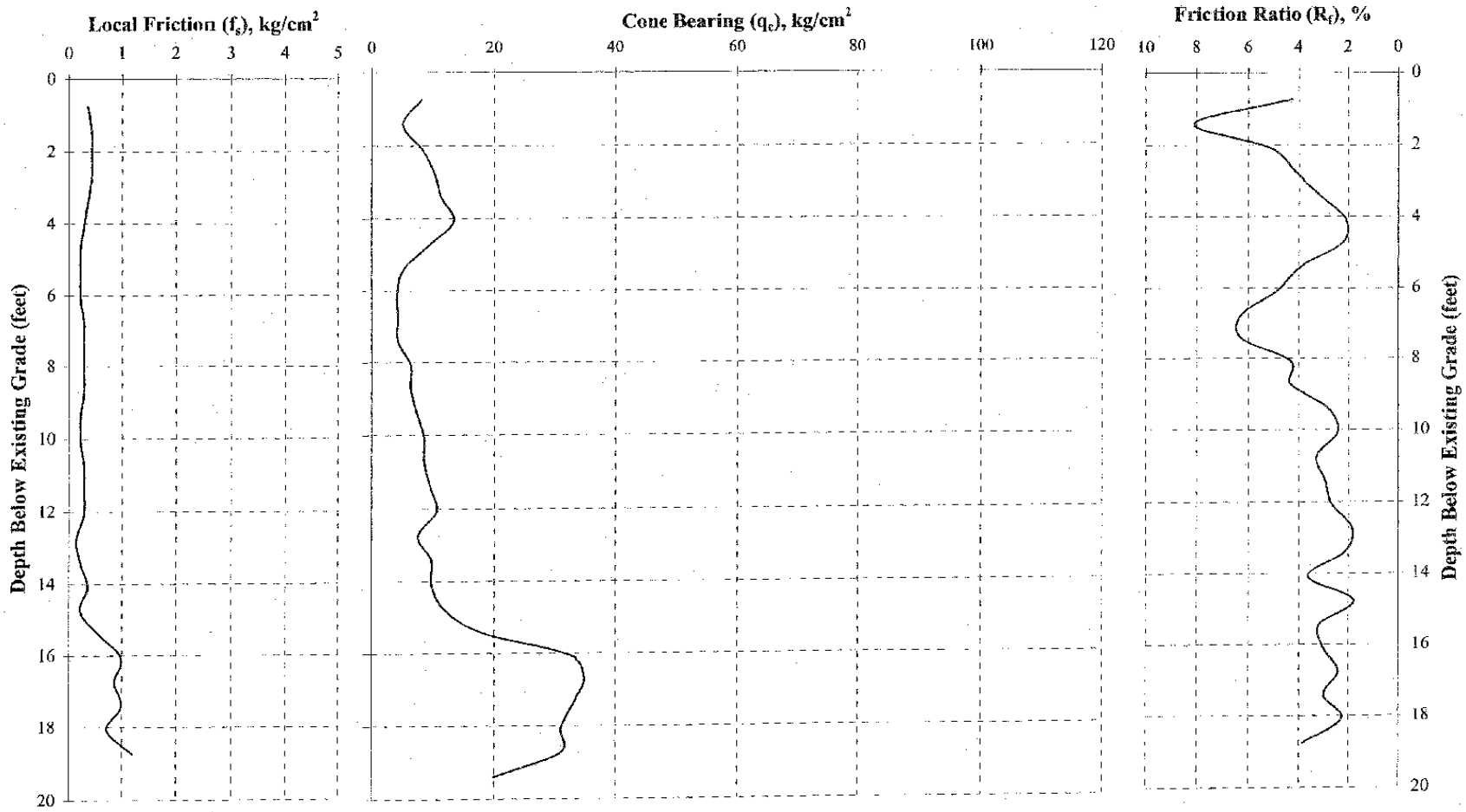

Figure B-4a

APPENDIX C.

BORING LOGS

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BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-1
Sheet: 1 of 1
Date: 5-7-04

ELEV. ft.	DEPTH ft.	GROUP SYMBOL	SOIL DESCRIPTION	SPT	N	SAMPLE NO.	Dry Dens. pcf	MOIST %	DEPTH ft.
1177.1	0.0	CL	LEAN CLAY; medium plasticity; very dark gray; wet; stiff. (Alluvium)						0
1176.1	1.0	CH	FAT CLAY; high plasticity; very dark grayish brown mottled with very dark gray; wet; stiff. (Alluvium)						1
1175.6	1.5	CH	Same as above except very stiff. (Alluvium)						2
1174.6	2.5	CH	Same as above except dark grayish brown highly mottled with very dark gray and olive brown; with a trace of lime nodules. (Alluvium)						3
									4
			Groundwater was encountered at 5.2 feet at 5 hours after drilling.						5
1171.6	5.5	CH	FAT CLAY; high plasticity; very dark grayish brown slightly mottled with very dark gray; saturated; very stiff. (Alluvium)						6
									7
1169.1	8.0	CL	LEAN CLAY; medium plasticity; grayish brown slightly mottled with dark yellowish red and black; saturated; very stiff. (Alluvium)						8
1168.1	9.0	CL	Same as above except stiff. (Alluvium)						9
1167.1	10.0	CL	Same as above except dark grayish brown. (Alluvium)						10
									11
1165.6	11.5	CL/CH	LEAN TO FAT CLAY; medium to high plasticity; dark grayish brown heavily mottled with very dark grayish brown and dark yellowish red slightly mottled with black; saturated; stiff. (Alluvium)						12
1164.1	13.0	CL	LEAN CLAY; with silty sand seams; grayish brown heavily mottled with dark yellowish red; saturated; stiff. (Alluvium)						13
1163.6	13.5	CL	LEAN CLAY; 5-10% fine sand; grayish brown heavily mottled with dark yellowish red; saturated; stiff. (Alluvium)						14
1162.6	14.5	SM	SILTY SAND; 60-70% fine sand; 30-40% fines with low plasticity; light grayish brown heavily mottled with yellowish red; saturated; medium dense. (Alluvium)						15

Figure C-1

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BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-2
Sheet: 1 of 2
Date: 5-7-04

ELEV. ft	DEPTH ft	GROUP SYMBOL	SOIL DESCRIPTION	SPT N	SAMPLE NO	Dry Dens. pcf	MOIST %	DEPTH ft
1194.5	0.0	CL	LEAN CLAY; medium plasticity; black; wet; medium stiff. (Topsoil)					0
1193.2	1.3	CL	LEAN CLAY; medium plasticity; very dark grayish brown; wet; medium stiff. (Topsoil)					1
1192.3	2.2	CL	Same as above except stiff. (Topsoil)					2
1191.5	3.0	CH	FAT CLAY; high plasticity; very dark grayish brown slightly mottled with dark gray; wet; stiff. (Subsoil)					3
1190.5	4.0	CL	LEAN CLAY; medium plasticity; dark olive brown; wet; stiff. (Lower-Subsoil)					4
1189.5	5.0	CL	Same as above except very stiff. (Lower-Subsoil)					5
1189.0	5.5	CL	LEAN CLAY; trace of fine sand; medium plasticity; olive brown; wet; very stiff. (Peoria)					6
								7
								8
1185.5	9.0	CL	Same as above except grayish brown. (Peoria)					9
								10
								11
1182.5	12.0	CL	SANDY LEAN CLAY; 30-40% fine to medium sand; medium plasticity; grayish brown mottled with olive brown and yellowish red; wet; very stiff. (Peorian Alluvium)					12
1181.5	13.0	CL	LEAN CLAY; medium plasticity; olive brown mottled with dark grayish brown; wet; very stiff. (Peorian Alluvium)					13
1180.5	14.0	CL	Same as above except stiff. (Peorian Alluvium)					14
1179.5	15.0							15

Figure C-2a

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Lincoln, NE 68501

BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-2
Sheet: 2 of 2
Date: 5-7-04

ELEV. ft.	DEPTH ft.	GROUP SYMBOL	SOIL DESCRIPTION	SPT N	SAMPLE NO.	Dry Dens. pcf	MOIST %	DEPTH ft.
1179.5	15.0	CL	LEAN CLAY; trace of fine sand; medium plasticity; olive brown mottled with dark grayish brown; wet; stiff. (Peorian Alluvium)					15
								16
								17
1176.5	18.0	CL	LEAN CLAY; trace of fine sand; medium plasticity; dark grayish brown; wet; stiff. (Peorian Alluvium)					18
								19
1174.5	20.0	CL	Same as above except medium stiff. (Peorian Alluvium)					20
								21
1172.5	22.0	CL	Same as above except with silt seams. (Peorian Alluvium)					22
1172.0	22.5	CL/CH	LEAN TO FAT CLAY; medium to high plasticity; very dark grayish brown mottled with dark grayish brown; wet; medium stiff. (Peorian Alluvium)					23
1170.5	24.0	CH	FAT CLAY; high plasticity; dark grayish brown mottled with grayish brown and yellowish red and black; saturated; stiff. (Peorian Alluvium)					24
								25
1169.0	25.5	CH	FAT CLAY; high plasticity; grayish brown heavily mottled with yellowish red and black and light gray; saturated; very stiff. (Peorian Alluvium)					26
								27
1166.5	28.0	CL	LEAN CLAY; medium plasticity; grayish brown mottled with yellowish red and black and light gray; saturated; stiff. (Peorian Alluvium)					28
								29
1164.5	30.0							30

Groundwater was encountered at 21.8 feet at 3 hours after drilling.

Figure C-2b

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Lincoln, NE 68501

BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-3a
Sheet: 1 of 1
Date: 5-7-04

ELEV. ft.	DEPTH ft.	GROUP SYMBOL	SOIL DESCRIPTION	SPT N	SAMPLE NO	Dry Dens. pcf	MOIST %	DEPTH ft.
1197.5	0.0	CL	LEAN CLAY WITH SAND; 20-25% fine sand; medium plasticity; very dark brown; wet; stiff. (Topsoil)					0
1196.5	1.0	CL	LEAN CLAY; 10-15% fine sand; medium plasticity; very dark grayish brown; wet; stiff. (Subsoil)					1
1195.8	1.7	CL	LEAN CLAY WITH SAND; 25-30% fine sand; medium plasticity; dark yellowish brown; wet; stiff. (Colluvium)					2
								3
1194.0	3.5	CL	LEAN CLAY; trace of fine sand; medium plasticity; yellowish brown; wet; stiff. (Peoria)					4
1193.4	4.1	CL	LEAN CLAY; medium plasticity; light olive brown; moist; hard. (Peoria)					5
1191.5	6.0	CL	SANDY LEAN CLAY; 40-50% fine to coarse sand with trace of gravel; medium plasticity; black; moist; stiff. (Peorian Alluvium)					6
1191.1	6.4	SM	SILTY SAND; 70-80% fine to medium sand; 20-30% fines with low plasticity; strong brown; moist; loose to medium dense. (Peorian Alluvium)					7
1190.2	7.8		Soil probe refusal on assumed Dakota Sandstone.					8
								9
								10
								11
								12
								13
								14
								15

Figure C-3a

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Lincoln, NE 68501

BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-3b
Sheet: 1 of 1
Date: 5-7-04

ELEV. ft.	DEPTH ft.	GROUP SYMBOL	SOIL DESCRIPTION	SPT N	SAMPLE NO.	Dry Dens. pcf	MOIST %	DEPTH ft.
1194.4	0.0	SM	SILTY SAND; 50-60% fine to coarse sand; 40-50% fines with low plasticity; dark yellowish brown; wet; loose. (Modern Alluvium)					0
1193.5	0.9	CL	LEAN CLAY; medium plasticity; grayish brown; wet; stiff. (Peoria)					1
								2
1191.4	3.0	CL	Same as above except soft. (Peoria)					3
								4
1189.8	4.6	CL	LEAN CLAY; medium plasticity; dark grayish brown; wet; stiff. (Peorian Alluvium)					5
1188.4	6.0	CL	Same as above except with 5-15% fine sand. (Peorian Alluvium)					6
1187.4	7.0	SC	CLAYEY SAND; 50-60% fine to medium sand; 40-50% fines with medium plasticity; dark yellowish brown; wet; medium dense. (Peorian Alluvium)					7
1186.8	7.6		Soil probe refusal on assumed Dakota Sandstone.					8
								9
								10
								11
								12
								13
								14
								15

Figure C-3b

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Lincoln, NE 68501

BORING LOG

PRELIMINARY GEOTECHNICAL STUDY
UPPER SOUTHEAST SALT CREEK SANITARY TRUNK SEWER
LINCOLN WASTEWATER SYSTEM
LINCOLN, NEBRASKA

Boring No. B-4
Sheet: 1 of 1
Date: 5-7-04

ELEV. ft	DEPTH ft	GROUP SYMBOL	SOIL DESCRIPTION	SPT N	SAMPLE NO.	Dry Dens. pcf	MOIST %	DEPTH ft
1188.3	0.0	CL	LEAN CLAY; medium plasticity; black; wet; medium stiff. (Topsoil)					0
1187.1	1.2	CL	LEAN CLAY; medium plasticity; very dark grayish brown; wet; medium stiff. (Alluvium)					1
1186.0	2.3	CL	Same as above except with silt seams. (Alluvium)					2
								3
								4
								5
1182.3	6.0	CL	LEAN CLAY; 5-10% fine sand; medium plasticity; very dark gray; wet; medium stiff. (Alluvium)					6
								7
								8
1179.9	8.4	CL	Same as above except saturated. (Alluvium)					
1179.3	9.0	CL	LEAN CLAY; 10-15% fine sand; medium plasticity; very dark gray; wet; medium stiff. (Alluvium)					9
								10
1177.3	11.0	CL	LEAN CLAY; with silt seams; medium plasticity; very dark gray; saturated; medium stiff. (Alluvium)					11
								12
								13
1174.3	14.0	CH	FAT CLAY; high plasticity; very dark gray slightly mottled with dark grayish brown; saturated; stiff. (Alluvium)					14
1173.3	15.0							15

Groundwater was encountered at 8.4 feet after drilling.

Figure C-4

APPENDIX D.

CRITERIA USED FOR VISUAL SOIL CLASSIFICATION

TABLE D-1

Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]			Group	Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well-graded gravel[F]
			Cu<4 and/or 1 >Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[1]
			Cu<6 and/or 1≥Cc≥3[E]	SP	Poorly graded sand[1]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OL	Organic clay[K,L,M] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor		PT	Peat	

[A] Based on the material passing the 3-in. (77-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded with silt
GP-GC poorly graded gravel with clay
[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
[H] If fines are organic, add "with organic fines' to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥4 and plots on or above "A" line.
[O] PI <4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

TABLE D-2

CRITERIA FOR DESCRIBING MOISTURE CONDITION OF CLAY SOIL	
Description	**Criteria**
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp, slightly wet, moisture content below plastic limit.
Wet	Moisture content above the plastic limit.
Saturated	Very wet. Usually soil is below water table.

TABLE D-3

CRITERIA FOR DESCRIBING MOISTURE CONDITION OF GRANULAR SOIL	
Description	**Criteria**
Dry	Absence of moisture, dry to the touch.
Moist	Damp but no visible free water.
Wet	Visible free water.
Saturated	Usually soil is below water table.

TABLE D-4

CRITERIA FOR DESCRIBING CONSISTENCY OF CLAY SOIL	
Density	**Penetration Resistance, N Blows per 12 in.**
Very Soft	Less Than 2
Soft	2-4
Medium	4-8
Stiff	8-15
Very Stiff	15-30
Hard	Greater Than 30

TABLE D-5

CRITERIA FOR DESCRIBING DENSITY OF COARSE-GRAINED SOIL	
Density	**Penetration Resistance, N Blows per 12 in.**
Loose	Less Than 10
Medium	10-30
Dense	30-50
Very Dense	Greater Than 50

TABLE D-6

CRITERIA FOR DESCRIBING STRENGTH OF ROCK	
Description	**Criteria**
Very soft	Permits denting by moderate pressure of the fingers.
Soft	Resists denting by the fingers, but can be abraded and pierced to a shallow depth by a pencil point.
Moderately soft	Resists a pencil point, but can be scratched and cut with a knife blade.
Moderately hard	Resistant to abrasion or cutting by a knife blade, but can be easily dented or broken by light blows of a hammer.
Hard	Can be deformed or broken by repeated moderate hammer blows.
Very hard	Can be broken only by heavy, and in some rocks, repeated hammer blows.