#14

TITLE: INVESTIGATION OF CONTAMINATION
PROPOSED CITY OF REGINA TRANSIT
OPERATIONS CENTRE

LOCATION: REGINA, SASKATCHEWAN

CLIENT: BUILDING DESIGN 2 LTD.

JOB NO: GE-620 DATE: MAY 12, 1986

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GROUND ENGINEERING LTD.
CIVIL & GEOTECHNICAL ENGINEERS
415 - 7th AVENUE • REGINA • SASKATCHEWAN • CANADA
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FILE GE-620

May 12, 1986

Building Design 2 Ltd.
1835 Albert Street
REGINA, Saskatchewan
S4P 2S9

ATTENTION: MR. CURTIS MILES

Dear Sir:

SUBJECT: INVESTIGATION OF CONTAMINATION
PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE
REGINA, SASKATCHEWAN

1.0 INTRODUCTION

This report presents the results of a subsurface soils investigation carried out at the site of the proposed Transit Operations Centre to be constructed for the City of Regina. The completed facility is to include administration, operations, maintenance, servicing, inside vehicle storage and site areas. Authorization to proceed with this work was given verbally by yourself in March, 1986.

The objectives of this investigation were to determine whether there was any contamination in the subsurface soils directly beneath the proposed location of the Transit Operations Centre; and if so, what was the extent, concentration, and type of contamination.

2.0 BACKGROUND

The proposed City of Regina Transit Operations Centre is located on the site of the former Imperial Oil Refinery. The above ground structures of the

refinery have been removed; however, most of the foundations as well as concrete slabs, partially filled basements, underground storage tanks and reservoirs, roads and storage tank pads are still partially intact. There is also an extensive system of abandoned underground utilities such as municipal services and industrial piping. An airphoto enlargement of the site from 1975 showing the structures prior to dismantling and the proposed location of the Transit Operations Centre is shown on Drawing No. GE-620-1.

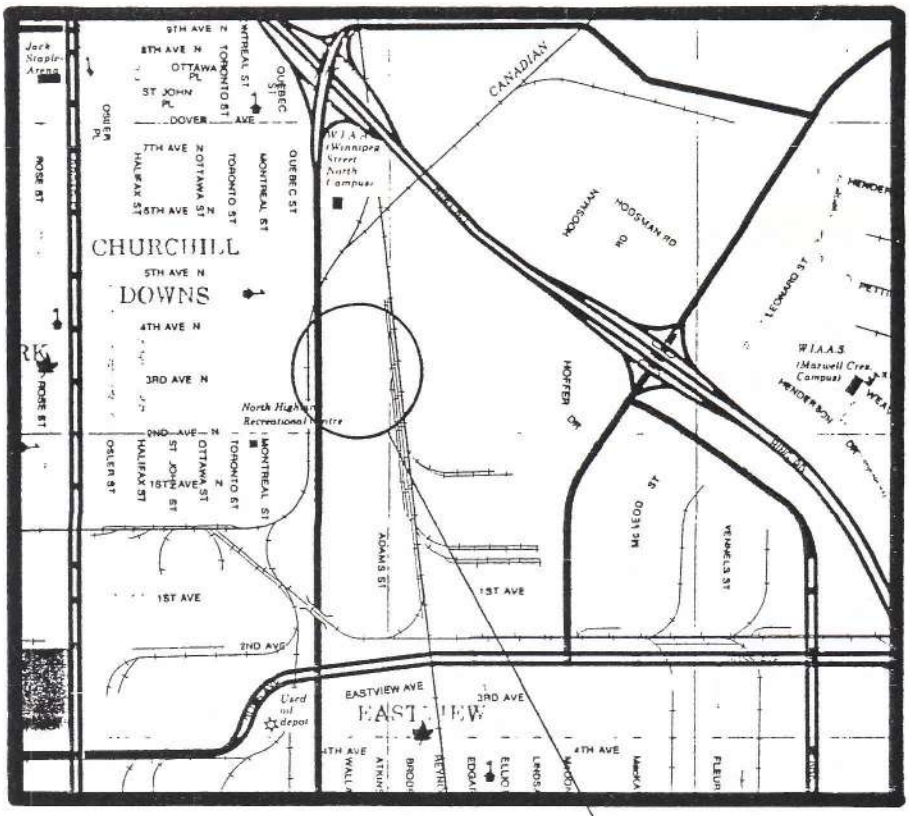
Hydrocarbon contamination of the site became evident in 1980 following a Geotechnical Investigation conducted by Ground Engineering Ltd. for the Transit Centre (refer to Ground Engineering Ltd. report dated October 7, 1980 File No. GE-620). At that time, it was noted that considerable contamination from hydrocarbons was present in the subsoils to depths of 7 to 10 metres. This contamination was found in all test holes drilled on the site. This geotechnical investigation based the conclusion of hydrocarbon contamination upon visual examination and odour, and did not attempt to determine actual hydrocarbon extent or concentration.

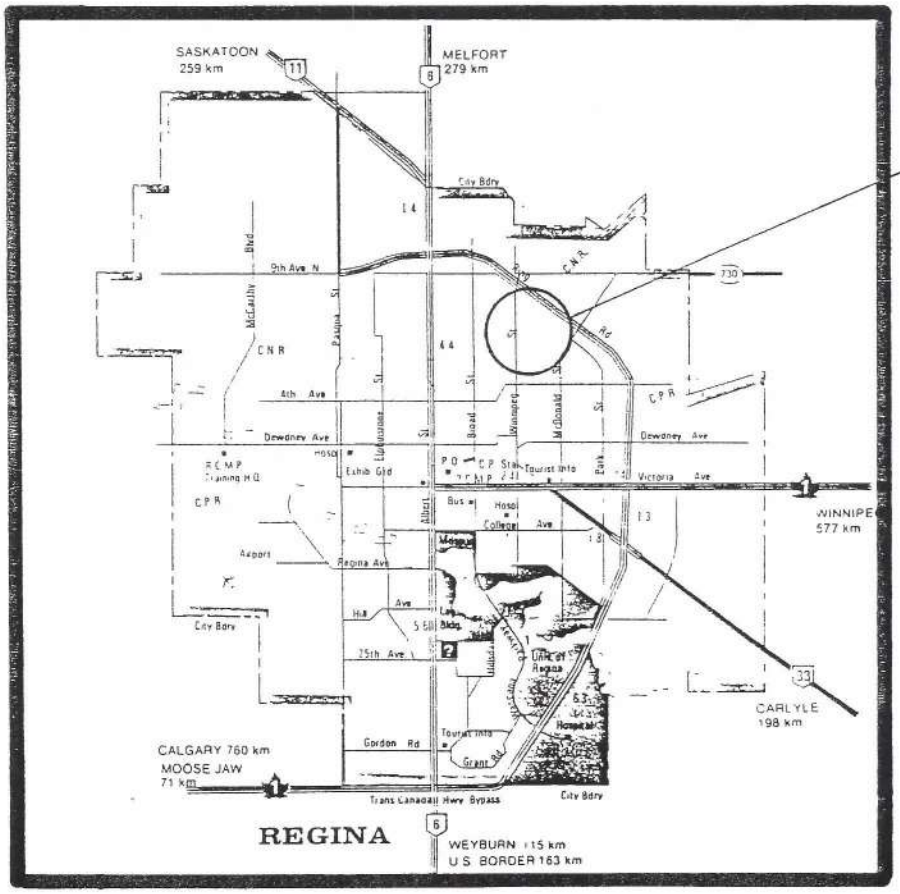
3.0 DESCRIPTION OF THE SITE

The study area as shown in Figure 1 is to located east of the 200 to 300 Block of Winnipeg Street in northeast Regina, Saskatchewan. The topography is relatively flat with the ground surface varying less than about 1 metre across the entire property.

4.0 FIELD AND LABORATORY INVESTIGATION

The subsurface soil conditions were investigated by a total of six (6) test borings drilled at the locations shown on Drawing No. GE-620-1. These test holes were drilled on April 3, 1986 using a Brat Model B22 digger equipped with a 150 mm diameter continuous flight auger to depths ranging from 8.2 to 11.3 metres below existing ground surface. Following test drilling, the test holes were left open for 24 hours to establish the location of any local water





STUDY AREA

FIGURE 1

Location of Study Area

tables and then backfilled with granular bentonite to ground surface. All test holes were drilled in the area for the proposed location of the Transit Operations Centre.

Representative disturbed and undisturbed soil samples were recovered from the test borings and taken to our laboratory for analysis. Each soil sample was visually classified and a natural moisture content test was performed on each soil sample. An estimate of the shear strength of the undisturbed soil samples was made using both a pocket penetrometer and a laboratory vane shear apparatus. Details of the soil profile, samples taken, laboratory test results and stratigraphic interpretation of the subsoils are appended to this report on Drawings No. GE-620-6 to -12 inclusive.

In addition, selected undisturbed soil samples were packaged and sent to the Saskatchewan Research Council (SRC) laboratory in Saskatoon, Saskatchewan for chemical analysis. Prior to packaging, the soil samples were fully trimmed and then wrapped in clean aluminum foil from which all possible residues of vegetable oil were removed. These precautions were undertaken to prevent possible cross-contamination of hydrocarbons or contamination from vegetable oil which could affect the accuracy of the chemical analysis.

5.0 GEOTECHNICAL ANALYSIS

5.1 Stratigraphy

The approximate boundaries of the various stratigraphic units encountered are illustrated in the cross-sections (Drawing GE-620-6) and the test hole logs.

The drilling information indicates that the site is overlain with an expansive, silty clay which extends to a depth of 5.8 to 8.5 metres below existing ground surface. This material is primarily highly plastic clay with numerous silt layers near its base. It is stiff, laminated, and moist with a water content close to the plastic limit. The clay is very nuggety with

numerous clearly developed slickenslides and prominent iron and manganese staining. The number of silt layers increases with depth. The silty clay is very dark gray in color to a depth of about 4.0 metres and olive brown in color below this depth. The very dark gray color is not considered to be a normal color of the clay in the Regina area and is probable due to hydrocarbon contamination.

Fill material was encountered in two (2) of the six (6) test holes drilled for this investigation. The fill material in Test Hole 108 was mostly clay with some gravel and rubble, and was encountered to a depth of 1.5 metres. The fill in Test Hole 113 was sand and gravel, and was encountered to a depth of 300 mm.

The surficial silty clay is underlain by silt and till stratigrphic units as shown in Drawing No. GE-620-1. Beneath most of the site a clayey silt unit directly underlies the surficial clay followed by a till stratigraphic unit. This is the situation most often encountered in the Regina area. However, in two of the test holes a till unit was encountered on top of the silt. This is occasionally encountered elsewhere but is not a normal occurance.

Where encountered, the silt is clayey, laminated, moist and stiff. It generally becomes sandy with depth. There is some evidence to indicate that the silt is fractured at this site. Occasionally, thin interbedded till seams were encountered.

The till units encountered are heterogeneous mixture of gravel, sand, silt and clay with occasional cobblestones and boulders. They are moist and stiff to hard in consistency.

5.2 Groundwater

Groundwater was encountered in only one test hole (TH 108) drilled for this investigation. In this test hole a water table was encountered at a depth of

2.0 metres below ground surface. It is considered that the water table is local in aerial extent and is most probable due to an open water filled excavation directly north of this area.

6.0 DISCUSSION

6.1 Level of Contamination

Visual examination of soil samples from this site has indicated that all samples from the clay stratigraphic unit have a strong odour of hydrocarbons. The strongest odours are from those samples near ground suface and at the clay/silt and/or till contact. The soil samples from the till and silt units had a very low odour of hydrocarbons except where fractures were clearly evident.

A total of eight (8) undisturbed soil samples out of four (4) test holes were chemically analyzed to determine hydrocarbon concentration. In addition, one of these samples was also analyzed for trace constituents and metals. A summary of the soil samples analyzed and the results of the chemical analysis is shown in Table 1 with the SRC laboratory forms shown in Appendix A. Figure 2 graphically indicates the concentration of hydrocarbons in relation to the soil stratigraphy.

Table 1 and Figure 2 indicate that the hydrocarbon concentration is generally less than 1000 parts per million (ppm) (i.e. 0.1%). The exceptions are Sample No. 17, TH 113 at a depth of 1.5 m, and Sample No. 26, TH 112 at a depth of 6.1 m. The hydrocarbon concentrations of these samples were 4200 and 13,500 ppm, repectively. This latter concentration converts to 1.35% which is considered a relatively high level of contamination. The chemical analysis from SRC generally indicated that the hydrocarbons were similar to diesel.

The highest hydrocarbon concentration of 13,500 ppm was located at the base of the surficial clay unit and on the top of a 1.1 metre thick till unit. This is the most likely location in which to find high concentrations considering

TABLE 1 SUMMARY OF CHEMICAL ANALYSES

TEST HOLE	SAMPLE NUMBER	DEPTH (m)	CHEMICAL ANALYSIS		
TH 108	#30	1.5	Hydrocarbon	88 ppm	
	#33	6.1	Hydrocarbon	470 ppm	
TH 111	#36	1.5	Hydrocarbon	840 ppm	
TH 112	#23	1.5	Hydrocarbon	730 ppm	
	#25	4.6	Hydrocarbon	540 ppm	
	#26	6.1	Hydrocarbon	13,500 ppm	(i.e. 1.35%)
	#28	9.1	Hydrocarbon	<20 ppm	
TH 113	#17	1.5	Hydrocarbon	4,200 ppm	

TRACE CONSTITUENTS

TH 112	#23	1.5	B	11 ppm
			Hg	<0.05 ppm
			P	580 ppm
			Phenol	0.5 ppm

TRACE METALS

Ag	<0.001	ppm
Al	52,000	ppm
As	11	ppm
Ba	370	ppm
Be	7	ppm
Ca	24,000	ppm
Cd	<1	ppm
Co	15	ppm
Cr	29	ppm
Cu	31	ppm
Fe	38,000	ppm
K	11,000	ppm
Mg	15,000	ppm
Mn	520	ppm
Mo	48	ppm
Na	1,100	ppm
Ni	42	ppm
Pb	73	ppm
Ti	1,100	ppm
V	110	ppm
W	<1	ppm
Zn	100	ppm

PHYSICAL PROPERTIES

Ph on solids (50% slurry)	8.07

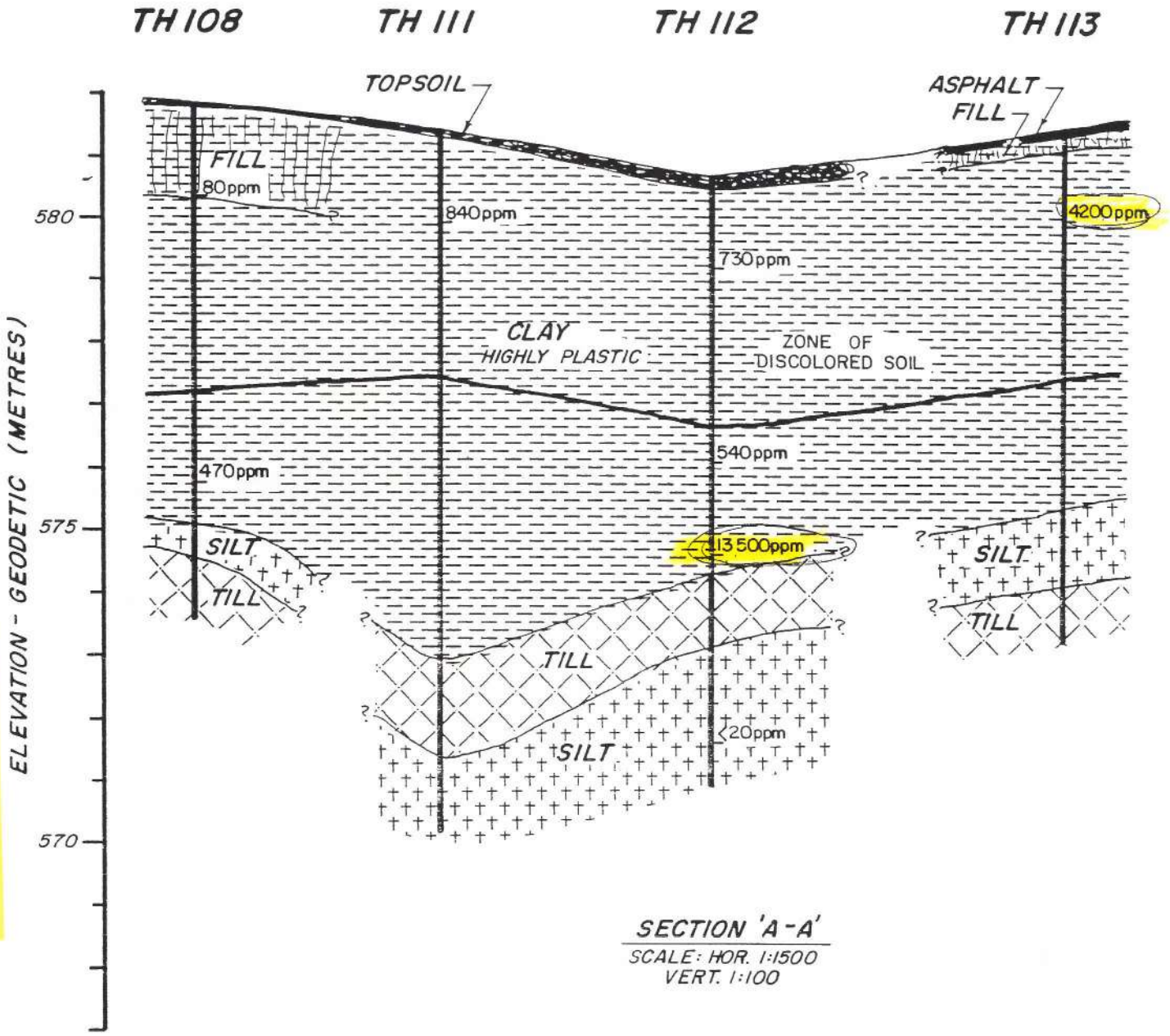


FIGURE 2 CONCENTRATIONS OF HYDROCARBONS

the nature of the soils encountered. The surficial clay is highly fractured. Thus, any hydrocarbon material accidentally spilled on the site would easily descend along these fractures to depth either carried by gravity or by water seepage. In contrast, the till stratigraphic unit and even the silt unit isfractured to a much lesser extent. Thus, at a minimum, both the till and silt stratigraphic unit will probably act as a low level barrier to the migration of hydrocarbons. Therefore, the highest concentrations of hydrocarbons should be near the contact between the clay and the silt or till.

Only one chemical analysis was performed on a sample from the silt stratigraphic unit. This analysis indicated a hydrocarbon concentration of less than 20 ppm. Visual examination and the odour of undisturbed sample from the silt (and the till as well) would generally indicate that hydrocarbon concentration was low. Therefore, it would appear that the underlying silt and till stratigraphic unit may be relatively free from hydrocarbon contamination except where fractures are present.

The analysis of trace constituents and trace metals did not indicate contamination of the site by materials other than hydrocarbons. The concentration of these trace materials are what could be considered near normal for the types of soils at the site. However, only one sample was analyzed for trace materials, and there is a possibility that some other type of contamination may be present in other areas of the site.

6.2 Potential Effects of Contamination

The investigation of hydrocarbon contamination at the site of the proposed City of Regina Transit Operations Centre has indicated that concentrations of hydrocarbons in the surficial clay vary between 80 and 13,500 ppm. Considering the extent of the site, the depth to which contamination was encountered, and the fact that the highest level of contamination was found with depth, hydrocarbon contamination is considered potentially severe.

The implications of this hydrocarbon contamination upon the proposed Transit Operations Centre mostly concern safety, both during construction and following completion of the facility. There is a potential for explosions should gas collect in confined areas and should there be a nearby source of sparks. As well, the odour of the hydrocarbons is very strong and in the most severe cases there is a possibility of workment collapsing due to the fumes. In other cases, the hydrocarbon odour may just be an irritant.

The potential problems of the hydrocarbon gas and odour can be minimized with careful attention to design and safety. A good ventilation system should solve most problems. In addition, if a barrier to gas migration could be placed on the subgrade below the building, and if all floor slabs were structurally supported with a ventilated crawlspace, the potential problems with gas could almost be eliminated.

The hydrocarbon contamination at this site also have implications which go beyond the proposed Transit Operations Centre. The "A" Zone of the Regina Aquifer may be located at a depth of about 14.9 to 18.3 metres below grade while the "B" Zone of the Aquifer may be located at a depth of about 22.6 to 32.0 metres (Interim Report on Installation of Mount Pleasant - Imperial Oil Groundwater Monitoring Systems, Beckie Hydrogeologists Ltd., January 23, 1986). Since the deepest and heaviest hydrocarbon contamination detected in this study is at a depth of approximately 6.1 metres, there is a potential of hydrocarbon contamination migrating deeper into the "A" Zone of the Regina Aquifer. This possibility should be carefully studied since it has some implications for the City of Regina water supply.

7.0 RECOMMENDATIONS

Due to the extent and degree of hydrocarbon contamination at this site, it is recommended that the City of Regina carefully consider the implications of the contamination upon the proposed Transit Operations Centre and upon possible contamination of the underlying Regina Aquifer. As well, it be recommended

that the City of Regina contact the appropriate environmental agency which has jurisdiction over this site and discuss with them the results of this investigation.

The eight (8) hydrocarbon analysis conducted for this investigation are not considered to constitute a detailed and exhaustive investigation of contamination at this site. Rather, this amount of testing constitutes a scan of the site to determine the potential for contamination. Therefore, further chemical analysis and test drilling may have to be performed to establish the true extent of hydrocarbon contamination. The remaining undisturbed soil samples from this investigation have been retained in our office, and further chemical analysis may be initiated on these samples prior to further possible test drilling.

8.0 CLOSURE

Should you have any questions whith regards to this matter, please contact this office.

Yours very truly,

GE GROUND ENGINEERING LTD.

Walter Buettner

Prepared by: WALTER BUETTNER, P.ENG.

Reviewed by: PAUL KOZICKI, P.ENG.

WB/elb
Distribution: Building Design 2 Ltd. (6 copies)
Office (1 copy)

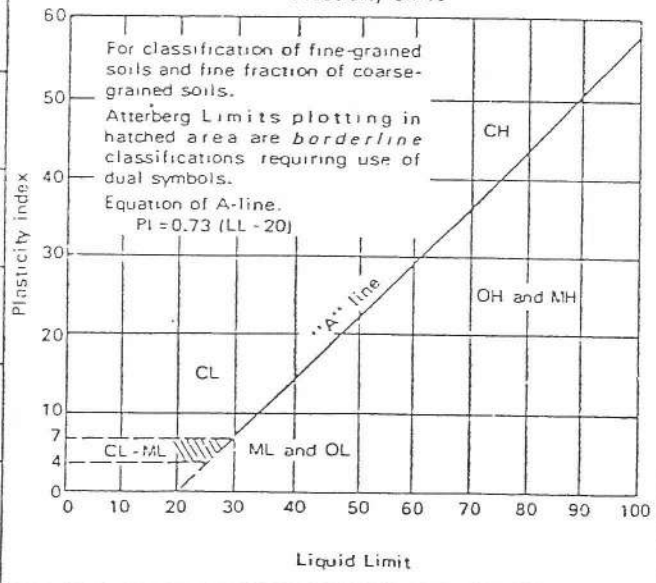
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 69 AND D 2488 – 69

(Unified Soil Classification System)

Major divisions			Group symbols	Typical names	Classification criteria	
Coarse-grained soils: More than 50% retained on No. 200 sieve*	Gravels: 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines: Less than 5% pass No. 200 sieve . . . . . GW, GP, SW, SP; More than 12% pass No. 200 sieve . . . . . GM, GC, SM, SC; 5 to 12% pass No. 200 sieve . . . . . *Borderline* classifications requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4. $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 / Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7 / Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
	Sands: More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 / Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7 / Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
Fine-grained soils: 50% or more passes No. 200 sieve*	Silts and clays: Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays: Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity		
	Highly organic soils		Pt	Peat, muck and other highly organic soils		

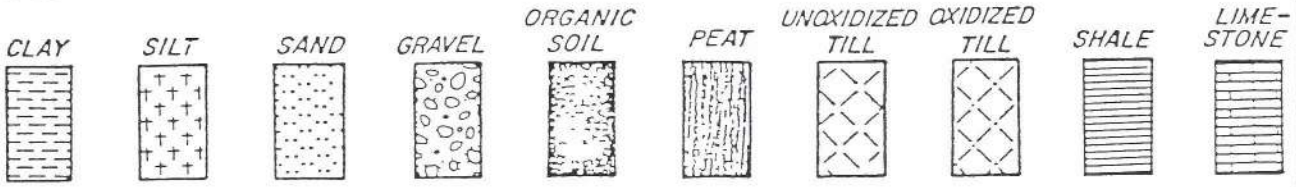
Plasticity Chart



*Based on the material passing the 3 in. (76 mm) sieve.

SE-1 (70-A)

SYMBOLS AND TERMS USED IN THE REPORT



The Symbols May Be Combined to Denote Various Soil Combinations, The Predominant Soil Being Heavier.

RELATIVE PROPORTIONS

TERM	RANGE
Trace	0 - 5%
A Little	5 - 15%
Some	15 - 30%
With	30 - 50%

CLASSIFICATION BY PARTICLE SIZE

Boulder	Over 8"
Cobble	3" - 8"
Gravel -	
Coarse	3/4" - 3"
Fine	#4 - 3/4"
Sand -	
Coarse	#4 = #10
Medium	#10 - #40
Fine	#40 - #200
Silt	#200 - 0.002 mm.
Clay	Finer Than 0.002 mm.

NOTE:
Sieve Sizes Shown Are Canadian Standard

DENSITY OF SANDS AND GRAVELS

DESCRIPTIVE TERM	RELATIVE DENSITY	STANDARD PENETRATION TEST
Very Loose	0 - 15%	0 - 4 Blows Per Foot
Loose	15 - 35%	4 - 10 Blows Per Foot
Medium Dense	35 - 65%	10 - 30 Blows Per Foot
Dense	65 - 85%	30 - 50 Blows Per Foot
Very Dense	85 - 100%	Over 50 Blows Per Foot

CONSISTENCY OF CLAYS AND SILTS

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH - TONS/SQ. FT.	N VALUE STANDARD PENETRATION TEST	REMARKS
Very Soft	Less Than 0.25	Less Than 2	Can Penetrate with Fist
Soft	0.25 - 0.50	2 - 4	Can Indent with Fist
Firm	0.50 - 1.0	4 - 8	Can Penetrate with Thumb
Stiff	1.0 - 2.0	8 - 15	Can Indent with Thumb
Very Stiff	2.0 - 4.0	15 - 30	Can Indent with Thumb-Nail
Hard	4.0 and Greater	Greater Than 30	Cannot Indent with Thumb-Nail

NOTES: 1. Relative Density Determined by Standard Laboratory Tests.
2. N Value - Blows/Ft. of a 140 Lb. Hammer Falling 30 In. on a 2 In. O.D. Split Spoon

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SYMBOLS AND TERMS USED IN THE REPORT (continued)

GROUNDWATER

Water level measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soil, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious waterbearing soil are present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.

Water level determined by piezometer installation - In all soils the levels can be considered reliable groundwater levels.

DESCRIPTIVE SOIL TERMS

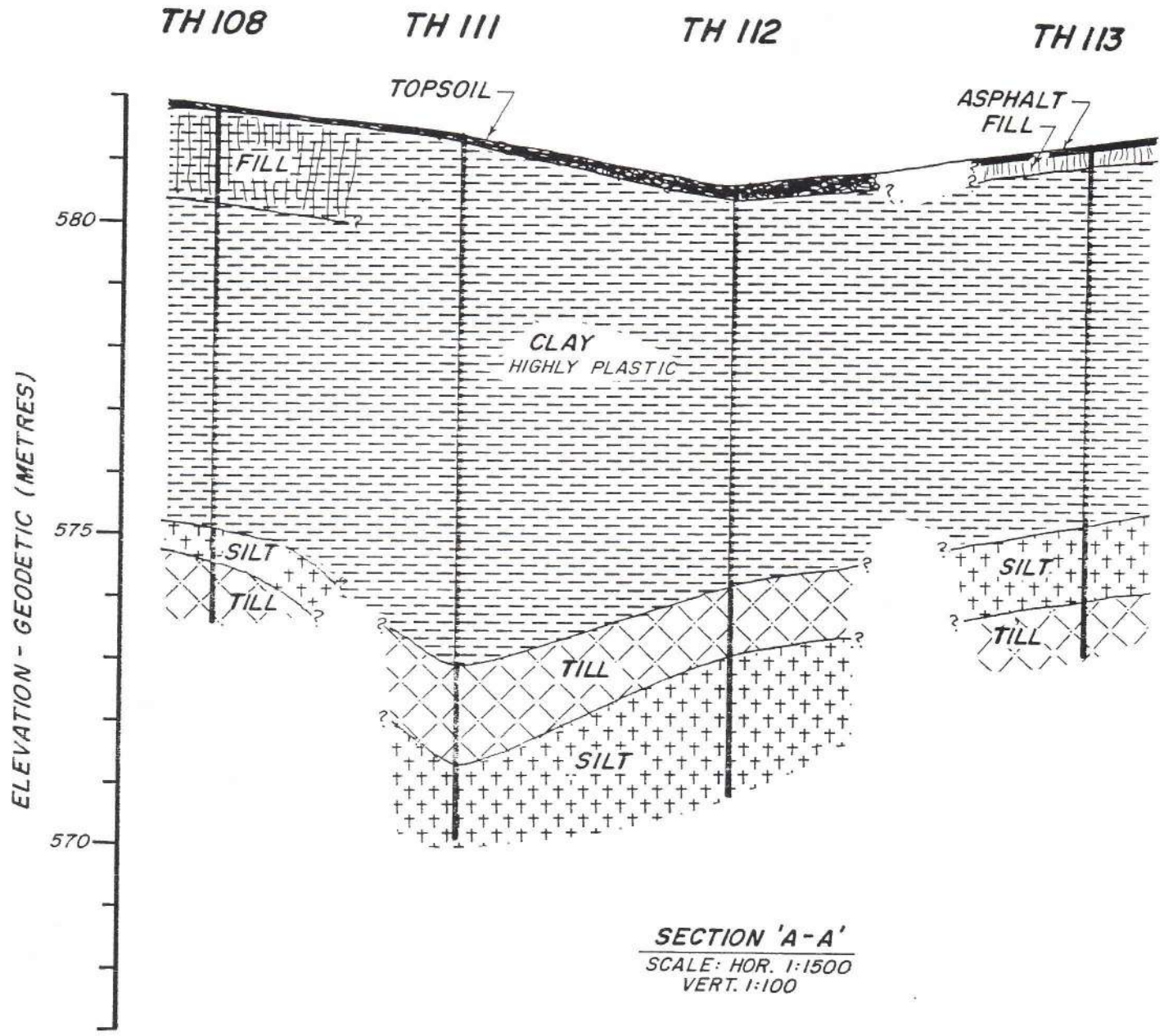
Well Graded	-	Having wide range of grain sizes and substantial amounts of all intermediate sizes.
Poorly Graded	-	Predominantly of one grain size.
Slickensides	-	Refers to a clay that has planes that are slick and glossy in appearance; slickensides are caused by shear movements.
Sensitive	-	Exhibiting loss of strength on remolding.
Fissured	-	Containing cracks, usually attributable to shrinkage. Fissured clays are sometimes described as having a nuggetty structure.
Stratified	-	Containing layers of different soil types.
Organic	-	Containing organic matter; may be decomposed or fibrous.
Peat	-	A fibrous mass of organic matter in various stages of decomposition. Generally dark brown to black in color and of spongy consistency.
Bedrock	-	Preglacial Material.
Drift	-	Material deposited directly by glaciers or glacial melt-water.
Alluvial	-	Soils that have been deposited from suspension from moving water.
Lacustrine	-	Soils that have been deposited from suspension in fresh water lakes.

DRILLING AND SAMPLING TERMS

SYMBOL	DEFINITION
C.S.	Continuous Sampling
Sy	3 Inch Thin Wall Tube Sample
Sy(2)	2 Inch Thin Wall Tube Sample
SS	2 Inch O.D. Split Spoon Sample
Blows / Ft.	"N" Value - Standard Penetration Test
Bag	Disturbed Bag Sample
No.	Sample Identification Number
⟶	Piezometer Tip
S.I.	Slope Indicator
SPG⟶	Observed Seepage

LABORATORY TEST SYMBOLS

SYMBOL	DEFINITION
○	Moisture Content - Percent of Dry Weight
⊢⟶	Plastic and Liquid Limit Determined in Accordance with ASTM D-423 and D-424
▲	Dry Density - Pounds per Cubic Foot
■	Shear Strength - As Determined by Unconfined Compression Test
⊠	Shear Strength - As Determined by Field Vane
□	Shear Strength - As Determined by Pocket Penetrometer Test
% SO_4	Water Soluble Sulphates - Percent of Dry Weight
M.A.	Grain Size Analysis



SECTION 'A-A'

SCALE: HOR. 1:1500
VERT. 1:100

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes, the boundaries are assumed from geological evidence and may be subject to considerable error.

GROUND ENGINEERING LTD. CIVIL AND GEOTECHNICAL ENGINEERS **REGINA, SASKATCHEWAN**	STRATIGRAPHIC CROSS SECTION 'A-A' PROPOSED TRANSIT OPERATIONS CENTRE REGINA, SASKATCHEWAN		
CLIENT BUILDING DESIGN 2 LTD.	APPROVED	DATE April, 1986	DWG No. GE-620-6

TEST HOLE LOG

HOLE NO. 108

DATE April 3, 1986

SAMPLE DATA | WEIGHT HAMMER | HEIGHT DROP

ELEV COLLAR

ELEV GROUND 581.85 m (Geodetic Datum)

CO-ORD LOCATION

SHEAR STRENGTH KIPS SQ FT ■ UNCONFINED □ POCKET PEN 1/2" LAB VANE (2, 4, 6, 8)

▲ DRY DENSITY LBS CU FT (80, 90, 100, 110, 120)

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT (10, 30, 50, 70, 90%)

DEPTH ELEV	NO TYPE	UNIT P.	% SO.	SYMBOL	DESCRIPTION OF MATERIAL
300mm	29 Bg			25mm	TOPSOIL
					FILL - clayey, moist, soft - rubble - below 1.0m, gravel, wet - silty
1.5m	30 Sy			1.5m	CLAY - highly plastic - calcareous - oxidized - very dark gray (2.5y 3/0) becoming olive brown (2.5y 4/4) and mottled below 4.6m - fractured and nuggety - moist, stiff - silt lenses - iron stains - salt streaks
3.0m	31 Bg				
4.6m	32 Sy				
6.1m	33 Sy			6.8m	SILT - clayey - oxidized, light brownish gray (2.5y 6/2) - moist, firm
7.6m	34 Sy			7.3m	TILL - clay, silty - calcareous - oxidized - very dark grayish brown (2.5y 3/2) - moist, hard
				8.2m E.O.H.	

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150mm diameter auger.
2. No water seepage.
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

TEST HOLE LOG

DATE April 3, 1986

HOLE NO. 109

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

ELEV COLLAR

ELEV GROUND 581.72 m (Geodetic Datum)

CO-ORD LOCATION

SHEAR STRENGTH KIPS SQ FT
■ UNCONFINED □ POCKET PEN ▽ LAB VANE
2 4 6 8

▲ DRY DENSITY LBS CU FT
80 90 100 110 120

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
10 30 50 70 90%

DEPTH ELEV	NO TYPE	UNIF PI	% SO.	SYMBOL
300mm	1 Bg			
1.5m	2 Sy			
3.0m	3 Bg			
4.6m	4 Sy			
6.1m	5 Bg			
	6 Bg			
7.6m	7 Sy			
9.1m	8 Sy			

DESCRIPTION OF MATERIAL

CLAY - silty
- highly plastic
- calcareous
- oxidized
- very dark gray (2.5y 3/0) becoming olive brown (2.5y 4/4) below 4 m
- fractured and nuggety
- moist and firm, becoming stiff below 4.6 m
- slickensides
- silt lenses
- glauber salts

5.8m

SILT - clayey becoming sandy with depth
- interbedded till lenses between 6.4 and 6.7 m
- laminated
- calcareous
- oxidized
- dark gray (2.5y 4/0) becoming light brownish gray (2.5y 6/2) below 9.1 m.
- moist, stiff
- iron stains

6.4m

6.7m

9.1m E.O.H.

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150 mm diameter auger.
2. No water seepage.
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

TEST HOLE LOG

DATE April 3, 1986

HOLE NO. 110

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

ELEV. COLLAR

ELEV GROUND 581.70 m (Geodetic Datum)

CO-ORD LOCATION

SHEAR STRENGTH KIPS/SQ. FT. ■ UNCONFINED □ POCKET PEN. ▽ LAB VANE

▲ DRY DENSITY LBS. CU. FT.

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT

DEPTH ELEV	NO. TYPE	UNIT WT.	% SO.	SYMBOL
300mm	9 Bg			
1.5m	10 Sy			
3.0m	11 Bg			
4.6m	12 Sy			
6.1m	13 Bg			
7.6m	14 Sy			
9.1m	15 Sy			

DESCRIPTION OF MATERIAL

CLAY - silty
- highly plastic
- calcareous
- oxidized
- very dark gray (2.5y 3/0) becoming olive brown (2.5y 4/4) below 4 m
- silt lenses below 2.4 m
- fractured and nuggety
- moist, stiff
- iron stains
- interbedded till between 5.6 and 5.8 m

5.6m
5.8m

SILT - clayey becoming sandy with depth
- calcareous
- oxidized
- mottled, gray (2.5y 5/0) to dark grayish brown (2.5y 4/2)
- fractured
- moist, stiff
- laminated

7.0m

9.7m E.O.H.

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150 mm auger.
2. Water at depth of 2.0 m immediately after drilling and 23 hours after drilling. Soil sloughing noted to depth of 6.0 m 23 hours after drilling
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

TEST HOLE LOG

DATE April 3, 1986 HOLE NO. 111

SAMPLE DATA | WEIGHT HAMMER | HEIGHT DROP

ELEV. COLLAR

ELEV GROUND 581.43 m (Geodetic Datum)

CO-ORD. LOCATION

SHEAR STRENGTH KIPS SQ FT ■ UNCONFINED □ POCKET PEN ▽ LAB VANE (2, 4, 6, 8)

▲ DRY DENSITY LBS CU FT (80, 90, 100, 110, 120)

PLASTIC LIMIT — WATER CONTENT o — LIQUID LIMIT (10, 30, 50, 70, 90%)

DEPTH ELEV	NO TYPE	UNIT Pt	% SO.	SYMBOL	DESCRIPTION OF MATERIAL
300mm	35 Bg			25mm	TOPSOIL
1.5m	36 Sy				CLAY - silty - highly plastic - calcareous - oxidized - very dark gray (2.5y 3/0) becoming olive brown (2.5y 4/4) below 4 m - fractured and nuggety - slickensided - moist, stiff - salt crystals - silt lenses - iron stains
3.0m	37 Bg				
4.6m	38 Bg				
6.1m	39 Sy				TILL - calcareous - oxidized - very dark gray (2.5y 3/0) - silt lenses - iron stains - moist, stiff - fractured and slickensided
7.6m	40 Sy			8.5m	
9.1m	41 Sy				SILT - sandy - calcareous - oxidized, light brownish gray (2.5 6/2) becoming unoxidized dark gray (5y 4/1) below 10.5 m - stiff, laminated - dry to moist
10.7m	42 Sy			10.1m	
				11.3m E.O.H.	

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150 mm diameter auger.
2. No water seepage.
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

TEST HOLE LOG

DATE April 3, 1986 HOLE NO. 112

SAMPLE DATA | WEIGHT HAMMER | HEIGHT DROP

ELEV. COLLAR

ELEV GROUND 580.65 m (Geodetic Datum)

CO-ORD. LOCATION

SHEAR STRENGTH KIPS SQ FT ■ UNCONFINED □ POCKET PEN ⊿ LAB VANE 2 4 6 8

▲ DRY DENSITY LBS CU FT 80 90 100 110 120

PLASTIC LIMIT | WATER CONTENT | LIQUID LIMIT

10 30 50 70 90%

DEPTH ELEV	NO TYPE	LINE P1	% SO.	SYMBOL	DESCRIPTION OF MATERIAL
300mm	22 Bg				200mm TOPSOIL
1.5m	23 Sy				CLAY - silty - highly plastic - calcareous - oxidized - very dark gray (2.5y 3/0) becoming olive brown (2.5y 4/4) below 4 m - fractured, nuggety - silt lenses - silty below 4.6 m - moist, stiff - salt crystals
3.0m	24 Bg				
4.6m	25 Sy				TILL - clay - moist, stiff - fractured
6.1m	26 Sy				
					6.4m
7.6m	27 Sy				SILT - sandy - calcareous - oxidized - dark grayish brown (2.5y 4/2) - fractured - iron stains - moist, stiff - laminated
9.1m	28 Sy				
					7.5m
					9.8m E.O.H.

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150 mm diameter auger.
2. No water seepage.
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

TEST HOLE LOG

DATE April 3, 1986

HOLE NO. 113

SAMPLE DATA				SYMBOL	
WEIGHT HAMMER					ELEV. COLLAR
HEIGHT DROP					ELEV GROUND 581.43 m (Geodetic Datum)
					CO-ORD LOCATION
DEPTH ELEV	NO TYPE	UNIF PI	% SO.		DESCRIPTION OF MATERIAL

SHEAR STRENGTH KIPS SQ FT
■ UNCONFINED □ POCKET PEN ☒ LAB VANE
2 4 6 8
▲ DRY DENSITY LBS CU FT
80 90 100 110 120

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
10 30 50 70 90%

300 mm 16 Bg
1.5m 17 Sy
3.0m 18 Bg
4.6m 19 Sy
6.1m 20 Sy
7.6m 21 Sy

50mm
300mm — ASPHALT

FILL - gravel, sand
- dry, moist

CLAY - silty
- highly plastic
- calcareous
- oxidized
- very dark gray (2.5y 3/0) becoming olive brown (2.5y 3/0) below 4 m
- fractured, nuggety
- silt lenses
- moist, stiff
- slickensided

6.1m

SILT - sandy
- calcareous
- oxidized
- dark grayish brown (2.5y 4/2)
- fractured
- laminated
- moist, stiff
- iron stains

7.3m

8.2m E.O.H.

TILL - clay
- moist, stiff
- iron stains
- fractured

NOTES:

1. Drilled using a Brat Model 22 digger equipped with a 150 mm diameter auger.
2. No water seepage.
3. Soil contaminated with hydrocarbons.
4. Test hole backfilled to surface with bentonite.

GROUND ENGINEERING LTD.
GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED CITY OF REGINA TRANSIT OPERATIONS CENTRE

LOCATION REGINA, SASKATCHEWAN

SASKATCHEWAN RESEARCH COUNCIL

APR 24 '86

Ground Engineering Ltd.
415 7th Avenue
Regina, Saskatchewan S4S 4P1
Attn: Walter Buettner

Date Samples Received: 10-Apr-86 Client P.O.:

SAMPLE	CLIENT DESCRIPTION
3455	#17 (GE-620) *SOIL*
3456	#25 *SOIL*
3457	#26 *SOIL*
3458	#28 *SOIL*

ANALYTE	UNITS	3455	3456	3457	3458
GLC Hydrocarbons	ug/g	4200	540	13500	<20

SAMPLE	CLIENT DESCRIPTION
3459	#30 *SOIL*
3460	#33 *SOIL*
3461	#36 *SOIL*

ANALYTE	UNITS	3459	3460	3461
GLC Hydrocarbons	ug/g	80	470	840

Hydrocarbons in samples are similar to diesel,

and are reported on as rec'd basis.

SASKATCHEWAN RESEARCH COUNCIL

Ground Engineering Ltd.

SAMPLE CLIENT DESCRIPTION
3462 #23 (GE-620) *SOIL*

ANALYTE	UNITS	3462
TRACE CONSTITUENTS		
B, ICP-AES	ug/g	11
Hg, solids	ug/g	<0.05
P, ICP-AES	ug/g	580
Phenol, colour.	ug/g	0.5
TRACE METALS		
Ag, ICP-AES	ug/g	<0.001
Al, ICP-AES	ug/g	52000
As, solids	ug/g	11
Ba, ICP-AES	ug/g	370
Be, ICP-AES	ug/g	7
Ca, ICP-AES	ug/g	24000
Cd, ICP-AES	ug/g	<1
Co, ICP-AES	ug/g	15
Cr, ICP-AES	ug/g	29
Cu, ICP-AES	ug/g	31
Fe, ICP-AES	ug/g	38000
K, ICP-AES	ug/g	11000
Mg, ICP-AES	ug/g	15000
Mn, ICP-AES	ug/g	520
Mo, ICP-AES	ug/g	48
Na, ICP-AES	ug/g	1100
Ni, ICP-AES	ug/g	42
Pb, ICP-AES	ug/g	73
Ti, ICP-AES	ug/g	1100
V, ICP-AES	ug/g	110
W, ICP-AES	ug/g	<1
Zn, ICP-AES	ug/g	100
PHYSICAL PROPERTIES		
pH on solids (50% slurry)	pH units	8.07
GLC		
Hydrocarbons	ug/g	730

All results reported on a dry basis except hydrocarbons which is as rec'd.