



Miller Environmental Corporation

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Committed to Leadership in Our Industry

May 13, 2022

Manitoba Conservation and Climate
Environmental Approvals Branch
1007 Century Street
Winnipeg, MB R3H 0W4

Attn: James Capotosto – Director, Environmental Approvals Branch

Dear Mr. Capotosto:

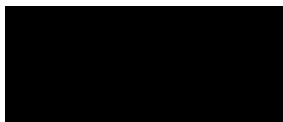
RE: Leachate Crop Irrigation Pilot Project Proposal

Please accept this as Miller Environmental Corporation's proposal to implement a leachate crop irrigation pilot project at Miller's processing facility for 2022. We had an opportunity to present the project on March 15, 2022 to Manitoba Conservation and Climate representatives, including representatives from the Environmental Approvals Branch. Through their comments and suggestions, and with the support of Crocus Environmental Ltd., the provided document explains the details of the pilot project. We look forward to the department's review and approval in the 2-week time period indicated to us during our meeting on March 15th.

If you have any questions, please feel free to contact me at 204-925-9604 or by email at daveh@millerenvironmental.mb.ca.

Sincerely yours,

Miller Environmental Corporation



Dave Howes
Director of Regulatory Affairs

CC: Tyler Kneeshaw – Manitoba Conservation and Climate
Paul Bauer – Vice President/General Manager, Miller Environmental Corporation
Yolo Ortiz – Operations Manager, Miller Environmental Corporation



CROCUS ENVIRONMENTAL LTD.

May 13, 2022

Manitoba Environment, Climate and Parks
Environmental Approvals Branch
123 Main Street, Suite 160
Winnipeg, Manitoba R3C 1 A5

Attention: Mr. James Capotosto, Director

Re:

Dear Mr. Capotosto,

On behalf of Miller Environmental Corporation (MEC), Crocus Environmental is pleased to submit a proposal for a pilot study at the Vaughn Bullough Environmental Center Licence (VBEC), for the implementation of a Pilot Leachate Irrigation Crop.

Currently leachate at the Vaughn Bullough Environmental Centre is treated through leachate evaporation via passive evaporation. Crop irrigation is being proposed as a sustainable alternative leachate treatment methodology to the current enhanced mechanical evaporation technique employed by MEC. Crop irrigation is proposed to reduce gas and odour emission produced through traditional evaporation. Additionally, Miller Environmental has expressed interest in harvesting the crop biomass in order to utilize the material as a bulking agent in other waste treatment processes. Therefore, leachate irrigation will provide a cradle to grave treatment process for leachate.

In the winter of 2020, Crocus Environmental carried out bench scale leachate-phytoremediation treatment experiments on the behalf of Miller Environmental. The findings of this study (presented in the attached report) provide preliminary results that suggest leachate crop irrigation treatment will provide sufficiently sustainable leachate treatment (for Miller Environmental specific leachate). However, a pilot scale project is needed to provide site specific design parameters and field data to assess the full-scale feasibility of this project.

The attached document contains a detailed description of the proposed pilot study and seeks authorization from Manitoba Conservation and Climate (MCC) to implement a field study at the Miller Environmental Vaughn Bullough Environmental Centre.

We would like to request that we here back from the province on this proposal by the end of May.

Given the results found in our bench scale experiments, our teams experience in waste treatment, environmental engineering and agriculture, and Miller Environmental experience in waste management, we are confident that the proposed and sustainable field scale pilot project will provide invaluable results for informing future leachate irrigation projects.

We look forward to hearing from you.

Thank you for your time and consideration.

Sincerely,

Crocus Environmental

CEO

Kenton McCorquodale-Bauer

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1. Background

1.1. Miller Environmental Corporation Facility

Miller Environmental Corporation (MEC) operates a licensed hazardous waste treatment facility (VBEC) that is located 70km south of Winnipeg. MEC provides environmentally sustainable hazardous waste management solutions for industry and residential customers. In the treatment and disposal of hazardous waste, approximately 10,000 m³ of leachate can be produced annually at the MEC's facility. The treatment of leachate can be costly and resource heavy. Additionally, leachate treatment methods often require high energy and chemical inputs.

1.2. Preliminary Research – Feasibility study on the application of crop irrigation for leachate management

In 2020, Crocus Environmental Ltd. (Crocus) was retained to conduct a feasibility study on the application of an innovative crop irrigation plan for leachate management at the MEC's facility. Leachate crop irrigation is basically a method for reusing the leachate and provides a cost effective and environmentally friendly alternative to traditional leachate treatment methods. This is in line with MEC's reputation as an environmental process leader. MEC's location and abundance of land makes leachate crop irrigation a potential solution for large volume leachate treatment.

Crocus research team worked closely with MEC's staff from August 2020 to May 2021 and conducted a series of experiments. Leachate characterization was done by taking multiple samples from different spots in the leachate pond and on different dates. A wide range of crops were studied and eventually two common forage crops, tall wheat grass and alfalfa were selected for bench-scale experiments. The crops were planted in soil, collected from the proposed crop location at the VBEC. Cylindrical planters (7in x 6 in) were used to grow the plants and the irrigation was done over two growth periods (each ~30 days) with various dilutions of leachate collected from the VBEC leachate pond on October 20th, 2020.

The results of the experiment suggested that the use of tall wheatgrass for the treatment of MEC's leachate through crop irrigation, is potentially an appropriate and effective phytoremediation method. Wheatgrass outperformed alfalfa in every measured parameter. Wheatgrass did not appear to be negatively affected by any concentration of leachate. Based on the soil analysis results, it was concluded that the use of 100% leachate, assuming leachate parameters remain consistent with those tested in this report, was sustainable for wheatgrass crop irrigation treatment. The majority of total metals examined in experiments were below CCME agricultural guidelines. The total uptake of the majority of examined metals by wheatgrass appeared to outstrip the amount of metals that would be delivered to the crop suggesting that significant metal accumulation in soil would not occur over time. The methodology and results of the bench experiment are discussed in detail in section 5.

2. Project Methodology

2.1. Overview

The field study will be carried out at the Miller Environmental Vaughn Bullough Center and will involve Crocus Environmental personnel and Miller Environmental employees. Leachate will be pumped from the leachate pond (shown in fig 1.) to pre-treatment tanks. Inside the tanks a chemical pre-treatment will be applied to the leachate to treat odour and sulfides. From the pre-treatment tanks, leachate will be pumped onto the leachate pilot crop. As a part of the proposed field study, pre-treatment-aeration retention time will be determined by measuring the required electroconductivity equilibration time within the aeration tank. From the aeration tanks, leachate will be pumped to the pilot crops and delivered through perforated soaker hoses. Soaker hoses will be used for crop irrigation rather than sprinklers to reduce leachate odor release.

2.2. Leachate Pre-Treatment

Miller Environmental has worked with Orin Remediation to develop a chemical pre-treatment of their leachate. The pre-treatment is a low dose addition of Orin Activator Solution catalyst and hydrogen peroxide. Lab scale results have shown that the addition of this chemical treatment significantly reduces leachate odour and sulfate concentration. Leachate will be pumped to a pre-treatment tank where it will be chemically pretreated for a time duration to be determined from the results of the proposed pilot scale study. Lastly the leachate will be filtered to remove solids. Figure 1, illustrated the pre-treatment design. Lab scale analysis has shown that with the addition of the chemical pre-treatment, filtration clear leachate. It is expected that after the pre-treatment process has been applied that the leachate will have improved parameters from the non-pretreated leachate parameters outlined in this report. From the aeration tanks the leachate will be delivered to the treatment crop through soaker hoses.

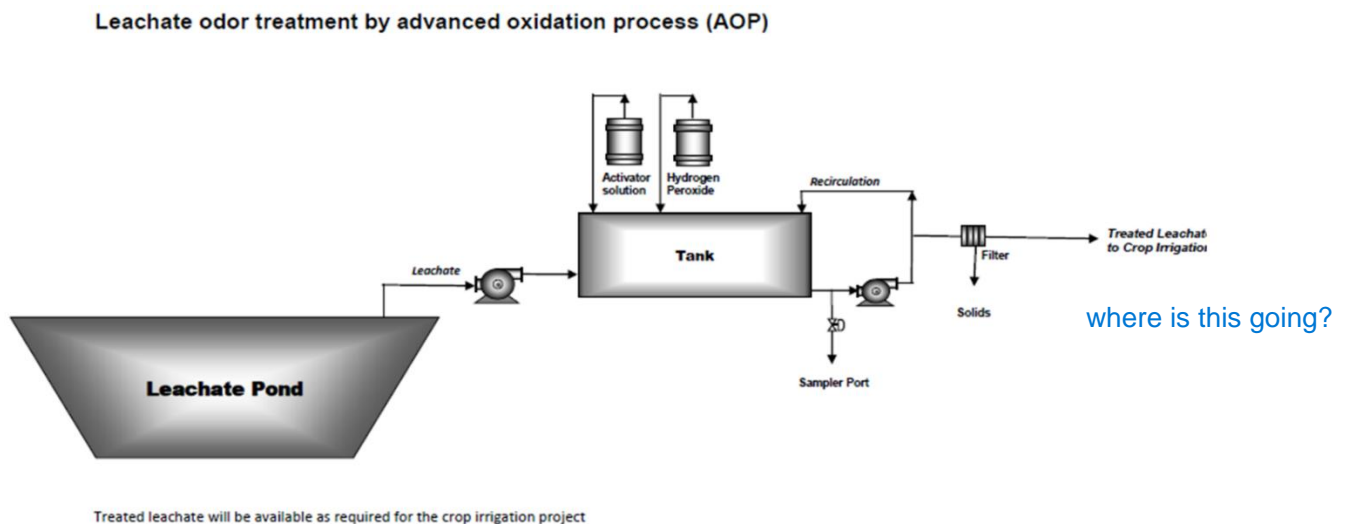


Figure 1 – Pre-Treatment System

2.3. Crop Type

Tall wheatgrass has been selected as the crop type to be used in the proposed pilot study. It was chosen based on its salt resistance, pH tolerance, water uptake, and growth rate. Additionally, tall wheatgrass outperformed alfalfa (a commonly used leachate treatment crop) in bench scale tests performed by Crocus Environmental (discussed in section 6) which evaluated the performance of each plant for the phytoremediation of Miller Environmental specific leachate.

Tall wheatgrass cultivation generally consists of two harvesting events. It is proposed to have two planting/harvesting events to test the feasibility of using the leachate for crop irrigation under different weather conditions. The proposed periods are May 15, 2022 to June 15, 2022 and July 1, 2022 to August 1, 2022. The four weeks growth periods are suggested based on the results of the phase I of the project and are subject to change based on the observations during the growth periods.

2.4. Crop Location

The pilot crop will be planted on a strip of land west of the leachate pond and east of the outer west drainage ditch. This location seems favorable due to its proximity to the leachate pond. Additionally, the land is sheltered from surface water accumulation by the west drainage ditch. For the pilot experiments, an area of 30m×35m (approximately 0.5 acres) will be used.



Figure 2 – Proposed Crop Location

Figure 2. illustrates the approximate proposed location of the proposed pilot crop area (shown in orange). The crop area has been drawn to approximately 35m by 30m to illustrate the expected area of the pilot crop.

2.5. Mitigation

The crop will be bordered by clay berms (1m) to ensure containment. The existing site drainage will be used to collect storm water and divert it from the crop. The crop area will be stripped the insitu clay and compacted to achieve containment. Site soil reports and hydrology is included in the appendix, along with the site drainage plan, elevation points, and existing monitoring wells.

2.6. Irrigation Volume

Past leachate irrigation projects and studies in and near Manitoba have applied leachate at rates generally between 90-100 L/m². KGS Group conducted research with the University of Manitoba where they tested municipal leachate at irrigation rates between 79 L/m² to 170 L/m² in green house conditions. Additionally, KGS Group conducted a pilot test in Saskatchewan, where leachate was applied at an estimated rate of 100 L/m². In Hallock (Minnesota, USA) irrigates aerated landfill leachate at a maximum rate of 93 L/m². An estimated volume of 600 m³ of leachate will be applied to the 0.5 acre crop area annually. Total leachate irrigation volume will depend on annual precipitation.

2.7. Analysis

The Crocus research team will monitor the leachate, crops, and the soil throughout the pilot project. The leachate characteristics will be assessed prior to application at each seeding event. Every second week pre-treated leachate will be sampled and analysed for total metals, conductivity, pH, chloride, sulphate, sodium, potassium, PAH's, COD and BOD at a CALA accredited lab. Soil and plant material will be assessed for contaminant attenuation through digestion and ICP analysis. Background soil analysis for total metals, leachable metals, and pH will be done prior to leachate application. Plant and soil samples will be taken after the first and second harvesting events. One plant and soil sample will be taken for every 100 m² (20 samples per harvest period, 40 samples per season) and analysed at a CALA accredited lab. Plant growth will be evaluated based on qualitative assessment and total net biomass change. Ground water will be measured at the drainage collection point. Well monitoring will be used to measure groundwater and ensure containment is effective.

2.7. System Performance Evaluation

Data collected will be used to evaluate the treatment performance and sustainability of the leachate irrigation system. Metal uptake of the crop (mg/kg) of total dry biomass will be compared to the mass of delivered metals in leachate (mg/L) by a mass balance shown in the equation below:

$$\text{Biomass dry weight}(kg) * \text{Plant}_{conc} (mg/kg) > \text{Irrigation volume } (L) * \text{Leachate}_{conc} (mg/L)$$

If the left side of the equation (metal uptake) is larger than the right side the system is then removing metal and treating it rather than accumulating it in soil and is therefore effectively treating the leachate and operating in a sustainable manner. Additionally, total metals and leachable metals in the crop soil will also be evaluated to determine project sustainability. Metal translocation factors (between the plant root and upper plant) will be measured to ensure that crop harvest is an effective method to remove metals from the treatment system.

3. Crop Implementation

3.1. Task 1 – Site preparation

The site preparation will include surveying, grading, supplying and assembling the required equipment, installing required signage, plowing & tilling, and providing required power. The site preparation will be done in early spring (April 15, 2022 – May 15, 2022).

Figure 3. illustrates the proposed drip irrigation design. Leachate from the leachate pond will be pumped through the drip irrigation hoses as shown.

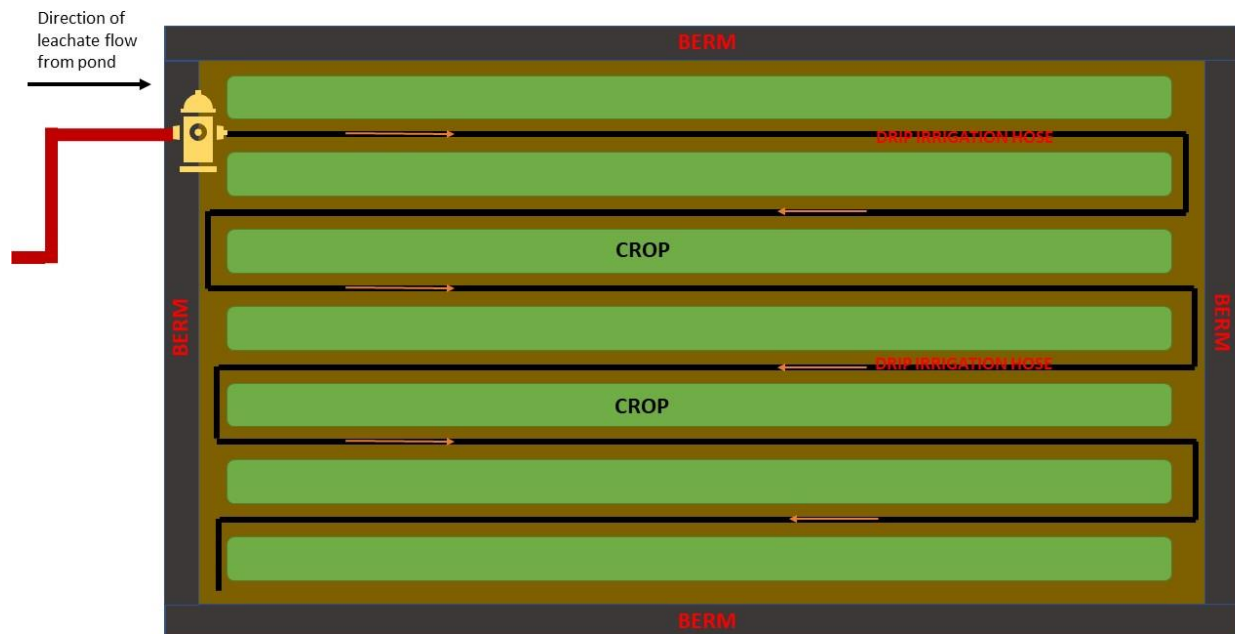


Figure 3 – Leachate Drip Irrigation

By implementing drip irrigation, odour will be controlled by limiting leachate volatilization and trapping odours in the ground. Additionally, drip irrigation will prevent surface run and control the distribution of leachate.

3.2. Task 2 – Planting

It is proposed to have two planting/harvesting events to test the feasibility of using the leachate for crop irrigation under different weather conditions. The proposed periods are June 15, 2022 to July 15, 2022 and July 15, 2022 to August 15, 2022. The four weeks growth periods are suggested based on the results of the phase I of the project and are subject to change based on the observations during the growth periods.

3.3. Task 3 – Harvesting and biomass management

At the end of each growth period, the crops will be harvested. The resulting biomass may be used by MEC as a bulking/bio enhancement additive in current MEC treatment activities. Additionally, the Crocus research team is currently investigating other full life cycle biomass condition solutions. The research on the biomass treatment is ongoing and will continue throughout the project. Bench scale experiments for the selected methodologies will be conducted after harvesting.

3.4. Task 4 – In depth analysis of data

After the completion of two growth periods and bench scale biomass treatment experiments, the collected data will be thoroughly analyzed. The results will be compared to the data of similar studies and phase I of the project.

3.5. Task 5 – Lifecycle cost analysis of crop irrigation for leachate management

The lifecycle cost analysis of the crop irrigation by leachate will be done for a period of 30 years. In addition to the capital and operational costs, the potential social and environmental impacts of the project will be identified.

3.6. Task 6 – Reporting

A draft report will be prepared after the completion of the project. Crocus team will schedule a meeting with MEC staff to discuss the draft. Applicable changes will be made by Crocus and the final report will be submitted to Manitoba Conservation and Climate.

4. Contingency Measures

4.1. Flood Management

Surface water will be diverted from the crop area through 1m clay berms and the existing ditches on site (specifically the west drainage ditch). In the event of flooding within the crop area it is proposed that irrigation treatment is stopped and the growth area is allowed to dry. In the event of crop loss due to flooding the crop will be replanted to re-establish the treatment system. It should also be noted that tall wheatgrass is flood resistant and is a fallow crop, meaning that once established the crop will grow back without seeding.

4.2. Metal Accumulation

Based on the results provided by the preliminary experiment discussed in section 6 and the data presented in table 8, it is expected that plant-metal uptake will outstrip metal accumulation. Soil will, however be monitored, to ensure that metal accumulation does not result in contaminated and unsustainable soil conditions. In the event that soil is contaminated over a period of time top soil will either be stripped and put back into the repository cell or will be left in place with the existing crop continuing to grow with leachate irrigation to achieve remediated soil. The compacted insitu clay liner will provide containment to ensure any metals in the top soil will not leach to the water table.

5. Schedule

Proposed detailed schedule for the project is presented in Appendix A. The following table outlines the key project dates:

Table 1 – Project schedule

Milestone / Task	Completion Date
Task 1 – Designing the crop plot, the crop irrigation system and a drainage plan	May. 30, 2022
Task 2 – Preliminary analysis of leachate and soil	June 6, 2022
Task 3 – Site preparation	June 30, 2022
Task 4 – Planting	July 8, 2022
Task 5 – Leachate, crop and soil monitoring	Aug. 30, 2022
Task 6 – Harvesting and biomass management	Sep. 30, 2022
Task 7 – In depth analysis of data	Oct. 31, 2022
Task 8 – Lifecycle cost analysis of crop irrigation for leachate management	Nov. 15, 2022
Task 9 – Reporting	Nov. 30, 2022

6. Completed Preliminary Bench Scale Research

The results of the discussed bench scale analysis have informed the design of the proposed pilot scale project. Bench scale analysis was conducted in the winter of 2020. Bench-scale experiments were performed to examine the effectiveness of two common forage crops, tall wheat grass and alfalfa, for the uptake of metals in the leachate. The crops were planted in soil, collected from the proposed crop location at the VBEC. Cylindrical planters (7in x 6 in) were used to grow each plot sample in.

6.1. Experiment methodology

6.1.2. Experiment Design

Each plant crop was irrigated over 2 growth periods (each ~30 days) with various dilutions of leachate collected from the VBEC leachate pond on October 20th, 2020.

The experiment design was laid out as shown in table 2.

Table 2. Experiment Design

Sample	Irrigation Solution	Replication
ALFALFA CONTROL	WATER	2
ALFALFA 25%	25% LEACHATE / 75% WATER	3
ALFALFA 50%	50% LEACHATE /50% WATER	3
ALFALFA 75%	75% LEACHATE / 25% WATER	3
ALFALFA 100%	100% LEACHATE	3
WHEAT GRASS CONTROL	WATER	2
WHEAT GRASS 25%	25% LEACHATE / 75% WATER	3
WHEAT GRASS 50%	50% LEACHATE /50% WATER	3
WHEAT GRASS 75%	75% LEACHATE / 25% WATER	3
WHEAT GRASS 100%	100% LEACHATE	3

Planter Layout:

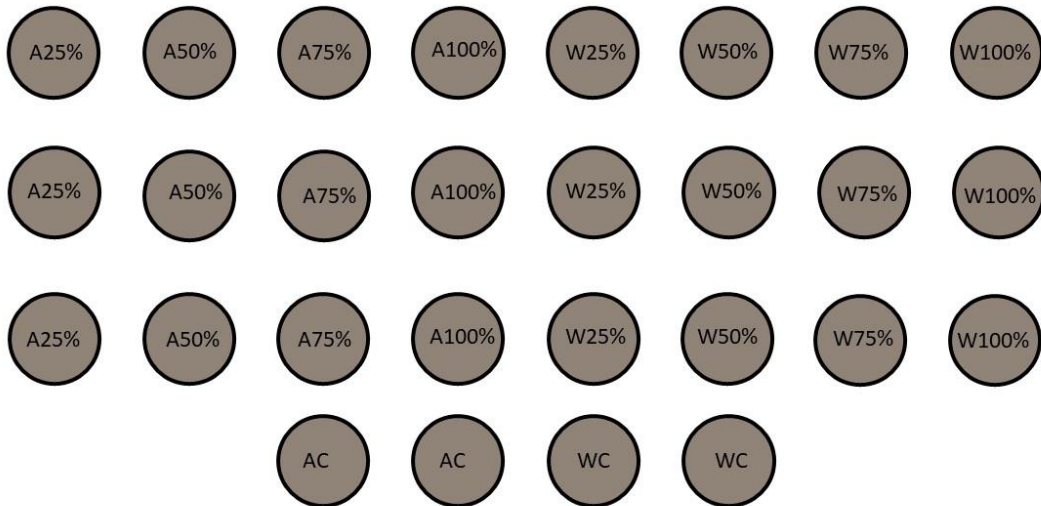


Figure 4 – Planter Layout

Two plantings were examined of each crop. Over the first growth period, the crop was planted in a high crop density, and over the second growth period the crops were planted sparsely. The same soil was used in both plantings to examine the effect of soil previously exposed to leachate on seeding and plant emergence. The double planting also mimicked mid-summer harvesting commonly used in agriculture for both crops.

LED grow lights were used as a light source. For the first growth period the lights were kept on for 24 hours a day and over the second growth period the lights were on a 12 hour timer.

6.1.2. Leachate Sampling and characterization

Sampling of the Miller Environmental leachate pond was carried out on August 25th, 2020. Samples were taken from a total of four locations within the pond. An additional 5th sample was taken from by Miller Environmental earlier this spring and was also taken by Crocus for analysis.

A description of each sample location is provided below:

Sample 1 – Sample was taken from the bottom of the pond on the center of the east toe.

Sample 2 – Sample was taken from the surface of the pond (approximately 10 cm below the pond surface) on the centre of the east toe.

Sample 3 – Sample was taken from the middle (depth) of the pond (approximately 100 cm below pond surface) on the centre of the south toe.

Sample 4 – Sample was taken from the bottom of the pond from the west evaporator pump.

Sample 5 – Was taken from the leachate pond by Miller Environmental Earlier this past spring.

An image with labelled sample points is provided below:

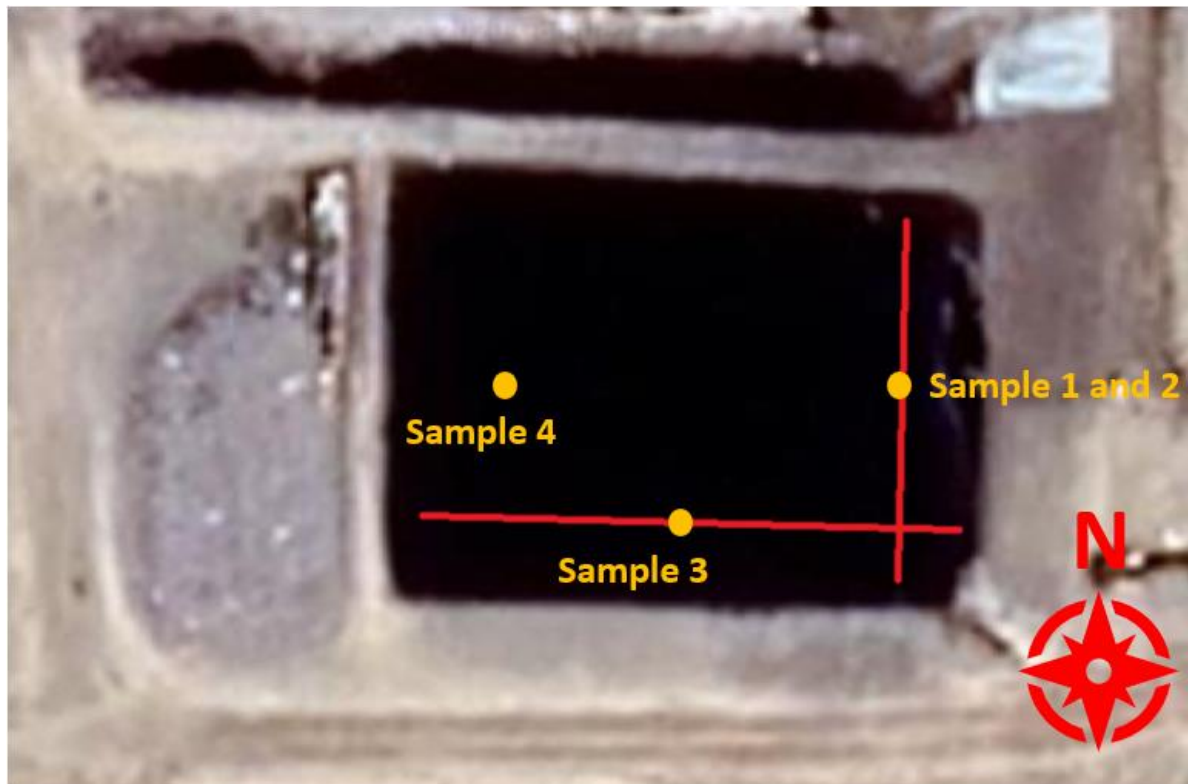


Figure 5 – Location of Leachate Sample Collection Points

6.1.3 Lab analysis

Water chemistry parameters were measured at the University of Manitoba. Nutrients and COD were examined through flourospectroscopy. pH and temperature were measured using a standard lab grade and calibrated pH meter. Total Suspended Solids (TSS) was measured through a standard filter weight analysis.

Soil was analysed for metals at a certified third party lab. Total metals was measured through CRC ICP-MS. Leachable metals were measured through O.Reg 347 methodology.

Plant tissue was also measured by a certified third party lab. CRC ICP-MS was used for tissue metals detection of cleaned dry plant tissue.

6.2. Experiment Results

6.2.1. Leachate analysis

Table 3. presents basic chemistry parameters for each leachate sample. The sample numbers refer to the samples described in section 4.2.

Table 3. Leachate Chemistry Parameters

	COD (MG/L)	TP (MG/L)	REACTIVE PHOSPHORUS (MG/L)	TKN (MG/L)	F.O.G (MG/L)	TSS (MG/L)	TEMPERATURE (C)	PH
SAMPLE 1	2132	4.23	4.54	N/A	N/A	29.58	N/A	N/A
SAMPLE 2	2082	4.30	4.73	N/A	N/A	27.27	20.5	8.5
SAMPLE 3	2477	N/A	N/A	16	81	73.05	N/A	N/A
SAMPLE 4	3396	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SAMPLE 5	2291	2.93	2.03	N/A	N/A	N/A	N/A	N/A

Table 4. presents metal concentrations (mg L^{-1}) detected in each sample of leachate collected from the VBEC leachate pond. The sample numbers refer to the samples described in section 4.2. CCME guidelines for agriculture irrigation water are provided for metals where applicable and concentrations that exceed the guidelines in the leachate are highlighted in orange.

Table 4. Metals (mg L^{-1}) in leachate from the VBEC leachate pond

METALS LEACHATE	CCME MAX CONC.	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5
AL	5	0.869	0.862	4.09	0.154	0.0073

SB		0.00388	0.00397	0.00391	0.00358	0.00323
AS	0.1	0.0925	0.0923	0.116	0.0828	0.0846
BA		0.0547	0.0562	0.112	0.032	0.0398
BE	0.1	0.00047	0.0005	0.00058	0.00044	0.00046
BI		0.000054	0.000061	0.000133	<0.000050	<0.00050
B		14.5	14.1	16.2	14.2	15
CD	0.0051	0.0142	0.0144	0.0187	0.0146	0.0158
CA		159	154	186	152	128
CS		0.0785	0.0796	0.0834	0.0746	0.0989
CR		0.0155	0.0167	0.0323	0.011	0.0163
CO	0.05	0.11	0.114	0.188	0.0808	0.0826
CU	Var	0.0343	0.0398	0.0601	0.0466	0.0265
FE	5	4.3	4.29	10.6	4.27	4.26
PB	0.2	0.00519	0.00608	0.0109	0.00329	0.00391
LI	2.5	0.465	0.435	0.468	0.426	0.511
MG		190	181	174	185	195
MN	0.2	1.78	1.79	2.16	1.61	1.2
MO	Nar	69.9	68.8	62.1	72.7	80.2
NI	0.2	2.79	2.81	3.7	2.47	2.59
K		173	170	192	172	169
P		27.5	27	35.6	26.1	17.6
RB		0.0486	0.048	0.0557	0.0464	0.0503
SE		0.00984	0.00982	0.0106	0.01	0.0101
SI		14.8	14	24	12.3	12.8
AG		0.000266	0.000107	0.000518	0.000056	0.000115

NA		2130	2200	1990	2210	2310
SR		0.82	0.836	0.855	0.778	0.751
S		553	564	458	568	583
TE		<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
TL		0.000042	0.000042	0.000114	0.000022	0.000023
TH		0.00011	0.00015	0.00055	<0.00010	<0.00010
SN		0.00162	0.00195	0.0041	0.00138	0.00013
TI		0.0506	0.0557	0.15	0.0358	0.0356
W		1.81	2.33	1.69	2.77	3.1
U	0.01	0.0125	0.0123	0.0126	0.0116	0.0126
V	0.1	8.89	8.88	9.27	7.49	9.34
ZN		0.128	0.138	0.239	0.0764	0.0464
ZR		0.00516	0.00523	0.00729	0.00421	0.00435

*CCME Canadian Environmental Quality Guidelines (agriculture irrigation water)

5.2.2. Plant growth

The growth of the two crop types were observed throughout the experiment for each leachate treatment. In both growth periods it was observed that wheatgrass outperformed alfalfa over every leachate concentration. Alfalfa completely died off in both experiments across leachate concentrations 25%-100%. Alfalfa died off quicker under stronger leachate concentrations. Wheat grass however showed no adverse effects under high leachate concentrations. In the first growth period, die off did occur after 30 days of growth, however, die off occurred uniformly across all leachate concentrations and the control, indicating that an uncontrolled variable was the cause of die off rather than leachate concentration as is discussed in section 6. No die off occurred during the second growth period.



Figure 6 – First Growth Wheatgrass and Alfalfa

Wheatgrass treated with 100% leachate is shown closest at the front of the image and decreases towards 25% at the back row. Control pots are shown on the left hand side. Alfalfa pots are shown at the back of the photo.



Figure 7 – First Growth Wheatgrass and Alfalfa (2)

Uniform wheatgrass growth is shown. It can be seen that wheat grass growth is far out pacing alfalfa growth.

6.2.3. Soil metals accumulation

Table 5. presents metal concentrations (mg L⁻¹) detected in soil irrigated with 100%, 25%, and 0% (water control) leachate. Only the samples treated with wheatgrass growth were analyzed due to the poor alfalfa growth performance. CCME metal concentration guidelines for agriculture soil are provided for metals where applicable and concentrations that exceed the guidelines in the leachate are highlighted in orange.

Table 5. Total metals in leachate irrigated soil (mg/kg)

METALS (SOIL)	CCME MAX CONC.*	100%	25%	CONTROL(NATIVE SOIL)
ALUMINUM (AL)		19700	17700	18100
ANTIMONY (SB)	20	0.32	0.28	0.31
ARSENIC (AS)	12	7.68	6.61	7.50
BARIUM (BA)	750	225	179	168
BERYLLIUM (BE)		0.71	0.66	0.65
BISMUTH (BI)		<0.20	<0.20	<0.20
BORON (B)	2	69.2	28.0	22.3
CADMIUM (CD)	1.4	0.551	0.453	0.457
CALCIUM (CA)		64000	55200	42100
CHROMIUM (CR)	64	31.5	28.3	29.4
COBALT (CO)	40	9.65	7.53	7.91
COPPER (CU)	63	23.9	21.2	23.7
IRON (FE)		21500	18700	20000
LEAD (PB)	70	10.1	9.01	10.1
LITHIUM (LI)		20.5	18.8	15.7
MAGNESIUM (MG)		24800	20200	18300
MANGANESE (MN)		743	513	575
MOLYBDENUM (MO)	5	242	24.3	1.15
NICKEL (NI)	50	32.2	22.7	23.8

PHOSPHORUS (P)		776	705	808
POTASSIUM (K)		4400	3770	4140
SELENIUM (SE)	1	0.38	0.33	0.38
SILVER (AG)	20	0.10	<0.10	<0.10
SODIUM (NA)		6400	1260	443
STRONTIUM (SR)		143	121	95.7
SULFUR (S)	500	2700	<1000	<1000
THALLIUM (TL)	1	0.263	0.225	0.249
TIN (SN)	5	<2.0	<2.0	<2.0
TITANIUM (TI)		300	256	236
TUNGSTEN (W)		5.82	0.67	<0.50
URANIUM (U)	23	2.11	1.67	1.16
VANADIUM (V)	130	73.9	60.4	62.3
ZINC (ZN)	200	66.8	61.0	63.7
ZIRCONIUM (ZR)		3.8	3.4	3.4

*CCME Canadian Environmental Quality Guidelines (Agriculture soil)

Table 6. presents the leachable metals in the soil irrigated with 100% leachate and treated with wheatgrass..

Table 6. Leachable metals (mg L⁻¹) in soil irrigated with 100% leachate

METAL (LEACHABLE)	CONC.
ALUMINUM (AL)-TOTAL	<0.50
ANTIMONY (SB)-TOTAL	<0.25
ARSENIC (AS)	<0.050
BARIUM (BA)	0.99
BERYLLIUM (BE)-TOTAL	<0.050
BISMUTH (BI)-TOTAL	<0.050

BORON (B)	<2.5
CADMIUM (CD)	<0.0050
CALCIUM (CA)-TOTAL	1140
CHROMIUM (CR)	<0.050
COBALT (CO)-TOTAL	<0.025
COPPER (CU)-TOTAL	<0.50
IRON (FE)-TOTAL	<2.5
LEAD (PB)	<0.025
LITHIUM (LI)-TOTAL	<5.0
MAGNESIUM (MG)-TOTAL	213
MANGANESE (MN)-TOTAL	1.40
MOLYBDENUM (MO)-TOTAL	0.348
NICKEL (NI)-TOTAL	<0.10
PHOSPHORUS (P)-TOTAL	<2.5
POTASSIUM (K)-TOTAL	<50
SELENIUM (SE)	<0.025
SILVER (AG)	<0.0050
STRONTIUM (SR)-TOTAL	2.99
THALLIUM (TL)-TOTAL	<5.0
TIN (SN)-TOTAL	<0.050
TITANIUM (TI)-TOTAL	<0.10
URANIUM (U)	<0.25
VANADIUM (V)-TOTAL	<0.050
ZINC (ZN)-TOTAL	<1.0

The final pH of the soil irrigated with 100% leachate was found to be 9.47. Chloride levels were found to be 2970, 2440, 3320 mg/kg for soil irrigated with 100%, 25%, and control (0%) leachate, indicating that leachate did not increase the chloride in soil.

6.2.4. Plant-water uptake

The volume of water delivered to each pot was measured over both growth periods. The soil moisture level was measured with a soil hydrometer. Soil pH was also measured. It was found that wheatgrass water uptake was higher than alfalfa, even when comparing control plots. Leachate was found to have little to no effect on soil pH.

6.2.5. Plant-metal uptake

Table 7. presents metal concentrations detected in plant tissue irrigated with 100% leachate and with water (control). Uptake is presented as the difference between metal concentration in the plants irrigated with 100% leachate and with water.

Table 7. Metal concentration (mg/kg) of plant tissue

METALS (PLANT TISSUE)	100%	CONTROL	UPTAKE
ALUMINUM (AL)	2480	266	2214.00
ANTIMONY (SB)	0.043	0.033	0.01
ARSENIC (AS)	1.14	0.299	0.84
BARIUM (BA)	54.7	53.9	0.80
BERYLLIUM (BE)	0.104	<0.010	0.10
BISMUTH (BI)	0.029	0.023	0.01
BORON (B)	55.4	16.9	38.50
CADMIUM (CD)	0.206	0.120	0.09
CALCIUM (CA)	11600	11100	500.00
CHROMIUM (CR)	0.313	0.0395	0.27
COBALT (CO)	5.96	4.50	1.46
COPPER (CU)	1.42	0.144	1.28
IRON (FE)	10.4	10.7	-0.30
LEAD (PB)	2570	376	2194.00
LITHIUM (LI)	1.53	0.265	1.27
MAGNESIUM (MG)	11.5	6.81	4.69

MANGANESE (MN)	10100	7580	2520.00
MOLYBDENUM (MO)	150	51.4	98.60
NICKEL (NI)	224	4.89	219.11
PHOSPHORUS (P)	16.9	2.41	14.49
POTASSIUM (K)	5440	7390	-1950.00
SELENIUM (SE)	35100	58200	-23100.00
SILVER (AG)	33.6	24.4	9.20
SODIUM (NA)	0.293	0.266	0.03
STRONTIUM (SR)	14900	5830	9070.00
SULFUR (S)	51.8	56.3	-4.50
THALLIUM (TL)	<0.020	<0.020	0.00
TIN (SN)	0.0415	0.0068	0.03
TITANIUM (TI)	0.41	0.66	-0.25
TUNGSTEN (W)	0.222	0.0343	0.19
URANIUM (U)	11.2	0.94	10.26
VANADIUM (V)	73.4	80.5	-7.10
ZINC (ZN)	3.57	3.23	0.34

6.3. Discussion

6.3.1. Leachate analysis

Table 2. presents the general water chemistry parameters for the leachate from the VBEC. The results suggest that the leachate contains sufficient nutrients for microbial and plant growth. While the pH is alkaline it is within the range of tolerable wheatgrass and alfalfa growth. The results indicate that the leachate has high COD and low dissolved oxygen, however, these factors should not affect plant growth after irrigation.

Table 3. presents metal concentrations in leachate and associated CCME guidelines for agriculture irrigation for each metal where applicable. The metals arsenic, cadmium, cobalt, nickel, uranium, and vanadium exceed the CCME guidelines. The average of the 5 samples (0.094 mg L^{-1}) falls below the guidelines for arsenic (0.1 mg L^{-1}). The average concentration of

uranium between the 5 samples (0.0123 mg L^{-1}) falls marginally above the recommended guidelines (0.01 mg L^{-1}) by 23%. Cadmium, cobalt and nickel all exceeded the guidelines by large margins. It is expected that the metal concentrations will be reduced after the pre-treatment and filtration process. However, given that these guidelines are meant for agriculture crops intended for human or livestock consumption, the maximum concentration of metals in leachate used for irrigation in treatment crops depends on plant viability and resulting soil metal concentration. These parameters are discussed in section 6.3 and 6.4.

6.3.3. Selection of crop type

In both growth periods it was observed that wheatgrass outperformed alfalfa in terms of biomass production, plant health, rate of growth and water uptake. Alfalfa appeared to be negatively affected by increasing leachate concentration. Wheatgrass on the other hand was observed to not be negatively affected by any concentration of leachate. Wheatgrass also showed healthy plant emergence after seeding in previously leachate irrigated soil. Based on these observations it is concluded that wheatgrass is the preferred crop choice for leachate treatment over alfalfa.

6.3.4. Wheatgrass uptake and performance

The metal uptake of wheat grass (Table 5.), the total metals in soils (Table 3.) and the leachable metals in soil (Table 4.) was analyzed. After two growth periods and a total leachate volume delivery of 2.3 L to each pot, the total metals were analyzed in the control, 25% leachate and 100% leachate pots. It was found that arsenic, barium, boron, calcium, lithium, molybdenum, sodium, strontium, sulfur, titanium, tungsten, uranium, and vanadium all showed positive increase in soil in relation to leachate concentration used for irrigation. The rest of the metal concentrations were observed to have no correlation to leachate concentration. The majority of metals that increased with leachate concentration, were observed to have only moderate increases. Molybdenum was found to have the greatest increase in soil concentration. Only molybdenum and sulfur concentrations were found to exceed the CCME guidelines for metals in agriculture soil. Molybdenum, in soil irrigated with 100% leachate, also exceeds the CCME guidelines for industrial soil as well, while soil irrigated with 25% leachate was under the CCME guidelines for commercial molybdenum in soil. No guidelines are set for sulfur in industrial soil. Leachable metal concentrations in soil irrigated with 100% percent leachate were extremely low across the board. The majority of leachable metals were below detectable limits. These results suggest that most of the environmentally available metals in the leachate is either taken up by the wheatgrass or bound to the soil.

Table 6. presents the metal contents of wheat grass irrigated with 100% leachate and tap water (control). The difference between the metal concentration in the two crops is also shown. It is assumed that the difference in metal contents is an indication of total metal uptake by the plant. The results between the metal contents in the two treatments was examined through a paired Willcoxon test. The results are shown below:

Wilcoxon signed rank test with continuity correction

data: Concentration by Irrigation Type

$V = 415$, $p\text{-value} = 0.002445$

alternative hypothesis: true location shift is greater than 0 for metal concentration in plant tissue irrigated with 100% leachate compared to control

The resulting p-value of the paired Wilcoxon test is 0.002445, indicating that the total metal concentration in wheatgrass tissue irrigated with 100% leachate is significantly higher than metal concentration in the control, indicating that there is a high probability that metal from leachate was treated through wheat grass uptake. For this analysis, the majority of the tissue examined was in the green emergent leaf and shoot section of the grass suggesting that significant translocation of metals within the grass occurred.

6.3.5. Estimated total metal uptake

Based on the estimated dry biomass of an acre of tall wheat grass and the calculated metal uptake reported in table 7, the total metal uptake of a 1 acre crop can be estimated. The dry biomass weight of wheatgrass per acre is estimated to be 3 tonnes. Table 8 contains the estimated metal uptake per acre of wheatgrass, the total estimated weight of each metal delivered to 1 acre (1214 m³) of wheatgrass (assuming 300 mm of leachate is used annually for irrigating 1 acre of wheatgrass), and the resulting metal left to accumulate in soil.

Table 8. Estimated metal uptake, delivery, and accumulation (kilograms) per acre

	ESTIMATED PLANT UPTAKE	METAL MASS IN LEACHATE PER ACRE	ESTIMATED SOIL ACUMULATION
METALS			
ALUMINUM (AL)-TOTAL	6642	1.452502	-6640.55
ANTIMONY (SB)-TOTAL	0.03	0.004509	-0.02549
ARSENIC (AS)-TOTAL	2.52	0.113679	-2.40632
BARIUM (BA)-TOTAL	2.4	0.071553	-2.32845
BERYLLIUM (BE)-TOTAL	0.3	0.000595	-0.29941
BISMUTH (BI)-TOTAL	0.03	0.0001	-0.0299
BORON (B)-TOTAL	115.5	17.9672	-97.5328
CADMIUM (CD)-TOTAL	0.27	0.018866	-0.25113
CALCIUM (CA)-TOTAL	1500	189.1412	-1310.86
CESIUM (CS)-TOTAL	0.81	0.100762	-0.70924

CHROMIUM (CR)- TOTAL	4.38	0.022289	-4.35771
COBALT (CO)- TOTAL	3.84	0.139707	-3.70029
COPPER (CU)- TOTAL	0	0.050332	0.050332
IRON (FE)-TOTAL	6582	6.730416	-6575.27
LEAD (PB)-TOTAL	3.81	0.007131	-3.80287
LITHIUM (LI)- TOTAL	14.07	0.559654	-13.5103
MAGNESIUM (MG)-TOTAL	7560	224.59	-7335.41
MANGANESE (MN)-TOTAL	295.8	2.073512	-293.726
MOLYBDENUM (MO)-TOTAL	657.33	85.87836	-571.452
NICKEL (NI)- TOTAL	43.47	3.486608	-39.9834
PHOSPHORUS (P)- TOTAL	0	32.48664	32.48664
POTASSIUM (K)- TOTAL	0	212.6928	212.6928
RUBIDIUM (RB)- TOTAL	27.6	0.060457	-27.5395
SELENIUM (SE)- TOTAL	0.09	0.012227	-0.07777
SODIUM (NA)- TOTAL	27210	2631.952	-24578
STRONTIUM (SR)- TOTAL	0	0.980912	0.980912
TELLURIUM (TE)- TOTAL	0	0	0
THALLIUM (TL)- TOTAL	0.09	5.9E-05	-0.08994
TIN (SN)-TOTAL	0	0.002229	0.002229
URANIUM (U)- TOTAL	0.57	0.014956	-0.55504
VANADIUM (V)- TOTAL	30.78	10.65164	-20.1284

ZINC (ZN)-TOTAL	0	0.15243	0.15243
ZIRCONIUM (ZR)-TOTAL	1.02	0.006371	-1.01363

Table 8. indicates that metal uptake of one planted acre of wheatgrass outstrips metal accumulation in soil for most metals. Copper and zinc are expected to accumulate in small concentration, while phosphorus and potassium is expected to accumulate in larger numbers. Given these results it is expected that crop irrigation will be an effective and sustainable treatment method for VBEC leachate. These results are preliminary and need further field and pilot experiments to confirm the indicated results.

6.4. Experiment Summary

The results of the experiment presented in this report suggest that the use of tall wheatgrass for the treatment of Miller Environmental leachate, through crop irrigation, is potentially an appropriate and effective phytoremediation treatment method. As discussed, wheatgrass outperformed alfalfa in every measured parameter and therefore the use of wheatgrass is recommended over alfalfa for leachate crop irrigation. Wheatgrass did not appear to be negatively affected by any concentration of leachate. Based on the soil analysis results, it is concluded that the use of 100% leachate, assuming leachate parameters remain consistent with those tested in this report, is sustainable for wheatgrass crop irrigation treatment. The majority of total metals examined in this experiment were below CCME agricultural guidelines. Molybdenum is significantly above both the agriculture and commercial soil guidelines. The concentration of molybdenum in soil should be closely examined in the phase 2 component of this project. However, based on the leachable metals in the soil examined and the estimated plant uptake, it is believed that the molybdenum concentrations in soil may not be of environmental concern. The total uptake of the majority of examined metals by wheatgrass appears to outstrip the amount of metals that would be delivered to the crop suggesting that significant metal accumulation in soil should not occur over time.

7. Project Team

The Project Team will be led by Kenton McCorquodale-Bauer M.Sc., Project Manager. A multi-disciplinary project team is assembled who understands the challenges of the project, who have superior project management skills, and who will ensure a focused, efficient approach through to the completion of this project. The team members for this project have significant depth of experience in environmental engineering and innovative projects similar in nature to this assignment. The following table illustrates role and certifications of our key team members:

Table 9 – Project team

Team member	Role	Certifications
Kenton McCorquodale-Bauer	Project Manager/Biosystems Scientist	M.Sc., PhD Candidate
Arman Vahedi	Senior Environmental Engineer	PhD, P.Eng.
Dennis Antony	Senior Project Manager	B.Sc.

Kenton McCorquodale-Bauer, M.Sc. EIT. – Project Manager

Kenton is an environmental consultant and laboratory expert at Crocus Engineering. He holds his M.Sc. in Biosystems Engineering from the University of Manitoba. Kenton has experience in site management, surveying, and wastewater treatment design. He is currently a PhD student studying biological wastewater treatment and phytoremediation at the University of Manitoba.

Arman Vahedi, PhD, P.Eng. – Senior Environmental Engineer

Arman Vahedi is a senior environmental engineer as well as a technical team lead at Crocus Engineering. Arman holds PhD. in Environmental Engineering and MA in Economics both from University of Manitoba and is a registered professional engineer in Manitoba. Dr. Vahedi has experience in planning, designing, and development of water, wastewater, and waste management facilities. Dr. Vahedi is also a Faculty Member at Red River College in Winnipeg and has several years of applied research experience.

Dennis Antony – Senior Reviewer

Mr. Antony is senior project manager at Crocus Engineering. Mr. Antony has a Bachelor of Science degree in Environmental Science (B.Sc.) and a Renewable Resource Diploma (R.R. D.). He is also a certified professional in Erosion and Sediment Control (CPESC). Mr. Antony has twenty years of environmental, construction project management, and resource management experience. He is proficient in a wide variety of soil, water and biomass field sampling techniques. Mr. Antony has comprehensive knowledge of the general operating practices, procedures and policies of federal, provincial and territorial environmental programs and management of environmental remediation projects involving different substances including petroleum hydrocarbons, polychlorinated biphenyls (PCBs), asbestos, metals and other hazardous materials. Additionally, Mr. Antony has experience in farming, seeding and harvesting.

8. Conclusion

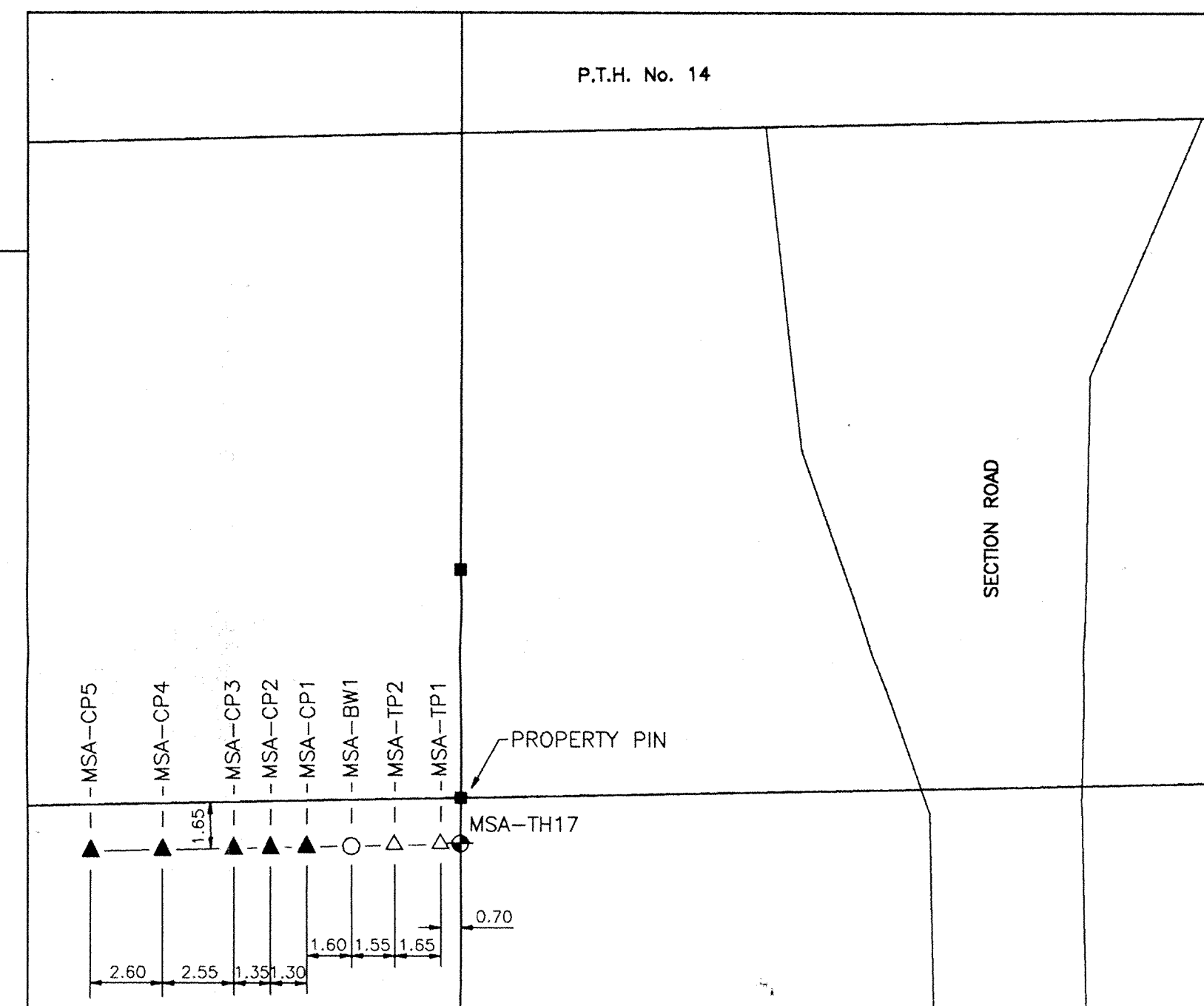
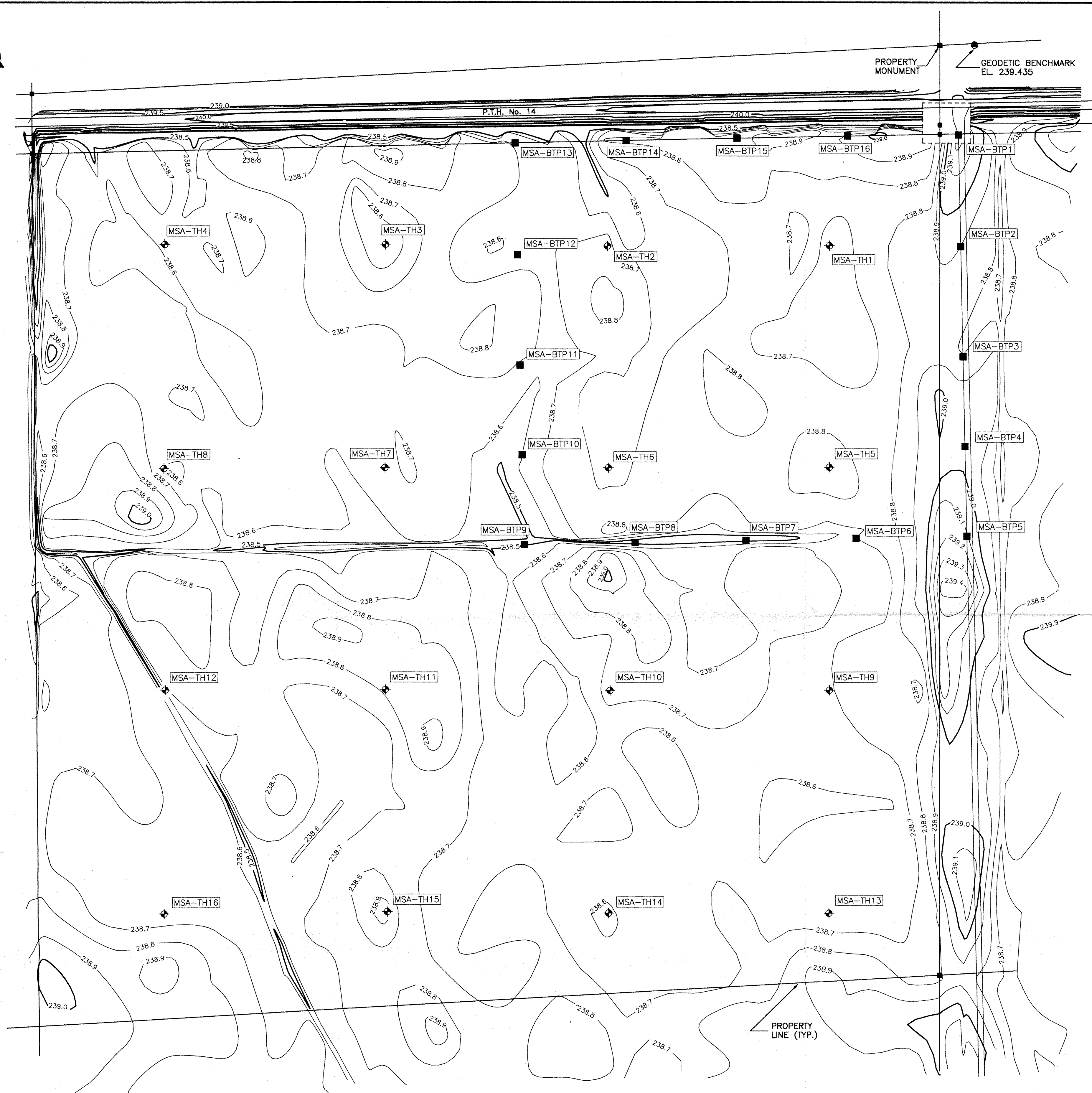
We look forward to working on this pilot scale project with Miller Environmental. We are confident that we can meet the challenges ahead and provide a sustainable project. We look forward to hearing from Manitoba Conservation and Climate.

Thank you for your consideration.

9. Appendices

Appendix A- Drawing of the site

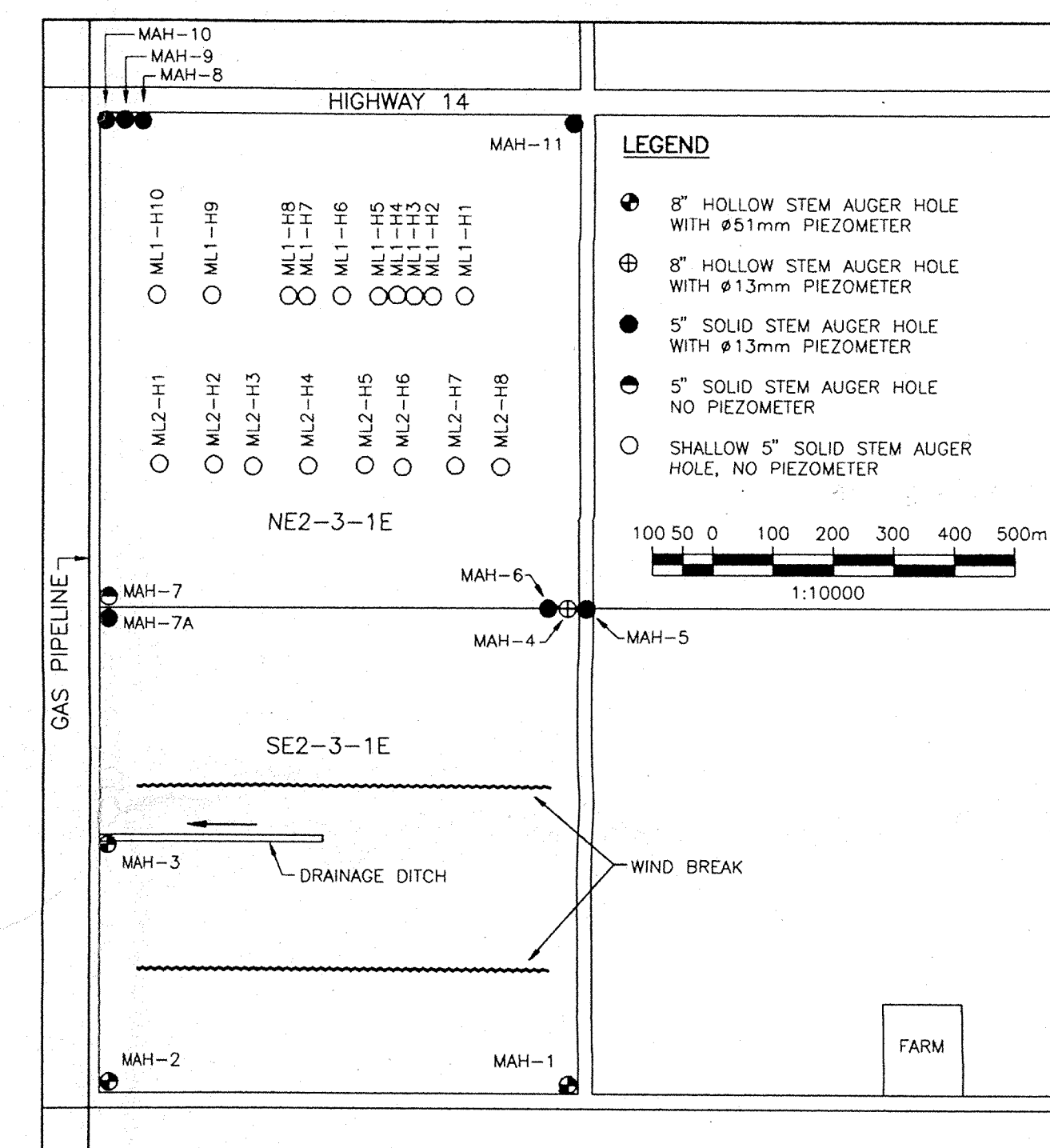
Appendix B – Geology and other site information



PIEZOMETER/WELL LOCATIONS
SCALE 1:200

LEGEND

- MSA-BTP1 - BACKHOE TEST PIT
- ◆ MSA-TH1 - TEST HOLE
- ▲ MSA-CP1 - CLAY PIEZOMETER
- △ MSA-TP1 - TILL PIEZOMETER
- MSA-BW1 - BEDROCK WELL
- 238.9 - TOPOGRAPHIC CONTOUR (0.1m INTERVAL)



PRELIMINARY TEST HOLE/PIEZOMETER LOCATIONS PROPERTY OF THE MHWMC RESOURCE CENTRE
(KGS, 1991)



REV.	DESCRIPTION	DWN.	APP.	DATE

uma **UMA Engineering Ltd.**
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

APPROVED BY: _____ DATE: _____
DRAWN BY: KK/JJS DESIGNED BY: LB
CHECKED BY: LB CHECKED BY: TW
SCALE: 1:2000 JOB No. 6544-003-01-06

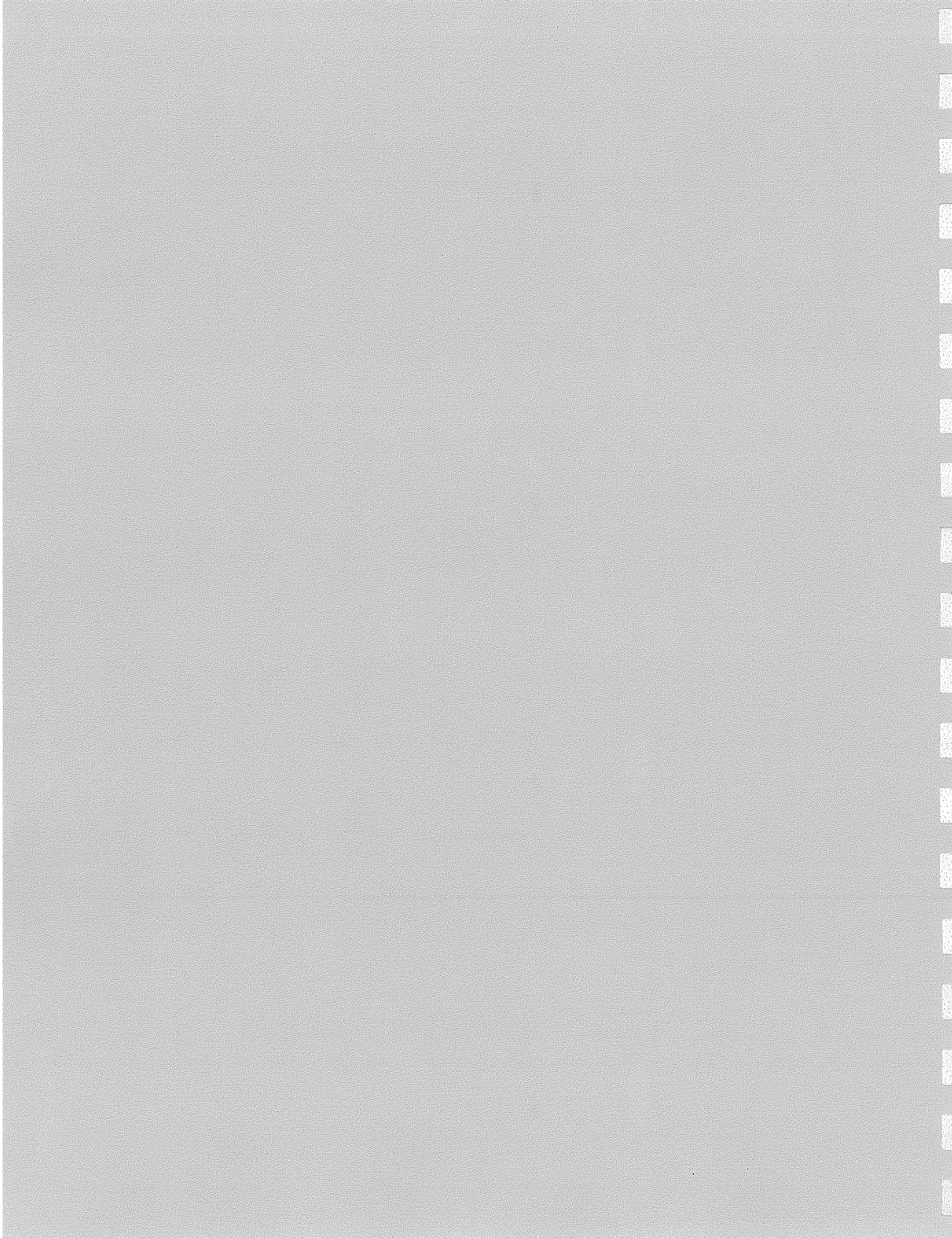
MANITOBA HAZARDOUS WASTE MANAGEMENT CORPORATION

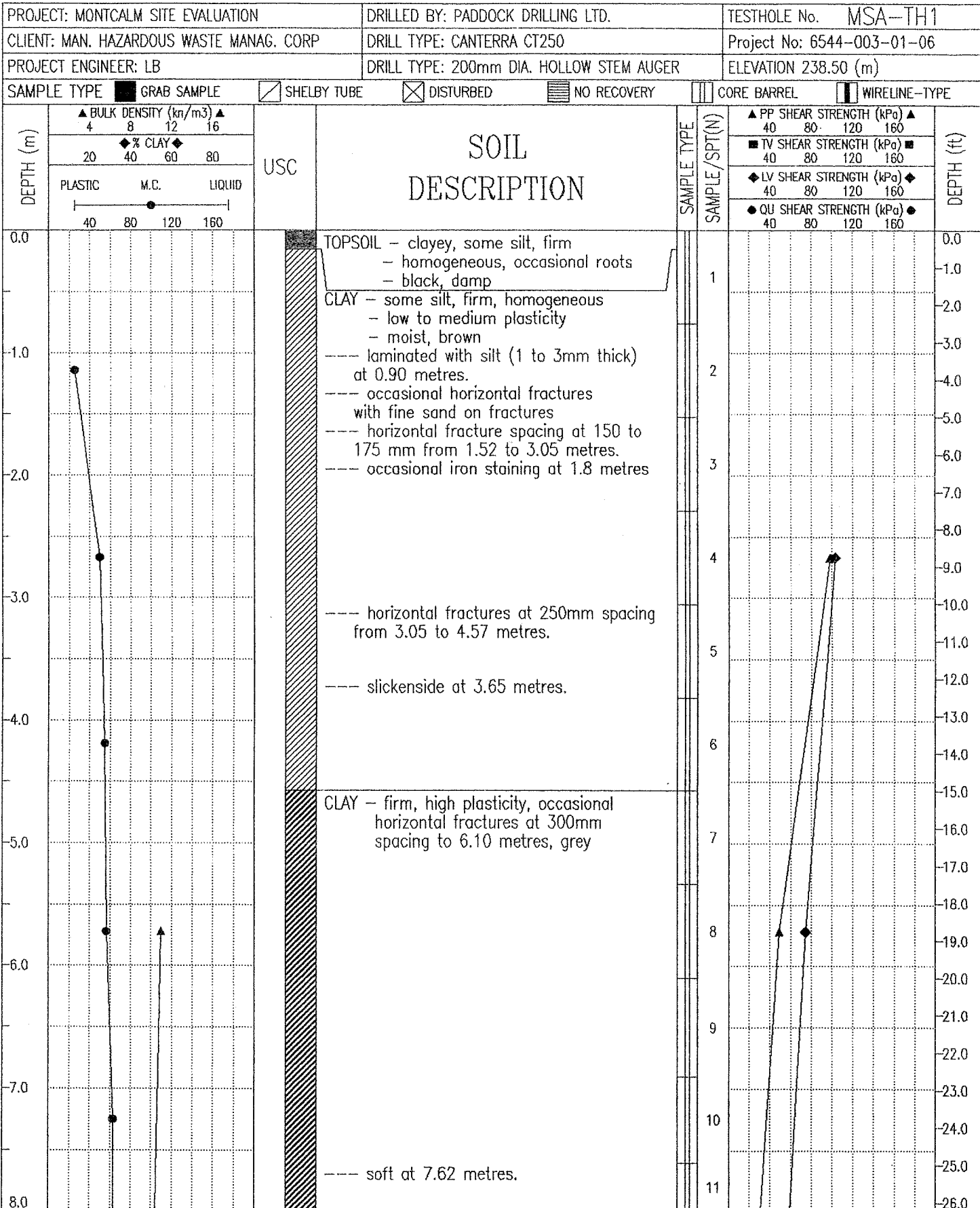
MONTCALM DETAILED SITE EVALUATION

TEST HOLE, TEST PIT AND PIEZOMETER LOCATIONS
NE 1/4 - 2 - 3 - 1E

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APPENDIX B
SITE INVESTIGATION METHODOLOGY





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COMPLETION DEPTH 13.7 m

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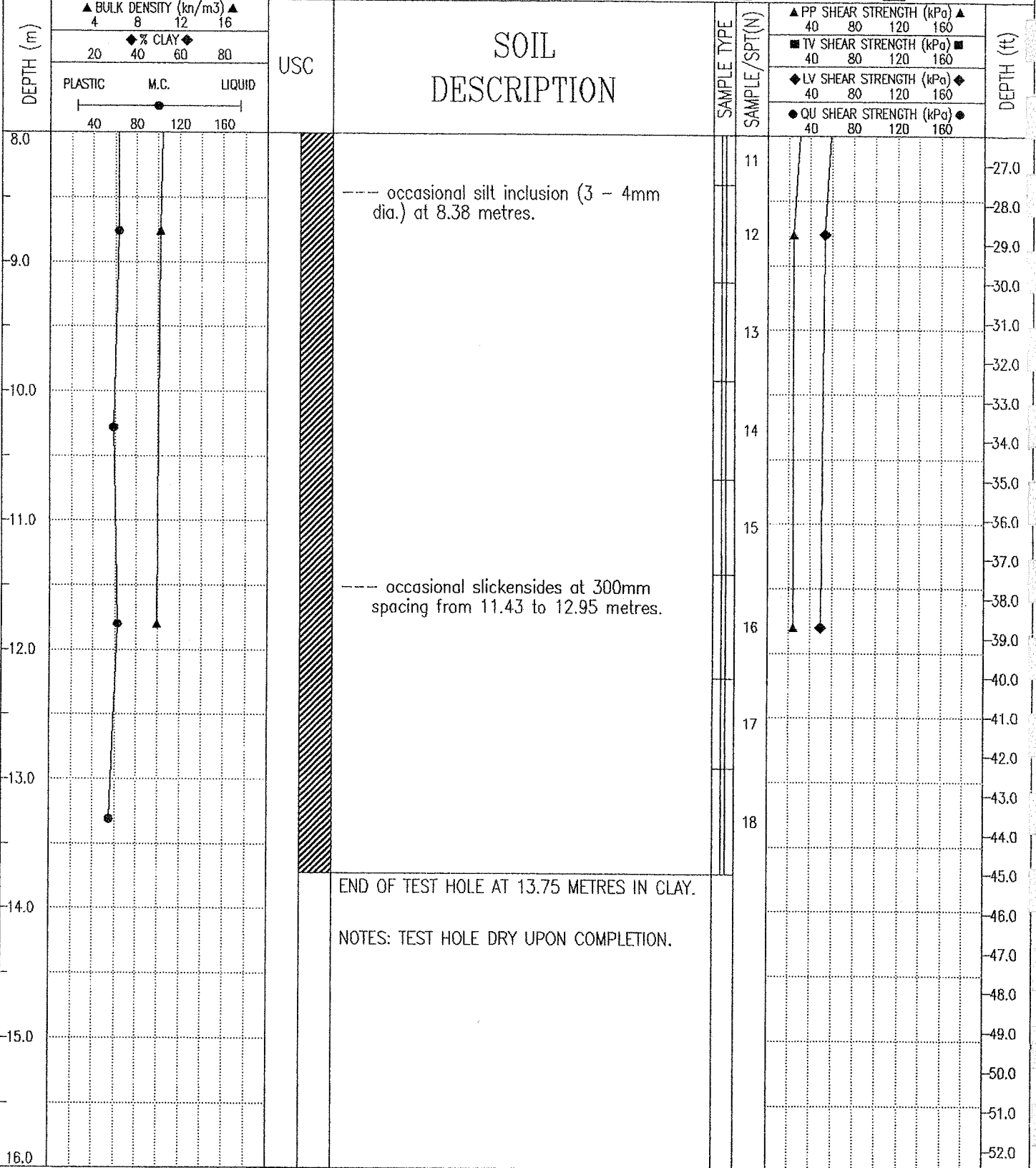
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Fig. No.

Page 1 of 2

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CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.50 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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Winnipeg, Manitoba

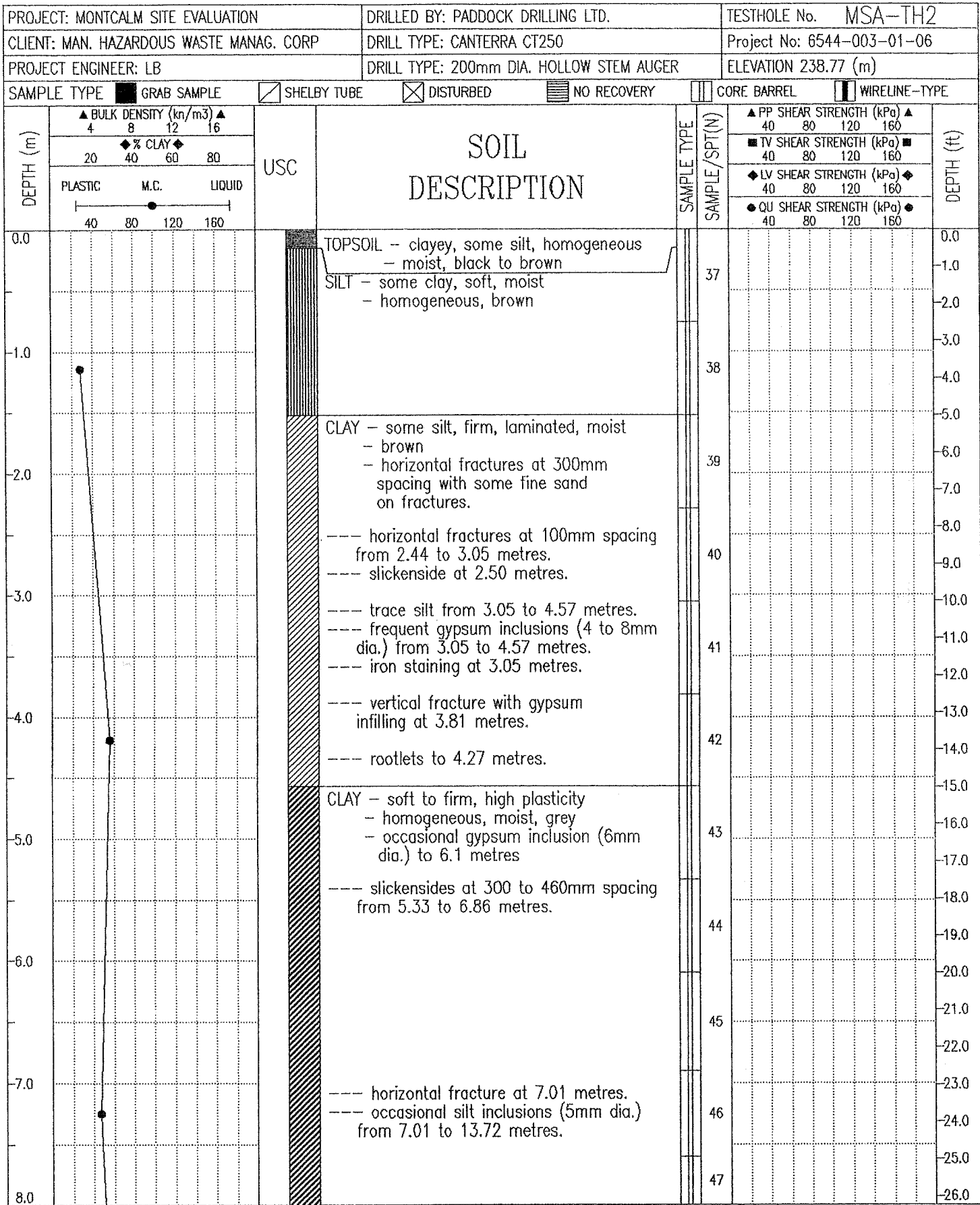
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DATE DRILLED: 31/05/91

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Fig. No.

Page 2 of 2

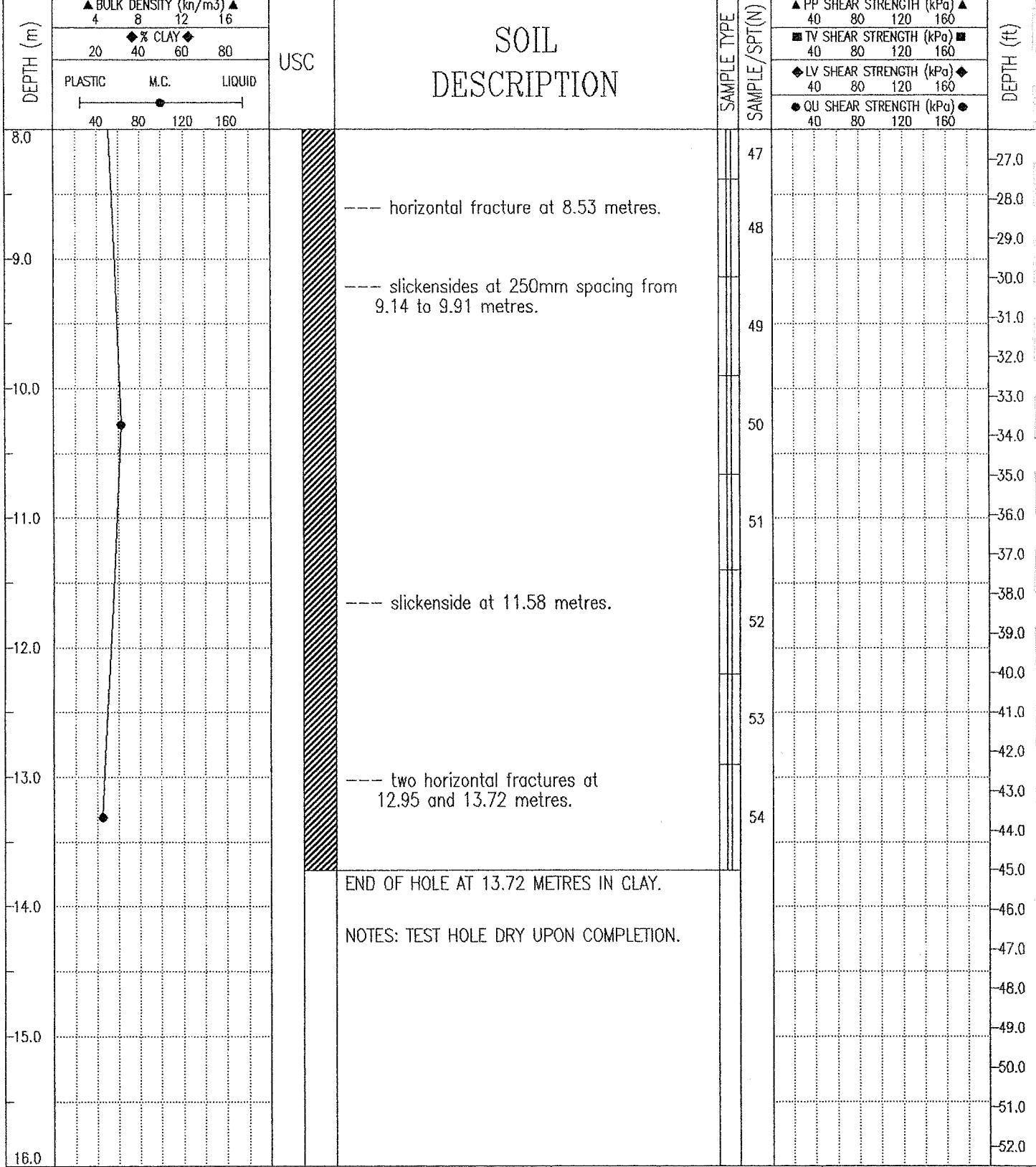


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COMPLETION DEPTH 13.7 m	DATE DRILLED: 31/05/91
LOGGED BY KK	Fig. No.
	Page 1 of 2

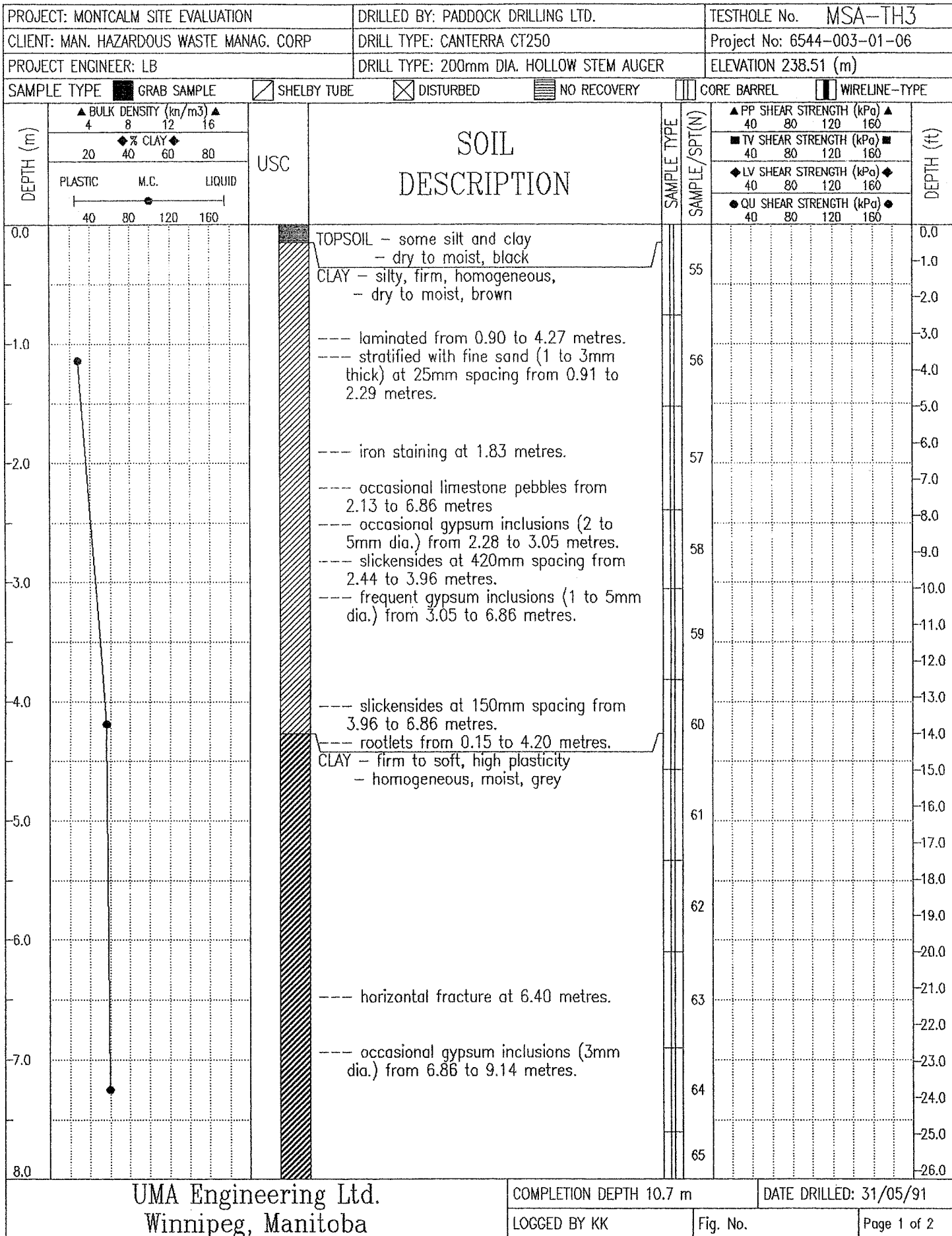
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PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.77 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 13.7 m	DATE DRILLED: 31/05/91
LOGGED BY KK	Page 2 of 2



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COMPLETION DEPTH 10.7 m

DATE DRILLED: 31/05/91

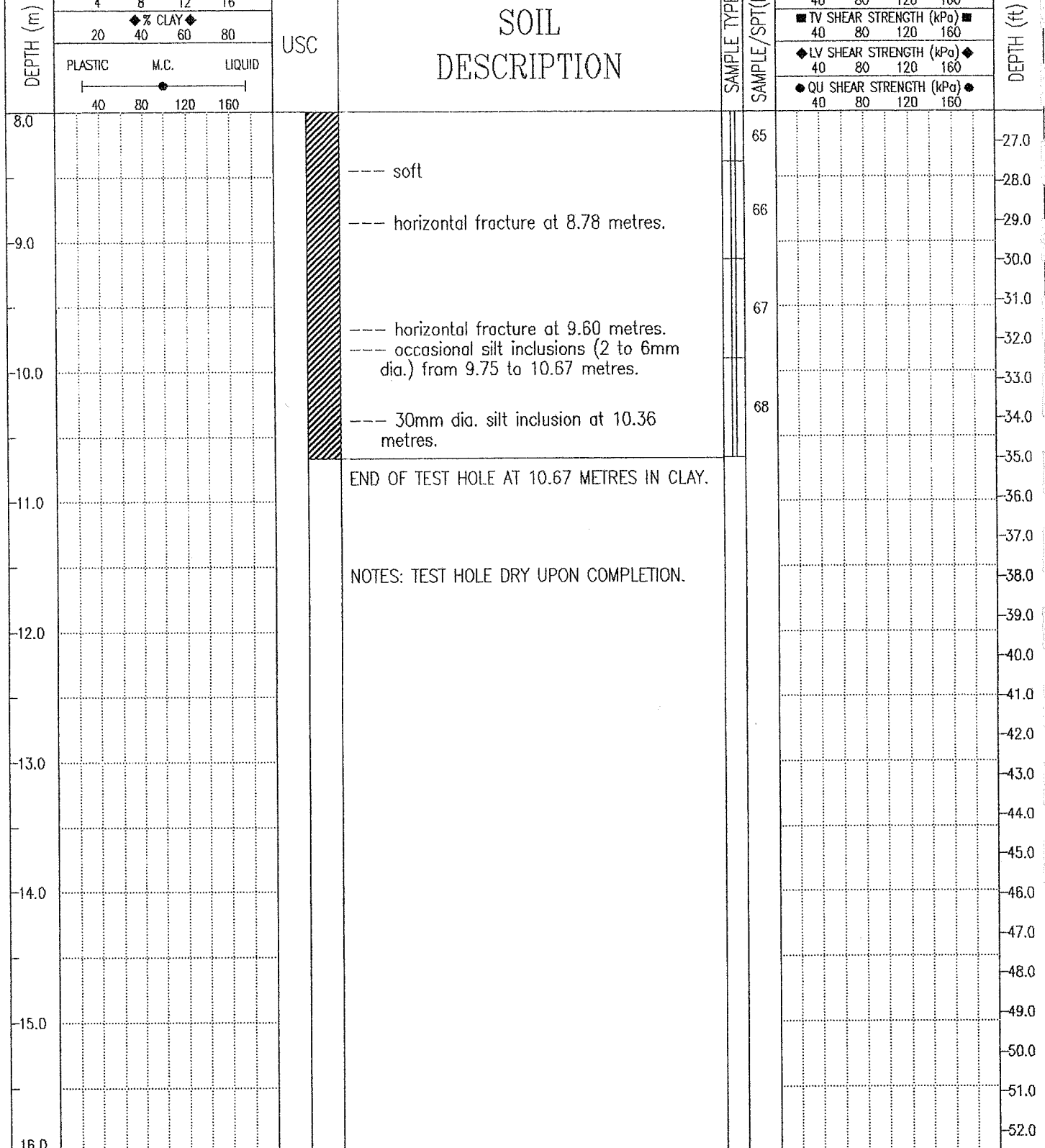
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Fig. No.

Page 1 of 2

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PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.51 (m)

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UMA Engineering Ltd.
Winnipeg, Manitoba

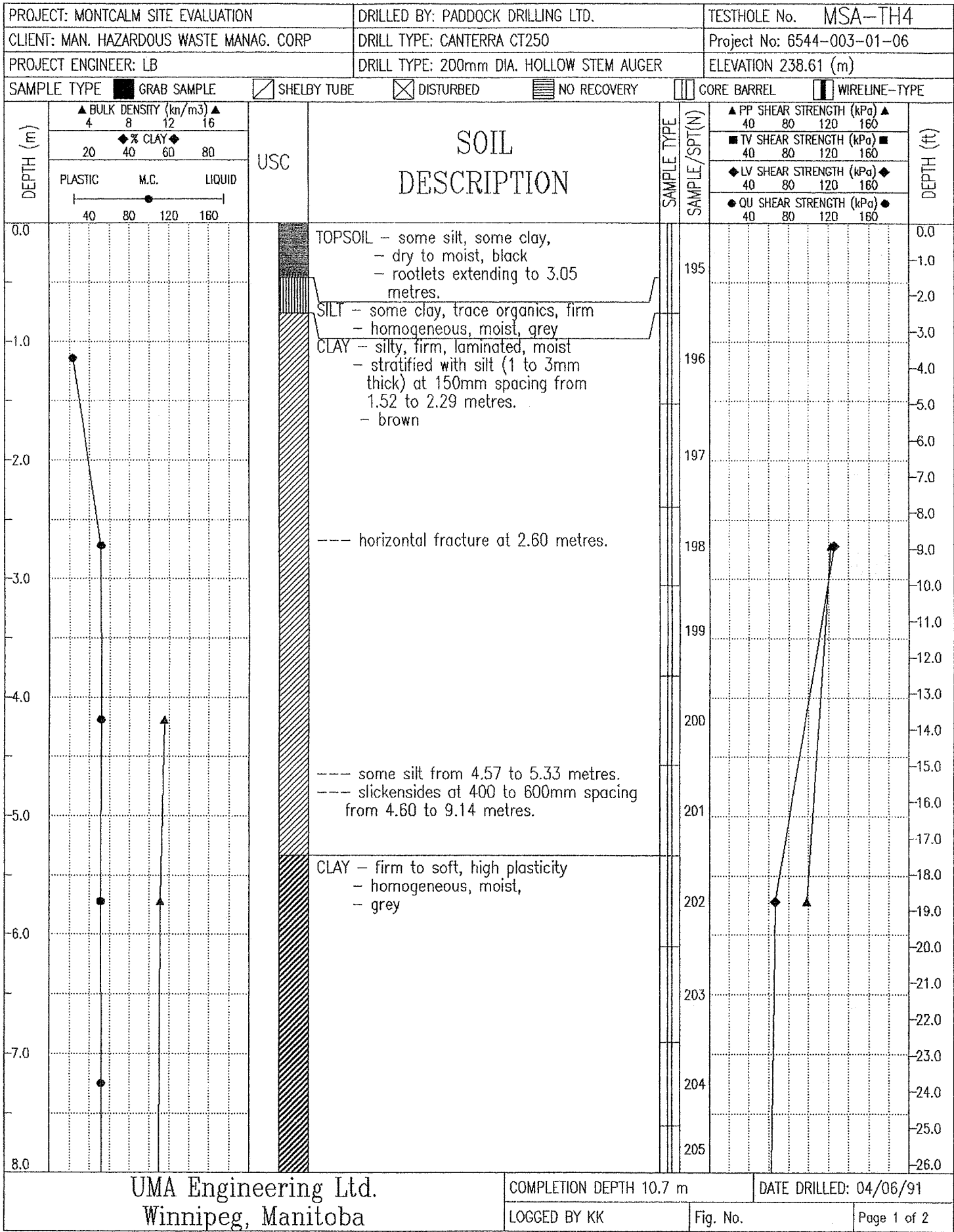
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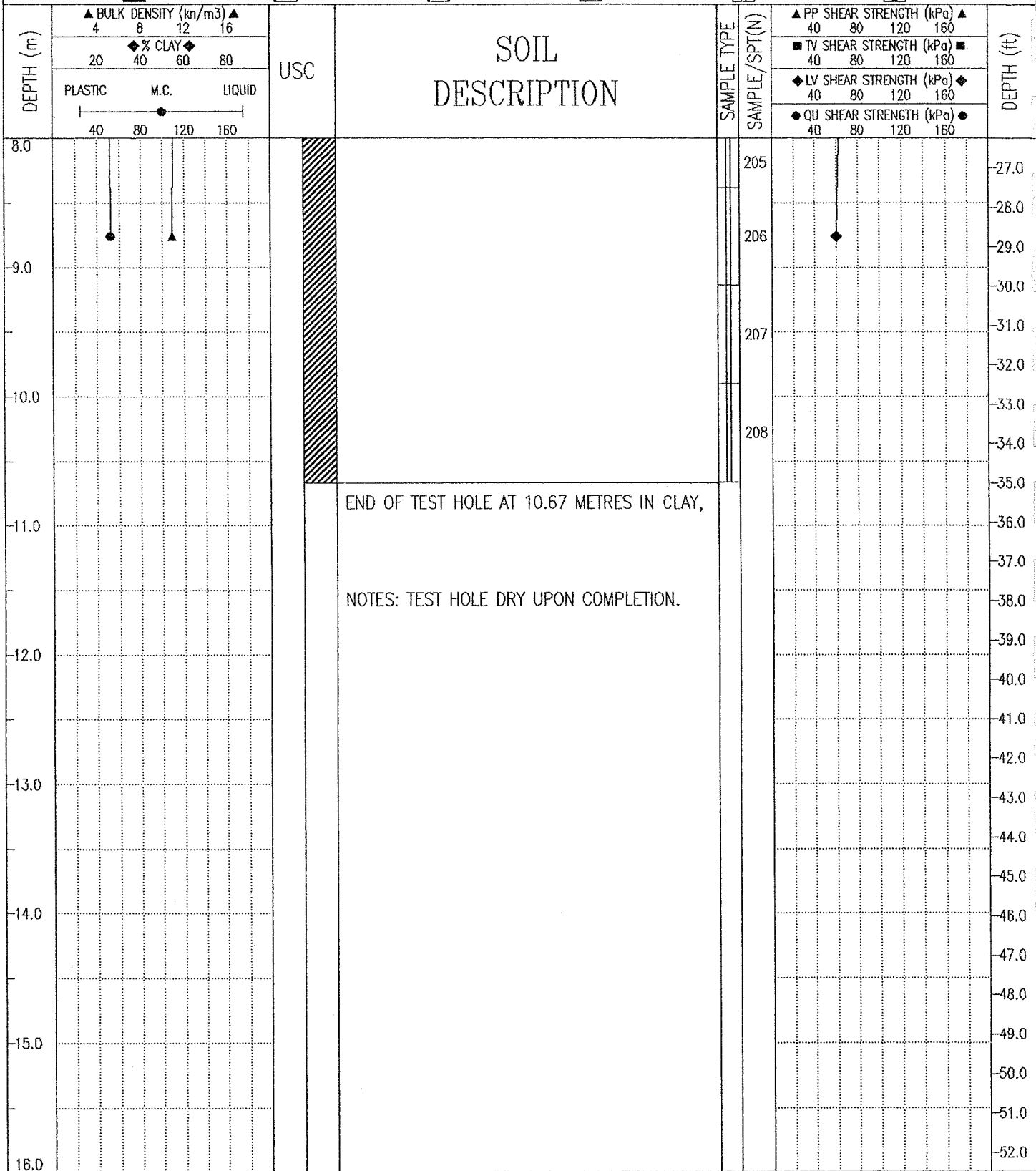
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Fig. No.

Page 2 of 2



PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH4
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PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.61 (m)
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<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd.
Winnipeg, Manitoba

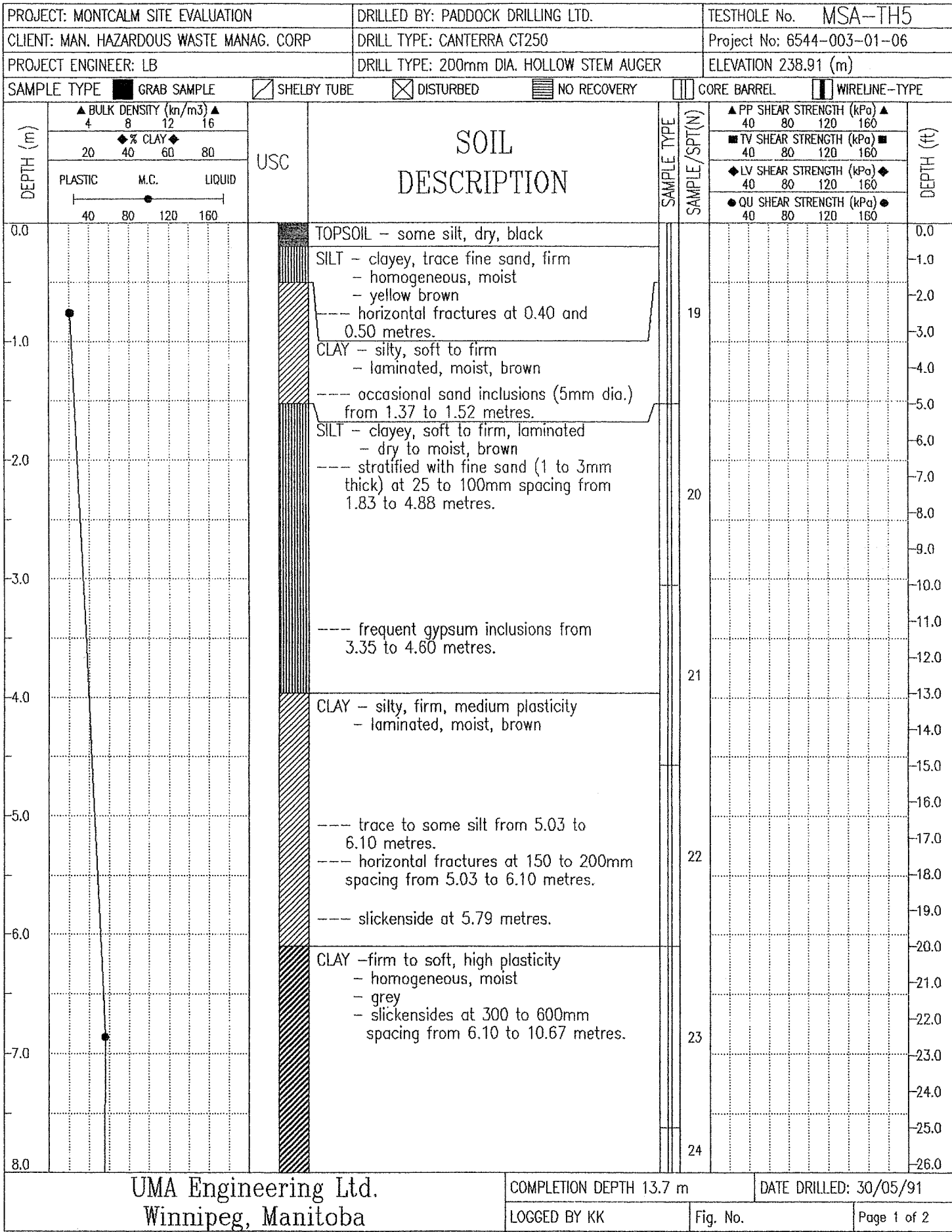
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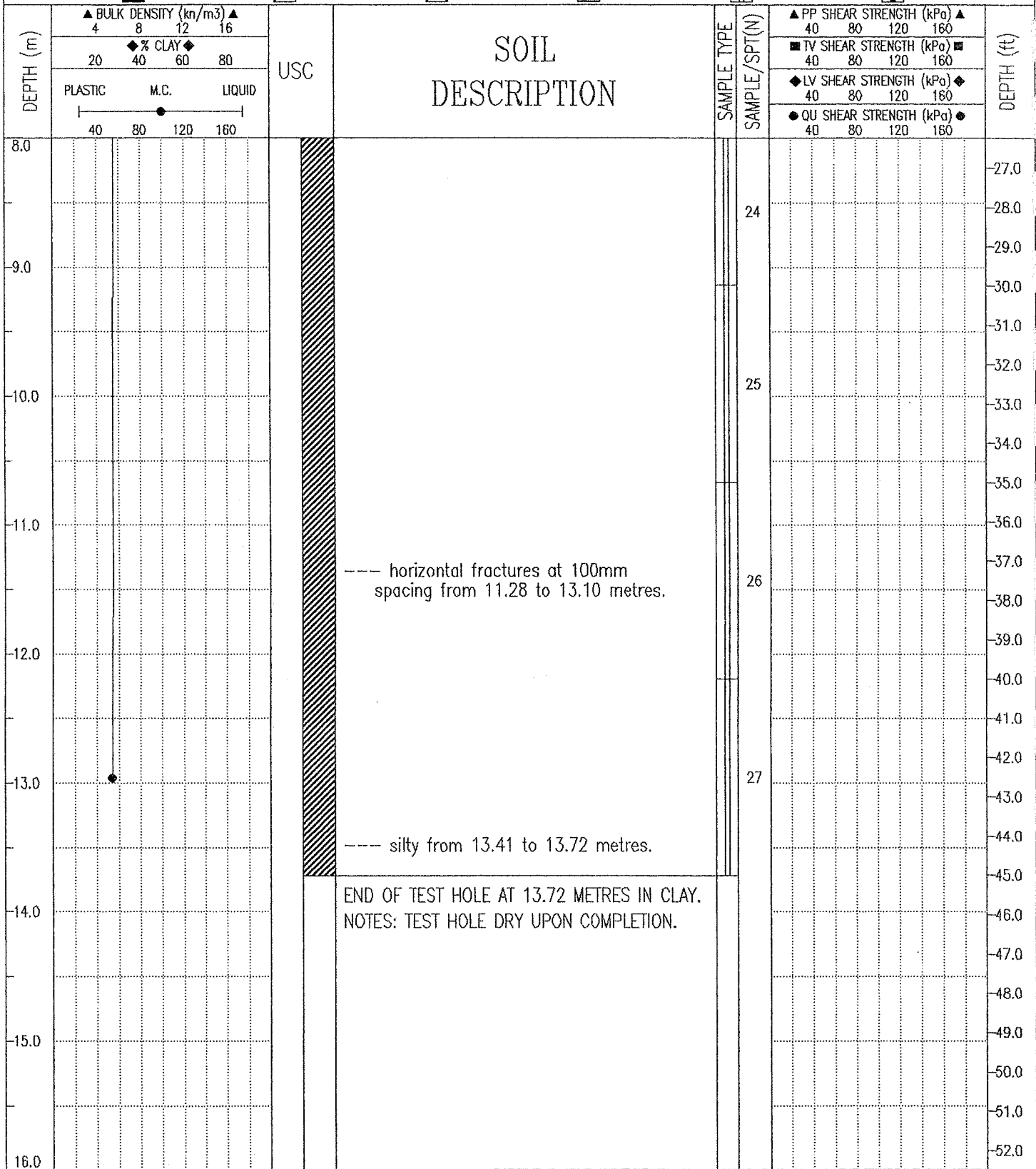
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Fig. No.

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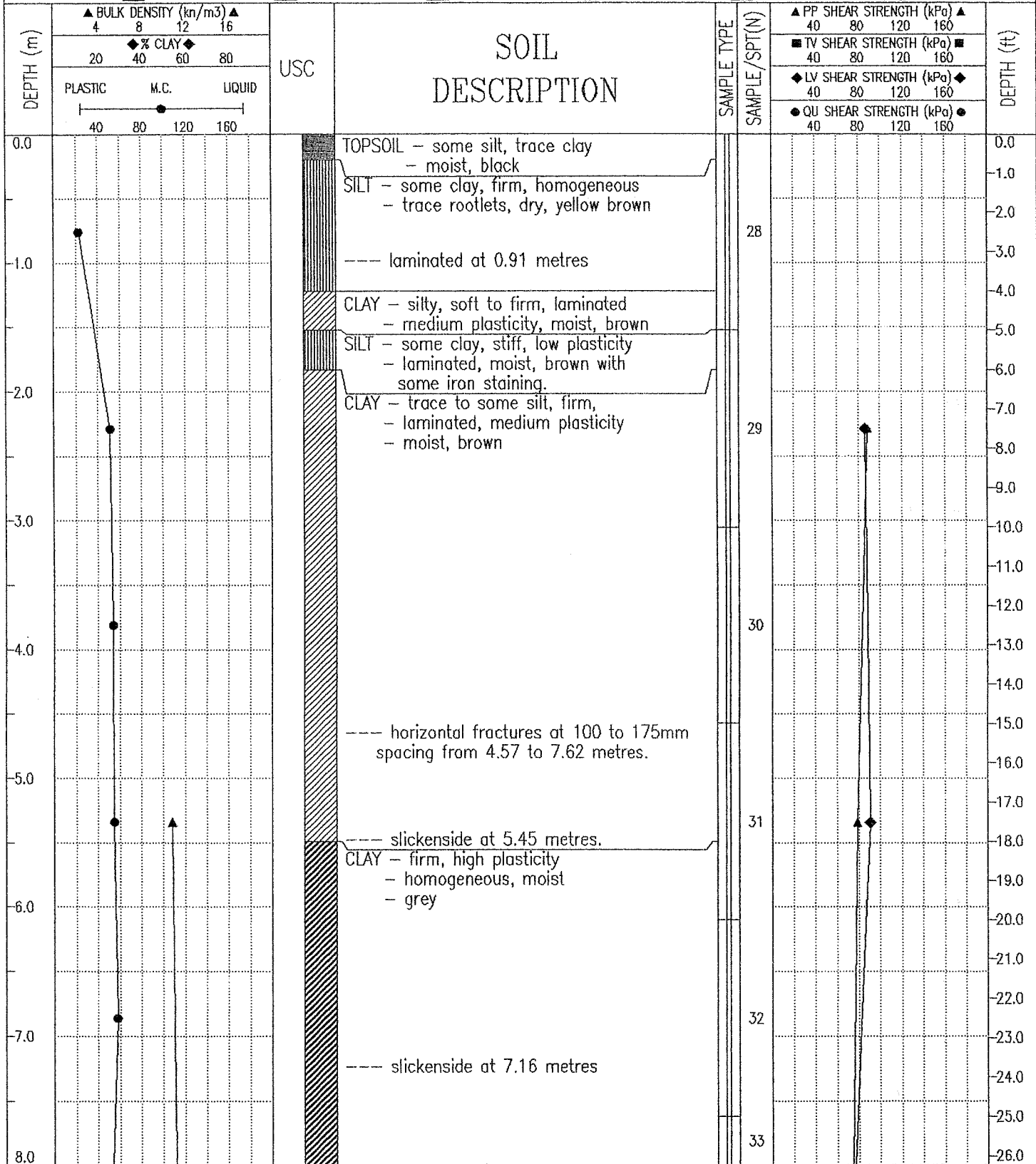


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PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.91 (m)
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UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 13.7 m	DATE DRILLED: 30/05/91
	LOGGED BY KK	Page 2 of 2

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH6
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.67 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



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COMPLETION DEPTH 13.7 m

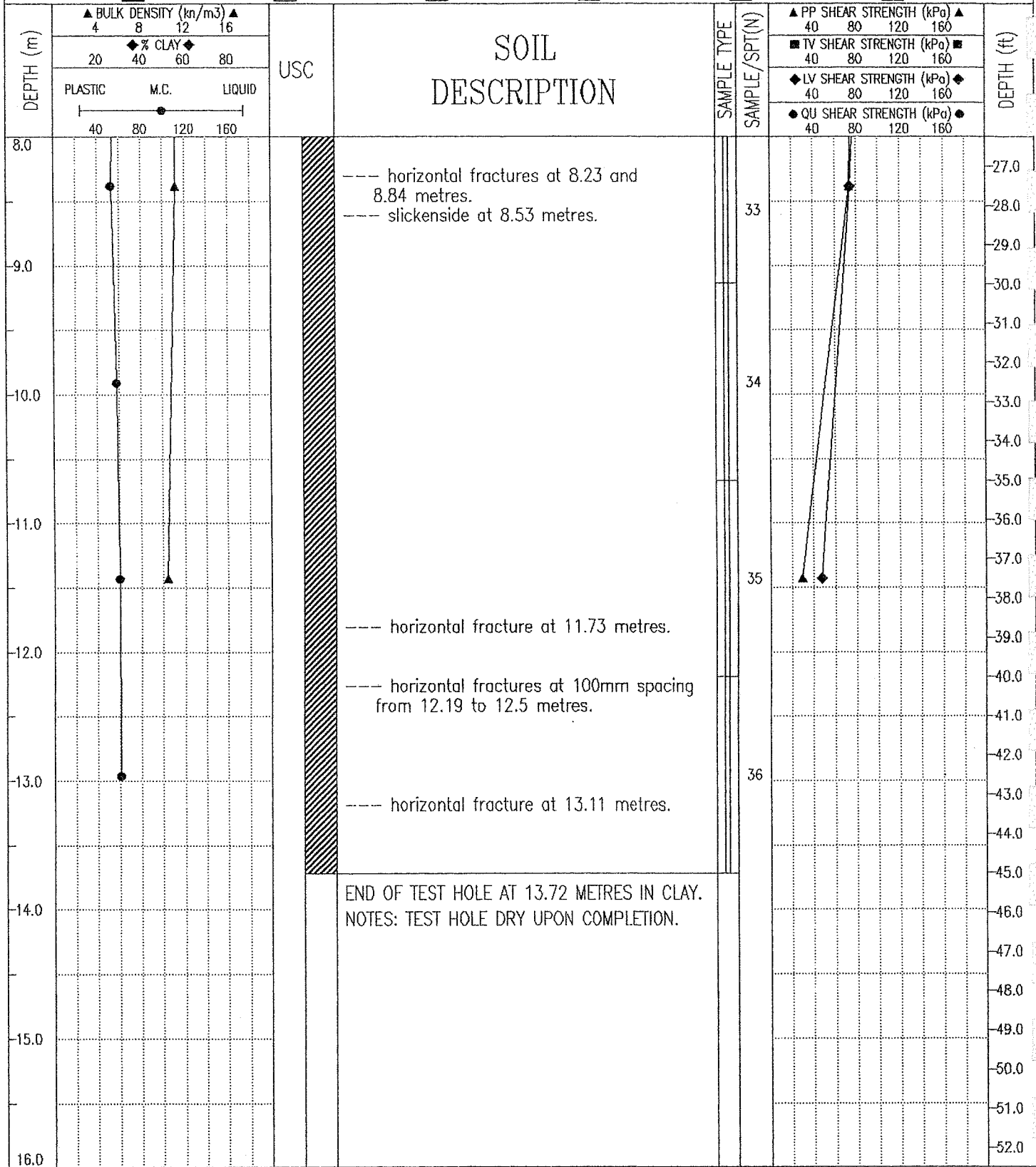
DATE DRILLED: 31/05/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH6
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.67 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



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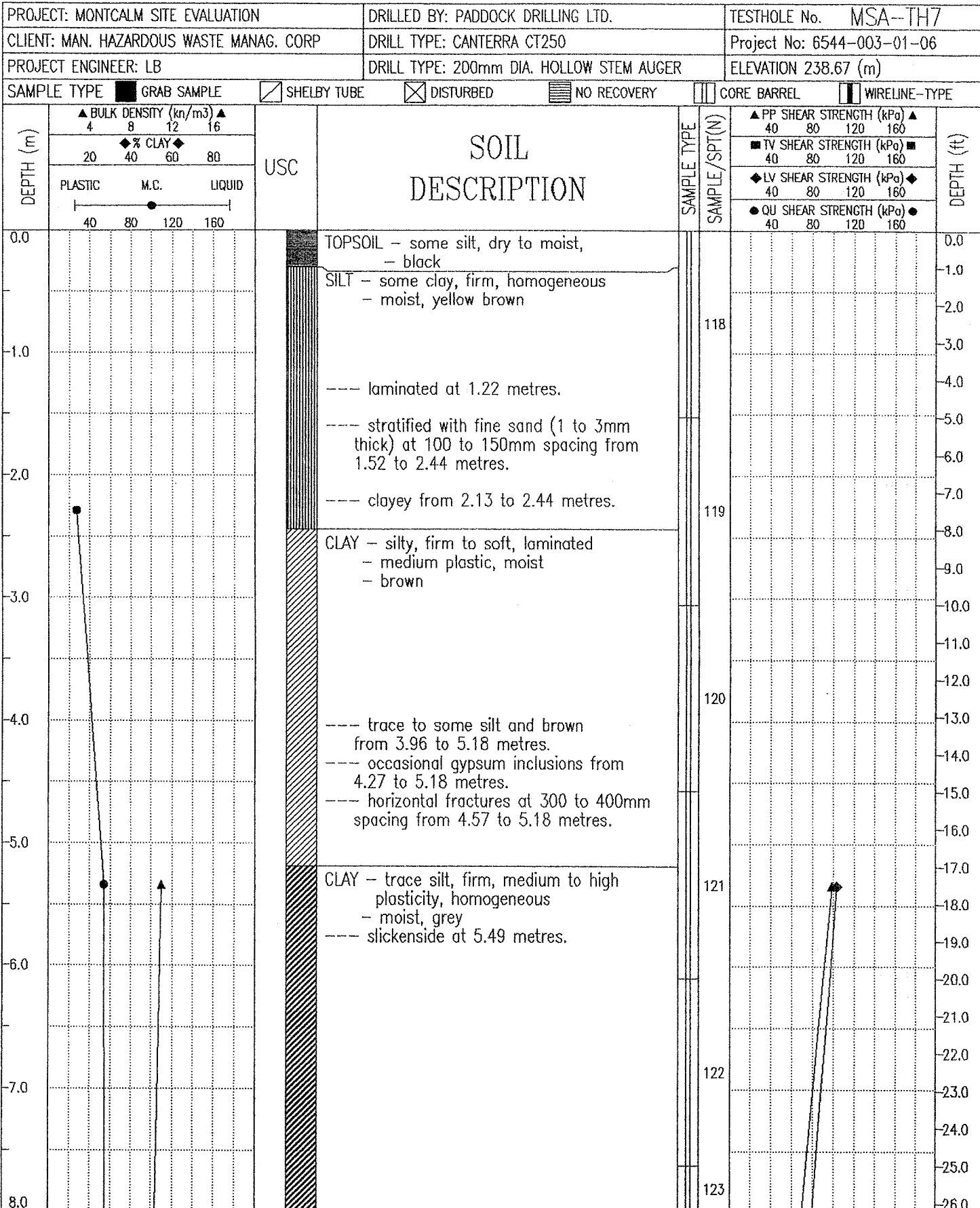
COMPLETION DEPTH 13.7 m

DATE DRILLED: 31/05/91

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Fig. No.

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COMPLETION DEPTH 10.7 m

DATE DRILLED: 03/06/91

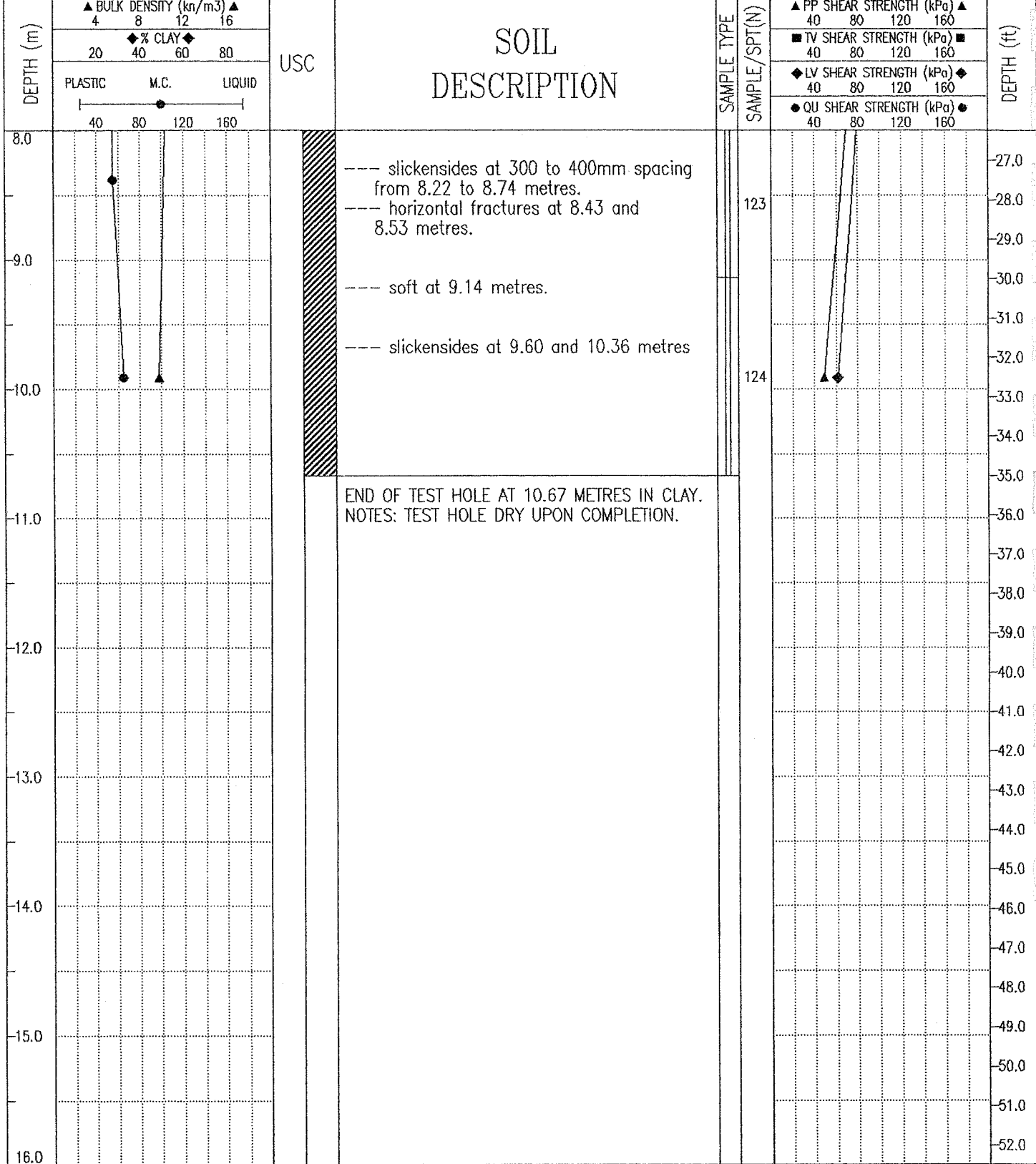
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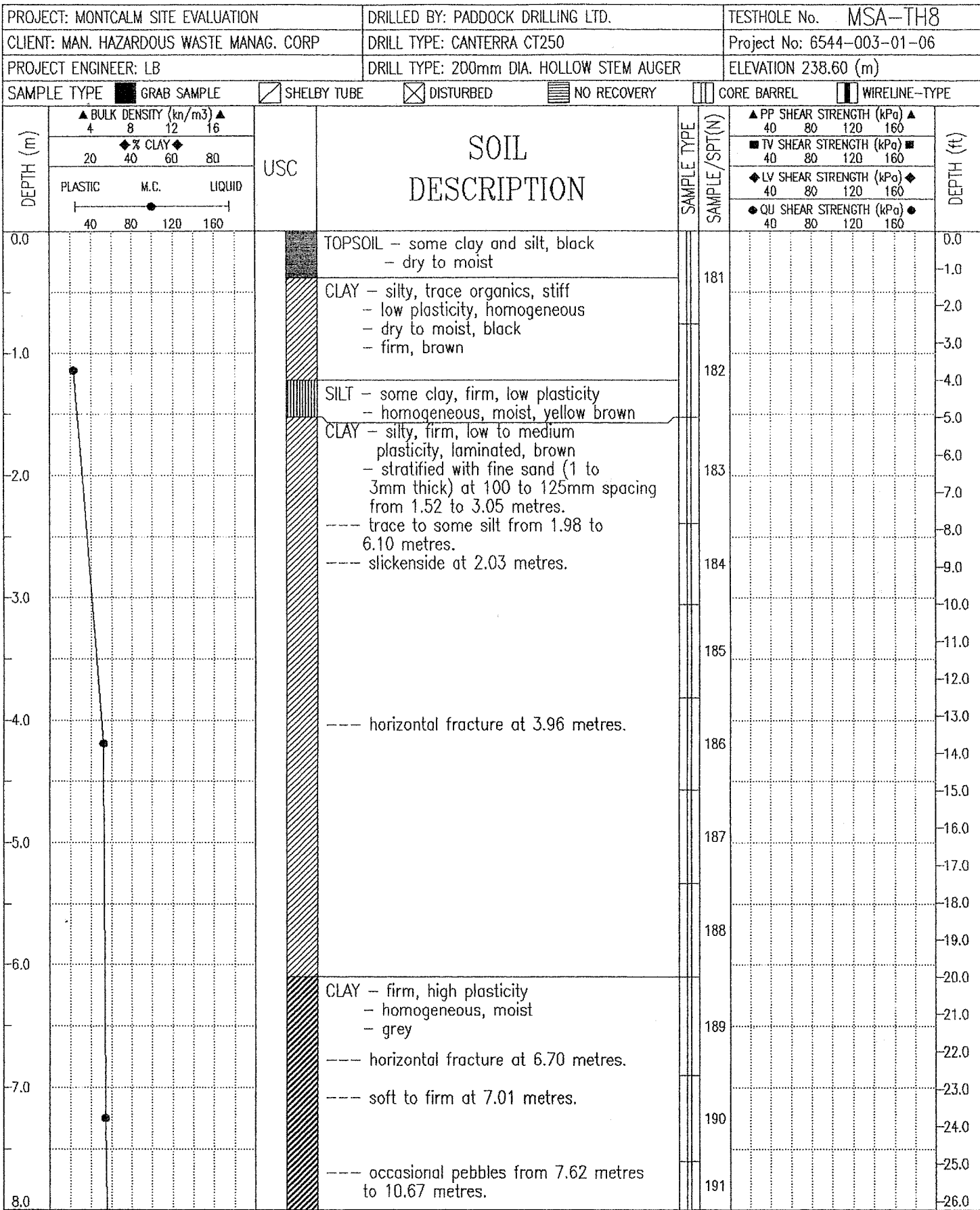
PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH7
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.67 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 10.7 m	DATE DRILLED: 03/06/91
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COMPLETION DEPTH 10.7 m

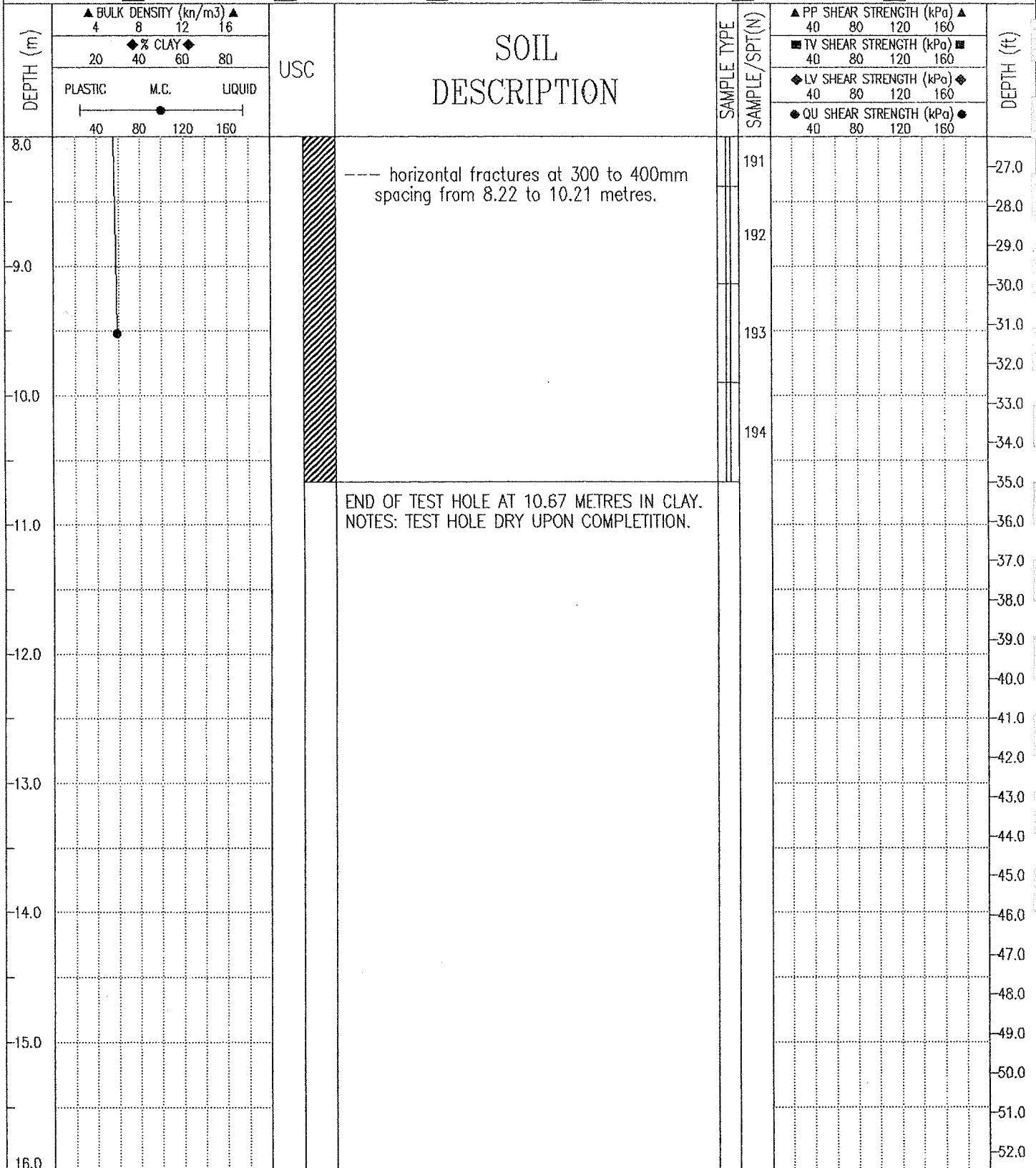
DATE DRILLED: 04/06/91

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH8
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.60 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 10.7 m	DATE DRILLED: 04/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH9	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.70 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE	
		<input type="checkbox"/> NO RECOVERY			

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲		USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲		DEPTH (ft)
	4	8					40	80	
	◆ % CLAY ◆						■ TV SHEAR STRENGTH (kPa) ■		
	20	40					◆ LV SHEAR STRENGTH (kPa) ◆		
	PLASTIC M.C. LIQUID						● QU SHEAR STRENGTH (kPa) ●		
	40	80					40 80 120 160		
	120 160								

0.0				TOPSOIL - some clay and silt, dry, black					0.0
				SILT - some clay, trace organics - firm, laminated, dry - yellow brown		69			-1.0
-1.0				--- moist from 1.22 to 2.29 metres.		70			-2.0
				--- stratified with fine sand (1 to 3mm thick) at 100mm spacing from 1.52 to 2.29 metres.		71			-3.0
-2.0						72			-4.0
				CLAY - silty, firm, medium plasticity - laminated, moist, brown - stratified with fine sand (3 to 10mm thick) at 40 to 100mm spacing from 2.29 to 5.49 metres.		73			-5.0
-3.0				--- occasional gypsum inclusions from 3.05 to 4.10 metres.		74			-6.0
				--- some silt from 3.50 to 5.49 metres.		75			-7.0
-4.0				--- slickenside at 4.11 metres.		76			-8.0
						77			-9.0
-5.0				CLAY - firm, high plasticity, homogeneous - moist, grey - slickenside at 5.58 metres.		78			-10.0
				--- horizontal fractures at 150 to 200mm spacing from 6.71 to 7.12 metres.		79			-11.0
-6.0				--- firm to soft from 6.82 to 10.67 metres.					-12.0
									-13.0
-7.0									-14.0
									-15.0
-8.0									-16.0
									-17.0
									-18.0
									-19.0
									-20.0
									-21.0
									-22.0
									-23.0
									-24.0
									-25.0
									-26.0

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COMPLETION DEPTH 10.7 m

DATE DRILLED: 03/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH9	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.70 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> WIRELINE-TYPE	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> CORE BARREL	
		<input type="checkbox"/> NO RECOVERY			

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲				DEPTH (ft)
	4	8	16					40	80	120	160	
	◆ % CLAY ◆							■ TV SHEAR STRENGTH (kPa) ■				
	20	40	60					◆ LV SHEAR STRENGTH (kPa) ◆				
	PLASTIC M.C. LIQUID							● QU SHEAR STRENGTH (kPa) ●				
	40	80	120									
8.0					---		79					-27.0
												-28.0
					---		80					-29.0
-9.0												-30.0
												-31.0
												-32.0
-10.0												-33.0
												-34.0
					---		82					-35.0
												-36.0
-11.0												-37.0
												-38.0
-12.0												-39.0
												-40.0
												-41.0
-13.0												-42.0
												-43.0
												-44.0
-14.0												-45.0
												-46.0
												-47.0
-15.0												-48.0
												-49.0
												-50.0
												-51.0
16.0												-52.0

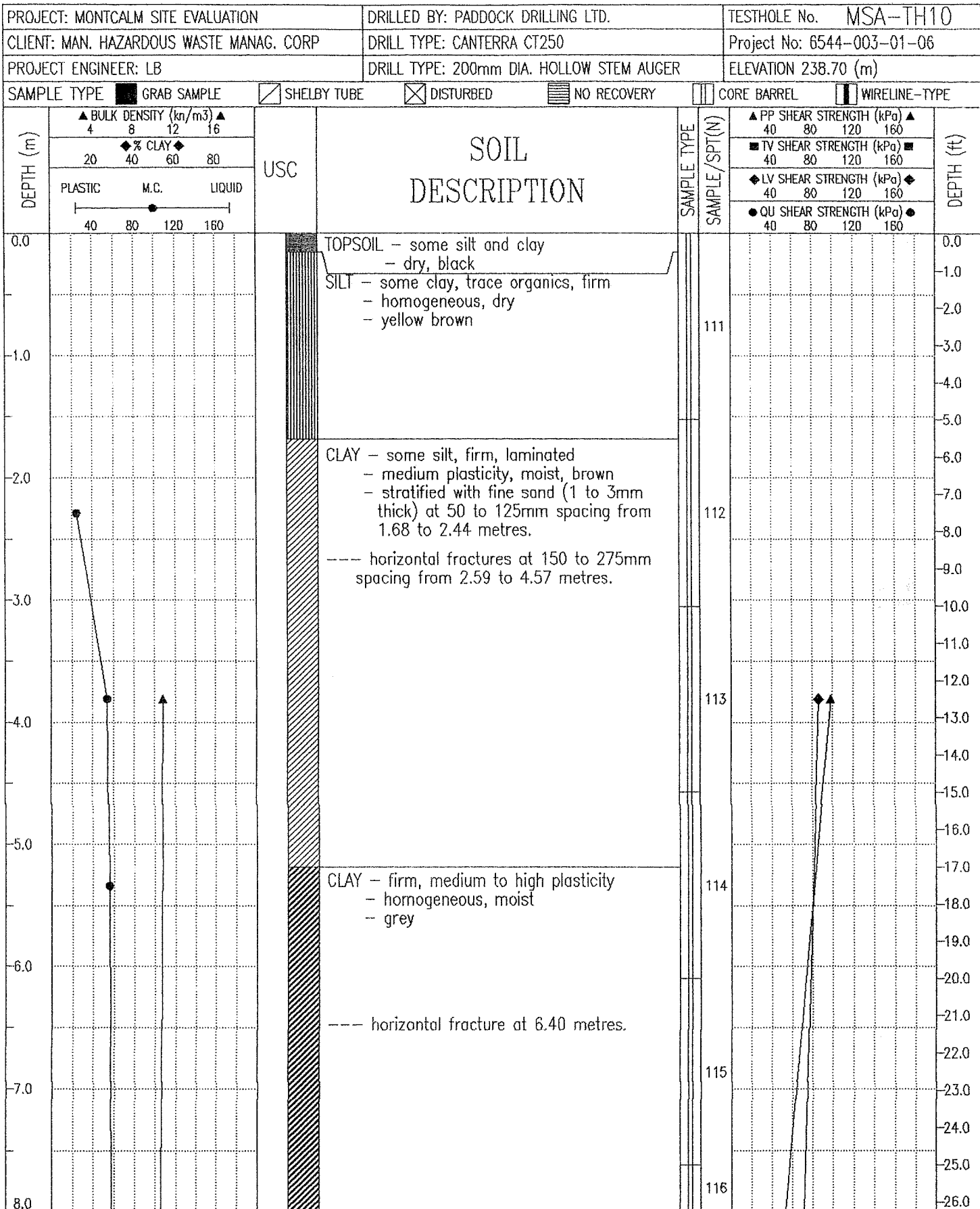
UMA Engineering Ltd. Winnipeg, Manitoba		COMPLETION DEPTH 10.7 m	DATE DRILLED: 03/06/91
		LOGGED BY KK	Fig. No. Page 2 of 2

--- slickenside at 8.08 metres.

--- horizontal fracture at 8.84 metres.

--- slickenside at 10.36 metres.

END OF TEST HOLE AT 10.67 METRES IN CLAY.
NOTES: TEST HOLE DRY UPON COMPLETION.



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COMPLETION DEPTH 10.7 m

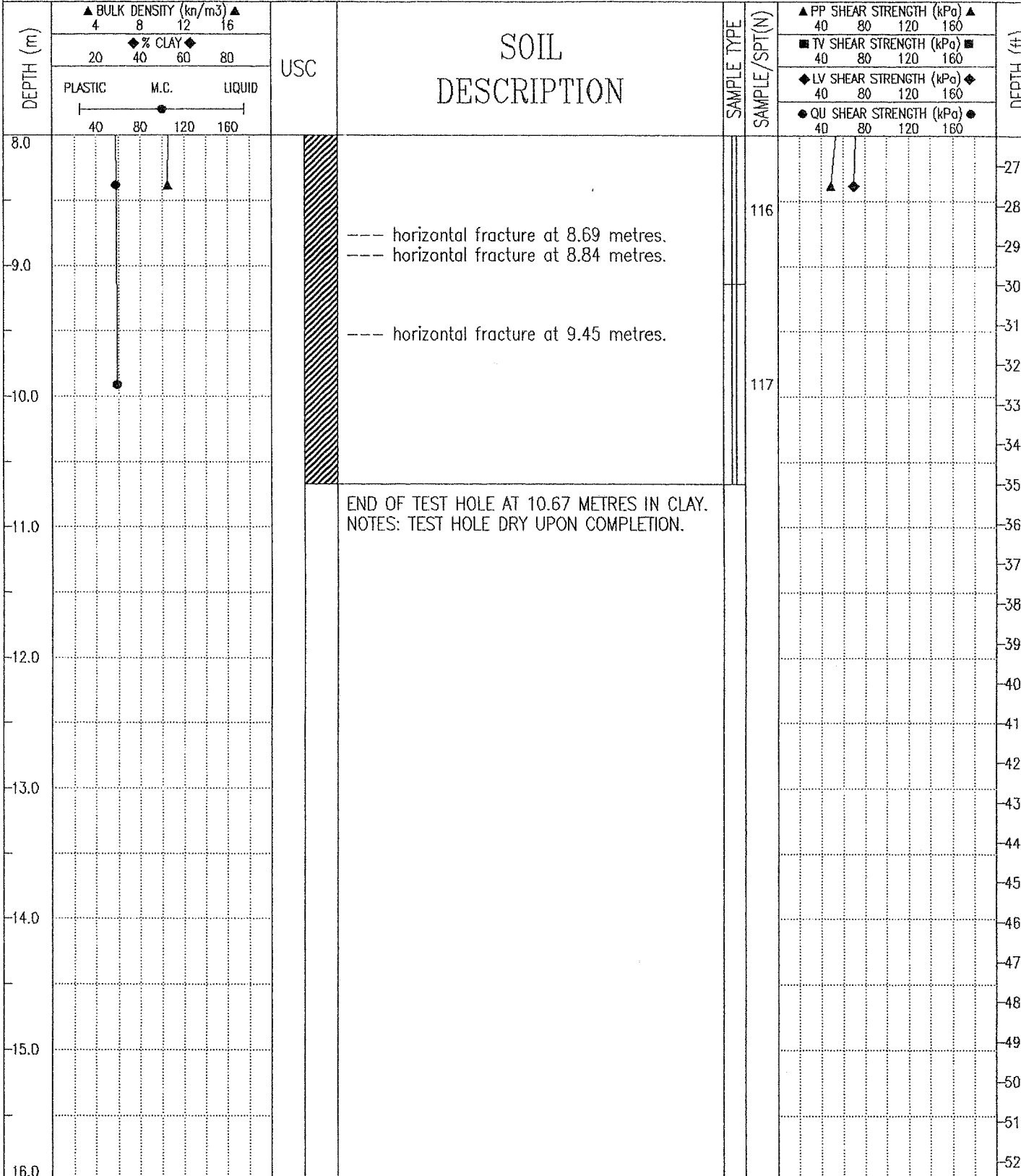
DATE DRILLED: 03/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH10
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.70 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE



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COMPLETION DEPTH 10.7 m	DATE DRILLED: 03/06/91
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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH11	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.81 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE	
		<input type="checkbox"/> NO RECOVERY			
<p>▲ BULK DENSITY (kn/m³) ▲ 4 8 12 16</p> <p>◆ % CLAY ◆ 20 40 60 80</p> <p>PLASTIC M.C. LIQUID 40 80 120 160</p>		<p>USC</p> <h2 style="text-align: center;">SOIL DESCRIPTION</h2>		<p>▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160</p> <p>■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160</p> <p>◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160</p> <p>● QU SHEAR STRENGTH (kPa) ● 40 80 120 160</p>	
DEPTH (m)				SAMPLE TYPE	DEPTH (ft)
				SAMPLE/SPT(N)	
0.0		TOPSOIL - silty, some clay - dry, black			0.0
		SILT - trace clay, trace organics - firm, homogeneous - dry to moist, brown --- yellow brown from 0.61 to 2.29 metres --- laminated from 0.9 to 2.29 metres.			1.0
-1.0					2.0
		--- stratified with fine sand (2 to 4mm thick) at 100mm spacing from 1.37 to 2.29 metres. --- some clay from 1.83 to 2.29 metres.			3.0
-2.0					4.0
		CLAY - silty, firm, - laminated, moist, brown - stratified with fine sand (2 to 4mm thick) at 100mm spacing from 2.29 to 3.05 metres.			5.0
-3.0					6.0
		--- horizontal fracture at 3.20 metres. --- slickenside at 3.35 metres.			7.0
-4.0					8.0
		--- trace silt from 3.66 to 5.33 metres. --- frequent gypsum inclusions from 3.81 to 5.18 metres.			9.0
-5.0					10.0
		--- slickenside at 5.03 metres.			11.0
-6.0					12.0
		CLAY - trace silt, firm, high plasticity - laminated, moist, grey --- slickenside at 5.59 metres.			13.0
-7.0					14.0
		--- slickenside at 6.25 metres. --- slickenside at 6.55 metres. --- horizontal fracture at 6.66 metres.			15.0
-8.0					16.0
		--- slickenside at 7.32 metres.			17.0
					18.0
					19.0
					20.0
					21.0
					22.0
					23.0
					24.0
					25.0
					26.0

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COMPLETION DEPTH 10.7 m

DATE DRILLED: 04/06/91

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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH11					
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06					
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.81 (m)					
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED					
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL					
				<input type="checkbox"/> WIRELINE-TYPE					
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION		SAMPLE TYPE	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80						■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160		
	PLASTIC M.C. LIQUID 40 80 120 160						◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160		
							◆ QU SHEAR STRENGTH (kPa) ◆ 40 80 120 160		
8.0				7.90 to 8.23 metres.					
				--- homogeneous from 8.23 to 10.67 metres	135				-27.0
				--- slickenside at 8.69 metres.	136				-28.0
-9.0				--- slickenside at 9.45 metres.	137				-29.0
				--- slickenside at 10.06 metres.	138				-30.0
-10.0									-31.0
									-32.0
-11.0				END OF TEST HOLE AT 10.67 METRES IN CLAY. NOTES: TEST HOLE DRY UPON COMPLETION.					-33.0
									-34.0
-12.0									-35.0
									-36.0
-13.0									-37.0
									-38.0
-14.0									-39.0
									-40.0
-15.0									-41.0
									-42.0
-16.0									-43.0
									-44.0
									-45.0
									-46.0
									-47.0
									-48.0
									-49.0
									-50.0
									-51.0
									-52.0

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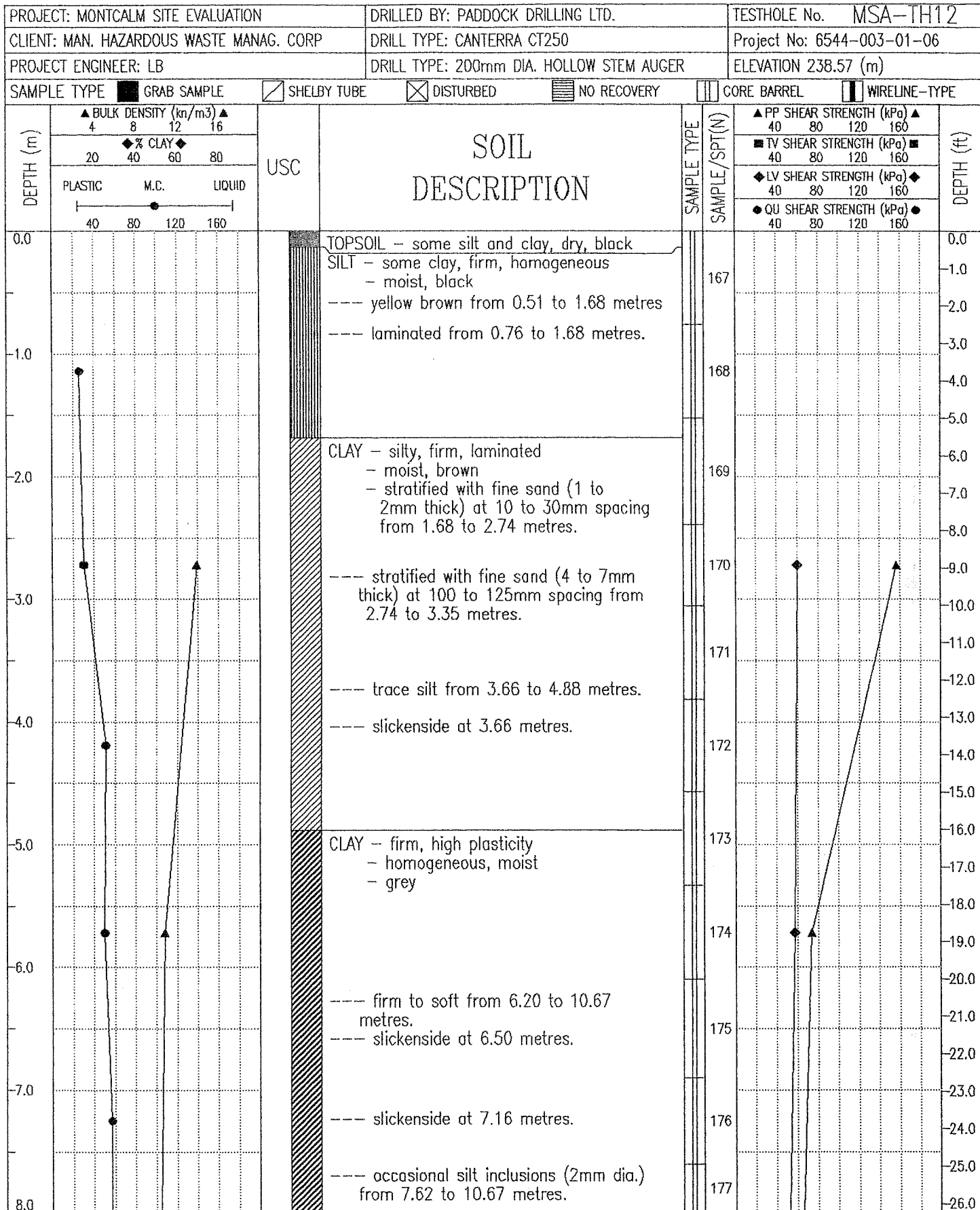
COMPLETION DEPTH 10.7 m

DATE DRILLED: 04/06/91

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COMPLETION DEPTH 10.7 m

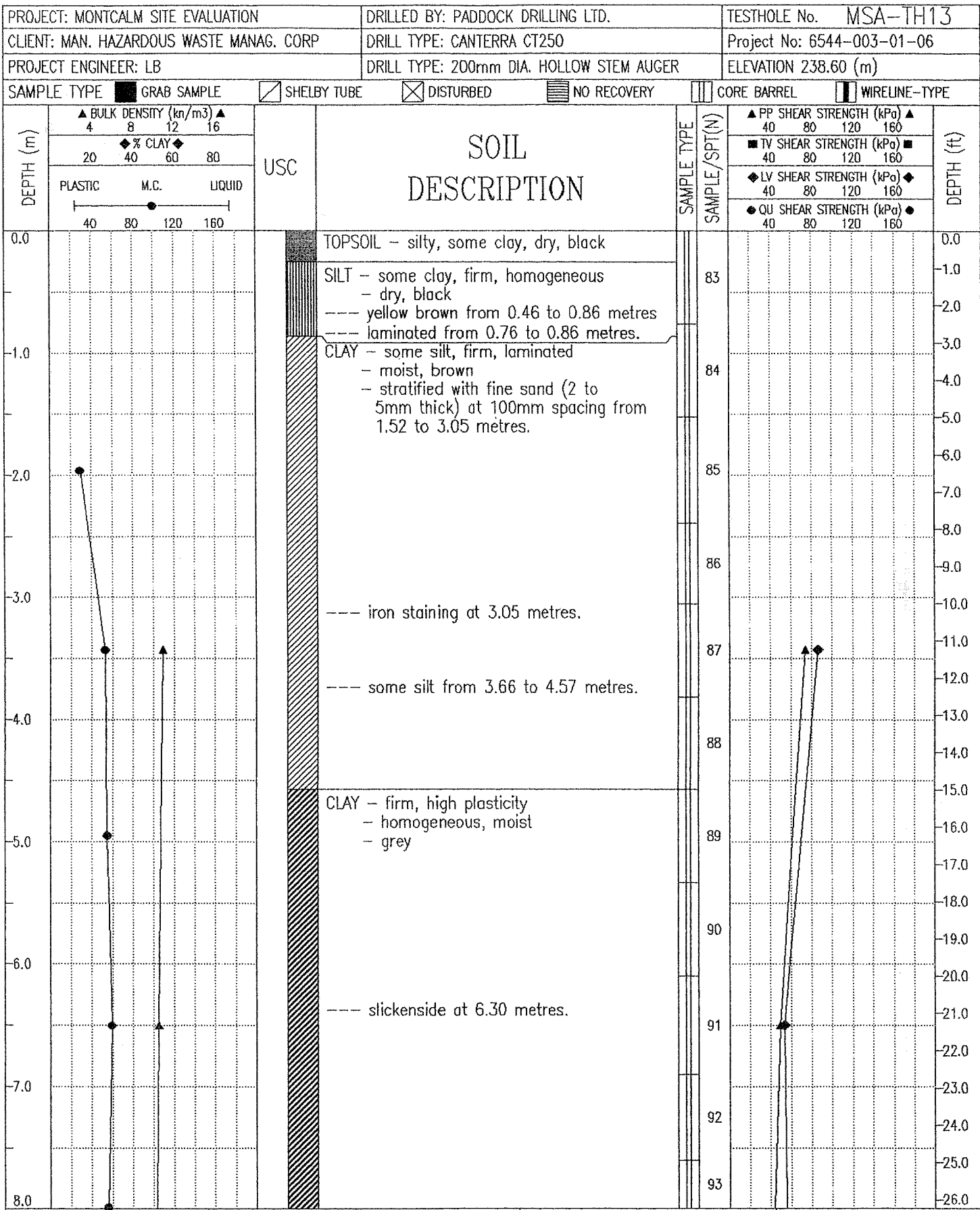
DATE DRILLED: 04/06/91

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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH12			
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06			
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.57 (m)			
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> NO RECOVERY			
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> CORE BARREL			
				<input type="checkbox"/> WIRELINE-TYPE			
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160	DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80					■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160	
	PLASTIC M.C. LIQUID 40 80 120 160					◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160	
						● QU SHEAR STRENGTH (kPa) ● 40 80 120 160	
8.0					177		-27.0
							-28.0
					178		-29.0
-9.0							-30.0
							-31.0
					179		-32.0
							-33.0
-10.0							-34.0
					180		-35.0
							-36.0
-11.0			END OF TEST HOLE AT 10.67 METRES IN CLAY. NOTES: TEST HOLE DRY UPON COMPLETION.				-37.0
							-38.0
							-39.0
-12.0							-40.0
							-41.0
							-42.0
-13.0							-43.0
							-44.0
							-45.0
-14.0							-46.0
							-47.0
							-48.0
-15.0							-49.0
							-50.0
							-51.0
16.0							-52.0
UMA Engineering Ltd. Winnipeg, Manitoba				COMPLETION DEPTH 10.7 m		DATE DRILLED: 04/06/91	
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				Fig. No.			



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COMPLETION DEPTH 10.7 m

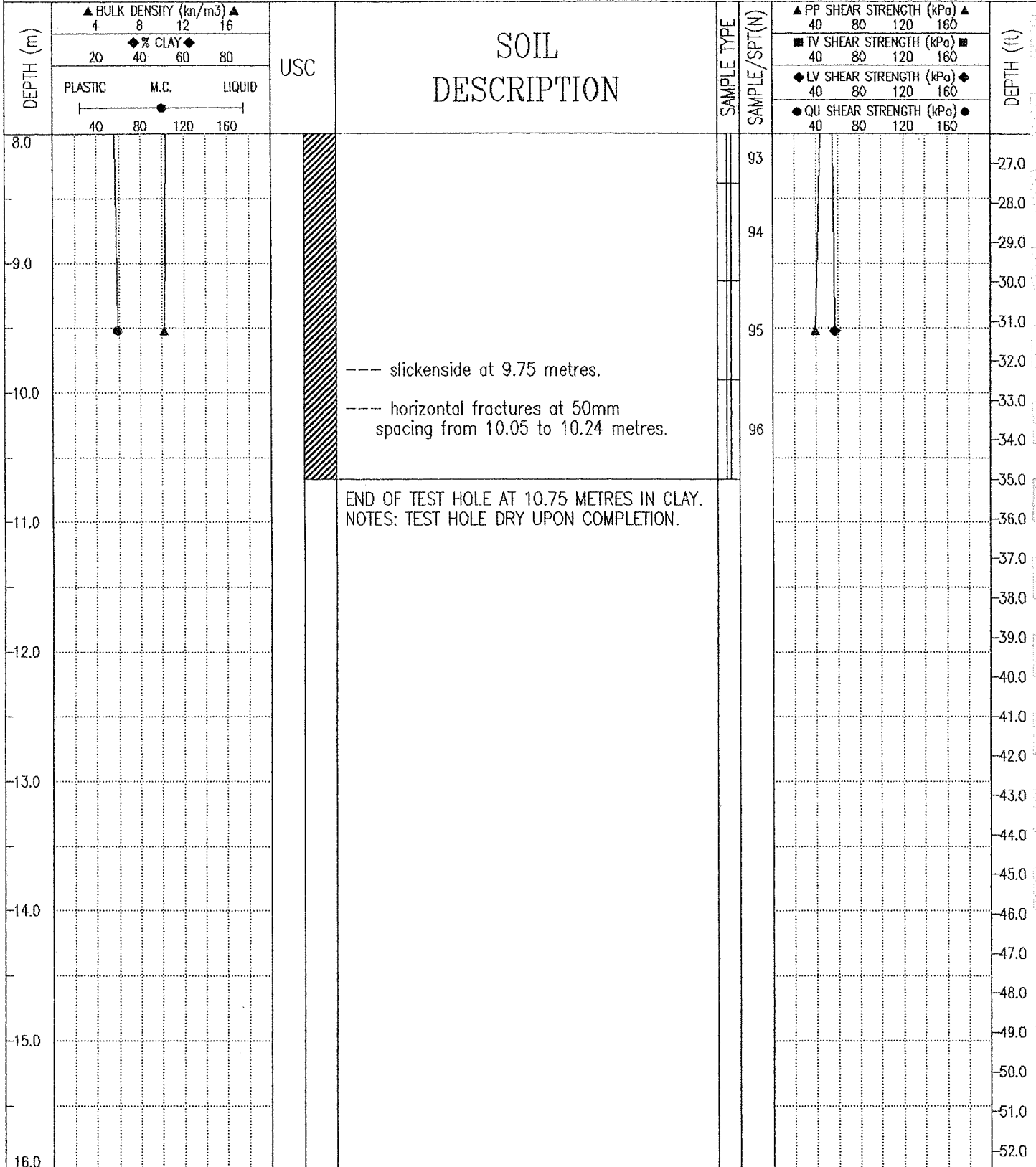
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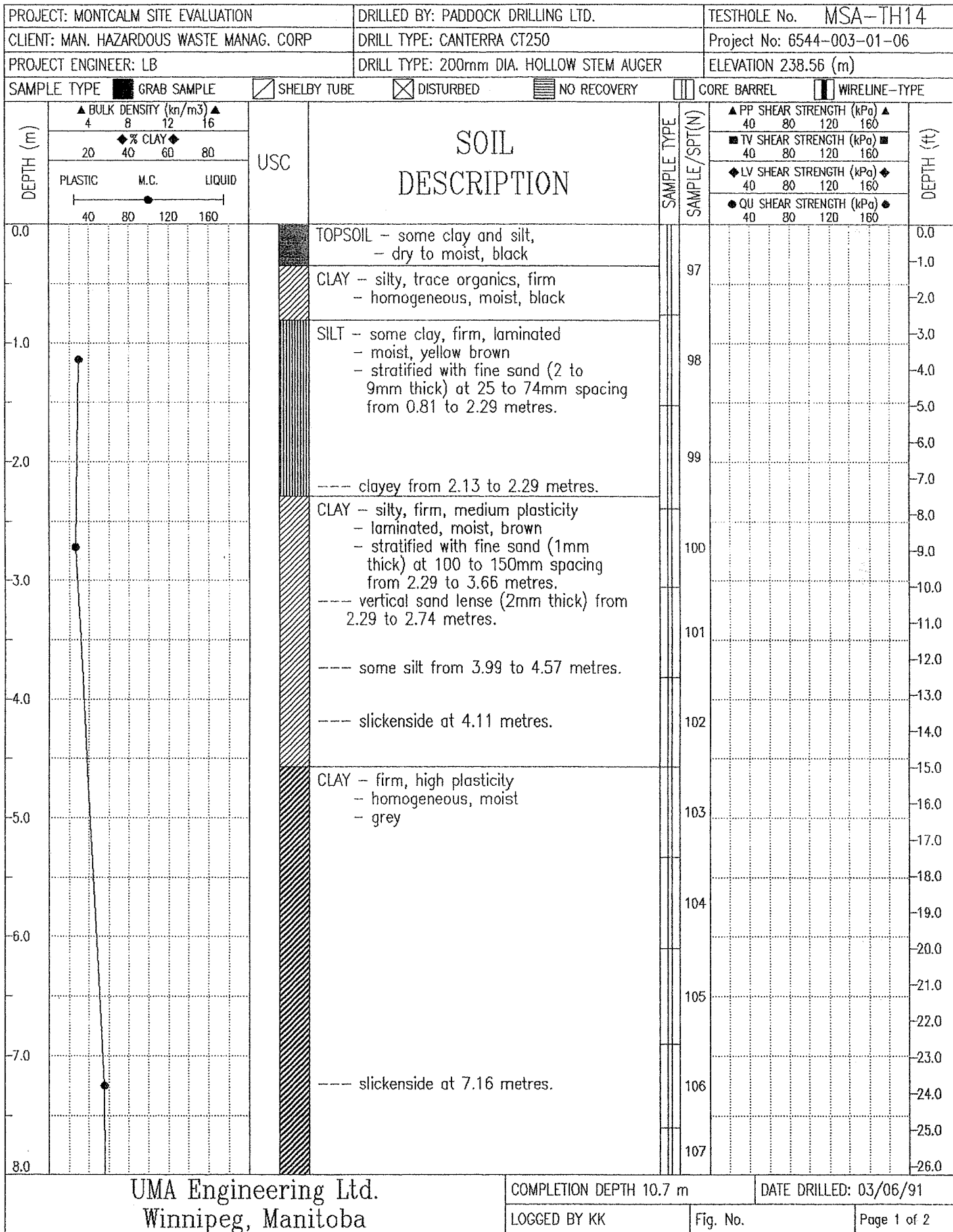
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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH13
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.60 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE





PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-TH14						
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06						
PROJECT ENGINEER: LB		DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER		ELEVATION 238.56 (m)						
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> NO RECOVERY						
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> CORE BARREL						
				<input type="checkbox"/> WIRELINE-TYPE						
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION		SAMPLE TYPE	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)	
	◆ % CLAY ◆ 20 40 60 80						■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160			
	PLASTIC M.C. LIQUID 40 80 120 160						◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160			
							● QU SHEAR STRENGTH (kPa) ● 40 80 120 160			
8.0				--- slickenside at 8.69 metres. --- horizontal fracture at 9.75 metres. --- slickenside at 10.21 metres. --- horizontal fracture at 10.36 metres.	107				-27.0	
					108					-28.0
-9.0					109					-29.0
					110					-30.0
-10.0									-31.0	
									-32.0	
-11.0									-33.0	
									-34.0	
-12.0									-35.0	
									-36.0	
-13.0									-37.0	
									-38.0	
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									-44.0	
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									-46.0	
									-47.0	
									-48.0	
									-49.0	
									-50.0	
									-51.0	
									-52.0	
END OF TEST HOLE AT 10.67 METRES IN CLAY. NOTES: TEST HOLE DRY UPON COMPLETION.										

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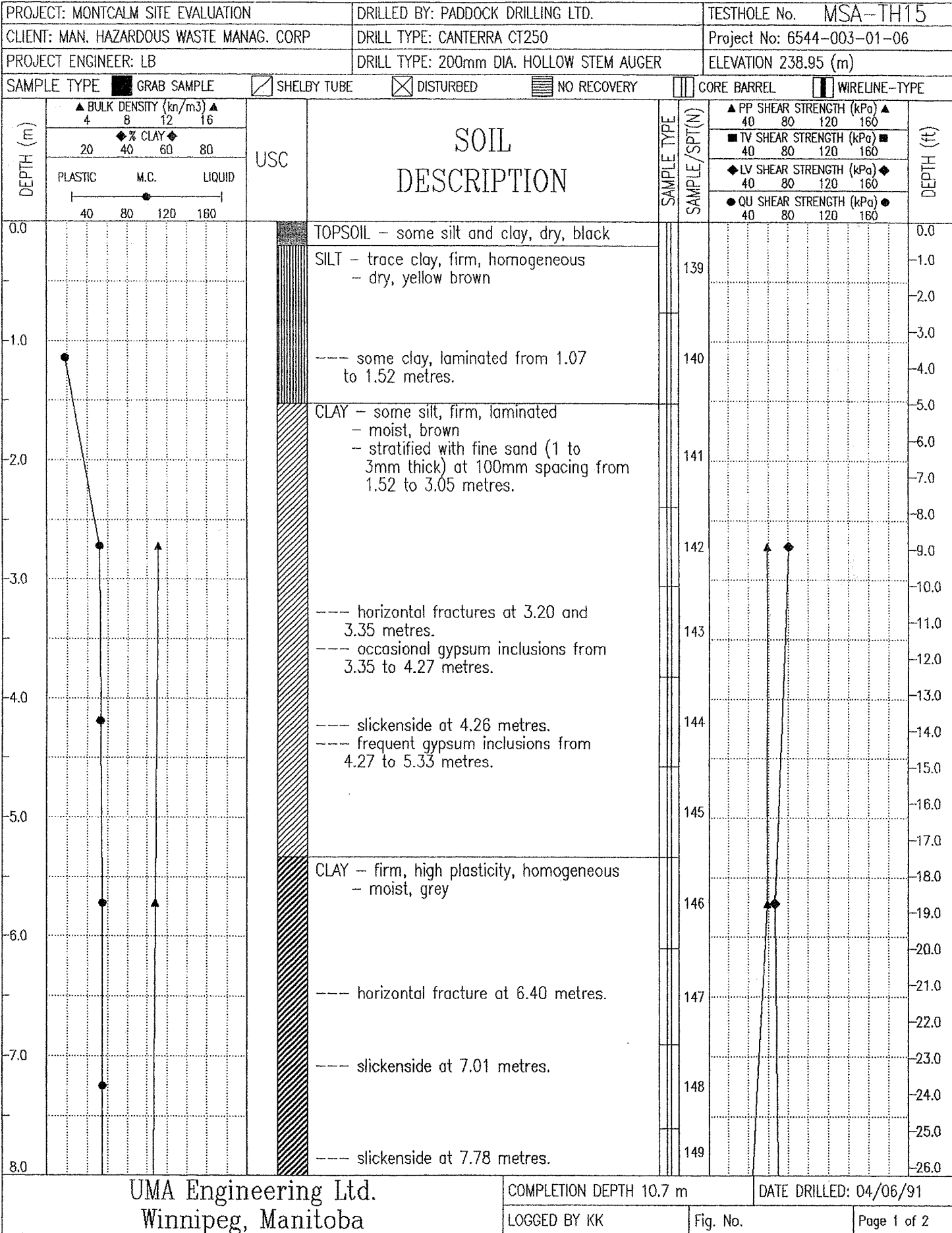
COMPLETION DEPTH 10.7 m

DATE DRILLED: 03/06/91

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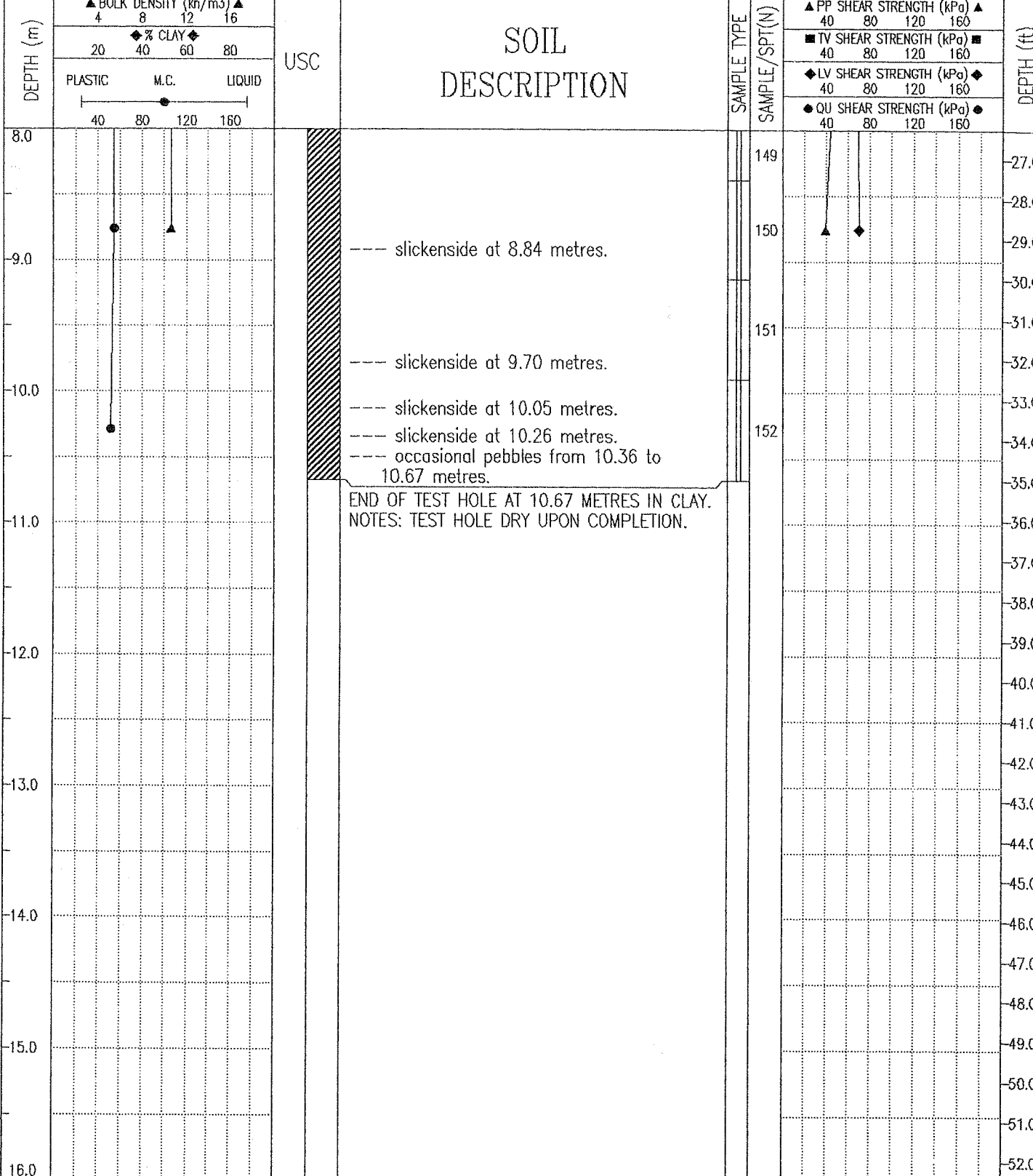
Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH15
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.95 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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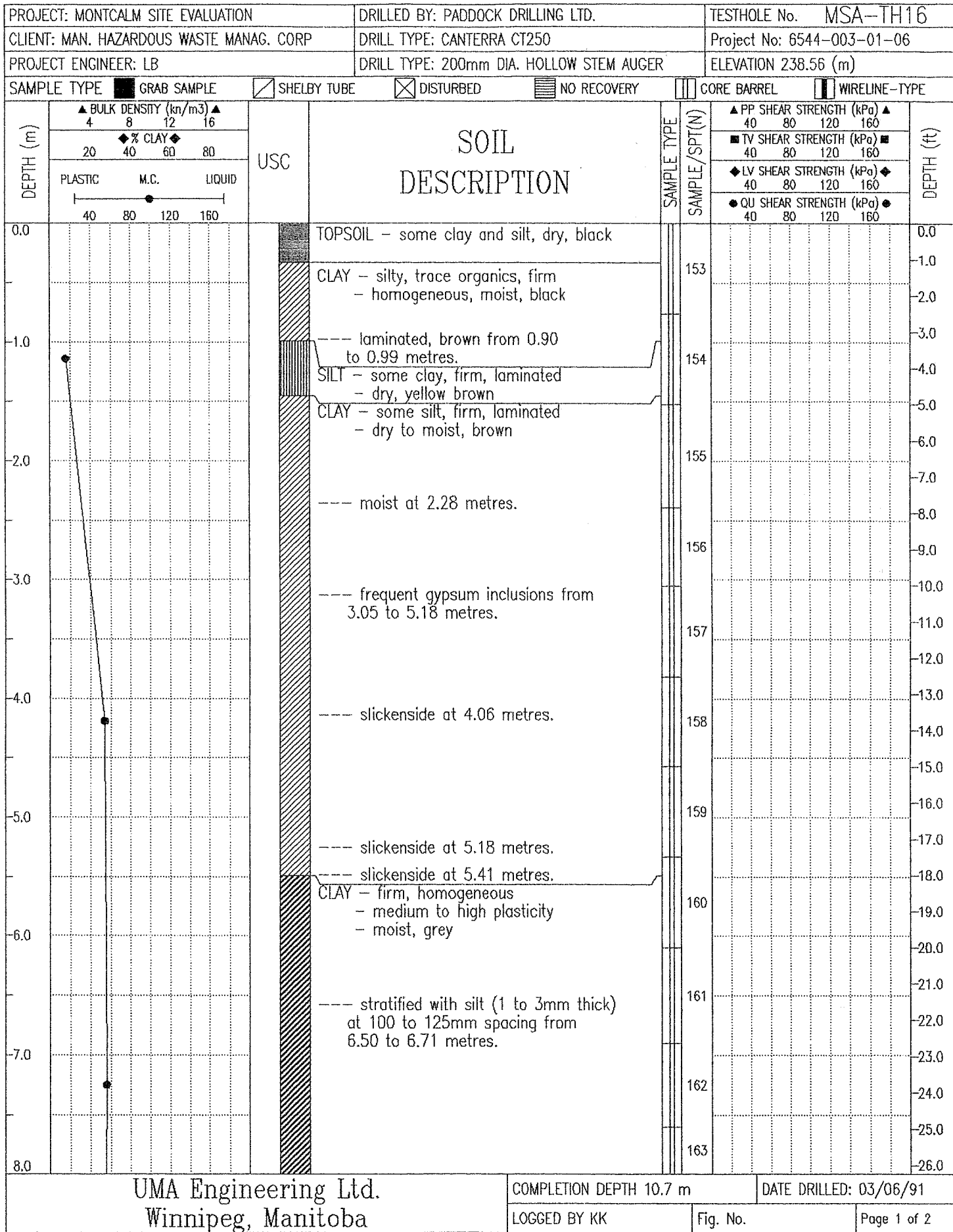
COMPLETION DEPTH 10.7 m

DATE DRILLED: 04/06/91

LOGGED BY KK

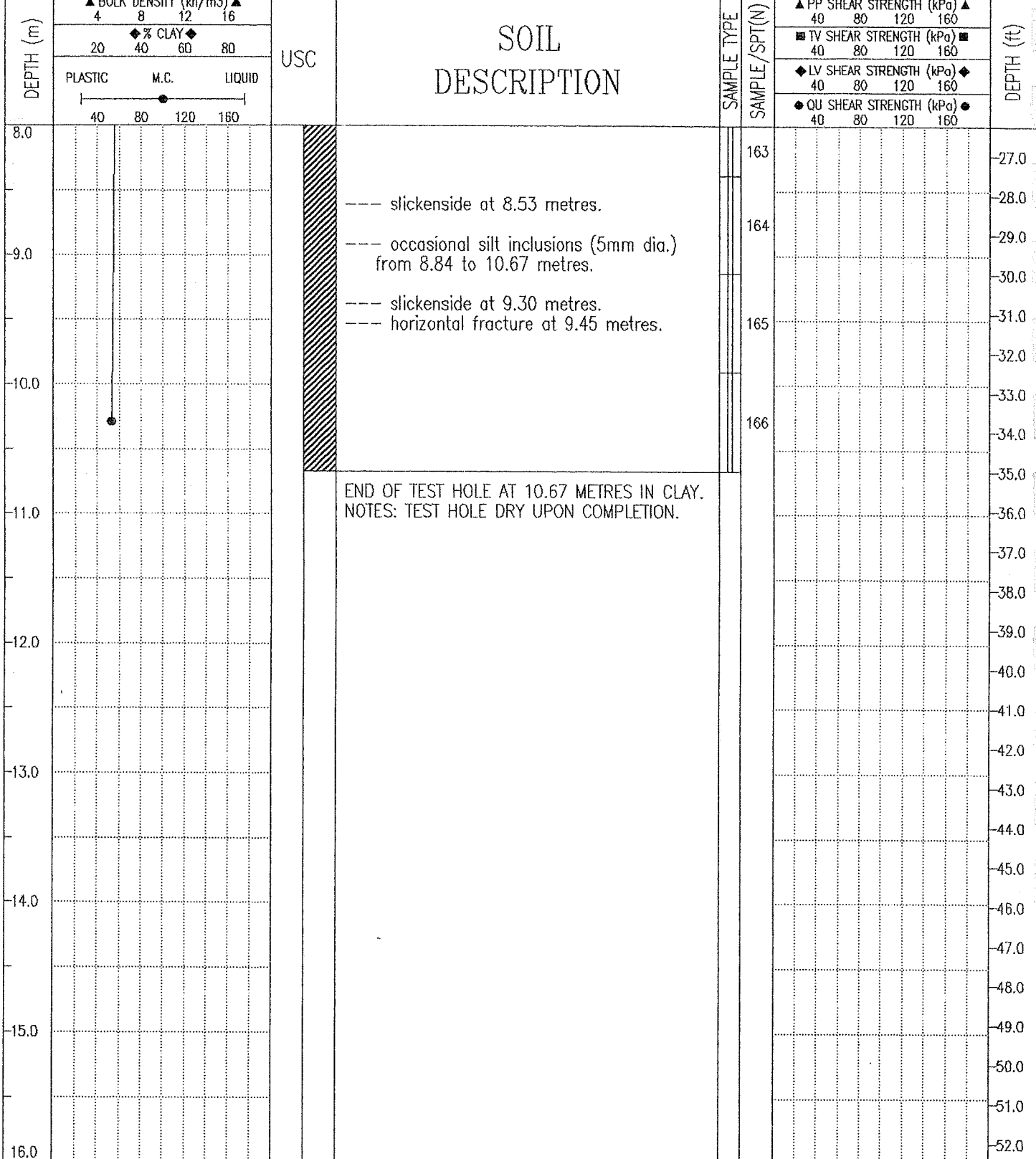
Fig. No.

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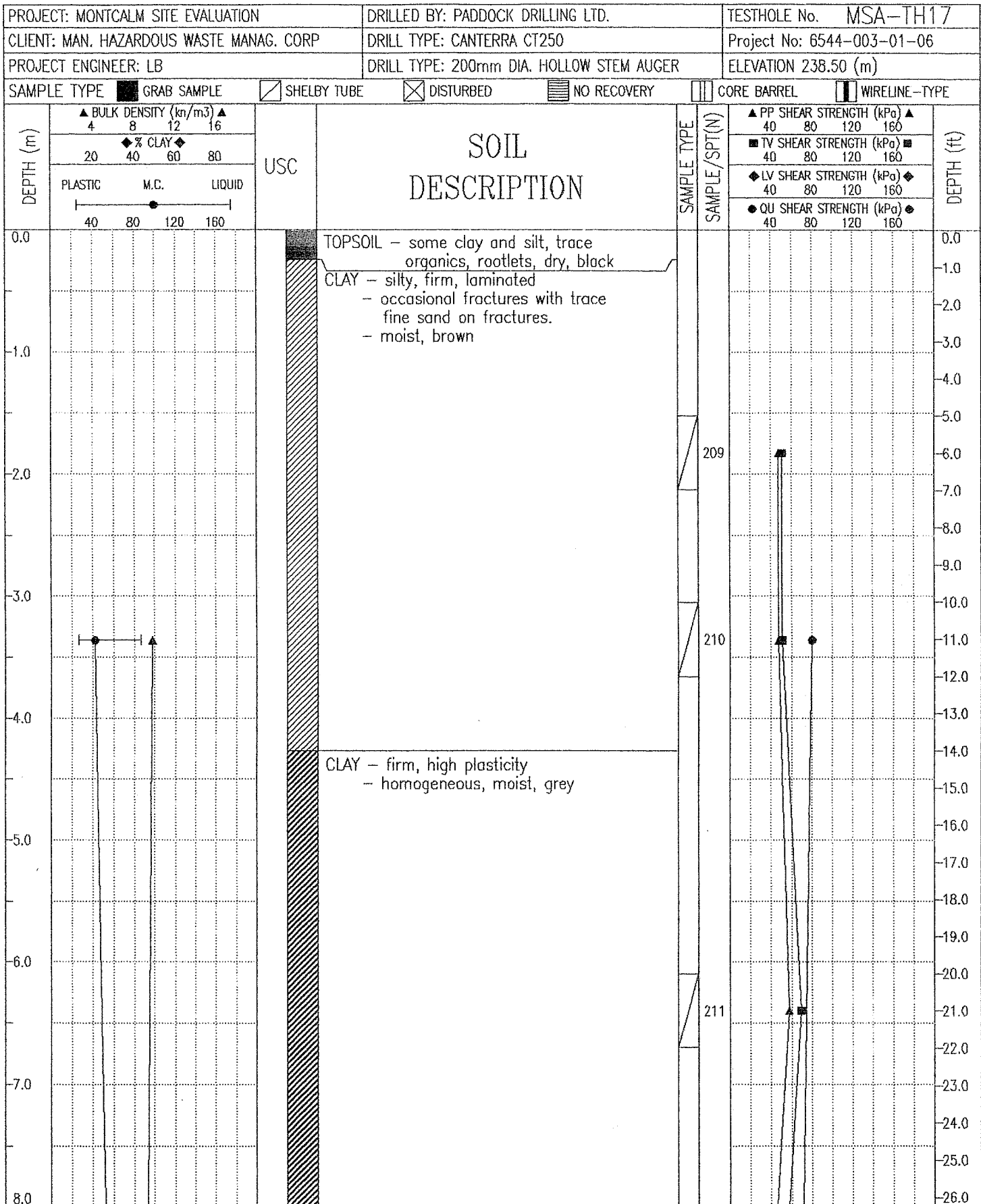


PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH16
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.56 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 10.7 m	DATE DRILLED: 03/06/91
	LOGGED BY KK	Fig. No.



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COMPLETION DEPTH 29.6 m

DATE DRILLED: 05/06/91

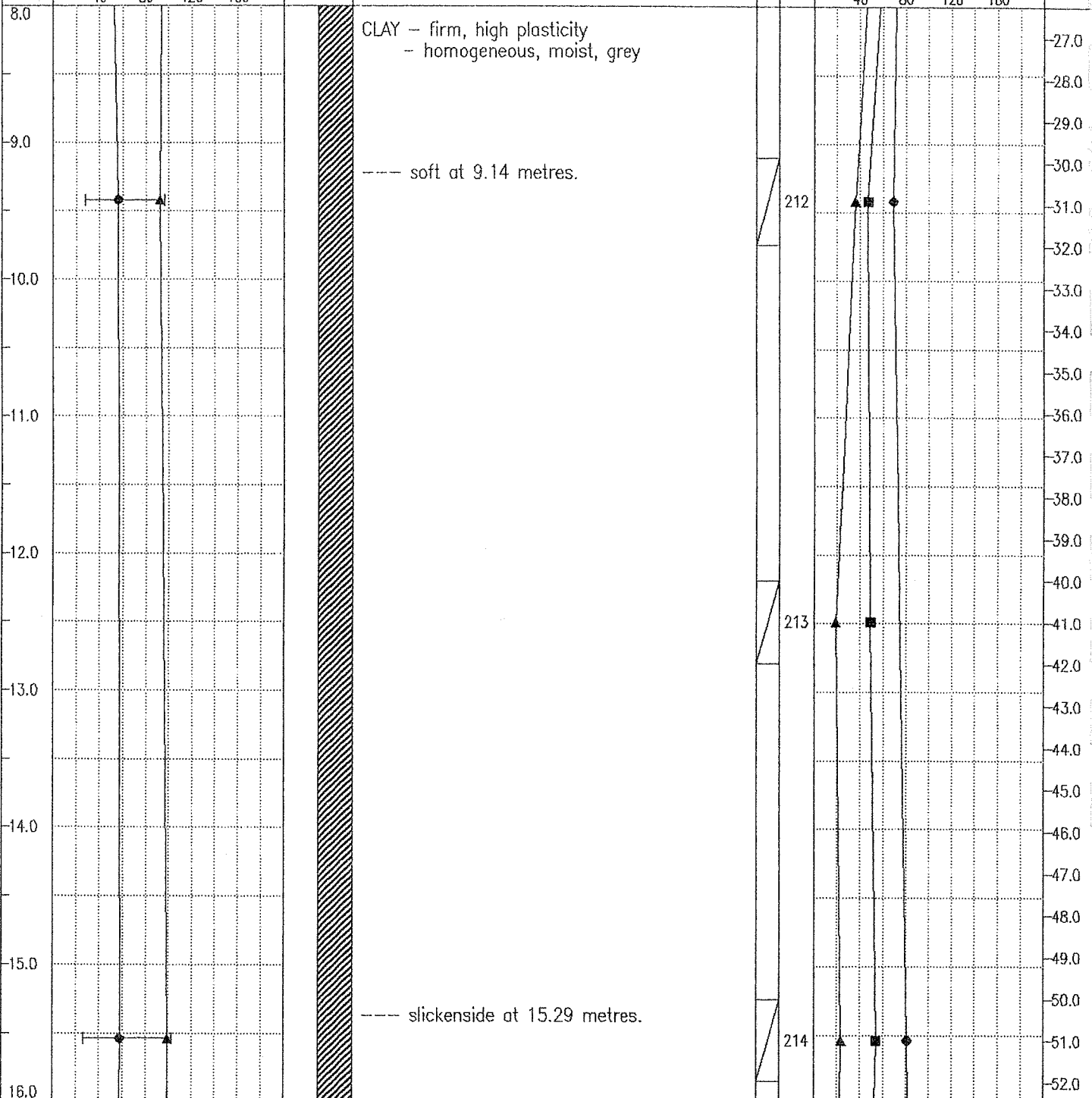
LOGGED BY KK

Fig. No.

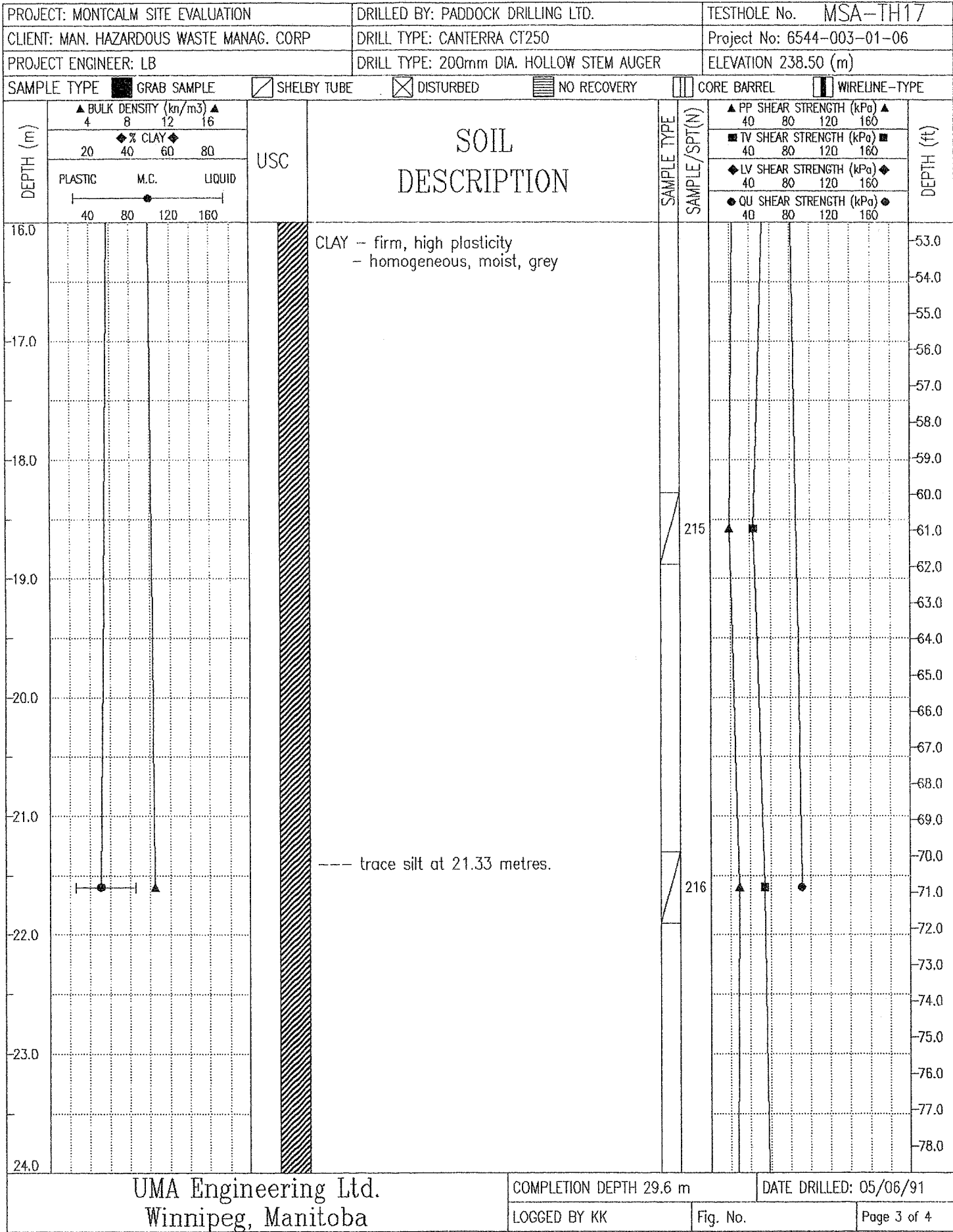
Page 1 of 4

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH17
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.50 (m)

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBLY TUBE	<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE
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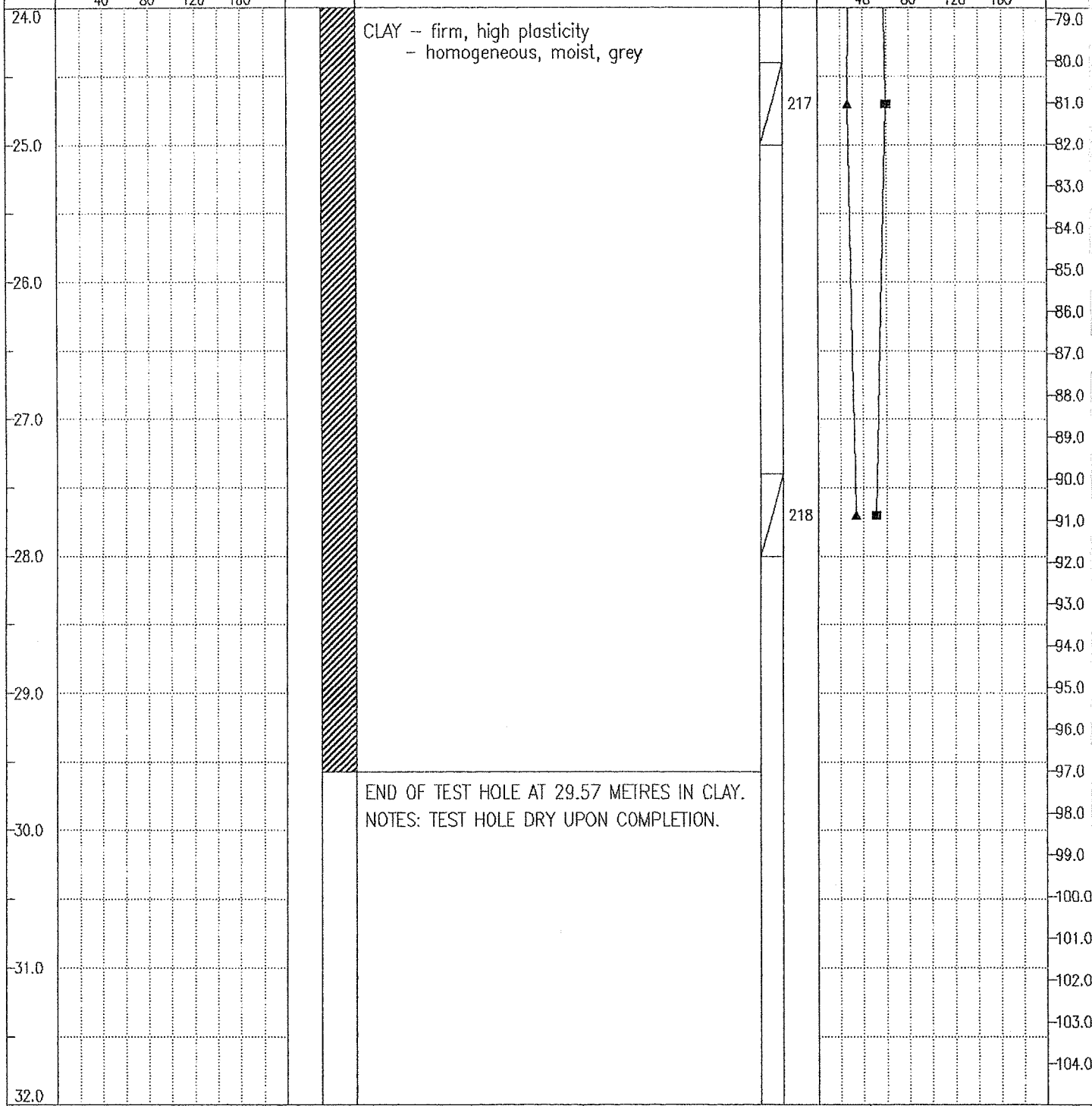
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 29.6 m	DATE DRILLED: 05/06/91
	LOGGED BY KK	Fig. No.



--- trace silt at 21.33 metres.

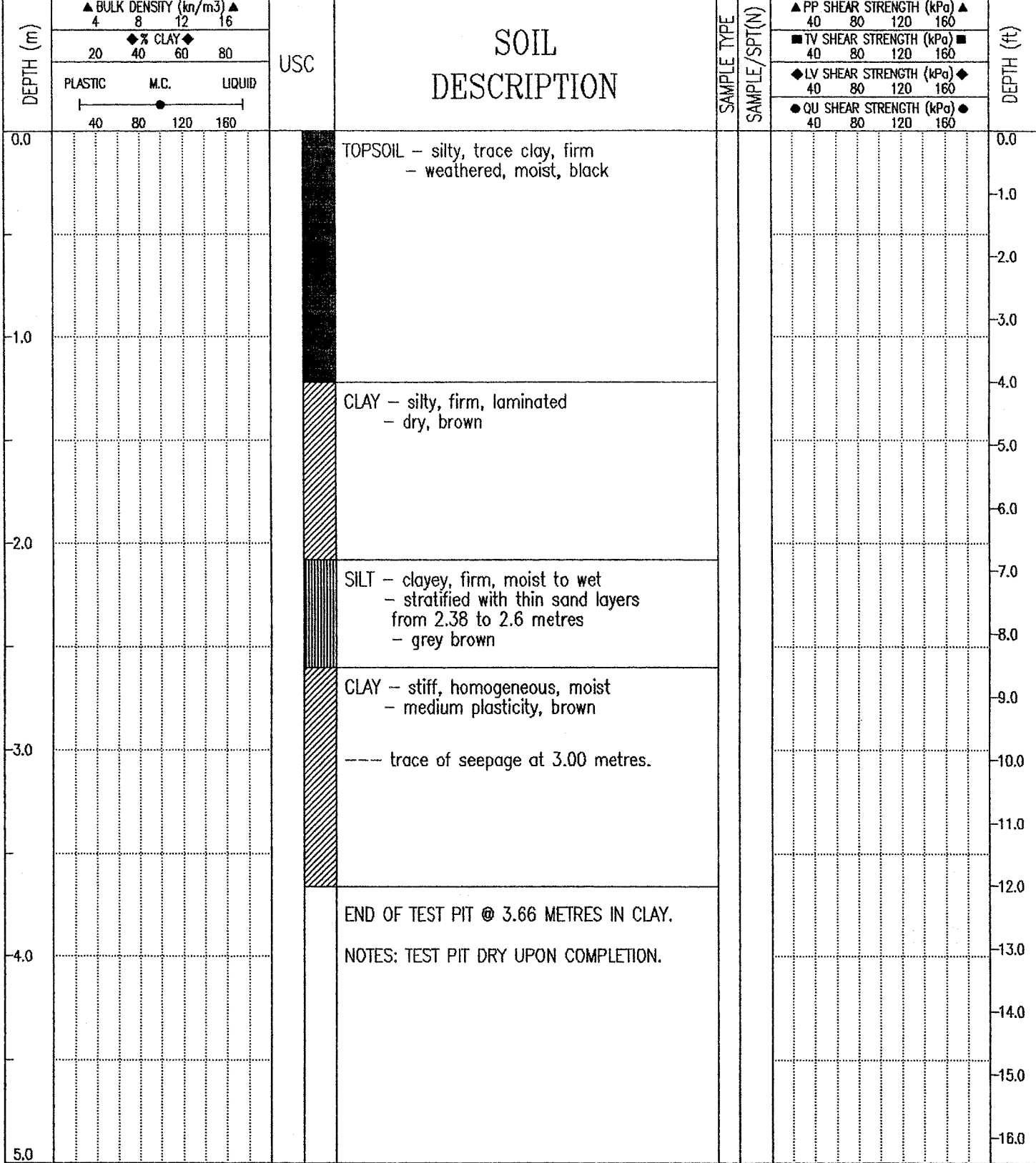
PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-TH17
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 200mm DIA. HOLLOW STEM AUGER	ELEVATION 238.50 (m)

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE
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PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.50 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE

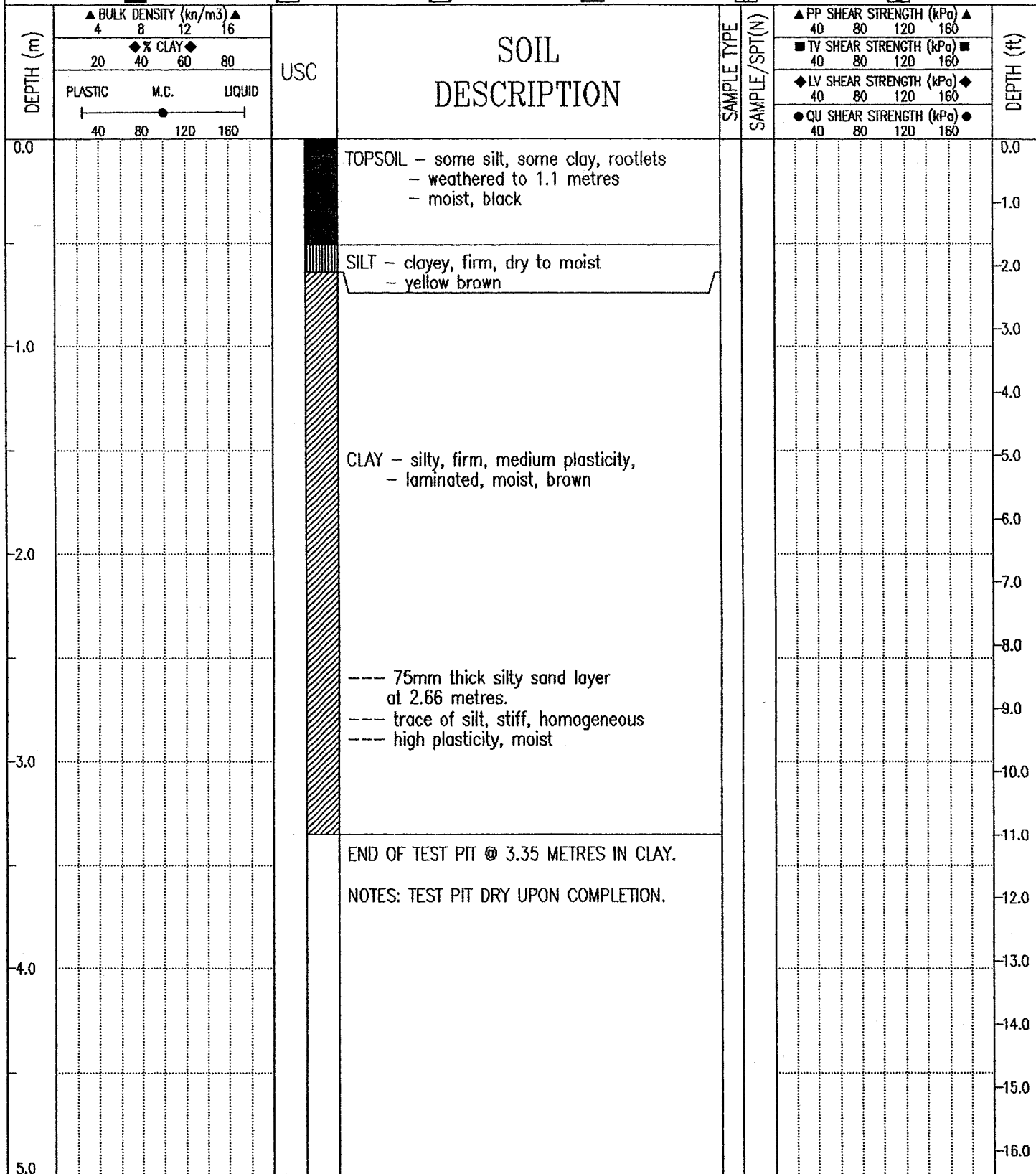


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COMPLETION DEPTH 3.7 m	DATE DRILLED: 17/06/91	
LOGGED BY KK	Fig. No.	Page 1 of 1

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.50 (m)

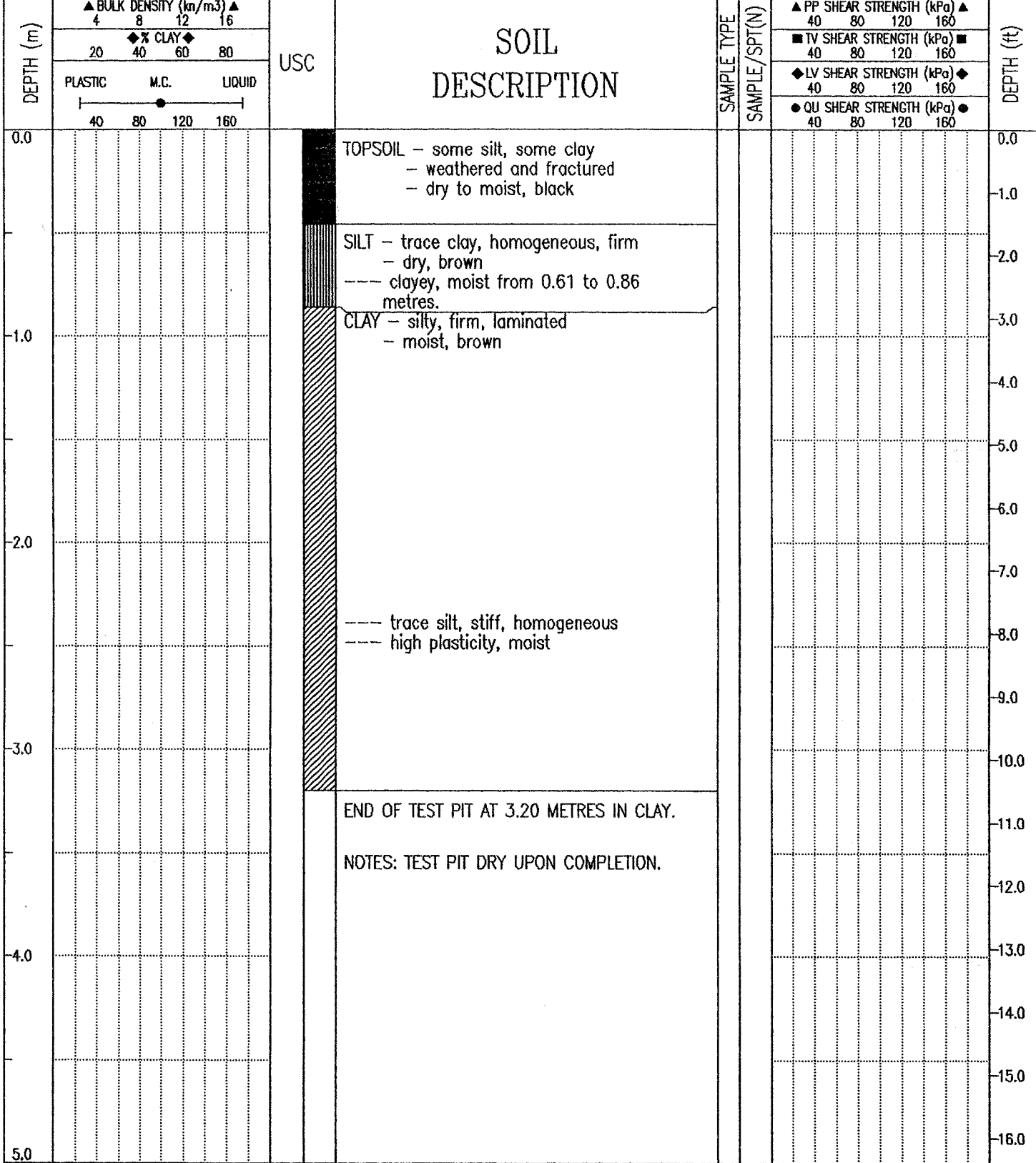
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UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 3.4 m	DATE DRILLED: 17/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP3
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.80 (m)

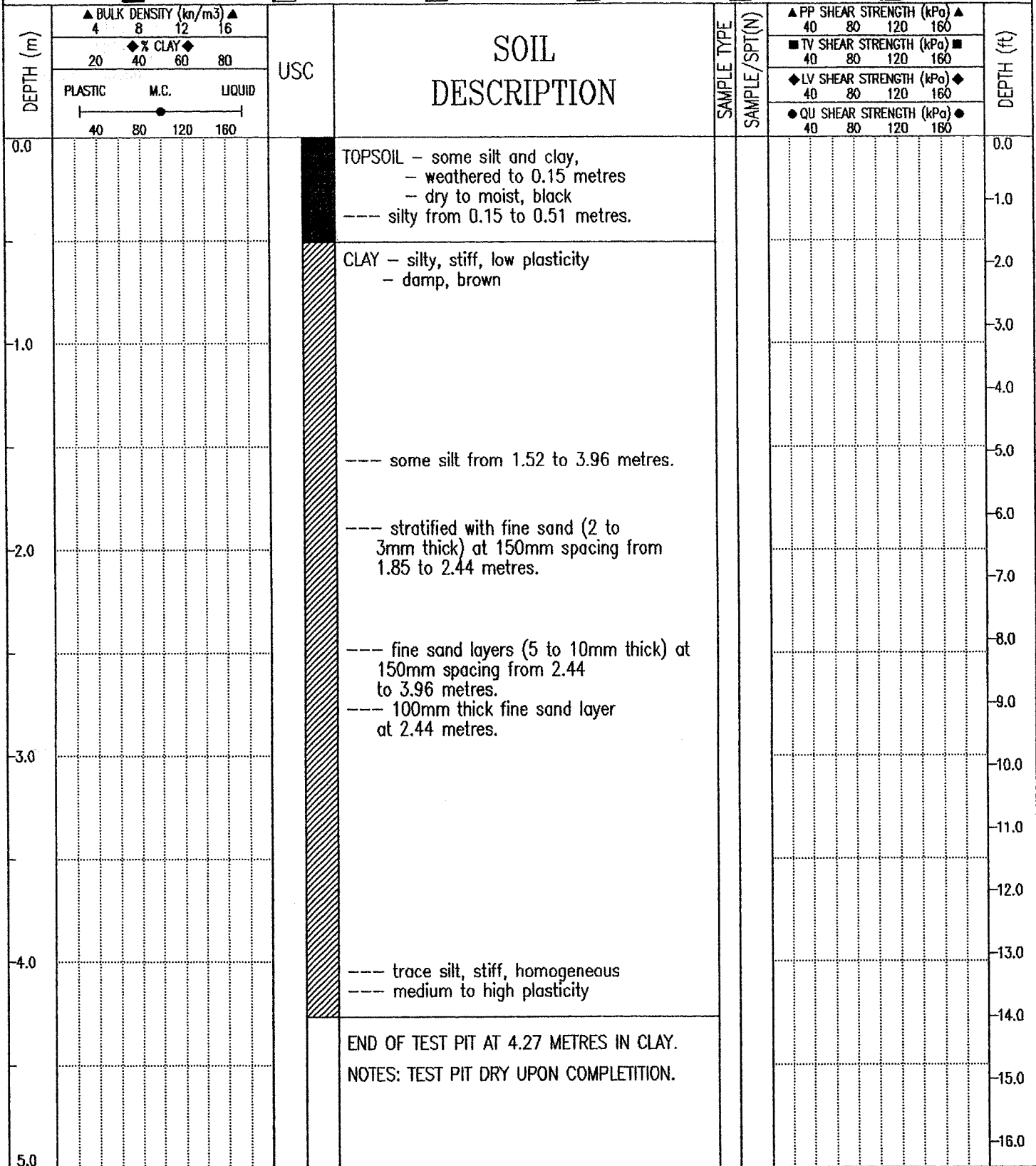
SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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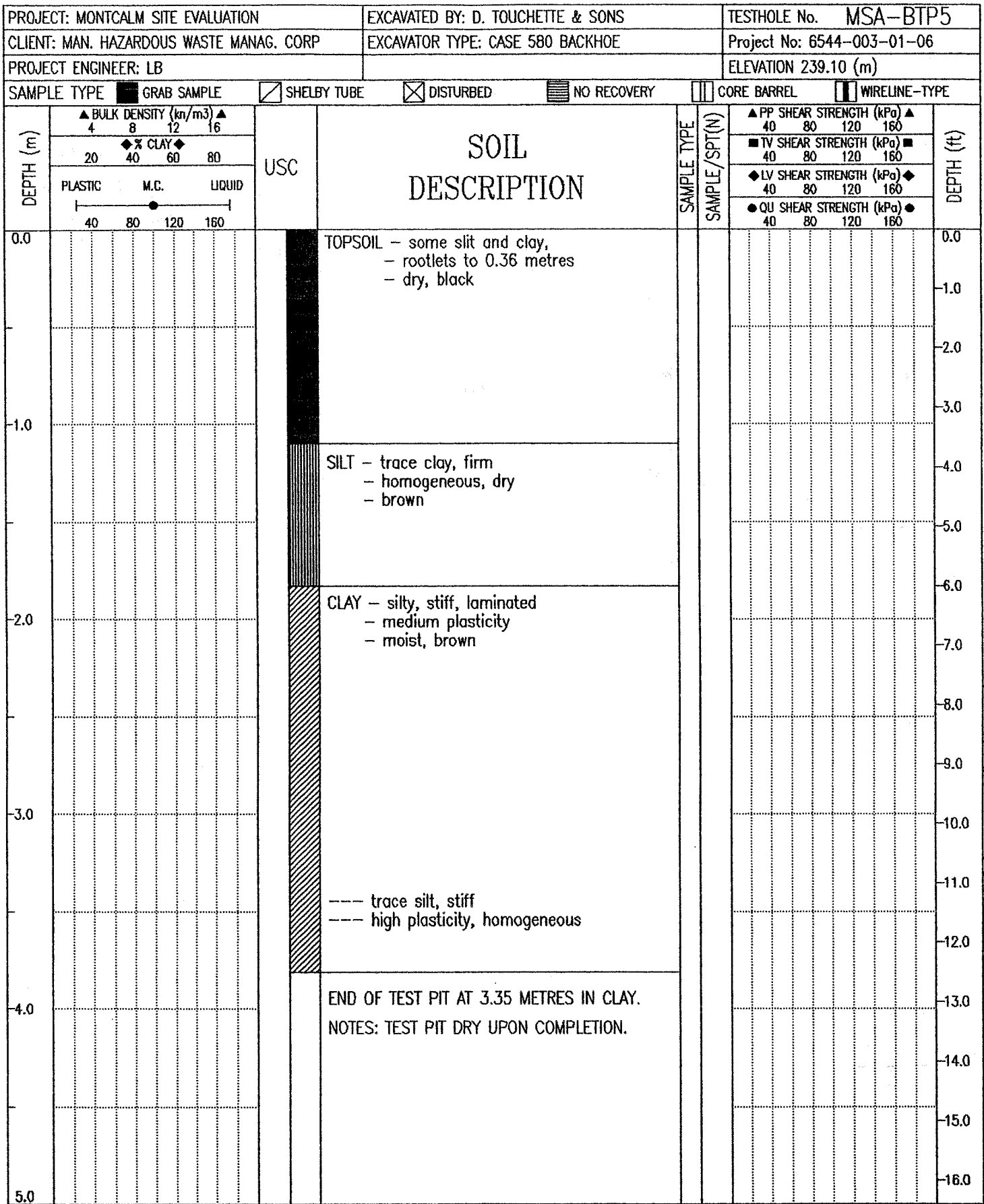
COMPLETION DEPTH 3.2 m	DATE DRILLED: 17/06/91
LOGGED BY KK	Fig. No.
	Page 1 of 1

SAMPLE TYPE: GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 4.3 m	DATE DRILLED: 17/06/91	
LOGGED BY KK	Fig. No.	Page 1 of 1



UMA Engineering Ltd.
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COMPLETION DEPTH 3.8 m

DATE DRILLED: 17/06/91

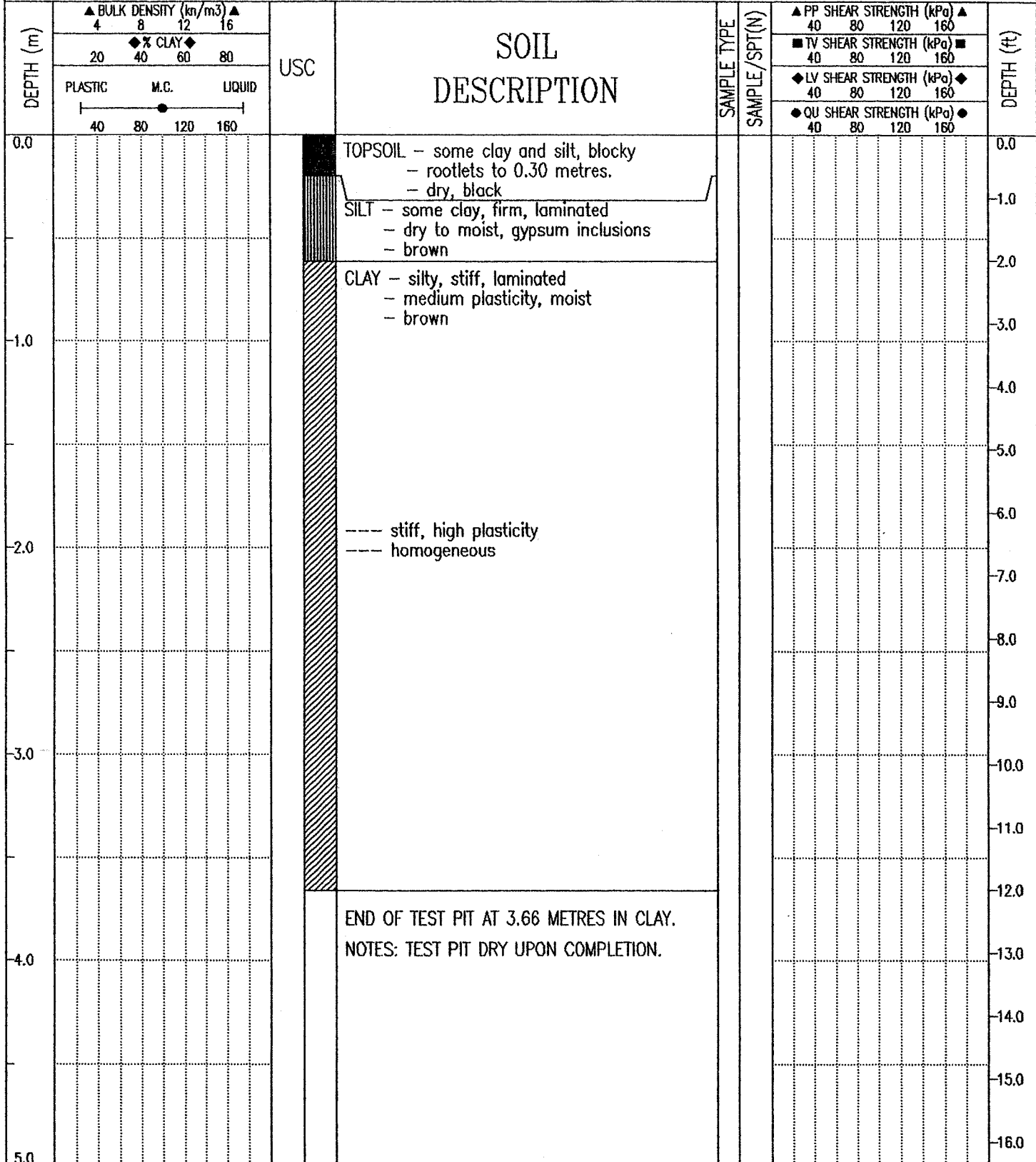
LOGGED BY KK

Fig. No.

Page 1 of 1

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP6
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.70 (m)

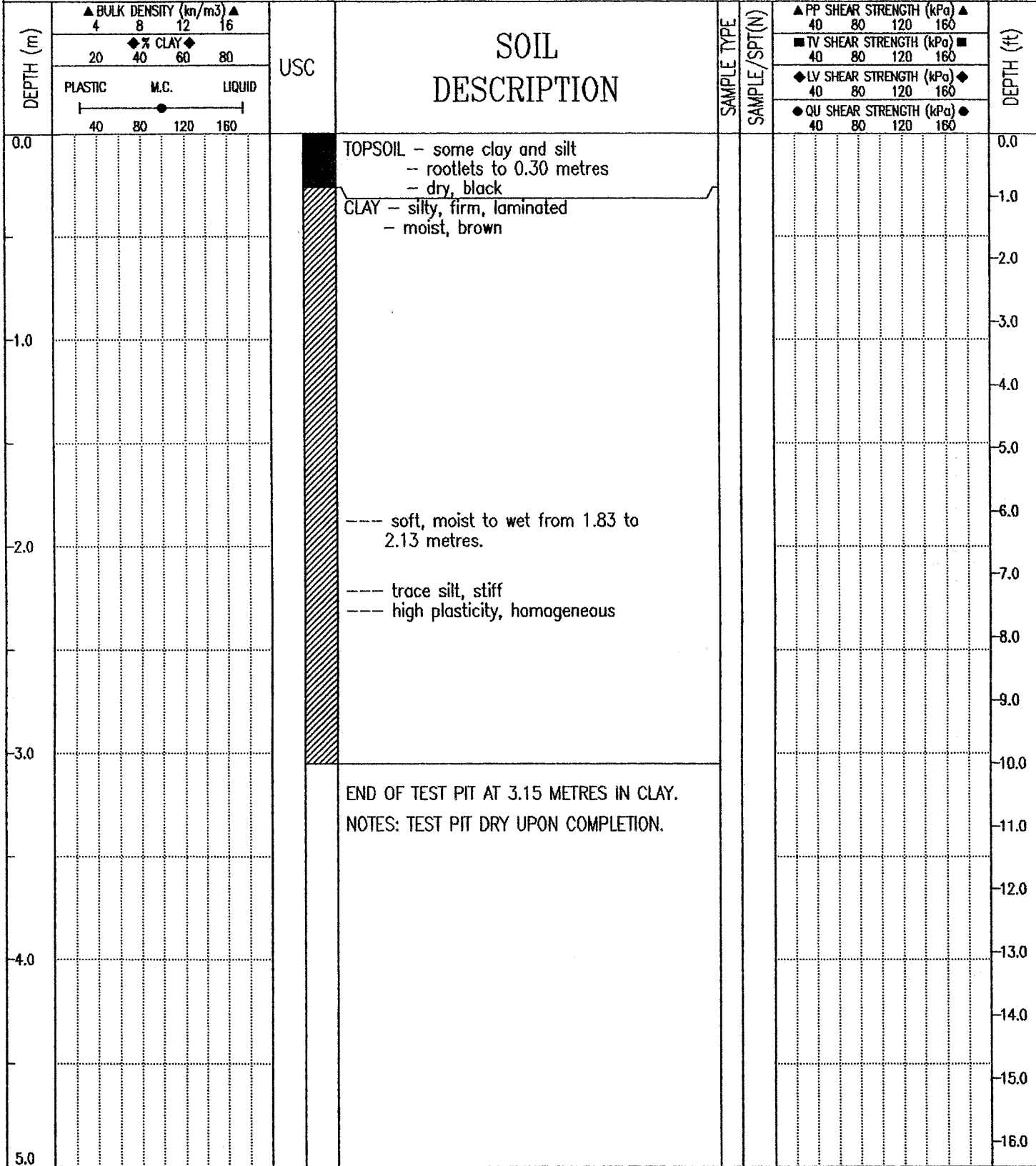
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UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 3.7 m	DATE DRILLED: 17/06/91	
	LOGGED BY KK	Fig. No.	Page 1 of 1

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP7
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.50 (m)

SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE
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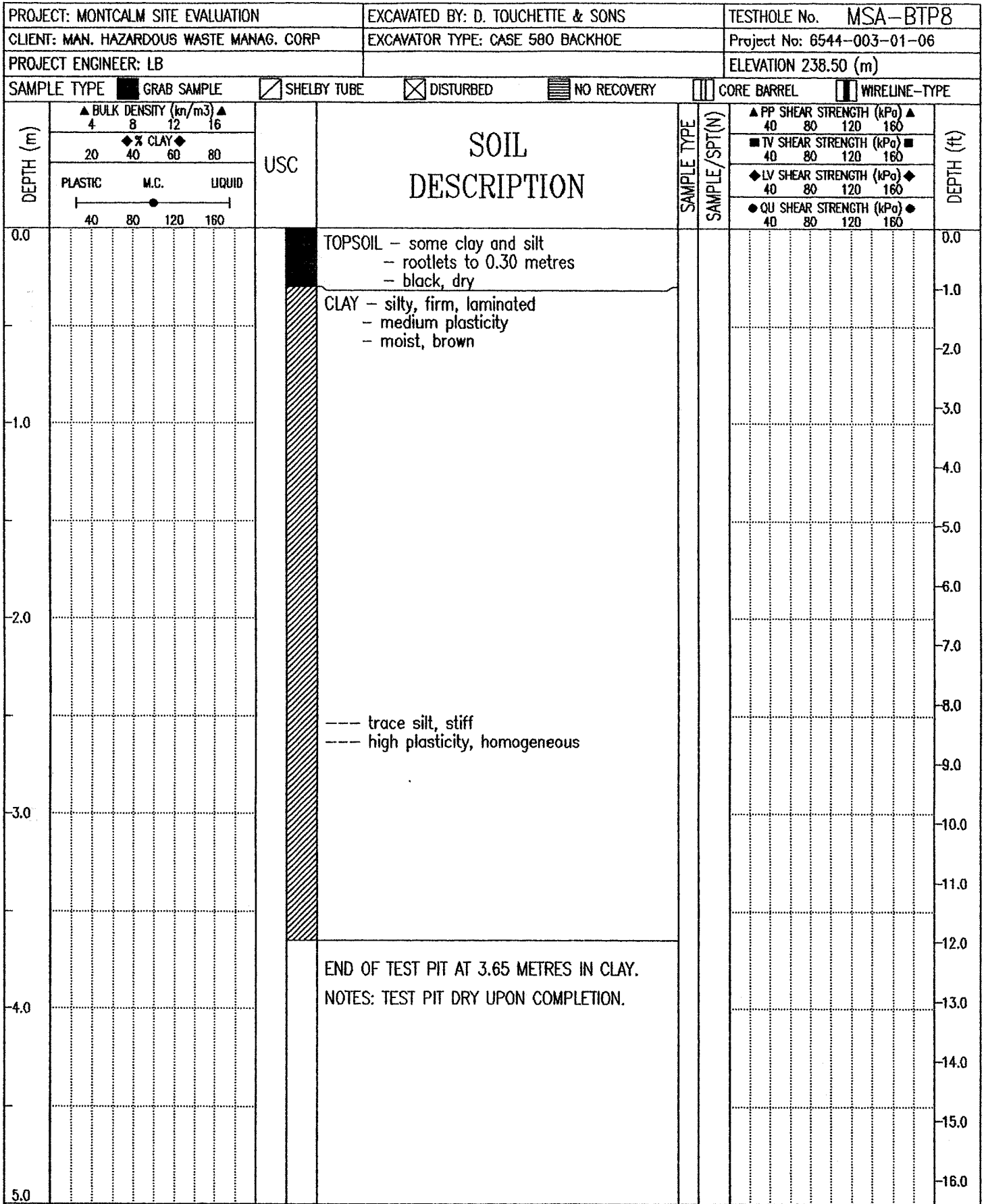
COMPLETION DEPTH 3.1 m

DATE DRILLED: 17/06/91

LOGGED BY KK

Fig. No.

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--- trace silt, stiff
 --- high plasticity, homogeneous

END OF TEST PIT AT 3.65 METRES IN CLAY.
 NOTES: TEST PIT DRY UPON COMPLETION.

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSA-BTP9
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.50 (m)

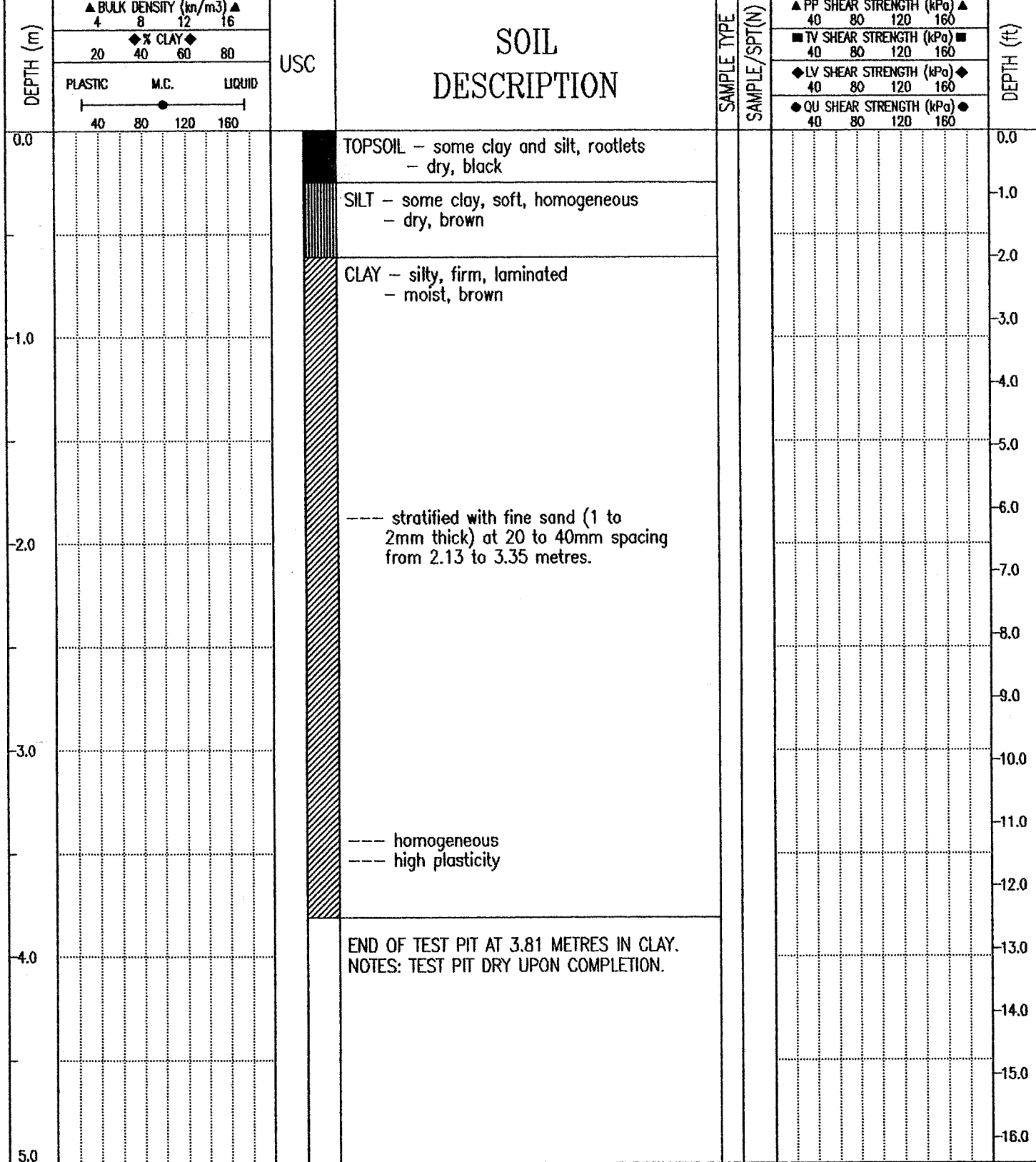
SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160				DEPTH (ft)	
	◆ % CLAY ◆ 20 40 60 80							■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160					
	PLASTIC M.C. LIQUID -----●----- 40 80 120 160							◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160					
								● QU SHEAR STRENGTH (kPa) ● 40 80 120 160					
0.0					TOPSOIL - some silt and clay - dry to moist - black								0.0
					CLAY - silty, stiff, laminated - moist, brown								1.0
													2.0
													3.0
													4.0
													5.0
													6.0
2.0					--- iron staining at 1.83 metres.								7.0
					--- high plasticity								8.0
					--- homogeneous								9.0
													10.0
3.0					END OF TEST PIT AT 3.05 METRES IN CLAY.								11.0
					NOTES: TEST PIT DRY UPON COMPLETION.								12.0
													13.0
													14.0
													15.0
5.0													16.0

UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 3.1 m	DATE DRILLED: 17/06/91	
	LOGGED BY KK	Fig. No.	Page 1 of 1

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSABTP10
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.60 (m)

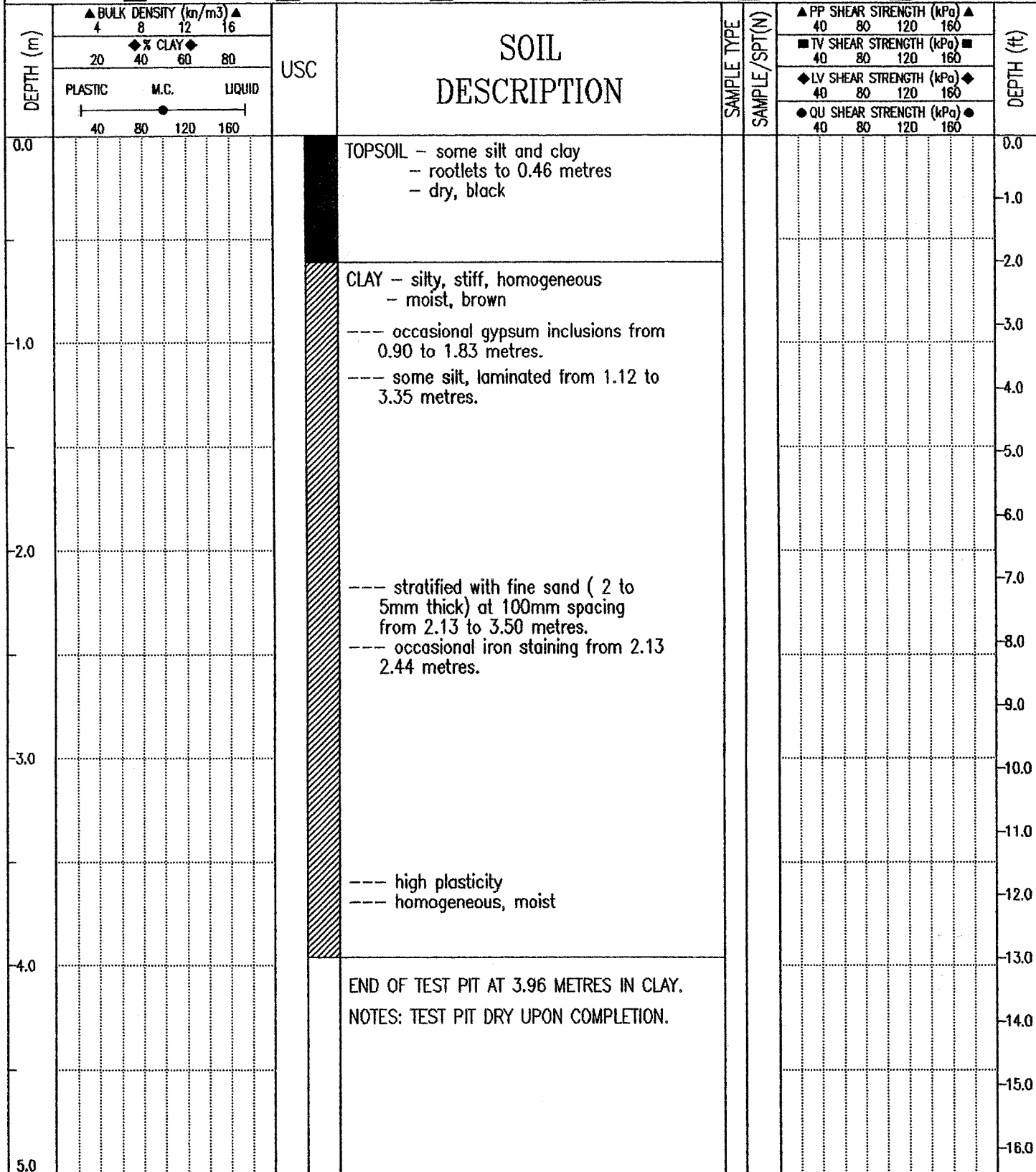
SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 3.8 m	DATE DRILLED: 17/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSABTP11
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.70 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 4.0 m

DATE DRILLED: 17/06/91

LOGGED BY KK

Fig. No.

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PROJECT: MONTCALM SITE EVALUATION		EXCAVATED BY: D. TOUCHETTE & SONS		TESTHOLE No. MSABTP12					
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		EXCAVATOR TYPE: CASE 580 BACKHOE		Project No: 6544-003-01-06					
PROJECT ENGINEER: LB				ELEVATION 238.70 (m)					
SAMPLE TYPE		<input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE		
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION		SAMPLE TYPE	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80						■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160		
	PLASTIC M.C. LIQUID 40 80 120 160						◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160		
							● QU SHEAR STRENGTH (kPa) ● 40 80 120 160		
0.0				TOPSOIL - silty, trace clay - dry, black					0.0
									-1.0
									-2.0
									-3.0
1.0				SILT - clayey, firm, moist - brown					-4.0
				--- trace fine sand from 1.37 to 2.13 metres.					-5.0
									-6.0
									-7.0
2.0				CLAY - silty, stiff, laminated - iron staining, moist - brown - stratified with fine sand (1 to 2mm thick) at 100mm spacing from 2.13 to 3.05 metres.					-8.0
				--- high plasticity --- homogeneous, moist					-9.0
									-10.0
3.0				END OF TEST PIT AT 3.05 METRES IN CLAY. NOTES: TEST PIT DRY UPON COMPLETION.					-11.0
									-12.0
									-13.0
									-14.0
									-15.0
4.0									-16.0
5.0									

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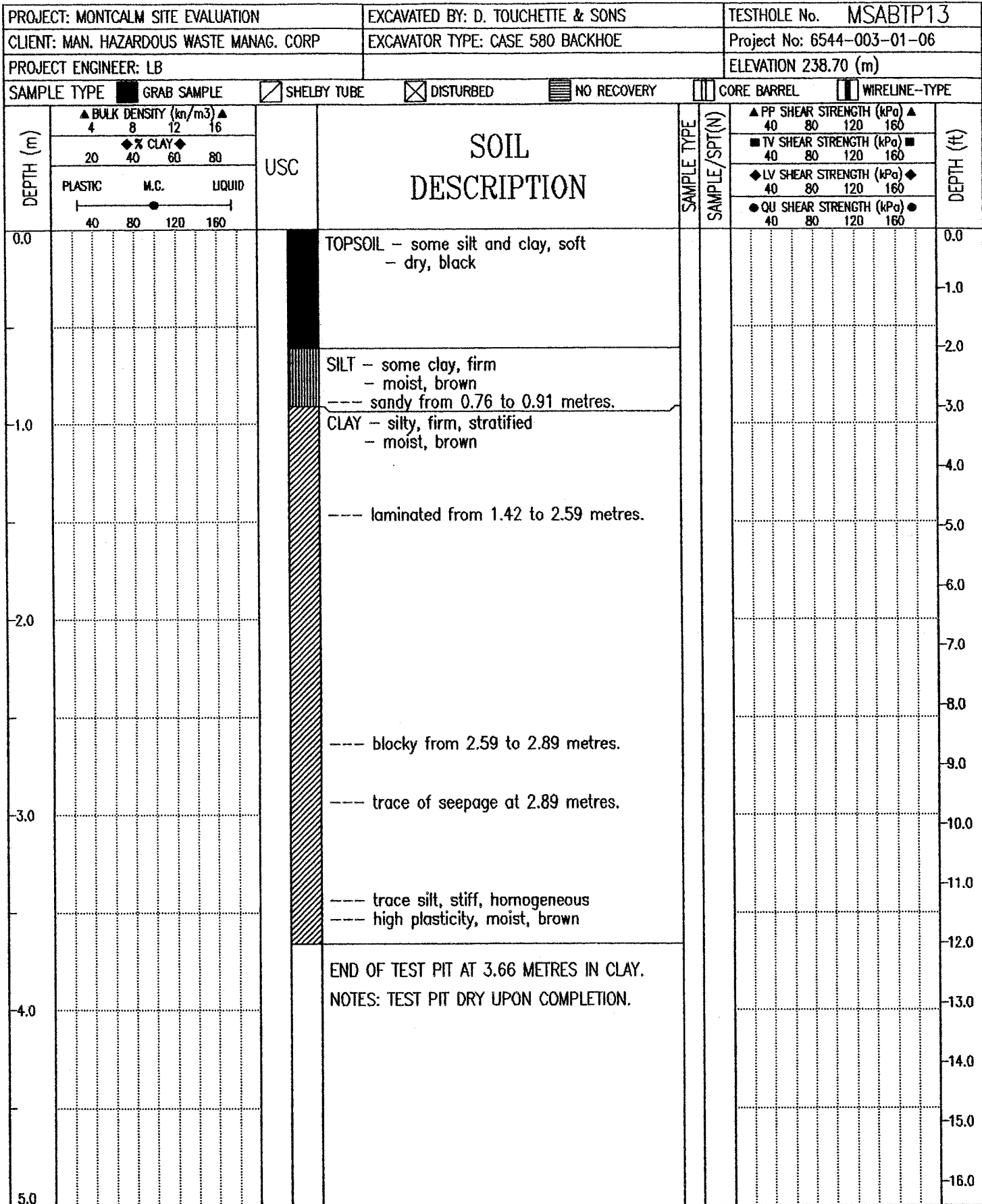
COMPLETION DEPTH 3.4 m

DATE DRILLED: 17/06/91

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Fig. No.

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COMPLETION DEPTH 3.7 m

DATE DRILLED: 17/06/91

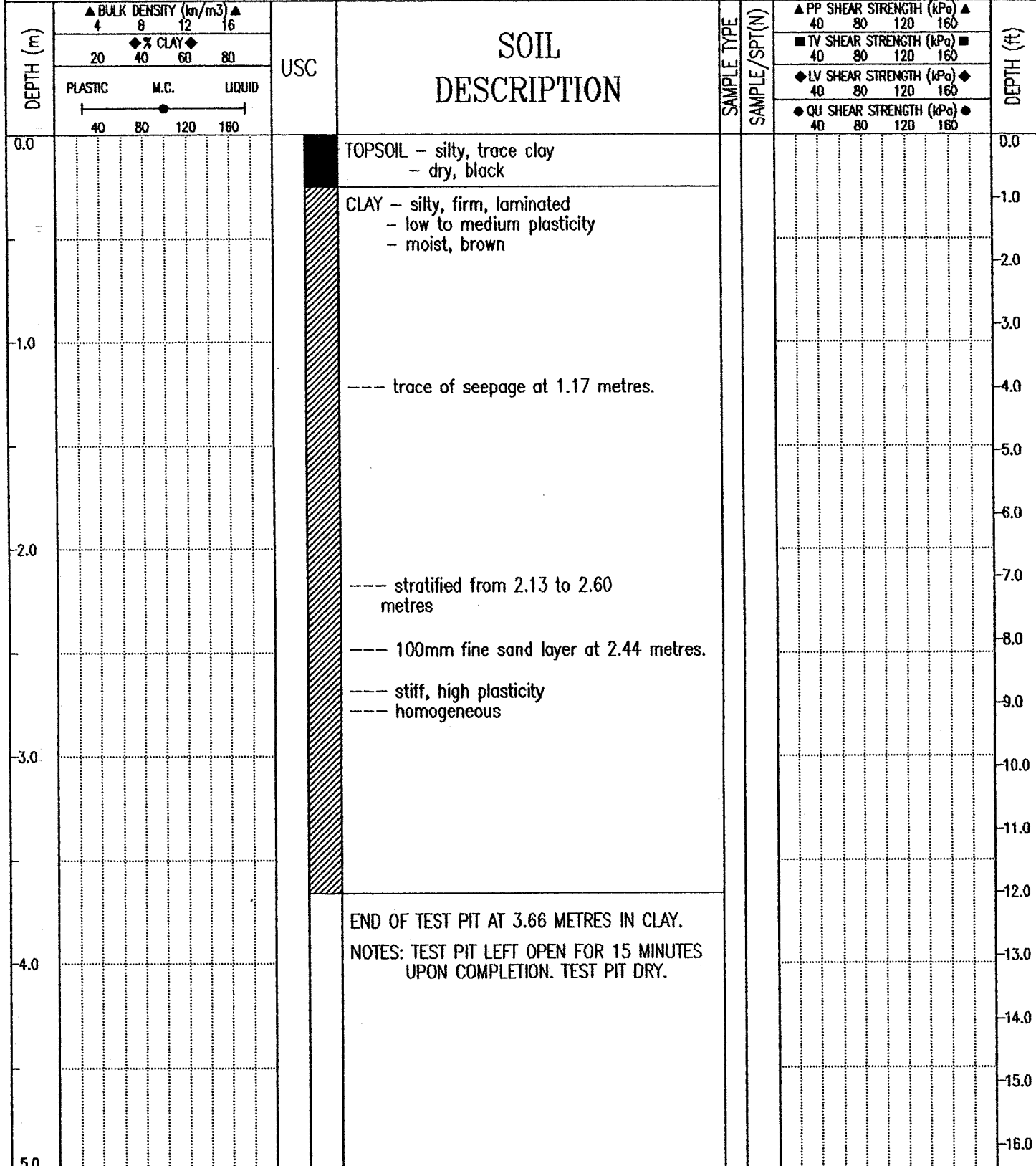
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Fig. No.

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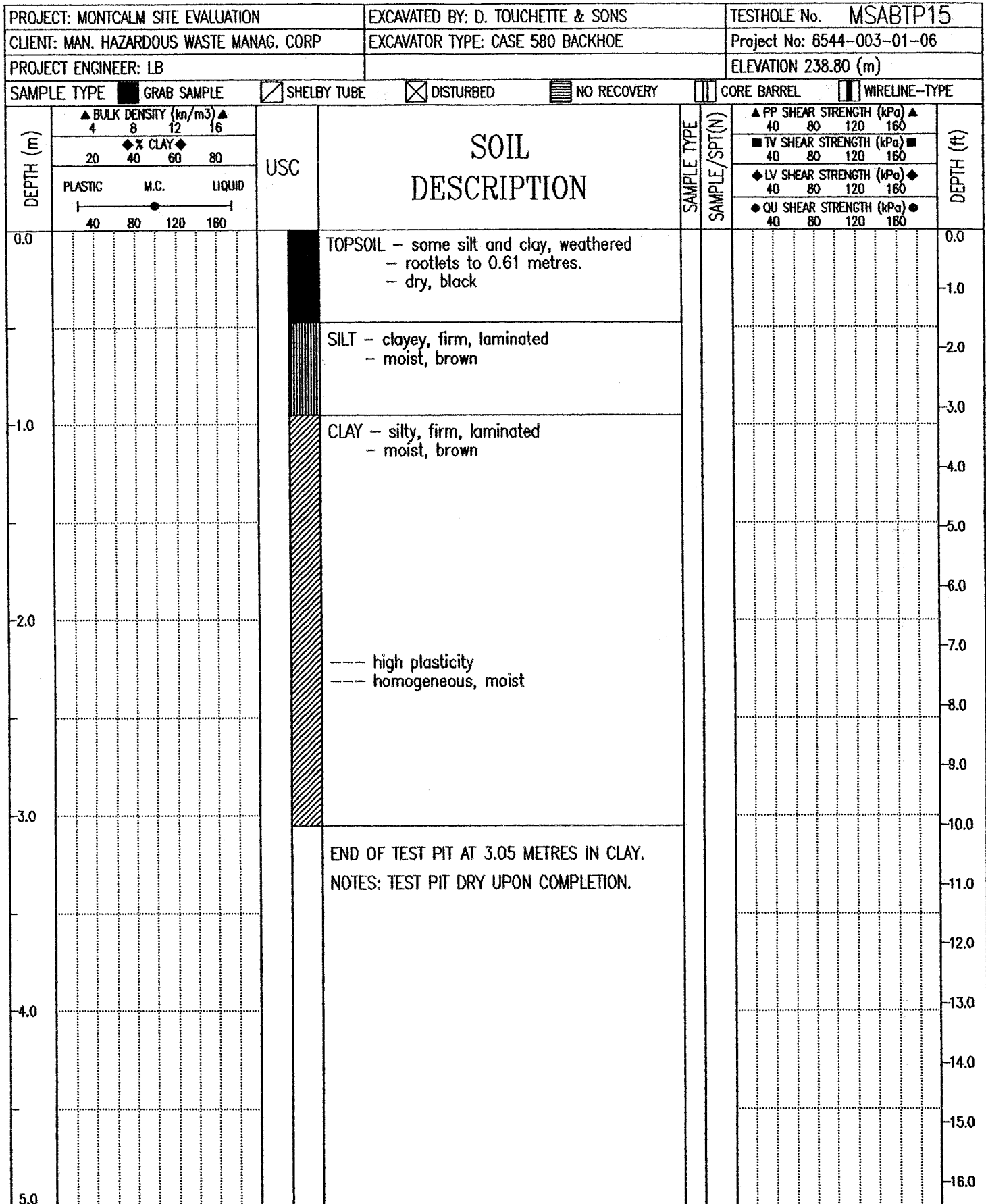
PROJECT: MONTCALM SITE EVALUATION	EXCAVATED BY: D. TOUCHETTE & SONS	TESTHOLE No. MSABTP14
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	EXCAVATOR TYPE: CASE 580 BACKHOE	Project No: 6544-003-01-06
PROJECT ENGINEER: LB		ELEVATION 238.70 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 3.7 m	DATE DRILLED: 17/06/91
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COMPLETION DEPTH 3.1 m

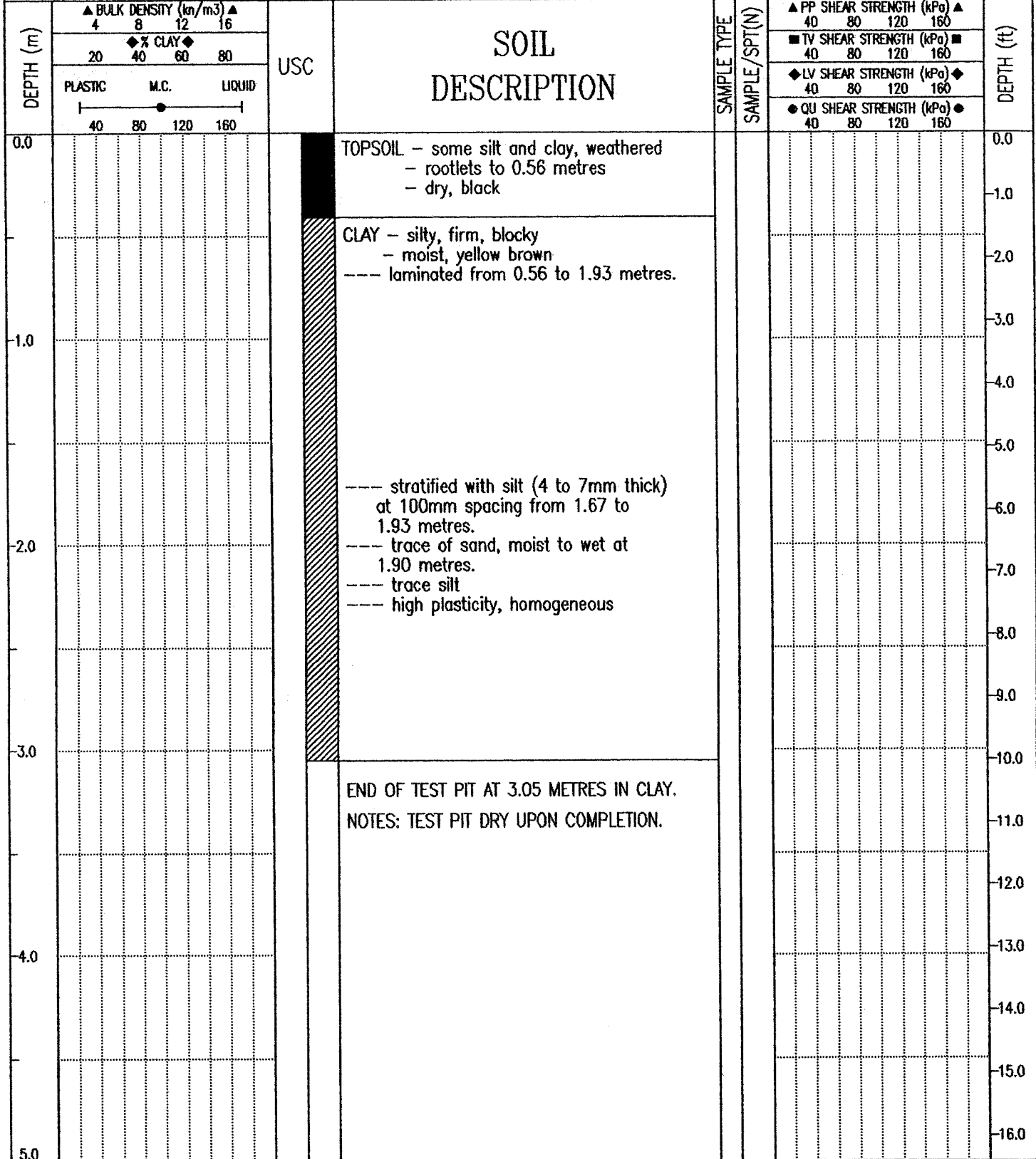
DATE DRILLED: 17/06/91

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Fig. No.

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SAMPLE TYPE GRAB SAMPLE SHELBLY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



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COMPLETION DEPTH 3.1 m	DATE DRILLED: 17/06/91	
LOGGED BY KK	Fig. No.	Page 1 of 1

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-CP1	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE	
		<input type="checkbox"/> NO RECOVERY			

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲				USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲				DEPTH (ft)
	4	8	12	16					40	80	120	160	
	◆ % CLAY ◆								◆ LV SHEAR STRENGTH (kPa) ◆				
	PLASTIC			M.C.					◆ QU SHEAR STRENGTH (kPa) ◆				
	40 80 120 160								40 80 120 160				
0.0						TOPSOIL - some clay and silt, trace organics, rootlets, dry, black							0.0
-1.0						CLAY - silty, firm, laminated - occasional fractures with trace fine sand on fractures. - moist, brown							-1.0
-2.0													-2.0
-3.0													-3.0
-4.0													-4.0
-5.0						CLAY - firm, high plasticity - homogeneous, moist, grey		219					-5.0
-6.0						END OF TEST HOLE AT 5.01 METRES IN CLAY. NOTES: TEST HOLE DRY UPON COMPLETION. 19mm DIA. PIEZOMETER INSTALLED. TOP OF PIEZOMETER ELEV. 240.110 PIEZOMETER INTAKE ELEV. FROM 234.490 TO 233.890 METRES.							-6.0
-7.0													-7.0
-8.0													-8.0

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COMPLETION DEPTH 5.0 m

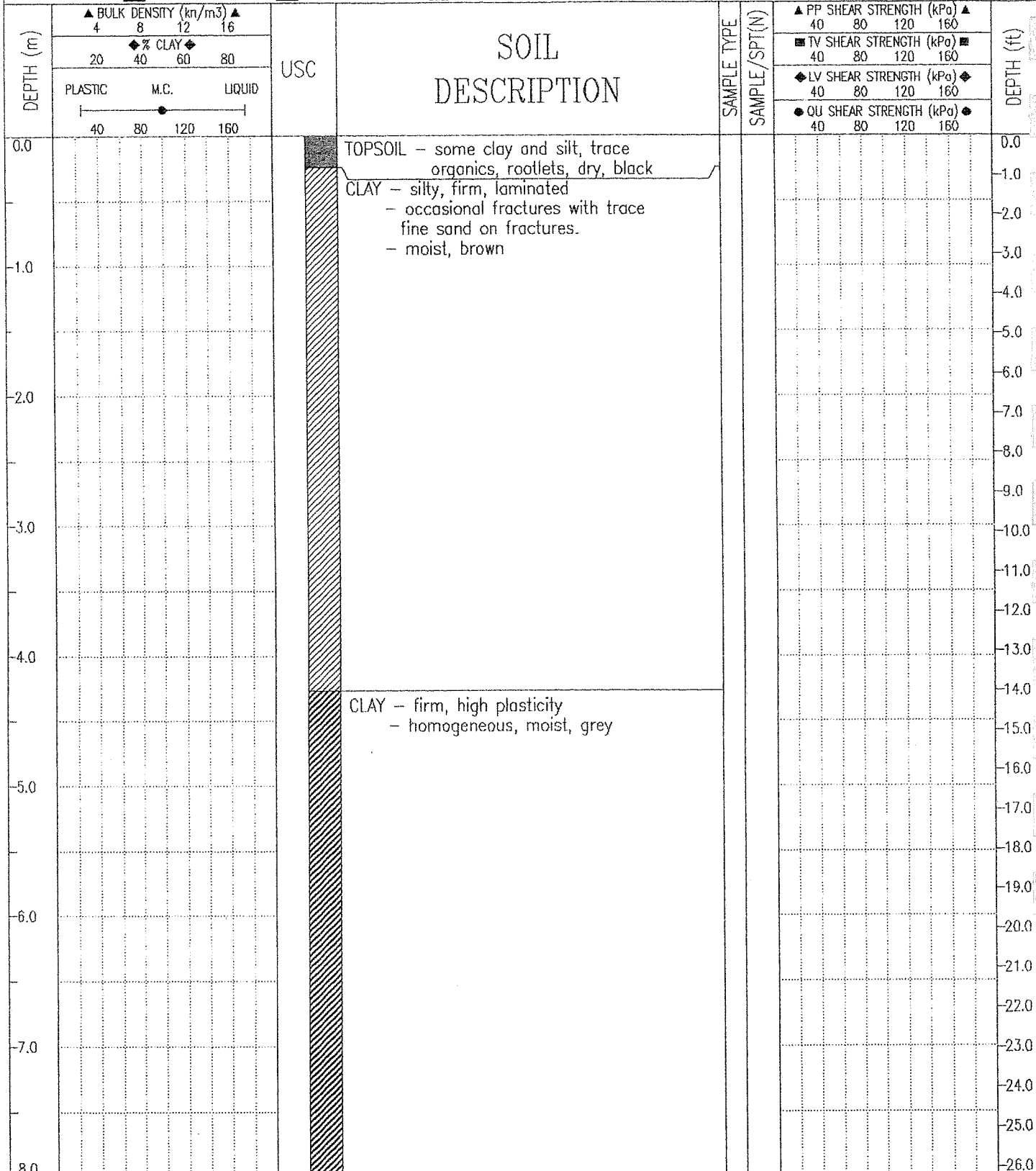
DATE DRILLED: 06/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



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COMPLETION DEPTH 9.4 m	DATE DRILLED: 06/06/91
LOGGED BY KK	Fig. No.
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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-CP2				
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06				
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)				
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED				
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL				
				<input type="checkbox"/> WIRELINE-TYPE				
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION	SAMPLE TYPE	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)
		◆ % CLAY ◆ 20 40 60 80				■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160		
	PLASTIC M.C. LIQUID 40 80 120 160					◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160		
						● QU SHEAR STRENGTH (kPa) ● 40 80 120 160		
8.0				CLAY - firm, high plasticity - homogeneous, moist, grey				27.0
								28.0
								29.0
9.0								30.0
								31.0
								32.0
10.0								33.0
								34.0
								35.0
								36.0
								37.0
								38.0
								39.0
12.0								40.0
								41.0
								42.0
								43.0
								44.0
								45.0
								46.0
								47.0
								48.0
								49.0
15.0								50.0
								51.0
								52.0
16.0								
UMA Engineering Ltd. Winnipeg, Manitoba				COMPLETION DEPTH 9.4 m		DATE DRILLED: 06/06/91		
				LOGGED BY KK		Fig. No.		Page 2 of 2

USC

SOIL DESCRIPTION

CLAY - firm, high plasticity
- homogeneous, moist, grey

END OF TEST HOLE AT 9.37 METRES IN CLAY.
NOTES: TEST HOLE DRY UPON COMPLETION.
19mm DIA. PIEZOMETER INSTALLED.
TOP OF PIEZOMETER ELEV. 240.143
PIEZOMETER INTAKE ELEV. FROM
230.133 TO 229.533 METRES.

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COMPLETION DEPTH 9.4 m

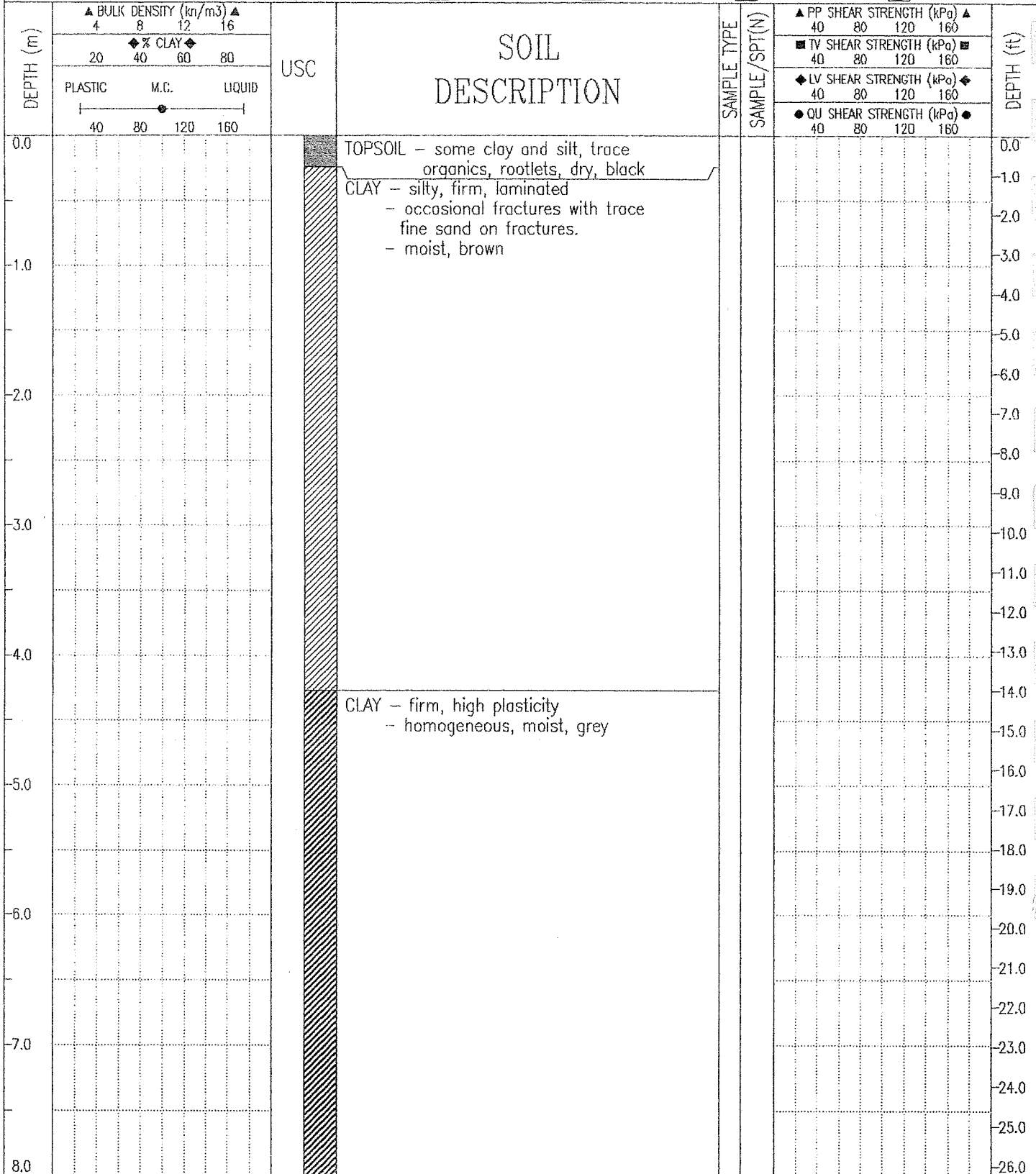
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Fig. No.

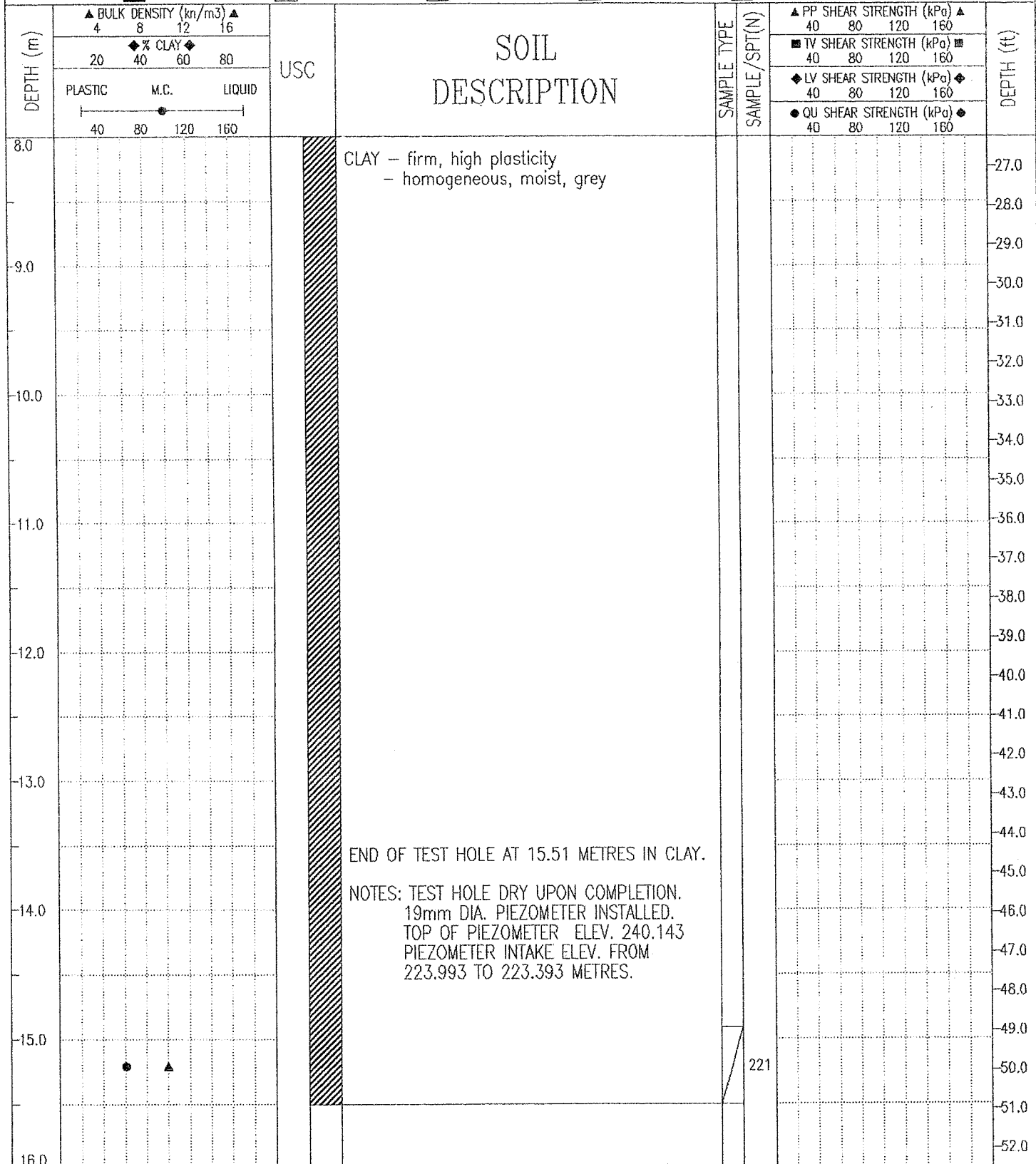
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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP3
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



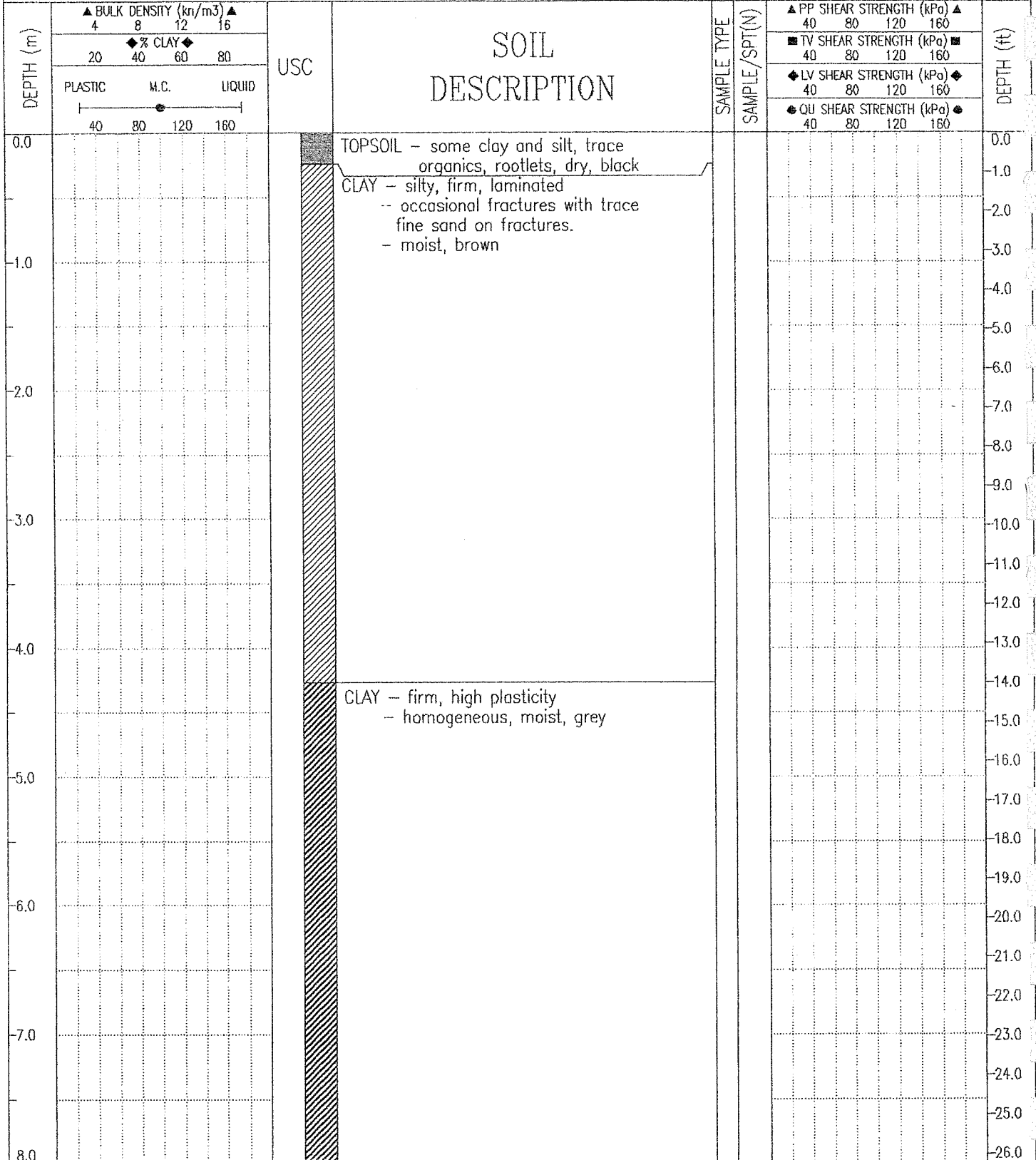
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 15.5 m	DATE DRILLED: 06/06/91
	LOGGED BY KK	Fig. No.
		Page 1 of 2

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP3
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE




UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 15.5 m	DATE DRILLED: 06/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP4
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 25.1 m	DATE DRILLED: 06/06/91
	LOGGED BY KK	Page 1 of 4

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-CP4							
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06							
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)							
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED							
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL							
				<input checked="" type="checkbox"/> WIRELINE-TYPE							
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)		
	◆ % CLAY ◆ 20 40 60 80						■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160				
	PLASTIC M.C. LIQUID 40 80 120 160						◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160				
	● QU SHEAR STRENGTH (kPa) ● 40 80 120 160										
8.0				CLAY - firm, high plasticity - homogeneous, moist, grey					-27.0		
											-28.0
											-29.0
											-30.0
											-31.0
											-32.0
											-33.0
											-34.0
											-35.0
											-36.0
											-37.0
											-38.0
											-39.0
									-40.0		
									-41.0		
									-42.0		
									-43.0		
									-44.0		
									-45.0		
									-46.0		
									-47.0		
									-48.0		
									-49.0		
									-50.0		
									-51.0		
									-52.0		
16.0											

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 25.1 m

DATE DRILLED: 06/06/91

LOGGED BY KK

Fig. No.

Page 2 of 4

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP4
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲				DEPTH (ft)		
	4	8	12					16	40	80	120		160	
	◆ % CLAY ◆							■ TV SHEAR STRENGTH (kPa) ■						
	20	40	60	80				40	80	120	160			
	PLASTIC			M.C.	LIQUID			◆ LV SHEAR STRENGTH (kPa) ◆						
	40	80	120	160				40	80	120	160			
								● QU SHEAR STRENGTH (kPa) ●						
	40	80	120	160				40	80	120	160			
16.0					CLAY -- firm, high plasticity - homogeneous, moist, grey								53.0	
														54.0
														55.0
														56.0
														57.0
														58.0
														59.0
														60.0
														61.0
														62.0
														63.0
														64.0
														65.0
														66.0
														67.0
													68.0	
													69.0	
													70.0	
													71.0	
													72.0	
													73.0	
													74.0	
													75.0	
													76.0	
													77.0	
													78.0	
24.0														

UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 25.1 m	DATE DRILLED: 06/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-CP4					
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06					
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)					
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED					
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL					
				<input type="checkbox"/> WIRELINE-TYPE					
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION	SAMPLE TYPE	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160		DEPTH (ft)	
	◆ % CLAY ◆ 20 40 60 80					■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160			
PLASTIC M.C. LIQUID						◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160			
40 80 120 160						● QU SHEAR STRENGTH (kPa) ● 40 80 120 160			
24.0				CLAY - firm, high plasticity - homogeneous, moist, grey				-79.0	
								-80.0	
								-81.0	
25.0	●	▲			222			-82.0	
								-83.0	
				END OF TEST HOLE AT 25.11 METRES IN CLAY.				-84.0	
				NOTES: TEST HOLE DRY UPON COMPLETION.				-85.0	
				19mm DIA. PIEZOMETER INSTALLED.				-86.0	
				TOP OF PIEZOMETER ELEV. 240.075				-87.0	
				PIEZOMETER INTAKE ELEV. FROM				-88.0	
				213.790 TO 214.390 METRES.				-89.0	
26.0								-90.0	
								-91.0	
								-92.0	
								-93.0	
								-94.0	
								-95.0	
27.0								-96.0	
								-97.0	
								-98.0	
								-99.0	
								-100.0	
								-101.0	
								-102.0	
								-103.0	
								-104.0	
32.0									

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COMPLETION DEPTH 25.1 m

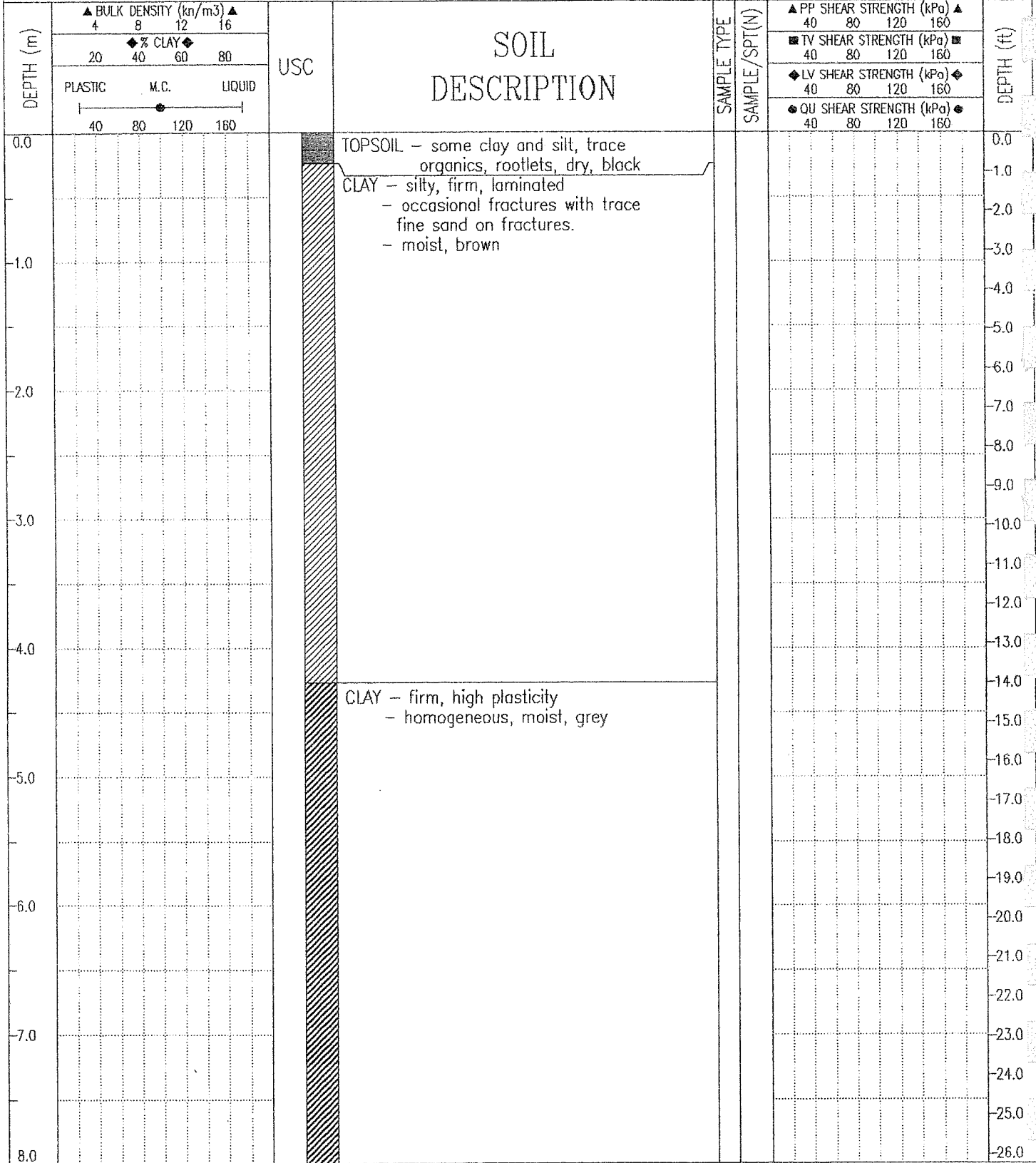
DATE DRILLED: 06/06/91

LOGGED BY KK

Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP5
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd.
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COMPLETION DEPTH 33.8 m


DATE DRILLED: 06/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA--CP5										
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06										
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)										
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED										
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL										
				<input type="checkbox"/> WIRELINE-TYPE										
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲			DEPTH (ft)			
	4	8	12					16	40	80		120	160	
	◆ % CLAY ◆								40	80		120	160	
	PLASTIC M.C. LIQUID								40	80		120	160	

	40	80	120	160										
8.0					CLAY - firm, high plasticity - homogeneous, moist, grey							27.0		
														28.0
														29.0
														30.0
														31.0
														32.0
														33.0
														34.0
														35.0
														36.0
														37.0
														38.0
														39.0
														40.0
														41.0
														42.0
												43.0		
												44.0		
												45.0		
												46.0		
												47.0		
												48.0		
												49.0		
												50.0		
												51.0		
												52.0		
16.0														

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 33.8 m
LOGGED BY KK


DATE DRILLED: 06/06/91
Fig. No. Page 2 of 5

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP5
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)

SAMPLE TYPE GRAB SAMPLE SHELBYS TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE

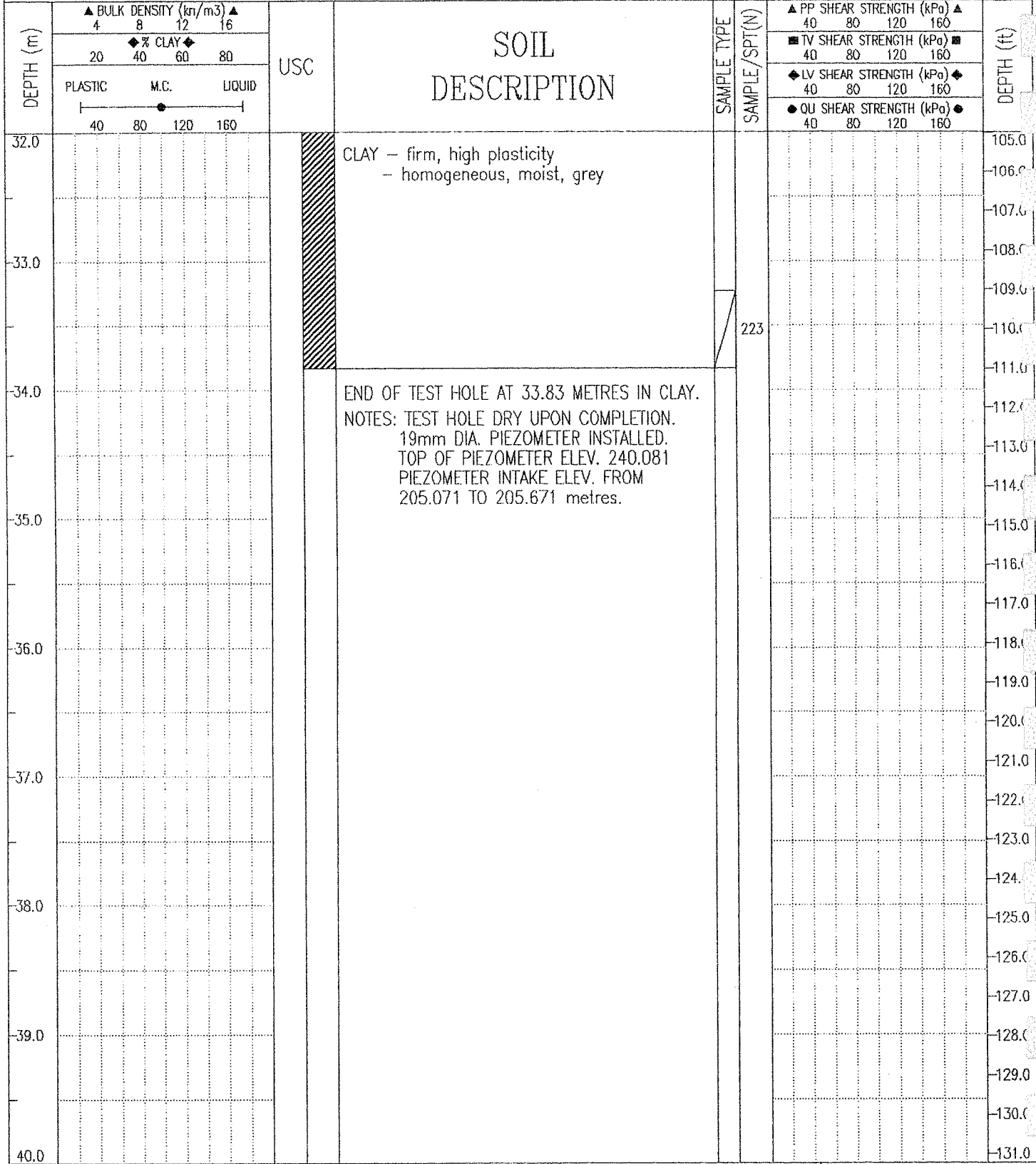
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160				DEPTH (ft)	
	◆ % CLAY ◆ 20 40 60 80							■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160					
	PLASTIC M.C. LIQUID 40 80 120 160							◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160					
								● QU SHEAR STRENGTH (kPa) ● 40 80 120 160					
16.0					CLAY - firm, high plasticity - homogeneous, moist, grey							-53.0	
													-54.0
													-55.0
													-56.0
													-57.0
													-58.0
													-59.0
													-60.0
													-61.0
													-62.0
													-63.0
													-64.0
													-65.0
													-66.0
													-67.0
													-68.0
												-69.0	
												-70.0	
												-71.0	
												-72.0	
												-73.0	
												-74.0	
												-75.0	
												-76.0	
												-77.0	
												-78.0	
24.0													

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: PADDOCK DRILLING LTD.		TESTHOLE No. MSA-CP5	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: CANTERRA CT250		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 125mm DIA. SOLID STEM AUGER		ELEVATION 238.50 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE	
		<input type="checkbox"/> NO RECOVERY			

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲				USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲				DEPTH (ft)			
	4	8	12	16					40	80	120	160				
	◆ % CLAY ◆								■ TV SHEAR STRENGTH (kPa) ■							
	20	40	60	80					40	80	120	160				
	PLASTIC M.C. LIQUID								◆ LV SHEAR STRENGTH (kPa) ◆							
	-----								40	80	120	160				
	40	80	120	160					◆ QU SHEAR STRENGTH (kPa) ◆							
									40	80	120	160				
24.0						CLAY - firm, high plasticity - homogeneous, moist, grey								-79.0		
																-80.0
																-81.0
																-82.0
																-83.0
																-84.0
																-85.0
																-86.0
																-87.0
																-88.0
																-89.0
																-90.0
																-91.0
														-92.0		
														-93.0		
														-94.0		
														-95.0		
														-96.0		
														-97.0		
														-98.0		
														-99.0		
														-100.0		
														-101.0		
														-102.0		
														-103.0		
														-104.0		
32.0																

UMA Engineering Ltd. Winnipeg, Manitoba		COMPLETION DEPTH 33.8 m		DATE DRILLED: 06/06/91	
		LOGGED BY KK		Fig. No.	

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: PADDOCK DRILLING LTD.	TESTHOLE No. MSA-CP5
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: CANTERRA CT250	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 125mm DIA. SOLID STEM AUGER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> NO RECOVERY
<input type="checkbox"/> DISTURBED	<input type="checkbox"/> CORE BARREL	<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd.
 Winnipeg, Manitoba

COMPLETION DEPTH 33.8 m	DATE DRILLED: 06/06/91
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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP1					
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06					
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)					
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> WIRELINE-TYPE					
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> CORE BARREL					
		<input type="checkbox"/> NO RECOVERY							
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲		SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲		DEPTH (ft)	
	4 8 12 16					40 80 120 160			
	◆ % CLAY ◆					◆ IV SHEAR STRENGTH (kPa) ◆			
	20 40 60 80					40 80 120 160			
PLASTIC M.C. LIQUID						◆ LV SHEAR STRENGTH (kPa) ◆			
40 80 120 160						● QU SHEAR STRENGTH (kPa) ●			
						40 80 120 160			
0.0	USC		TOPSOIL - some clay and silt, trace organics, rootlets, dry, black					0.0	
-1.0			CLAY - silty, firm, laminated					-1.0	
			- occasional fractures with trace fine sand on fractures.					-2.0	
			- moist, brown					-3.0	
-2.0								-4.0	
								-5.0	
								-6.0	
								-7.0	
								-8.0	
								-9.0	
								-10.0	
								-11.0	
								-12.0	
								-13.0	
-4.0			CLAY - firm, high plasticity				-14.0		
			- homogeneous, moist, grey				-15.0		
-5.0							-16.0		
							-17.0		
							-18.0		
							-19.0		
							-20.0		
							-21.0		
							-22.0		
							-23.0		
							-24.0		
							-25.0		
							-26.0		
8.0									

UMA Engineering Ltd.
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COMPLETION DEPTH 44.2 m

DATE DRILLED: 18/06/91

LOGGED BY KK

Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲				DEPTH (ft)		
	4	8	12					16	40	80	120		160	
	◆ % CLAY ◆							■ TV SHEAR STRENGTH (kPa) ■						
	20	40	60					40	80	120	160			
	PLASTIC M.C. LIQUID							◆ LV SHEAR STRENGTH (kPa) ◆						
	40	80	120	160				40	80	120	160			
								● QU SHEAR STRENGTH (kPa) ●						
	40	80	120	160				40	80	120	160			
8.0					CLAY - firm, high plasticity - homogeneous, moist, grey								-27.0	
														-28.0
														-29.0
														-30.0
														-31.0
														-32.0
														-33.0
														-34.0
														-35.0
														-36.0
														-37.0
														-38.0
														-39.0
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														-41.0
														-42.0
													-43.0	
													-44.0	
													-45.0	
													-46.0	
													-47.0	
													-48.0	
													-49.0	
													-50.0	
													-51.0	
													-52.0	
16.0														

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 44.2 m	DATE DRILLED: 18/06/91
LOGGED BY KK	Fig. No.
	Page 2 of 6

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP1					
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06					
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)					
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL					
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE					
		<input type="checkbox"/> NO RECOVERY							
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲		SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲		DEPTH (ft)	
	4 8 12 16					40 80 120 160			
	◆ % CLAY ◆					■ TV SHEAR STRENGTH (kPa) ■			
	20 40 60 80					40 80 120 160			
PLASTIC M.C. LIQUID		USC	CLAY - firm, high plasticity - homogeneous, moist, grey			◆ LV SHEAR STRENGTH (kPa) ◆			
-----						● QU SHEAR STRENGTH (kPa) ●			
40 80 120 160						40 80 120 160			
16.0								53.0	
								54.0	
								55.0	
-17.0								56.0	
								57.0	
								58.0	
-18.0								59.0	
								60.0	
								61.0	
-19.0								62.0	
								63.0	
								64.0	
-20.0								65.0	
								66.0	
								67.0	
-21.0								68.0	
								69.0	
								70.0	
-22.0								71.0	
								72.0	
								73.0	
-23.0								74.0	
								75.0	
								76.0	
-24.0								77.0	
								78.0	
UMA Engineering Ltd. Winnipeg, Manitoba				COMPLETION DEPTH 44.2 m		DATE DRILLED: 18/06/91			
				LOGGED BY KK		Fig. No.		Page 3 of 6	

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input type="checkbox"/> CORE BARREL <input type="checkbox"/> WIRELINE-TYPE		

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE / SPT (N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160				DEPTH (ft)	
	◆ % CLAY ◆ 20 40 60 80							■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160					
PLASTIC		M.C.		LIQUID		◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160				● QU SHEAR STRENGTH (kPa) ● 40 80 120 160			
40 80 120 160		40 80 120 160		40 80 120 160		40 80 120 160				40 80 120 160			
24.0					CLAY - firm, high plasticity - homogeneous, moist, grey							79.0	
													80.0
													81.0
													82.0
													83.0
													84.0
													85.0
													86.0
													87.0
													88.0
													89.0
													90.0
													91.0
												92.0	
												93.0	
												94.0	
												95.0	
												96.0	
												97.0	
												98.0	
												99.0	
												100.0	
												101.0	
												102.0	
												103.0	
												104.0	
32.0													

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP1			
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06			
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)			
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED			
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL			
				<input type="checkbox"/> WIRELINE--TYPE			
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160	DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80					■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160	
	PLASTIC M.C. LIQUID 40 80 120 160					◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160	
						● OU SHEAR STRENGTH (kPa) ● 40 80 120 160	
32.0			CLAY - firm, high plasticity - homogeneous, moist, grey				105.0
							106.0
							107.0
							108.0
-33.0							109.0
							110.0
							111.0
							112.0
-34.0							113.0
							114.0
							115.0
-35.0							116.0
							117.0
							118.0
-36.0			SILT TILL - some clay and gravel - dense, grey				119.0
							120.0
							121.0
-37.0							122.0
							123.0
							124.0
-38.0							125.0
							126.0
							127.0
-39.0							128.0
							129.0
							130.0
40.0							131.0

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 44.2 m

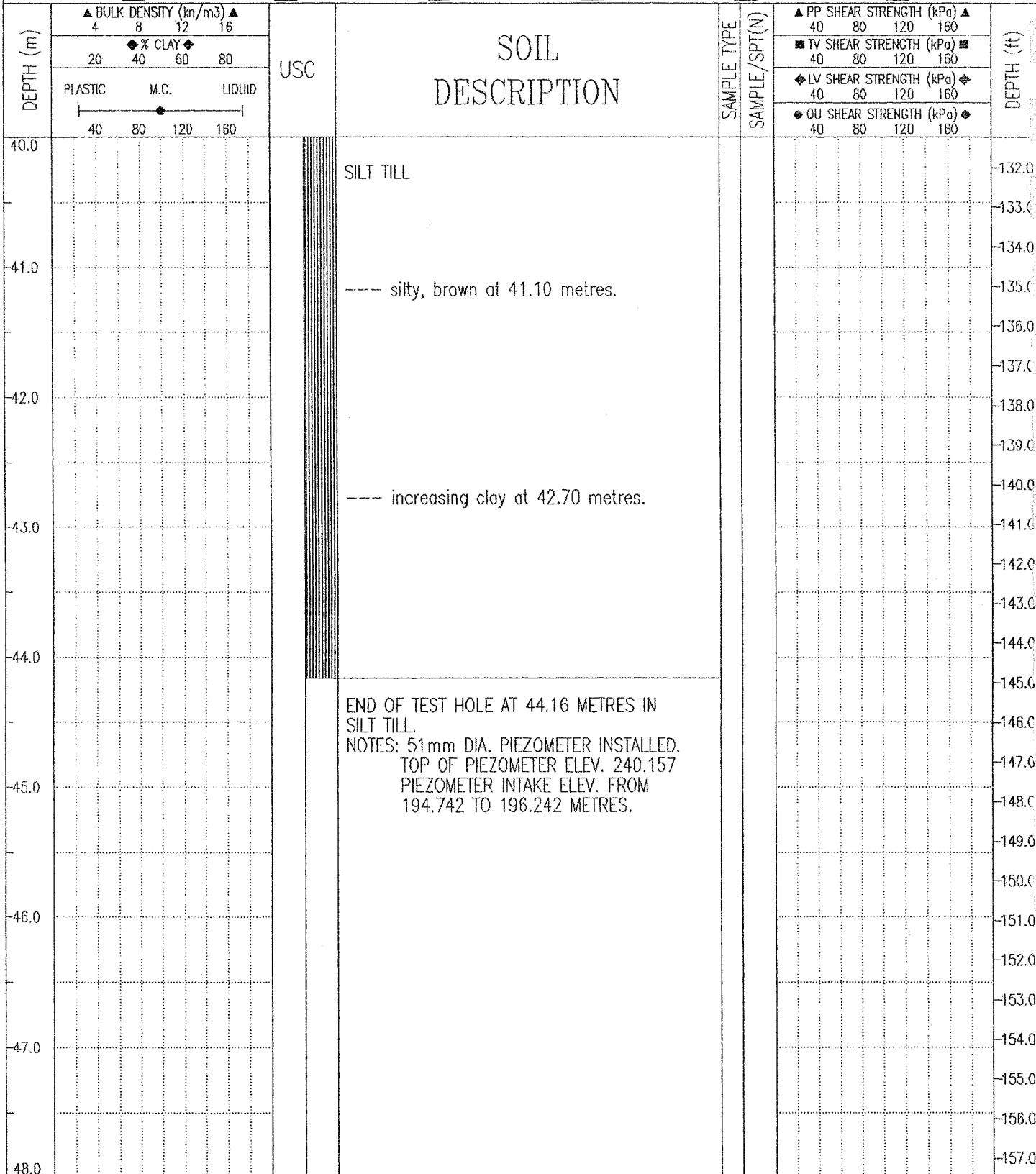
DATE DRILLED: 18/06/91

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Fig. No.

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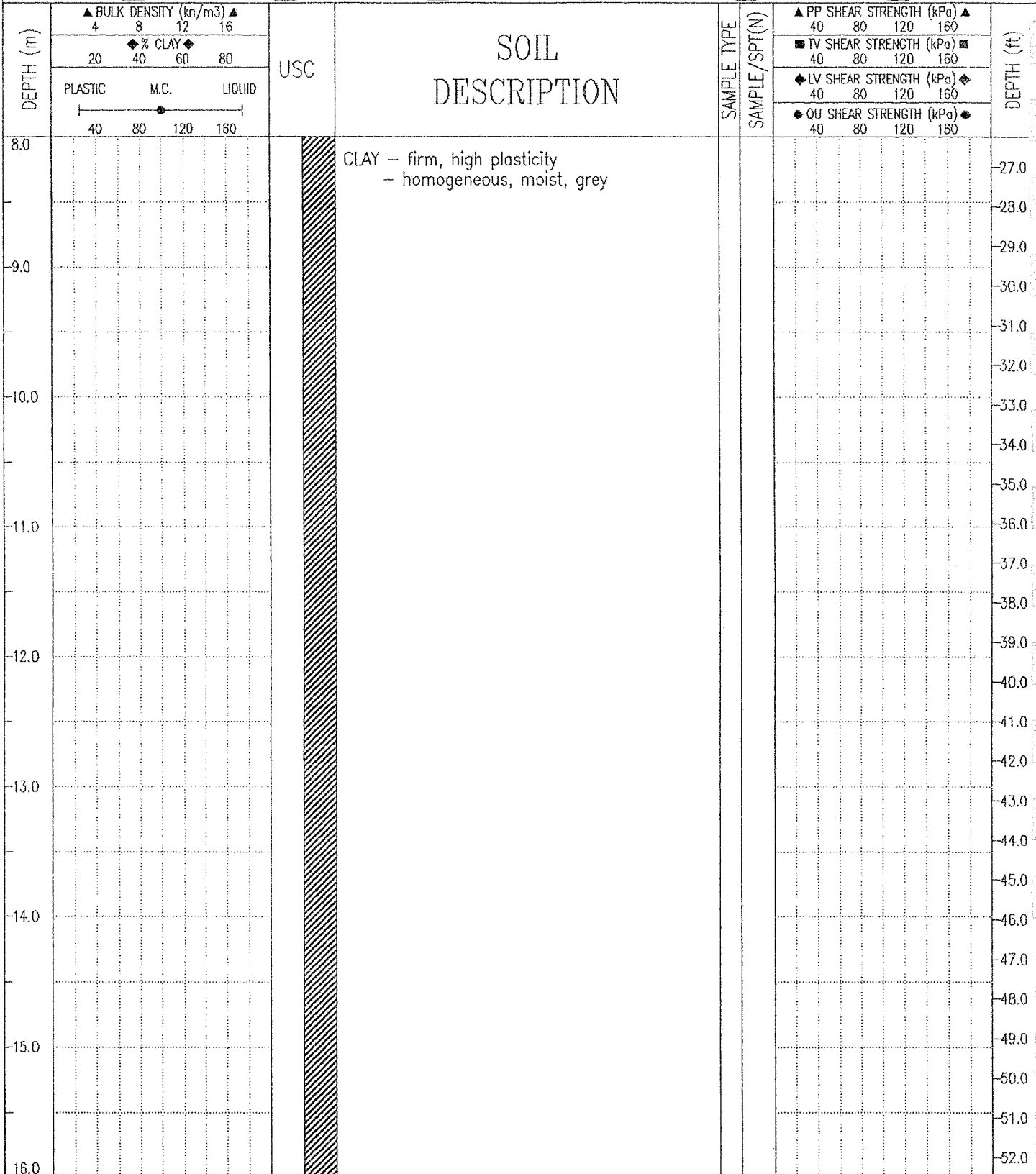
PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 44.2 m	DATE DRILLED: 18/06/91
	LOGGED BY KK	Fig. No.
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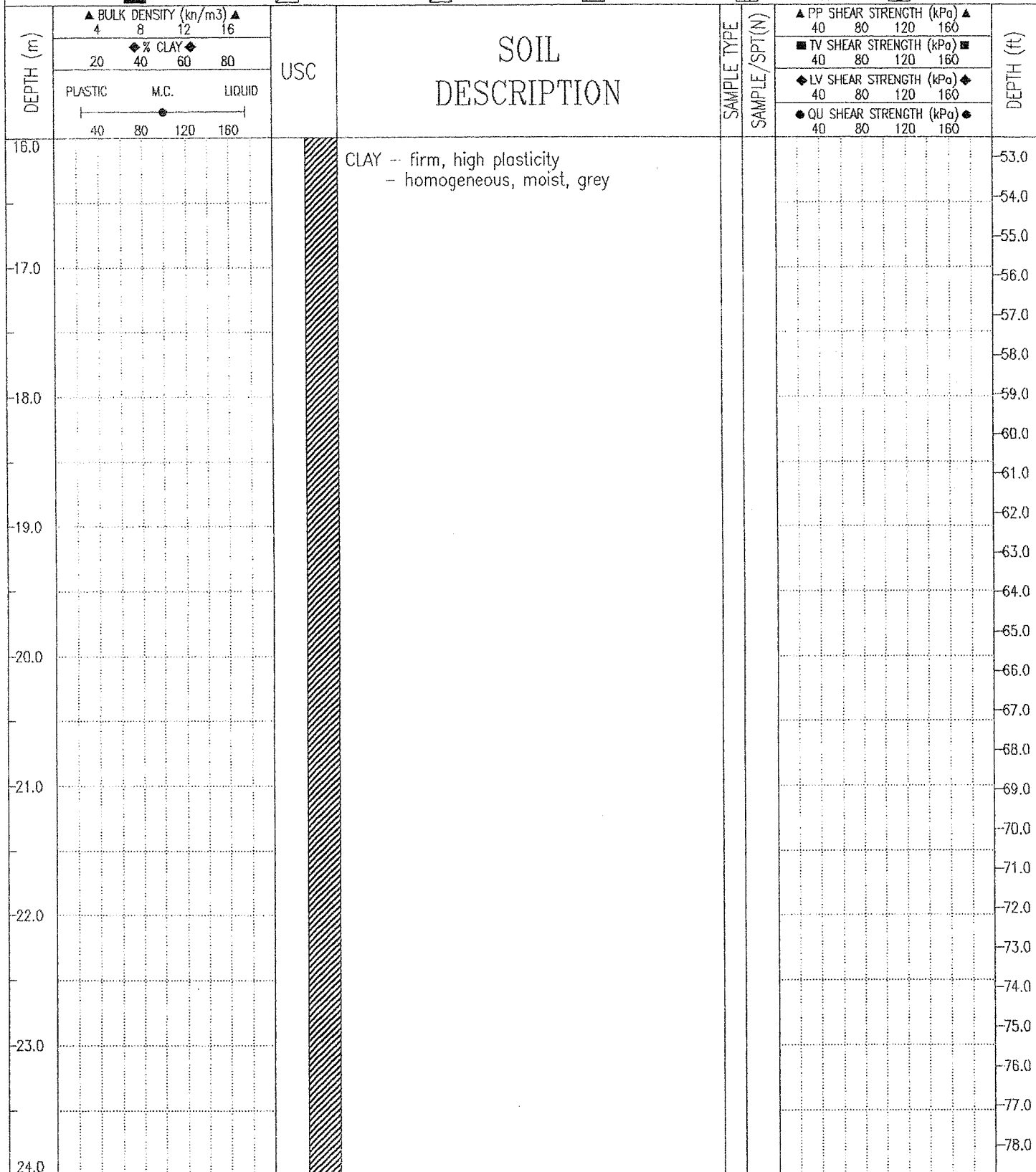
PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP2		
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06		
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)		
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> CORE BARREL		
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> WIRELINE-TYPE		
		<input type="checkbox"/> NO RECOVERY				
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16		USC	SOIL DESCRIPTION		DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80					
	PLASTIC M.C. LIQUID					
	40 80 120 160					
0.0	TOPSOIL - some clay and silt, trace organics, rootlets, dry, black				0.0	
-1.0	CLAY - silty, firm, laminated - occasional fractures with trace fine sand on fractures. - moist, brown				-1.0	
-2.0					-2.0	
-3.0					-3.0	
-4.0					-4.0	
-5.0					-5.0	
-6.0					-6.0	
-7.0					-7.0	
-8.0					-8.0	
-9.0					-9.0	
-10.0					-10.0	
-11.0					-11.0	
-12.0					-12.0	
-13.0					-13.0	
-14.0					-14.0	
-15.0					-15.0	
-16.0					-16.0	
-17.0					-17.0	
-18.0					-18.0	
-19.0					-19.0	
-20.0					-20.0	
-21.0					-21.0	
-22.0					-22.0	
-23.0					-23.0	
-24.0					-24.0	
-25.0					-25.0	
-26.0					-26.0	
UMA Engineering Ltd. Winnipeg, Manitoba		COMPLETION DEPTH 56.7 m		DATE DRILLED: 18/06/91		
		LOGGED BY KK		Fig. No.		
				Page 1 of 8		

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 56.7 m	DATE DRILLED: 18/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 56.7 m

DATE DRILLED: 18/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲		USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE /SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲		DEPTH (ft)
	4	8					40	80	
	◆ % CLAY ◆						■ TV SHEAR STRENGTH (kPa) ■		
	20	40					40	80	
	PLASTIC M.C. LIQUID						◆ LV SHEAR STRENGTH (kPa) ◆		
	40	80					40	80	
	-----						● QU SHEAR STRENGTH (kPa) ●		
	40	80					40	80	
24.0				CLAY - firm, high plasticity - homogeneous, moist, grey					-79.0
									-80.0
									-81.0
									-82.0
									-83.0
									-84.0
									-85.0
									-86.0
									-87.0
									-88.0
									-89.0
									-90.0
									-91.0
									-92.0
									-93.0
									-94.0
									-95.0
									-96.0
									-97.0
									-98.0
									-99.0
									-100.0
									-101.0
									-102.0
									-103.0
									-104.0
32.0									

UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 56.7 m	DATE DRILLED: 18/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP2			
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06			
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)			
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED			
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL			
				<input type="checkbox"/> WIRELINE--TYPE			
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160	DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80					■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160	
	PLASTIC M.C. LIQUID 40 80 120 160					◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160	
						● QU SHEAR STRENGTH (kPa) ● 40 80 120 160	
32.0			CLAY - firm, high plasticity - homogeneous, moist, grey				105.0
							106.0
							107.0
							108.0
33.0							109.0
							110.0
							111.0
							112.0
34.0							113.0
							114.0
							115.0
							116.0
35.0							117.0
							118.0
							119.0
							120.0
36.0			SILT TILL - some clay and gravel, dense - grey				121.0
							122.0
							123.0
							124.0
37.0							125.0
							126.0
							127.0
							128.0
38.0							129.0
							130.0
							131.0
39.0							
40.0							

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 56.7 m

DATE DRILLED: 18/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE--TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160				DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80							■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160				
	PLASTIC M.C. LIQUID ----- 40 80 120 160							◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160				
								◆ QU SHEAR STRENGTH (kPa) ◆ 40 80 120 160				
40.0					SILT TILL							-132.0
												-133.0
												-134.0
41.0					--- silty, brown at 41.10 metres.							-135.0
												-136.0
												-137.0
42.0												-138.0
												-139.0
												-140.0
					--- increasing clay at 42.70 metres.							-141.0
43.0												-142.0
												-143.0
												-144.0
44.0					--- very dense, some gravel, brown at 43.89 metres.							-145.0
												-146.0
												-147.0
45.0												-148.0
												-149.0
												-150.0
46.0												-151.0
												-152.0
												-153.0
47.0												-154.0
												-155.0
												-156.0
48.0												-157.0

UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 56.7 m	DATE DRILLED: 18/06/91
	LOGGED BY KK	Fig. No.
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PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-TP2	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 171mm DIAMETER		ELEVATION 238.50 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> WIRELINE -TYPE	
		<input checked="" type="checkbox"/> DISTURBED		<input type="checkbox"/> CORE BARREL	
		<input type="checkbox"/> NO RECOVERY			
DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16 ◆ % CLAY ◆ 20 40 60 80		USC	SOIL DESCRIPTION	DEPTH (ft)
	PLASTIC M.C. LIQUID -----●----- 40 80 120 160				
48.0				SILT TILL	-158.0
					-159.0
					-160.0
-49.0					-161.0
					-162.0
					-163.0
					-164.0
-50.0					-165.0
					-166.0
					-167.0
-51.0					-168.0
					-169.0
				--- increasing silt, soft to medium dense at 51.51 metres.	-170.0
					-171.0
-52.0					-172.0
					-173.0
					-174.0
-53.0					-175.0
				--- dense at 53.34 metres.	-176.0
					-177.0
					-178.0
					-179.0
					-180.0
-55.0					-181.0
					-182.0
					-183.0
56.0					

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 56.7 m

DATE DRILLED: 18/06/91

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Fig. No.

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PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-TP2
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 171mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE

DEPTH (m)	▲ BULK DENSITY (kn/m ³) ▲ 4 8 12 16			USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE/SPT(N)	▲ PP SHEAR STRENGTH (kPa) ▲ 40 80 120 160				DEPTH (ft)
	◆ % CLAY ◆ 20 40 60 80							■ TV SHEAR STRENGTH (kPa) ■ 40 80 120 160				
	PLASTIC M.C. LIQUID							◆ LV SHEAR STRENGTH (kPa) ◆ 40 80 120 160				
	----- ----- ----- -----							◆ QU SHEAR STRENGTH (kPa) ◆ 40 80 120 160				
56.0					SILT TILL							-184.0
												-185.0
												-186.0
-57.0					END OF TEST HOLE AT 56.70 METRES IN SILT TILL.							-187.0
												-188.0
												-189.0
												-190.0
-58.0					NOTES: 51mm DIA. PIEZOMETER INSTALLED. TOP OF PIEZOMETER ELEV. 240.111 PIEZOMETER INTAKE ELEV. FROM 182.199 TO 183.699 METRES.							-191.0
												-192.0
												-193.0
-59.0												-194.0
												-195.0
												-196.0
60.0												-197.0
												-198.0
												-199.0
												-200.0
-61.0												-201.0
												-202.0
												-203.0
-62.0												-204.0
												-205.0
												-206.0
-63.0												-207.0
												-208.0
												-209.0
64.0												

UMA Engineering Ltd.
Winnipeg, Manitoba

COMPLETION DEPTH 56.7 m	DATE DRILLED: 18/06/91
LOGGED BY KK	Fig. No.
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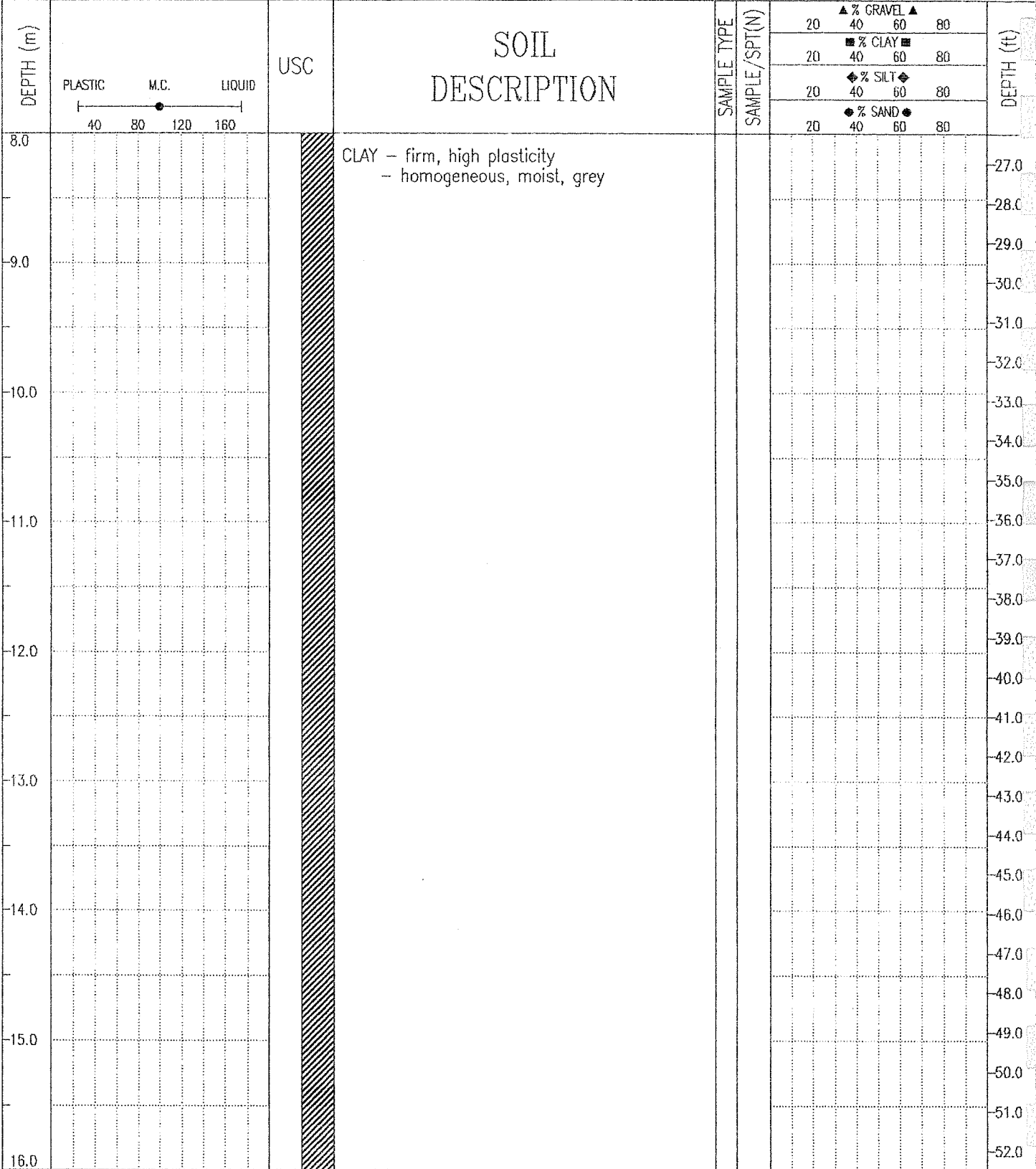
PROJECT: MONTCALM SITE EVALUATION		DRILLED BY: FRIESEN DRILLING LTD.		TESTHOLE No. MSA-BW1	
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP		DRILL TYPE: FAILING ROTARY RIG		Project No: 6544-003-01-06	
PROJECT ENGINEER: LB		DRILL TYPE: 300, 190, 95mm DIAMETER		ELEVATION 238.50 (m)	
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> SHELBY TUBE		<input checked="" type="checkbox"/> DISTURBED	
		<input type="checkbox"/> NO RECOVERY		<input type="checkbox"/> CORE BARREL	
				<input type="checkbox"/> WIRELINE-TYPE	

DEPTH (m)		USC	SOIL DESCRIPTION				DEPTH (ft)	
			20	40	60	80		▲ % GRAVEL ▲
			20	40	60	80		■ % CLAY ■
			20	40	60	80		◆ % SILT ◆
			20	40	60	80		● % SAND ●

0.0			TOPSOIL - some clay and silt, trace organics, rootlets, dry, black		0.0
-1.0			CLAY - silty, firm, laminated - occasional fractures with trace fine sand on fractures. - moist, brown		-1.0
-2.0					-2.0
-3.0					-3.0
-4.0					-4.0
-5.0					-5.0
-6.0					-6.0
-7.0					-7.0
-8.0					-8.0
-9.0					-9.0
-10.0					-10.0
-11.0					-11.0
-12.0					-12.0
-13.0					-13.0
-14.0					-14.0
-15.0			CLAY - firm, high plasticity - homogeneous, moist, grey		-15.0
-16.0					-16.0
-17.0					-17.0
-18.0					-18.0
-19.0					-19.0
-20.0					-20.0
-21.0					-21.0
-22.0					-22.0
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-24.0					-24.0
-25.0					-25.0
-26.0					-26.0

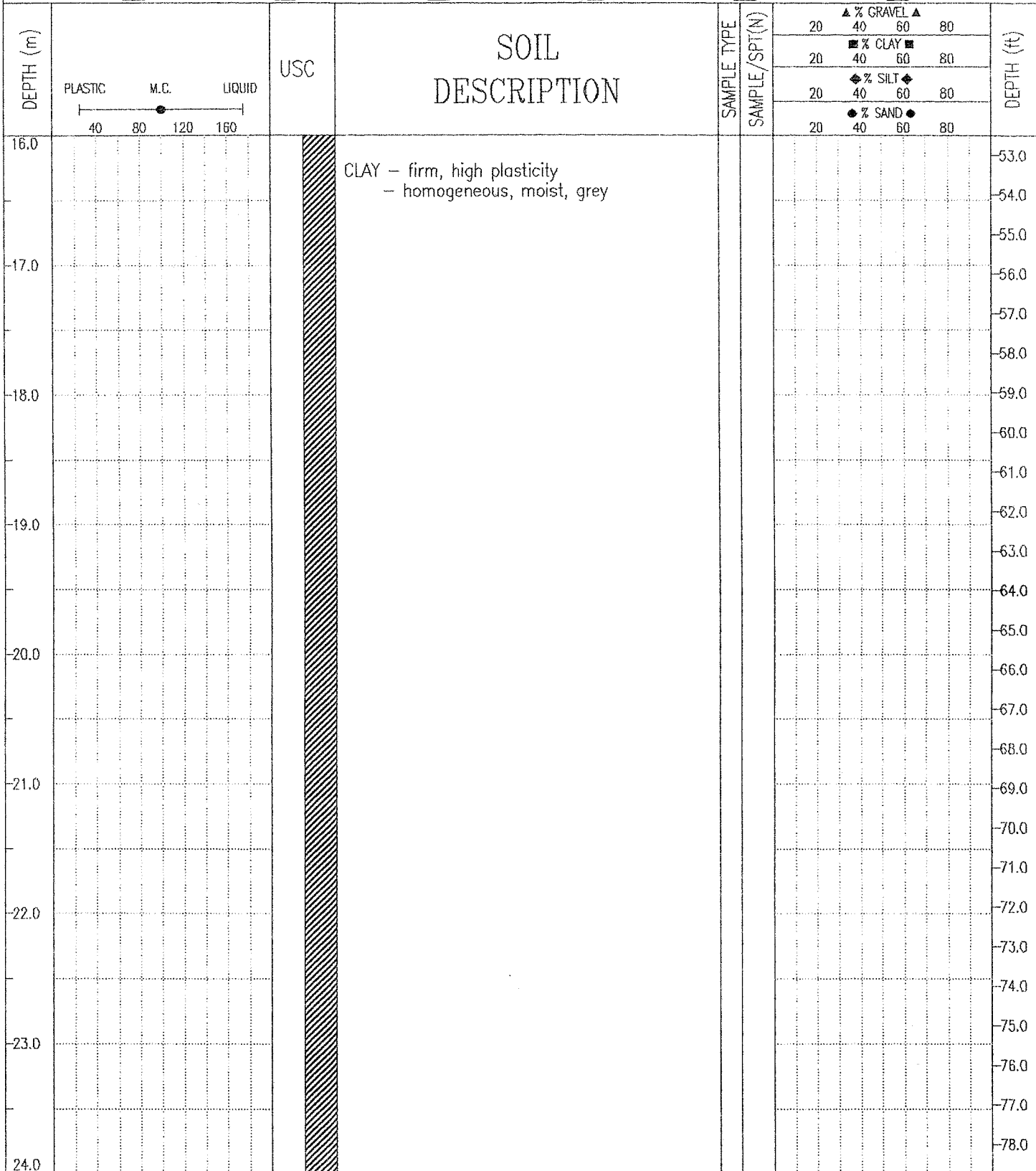
UMA Engineering Ltd. Winnipeg, Manitoba		COMPLETION DEPTH 76.2 m		DATE DRILLED: 12/06/91	
LOGGED BY KK		Fig. No.		Page 1 of 10	

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB.	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No.
		Page 2 of 10

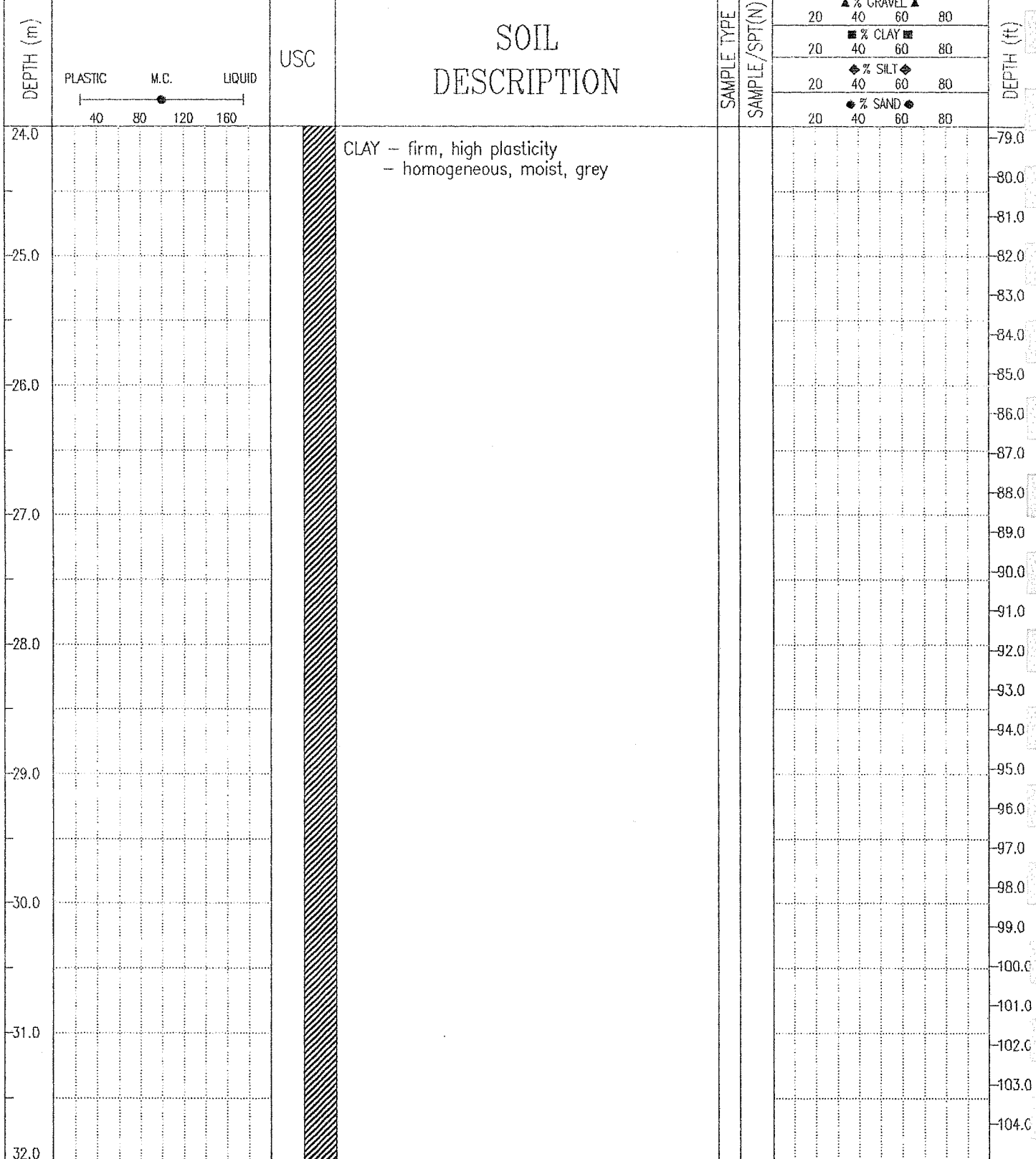
PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input type="checkbox"/> CORE BARREL <input type="checkbox"/> WIRELINE--TYPE		



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No.

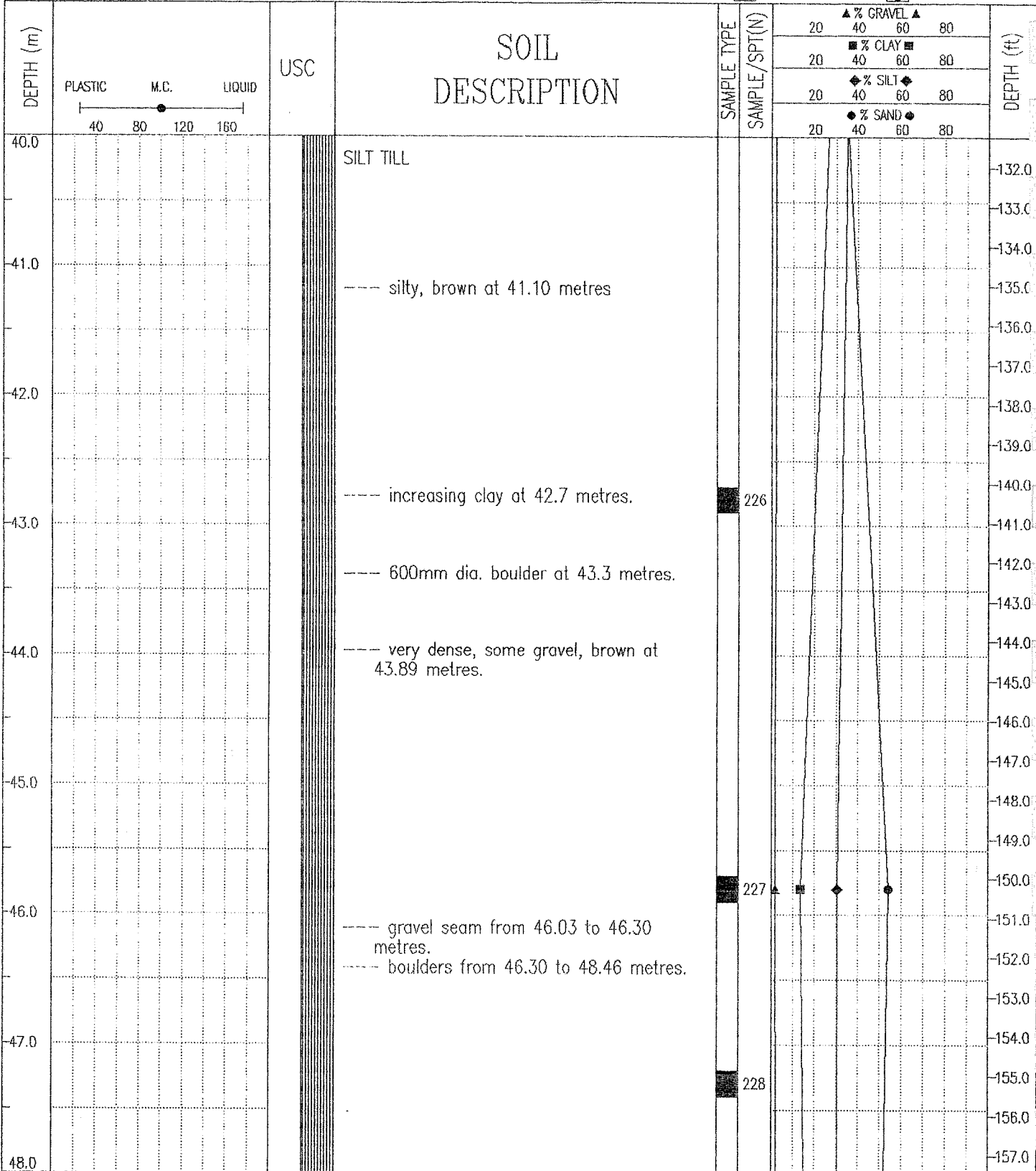
PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)

SAMPLE TYPE GRAB SAMPLE SHELBY TUBE DISTURBED NO RECOVERY CORE BARREL WIRELINE-TYPE



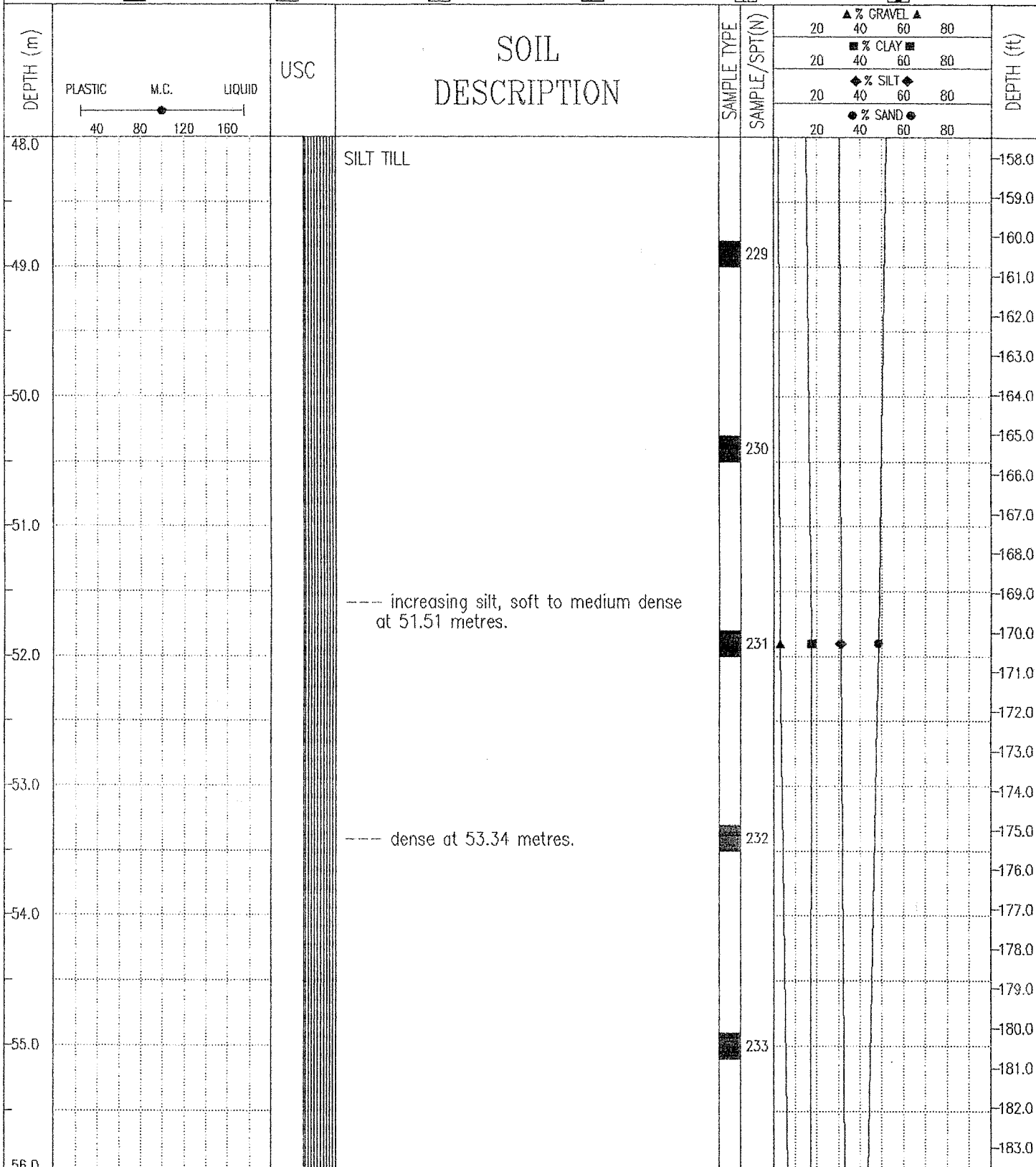
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
LOGGED BY KK	Fig. No.	Page 4 of 10

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input type="checkbox"/> CORE BARREL <input type="checkbox"/> WIRELINE--TYPE		



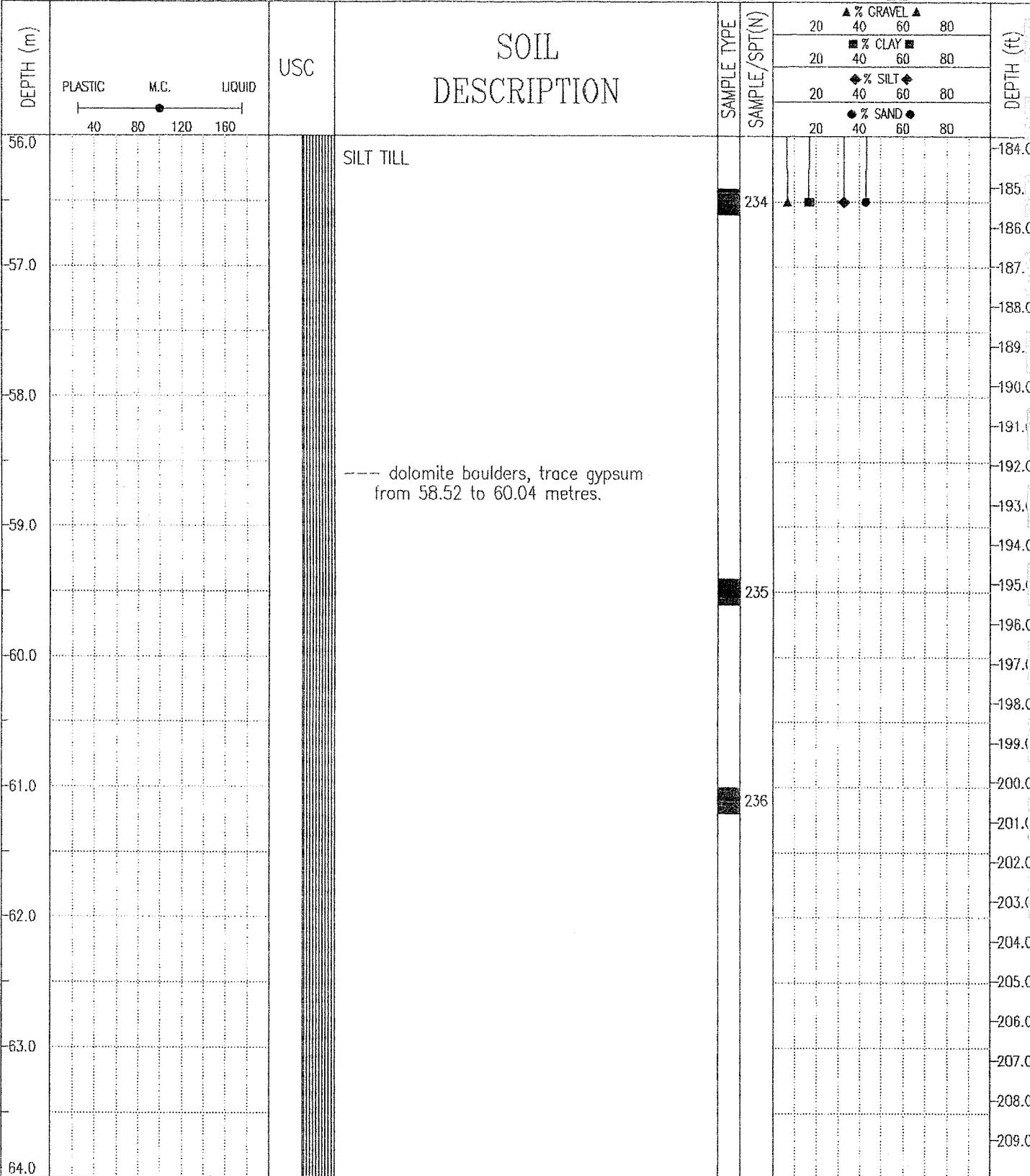
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Page 6 of 10

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input type="checkbox"/> CORE BARREL <input type="checkbox"/> WIRELINE-TYPE		



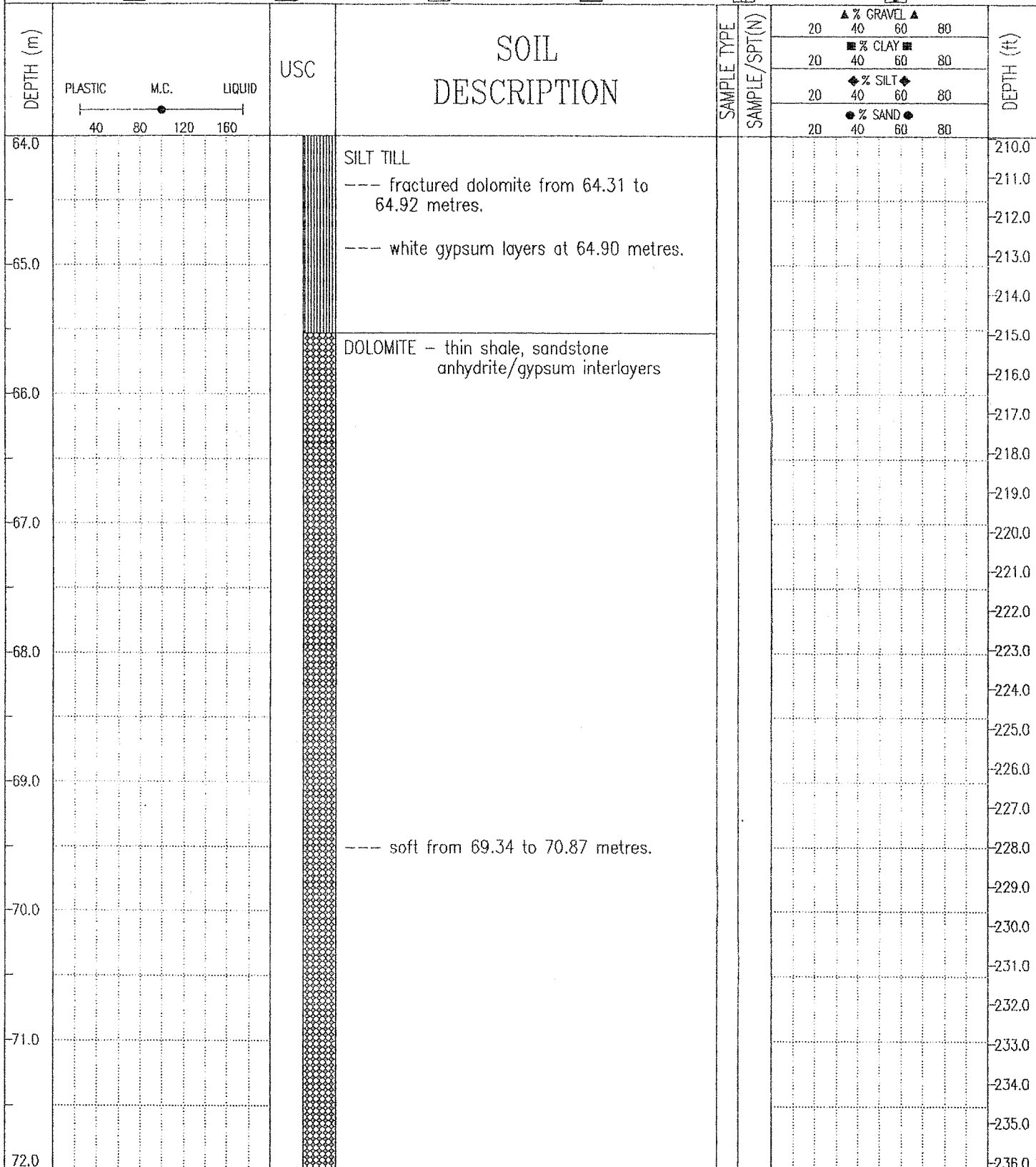
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No.

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA--BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



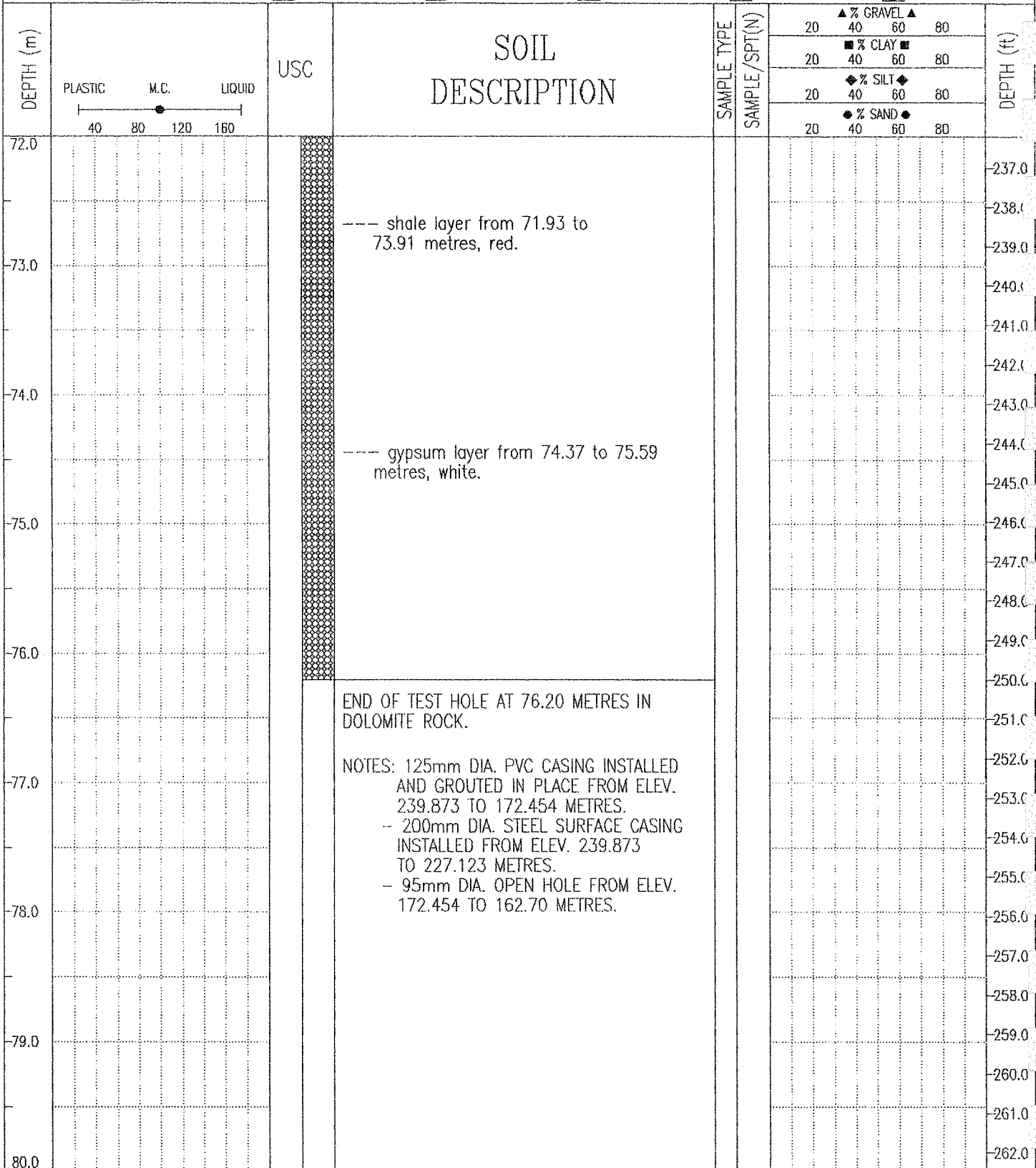
UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No. Page 8 of 10

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA--BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> SHELBY TUBE	<input checked="" type="checkbox"/> DISTURBED
	<input type="checkbox"/> NO RECOVERY	<input type="checkbox"/> CORE BARREL
		<input type="checkbox"/> WIRELINE-TYPE



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No.
		Page 9 of 10

PROJECT: MONTCALM SITE EVALUATION	DRILLED BY: FRIESEN DRILLING LTD.	TESTHOLE No. MSA-BW1
CLIENT: MAN. HAZARDOUS WASTE MANAG. CORP	DRILL TYPE: FAILING ROTARY RIG	Project No: 6544-003-01-06
PROJECT ENGINEER: LB	DRILL TYPE: 300, 190, 95mm DIAMETER	ELEVATION 238.50 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input type="checkbox"/> CORE BARREL <input type="checkbox"/> WIRELINE - TYPE		



UMA Engineering Ltd. Winnipeg, Manitoba	COMPLETION DEPTH 76.2 m	DATE DRILLED: 12/06/91
	LOGGED BY KK	Fig. No.

SUMMARY OF PIEZOMETRIC ELEVATIONS

UMA Engineering Ltd.
Earth Sciences Division
Winnipeg, MB

MONTCALM SITE EVALUATION
MAN. HAZ. WASTE MAN. CORP
JOB No.: 6544-003-01-06

SITE	MSA-CP1	MSA-CP2	MSA-CP3	MSA-CP4	MSA-CP5	MSA-TP1	MSA-TP2	MSA-BW1
INTAKE LOCATION	CLAY	CLAY	CLAY	CLAY	CLAY	TILL	TILL	BEDROCK
INTAKE TYPE	SLOTTED SCREEN	SLOTTED SCREEN	SLOTTED SCREEN	SLOTTED SCREEN	SLOTTED SCREEN	SLOTTED SCREEN	SLOTTED SCREEN	OPEN HOLE
TOP OF PIPE ELEV. (m)	240.110	240.143	240.073	240.075	240.081	240.157	240.111	239.873
INTAKE ELEV. (m)	234.490- 233.890	230.133- 229.533	223.993- 223.393	214.390- 213.790	205.671- 205.071	196.242- 194.742	183.699- 182.199	172.454- 162.700

DATE OF READING	PIEZOMETRIC ELEVATION							
	MSA-CP1	MSA-CP2	MSA-CP3	MSA-CP4	MSA-CP5	MSA-TP1	MSA-TP2	MSA-BW1
JUNE 14	234.120	230.023	225.628	219.240	207.656			
JUNE 17	234.220	230.193	226.833	223.385	211.206			
JUNE 18	234.240	230.223	227.403	224.315	212.201			
JUNE 19	234.260	230.243	227.883	225.245	213.321			
JUNE 21	234.320	230.323	229.313	226.985	215.481			
JUNE 27	234.550	230.693	232.143	230.655	220.801			
JULY 04	234.790	231.583	233.993	233.075	225.301			
JULY 11	234.900	232.633	235.003	234.425	228.451			
JULY 19	235.075	233.473	235.703	235.365	231.021			
JULY 22	235.130	233.663	235.873	235.575	231.701	244.835	244.622	245.445
AUGUST 01	235.900	234.273	236.303	236.215	233.691			
AUGUST 09	236.240	234.643	236.503	236.555	234.841			
AUGUST 16	236.580	234.913	236.733	236.795	235.661			
AUGUST 29	237.020	235.243	236.593	236.585	236.671			
SEPT. 13	237.190	235.560	236.430	236.420	237.426			
OCTOBER 02	237.440	235.880	236.330	236.240	238.110			

HYDRAULIC CONDUCTIVITY TEST

ASTM D5084-90

SAMPLE INFORMATION:

HOLE No.: MSA-CP1

DEPTH: 4.57 m SAMPLE No.: 2 19

SAMPLE CHARACTERISTICS

	DIMENSIONS		DRY UNIT WEIGHT (KN/M3)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)
	DIAMETER (cm)	HEIGHT (cm)			
BEFORE TEST	7.121	7.070	17.1	51.9	90.0
AFTER TEST	7.165	7.139	16.9	51.6	

BACK PRESSURE APPLIED (KPa)= 103.4
 EFFECTIVE CONSOLIDATION STRESS (KPa)= 103.4
 PERMEANT USED: DEAIRED TAP WATER
 B (degree of saturation) (%) = 92.0

HYDRAULIC CONDUCTIVITY

	TIME (sec)	VOLUME COLLECTED (cc)	TEMPERATURE (deg C.)	K (cm/sec)
	8820	0.3	29	7.73 E-09
	15360	0.5	30	7.24 E-09
	3000	0.1	29	7.57 E-09
	8940	0.3	29	7.63 E-09

HYDRAULIC CONDUCTIVITY (cm/sec)= 7.5 E-09

REMARKS:

UMA Engineering Ltd.
 1479 Buffalo Pl.
 Winnipeg, MB
 CANADA R3T 1L7

DATE: AUGUST 30, 1991

JOB No.: 6544 003 01

PROJECT: MONTCALM SITE EVALUATION

LOCATION: MONTCALM, MB

SITE:

TECHNICIAN: R.L.

HYDRAULIC CONDUCTIVITY TEST

ASTM D5084-90

SAMPLE INFORMATION:

HOLE No.: MSA-CP2

DEPTH: 9.14 m SAMPLE No.: 220

SAMPLE CHARACTERISTICS

	DIMENSIONS		DRY UNIT WEIGHT (KN/M3)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)
	DIAMETER (cm)	HEIGHT (cm)			
BEFORE TEST	7.212	7.370	16.7	56.2	94.2
AFTER TEST	7.274	7.420	16.4	58.1	

BACK PRESSURE APPLIED (KPa)= 103.4
 EFFECTIVE CONSOLIDATION STRESS (KPa)= 137.9
 PERMEANT USED: DEAIRED TAP WATER
 B (degree of saturation) (%) = 98.8

HYDRAULIC CONDUCTIVITY

	TIME (sec)	VOLUME COLLECTED (cc)	TEMPERATURE (deg C.)	K (cm/sec)
	3180	0.2	28	8.84 E-09
	12420	0.8	28	9.06 E-09
	4860	0.3	28	8.68 E-09
	58020	3.7	28	8.97 E-09

HYDRAULIC CONDUCTIVITY (cm/sec)= 8.9 E-09

REMARKS:

UMA Engineering Ltd.
 1479 Buffalo Pl.
 Winnipeg, MB
 CANADA R3T 1L7

DATE: AUGUST 30, 1991

JOB No.: 6544 003 01

PROJECT: MONTCALM SITE EVALUATION

LOCATION: MONTCALM, MB

SITE:

TECHNICIAN: R.L.

HYDRAULIC CONDUCTIVITY TEST

ASTM D5084-90

SAMPLE INFORMATION:

HOLE No.: MSA-CP3 DEPTH:15.24 m SAMPLE No.: 221

SAMPLE CHARACTERISTICS

	DIMENSIONS		DRY UNIT WEIGHT (KN/M3)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)
	DIAMETER (cm)	HEIGHT (cm)			
BEFORE TEST	7.203	7.141	16.1	61.0	92.0
AFTER TEST	7.214	7.169	16.1	63.2	

BACK PRESSURE APPLIED (KPa)= 103.4
 EFFECTIVE CONSOLIDATION STRESS (KPa)= 200.0
 PERMEANT USED: DEAIRED TAP WATER
 B (degree of saturation) (%) = 94.0

HYDRAULIC CONDUCTIVITY

	TIME (sec)	VOLUME COLLECTED (cc)	TEMPERATURE (deg C.)	K (cm/sec)
	3420	0.5	26	1.32 E-08
	9960	1.6	26	1.44 E-08
	2160	0.3	26	1.25 E-08
	720	0.1	26	1.25 E-08

HYDRAULIC CONDUCTIVITY (cm/sec)= 1.3 E-08

REMARKS:

UMA Engineering Ltd.

1479 Buffalo Pl.
 Winnipeg, MB
 CANADA R3T 1L7

DATE: AUGUST 30, 1991

JOB No.: 6544 003 01

PROJECT: MONTCALM SITE EVALUATION

LOCATION: MONTCALM, MB

SITE:

TECHNICIAN: R.L.

HYDRAULIC CONDUCTIVITY TEST

ASTM D5084-90

SAMPLE INFORMATION:

HOLE No.: MSA-CP4

DEPTH: 24.68 m SAMPLE No.: 222

SAMPLE CHARACTERISTICS

	DIMENSIONS		DRY UNIT WEIGHT (KN/M3)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)
	DIAMETER (cm)	HEIGHT (cm)			
BEFORE TEST	7.263	7.282	17.4	47.0	85.0
AFTER TEST	7.229	7.288	17.5	46.1	

BACK PRESSURE APPLIED (KPa)= 103.4
EFFECTIVE CONSOLIDATION STRESS (KPa)= 255.1
PERMEANT USED: DEAIRED TAP WATER
B (degree of saturation) (%) = 94.5

HYDRAULIC CONDUCTIVITY

	TIME (sec)	VOLUME COLLECTED (cc)	TEMPERATURE (deg C.)	K (cm/sec)
	3180	0.6	25	1.14 E-08
	3720	0.8	25	1.30 E-08
	4800	0.9	25	1.14 E-08
	4920	1.0	25	1.23 E-08

HYDRAULIC CONDUCTIVITY (cm/sec) = 1.2 E-08

REMARKS:

UMA Engineering Ltd.
1479 Buffalo Pl.
Winnipeg, MB
CANADA R3T 1L7

DATE: AUGUST 30, 1991

JOB No.: 6544 003 01

PROJECT: MONTCALM SITE EVALUATION

LOCATION: MONTCALM, MB

SITE:

TECHNICIAN: R.L.

HYDRAULIC CONDUCTIVITY TEST

ASTM D5084-90

SAMPLE INFORMATION:

HOLE No.: MSA-CP5 DEPTH:36.88 m SAMPLE No.: 2 23

SAMPLE CHARACTERISTICS

	DIMENSIONS		DRY UNIT WEIGHT (KN/M3)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)
	DIAMETER (cm)	HEIGHT (cm)			
BEFORE TEST	7.256	7.205	16.8	52.6	90.0
AFTER TEST	7.223	7.085	17.0	47.3	

BACK PRESSURE APPLIED (KPa)= 103.4
 EFFECTIVE CONSOLIDATION STRESS (KPa)= 379.2
 PERMEANT USED: DEAIRED TAP WATER
 B (degree of saturation) (%) = 95.0

HYDRAULIC CONDUCTIVITY

	TIME (sec)	VOLUME COLLECTED (cc)	TEMPERATURE (deg C.)	K (cm/sec)
	7500	0.5	27	3.48 E-09
	5880	0.4	27	3.54 E-09
	11340	0.75	27	3.45 E-09
	48360	3.3	27	3.56 E-09

HYDRAULIC CONDUCTIVITY (cm/sec)= 3.5 E-09

REMARKS:

<p>UMA Engineering Ltd. 1479 Buffalo Pl. Winnipeg, MB CANADA R3T 1L7</p>	<p>DATE: AUGUST 30, 1991 JOB No.: 6544 003 01 PROJECT: MONTCALM SITE EVALUATION LOCATION: MONTCALM, MB SITE: TECHNICIAN: R.L.</p>
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FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-CP1

Depth of Intake: 4.57 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 1.9
 D = 12.5
 L = 60.9
 t₂ - t₁ = 1,296,000
 H₁/H₂ = 2.6
 m = -1

FIELD CONDUCTIVITY (CM/SEC) = 1.2 E - 08

Remarks: t₂ - t₁ and H₁/H₂ calculated from clay piezometer hydrographs using levels recorded on August 1 and 16, 1991. Static levels based on August 29, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-CP2

Depth of Intake: 9.14 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 1.9
 D = 12.5
 L = 60.9
 t₂ - t₁ = 1,296,000
 H₁/H₂ = 2.9
 m = 1

FIELD CONDUCTIVITY (CM/SEC) = 1.4 E - 08

Remarks: t₂ - t₁ and H₁/H₂ calculated from clay piezometer hydrographs using levels recorded on August 1 and 16, 1991. Static levels based on August 29, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-CP3

Depth of Intake: 15.24 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 1.9
 D = 12.5
 L = 60.9
 t₂ - t₁ = 1,296,000
 H₁/H₂ = 2.1
 m = 1

FIELD CONDUCTIVITY (CM/SEC) = 9.5 E - 09

Remarks: t₂ - t₁ and H₁/H₂ calculated from clay piezometer hydrographs using levels recorded on August 1 and 16, 1991. Static levels based on August 29, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-CP4

Depth of Intake: 24.68 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
D = diameter of the intake, cm
L = length of intake, cm
H₁ = piezometric head for t = t₁, cm
H₂ = piezometric head for t = t₂, cm
t = time in seconds
m = transformation ratio

d = 1.9
D = 12.5
L = 60.9
t₂ - t₁ = 1,555,200
H₁/H₂ = 5.1
m = 1

FIELD CONDUCTIVITY (CM/SEC) = 1.8 E - 08

Remarks: t₂ - t₁ and H₁/H₂ calculated from clay piezometer hydrographs using levels recorded on July 22 and August 9, 1991. Static levels based on August 29, 1991 reading.

UMA ENGINEERING LTD.
1479 Buffalo Place
Winnipeg, Manitoba
Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-CP5

Depth of Intake: 36.88 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 1.9
 D = 12.5
 L = 60.9
 t₂ - t₁ = 1,296,000
 H₁/H₂ = 2.9
 m = 1

FIELD CONDUCTIVITY (CM/SEC) = 1.4 E - 08

Remarks: t₂ - t₁ and H₁/H₂ calculated from clay piezometer hydrographs using levels recorded on August 1 and 16, 1991. Static levels based on August 29, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-TP1

Depth of Intake: 43.41 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 5.1
 D = 17.1
 L = 152.4
 t₂ - t₁ = 540
 H₁/H₂ = 1.4
 m = 1

FIELD CONDUCTIVITY (CM/SEC) = 3.4 E - 05

Remarks: t₂ - t₁ and H₁/H₂ calculated from rising head test. Static levels based on July 22, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

MANITOBA HAZARDOUS WASTE MANAGEMENT CORPORATION

MONTCALM SITE EVALUATION

RISING HEAD TEST

PIEZOMETER No.: MSA-TP1
 TOP OF PIPE ELEV. 240.157
 STATIC WATER ELEV. 244.835

ELAPSED TIME MIN	ELAPSED TIME SEC	DEPTH FROM TOP OF PIPE	ELEV. FROM TOP OF PIPE	HEAD DIFFERENTIAL
0.00	0	8.85	231.307	13.528
0.50	30	8.60	231.557	13.278
1.00	60	8.20	231.957	12.878
1.50	90	7.88	232.277	12.558
2.00	120	7.58	232.577	12.258
2.50	150	7.31	232.847	11.988
3.00	180	7.12	233.037	11.798
3.50	210	6.88	233.277	11.558
4.00	240	6.69	233.467	11.368
4.50	270	6.40	233.757	11.078
5.00	300	6.18	233.977	10.858
5.50	330	5.96	234.197	10.638
6.00	360	5.80	234.357	10.478
6.50	390	5.55	234.607	10.228
7.00	420	5.33	234.827	10.008
7.50	450	5.10	235.057	9.778
8.00	480	4.96	235.197	9.638
8.50	510	4.80	235.357	9.478
9.00	540	4.61	235.547	9.288
9.50	570	4.45	235.707	9.128
10.00	600	4.27	235.887	8.948
10.50	630	4.10	236.057	8.778
11.00	660	3.96	236.197	8.638
11.50	690	3.82	236.337	8.498
12.00	720	3.66	236.497	8.338
12.50	750	3.50	236.657	8.178
13.00	780	3.37	236.787	8.048

13.50	810	3.28	236.877	7.958
14.00	840	3.10	237.057	7.778
14.50	870	3.00	237.157	7.678
15.00	900	2.88	237.277	7.558
15.50	930	2.76	237.397	7.438
16.00	960	2.65	237.507	7.328
16.50	990	2.53	237.627	7.208
17.00	1020	2.46	237.697	7.138
17.50	1050	2.33	237.827	7.008
18.00	1080	2.22	237.937	6.898
18.50	1110	2.12	238.037	6.798
19.00	1140	2.06	238.097	6.738
19.50	1170	1.98	238.177	6.658
20.00	1200	1.90	238.257	6.578
21.00	1260	1.72	238.437	6.398
22.00	1320	1.52	238.637	6.198
23.00	1380	1.35	238.807	6.028
24.00	1440	1.19	238.967	5.868
25.00	1500	1.10	239.057	5.778
26.00	1560	0.85	239.307	5.528
27.00	1620	0.68	239.477	5.358
28.00	1680	0.53	239.627	5.208
29.00	1740	0.40	239.757	5.078
30.00	1800	0.28	239.877	4.958
31.00	1860	0.00	240.157	4.678

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-TP2

Depth of Intake: 55.95 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (2 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter in uniform soil

Where:

d = diameter of the standpipe, cm
 D = diameter of the intake, cm
 L = length of intake, cm
 H₁ = piezometric head for t = t₁, cm
 H₂ = piezometric head for t = t₂, cm
 t = time in seconds
 m = transformation ratio

d = 5.1
 D = 17.1
 L = 152.4
 t₂ - t₁ = 480
 H₁/H₂ = 1.8
 m = 1

FIELD CONDUCTIVITY (CM/SEC) = 7.8 E - 05

Remarks: t₂ - t₁ and H₁/H₂ calculated from rising head test. Static levels based on July 22, 1991 reading.

UMA ENGINEERING LTD.
 1479 Buffalo Place
 Winnipeg, Manitoba
 Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

MANITOBA HAZARDOUS WASTE MANAGEMENT CORPORATION

MONTCALM SITE EVALUATION

RISING HEAD TEST

PIEZOMETER No.: MSA-TP2
 TOP OF PIPE ELEV. 240.111
 STATIC WATER ELEV. 244.622

ELAPSED TIME MIN	ELAPSED TIME SEC	DEPTH FROM TOP OF PIPE	ELEV. FROM TOP OF PIPE	HEAD DIFFERENTIAL
0.50	30	6.60	233.511	11.111
1.00	60	6.04	234.071	10.551
1.50	90	5.55	234.561	10.061
2.00	120	5.00	235.111	9.511
2.50	150	4.60	235.511	9.111
3.00	180	4.08	236.031	8.591
3.50	210	3.52	236.591	8.031
4.00	240	3.20	236.911	7.711
4.50	270	2.80	237.311	7.311
5.00	300	2.70	237.411	7.211
5.50	330	2.25	237.861	6.761
6.00	360	1.98	238.131	6.491
6.50	390	1.72	238.391	6.231
7.00	420	1.45	238.661	5.961
7.50	450	1.23	238.881	5.741
8.00	480	1.06	239.051	5.571
8.50	510	0.81	239.301	5.321
9.00	540	0.75	239.361	5.261
9.50	570	0.58	239.531	5.091
10.00	600	0.45	239.661	4.961
10.50	630	0.30	239.811	4.811
11.00	660	0.18	239.931	4.691

FIELD CONDUCTIVITY TEST

Piezometer Location: MSA-BW1

Depth of Intake: 71.32 m

Hvorslev Equation $K = \frac{d^2 \cdot \ln \cdot (4 mL/D) \cdot \ln H_1/H_2}{8 \cdot L \cdot (t_2 - t_1)}$

Well Point - Filter at impervious boundary

Where:

d = diameter of the standpipe, cm
D = diameter of the intake, cm
L = length of intake, cm
H₁ = piezometric head for t = t₁, cm
H₂ = piezometric head for t = t₂, cm
t = time in seconds
m = transformation ratio

d = 12.7
D = 9.5
L = 1000
t₂ - t₁ = 1,020
H₁/H₂ = 1.4
m = 1

FIELD CONDUCTIVITY (CM/SEC) = 4.3 E - 05

Remarks: t₂ - t₁ and H₁/H₂ calculated from rising head test. Static levels based on July 22, 1991 reading.

UMA ENGINEERING LTD.
1479 Buffalo Place
Winnipeg, Manitoba
Canada, R3T 1L7

Date: September 5, 1991
Job No.: 6544 003 01
Project: Montcalm Site Evaluation
Location: Montcalm, Manitoba
Technician: KK/LB

MANITOBA HAZARDOUS WASTE MANAGEMENT CORPORATION

MONTCALM SITE EVALUATION

RISING HEAD TEST

PIEZOMETER No.: MSA-BW1
 TOP OF PIPE ELEV. 239.873
 STATIC WATER ELEV. 245.445

ELAPSED TIME MIN	ELAPSED TIME SEC	DEPTH FROM TOP OF PIPE	ELEV. FROM TOP OF PIPE	HEAD DIFFERENTIAL
0.50	30	7.98	231.893	13.552
1.00	60	7.80	232.073	13.372
1.50	90	7.68	232.193	13.252
2.00	120	7.55	232.323	13.122
2.50	150	7.40	232.473	12.972
3.00	180	7.32	232.553	12.892
3.50	210	7.18	232.693	12.752
4.00	240	7.03	232.843	12.602
4.50	270	6.84	233.033	12.412
5.00	300	6.78	233.093	12.352
5.50	330	6.70	233.173	12.272
6.00	360	6.60	233.273	12.172
6.50	390	6.50	233.373	12.072
7.00	420	6.37	233.503	11.942
7.50	450	6.18	233.693	11.752
8.00	480	6.11	233.763	11.682
8.50	510	5.99	233.883	11.562
9.00	540	5.88	233.993	11.452
9.50	570	5.78	234.093	11.352
10.00	600	5.65	234.223	11.222
10.50	630	5.60	234.273	11.172
11.00	660	5.47	234.403	11.042
11.50	690	5.36	234.513	10.932
12.00	720	5.28	234.593	10.852
12.50	750	5.15	234.723	10.722
13.00	780	5.02	234.853	10.592
13.50	810	4.93	234.943	10.502

14.00	840	4.81	235.063	10.382
14.50	870	4.72	235.153	10.292
15.00	900	4.66	235.213	10.232
15.50	930	4.54	235.333	10.112
16.00	960	4.44	235.433	10.012
16.50	990	4.35	235.523	9.922
17.00	1020	4.29	235.586	9.859
17.50	1050	4.18	235.693	9.752
18.00	1080	4.05	235.823	9.622
18.50	1110	3.98	235.893	9.552
19.00	1140	3.91	235.963	9.482
19.50	1170	3.79	236.083	9.362
20.00	1200	3.70	236.173	9.272
21.00	1260	3.52	236.353	9.092
22.00	1320	3.32	236.553	8.892
23.00	1380	3.16	236.713	8.732
24.00	1440	3.03	236.843	8.602
25.00	1500	2.82	237.053	8.392
26.00	1560	2.70	237.173	8.272
27.00	1620	2.48	237.393	8.052
28.00	1680	2.35	237.523	7.922
29.00	1740	2.19	237.683	7.762
30.00	1800	2.02	237.853	7.592
31.00	1860	1.90	237.973	7.472
32.00	1920	1.76	238.113	7.332
33.00	1980	1.59	238.283	7.162
34.00	2040	1.43	238.443	7.002
35.00	2100	1.30	238.573	6.872
36.00	2160	1.14	238.733	6.712
37.00	2220	1.01	238.863	6.582
38.00	2280	0.90	238.973	6.472
39.00	2340	0.80	239.073	6.372
40.00	2400	0.61	239.263	6.182
41.00	2460	0.48	239.393	6.052
42.00	2520	0.35	239.523	5.922
43.00	2580	0.22	239.653	5.792



Yazon, Edwin (CC)

From: Yazon, Edwin (CC)
Sent: June 16, 2022 3:19 PM
To: Yazon, Edwin (CC)
Subject: FW: File 3440.20 - MEC - Leachate Crop Irrigation Pilot Project

Edwin Yazon, P. Eng.

Environmental Engineer, Environmental Approvals
Environment, Climate and Parks
Edwin.Yazon@gov.mb.ca / Cel: 431-335-2554
1007 Century St., Winnipeg, MB R3H 0W4

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24/7 Environmental Emergency Response Line (204) 944-4888
Toll Free in Manitoba 1-855-944-4888

From: Dave Howes <daveh@millerenvironmental.mb.ca>
Sent: June 16, 2022 2:53 PM
To: Yazon, Edwin (CC) <Edwin.Yazon@gov.mb.ca>
Subject: RE: File 3440.20 - MEC - Leachate Crop Irrigation Pilot Project

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ATTENTION: ce courriel provient d'un expéditeur externe. Ne cliquez sur aucun lien et n'ouvrez pas de pièce jointe, excepté si vous connaissez l'expéditeur.

Hi Edwin,

The answers to your questions are below in [blue](#). If you need anything else, please let me know. Thanks.

Dave

From: Yazon, Edwin (CC) <Edwin.Yazon@gov.mb.ca>
Sent: June 16, 2022 10:40 AM
To: Dave Howes <daveh@millerenvironmental.mb.ca>
Subject: File 3440.20 - MEC - Leachate Crop Irrigation Pilot Project

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Good morning Dave,

I am currently reviewing MEC's leachate crop irrigation pilot project submission.

I have some questions about the pilot project:

- What is the plan about filtered solid in the pre-treatment tank? Where is it going?
Filtered solids will be treated in our stabilization process. This will be part of our proposed closed loop system.
- The report did not indicate the location of the drainage collection point. Page 9 of the report indicates "groundwater will be measured at the drainage collection point. Well monitoring will be used to measure groundwater and ensure containment is effective. Please provide additional information.
The term "drainage collection point" is a left-over idea from an older iteration of the design and should have been removed. There is no drainage collection point on the current design and there is no plan to release drainage or groundwater from the containment area. If there is standing water, it will be sampled and tested and managed internally. Groundwater will continue to be monitored through existing monitoring wells and managed through licenced monitoring requirements.

Sincerely,

Edwin Yazon, P. Eng.

Environmental Engineer, Environmental Approvals

Environment, Climate and Parks

Edwin.Yazon@gov.mb.ca / Cel: 431-335-2554

1007 Century St., Winnipeg, MB R3H 0W4

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