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Pedotechnique and its application to soil survey: a proposal



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Pedotechnique and its application to soil survey: a proposal

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LRRRI Contribution no. 82-12

Research Branch
Agriculture Canada
1982

Copies of this publication are available from:
Land Resource Research Institute
Research Branch, Agriculture Canada
Ottawa, Ont.
K1A 0C6

Produced by Research Program Service

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ABSTRACT

This publication concerns "engineering" interpretations of pedological soil surveys in Canada. A proposal was made in response to a request by the Expert Committee on Soil Survey (ECSS) to set up national systems for soil survey methodology. A methodology termed the pedotechnical system for soil survey interpretations was proposed and subsequently tested by pedologists in three provinces in Canada during the 1980-81 soil survey field season. This publication is a record of that proposal.

RESUME

La présente publication traite des interprétations "techniques" des prospections pédologiques au Canada. En réponse à une demande du Comité d'experts sur la prospection pédologique, on a fait une proposition en vue d'établir des systèmes nationaux sur la méthodologie de la prospection. Une méthodologie appelée "système pédotechnique d'interprétation des données pédologiques" a été proposée et subséquemment testée par des pédologues dans trois provinces canadiennes au cours de la saison de prospection de 1980-1981. La présente est un compte rendu de cette proposition.

INTRODUCTION

Application of pedological soil surveys for agricultural purposes has generally been known and well understood. In contrast, their use for engineering purposes is not so widely appreciated, although the first mention of their use for such purposes in Canada goes back quite a long way. Harcourt (1923) referred to the use of soil surveys by highway and construction engineers. Further reference to engineering construction was made by Joel (1933) in discussing soil surveys in western Canada. From the Highway Engineering point of view, Rutka (1961) discussed the use of soil surveys for road construction in relation to pavement behaviour. During this period, use was being made of the survey information by other engineers, but little attempt seems to have been made to accommodate to the needs of these potential users, except informally by giving verbal advice on request.

It was not until 1968 that the Canada Soil Survey Committee included engineering interpretations as a topic on the agenda of its meeting (Pawluk, 1968). Further reports were prepared (Pawluk 1970) and a start was also made to include "engineering chapters" with soil survey reports. In certain cases engineers and geologists were invited to write these engineering chapters, (White, 1971; Wilson, 1973).

Considerable progress on engineering interpretations has been made in the USA (USDA 1971, McCormack 1977). The "Guide for Interpreting Engineering Uses of Soils", provides a comprehensive system showing how Soil Survey information can be used for a great variety of uses which are classified under the general heading of engineering. In 1973, the Canada Soil Survey Committee adopted the USDA system for interpreting the engineering uses of soils (Acton 1973).

In 1973, a geotechnical engineer - engineering geologist was employed by the Soil Research Institute of Agriculture Canada to improve existing engineering interpretation systems. It was the first time an engineer had been employed specifically for this purpose. Difficulties were found in properly comprehending pedological mapping and interpretation systems. National standards did not exist. A draft document (Mapping Systems Working Group, 1979) was published. A revised National System of Soil Classification was published in 1978 (CSSC 1978), but national systems for soil survey interpretations were needed. Various proposals were made by the author towards a national system for engineering interpretations resulting in the pedotechnical system.

The central problem for the Canadian scene was identified as the lack of a standardized system which could assure a degree of quality control over interpretations. The root of the problem was also identified as interdisciplinary. Canadian pedologists are normally responsible for engineering interpretations. But the disciplines of pedology and engineering are generally never linked either in formal training or in subsequent practice. The pedotechnical system was proposed to close a communication gap. Geotechnique is well established as the link between Geology and Engineering. Pedotechnique was proposed as the equivalent in pedological terms.

The "Proposed Pedotechnical Interpretation System for Soil Surveys in Canada" was first produced as a draft publication with limited circulation in 1979. This was reviewed by selected National Soil Survey units, Pedological Institutes and Engineering Groups. As a result of this first external review process, the ECSS decided on a full scale field testing programme for 1980-81. To provide a basis for this test two other draft documents were compiled: "The Pedotechnical Interpretation System for Soil Survey in Canada" and an example of the application of this to a completed soil survey "Guide to the use of the Nepean-Gloucester Soil Survey Map, Pedotechnical Aspects". The results of this field testing in three provinces in Canada was given at the March 1981 ECSS meeting. They indicated neither complete acceptance of the proposal; nor complete rejection. The following work is a record of the initial proposal.

MATERIALS AND METHODS

Only the mapping units from an existing modern soil survey are used to demonstrate the system (Marshall et al., 1979). The particular mapping units chosen from this survey are units within the Castor Soil Association. Only the pedological information given in that report is used. In certain special cases (for demonstration purposes) the data may not completely relate to the Castor Soils; these cases are indicated.

The method proposed is to identify first of all, two types of interpretations. The first is the interpretation of the landscape. Modern soil surveys use more complex mapping units than formerly. For better communication there is a need to express these mapping units in different terms, for different purposes. The method proposed is to separate that information relevant to engineering or to engineering interpretations and illustrate this on a single sheet termed the Pedotechnical

LAYOUT OF PEDOTECHNICAL SETTING

Association..... 1.	2.	3.
4.		
①	②	③
	④	⑤
		⑥
		⑦
		⑧
5.		⑨

Modules 1,2,3..... define the Mapping Unit concepts

" 4 ①to⑨..... define the pedotechnical characteristics
of central theme of typical Subunit

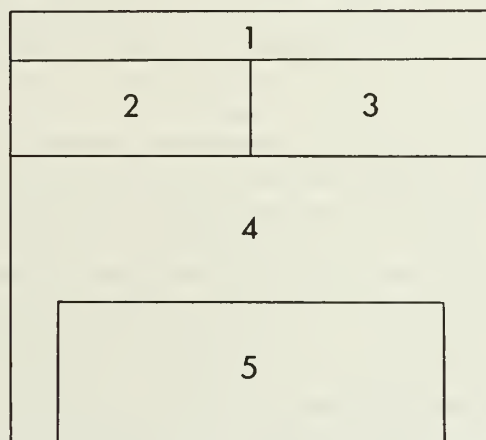
" 5..... Warning against misuse of information

- | | | |
|--------------|---|--|
| Module No. 1 | - | Cross sectional sketch (as used in General Legend) |
| " 2 | - | Basic concept of typical subunit together with characteristics which vary with the seasons (Jan-Dec) |
| " 3 | - | Basic concepts of main subunits, plus phases |
| " 4① | - | Index properties (plasticity, etc.) |
| " ② | - | Moisture regime (moisture availability, infiltration) |
| " ③ | - | Stability – Strength (trafficability, pen. resist., etc) |
| " ④&⑤ | - | Soil chemistry & Mineralogy |
| " ⑥ | - | Grain size distribution |
| " ⑦ | - | Textural relationships |
| " ⑧ | - | Compaction characteristics |
| " ⑨ | - | Erosional & corrosional characteristics |

Depth below ground surface is shown in metres;

Figure 1 Layout of Pedotechnical Setting Sheet

LAYOUT OF INTERPRETATION SHEET



- Module 1 – Title and Reference No.
- ” 2 & 3 – Further breakdown of Problem according to factors considered.
- ” 4 – Working part of interpretation giving limiting factors in same format as data in Pedotechnical settings.
- ” 5 – The 'Interpretation Table', to obtain the Interpretation symbol by matching factors and data given in 4.

Setting Sheet. This sheet consists of several separate modules (Fig. 1). These permit attention to be focussed on perhaps only the one or two aspects of the landscape in which the user may be interested at any particular instance. The pedotechnical setting sheets give interpretations of mapping concepts; they are not to replace tables of data used to define modal sites.

The second type of interpretation is for the particular use to which the soil survey may relate. For planning and similar purposes it is present practice to provide "engineering" interpretations for people who may not be interested in the soil survey map itself, but what the map means in terms of possible restrictions or limitations for land use purposes. Because the method by which engineers would approach such land use problems is quite different from interpretation of soil surveys by pedologists, the term pedotechnical interpretation is preferred for this phase of the work. The method of compiling pedotechnical interpretations is to design an interpretation sheet which is compatible with the setting sheet (Fig. 2). Only the two documents need be used to make interpretations. It is believed that a better degree of quality control over the interpretations may be maintained and acceptance of the survey's findings better appreciated. All the information from which the interpretations have been derived is readily available for discussion if necessary. With practice, it should be possible to make interpretations by visual comparison between setting sheets and interpretation sheets.

The final stage, the Pedotechnical Report is to put all of this information together and present this to the interested user. The main consideration is to cater to the needs of a number of entirely different types of user. The information is often required before the soil survey has been completed although the major requirement is to produce the standard type of Soil Survey Report. With the computerizing of the cartographic process there is also now a requirement to make use of the CanSIS capabilities in the form of data storage and derived map production.

These requirements indicate a preference toward a report which can be produced at any stage during the survey, while at the same time having a format which can be incorporated, with minimum alterations, into the standard Soil Survey Report.

RESULTS

THE PEDOTECHNICAL SETTING SHEET

The general layout of the Pedotechnical Setting Sheet is given in Fig. 1. The separate modules as they have now

been compiled to define relevant aspects of the Castor Soil Association (as a mapping concept) are presented.

Module 1 Soil Associations

This module (Fig. 3) is a space allocated for a very simple sketch of the geological criteria including materials, thickness limits of the Soil Associations and its related Associations. The information shown in cross section format may not be exactly what the pedologist has in mind as a total concept. However, it is all that is necessary for quick reference pedotechnical purposes.

Basically the sketch indicates that the soil with the symbol C on the map is also related to the P, U, J, M and I soils - i.e. they include Silts and Sands overlying Marine clay (except the I Soil which overlies Grenville Till). The C and P soils are sandy silt overlying marine clays. The difference between C and P is the depth to the marine clay. If greater than 1 meter, the symbol P is used instead of C. If the overlying material is a silty sand instead of sandy silt the terms M and J are used. If the material is even coarser Sand, and it is over 1 meter deep the symbol U is given. Normally the P-J soils are between 1 and 2 metres deep over marine clay whereas the U soils are generally between 2 and 5 meters deep.

Module 2 Typical Mapping Unit

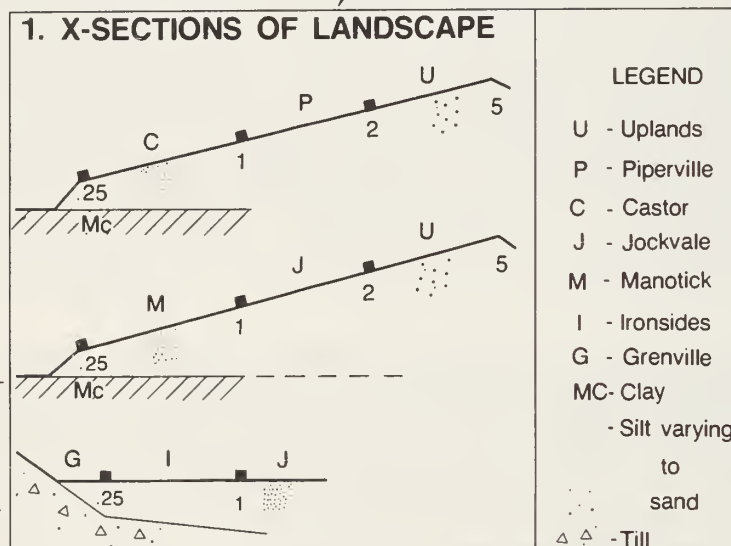
Module 2 represents the most typical mapping unit of the soil association (Fig. 4) and in the example given this is the unit C3. The C3 mapping unit consists of 75% gB (gleyed Brunisol) "dominant" soils on gentle slopes with imperfect (I) internal drainage and 25% G (Gleysol) "significant" soils in depressional areas with poor (P) internal drainage. All of this is indicated on the module by the ground surface line showing a gentle (simple) slope with a depressional area. The ground surface line is divided proportionally (in the example 25% is shown to be depressional). The soil development and internal drainage are shown by the symbols gB/I and G/P.

The profile module on the left side permits the pedological horizons to be indicated - the vertical scale is in meters. The central part of the module provides information on the water content and moisture regime. In the example, only the ground water table (for one point at a depth of 1 m) is shown. The ordinate scales are given on the right side of the module and the abscissa scale is given at the bottom. The abscissa is an annual time scale from J (January) to D (December). The water

PEDOTECHNICAL SETTING CASTOR (C) ASSOCIATION:

MODULE 1:

The setting of the Castor association C,
among its group of related soils:
(i.e. Silt & Sand over marine clay (&till):



Names of
related soils

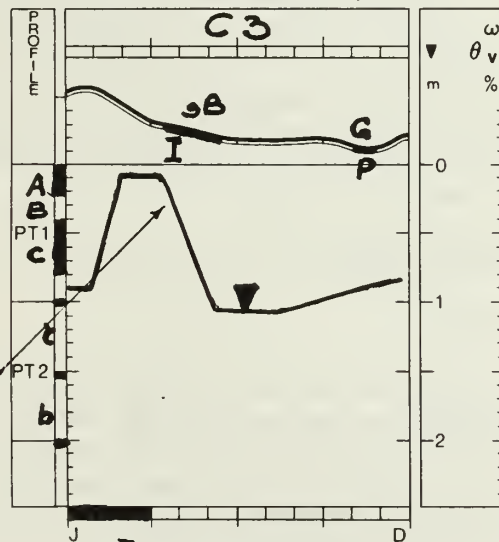
Three sectional diagrams showing
basic criteria of material type and
sequence, the thickness separations
in metres (e.g. .25 as above = 25 cms)
and the most general position on the
landscape:

MODULE 2

The C3 subunit is Dominant Series
(It is a complex 75% gB, 25% G)

Dominant Soil
is gleyed Brunisol,
gentle slopes
(simple), and
imperfect I
internal drainage

2. TYPICAL MAPPING UNIT



Significant Soil
is Gleysol, in
depressional areas
with poor P,
internal drainage
(usually 25%
of subunit area)

No information on
soil moisture θ
is available today

Imperfect I drainage in these soils
means, with reference point at 1 m. the
piezometric level ∇ varies as shown
from .9 m in January to .5 m in May
and is below 1 m in June.

25% of Total
Map area is
Castor (C) soil:

Figure 4 Typical Map Unit Module (No. 2)

table module indicates (for C3 soils), that the water table is likely to be at ground surface in the spring and below 1 meter in mid summer. The lowest level is not indicated because none of the observation points was extended below a depth of 1 meter. The abscissa scale can also be used for other purposes. For instance it could indicate the relative areas of the total map area occupied by the various soils. The example indicates that the C (Castor) soils occupy 25% of the total map area (the actual values and soil horizons shown are not necessarily accurate but are used here, only for demonstration).

The significance of the PT layers (PT1, PT2 etc.) will be given in the Discussion.

Characteristics of a Typical Unit

The remaining modules of the pedotechnical setting document are to complete the description of the mapping units - or as much of it as required for the kind of interpretation desired. Characteristics of a typical map unit include basic index properties in addition to those relative to water regime, stability and strength, chemistry, mineralogy, grain size, texture and compaction. The information is given by simply placing a dot or dash in the appropriate position. Legends to these modules are given in Figures 5 to 11 which follow. Note the same legend is used for all symbols on each module and the scale is the same for all index values. The data shown in the examples given is for illustrative purposes only and not specific to the C3 map unit.

The completed setting sheet is illustrated on Fig. 12.

Module 5 Disclaimer

The graphical plots, interrelationships and quantitative values shown are intended for descriptive and interpretation purposes. They are not intended for the design of any specific structure in any specific site within delineations. Anyone claiming to be able to use it for design or similar purposes should be clearly warned that such claims cannot be considered.

The disclaimer included with the document comprises module no. 5. It refers to all of the information given. None of it is intended to replace the type of information given in an engineering report describing a specific site in a map unit. The information given is to show the general properties pertaining to all geographic areas with the same map unit symbology -- not to any single delineation.

Module 4①

Depth (metres)

Depth of A,B,C
Horizons given
in Module 2.

2nd metre top
& bottom half:

3rd metre;
(No information
from this survey)

Same scale for
all index values

Legend for all
symbols used above:

LS - Linear shrinkage	W - Natural Water Content
SL - Shrinkage limit	η - Porosity
PL - Plastic limit	LL - Liquid limit
FME - Field moisture Equivalent	FS - Free Swell
	SE - Sand Equivalent

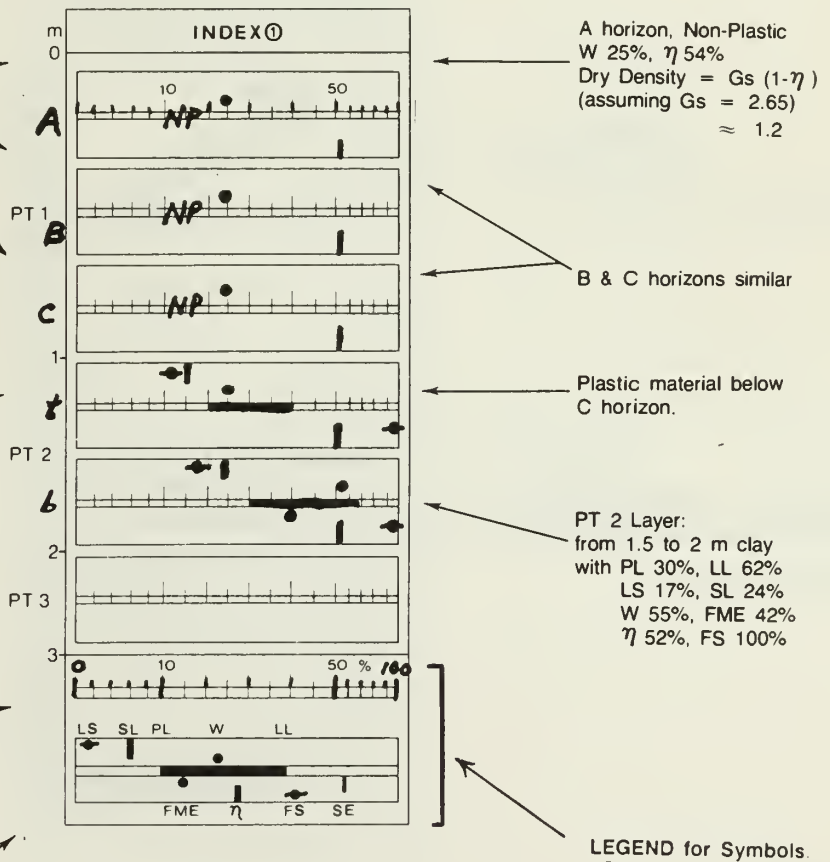
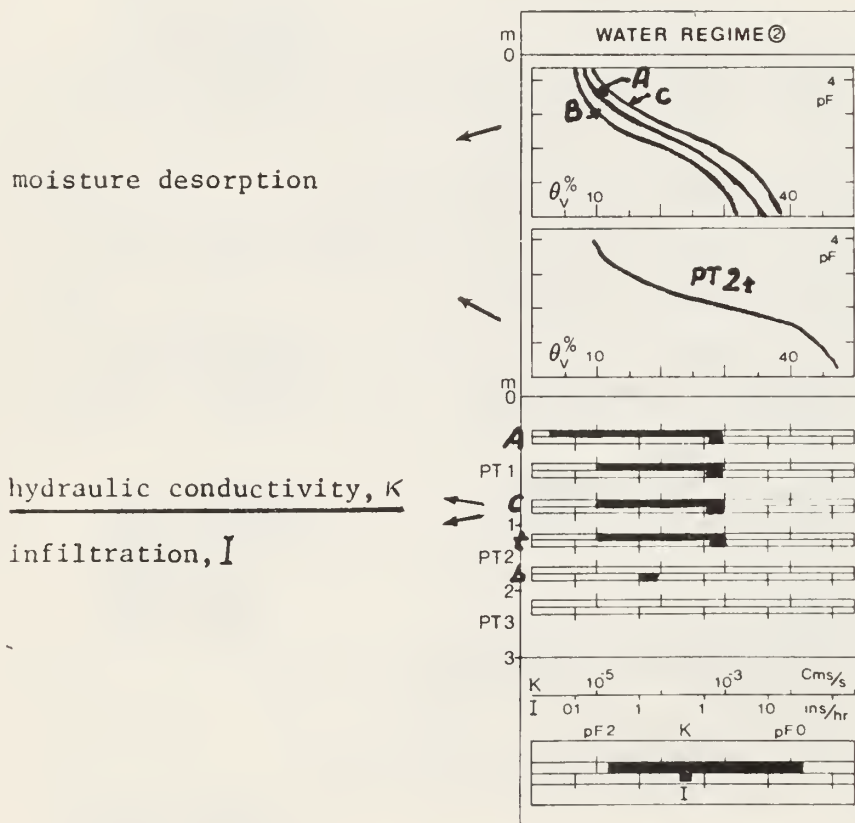


Figure 5 Index Module (No. 4 (1))

MODULE 4 ②



example:

A horizon:

$$\theta_v\% = 36 \text{ (pF0)}$$

$$= 7 \text{ (pF0.4.5)}$$

$$K \text{ cm/s} = 1 \times 10^{-3} \text{ (pF0)}$$

$$= 2 \times 10^{-6} \text{ (pF2)}$$

$$I \text{ ins/hr} = 2 \text{ (pF0)}$$

NB

$$\theta_v = \omega \times \gamma_d$$

(weight % x
dry bulk density)

$$pF2 = 1/10 \text{ bar}$$

$$pF3 = 1000 \text{ cm water}$$

Figure 6 Water Regime Module (No. 4(2))

MODULE 4 ④ & ⑤:

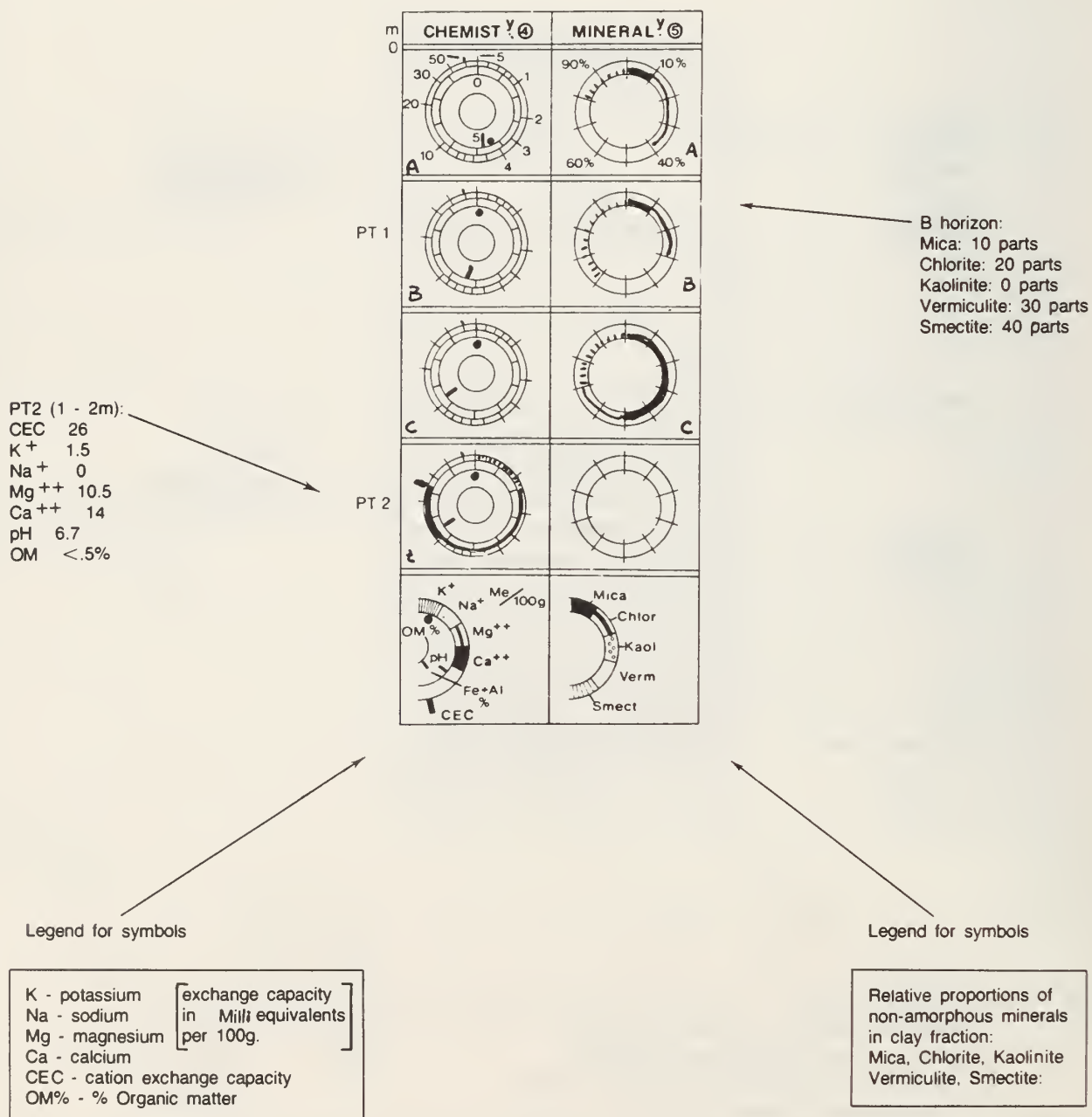
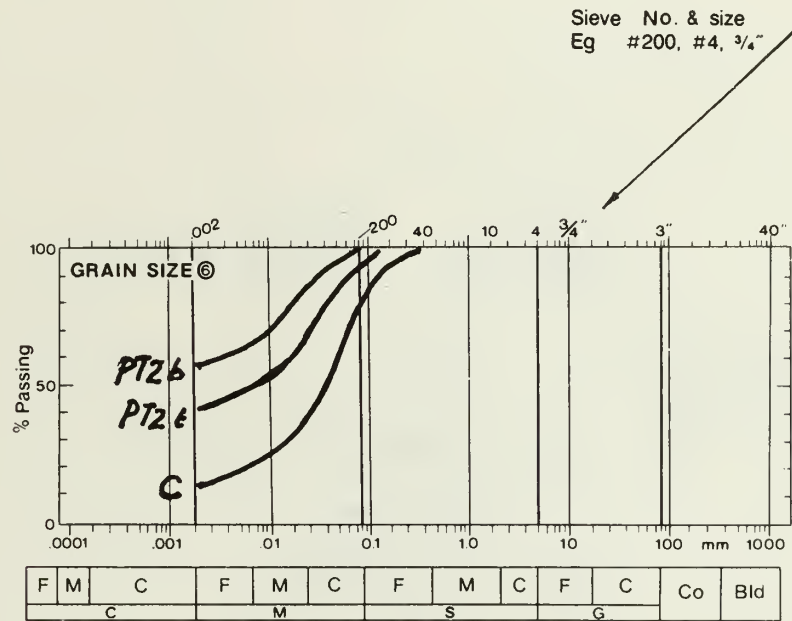


Figure 8 Soil Chemistry and Mineralogy (No. 4(4) & (5))

MODULE 4 ⑥:



Textural Size ranges:

C - <u>Clay</u>	M - <u>silt</u>
F - fine	F - fine
M - medium	M - medium
C - coarse	C - coarse
S - <u>Sand</u>	G - <u>Gravel</u>
F - fine	F - fine
M - medium	
C - coarse	C - coarse
Co - Cobbles	Bld - Boulders

Figure 9

Grain Size Distribution (No. 4(6))

MODULE 4 ⑦:

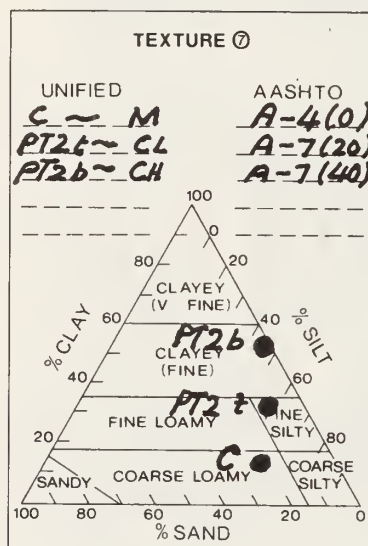


Figure 10

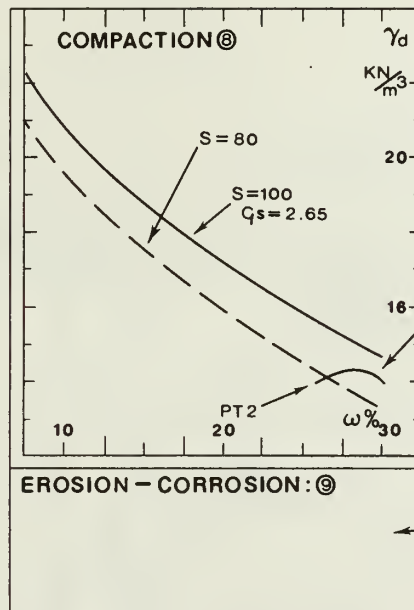
Textural Relationships (No. 4 (7))

MODULE 4 ⑧ & ⑨:

	η		
q_s	2.5	2.65	2.8
	.12	.17	.21
	.20	.25	.29
	.28	.32	.36
	.36	.40	.43
	.44	.47	.50
	.52	.55	.57

$$\gamma_d = \frac{\gamma}{1 + \omega} = \frac{\gamma_w \cdot q_s}{1 + \omega \cdot q_s}$$

$$\eta = 1 - \frac{\gamma_d}{q_s}$$



PT2 (1-2m):
Opt. moist. content 28.
Max. dry density 14.5.
assuming $q_s = 2.65$, the
saturation % = 90 and
porosity % = 45.

No information from
this soil survey

LEGEND for Symbols:

γ_d - dry density KN/m³
 ω - moisture content %
 S100 - 100% Saturation curve for $q_s = 2.65$
 S80 - 80% Saturation curve for $q_s = 2.65$
 η - porosity for equivalent dry density
 for q_s from 2.5 to 2.8

Figure 11 Compaction, Erosion and Corrosion (No. 4 (8) & (9))

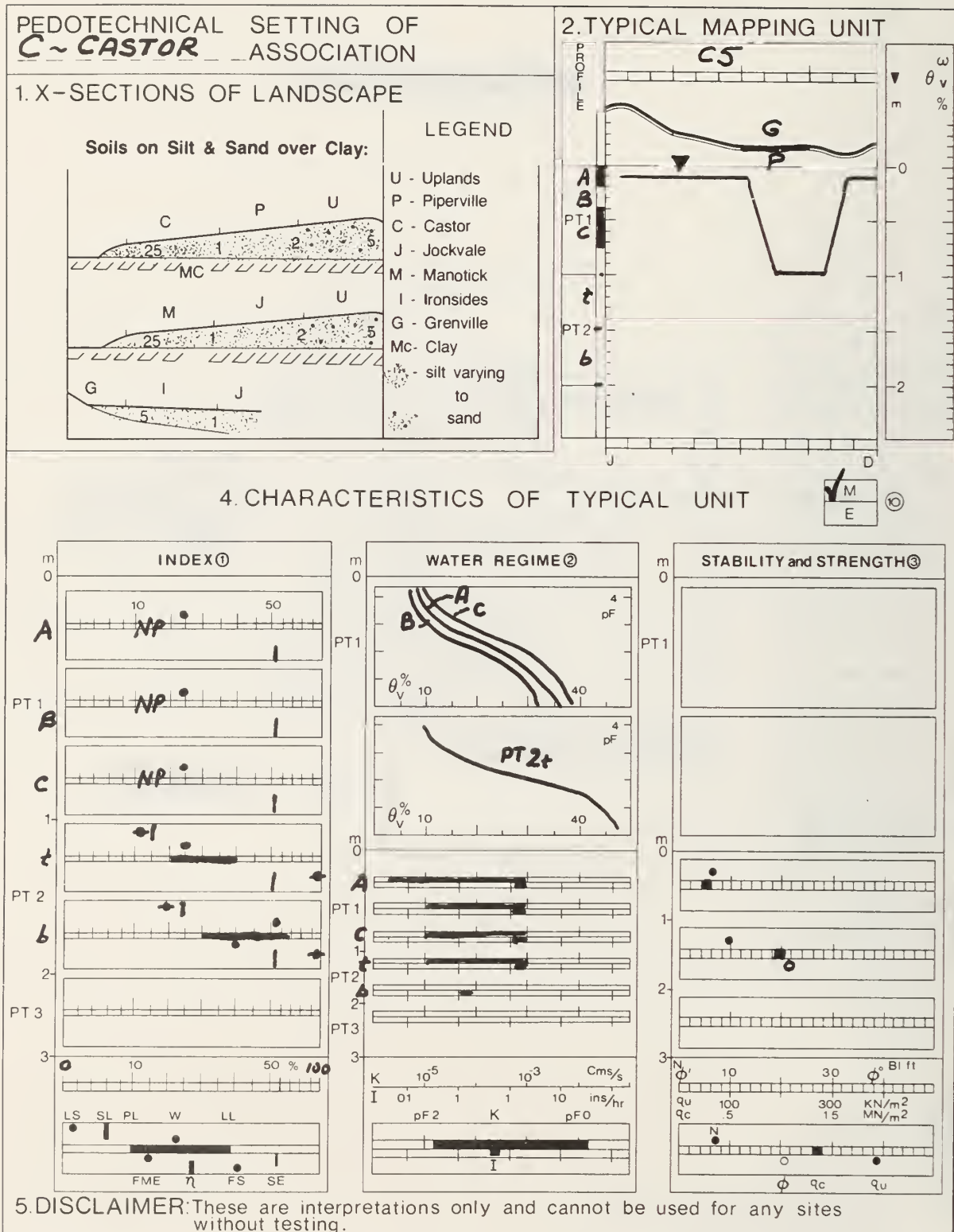


Figure 12 The Pedotechnical Setting Sheet

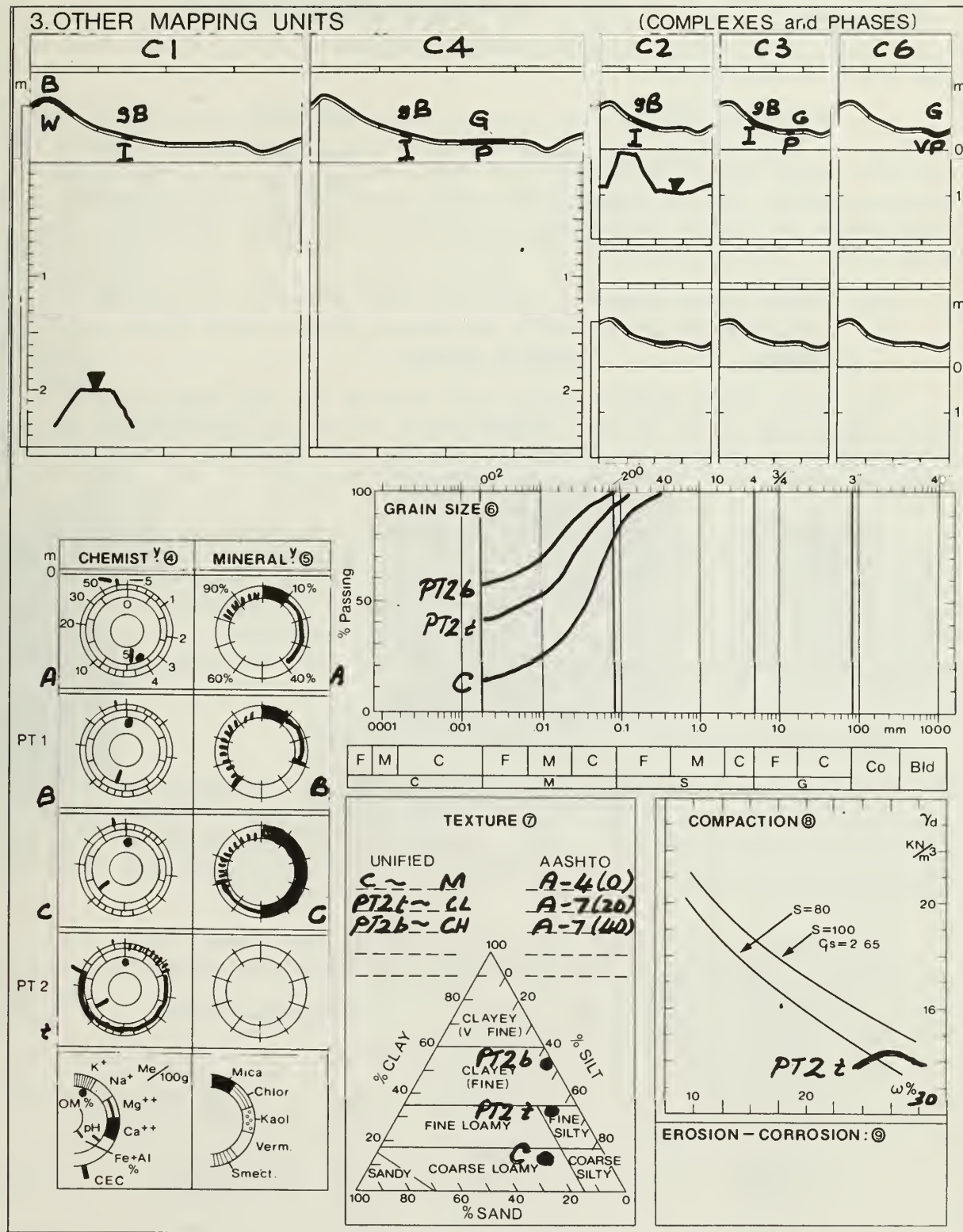


Figure 12 The Pedotechnical Setting Sheet

The properties given are generally those characteristic of the soil component which is dominant within a given map unit. The position which it occupies on the landscape is shown by the longest ground line in Fig. 4, which refers to the dominant soil i.e. that soil which characterizes anywhere from 50 to 85% of the area delineated.

Due to the size of the survey area and the relatively large number of map units, it is generally not possible to sample and analyze each soil component or replicates of each component. Consequently, it is important to document the relevance and precision of index properties for the soil component in question. Two classes of data relevance have been established:

- 1) data from samples and testing at Modal sites (M)
- 2) estimated data where no modal sites have been sampled (E).

The data from Modal sites (M) refers to any one sample or test from any part of any modal site which is considered by the pedologist as being representative of the central theme of the mapping unit.

For the engineer, it should also be pointed out that a "variability factor" is already built into every mapping unit under the title of "inclusions". Even in the most uniform, homogeneous area there is permitted up to 15 percent of different soils without having to describe them. This further demonstrates that the information given for mapping units does not apply to any particular site.

THE PEDOTECHNICAL INTERPRETATION SHEET

The general layout of the Pedotechnical Interpretation Sheet as designed is given on Fig. 2. The individual interpretation sheets as they have now been compiled for "engineering" interpretations of the Castor and related soil associations from the Ontario Soil Survey Report No. 47 are presented.

The "Resource Materials" Interpretation Sheet (Fig. 13)

Three separate interpretations for Resource Materials can be made from this sheet

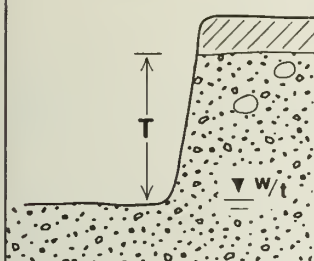
1. Gravel (and sand)
2. Road Fill
3. Rock Fill.

INTERPRETATION

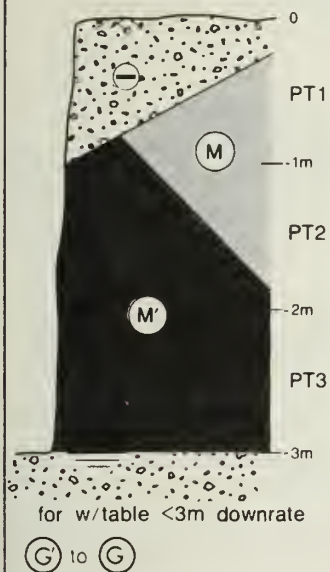
RESOURCE MATERIALS

LAND AS A POTENTIAL

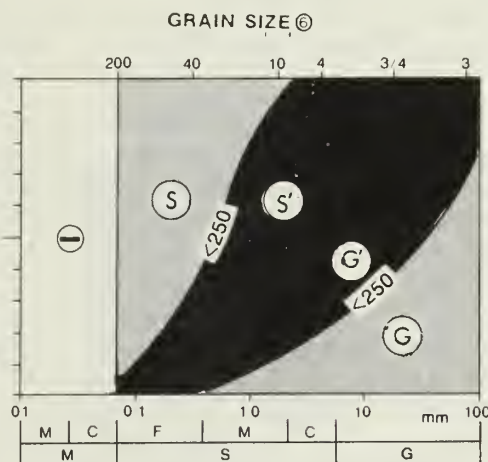
RESOURCE,

FACTORS	TYPE OF MATERIALS
 <p>Thickness W/ Table Texture Stones</p>	<p>Gravel (or sand) ————— G (S) Road Fill ————— F Rock Fill ————— R</p>

THICKNESS
and w/ table

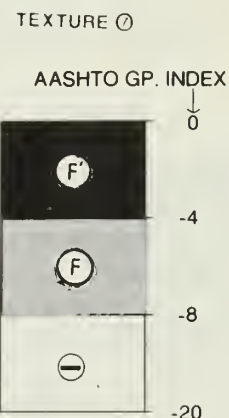


GRAVEL (or sand)



For Stones (>100 mm) 10% to 50% downrate
G' to G
(*DHO. Gran. "C" Petrog. No <250)

ROAD FILL



RESOURCE CLASS	GRAVEL (and sand)	ROAD FILL	ROCK FILL
UNLIKELY	Thickness or Texture —	Thickness or AASHTO —	Rock below PT2 —
POSSIBLE	Thickness (M) Texture (G) or (G')	Thickness (M) AASHTO (F) or (F')	Rock in PT2 (limestone, L) (sstone, S)
PROBABLE	Thickness (M') Texture (G')	Thickness (M') AASHTO (F')	Rock in PT1 (Granite, g) (Shale, h)

Figure 13

Interpretation (Resource Materials)

The "Gravel (or sand) module" consists of a "textural diagram" giving the limits for "granular c" material based on the Ontario Department of Transportation specifications. It has been plotted on the same grain size distribution sheet as that used on the Pedotechnical Setting Sheets. Consequently, an interpretation can be made by transferring the appropriate curve from the Setting document. With practice this can be done at a glance by visually matching significant points.

The principle involved in the use of textural diagrams is that any grain size distribution curve which fits entirely within the dark shaded area (or envelope) can be given the interpretation symbol S' or G' -- a probable resource of either Gravel (G) or Sand (S). The dashed line differentiates sand and gravel.

Less favourable material (poorly graded materials which have a lower uniformity coefficient) is indicated by the lighter shaded area. 'Possible' sources of Sand and Gravel are thereby indicated if the grain size curves fit into both the dark shaded and light shaded areas.

If there is also some petrographic information available from the soil survey, this could be useful for refining the interpretation with regard to the quality of the gravel/sand materials. A petrographic number of 250 is considered to be the maximum for 'granular c' material.

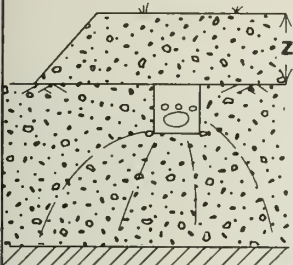
If the grain size curve enters the "-" region (see left side of Gravel Module), the Resource Material can be considered to be in the 'unlikely' category and the interpretation class symbol "-" given (see Table at bottom of sheet). However, if the grain size curve fits into the "G" region it cannot be given a G class symbol unless the thickness and water table module is also considered. Thus if there is less than 1 metre of material it can be considered only in the "unlikely" class. If the water table (during the construction or operating season) is less than 3 meters in depth, the highest class is G (a "possible" source).

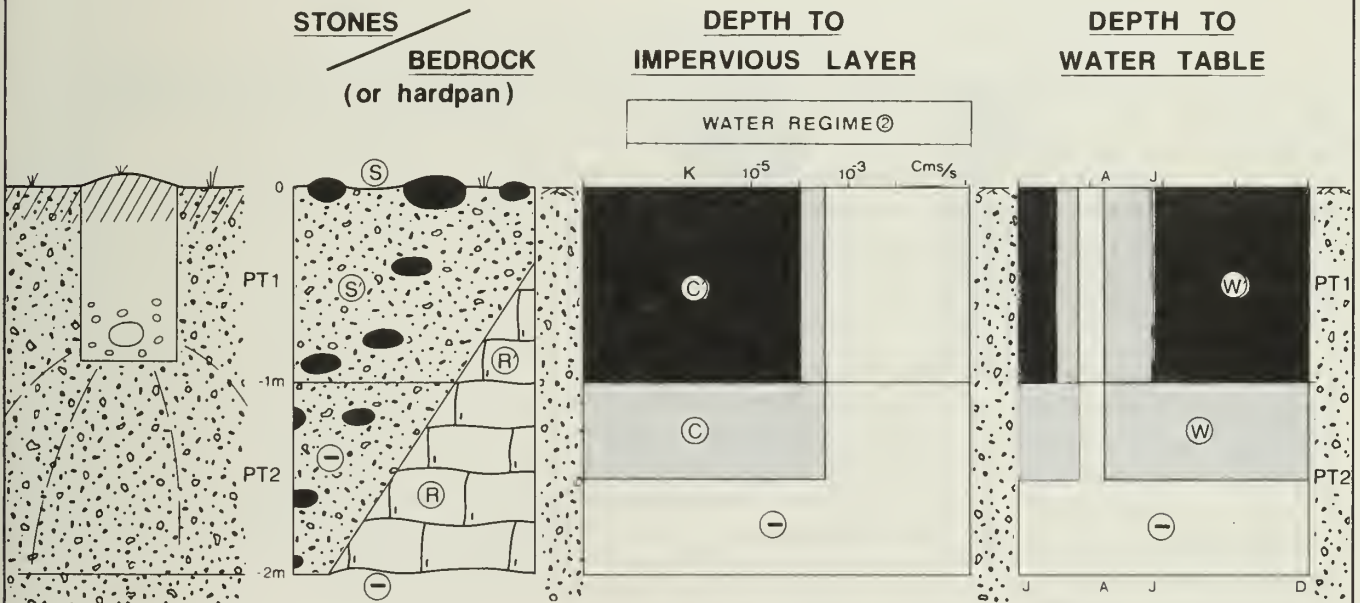
Interpretations for Road Fill is considered according to the second column in the interpretation table. For this interpretation the Aashto Group Index Number has been used (see right hand module). This Group Index can be determined from a combination of data from the grain size distribution module and the Index Module. Values less than 4 are interpreted as a prime source of fill (F') but interpretation ratings can be

INTERPRETATION

SEPTIC TANKS

SOIL PROBLEMS DUE TO
DEPTH OF SOIL FILTER, D

PROBLEM	FACTORS CONSIDERED
 <p>Extra Filter (z) Required</p>	<p>Depth to Bedrock (and hardpan) ———— Dr</p> <p>Presence of Stones ———— Ds</p> <p>Depth to Impervious Layer ———— Dc</p> <p>Depth to Water Table ———— Dw</p>



INTERPRETATION

PROBLEM CLASS	STONES in PT1 layer		BEDROCK AND HARDPAN		IMPERVIOUS LAYER		WATER TABLE	
UNLIKELY	below PT1	—	below PT2 —	—	zone —	—	within zone —	—
POSSIBLE	at surface only (S)	Ds	in PT2 only (R)	Dr	zone (C)	Dc	within zone (W)	Dw
PROBABLE	in PT1 (S')	D's	in PT1 (R')	D'r	within zone (C')	D'c	within zone (W')	D'w

Figure 14

Interpretation (Septic Tanks) (Sheet D)

reduced to the "-" (unlikely) class if there is inadequate thickness as previously described. Downrating into the F class can also result due to thickness, shallow water table or if the grain size curve exhibits more than 10% of stones (100 mm).

The "Rock Fill" column completes the interpretive Table. If bedrock occurs only in the PT 3 layers, the symbol "-" indicates an unlikely source, whereas if bedrock occurs in the PT 1 layer, it is considered as a probable source (R'). The quality of the rock is normally indicated in pedological survey and this information could be useful for further designating the type of rock fill (eg. granite, g; shale h; limestone, l; and sandstone, s). For poorly drained units where the water table during the summer period is less than 3 metres below ground surface the "Probable" rating could be downrated to only a "Possible" rating for consideration concerning possible environmental impact restrictions.

The "Septic Tank" Interpretation Sheets (Figs. 14, 15, 16)

For this interpretation, Septic Tanks have been considered as a soil pollution problem and in order to provide for possible mitigation measures it is considered in three parts:

- i inadequate depth of soil filter (D)
- ii inadequate attenuation of nutrients (N)
- iii unfavourable setting and slopes (S)

SHEET (D) (Fig. 14)

Inadequate soil depth may be due to the presence of bedrock (or hardpan) (r); an impervious layer (c) and depth to the water table (w). Pollution Mitigation may be accomplished by adding fill to increase the effective depth of the soil filter. The criteria adopted are from the Environment Division of the Ontario Ministry of Environment. The Sketch (extreme left) shows the total thickness of soil required according to the Ministry's regulations. The first module (Stones/Bedrock) shows for example that if the bedrock surface is in the PT 1 layer (less than 1 metre) then the "Probable Class for pollution hazard" (D') is given in the interpretation table, whereas for bedrock in the PT 2 layer the "Possible" class (D), indicates that only nominal amounts of fill would be required to up-grade sites to an acceptable thickness.

The next module, "Depth to Impervious Layer", uses the Water Regime Module of the Setting Sheet. The "Possible" class is defined as soil with infiltration rates between 60 to 120 minutes per inch (7×10^{-4} to 3.5×10^{-4} cm/s) at depths between 1 and 1.5 metres.

INTERPRETATION

SEPTIC TANKS

SOIL PROBLEMS DUE TO
NUTRIENT ATTENUATION, N

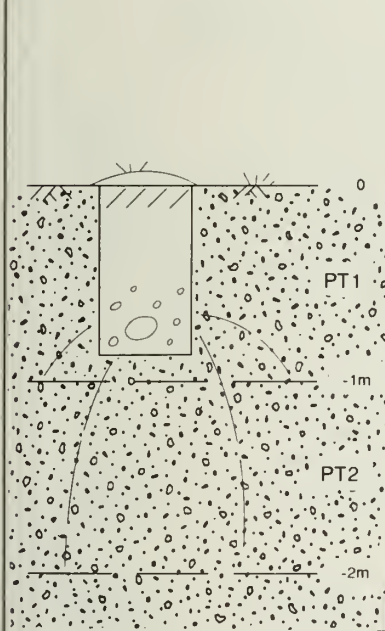
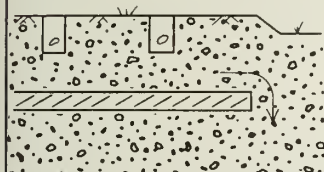
PROBLEM

Improving Soil as
a Biological Filter

IMPROVEMENTS REQUIRED FOR

Denitrification ————— Nn

Phosphorous Retention — Np



DENITRIFICATION

WATER REGIME

K 10^{-5} 10^{-3} Cm/s

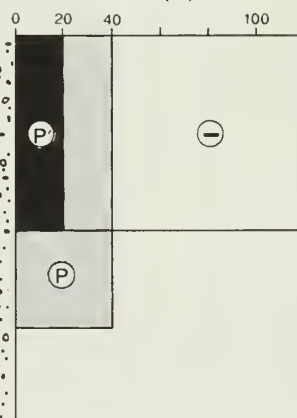


N.B. * for Well Structured Soils,
uprate $\text{N}' \rightarrow \text{N}$ and
 $\text{N} \rightarrow -$

PHOSPHOROUS RETENTION

INDEX

S.E. (%)



S.E. = Sand Equivalent
K = Hydraulic Conduct.

INTERPRETATION

PROBLEM CLASS	DENITRIFICATION (PT1 and PT2 Layers)		PHOSPHOROUS RETENTION (PT1 and PT2 Layers)	
UNLIKELY	zone $-$	$-$	zone $-$	$-$
POSSIBLE	zone N (*adjust for structure)	Nn	zone P	Np
PROBABLE	zone N' (*adjust for structure)	N'n	zone P'	N'p

Figure 15 Interpretation (Septic Tanks) (Sheet N)

In the next module, "Depth to Water Table", use is made of the water table module of the Setting sheet. It illustrates the relation between the depth to the water table and the time of the year. For many soils in Ontario, the water table is near the ground surface immediately after snow-melt. This in itself is not considered a limiting factor, the important period being the late spring and summer. Thus for soils which have persistently high water tables (less than 1 metre) a considerable amount of soil filter must be added to upgrade sites whereas only nominal amounts will be required for somewhat deeper water tables.

SHEET (N) (Fig. 15)

The problem here is seen as the passage of the nutrients Nitrogen and Phosphorus into ground and surface waters. The passage of nitrate nitrogen into ground waters being used for domestic drinking water supplies can result in conditions toxic especially for younger children. The passage of phosphorus into surface water bodies creates excessive plant growth. It is possible to mitigate these problems by improving the soil as a biological filter and the Ministry of Environment may call for such measures to be implemented. For example, it is possible to promote increased denitrification by ponding the effluent and assuring a minimum retention period under anaerobic conditions. The denitrification module again makes use of the water regime module of the Setting Sheet and identifies the Possible class (Nn) as soils with hydraulic conductivity values between 5×10^{-2} and 1×10^{-2} cm/s between depths of 1 to 1.5 metres. For certain clay soils, high permeability values may be due to well developed soil structure. These soils are not considered to be so prone to nutrient problems and hence may be uprated as indicated.

The "Phosphorus Retention" module is only an attempt to consider this problem which is generally admitted but official criteria have yet to be developed.

SHEET (S) (Fig. 16)

Under this heading have been grouped three rather different types of settings which could create pollution problems. The 'Inundation module' identifies two types of inundation. Inundation due to poor soil drainage (recognizeable from soil profiles in certain depressional areas) and inundation due to flood in river valleys (also recognizeable from soil profiles and predicted by other types of hydrological surveys).

INTERPRETATION

SEPTIC TANKS

SOIL PROBLEMS DUE TO SETTING AND SLOPE, S

Inundation



PROBLEM

danger of pollution
due to
unfavourable settings

SETTINGS CONSIDERED

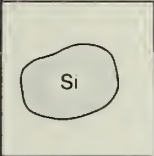
Inundation ————— Si
Hydrogeology ————— Sh
Unfavourable Slopes ————— Ss

INUNDATION

HYDROGEOLOGY

SLOPES

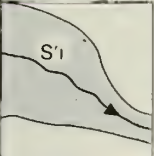
Soil Map



Overland Flow

Si { v.p. drained
or
peaty
or
organic soils

Geotech Setting



Floodplain

S'i { predicted
floodplain

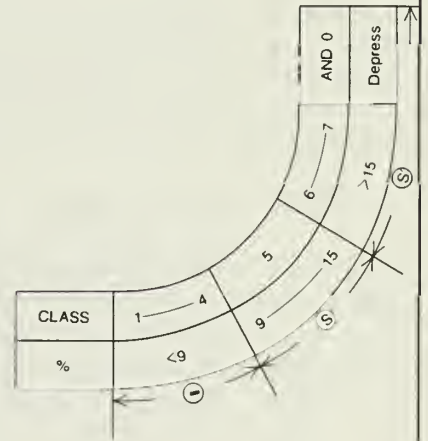
NB

1. This aspect is normally beyond the
scope and expertise of pedological
survey.

2. Where hydrogeological problems
appear evident, these may be indicated-
but only to emphasize the need for
consultation with hydrogeologists.

g.w. D-major ground water discharge
areas.

g.w. R-major ground water recharge
areas.



INTERPRETATION

PROBLEM CLASS	INUNDATION		HYDROGEOLOGICAL PROBLEMS		UNFAVOURABLE SLOPES	
UNLIKELY	well drained to poor	—	(unaware of any)	—	zone ⊖	—
POSSIBLE	Si as above	Si	g.w. D	Sh	zone ⊕	Ss
PROBABLE	S'i as above	S'i	g.w. R	S'h	zone ⊕	S's

Figure 16

Interpretation (Septic Tanks) (Sheet S)

The "Hydro-geology" module is added here as a reminder that this is also an important aspect when considering septic tanks. It is not normally part of soil survey but requires careful consideration by those dealing with this subject. The "Slopes" module recognizes the limits established by the Ministry of Environment. Thus for slopes between 9 and 15 percent there are regulations concerning modifications to the layout of tile beds. Tile beds are not normally permitted on slopes greater than 15%. This is a severe restriction because it is difficult to alter such slopes and alternative disposal systems are normally required.

The Septic Tank Interpretation symbol

The symbol is given alphabetically so that each problem category is recognizable. Thus the total symbol might be:

$$\frac{Dw' Nn}{Sis'}$$

and this could have been derived from a pedotechnical setting document showing: -

Depth to water table (spring-summer) 1 metre, very pervious soil which is clayey but well structured;
Poor surface drainage in depressional topography with peaty layer.

The "Dwellings" Interpretation Sheet (Figs. 17, 18, 19, 20)

For this interpretation four categories of soil problems have been considered:-

- i Difficult excavations
- ii Flooding
- iii Heaving ground
- iv Settlement

SHEET (E) (Fig. 17)

Two types of excavation problems are considered:

The "Hard Materials" module shows the PT layers with respect to a typical basement excavation. If bedrock occurs in the PT 1 layer the symbol Er' is given in the Interpretation Table.

The "Wet Excavation" module shows that the combination of certain fine granular soils and high water tables (during the normal construction season) will indicate construction difficulties. Water tables less than 1.5 metres deep during mid summer and soil grain size curve with low uniformity coefficient in the dark shaded portion of the envelope are assigned the symbol Ew' indicative of a probable class.

SHEET (F) (Fig. 18)

Two types of flooding problems are recognized:

The "Basement Flooding" module shows the PT layers in relation to typical dwelling with basement excavated below frost penetration depth (Eastern Ontario). For unserviced areas relying on sump pumps, flooding hazards exist. The problem results from a combination of water table condition and pervious soils at the basement level.

The "Inundation" module shows the conditions for flooding by overland flow. These are the same conditions which have already been considered in the septic tank interpretation.

SHEET (H) (Fig. 19)

Three types of heaving problem soils are considered:

The "Frost Adhesion" module shows a frost susceptible soil as a function of its grain size and position of the water table during winter. The problem cited is adhesion. Frost susceptible soils are recognized if the grain size curve passes anywhere into the H' zone of the envelope. The possible category lies in the area ACBD and this is for poorly graded soils with a low uniformity coefficient.

The "Expansive Soil" module shows the combination of moisture susceptible (swelling) soils and the position of the water table. If the soil remains in a saturated condition it is not likely to swell even if its index properties indicate that it has the potential to do so. To satisfy the requirements for swelling, all of the index properties should fit the H' class i.e. the Index properties including:

- Plasticity Index (25%+)
- Grain size ($<1\mu$) (20%+)
- Free Swell (F.S. >100%)
- Shrinkage Limit (S.L. <10%)

The "Expansive Rock" module illustrates a very special problem, typical of certain parts of Eastern Ontario. It shows the combination of low water tables with potential chemical or mineralogical indicators that the bedrock can be moved by bacterial action. A general clue for this type of condition is the presence of pyrite occurring in shale bedrock. Expansive rock is not unique to this area nor to this type of reaction. The module could be varied according to specific regional problems of this type.

INTERPRETATION

DWELLINGS

SOIL PROBLEMS DUE TO EXCAVATION, E

PROBLEM

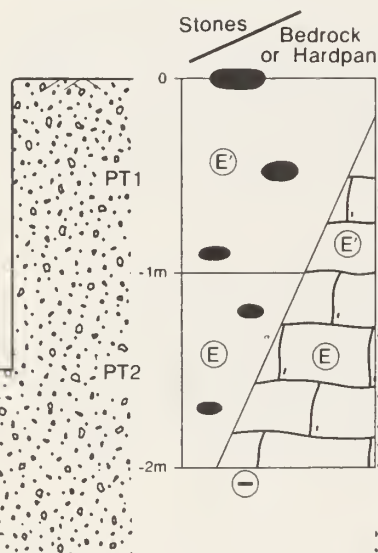
Difficult
Excavations

TYPES OF PROBLEM CONSIDERED

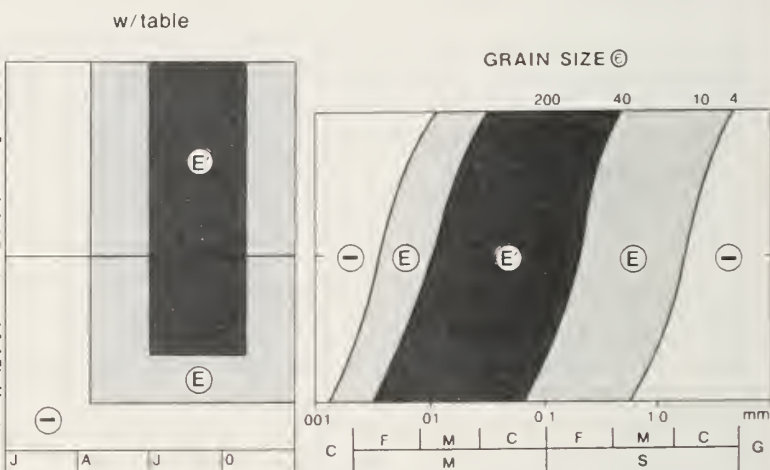
Hard Materials ——— E

Wet Excavation ——— Ew

HARD MATERIALS



WET EXCAVATION



INTERPRETATION

PROBLEM CLASS	HARD MATERIALS		WET EXCAVATION		
			w/table	grain size	
UNLIKELY	Other Soils or Bedrock etc. in zone —	—	zone — PT1 and 2	All Soils	—
POSSIBLE	Stones Hardpan Bedrock s h r } in PT2	E	zone E	zones E and E' and organic soil	Ew
PROBABLE	Stones Hardpan Bedrock s h r } in PT1	E'	zone E' PT 1 and 2	zone E' and organic soil	E'w

Figure 17 Interpretation (Dwellings) (Sheet E)

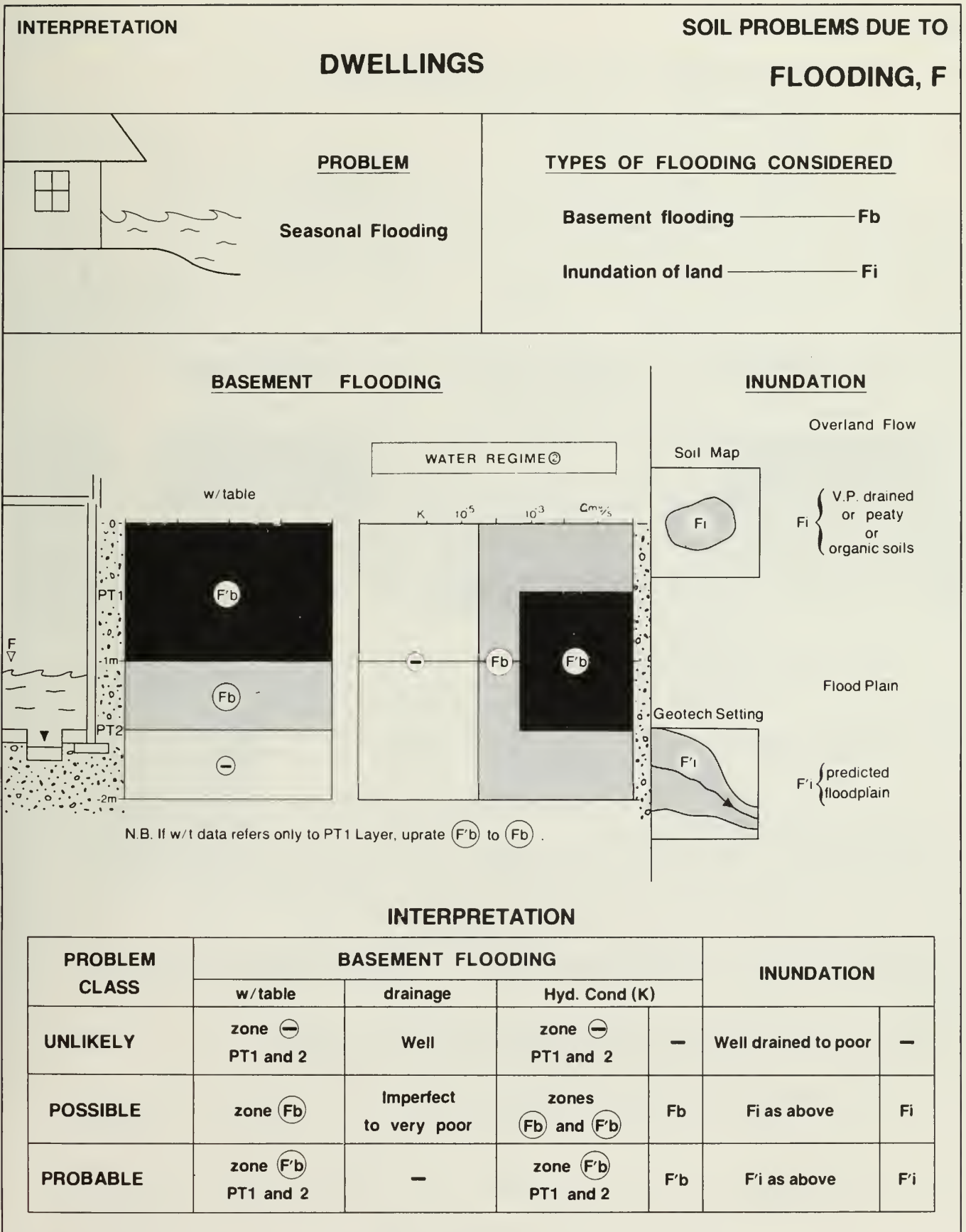


Figure 18 Interpretation (Dwellings) (Sheet F)

SHEET (S) (Fig. 20)

Three types of problems have been considered:

- i differential settlements (or bearing strength)
- ii subsidence of organic soils
- iii shrinkage due to trees.

The "Bearing" module illustrates the interrelationships between settlement due to bearing, grade depth of foundation members and effects of soil condition well below the foundation depth. For this interpretation a load Q was determined for a single column footing for a typical 3 storey dwelling in Eastern Ontario (see sketch at left centre). From this load Q, bearing pressures were determined assuming various types of footing geometry and grade depth. Differential settlement due to these loads were determined assuming soil strength values measured in situ by various types of test which included the Standard Penetration Test (N), the Static Cone (100 mm²) Test (q_c) and the undrained shear strength (q_u). An interpretation module was then compiled to indicate, in a conservative way, how in situ estimates of strength parameters can be used to identify problem soils. The relationship between tolerable settlement, soil type and building structure is complex and is within the domain of foundation engineering. The objective here is to emphasize this and bring to the attention of planners and others that even for small lightly loaded dwelling structures certain soils should be investigated by experts.

The "Subsidence" section of the interpretation table is for organic soils or organic phases of mineral soils. The hazard is in long term subsidence due to bio-chemical digestion or oxidation of organic material left in place at building sites. Particularly susceptible are service areas, and streets.

The "Shrinkage" module identifies the problem which is particularly serious in parts of Eastern Ontario with building sites situated in areas where the clay soils are shrinkable due to changing environmental conditions (eg. planting certain species of trees too close to dwellings). It is only the soils at depths below the footings which are effective in creating the problem and this is shown by the shrinkage module. The parameter used to identify shrinkable soil is the liquidity Index (LI). This is obtained from the Index values in the Setting document as

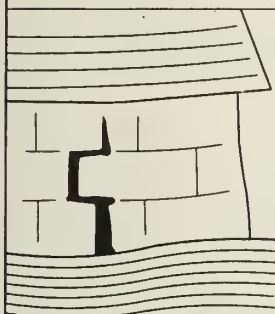
$$\frac{(W-PL)}{(LL-PL)} \quad \text{or} \quad \frac{\text{Natural Moisture Content}-\text{Plastic Limit}}{\text{Plasticity Index}}$$

The "Dwellings" Interpretation Symbol

INTERPRETATION

DWELLINGS

SOIL PROBLEMS DUE TO
HEAVE OR UPLIFT, H



PROBLEM

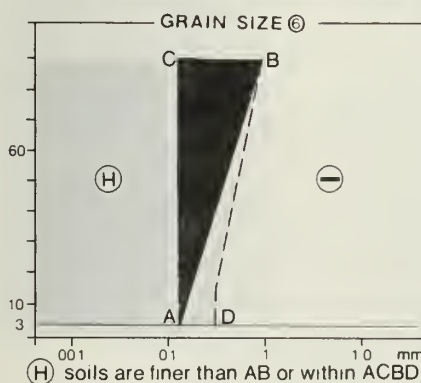
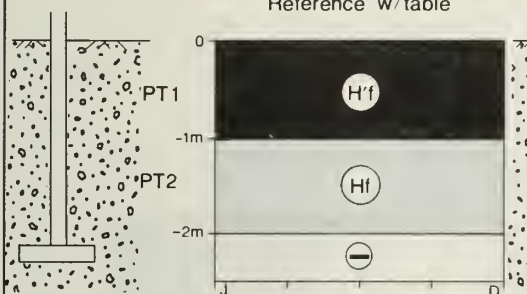
Cracking of walls
due to
differential heave

TYPES OF HEAVE CONSIDERED

Frost Adhesion ————— Hf
Expansive Clays ————— Hc
Expansive Rocks ————— Hr

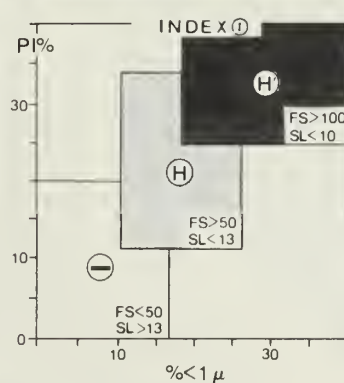
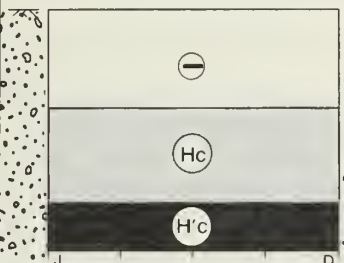
FROST ADHESION

Reference w/table



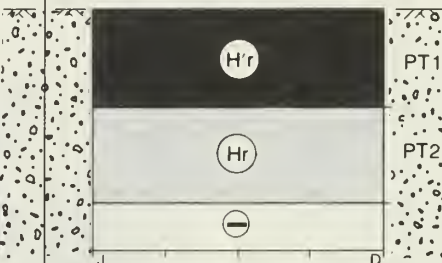
EXPANSIVE SOILS

Reference w/table



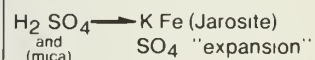
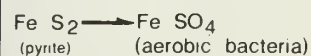
EXPANSIVE ROCK

Reference w/table



Hr = Shales with Pyrite

Typical Reactions



INTERPRETATION

PROBLEM CLASS	FROST ADHESION	EXPANSIVE CLAY	EXPANSIVE ROCK
UNLIKELY	w/table \ominus all soils	\ominus	w/table \ominus Hr and other soils
POSSIBLE	w/table zone Hf H soils in PT1	Hf w/table in Hc H and H' soils in PT1	Hc w/table in Hr Hr soils in PT1
PROBABLE	w/talbe in Hf H soils in PT1	Hf w/table in Hc H' soils in PT1	Hr w/table in Hr Hr soils in PT1

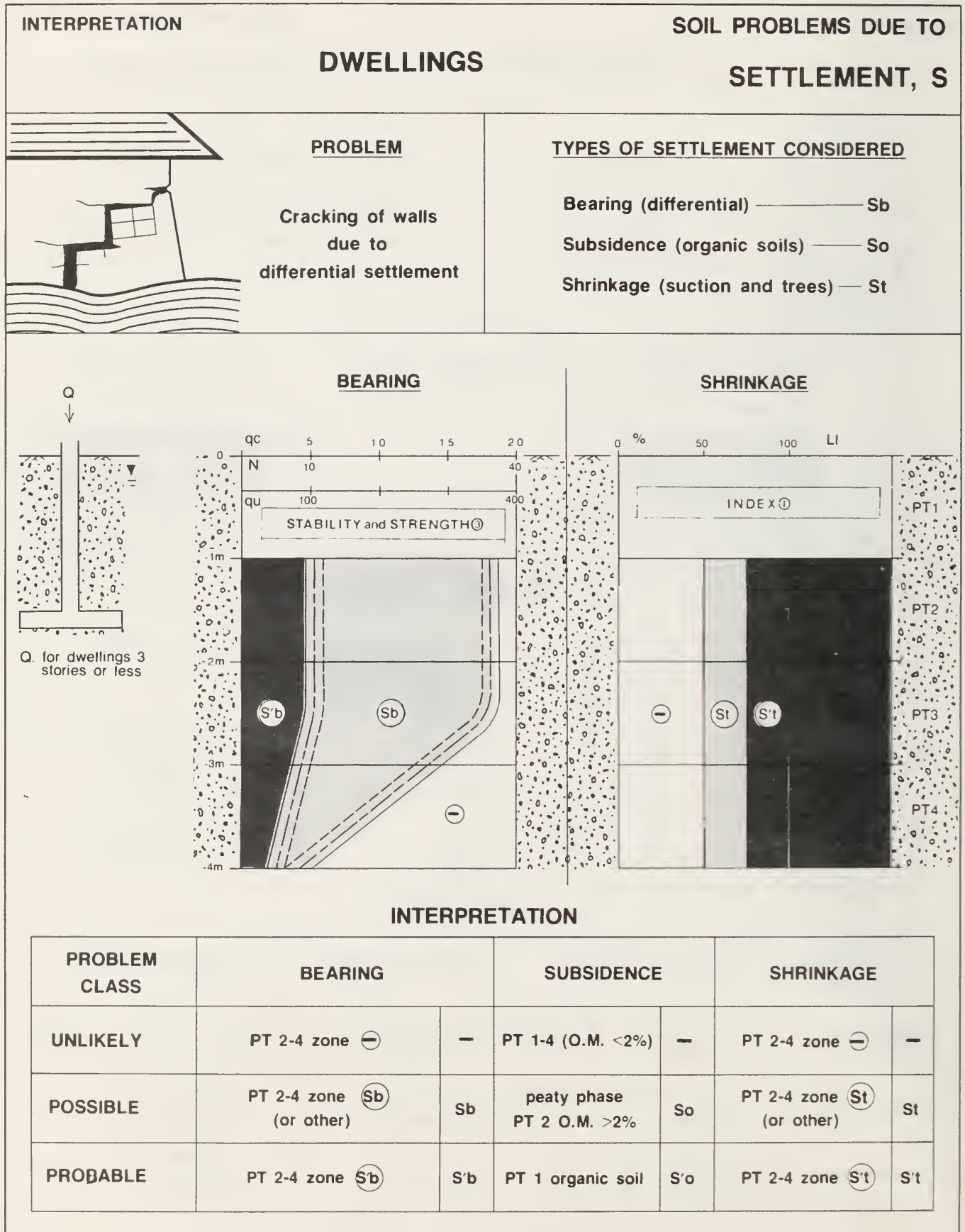


Figure 20

Interpretation (Dwellings) (Sheet S)

The complete symbol for the Dwelling interpretation includes an entry for each problem type:

<u>Ew'Fbi</u>	could thus be the interpretation symbol if the pedotechnical setting sheet indicated water table in PT 1 during the summer and grain sizes in the coarse silt range (Ew'); a peaty phase overlying the silt which has in situ hydraulic conductivity values in the 10^{-4} cm/s range (Fbi), frost susceptible soils with high water table in the winter period (Hf') and an organic surface layer (So).
<u>Hf'So</u>	

THE PEDOTECHNICAL REPORT

The report resulting from the application of the pedotechnical approach as outlined consists primarily of maps and map legends. The report text explains briefly how to use these maps and legends.

Considering the official soil survey map; the completed Pedotechnical Setting Sheets now constitute a Detailed Legend to this map. As a legend these sheets can be reproduced either in the form of an expanded legend, or as separate pages in the report, or in microfiche form (Marshall et al 1979). When only module 1 from each of the setting sheets is selected and grouped together, they constitute a General Legend.

The second type of Pedotechnical legend is the interpretive legend. When all the map units have been interpreted and given interpretation symbols based on the pedotechnical interpretation sheets, the result is a list of Interpreted Map Unit Symbols (Table 1). This constitutes a General Legend to the official map for interpretive purposes. The pedotechnical interpretation sheets then constitute a Detailed Legend for interpretations. The List of Interpreted Map Units plus the pedotechnical interpretation sheets can be reproduced either in the form of an expanded legend, or as separate pages in the report or in microfiche form (Marshall et al 1979).

These two types of legend permit the published soil survey map to be readily used in both the detailed or the general mode by either the technical or the non-technical.

Technology and capability is now available for computerized mapping. The Canadian (CANSIS) system is now operative for the economic production of maps. For those soil surveys which have been able to make use of these facilities, it is no longer

necessary to go through the route (as described) of using the original soil survey map for interpretive information. The turn-around document system of CANSIS permits symbol conversion to reproduce a derivative map. The pedotechnical interpretation sheets provide detailed legends for these derivative maps. For this purpose the interpretation sheets are assembled either in the form of an expanded legend, or as separate pages in the report or in microfiche form.

By further manipulating the scale factor, the original map can also be converted into a small scale generalized map. The generalized pedotechnical map is a derivative map using module 1 of the setting sheet as the legend. A group of generalized maps which includes interpretive maps and related geotechnical maps describes the geotechnical setting of the surveyed area. This is demonstrated in another publication (Wilson 1981).

DISCUSSION

This pedotechnical alternative to engineering interpretations was compiled at the request of the ECSS to set up national systems for soil survey methodology in Canada. Reports and discussions by three soil survey groups who tested the proposed system are given in the Proceedings of the Third Council Meeting, Expert Committee on Soil Survey, Ottawa, March 1981. The final recommendation was that the proposal be published to receive more thorough trial and review by the scientific community at large.

The proposed system is described in two separate publications; Pedotechnique which describes the pedotechnical approach to interpretations and a section or chapter of a modern soil survey report which incorporates that approach. Both texts have been revised, taking into consideration where possible the recommendations of the testing and review process.

The Pedotechnical Setting Sheet was the source of many misconceptions. The information given is not site specific; it defines a mapping concept, for interpretation purposes. Actually illustrated is the central theme of the dominant Soil Series of each Family or Association. Field and laboratory data are not collected to compile a modal site description, but to define a mapping concept in broader terms. The pedotechnical system is not an "anti-tabular" system per se; nor is it an alternative data collection or data storage system. It is an interpretation system; interpretations are made from the descriptive and tabular data available elsewhere in the Soil Report. No extra data are requested to make these interpretations; much more information could be given and would

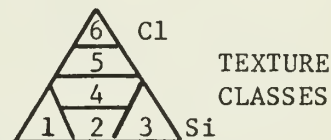
GENERAL LEGEND (INTERPRETATIONS)

Mapping Unit

$$\frac{C\ 2}{2.3} =$$

Castor subunit 2

Texture class 2. Slope class 3



SLOPE CLASSES

	%	%
0=	-2 to 0	4= 5 to 10
1=	0 to $\frac{1}{2}$	5= 10 to 15
2=	$\frac{1}{2}$ to 2	6= 15 to 30
3=	2 to 5	7= 30 to 60

Agricultural Capability

Limitations	{	F fertility	V variability
		W wetness	R rockiness
		I inundation	T topography
		M moisture	P stones

construction material

potential source	{	S,G. Sand, gravel
		F Roadfill
		R Rockfill
		- low potential

Dwelling sites

soil problems	{	E, difficult excavations due to rock (r), stones (s), wetness (w)
		F, flooding due to surface inundation Fi, water table Fb
		H, heaving ground due to frost adhesion Hf, swelling clay Hc, expansive rock Hr,
		S, settlement due to inferior bearing Sb, soil shrinkage St, organic soil So

Septic Tanks

Soil problems	{	D, lack of aerated soil Dw above water table Dr " bedrock Dc " impervious layer Ds clear of stones
		N, nutrient attenuation Nn, Np poor attenuation of nitrogen & phosphorus
		S, inferior setting Si inundated soils Ss adverse slopes

NB / indicates a 0 indicates unit
severe condition not interpreted,

- indicates unlikely
soil problems

Table 1 List of Interpreted Map Units

MAP UNIT SYMBOL ↓	INTERPRETATION SYMBOLS				
	Agriculture (Class)	Cons. Materials (potential)	Recreation (limitations)	Dwellings (Soil problems)	Septic Tanks (pollution problems)
$\frac{C5}{3.2}$	3FW	$\frac{--}{--}$	0	$\frac{Ew Fb'}{Hf' St'b}$	$\frac{Dw'-}{-}$
$\frac{C5-S}{3.2}$	4FRW	$\frac{--}{R}$	0	$\frac{Er Fb}{--}$	$\frac{Dr'-}{-}$

Table 1 List of Interpreted Map Units

be made use of, but it is no more essential for pedotechnical interpretations that it is for other systems. The same applies to statements with regard to the possible range of soil properties or variations of these in specific regions of the mapped area. This type of information is already given in the pedological sections of the report and is illustrated by tabular listings of specific modal sampling sites. To include all of this would enormously complicate the interpretation process and detract from a major recommendation which was "to keep it simple".

The PT layer is introduced because "engineering" interpretations have depth requirements. The PT 1 layer is defined as the top 1 metre of the landscape; it usually includes the A, B and C pedological horizons. The PT 2 layer is the second metre, the PT 3 layer is the third metre. The PT layer encourages what has already been initiated - an interest in the soils below control sections. For special surveys, mapping units could be differentiated according to the PT 2 or PT 3 layer characteristics. PT layers conveniently allow mapping concepts to be illustrated. They serve as reminders to provide information whenever it is intended to make interpretations which involve soils below the control section.

The Pedotechnical Interpretation Sheet did not present the same conceptual problems. There are several objectives in using this approach. The need for standardization has been referred to. With a standardized setting sheet and a standardized interpretation sheet, interpretations should be amenable to a greater degree of quality control. The system also provides reminders in establishing mapping units for soil surveys which are funded for their value as resource inventories. Thus two mapping units might be set up as:

Mapping Unit A
PT 1 sand
PT 2-3 clay

Mapping Unit B
PT 1-3 sand

With the pedological "control section" these units could be described as the same soil. However, a resource manager might prefer that these two units be separated as defining two entirely different potentials in the search for resource materials. It is admitted that some familiarity may be necessary to cope with interpretation envelopes. But once this is achieved, the framework established is useful for quick recall; for verifying interpretations made and for considering alternatives in discussion.

The type of engineering interpretation required for the Soil Survey Report may not be exactly how the engineer would see the overall problem. Their work normally involves making interpretations for specific parcels of land including areas on which to build a dam or a group of buildings. A Soil Survey Map Delineation is really a large site specific entity representing a real specific land area. But MAP UNIT SYMBOLS represent concepts only. The interpretation process in Pedotechnique is seen as a transposition of Map Unit Symbols by Interpretation Symbols. In the case of pedotechnical interpretations the only engineering input may be in setting out the framework so that the pedologist can interpret map units within this framework. The framework may be based on either the individual soil or landscape factors involved or, according to direct performance observation, if available. The discussion in this text is limited mainly to the former. A separate publication is in preparation giving pedotechnical interpretations for the soils of the Ottawa urban fringe area to accompany Ontario Soil Survey Report No. 47.

It will be noted that on the interpretation sheets the emphasis is purposely directed to specific aspects of each problem. In the case of Septic Tanks for instance, it is known that Hydrogeological aspects are an important factor but that these may often be beyond the scope of the particular survey. The pedologist cannot confidently use the term "suitable for septic tanks" if the hydrogeological conditions were in fact unknown at the time of the survey. However, he can confidently indicate problems due to slope, inundation, etc., about which he has some information. This is quite different from attempting to rate specific areas or specific delineations as being suitable or not suitable for septic tanks. Such recommendations can be given by others who may, if they so choose, use only the Soil Survey Map. Others may generally wish to include extra information in addition to the Soil Survey*. By setting out the interpretation sheets in this way it is intended to remove the onus from the pedologist for making engineering judgments of specific delineations.

The main objections with regard to the Pedotechnical Report concern the volume and the effort required to compile it. These may be somewhat pessimistic - the volume question has already been solved by the successful publication of the Ontario Soil Survey Report No. 47 (The Ottawa Urban Fringe 1979). This report shows that detailed information (like the setting sheets and interpretation sheets) can be produced in microfiche form in a small pocket on the back page of the report.

* Scott, J.S. 1979. Personal communication from Terrain Sciences division, EMR, Ottawa.

The time factor is one which will undoubtedly decrease as the methodology develops. Moreover the setting sheet is intended to be compiled during the course of the survey while the field and laboratory work is still in progress.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that a requirement exists to follow up the lead to establish national interpretive systems for soil survey. The pedotechnical methodology outlined for "engineering" interpretations, has been compiled from an engineer's viewpoint. It is recommended that it be followed up by extended cooperative work with pedologists involved in on-going surveys.

ACKNOWLEDGEMENTS


Acknowledgement is given to the typing and cartographic staff at Land Resource Research Institute for production of this document. Acknowledgement is also given to all reviewers of previous approximations; to the Agriculture Canada soil survey correlators, to each of the Federal and Provincial survey units and a number of professionals from other disciplines. Whenever possible the comments from these reviewers have been considered and the text and the approach have been adjusted accordingly.

Finally to colleagues in the USA, little of this could have been written without their advice and cooperation.

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