National Soil Inventory of Scotland (1978-1988)

Soil location, sampling and profile description protocols (NSIS_1)

Compiled by: **Lilly, A., Bell, J.S., Hudson, G., Nolan, A.J. and Towers, W. 2010**

These methodologies and protocols are based on original, non-attributed documentation by J. Martin Ragg, James H. Gauld, John S. Bibby and Gordon Hudson with additional contributions by Soil Survey Staff and from sources such as Brown et al, 1987 and Soil Survey of Scotland, 1979. The intention of this document is to collate this reference material and provide definitions of terminology used in site and profile descriptions as well as outlining the principles behind the National Soil Inventory of Scotland and the methods used to locate sampling sites. It is designed as a reference document to be quoted in publications that use NSIS_1 data and as an introduction to the soil profile data stored within the Scottish Soils Database. The current authors acknowledge the contributions and work done by those former members of the Soil Survey of Scotland.

Reference as: Lilly, A., Bell, J.S., Hudson, G., Nolan, A.J. and Towers, W. (Compilers). 2010. National Soil Inventory of Scotland 1 (NSIS_1): site location, sampling and profile description protocols. (1978-1988). Technical Bulletin, Macaulay Institute.

In the late 1970s it was proposed to undertake an inventory of the soils of Scotland allied to the reconnaissance scale 1:250 000 national soil mapping programme. This National Soil Inventory of Scotland (NSIS) was to comprise environmental, soil morphological and analytical data. The aim was to provide statistical summaries of soil characteristics at a number of levels, that is, for all Scotland, for regional subdivisions (geographic or geopolitical), for major soil groups and subgroups, for large, extensive soil map units and for displaying regional trends in soil properties.

The Inventory was based on a systematic sampling scheme aligned with the Ordnance Survey national grid which has its origin at a latitude of 49 degrees 45 minutes and 58 seconds North and a longitude of 7 degrees 33 minutes 23 seconds West which is located southwest of the Isles of Scilly.

The soil profiles at each 5km grid intersect were described, with the information recorded on a prescribed proforma (known as a 'profile description card', see Appendix 1) using standardised terminology (Appendix 2) including codes for rock types (Appendix 3) and horizon nomenclature (Appendix 4). The soil profiles at the 10km grid intersects were described and, in addition, the major soil horizons in the profile were sampled for analysis of a wide range of chemical and physical properties (Appendix 5). The proforma was designed to be compatible with electronic storage of soil data (Brown et al, 1987) and later, it was formulated within field computers (Husky's) thus avoiding any transcription errors from card to database. The sample frame comprised 3127 locations at 5km spacing and 787 at 10km spacing. Some sites were rejected during the sampling programme as they either fell on land owned by MOD or were found to lie below high water mark. Also, some sites in Orkney were not completed, giving rise to a total number of visited NSIS sites for which data were recorded in the Scottish Soils Database of 3094. Of these, 721 soil profiles on the 10km sample frame were sampled along with an additional 297 soil profiles on the 5km sample frame. The soil samples were analysed for a standard suite of soil chemical and physical properties (Appendix 5) and, at a later date, surface samples were analysed for a range of heavy metals (Appendix 6).

METHODOLOGIES AND PROTOCOLS FOR SITE LOCATION

Identification of Ordnance Survey Grid Intersects

Since the detail shown by different scales and series of Ordnance Survey maps varies, it was decided that one map series and scale should be used to identify and mark the grid intersects on air photographs. Although the most accurate maps are the 1:10 000 scale, these were not widely available, therefore, it was decided to use the second series 1:50 000 scale OS maps. The 10km NSIS sample locations were plotted from these maps onto air photos that had an approximate scale of 1:25 000 using a Zeiss 'sketch master' that allows the superimposition of both map and photo images having different scales. The location of the grid intersect was generally marked on the photo using a Rotring pen as a small dot approximately 0.5 mm diameter. Ink generally does not erase easily in the field as it is not water soluble. Other methods used to mark the sample location included chinagraph pencil or a pin prick. The national grid reference was clearly marked on the photograph and the position of the site was often indicated by marking the edges of the photograph with lines drawn perpendicular to the photo edge and in line with the dot.

Location of Sites in Field

Navigation to the site generally involved using relevant maps and air photos. Having located the site as accurately as possible, using the annotated air photo, a soil pit was dug at that point and the soil and site described and relevant samples taken (see Profile Sampling Protocols below). In some cases where the photo quality was poor or tones were even and where there were no obvious features to allow accurate location, the site was located using the surveyor's best estimate of position. The surveyor then recorded on the soil profile description sheet how accurately, in their opinion, the site had been located using the following classes:

A – located within the area delineated by the photo mark
B – within 10m of the area delineated by the photo mark
C – within 50m of the area delineated by the photo mark
D - approximate location only
SU – supplementary point (where a soil profile could not be located within 100m of the actual NSIS georeference)

Where the site landed on an area with no soil cover, for example, rock, water, road or building, a site having a soil profile within 100m from the grid intersect was sought. Where several possibilities exist, the selection of the supplementary point was made in the order north, east, south, west from the original sample location

SOIL PROFILE DESCRIPTION AND SITE CHARACTERISATION PROTOCOLS

At each location a soil pit, rectangular in shape, was dug by spade and was sufficiently large to allow sampling of each of the major horizons. It was of sufficient depth to allow the description and sampling of the parent material (where possible, to at least 75cm depth or 1m in peats). The pit was orientated, where possible, so that the profile face to be described and sampled faced the sun or the direction of maximum light to facilitate identification of soil horizons. Each horizon was described in turn using standardised and agreed terminology that constrained the amount of information recorded (Appendix 2). The information was recorded on a specially designed proforma (and latterly on Husky Hunter field computers) in the field and subsequently entered or uploaded into the Scottish Soil Database. A copy of the profile description card used is shown in Appendix 1.

The site characteristics that influence soil development and soil profile characteristics (soil morphological data) were recorded in a coded form (Appendices 2 and 4). The presence of impediments such as rock and boulders and the occurrence of water, either from groundwater or seepage into the pit, which curtailed digging and sampling were noted on the profoma.

PROFILE SAMPLING PROTOCOLS

Profile Sampling

Once the profile pit was dug and the profile face cleaned, the limits of the horizons to be sampled were marked with a knife or trowel on the pit face and wherever possible, with the exception of iron pans (Bf horizon), which are usually very thin and often difficult to sample, each horizon in the profile was sampled. Approximately 1 to 1.5 kg of relatively stone free soil (with as many stones as possible removed from the sample in the field) was collected from each horizon. As many stones as possible were removed from the sample in the field.

Samples were generally taken from a 10 cm thick band, approximately in the middle of the horizon or at depths thought to be appropriate where the thickness of the horizon is judged to warrant more than one sample. In some situations where the horizon thickness is less than 10 cm, the top and bottom sample depths were set to allow a representative and pure sample to be collected from the horizon. Thin transition zones up to 6 cm thick were excluded where boundaries are gradual or diffuse.

The soil material was loosened and extracted using a trowel or knife, collected in a sampling tray held level with the lower boundary of the sample depth, and placed in a bag. In general, soils were sampled sequentially beginning with the lowest horizon to prevent contamination from the upper layers during the sampling process. The soil sample was placed into a 500 gauge LDPE (Low Density Polyethylene) bag. Two labels were prepared with profile name, National Grid Reference, horizon symbol, depth of sample, date of sampling and surveyor initials written legibly. Excess air was removed from the sample bag before sealing which was done as soon as possible after the sample was taken from the profile pit to avoid any risk of contamination. The bag was made air tight by folding over the top few centimetres twice. One label was either slotted under this fold and another attached to the outside of the fold before the bag was stapled shut. If the sample was to be double bagged, for example, where there was a possibility that the bag may be torn during its transportation to the lab or where the sample was excessively wet, one bag was placed inside another. In this case a sample label was placed inside the second bag (not inside the bag with the sample) and the other label stapled inside the fold as before.

Once sampling and collection of the soil morphological data were completed the soil pit was refilled with the original spoil with lowest horizons first followed by the replacement of the topsoil and turf (if available).

NSIS DATA MANAGEMENT AND SAMPLE ARCHIVING

Data Management

The Soil profiles from the first National Soil Inventory Sampling programme, sampled between 1978 and 1988, were identified by National Grid Reference, and this was used in the Scottish soils Database as a unique primary key since no two soil profiles should have been sampled at the same location. The soil morphological data (profile descriptions) and site characteristics were either recorded on forms designed for the purpose or on field computers. Textual field descriptions were recorded as codes in the field (see Appendices 2, 3 and 4) and these codes (along with decoding routines) were stored in the database. Data from the forms were double-entered into the computer and cross-checked for typing errors. Samples were given unique identification numbers and linked to the field data by grid reference, depth and horizon symbols. Analytical data returned from the laboratory were subjected to the same double-entry validation procedure.

Data were originally stored in DBASE II and transferred to an Oracle® Relational Database Management System around 1988. Each time data were migrated to different or newer versions of the database software, a range of routines written in the language of the new database were run to validate the data against known values. As an additional check on data entry, profile descriptions were produced and validated by the soil surveyor responsible for the data collection.

More recently, with advances in databasing, some modification to the range of data collected and the resampling of a selection of soil profiles from the 10km National Soil Inventory, there has been a requirement to restructure the Scottish Soils Database. In particular, the use of National Grid Reference as the primary key became obsolete as the same location could be recorded for a subsequent profile and was replaced by a unique number (PROFILE_ID). Similarly, a unique horizon identifier (HORZ_ID field) to explicitly carry out the many-to-many links between horizons and samples was added.There was also some rationalisation of database field/attribute names to aid in distinguishing between data fields and to clarify distinctions between site and profile locations.

The attribute names that have been changed are indicated (*) in the attribute table in Appendix 2. Attributes such as stoniness and roots are described as a single entity in the table but are, in fact composite observations that encompass, type, frequency, size which are given separate fields within the database.

Sample Archiving

Air-dried (at 30^{O} C) and sieved (<2 mm) soil samples from NSIS are stored in plastic pots, which hold a maximum of 340g of mineral soil material or 100g of organic soil material. Only one pot of soil was retained from each sample. These pots are labelled with the unique identification number and arranged in sample identification number order on trays in the National Soil Archive of Scotland.

These soil samples were moved in the early 1990s from the original storage area into the current building and are housed along with other soil samples in the Archive on Level 1 of the Macaulay Institute. The archive storage facility was recently renovated and samples are now on lockable purpose-built shelving

Sample splitting and sub-sample preparation is now controlled to ensure that each sub-sample is representative of the original sample but it is unclear if these protocols were followed in the past.

BIBLIOGRAPHY

Birse, E. L. (1971). *Assessment of the Climatic Conditions in Scotland Map 3. The Bioclimatic Subregions*. The Macaulay Institute for Soil Research, Aberdeen.

Bown, C. J. and Heslop, R. E. F. (1979). *The Soils of the Country round Stranraer and Wigtown*. The Macaulay Institute for Soil Research, Aberdeen.

Brown, K.W.M., Gauld, J.H., Smith, B.F.L, Bain, D.C., Burridge, J.C. and Inkson, R.H.E. 1987. Design of a database for Scottish Soils. Journal of Soil Science, 38, 267-277.

Hodgson, J. M. (1974). Soil *Survey Field Handbook.* Technical Monograph No. 5. Soil Survey of England and Wales. Rothamsted Experimental Station. Lawes Agricultural Trust. Harpenden.

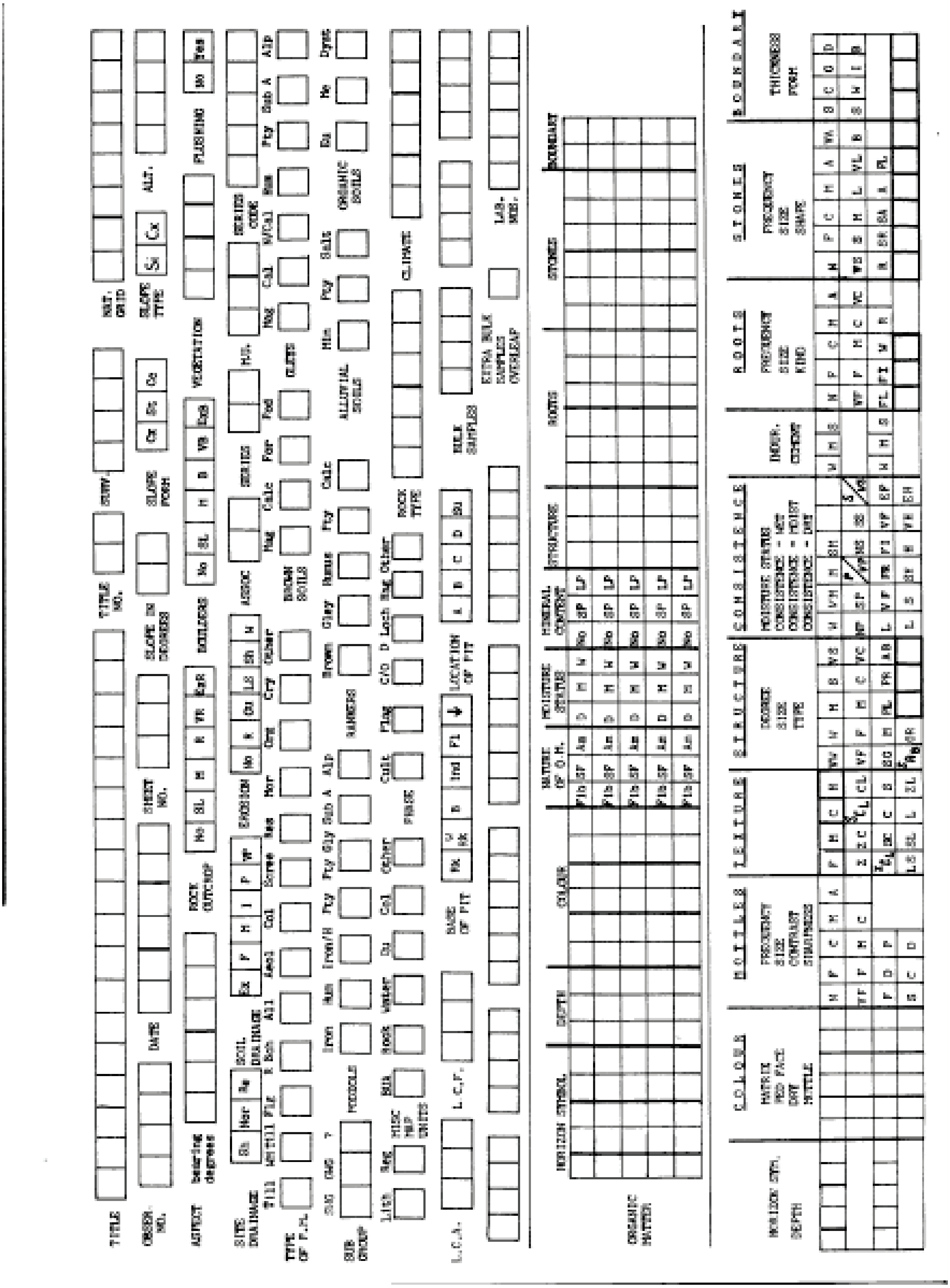
McGrath, S.P. and Loveland, P.J. (1992). The Soil Geochemical Atlas of England and Wales. Blackie Academic and Professional, Glasgow.

Robertson, J. S. (1984*). A Key to the Plant Communities of Scotland.* Soil Survey of Scotland Monograph. The Macaulay Institute for Soil Research, Aberdeen.

Soil Survey of Scotland. 1979. Coding soil profile descriptions for computer: Profiles for Soil Inventory. Macaulay Institute for Soil Research.

Soil Survey Staff. 1951. Soil Survey Manual. US Department of Agriculture Handbook No. 18. USDA. Washington.

Appendix 1: soil profile description proforma:



HORIZON SYMBOL DEPTH	COLOUR	MOTTLES					TEXTURE				STRUCTURE					CONSISTENCE						IND. CEMENT			ROOTS					STONES						BOUNDARY			
		N	F	C	M	A	F	M	C	H	VW	W	M	S	VS	W	VH	M	SH			W	M	S	N	F	C	M	A	N	F	C	M	A	VA	S	C	G	D
		VF	F	M	C		Z	ZC	$^{S}C_{L}$	CL	VF	F	M	C	VC	NP	SP	P/VP	NS	SS	S/VS				VF	F	M	C	VC	VS	S	M	L	VL	B	S	W	I	B
		F	D	P			$^{Z}C_{L}$	SC	C	S	SG	M	PL	PR	AB	L	VF	FR	FI	VF	EF	W	M	S	FL	FI	W	R		R	SR	SA	A	PL					
		S	C	D			LS	SL	L	ZL	$^{S}A_{B}$	GR				L	S	SH	H	VH	EH																		
		N	F	C	M	A	F	M	C	H	VW	W	M	S	VS	W	VH	M	SH			W	M	S	N	F	C	M	A	N	F	C	M	A	VA	S	C	G	D
		VF	F	M	C		Z	ZC	$^{S}C_{L}$	CL	VF	F	M	C	VC	NP	SP	P/VP	NS	SS	S/VS				VF	F	M	C	VC	VS	S	M	L	VL	B	S	W	I	B
		F	D	P			$^{Z}C_{L}$	SC	C	S	SG	M	PL	PR	AB	L	VF	FR	FI	VF	EF	W	M	S	FL	FI	W	R		R	SR	SA	A	PL					
		S	C	D			LS	SL	L	ZL	$^{S}A_{B}$	GR				L	S	SH	H	VH	EH																		
		N	F	C	M	A	F	M	C	H	VW	W	M	S	VS	W	VH	M	SH			W	M	S	N	F	C	M	A	N	F	C	M	A	VA	S	C	G	D
		VF	F	M	C		Z	ZC	$^{S}C_{L}$	CL	VF	F	M	C	VC	NP	SP	P/VP	NS	SS	S/VS				VF	F	M	C	VC	VS	S	M	L	VL	B	S	W	I	B
		F	D	P			$^{Z}C_{L}$	SC	C	S	SG	M	PL	PR	AB	L	VF	FR	FI	VF	EF	W	M	S	FL	FI	W	R		R	SR	SA	A	PL					
		S	C	D			LS	SL	L	ZL	$^{S}A_{B}$	GR				L	S	SH	H	VH	EH																		
		N	F	C	M	A	F	M	C	H	VW	W	M	S	VS	W	VH	M	SH			W	M	S	N	F	C	M	A	N	F	C	M	A	VA	S	C	G	D
		VF	F	M	C		Z	ZC	$^{S}C_{L}$	CL	VF	F	M	C	VC	NP	SP	P/VP	NS	SS	S/VS				VF	F	M	C	VC	VS	S	M	L	VL	B	S	W	I	B
		F	D	P			$^{Z}C_{L}$	SC	C	S	SG	M	PL	PR	AB	L	VF	FR	FI	VF	EF	W	M	S	FL	FI	W	R		R	SR	SA	A	PL					
		S	C	D			LS	SL	L	ZL	$^{S}A_{B}$	GR				L	S	SH	H	VH	EH																		
		N	F	C	M	A	F	M	C	H	VW	W	M	S	VS	W	VH	M	SH			W	M	S	N	F	C	M	A	N	F	C	M	A	VA	S	C	G	D
		VF	F	M	C		Z	ZC	$^{S}C_{L}$	CL	VF	F	M	C	VC	NP	SP	P/VP	NS	SS	S/VS				VF	F	M	C	VC	VS	S	M	L	VL	B	S	W	I	B
		F	D	P			$^{Z}C_{L}$	SC	C	S	SG	M	PL	PR	AB	L	VF	FR	FI	VF	EF	W	M	S	FL	FI	W	R		R	SR	SA	A	PL					
		S	C	D			LS	SL	L	ZL	$^{S}A_{B}$	GR				L	S	SH	H	VH	EH																		

NOTES: Incl. Veg. lists, Topography, Sketch, Additional Features, Additional bulk samples.

Appendix 2: Site and soil profile descriptions

The following outlines both the definitions and codes used to capture field information on both soil and site characteristics. These codes rather than textual information are stored within the Scottish Soil Database in order to reduce the volume of data to be stored. As computer scripts are required to decode this information, the attributes described were recorded in a specified method which generally involved entering the data in specified boxes and with a specified layout, such as, textual information being right justified. This facilitated database searches using ‘strings’ and sub-strings’.

Data capture for some attributes made use of multiple choice where the standardised attribute codes were printed on the card and the appropriate code that described the conditions of the soil was ticked. This method was designed to minimise errors and standardise the computer input. In other instances the code had to be entered onto the card as either numeric or alphabetic codes.

Attributes recorded, their definition and relationship to measured soil properties.

Environmental Properties:

Attribute name	Description
Title*	The site name, often the location, hill or farm name
Title No.*	Used where two or more profiles had the same title or site name
Surv*	The surveyor who described and sampled the profile
Nat Grid*	The letter symbols of the 100 km square followed by the six figure reference
Obser No.	Not used
Date*	The date when the profile was described
Sheet No.*	The number of the third edition soil map sheet
Slope in degrees*	The slope angle as measured in the field
Slope form	The curvature or shape of the slope
Slope type	Whether simple or complex slopes
Alt*	The altitude in metres above sea level, taken from an Ordnance Survey map
Aspect –bearing*	The direction of slope as a bearing
Aspect – degrees*	The direction of slope as an angle
Rock outcrop*	The presence and frequency of rock outcrops
Boulders*	The presence and frequency of surface boulders
Vegetation	The vegetation community classified according to Robertson (1984)
Flushing	The presence of near continuous lateral flow of water through the soil
Site drainage	The flow of water across the landscape at the pit location
Soil drainage	The natural drainage characteristics of the soil profile
Erosion*	The type of erosion, if any, present
Assoc*	The two-letter symbol for the soil association
Series*	The two-letter symbol for the soil series
MU	The soil map unit at the grid intersection; rarely used
Series code	The 5 digit code for the soil series
Type of PM*	The soil parent material
Soil classification	According to the Scottish soil classification
Misc map units*	Non-soil map units

Phase*	Subdivision of some major soil subgroups
Rock type	The lithology of rocks/stones within the soil profile
Climate	The climate of the NSIS location according to Birse, (1971)
LCA	The Land Capability for Agriculture class, division and limitation type
LCF	The Land Capability for Forestry class and limitation type
Base of pit*	The presence or otherwise of any restrictions on the profile depth
Location of pit*	The surveyors best estimate of the location of the profile in relation to the mark on the photograph
Bulk samples*	The depth at which samples were taken
Extra bulk samples*	An indication if additional samples were taken
Lab Nos.*	Sample identification numbers (added retrospectively)*

Profile Morphological characteristics: Organic soil horizons

Horizon symbol*	The master and sub-horizon horizon symbol(s)
Depth*	The depth (cm) of the base of the horizon measured from the soil surface (including litter layers)
Colour	The colours of soil in the horizon according to the Munsell notation
Nature of OM	The degree of decomposition of the organic material
Moisture status	The moisture status of the organic horizon at the time of sampling
Mineral content	The presence and degree of mineral matter
Structure degree	The degree of aggregation
Structure size	The size class of aggregates
Structure type	The type of aggregation
Root frequency	The frequency class of roots
Root size	The size class of roots present
Root kind	The type of roots present
Stone frequency	The frequency class of stone content
Stone size	The size class of stones present
Stone shape	The shape of stones present
Stone lithology	The lithology of stones present
Boundary thickness*	The thickness of the transition zone between soil horizons
Boundary form*	The degree of irregularity of the horizon boundary

Profile Morphological characteristics: Mineral soil horizons

Horizon symbol*	The master and sub-horizon horizon symbol(s)
Depth*	The depth (cm) of the base of the horizon measured from the soil surface (including litter layers)
Colour	The colours of soil in the horizon according to the Munsell notation
Mottle Frequency	The frequency class of mottles (sites of reduction)
Mottle size	The size of mottles present
Mottle contrast	The relative colour difference between mottle and soil matrix
Mottle sharpness	A description of the transition zone between mottle and matrix
Texture	Field estimate of the soil texture with subdivisions if necessary
Structure degree	The degree of aggregation
Structure size	The size class of aggregates
Structure type	The type and shape of aggregation
Consistence –moisture status	The moisture content class of the horizon at the time of sampling
Consistence	The cohesiveness of the soil
Indur*	The degree of natural compaction
Cement*	The degree of cementation
Root frequency	The frequency class of roots
Root size	The size class of roots present
Root kind	The type of roots present
Stone frequency	The frequency class of stone content
Stone size	The size class of stones present
Stone shape	The shape of stones present

Stone lithology	The lithology of stones present
Boundary thickness*	The thickness of the transition zone between soil horizons
Boundary form*	The degree of irregularity of the horizon boundary

* Name subsequently changed within the revised (2011) Scottish Soils Database.

Detailed descriptions of attributes recorded:

Title – This was the site name which was generally the location, hill or farm name. The title and title number were essentially a mnemonic for the surveyor and an aid to identifying specific profiles.

Title No. – The title number was entered if relevant, that is, if two or more profiles were given the same name.

Surv – The surveyor who described and sampled the profile was recorded using a standard set of initials. With most textual information, these were entered right justified.

The standard set of initials is:

Surveyor Initials	Surveyor Name
AJN	Andrew Nolan
AL	Allan Lilly
BMS	Brian Shipley
CGBC	Colin Campbell
CJB	Cyril Bown
DJH	David Henderson
DWF	Don Futty
FTD	Frank Dry
GGW	Gary Wright
GH	Gordon Hudson
JAH	Andrew Hipkin
JHG	Jim Gauld
JSBE	John Bell
JSBI	John Bibby
REFH	Rodney Heslop
TWMB	Tom Brown
WT	Willie Towers

Nat Grid – The letter symbols of the 100 km square were entered in the first two blank boxes in the Nat Grid attribute field of the profoma (for example NJ) followed by the six figure reference (this is known as an alpha-numeric National Grid Reference). This reference was crucial for the information stored within the Scottish Soils Database as all sorting and retrieval of information was based on this unique georeference.

Observ No. – This field was not used.

Date – The date when the profile was described was recorded according to the format ddmmyy. Zero was used where day or the month was <10 for example 070787 (7 July 1987)

Sheet No: If relevant, the number of the third edition soil map sheet was recorded with the numbers being right justified, for example, sheet 23 was recorded as:

	2	3

Slope in degrees – The slope of the site was measured using an Abney level and the slope in degrees was entered into the proforma. Slopes <10 had their value right justified:

	3

Slope form – A general description of the landscape was made with the type of slope along the direction of the true slope recorded as one of three categories: Cx=Convex; St=Straight; Cc=Concave (all stored in uppercase within the database).

Slope type – As well as a description of the slope form, the type of slope was also recorded in two categories: Simple (Sl) or Complex (Cx). These descriptions followed the definitions published in Hodgson (1974) and are all stored in uppercase within the database.

Alt – The altitude in metres above sea level, as shown on the Ordnance Survey map, was recorded. This may have been done retrospectively, in the office, when the profile description was being entered into the Scottish Soil Database or in the field at the NSIS location.

Aspect – the site aspect, that is, the direction the slope faced, was recorded as both a bearing (such as north north east) and in degrees. Level ground had no aspect. Again the information was right justified, for example an aspect of 25° was entered as:

N	N	E		2	5

Aspect

Code	Name	Code	Name
N	North	S	South
NNE	North north east	SSW	South south west
NE	North east	SW	South west
ENE	East north east	WSW	West south west
E	East	W	West
ESE	East south east	WNW	West north west
SE	South east	NW	North west
SSE	South south east	NNW	North north west

Rock outcrop – The relative spacing of visible rock outcrops within a 100m radius of the profile pit was assessed at each site. In some areas large boulders (>60 cm) could not be readily distinguished from rock outcrops and were treated as outcropping rock for the purposes of this assessment. Where rock outcrops and discrete boulders were both present they were collectively described as rock outcrops. Where only boulders were present the major impedance to tillage e.g. boulder-strewn slopes and moraines, they were described separately from rock. The degree of rockiness was assessed by estimating the average distance between visible rock outcrops or boulders and recorded as one of six categories:

Code	Rockiness	Definition
No	Non-rocky	Occurrences are greater than 100 m apart
SL	Slightly rocky	Rock outcrops are 35-100 m apart
M	Moderately rocky	Rock outcrops are 10-35 m apart
R	Rocky	Rock outcrops are 3-10 m apart
VR	Very rocky	Rock outcrops are less than 3 m apart
ExR	Extremely rocky	Rock pavements and cliffs

Boulders – Where the land surface was littered with boulders (>60 cm diameter) rather than rock outcrops, a similar assessment procedure and classes was used.

Code	Boulderiness	Definition
No	Non-bouldery	Occurrences are greater than 100 m apart
SL	Slightly bouldery	Boulders are 35-100 m apart
M	Moderately bouldery	Boulders are 10-35 m apart
R	Bouldery	Boulders are 3-10 m apart
VR	Very bouldery	Boulders are less than 3 m apart
ExR	Extremely bouldery	Boulder fields

Vegetation – The vegetation community at each site was classified according to Robertson (1984). This involved identifying dominant and important indicator species at each site. The plant community was then identified by following a series of keys published in Robertson's '*A Key to the Plant Communities of Scotland'*. This was often done in the field although classification could be done at a later stage provided the key species were identified at the site. Each of the 271 communities recognised has a unique code based on a hierarchical system such that the letters preceding a numeral within the code identified a broad community while the number identified subdivisions and the final letter identified subassociations. For example, Moist boreal heather moor was coded

C	U	2	C

whilst Lichen-rich boreal heather moor was coded

C	U	2	D

with the numeral always written in the box with heavy outline.

Flushing – Flushing occurs where there is a near continual lateral flow of water through the surface horizons and across the soil surface. This affects both the nutrient status and vegetation community associated with the soil. The presence of flushing was recoded on the proforma as simply Yes or No and within the database as Y or N.

Site drainage – The site drainage refers to the flow of water at the site. Three categories were used:

Code	Drainage type	Definition
Sh	Shedding site	Slopes with run-off exceeding the amount of water reaching the site from higher slopes e.g. many convex slopes and upper slopes of hills.
Nor	Normal site	Slopes on which run-off might be expected to equal approximately the amount of water running down from higher land onto the site e.g. straight slopes in mid slope situations.
Re	Receiving site	Situations where a site receives more water from slopes above than is lost by run-off e.g. lower concave slopes, basins and channels.

Codes all stored in uppercase within the database

Soil Drainage – The natural drainage of the soil was assessed after digging the profile pit and taking account of the morphological properties of the soil, in particular, the degree of gleying and where it occurred within the soil. The general characteristics of each class are given below and follow those published in The '*Soils of the country round Stranraer and Wigtown'* (Bown and Heslop 1979).

Code	Drainage category	Description
Ex	Excessive	Soil horizons are shallower than normal and B horizons are bright and uniform in colour. Often coarse sandy soils
F	Free	Soils with B horizons that are bright and uniformly coloured
M	Moderate	Soils with B horizons showing slight dullness and few mottles in the subsoil.
I	Imperfect	Soils with B horizons that are less bright than those of freely drained soils and have appreciable mottling.
P	Poor	Soils with B horizons that are dull and mottling is evident. The surface horizon is often mottled and gleyed.
VP	Very poor	Soils with B horizons that are dull and mottling is very evident. The surface horizon is mottled and gleyed and

		may be humose.

Erosion- The type of erosion around the profile pit was assessed in the field and categorised into one of six categories:

Code	**Erosion type**	**Description**
No	None	No erosion present
R	Rill	A rill is a small channel which can be completely smoothed out by normal cultivation, that is, <25 cm deep.
Gu[#]	Gully	A gully is a channel too big to be smoothed out by normal cultivation.
LS	Landslip	Intact areas which have slipped *en masse* downslope, e.g, arcuate slip features, irregular microrelief.
ST *	Sheet	The erosion of a thin layer of surface soil which can include small rills.
W	Wind	The movement of surface material by wind action, e.g. roots of crops exposed, or patches of seedlings blown away.

** - initially SH was used to designate Sheet erosion and some early profile description cards will have this code but ST is used within the Scottish Soils Database.*
[#] stored as uppercase in the database

Association – The two-letter symbol for the soil association that appears on 1:63 360 and larger scale maps was recorded either on-site (if known) or in the office after consultation with existing maps and reference documents. The soil association is defined as a grouping of soils developed on similar parent material. This is often based on stratigraphy, for example, soils derived from lower Old Red Sandstone sediments are a different association from those derived from upper Old Red Sandstone sediments.

Series - The two-letter symbol for the soil series that appears on 1:63 360 and larger scale maps was recorded either on-site or in the office. The soil series is defined as soils with a similar type and arrangement of horizons developed on similar parent material. These also, in the main, have the same drainage category but there are some exceptions to this with some series occurring across two drainage categories.

MU – This field (mapping unit) appears on the profile description card but was rarely used and is not part of the Scottish Soils Database. Its purpose was to record if the soil series described at the NSIS grid intersect was different from the soil mapping unit. The right-hand box with bold outline was used for any mapping unit subdivision or lower case letter “c” in labelling soil complexes

Series code – The series code is the 5 digit number devised to ensure that all soil series identified has a unique code. This was not the case for the two-letter series symbol which is not unique. The code is in 2 parts with the first three digits indicating the soil association and the final two, the soil series. Where the series was unknown or not yet mapped but the association was known, the association code was entered in the first three blank boxes of the proforma. The Association codes are numeric beginning with 003 for the Aberlour Association and continuing to 923 for the Yarrow Association. The Association names were ranked in alphabetical order and the numeric codes also reflect this ranking. The two letter series code primarily took account of the major soil subgroup, drainage category and texture as well as land use, presence of organic surface layers and soil thickness (see below). The link between drainage categories and the shallow or mountain soils was not rigidly applied:

	Wholly or in part cultivated: Brown Earth, Brown Calcareous, Brown Magnesian, Humus-iron podzol, Iron podzol, Humus podzol, Mineral* gleys			**Peaty podzol, Peaty gley, Humic gley**	**Skeletal, Ranker, Lithosol, Oroarctic (Alpine)**	
Drainage	**Texture**			**Organic**	**Shallow or mountain soil types**	
	Fine	Medium	Coarse			
Excessive	00	10	20	30	40	Skeletal
Free	01	11	21	31	41	Ranker
Free	02	12	22	32	42	Brown lithic
Free	03	13	23	33	43	Oroarctic
Imperfect	04	14	24	34	44	Sub alpine
Imperfect	05	15	25	35	45	Paleosol
Poor	06	16	26	36	46	Peaty lithic
Poor	07	17	27	37	47	
Very poor	08	18	28	38	48	
Very poor	09	19	29	39	49	

* includes noncalcareous and calcareous gleys

Type of Parent Material – No clear definitions of the types of parent material recognised were given though some descriptions appear in various soil memoirs.

Code	**Parent material**
Till	Unaltered till
Wm Till	Water-modified or layered till
Flg	Fluvioglacial
RBch	Raised beach
All	Alluvium including marine alluvium
Aeol	Aeolian
Col	Colluvium
Scree	Scree
Res	Residual or extremely stony
Mor	Moraine

Org	Organic deposit
Cry	Cryogenic deposit
Other	Other

Any parent material type designated as ‘other’ was explained in the NOTES section of the profile description proforma by the Surveyor.

Soil Classification – The soil classification fields on the profile description proforma were grouped into categories that reflected the major soil groups (*Soil Survey of Scotland. 1984. Organisation and Methods of the 1:250 000 Scale Soil Survey of Scotland. Macaulay Institute for Soil Research*): brown soils, gleys, podzols, rankers, alluvial soils and organic soils. Within these categories the major soil subgroup could be indicated. There was a further subdivision of the gley soils to indicate whether the soil was a surface-water (SWG) or ground-water (GWG) gley soil. If such a decision could not be made, the field marked ‘?’ was used.

Some of these codes were subsequently modified within the Scottish Soils Database. Please refer to the Soil Data Manager, for the most recent list.

Major soil group	Major soil subgroup code	Major soil subgroup
Brown Soils	Mag	Brown magnesian soil
	Calc	Brown calcareous soil
	For*	Brown forest soil*
	Pod	Brown podzolic soil
Gley Soils	Mag	Magnesian gley soil
	Cal#	Calcareous gley soil
	N/Cal	Noncalcareous gley soil
	Hum	Humic gley soil
	Pty	Peaty gley soil
	SubA’	Subalpine gley soil
	Alp’	Alpine gley soil
Podzols	Iron	Iron podzol
	Hum	Humus podzol
	Iron/H	Humus-iron podzol
	Pty	Peaty podzol
	Pty Gly	Peaty gleyed podzol
	SubA’	Subalpine podzol
	Alp’	Alpine podzol
Rankers	Brown	Brown ranker
	Gley	Gley ranker
	Hum	Humic ranker
	Pty	Peaty ranker
	Calc	Calcareous ranker

Other soils	Lith	Lithosol
	Reg	Regosol
Alluvial Soils	Min	Mineral alluvial soil
	Pty	Peaty alluvial soil
	Salt	Saline alluvial soil
Organic soils	Eu	Eutric
	Me	Mesic
	Dyst	Dystric

For* - these soils are now known as Brown earths with a major soil subgroup code of Eart
Cal[#] - stored as calc within the Scottish Soils Database
SubA' and Alp' – also known as hemioroarctic (SubA) and oroarctic (Alp)

Miscellaneous Map units – These fields indicated if the NSIS location fell on land with no soil cover. Relocation protocols described above were used to find a suitable site but if this was unsuccessful, the appropriate code from the list below was used.

Code	Description
BUA	Built-up area including roads
Rock	Rock outcrop
Water	Lochs, rivers, streams
QU	Quarry and associated disturbed ground
Col	Coal mine, tip
Other	

If 'Other' was indicated, then a full explanation was given in the notes section

Phase – The soil phase is in part a subdivision of some major soil subgroups and was originally introduced for mapping rather than profile classification. They are either management related or landscape related. Within the 1:25 000 scale soil mapping, many more soil phases are recognised (48) and only a few were used within the NSIS sampling programme. The full list is held as a table (PHASE_CODES) within the Oracle® Relational Database Management System.

Code	Description
Cult	Cultivated
Plag	Plaggen (man-made or man-affected outwith the normal management operations)
C/O	Cut-over (usually organic soils)
D Loch	Dubh-lochans (pools which form discrete, closely packed groups in areas of deep blanket peat)
Hag	Hagged or severely eroded peat

Other

If ‘Other’ was indicated, then a full explanation was given in the notes section

Rock Type – The dominant rock type(s) of the stones within a profile were recorded as a 1-3 digit code either in the field if the code was known or in the office after consultation with a list of codes (see Appendix 3). Up to two rock types could be recorded. Additional ones were recorded in the notes field. Data entry was right justified such that a soil with both greywackes (591) and granite rocks (1) was coded as

5	9	1			1

The dominant rock type code was recorded in the first three blank boxes of the profile description card

Climate – The climate of the NSIS location was taken from *Birse, E.L. 1971. Assessment of Climatic Conditions in Scotland. 3. the Bioclimatic Sub-Regions. Macaulay Institute for Soil Research. Aberdeen.* This 1:625 000 scale map classifies all of Scotland into climatic regions based on the degree of Oceanicity, wetness and temperature. Each of these regions has either a 5 or 6 digit code. The bioclimatic region was read from the climate map for the NSIS location and entered onto the profile description proforma in the office prior to entry to the Scottish Soils Database.

LCA – The Land Capability for Agriculture class with sub-class limitations is assessed using the monograph produced by *Bibby, J.S., Douglas, H.A., Thomasson, A.J. and Robertson, J.S. 1982. Land Capability Classification for Agriculture. Soil Survey of Scotland Monograph. The Macaulay Institute for Soil Research. Aberdeen.* The assessment was made of the land surrounding the NSIS profile pit. The profile description card had three blank boxes for this attribute, the first two for the LCA class and division while the third was used to record the limitation type:

3	1	W

LCF – The Land Capability for Forestry was rarely recorded primarily as the guidelines were only published towards the end of the NSIS sampling programme.

Base of Pit – Any attribute of the soil that restricted the depth of the profile pit was recorded in this field (see section on Soil Profile Description and Site Characterisation Protocols). If there were no restrictions, the ↓ symbol was ticked on the card and recorded in the Scottish Soils Database as ‘ARRO’

Code	Description
Rk	Solid rock
W RK	Weathered rock
B	Boulder
IND	Induration

FL	Pit flooded
↓	Bottom horizon continues down

* Coded as RK in the database

Location of Pit – The accuracy of the location of the profile pit in relation to the mark on the photograph as assessed by the surveyor (see section Methodologies and Protocols for Site Location).

Code	Description
A	located within the area delineated by the photo mark
B	within 10m of the area delineated by the photo mark
C	within 50m of the area delineated by the photo mark
D	approximate location only
SU	supplementary point (where a soil profile could not be located within 100m of the actual NSIS georeference)

Bulk Samples – There are 8 separate entry fields on the profile description card for soil sample depths. The first 5 have space for depths between zero and 99 cm while the remainder have space for depths of 100 to 999 cm. These were used to record the sample depths of each soil horizon sampled (if there were more than 8 horizons, the additional samples were recorded in the notes field and the box marked '*EXTRA BULK SAMPLES OVERLEAF*' was marked. The depth of the upper limit of the sample was recoded first and then the depth to the lower limit. Thus a sample from a topsoil at 10 to 20 cm depth was recorded as

1	0	2	0

and a sample at a depth of 95 to 105 cm (which was greater than the minimum depth required) was recorded as

	9	5	1	0	5

Within the database these depths are recorded as 1020 95105

LABNOS- once soil samples were booked into the sample preparation procedure they were allocated sample identification numbers (variously known as lab numbers or bible numbers). These numbers were added to the profile description proforma at a later date.

The next stage in the process of collecting the NSIS profile information was the description of the soil profile itself. The soil profile description proforma was further divided into two parts; one part to describe the organic layers and the other to describe the mineral layers. Although many of the soil attributes recorded were common to both types of horizon, there are significant differences that warrant separate protocols. Each horizon in the profile was identified and described in turn, generally from the surface downwards. There was space on the proforma card to describe up to 5 organic and 6 mineral horizons with additional horizon data either being recorded in the NOTES section or on a new card.

Organic Horizons

The first section was used to describe the organic horizons (L, F, H and O) present in the profile. Buried organic horizons were described in the mineral horizon section.

Horizon Symbol –The master and sub-horizon (or qualifier) symbol(s) classify the pedogenic properties of the horizon (see Appendix 4*).* In order to facilitate database searches, the master and sub-horizon symbol(s) had to be entered in a specific format, thus, numbers (where there were more than one horizon with the same master and sub-horizon symbol(s)) were only entered into the two right-hand blank boxes while the master horizon symbols were entered in boxes two and three. The information in these text fields (and the Scottish Soils Database) was right justified. For example;

	L	F		
		O		1
		O		2

Depth –The depth (in centimetres) of the base of the horizon as measured from the soil surface (including litter layers). These values were right justified.

		5
	2	0
1	0	0

Colour – The Munsell colour of the horizon was recorded with the hue number, right justified in boxes one and two (ignoring decimal points), the hue letters were also right justified in boxes three and four and the value and chroma in boxes five and six respectively. Values (degree of lightness) of 2.5 (of the only Munsell colour value with a half degree of difference) were recorded as 2. Thus colours 10YR3/2, 7.5YR2.5/1 and 5Y 2/2 were entered as:

1	0	Y	R	3	2
7	5	Y	R	2	1
	5		Y	2	2

Nature of O.M. – The nature of the organic horizon was subdivided into 3 categories; fibrous, semi-fibrous and amorphous:

Code	Type	Description
Fib	Fibrous	Plant remains are easily recognised; the original structure and some of the mechanical strength of the plant materials are maintained.
SF	Semi-fibrous	Consists mainly of partially decomposed plant remains which are recognisable but fibrous in appearance only; when moist, peat is soft and plastic in character.
Am	Amorphous	Absence of recognisable plant remains and highly decomposed.

Once identified, the type of organic matter was recorded by ticking the appropriate box on the profile description card. The codes were entered into the database in uppercase.

Moisture Status - The moisture status of the organic horizon was recorded in three categories: wet, moist, dry. These were field observations of the condition of the soil at the time of the profile description and are defined in terms of colour changes when wetted.

Code	Type	Description
W	Wet	Glistening water films visible on peds
M	Moist	Soil does not change colour when moistened
D	Dry	Colour darkens when wetted

Mineral Content – Some organic horizons have an admixture of mineral material ranging from a few sand grains to lenses of mineral material. In some cases the mineral material is mixed throughout the horizon. Although the distinction between Sandy peat and Loamy peat was defined in terms of the percentage of sand content, the field-based assessment was based on hand texturing and visual assessment.

Code	Type	Description
No*	None	No recognisable mineral grains present
SP	Sandy peat	Mineral fraction >50% sand
LP	Loamy peat	Mineral fraction <50% sand

* entered as uppercase in the database

Structure - The degree of aggregation within organic horizons was described using the same terminology as applied to mineral soils (see section **MINERAL SOILS**). This does not imply that the processes of aggregation were the same, but only that the size and shape of aggregates could be described in a similar fashion. The structure was visually assessed for three main criteria: degree, size and type of structure and recorded in blank boxes one, two and three respectively. Only the main soil structure was recorded for organic horizons and only those definitions relevant to organic horizons are described below.

Degree (Taken from *Soil Survey Field Handbook, Hodgson, 1974 and Soil Survey Manual, Soil Survey Staff, 1951*). The degree of aggregation is divided into four main categories (with further subdivisions of weakly and strongly developed categories)

> ***Apedal (or structureless)*** – no observable aggregation, that is, without a definite orderly arrangement of natural lines of weakness. Apedal is divided into 2 categories, single grain (which does not occur in organic horizons) and massive:
>
> ***Massive*** – when disturbed soil breaks into masses which may be easily crushed (or broken) into smaller pieces or may be strongly coherent. The ease with which they can be crushed is described under 'Consistence'. Massive soil materials can have a wide range of consistence properties".
>
> ***Weakly Developed*** (***Very Weakly Developed***) – poorly formed, indistinct, weakly coherent peds that are barely observable in place.
>
> ***Moderately Developed*** – well formed moderately durable peds which are evident but not distinct in undisturbed soil.
>
> ***Strongly Developed*** (***Very Strongly Developed)*** – durable peds that are quite evident in displaced soil, adhere weakly to one another and withstand displacement, separating cleanly when the soil is disturbed.

Size and Shape

The size and shape of peds were described in terms defined in *Soil Survey Manual, Soil Survey Staff, 1951* and are more appropriate to mineral soils, however, the same size and shape classes were also applied to organic horizons.

Size and shape of aggregates

Size	Shape and arrangement of peds and fragments				
	Platy [1]	*Prismatic* [2]	*Angular blocky* [3]	*Subangular blocky3*	*Granular3*
Very Fine	Very fine platy; < 1mm	Very fine prismatic; <10 mm	Very fine angular blocky; <5 mm	Very fine subangular blocky; <5 mm	Very fine granular; <1 mm
Fine	Fine platy; 1to 2 mm	Fine prismatic; 10 to 20 mm	Fine angular blocky; 5 to 10 mm	Fine subangular blocky; 5 to 10 mm	Fine granular; 1 to 2 mm
Medium	Medium platy; 2 to 5 mm	Medium prismatic; 20 to 50 mm	Medium angular blocky; 10 to 20 mm	Medium subangular blocky; 10 to 20 mm	Medium granular; 2 to 5 mm
Coarse	Coarse platy; 5 to 10 mm	Coarse prismatic; 50 to 100 mm	Coarse angular blocky; 20 to 50 mm	Coarse subangular blocky; 20 to 50 mm	Coarse granular; 5 to 10 mm
Very Coarse	Very coarse platy; >10mm	Very coarse prismatic; >100 mm	Very coarse angular blocky; >50 mm	Very coarse subangular blocky; >50 mm	Very coarse granular; >10 mm

Reproduced from *Soil Survey Manual, Soil Survey Staff, 1951*

1 Aggregates where the horizontal length is much greater than the vertical size. Platy structure is described as lenticular when plates are thick in the middle and thin towards their edges.

2 Aggregates where the vertical length is much greater than the horizontal.

3 Aggregates which are block-like, polyhedron-like, or spheroidal, Subdivisions are made according to the angularity or roundness of the aggregates.

Data on soil structure were recorded onto the profile description proforma as a series of codes shown below:

Degree		***Size***		***Shape***	
VW	Very weak	VF	Very fine	M	Massive
W	Weak	F	Fine	PL	Platy
M	Moderate	M	Medium	PR	Prismatic
S	Strong	C	Coarse	AB	Angular blocky
VS	Very strong	VC	Very coarse	SAB	Subangular blocky
				GR	Granular
				SG	Single Grain

Box one was used to record the '*Degree*', box two for '*Size*', and box three for the '*Shape*' of the primary.

W	M	SAB

Weak Medium Subangular Blocky

		M

Massive

Roots - The frequency, size and kind of the dominant root type were recorded for each horizon in blank boxes one, two and three respectively and secondary roots in boxes 4, 5 and 6.

Frequency - Root frequency is determined by estimating the number of roots in 100 cm^2 area of soil on the profile face or by comparisons with dot diagrams. See below which is taken from *Soil Survey Field Handbook, Hodgson, 1974*. The frequency category codes were entered in blank boxes one and four, if applicable (see below).

Code	***Frequency Class***	***Number of roots per 100 cm^2***	
		Very fine and fine roots	*Medium and coarse roots*
N	None	0	0
F	Few	1-10	1 or 2
C	Common	10-25	2-5
M	Many	26-200	>5
A	Abundant	>200	-

Size - The diameter of roots were measured or assessed visually and the category code entered in blank boxes two and five if applicable.

Code	***Size class***	***Size range (mm)***
VF	Very fine	<1
F	Fine	1-2
M	Medium	2-5
C	Coarse	5-10
VC	Very coarse	>10

Kind - The nature or type of the roots was recorded in blank boxes three and six.

Code	***Root type (Kind)***	***Example root types***
FL	Fleshy	tap roots or bracken root stock
FI	Fibrous	grass roots
W	Woody	larger tree roots
R	Rhizomatous	rhizomes

Thus, a horizon with Abundant Fine Fibrous and Common Medium Woody roots would be coded as:

A	F	FI	C	M	W

Stones - the frequency, size and shape of the dominant and secondary stone sizes only were recorded. This may mean that the frequency and shape of different sized stones were not recorded though there was the option to record additional stone sizes in the notes section of the proforma. The frequency, size and shape of any stones were recorded in blank boxes one, two and three respectively for the dominant stone size and blank boxes four to six for the secondary stone size.

Frequency - The frequency of stones refers to the percentage by volume of stones in the horizon and was visually assessed in the field. A total of six frequency classes were used:

Code	***Frequency class***	***Volume (%)***
N	None	0
F	Few	1 - 5
C	Common	6-15
M	Many	16-35
A	Abundant	36-70
VA	Very abundant	>70

Size - The size range of the stones were estimated or measured in the field and placed into one of 6 categories. The size was based on the long axis of the stone. Stones > 60cm were classified as boulders. The stone size was entered into blank boxes two and five for dominant and secondary stone size respectively.

Code	***Size class***	***Size range (cm)***
VS	Very small	<0.6
S	small	0.6-2
M	Medium	2-6
L	Large	6-20
VL	Very large	20-60
B	Boulder	>60

Shape – The categories of stone shapes that have more or less equal sized axes are rounded, subrounded, subangular or angular. The specific category depends on the degree to which the stones have had the sharp edges worn away by erosion, transport or weathering and is a largely subjective assessment. Stones with unequal axes are described as being platy. The codes are entered in blank boxes three and six.

Code	***Shape category***
R	Rounded
SR	Subrounded
SA	Subangular
A	Angular
PL	Platy

Boundary – Although horizon boundaries are three-dimensional, they are normally described in two-dimensions as observed on the face of the soil pit. The characteristics of the boundary between two horizons are described in terms of the thickness of the transition zone and the form of the boundary, that is, the degree of irregularity observed on the pit face. The code for boundary thickness is entered into the first blank box on the proforma and the code for the form of the boundary is entered in the second blank box.

Thickness - The distinctness of a horizon boundary depends partly on the contrast between adjacent horizons and partly on the thickness of any transitional zone.

Code	***Category***	***Thickness of transition zone (cm)***
S	Sharp	<2
C	Clear	2 - 5
G	Gradual	5 - 12
D	Diffuse	>12

Form - The form of the horizon boundary is the degree of irregularity and is described as a two dimensional feature.

Code	***Category***	***Description***
Sm*	Smooth	Nearly planar
W	Wavy	Pockets wider than deep
I	Irregular	Pockets deeper than wide
B	Broken	Not continuous

* Coded as uppercase in the database

Mineral Horizons

The second section was used to describe the mineral horizons present in the profile. While much of this information is repeated from the section above, there are significant differences and not all profiles have both organic and mineral horizons.

Horizon Symbol – The master and sub-horizon (or qualifier) symbol(s) classify the pedogenic properties of the horizon (see Appendix 4*).* In order to facilitate database searches, the master and sub-horizon symbol(s) had to be entered in a specific format, thus, numbers (where there were more than one horizon with the same master and sub-horizon symbol(s)) were only entered into the two right-hand blank boxes while the master horizon symbols were entered in boxes two and three. The information in these text fields (and the Scottish Soils Database) was right justified. For example;

		A	h	1
		A	h	2
	B	C	s	g

The first box was reserved for a numeric if there were more than one horizon with the same designation or there was a lithological change in parent material or where the horizon was buried, a 'b'

Depth –The depth (in centimetres) of the base of the horizon as measured from the soil surface (including litter layers). These values were right justified.

		5
	2	0
1	0	0

Colour – The Munsell colour of the horizon was recorded with the hue number, right justified in boxes one and two (ignoring decimal points), the hue letters were also right justified in boxes three and four and the value and chroma in boxes five and six respectively. Values (degree of lightness) such 2.5 were recorded as 2. Thus colours 10YR3/2, 7.5YR2.5/1 and 5Y 2/2 were entered as:

1	0	Y	R	3	2
7	5	Y	R	2	1
	5		Y	2	2

Unlike organic horizons, the colour of mineral horizons was recorded for the soil matrix (COL_MAT); soil mottles of two kinds, if present (COL_MOT1 and COL_MOT2); ped faces (COL_PED) There was also a space to describe the overall matrix colour of the soil in the dry state if required (COL_DRY).

Mottle – Mottling is caused by temporary and periodic reducing conditions in the soil. Only the frequency, size, contrast and sharpness of the dominant mottle type in the horizon were described to avoid complex descriptions when many colours are present. If other mottles existed in the horizon these were described in the notes section. Each line of the profile description proforma included the relevant codes to describe each individual component of soil mottling required.

Frequency – The percentage area of the horizon face covered by mottles present was visually estimated. Diagrams showing proportions of area covered for different patterns of mottling were given in Hodgson (1974) and were used as a guide in the field.

Code	***Frequency Class***	***Area covered (%)***
N	None	0
F	Few	<2
C	Common	2-20
M	Many	21-40
A	Abundant	>40

Size – The diameter of mottles was measured and allocated to one of four different size classes described where appropriate.

Code	***Size class***	***Size range (mm)***
VF	Very fine	<2
F	Fine	2-5
M	Medium	5-15
C	Coarse	>15

Contrast – The difference between mottle colour and the matrix is known as the degree of contrast and this was visually estimated based on the following descriptions:

Code	***Category***	***Description***
F	Faint	Similar colour to matrix
D	Distinct	Readily seen
P	Prominent	Colour very different to matrix

Sharpness – The sharpness of the mottle edge was visually estimated.

Code	***Category***	***Description***
S	Sharp	Knife edge
C	Clear	<2 mm
D	Diffuse	>2 mm

Texture – During the NSIS sampling programme, the United States Department of Agriculture (USDA) soil texture classes were in use. These were replaced by the British Standard Texture Classification (BSTC) in January 1986. Twelve USDA texture classes were recognised (Figure 1). In the field, soil texture class was estimated by hand using the feel of the soil in a moist state, how the soil behaved when rolled and, on some occasions the sound the soil made when rubbed between the fingers. Flow charts were available to guide surveyors and regular checks were made between estimates by hand and actual measured particle size.

Figure 1 USDA Soil Textural Classification: Soil Survey Manual, Natural Resources Conservation Service.

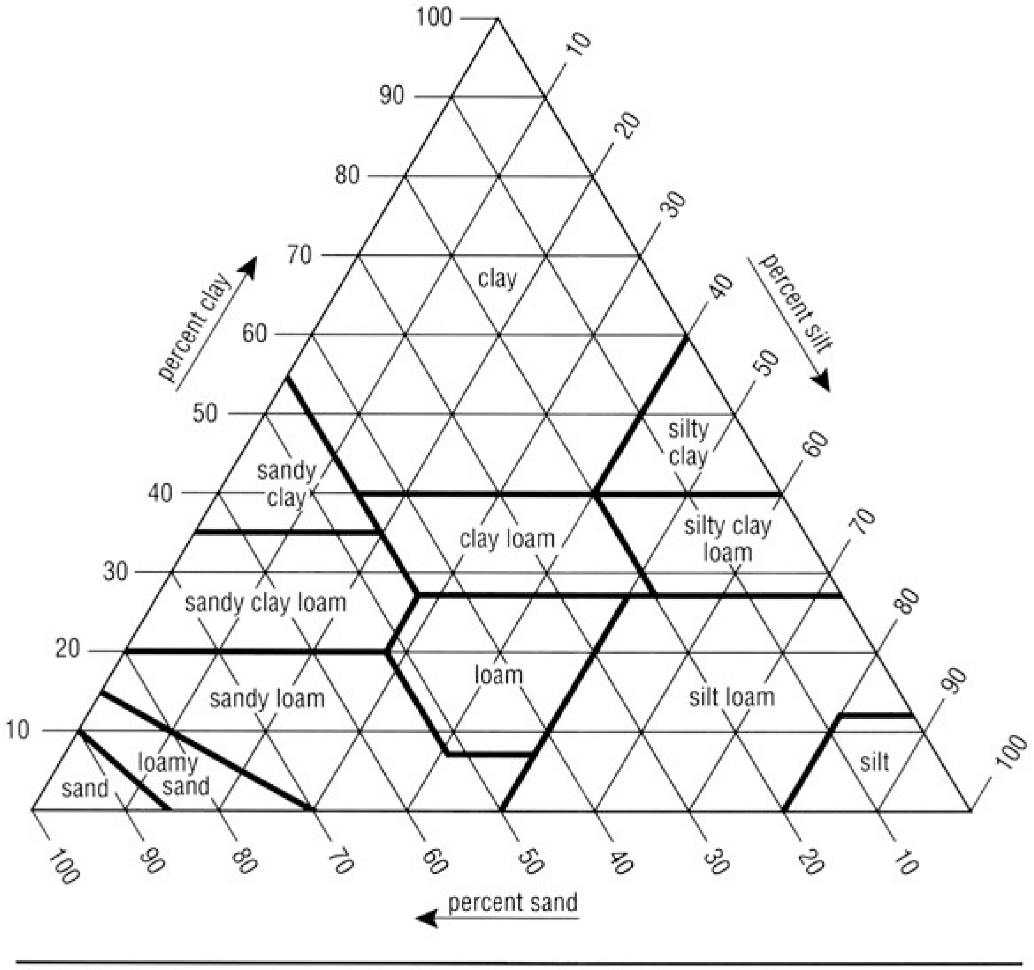


Chart showing the percentages of clay, silt, and sand in the basic textural classes.

Codes for USDA/FAO texture classes

S	Sand	SCL	Sandy clay loam	CL	Clay loam
LS	Loamy sand	ZL	Silt loam	SC	Sandy clay
SL	Sandy loam	ZCL	Silty Clay loam	C	Clay
L	Loam	ZC	Silty clay	Z	Silt

Qualifiers such as fine, medium and coarse were used for the sandy textures (sand, loamy sand and sandy loam) and humose was used as a qualifier for all textures. These qualifiers are shown on the upper row of the soil texture field on the soil profile description proforma and the remaining boxes have the codes for the soil texture classes. Although only one texture box could be selected, it was permissible to have two qualifiers, e.g. HFSL=Humose fine sandy loam. Although these qualifiers were defined in terms of proportions of sand content in specific size ranges, the field assessment was made solely on the feel of the soil.

Definition for texture qualifiers

F Fine – more than two-thirds of the sand fraction (0.06-2 mm) is between 0.06 and 0.2 mm.

M Medium – less than two-thirds of the sand fraction is between 0.06 and 0.2 mm and less than one-third of the sand fraction is larger than 0.6 mm.

C Coarse – more than one-third of the sand fraction is larger than 0.6 mm.

H Humose – has insufficient organic matter to be classed as organic but has:
a) more than 7% organic carbon (12% organic matter) if the mineral fraction (<2 mm) has 50% or more clay, or
b) more than 4.5% organic carbon (8% organic matter) if the mineral fraction has no clay, or
c) proportional organic carbon contents if the clay content is between 0 and 50%.

(from Hodgson, 1974)

Structure – Soil structure is the degree of aggregation within soils where the primary soil particles such as sands, silts and clays are bound together in a semi-permanent state. The primary soil structure was visually assessed for three main criteria: degree, size and type of structure and recorded by ticking the appropriate box on the soil profile description proforma which best describes the degree (top row of boxes), the size (row 2) and type (rows three and four) of structure. Where two structures were present, e.g. moderate, medium angular blocky breaking to weak fine granular, the symbol for the secondary structure is entered in the appropriate order in the three blank boxes with heavy outline on row four of the structure attribute field on the profile description card.

Degree (Taken from Soil Survey Field Handbook, Hodgson, 1974 and Soil Survey Manual, Soil Survey Staff, 1951)

"The degree of ped development is distinguished in the field by the proportion of the soil appearing as peds and by the frequency and distinctness of natural surfaces that persist through cycles of wetting and drying. It reflects both cohesion within peds and adhesion between neighbouring peds. It is assessed by the ease with which the soil separates into peds and their durability when separated. Grade varies with soil-water state, and is normally described at the soil-water state in which the soil is found. The terms describing the degree of ped development are as follows:

> ***Apedal (or structureless)*** – no observable aggregation; without a definite orderly arrangement of natural lines of weakness. Apedal are divided into:
>
> ***Single grain*** – soil which separates when disturbed into individual primary particles with such coatings as adhere to them. The primary particles may however be held together by surface tension when very moist or wet.
>
> ***Massive*** – when disturbed soil breaks into masses which may be easily crushed (or broken) into smaller pieces or may be strongly coherent. The ease with which they can be crushed is described under 'Consistence'. Massive soil materials can have a wide range of consistence properties".
>
> ***Weakly Developed*** – poorly formed, indistinct, weakly coherent peds that are barely observable in place. When disturbed, the soil breaks into a few entire peds, many broken peds and much unaggregated material. A ***very weakly developed*** grade is recognised where it can be distinguished consistently from better developed structure within the weakly developed class.
>
> ***Moderately Developed*** – well formed moderately durable peds which are evident but not distinct in undisturbed soil. When disturbed, the soil breaks down into a mixture of many distinct entire peds, some broken peds and a little unaggregated material.
>
> ***Strongly Developed*** – durable peds that are quite evident in undisplaced soil, adhere weakly to one another and withstand displacement, separating cleanly when the soil is disturbed. Disturbed soil material consists very largely of entire peds and includes a few broken peds and little or no unaggregated material. If the soil separates with little manipulation into entire, durable peds, the grade of the soil may be described as ***very strongly developed***.

Size and Shape

The size and shape of peds are described in terms defined in Soil Survey Manual, Soil Survey Staff, 1951 (Table 2).

Size and Shape of Peds and Fragments

Size	***Shape and arrangement of peds and fragments***				
	Plate-like with one dimension (the vertical) limited and much less than the other two; arranged around a horizontal plane; faces mostly horizontal	Prism-like with two dimensions (the horizontal) limited and considerably less than the vertical; arranged around a vertical line; vertical faces well defined; vertices angular	Block-like, polyhedron-like, or spheroidal, with three dimensions of the same order of magnitude, arranged around a point		
			Block-like; blocks or polyhedrons having plane or curved surfaces that are casts of the moulds formed by the faces of the surrounding peds		Spheroids or polyhedrons having plane or curved surfaces with slight or no accommodation to the faces of surrounding peds
			Faces flattened; most vertices sharply angular	Mixed rounded and flattened faces with many rounded vertices	
	Platy [1]	*Prismatic* [2]	*Angular* [3] *blocky*	*Subangular blocky*	*Granular*
Very Fine	Very fine platy; < 1mm	Very fine prismatic; <10 mm	Very fine angular blocky; <5 mm	Very fine subangular blocky; <5 mm	Very fine granular; <1 mm
Fine	Fine platy; 1to 2 mm	Fine prismatic; 10 to 20 mm	Fine angular blocky; 5 to 10 mm	Fine subangular blocky; 5 to 10 mm	Fine granular; 1 to 2 mm
Medium	Medium platy; 2 to 5 mm	Medium prismatic; 20 to 50 mm	Medium angular blocky; 10 to 20 mm	Medium subangular blocky; 10 to 20 mm	Medium granular; 2 to 5 mm
Coarse	Coarse platy; 5 to 10 mm	Coarse prismatic; 50 to 100 mm	Coarse angular blocky; 20 to 50 mm	Coarse subangular blocky; 20 to 50 mm	Coarse granular; 5 to 10 mm
Very Coarse	Very coarse platy; >10mm	Very coarse prismatic; >100 mm	Very coarse angular blocky; >50 mm	Very coarse subangular blocky; >50 mm	Very coarse granular; >10 mm

1 Platy structure is described as lenticular when plates are thick in the middle and thin towards their edges.

2 Aggregates similar to prisms but with rounded tops are described as columnar. Columnar aggregates are rare in the British Isles.

3 Aggregates with approximately tetrahedral form found in some soils can be described, for example, as '*tetrahedral angular blocky*'.

Data on soil structure were recorded onto the profile description proforma as a series of codes shown below. Unlike the soil structure description of the organic layers, the soil structure classes for the primary structure in mineral layers were printed on the proforma, requiring only the relevant category to be ticked. Secondary structures were recorded by writing in the appropriate codes into a series of blank boxes:

Degree		***Size***		***Shape***	
VW	Very weak	VF	Very fine	M	Massive
W	Weak	F	Fine	PL	Platy
M	Moderate	M	Medium	PR	Prismatic
S	Strong	C	Coarse	AB	Angular blocky
VS	Very strong	VC	Very coarse	SAB	Subangular blocky
				GR	Granular
				SG	Single Grain

Box one was used to record the '*Degree*', box two for '*Size*', and box three for the '*Shape*' of the primary structure while boxes four, five and six were used to record the '*Degree*' '*Size*' and '*Shape*' of any secondary structure.

W	M	SAB

Weak Medium Subangular Blocky

		M

Massive

Massive and single soil structures have no degree or size.

Consistence – Consistence refers to soil characteristics determined by the kind of cohesion and adhesion. It describes the strength, characteristics of failure, stickiness, plasticity, cementation and induration. Strength and characteristics of failure vary widely with soil-water state and therefore the moisture status of the soil at the time of assessment is also recorded. In general, cohesion is assessed under conditions of the natural soil moisture status which has a degree of subjectivity though guidelines are given to assess this status in the field. The codes are printed on the proforma and the categories that describe the soil conditions were ticked.

Moisture Status – the moisture status was recorded on the top row of the Consistence attribute field using the 5 categories listed below:

Code	***Category***	***Description***
W	Wet	Glistening water films visible on peds and particles
VM	Very moist	At or near field capacity. Fingers quickly moistened when soil is handled
M	Moist	Soil does not change colour when moistened
SM	Slightly moist	Soil only darkens slightly when moistened
D*	Dry	Colour darkens when wetted

* Not shown on card

Consistence when the soil was wet

When the soil was wet, the consistence was described in terms of both the plasticity and stickiness of the soil in the following categories:

Plasticity

Code	Category	Description
NP	Non-plastic	Will not form a 4 cm x 6 mm wire
SP	Slightly plastic	Will form a 4 cm x 6 mm wire but easily fractured or deformed
P	Plastic	4 cm x 4 mm wire easily formed
VP	Very plastic	4 cm x 2 mm wire easily formed

Stickiness

Code	Category	Description
NS	Non-sticky	Does not adhere to fingers
SS	Slightly sticky	Adheres to finger or thumb when pressed
S	Sticky	Adheres to finger and thumb when pressed
VS	Very sticky	Adheres strongly to finger and thumb

The data were recorded on the second line of the consistence attribute field on the proforma by ticking the appropriate box. Both boxes for Plastic and Very plastic and for Sticky and Very sticky were subdivided so care was required when recording this information on the proforma and when entering into the Scottish Soils Database.

Consistence when the soil was moist

When the soil was very moist, moist or slightly moist, the consistence was described in terms of the coherence and the pressure required to crush the soil in the following categories:

Code	***Category***	***Description***
L	Loose	Non-coherent
VF	Very friable	Crushes under very gentle pressure and coheres
FR	Friable	Crushes easily under gentle or moderate pressure and coheres
FI	Firm	Crushes under moderate but noticeable pressure
VF	Very firm	Crushes only under strong pressure, but can only just be crushed between finger and thumb
EF	Extremely firm	Crushes only under very strong pressure, cannot be crushed between finger and thumb

This information was recorded on the third line of the consistence attribute field on the proforma. As there was some confusion between the codes, some of these were later changed and are recorded in the Scottish Soils Database as L, VFRI, FRI, FRM, VFRM and EFRM for Loose, very friable, friable, firm, very firm and extremely firm respectively.

Consistence when the soil was dry

When the soil was dry, the consistence was described in terms of the pressure required to break soil aggregates in the following categories:

Code	***Category***	***Description***
L	Loose	Non-coherent
S	Soft	Only very weakly coherent, breaks very easily
SH	Slightly hard	Weak resistance to pressure but broken easily between finger and thumb
H	Hard	Moderate resistance to pressure, but can only just be broken between finger and thumb
VH	Very hard	Very resistant to pressure but can be broken in the hands
EH	Extremely hard	Cannot be broken by hand

Induration –An indurated horizon has a high degree of compactness and density, which means that considerable physical effort is required to dig through these soil layers. Indurated horizons are much more resistant to vertical than horizontal disruption and will generally exhibit some degree of explosive (brittle) failure when small pieces are compressed along its horizontal axis. Strongly and moderately indurated horizons are generally not penetrated by roots even though a characteristic of these layers is the presence of narrow round holes. Three categories of induration were recognised and were recorded on the proforma by ticking the appropriate box which best describes any induration present in the horizon.

Code	***Category***	***Description***
W	Weak	No great force is required to break the specimen, but a well defined brittle fracture is present
M	Moderate	Can be broken with some effort with the hands
S	Strong	Cannot be broken with the hands, can only be crushed under foot or with a hammer

Cementation –Cementation of soil is caused by substances such as calcium carbonate, humus, silica or compounds of iron, manganese or aluminium. A cemented soil does not slake when an air-dried block is placed in water for one hour. However, if only weakly cemented, the hardness of the soil mass will be somewhat reduced by the same treatment, but the brittle fracture will be retained. Three categories of cementation were recognised and were recorded on the proforma by ticking the appropriate box which best describes any cementation present in the horizon.

Code	***Category***	***Description***
W	Weak	Brittle and hard but can be easily broken by the hand. When placed between extended forefinger and thumb, the applied pressure will force the soil mass to explode rather than crumble
M	Moderate	Brittle but can only be broken with extreme pressure in the hand. Easily broken with a hammer
S	Strong	Can only be broken by a hammer, which generally rings as a result of the blow

Roots - The frequency of the main type (*kind*) of roots was recorded along with their size and type for each horizon. The data entry to the proforma was slightly different to the recording of roots in organic layers in that the frequency of the primary root type was recorded on line one of the attribute field with size and type on line two and three respectively. Any additional root type was recoded in additional blank boxes by entering the codes listed below.

Frequency - Root frequency is determined by estimating the number of roots in 100 cm^2 area of soil on the profile face or by comparisons with dot diagrams. See Table 3 (*Taken from Soil Survey Field Handbook, Hodgson, 1974*). The frequency category code was ticked on line one of the attribute field for the main root type or entered as a code in blank box one for an additional root type.

Code	***Frequency Class***	***Number of roots per 100 cm²***	
		Very fine and fine roots	*Medium and coarse roots*
N	None	0	0
F	Few	1-10	1 or 2
C	Common	11-25	2-5
M	Many	26-200	>5
A	Abundant	>200	-

Size - The diameter of roots were measured or assessed visually and the category code ticked on line two for the main root type while the size of the secondary roots was entered as a code in blank box two.

Code	***Size class***	***Size range (mm)***
VF	Very fine	<1
F	Fine	1-2
M	Medium	2-5
C	Coarse	5-10
VC	Very coarse	>10

Kind - The nature or type of the roots was recorded by ticking the category code on line three while the type of the secondary roots was entered as a code in blank box three.

Code	***Root type (Kind)***	***Example root types***
FL	Fleshy	tap roots or bracken root stock
FI	Fibrous	grass roots
W	Woody	larger tree roots
R	Rhizomatous	rhizomes

Stones - the frequency, size and shape of the dominant stone size and of a secondary stone size only were recorded. This may mean that the frequency and shape of different sized stones were not recorded though there was the option to record additional stone sizes in the notes section of the proforma. The data entry to the proforma was slightly different to the recording of stones in organic layers in that the frequency of the primary stone size was recorded on line one of the attribute field with size and shape on line two and three respectively by simply ticking the appropriate codes. Any additional stones were recoded in blank boxes 4, 5 and 6 by entering the codes listed below.

Frequency - The frequency of stones refers to the percentage by volume of stones in the horizon and was visually assessed in the field. A total of six frequency classes were used:

Code	***Frequency class***	***Volume (%)***
N	None	0
F	Few	1 - 5
C	Common	6-15
M	Many	16-35
A	Abundant	36-70
VA	Very abundant	>70

Stone frequency for secondary stone types was recorded in blank boxes four to six with the first three reserved for recording the lithology of the primary stones (see Appendix 3) with the numeric code being right justified as before (Rock Type attribute field). Lithology of the secondary stones were recorded on the form in boxes seven to nine as right justified numeric codes (Appendix 3).

Size - The size range of the stones were estimated or measured in the field and placed into one of 6 categories. The size was based on the long axis of the stone. Stones > 60cm were classified as boulders. The stone size was entered into boxes on line two for the dominant stone type and in blank box five for a secondary stone size.

Code	***Size class***	***Size range (cm)***
VS	Very small	<0.6
S	small	0.6-2
M	Medium	2-6
L	Large	6-20
VL	Very large	20-60
B	Boulder	>60

Shape – The categories of stone shapes that have more or less equal sized axes are rounded, subrounded, subangular or angular. The specific category depends on the degree to which the stones have had the sharp edges worn away by erosion, transport or weathering and is a largely subjective assessment. Stones with unequal axes are described as being platy. The codes for stone shape were recorded on line three of the attribute field for primary stones and in blank box six for secondary stones.

Code	*Shape category*
R	Rounded
SR	Subrounded
SA	Subangular
A	Angular
PL	Platy

Boundary – Although horizon boundaries are three-dimensional, they are normally described in two-dimensions as observed on the face of the soil pit. The characteristics of the boundary between two horizons are described in terms of the thickness of the transition zone and the form of the boundary, that is, the degree of irregularity observed on the pit face. The code for boundary thickness is recorded by ticking the appropriate code in the upper line of codes and the form of the boundary is recorded by ticking the appropriate code in the lower line of codes.

Thickness - The distinctness of a horizon boundary depends partly on the contrast between adjacent horizons and partly on the thickness of any transitional zone.

Code	*Category*	*Thickness of transition zone (cm)*
S	Sharp	<2
C	Clear	2 - 5
G	Gradual	5 - 12
D	Diffuse	>12

Form - The form of the horizon boundary is the degree of irregularity and is described as a two dimensional feature.

Code	*Category*	*Description*
S	Smooth	Nearly planar
W	Wavy	Pockets wider than deep
I	Irregular	Pockets deeper than wide
B	Broken	Not continuous

Notes – At the end on the profile description card there is a space for adding any additional information that could not be recorded on the allocated spaces within the proforma. There is also space to record any other relevant information regarding site or soil, such as:

Veg: - This includes a list of the plant species (and an assessment of cover of each where possible) at the site to aid in the determination of the plant community.

Sketch – An annotated sketch of site location could be drawn if necessary.

Additional Samples - The depths and horizon symbol of any additional samples were listed.

APPENDIX 3 ROCK TYPES

The frequency, size and shape of stones within the soil were coded according to standard terms. However, rock type was also recorded using the following codes. The original list was not exhaustive and rock types were added when required.

IGNEOUS ROCKS (1-200)			
	GRAIN SIZE		
	COARSE	MEDIUM	FINE
ACID	GRANITE 1 GRANOPHYRE 2 PEGMATITE 3 TRONDHJEMITE 4 ADAMELLITE 5 GRANODIORITE 6 FOLIATED GRANITE 7 UNDIFF ACID 15	MICROGRANITE 16	RHYOLITE 31 ACID PITCHSTONE 32 QUARTZ PORPHRY 33 FELSITE 34
INTER-MEDIATE	SYENITE 46 DIORITE 47 MONZONITE 48 UNDIFF INTERMED 60	MICROSYENITE 61 MICRODIORITE 62	TRACHYTE 76 ANDESITE 77 INTERMED PITCHSTONE 78
BASIC	GABBRO 91 EUCRITE 92 ALLIVALITE 93 MUGEARITE 94 HARRISITE 95 TESCHENITE 96 KENTALLENITE 97 UNDIFF BASIC 105	DOLERITE 106 QUARTZ DOLERITE 107 OLIVINE DOLERITE 108	BASALT 121 CRINANITE 122 PNEUMATOLYSED BASALT 123
ULTRA-BASIC	PERIDOTITE 136 PYROXENITE 137 HORNBLENDITE 138 PICRITE 139 SERPENTINITE 140 INDIFF U/BASIC 180		

PYROCLASTIC ROCKS			
VERY COARSE	COARSE	FINE	NON-CRYSTALLINE
AGGLOMERATE 181	VOLCANIC BRECCIA 187	TUFF 191	GLASS 196 PUMICE 197

METAMORHIC ROCKS (201–500)		
	NORMAL FABRIC	**ROCK TYPE**
UNFOLIATED	HORNSFELIC	HORNFELS 201
	GRANULOSE	DOLOMITE 221 ECLOGITE 222 EPIDIORITE 223 LIMESTONE 224 MARBLE 225 QUARTZITE 226
FOLIATED (flaky minerals occurring in layers)	POORLY FOLIATED	AMPHIBOLITE 241 ARGILLITE 242 CHARNOCKITE 243 GRANULITE 244
	STRONGLY DEVELOPED CLEAVAGE PLANES	SLATE 261 BLACK SLATE 262
	CLEAVAGE PLANES BECOMING SCHISTOSE	PHYLLITE 281
	SCHISTOSE (finely foliated)	ANDALUSITE SCHIST 301 ANDALUSITE-CORDIERITE SCHIST302 CALCAREOUS SCHIST 303 CHLORITE SCHIST 304 EPIDOTE-CHLORITE SCHIST 305 GARNET SCHIST 306 GLAUCOPHANE SCHIST 307 GRAPHITE SCHIST 308 HORNBLENDE SCHIST 309 MICA SCHIST 310 QUARTZ SCHIST 311 QUARTZ-MICA SCHIST 312 SCHISTOSE GRIT 313 SCHISTOSE FLAGS 314 SILLIMANITE SCHIST 315 STAUROLITE SCHIST 316 TALC SCHIST 317 BLACK SCHIST 318 ARGILLACEOUS SCHIST 319 UNDIFF SCHIST 380
	GNEISSIC	UNDIFF GNEISS 440
	INJECTED WITH GRANITE	MIGMATITE 441 BIOTITE GNEISS 442 GRANITIC GNEISS 443
BRECCIATED	MYLONITIC	MYLONITE 461
	AUGEN	AUGEN GNEISS 481

SEDIMENTARY ROCKS (500-700		
GRAIN SIZE	**ROCK TYPE**	
AMORPHOUS-MICROCRYSTALLINE	FLINT CHERT QUARTZITE	500 501 502
CLAYEY	MUDSTONE CALCAREOUS MUDSTONE CLAY SHALE DIATOMITE	521 522 523 524
SILTY	SILTSTONE SILTY SHALE FLAGSTONE UNDIFF SHALE	541 542 543 555
SANDY	FELSPATHIC SANDSTONE MICACEOUS SANDSTONE SILICEOUS SANDSTONE CALCAREOUS SANDSTONE ARKOSE SANDSTONE FERRUGINOUS SANDSTONE GRIT ARKOSE GRIT AEOLIAN SANDSTONE UNDIFF SANDSTONE	561 562 563 564 565 566 567 568 569 590
MIXED	GREYWACKE	591
COARSE	BRECCIA COMGLOMERATE	611 612
CARBONATIC	LIMESTONE SHELLY LIMESTONE OOLITIC LIMESTONE PISOLITIC LIMESTONE CHALK CORNSTONE DOLOMITIC LIMESTONE	631 632 633 634 635 636 637
CARBONACEOUS	COAL	681

APPENDIX 4 SOIL HORIZON NOMENCLATURE

Horizon nomenclature
In order to compare and classify soil profiles, it is convenient to designate soil horizons by a letter notation, the same letter being applied to similar horizons in profiles of similar type. The internationally approved symbols used are set out below.

Master horizons.
A master horizon is represented by one of nine capital letters: L, F, H, O, A, E, B, C or R. An Arabic figure following a letter indicates vertical subdivision (e.g. C1, C2). A transitional horizon with properties of two master horizons is shown by the combination of two capital letters (e.g. AE, BC). In layered parent materials, an Arabic numeral is used as a symbol prefix when it is necessary to distinguish lithological or textural contrasts (e.g. 2C when the C horizon differs from the material in which the solum, i.e. A and B horizons, is presumed to have formed.

L	Fresh annual litter, normally loose, original plant structures obvious.
F	Decomposed litter, only some of the original plant structures obvious.
H	Well-decomposed organic matter formed under aerobic conditions. Plant structures not visible. May be mixed with some mineral matter. (Mor humus).
O	Peaty material formed under wet, anaerobic conditions.
A	Mineral horizon formed at or near the surface that shows an accumulation and incorporation of organic matter, or which has morphology acquired by soil formation but lacks the properties of E or B horizons.
E	Eluvial horizon underlying an H, O or A horizon from which it can normally be differentiated by a lower content of organic matter and lighter colour, particularly when dry. Usually shows a concentration of sand and silt fractions with a large component of resistant minerals resulting from a loss of clay, iron or aluminium.
B	Mineral horizon in which there is little or no obvious rock structure and having one or both of the following: 1. alteration of the original material involving solution and removal of carbonates; formation, liberation or residual accumulation of silicate clays or oxides; formation of granular, crumby, blocky or prismatic peds; or (normally) some combination of these; 2. illuvial concentration of silicate clay or iron, aluminium or humus.
C	Mineral horizon of unconsolidated material from which the solum is presumed to have formed.
R	Underlying consolidated bedrock sufficiently coherent when moist to make hand digging with a spade impracticable.

Sub-horizons or qualifiers

A lower case letter may be added to the capital to qualify the master horizon designation. More than one letter may be used if necessary, e.g. Bhs1 indicates the first of two B horizons enriched in humus and sesquioxide material. Symbols may be bracketed if the feature development is weak
.
These symbols have more precise significance when applied to specific major soil subgroups.

b	Buried (e.g. bA).
f	Sharply defined thin iron pan.
g	Horizon with gley features.
h	Accumulation of organic matter in a mineral horizon (e.g. Ah or Bh).
m	A cemented horizon, other than a thin iron pan. Often used in conjunction with another symbol (e.g. Bmh for a horizon cemented with organic matter).
p	Disturbed by ploughing.
s	Accumulation of sesquioxide material.
t	Accumulation of illuvial clay.
w	Alteration in situ in accordance with section 1 of the description of the B horizon
x	Indurated layer, compacted but not cemented.

APPENDIX 5: Range of chemical and physical properties measured on the original NSIS samples:

Attribute name	description
LABNO	Sample identification number
HOR_SYMB	Horizon notation as assessed in the field
TOP	Upper limit of sample depth
BOTTOM	Lower limit of sample depth
LOI	Loss on Ignition (percentage)
CA	Calcium content (meq/100g)
MG	Magnesium content (meq/100g)
NA	Sodium content (meq/100g)
K	Potassium content (meq/100g)
H	Hydrogen and Aluminium content: Exchangeable acidity (meq/100g)
SUM	Sum of the geometric mean values of all exchangeable cations (Ca, Mg, Na, K and H)
SATN	Percentage saturation of base cations (Ca, Mg, Na and K) as a proportion of the Sum of exchangeable cations
PHW	pH in water
PHCACL	pH in Calcium chloride
C	Elemental Carbon content (percentage)
N	Elemental Nitrogen content (percentage)
DER_OM	Organic Matter content derived from C*1.724
TOTP	Total Phosphate (mg P_2O_5/100g)
CLAY	Percentage clay (<2microns)
SAND	Percentage sand (50- 2000 microns)
SILT	Percentage silt (2- 50 microns)
UBSAND	Percentage sand (60- 2000 microns)
UBSILT	Percentage silt (2- 60 microns)

APPENDIX 6: Range of heavy metals and macronutrients measured on NSIS surface horizon samples from the 10km grid. All the elements were extracted by Aqua regia digest from ground <2mm soils using the procedure described by McGrath and Loveland or by EDTA extraction . All metals except Cd, were determined by ICP-AES (Inductively Coupled Plasma – Atomic Emission Spectrometry) while Cd, was determined by GFAAS. (Graphite Furnace Atomic Absorption Spectrometry).

Element	Chemical symbol
Calcium	Ca
Sodium	Na
Potassium	K
Magnesium	Mg
Copper	Cu
Zinc	Zn
Iron	Fe
Manganese	Mn
Aluminium	Al
Nickel	Ni
Cadmium	Cd
Chromium	Cr
Cobalt	Co
Lead	Pb
Strontium	Sr
Molybdenum	Mo
Titanium	Ti
Barium	Ba
Phosphorous	P