

On-site Wastewater Management Training Course

Soil Assessment for On-site Wastewater Management

Honorary Associate Professor Phillip Geary
School of Environmental & Life Sciences
The University of Newcastle NSW

Centre for Environmental Training cet

Site and Soil Evaluation (SSE)

- Soils are examined as part of any SSE to determine their capability to assimilate and treat domestic wastewater
- SSE is key to sound OWMS selection, location & sizing
- Need to determine if wastewater can be managed within property boundaries & to size EAA (effluent application area)



cet

Site and Soil Evaluation (SSE)

- SSE can be undertaken on individual lot scale or on a broad scale e.g. subdivision
- SSE should comprise both desktop & field analysis
- Important soil features can be investigated in the field & samples collected for later detailed analysis
- SSE needs to be undertaken by suitably qualified & experienced professionals



Centre for Environmental Training cet

Soil Assessment

- Depends on scale (lot or broad)
- Min. 3 observation boreholes for lot (Appendix D3 AS/NZS1547:2012) or 1 test pit & 2 boreholes (NSW Guideline 2025)
- Excavation of a borehole or soil pit to determine location of best soils undertaken by;
 - backhoe (may not be economic)
 - hand digging or corer or
 - soil auger
- Min. depth should be 0.6m below the proposed point of application, or to refusal
 - AS/NZS 1547 requires 1.5m below POA, NSW Guideline (2025) suggests min 1m or 0.6m below POA



Soil Augering/Excavation

- Record borehole/site location
- Layout in order of recovery; do not spread out
- Identify differences by feel when augering
- Decide on horizons or layers and describe including depth
- Number horizons/layers, look at important properties and record information using soil assessment sheets in NSW Guideline



Soil Borelog and Profile Description



Depth (m)	Horizon (Layer)	Texture	Structure	Colour	Mottles
0.3	A ₁	SCL	Moderate	Dark Grey	Nil
0.6	A ₂	SCL	Moderate	Grey Brown	Nil
1.2	B	LC	Weak	Strong Yellow	Red and Grey
> 1.2	C	Broken Down Parent Material			

Describe the properties of soil **horizons or layers** which can be distinguished from those above and below e.g. topsoil and subsoil

Centre for Environmental Training cet

Key Soil/Risk Considerations

- What is the depth of soil and what are the features of each layer or horizon present?
- Is there a limiting layer or horizon?
- Soil colour and mottling (if present)
- Is soil saturated or water table encountered?
- What is the soil's texture and structure?
- % of coarse fragments (rocks and nodules) and cracks which may affect drainage
- Is there weathered rock or bedrock at depth?
- Is the soil dispersive and/or sodic?
- How do we use information obtained from our soil to determine the design loading rate (DLR) or design irrigation rate (DIR)?

Centre for Environmental Training cet

Other Soil Test Data

- **pH** – acidity/alkalinity
- **Electrical Conductivity** - salinity
- **Cation Exchange Capacity (CEC)** - capacity of soil to hold and exchange cations (positively charged molecules)
- **Exchangeable Sodium % (ESP)** - indicator of soil sodicity which affects soil structural stability and overall susceptibility to dispersion.
- **Emerson Aggregate Test** – for dispersion
- **Phosphorus sorption (P_{sorb})** - direct measure of ability of soil to adsorb (bind) phosphorus
- **Permeability** – hydraulic conductivity



cet

Reflects underlying mineralogy of the soil, its fertility, & ability to drain (permeability). Generally:

- **dull** colours - wetness during formation (iron reduced to ferrous Fe^{2+} form)
- **pale** colours - from pale rocks (e.g. rhyolite) or leached from darker minerals
- **dark** colours - from dark rocks e.g. basalts or they contain high levels of organic matter
- bright **red** colours - from well aerated soils with high iron (oxidised to ferric Fe^{3+} form) & aluminium content
- **bleached** (pale) - minerals removed by water

Soil Colour



Centre for Environmental Training cet

Soil Mottling

- Is if more than 10% of soil is of a contrasting colour
- Important indicator of soil drainage characteristics
 - colour different from main soil colour, may be spots, blotches or streaks
 - bright colours (orange and yellow) – indicative of oxidising conditions
 - very dull grey colours – strong iron reduction (gleying) – saturated or anoxic conditions
- Mottling indicates periodic waterlogging



Centre for Environmental Training cet

Soil Waterlogging

- Important to identify the reason for wetness in SSE
- Could be due to shallow groundwater or seepage from upslope areas and may be permanent or seasonal
- Perched water tables may also occur
- Look for limiting horizons such as shallow hardpan (e.g. coffee rock, iron pan) with waterlogging features such as mottling or gleying

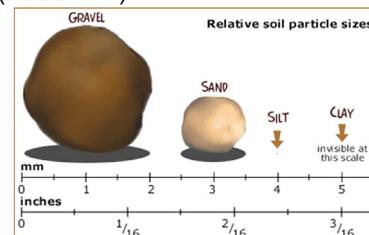


Centre for Environmental Training cet

Soil Particle Size and Texture

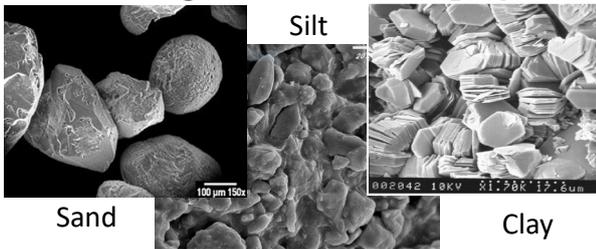
Soil textures are classified according to the relative proportions of different particle sizes being present:

- sand (0.02-2mm),
- silt (0.002-0.02mm)
- clay (<0.002mm)



Centre for Environmental Training cet

Scanning Electron Micrographs



Sand

- Sand is a granular material composed of finely divided mineral particles – it is defined by its grain size with the most common constituent being silica which is inert and hard

Silt

- Clay minerals are flat, like pages in a book, with the space between the platelets being variable and being filled with water and exchangeable cations

Clay

cet

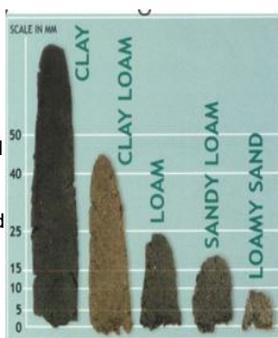
Soil Particle Size and Texture

- Examine soil texture in soil pit or on sample – important for soil drainage
- The relative proportion of sand, silt and clay in a soil sample
 - can be determined by laboratory sieving methods (PSA) and fractionation and/or
 - using a field textural method (ribbon test)



Field Textural Determination

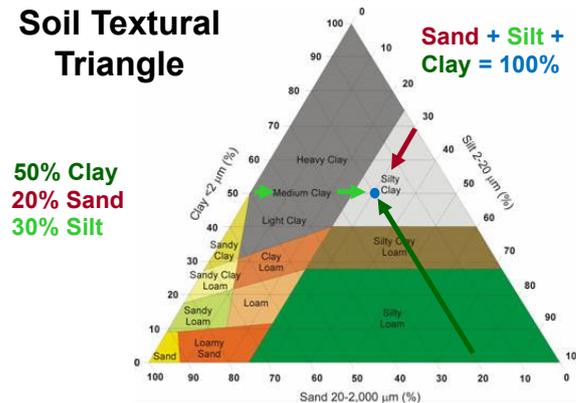
- 'Ribbon Test' developed to provide a fast and repeatable method for field description of in-situ soil texture
 - subjective test
 - requires practice and skill development
- Determine relative proportions of silt, sand clay fractions based on moistened bolus
- Used to assess soil hydraulic capacity and infer design loading rate (DLR)



<https://soilquality.org.au/> Fact Sheets on Soil Texture

Centre for Environmental Training cet

Soil Textural Triangle



<https://soilquality.org.au/> Fact Sheets

Centre for Environmental Training cet

Soil Texture Groups

Texture Group	Texture Grades
Sands	sand, loamy sand, clayey sand
Sandy loams	sandy loam, fine sandy loam
Loams	loam, silty loam,
Clay loams	sandy clay loam, clay loam, silty clay loam, fine sandy clay loam, sandy clay
Light clays	silty clay, light clay, light medium clay
Medium-heavy clays	medium clay, heavy clay

Centre for Environmental Training cet

Soil Structure

- Arrangement of soil particles into natural aggregates (peds)



- Describes the distinctness, size and shape of peds
- Described in terms of structureless, massive, weak (peds indistinct), moderate or strong structure (peds distinct)

Centre for Environmental Training cet

Soil Structure

- Should be described from a 'fresh' vertical exposure
- CANNOT be assessed from an augered hole
- Soil structure affects; permeability, aeration, drainage, erosivity, surface condition, stability and general soil productivity

No structure

Sub angular blocky

Drop Test Method

Granular

Soil Dispersion

- Soil aggregates collapse when soil gets wet by fresh water because the individual clay particles swell and disperse into solution
- Collapse of structure causes the soil to slump, lose porosity and permeability and restricts root growth of most plants
- Emerson Aggregate Class (EAC) – test of soil structural stability and susceptibility to erosion

<https://www.agric.wa.gov.au/dispersive-and-sodic-soils/identifying-dispersive-sodic-soils>

Water in Soil – Porosity

- Portion of soil occupied by air and water
- Determined by arrangement of solid particles
- Sands have large pore spaces between the particles, but few compared to silt or clay

Pore Space in Sandy Soil vs. Clay Soil

Sandy Soil

Larger pores

Less total pore volume
= Less porosity

Clay Soil

Smaller pores

Greater total pore volume
= Greater porosity

Range of porosities (%)

- Sands - 25-50
- Silts - 35-50
- Clays - 40-70

©The COMET Program
Centre for Environmental Training cet

Water Movement in Soil

- Soil is hydrophilic – attracts water to its surface very strongly
- All soil pores act as capillaries; capillary forces control water movement between voids
- Soil suctions can be measured
- Sands contain mostly large pores so these can only be full at low suctions; clays with mainly smaller pores, require a wider range of suctions

Sponge

<https://southernscientificireland.com/2025/02/07/key-soil-properties/> Centre for Environmental Training cet

Water Movement in Soil

- Permeability or hydraulic conductivity is the velocity of movement of a fluid (water) through a porous medium relative to the pressure gradient (hydraulic head) which brings about the movement

Downward Flow

Potential at top of soil is greater than at bottom.

Horizontal Flow

Potential at right is greater than at left.

<http://soilphysics.okstate.edu/software/water/nfil.html>

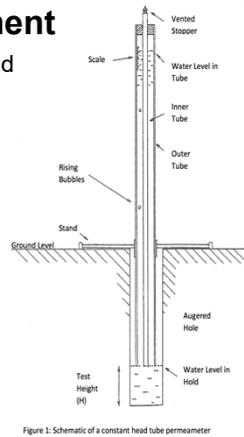
Laboratory Measurement

- Can be measured in a laboratory under standard conditions involving a constant head of water
- In lab soil placed in columns (necessary to know soil bulk density) and water added at a known rate

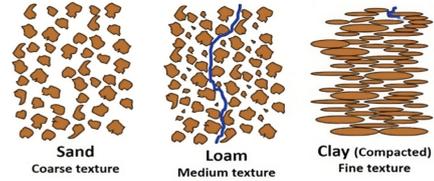
cet

Field Measurement

- Can be measured in field using permeameters – rely on constant head (see Appendix G AS/NZS1547:2012), Guelph and Cromer permeameters



Water in Soil - Permeability

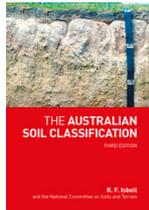


Texture Group	Typical Permeability K_{sat} (m/d)
Gravels and sands	> 3.0
Sandy loams	1.4 – 3.0
Loams	0.5 – 1.5
Clay loams	0.06 – 1.5
Light clays	< 0.06 – 0.5
Medium-heavy clays	< 0.06

cet

Further Reading

- AS/NZS 1547:2012 On-site Domestic Wastewater Management, Standards Australia, SAI Global, Sydney, NSW.
- AS 1726:2017 Geotechnical Site Investigations, Standards Australia, SAI Global, Sydney, NSW.
- Geary, P.M., Whitehead, J. & Patterson, R. (1999) Skills to Assess the Suitability of Sites for On-site Wastewater Disposal, Environmental Health Review - Australia, 28, 2, 42-47.
- Isbell, R.F. National Committee on Soil & Terrain (2021) The Australian Soil Classification, CSIRO. (<https://www.publish.csiro.au/book/8016>)



Centre for Environmental Training cet

