On-site Wastewater Management Training Course

# Soil Assessment for On-site Wastewater Management

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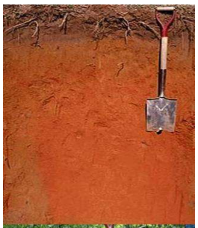
## Site and Soil Evaluation (SSE)

- 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)



## 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

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## 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 Gley |
| > 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

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## 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)?

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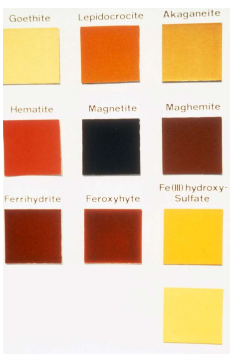
## Soil Test Data

- **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

## Soil Test Data - Colour

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 Test Data - 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

Mottled soil

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## Soil Test Data - 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

Gleyed soil

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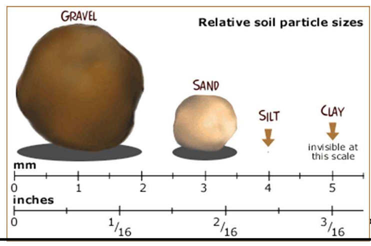
## Soil Test Data - Particle Size and Texture

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)

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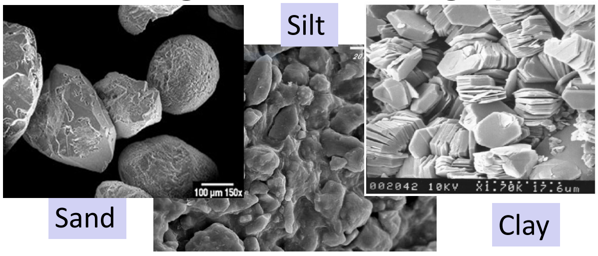
## Scanning Electron Micrographs




- 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
- 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

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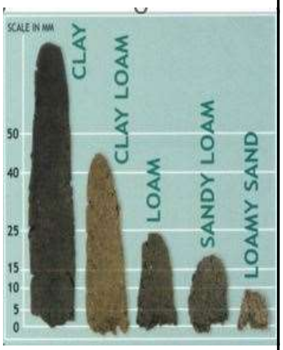
## Particle Size and Texture

- 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)




Fact Sheets on Soil Texture

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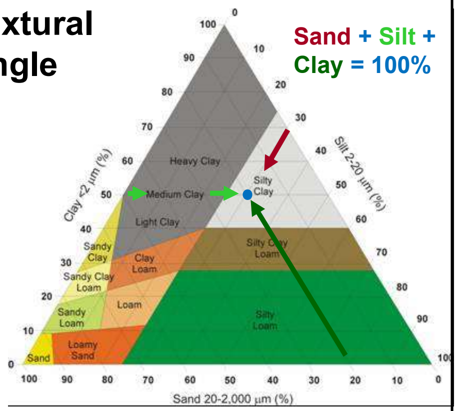
## Soil Textural Triangle

Sand + Silt + Clay = 100%

50% Clay
20% Sand
30% Silt




Fact Sheets

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## 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 |

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## Soil Test Data - 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)

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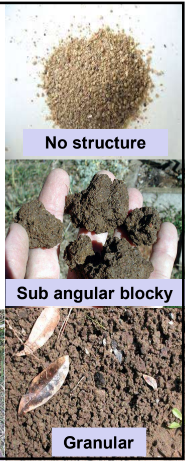
# Soil Structure

- 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

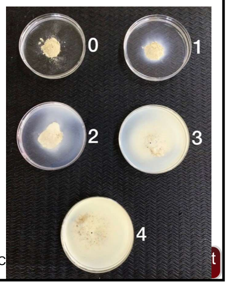



Drop Test Method

# Soil Dispersion

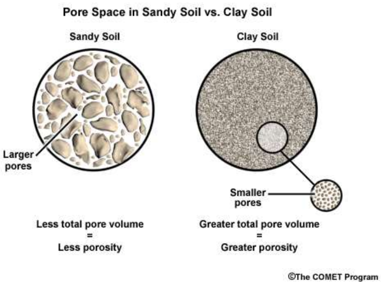
- Soil aggregates collapse when soil gets wet by fresh water because the individual clay particles swell and disperse into solution
- Collapse of structure causes the soil to slump, lose porosity and permeability and restricts root growth of most plants
- Emerson Aggregate Class (EAC) – test of soil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



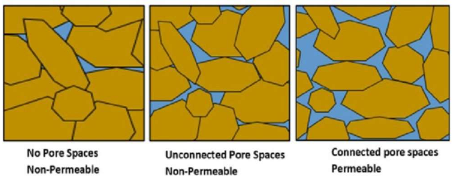

<u>Range of porosities (%)</u>

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



# Water Movement in Soil

- Soil is <u>hydrophilic</u> – 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



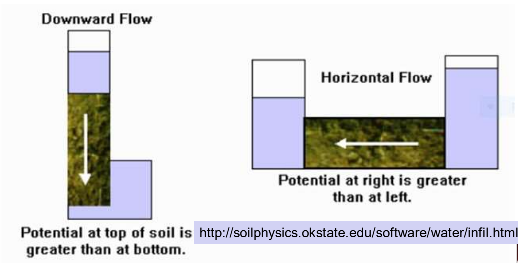

Sponge

https://southernscientificireland.com/2025/02/07/key-soil-properties/



# Water Movement in Soil

- <u>Permeability or hydraulic conductivity</u> 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




http://soilphysics.okstate.edu/software/water/infil.html

# Laboratory Measurement

- Can be <u>measured</u> 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

## Field Measurement

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

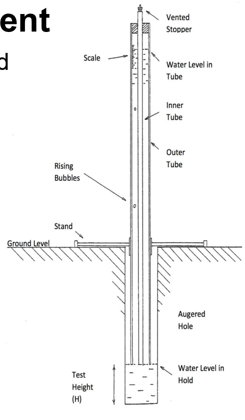
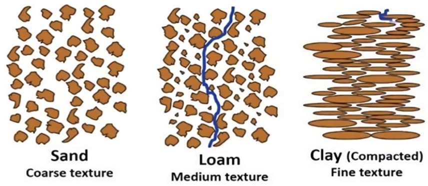


Figure 1: Schematic of a constant head tube permeameter

## 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 |

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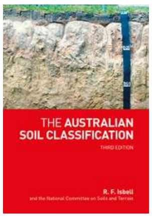
## Further Reading


- 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.
- Whitehead, J., Geary, P. & 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)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