Management of Dispersive Soils in Urban Areas.





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Problems: Roads and Culverts

Honeywood Estate: Brighton

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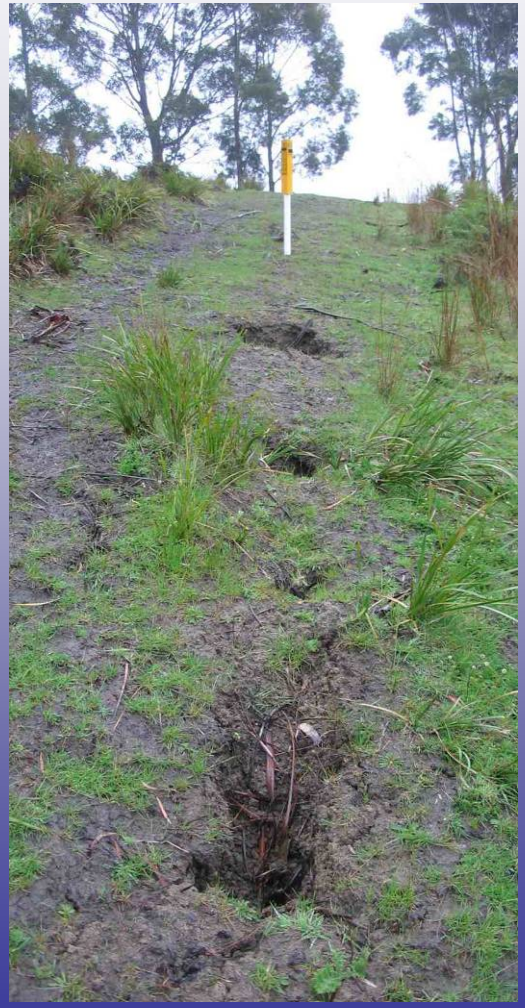
Problems: Drains and Culverts

Honeywood Estate: Brighton

Problems: Excavation & Foundations

Richmond: Vineyard Factory

Problems: Cables & Pipes



Dunalley : Dolerite / T. Sandstone

Chain of Lagoons: Granite

Dunalley : T. Sandstone

Problems: Dam Failure

Penna: Permian Mudstone.

Tunbridge: Blackman Crk. Dam

Problems: Removal of Topsoil

Brighton

Problems: Septic Systems

Honeywood: Triassic Sandstone

Problems: Sedimentation & Turbidity

Honeywood: Triassic Sandstone

Problems: Tunnel Driven Gully Erosion

Mt. Rumney

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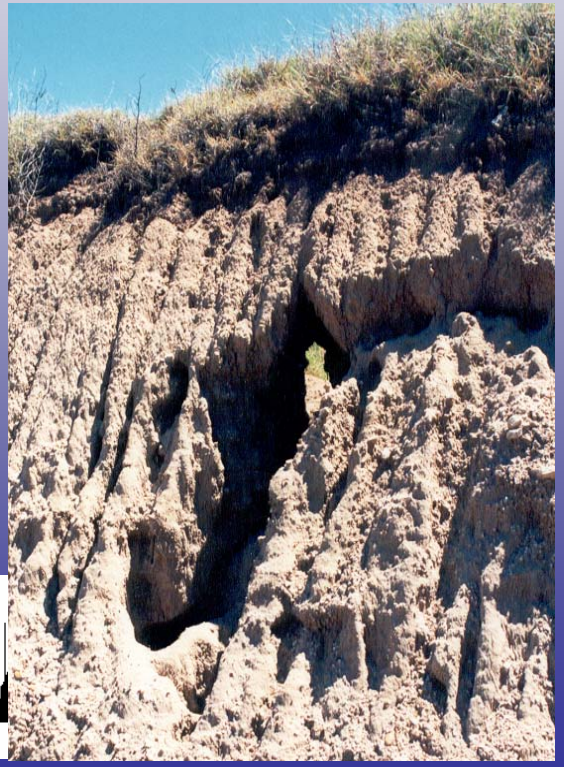
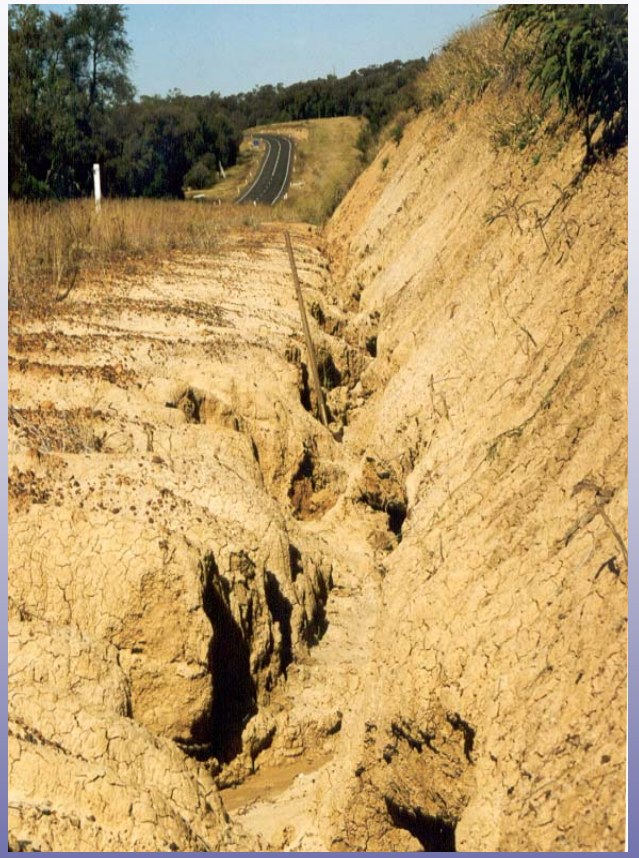
Problems: 10 + Years After Disturbance

Woodbridge: Permian Mudstone

Queensland Examples

- *Tunnelling*
- *Gully formation*
- *Erosion*
- *High Suspended Sediment Loads*
- *Riverine Contamination*





Courtesy of

Landloch

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Queensland Examples

Tunnelling of sandy material - lateral water flow under road creating with tunnel at lowest point where pore pressures are greatest

Courtesy of

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Areas of patched road due to slumpage associated with tunnelling

Courtesy of

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Landloch

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Tunnel in a dam wall at Withcott

Courtesy of

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What is a Dispersive Soil

Dispersive Soils

- Appear to ‘dissolve’ in water.
- Responsible for tunnel erosion.
- Dispersive soils are usually sodic.
- Structurally unstable, require special consideration for development.

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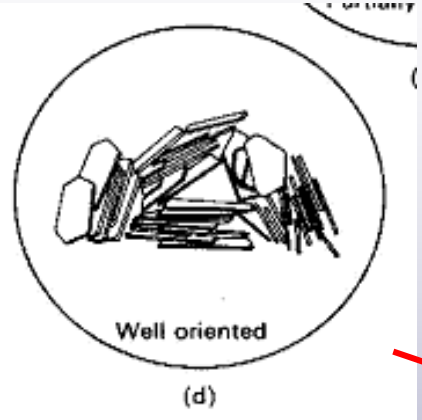
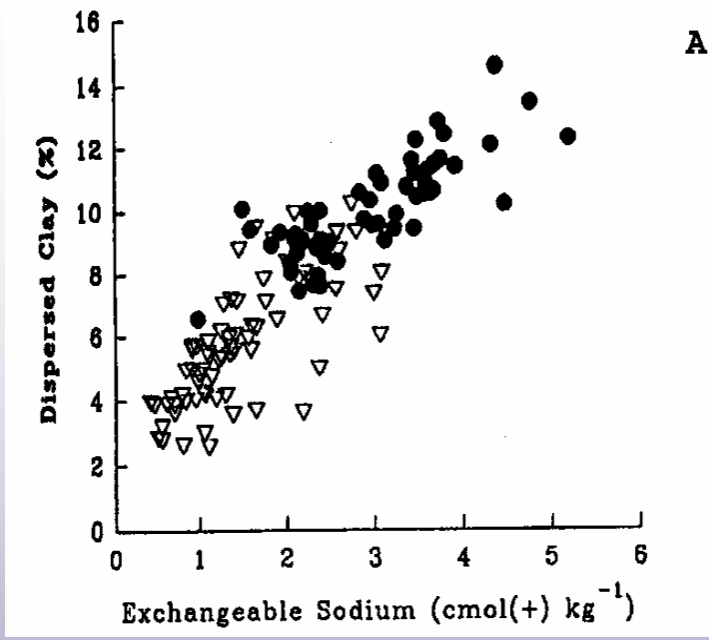
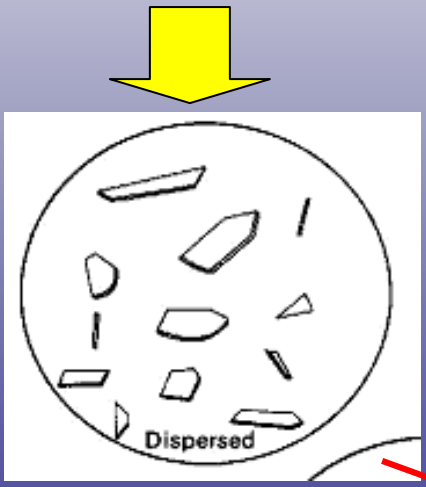
Sodic Soils & Dispersion.



Normal: Clay Platelets are bunched together.

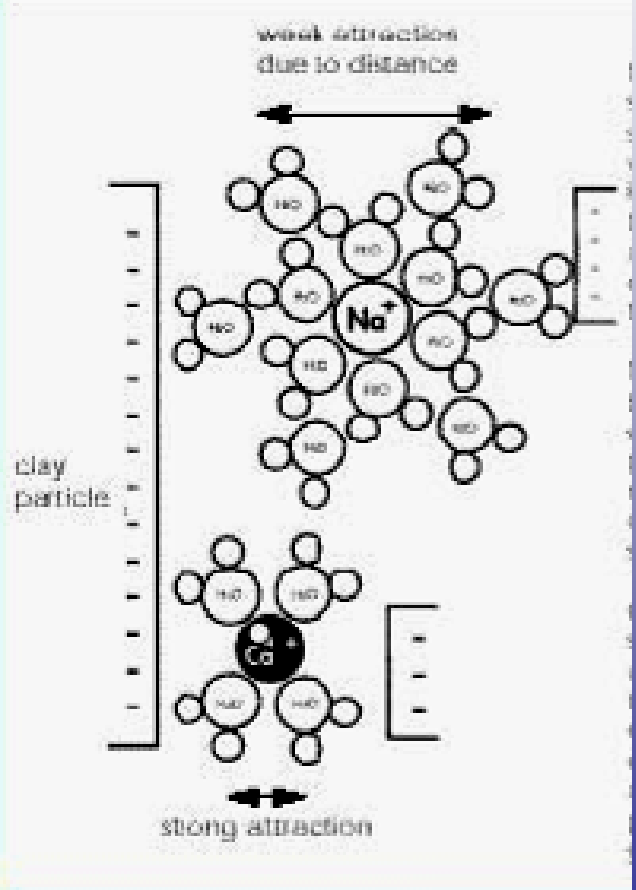




Dispersion: Process where individual clay platelets separate from clay structures.

Dried Aggregates in Rainwater

Dispersion



Dispersion of Sodium Based Clay Structures

- Weakness caused by large monovalent ion.
- Diffuse double layer of electrons around Na ion
- Double layer of hydration
- Clay swelling
- In low electrolyte water ~ Dispersion
- In high electrolyte ~ Swelling

What is a Sodic Soil

- ESP Greater than 6

Exchangeable Sodium Percentage (ESP) = $\frac{\text{Exchangeable Na} \times 100}{\text{Cation Exchange Capacity}}$

Definition of sodic soils

Non-sodic	- ESP	<6
Sodic	- ESP	6-14
Strongly sodic	- ESP	≥15

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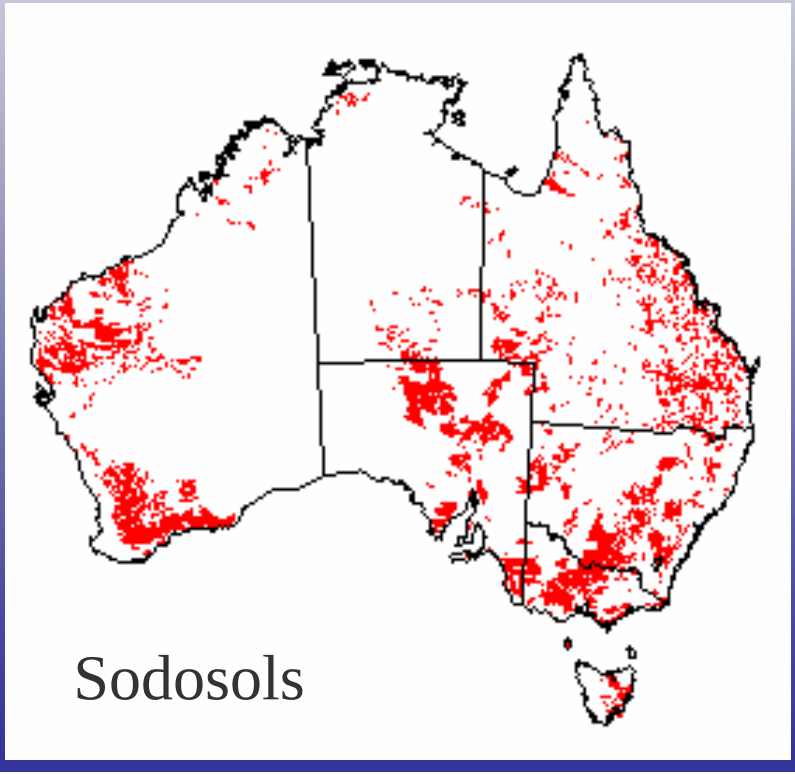
Sodic Soils: National Snapshot.

- 200 million Ha: Area affected by sodicity
- 5 times: Proportion of sodic vs saline affected land
- 90 million ha: Area of pasture and cropping country directly affected.
- $ 6.75 Billion: Estimated yield loss for wheat alone

(National Audit soil sodicity)

Approx. 30% of Australia is sodic



Sodosols

Sodicity and Soil Classification

Chromosol

Vertosol

Sodosol

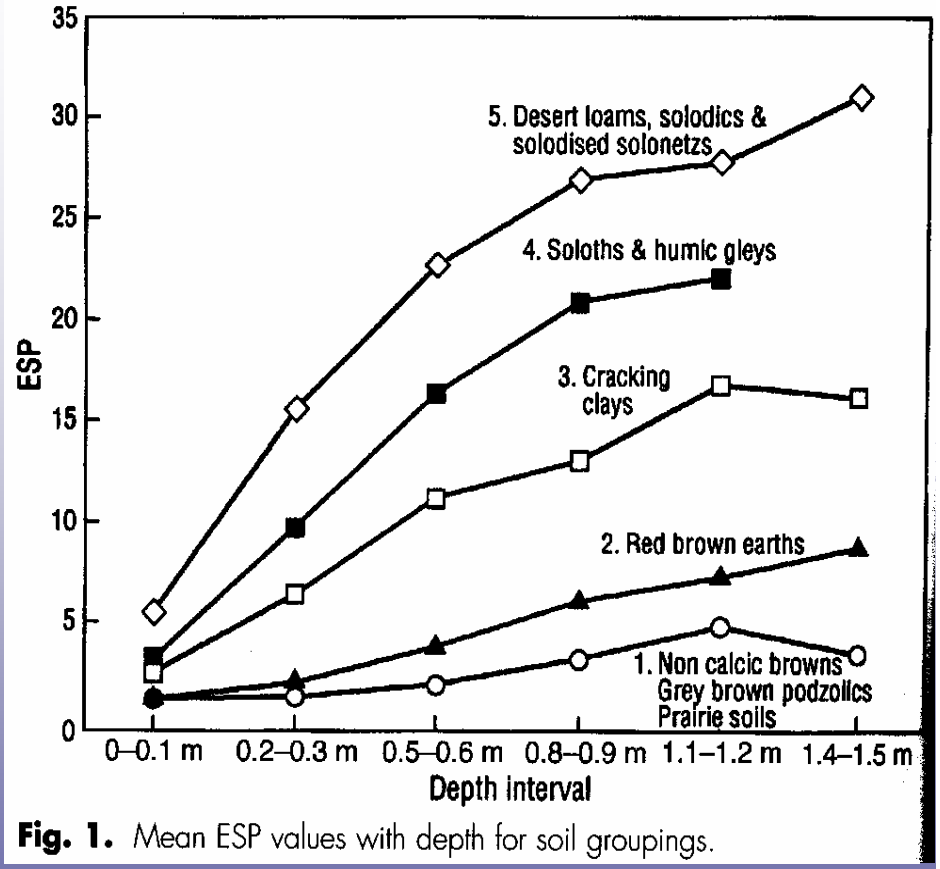


Fig. 1. Mean ESP values with depth for soil groupings.

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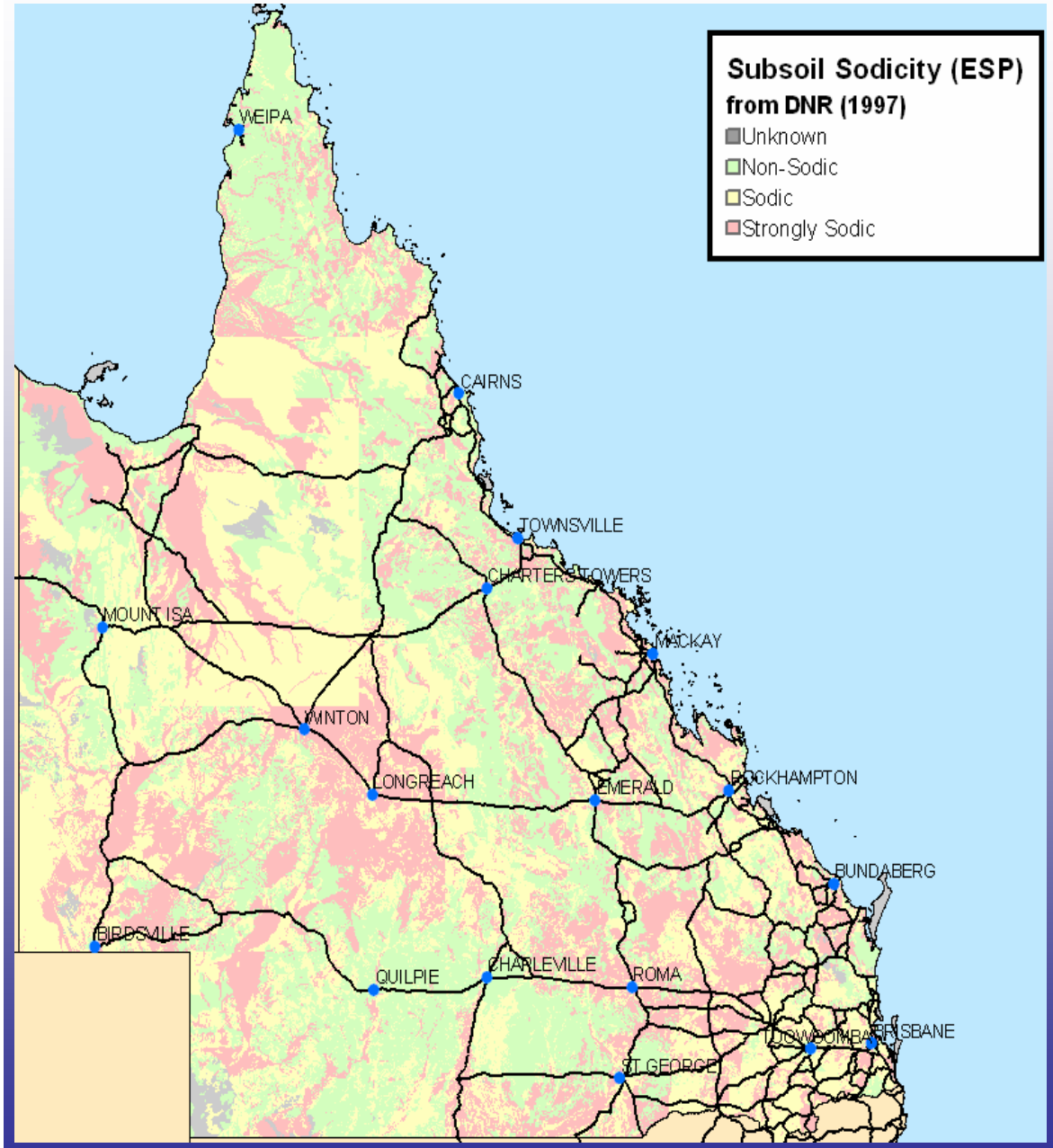
Distribution of Sodic Soils in QLD



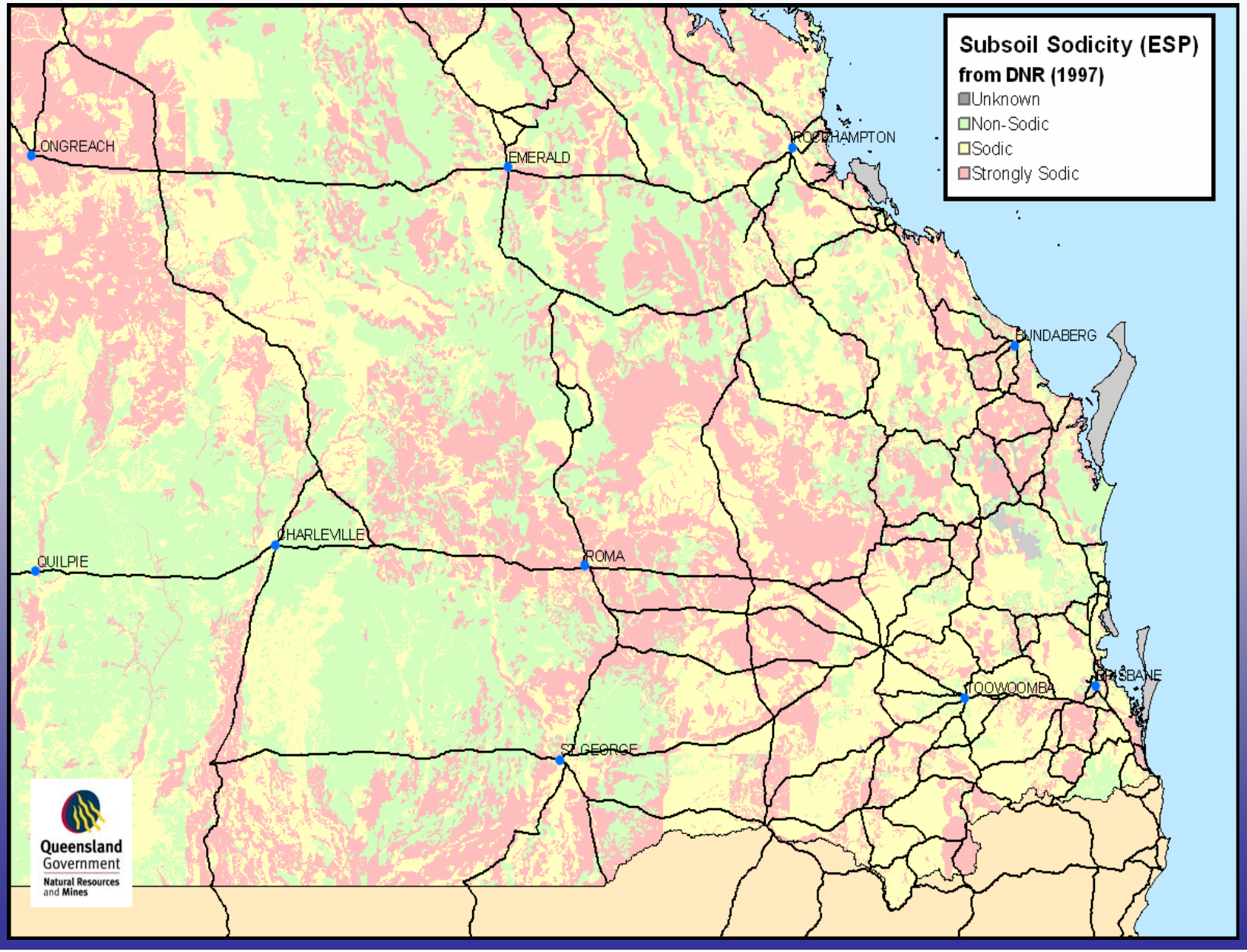
By area:

25% Strongly Sodic

20% Variably Sodic

(Shaw *et al.* 1995)

Distribution of Sodic Soils (SE Qld)



Activities that increase likelihood of tunnel erosion / soil dispersion.

- Overgrazing
- Removing topsoil
- Excavation of dispersive soil
- Poor compaction of sodic clay
- Concentration of runoff
- Septic trenches
- Drains and Culverts

Prevention Strategies

1). Awareness and Education
- Development of Guidelines
- Extension support & advice (?)

2). Avoidance
- Test and map presence of dispersive soils

3). Prevent rainwater coming into contact with subsoils
- Avoid ponding water
- Don't remove topsoil
- Cover exposed subsoils with topsoil
- Minimise excavations
- Raintank Outlets, culverts etc

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Prevention Strategies

4). Compaction

- Compact exposed subsoils (approx 98% proctor).
- Compact structurally important dispersive soils ie dams

5). Chemical Amendment

- Application of Gypsum or hydrated Lime
- Around 2% by weight for structures, ie dams, reclaimed areas.
- 0.5-1.5 t/ha for broadscale land management
- Get Soil Tests

6). Land & Water Management

- Prevent concentrating surface water ie culverts
- Spread captured water on high areas away from buildings
- Treat water or discharge areas with gypsum.
- Maintain healthy pasture

Identifying Dispersive Soils

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Spew Holes

Dribble Patterns

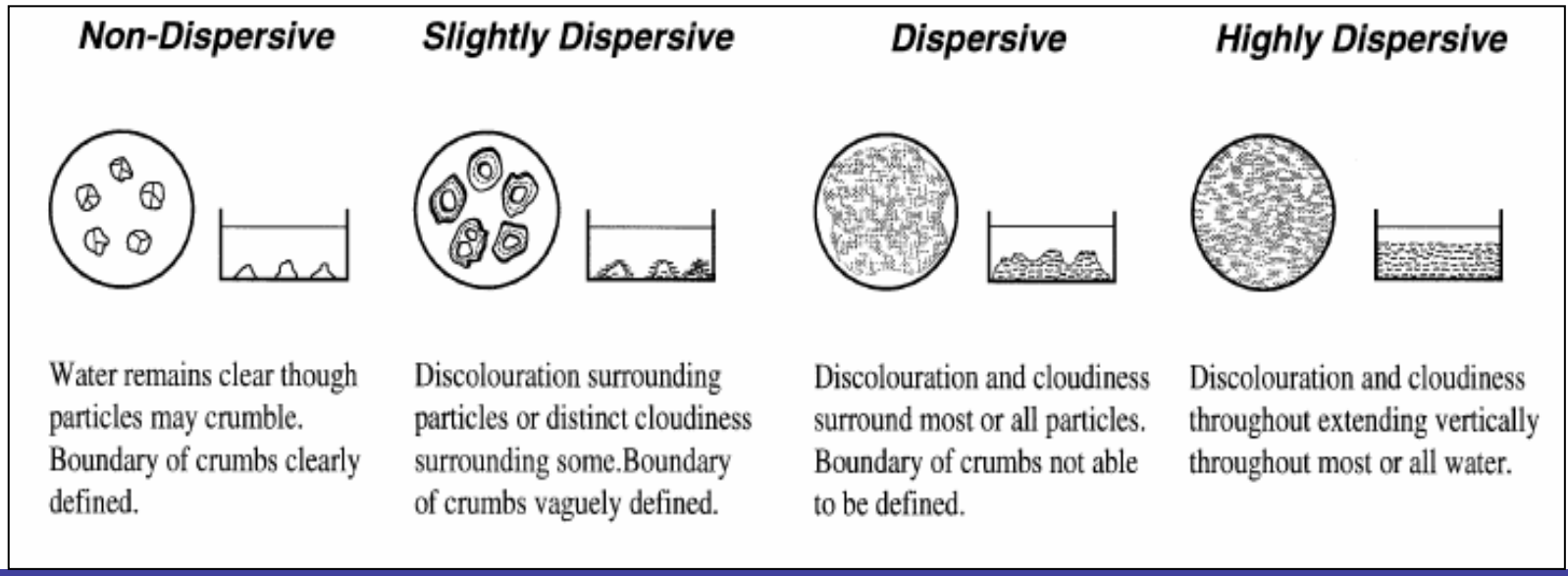
Muddy dams

Pocketing

Identifying Dispersive Soils :

Field Techniques.

1). Collect soil aggregates (1-2 cm diameter)
2). Dry aggregates in the sun for a few hours
3). Place the aggregates distilled water.
4). Observe presence of milky ring around the aggregates after 20 mins &60 mins.



Identifying Dispersive Soils - Analytical Approaches

Chemical tests.

- Exchangeable Sodium Percent (ESP)
- Sodium Absorption Ratio (SAR).

Physical tests

- Emerson soil crumb test (AS 1289.3.8.1-1997)
- Pinhole test (AS 1289.3.8.3 – 1997)
- Dispersion Index
- Double Hydrometer test

Pinhole test for compacted soils & fill. (Photo, Raine & Loch 2003).

$$SAR = \frac{Na+}{((Mg^{2+} + Ca^{2+})/2)^{1/2}}$$

Combined Chemical & Physical Tests (Rengasamy 2002).

- Measurement of clay dispersion (514.01)
- Measurement of dispersive potential (514.03).

$$ESP = \frac{Na+}{Na^{+} + Mg^{2+} + K^{+} + Ca^{2+}}$$

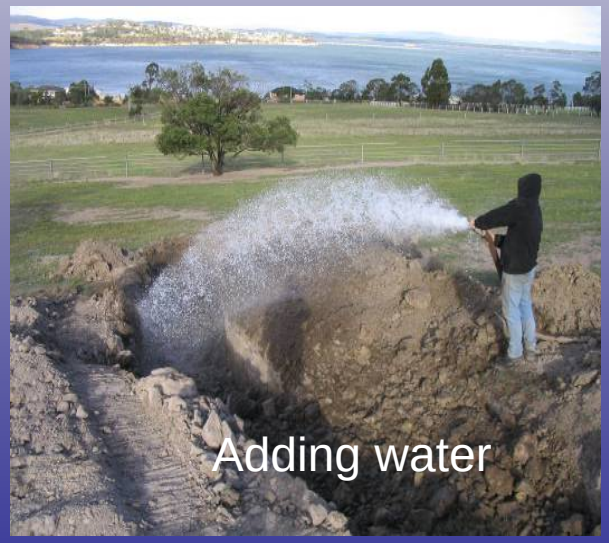
Example : Penna Tunnel Repair

Basic Steps

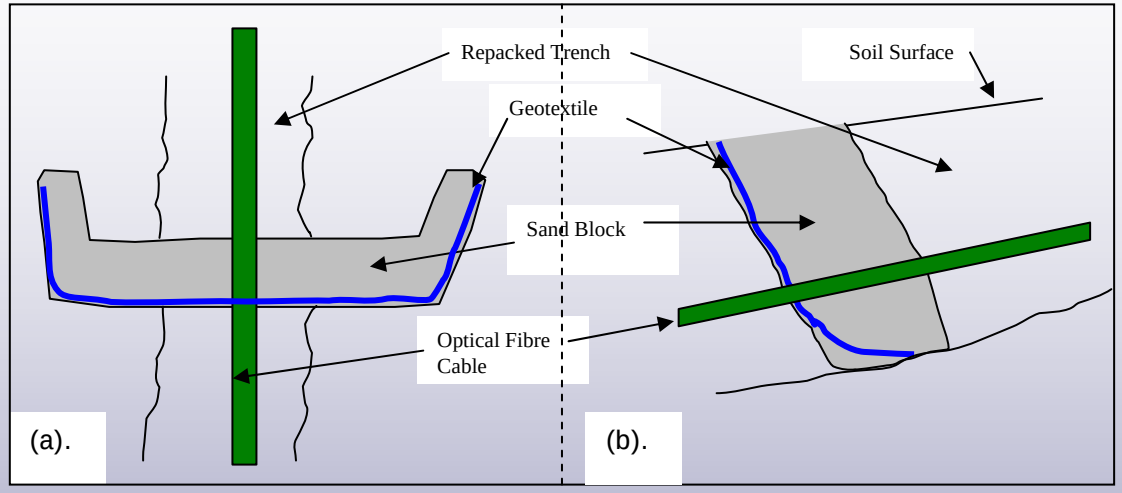
1). Excavate tunnel system
2). Repacking trench
3). Gypsum & hydrated lime
4). Topsoil
5). Revegetate

Penna.

- 10m (75m) Long
- Excavation
- Refilling
- Gypsum
- Sandblocks
- (Poor compaction)
- $??



Use of Sand Blocks



Excavate across trench/tunnel

Geotextile downslope wall

Fill with fine sand and gypsum 5% wt

Leave sand exposed on surface

Finished Repair Jobs

Traditional Approaches of ripping and filling have about 50% success rate

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Compaction

- Prevents the movement of dispersed clay platelets through the surrounding soil.
- Dispersive soils are difficult to compact.
- Compact at 1.5 -2% above the optimum moisture content
- Track rolling is not good enough, need sheepsfoot roller.
- a D6 dozer applies 0.6 kg/cm^2 pressure compared to 9.3 kg/cm^2 for a sheepsfoot roller
- 98% Proctor dry density
- For dams compact to around 10-5 to 10-7 cm/sec .
- Get engineering advice

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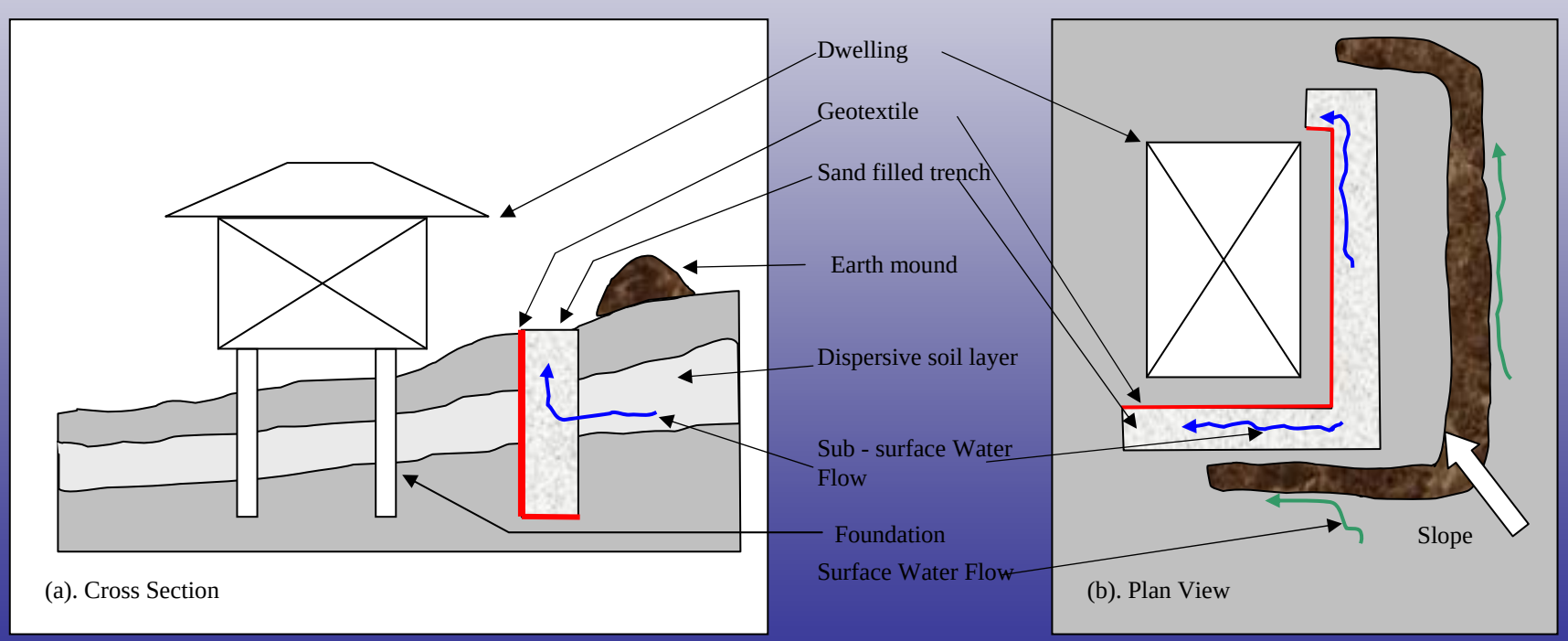
Use of rock

Mixed results ~ Carn't be relied upon.

Excavation, Cut & Fill

- Don’t Cut and Fill
- Use Pier & Post
- Consider Hydrological isolation.



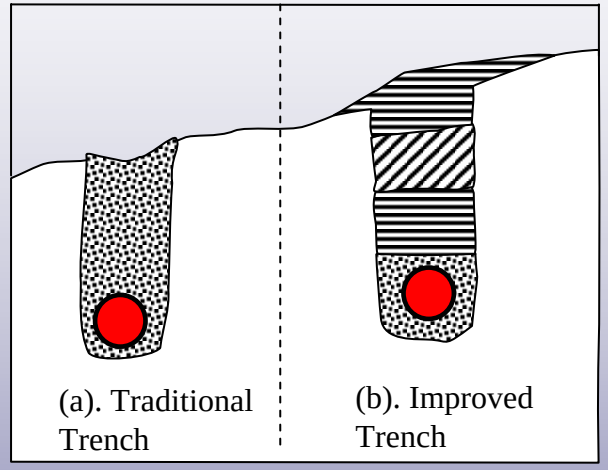
Hydrological isolation technique.

Repair of the Dunalley Tunnels

- Replaced Cable
- Low sodicity (ESP 2.4 -9.5) spoil from the excavated trench was treated with 1.0-1.3% gypsum
- 300m^3 of non-sodic (ESP <6) soil was carted to the site and treated with 0.1% gypsum.
- Treated soil was repacked into the trench in 150mm thick layers using whacker packers.

Hardie, M, Cotching WE, Zund P (2007) Rehabilitation of field tunnel erosion using techniques developed for construction with dispersive soils. *Australian Journal of Soil Research* 45(4) 280–287.

Improved Trenches and supply of services

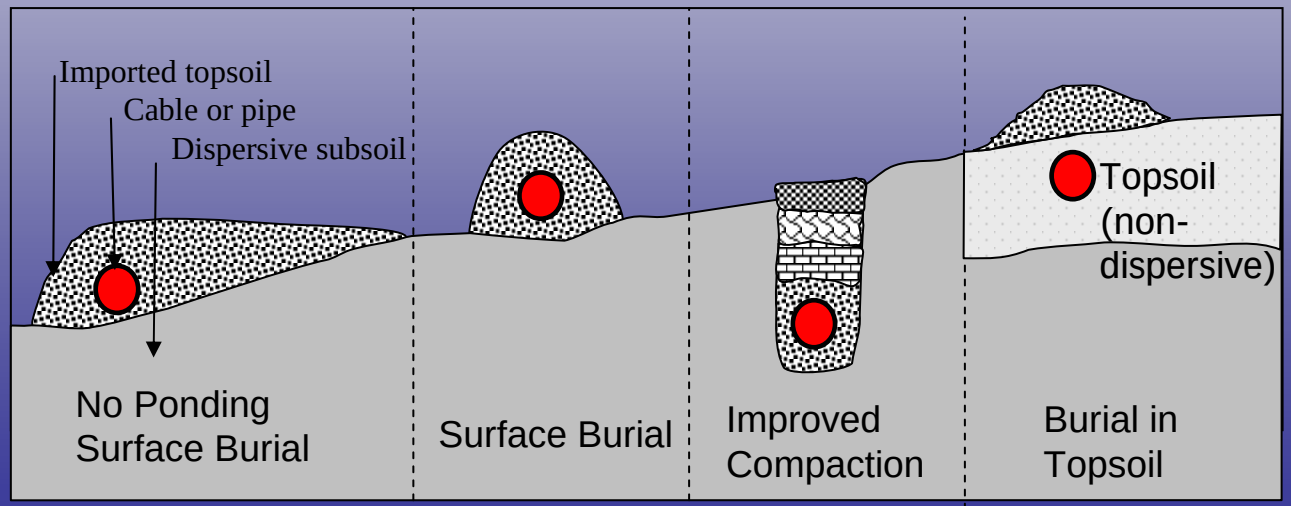


Improved Trenching

- Compaction with whacker packers.
- Use of Gypsum / hydrated lime.
- Topsoil burial

Consider

- Overhead Power and Telephone
- Rainwater tanks



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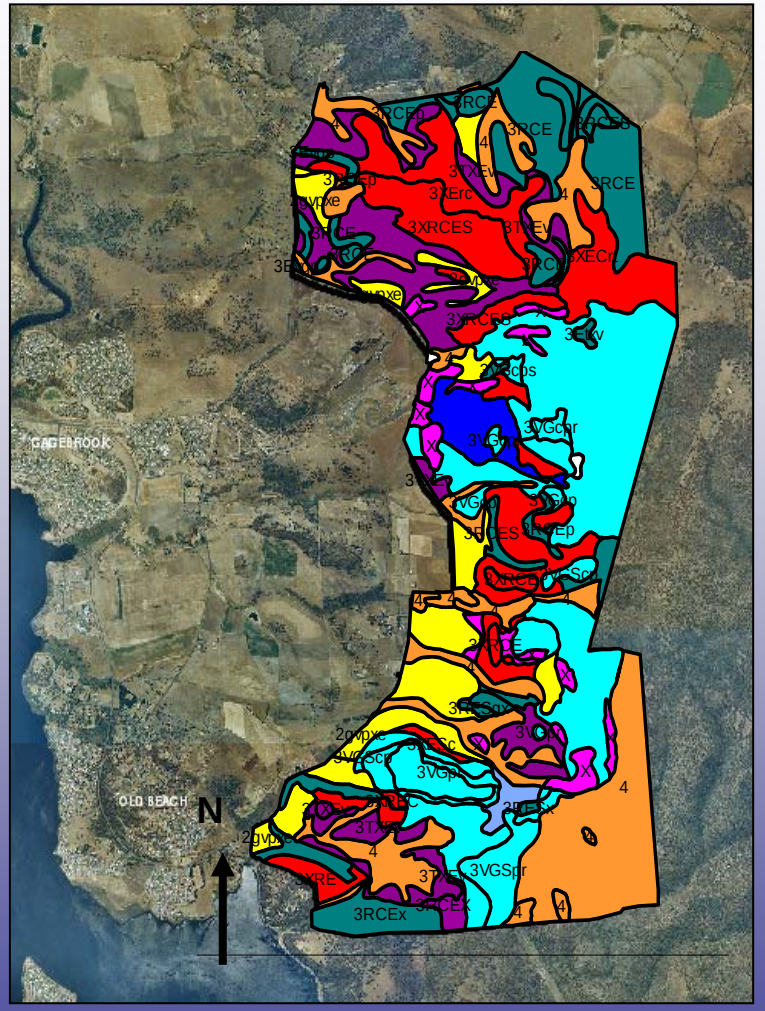
Planning Schemes.

Brighton Example

- Mapping still not suitable at property level.
- Planners didn't understand the map.
- Scaled response required
- Resulted in limited use



1:10000 Brighton Land Use Suitability Mapping (Cumming 2003)

Guidelines for Development and Construction on Dispersive Soils.

Difficulties with
- Obtaining external funding
- Lack of research data & Information.
- Lack of awareness
- Lack of secondary expertise & training.
- Difficulty engaging councils.
- Difficulty engaging engineers.
- Lack of support from regulators / planners.

Long Term
Building Codes
Planning Schemes

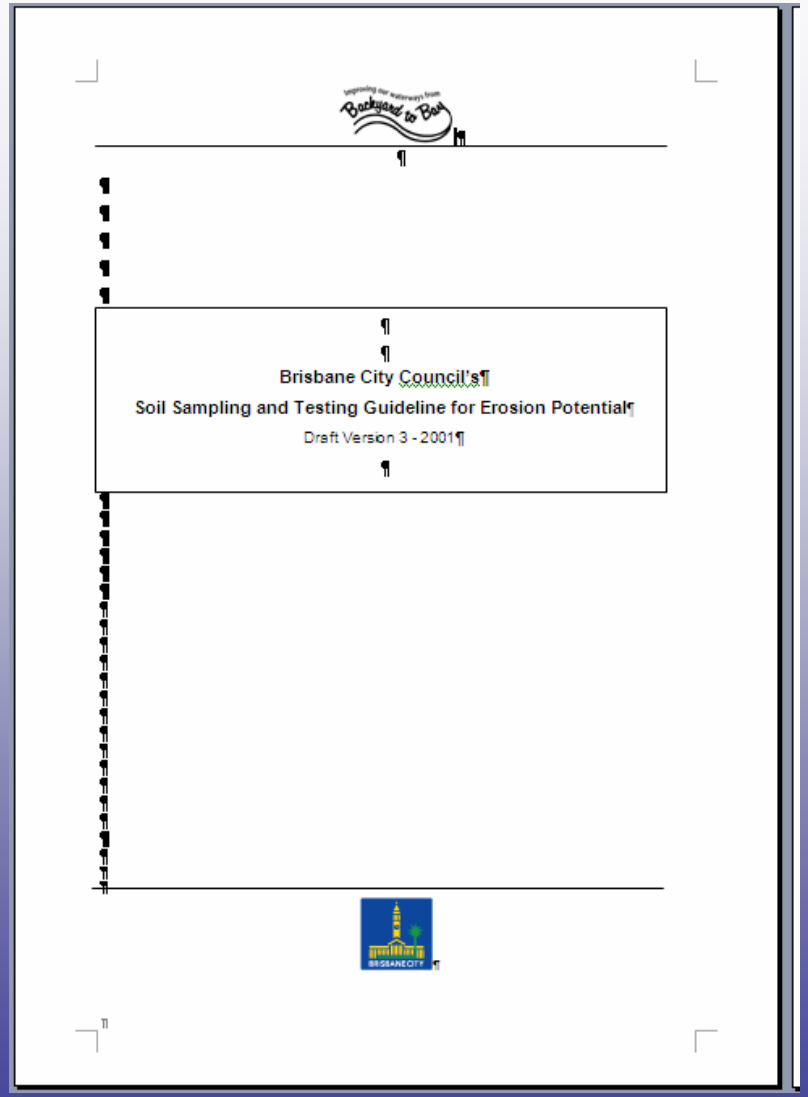
Dispersive Soils and Their Management :
Technical Reference Manual
for Councils, Consultants and Landholders.

Marcus Hardie
Land Management Officer
DPIWE

Contributions From;

Richard Doyle	Bill Cotching	Tim Duckett	Peter Zund

Brisbane City Council Approach


Brisbane City Council's
Soil Sampling and Testing Guideline for Erosion Potential
Draft Version 3 - 2001

The aim of the procedures …….soil erosion potential and dispersion risk during land-disturbing activities ……. appropriately manage ……. dispersive soils, …… degradation of water quality …..

Table 3 - Site Assessment Test Requirements

Required Testing - Level 1 Assessment	Number of Tests
• **Emerson Class Number – AS1289 3.8.1** • An accurate visual 'Soil Classification' by a suitably experienced person – AS1726 • Electrical Conductivity & pH – AS1289 4.3.1 • Particle Size Distribution – AS1289 3.6.1 • **Dispersion Index – AS1289 3.8.2** (including PSD (fine) AS1289 3.6.3)	Determined on representative topsoil & subsoil samples, (minimum 1 test from topsoil & subsoil horizon per 2 boreholes (ie. 8 tests for 8 boreholes)). To be undertaken on each sample. To be determined on a representative upper topsoil sample (ie. for revegetation assessment) and a