Mass Movement:
Why Slopes Fail

Mass movement

- Underlying mechanisms
- Prediction/Risk assessment
- Mitigation
- Preparation
- Rehabilitation

Mass Movement

- The type of mass movement is identified by the type of material involved (e.g. mud, earth, debris, rock) and the mechanism of movement (e.g. fall, slide, slump, flow, creep).

Mass Movement - Impacts

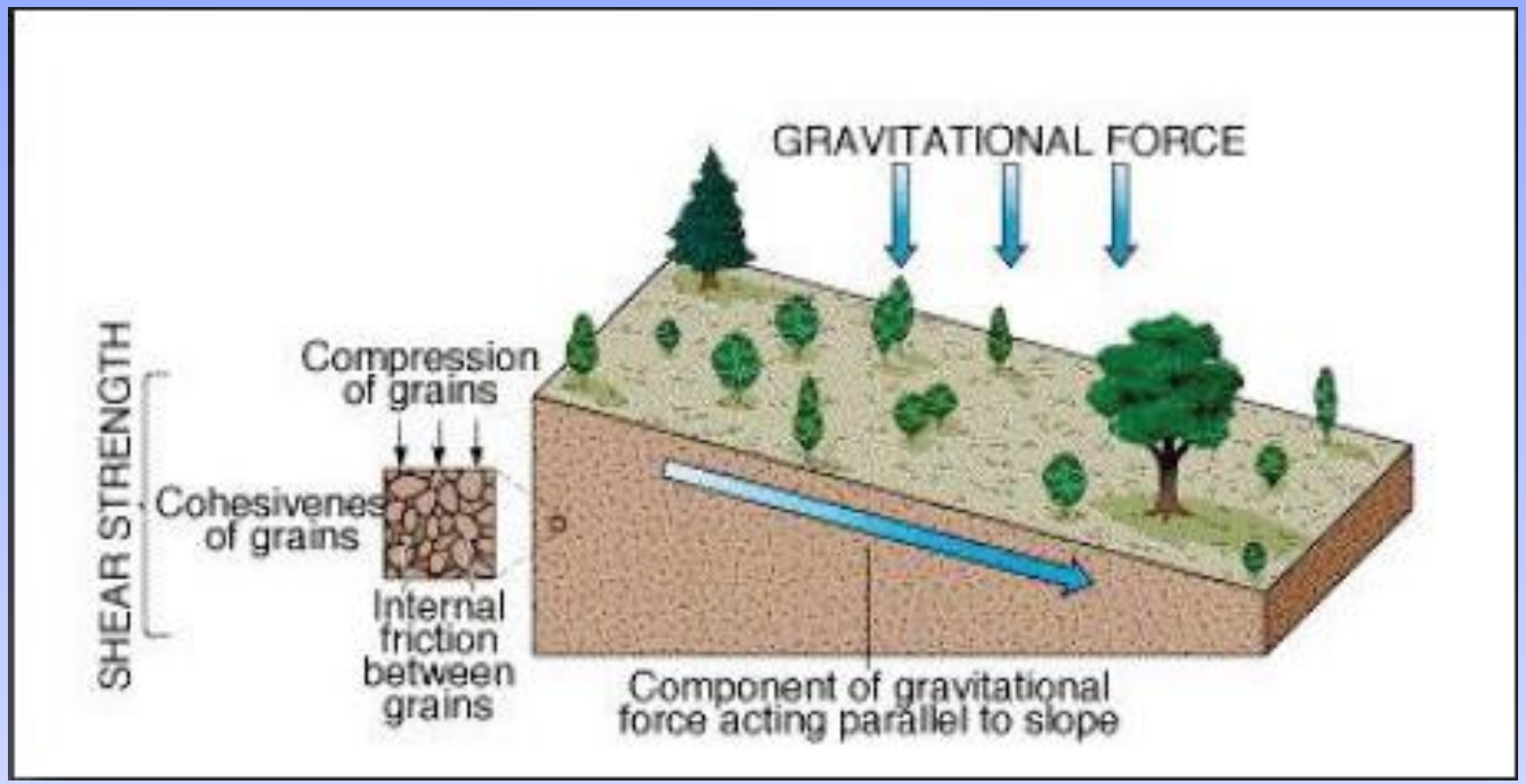
- Impact

- Potential injury and loss of life
- Loss of topsoil, exposure subsoil
- Infrastructure damage
- Offsite damage (waterways, infrastructure)

Mass Movement - Causes

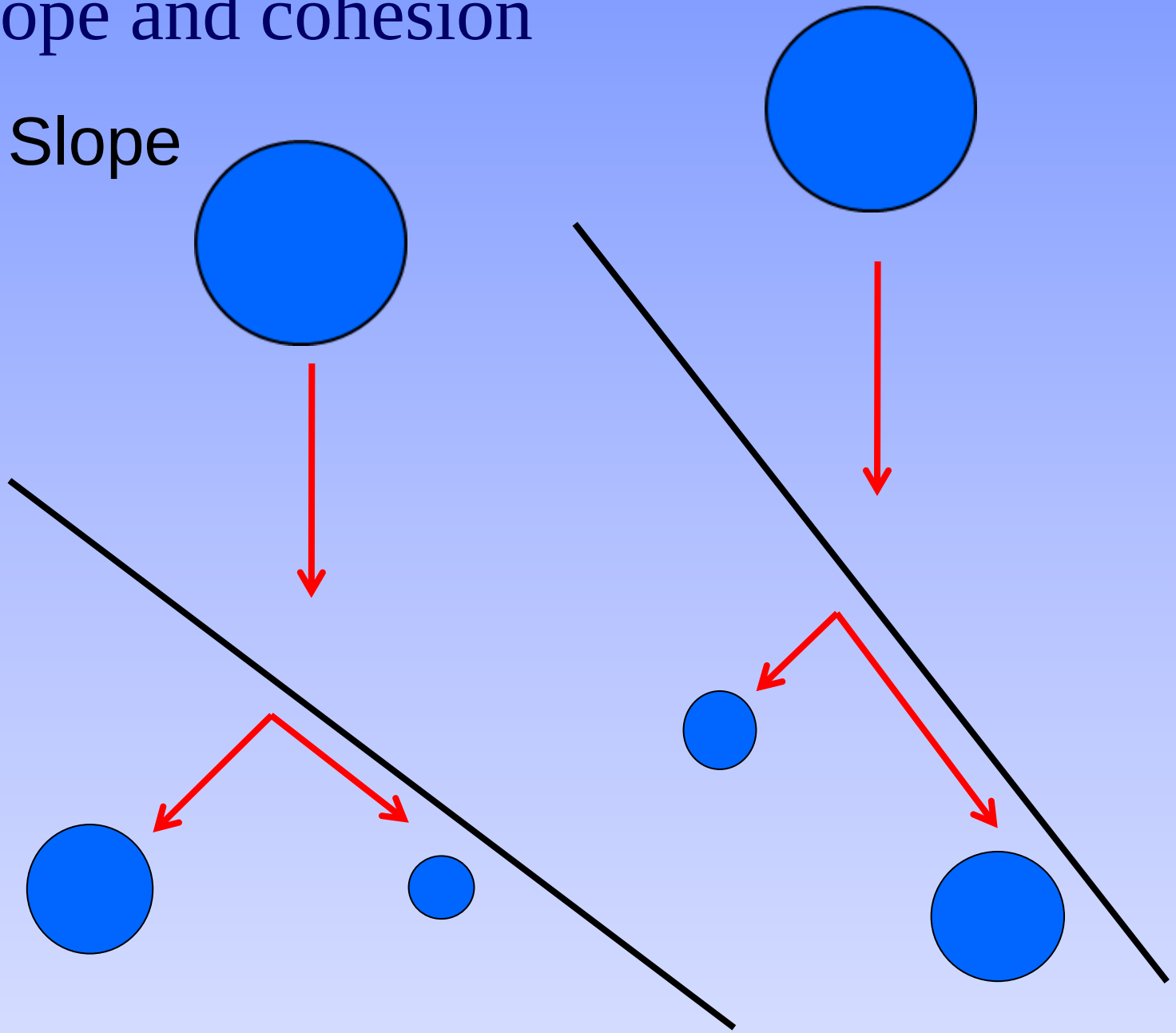
- The key factors which affect mass movement are: slope angle, material strength and water content
- Steeper slope angle = higher gravitational forces.
- Cohesion of the materials (**regolith**/substrate)
- Water content

Slope and cohesion



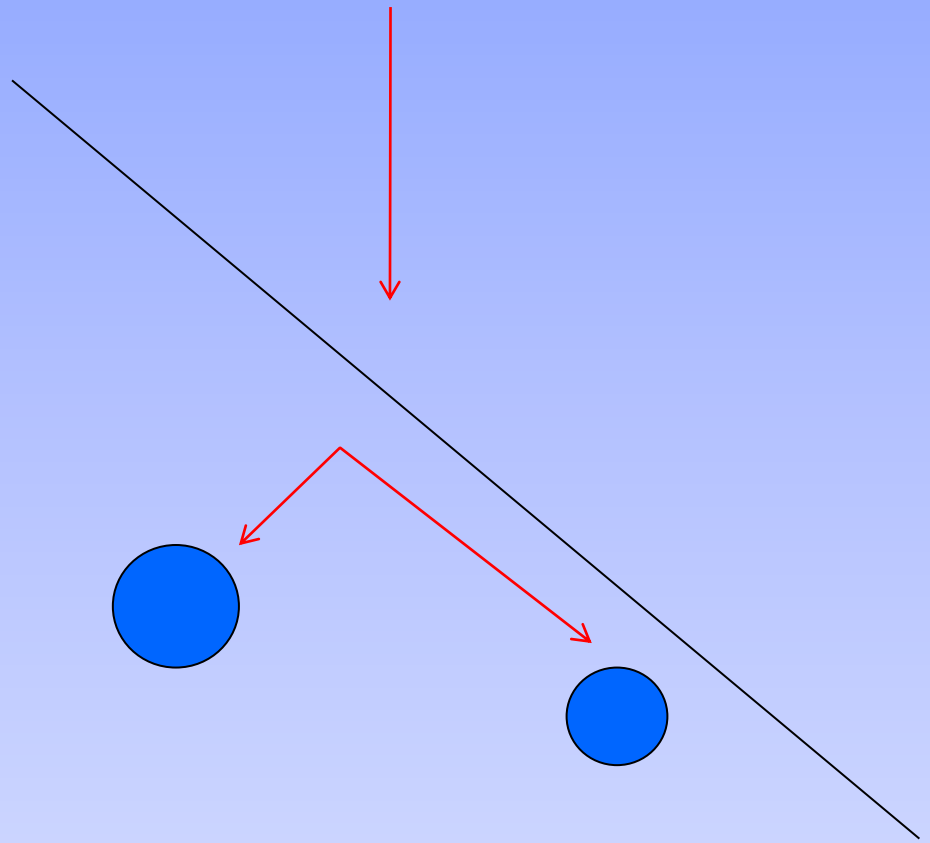
Slope and cohesion

- Slope



Slope failure

- Triggers
  - Excessive rain
  - Earthquakes
  - Overloading
  - Undercutting



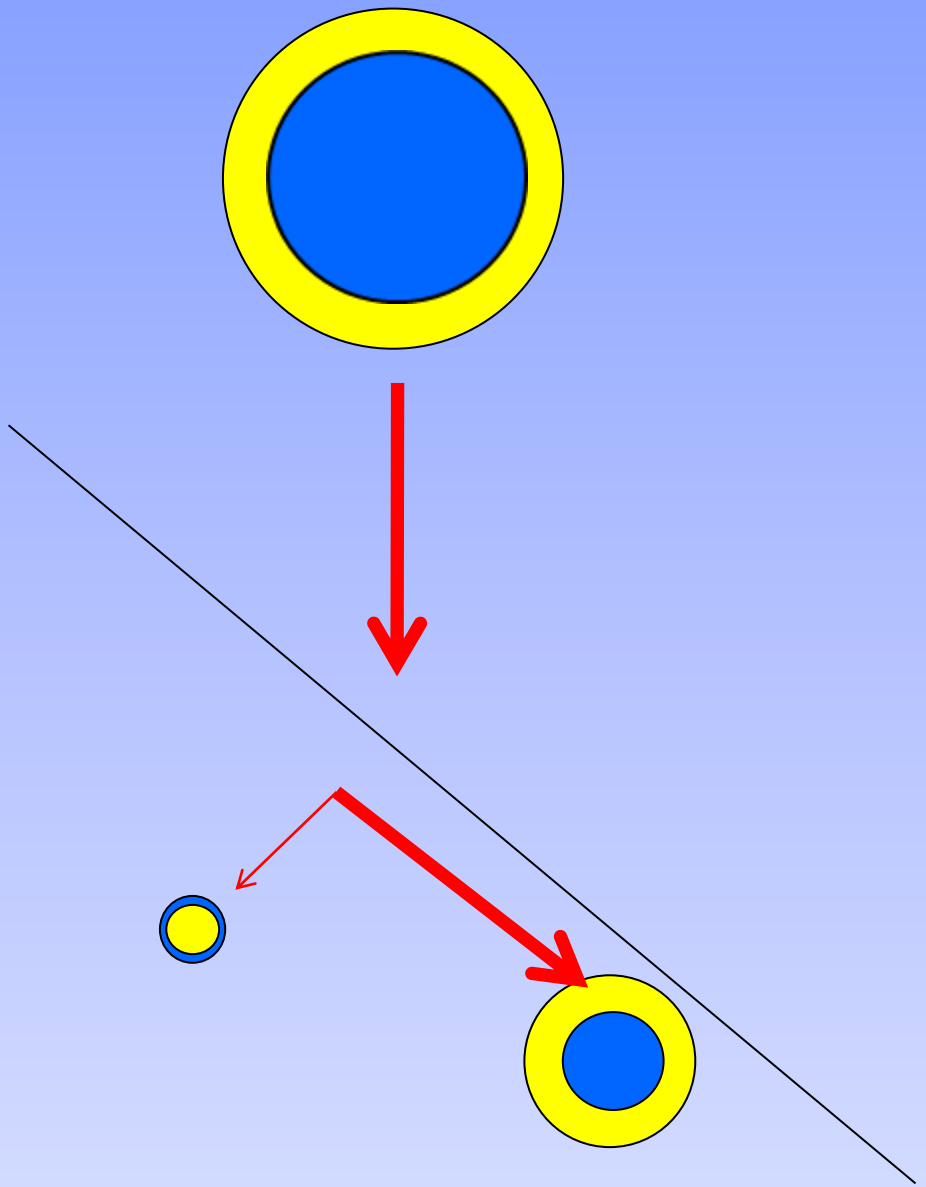
Slope and cohesion

- Water content

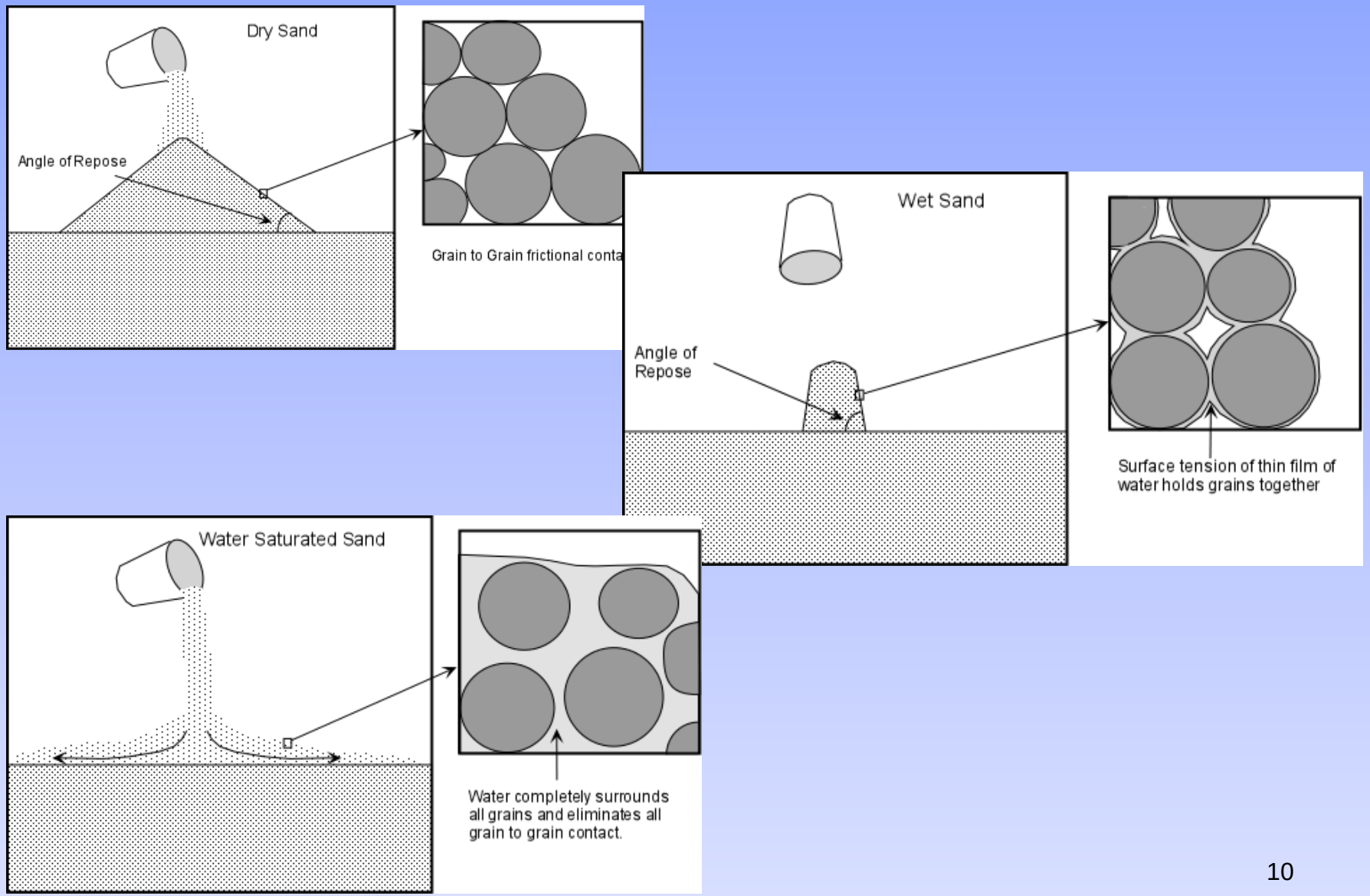
a) Additional mass

b) Initially increased and then reduced cohesion

c) Lubrication



Water content – cohesion



Mass Movement - Causes

- Reduced slope cohesion.
- Transpiration reduced
- Soil and regolith bound by roots

Fire

- Increased peak flows x 30, erosion rates of 22 tonnes/ha and debris flows.

- Soil and regolith bound by roots

Mass Movement - Causes

- Vegetation (especially trees) increases material strength and serves to decrease water content of soils by evapo-transpiration and interception.

  Trees are more effective than grasses or herbaceous vegetation with shallow root systems.

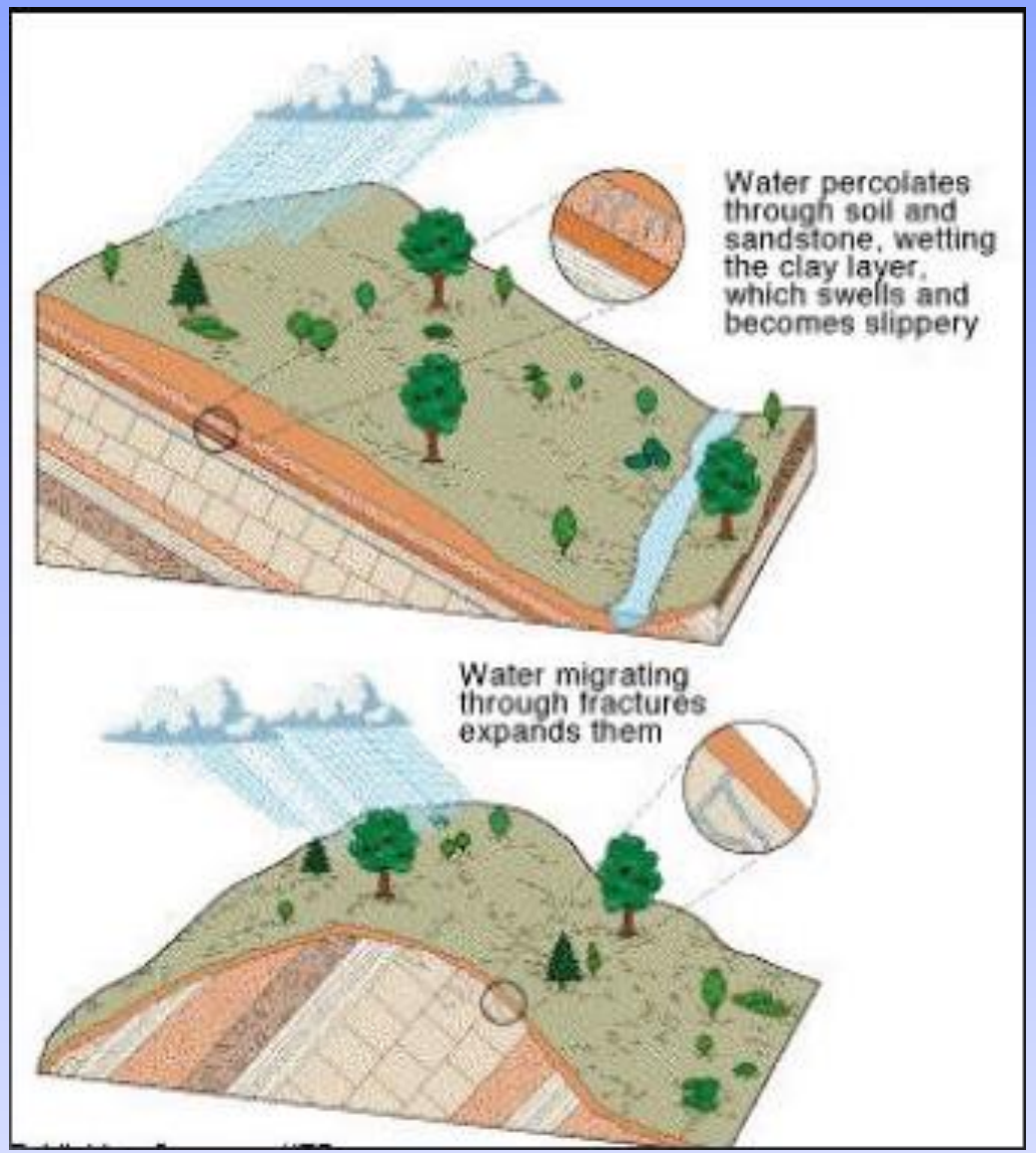
  Isolated trees are not sufficient to stabilise slopes against mass movement.
- Trees can be problematic on very steep slopes

- Geology

a) Zones of weakness along bedding planes

b) Zones of weakness across bedding planes

c) Degree and depth of weathering (geology and climate)



Mass Movement – Richmond

- Landform and geology as it affects mass movement in the this area can be split into 4 types.

  They are:

Mass Movement – Richmond

- 1. Benched terrain of the Lismore basalt
  Layering of the basalt flows in the Lamington volcanics has produced a distinct series of benches.

- 1. Benched terrain of the Lismore basalt

  Mass movement in basalt areas appears to be concentrated on the steeper (> 23º) slopes between bench areas.

- 1. Benched terrain of the Lismore basalt

  At the base of slopes, earthflows may develop in deep colluvium.

- 2. Low rolling country of the ‘soft’ sedimentaries. Shallow earth slumps and slides in the weathered mantle and deep-seated failures that affect the bedrock in the Jurassic-Cretaceous sedimentary rocks (esp. Walloon coal measures).

- 3. The steep slopes of the harder volcanics and indurated sedimentaries.
  - These are steep mountainous slopes that are mostly forested.
  - No significant mass movement has been observed in areas underlain by sandstone/conglomerate or metamorphic rocks (i.e. the ‘harder' sedimentary rocks) away from the area of contact with the volcanics.
  - Where movement has occurred it is restricted to steeper slopes; much like the situations with basalts

4. Contact zones

Between the volcanic rocks (eg. basalt) and the underlying sedimentary rocks.

A permeable bed overlying soft impermeable beds, results in zones of seepage and areas of major weakness producing large complex failures.

Slopes as low as 12^{o} have slumped after heavy rain.

4. Contact zones

Source Kate Steel LCC

Mass Movement – Management

- Prevention is the best policy: avoid clearing and disturbing land prone to mass movement. (Manage land according to its capability for sustainable use)

Identification of High Risk Areas

Indicators:
Old areas of Mass Movement,
Geology,
Soil Type,
Cracks,
Soil Creep,
Profile and Site Drainage,
Slope,
Laboratory measurements (especially strength measures)

Identification of High Risk Areas

Old areas of Mass Movement

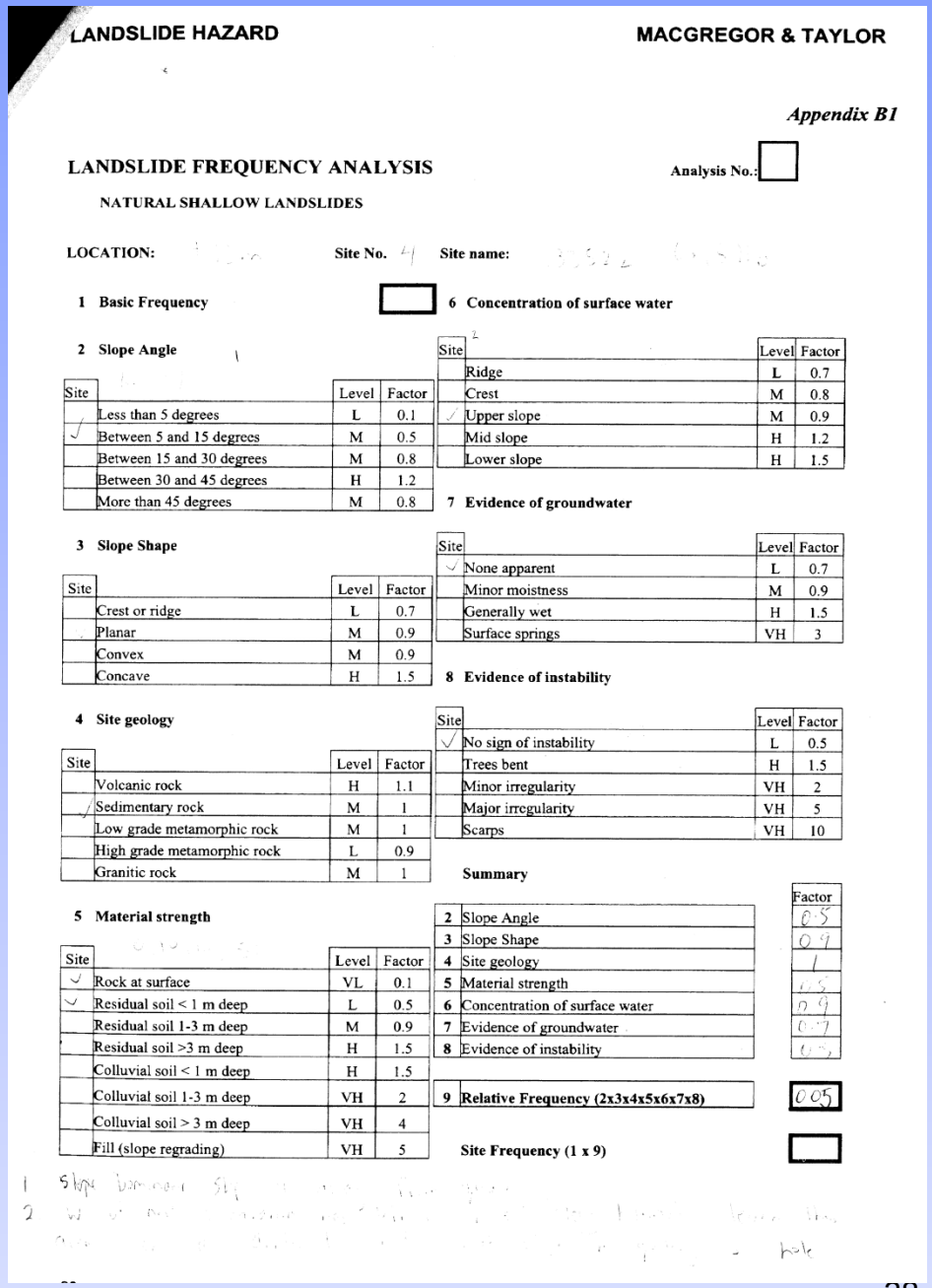
- Soil Creep (Slow earthflow)

Mass Movement – Management

- Identification of Areas of High Likelihood of landslide

Relative Frequency	Likelihood Rating
< 0.2	Very Low
0.2 – 0.6	Low
0.6 – 2.0	Moderate
2.0 – 6.0	High
>6	Very High

Slope
Geology
Material strength
Water movement
(Climate Change)



LANDSLIDE HAZARD — MACGREGOR & TAYLOR

Appendix B1

LANDSLIDE FREQUENCY ANALYSIS — Analysis No.:

NATURAL SHALLOW LANDSLIDES

LOCATION: Site No. 4 Site name:

1 Basic Frequency

2 Slope Angle

Site		Level	Factor
	Less than 5 degrees	L	0.1
✓	Between 5 and 15 degrees	M	0.5
	Between 15 and 30 degrees	M	0.8
	Between 30 and 45 degrees	H	1.2
	More than 45 degrees	M	0.8

3 Slope Shape

Site		Level	Factor
	Crest or ridge	L	0.7
	Planar	M	0.9
	Convex	M	0.9
	Concave	H	1.5

4 Site geology

Site		Level	Factor
	Volcanic rock	H	1.1
✓	Sedimentary rock	M	1
	Low grade metamorphic rock	M	1
	High grade metamorphic rock	L	0.9
	Granitic rock	M	1

5 Material strength

Site		Level	Factor
✓	Rock at surface	VL	0.1
✓	Residual soil < 1 m deep	L	0.5
	Residual soil 1-3 m deep	M	0.9
	Residual soil >3 m deep	H	1.5
	Colluvial soil < 1 m deep	H	1.5
	Colluvial soil 1-3 m deep	VH	2
	Colluvial soil > 3 m deep	VH	4
	Fill (slope regrading)	VH	5

6 Concentration of surface water

Site		Level	Factor
	Ridge	L	0.7
	Crest	M	0.8
✓	Upper slope	M	0.9
	Mid slope	H	1.2
	Lower slope	H	1.5

7 Evidence of groundwater

Site		Level	Factor
✓	None apparent	L	0.7
	Minor moistness	M	0.9
	Generally wet	H	1.5
	Surface springs	VH	3

8 Evidence of instability

Site		Level	Factor
✓	No sign of instability	L	0.5
	Trees bent	H	1.5
	Minor irregularity	VH	2
	Major irregularity	VH	5
	Scarps	VH	10

Summary

		Factor
2	Slope Angle	0.5
3	Slope Shape	0.9
4	Site geology	1
5	Material strength	0.5
6	Concentration of surface water	0.9
7	Evidence of groundwater	0.7
8	Evidence of instability	0.5
9	**Relative Frequency (2x3x4x5x6x7x8)**	0.05

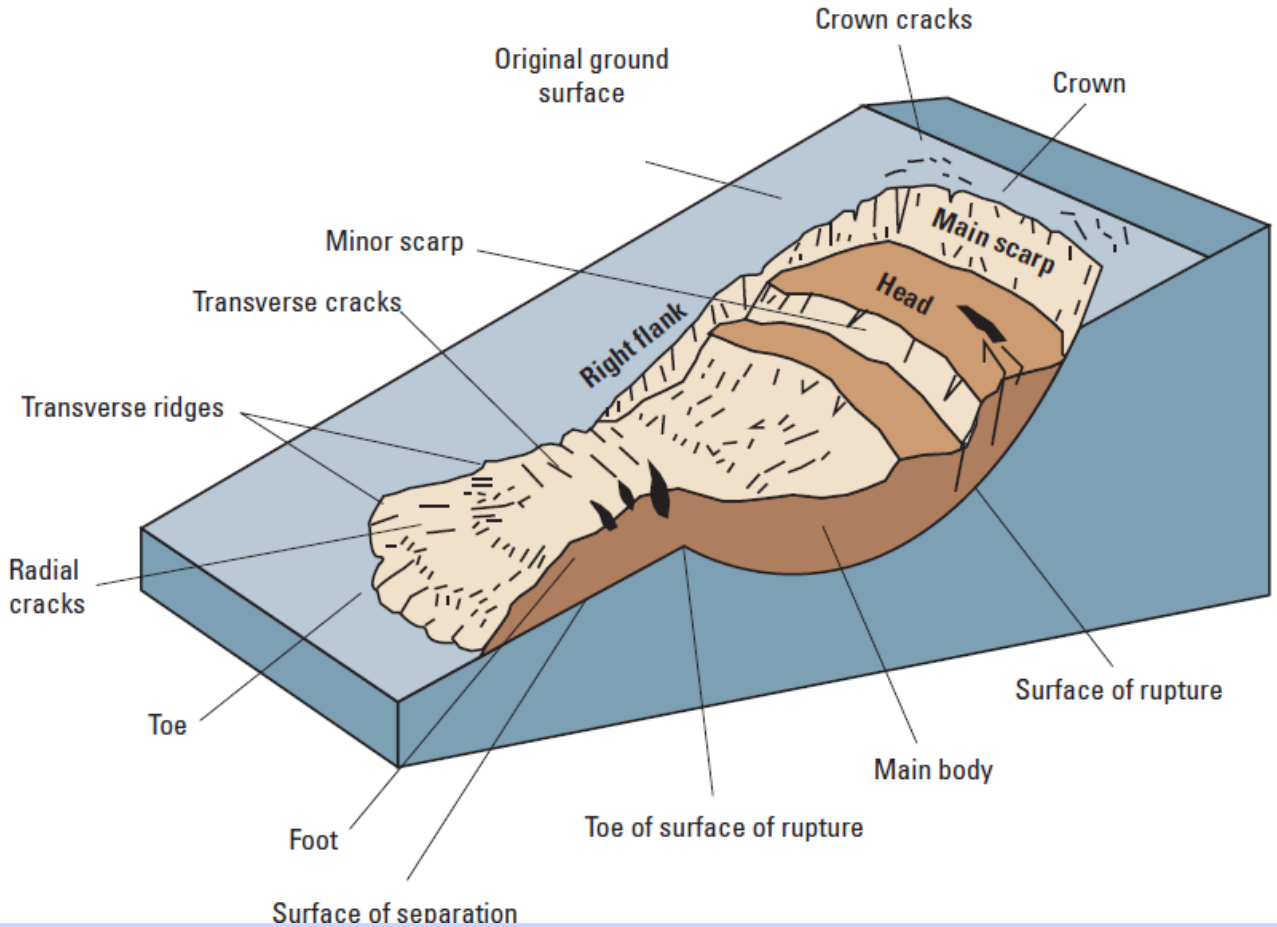
Site Frequency (1 x 9)

Management

- 1.Tree planting.
- 2.Surface drainage.
- 3. Sub surface drainage.

- Subsurface drainage

Mass Movement – Rehabilitation

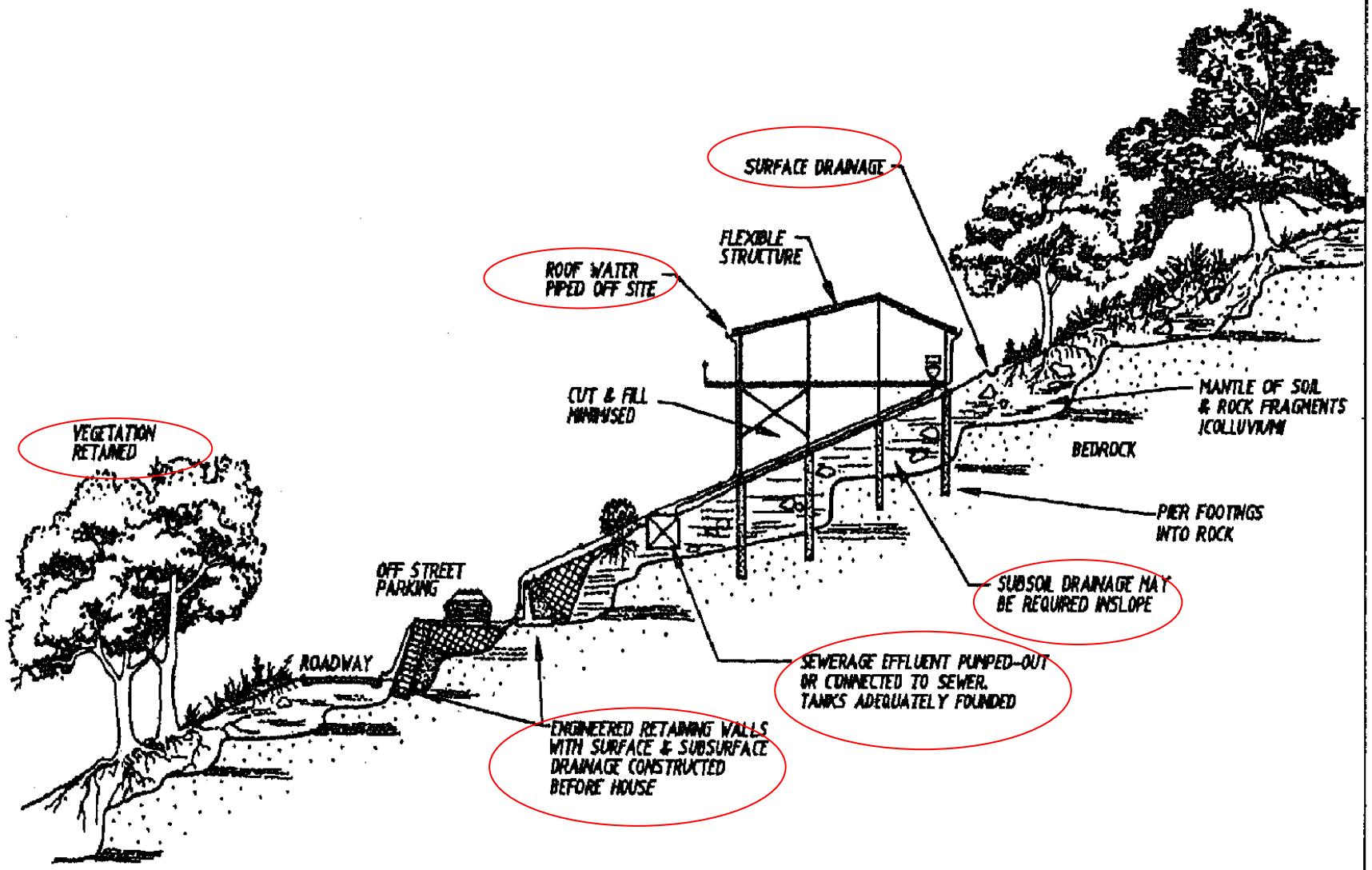


- Slope stabilisation

- Preparation
  - Familiarise yourself with the local risk
  - Plan private and public infrastructure
  - Observe water flow around your property
  - Look for signs of land movement
  - Have emergency plans and
  - Plan in conjunction with neighbours

M

EXAMPLES OF GOOD HILLSIDE PRACTICE



Source: AGS 2000

- Storm Response
  - Stay awake
  - Consider leaving (if safe to do so).
  - Listen for unusual sounds
  - Stay in contact with neighbours

- Future needs
  - Landslide inventory
  - Updated, region-specific risk assessment processes
  - Updated landslide risk mapping
  - Rehabilitation guidelines