Exercise 3

Erosion Hazard Assessment and the Revised Universal Soil Loss Equation (RUSLE)

Erosion hazard assessment

- Blue Book uses RUSLE to assess erosion hazard and considers the following factors:
  - Rainfall erosivity / intensity
  - Soil type and erodibility
  - Slope length/steepness
  - Conservation practice
  - Cover type

Erosion hazard assessment

- Some of the factors in RUSLE are things which we cannot control:
  - Rainfall erosivity / intensity
  - Soil type and erodibility
  - Slope steepness

Erosion hazard assessment

- Some of the factors in RUSLE are things we can control:
  - Slope length
  - Conservation practice
  - Cover type

Erosion hazard assessment

- In this exercise we are going to consider the factors for a typical construction job in Port Macquarie to see to what extent we can have a positive influence on the outcome by controlling the factors that are within our control

The Project

- 400 metres of new road is going to be constructed at Thrumster to access a new ‘rural residential’ land release. The pavement is going to be sealed but the shoulders only graded
- The gradient of the road is 4%
- The soils are ‘Thrumster’ soils with 10cm of clay loam topsoil overlying light clay subsoil

RUSLE

- RUSLE Equation:

$$A = R \times K \times LS \times P \times C$$

Where:

- A = Computed soil loss (tonnes/ha/year)
- R = rainfall erosivity factor
- K = soil erodibility factor
- LS = slope length / gradient factor
- P = erosion control practice factor
- C = ground cover and management factor

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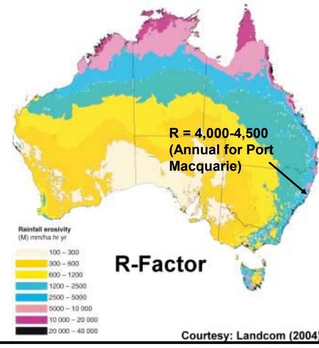
Rainfall Erosivity (R-factor)



Courtesy: Landcom (2004)

- The Rainfall Erosivity or R-factor for Port Macquarie is about 4,000 on the coast and about 4,500 further west at the Pacific Highway intersection

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Low or High Hazard Sites

- Figure 4.6 in the Blue Book compares R-factor and Slope to determine if a site is Low Erosion Hazard (below the A-line), or High Erosion Hazard (above the A-line)
- At what Slope (gradient) does a site in Port Macquarie become a High Hazard site?

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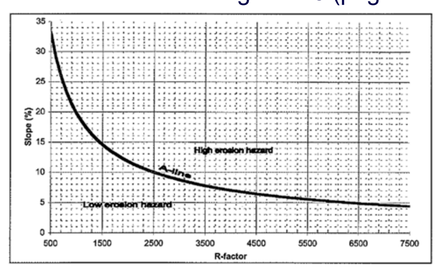
Low or High Hazard Site?

- Blue Book Reference Figure 4.6 (page 4.10)



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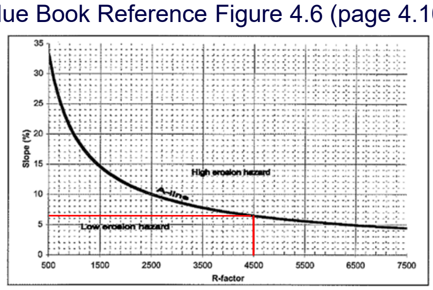
Low or High Hazard Site?

- Blue Book Reference Figure 4.6 (page 4.10)



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High Hazard Sites

Standard erosion controls apply to all sites:

- Stabilised access
- Water management (BB Ref Chapter 5)
- Stockpile management
- Stabilisation requirements (BB Ref Chapter 7)

High erosion hazard sites also require:

- Timing of works should be undertaken in drier months
- Management of batter gradients

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Rainfall Erosivity (R-factor)

PORT MACQUARIE AIRPORT Mean rainfall (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
142.7	167.6	182.3	131.3	104.4	138.2	61.6	61.7	59.2	75.4	144.7	109.1

Which months would you choose to work in Port Macquarie?

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Soil Type and Erodibility (K-factor)

- A measure of the susceptibility of soil particles to erosion
- Affected by soil texture, structure, organic matter, profile permeability and other parameters
- Generally, fine sands and silts are most erodible, but dispersible clays can be highly erodible
- BB Ref Appendix C or Lab test results

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K-factors (after Rosewell 1993)

Table E4 – Default soil erodibility K-factors based on soil texture class

Soil texture	Symbol	Estimated clay content (%)	K-factor [1]
Sand	S	< 10	0.015
Clayey sand	CLS	5–10	0.025
Loamy sand	LS	5–10	0.020
Sandy loam	SL	10–15	0.030
Fine sandy loam	FSL	10–20	0.035
Sandy clay loam	SCL	15–20	0.025
Loam	L	about 25	0.040
Loam, fine sandy	Lfsy	about 25	0.050
Silt loam	SiL	about 25 and more than 25% silt	0.055
Sandy clay loam	SCL	20-30	[0.043]
Clay loam	CL	30–35	0.030
Silty clay loam	SiCL	30–35 and more than 25% silt	0.040
Fine sandy clay loam	FSCL	30–35	0.025
Sandy clay	SC	35–40	0.017
Silty clay	SiC	35–40 and more than 25% silt	0.025
Light clay	LC	35–40	0.025
Light medium clay	LMC	40–45	0.018
Medium clay	MC	45–55	0.015
Heavy clay	HC	> 50	0.012

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Soil Type and Erodibility (K-factor)

- What is the K-factor for clay loam topsoil?
- What is the K-factor for light clay subsoil?
- The subsoils are generally of more significance in construction and will be exposed in this example
- (Increase by 20% for dispersive soils)

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Slope Length / Steepness (LS-factor)

- A measure of the combined effect of slope length and gradient on soil loss
- Increases as slopes get steeper and longer
- Gradient has greater influence

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LS-factor

Table A1 LS-factors on construction sites using the RUSLE

Slope ratio	Slope gradient (%)	Slope length (m) 5	10	20	30	40	50	60	70	80	90	100	150	200	250	300
100:1	1	0.09	0.11	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.20	0.23	0.24	0.26	0.27
50:1	2	0.14	0.18	0.24	0.28	0.31	0.34	0.36	0.39	0.41	0.43	0.44	0.52	0.58	0.64	0.69
33.3:1	3	0.17	0.24	0.34	0.41	0.47	0.52	0.57	0.61	0.65	0.69	0.72	0.87	1.00	1.11	1.22
25:1	4	0.21	0.30	0.44	0.54	0.63	0.71	0.78	0.85	0.91	0.97	1.03	1.26	1.47	1.65	1.82
20:1	5	0.24	0.36	0.54	0.68	0.80	0.91	1.01	1.10	1.19	1.27	1.35	1.70	2.00	2.28	2.53
16.6:1	6	0.28	0.42	0.64	0.81	0.97	1.11	1.24	1.36	1.47	1.58	1.68	2.14	2.54	2.91	3.25
12.5:1	8	0.34	0.53	0.83	1.08	1.31	1.51	1.70	1.88	2.05	2.21	2.37	3.07	3.70	4.28	4.82
10:1	10	0.42	0.68	1.09	1.44	1.75	2.04	2.31	2.56	2.81	3.04	3.27	4.06	4.94	5.75	6.52
8.3:1	12	0.52	0.85	1.39	1.85	2.27	2.66	3.02	3.37	3.70	4.02	4.33	5.77	7.07	8.28	9.42
7.1:1	14	0.62	1.02	1.69	2.26	2.79	3.28	3.74	4.18	4.61	5.02	5.42	7.27	8.95	10.52	12.01
6.3:1	16	0.71	1.19	1.98	2.67	3.31	3.90	4.46	5.00	5.52	6.02	6.51	8.78	10.86	12.81	14.65
5.5:1	18	0.80	1.35	2.27	3.07	3.82	4.51	5.17	5.81	6.42	7.02	7.59	10.30	12.78		
5:1	20	0.89	1.50	2.55	3.47	4.32	5.12	5.88	6.61	7.32	8.01	8.68	11.92	14.84		
4:1	25	1.09	1.88	3.23	4.43	5.54	6.59	7.60	8.57	9.51	10.43	11.32				
3.3:1	30	1.28	2.23	3.86	5.32	6.69	7.99	9.23	10.43	11.60	12.74	13.85				
2.5:1	40	1.61	2.83	4.98	6.92	8.74	10.48	12.15	13.77							
2:1	50	1.88	3.33	5.89	8.22	10.42	12.52	14.55								

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Slope Length / Steepness (LS)

- Assume slope is 4% and slope length is 50 metres
  What is the LS-factor?
- As we can control this factor, we will shorten the slope length to 20 metres using temporary earth banks
  What is the LS-factor?

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Temporary Earth Banks

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LS-factor

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LS-factor

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Conservation Practice (P-factor)

- Relates to surface condition rather than cover
- Reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill, e.g.
  - Track walking up/down slope rather than across slope
  - Straw crimping
  - Loose soil surface

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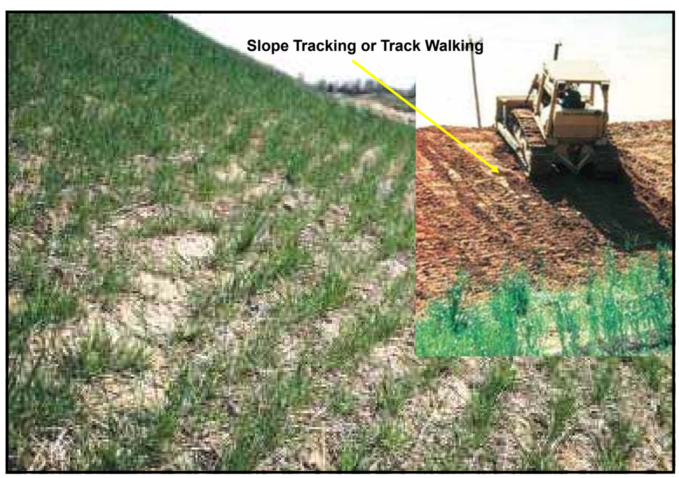

Conservation Practice (P)

Table A2 P-factors for construction sites (Goldman et al., 1986)

Surface condition	P-factor
Compacted and smooth	1.3
Track-walked along the contour[6]	1.2
Track-walked up and down the slope[7]	0.9
Punched straw[8]	0.9
Loose to 0.3 metres depth	0.8

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Conservation Practice (P)

- Now assume the surface has been track walked along the contour

  What is the P-factor?
- Now assume the surface has been track up and down the slope
- Why would track walking up and down the slope be better?

  What is the P-factor?

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Cover Type (C-factor)

- A measure of the amount and effectiveness of ground cover
- Reduce the erosion hazard by maintaining good ground cover (lower C-factor) – a key erosion control practice!
- Proper rehabilitation should ensure C-factors drop to below 0.15 within 20 days of completing work

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Cover Type (C-factor) for Grass

Grass Cover	C-Factor
No cover, soil smooth and compacted	1.0 **(High)**
20%	0.45 **(Med)**
50%	0.15 **(Low)**
70%	0.05
100%	< 0.01

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Cover Type (C-factor)

- Assume there is no grass cover and the surface is smooth and compacted

  What is the C-factor?

  What effect would 20% cover of newly established grass have on the C- factor?
- BB Ref Appendix A, Table A3 Soil Stabilisation Control Matrix shows C-factors for various surface treatments

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Cover Type (C-factor)

- Reduce the erosion hazard by maintaining good ground cover (lower C-factor) – a key erosion control practice!
- Proper rehabilitation should ensure C-factors drop to below 0.15 within 20 days of completing work
- So, how do we achieve a suitable C-factor?

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Estimates of Soil Loss

Estimates of soil loss helps to:

- Assess erosion risk
- Identify measures to overcome erosion risk
- Compare effectiveness of erosion control measures
- Estimate capacity of sediment basins

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RUSLE

- Equation:

A = R x K x LS x P x C

Where:

- A = Computed soil loss (tonnes/ha/year)
- R = rainfall erosivity factor
- K = soil erodibility factor
- LS = slope length / gradient factor
- P = erosion control practice factor
- C = ground cover and management factor

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RUSLE

Limitations:

- Only predicts sediment entrained by erosion
- Predicts average annual soil loss, not soil loss for one storm event
- Effective for sheet and rill erosion on slopes <300 metres but not concentrated flow or long slopes
- Does not adequately take into consideration dispersibility in K-factor

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RUSLE

- We can now calculate the soil loss using the values given as examples
- Equation:

A = R x K x LS x P x C

A = 4,000 x 0.025 x 0.71 x 1.2 x 1.0

A = 85.2 tonnes/ha/year

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Discussion

Which of the previous erosion factors can be readily manipulated to reduce the erosion hazard on your construction site, and how?

- Rainfall, soil type – NO
- Slope length, cover type - Possible
- Conservation practice – DEFINITELY!

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RUSLE

- Now calculate the soil loss with improved management practices used in the examples
- Equation:

A = R x K x LS x P x C

A = 4,000 x 0.025 x 0.44 x 0.9 x 0.45

A = 17.8 tonnes/ha/year

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Conclusion

- We can make a significant difference to the erosion risk of projects by carefully managing those factors that we can control
- In this case we reduced the computed soil loss from

  A = 85.2 to 17.8 tonnes/ha/year

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