

Landslides

STUDENT ACTIVITIES

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LANDSLIDE COMPREHENSION (THREE-LEVEL GUIDE)

Recommended Age: Upper primary to secondary

Instructions

Read “The Nature of Landslides” pages 2-4. Now that you have read the text, look at the following statements. Put a tick in the last column if you agree with the statement. List some words or phrases from the text that support your answer, and record the number of the section of text that contains your evidence. The first line has been completed for you.

Level I: Literal Level

Answer the following questions finding the evidence from the text and recording the key facts.

Question Number	Statement	Section Number	Key Facts/ Evidence	Agree
Example:	There have been more deaths caused by earthquakes than landslides in Australia.	2	15 people have died from earthquakes versus at least 110 deaths caused by landslides.	✓
1.	All landslides travel fast.			
2.	Earthquakes can cause landslides.			
3.	Heavy rainfall is not a cause of landslides.			

Question Number	Statement	Section Number	Key Facts/ Evidence	Agree
4.	The distance travelled by landslides is usually the same – usually about 500 metres.			
5.	Up until 2010 the worst landslide disaster in Australia occurred at Thredbo in NSW.			

Level 2: Interpretative Level

Read these statements. Does the text give you these ideas?

What words and phrases from the text support your answer?

Question Number	Statement	Section Number/s	Key Facts/ Evidence	Agree
6.	All ledges on cliffs are equally stable.			
7.	Children at the beach should never dig into high sand cliffs.			

Level 3: Applied Statements

Read the following opinions and think about them, helped by your new knowledge about landslides. Then write your personal response to the statement. You can include quotes from the text, or draw on your own experience in your answer.

Possible ways to begin a response:

This connects to my life in this way...

I wonder...

This is important because...

I don't understand _____ because _____ .

Question Number	Statement	Justification/discussion	Agree
8.	In heavy rain a tour guide instructs a group of holiday makers to shelter under the base of a cliff which collapses killing four people. The tour operator should have known better.		
9.	A visiting geologist stands on a forested hillside. Some of the trees have fallen or are tilted down hill. He says that this land should not be built on because it is too unstable. He has given good advice.		
10.	A house built on flat land on a valley floor is safe from landslides.		

SLIPPERY SLOPES = RISKY BUSINESS

Recommended Age: Lower secondary

Building on a slope can be a risky business. Before beginning to build, scientists, engineers and architects must test and measure how stable the slope is. Buildings and roads can weaken the stability of a slope.

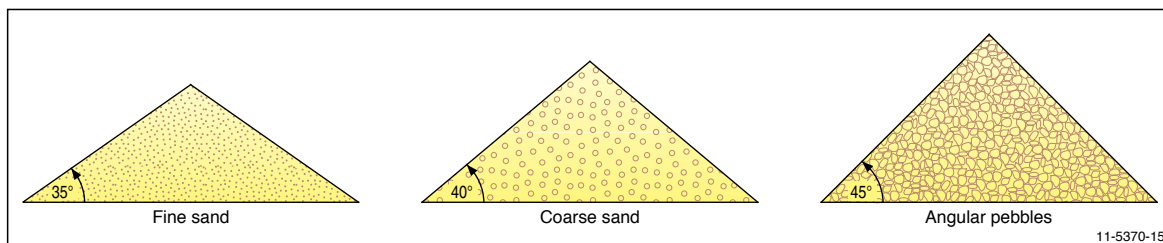
If material is excavated from the bottom of the slope in the process of building a road or house, the chance of a landslide event increases. This is also the case when the top of a slope is loaded down by a new house or material and the slope is unable to support the additional weight.

Nevertheless, preventative measures can be taken to reduce the risk of landslides. For example, the side/s of an excavation or road cut can be strengthened by retaining walls, concrete or gabions (hard rock fragments in a wire basket good for stabilising cut slopes). Additionally, installing good drainage and reducing the angle of the cut slope to make it less steep can help prevent a potential disaster.

The angles of slopes are measured when assessing the risk of landslides. Different materials naturally rest at different angles. For example, fine sand sits at about 35 degrees but sharp, pointy pebbles are stable at a steeper angle of 45 degrees. This means that it would be dangerous to build on sand that was at 40 degrees, but if the material was pointy pebbles, it would be safe to build here.

Local authorities are responsible for assessing construction sites. These assessments then effect the strictness of the building requirements. For instance, the riskier a slope is to build on, the stricter the building requirements need to be.

Even so, figuring out risk ratings is a costly and time consuming task and often ratings may not be entirely accurate. One must first explore the soil type, vegetation, land use and weather conditions before calculating the risk.



Precautions when building on a risky slope

Using the words below copy and complete the following sentences:

drainage

excavate

stabilise

friction

vegetation

1. When benching (cutting) into the slope, you may need to _____ the cut slope.
2. Provide good _____ to direct water away from the site.
3. _____ existing soil and replace it with granular rock pieces which offer better _____ and drainage.
4. Keep _____ whose root system will stabilise the slope.

Complete ONE of the following as a paragraph in your book:

- a) Understanding the dangers of landslides is important because ...
- b) After reading about landslides, I'm wondering ...
- c) The story about landslides reminds me of ...

CAN YOU OUTFRAN A LANDSLIDE?

Recommended Age: Lower secondary

Can you outrun a landslide? How about a rockfall? You will find out in this activity!

First of all, find out how fast you can sprint 100 metres. To do this, use a stopwatch to time how many seconds it takes you to run 100 metres, then use the following equation:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

For example, if Cathy Freeman runs 100 metres in 11.24 seconds, her sprinting speed is:

$$\frac{100}{11.24} = 8.9 \text{ m/s}$$

Repeat your measurement three times, and record the numbers in a table.

Distance (m)	Time (s)	Speed (m/s)

1. Calculate your average sprinting speed over 100 metres.
2. a) Using your answer from question 1, estimate how long it would take you to run 500 metres.
b) Describe how you made your estimate.

Now, work out if you could outrun landslides in each of the given scenarios.
Show all of your workings.

Scenario 1

Watch out! A mud flow (called a 'lahar' in Indonesian) caused by a volcanic eruption is heading your way! It is 50 metres upslope from where you are standing and travelling at 100km/h! You can run at 2 metres per second. Will you outrun it?

First step: How fast is 100 km/h in m/s? (Remember there are 1000 metres in 1 kilometre, and 3600 seconds in 1 hour).

$$1\text{km/h} = \frac{1\text{km}}{1\text{h}} = \frac{1000\text{m}}{3600\text{s}}$$

Second step: Fill in the table showing how far you and the mud will travel over time.

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres				
Mud (___m/s)	0 metres				834

Third step: Remember that the mud started 50 metres behind you, so now subtract 50m from each of the figures for distance for the mudslide.

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres				
Mud (corrected)	-50 metres				834

Fourth step: Using graph paper, draw up axes. Put distance (m) on the y-axis using a range of -100m to 800m. Put time (s) on the x-axis. Plot the data for how far you run in 30 seconds. Now plot the data for the mudslide.

Fifth step: Does your line intersect the mudslide line? Y / N

If your answer is yes, how many seconds after you started running did the mudslide catch up with you?

Scenario 2

Oh dear, I think you may be in a spot of trouble! A landslide is heading your way at 0.000576 km/h . You can run at 2 m/s , but it's already 30 metres away from where you're standing. Can you escape?

First step: (Conversion from km/h to m/s .)

Second step:

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres				
Landslide (__m/s)	0 metres				

Third step:

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres				
Landslide (<u>corrected</u>)	metres				

Fourth step: Graph the data for you and the landslide. Use the range -40 to 70 (in metres) on the y-axis, and time (in seconds) on the x-axis.

Fifth step: Do your two lines intersect? Do you manage to outrun the landslide?

Scenario 3

Your house has been built on clay which is subject to soil creep. This is putting stress on the footings of the house. Some of the footings rest on the clay while other footings are on hard rock. The clay is creeping at 1 cm/y. A movement of only 5 centimetres may damage your house! You will need to stabilise and strengthen the footings in clay before your house is damaged. How much time do you have to fix your house before it becomes damaged?

VEGETATION MARKERS

Recommended Age: Lower secondary

A local amateur plant collector, Jayne Murek, has sent you a map of an area close to her home. Jayne has marked on this map the position of five different plant species that she has identified. She has also noted that the cliffs in this area have some fresh rock faces, or scars, which she thinks are the result of landslides that have occurred in the past.

From your experience in searching for evidence of landslides you know that some plant species are very quick to colonise the disturbed ground after a landslide, while others are very slow to colonise the new area. In an area close to where Jayne lives, you have recognised that the five plants Jayne has mapped tend to colonise disturbed land in the following order

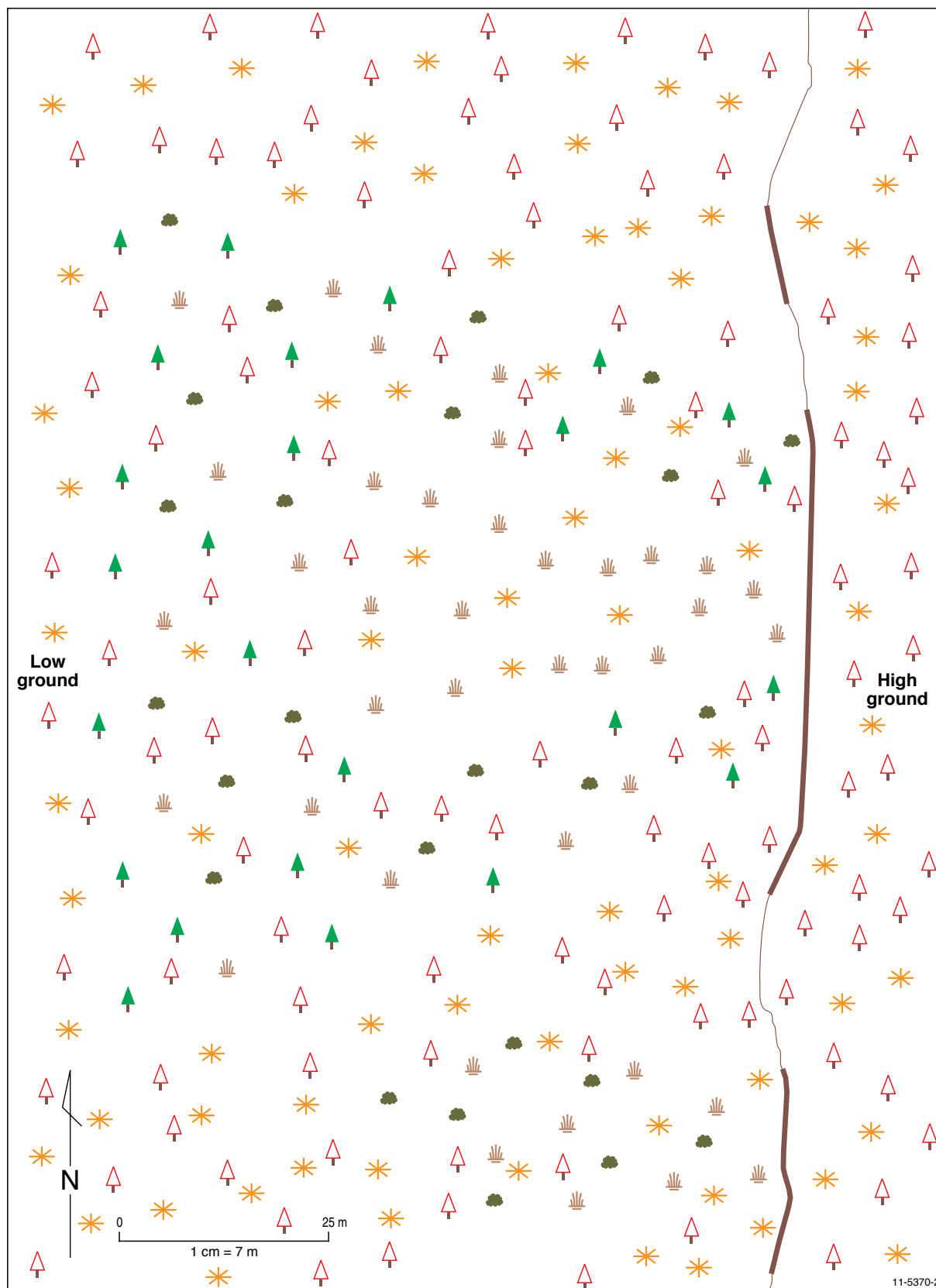
First to colonise	Tussock grass
	Wattle
	Mallee bush
	Red barked gum
Last to colonise	Native Pine

You also have noticed that over time many species die off and often only the gum trees and wattles survive.

To discover the extent and relative age of possible landslides in Jayne's mapped area follow these steps:

- 1. Draw a line on the map which divides those areas which only contain red barked gum and wattles from those areas containing other species. Colour the areas where only red barked gums and wattles are found with a **green** pencil.**
How many landslide 'scars' can you recognise from this level of evidence?
- 2. Recent landslides will have only tussock grass and wattles growing on the disturbed materials. Draw a line around any area where only these species can be found. Colour this area in with a **red** pencil.**
How far from the cliff has the most recent landslide altered the vegetation?
- 3. Medium aged landslides will have tussock grass, wattles, mallee bush and red barked gums but no native pines. Find any of these areas which Jayne has marked and colour this area in with an **orange** pencil.**
How far from the cliff has the medium-aged landslide altered the vegetation?
- 4. The oldest landslides will have all the species growing on them. Find any of these areas which Jayne has marked and colour this area in with a **yellow** pencil.**
- 5. How many landslide scars can you now recognise?**
- 6. How far from the cliff has the largest landslide altered the vegetation?**
- 7. How many cliff scars can you find which do not appear to have vegetation evidence for a landslide?**
- 8. Why do you think that no vegetation evidence can be found here?**

JAYNE'S VEGETATION MAP



— Cliff line
— Cliff scar

Tussock grass
Red barked gum
Native pine

Mallee bush
Wattle

LANDSLIDE DEBATE ISSUES

Recommended Age: Upper primary to secondary

In groups debate the following five issues involving landslides. It is important that you justify your responses with a carefully considered argument. That is, you will have to be able to explain your reasons. You will be told whether you are to argue for or against the topic. The first topic suggests some example arguments for both sides. For the other topics you will have to work out the possible arguments for and against each statement.

1. House foundations move — should the council pay?

The council of Bimbdoon advertised, 'A 4 acre block of land in Bimbdoon's picturesque hinterland, with magnificent northerly views over mountains and valleys', in their local newspaper. Mr. and Mrs. Rafelli who were planning to build their dream home were excited about the prospect of living with such magnificent scenery, and therefore bought the land and built on it. After 13 months of living in their house it was discovered that the foundations had moved, resulting in cracking of their walls. To repair the damage to the house it will cost them \$30 000. However, even after the house is fixed they have been given no guarantee that the foundations will remain stable.

Should the Council have to pay for the damage to their house?

Arguments For

The council should pay, because they sold a block of land which was unsuitable to build on.

Arguments Against

The Rafellis should have investigated the block of land more thoroughly. If unsure of the stability of the land they should have called geotechnical experts in to assess the site before purchasing the land.

2. Should councils increase funding to ensure all drains are free from blockages?

Phil, a ratepayer in the Mogdon Valley is concerned that the council is not keeping the drains clean enough. Phil suggests that the council make drain cleaning a higher priority in the valley, rather than spending so much time on tree planting. The Mogdon Valley is surrounded by three very steep slopes. Maddie, another ratepayer, wants to see more trees planted to prevent the drains from becoming blocked with sediments that flow off the slopes.

Identify the arguments for and against Phil's view on keeping the drains clean, rather than tree planting.

Should the council make cleaning the drains a higher priority than tree planting?

3. Is farmer Tom to blame?

One day a farmer named Tom decided to clear his land to improve the pasture for his sheep. His property was located at the top of a steep slope above another farmer's property. Paul's land was down slope from Tom's, and was valuable because it included a large dam. However, when Tom cleared his land of vegetation it altered the flow of water in the area. The water, instead of being captured by vegetation and soaking into the soil, flowed down the steep slope onto Paul's property. The change in water flow caused erosion and an undercut to develop on Paul's property.

A year after Tom's property had been cleared of vegetation, the undercut slope crumbled, resulting in a significant landslide. The debris caused significant damage to the dam and Paul is now struggling to provide adequate water for his sheep.

Paul is suing Tom for causing a landslide that has ruined his dam.

First, draw a mind map of your interpretation of the two properties and then work out the arguments for and against Paul's claim.

Should farmer Tom have to pay compensation for damaging farmer Paul's dam?

4. Should councils provide approval for building before a risk map of the area is completed by the government?

Whister and White Constructions Pty Ltd want to build a small housing development on the Great Pinnacles, a sandstone cliff top which has fantastic views of the ocean.

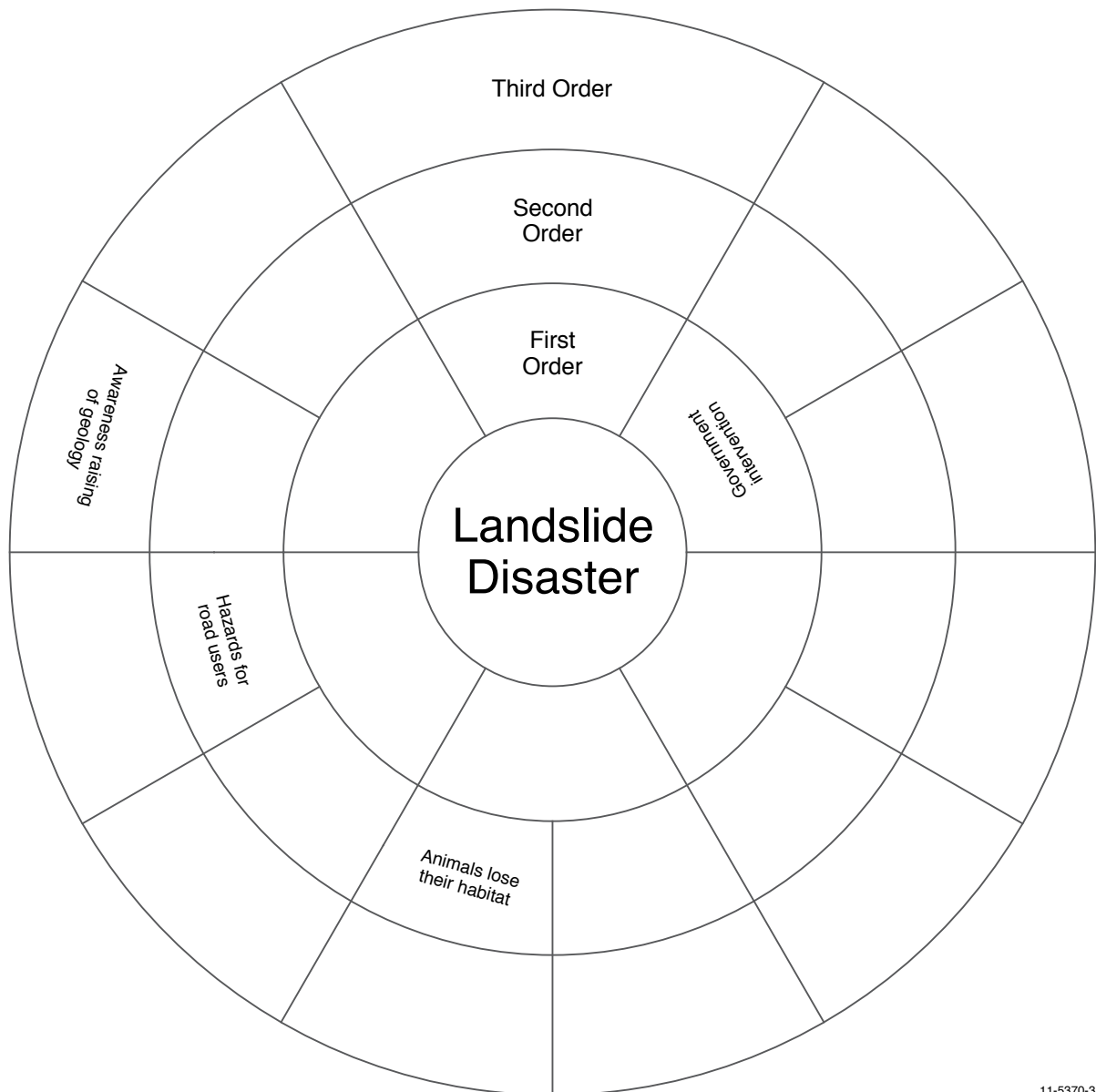
They argue that the area is safe because it has not recorded any natural disasters in the last 50 years. The government agrees that the land would fetch a high price, but insists that no construction can begin until a risk assessment is completed which includes the potential for the cliff to collapse.

Identify the arguments for and against the council granting permission for construction before the risk assessment is completed.

Should the developers have to wait for permission from the council before they can start developing?

LANDSLIDES EFFECTS WHEEL

Recommended Age: Middle to senior secondary



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How to use the Landslides Effect Wheel

This circular structure is called an effects wheel. There are three orders or parts to this landslides effects wheel: first order, second order, and third order. You can turn the wheel around so you can read the writing easily.

First order effects: follow immediately from the landslide event.

Second order effects: follow from the first order effects.

Third order effects: follow from the second order effects.

Effects after a landslides disaster

The list below includes first, second and third order effects of a landslide disaster.

- Animals lose their habitat
- Chance of more road accidents
- Cost of damage (generally) not recovered from insurance agencies
- Cost of structural damage estimated
- Engineering and architectural design re-evaluated
- Earth flow
- Emergency Management Plan
- Human lives threatened
- Immediate reduction in animal population size
- Increased traffic on other roads
- Increased danger during rainfall
- Increased turbidity into rivers
- Insurance agencies involved
- Media coverage
- New plant and animal life
- Police guard public safety
- Regeneration of area
- Rescuers search for people
- Road blocked
- Sediments into waterway
- Vegetation lost
- Water redirected

Your task

- Identify the five first order effects. (One is already provided for you in the wheel). Write them into the wheel. For each first order effect there are two second order, and two third order effects. They will all relate to each other.
Eg [first order] = earth flow. [second order] = sediments in waterways
[third order] = increased turbidity into rivers.
- Organise all of these effects into their orders, then fill in the wheel.
- Analyse the effects of landslides by exploring their social, political, economic and scientific consequences. Do this by grouping the first order effects into social, political, economic and scientific consequences. Write your answers into the table below. For example, Human lives threatened would be a social concern so write 'human lives threatened' under the social column.

Note: first order effects can have multiple consequences, so may appear in more than one column.

	Social	Political	Economic	Scientific
First Order Effects	Human lives threatened			

GREAT GEOTECHNICAL GADGETS

Recommended Age: Secondary

Writing an article for a local newspaper

You are a highly respected geotechnical expert with experience in landslide processes.

There has been a landslide in a steep region of your local area. The landslide killed two young children and injured three people.

As a geotechnical expert you know that it is too early to speculate because investigations are only just beginning. You have a few hunches though, so you have ordered a range of investigations and studies.

- climate data (including rainfall over a long time)
- collection of soil data
- investigation of underground water courses
- assessment of existing drainage systems
- inspection of the remaining foundations
- use of monitoring devices (inclinometers and piezometers)

Note: **Inclinometers** are instruments which can measure angles. An inclinometer can be used to measure slopes and the movement of soils.

Piezometers are designed to measure fluid pressure. Ground water level and pore pressure can provide valuable information which can be interpreted along with rainfall data, water courses and drainage systems to indicate stability of the ground.

Your task

A journalist wants you, the geotechnical expert, to explain why these investigations are important. You have been asked to write an article for the local newspaper, which explains what may be discovered from the investigations and studies. You may use your own starting/topic sentence or the one below.

“Investigations are beginning, but, it is far too early for me to comment on the cause of this terrible disaster. Let me explain the importance of these investigations...”

OR

Prepare a transcript of an interview between you and the journalist for television or radio to present in front of the class.

OR

Video a television interview between you and the journalist. You may include interviews with members of the community who have been affected by the landslide.

GO BUSH ON SLIDE ISLAND

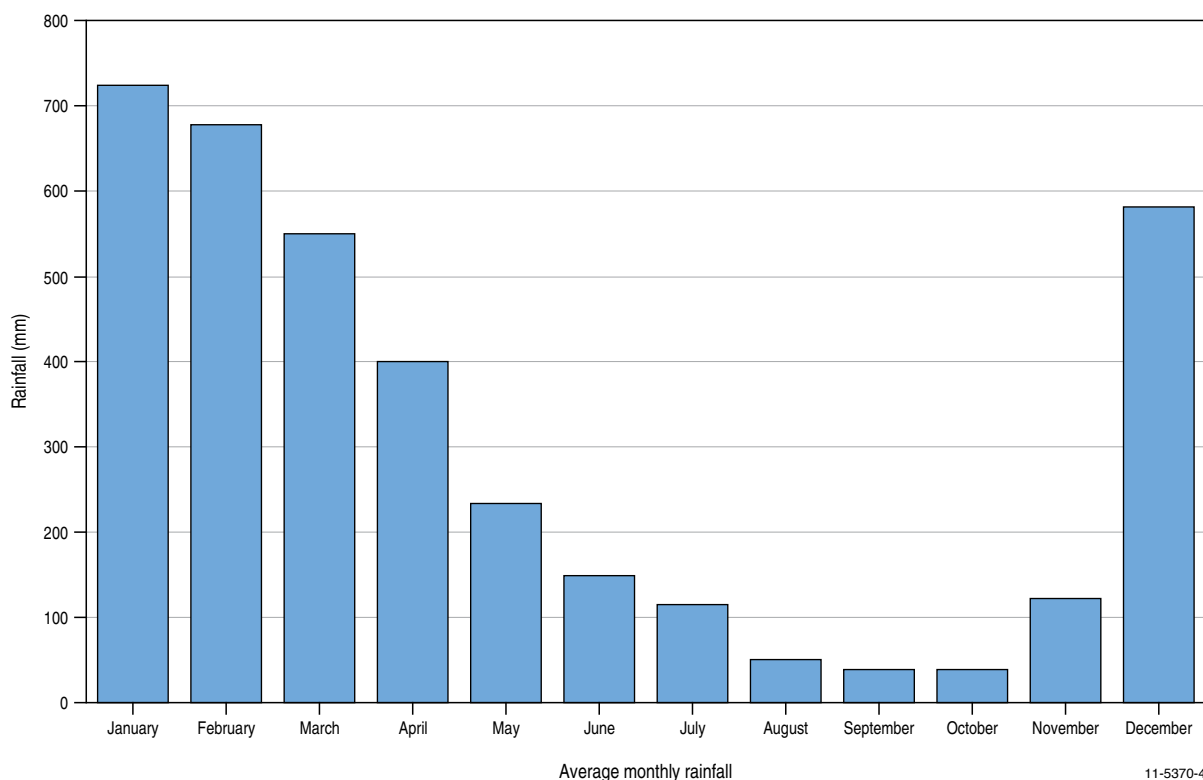
Recommended Age: Secondary

Brett and Bettina are planning to go bushwalking on Slide Island, a tropical island in the Pacific Ocean. They plan to camp out for about a week. They have heard reports from their friends of all the great spots to see, but they are a little concerned about the risk of rockfalls and landslides in the area. They have a geological map, a topographic map and the monthly rainfall data for Slide Island. Their goal is to get to the top of both Slump Peak and Mt Debris, and to see as much of the island as possible. Help Brett and Bettina to plan their walk, so that they avoid the risk of landslides.

Your tasks

1. Study the topographic and geological maps and the rainfall chart. Then read the reports from their friends.
2. Choose the safest month (in terms of landslide risk) for Brett and Bettina to go on their walk.
3. Draw Brett and Bettina's walking route on to the topographic map. Note that they start their walk from the 'drop off point' on the east side of the island.
4. Put crosses on the topographic map where, in your opinion, the places of greatest risk of landslides are located.
5. Write a one page report about why you have chosen this route, and which month you have chosen.

Average Monthly Rainfall for Slide Island



Reports from friends

Before Brett and Bettina went on their bushwalk around Slide Island their friends wrote about various sites they had explored. Brett and Bettina marked these sites out on their topographic map. Recorded below are the comments that their friends made about each location.

Site A

“There are huge big boulders here, some seem to be just balancing on top of each other. It’s very eerie here. We wondered if this place was culturally significant to the local inhabitants of the island.”

Site B

“A spectacular view of the ocean from here, well worth climbing down the cliffs to sit on some big rocks right next to the ocean.”

Site C

“Here we collected some beautiful rocks with big black crystals in them.”

Site D

“We had to use ladders to climb to the top of Mt Debris, but the view at the top is worth it.”

Site E

“The trees seem to be growing horizontally here!”

Site F

“We saw some lovely orchids here.”

Site G

“A very steep climb from here to the top of Slump Peak. There are lots of cracks and joints in the rock.”

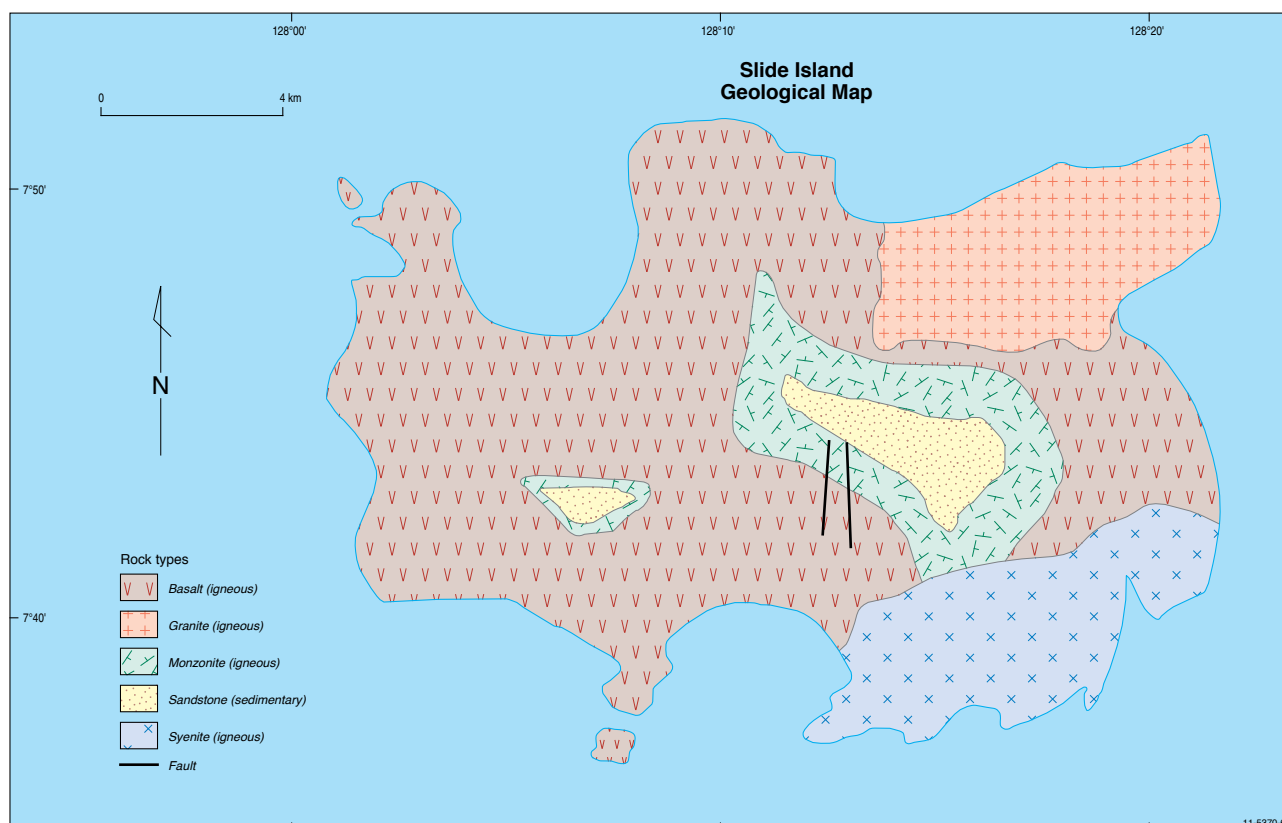
Site H

“Beautiful white sandy beaches here.”

SLIDE ISLAND – TOPOGRAPHIC MAP



SLIDE ISLAND – GEOLOGICAL MAP



RISKVILLE'S NEW HOSPITAL

Recommended Age: Secondary

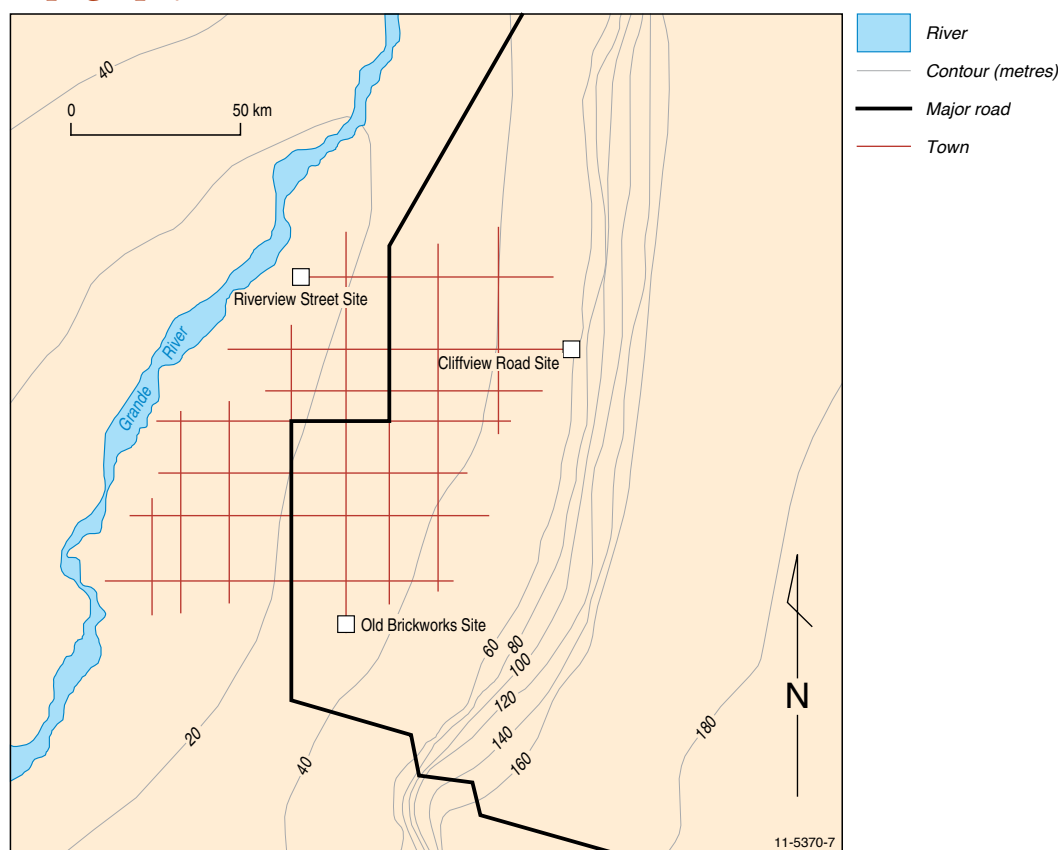
Riskville is a town with a population of 100 000 people, located a few kilometres from the Australian coast. The government has decided to build a new hospital in the town and has asked a number of scientists for information about the area to assist the town planners in deciding on a suitable location.

It is your job, as the landslide expert, to provide advice to the town planners about the landslide risk for the town and where you feel is the best site for the new building. There are three sites available:

1. Riverside Street Site
2. Cliffview Road Site
3. Old Brickworks Site

Below is the town map provided to you by the town planners with their proposed sites. The map also shows the main roads in the town, the topography (shown by contours) and the position of the Grande River.

Topography of Riskville Area

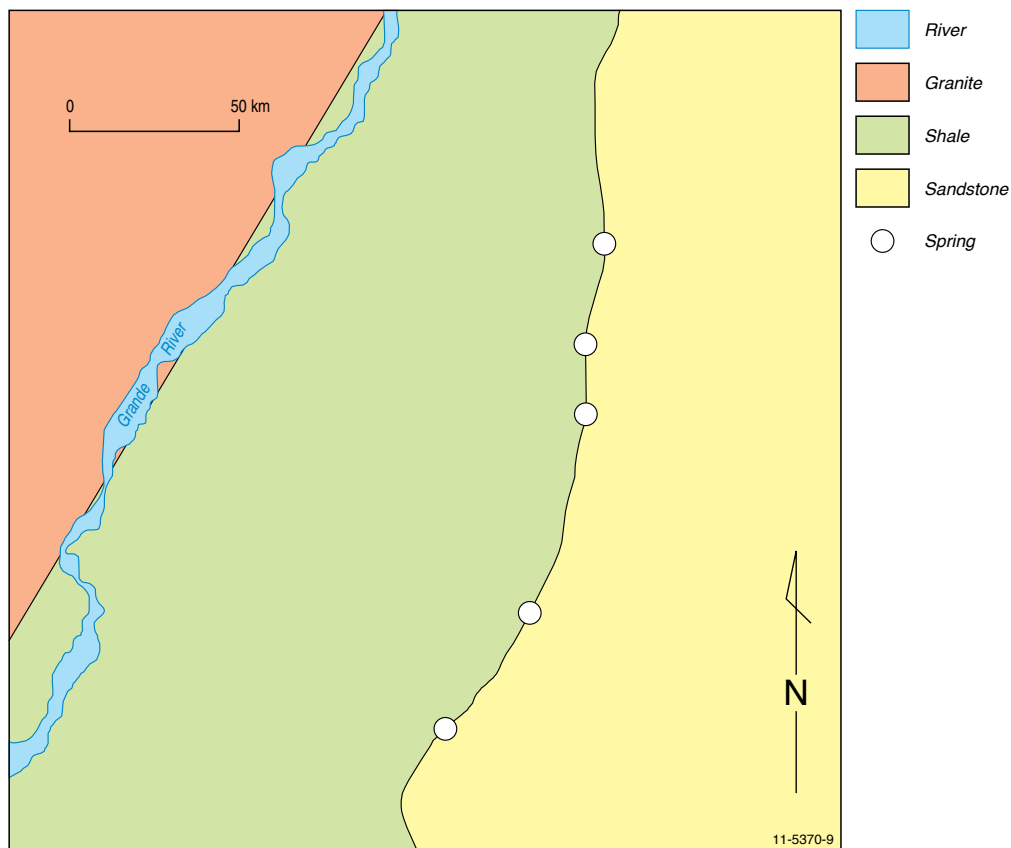


The scientists (a geologist and meteorologist) have each provided information about the town in one page reports. The town planners have asked you to provide them with a map of the town which shows the high landslide risk area.

The main factors in determining landslide risk in this region are rock type, rainfall patterns, groundwater and past landslide history. A high risk area will be one which has 'unstable' geology (for example loose rocks that are lying on top of soil comprised of clay material), numerous groundwater seeps or springs, heavy rainfall and some history of landslides.

GEOLOGIST REPORT

Geology of Riskville Area



Three major rock types outcrop in the Riskville Area.

Sandstone

This rock type makes up the cliffs and the plateau to the east of the town.

This rock type is quite strong. However, it tends to break along joints which can make parts of the cliffs east of Riskville quite unstable.

Shale

Most of Riskville is built on shale which underlies the sandstone. The shale tends to break up into flat sheets. When the shale becomes saturated with water it decomposes to a clay. In some places this clay has been used for making bricks.

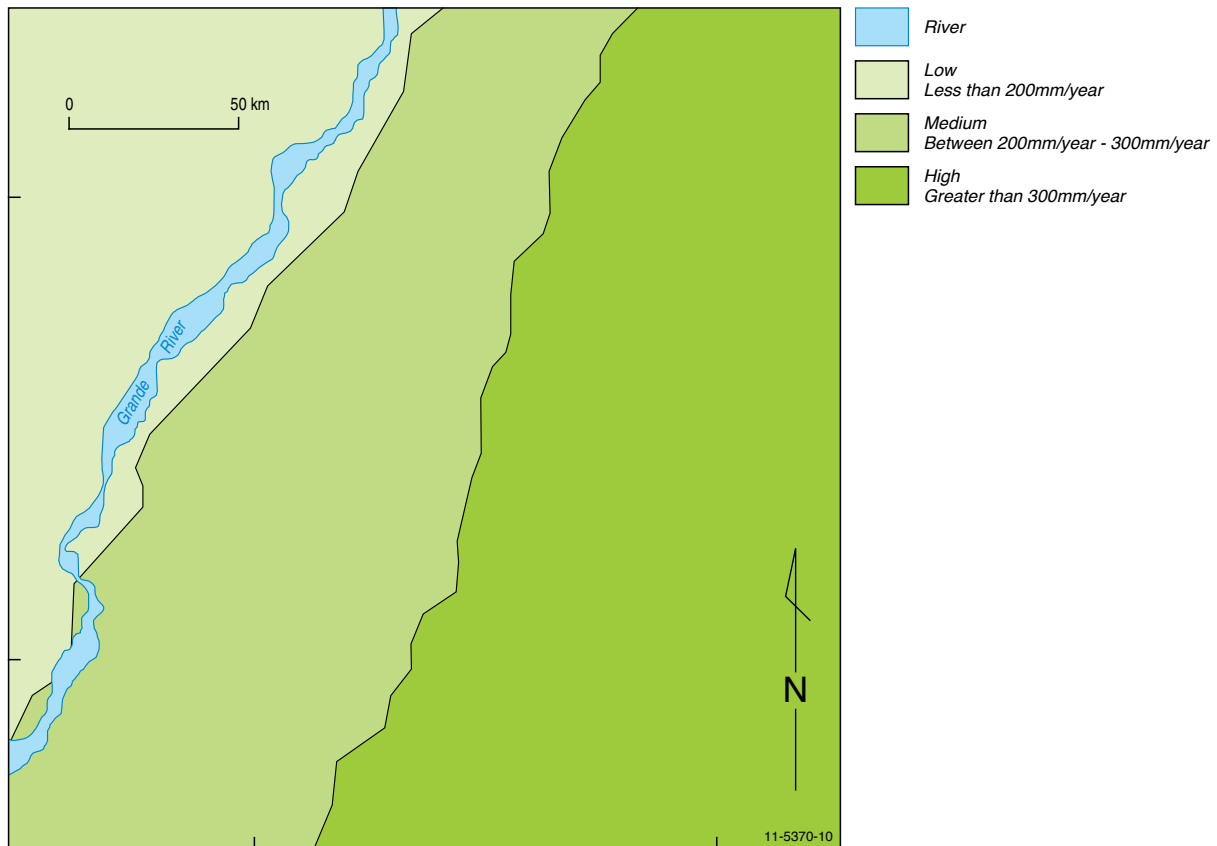
A number of permanent springs have formed at the boundary between the sandstone and the shale. Around these springs the shale has completely decomposed and there is evidence for numerous small landslides.

Granite

This rock type is only found to the west of the Grande River. Some tors (rounded boulders) have developed from the granite to the west of the area.

METEROLOGIST REPORT

Rainfall in the Riskville Area



Low Zone

The lowest rainfall zone occurs to the west of the Grande River. This area receives less than 200 millimetres a year and most of this falls in January. The area could be considered as desert.

Medium Zone

This zone occurs between the Grande River and the base of the cliffs to the east of the town. Rainfall in this zone occurs mainly in January-February with smaller falls evenly distributed throughout the year.

High Zone

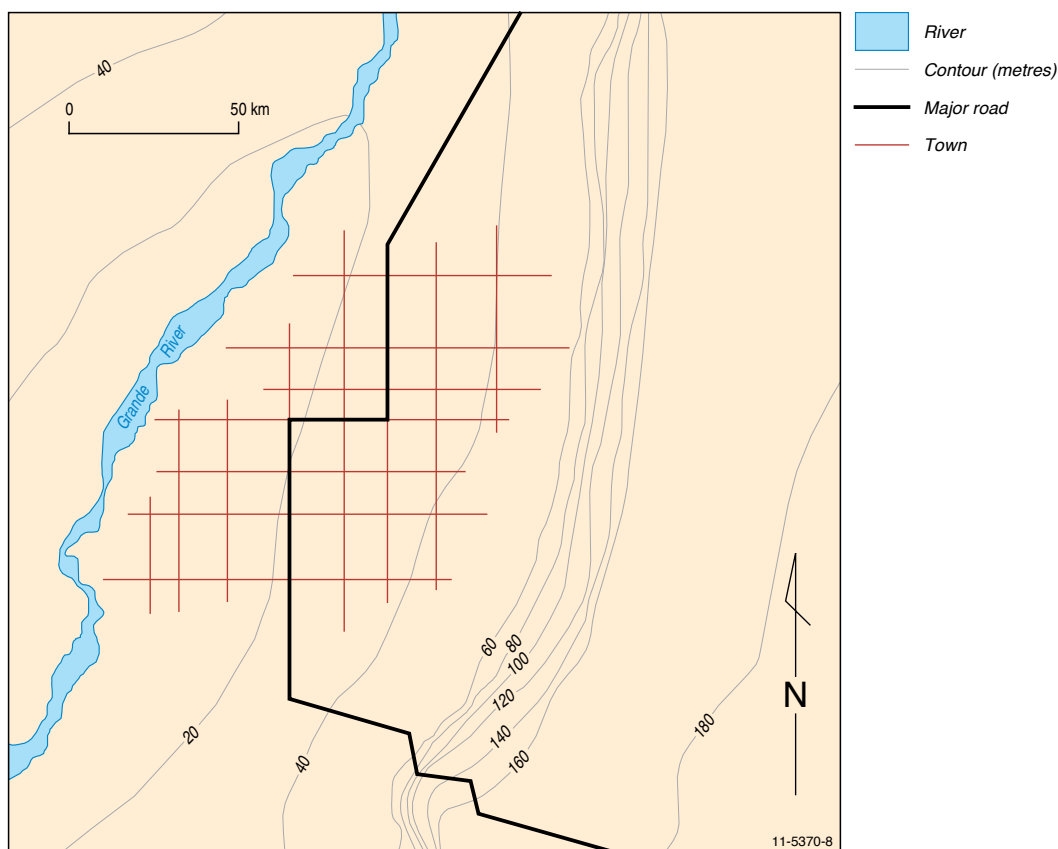
This zone occurs along the cliffs and extends well to the east of the area. The rainfall here is known as orographic rainfall, which is formed as air rises over the cliff, and occurs throughout the year.

Flood Season

The Grande River has a flood season in January each year. The flood waters have been known to extended well into Riskville town.

The task

On the map below shade and label the area that you consider to be at highest risk from landslides. This map is the same scale as the other maps so you can place it on top of the other maps to help you.



1. Based on your landslide risk map, which of the three proposed sites would you suggest would be best for the new hospital and why?

2. What other hazard factors might the government town planners need to take into consideration when making the final decision?

Landslides

ANSWER SHEETS

LANDSLIDE COMPREHENSION (THREE-LEVEL GUIDE)

Recommended Age: Upper primary to secondary

Instructions

You are to read the background information called 'The Nature of Landslides' (on pages 2 to 4) . Put a tick in the last column if you agree with the statement. Write down the key facts or evidence in the column provided. Write down the number of the section from which you got the facts. Follow the example given.

Level I: Literal Level

Answer the following questions finding the evidence from the text and recording the key facts.

Question No.	Statement	Section Number	Key Facts/ Evidence	Agree
Example	There have been more deaths caused by earthquakes than landslides in Australia.	2	15 people have died from earthquakes versus at least 110 deaths caused by landslides.	
1.	All landslides travel fast.	4	The speed of landslides vary considerably, such as debris flows that can travel up to 85 km/yr versus creep movement that move extremely slowly at mm/yr.	
2.	Earthquakes can cause landslides.	3	Earthquakes can certainly trigger a landslide.	✓
3.	Heavy rainfall is not a cause of landslides.	3	Heavy rainfall can be a contributing factor in a landslide.	
4.	The distance travelled by landslides is usually the same - about 500 metres.	5	In a landslide the land can move from a short distance (centimetres) to an extremely long distance (kilometres).	
5.	Up until 2010 the worst landslide disaster in Australia occurred in NSW.	2	18 people were killed in Thredbo disaster in NSW on 30 July 1997.	

Level 2: Interpretative Level

Use the information within the text to make your decision, that is interpret the information given. The answers may not be obvious. Record your key facts or evidence and section number or numbers in the appropriate column.

Question No.	Statement	Section Number/s	Key Facts/ Evidence	Agree
6.	All ledges on cliffs are equally stable.	4 & 8	Some rock types are more as susceptible to landslides than other rock types. Materials are also often weakened by weathering.	
7.	Children at the beach should never dig into high sand cliffs.	8	It is true that there is safety risks involved digging into the side of sand cliffs. Sands can collapse readily when trenches and holes are dug into them. For example, at Binalong Bay.	✓

Level 3: Applied Statements

Read the following opinions and think about them, helped by your new knowledge on landslides. Now write your personal response to the statement. You can include quotes from the text, or draw on your own experience in your answer.

Possible ways to begin a response:

This connects to my life in this way...

I wonder ...

This is important because ...

I don't understand _____ because _____

Question No.	Statement	Justification or Discussion
8.	A tour guide instructs a group of holiday makers to shelter under the base of a cliff which collapses killing four people. The tour operator should have known better.	It may be unsafe to sit at the bottom of a cliff, especially if there is evidence of fallen debris. There would be less chance of a group being injured if they were to take shelter in a building rather than under a cliff.
9.	A visiting geologist stands on a forested hillside. Some of the trees have fallen and are tilted down hill. He says that this land should not be built on because it could have a serious landslide. He has given good advice.	Yes – observing trees tilting down the slope is usually evidence of a previous landslide or creep.
10.	A house built on flat land on a valley floor is safe from landslides.	No, because there may be a landslide risk on or near the mountain and the run-off may flow through the valley.

SLIPPERY SLOPES = RISKY BUSINESS

Recommended Age: Upper primary

Building on a slope can be a risky business. Before beginning to build, scientists, engineers and architects must test and measure how stable the slope is. Buildings and roads can weaken the stability of a slope.

If material is excavated from the bottom of the slope in the process of building a road or house, the chance of a landslide event increases. This is also the case when the top of a slope is loaded down by a new house or material and the slope is unable to support the additional weight.

Nevertheless, preventative measures can be taken to reduce the risk of landslides. For example, the side/s of an excavation or road cut can be strengthened by retaining walls, concrete or gabions (hard rock fragments in a wire basket good for stabilising cut slopes). Additionally, installing good drainage and reducing the angle of the cut slope to make it less steep can help prevent a potential disaster.

The angles of slopes are measured when assessing the risk of landslides. Different materials naturally rest at different angles. For example, fine sand sits at about 35 degrees but sharp, pointy pebbles are stable at a steeper angle of 45 degrees. This means that it would be dangerous to build on sand that was at 40 degrees, but if the material was pointy pebbles, it would be safe to build here.

Local authorities are responsible for assessing construction sites. These assessments then effect the strictness of the building requirements. For instance, the riskier a slope is to build on the stricter the building requirements need to be.

Even so, figuring out risk ratings is a costly and time consuming task and often ratings may not be entirely accurate. One must first explore the soil type, vegetation, land use and weather conditions before calculating the risk

Precautions when building on a risky slope

Using the words below copy and complete the following sentences: drainage, excavate, stabilise, friction, vegetation

When benching (cutting) into the slope, you may need to **stabilise** the cut slope.

Provide good **drainage** to direct water away from the site.

Excavate existing soil and replace it with granular (pointy) rock pieces which offer better **friction** and drainage.

Keep **vegetation** whose root system will stabilise the slope.

Complete ONE of the following as a paragraph in your book:

- a) Understanding the dangers of landslides is important because ...
- b) After reading about landslides, I'm wondering ...
- c) The story about landslides reminds me of ...

CAN YOU OUTFRAN A LANDSLIDE?

Recommended Age: Lower secondary

Please show all workings!

Scenario 1

Watch out! A mud flow (“called a ‘lahar’ in Indonesian) caused by a volcanic eruption is heading your way! It is 50 metres upslope from where you are standing and travelling at 100km/h. Will you outrun it?

First step: = so multiply km/h by 1000, and divide by 3600 to obtain the result in $1\text{km/h} = \frac{1\text{km}}{1\text{h}} = \frac{1000\text{m}}{3600\text{s}}$

$$\frac{\text{km}}{\text{h}} \div \frac{\text{min}}{\text{h}} \div \frac{\text{s}}{\text{min}} \times \frac{\text{m}}{\text{km}}$$

$$\therefore \frac{\text{km}}{\text{h}} \times \frac{\text{h}}{\text{min}} \times \frac{\text{min}}{\text{s}} \times \frac{\text{m}}{\text{km}}$$

$$\therefore \text{m/s}$$

Answer: 27.8 m/s

Second step: Draw a table showing how far you, and the mud, will have travelled over time.

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres	2	20	40	60
Landslide (27.8m/s)	0 metres	27.8	278	556	834

Third step: Remember that the mud started 50 metres behind you, so now subtract 50m from each of the figures for distance for the mud.

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres	2	20	40	60
Landslide (<u>corrected</u>)	-50 metres	-22.2	228	506	784

Fourth step: (Graph)

Fifth step: The two lines intercept after two seconds of running, when you have only run four metres. You didn't succeed in outrunning the mudslide.

Scenario 2

First step: so multiply km/h by 1000, and divide by 3600 to obtain the result in m/s.

$$0.000576 \text{ km/h} \div 60 \text{ min/h} \div 60 \text{ s/min} \times 1000 \text{ m/km} = 0.00016 \text{ m/s}$$

$$\frac{\text{km}}{\text{h}} \div \frac{\text{min}}{\text{h}} \div \frac{\text{s}}{\text{min}} \times \frac{\text{m}}{\text{km}}$$

$$\therefore \frac{\cancel{\text{km}}}{\cancel{\text{h}}} \times \frac{\cancel{\text{h}}}{\cancel{\text{min}}} : \frac{\cancel{\text{min}}}{\text{s}} \times \frac{\text{m}}{\cancel{\text{km}}}$$

$$\therefore \text{m/s}$$

Second step:

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres	2	20	40	60
Mud (___m/s)	0 metres	0.00016	0.0016	0.0032	0.0048

Third step:

	0 seconds	1 s	10 s	20 s	30 s
You (2 m/s)	0 metres	2	20	40	60
Landslide (___m/s)	-30 metres	-29.9998	-29.9984	-29.9968	-29.9952

Third step: Yes, you easily outrun the landslide.

Scenario 3

At a speed of 1 centimetre every year, you have five years to fix your house. After five years, the ground will have moved five centimetres, which is the amount needed to do serious damage to your house.

VEGETATION MARKERS

Recommended Age: Lower secondary

A local amateur plant collector, Jayne Murek, has sent you a map of an area close to her home. Jayne has marked on this map the position of five different plant species that she has identified. She has also noted that the cliffs in this area have some fresh rock faces, or scars, which she thinks are the result of landslides that have occurred in the past.

From your experience in searching for evidence of landslides you know that some plant species are very quick to colonise the disturbed ground after a landslide while others are very slow to colonise the new area. In an area close to where Jayne lives, you have recognised that the five plants Jayne has mapped tend to colonise disturbed land in the following order

First to colonise	Tussock grass
	Wattle
	Mallee bush
	Red barked gum
Last to colonise	Native Pine

You also have noticed that over time many species die off and often only the gum trees and wattles survive.

JAYNE'S VEGETATION MAP

To discover the extent and relative age of possible landslides in Jayne's mapped area follow these steps:

1. Draw a line on the map which divides those areas which only contain red barked gum and wattles from those areas containing other species.

How many landslide 'scars' can you recognise from this level of evidence?

There is evidence for two landslides.

2. Colour the areas where only red barked gums and wattles are found with a green pencil. Recent landslides will have only tussock grass and wattles growing on their recently disturbed materials. Then draw a line around any areas which Jayne has marked that only these species can be found. Colour this area in with a **red** pencil.

How far from the cliff has the landslide altered the vegetation?

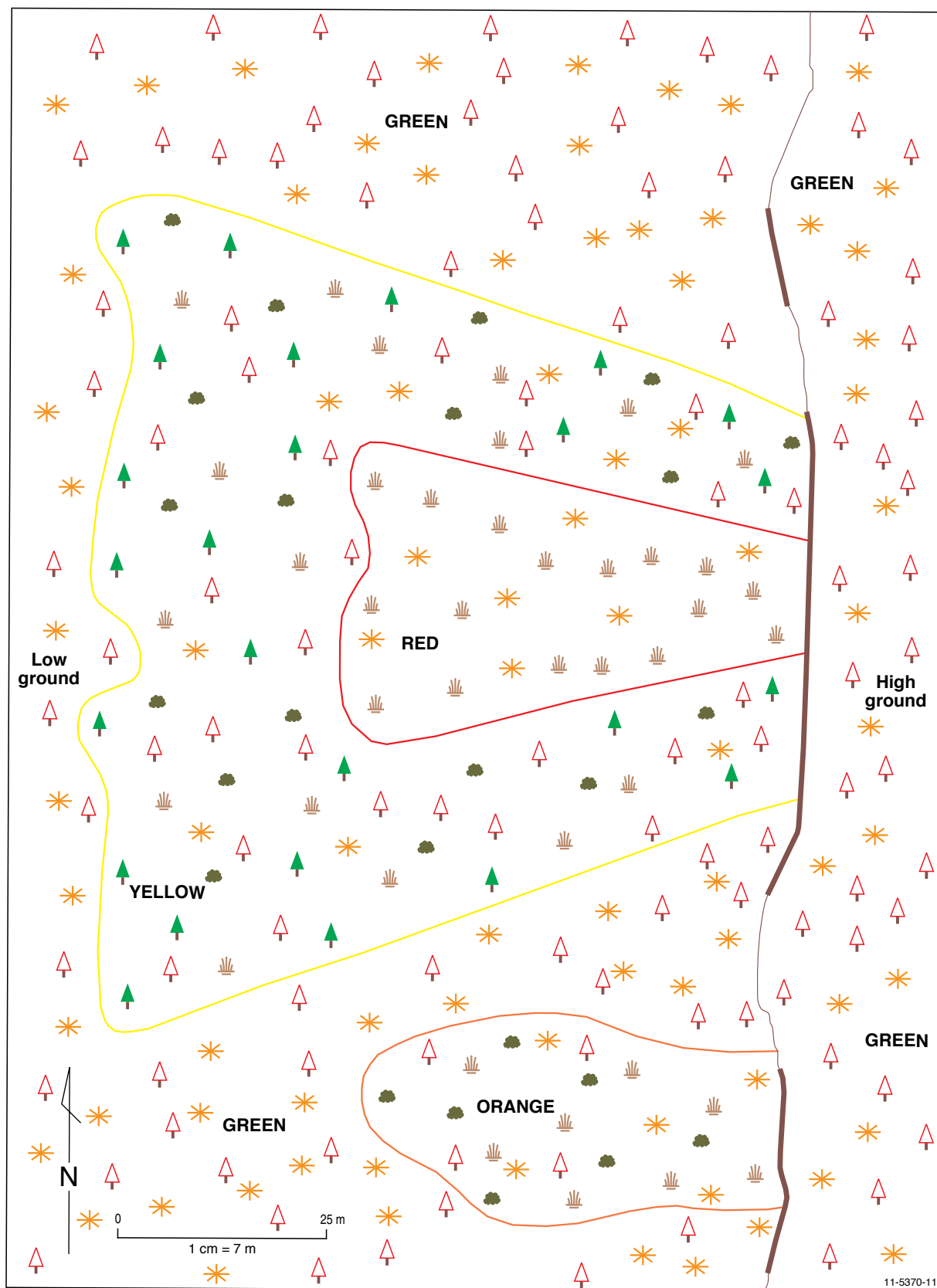
Approximately 55 metres

3. Medium aged landslides will have tussock grass, wattles, mallee bush and red barked gums but no native pines. Find any of these areas which Jayne has marked and colour this area in with an orange pencil.

How far from the cliff has the landslide altered the vegetation? **Approximately 50 metres**

4. The oldest landslides will have all the species growing on them. Find any of these areas which Jayne has marked and colour this area in with a **yellow** pencil.
5. How many landslide scars can you now recognise? **There is evidence for three landslides.**

6. How far from the cliff has the largest landslide altered the vegetation? **Approximately 85 metres.**
7. How many cliff scars can you find which do not appear to have vegetation evidence for a landslide?
Only one cliff scar has no evidence of a landslide.
8. Why do you think that no vegetation evidence can be found here?
The landslide which caused the rock scar may be very old and so the vegetation evidence has changed so that it appears the same as the background vegetation, in other words, only wattles and red barked gums. Or, the scar may be the result of a rock fall which had minimal effect on the vegetation.



- | | | |
|--------------|----------------|-------------|
| — Cliff line | Tussock grass | Mallee bush |
| — Cliff scar | Red barked gum | Wattle |
| | Native pine | |

Recommended Age: Middle to senior secondary

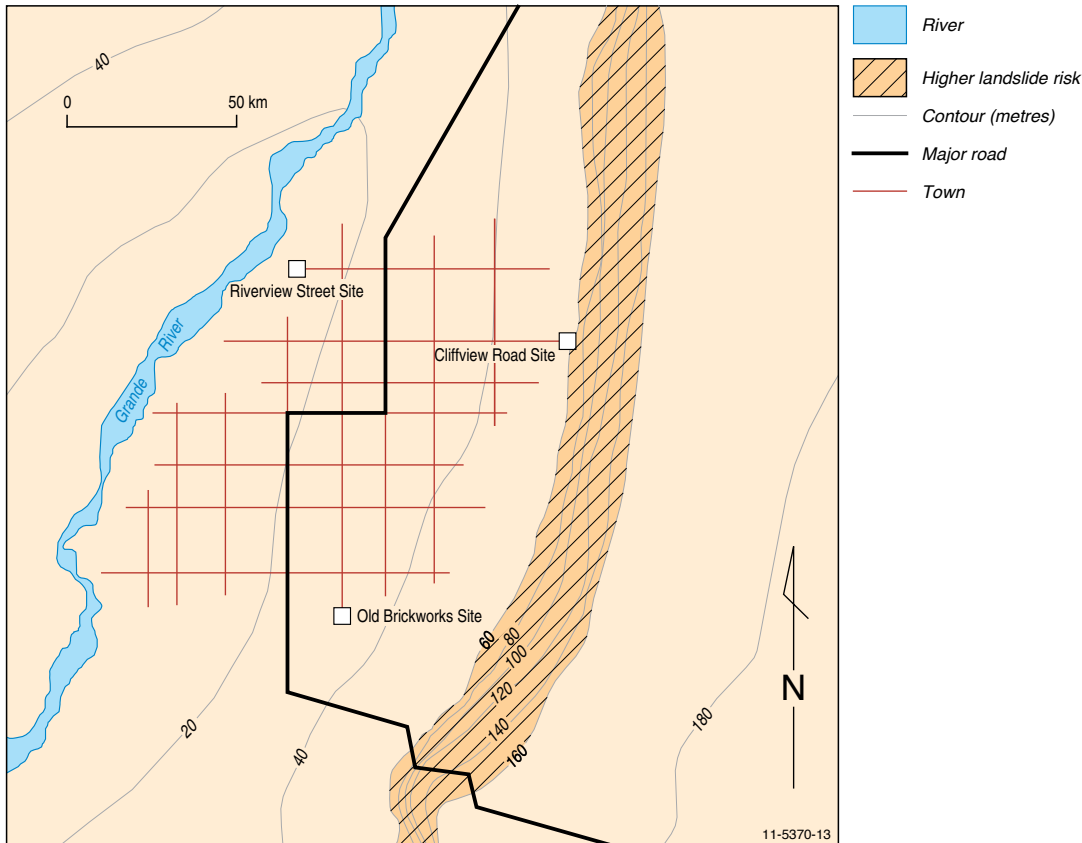
ANSWER SHEETS

RISKVILLE'S NEW HOSPITAL

Recommended Age: Secondary

The task

Using the information you have been given, on the map below draw a line around the area that you consider to be at highest risk from landslides in the Riskville area. This map is the same scale as the other maps so you can place it on top of the other maps to help you.



1. Based on your landslide risk map, which site would you suggest would be best for the new hospital and why?

The best site based on landslide risk alone would be the Riverview site. The other two sites are close to steep slopes with springs and consequent landslide risk. Riverview is relatively flat.

2. What other hazard factors might the government town planners need to take into consideration when making the final decision?

If the hospital was built on the Riverview site flood waters could possibly cut off access to the hospital.

