Landscapes, rocks and tunnels: Practical considerations in transport geography

Key Learning Area	Unit or lesson title and main focus questions	Most appropriate level and suggested number of lessons
Geography	**Landscapes, rocks and tunnels: Practical considerations in transport geography** What landscapes and rock types does the railway cross, both underground and over ground?	**Stage 5** 1–3 lessons

Teacher briefing

Sydney Metro Northwest *Environmental Impact Statement 2,* provides easily accessed geological data on the construction of the Sydney Metro Northwest tunnels. This activity provides Stage 5 students with the opportunity to explore the basic ideas of geotechnics and some of the geological issues that need to be solved when building a tunnel.

Focus questions:

- Which part of Sydney Metro Northwest is underground?
- What rock types does it pass through?
- What technical problems might these rock types present to engineers and how will they solve these?
- Do the above ground sections of the rail line present the same or different challenges?

Requirements for these lessons

- Internet connected computers
- Google Earth or Google Maps
- Activity sheet 1 – Map of Epping-Rouse Hill
- Graph paper.

Key terms and vocabulary

Geotechnics, cross-section, geological long section.

Web links

***Submissions Report Stage 1,* Chapter 2**

https://www.sydneymetro.info/documents

Sydney Metro Northwest *Environmental Impact Statement 2,* Appendix C – Geological long section

(This version only includes the cross-sections, with different page orientation)

https://www.sydneymetro.info/sites/default/files/29_Appendix_C_-_Geological_Long_Section.pdf%3Fext%3D.pdf

Sydney Metro Northwest *Environmental Impact Statement 1,* Appendix A – Geological long section

https://www.sydneymetro.info/sites/default/files/26_Appendix_A_-_DGRs__CoA___SoC.pdf%3Fext%3D.pdf

Sydney Metro Northwest *Environmental Impact Statement 2,* Project Description – Operations Part 1, Chapter 6

https://www.sydneymetro.info/sites/default/files/document-library/NWRL_EIS_2_Section_1overview.pdf

Sydney geological map

http://www.resources.nsw.gov.au/__data/assets/image/0005/287204/Sydney_500k.jpg

Any topographic map of the area, or SIX Viewer

https://six.nsw.gov.au/wps/portal

Background information

Students explore geological problems engineers have solved when planning Sydney Metro Northwest. The main rock type in this area is Hawkesbury sandstone that can be easily tunnelled, but may require support. Tunnels are unlike any other civil engineering structures. In buildings or bridges the construction materials have defined and testable properties, whereas this is not the case with tunnelling.

No matter how much of the ground is tested in preliminary site investigations, usually through borehole cores tested in the laboratory, only a small fraction of the tunnel construction area can be tested. Therefore, it is up to engineers to determine the relevant ground conditions and the effects of layering, fissures and discontinuities. Much of this assessment is based on geological and geographic judgment and experience.

A passage describing the planned tunnels from the Sydney Metro Northwest *Environmental Impact Statement 2* Overview

The tunnels would have a maximum vertical grade of 4.1 per cent and have been designed with an appropriate curvature to accommodate an operating speed of 100 kilometres per hour. The vertical gradient of the tunnels is influenced by the topography, geological constraints, presence of watercourses and the alignment has been designed to provide sufficient clearance to existing and proposed building basement levels (for example below Castle Hill town centre). The tunnel crown (top of the tunnel) would be located at its shallowest point approximately three metres below ground surface and at its deepest point approximately 58 metres below ground surface. On average the tunnels would be more typically in the 20–25 metre depth range and tunnel depth would tend to be at its shallowest at station locations and at the northern tunnel portal.

Syllabus links

Geography K–10

Geography Stage 5 – Changing places

– the management and planning of Australia's urban future.

Environmental change and management

– human-induced environmental changes across a range of scales

– the causes, extent and consequences of the environmental change

– management of the environmental change.

(GE5–2) explains the processes and influences that form and transform places and environments

(GE5–7) acquires and processes geographical information by selecting and using appropriate and relevant geographical tools for inquiry

(GE5–8) communicates geographical information to a range of audiences using a variety of strategies.

Learning experiences

Step 1 – Class discussion

Display Sydney Metro Northwest *Environmental Impact Statement 1*, Appendix C – Geological long section **https://www.sydneymetro.info/sites/default/files/29_Appendix_C_-_Geological_Long_Section.pdf%3Fext%3D.pdf** on the interactive whiteboard, or distribute the pdf for students to view on their own computers.

The teacher explains that most geographical studies create and analyse maps that 'look down' on the Earth. However, engineers working on Sydney Metro Northwest examine 'side-on' maps to see where the rail line will be elevated, where it will dip underground, and which rock types it will pass through.

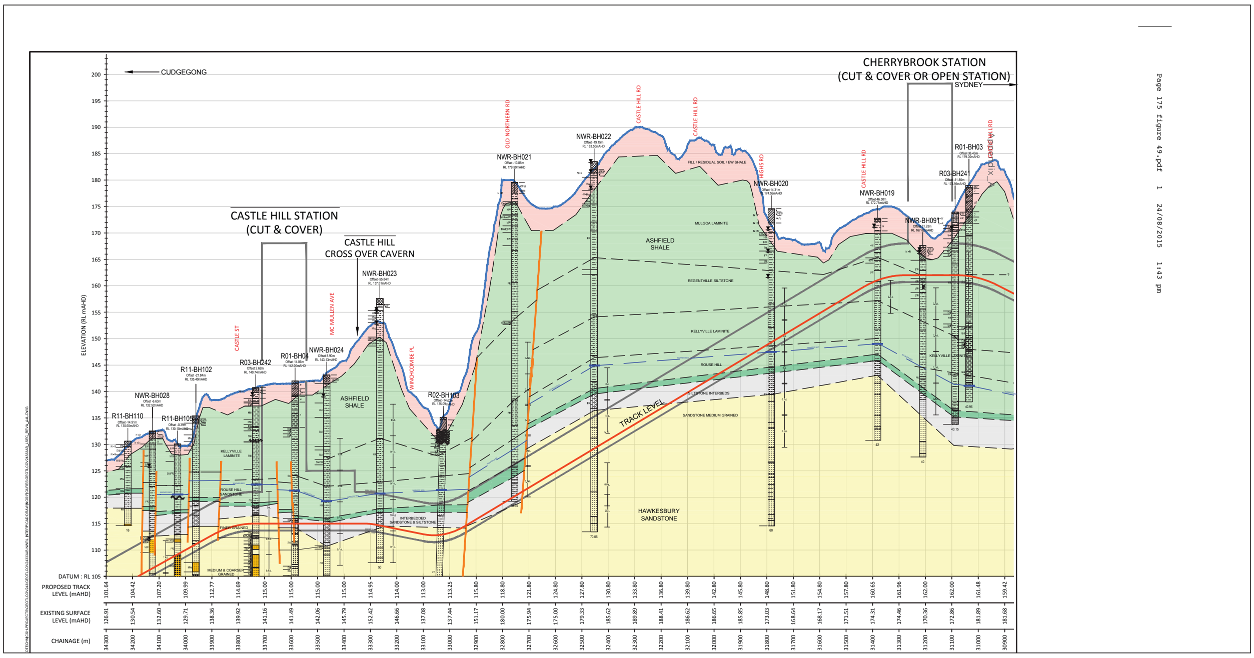

Figure 20: A page from Sydney Metro Northwest *Environmental Impact Statement 1,* Appendix A – Geological long section.
Source: https://www.sydneymetro.info/sites/default/files/Sydney_Metro_Northwest_Environmental_Impact_Statement_1-Appendix_A.pdf

Figure 21: An example of mapping the route as displayed in Sydney Metro Northwest *Environmental Impact Statement 1*, Appendix A – Geological long section.
Source: https://www.sydneymetro.info/sites/default/files/Sydney_Metro_Northwest_Environmental_Impact_Statement_1-Appendix_A.pdf

Step 2 – Listing the rock types

With reference to Figure 20 (page 201) (the geological long section detailing the rock and soil types for each section of the alignment), students list the rock types that will need to be excavated to construct these different sections of the line. They are instructed to mark these rock types on Activity sheet 1 (page 205).

Using the Castle Hill Station example shown in Figure 20, the teacher guides the students to identify the soil and rock types that must be excavated. In order of descending depth these are:

1. Fill residual soil/EW shale (shown in pink/salmon on the cross-section).
2. Kellyville laminate (a type of Ashfield shale, shown in green).
3. Rouse Hill sandstone (a type of Ashfield shale, shown in green).
4. Interbedded sandstone and siltstone (shown in grey).
5. Hawkesbury sandstone (shown in yellow).

Other examples such as Cudgegong Road Station are almost completely Hawkesbury sandstone (shown in yellow) and Bella Vista Station is almost entirely resting on Ashfield shale (shown in green).

Students should explore the Index and Geotechnical Legend (Figure 22) lists all of the rock and soil types on the internet.

Soil and rocks

Topsoil	Gravelly clay	Silty sandstone	Interlaminated siltstone and sandstone
Fill	Gravelly sandy clay	Conglomerate	Interbedded siltstone and sandstone
Asphalt	Sandy clayey silt	Shale	Interbedded shale and sandstone
Silty gravel	Sandy silt	Mudstone	Interbedded shale and siltstone
Clay	Sandy silty clay	Sandstone	
Silty clay	Silt	Siltstone	
Clayey sand	Clayey gravel	Sandstone	
Cobbles	Gravelly sandy silt	Claystone	
Clayey silt	Gravelly sand		
Sand	Silty clayey gravel		
Silty sand			

Geological material

Fill	Bringelly shale
Fill/residual soil/EW shale	Siltstone or siltstone and sandstone interbedded unit
Alluvium	Minchinbury sandstone
Ashfield shale	Volcanic ash correlation layer
Mittagong formation	Possible fault displacement
Hawkesbury sandstone	

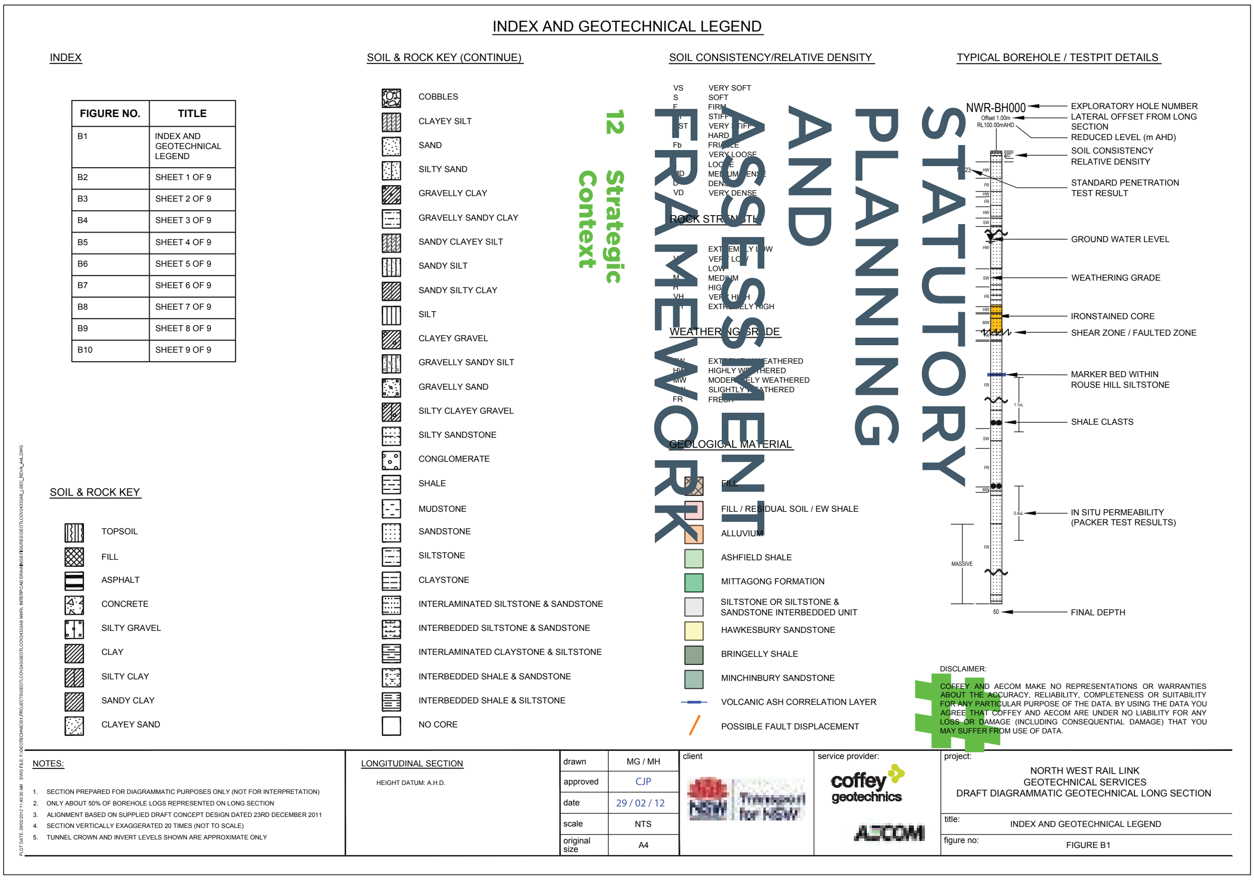

Figure 22: The Index and Geotechnical Legend lists of all the soil and rock types across which the railway travels.

Step 3 – Making a map

- Using the maps and diagrams in Sydney Metro Northwest *Environmental Impact Statement 1*, (Appendix A, page 201 – Geological long section) as a guide, students draw the route of Sydney Metro Northwest on their map (Activity sheet 1, page 205), marking those sections that run above ground and underground
- Using the Geological long section diagrams, students note down the heights above sea level of each main part of the track. The scale used on the Geological long sections is marked in mAHD, the abbreviation for elevation in metres with respect to the Australian Height Datum, that sets mean sea level as zero elevation
- Close reading of the geological long section diagrams can also provide an opportunity for the teacher to discuss surveying and the measurement called 'chainage' along the foot of each diagram
- It is also important to note while examining these geological diagrams, that the cross-sections are vertically exaggerated 20 times and not to scale
- Students should summarise their geological findings and describe the geology of the area in general terms.

Teacher references and extension work

Some students will become very interested in the geology and engineering of tunnels.

- Explore Sydney rock types in greater detail. Showing students rock microstructure (the ways the minerals or particles are joined in rocks) can introduce them to this field. Using photomicrographs of rocks, for example, it is possible to examine the composition and resultant strength of the rock
- Explore tunnelling methodologies. They may look either at earlier tunnelling systems and compare them or explore contemporary tunnelling technology on the web.

Figure 23: Tunnelling boring machine breaks through at Cherrybrook Station, January 2016.

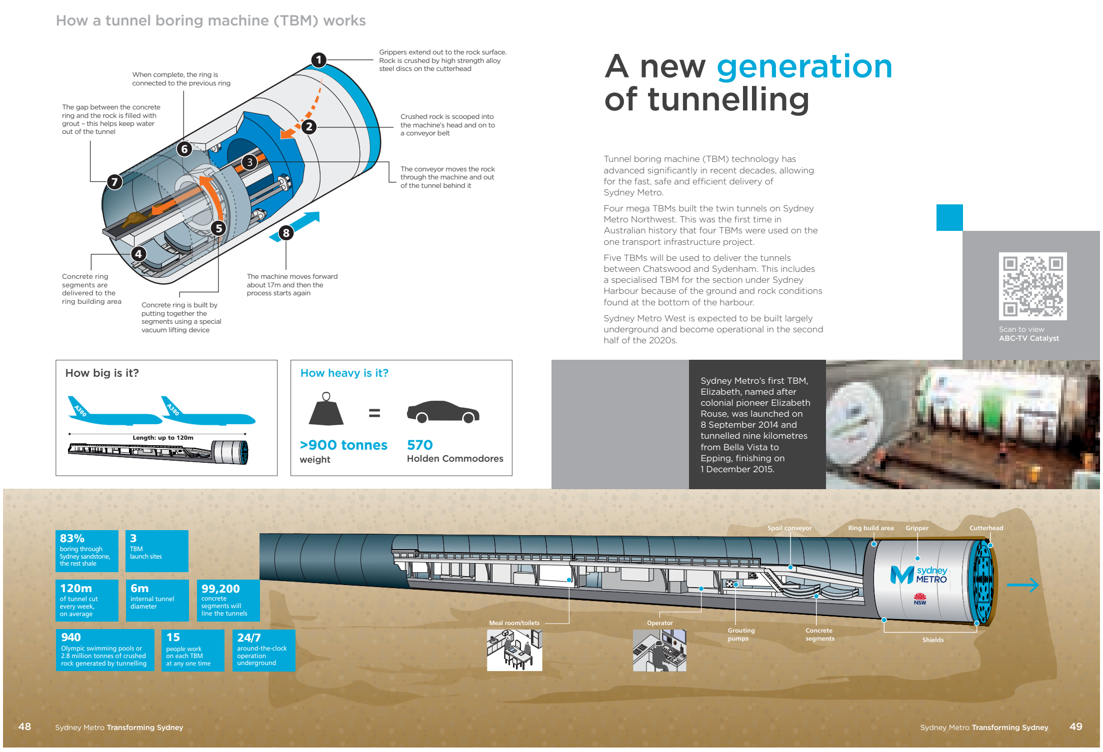

Figure 24: Tunnel boring machine information sheet.

Activity sheet 1

An example base map, showing Epping to Rouse Hill.

This can be created easily by typing ‘Castle Hill, NSW’ into Google Maps, and capturing the screen, and printing it.

http://maps.google.com.au/maps?q=Castle+Hill,+NSW&z=13

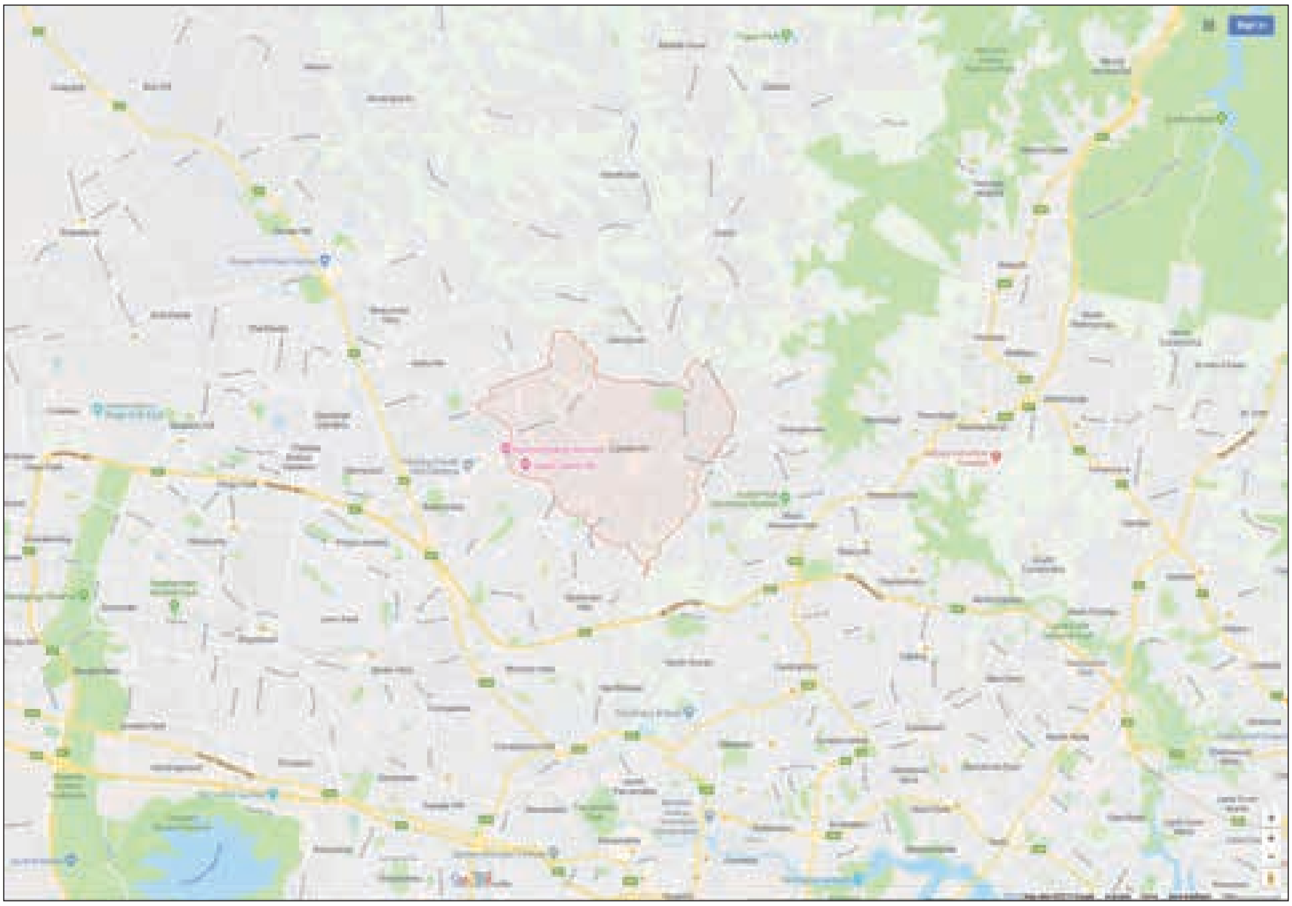

Figure 25: An example base map, showing Epping to Rouse Hill. Copyright, Google Maps 2013.

Northwest