TOOWOOMBA BYPASS - RANGE CROSSING WITH TUNNELS

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Figure 1. Western portal area showing the location of the completed pilot tunnel

Abstract
In response to increased traffic volumes on the Toowoomba range road, the district has been planning a bypass route. A section of the bypass will include parallel road tunnels through the range crest. In order to achieve greater certainty at the tender box, a small pilot tunnel was recently excavated.

Introduction
In recent years traffic volumes on the Toowoomba range road have increased greatly. Traffic accidents with subsequent delays have plagued this vital link between the Darling Downs and the Lockyer valley for most of its life. Traffic studies have identified the need for a second range crossing which will bypass Toowoomba City centre to the north of the current range road. The new 42.2km alignment requires the construction of parallel twin road tunnels 735m long.

A small pilot tunnel has been constructed along the alignment of the proposed west bound traffic tunnel to assess the geology of the site to reduce project risk (Figure 1). The tunnels will pass through 20 to 25 million year old Main Range Volcanics – a suite of rock types dominated by basalt flows. A number of different geotechnical factors have been measured and reported as part of the project.

History of the Toowoomba range crossings
Toowoomba City lies on a relatively flat plateau on the edge of the Great Dividing Range. A feature of the city is its high position on an escarpment of the range, which commands scenic views of the Lockyer Valley below. Crossing the Great Dividing Range to the Darling Downs by road at Toowoomba has a colourful history stretching back to the earliest days of European settlement.

The first crossing was Gorman's Gap, just south of modern-day Toowoomba. It was discovered in 1840 with help from a convict who was recaptured after living with Aboriginal tribes in the area for fourteen years. Gorman's Gap created a much needed supply line for early Darling Downs squatters. It eliminated the need to travel 800 km to Sydney, but was aptly named the Hell Hole Road, due to its steepness and danger. It took three days to travel just 12km.

In 1849 surveyor J.C. Burnett found a better route to the north, which was to later become the famous Toll Bar Road. In 1853 a gang of twelve workers cleared and constructed a better road on this initial route, already well used by bullockies.

Drayton was still the major settlement in the area when the Toll Bar Road opened in January 1855. A simple gatehouse was erected at the top of the range, near the current intersection of Ipswich and Curtis Streets in Toowoomba. A bar crossing the road and a fence either side stopped traffic and enabled toll collection of approximately two pence. With unlimited water and green pastures, the area near the top of the Toll Bar Road became a preferred stopover for bullock teams and the permanent settlement of Toowoomba soon sprang up. The Toll Bar Road consisted of a rough stone pavement on very steep grades. As the road was unsealed and very steep, with grades as much as 14%, it was subject to severe scouring during heavy rains. The road became expensive and difficult to maintain.

The railway line to Toowoomba was completed in 1867 and dramatically cut the amount of goods carted on the Toll Bar Road. As a result, authorities lifted the toll in 1867, however the Toll Bar Road remained a vital transport link.

On 13 December 1921, the Brisbane-Toowoomba Road was declared a Main Road under the *Main Roads Act 1920*. Following the declaration as a Main Road, strong representations were made by local bodies for improvement to the surface. At that time bitumen surfacing was not favoured as a considerable number of horse-drawn vehicles used the road and horses would not be able to retain a footing if the surface was too smooth.

On 24 September 1932, the Main Roads Commission proclaimed the Toll Bar Road a State Highway when it became part of the Lockyer-Darling Downs Highway. It wasn't until 1938 that a major upgrade of the range road took place. The most significant change was to the uppermost section, with the new route reaching the top of the range further north.

Work on the new route was completed by Christmas of 1939. On 29 January 1940, a two-lane bitumen Toowoomba range road was formally opened by the Honourable H.A. Bruce, Minister for Public Works, MLA.

The new range road covering the range section proper, constituted a vast improvement on the old Toll Bar Road as it provided a 6.1m wide bitumen surfaced pavement over a length of 3.7km and climbed a total height of 350m. The average rate of climb was nearly 9%, although the actual grades varied between 7.5% and 10.5% with the exception of a short flattening in the vicinity of a saddle which had become known as "Essex Evans" due to the fact that the poet George Essex Evans (1863-1909) once resided at this location.

The road grew in importance as a link from Brisbane to the west. The next major improvement was in 1964 when Main Roads Department commenced the duplication of the road at an estimated cost of £185,000. By 1964 the traffic volume had reached 2,300 vehicles per day, of which approximately 500 were heavy trucks and semi-trailers. Although the total volume was not excessive for a two lane road, frustrating delays were caused to passenger and other light vehicles by their inability to overtake and pass slow moving heavy vehicles due to the limited visibility which is inherent in such topography. Consideration was given to the provision of climbing lanes for heavy vehicles but this was rejected mainly on the grounds that it would not provide a complete solution for the reason that similar delays would be occasioned by heavy vehicles descending the range in low gear, and the provision of a third lane might provide too much of a temptation for the impatient motorist.

The alignment of the upgrading project was along the existing road from the foot of the range proper to the saddle at Essex Evans. However, an entirely new up-lane from Essex Evans to the top was constructed on the southern side of the existing road. The new up-lane was slightly longer, with improved horizontal and vertical alignment and an increased width of 7.3m.

In the intervening years there have been numerous road projects on the range; however the basic route has remained unaltered since 1940.

Planning for the Toowoomba bypass

In 1991, Toowoomba district (1) identified the future need for a second range crossing. Traffic volumes currently are in excess of 20,000 vehicles per day with 15% comprised of heavy vehicles. The range crossing is plagued by extensive delays due to accidents and vehicle breakdowns.

An Ove Arup Traffic Planning Study (2) completed in 1995 confirmed the district's recommendations for a second range crossing. A Maunsell concept phase planning report (3) in 1997 identified an alignment route option passing to the north side of Toowoomba City. The traffic planning study identified that 85% of traffic using the Warrego Highway wished to stop in Toowoomba thus any bypass route had to be reasonably close to the city. The proposed new alignment for the Warrego Highway would commence on the eastern side of town, bypassing Toowoomba City centre to the north and linking up on the western side of Toowoomba with the existing national highway routes to Darwin (via Warrego Highway) and Melbourne (via Gore Highway) (Figure 2).

The proposed bypass is 42.2km long; has estimated earthworks quantities of 8.5Mm^3 of cut and a similar quantity of fill; up to 40 bridge structures; 5 major interchanges; and twin 735m long three lane tunnels through the range crest.

In 2001, Main Roads Project Development Office (now Major Projects Office) commenced the detailed planning phase of the project with the preferred alignment option ultimately refined by 2004. In late 2005, the federal government announced further funding of $10M (overall investment has been $43.25M to date) to advance the business case for the project.

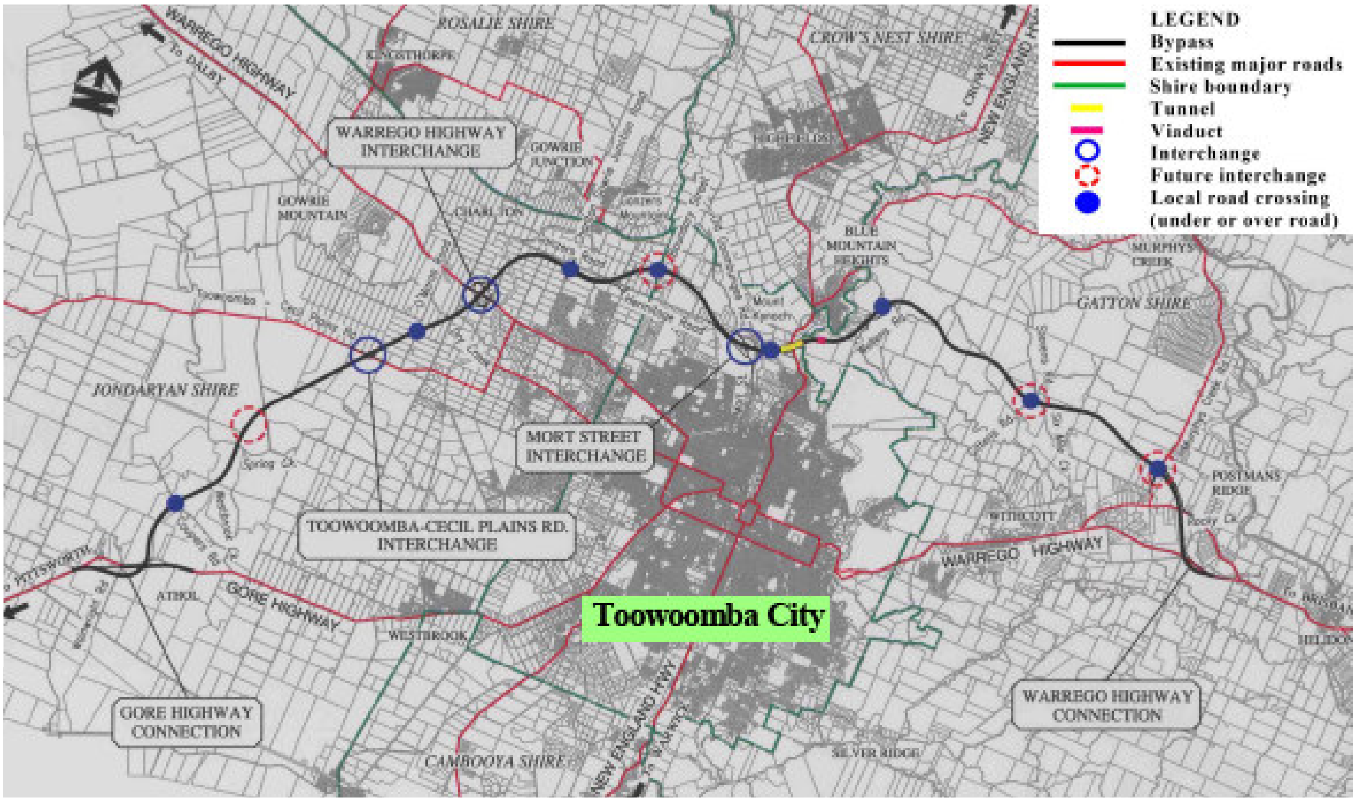

Figure 2 - Toowoomba bypass – general layout plan

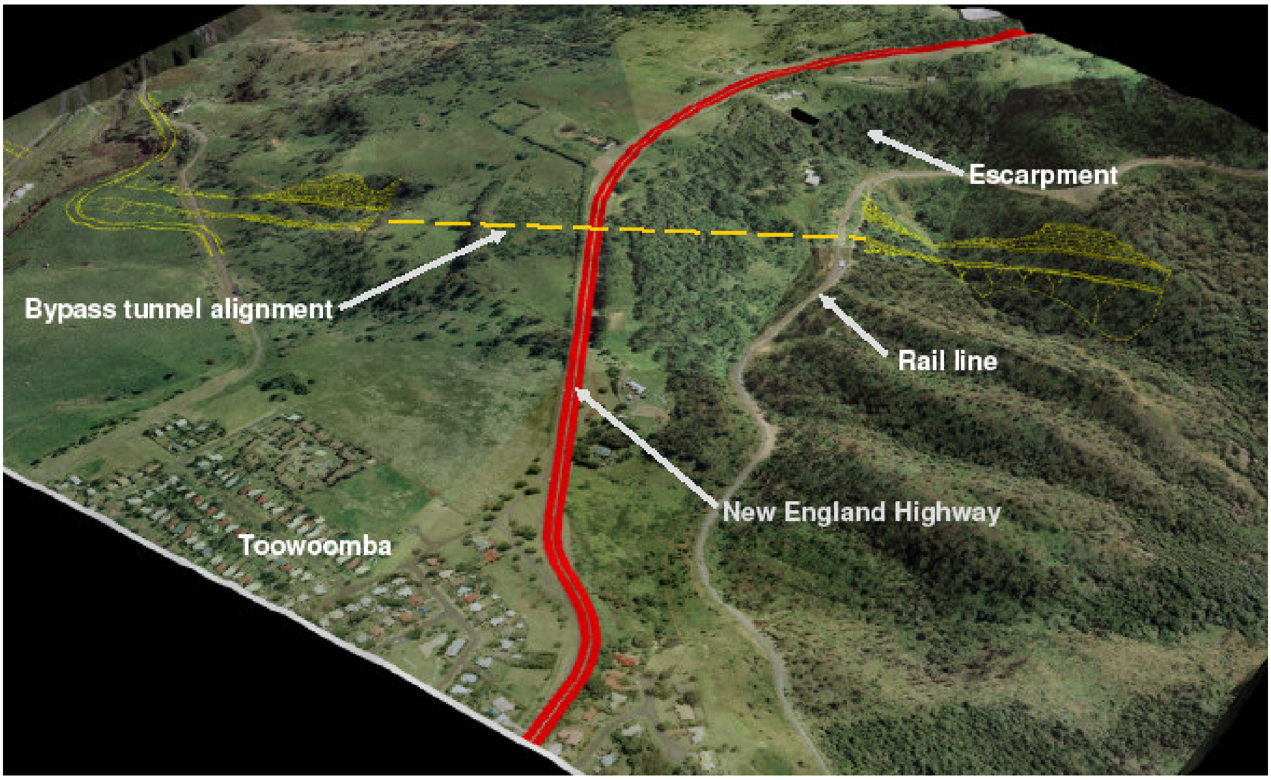

Figure 3. Bypass tunnel alignment

A part of the business case is the construction of a small pilot tunnel. The pilot tunnel will reduce the risk for the project by providing the required geological data to facilitate the design, construction and cost assumptions for the main tunnels. As the tunnel costs are a significant proportion of the overall bypass funding, the risk of latent claims is minimised considerably.

The remainder of this article describes the pilot tunnel and geological features surrounding the tunnelling.

Geomorphology and geology of the Toowoomba Range area

In eastern Australia, two of the most prominent continental size features are the well known Great Dividing Range and the lesser known Great Escarpment. Both of these are evident for many thousands of kilometres from the Victorian border through New South Wales extending to Cape York in north Queensland.

The Great Dividing Range divides the watershed between coastal flowing rivers and inland flowing rivers, whereas the Great Escarpment separates tablelands. The Great Escarpment is a much more obvious landscape feature with steep gorge-like valleys and abrupt elevation changes of up to 1000m. At Toowoomba the maximum scarp is approximately 400m high.

Usually these two great landscape features do not coincide at the same geographic location – the Great Dividing Range is usually found well west of the Great Escarpment. Toowoomba is one of the few exceptions where both features are coincident.

Figure 3 shows the proposed tunnel in relation to Toowoomba and the range. The yellow linework represents the alignment and approach earthworks to the tunnel. The red line is the current New England Highway.

The three major roads into Toowoomba from the east – Murphy's Creek Road, the Warrego Highway and Flagstone Creek Road all traverse along remanent sandstone spurs which connect the Lockyer Valley floor with the Toowoomba plateau. Over half the ascent on these roads was able to be achieved via these sandstone spurs before the steeper basalt terrain was encountered. However, no similar sandstone spurs exist for the route for the new bypass and the majority of the climb up the escarpment would have been on the volcanic derived terrain. The tunnels will take out 85m of elevation and will alleviate a high proportion of the climb normally achieved by deep cuttings and high fill embankments.

The Main Range Volcanics overlay a sequence of gently dipping sedimentary rocks from the Clarence – Moreton Basin. The Toowoomba bypass route traverses both these two major rock groups however the tunnels will only pass through the upper Main Range Volcanics.

The volcanics consist of basalt flows, some ponded in their craters; interbeds of tuff and some rare interflow sediments and low quality coal. The youngest basalts are 18 million years old with the oldest (lower) being 27 million years old (6). Tops of individual basalt flows are highlighted by zones of vesicles (gas holes) and thicker flows have a dominant columnar jointing pattern caused by slow cooling.

The "ponded basalts" are where rising lava has broken through the existing ground surface and spread out within its crater forming a wine glass shaped body of rock. Figure 4 presents a series of diagrams depicting the formation of these lava pools and subsequent eroded landscape feature that can be seen today (7). The younger age of 18 million years are commonly found in the lava pool basalts. All of Toowoomba's major quarries win high quality basalt rock from these lava pools.

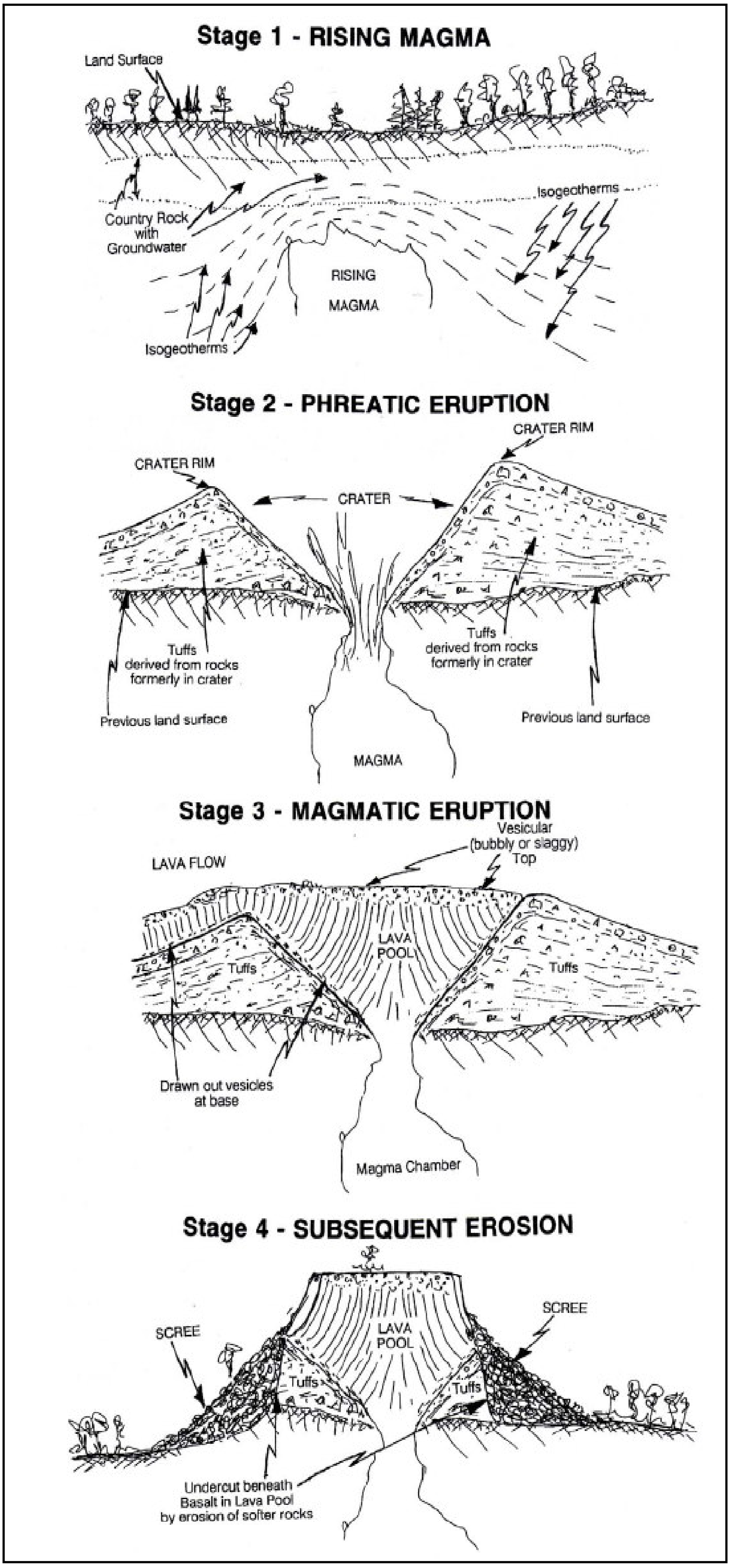

Figure 4. Formation of a lava pool (Ref 7)

Figure 5. Mt Tabletop east of Toowoomba exhibits typical features of a remanent lava pool

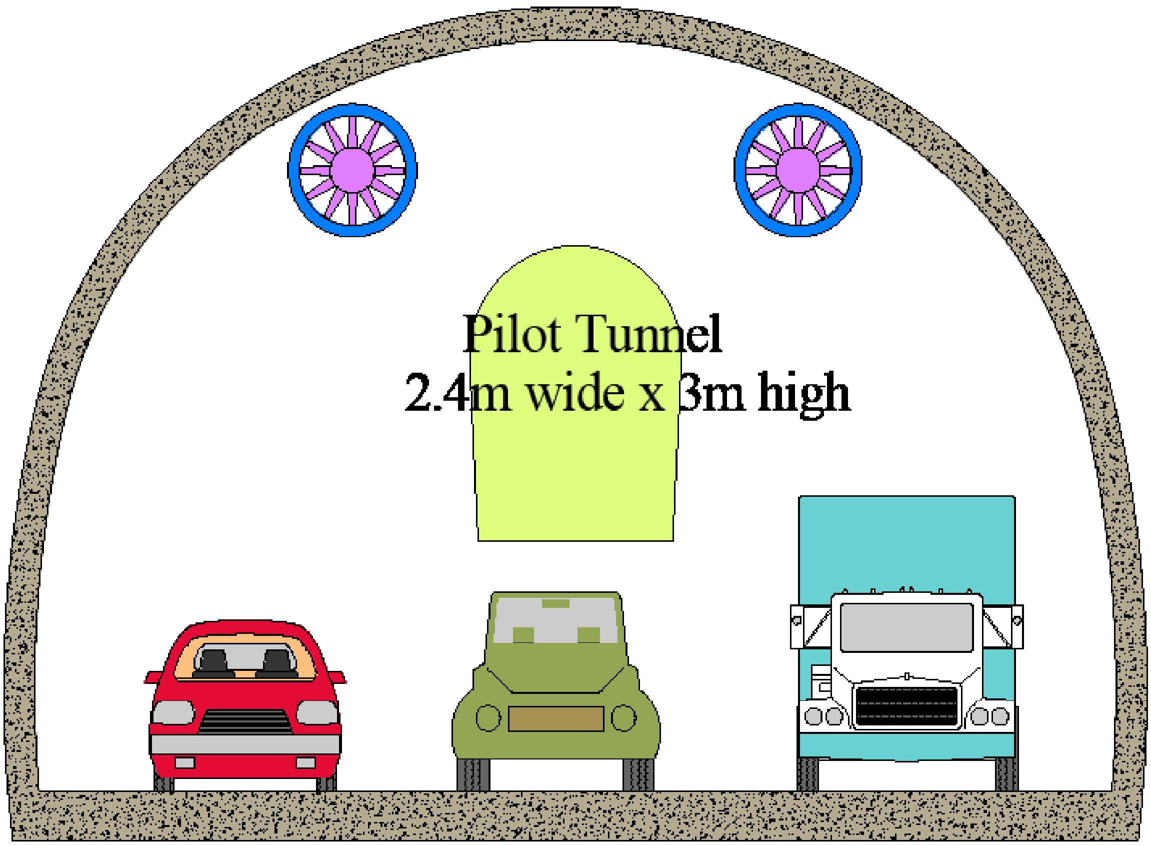

Figure 6. The location of the pilot tunnel is in the centre of the three lane westbound tunnel

Construction of the pilot tunnel

The pilot tunnel has a horseshoe shaped cross section (Figure 6) with dimensions of 3m high and 2.4m wide. It is located in the centre on the future westbound tunnel. It has been excavated by drill and blast methods, with a maximum explosive round depth of 2.5m. Excavations started from the western portal on 4 May 2007 where approximately 40,000m^3 of material was removed to access the portal invert level 15m below. The tunnelling contract was awarded to Avko Mining, a Kalgoorlie based company. On 3 August 2007 the tunnel proper started. For the first 29m a small excavator was used to win the rock. The work proceeded eastwards down a grade of 4.5%. On 21 August 2007 the first drill and blast took place(Figure 7,8). Up to 6m per day advancement in the tunnel occurred, with the last blast at the 625.9m mark being completed on 17 December 2007.

The pilot tunnel crown and wall support design is based on the 'Q' rock mass rating system (4). The rock in the pilot tunnel was delineated into four rock mass types using the following methods of support:-

- Type 1 – Random rock bolts
- Type 2 – Random rock bolts and meshing
- Type 3 – Closer rock bolts, meshing and 'W' straps
- Type 4 – Steel sets, hardwood timber lagging and longitudinal rock bolts

Most of the rock bolts are fibreglass so they will lessen the impact on future excavation of the main tunnel.

The pilot tunnel allowed visual inspection and an integrated picture of the geological conditions. It also allowed instrumentation and monitoring of the rock behaviour. The pilot tunnel was planned not to extend the full length of the main tunnel site. It was originally planned to be excavated for 525m of the 735m. However, another 100m was added onto the contract with the tunnel excavated to 625.9m. For the last 100m of the tunnel length, a slightly dipping cored borehole was drilled. This gave samples of the bedrock as well as a hole to drain groundwater from the tunnel.

Due to the complex slope of the range and the borehole being on a slight gradient, the final borehole length as it emerged on the eastern side was 166m long.

At the time of construction of the pilot tunnel, the overall comment on groundwater was it was a 'dry' tunnel. However at the time of the pilot tunnel construction, Toowoomba was experiencing its worst drought on record. After recent rainfall, the current groundwater drainage rate is approximately 10,000 L/day.

Preliminary tunnel geology

Seventeen boreholes had been drilled by Main Roads along and around the location of the tunnel. Investigation drilling of the ridge shows that the twin tunnels should only intersect rocks belonging to the Main Range Volcanics of Tertiary Age. Previous drilling for a proposed rail tunnel (8) put the lower boundary of the volcanic sequence and the Walloon Coal Measures at approximately RL 520 - some 25m to 50m below the road tunnel.

The tunnel alignment crosses the escarpment just to the south of Mt. Kynoch. At this point the escarpment forms a well defined ridge (saddle at RL 640m) with very steep eastern flanks and more moderately sloping western flanks. On the steep eastern slopes of the escarpment a thick colluvial surface cover was present over weathered bedrock. This colluvium is subject to landslides (9). This cover was generally up to 2m in thickness, but was locally deeper (up to 6m) on the break.

The western portal is in cleared farming land whereas the eastern portal is just east of the current main railway line and in very steep terrain, heavily timbered and difficult to access.

The excavations for the western portal in mid-2007 revealed primarily distinctly weathered basalt but it was also interspersed with red ash material. This is clearly visible in the cut batters at the western portal. Colluvial infilled gully of basalt boulders and clay is evident between the main eastern batter slope the adjacent slope to the north.

Figure 7. Type 4 supports – steel mesh with rock anchor bars, curved steel sets bolted together and timber lagging in between

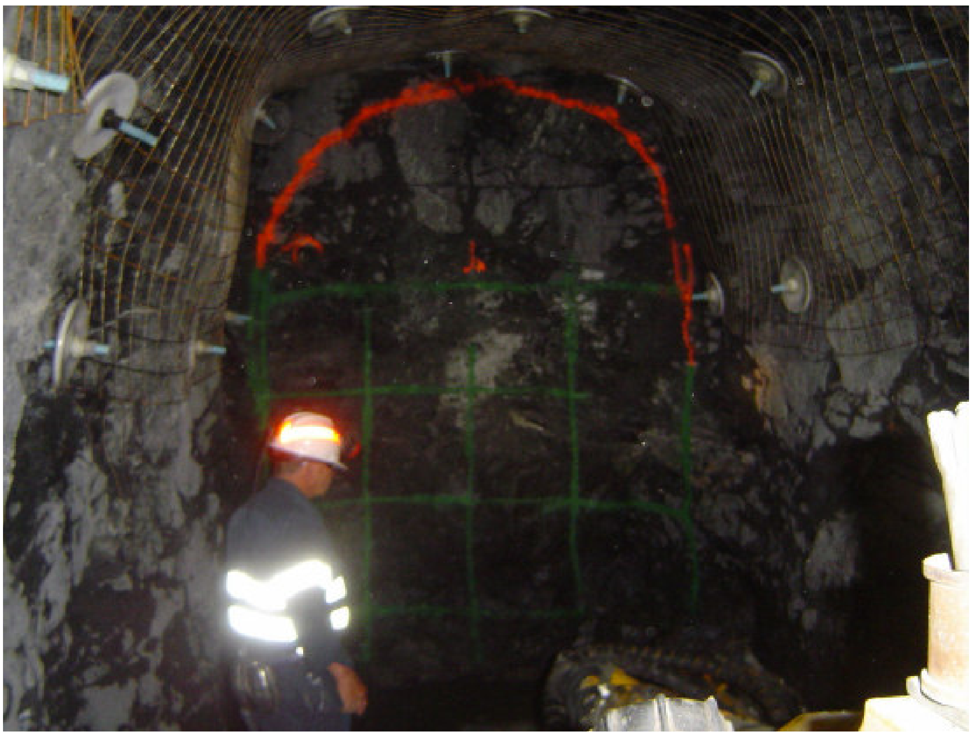

Figure 8. Marking out the face for blast holes in the pilot tunnel

It was postulated that at the tunnel location two distinct eruptive phases can be recognised. The most recent eruptive phase took place 19 million years ago and is represented by the surface basalts down to a depth of approximately 50m where a prominent claystone/coal/tuff interbed 2-4m in thickness is found.

Some of the upper basalt layers may have come from overtopping lava flowing from the Harlaxton Quarry lava pool some 2km to the southeast. The top and bottom of each of these basalt flows often exhibiting vesicular and amygdaloidal textures.

Preliminary results of the geological mapping of the pilot tunnel show that the claystone layer was intersected at the 70m mark in the floor of the tunnel. It was found to be less than 1m thick but was of very poor rock mass strength. As the tunnel advanced this layer ultimately 'rose' to the crown of the tunnel. The roof was unstable until the 130m mark where sufficient support from the better quality basalt was achieved. Samples of this claystone material have been sent for pollen spore analysis which may give the age of this material.

This claystone layer was thought to be the most challenging part of the pilot tunnel. However as it was less than 1m thick it did not slow down the advance of the tunnel as much as what was anticipated. A perched water table was above this claystone layer but did not yield much water.

The older eruptive phase took place 27 million years ago and is represented by the basalts below the claystone/coal/tuff interbed. These basalts had high volatile (gas and liquid) content in thickness with a large percentage of rock having amygdaloidal textures but no apparent flow structures.

The basalt below the claystone layer was in parts quite massive with little or no regular jointing pattern. At around the 250m length unusual 'curved' jointing planes lined with veins of weathered calcite predominated. Further into the tunnel amygdaloidal basalt richly lined with white crystalline zeolite minerals were common. This basalt commonly had voids with the largest void being several metres with the largest voids also seeping water.

Past the 450m length, red ash material was commonly found intermixed with the dull grey coloured basalt. This is similar material to that observed in the western portal batter slopes.

The mapping from within the tunnel has allowed better correlation between the original boreholes. The 160m long near horizontal drain hole has also presented rock quality information in the eastern portal area where no drilling has previously taken place.

Procurement phase

Two main documents will be produced from the pilot tunnel investigation. One will detail the excavation characteristics of the rock within the tunnel and another on the design and support of the future twin tunnels. The excavation report will have to encapsulate all possible excavation techniques that a potential tunnelling contractor may wish to use – be it drill and blast methods, roadheaders etc. The design report will determine the style of tunnel support, waterproofing, structural lining etc.

As the pilot tunnel is now complete, a third document, a Geotechnical Baseline Report (GBR) will be produced. It will be used to assist in the detail design phase. It is important that the GBR be continuously updated before and during the tender phase otherwise its impact and benefits will diminish. GBR will facilitate a better valued tender price for the construction of the twin road tunnels.

The GBR is an interpretative geotechnical report which states the baseline conditions expected to be encountered underground. Risks associated with the conditions consistent with or less adverse than the baseline are allocated to the contractor and those significantly more adverse than the baseline are accepted by the owner (5).

The baselines are contractual baselines, not necessarily geotechnical fact. Baselines translate the facts and opinions about subsurface conditions into a set of relatively simple statements. Baselines may be expressed as a maximum value, minimum value, average or a typical value. Items that should be addressed include:

- the estimated amounts and distribution of different materials along the alignment
- groundwater levels and groundwater conditions expected, including baseline estimates of pumping rates
- construction impacts on adjacent facilities such as the railway, water mains, nearby housing, etc.

Conclusions

The pilot tunnel has allowed geotechnical and engineering design staff gain an invaluable insight into the geology of the Main Range Volcanics. Although no great unexpected features were observed during the pilot tunnel excavations, the tunnel filled in most of the gaps from the previous geological data. It has also allowed the opportunity for many academics and professionals from outside the department to gain a better understanding of the complex geology of the Toowoomba Main Range Volcanics. Further monitoring and interpretation of testing is still ongoing and will be ultimately included in future contract documents.

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