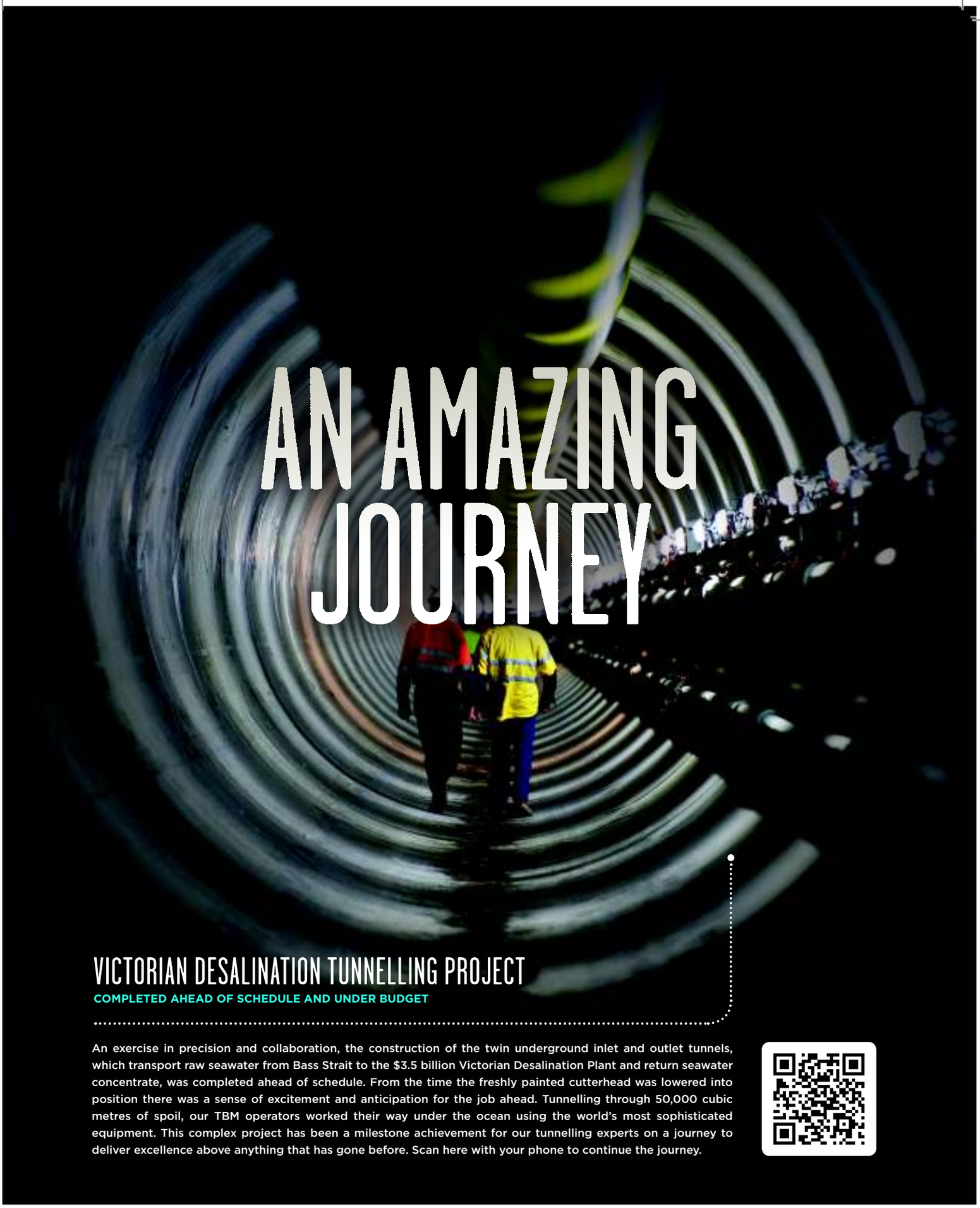

AN AMAZING JOURNEY

VICTORIAN DESALINATION TUNNELLING PROJECT

COMPLETED AHEAD OF SCHEDULE AND UNDER BUDGET

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Contents

October 2012 No. 14 **ISSN 1031–6760**

AUSTRALIAN TUNNELLING NEWS

NEW ZEALAND TUNNELLING NEWS

ASIAN TUNNELLING NEWS

REST OF THE WORLD TUNNELLING NEWS

AUSTRALIAN/NEW ZEALAND UNDERGROUND MINING NEWS

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Cover photo:
M2 Epping Tunnel enlargement – Courtesy of Leighton Contractors

Australasian Tunnelling Society is a Technical Society of Engineers Australia and affiliated with Australasian Institute of Mining and Metallurgy, the Institute of Professional Engineers New Zealand.

The ATS Journal is the official journal of the Australasian Tunnelling Society.

Chairmans Foreword

I am very pleased to advise that the Society has continued to hold technical sessions of interest and relevance to members with some Technical Sessions proving so popular they have been held in more than one Chapter. The Executive Committee and I would like to thank each of our Chapters for the fantastic work they undertake in bringing these sessions to members as well as the Presenters who continue to be willing to share their expertise and time.

As previously reported the ATS Executive Committee continues to focus on corporate governance and is working with Engineers Australia in the work being undertaken around regulations and terms of reference for all constituent bodies of the organisation. We believe this will lead to much easier administration of our society and make it much easier for members to manage their membership.

We have been critically reviewing the ATS Journal with a view to continuing to improve its contents as well as continuing to ensure it stays of relevance to our members. The ATS Journal remains extremely popular outside of the ATS membership base with regular requests being received from individuals and companies wishing to purchase it, however it is a benefit of ATS membership which will remain available to members only.

The ATS held its Tunnel Design and Construction Short Course in September 2012 which again proved extremely popular. Featuring a series of presentations by leading experts in the tunnelling industry on topics relevant to the current tunnelling industry in Australia, the course included topics such as health and safety, tunnel design, risk assessment and risk management, quality management, management of groundwater issues and tunnel construction. Course delegates received a comprehensive set of course notes, as well as access to the presentation material. In addition to the lecture style presentations, some topics were delivered in an interactive workshop format.

The Society has constituted a working group to make submissions to Safe Work Australia on the draft Guide for Tunnelling Work and we thank members of the Working Group as well as our members for contributing their time and expertise to this body of work.

Our New Zealand Chapter also developed and submitted a submission to the Royal Commission on the Pike River Coal Mine Tragedy.

Yours,

Simon Knight – Chairman

EDITOR'S NOTE

As noted by Simon we have been reviewing the Journal and this issue has a few changes – you will note that the conferences and events are now listed rather than displaying full details. We have always wanted to present more technical articles than news articles however this relies on the information that you send us for publication. There are two great articles in this issue – namely the *"Repair and Modification of NZ Railway Tunnels"* by Graham Ramsay and the *"Current state of the art usage of structural synthetic fibres as a replacement for steel mesh and steel fibres in precast segmental linings"* by Garry Martin.

It is always difficult to determine what projects we publish in the journal however we have sought to reduce the amount of information on International projects and underground mining. The international projects selected are generally those which are either significant, particularly relevant to Australian tunnelling or involve some of our Platinum, Gold or Silver sponsors. Many ATS members are involved in underground mining and the projects selected for the journal are considered of interest or again involve some of our sponsors.

Your view on these changes is important to us. Please let us know if you approve or would like to return to the previous format. In the meantime I would of course be delighted to receive any articles that our members care to provide.

David Lees – Editor

THE DAVID SUGDEN YOUNG ENGINEERS WRITING AWARD 2013

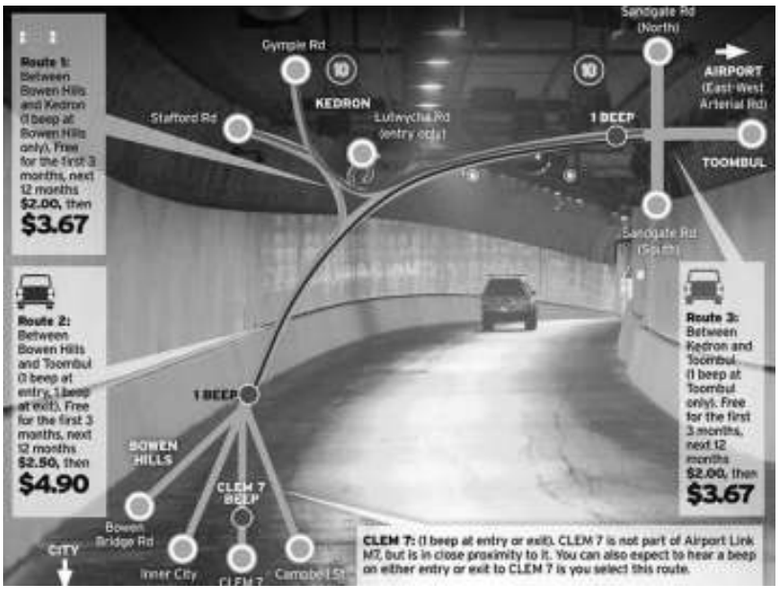
SPONSORED BY ATS

Win a chance to attend the 2014 ITA World Tunnel Congress in Iguassu Falls, Brazil with accommodation

- The competition is open to all ATS Members and University Students under 35 years of age (as at 30 June, 2013)
- The task is to write a technical paper on any subject related to tunnelling and underground construction — not less than 2,000 words and not more than 5,000 words.
- Best paper to be judged by the ATS Executive Committee.
- Closing date 30th June 2013
- Winner announced by 31 August, 2013
- The prize includes complimentary conference registration fees and $2,000 towards personal travel and accommodation costs at the ITA World Tunnel Congress to be held in Iguassu Falls, Brazil from 9–14 May 2014.

The winner may also be asked to be part of the ATS National Committee as the Young Engineers Representative.

For more information contact Sheryl Harrington at the ATS Secretariat
Phone 1300 653 113 — Email: sharrington@engineersaustralia.org.au



Airport Link opens

Airport Link, Australia's biggest piece of privately funded road infrastructure, opened to traffic at 11.55pm on Tuesday 24th July with 135,000 vehicles forecast to use it each day. With the tunnel toll-free until August 22, hundreds of south-bound motorists ventured inside from entrances on Stafford Road at Kedron, Sandgate Road at Nundah, and the East-West Arterial at Toombul.

After years of construction, the first motorist to drive the Airport Link was finally able to see the light at the end of Brisbane's newest tunnel. Lord Mayor Cr Graham Quirk said, "This is a revolutionary project, this is another big win for Brisbane." He said the tunnel worked with the city's river crossings to ensure drivers had more route options.

The $4.8 billion project is Australia's longest road tunnel at 6.7km, and allows commuters to avoid up to 18 sets of traffic lights. BrisConnections boss Dr Ray Wilson said Airport Link would exceed expectations and "improve a lot of people's lives". "People are really going to be able to enjoy the benefits of this fantastic new piece of infrastructure, saving enormous amounts of time, taking people out of those traffic jams . . . and making their trips to the airport and other places more simple and certain," he said.

"We think (the three-month toll-free period) will give people time to understand the benefits of the road, and when people understand the benefits, we're pretty confident they're going to use it and use it in good numbers."

Fixed speed cameras in the tunnel will operate from day one, speeds may vary from 40km/h to 80km/h but motorists will be kept well informed by variable speed signs placed at 120m intervals throughout the tunnel.

Dr Wilson also praised construction company Thiess John Holland and parent Leighton Holdings, despite the project coming in almost a month late. "They've done an unbelievable job delivering this tunnel in as short a time as they have," he said. "We broke ground on this project in October 2008, so about three years and nine months to deliver this tunnel as you see it now." Despite this, BrisConnections will collect $23.375 million in late fees from Leighton. A Leighton Holdings spokesman said it had made commercial allowances for the penalty and had agreed no legal action would be taken.

Airport Link 'Australia's safest tunnel'

Dr Wilson said that system, combined with computerised message boards and 500 cameras, meant the Airport Link road tunnel would be Australia's safest. "It's a marvel of which people in Queensland, Australia and Brisbane should be absolutely proud. Not only is it going to be a technological marvel, but it is going to be a marvel in terms of changing the way everybody in this city moves around this city."

Mr Wilson said the $4.8 billion Airport Link network of toll tunnels, busways and freeways was Brisbane's traffic game changer. Airport Link's control room will be managed by two operators, plus a supervisor, in rotating shifts on a 24-hour timetable. "These guys would trigger the deluge system in case of an emergency," Mr Wilson said. "There are liner heat detectors in this tunnel, where micro processors every six minutes would say something is hotter than it should be and it is moving down the tunnel and these guys will know if it is moving or it is stopped."

Mr Wilson said the tunnel deluge system was the most sophisticated fire protection system in an Australian tunnel. Micro-heat detectors in the tunnel measure changes in temperature every six minutes. In the event of a fire, half of Brisbane's annual rainfall can be automatically dropped onto the fire in an hour. Mr Wilson said, "This system is incredible. This puts something like 600 millimetres an hour of water on a selected spot. Brisbane's annual rainfall is around 1200 millimetres, so 600 millimetres is half the annual rainfall in an hour. That will put out a very major fire in a matter of minutes. That is one of the primary safety features that we have."

Some of Airport Link's other features include:

Underground loudspeaker systems – These have been specifically tuned so that drivers will get a clear message. They are designed so even if the (speakers) over-lap drivers will get a clear message.

Airport Link control room.

500 underground cameras – Whilst these technologies have been used in other tunnels, these are more technology advanced. They are read on 46 individually-controlled monitors in the control room.

Speed cameras – Airport Link will have six fixed speed cameras in 10 possible locations.

Signage around Airport Link's exits and entrances – There are travel time signs which will give people an estimate of how long it will take to get to various destinations. Variable message signs in the tunnel are 120 metres apart, which is closer than in the Clem7.

Tolls – The Airport Link is to be free for the first four weeks for everybody, and for the next eight weeks would remain free for motorists with a valid electronic tag. After those initial 12 weeks, reduced tolls would be enforced for six months – $2 for shorter journeys and $2.50 for longer journeys. Nine months after opening, Mr Wilson said motorists would pay $2.90 for shorter trips and $3.75 for the longer trips. Fifteen months after opening, full tolls will be in force ($3.65 short journey; $4.95 to the airport).

Time saving – Time savings are estimated at least 20 minutes from the city to the Airport, 15 minutes on the shorter trips i.e. the city to Kedron.

AIRPORT LINK OPEN DAY

The Airport Link was opened to the public for a preview on Sunday 15th July 2012. A burst of streamers made a colourful start to a cold, grey day, as about 5000 people hit the bitumen along a section of the $4.8 billion tollway.

Northern busway

The $444 million northern busway took three years to build – Thiess John Holland handed it over to the state government and TransLink earlier this year.

The project includes busway stations in a high quality urban design and modern landscaping.

Talks between the Rail Bus and Tram Union and the government have resulted in cancellation of the boycott, triggered by drivers' concerns they had not had the chance to become familiar with the tunnel before its opening.

Premier Campbell Newman said the northern busway would provide a boost to the public transport on the north side of Brisbane. "One busway lane can carry the same number of commuters as nine traffic lanes on Gympie Road," he said.

Minister for Transport and Main Roads Scott Emerson said the new busway would encourage more public transport. "This tunnel is at the heart of the Windsor to Kedron busway and will take hundreds of busses off the roads putting them underground," he said.

He said the tunnel buses would carry 12,000 busway passengers a day.

Hundreds explore Northern busway tunnel

Brisbane's northern busway tunnel between Lutwyche and Kedron was opened to the public on 16th June, with families and friends exploring the project.

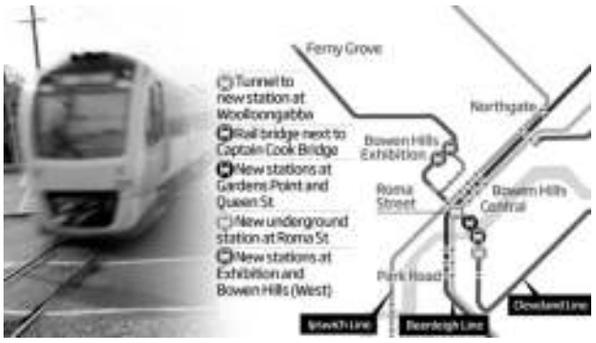
Cross River Rail project

On 20 June 2012, a budget version of Cross River Rail was unveiled by the Queensland State Government. Costed at almost half the amount of the previous government's proposal, the plan offers chances for the private sector to contribute in return for commercial space at train stations.

The $4.5 billion proposal still includes the two underground tunnels of the original plan which carried an $8.3 billion price tag. It also includes four underground stations at Roma Street, Albert Street, Boggo Road and Woolloongabba but there will be no station upgrades or extra train lines south of Yeerongpilly or north of Victoria Park.

The project cannot be delivered before 2020, so the State Government is also looking at interim measures to increase capacity on the train network before 2016. By that time, the CityTrain network will be unable to carry any more cross-river services on the Merivale Bridge to meet demand without additional infrastructure.

The Queensland State Government is now preparing a submission for the Federal Government and Infrastructure Australia.



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Legacy on its way

The Legacy Way tunnel will save motorists travelling from the Centenary Highway to Bowen Hill around 10 minutes, but will let commuters link to the Clem 7 and Airport Link tunnels. The toll tunnel will be finished in late 2014 and opened "very early" in 2015. The Federal Government has provided $500 million towards the Brisbane City Council project.

Conveyor Tunnel

Road tunnelling at Brisbane's Legacy Way from Toowong to Bowen Hills began in June, but one of the key steps to get ready for that larger excavation work was finished in March – a 530 metre tunnel for a conveyor belt – that would run from the toll tunnel project site to the nearby Mt Coot-tha quarry.

This tunnel runs about 30 metres to 35 metres under the Mt Coot-tha Botanical Gardens and would allow one million cubic metres of excavated rock and soil to be dumped at the quarry.

It means trucks carrying the rock and the soil will not have to drive from the site, out on the Western Freeway and then about one kilometre to the quarry. The benefit of using the Mt Coot-tha quarry and this conveyor belt will be that we will have some 96,000 less truck movements off the local roads. The cost of the 530 metre tunnel for the conveyor belt \, which was not included in the original design for the project, is still funded from within the existing $1.5

Legacy Way TBMS

Manufacturer Herrenknecht conducted a trial assembly of the first TBM at a Hemmant site near the Port of Brisbane, which was then disassembled and transported in 90 loads to the assembly site at Toowong, near the western portal. The largest component, the 6-metre diameter 182-tonne main drive, was delivered to site on 15 May. The journey was a complex night delivery over 2 days involving travel on the Gateway, Logan and Centenary Motorways and the Western Freeway.

The journey involved travel on the wrong side of the divided highway to cross the Brisbane River, as the outbound side was built later than the inbound side and has a higher capacity. Temporary road closures were required as part of this journey.

The main drive was the only TBM component requiring this treatment: around 90 deliveries were required for each TBM and apart from the main drive, a further 27 deliveries for each TBM were required outside normal site hours because of the dimensions of the load.

The primary means of assembling the TBM was a 260-tonne gantry crane set up over the entry shaft, and smaller (60t and 40t capacity) gantry cranes assist with the assembly work. Each TBM took around 3 months to assemble, and there is a 1-month overlap period during which both TBMs are being assembled.

When assembled, each TBM is over 90 metres long, and have a 12.4-metre cutting head for working in the hard rock conditions experienced over the route. The parallel tunnels will each be 4.3 kilometres long and will be lined with concrete segments as the work progresses. The maximum depth below ground level is 40 metres.

Annabell starts digging

The two TBMs, named Annabell and Joyce, were assembled on site before the tunnelling phase of the $1.5 billion dollar could tunnel begin.

Annabell was named after Annabell MacKinney, the daughter of the late Lance Corporal Jared MacKinney, who was killed in action in Afghanistan in 2010.

Joyce recognises Joyce Tweddell, a World War II nurse who showed immense courage after being held as a prisoner of war in Sumatra for three years before going on to become Queensland's chief radiographer.

Tunnel digging on Brisbane's third toll tunnel, following the Clem7 and Airport Link, started in August and should be finished by late 2013.

Sydney Opera House VAPS Project

John Holland is the contractor for the major works package of the Vehicle Access and Pedestrian Safety (VAPS) project at Sydney Opera House. John Holland is responsible for the excavation and construction of the new underground loading dock and upgrade of the Forecourt roadway. Work commenced in January 2012.

The contract, with an approximate value of just over $100 million, is part of the $152 million upgrade of Sydney Opera House and is the biggest building works on the site since its opening in October 1973.

The project involves:

- Excavation and construction of a new access road and loading dock under the Forecourt & Vehicle Concourse; and
- Raising of the existing road to remove the kerbs

The Vehicle Access & Pedestrian Safety Project (VAPS) is an important milestone in Sydney Opera House's history. Funded by the NSW Government, the project will enhance tourist and visitor safety by removing heavy vehicle movements from the Forecourt to a purpose built underground roadway and loading dock accessed from the southern end of our site, near Macquarie Street. This will allow pedestrians to have safe and exclusive access to all the Sydney Opera House facilities at Forecourt level.

M2 Epping Tunnel widening

The Epping Tunnel is being widened to provide three general traffic lanes and one breakdown lane in each direction as part of the $550million Hills M2 Upgrade.

Work was completed in the citybound tunnel in July 2012. This included laying new pavement, installing the new tunnel portal facades and commissioning and testing the new tunnel services. Major works in the westbound tunnel commenced in August with eastbound and westbound traffic diverted to the newly widened citybound tunnel to create a work area inside the westbound tunnel for service relocation and roof strengthening work.

On completion, the Norfolk Tunnel will provide three general traffic lanes and one breakdown lane in each direction.

Since work commenced to widen the citybound tunnel:

- Over 500 new lights were installed in the citybound tunnel.
- Over 12km of new cabling was installed inside the citybound tunnel.
- 2,950 rock bolts were installed in the citybound tunnel.
- 17,000m3 of rock excavated for the citybound tunnel widening: 12,500m3 inside and 4,500m3 outside the tunnel.

M5 East tunnel report

NSW Roads Minister Duncan Gay says he will release a study which reportedly addresses the issue of lung cancer among residents near Sydney motorway.

Mr Gay said the report investigated internal filtration in the M5 East tunnel. "We are looking to address the issues to do with pollution in that tunnel in a proper and a professional way and when the report is out you'll see that we've done that," he said. But Mr Gay says he will wait for the report before making a decision on whether to warn motorists and residents about the health hazards of living near the M5.

M5 East tunnel fire

There were massive delays on the M5 east tunnel on the evening of 3rd August after a truck caught fire in the inside the west-bound tunnel at Arncliffe. The motorway was closed in both directions while crews worked to put out the flames.

A truck carrying mattresses caught fire about 3pm. Fire crews were called and the tunnel's sprinkler system was activated to extinguish the blaze. The truck driver escaped uninjured.

All road tunnels in New South Wales have extensive fire safety systems in place. In the M5 East Tunnel, there is a number of different systems are in place. There are systems that identify heat and smoke, there is a deluge system that can be both manually and automatically automated, and there are CCTV cameras. All those systems work together. In the event of a fire, or detection of heat or smoke, automatic systems come into place, which are supervised by the operators in the control room via CCTV cameras, and they can activate any length of deluge within a tunnel.

Trainee Orace Hayden has found the Fremantle tunnel project offers more challenges than his last job.

Youth build tunnel and careers in Perth

More than 60 trainees are part of the team building sinking the Fremantle rail line.in Perth Working as part of the Perth City Link Rail Alliance team, the trainees learn directly from qualified tradespeople while also completing a Certificate II in General Construction and getting specialist training in areas such as scaffolding and fire safety.

Perth City Link Rail Alliance HR/IR Manager Justin Prince said this was more than just meeting a State Government project requirement, but was also an investment in local talent that would help address WA's skills shortage. "This is a long-term commitment to ensuring we have the right people for future projects from a local talent pool," Mr Prince said. "We are really impressed at the hard work and commitment each of our trainees has shown. Every day they surprise us with the quality of their work and their eagerness to learn."

Trainee Orace Hayden, 26, has found the Fremantle tunnel project offers more challenges than his last job, digging gardens and graves. Each day brings new experiences, from fixing steel or building a pergola to completing a basic traffic management course.

Another trainee, Jack Foster, 18, is an early bird in more ways than one. He applied for the traineeship straight out of school – and now he's leaving his Two Rocks home bright and early at 4.30am each day to get to the site on time.

Graham Farmer leaks to be addressed

Rusty and outdated equipment has been blamed for incidents in 2011 when water spilt into the Graham Farmer Freeway tunnel. The incidents have prompted Main Roads WA to budget $4 million to upgrade, repair or replace the equipment.

Two of the incidents last year caused water to pour on to traffic. One was when the sprinkler system self-activated and the other was when heavy rain overflowed through the ceiling exhaust system. The other incidents were during routine maintenance.

Responsibility for the operation, maintenance and repair of the tunnel was originally contracted to the Baulderstone Clough joint venture but after 10 years, it became the responsibility of Lend Lease Infrastructure Services.

The contractors have to maintain all mechanical, electrical, ventilation and control systems in the tunnel and refurbish any item that has reached the end of its economic service life. But Main Roads has identified tunnel systems and equipment that are "approaching obsolescence" and has developed a program to upgrade or replace them as a priority.

Just over $2 million had been allocated for tunnel systems rehabilitation this financial year and another $2 million was proposed to be spent in 2012–13.

Extra lanes for Northbridge Tunnel and another tunnel

The lobby group, City Gatekeepers, says adding extra lanes to the Mitchell Freeway and Northbridge tunnel will not ease the traffic congestion caused by closing Perth's Riverside Drive.

The WA State Government announced the $57 million earlier this year which will add one lane in each direction to the tunnel. An extra lane will also be added to the freeway from the tunnel through to Hutton Street.

Both projects, up to Vincent Street, will be finished by May 2013 before Riverside Drive is closed for the waterfront development.

Meanwhile Former WA transport minister Alannah MacTiernan believes it is time for the State Government to consider a second city tunnel – a move Transport Minister Troy Buswell said was inevitable. Mr Buswell said population growth would mean major infrastructure such as another tunnel would need to be considered in the next 10 to 30 years.

F3 M2 missing link tunnel

Transurban has submitted an unsolicited proposal to build an eight kilometre tunnel under Pennant Hills Road, which would provide the missing link between the two busy Motorways.

The Roads Minister Duncan Gay says he will be pushing to make the plan a reality, but there is no guarantee it will go ahead. He says it is too early to put a price tag on the project or say how much the Government would consider chipping in. "A tunnel of approximately eight kilometres, we think it's worthwhile and certainly as the minister who will be doing the coordination, I will be doing my best to try and make sure it happens," he said. "At this stage it's very early, there is probably only a 50–50 chance of this happening." A cross agency assessment committee will consider the proposal over the next six months.

Eight councils have joined forces to pressure the New South Wales Government to prioritise plans for a tunnel connecting the F3 and M2 motorways. The councils, including Hornsby, Lane Cove, Hunters Hill and Gosford, have commissioned a report into the need for the tunnel saying the link would significantly improve housing and business developments in the area and reduce travel times by around 10 minutes.

Maldon to Dombarton Rail Link

The Federal Government says work will begin soon on getting the Maldon to Dombarton Rail Link project 'shovel ready' ahead of possible inclusion in its next round of road and rail infrastructure funding.

Federal Infrastructure and Transport Minister Anthony Albanese says approval has been given for the release of the previously announced $25.5 million needed to complete the planning and detailed design work, with these pre-construction activities to be undertaken by Transport for NSW.

Preconstruction activities are expected to be completed within the next two years. The project involves laying 35 kilometres of standard gauge track connecting Port Kembla directly to the Main North South Line via Dombarton. It would also include two passing loops, bridges over the Nepean and Cordeaux Rivers and one of Australia's longest tunnels. As well as completing the detailed planning and design work, the additional funding will also be used to finalise a realistic construction timetable and cost estimate for the project.

Work on the rail link originally started in 1983, but was abandoned in 1988. An initial feasibility study carried out for the Federal Government in 2009 estimated the cost of finishing the link at $550 million. It found that the project had the potential to become a catalyst for additional trade and commerce in the Illawarra region and the ability to avoid or forestall other transport congestion issues on both road and rail.

2nd Harbour Tunnel to ease gridlock

The State Government has admitted it plans to extend the $4.5 billion Western Express rail project with a cross-Harbour tunnel. Experts say a new rail crossing is desperately needed to allow for more capacity, and would require two new tunnels – most likely west of the Harbour Bridge – at a cost of $3 billion to $4 billion.

The Western Express – to be finished by 2018 – will take commuters from Sydney's west into the CBD on extra long express trains. It also includes a 5km priority tunnel known as the City Relief Line, with new platforms at Redfern, Railway Square, City West (near Town Hall) and Wynyard.

The Government has been planning the crossing for some time, commissioning a report last year on the best route for an underground line from Redfern to St Leonards. A report from Halcrow

Engineering, commissioned by RailCorp and completed in February 2010, has been superseded by current studies for the Western Express.

The NSW Government pledged $30 million for design and planning work for the Western Express rail service in 2011 year's Budget.

NORTH WEST RAIL

NSW Minister for Transport Gladys Berejiklian addressed hundreds of industry representatives from Australia and overseas at a North West Rail Link project briefing held in Sydney's north west on 26th June 2012. More than 320 people representing 170 national and international firms had registered for the briefing, which was also attended by NSW Premier Barry O'Farrell.

"This is a multi-billion-dollar contract – one of three major contracts to build and operate the North West Rail Link. It was really important to the success of this tender process that everyone could see our vision for rail and how the North West Rail Link fits in," said Ms Berejiklian.

The North West Rail Link project has attracted interest from companies across Australia and around the world including the UK, Spain, China, France and Italy. There will be three major contracts for the North West Rail Link project

- Tunnelling;
- Surface construction works; and
- Rail systems, trains and operations.

The first of two Environmental Impact Statements has also just been exhibited for public comment, with the second to go on display later this year. The NSW Government is investing $3.3 billion into the North West Rail Link over the next four years, with $360 million in this year's State Budget alone. The North West Rail Link will be the first rail line to feature new generation single deck, high frequency trains as part of Sydney's Rail Future.

On Friday 28th June the NSW Government called for expressions of interest to build 15.5km of tunnels between Bella Vista and Epping.

Consortia show interest in Sydney rail link

Expressions of interest (EOI) have been lodged by six consortia for Sydney's North West Rail Link. The EOIs, which represent around 60 companies, hail from Australia, the UK, US, France, Italy, Spain, South Africa, China and Japan.

The New South Wales Government proposes to call for tenders in October, with the contract awarded in mid-late 2013, and tunnelling to commence in 2014. Contracts for surface construction, rail systems, trains and operations, will be tendered later this year.

Small tunnels

It is reported that tunnels for the North West Rail Link will have an internal diameter of 6.1 metres when they are completed in four years. This decision has been attacked suggesting that it shows the government is not planning for the future.

This report has sparked fears that most existing trains on the network will not fit in the tunnels, ruling out an integrated system and other future transport options. The government has said that the tunnels were not about saving money. They had been designed to suit smaller, single-decker train carriages under a metro-style system planned for the link.

North Strathfield Rail Underpass Tender

Transport for NSW has released a tender for North Strathfield Rail Underpass Alliance as part of the Northern Sydney Freight Corridor. North Strathfield Rail Underpass project will remove the existing operational conflict between freight and passenger trains on the Main North Line between Parramatta Road and Homebush Bay Drive.

The Alliance works will include construction of a dedicated Up Relief for freight trains, a shallow driven tunnel (under operational tracks), station upgrade works, civil works and other structures, protection or relocation of existing services, track and rail systems in a live operating rail environment.

The North Strathfield Rail Underpass project will resolve two issues in the area of the service:

- A steep incline slowing freight uphill from Parramatta River to Hornsby;
- Freight trains crossing tracks causing delays to passenger services.

In order to overcome these issues, Transport for New South Wales has proposed the construction of a 200 m tunnel under the M4 Motorway and running parallel to Queen Street.

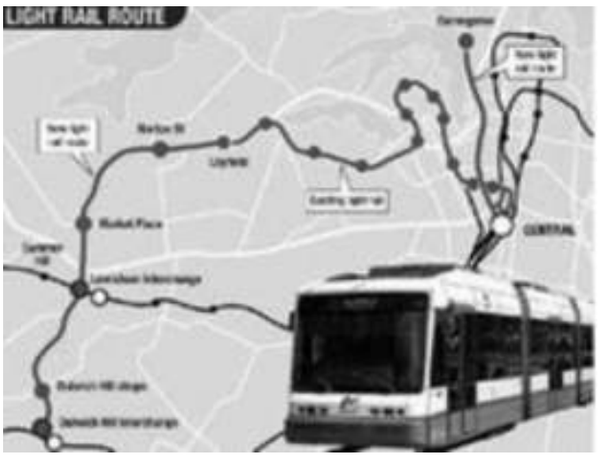
The project is due to be complete in late 2015.

Construction begins on Inner West Light Rail

Early work for the Inner West Light Rail extension is underway with survey, investigation and other preparatory works being carried out along the 5.6km project corridor. These works will allow major construction of the Inner West Light Rail Extension to begin later this year.

A contract for design and construction of the Inner West Light Rail Extension was awarded to John Holland six weeks ago, and already teams are out in the field preparing for major construction.

The Inner West Light Rail Extension will connect to the existing light rail service, which operates from Central to Lilyfield, and will run along the former Rozelle freight rail corridor, through the Inner West to Dulwich Hill. The project involves the construction of nine new light rail stops: Leichhardt North, Hawthorne, Marion, Taverners Hill, Lewisham West, Waratah Mills, Arlington, Dulwich Grove and Dulwich Hill Interchange. The route includes a tunnel which passes under City West link road.



Northern suburbs tunnel options

There are six options in the government's bus rapid transit (BRT) prefeasibility study for the northern suburbs. One proposal is a two-lane tunnel for buses under Military Road. The tunnel would extend from Spit Junction to the Warringah Freeway.

NSW Treasurer Mike Baird said his preferred option was the tunnel, and that he would ask Infrastructure NSW to consider opening it to cars as well as buses but this would be dependent on how willing motorists would be to pay a toll to contribute to the tunnel's construction, he said.

The report conceded that the benefits of all six options failed to outweigh the costs; and that the bus rapid transit, which would take priority over cars all day, would come at a cost to motorists.

Bondi Ocean Outfall Sewer wins national award

Sydney Water and the Water Infrastructure Group were praised for their commitment to safety when presented with an award at the Australian Water Association National Water Awards in May 2012.

Sydney Water Managing Director Kevin Young said the Australian Water Association National Safety Excellence Award 2012 was proof of the organisation's strong safety record while rehabilitating the Bondi Ocean Outfall Sewer, a key part of Sydney's infrastructure.

The project was also the winner of the 2011 ASTT Rehabilitation Project of the Year award at No-Dig Down Under 2011, the ASTT's 9th annual conference and exhibition.

"The $A6.9 million Bondi Ocean Outfall Sewer project involved restoring 911 m of a 120-year-old concrete and brick sewer," said Mr Young. "The rehabilitation saw crews working at night to install 611 m of PVC lining and applying 300 m of a calcium aluminate cement coating."

The Bondi Ocean Outfall Sewer (Boos) is responsible for transporting all wastewater from Sydney's central business district, and the eastern and inner western suburbs of Sydney to the Bondi wastewater treatment plant. It was the first ocean outfall sewer of its type to be designed and built in Australia. The BOOS was built as an alternative means for disposing of the city's sewage which was being drained into Sydney Harbour.

The structure of the brick oviform varies depending on the method of original construction. The tunnel section is an oviform sewer 2.49 m high and 2.18 m wide, constructed of bricks with a concrete base; while the trench section is an oviform sewer 2.58 m high and 2.28 m wide, internally constructed completely of brick.

The BOOS is considered a masterpiece of its time; however, after 120 years of continuous service, Sydney Water decided to rehabilitate the asset as part of its $560 million Sewer Fix Program. Given that there is no alternative to the BOOS for the collection and transportation of sewage from the inner western suburbs, Sydney city and eastern suburbs to the Bondi Sewage Treatment Plant, ensuring the service life of this asset for another 50 years was of critical importance.

The $A6.9 million Bondi Ocean Outfall Sewer project involved restoring 911 m of a 120-year-old concrete and brick sewer.

Water Infrastructure Group started work on site in January 2010 and rehabilitated a 911 m section of the BOOS which runs from Bellevue Hill through to North Bondi. For the works, Water Infrastructure Group used a combination of two technologies — their own propriety PVC lining system, Panel Lok, which was installed for two-thirds of the total length; and Calcium Aluminate Cement (CAC) coating, which was used for the remaining third. Significantly, this was the first time CAC coating was used by Sydney Water on a large scale.

Melbourne Main Sewer Replacement complete

The Melbourne Main Sewer Replacement, involving the construction of approximately 2.3 km of new sewer in central Melbourne, is now complete.

Most project work to construct the new sewer tunnel took place using tunnel boring machine (TBM) 10 m below ground. The TBM was 103 m in length, weighed 164 tonnes, as was used to tunnel through a variety of ground conditions, excavating materials including Coode Island silt, Port Melbourne sand and basalt clay.

The new sewer tunnel runs south from the Yarra River to Fennell Reserve and through to Swallow Street, where it will connect into the Hobsons Bay Main. The project cost an estimated $A220 million to complete.

CATARACT TUNNEL REPAIRS

The Cataract Tunnel/Upper Canal system forms part of the Upper Nepean Transfer Scheme owned and operated by the SCA. The system has significant heritage value due its history and engineering features. The Tunnel carries water for 3 km from the Broughton's Pass Weir pondage to the start of the open section of the Upper Canal at Brooks Point.

The Cataract tunnel is 9725 ft or 2964m in length. It has a cross section of 10'6" x 8'6" or 3.2 x 2.6m. The tunnel has a grade of 1 in 1508 or 0.06% with a depth of water 8' or 2.4m and a capacity of 97,000,000 gallons per day. It is excavated through Hawkesbury Sandstone with a maximum depth of overburden of 70m with three vertical shafts and is completely unsupported throughout. The tunnels were excavated by drill and blast using black powder.

Longwall mining at Appin Colliery has been occurring in the vicinity of the Cataract Tunnel since 1999. Some temporary mitigation measures were implemented to minimise subsidence impacts to the Tunnel and the water supply during mining. These included:

- installation of steel mesh, shotcrete and rock bolts in the tunnel and at the Brooks Point Tunnel Portal;
- Installation of tendon cables and standing timber prop setters at 0.4m centres around a fault near the tunnel portal and installation of timber prop setters, mesh and rock bolts in other areas along the length of the tunnel.

Some structural impacts occurred to the tunnel during mining. Sections of the tunnel are now considered to be in a deteriorated state. These impacts were within anticipated ranges and largely consisted of cracking of the bedrock forming the tunnel walls and some destabilisation of the rock above the tunnel due to shifting along the fault line near the northern tunnel portal.

Mine subsidence from longwalls 401–409 is now complete and SCA and BHP Illawarra Coal are repairing the tunnel in stages. The rectification work will be undertaken in stages over a 3-5 year period. Stage 1 of the remediation and rectification works focuses on sealing cracks in the tunnel walls and consolidating the ground above the tunnel to improve its integrity and allow removal of the temporary props inside the tunnel at the faulted area near the Brooks Point portal (the northern end of the tunnel). The proposed rectification works consisted of drilling and grouting in an area measuring approximately 80m x 20m above the centreline of the Tunnel near the portal.

The proposed post mining rectification work on the Cataract Tunnel are considered essential to protect its significant heritage value and continued operation as part of the Upper Nepean Transfer Scheme.

The Cataract tunnel is 9725 ft or 2964m in length. It has a cross section of 10'6" x 8'6" or 3.2 x 2.6m. The tunnel has a grade of 1 in 1508 or 0.06% with a depth of water 8' or 2.4m and a capacity of 97,000,000 gallons per day.

Metro moves to plug leaks in City Loop tunnels

Following a walk-through tunnel inspection by Alan Osborne, the man in charge of safety on the state's rail system in February it was decided that the tunnel walls of Melbourne's City Loop will be injected with sealant in an attempt to stem serious water leaks and halt concrete erosion in the underground rail system.

The work will be funded from Metro's maintenance budget but Mr Osborne said he was confident the measures would fix the problem. The acidic water leaking through the walls was causing two safety risks, Mr Osborne said. The water was corroding the electrical lines that power the trains and was also corroding the pads that bolt down the track sleepers.

The trial took place in June, when other works were planned within the tunnel. ''It was Metro's idea to trial this methodology based on advice from an independent tunnel expert who we engaged," Metro spokeswoman Geraldine Mitchell said. ''This particular methodology has proven to be successful in other road and rail tunnels across Europe."

Tom Sargant, Public Transport Victoria's director of technical services, said the government would work with Metro to ensure it achieved ''a successful and cost-effective solution" to the water leakage and corrosion problems.

Mr Osborne said he was satisfied with the tunnel's passenger walkway – which has been criticised as being too narrow in the event of an emergency – and access to emergency exits. ''I actually think what we've got is better than many rail systems around the world," he said. Mr Osborne said he wanted Metro to bring its maintenance of the 30-year-old City Loop into its mainstream maintenance and safety systems."The tunnel itself has been maintained but it is showing its age a little bit."

Tunnel boring to prevent flooding in Victoria

Melbourne Water is in its final stages of the Sandgate Avenue Drain Flood Mitigation Project, a project that has utilised the services of a tunnel boring machine for constructing a flood-alleviating stormwater tunnel in Frankston, Victoria.

Frankston is a low-lying area of Melbourne subject to serious flooding during severe wet weather, and this project will improve the drainage in the area to reduce the effects of flooding on homes and businesses. The project, which is being delivered by the Pipelines Alliance, is the biggest single project Melbourne Water has undertaken to improve drainage.

The final stage of works started in January 2012 and will be completed in mid-2013, and involves installing drainage pipe work through the Monash University Peninsula Campus, and along Bloom Street, Roberts Street, Heatherhill Road and Manly Avenue.

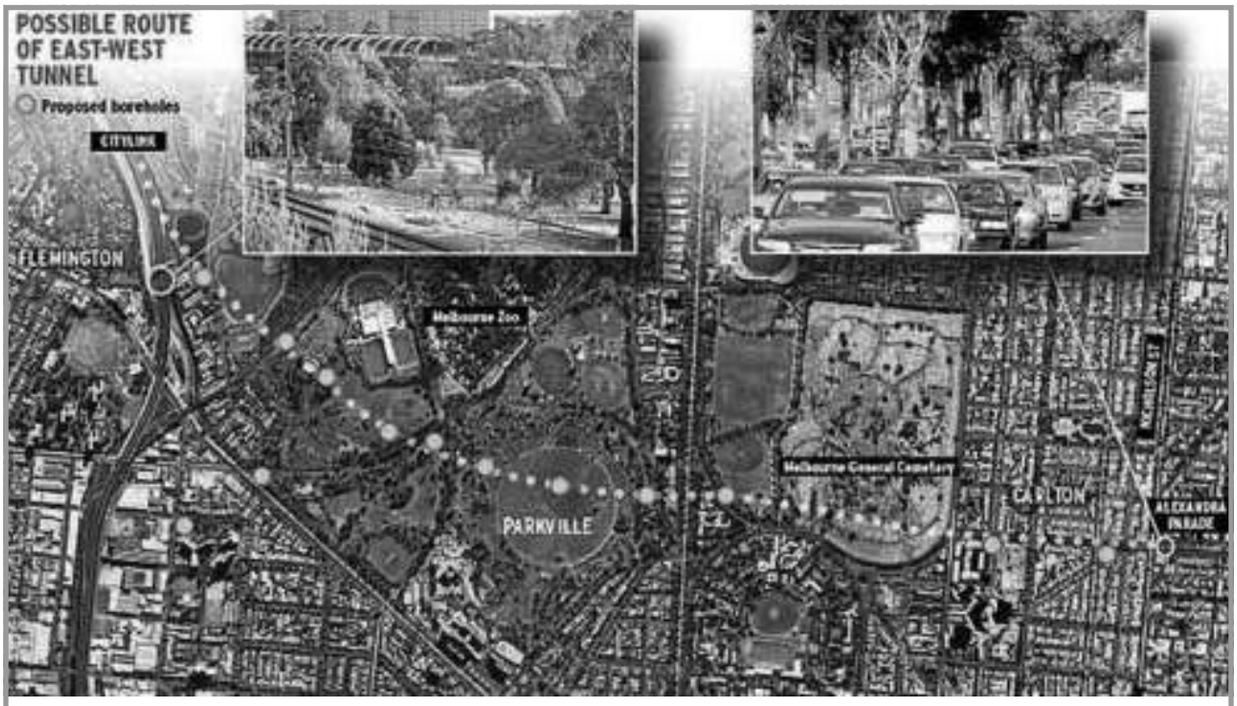
The $A73 million project has been split into three separate stages with work starting in September 2009. Stage 1 of the works work began in September 2009 and was completed in 2011. This involved the tunnel boring machine 'Sandy' laying a 1.5 km drainage pipeline between Monash University's Peninsula campus and Kananook Creek. This stage cost $A41 million.

Stage Two work began in September 2010 and will be completed in early 2012, and entails building and upgrading Beach Street and Frankston's Central Activity District, and the installation of a gross pollutant trap in Olsen Street. The second stage of the project is costing $A12.5 million.

Melbourne Metro rail tunnel

The proposed Melbourne Metro rail tunnel would pass under the CBD from Footscray to the Domain with five underground stations along the way. The Victorian Government has budgeted $49.7 million to buy land along the proposed route so it can proceed quickly when it secures federal funding.

"Melbourne Metro will strengthen and expand the inner core of the rail network and provide extra capacity to increase services and improve public transport across Melbourne," Mr Mulder said. Melbourne Council supports the project, while Federal Government body Infrastructure Australia in 2010 classified the $4.9 billion first stage of the project as "ready to proceed".



MELBOURNE EAST-WEST ROAD CONNECTION

The East-West road connection is a proposed 18 kilometres long freeway standard road to run from Melbourne's western suburbs to the Eastern Freeway. It was proposed in the 2008 East-West Link Needs Assessment (EWLNA) report by Sir Rod Eddington, but similar ideas have been proposed at various times. In May 2010 a submission to the Rudd government said that benefits from the road would total $1.14 billion, only one third of the $3.5 billion construction cost estimated in October 2008. By 2010 the estimated construction cost had increased to $5 billion.

Route

Stage One – Inner West to the Port

(a) Construction of tunnels connecting Geelong Road and Sunshine Road to the Port of Melbourne area, running under Footscray Road and the Maribyrnong River along the alignment of Buckley Street, with a new interchange in the port area connecting Footscray Road and Dynon Road.

(b) Construction of an elevated road over the Maribyrnong River connecting to the West Gate Freeway near Williamstown Road to Footscray and Dynon Roads. The new road would also include a connection to Hyde Street, providing a new route for truck access into the port and allowing the extension of truck bans in Footscray and Yarraville. Estimated cost: $2 billion.

Stage Two – West Melbourne to Flemington/Parkville

This section would require a mix bored tunnel and cut-and-cover construction, in order to traverse the developed inner city areas of North Melbourne and Kensington. From the port interchange, the route would follow a north-east alignment adjacent to Kensington Road, with J.J. Holland Park required as a staging point for deep tunnelling. Tunnels in this section are likely to be two or three lanes in each direction. Estimated cost: $5.5 billion.

Investigation works

The state's biggest infrastructure project in years was officially kick-started with a $15 million cash injection by the State Government which the Baillieu Government announced it would spend developing a business case and preliminary drilling work for the $5 billion East-West tunnel.

Preliminary work on the East West Link – including geotechnical drilling, and engineering and environmental surveys has begun.

The government will seek funding from the private sector along with a massive cash injection from the Federal Government for what it has labelled its priority infrastructure project.

Melbourne's Docklands tough jacking pipe conditions

The creation of a new, more advanced and higher capacity sewer main to support the growing needs of Melbourne's Docklands required the use of technologically advanced products that would stand the test of time.

The tricky ground conditions and the presence of Melbourne's infamous Coode Island Silt required a specialised team in order to complete the project. Theiss took on the challenge.

With the area's high volume of traffic and limited time in which to complete the project, HOBAS was selected as the product of choice to deliver the trenchless piping component of the sewer upgrade.

Thiess Services Project Manager Dean Larrassey said he had worked with HOBAS pipe numerous times overseas so knew the product could stand up to the challenges of the project.

"Because of the high volume of traffic experienced along Lorimer Street, we knew jacking was the way to go, so we used a micro-boring machine to jack approximately 500m of HOBAS pipe through the infamously difficult Coode Island Silt.

"The HOBAS pipe was easy to install in that it performed exceptionally well in the less than favourable ground conditions and we were able to complete the project right on schedule.

"Further to the actual product's performance, we were very happy with the hands-on expertise we received from our HOBAS supplier, Global Pipe – their team was attentive, helpful and they went over and above our expectations in terms of on the ground support," he said.

Andy Holman, executive director of Global Pipe Australia, said HOBAS CC-GRP jacking pipe is regularly selected to complete notoriously difficult projects due to its well established behaviour in pipe jacking and its very long asset life.

The tricky ground conditions and the presence of Melbourne's infamous Coode Island Silt required a specialised team in order to complete the project. Theiss took on the challenge.

"HOBAS has been used internationally for over 30 years and is now the product of choice among Europe's largest engineering companies.

"The HOBAS centrifugal cast pipe uses patented technology to provide the most efficient, long-lasting and highest quality CC -GRP pipe currently in the world. The design has a 100+ year life span which means it can typically outperform old-world products such as concrete or steel in corrosive environments such as sewer systems," he said.

Tunnelling under the Yarra River

Yarra Valley Water's $A2.7 million project to replace a 100-year-old sewer siphon that crosses underneath the Yarra River was completed in April.

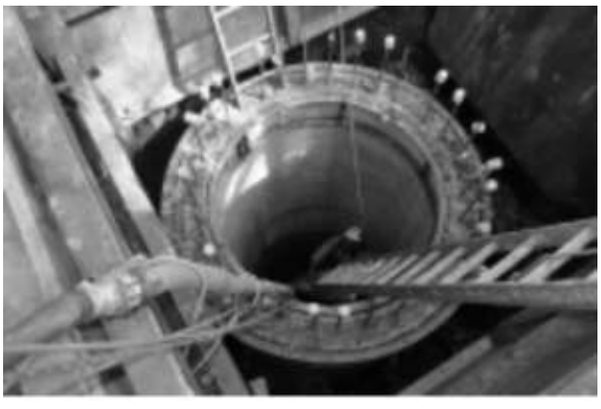
Replacing the 160 m of curved siphon was carried out by a small team using two state-of-the-art boring machines. The new syphons pass below the river at a safe level to ensure the river is unaffected by the works.

The siphon, which connects the sewerage network on either side of the river and is located near the Capital City Trail Bridge, was first built in 1911 by what is believed to be a team of Welsh miners by hand tunnelling with simple shovels. The miners even managed to cut through rock, constantly pumping water as they worked and demonstrating thorough craftsmanship – even the plans are hand-drawn.

The existing sewer siphon is encased in a beautiful old red brick tunnel that has been hidden beneath the river for an entire century. This siphon and a couple of others like it along the Yarra River, were critical to the urban development of Melbourne; at the time, Melbourne's sewage was sent to Werribee so finding a way for the system to cross the river was critical to the City's expansion.

Yarra Valley Water Managing Director Tony Kelly said that Yarra Valley Water investigated replacing the existing siphon within the brick tunnel casing, sending down a mini-submarine with cameras to assess the state of the tunnel; however it was deemed too unsafe a procedure.

The siphon replacement involved excavating a deep 3 x 20 m shaft on the southern side of the Yarra River with the sewer syphons directionally drilled from the northern side. A boring machine then connected the new syphons to the existing sewerage network on Walmer Street, on the southern side of the river.



Wonthaggi tunnels fill with water

Victoria's new Wonthaggi Desalination Plant moved a step closer to completion, with its two underground tunnels successfully filled with seawater in March

To fill the desalination plant tunnels, a team of divers opened small valves on the marine structures that have been installed on the seabed. This allowed seawater to flow slowly into the tunnels. Temporary water plugs were then removed and replaced with permanent steel plates.

Tunnel filling is just one of many activities that must be completed as part of the commissioning of the plant, the full commission process involved more than 200,000 tests taking several take months to complete. The plant's first potable water was produced in July as part of the commissioning process when the section of the plant that remineralises the RO water came online.

The reverse osmosis (RO) water, otherwise known as desalinated water, was produced on 30 June 2012 with seawater flowing into the plant via the 1.2 km underground intake tunnel, which was then filtered prior to the reverse osmosis process where ultrafine RO membranes separated salt from seawater.

The quantity of production will progressively increase during commissioning over the next five to six months and be fully operational before the end of 2012, with reliability testing expected to be finalised in February 2013.

Microtunnelling for the environment

Züblin won the Tunnelling Project of the Year award at the 2011 International Tunnelling Awards for their work at the Southern Seawater Desalination Plant in Western Australia.

The project was selected unanimously as the Tunnelling Project of the Year by a panel of industry experts from across the globe. The project overcame considerable technical challenges and risks associated with both ground conditions and geographical location, as it required both onshore and offshore engineering works.

Tunnel materials

The Southern Seawater Joint Venture contracted Züblin to manufacture and install two intake tunnels and one outfall tunnel for the new Southern Seawater Desalination Plant, which is part of a significant Water Corporation initiative to ensure Western Australia's future water supplies.

The intake tunnels had a length of 850 m each and an internal diameter of 2.4 m, while the outfall tunnel was 950 m with an internal diameter of 2 m. At the completion of each shore-crossing tunnel the pipe jacking tunnel boring machine (TBM) was recovered from the seabed.

Züblin produced the HDPE lined concrete jacking pipes from its factory in Southeast Asia and shipped them to Australia to be used for the tunnel construction. The tunnels constructed formed a shore crossing beneath pristine sand dunes and the ocean in an environmentally sensitive area of south-west Western Australia. The tunnels were designed with alignments that traversed beneath the earth, across the shore and beneath the seabed for between 850 and 950 m, in a curved 'S' shaped spiral, requiring the use of leading edge equipment and a highly skilled workforce. All tunnels were completed within a few millimetres of the designed completion point.

Upon completion of the tunnel drives the TBMs were recovered from their final position, towed behind a barge to Bunbury Port, removed from the ocean and transported back to site where they were fully refurbished for use again on other Züblin projects.

A fragile environment

The tunnels were an essential component of the desalination plant for the supply and discharge of seawater in order to produce much-needed potable water. The site of the Southern Seawater Desalination Plant was identified as environmentally fragile and subject to very close scrutiny by local residents, environmentalists and the Department of Environment and Conservation.

The areas of greatest potential environmental impact were the onshore sections, including sand dunes, native vegetation and the ocean floor, approximately 500 m into the sea. The impact caused by excavating 500 m of seabed would have been significant, including the destruction of habitat for reef growth, reef dwelling animals, seaweed, fish and other sea-life such as turtles and dolphins.

For this reason, tunnel boring and pipe jacking technologies were selected for the tunnel construction, as these technologies would leave a considerably smaller footprint on the environment than alternative methods.

Pipe jacking for the construction of the three tunnels was completed in a non-invasive manner, without dust, plumes in the ocean, noise pollution, air pollution or disturbance to the local community — and most importantly, the land surface was left undisturbed.

Another substantial environmental benefit gained by the use of pipe jacking techniques, when compared with open-cut approaches, was that no incoming tipping of spoil and quarrying of imported stone fill occurred, which led to a 90 per cent reduction in heavy vehicle movements.

Minimising community impacts

The impact to the local community was minimised with regular recreational activities continuing in the area throughout the construction period, with a short beach closure during tunnel construction under the beach area as a safety precaution only.

Trenchless technology meant the area was not impacted by lengthy stretches of open trenches during tunnel

construction. With pipe jacking, there was no surface scarring; no re-instatement of the landscape/oceanscape was required, again providing a more cost-effective option.

Using new technologies

The implementation of new industry technologies was key to the successful completion of the project. The use of a dual mode pipe jacking machine allowed the TBM to be operated in slurry mode or earth pressure balance mode to cope with the variations in ground conditions, thereby providing greater flexibility, safety and efficiency during the tunnelling operations. Furthermore, Züblin employed an orbital welder which provided a 360° HDPE weld around the pipe joints that provides protection against marine growth; a two-way lubrication system to reduce the effect of friction; and designed and produced the jacking pipes to provide the tunnels with a 100-year life span.

Corkscrew complications

Successful completion of the project relied on Züblin facing several major obstacles, including variable ground conditions, design alignment and developing solutions to achieve successful, on-time construction.

The complex tunnel alignment for the three tunnels provided a challenge that had not been undertaken before in Western Australia. Each tunnel had a different configuration that not only deviated on the vertical plane, but also on the horizontal plane in a corkscrew fashion.

Precision in the guidance of the TBM was guaranteed through a universal navigation system that immediately processed all the parameters on the current line of drive and displayed the progress of the tunnel being driven. Remarkably, given the complex design, the universal navigation system ensured that each tunnel was completed to within a few millimetres of the designed final tunnel position.

The ground conditions were highly variable, ranging from soft sand to hard rock, with voids in the alignment path. Countering this problem meant ensuring the use of the latest technology, dual-mode pipe jacking machine that could handle such conditions and a well-trained, experienced tunnelling team who could monitor and adjust the operations to suit any conditions encountered.

Recovery of the TBM

Recovering the tunnel boring machine from an offshore and underwater location had not been attempted before in Western Australia. The process was facilitated by introducing a recovery can and bulkhead, enabling safe recovery from beneath the seabed, leaving the tunnel dry and enabling completion works to continue inside the tunnel after the recovery. This also allowed the off-shore team to take advantage of breaks in the weather to achieve the recovery safely.

Successful completion

It was the culmination of the use of new industry technologies, developed between Züblin and the TBM manufacturers over many years, and a well-informed, well trained and loyal workforce that ensured the difficult project was completed successfully, with the end result being three high-quality, lined tunnels that left no environmental footprint outside the plant construction fence. The environment along the tunnel alignment has not been disturbed and the project was finished ahead of time and hit budget targets.

The trenchless tunnelling approach adopted by Züblin on this project meant that Water Corporation incurred no project delays due to inclement weather or high seas. The Southern Seawater Joint Venture expressed their appreciation to Züblin for their operational, safety and environmental excellence throughout the construction period.

The International Tunnelling Award was the second major award for this project, after winning a Civil Contractors Federation (WA) Earth Award in 2011.

UEA in Gold Coast pilot-guided success

UEA Trenchless has used pilot auger boring to install steel pipe under the Gold Coast Highway in Broadbeach, Queensland. The pipe will be used as a casing for a ductile iron (DICL) water main.

Working for CLM Infrastructure, UEA used a pilot-guided boring machine (GBM) to drill a pilot hole which, thanks to laser guidance, achieved on-target accuracy of less than 10mm. This was followed by the installation auger, which pushed out the 100mm pilot tube and replaced it with the 550mm steel casing pipe. Ground conditions comprised unstable, fine sand which some contractors have found can undermine and destabilise the main highway throughout the Gold Coast area.

A spokesperson for UEA said the company did not experience any undermining or over excavation subsidence when the pilot tube microtunnelling method was used. This was said to have assured main contractor Baulderstone said that the strict grade tolerances and safe clearances from existing infrastructure could be met using the technique. Once the steel casing pipe was installed, the DICL pipe was jacked through with an auger boring machine, after which the annulus was filled with an approved grout mix.

The UEA spokesman added that pilot tube microtunnelling can be used for trenchless installations up to 600mm-diameter and up to 80m in length, depending on ground conditions. It is particularly applicable to critical on-grade projects requiring high degrees of accuracy.

Tunnelling in the Top End

Winslow Infrastructure has maintained a strong reputation for completing challenging projects by installing almost 1 km of DN900 sewer by microtunnelling in Darwin. Navigating cyclones, extreme heat and multi-storey residential properties alongside the pipeline alignment, the trenchless component was completed to program and without incident.

The project, which is part of Power & Water's Larrakeyah Sewer Diversion Scheme, began in January 2011. Winslow was engaged by MacMahon Contractors to construct eleven tunnel drives, ranging in lengths from 40 m to 160 m.

The route of the pipeline commenced with a crossing under Darwin's Stuart Highway, and then negotiated through multi-storey residential areas towards the existing sewer system in Darwin's CBD. The geology comprised predominantly porcellanite and phyllite rock, which varied from fresh to highly weathered throughout the tunnel alignment. Bands of stiff clay and granular material were evident, particularly at the downstream end of the pipeline route. The slurry TBM was manufactured by mts Perforator with a rock head favoured over a mixed face cutter head.

This decision proved to be well founded, with maximum advance rates of 22 m per shift achieved whilst jacking Hobas GRP jacking pipes. The Hobas pipe assisted to maintain low jacking forces, due to the exceptional frictional properties of the GRP pipe.

As the contract started during Darwin's notorious wet season, a critical issue was the control of floodwater entering the shafts and tunnels. This wasn't assisted by experiencing the heaviest rainfall on record and the arrival of Cyclone Carlos in February. Determined to proceed against the elements, the first two drives had been successfully completed by the start of the dry season.

Another challenge was the extremely shallow grade of the alignment, generally limited to 0.2 per cent. The experience of the operators was critical to maintain exacting tolerances in variable geology, and the survey data was monitored continuously. On completion of the contract all drives had been completed within tolerance.

The contract had many potential problems at its outset, with deep shafts and tunnels weaving through residential and tourist areas. However by maintaining an excellent working relationship with main contractor, MacMahon, and managing the numerous site moves with minimum disruption, the contract was completed successfully.

Winslow minimised their footprint in the heart of Darwin's CBD by ensuring effective production rates whilst liaising effectively with local residents and stakeholders to achieve a successful completion.

Thiess wins Chevron microtunnel contract

Thiess has won an $US61.9 million microtunnelling contract for the Chevron-operated Wheatstone Project in Western Australia.

The contract will involve Thiess constructing a 1.2 km long tunnelled shore crossing under the ocean. The tunnel will connect two offshore gas reserves to Chevron's greenfield LNG plant at Ashburton North, near Onslow in the state's North West.

The Wheatstone microtunnel will be 2.5 m in diameter and will be delivered by a tunnel boring machine (TBM) and lined by pipejacking. The microtunnel will accommodate a 1.1 m diameter pipeline to deliver gas from Chevron's Wheatstone and Iago reserves.

Thiess Tunnelling General Manager Glen Ashton said "This is an exciting project for Western Australia and Thiess is committed to engage local suppliers and subcontractors, which will in turn boost local employment and training opportunities."

Construction on site will commence after the cyclone season in 2013.

Humes' segmental shaft solutions

Humes' segmental shafts have recently been released on the Australasian market and are increasingly becoming the shaft of choice in major projects across Australia.

Humes segmental shafts have been used on many high-profile projects throughout Australia. These include: the Sydney Desalination Pipeline, where Humes was commissioned to design and supply segmental shafts for the construction of two temporary shafts to be used as jacking pipe launch and retrieval pits, with 7.5 m internal diameters and depths of approximately 12–15 m; the NPI – Stage 2 where Humes constructed two 6 m segmental shafts with depth of 7 m and 14 m for receiving DN1500 jacking pipe; and the Brisbane City Works, where the company constructed an 8 m deep launch shaft for DN1650 butt joint jacking pipe at a site located in the heart of a residential and commercial area.

Applications

Humes' precast concrete shafts are ideal for a variety of applications including: ventilation shafts, escape shafts, launch and retrieval shafts for pipe jacking applications, storage overflow and pump stations, water harvesting and reuse.

Precast shafts provide installation contractors with a number of significant benefits over traditional shaft construction methods including greater installation efficiencies, cost benefits, and a safer work environment. Humes' precast shafts also help to reduce the environmental impact of construction.

Cost savings

Installation time is significantly reduced as excavation and ring placement can be on a continuous cycle. The precast concrete segments provide a one-pass finished shaft, so no further concrete work is required to finish the structure. There is no requirement for specialist labour and a small team should be capable of managing the entire installation process.

Safer work environment

The majority of work can be carried out above ground. Overhead services hazards are eliminated as no large cranes are required. The system has a built-in safety barrier created by the installation of the top ring.

Minimal environmental impact

Noise and ground vibration are virtually eliminated because no hammering is required. The excavation and site storage areas are minimal, as the precast units are relatively compact at less than 2.5 m wide. Shaft installation does not require the use of water or wet concrete (except for the base).

Innovative design

The shaft can be installed accurately due to the high degree of control over the rate and direction of installation. No bracing is required due to its structurally-efficient circular shape. The shaft gains structural stability from the surrounding soil so tie-backs or ring-beams are not required to support the segments. Installation methods used mean the shaft is suited to a variety of soil conditions. The extensive diameter range from 3 to 25 m diameter makes the shafts suited to virtually any project. A unique external fixing is used to join the segments, eliminating the need for specialist trades, like welders, on site.

Construction in any soil condition

There are three techniques available to install a precast concrete segmental shaft. These are the caisson method, which is generally used in softer soils with or without the presence of ground water. Caissons are either installed as a 'wet caisson' where the water level inside the caisson is slightly higher than the external ground water level, or as a 'dry caisson' where the inside of the caisson is open to the atmosphere. In the caisson method, the precast concrete elements are erected at the surface and are then lowered into the ground whilst excavation progresses. Secondly, the underpin method can be used in competent ground that is suitable for the required depth to install the shaft lining. In this method, the precast concrete elements are progressively installed at the base of the excavation. The last method is a combination of the previous two, ideal for use if the soil condition varies. Installation commences with the caisson method (using a special choker ring) and then shifts to the underpin method when the hard soil ground is reached. With some ground conditions it may be necessary or cost effective to stop the caisson at a certain depth.

Humes, Australia's largest civil precast concrete manufacturer, provides a large range of solutions for bridges and platforms, road and rail infrastructure, tunnels and shafts, retaining walls pipeline systems, water treatment, detention and reuse, drainage and traffic management.

Adavale Basin salt storage for gas

The development of underground gas storage facilities will be an important development for the natural gas industry in Queensland, with the ramp-up of the many proposed CSG-to-LNG projects in the state.

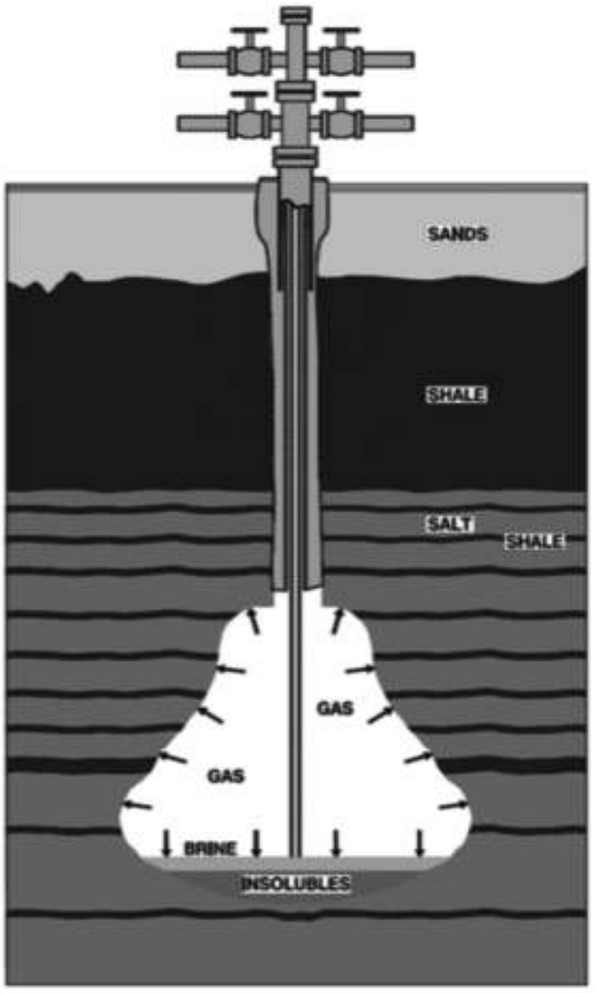
Gas storage facilities utilise either high-quality depleted reservoirs that have been converted into gas storage facilities, or large salt cavern pressure-vessels that have been solution–mined into underground rock salt deposits of sufficient depth and thickness. Salt cavern storage can easily meet demand by solution mining additional caverns at any given site, and unlike many depleted reservoir storage facilities, gas produced from salt caverns is exactly the same quality as that injected into the cavern, as salt is inert with respect to hydrocarbons.

The production of onshore CSG from South East Queensland has introduced a number of challenges to Australia's gas industry. One of those challenges is the construction and operation of sufficient underground gas storage facilities to ensure a low cost and reliable delivery of gas to these capital-intensive LNG export projects.

Various project operators have, and continue to search for, new gas storage facilities to be integrated as part of a project's overall development, as is the case with Santos' proposed $15.2 billion Gladstone LNG Project and the associated Roma Underground Gas Storage project. Similarly, AGL's Silver Springs Gas Storage Project is intended to serve some or all of the gas storage requirements for QGC's proposed $15 billion Queensland Curtis LNG Project.

While AGL, Santos and others are currently attempting to convert depleted gas reservoirs located in the Bowen and Surat basins into suitable gas storage facilities, the ability of these depleted reservoirs to perform adequately is yet to be demonstrated. Another attractive gas storage option for any or all of the proposed CSG-to-LNG project owners could be provided by the high-quality Boree Salt deposit located in the southern portion of the Adavale Basin.

Salt has many unique characteristics that are desirable and sought after for hydrocarbon storage. While salt caverns are yet to be made in Australia for this purpose, they are commonly found overseas in most other OECD countries because of their excellent hydrocarbon containment and hydrocarbon-cycling characteristics. Rock salt is essentially impermeable when subjected to the pressures commonly encountered in underground gas storage caverns. Most naturally-occurring rock salt deposits exhibit compressive strengths that exceed that of structural concrete. Another extremely desirable mechanical characteristic of rock salt is its tendency to flow or creep when subjected to moderate stress differentials across the salt. This desirable deformation characteristic enables salt to be self-healing, if and when, a fracture might develop near an underground salt cavern due to any tectonic activity.



One of those challenges is the construction and operation of sufficient underground gas storage facilities to ensure a low cost and reliable delivery of gas to these capital-intensive LNG export projects.

Solution-mined excavations in salt have occurred since the 1800s. Petroleum companies realised in the late 1940s that solution-mined salt caverns were ideal for the temporary storage of large quantities of LPG and natural gas liquids.

The use of such caverns for the temporary storage of gas commenced in the early 1970s but depleted reservoirs were the storage container of choice until the liberalisation of gas industries in the 1980s in North America, and a decade later in Europe. Salt caverns became very popular due to their much higher cycling performance characteristics, which more than compensated for their

higher development cost on a per working gas capacity basis. Salt domes located at depths ranging from 300 m to 3,000 m below the surface are sought after in particular because large caverns can be easily, economically and predictably excavated in such salt deposits through solution mining.

A scoping study recently performed by a consortium of Canadian-based salt cavern development experts confirmed from existing seismic and well data from a well located south of Blackall, Queensland, that the Boree Salt is a world-class salt deposit that appears to be suitable for the low-cost development of large salt caverns for gas storage application. The very pure and 500 m thick salt found 2,000 m below the surface is nearly ideal for the solution mining of large high-performance gas storage caverns.

At this stage it is anticipated that each salt cavern conservatively solution – mined to a depth of only 215 m and a diameter of only 80 m could contain 7.5 PJ of maximum working gas capacity, and a maximum withdrawal rate exceeding 500 terrajoules per day (TJ/d) from a single withdrawal well.

The Boree salt deposit is very large, thereby easily accommodating the development of a multiple cavern storage field linked to a centralised compression facility and a large-diameter pipeline that would interconnect with the many proposed CSG feedstock pipelines terminating at Gladstone, Queensland. The proven superior gas storage qualities associated with such a salt deposit is attractive and while the Boree Salt is located west of Gladstone, it remains within the economic reach of providing gas storage services to these gas export projects.

Eastern Australia in general, and South East Queensland in particular, requires large new open-access gas storage facilities in order to accomplish the goals of the gas industry and the Boree Salt can play a role in that regard.

Waterview Connection on track with tunnelling milestone

After years of planning, the New Zealand Transport Agency (NZTA) has begun construction on its largest, most challenging and most expensive project to date. Comprising 2.5km of tunnel, the NZ$1.4b Waterview Connection project will integrate an extra 4.8km of 6-lane motorway through and beneath the city's Western suburbs, linking State Highways 16 and 20 to complete a motorway ring route around the city

The NZ Transport Agency has announced that excavation work for the first of Waterview Connection's two 2.4 km long motorway tunnels beneath suburban Auckland is on-track to begin in 2013. NZTA State Highways Manager for Auckland and Northland Tommy Parker said when the southern approach trench was complete, the TBM would descend to 45 m beneath the surface, passing below hard volcanic rock and leaving intact the open space, communities and commercial precincts above.

"To create the launch pad for the machine, we first have to excavate through a significant chunk of this basalt to reach the softer soil conditions below, and that is the process we have officially begun today," Mr Parker said.

The 85 m long tunnel boring machine (TBM) will now be assembled before beginning excavation of the tunnels next year.

The 5 km Waterview Connection, including two 2.4 km tunnels between Owairaka and Waterview, will provide a new six lane motorway link between SH16 and SH20 to complete Auckland's Western Ring Route. It is New Zealand's largest and most complex road project to date, and one of the seven Roads of National Significance identified as key to enabling economic growth for New Zealand.

Victoria Park Tunnel 'cuts travel time'

Motorists are praising Auckland's newest motorway upgrade which they say has already cut travel times, even though roading authorities warned it could take time for improvements to be seen.

The New Zealand Transport Authority opened the third and final lane in the Victoria Park Tunnel and extended the moveable lane barrier on 2nd April in the final stage of the $340 million upgrade. After major delays when the tunnel first opened, transport officials said it would take some time for the improvements in travel times to be seen but motorists say traffic is already flowing more smoothly.

Milford bus tunnel 'technically viable'

Milford Dart Ltd's proposal to build an 11.6km, $150 million commercial bus tunnel through two national parks is "technically viable" and the tunnel could be constructed and operated within environmental and safety constraints, the company's engineering expert says.

The Department of Conservation (Doc) has resumed its hearing into the proposal, after Minister of Conservation Kate Wilkinson signalled her intention to grant the company a concession for the tunnel, proposed to run from the Routeburn road in the Mt Aspiring National Park to the Hollyford road in the Fiordland National Park. However, the company's engineering evidence could not be furnished at that time because it was stuck in a red-stickered building in quake-hit Christchurch.

But now URS New Zealand Ltd has passed their 27-page statement to Doc hearings Chairman Paul Green and assistant Chris Visser, completing the submission process. URS said submitters had made several comments on "perceived design deficiencies" of the tunnel which implied a "lack of understanding" of the stage the project was at in terms of design. The MDL proposal is now at the pre-feasibility design stage. Subject to a concession being awarded by Doc, MDL would consider whether to advance to the design stage.

URS stated the estimated construction period of three to four years for the 11.6km tunnel was "well within the capabilities" of the tunnel-boring machine proposed for excavation of the tunnel. Progress would average 12m–15m a day and the cost estimate was "realistic" for the stage of design the tunnel was at.

Another major point of concern for the submitters during the two weeks of hearings held in March related to safety aspects of the tunnel, including the diameter, "fire-life safety" and emergency egress provisions. URS said MDL's proposal was for a bus tunnel, "not a road tunnel", and, as such, New Zealand Transport Authority standards had "no relevance inside the tunnel".

The single-lane bus transportation tunnel was based more on typical underground railway tube tunnels and it would accept only diesel buses which complied with the minimum standards of fitness for purpose and mechanical condition. The 5m excavated diameter would provide for "sufficient space" for a running surface, side kerbs for bus guidance and passenger egress in an emergency. Other safety provisions included automatic solid security gates at each portal, preventing "people and animal access" and no uncontrolled vehicle access.

Buses would be designed with two-hour fire-rated engine compartments separating the engine, diesel tank and passengers and compartments containing fire-detection and suppression equipment. The tunnel controller would be in radio contact with buses, which would be staggered at a distance of at least 1km inside the tunnel to mitigate the risk of "bus-to-bus accidents". The controller would also be able to track the position of buses.

There would be no forced ventilation inside the tunnel because the "piston effect" of buses moving through it would provide adequate changes of air within the tunnel. An emergency forced ventilation system will be installed in the Hollyford portal structure, which will start automatically in the event of a fire. Safety and emergency

egress procedures would be developed and emergency rescue vehicles stationed at the Hollyford portal.

Tucked into the south-west corner of the country's fabled South Island this deeply photogenic enclave is also the most difficult part of New Zealand to reach, thanks mainly to the rough outcrops of the Southern Alps, where few roads have ever been built. As a result of this remoteness – as well as the wonders of its scenery – the wider Te Wahipounamu area has been listed as a Unesco World Heritage site since 1990. Unesco describes it glowingly as 'the least-disturbed tenth of New Zealand's land mass', and adds that 'the landscape in this park has been shaped by successive glaciations into fjords, rocky coasts, towering cliffs, lakes and waterfalls.'

The 11.3kilometre bus tunnel would run from the small town of Glenorchy, 20 miles north-west of Queenstown, into the Hollyford Valley and will improve access to the region. It will significantly shorten journeys between Queenstown, the nearest big town to the area, and the iconic fjord of Milford Sound. In doing so, it would have to force its way through a section of Mount Aspiring National Park – which is part of the Unesco-listed Te Wahipounamu.

The proposed tunnel would make access to Milford Sound far easier from the tourist hotspot of Queenstown and would radically alter the traditional journey to Milford Sound.

Currently, tourists wishing to reach the fjord from Queenstown have to undertake a winding adventure of 177 miles, driving south along the lower portion of Lake Wakatipu (the epically long lake on which Queensland sits), then west towards the small town of Te Anau (which lies next to the lake of the same name), and north on the winding ribbon of Highway 94 – the only road that ventures to the shoreline of Milford Sound.

A tunnel from Glenorchy would render this grand odyssey obsolete. However, opposition to the plan has been vociferous. Frana Cardno, mayor of Southland District, the administrative area that covers much of the south-west of the South Island, has promised a judicial review if the tunnel is given the green light by New Zealand's Department of Conservation. She claims that the project would 'threaten the protection of conservation land in Fiordland. Her reservations have been echoed by other opponents of the tunnel. Over 15,000 people have signed a petition demanding that the idea is scrapped. The petition has become the largest hosted by Change.org in New Zealand, an online platform for petitions.

The Conservation Department would need to grant a concession for the tunnel to progress before Milford Dart Ltd could begin the resource consent process. New Zealand's Department of Conservation has been making positive noises about granting permission for the tunnel, but a decision has not formally been made. In an unusual move, the department opened submissions on the proposed tunnel to the public late last year.

The success of the Glenorchy community's petition is being closely followed by its Te Anau neighbours. Community members from Te Anau are uniting to battle against the monorail and tunnel development proposals that they say threaten the protection of conservation land in Fiordland.

Supporters of the project point out that there is a precedent for such construction. A road tunnel already exists in Fiordland National Park – the Homer Tunnel, which opened in 1954. While considerably shorter than the new proposal – at 1270 metres (just under a mile) – this passageway slices through the Main Divide, a section of the Southern Alps. Highway 94 slips through the tunnel as it ebbs from Te Anau to Milford Sound.

The Homer Tunnel has also had its problems. In 2002, a tour bus carrying holidaymakers from Singapore caught fire while driving through. All passengers were successfully evacuated, although three people were taken to hospital and treated for smoke inhalation.

Queenstown Lakes District Council's transport boss has warned that funding for the roads to the proposed $160 million tourist tunnel should not be taken for granted. Although upkeep and maintenance for the roads from Queenstown, through Glenorchy, and to the proposed tunnel entrance at the end of the Hollyford Rd were now fully funded by the NZ Transport Agency, conditions could change if the tunnel went ahead.

The predicted 80 bus movements per day could easily grow if the tunnel was commercially successful, and there could be demand to seal the unsealed Routeburn Rd. Narrow roads and single-lane bridges all along the route could also be problematic, as well as the noise and vibrations that buses would cause in Glenorchy.

Wellington Tunnels Alliance wins award for best safety initiative

The Wellington Tunnels Alliance won a major award at the New Zealand Workplace Health and Safety Awards. The 11 categories of awards, in their eighth year, are organised by Safeguard magazine and supported by the Department of Labour. The awards are judged by a five-strong panel representing the Department of Labour, ACC, and NZ Council of Trade Unions, Safeguard, and an industry health and safety practitioner. Wellington Tunnels Alliance won the Kensington Swan best initiative to address a safety hazard.

The Terrace Tunnel upgrade required the tunnel to be kept open during the day while the ceiling was progressively demolished at night. A large self-driving mobile work deck shaped to the ceiling's contours could be elevated to varying working heights as a safe and productive work platform which also helped minimise manual handling risks.

Auckland inner city rail link route

Officials are contacting more than 200 landowners whose properties are in the way of the route for the Auckland inner city rail link.

The City Rail Link, which is expected to cost up to $2.86 billion. It extends the rail line through Britomart, under Albert, Vincent and Pitt Streets, then beneath Karangahape Road and the Central Motorway Junction to Symonds Street before rising to join the western line. Authorities need to buy property from 210 owners to secure the route. Underground land from 70 interests, including 12 unit title developments with multiple owners, also need to be purchased for the tunnels and stations.

Auckland Mayor Len Brown said the route identification was a big step towards the completion of "one of the most important public transport projects" in the recent history of Auckland.

The rail link would be built in two 3.5km long, twin tunnels up to 45 metres below the city. It would make Britomart a through station rather than a dead end, allowing faster, more frequent and reliable train services, Auckland Transport said. The CRL would also provide three additional city centre stations at Aotea Centre, Karangahape Road and Newton and an interchange adjacent to New North Road, Mr Warburton said.

The Auckland Council transport organisation says a staged approach to developing stations along a 3.5km route for the twin tunnels from Britomart to Mt Eden is among options it is considering for "optimising" project management and finances.

One scenario would be to open the tunnel with just a station near Aotea Square in the first instance, to be followed by others below Pitt St and Symonds St as finances and patronage dictate for a project which threatens to balloon to almost $3 billion.

It is even unclear whether the tunnels would form a true central city loop, as land constraints mean it may initially have only a western connection with the existing network where it will emerge at Mt Eden, rather than an east-facing link as well.

An official cost figure of $2.86 billion, as well as being in inflation-adjusted dollars to 2021, includes $336 million for new trains and $140 million for what Auckland Transport is calling "other network optimisation". The Auckland Transport official said the organisation was looking at a range of ideas, after cost concerns raised by ratepayers and others

But as the business case for Auckland's proposed $2.4 billion rail tunnel went under a Treasury blowtorch, Super City leaders turned to international consultants to shore up their cause. Transport Minister Steven Joyce, despite saying the case for building the 3.5-kilometre link has not yet been made, is not ruling out its ultimate construction. He says KiwiRail has no money for protecting the route in the meantime, and that Aucklanders rather than the Government must be prepared to pay if they want the project kept alive. He is, meanwhile, recommending a more thorough study of the central city's transport needs, including whether more bus projects and park-and-ride stations could provide better uses of existing networks.

Further steps taken to reopen historic tunnel

Negotiations might reopen with landowners in Tongaporutu about vehicle access to the historic Te Horo Stock Tunnel. The approach is being considered to enable New Plymouth District Council to restart work to shore up the walls and ceiling of the tunnel so that it can once again be used safely by the public – 14 years after it was closed due to safety concerns.

"The tunnel was built in the 1880s and is a site of regional significance as well as being a key part of the Whitecliffs Walkway," says General Manager Community Assets Anthony Wilson. "We'd like to negotiate a permanent road access to the tunnel not just for the repairs, but also for future checks and maintenance."

Te Horo Stock Tunnel is located on a public road and as such, NPDC is responsible for maintaining it to a safe standard. The only public road access to the tunnel is from SH3 via Clifton Road, which has a section missing due to coastal cliff erosion. The only practical route around the eroded area is through private land. Negotiations with the landowner over site access have been unsuccessful since the tunnel repair work stalled nine years ago when access over the private land was denied.

Mr Wilson says an application under the Public Works Act would be made if this fresh round of negotiations came to naught. "At the end of the day it's about making this historic structure safe and confirming public access to the full walkway, while minimising disruption to the landowners," he says.

Following the Cave Creek disaster, when 14 people died when a viewing platform in the South Island collapsed, the Department of Conservation closed the 95m stock tunnel in 1995 due to safety concerns. The closure meant that people on the Whitecliffs Walkway could not return to Pukearuhe through the tunnel and along the beach.

Work to restore the tunnel began in May 2000 with a $53,000 grant from the Lottery Grants Board, $10,000 from the TSB Community Trust and $20,000 from New Plymouth District Council. The project was one day from completion when the landowner denied the contractors entry. Since then, the restoration work has deteriorated and will need to be redone before the tunnel can be used by the public.

Homer Tunnel investigations near end

The New Zealand Transport Agency (NZTA) is close to finishing its first stage of investigating options for improving the long-term operation, efficiency and safety of the Homer Tunnel. It is also implementing further operational improvements within and around the tunnel, to increase driver information and safety.

NZTA southern regional director Jim Harland said the agency was working towards finishing its first investigation phase in respect of the roadway, which links Milford Sound to Te Anau and Queenstown. "Once a preferred option is selected, we will consult with stakeholders and the wider community on this. Options currently under consideration range from retrofitting the existing tunnel to boring a new one," he said.

In the last five years the NZTA has invested $500,000 on safety improvements on State Highway 94 from the Hollyford turnoff to Milford Sound, including the Homer Tunnel. Tunnel specific improvements include realignment of the curve on the eastern approach to the Homer Tunnel entrance, improved communications including an emergency phone at the western portal of the tunnel, and the installation of monitoring cameras at the tunnel portals.

Central Interceptor wastewater tunnel

Watercare is seeking consent from Auckland Council to build the 13km underground tunnel that would replace the current Western Interceptor pipeline and carry sewage from Western Springs to the Mangere Wastewater Treatment Plant. The tunnel will ensure Auckland's wastewater system copes as the city grows and will help resolve overflow issues the current network is facing, as there are around 100 locations in central Auckland where wastewater overflows from the current pipe after bad weather and the new system should reduce that by at least 80 per cent.

Construction on the $800 million project would begin in 2017 if consent is granted, and it would be completed by 2023. It is still only in the planning stages and the final design will be developed from 2014. At this stage the three main construction sites are expected to be at Western Springs, May Rd in Mt Roskill and at the Mangere Wastewater Treatment Plant. Work will also be done at 16 smaller sites in areas including Mt Albert, Blockhouse Bay, Mt Roskill, Hillsborough and Sandringham.

Small vents to allow trapped air out of the tunnel after extreme weather will need to be built along the route. Potential locations for one of these vents are Walmlsey Park or Underwood Park in Mt Roskill. According to Watercare the vents would only need to be opened once every two to five years.

Christchurch to rehabilitate brick barrel pipes

Parts of the wastewater and stormwater network in Christchurch consisting of brick barrel pipes constructed more than 100 years ago, will be restored using Trenchless Technology.

The pipes, generally between 450 and 1,300 mm diameter, and buried 2-4 m underground, suffered significant structural damage in the 2011 earthquakes in Christchurch. The pipes, located under streets in and around the Christchurch city centre and in nearby Lyttelton, carry wastewater and stormwater to the Bromley treatment plant.

MacDow Fletcher, a part of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT), is undertaking repairs and rebuilds on approximately 5 km of brick barrel wastewater and 5.5 km of stormwater pipes. MacDow Fletcher contractors will enter street manholes and then use robotic technology to move material into the pipelines. A machine will line the pipes with a spiral-bound material to seal and strengthen them, and any collapsed sections will be excavated and replaced.

REPAIR AND MODIFICATION OF NZ RAILWAY TUNNELS

By Graham Ramsay, Beca Infrastructure Limited

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SUMMARY

The current NZ rail network is approximately 4000km long with 145 tunnels ranging in length from 50m to 9km and with a total length of 87km. The tunnels were opened between 1867 and 1980 and have been constructed in a diverse range of geological conditions. Tunnel cross-sections and lining arrangements have varied over the period and only two tunnels can be considered as being modern designs.

The tunnels have performed remarkably well and the major reasons for modifications have been invert lowering to provide greater clearances for larger rolling stock or to permit electrification. A few tunnels have required works to repair lining failures due to swelling ground pressures and in a small number of tunnels lining repairs have been required to remedy lining deterioration due to a low standard initial construction.

This paper describes the philosophy and approach taken in the repair and modification of a number of tunnels over the last 30 years.

1 INTRODUCTION

The earliest tunnels on the NZ rail network were constructed in the 19th century and were lined after excavation with a masonry or unreinforced in-situ concrete lining.

Except in areas where swelling minerals are present in the ground or the tunnels were constructed through landslide slip surfaces the tunnel linings have been structurally adequate.

In a few tunnels poor initial concrete quality combined with the effects of corrosive steam locomotive exhaust has resulted in surface erosion sufficiently severe to warrant remedial works.

The major challenge has been to pass ever increasing sized rolling stock and containers through the tunnels and to provide for the installation of overhead electrification traction cables. To date this has been achieved by lowering the rock floor of the tunnels enabling lowered rails.

The construction of the railway network was largely undertaken by the Public Works Department (later Ministry of Works and Development (MWD)). The maintenance and modification of the network was the responsibility of New Zealand Government Railways (NZGR or NZR) until 1991.

From 1993 to 2003 the network was in private ownership, after which it was purchased back by the government and became the responsibility of ONTRACK, which has become KiwiRail Network (KRN) with the formation of KiwiRail in 2008.

2 OVERVIEW OF NZ RAIL TUNNELS

2.1 History

The development of the New Zealand railway network can conveniently be subdivided into three stages with corresponding evolution of tunnel size, design and form of construction.

Downer (1977) provides a history of the construction of a number of the major tunnels but otherwise there is little published information on the history of the tunnels.

The following is a brief simplified chronology of the construction of the major lines still in operation, a significant number of local branch lines having been closed in the second half of the 20th century. .

2.1.1 19th Century

The development of the network commenced in the 1860's with a number of short provincial railways heading from a port into the hinterland. Railway construction began in the South Island and the 2596m long Lyttelton Tunnel, built in 1867 was a significant achievement for the pioneers. The Main South Line (MSL) between Christchurch, Dunedin and Invercargill opened in 1879. In Auckland, the railway to Drury included a 340m long single track brick tunnel between Parnell and Newmarket that was opened in 1873.

In 1870, Julius Vogel, set about creating a national network and standardising the track gauge. The private Wellington & Manawatu Railway Company (WMR) opened its line from Wellington to Palmerston North in 1886 which enabled trains to run from Wellington to New Plymouth and later to Napier when the difficult section through the Manawatu Gorge was completed in 1891. The Government's line from Wellington crossed over the Rimutaka range using a third rail Fell engine system. Other railways in the North Island went to Thames, Rotorua and Helensville. Progress continued on constructing the North Island Main Trunk (NIMT) which eventually met in the middle in 1908. The Government then purchased the WMR.

2.1.2 Early 20th Century

The first half of the 20th century saw the fleshing out of the network by the connection of isolated lines to form trunk routes and the construction of new lines including:

- the Midland Line from Christchurch to the West Coast including the 8565m long Otira Tunnel which took 11 years to complete and contained electric traction from the start when it opened in 1924;
- the completion of the North Auckland Line (NAL) which had been built progressively from 1880 to 1925;
- the Stratford – Okahukura Line (SOL) opened in 1933 providing a connection to the Marton – New Plymouth Line and also an alternative route to the central North Island section of the NIMT;
- the extension of the Palmerston North to Napier Line onward to Gisborne (the PNGL) opened in 1943;

- the central section of the Main North Line (MNL) between Christchurch and Picton opened along the Pacific coastline in 1945.

All of these entailed significant tunnelling accounting for two thirds of today's tunnels.

In addition to completing the network, attention turned to providing deviations to eliminate difficult sections of line. This work involved the construction of the longer and wider tunnels. In 1915 a new double track tunnel was provided parallel to the original one near Newmarket. And, to provide an easier route into Auckland, the eastern line in from Otahuhu to Parnell via Glen Innes opened in 1930. Then in 1937, two double track tunnels totalling 5.5km eliminated the steep and winding access into Wellington. The Turakina – Fordell deviation opened in 1947 with three tunnels totalling 3.5km. A new record for length was set in 1955 when the 8789m long Rimutaka Tunnel was opened to eliminate the 1 in 15 Fell incline.

2.1.3 Late 20th Century

KRN's newest two tunnels show a step change in construction method and size. The Kaimai Tunnel is New Zealand's longest railway tunnel at 8879m. It was also built for a deviation that enabled a more direct route to the port of Tauranga and the Bay of Plenty when it opened in 1978. Finally, the 1272m long Poro-o-Tarao tunnel was opened in 1980 and was constructed to bypass a tunnel on the NIMT that had suffered major lining failures.

2.2 Size and Shape of Tunnels

The tunnels dealt with in this paper were constructed in the 19th or early 20th centuries. Jones (1987) has set out the evolution of the tunnel profiles over this period. Tunnels built between 1881 and 1892 have the Vogel profile (named after Works Minister Julius Vogel) with an initial height of 4300mm and width of 3800mm. From 1901 through to the 1970's a larger Ward-Cadman profile (named after Ministers of Railways Ward and Cadman) was adopted with an initial height of 4630mm and width of 4530mm.

There was a rapid evolution of the size of locomotives and rolling stock during this period and some of the Vogel profile tunnels on the NIMT had their floors lowered soon after being opened.

One important feature was the shift in the 1930's from a predominant horseshoe shape of the 19th century and early 20th century tunnels to vertical straight walls following American practice. A number of the tunnels with the vertical walls have exhibited poor structural performance.

Practice in the 19th century appears to have been to retain a vertical centreline in curved tunnels rather than tilt the centreline to match the track cant. This creates challenges when determining the optimum track position to maximise clearances in tunnels that include both straight and curved sections.

2.3 Lining form

The early 19th century tunnels and those on the WMR line to Palmerston North are generally either unlined (not common) or masonry (brick or local building stone). Brick linings with two or three layers and various bond arrangements have been observed. Later in the 19th century there was a general transition to in-situ concrete walls with a crown lining of precast concrete blocks. Only in one case was an invert lining provided.

In the early 20th century there was a move to fully concreted arch linings. In many cases the concrete was not of a high quality and the construction techniques were still in the process of development. This has resulted in both poor quality concrete with segregation and variable thicknesses in the crown where concrete appears to have been pushed into place.

The tunnels constructed in the late 20th century have modern cast in situ concrete linings and have not presented any structural or serviceability issues and are not discussed further in this paper.

2.4 Geological setting

New Zealand is a geologically young country with a wide range of geological conditions which can be very generally subdivided into the following categories:

- Greywacke bedrock which is a strong rock which has been heavily faulted, folded and sheared during major tectonic activity over the last 200M years. It can locally vary from massive to very closely jointed sandstone with compressive strengths up to 200MPa through to thick or thin beds of weak fissile argillite. Near the surface the greywacke is weathered sometimes heavily.
- Metamorphic rocks, schists and gneiss, formed by alteration of the greywacke / argillite basement rock. These rocks are predominantly found in the South Island.
- Sedimentary rocks laid down from the Tertiary (20M years before present) through to the Pliocene. These are commonly referred to as "papa" or "soft rock" and are characterised as massive thick deposits of mudstones, siltstones, sandstones and limestones all with low strength and many with low resistance to weathering.
- Volcanic deposits of various origins including lava flows, ignimbrite sheets and ash deposits.

An important feature of geological settings is the presence of swelling clays (typically smectite or montmorillonite) locally in both volcanic and soft rocks.

3 TUNNEL PERFORMANCE

3.1 General Condition and Records

For the predominant proportion of the tunnels there are no records of tunnel lining performance issues and no current indications of problems.

A small number of tunnels experienced lining problems soon after commissioning and have been the subject of ongoing review and/or remedial work. Only in the case of the NIMT Poro-o-Taroa tunnel has replacement been necessary.

In a number tunnels investigated for remedial works or invert lowering there are areas of historical lining

replacement that are not recorded in files, though in some cases long standing KiwiRail employees can recall the work being undertaken.

All tunnels have been subject to periodic inspections. However these have generally been undertaken by tradesmen from a structures background and without specific professional engineering or tunnelling expertise. As a result the reports from the inspections are often of limited value in terms of assessing the severity and history of development of lining issues, rather concentrating on operational issues such as water falling on rails, invert drainage, track condition and signage.

There are frequent reports of long standing issues adjacent to portals with water ingress and extensive cracking of the lining. The crack patterns are indicative of the tunnel barrels supporting the portal faces, which were constructed integral with the tunnel lining and without a footing capable of resisting the earth pressures on the back of the portal face.

As discussed in the specific case histories below, measurements have been made in a small number of tunnels to monitor the rate of convergence of the walls.

3.2 Tunnel "Failures"

Of the approximately 200 tunnels constructed on the original network, very few have failed to the extent of requiring bypassing or extensive remedial works.

Two tunnels, (PNGL 24) and WMR Tunnel 12 were constructed through active landslides and in both cases the tunnel lining suffered collapses soon after opening and the line was diverted around the tunnel.

One of the earliest and longest tunnels on the NIMT, Poro-o-Tarao, suffered major lining distress from the 1920's onward due to wall bulging after early lowering of the invert and softening of the invert as result of heavy water inflows. A deviation with a 1300 m long tunnel was opened in 1980 to bypass the original tunnel.

4 TUNNEL MODIFICATION OR REPAIR

4.1 Reasons for Modification or Repair

The tunnel modification and repairs described in this paper arise from three primary reasons which have different timeframes and priorities.

4.1.1 Structural Failure

In a small number of tunnels structural failure of the lining has occurred evidenced by bulging of tunnel walls and cracking of the lining. Apart from in the two tunnels constructed through landslides, these failures have been gradual and have not resulted in an actual lining collapse. Because of the three dimensional geometry, determination of the degree of cracking and bulging which is acceptable before remedial action is required to prevent failures is largely a matter of judgement based on simple analyses.

In most of the fully investigated case histories of structural failure the causative factor appears to be the presence of swelling ground rather than construction deficiencies or rock loading on the crown.

4.1.2 Lining deterioration

There are a few localities on the network where linings were constructed from inferior concrete and the exhaust gases from coal fired steam trains attacked the lining to the extent that remedial works were undertaken.

4.1.3 Inadequate Operational Clearances

By far the most common reason for tunnel modifications has been to allow the passage of larger rolling stock and containers or to permit electrification of the line.

4.2 Design Philosophy

A major consideration in developing designs for modification works has been what design philosophy should be used given that the tunnels were not designed or constructed to the standards applying to modern tunnels.

4.2.1 Building Act

Until the enactment of the Building Act in 2004, design of public works in New Zealand was to standards established by the relevant government department.

The Building Act applies to transportation tunnels, and as a consequence new tunnels or significant structural modifications to existing tunnels may require a Building Consent. The three basic issues that must be addressed in a Building Consent Application are:

- Strength and structural adequacy
- Achievement of a durability for a design life of 50 years
- Fire protection

Though the Building Code does refer to general loadings and material codes, it does not contain or refer to any specific standards relating to loadings on, structural design of, or fire protection for tunnels.

4.2.2 Modern Tunnel Design Approach

Modern tunnels requiring a supporting lining are generally designed and constructed with the assumption and objective that either:

- an internal support structure is provided (by a structural lining with or without primary support such as steel sets) with filling between the excavated ground structure so that there is a positive transfer of loading and reaction between the ground and the support structure; or
- creation of a reinforced arch in the ground around the opening by rock-bolting with an integrated structural surface membrane where required.

In both cases a key assumption is that there will be intimate load transferring contact between the lining/load supporting elements and the natural ground. With cast in place or precast linings this contact is established by grouting of the space between the lining and the excavated ground surface.

The existence of the intimate lining – ground contact makes it possible to theoretically analyse the load interaction between the lining and the ground.

4.2.3 19th Century Practice in NZ

The author has not sighted any information on the design approach adopted in the 19th century. There are references to a rule of thumb that the lining should have 1 inch thickness per foot of width (which generally matches lining thicknesses observed on the WMR and NIMT tunnels).

Apart from tunnels in massive self supporting volcanic rock where a lining is clearly not required and was not provided, there does not appear to have been any systematic adjustment of lining thicknesses to reflect differences in ground conditions. Site investigations beyond observation of exposures were not normal practice at the time.

Loose backpacking between masonry tunnel walls and the ground has been observed in most cases but is not effective in creating positive load transfer between the tunnel lining and the ground.

Where holes have been drilled through cast in-situ concrete walls, localised gaps between the lining and the ground have been observed but it is not clear whether this is due to poor concrete placement or the result of timber inclusions rotting out.

Tunnel lining crown sections appear to have been laid on centering and while backpacking has been observed in some shoulder investigation holes it is not expected that this would have been extensive.

4.2.4 Design Philosophy for Repairs and Modifications

The modern tunnel design processes described in section 4.2.2 are not applicable to historic tunnels where the lining is not in contact with the ground.

The case histories presented in this paper have generally adopted one of the following design philosophies:

Vertical and horizontal rock loads from a paper by Terzaghi which was based on case histories from early tunnel construction;

Replacement of "like" with "like" (i.e. replicating structural capacity) when replacing elements that have not failed in service over an extended period.

4.3 Structural repairs to linings

4.3.1 Lining Replacement

Sections of lining in at least two tunnels (NIMT Tunnel 4 and MSL Tunnel 5 Mihiwaka) have been replaced in the historical past but details of the reasons for the replacement, the design assumptions, or the construction methodology are not known. In both cases the new lining is to the same horseshoe profile as the original.

Further sections of the lining at Mihiwaka were replaced by KRN in 2009. The tunnel is constructed through volcanic deposits with some sections being unlined and with the remainder lined with ashlar masonry in the walls and brick in the crown.

Some sections within the lined length have exhibited significant bulging and longitudinal cracking. Investigations and testing in the 1980's indicated the presence of swelling clay minerals within the breccia matrix. The bulging is generally confined within the walls and the inward movement is of the order of 200mm. It was considered that, if no action is taken, at some time in the future the thrust line from the bulged walls will pass outside the wall foundations with a risk of failure of the unreinforced masonry wall.

KRN is replacing the bulging sections of wall in 1 metre wide hit and treble miss panels using a precast panel which performs two functions. Primarily it acts as formwork for in-situ concrete placed behind the panel and secondly as a component of the new structural wall. Details are shown in Figure 1. To facilitate construction handling, the thickness of the 3.1m x 1m panel was minimised to that required to provide the flexural strength required for handling stresses and to resist the pressure of the placed concrete. The panel has shear transfer reinforcement on the back face to enable the panel to act compositely with the concrete backfill as an unreinforced vertical load bearing wall.

It was noted during construction that there was intimate contact between the back of the ashlar lining and the volcanic breccia which is attributed to swelling of the breccia. It was also noted that sections of the ashlar lining on the opposite side of the tunnel had been replaced with in-situ concrete at some time in the past, there are no formal records but in house recollections are that the lining replacement was done in the 1950's. There are no indications of cracking or bulging of the replacement concrete sections after 50+ years of service.

Consideration was given to placing a "compressible" polystyrene panel behind the in-situ concrete to accommodate any future ground swelling. However the compression available from the polystyrene is limited and the acceptable performance of the 50 year old repairs on the other side of the tunnel was taken as a precedent for a "like" with "like" design approach.

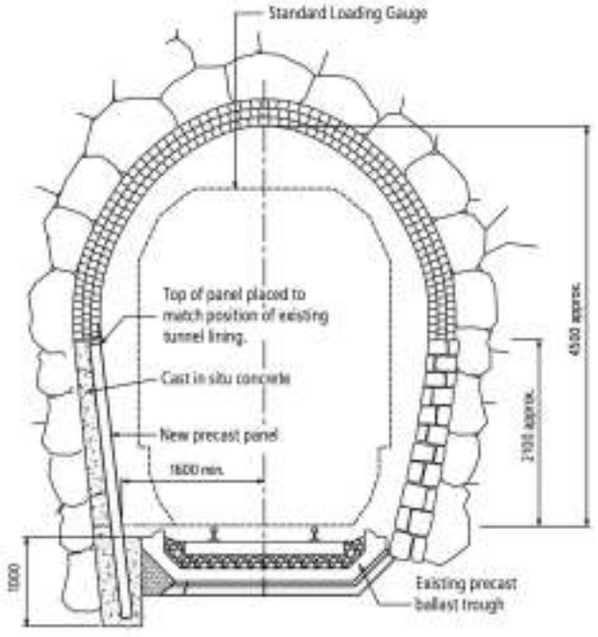

Figure 1 Mihiwaka Tunnel Repair

4.3.2 Provision of Support to Linings

Major cracking indicating a potential for lining collapse were observed in four tunnels soon after their construction. These are:

- The 574m long Makarau Tunnel 9km north of Helensville on the NAL which has experienced major lining cracking over approximately 70% of its length;
- the Fordell and Turakina Tunnels on the Marton – New Plymouth line; and
- Tunnel 26 on the PNGL.

Makarau Tunnel

Makarau Tunnel was constructed in part through Northern Allochthon, a geological unit of mass transported materials with difficult properties including low strength and swelling potential. The contractor experienced major problems to the extent that he successfully petitioned parliament in 1897 seeking additional financial compensation. This was on the basis that the conditions encountered had been unexpected and that there were no boreholes that would have indicated the presence of the materials that collapsed during construction.

Within a year of completion of construction in 1897, longitudinal cracking was observed and sets and invert struts fabricated from rail were progressively installed over the next 20 years to support the lining over the section through the Northern Allochthon. While several studies have been undertaken for construction of a bypass cutting or tunnel, the existing tunnel is still in service with the rail lining support.

Fordell and Turakina Tunnels

The Fordell and Turakina tunnels were completed around 1947 as part of 16km long deviation to bypass a section of the MNPL with very poor alignment. The tunnels had straight vertical walls and during construction the lining exhibited substantial cracking and distress leading to them being strengthened by the construction of a haunch in the lower walls (Kalaugher 1947).

PNGL Tunnels

The tunnels between Wairoa and Gisborne on the PNGL were constructed of in-situ concrete on the same vertical wall profile used on the Fordell and Turakina tunnels. Construction photographs indicate the use of a large amount of temporary timber sets and lagging, which is likely to have been untreated timber and was probably left in place during the concreting.

Soon after construction three tunnels on the line developed extensive longitudinal cracking and there were concerns as to whether the tunnel profiles were closing. A number of cross-sections were instrumented with a pattern of eyebolts that were monitored with a tape extensometer. The monitoring did not disclose any ongoing movements except at one point in Tunnel 26. At that point there was a clear and significant inward movement of the walls (reaching a total closure of 300mm) and with a cracking pattern that could form a failure mechanism. Subsequent drilling investigations disclosed the presence of swelling clay minerals in the tertiary mudstone through which the tunnel was constructed at that point.

In 1985 a 16m long section in Tunnel 26 was supported internally by steel sets formed by welding straight lengths of 200UC60 section. Invert struts were also provided and the invert struts and the wall sections of the sets were connected with tie bolts and encased in cast-insitu concrete.

4.4 Lining deterioration repairs

The Stratford Okahukura Line tunnels constructed in the 1930's have cast in situ concrete linings. The line traverses country with no road access and was constructed on two fronts from the two ends. The tunnel concrete was batched using the aggregate available at the two ends. At the eastern end sound river gravels were available but on the western end the locally available aggregate was "shell rock" which is a very weak lime cemented conglomerate of sand and shells.

The concrete made from the shell rock concrete was poor with low durability and very quickly started to break down under the attack from the acidic steam locomotive exhaust. As a result the surface of the concrete became chalky and began to exfoliate.

To halt this deterioration, remedial works were undertaken in the 1950's under contract by Downer Construction and Fletcher Construction. The works involved stripping the deteriorated concrete from the surface of the tunnels and applying a gunite (sprayed mortar) surface. These repairs were effective. The key activity was the removal of the deteriorated concrete and both contractors used an ingenious arrangement (Pers. comm. from R Foster, the Fletcher contract manager) comprising a winch mounted on the last of a rake of wagons. Chains were attached to the rim of the winch to act as flails to dislodge the deteriorated concrete and the winch position could be adjusted so that the chains could attack all parts of the tunnel perimeter.

There have been a few incidents, fortunately rare and not necessitating extensive repairs, of concrete falling from the tunnel crown in tunnels on both the SOL and PNGL. These falls have been from the crown where, due to inadequate placing equipment and techniques at the time, the cast in-situ concrete thickness can be as little as 25mm adjacent to the construction joints.

4.5 Lining enlargement

4.5.1 Original Poro-o-Tarao Tunnel

A trial enlargement of the lining profile in a 12m length of the Poro-o-Tarao tunnel was undertaken by NZ Government Railways (NZR) during the 1960s.

Poro-o-Tarao was one of the smallest tunnels on the NIMT being constructed with a brick lining to the smaller "Vogel" profile between 1885 and 1891. As a result it was one of the first tunnels to have its invert lowered to allow larger rolling stock to pass. The tunnel is constructed through weak mudstones with considerable ground water inflow. Steel props were installed to support the base of the walls which were above the lowered invert excavation. Failures of these props and of the tunnel dewatering

system resulted in local areas of significant inward movement and cracking of the brickwork sufficient to allow insertion of an arm up to the elbow.

In 1934 a 45m bulging length was reconstructed to the original profile with a reinforced concrete invert concrete. In 1965 a further 12m bulged length was replaced both to improve clearances and to investigate the cost and feasibility of enlarging the full tunnel length under service. The enlargement method is described by Webley (1970). A total of only 29 hours of occupation in 6 different occasions was available per week with the longest individual occupation being 10 hours. The trial was completed by NZR staff after the two contractors engaged did not perform acceptably. The proposal to enlarge the existing tunnel under service was abandoned after it became apparent that it would take at least 9 years of work to enlarge the tunnel at twice the cost of a new tunnel. A 1300m long deviation tunnel was constructed to replace the original tunnel.

4.5.2 Poro-o-Tarao Monitoring Plan

Towards the end of the construction of the replacement Poro-o-Tarao tunnel, concerns began to be held that a collapse of some sections of the lining in the original tunnel might occur before the new tunnel was available. Closure of the tunnel would have closed the line from Auckland to Wellington, there being no alternative detour route available. Accordingly NZR asked MWD to instigate monitoring and prepare contingency plans (MWD 1976) to reinstate the tunnel in the event of a lining collapse.

NZR had records extending back to the 1920's of the progressive reduction in the tunnel cross-section. These records were obtained using a "sunflower" wagon and from direct measurement of the tunnel width. The "sunflower" wagon provided a composite profile of the tunnel relative to the track position using a series of adjustable arms with a number of lead strips of different lengths at the outer end. The arms were spaced radially at 10 degree intervals. By towing the sunflower wagon through the tunnel a number of times and adjusting the position of the arms until one or more lead strips on each arm was bent over it is possible to establish a composite profile.

The closure records indicated that since the 1920's the tunnel appeared to have had two average closure rates: 2-3mm per year during periods when tunnel drainage was working and effective strutting was in place, and 8-10mm per year when tunnel drainage and lateral support to the lining footing had been allowed to deteriorate.

MWD installed instrumentation at a number of cross sections. This comprised both an array of points to be monitored by a tape extensometer to determine liming distortions and closures plus custom manufactured magnetic target borehole extensometers to measure absolutely the inward movement of the lining and movements in the ground behind the lining. These instruments were read monthly and had an assessed ability to monitor convergence with an accuracy of + or – 0.1mm.

At one stage the monitoring over a three month period suggested that movements had moved from an average rate of 2-3mm per year to a rate of 6mm per year. An inspection was arranged which established that the central invert drain flushing system had blocked and some of the steel props appeared to be buckling.

4.5.3 Poro-o-Tarao Contingency Plan

The contingency plan for reopening the existing tunnel in the event of a collapse (MWD 1976) was based on immediately stopping work on the replacement tunnel and re-deploying the equipment and tunnelling resources into the existing tunnel. Designs were drawn up for a self contained rail mounted work train supporting a road header excavator with muck conveyors and with shotcreting and rock bolting stations. NZR flat deck and well deck wagons suitable for forming the work train were identified and the necessary modifications designed.

The proposed reinstatement method was based on forming reinforced shotcrete arches in slots cut into the country and spanning between those with mesh reinforced shotcrete. The method was based on similar repairs carried out in European tunnels.

Fortunately the existing tunnel remained in service until the new tunnel was completed and opened and it was not necessary to implement the contingency plan.

4.5.4 NIMT Electrification Feasibility Study

Prior to the electrification of the NIMT between Frankton and Palmerston North in the 1980's, consideration was given to enlarging a number of the tunnels under service as an alternative to lowering the inverts.

MWD undertook a detailed feasibility study in 1982 which considered alternative means of enlargement. The brief specified one 3 day long occupation per week. The study concluded that a construction period of the order of 2 years would be required for the longest (600m) tunnel. The work would also have a high cost as parallel simultaneous excavation and lining operations were proposed with a substantial workforce that would be paid for a full weeks work with actual average working time of 3 days. Neither the time nor the cost was acceptable and the enlargement did not proceed.

4.5.5 Johnsonville Tunnels

Part of the WRRP project (Gordon 2010) involves modifications to the Johnsonville commuter line to enable the new Matangi EMUs to pass through the tunnels. Tunnel invert lowering was identified as the primary means of achieving this. However for programming reasons, modifications work needed to be undertaken before the characteristics of the new EMUs had been finalised.

The initial analyses indicated that along approximately 210m of tunnel wall the clearances achievable with invert lowering alone would be insufficient and some wall modifications would be required.

A contingency design was undertaken and Building Consents obtained for replacing the inclined lower brick wall with a precast panel with a recess using the

arrangement shown in Figure 2. The panel and rock bolts were designed using the loads established for invert lowering as described in section 5.5.

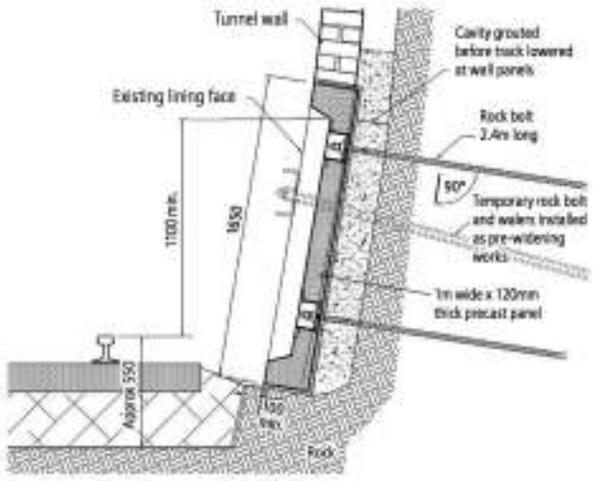

Figure 2 Proposed Johnsonville Wall Widening.

When the final EMU characteristics became available it was established that the widening was not necessary and the modifications did not proceed.

5 INVERT LOWERING

5.1 Background

Over the last 50 years there has been a progressive increase in the height of wagons and their loads as container heights have increased from 8' 6" to 9' 6" and now to 10' and with the introduction of industry specific rolling stock such as milk tankers. The height of tunnels on a route has been a major constraint and there have been periods (Rails 1998) when it has been necessary to unload the larger containers from rail to trans-ship them by road past undersize tunnels.

Lowering of a tunnel invert was established at an early stage as an effective means of gaining additional height. However where the invert lowering excavation extends below the foot of the original lining there is no longer a lateral earth pressure load to support the base of the wall against inward movement.

The electrification of the NIMT in the 1980's and the upcoming electrification of the Auckland commuter network also requires track and invert lowering to accommodate the traction overheads.

5.2 Early Approach to Invert lowering

In early invert lowering cases restraint to the base of the walls lower walls was restored either by installing a precast trough invert section as shown in Figure 1, or by propping the walls off each other using various arrangements of steel and cast in situ or precast concrete struts installed between the sleepers.

One example is the strutting in the NIMT tunnels between Pukerua Bay and Paekakariki described in Rails (1996). That article also describes the placing of concrete in the floor of one tunnel to encase the sleepers and struts and effectively form a slab invert.

Some early trials with rock bolts were undertaken by NZR using the expansion shell anchors available at the time but these were unsuccessful.

The major drawback with the use of struts between the walls is the complication of track and invert drainage maintenance as the struts prevent the use of normal ballast tamping equipment and severely hamper access to central invert drains.

5.3 NIMT Electrification Invert Lowering

The NIMT electrification required lowering of a number of tunnels which could not be daylighted or bypassed. MWD was asked to investigate the options and feasibility of enlarging the tunnels (described above) or lowering the invert with provision of either a slab track or ballast trough, the latter being the NZR preference. All work had to be undertaken in limited occupations.

5.3.1 Options Considered

After considering the slab track and invert trough options, MWD proposed an alternative of restraining the walls with the system of rock bolts and steel channel walers shown in Figure 3. The advantage of the system was the ability to install the wall support in a number of occupations without any need to disturb the track. The invert lowering preparation of the new formation and track installation could then be undertaken in a single operation.

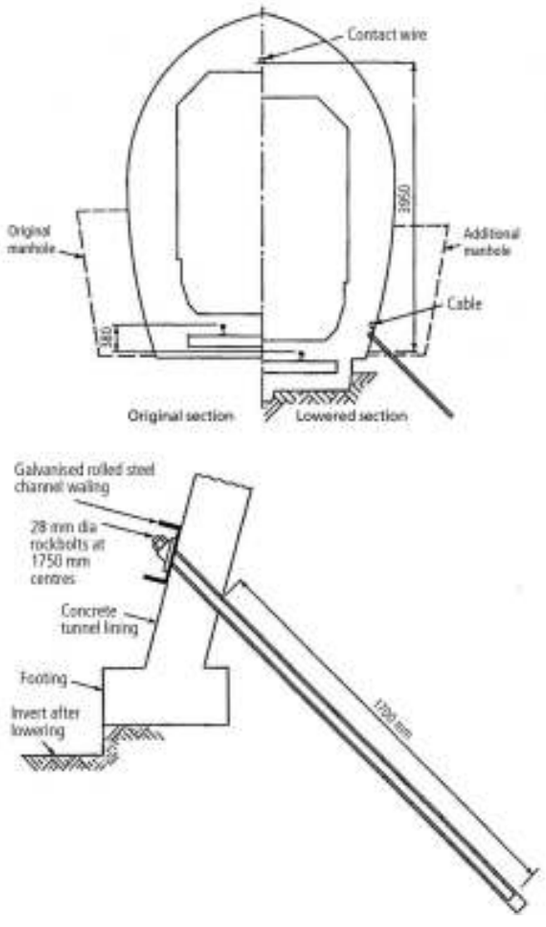

Figure 3 NIMT Electrification Invert Lowering (from Jones (1977))

The proprietary Perfo rock bolt type selected had been successfully used by MWD on a number of other projects in materials similar to the siltstone and sandstone "papa" rocks at the tunnels to be treated. From the previous projects indicative design bond stresses had been established and it had been noted that for consistent achievement of the pullout bond stress careful drilling of the hole to the correct depth and diameter was essential. This was because the system relies on a measured amount of grout introduced in a perforated tube (formed from two half shells) being forced out into the surrounding annulus by the introduction of a threaded rock-bolt driven with a percussion hammer.

The system had the advantage of not relying on mechanical anchorages which had been found to be problematical in papa. After installation of the rock-bolts and time for the mortar to cure, the walers were installed and the nuts of the bolts installed and torqued to an equivalent 50kN bolt load.

5.3.2 Design Loadings

The determination of design loadings for the rock bolt system was approached using vertical and horizontal rock loadings proposed for different ground conditions by Terzaghi (1968). The tunnels being treated were constructed with cast in situ walls and crown formed from concrete blocks and there were no indications of water inflow or lining distress. Further, there were a number of examples of single lane road tunnels in similar materials which had stood unsupported and unlined without any problems. It was therefore quite possible that the loadings on the tunnel linings might be small.

Modern tunnel design approaches did not appear to be useful for determining loadings on the linings as they are based on a tunnel analysis and design philosophy assuming intimate contact between the ground and the supporting lining, which was not the case with the NIMT tunnels.

Application of Terzaghi method with the assumption of a relatively competent ground class produced loads that appeared to be sensible and similar the working capacity of struts used up to that time. The loads could be resisted with a reasonable rock bolt size spacing and waler section.

The construction is described by Jones (1987) and preceded without difficulty. There have been no indications that the system has not been effective. The style of rock bolt used does not appear to be still in use and does not provide the double corrosion protection required by modern practice and to comply with the Building Act.

5.4 Manawatu Gorge Tunnel

Lowering of PNGL Tunnels 1 & 2 in the Manawatu Gorge was undertaken in 2008 using an identical waler section and a similar bolting arrangement to the NIMT Electrification project. However the Perfo bolt was replaced with galvanised Reidbar – a proprietary high strength deformed bar system with a matching nut and a range of termination hardware.

The Reidbar was grouted into place with grout introduced to the base of the hole through a plastic tube taped to the bar. Bar to ground bond stress had been established with test anchors installed outside the tunnel in two different ground conditions.

The only significant difference between the NIMT and Manawatu Gorge applications was the use of a grout rather than a mortar for fixing the rockbolt. This led to the possibility both of grout flowing out into any gaps behind the cast in-situ wall (which was observed) and also of the grout flowing out to the lining surface and removing the ability to tension the bar. The latter possibility was addressed by wrapping the outer 500mm length of the bar with Denso tape to de-bond it.

No problems were experienced with installing the bolts and walers, though the curvature in the tunnel did present some challenges.

5.5 Johnsonville tunnels

5.5.1 Background

The Wellington Rail Rejuvenation Project (WRRP) described by Gordon (2010) includes the replacement of 1950's English Electric EMU's with new Matangi EMU's. The 1970s Ganz Mavag EMU's units currently in service will be retained but cannot be used on the Johnsonville branch commuter line because of power limitations, and future services will be provided with the new Matangi units.

The Johnsonville line was constructed by the Wellington Manawatu Railway Company in the 1880's as part of their line to Longburn near Palmerston North. It was taken over by the government and became part of the NIMT in 1908. In 1938 it was truncated at Johnsonville and became a branch line when the twin track Tawa deviation tunnels were opened. The line has seven single track brick lined tunnels with a total length of a 944m and is constructed through the regional greywacke bedrock formation.

In 2008 KRN established the likely need to modify the track position to allow passage of the new Matangi EMU's and engaged Connell Wagner (now Aurecon) to undertake laser surveys of the tunnels and create a digital model of the internal tunnel surface. This was used by Aurecon to establish the track level to achieve vertical clearances and the horizontal rail position which optimised the clearances from the moving EMU to the tunnel lining.

The initial analyses indicated that to achieve the dynamic clearances sought by KRN the track would need to be lowered by around 550mm and that the horizontal clearances varied throughout the tunnels because of track cant in curved sections. In most sections horizontal clearances within the permissible range could be achieved though the amount to which surface mounted walers plates and rockbolts could protrude beyond the lining face varied.

5.5.2 Lowering Design

In June 2008 KRN appointed Beca in association with Parsons Brinkerhoff (PB) to determine concepts for lowering the inverts and tunnel widening (where required) and to prepare designs and consenting and

construction documentation to enable the tunnels to be lowered in a scheduled closedown over the following December – January. Investigations already carried out had indicated the walls to be two brick thickness (alternating header and stretcher courses) contrary to file records which suggested a three brick thickness. Subsequent investigations indicated the crown to be also two bricks thick in a stretcher bond.

A preliminary scoping report was prepared largely based on the studies and designs for the tunnel works in the 1980's NIMT electrification. However it was necessary to recognise and allow for the major difference between the Johnsonville tunnels (with a brick arch with loose spall back packing behind the walls) and the NIMT tunnels which had insitu concrete walls cast against the country. The proposals therefore included low pressure void filling grouting of the gap behind the lower wall sections to provide a resistance for the rock bolt tensioning. Also to reflect the varying permitted protrusion of hardware beyond the lining surface a number of concepts were developed including surface mounted and recessed UC walers and a "top hat" recessed plate concept identified by Novare a consultant to KRN.

A workshop was held which concluded that there was neither a justification for nor finances and time for overall enlargement and relining of the tunnels. Key concerns expressed and noted during the workshop included the possibility of extensive grout loss through and underneath the lining and the potential for grouting pressures to "blow" the lining off. PB had experienced problems on tunnel refurbishments at Folkestone in the UK where the grouting operations were abandoned as a result. Also a tunnel engineer who had supervised construction of a two lane road tunnel in Wellington expressed concerns that ground conditions could vary significantly over short distances and that difficulties might be experienced with rock bolt drilling and anchorage.

After the workshop, construction drawings and specifications, and building consent applications were developed for the general arrangements shown in Figure 4. To address the concerns of variable ground conditions, alternative designs were developed for two classes of ground, "Good" and "Poor", with loadings based on Terzaghi (1968). It was assumed that lateral support would be initially provided assuming "Good" ground conditions given that there was no evidence of significant poor ground or water inflow from the, albeit widely spaced, investigation bore holes or from lining inspections. The design included the ability to increase the amount of lateral support (closer spaced rock bolts where walers were used) if inspections of the invert after exposure for lowering indicated "Poor" ground conditions.

A major consideration was the need to obtain Building Consents and the requirement for all structural components to have a design life of 50 years. For the rock bolts this implied provision of a double corrosion protection system. The rock bolt types previously used on the NIMT and Manawatu Gorge lowering had only a single protection system (galvanising). A proprietary bolt system (Strata Control CT – similar in principle to the Dywidag DCP system) was identified which provided double corrosion protection, the first layer being provided by a HDPE sheath and the second by grout confined between the sheath and the bolt. Potential drawbacks recognised with this system were that when the bolt is installed initial tension is applied (prior to grouting) using a mechanical expansion shell anchorage and, once the bolt has been grouted, it is not possible to re-tension it or remove any hardware between the head of the bolt and the wall.

The rock bolt specification included a range of pre-production proving tests, production quality control tests and the installation of sacrificial witness bolts (installed to the production specification) which can be drilled out in future if required to check the bolt condition.

For the "good ground" condition, a 50kN preload in the rockbolts was sufficient to allow the vertical load on the lining predicted using the Terzaghi approach to be resisted in friction in the lining-grout- ground system. With the higher loadings in "poor ground" and the lower friction values, friction alone was insufficient and some additional lateral support to the base of the lining was required. Accordingly it was proposed that in "poor ground" a wall of 100mm diameter 2m long grouted stainless steel mini-piles at 180mm centres would be provided immediately alongside the foot of the lining. The mini-piles were prefabricated and comprised a Dywidag bar grouted inside a steel tube.

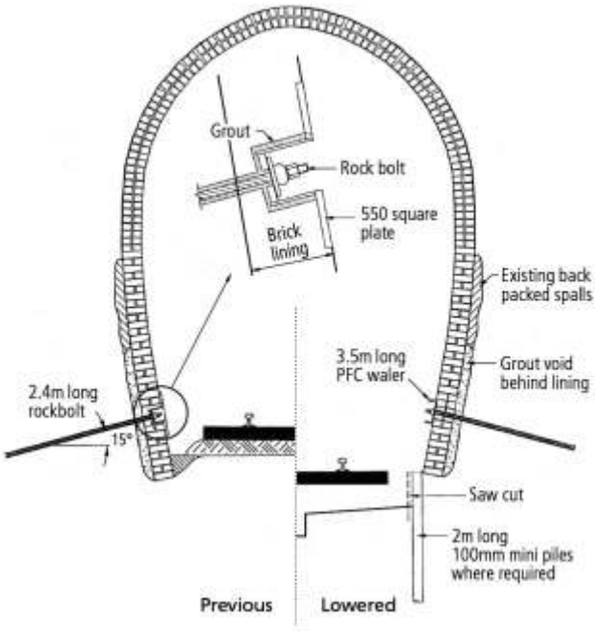

Figure 4: Johnsonville Tunnel Invert Lowering.

5.5.3 Programming of Building Consents and Contractor Engagement

Because of tight programme requirements, the contact grouting and rock bolting contractors were separately engaged. The grouting, which was required to be complete before rock bolts could be installed, proceeded in parallel with the obtaining the Building Consents for the rock bolting systems restoring lateral support to the foot of the linings.

After the actual extent of lowering required had been established a separate Building Consent application was lodged for the actual invert lowering (and resistance of vertical loads on the lining). This was processed while installation of the rock bolts was proceeding.

5.5.4 Construction of Lateral Support

The grouting of the void behind the lining and the installation of rockbolts and walers or top-hats over the 900m of tunnels was undertaken by two separate contractors in four weekday evening occupations of 10 hours and occasional full weekend occupations. This was possible as the line is a passenger only branch line with moderate passenger numbers and hence trains could be replaced by buses.

The grouting proceeded without incident, the contractor opting to grout in three lifts rather than in a single lift with provision of temporary lateral support. No grout migration through the lining was observed and an atypical high grout take was observed at only one location adjacent to a man refuge. During ballast removal and invert excavation prior to the invert lowering there was one report of a small volume of "conglomerate" being encountered and this would have been grout impregnated ballast.

During the rock bolt contract tender period one tenderer expressed severe reservations regarding the ability to drill the holes and a successful above ground trial was undertaken in an adjacent quarry.

The rockbolting and waler/plate installation was completed within the limited construction period but only after additional occupations were made available and the contractor had augmented the originally proposed single drilling rig with two further rigs. In initial trials and production there were problems with low drilling production rates and with some failures of the mechanical anchorages to grip meaning the required 50kN preload could not be applied, and necessitating recovery and replacement of those bolts. The ability to achieve anticipated production rates was exacerbated by the short contract establishment and mobilisation period available to the contractor.

To assist in overcoming initial production difficulties, PB arranged for a professional tunnel construction adviser experienced with the drilling equipment and rock bolt installation to visit the site and advise the contractor and KRN supervision staff on equipment settings and drilling and bolt installation practice.

5.5.5 Invert Lowering Operation

The invert lowering operation was planned and undertaken by KRN staff and contractors. The adopted process after removal of the track and ballast was to use a large 1.2m diameter tungsten carbide tipped saw to cut a vertical face into the bedrock 100mm out from the tunnel lining face and to the required depth. The rock to be excavated was then broken up with a hydraulic breaker mounted on a digger, pushed up into heaps with a dozer and removed with rubber tyred loaders.

After the new invert had been exposed and before the drainage blankets and new ballast was placed, the invert was logged and recorded by a Beca engineering geologist. It was then inspected by the Beca tunnel designer to ascertain whether any "poor ground" had been encountered and whether any remedial works were required to repair rock falls from beneath the foot of the lining. In the event no "poor" ground was observed and no remedial works were required.

The total operation of track removal lowering and track replacement was achieved within the programme, the only significant issue being that where the rock saw encountered a metal item, such as an old rail spike, the tungsten carbide tips were stripped from the blades. After discussion it was agreed to obtain replacement blades rather than proceed without the vertical saw cuts and run the risk of over break disturbing rock beneath the tunnel lining footing.

6 CONCLUSIONS

This paper reports on the generally acceptable performance of the large number of railway tunnels built in NZ through the latter half of the 19th century and first half of the 20th century.

Despite being built to simple designs well below current "good practice" they have performed remarkably well. However these simple designs did not prove adequate where swelling ground conditions are present. The replacement in the 1930's of the traditional horseshoe profile with a profile with vertical walls was not a success. A significant number of tunnels with the new profile have exhibited extensive longitudinal cracking.

This paper reports on a number of successful tunnel lining repair and invert lowering operations. These have however frequently taken longer and cost more than anticipated. The author's opinion is that this has often been a consequence of tight programmes, inadequate planning, and an unwillingness to develop specific equipment and procedures for establishing and disestablishing operations in the very limited occupation times generally available.

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- KRN staff member Michael Berry for checking and correcting dates and other historical facts
- The approval of KRN to the publication of this paper.

Cat EPB TBM conquers severe geologic challenges in Beijing

April 10, 2012, marked a milestone in the construction of the Metro Line 9 in Beijing, when a Cat tunnel boring machine (TBM) made a major breakthrough in a section with very difficult geological conditions. Beijing Metro Line 9 will provide an additional 16.45 km of metro and is planned to be operational by the end of 2012.

The project owner, Beijing MTR Corp., together with the contractor, Beijing Urban Construction Group (BUCG), held a ceremony at the construction site together with managers from Caterpillar Tunnelling Canada Corp. (previously known as LOVAT). China's official CCTV and other general and trade media covered the ceremony.

The construction of Lot 6 of the Beijing Metro Line 9 consists of two parallel tunnels with a total length of 1.2 km each that pass underneath a lake in the western part of the capital. It is believed to be the most difficult section that the alignment has to run through due to the water-rich conglomerate containing big boulders (1.2 to 1.5 m), which are rarely seen in other subway projects in China or anywhere else around the world.

Caterpillar Tunnelling Canada worked closely with BUCG and supplied a 6.28-m, 1200-kW earth pressure balance tunnel boring machine specially designed to tackle such tough geological challenges. After 746 days of underground excavation, the contractor aptly nicknamed the TBM Diamond due to the unprecedented long life of the proprietary Caterpillar Tunnelling ripper teeth. The system set a new performance benchmark for fracturing boulders in this complex geology.

Beijing Metro Line 9 will provide an additional 16.45 km of metro and is planned to be operational by the end of 2012.

In addition to the Beijing Metro Line 9 Project, Cat TBMs have delivered outstanding performance in similar metro projects in Guangzhou, Shenzhen and Chongqing in southern China.

World's highest and longest tunnel-to-tunnel bridge

China has done it again the Aizhai Bridge is a suspension bridge on the G65 Baotou-Maoming Expressway near Jishou, Hunan. It is the world's highest and longest tunnel-to-tunnel bridge with a main span of 1,146 metres and a deck height of 350 metres.

Construction began in October 2007 and was completed in Dec 2011 with the assistance of a $208 million load from the Asian Development Bank, cutting travel time from Jishou to Chadong from four hours to less than one hour.

Beijing building 45-km underground water tunnel

Beijing has started work on an underground water diversion tunnel to help bring water from the country's south to the thirsty national capital.

The tunnel will be about 44.7 km long and involves an estimated investment of 9.17 billion yuan (1.4 billion U.S. dollars). The tunnel will supply water to the downtown area and two suburban areas in the southeast where local water sources have been unable to meet fast growing demand.

One billion cubic metres of water will be diverted from the Yangtze River, the country's largest, to Beijing annually through the middle route of the South-to-North Water Diversion Project after the flood season in 2014, the official said.

The South-to-North Water Diversion Project is designed to divert water from the water-rich south of China, mainly the Yangtze, to the country's arid northern regions. Over the next few years, Beijing will also finish building 21 other affiliated diversion projects, water conservation projects and water plants.

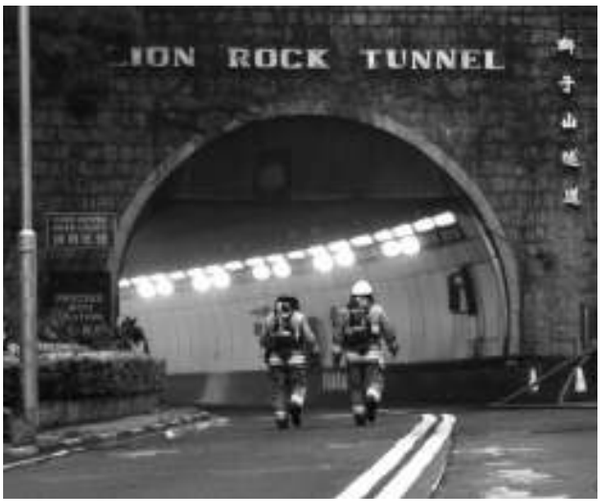
Xiamen Xiang'an Undersea Tunnel

The Xiamen Xiang'an Undersea Tunnel is the first undersea tunnel in mainland China and was open to traffic on 26th April, 2010. Now Xiamen is scheduled to build another two undersea tunnels. With a total investment of RMB 5.5 billion, Xiamen plans to start construction of a western tunnel connecting Xiamen Island and Haicang District this year, which is expected to be completed in 2016.

The Xiamen western tunnel will have a total length of 9.03 km, and its tunnel length will reach 6.26 km. It is designed to be a standard two-way six-lane freeway with a speed of 80 km/h to ease the heavy traffic load of Haicang Bridge, and reduce the traffic distance between Haicang bonded port area and Xiamen Island.

In addition, with a total investment of RMB 2.9 billion, the Xiamen-Zhangzhou Undersea Tunnel linking Hulishan Fortress at Huandao Road in Xiamen and the Zhangzhou Development Zone is expected to start construction by the end of 2013.

Upon its completion, the travel time between Xiamen and Zhangzhou will be shortened to less than 10 minutes. By then, Xiamen is expected to be the first city in China to have three undersea tunnels.



Fire closes Lion Rock tunnel

A fire broke out in Lion Rock Tunnel in Hong Kong early on the morning of Thursday 8th March 2012, closing the Kowloon-bound side and causing lengthy delays for commuters and other traffic.

The Fire Services Department said the blaze began at 3.33am when asphalt material encasing underground water pipes caught fire. It was upgraded to a No 3 alarm at 6.18am. Maintenance work was under way inside the tunnel when the fire began, and about 20 workers were forced to leave. No injuries were reported.

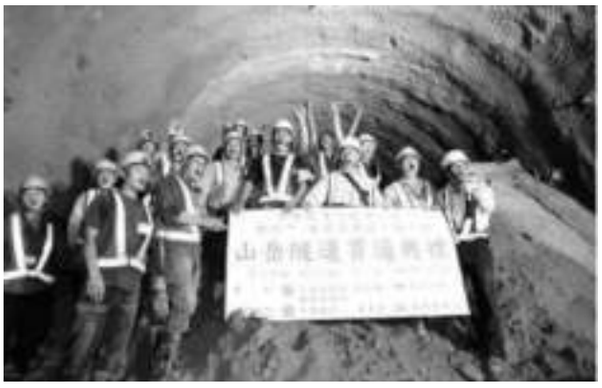
Dense smoke spilled from the entrance through the morning, as fire engines and an ambulance stood by outside. Morning commuters were forced to take roundabout routes to get to work. Firefighters were using eight jets and six breathing apparatus teams, as well as foam to contain the fire, the department said. The blaze was brought under control at 11.24am and no casualties were reported, according to the Fire Services Department.

New Territories East divisional commander Leung Kwok-ming of Fire Services Department said initial investigations showed that materials used to repair water mains in the tunnel had caught fire. A week-long special traffic arrangement was enacted at the tunnel closing it for four days. The tunnel was fully operational by Monday 19th March, three days ahead of schedule.

Taiwan Railway celebrates breakthrough of Shanyue Tunnel

On 3rd July the Taiwan Railway Administration (TRA) celebrated the breakthrough of the Shanyue Tunnel connecting Taipei's Nangang district and New Taipei City's Sijhih District, which would improve the mass transit service between the metropolitan areas.

Since the high-speed rail began operations in 2006, TRA has planned to improve mass transit service between the nation's metropolitan areas. To increase the transport capacity, TRA decided to construct a third line of 2.21km between Sike Station and Nangang Station. TRA said the Shanyue Tunnel was the most difficult part of the construction. Though the tunnel is only 0.72km long, it was constructed in a difficult geological area. Construction of the tunnel started in September 2010.



Jalan Sultan soil safe for Singapore MRT tunnels

Chinatown's soil, according to MRT Corp, is not limestone, but is safe for tunnelling. My Rapid Transit (MRT) Corp chief executive officer Azhar Abdul Hamid said that contrary to popular opinion, the soil beneath Jalan Sultan was not limestone. Instead, he referred to Chinatown's soil as "Kenny Hills formation" or a kind of hard rock.

Azhar's statement was contrary to what national transport company Prasarana told KL lot-owners affected by MRT construction in August last year. At the time, Prasarana told them that KL's soil consisted of "karstic" limestone rock, which was unpredictable and unsafe for buildings above in the event of underground tunnelling. The company argued that lots along Jalan Sultan and Bukit Bintang would have to be acquired, and possibly be demolished to make way for the MRT.

Hong Kong-Zhuhai-Macau Bridge

The Hong Kong-Zhuhai-Macau Bridge is a series of bridges and tunnels that will connect Hong Kong, Macau and Zhuhai, three major cities situated on the Pearl River Delta in southern China. The proposed 50 km link is expected to cost US$10.7 billion.

With its length, it would become one of the landmarks within the area. The longest bridge section will be 22.8 km long and include three cable-stayed spans between 280 m and 460 m. Construction formally began on 15 December 2009. The bridge is due for completion in 2016.

The tunnel will consist of a submerged tube with approximately 32 elements submerged at depths of more than 40 metres below the water. The tunnel will exceed the length of the Oresund fixed link's immersed tunnel between Denmark and Sweden – by about 40 per cent.

The project will push the boundaries for what is technically possible. The tunnel will be constructed on a soft seabed requiring soil improvement to prevent the elements from settling, and in rough, open waters under deep navigation channels trafficked by the world's largest ships.

Sediment accumulation is another challenge to consider. The tunnel is placed in a deep excavated trench and after it has been in use for a few decades; layers of sediment up to 20 metres thick will accumulate above it. The sediment combined with water pressure from above will impose enormous forces on the tunnel's central sections.

The design also has to address the risk of earthquakes in the area. In particular, the joints between the tunnel elements must stay watertight when exposed to seismic ground movements.

Robbins EPBs rally at Nanjing Metro

Construction of the 40.2 km (25.0 mi) long Metro Line 3 and the 41.4 km (25.7 mi) long Metro Line 10 is well underway for owner Nanjing Metro Company. The new subways are part of the municipal government's extensive plans to improve access across the Yangtze River Basin with up to 17 rail routes totaling 600 km (370 mi) by 2030.

Robbins provided four 6.5 m (21.4 ft) diameter EPBs with mixed ground cutterheads for two metro lines under construction. The two pairs of EPBs are excavating Line 3 Lot 11 and Line 10 Lot 5, for the China Railway Construction Corporation (CRCC) 13th Engineering Bureau and 23rd Engineering Bureau, respectively.

The two Robbins TBMs for Line 10 were launched in December 2011 and February 2012, while the Line 3 machines were launched in January and March of 2012. As of May 2012 the Line 10 EPBs had excavated over 600 m and 500 m (1,970 ft and 1,640 ft) of Line 10, respectively. Advance rates are on the order of 40 mm (1.6 in) per minute, while settlement has stayed below the required limits. At Line 3, the Robbins machines have excavated over 500 m and 100 m (1,640 m and 330 ft), respectively, with advances topping 60 mm (2.4 in) per minute.

Ground conditions on both Nanjing lines include soft soil, silty sand, manmade materials, small pebbles, and sandstone. Shallow cover of 8 to 10 m (26 to 33 ft), a sensitive urban environment, and strict settlement requirements of less than 10 to 20 mm (0.4 to 0.8 in) are requiring customized excavation methods. "The earth is quite soft so we are keeping the thrust force very low (6,000 to 9,000 kN / 1.4 to 2.0 million lb). The operator is also employing continuous monitoring to maintain the proper alignment and earth pressure," said Jason Xiao, Robbins Project Manager. Foam additive will also be used to make the ground less sticky and reduce the required torque to excavate the material.

Tunnel linked to looming North Korea nuclear test

Recent satellite images show North Korea is digging a new underground tunnel in what appears to be preparation for a third nuclear test, according to South Korean intelligence officials.

The excavation at North Korea's northeast Punggye-ri site, where nuclear tests were conducted in 2006 and 2009, is in its final stages, according to a report by intelligence officials.

Dirt believed to have been brought from other areas is piled at the tunnel entrance, the report said; something experts say is needed to fill up underground tunnels before a nuclear test. The dirt indicates a "high possibility" North Korea will stage a nuclear test, the report said, as plugging tunnels was the final step taken during its two previous nuclear tests.

Singapore Power seek S$1.5 billion project facility

Singapore Power Ltd. hired six banks to help arrange a S$1.5 billion ($1.2 billion) 10-year project finance loan. The proceeds will help fund the construction of two tunnels to carry electricity cables under Singapore.

Singapore Power have started inviting engineering and building tenders for the project, according to notices posted on its website. The project involves construction of two tunnels running 18.5 kilometres (11.5 miles) north-south and 16.5 kilometres east-west across the island. Each tunnel will be about 6 metres wide.

When completed, the two tunnels will provide secure corridors for faster and more efficient installation of transmission cables and replace the aging circuits, according to Singapore Power's latest annual report. The tunnels are expected to take five to seven years to build.

Singapore undersea tunnel to be completed by year-end

A 420m long undersea tunnel for motorists, the first of its kind in Singapore, will be completed by the end of the year. The tunnel is part of the 5km Marina Coastal Expressway – a $4.3 billion project which will facilitate traffic flow in and out of the Marina Bay area.

The new expressway will link the East Coast Parkway (ECP) and Kallang-Paya Lebar Expressway with the Ayer Rajah Expressway in the west.

Targeted to complete by the end of 2013, the five-lane expressway – which started construction some three years ago – will be able to carry up to 10,000 vehicles an hour in each direction. It will also allow motorists to bypass the Marina Bay Area, which is expected to see heavier traffic in the coming years with new developments like a financial centre, an international cruise terminal and Gardens by the Bay coming up.

The expressway will have a total of nine entry and exit points to the ECP, Marina Boulevard, Central Boulevard and Maxwell Road. Compared to the other nine expressways, it will be the most expensive built in Singapore, in terms of cost per kilometre.

The first stage of the undersea tunnel section, which dives 20m under the sea, has been completed. Because of the discharge of water from the nearby Marina Barrage, building the undersea tunnel is especially complex. The barrage discharges up to 2,000 cubic metres of water per second at its peak. To cope with this, engineers had to build temporary walls strong enough to withstand the force of the discharge.

China tunnel into Afghanistan

China is opening its narrow border with Afghanistan with roads and probably a tunnel under the Pamir ranges skirting Jammu and Kashmir with strategic implications for India.

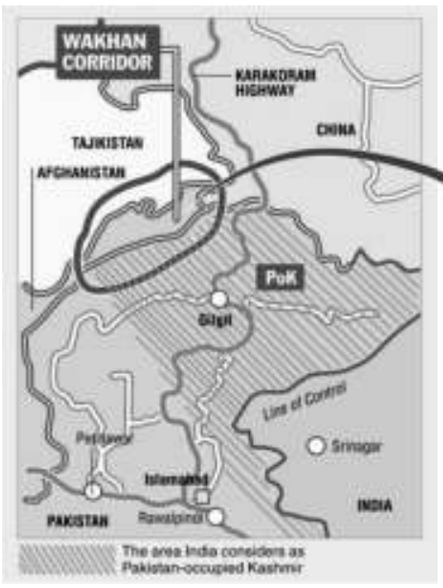
The Chinese connection to Afghanistan is through the Wakhan Corridor that skirts the northern areas of Jammu and Kashmir, territory that India claims but is under Pakistani occupation – but for this, India would have had direct access to Afghanistan through the Wakhan Corridor.

China's objectives seem to be increase connectivity with Afghanistan where it already has considerable presence along with India in development and other projects.

The presence of Chinese People's Liberation Army (PLA) soldiers, mostly engineers, has been increasing in Pakistan-occupied Kashmir. The building of the Karakoram highway abutting the Siachen glacier to its northeast through Shaksgam valley in Aksai Chin — India-claimed territory that Pakistan has ceded to China — is also a strategic concern of the Indian Army.

Despite being adjoining countries, Afghanistan and China do not have a border crossing since the Wakhjir pass was shut after Mao Tse Tung's communist forces took over China in 1949. Through the wars that have ravaged Afghanistan since the Soviet invasion (1979), the sparsely populated Wakhan has been largely peaceful.

The Wakhan Corridor was a creation of "The Great Game" when Britain and Russia competed for strategic space. It roughly defined the border between British India and the Russian Empire in the late 19th century. The Wakhjir pass itself remains closed for nearly half the year. A tunnel under the mountains would be an engineering feat — rivalling the kind that China has demonstrated with its railway line through Tibet — that would ensure all-weather access.



Chinese-built tunnel projects in Tajikistan

On July 11, the excavation of the Shahristan tunnel connecting northern and southern Tajikistan was completed. When opened, the 5,253-meter-long tunnel will reduce travel time between Dushanbe and Khujand by two hours. More importantly, the tunnel will make the route safer and more reliable in the winter and spring months.

Currently, vehicles must cross the 3,345-meter snow-covered Shahristan pass, which is subject to regular avalanches and mudslides that claim dozens of lives each year. According to Rustam Abdulloev, deputy director for the Dushanbe-Khujand-Chanok highway project (DKC), currently workers are using the tunnel, but it will not officially be opened until September 25.

The DKC serves as a vital trade artery connecting the capital of Dushanbe to the economically vital Sughd province and the Ferghana Valley. The project, which began in 2006 under the management of the Chinese company "China Road," is financed by a $296 million loan from the Chinese government. The projected cost of the tunnel is $80 million.

When opened, the 5,253-meter-long tunnel will reduce travel time between Dushanbe and Khujand by two hours.

Ghat-ki-Guni tunnel

According to Rohan Rajdeep Infrastructure Private Limited (RRIPL), the company carrying out the Ghat-ki-Guni tunnel, 80 per cent of the 100-men-strong workforce is youths, many of the fresh out of their college campus. Together they are building the twin tube tunnel on the Eastern Gateway of Jaipur.

The young engineers (most of them from civil, electrical and mechanical background) are from Rajasthan, UP, Madhya Pradesh, Maharashtra, Andhra Pradesh, Jharkhand and West Bengal. "In last five months, we've learnt about the culture, food, songs and even the lingo of different states of India. This tunnel actually has become mini-India for us and will stay etched in our memories forever," said a young surveyor from UP's Ballia district.

From blasting rocks to creating passage for the tunnel; from building roads to fixing lights and German-crafted fans, this young team is rethinking a new approach to development. They are fire-fighting, laying water pipelines and blasting through rocks to complete the tunnel and gift it to Jaipur on the Independence Day.

While, the bulk of engineering work is being done by young engineers from Rajasthan, West Bengal and Maharashtra, the critical work of surveying has been trusted in the hands of youngsters from Ballia and Gorakhpur districts of Eastern UP. Skilled workers from Bihar, Jharkhand and Andhra Pradesh are working with engineers on ground giving shape to the dream. "Institutes like IIT-Mumbai are involved in designing the project and in offering technical consultancy," Pathak added. The RRRIL is carrying out the 150-crore project since December 2010 to provide an alternative route to the narrow Jaipur-Agra Road. Ghat-ki-Guni tunnel becomes an example of what young minds can do when they come together from across the country.

Giant tunnel takes shape under Mumbai airport

By September 2013, more than half of Mumbai's homes will enjoy better and consistent water supply minus the frequent cuts. Work on the mammoth 12.2-km long and nearly 4-km wide underground tunnel connecting the city's water distribution hub at Maroshi to Matunga has been completed. The BMC project which was contracted in 2007 promises efficient water supply to residents in the western suburbs and south-west Mumbai- will replace the old corroded water pipelines that the city currently relies on.

The tunnel, however, will be operational only by September 2013 because engineers have to complete the cementing work and construct around five to six shafts linking it to other smaller water distribution networks.

According to BMC officials, the tunnel will be Mumbai's main water supply trunk providing water to almost the entire city, barring the far eastern and western suburbs. It will be connected to another tunnel, which is already operational between Ruparel College in Matunga and the Malabar Hill via Mahalaxmi. It will have five to six shafts from where a large number of distribution pipelines will carry water to several areas.

With the tunnel nearly 80 ft underground, officials are hoping to reduce loss of water through theft and leakages by nearly 10%. "No one will be able to tamper with it and repair work will be minimal," the official added.

Old Delhi station tunnel hits technical hurdles

The railways' ambitious plan to convert a century-old British era tunnel at the Old Delhi railway station into a subway for passengers might take a couple of years to complete. In January, the Delhi division of northern railways had with much fanfare announced that to decongest the overcrowded over-bridges at the Old Delhi station, the 103-year-old tunnel, which was being used to transport parcels and goods, would be thrown open for the public after making necessary changes.

The tunnel runs right under the tower clock on the main entrance of the SP Mukhergee Marg. The length of this is tunnel is 70 meter, width 3.14 meter and height is 2.1 meter.

The Old Delhi railway station receives a footfall of many thousand passengers every day and there are only two over-bridges. The danger of a stampede during peak traffic time always looms large. To tackle the problem, the railways had planned to open the 70-meter-long tunnel of the heritage station building for passengers by installing lifts and escalators at all platforms.

India's longest road tunnel under construction

The Shivalik mountain range of the Himalayas is the site for the construction of India's longest all-weather road tunnel — the Chenani-Nashri tunnel — which will connect Srinagar with the rest of the country.

The arduous trek to Kashmir may soon be a thing of the past. A new passage to Srinagar now under construction will not only bring the regions of Jammu and Kashmir closer but will also end the isolation of the valley from the rest of the country.

The 288-km distance between Jammu and Srinagar will be reduced to 238 km but more importantly the 10-hour journey will be covered in just about five hours, avoiding perilous points such as Khooni Nala (bloody path) where shooting stones slide at the speed of a bullet taking a heavy toll of life.

The two tunnels will also end the snow-related traffic jams that last several days. The Chenani-Nashri Tunnel which is being blasted through the Mury formation range of the Shivalik range — derived from Mury village in Pakistan from where it starts — at an elevation of 1.2 km is 9 km long and will be the longest tunnel in the country when completed in 2016, the deadline for the entire project estimated to cost Rs. 10,600 crore.

The proposed two-lane tunnel with a separate escape route avoids Patnitop, a tourist spot during the winter for its snow, and the steep Nagroda bypass which the State government declared unfit for use after truck drivers found it difficult to negotiate not only the steep gradient but also the sharp and narrow bends on the range.

The twin tunnels with inbuilt escape routes in case of snow storm or blizzards are being built at an elevation of 1.8 km. Though their entrances are not free from snow, experts maintain clearing a four-lane road of snow would be much easier than a two-lane one.

The four-year wait might get prolonged given that the NHAI is yet to award the contract for the 43-km-long Udhampur-Ramban and 36-km-long Ramban-Banihal stretches due to various reasons, including the fact these are among the toughest sections of the project.

Neelam-Jhelum Hydropower Project

The TBMs have been detained on the site of Neelam-Jhelum Hydropower Project (NJHP) but commissioning finally started in the last week of July with first cutting in tunnel rock likely to be observed by September.

To date only 34.12 percent development and construction work has been completed, while excavation of 32 kms long tunnel could take more than a couple of months even working on 24-hour basis.

Reportedly, TBMs, which were imported by WAPDA, were not mentioned in the original contract being implemented by a Chinese company, however, the Chinese contractor came up with a proposal to use it without the endorsement of a credible foreign consultant. As no international consultant recommended the use of the TBMs for the NJHP, WAPDA managed to get the endorsement from a retired employee who now works as a consultant.

WAPDA claimed that TBMs technology would reduce construction period of the project by about 18 months, resulting in an estimated benefit of Rs 60 billion, adding that NJHP, due to be completed in 2016, would provide about 5.15 billion units of electricity annually to the national grid, but the proposed acceleration of the tunnel construction by use of TBMs method would increase the project cost by around Rs 16 billion.

The main diversion tunnel of about 17.5 kms has been completed, and the river has been diverted, but work on power house, headrace tunnel and tunnel excavation is yet to be started.

Mataf, Zamzam tunnel projects in progress

Work on the expansion of the Mataf area and a tunnel to the Zamzam was carried out at a rapid pace to be completed by mid August. Progress was made without much inconvenience to worshippers. The movement of worshippers in the Mataf area has not been disrupted despite the fact that the number of Umrah pilgrims has increased by 20 percent this year. The tallest crane in the world (200 metres high) was used in the east courtyards of the Grand Mosque. This crane, manufactured in Germany, transported construction materials from the courtyards to the Grand Mosque without disrupting the movement of Umrah pilgrims and visitors.

Solar-powered lights to brighten Manila tunnel

Solar-powered light emitting diodes (LEDs) lit up Boni Tunnel in Manila from in May 2012. The Department of Energy inaugurated the solar-powered LEDs along the tunnel, which intersects EDSA along Boni Avenue. The 188 tubular LEDs, powered by the grid-interactive photovoltaic system, replaces the dim tubular fluorescent lights and high pressure sodium lamps, which the DOE said poses risks to motorists.

Energy Secretary Jose Rene D. Almendras said the use of energy efficient lighting systems in the local government units will lessen government expenditures. "It is very important for us today to continuously moderate electricity consumption. In reducing consumption, we also lessen our carbon footprints effectively contributing to the solutions towards the issue of climate change," he said, in a statement.

The 297.20 metre Boni tunnel has a total power demand of 6.58kW, which costs up to P570,640 every year. The LED master lamps, with a service life of 30,000 hours, can reduce the electricity expenditure of Mandaluyong City by up to P240,000 a year.

The project to revolutionise one of the country's major roadways was started in May last year through a Memorandum of Agreement signed by the DOE, DPWH, Metropolitan Manila Development Authority (MMDA), Mandaluyong City LGU, PNOC Renewables Corporation (PNOC RC), and Philips Electronics and Lighting, Inc. (Philips). The different public and private entities distributed the cost and responsibilities of the project implementation.

The Asian Development Bank (ADB) also contributed to the project by providing lithium batteries and other accessories for the solar power assembly.

Auckland Tunnel thrown open to traffic

Himachal Pradesh Chief Minister Prem Kumar Dhumal opened the two-lane Auckland Tunnel for traffic. It is the first such project in the city since the British days and also the first project under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) to be completed in the state.

Built at a cost of Rs 10 crore after more than two year's engineering task, the tunnel will divert the heavy traffic on the Cart Road, especially near the Auckland House School, Rajkiya Kanya Mahavidyala (RKMV) and Chapsle School, and reduce a distance between the Victory Tunnel and Sanjauli by nearly one kilometre. Actual length of the tunnel is 75 metres.

The Engineer-in-Chief, PWD, NL Sharma said, that the successful completion of Auckland Tunnel has created scope for building four more traffic tunnels for which the Detailed Project Reports (DPRs) are being prepared.

However, rebuilding the Auckland Tunnel, which had remained closed for a long time owing to its dilapidated condition and seepage of water from overhead drinking water supply pipes, was not an easy one as the base of the existing pedestrian tunnel was lowered by about 20 ft and widened to make way for double lane vehicular traffic. A 70 metre long bridge will also be constructed over the eastern portal of the tunnel to eliminate the hairpin bend on the Circular Road.

"The strata was very loose and as machines drilled the hole, landslides would fill up the empty space. We are happy that we accomplished the task," Sanjay Sood, promoter of the AKS Engineers and Construction, the firm entrusted with the job Earlier, the state High Court had set a deadline for the PWD to complete the tunnel before mid-April. The HC, in past six months, has passed at least six orders and monitored the work progress on monthly basis.

Sharma, however, said that the PWD will take few more days to build the 70-metre long bridge at the eastern portal of the tunnel.

Delhi Metro tunnel boring staff posing with the cutter of the TBM after completion of tunnelling of the Central Secretariat-Janpath metro railway stretch.

DELHI METRO PHASE-III

Delhi Metro is planning to keep a close watch on its construction work this time around. It will be setting up a central control centre for tunnel boring machines (TBMs), for the first time ever. During peak construction period, around 26 TBMs will be working simultaneously all over the city. The performance of TBMs will be monitored in sensitive areas through a centralized control centre. To be connected by GPS, the control centre will keep a close watch on the TBMs.

The centre will be the hub of the various on-going construction sites. It's expected to prove challenging, especially as the TBMs are owned by various contractors. Hooking them up on a single server will not only provide an instant look into the construction site but also help the Metro monitor work, especially in sensitive areas like the heritage zones.

In Phase II of the Metro network, only 14 TBMs were used. Phase-III, which connects another 103km of the capital with the Metro, is expected to be completed on time by 2016. All civil tenders on two corridors, Central Secretariat to Kashmere Gate and Jahangirpuri to Badli, have been awarded and contractors have begun work, while the design of stations and alignment in Phase III have been finalised.

Delhi Metro is conducting detailed traffic diversion schemes in coordination with the traffic police, and by engaging a specialised agency. The "guiding principles" for traffic management during Phase III are: minimizing dislocation of traffic, improving the geometries, including widening of roads and alternative roads, and deploying adequate trained traffic marshals.

Under Phase 3, tunnelling will take place beneath the city's inner and outer ring roads, and also under old Delhi in areas where traffic congestion is at its worse. Work has already started on the Central Secretariat-Kashmir Gate line with of this tunnel bored section. Phase 3 is expected to be completed by 2016.

Water seepage closes Delhi metro airport link

Delhi Metro's Airport Express Line has been forced to close due to alleged substantial volumes of water seepage. Some reports claim that mud inflows have also occurred. The seepage is said to be more pronounced between New Delhi and Shivaji Stadium, where the tunnel lies at a depth of 20-35m below ground level.

Large amounts of seepage were reported as far back as November 2012. The line was eventually closed on July 8, 2012, since when it has been claimed that water seepage along a 2.5km stretch has resulted from ineffective waterproofing applied at the time of construction.

Delhi Metro Rail Corporation (DMRC) had stated previously that the seepage was a natural phenomenon and a result of the high water-table in the area. It also claimed that water inflows were in accordance with international standards and 'under control'.

New Delhi Municipal Committee (NDMC), which inspected a 2.5km stretch of tunnel, has since stated that the seepage in some areas could be attributed to inadequate waterproofing measures in some sections of the tunnel. The matter now forms the subject of a bitter dispute between DMRC and concessionaire Reliance Infrastructure.

The US$1.1 billion Delhi Metro Airport Express extends from New Delhi railway station to the airport and beyond. Of the 22.7km length, some 17km is underground, with the remainder being elevated. The line became operational in February 2011 after having been completed in record time – 27 months from the award date. It is India's first high speed metro to have been delivered under a private public partnership (PPP).

8.3 Km long deep sea tunnel to carry drinking water from Thane To Mumbai

A tunnel being built at a cost of Rs 1145.88 crore will carry drinking water from Thane to Mumbai. It will connect Kapurbawdi in Thane district to Bhandup in suburban Mumbai to quench the thirst of Mumbaikars. The 8.3 kilometre long tunnel is being developed at a depth of nearly 100 metres.

Work on the deep sea tunnel is progressing well and it will be completed next year. The project is being executed jointly by Unity Infra and IVRCL Infrastructures & Projects, who have formed a joint venture for the purpose. The work, which started in 2009, should be completed in the next 9 months.

The tunnel will transport potable water from the Modaksagar, Gargai and Pinjal dams. Once completed, the water supply to Mumbai, which is at present 2,000 million litres a day (MLD) and will go up to 3,800 ML.

The tunnel will have a diameter of 11.9 and reach to a depth of over 100 metres.

HCC receives contract for rail tunnel in Manipur

Hindustan Construction Company (HCC) has bagged a Rs 162-crore order from North Frontier Railway to develop a rail tunnel.

Under the contract, the leading infrastructure company will build a tunnel between Kambiron Road and Thingou stations on the new railway line coming up between Jiribam and Tupul in Imphal, Manipur.

This is the third order HCC has received from North Frontier Railway on Jiribam-Tupul Railway line. In 2010, the company was awarded two contracts of Rs1.97 billion and Rs3.12 billion for construction of two BG tunnels of lengths 3.250 km and 4.694 km.

The project scope involves construction of single line BG tunnel of approximate length of 3.3 km including earthwork, slope protection & stabilization, RCC portal walls, permanent tunnel support, construction of side drains, rock supporting system and ancillary work.

As part of the overall masterplan for development of infrastructure in north-eastern India, a rail link has been planned to connect all state capitals. Construction of the new lines is currently underway to connect the capitals of Arunachal Pradesh, Manipur, Nagaland, Mizoram and Meghalaya with 125km of broad gauge rail. The new rail link will pass through deeply forested and mountainous terrain, and will require a large number of tunnels and bridges.

AECOM wins supervision contract

AECOM has been awarded the design and construction supervision contract. The scope of the 24 month contract includes:

- Initial and detail design of tunnel support, lining, ventilation, tunnel illumination, drainage, safety and surveillance systems.
- Preparation of method statements for construction, disposal and Quality Assurance Plans
- Environmental impact assessment and environmental mitigation program
- Construction supervision and design support during construction

Close monitoring on Abu Dhabi microbore

India-based Encardio-rite (ER) has carried out instrumentation and monitoring for an Abu Dhabi microtunnel contract that is part of the 3.2km Al Salam Street expressway tunnel project.

ER worked on a 56m microtunnel, built by a Herrenknecht AVN 1800 microtunnelling machine which laid 1.8m ID / 2.2m OD reinforced-concrete HDPE-lined drainage pipes. Forepoling was used for ground reinforcement to minimise the risk of road settlement due to the tunnelling.

ER was called in to monitor the project by the owner, Abu Dhabi's Department of Municipal Affairs, which was concerned at the challenges involved. This included an insufficient overburden of just 3m, and the fact the tunnel had to pass below the Corniche Road, one of Abu Dhabi's most important and busiest thoroughfares.

During the early stages of work, ER supplied and installed instruments to monitor ground behavior due to tunnelling works. In all, 99 monitoring points comprising eight inclinometers, eight multi-point borehole extensometers, six vibrating wire pyrometers, three earth-pressure cells, 68 settlement points, three open standpipes and three dial gauges were placed at key points.

Monitoring and reporting of all points, including the settlement points using precise levelling, took place at a monitoring frequency of up to every hour. The processed data was reported to the client almost instantaneously after each monitoring cycle, using a 3G wireless modem via the internet.

The monitoring data showed that the ground movements were well within the control value set out by the owner, ie 6mm of settlement at the ground surface. The tunnelling works progressed smoothly without any impact on the Corniche Road.

Forepoling was used for ground reinforcement to minimise the risk of road settlement due to the tunnelling.

Much-delayed Zojila Pass twin tunnels

Residents of Kargil and Leh, the twin districts in Jammu and Kashmir, which remain inaccessible for rest of the country due to inclement weather, might finally get some respite. The road transport and highways ministry has cleared the decks for works to start on the much-delayed project to link the two strategically important districts to rest of India.

Two state of the art all-weather tunnels across on National Highway-1 will be constructed. The length of the two tunnels would be approximately 19 kilometres. Once complete, this would result in the road that connects Kargil and Leh to remain open throughout the year.

Though first approved way back in 2005, the twin tunnel had remained on the drawing board ever since on account of technical difficulties in implementing the project in such a difficult terrain. Work gathered momentum only late last year after Congress general secretary Rahul Gandhi, following a visit to J&K, requested the road minister CP Joshi to expedite it.

While in the first phase a 6.5 km long tunnel estimated to cost about R200 crore would be constructed across Zojila Pass, in the second phase a 13 km long tunnel would come up.

Monaco city tunnel

Monaco has embarked on a US$131 million tunnel project, aimed at easing traffic on one of the Principality's most heavily used entrances – the Boulevard de Jardin Exotique.

Excavation is set to begin early next year, with the project expected to take 56 months to complete.

The 2km tunnel, measuring 6.1m wide by 4.5m high, will be suitable for trucks. It will be unidirectional and extend from the Boulevard du Jardin Exotique to the Boulevard Charles III.

Planners expect the tunnel to be used by about 12,700 vehicles per day, reducing road traffic by 40%.

Great St Bernard TBM breaks through

Caterpillar Tunnelling reported that the CAT double shield hard rock TBM (RMP167-26700) operated by Condotte S.p.A. in the Great St Bernard service and safety tunnel broke through on June 6th 2012 in Italy.

It is Caterpillar Tunnelling's first successful breakthrough of a double shield hard rock TBM that was completely designed and built by Caterpillar Tunnelling.

The TBM was launched on the north face in Switzerland and mined 5522m southward to breakthrough on the south face in Italy. The machine has reached its best month of 640m, best day of 35.2m and an average advance rate of 18m/day.

London's CrossRail

Boris Johnson and British transport secretary Justine Greening with various other dignitaries attended the official ceremony to switch on the first two tunnel boring machines (TBMs) at Westbourne Park that will spend the next few years drilling beneath the streets of London for the CrossRail project.

The first of the "voracious worms nibbling their way under London", as the Mayor described them, began work in January, while a second started its journey eastwards in April, reaching Farringdon in 2013. Later that year a further two machines will be launched at Royal Docks and piloted westwards via Whitechapel and Liverpool Street before the tunnels are completed at Farringdon another pair will bore the tunnels for the Plumstead branch.

A naming competition, open to the public, resulted in the first two machines being christened Phyllis Pearsall, in honour of the woman credited with drafting the London A-Z map, and Ada Lovelace, who worked on Charles Babbage's early computing device. Two of the remaining three pairs of TBMs will be named Victoria & Elizabeth and Sophia & Mary.

The first TBM (Phyllis) has now reached Paddington having excavated 750m from Royal Oak. In so doing, the 7m-diameter machine has mined under London

The first TBM (Phyllis) has now reached Paddington having excavated 750m from Royal Oak.

Underground's Hammersmith & City metro line and the Great Western main line. A second TBM (Ada) broke ground on August 20 at Royal Oak Portal and has also started tunnelling toward Paddington. CrossRail's total length of 118km will include 21km of twin-tube tunnels under central London. The project is scheduled to be completed in 2018.

London metro stations to get cooling systems

In a bid to ensure lower summer temperatures, new plans announced by London Underground (LU) will see tunnels at Green Park and Oxford Circus stations get new air cooling technology. The work, scheduled to begin later this month, is part of the on-going work to 'cool the tube'.

Borehole cooling technology will be used at Green Park station. Naturally cool water from boreholes already drilled by LU deep below the station will now run through air cooling units that will lower temperatures on Victoria and Piccadilly line platforms.

Air cooling units have already been installed in the ticket hall at Oxford Circus station, but others will now be installed on every platform (Bakerloo, Central and Victoria lines).

Morgan Sindall has been awarded the contract for work to install eight air cooling units at Green Park while Birse Metro has been awarded the contract to install 14 air cooling units as well as associated construction services at Oxford Circus. LU will project-manage the work using tight controls to ensure the programme is delivered efficiently and with the minimum disruption for passengers. The work is scheduled for completion this summer.

LU's capital programmes director David Waboso, said: "Cooling the Tube is one of the greatest engineering challenges faced by London Underground. We are investing millions to cool temperatures for passengers through a programme that will include the delivery of new air-conditioned trains."

London's underground is the oldest metro system in the world and will celebrate its 150th anniversary in 2013.

Swiss opts for second Gotthard tunnel

The Swiss government's decision to construct a second road tunnel through the Gotthard – to allow renovation on the existing facility – has triggered a mixed reaction of approval, scepticism and concern.

The plan envisages full closure of the current 30-year-old tunnel, one of Europe's major north-south transit routes, for two-and-a-half years, as opposed to partial closure over a longer period.

The projected cost of the second tunnel option is "close to SFr2.8 billion" ($2.9 billion). This estimate includes the cost of keeping the current road tunnel in operation for longer as the new tunnel would be finished in 2027 at the earliest. The government accepts that the investment is higher than for the other options but argues that as it would be a sustainable investment the money is better spent.

UK's proposed high speed rail line

A consortium led by ERM, which includes Mott MacDonald and Temple Group, has won two major environmental impact assessment contracts for HS2 – the UK's proposed high speed rail line.

The two contracts form part of HS2's Lot 3 Environmental Services. In order to reduce the line's environmental impact, the consortium will work closely with HS2's environment, design and engineering teams.

The areas to be covered are the London metropolitan area and Rural South section of the route covering Buckinghamshire, Hertfordshire, Oxfordshire and Northamptonshire.

To start with, each company in the consortium will carry out environmental surveys for allocated sections of the route. Areas assessed will include the natural environment (biodiversity, water resources, geology and visual impact); the historic environment (built heritage and archaeology); the built environment (townscape, traffic and transport, waste and resources and planning policy); and the community (noise, air quality, community, property and agriculture). The contracts began on March 22 and will continue up to the end of 2013.

New approach to refurbishing the Connaught Tunnel

Connaught Tunnel in the Royal Docks was built in 1878 and was part of the North London Line until 2006. The tunnel will be extensively refurbished as part of works to construct CrossRail's new Abbey Wood branch.

Sections of the existing tunnel are in a poor structural condition. In 1935, larger ships began scraping the bottom of the Royal Victoria Dock which sits above the Connaught Tunnel. As part of work to deepen the dock, the central section of the tunnel was narrowed with brickwork removed and steel segments installed.

CrossRail originally planned to strengthen the central section of the tunnel by removing the existing steel linings and back filling the entire section with concrete foam. These tunnels would then have been enlarged by boring through the concrete to create tunnels that are large enough for CrossRail trains to pass.

CrossRail will now place cofferdams in the Connaught Passage between the Victoria and Royal Albert Docks, pump out the water and create a dry construction site allowing workers to dig down to the tunnel to undertake the enlargement work through a 'cut and cover' approach.

Linda Miller, Connaught Tunnel Project Manager said: "The central section of the Connaught Tunnel is in a poor structural condition. To ensure we can undertake the tunnel enlargement work as safely as possible we have now decided to drain a section of the Royal Docks and then dig down into the tunnel. This will be the first time the tunnel has been exposed from above ground since its construction in the 1870s. While we will be using modern techniques, we will be using a similar cut and cover approach that was used to build the original tunnel which saw the tunnel constructed first with the docks then built over the top."

During World War II, more than 40,000 explosive devices were dropped on London with the docks and rail lines particularly targeted due to their crucial role in delivering supplies to the British war effort. Connaught Tunnel was hit by a bomb in 1940. CrossRail will be undertaking further repair work to the damaged section of the tunnel. Ahead of major CrossRail is undertaking an extensive search of the wider construction area to identify any remaining undiscovered devices that failed to detonate on landing during World War II. The geology of the Royal Docks area meant that some devices that didn't explode on landing sunk into the first few metres of soil.

A team of highly trained specialists are currently using armoured vehicles with magnetic equipment to investigate the ground around Connaught Tunnel. Their work involves sending probes into the ground in three metre intervals and analysing the results. CrossRail already has a detailed understanding from existing London-wide maps and ground surveys about where potential devices could exist.

After surveys for unexploded ordnance are completed, CrossRail archaeologists will open excavation trenches in an attempt to locate evidence of human settlement and farming in the area dating back nearly 6,000 years. Working with the Museum of London Archaeology, CrossRail also aims to map the effect of the River Thames on the area during historic and prehistoric times.

Sitting above the Connaught Tunnel near Connaught Bridge is the tunnel pump house. This attractive Victorian building is too small to accommodate the larger modern pumping equipment that will be installed as part of the tunnel's major refurbishment. Subject to structural surveys, CrossRail proposes donating the structure to the SS Robin Trust.

The SS Robin is one of the world's oldest steamships and was built in east London. The ship's trust is seeking a permanent berth in the Royal Docks and the pump house structure would form the quayside ticket office. The cofferdam works which will commence in 2013 have been planned in conjunction with the Royal Docks Management Authority and timed to start after the London Boat Show.

World's longest road tunnel is a trip through hyperspace

Completed in 2000, Norway's fifteen-mile-long Lærdal Tunnel cuts through a mountain range near the village of Lærdalsøyri. To ease drivers' claustrophobia and to prevent the underground monotony from lulling motorists to sleep, the tunnel is punctuated with a series of caverns designed to resemble impending

Since it takes the average driver 20 minutes to travel through the tunnel, special design features were added in order to prevent drivers from falling asleep. The tunnel is thus divided into four different sections that are broken up by "mountain caves." The mountain caves are 3.7 miles (6 km) apart and each one is equipped with special lighting that gives off the illusion of driving into daylight.

Turkey Highway tunnel is third longest tunnel in the world

The construction of a new highway tunnel in the northeastern region of Turkey, which is planned to be the third longest tunnel in the world, is invigorating the commercial prospects of local businessmen, both regionally and internationally.

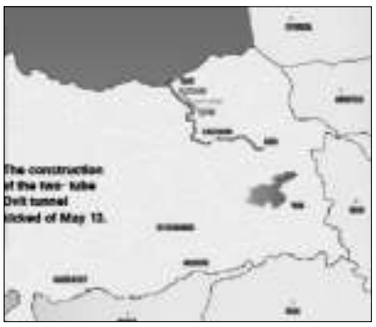
The building of the highway tunnel over is deemed to be a strategic project accelerating land transport from Turkey's northern highland provinces to eastern, southeastern provinces and all the way to Iran and Central Asia.

The tunnel is set to cut through the Ovit Mountain, which is located between Ikizdere, a district in the northwestern province of Rize, and eastern province of Erzurum's spir. The project will eventually exceed 17 kilometres, including the link roads around it.

The red line shows the current highway from Rize to Erzurum and Agrı. The green line shows the tunnel's location.

When the project is completed the travel time between the southeastern province of Mardin and the Black Sea province of Rize will drop to just 4.5 hours from the current 10-11 hours.

The cost of the project is estimated at 800 million Turkish Liras, and upon completion it will be the longest tunnel in Turkey. The tunnel will enable transport all year round between Rize and Erzurum. The current passage over the mountains is mostly closed during winters due to risk of avalanches and heavy snow.



The idea to build a tunnel in the region started as long ago 132 years ago, during the reign of Sultan Abdülhamid II, Prime Minister Erdogan said.

Canary Wharf station box completed

CrossRail has announced the completion of the concrete box for Canary Wharf station, one of CrossRail's key interchanges in London. Canary Wharf Group (CWG) handed over the structure to CrossRail on March 26. Completed five months ahead of schedule, the structure features twin 7.6m-diameter rings at both ends ready for the passage in 2013 of the tunnel boring machines.

Located 28m below ground and beneath a dock of the River Thames, the reinforced concrete structure is over 30m-wide and 250m-long. It is 10m longer than Canary Wharf tower would be if it were laid on its side. Four levels of concrete slabs have been constructed using the 'top-down' method, the lower two for the station, and the upper two for retail purposes.

Around 200,000m3 of spoil was excavated, of which around a quarter was reused on site and the remainder sent to regeneration sites in and around the capital. The majority was removed by barges.

Constructing the station necessitated the installation of a piled cofferdam to isolate the dock and allow pumping out of 98mL of water. The relatively new Giken 'press-in' piling technique from Japan was used to install the 18.5m-long tubular piles for the 1.2m-wide cofferdam. It is only the third application of the technique in the UK.

When the TBMs have passed though the station, CWG will begin the fit-out work which is scheduled for completion in 2015. Arup was the engineer for the structure, built by London-based Expanded Structures. The piling work was by Expanded Piling.

FLASHES OF LIGHT AT THE END OF THE TUNNEL

Excavation of a complex tunnel system for the XFEL European research facility in metropolitan area Hamburg was successfully completed in early June when the Herrenknecht AMELI tunnel boring machine entered its last target shaft. AMELI and its TBM sister TULA had to be relocated several times for the eleven tunnel sections between the research centre DESY in Hamburg Bahrenfeld and Schenefeld in the district of Pinneberg. Exact laser technology provided by the Gesellschaft für Vermessungstechnik (VMT) kept the two TBMs perfectly on course over the route totalling 5.78 kilometres.

As of 2015, electron and x-ray light – not traffic or water – will be flowing through the European XFEL (X-Ray Free-Electron Laser) research project tunnel system. Up to 27,000 ultra-short laser flashes per second will be generated in the x-ray range by XFEL with the aim of enabling the shooting of chemical reactions, for example, and giving rise to entirely new research opportunities for physicists, biologists, chemists, doctors and material scientists.

"Technically, the tunnel system is extremely complicated", reports Steffen Benad from Herrenknecht, who provided support at the jobsite in western Hamburg. "Just imagine how large this structure is and then how small the light beam will be at the end." The two 500 and 560-ton Mixshields with diameters of 6.16 and 5.45 metres were baptised TULA (Tunnel for Laser) and AMELI (Am Ende Licht – Light at the end). They were used by Hochtief AG and Bilfinger Berger AG for excavating the complex tunnel system network. In order to keep them exactly on course in the 3.4-kilometer plant, Herrenknecht used a laser-guided navigation system from VMT. By late July 2011, TULA had successfully completed its task for the more than two kilometre long main tunnel and the two further 600 meter long sections.

The tube system network at the end of the tunnel proved particularly complex for the engineers. The total of eight tunnel sections involved moving

AMELI three times through a finished shaft and lifting it out of the shaft four times for relocation.

"Tunnelling is one of the most difficult areas of the construction", claimed Prof. Dr. Massimo Altarelli, CEO at European XFEL GmbH, within the framework of a ceremony. "We are delighted that this work is being completed on time." Operation of the two Herrenknecht machines for the tunnel system network over a total distance of 5.78 kilometres took from July 2010 to the end of June 2012.

Prof. Dr. Helmut Dosch, Chairman of the Deutsche Elektronen-Synchrotron DESY Board, head shareholder of the European XFEL GmbH, was visibly satisfied: "Completion of tunnelling work on time has enabled us to achieve a key milestone for this unique research facility." And now there's nothing to stop the installation of technical infrastructure and accelerator components.

There is a tradition of collaboration with Herrenknecht in Hamburg which is also associated with various innovations. For the first time in 1985, Herrenknecht supplied a Mixshield to Hamburg for the construction of the HERA (Hadron-Elektron-Ring-Anlage) elementary particle accelerator. This was the first machine to move safely in soil containing excessive ground water. In 1997, Herrenknecht supplied the world's largest Mixshield at the time for excavation the 4th Elbe Tunnel tube.

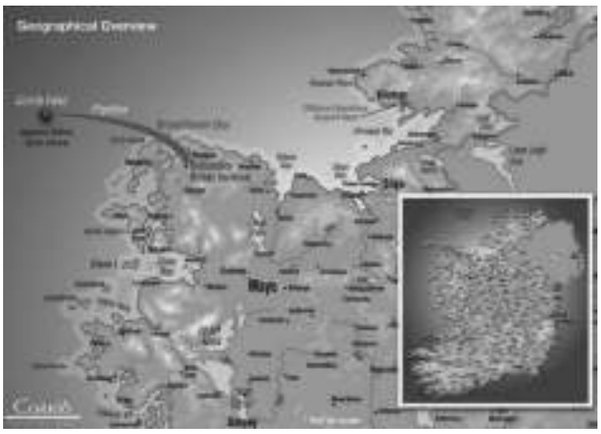
Other key projects in Hamburg:

1985–1987: Herrenknecht delivered its first Mixshield for the Hadron-Elektron-Ring-Anlage. Diameter: 5.95 metres Tunnel length: 6,300 metres

1997–2000: Herrenknecht Mixshield TRUDE (deep under the Elbe) masters the fourth tube of the Elbe Tunnel – Diameter: 14.2 metres Tunnel length: 2,560 metres

2004–2006: SOFIA Olsdorf-Airport suburban railway – Diameter: 6.87 metres Tunnel length: 3,413 metres

2008–2010: The Mixshield VERA excavated for the U4 metro line (from the Elbe toward the Alster) – Diameter: 6.57 metres Tunnel length: 5,620 metres.



Corrib tunnel project

A contractor has been appointed for the 4.9km tunnel to onshore pipeline works, which is the final phase of the scheme to be completed.

Shell Ireland appointed BAM Contractors Ltd to tunnel under Sruwaddacon Bay in north Mayo to the Bellanaboy Gas Processing Terminal. The controversial Corrib gas field lies about 80 kilometres off the north-west coast.

BAM has already started work on site, with preparations for the installation of the tunnel drive shaft currently under way.

A tunnel boring machine (TBM) with an internal diameter of 3.5m will be used for the work and this is expected to arrive on site during the summer.

Tunnelling is planned to start towards the end of the year and is expected to take around 15 months to complete.

When the tunnel has been constructed and the TBM removed, the 20in gas pipeline will be installed in the tunnel. The tunnel will be the longest of its kind in Europe.

The project is expected to be completed in late 2014.

A tunnel boring machine (TBM) with an internal diameter of 3.5m will be used for the work.

Las Vegas tunnel accident

State safety regulators in southern Nevada are investigating a fatal construction accident that occurred on 12th June in a water supply tunnel being built at Lake Mead, the latest in a series of mishaps and setbacks at the multi-million dollar project that began in 2009. A Nevada Occupational Safety and Health Administration investigator visited the 3-foot-diameter tunnel where one man was killed and another injured approximately 600 feet below ground near the Lake Mead National Recreation Area.

Thomas Albert Turner, 44, of Henderson, and another worker were alone in a segment of the tunnel when they were hit by exploding grout material after some material became loose, officials for the Southern Nevada Water Authority said. Turner was killed, while the second man sustained minor injuries, authority spokesman Bronson Mack said. An update on his condition was not available Tuesday and authorities had not confirmed his identity.

The tunnel is part of a troubled effort to drill a third drinking water supply line to the Lake Mead reservoir. The project has been hit with flooding and cave-ins since construction began in 2009, and work has been delayed by about two years. Workers in other areas of the tunnel were not affected by the accident.

Las Vegas depends on Lake Mead for about 90 percent of its drinking water. Construction on the third tunnel began amid concerns over the Colorado River reservoir's shrinking supply. The third intake is designed to keep water flowing to Las Vegas even if drought shrinks the lake below the level of the two existing conduits.

The new tunnel, bored through solid rock beneath Lake Mead, will be 3 miles long.

"During the assembly of some segments of the tunnel ring, one of the segments became loose, and the grout material exploded and hit two workers," Southern Nevada Water Authority spokeswoman Nicole Lise said. Mack said the tunnel is not flooded and is still intact. He said the water authority will conduct an investigation into the accident.

The project was delayed last year after a cavern 600 feet underground filled with water and muck. In another delay, some mining equipment was lost to flooding.

Norwegian Hydropower – Tunnel focus

The strategic prospects for Norwegian hydro to become the "battery of Europe" brings the prospect of significantly more tunnelling activity. At this stage, it is envisaged that much of the tunnelling would be excavations for new projects, such as power and transfer tunnels. However, there might also be a need for underground works to strengthen or alter existing assets at long established plants, which would be functioning under altered operating regimes as a consequence of the link-up to part of the Continental grid.

Existing hydropower stations and their underground infrastructure will need to be checked through hydraulic, sedimentation, geotechnical and engineering assessments to determine what, if any, changes might be needed to cope with flows that differ in patterns, frequencies and intensities of change from those of the original design.

Of potential benefit to help inform the discussion on water hammer and flow fluctuation at existing power tunnels are studies being undertaken by the Norwegian University of Science and Technology (NTNU). Much of the work, being undertaken as part of PhD research, involves work at the tunnels of the Tonstad and Tyin schemes.

New tunnels

Norway has already identified the technical potential to build up to 20GW more hydroelectric capacity in the south of the country, nearest the European market, and do so without constructing any new reservoirs.

The focus is on constructing pumped storage plants to balance the European wind production. It is envisaged that 1-2GW can be added annually with a peak of 6GW on one year. The required tunnelling rates are estimated, on average, to be 3Mm3 per year with a maximum of 10Mm3 – all of which would be in addition to the industry's existing underground infrastructure activities.

Existing tunnels

The majority of hydropower plants in Norway were built before 1990 and the advent of the liberated energy market. Before then, the operational regimes of the plants were designed to be relatively steady, and afterwards some stations have been used for peak load purposes. There was 3500km of hydropower tunnels built between 1950 and 1990, and investigations by Tidemann and Bruland showed the general stability was good but there were some problems.

In preparation for the proposed strategic, long-term changes for Norwegian hydro operations, early studies are underway to generally investigate how altered flow regimes can affect power tunnel networks and associated underground structures at existing plants.

The aim is to create tools to help identify, characterise and get the scale of any altered risk, and therefore be useful in prevention planning as well as assisting plant owners to examine how fast production/discharge can be changed without causing undue stress and possible failures or uneconomical wear on equipment. In addition to pressure changes, some altered risks may be generated from the development of different air entrainment patterns and also shifts in sedimentation.

The next stage of work is to create a CFD model "to simulate the hydraulics in critical parts of a waterway during hydro peaking," she says, adding that the most relevant software for the work is OpenFOAM and STAR-CCM+. The critical part for mass oscillations is the surge chamber while the sand trap is crucial for sediment handling. Once the CFD simulations have been completed the research will move to physical modelling in the NTNU hydraulic laboratory.

Choices ahead

In addition to gaining timely, and sufficient, access to hydro tunnels, the main challenges in the research work are to simulate realistic load regimes and select correct hydraulic fluctuations.

More generally, the risks from altered flow regimes that the future macro-plans for Norwegian hydro might present to plant owners might include: falling rock or collapses at zones of weakness with varying degrees of blockage; increased sediment transport which would impact the wear on turbines; and; increased head loss due to air pockets which would also lead to more cases of blow outs.

The current focus of methods to deal with such risks include redesigning critical parts of plants and strengthening support in structurally weak zones. The addition of new excavations at key points as part of re-engineering of waterway systems, and their hydraulic patterns, might also be considered.

Galleria Sparvo: World's largest TBM

"With the world's largest TBM, we have become accustomed to setting new records – two of which are its size and advance rate", explained Alfonso Toto, CEO and Managing Director of Toto Costruzioni Generali, during the first breakthrough celebrations while building the Sparvo Tunnel at the end of July. The Herrenknecht Earth Pressure Balance Shield with a world record diameter (15.55 metres) required just under twelve months to build the 2.413-meter tunnel. Each tunnel tube is spacious enough for two lanes, and each has its own hard shoulder. With the TBM Martina equipped for particularly gaseous soil, Herrenknecht has set new standards in tunnel boring machines.

During the course of extending the A1 in Italy, a currently busy section between Bologna and Florence is being extended to include a new alternative route. One feature of this route is the Sparvo Tunnel under construction since August 2011 which represents a new record in mechanized tunnelling in terms of size as it has a boring diameter of 15.615 metres and comprises two parallel tubes 2.5 kilometres in length. The alternative route aims to significantly reduce travel time for up to 90,000 vehicles per day. The client Autostrade per l'Italia S.p.A. anticipates the tunnel opening in mid-2013.

The excavation task is regarded as the most demanding part of the overall project, not only on account of its sheer size but also because of the prevailing geological conditions: the geology in the tunnel route comprises mainly clay, claystone, sandstone and limestone. What's more, there is partially an extensive prevalence of firedamp. In order to achieve the requisite safety and speed during construction, the Italian client opted to use mechanized tunnelling technology. To this aim, Toto Costruzioni Generali S.p.A. commissioned Herrenknecht AG with building a tunnel boring machine in 2010. Toto is the leading partner in a joint-venture which also includes Vianini Lavori S.p.A. and Profacta S.p.A. With the aid of the 4,300-tonne and 130-meter Herrenknecht Earth Pressure Balance Shield equipped with 12,000 Kilowatt drive power, Toto has now completed the first tube. Toto reported to the media after the initial breakthrough: "A top advance rate of 22 metres per day has confirmed the superiority of mechanized tunnelling when compared to conventional technology." This process involved the removal of 4,215 cubic metres of soil – a major challenge for site management. Over the next few months, the Martina TBM will be turned around for the second tube which is spaced 20 metres away.

"This machine was intended to set new standards, including with regard to its features for particularly gaseous soil", explains Herrenknecht Project Manager Alexander Ell. Hand in hand with Toto and with the support of the local authorities as well as the Universities of Bologna and Turin, Herrenknecht has developed a complex safety system which includes explosion-protected equipment, a fully-enclosed conveyor belt, a permanent fresh air supply to all areas as well as permanent monitoring of housing tightness and gas concentration. "The concentration of methane at the tunnel face was so high that fresh air had to be transported to the excavation chamber over longer periods of time", reports Ell and establishes with satisfaction: "So far, our new system has worked just the way we have anticipated."

Second Ave Subway

The Metropolitan Transit Authority has released new photos of construction on the first phase of New York's Second Avenue Subway, a more than $4 billion project that will run new tunnels between 63rd Street and 96th Street on the East side and is expected to be complete in 2016. The entire line, which will be built in four phases, will run from 125th Street to the Financial District.

These pictures are the construction of the 72nd Street station. The 72nd Street was conceived as a three track station with two island platforms, but prior to construction was reduced to a two track, one island platform station. This is the southern-most Second Avenue line station before the connection to the BMT 63rd Street Line and the Lexington Avenue – 63rd Street station.

Future entrance to the Second Avenue Subway's 72nd Street Station.

Inflatable cylindrical plugs developed for protecting mass transit systems from flood

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) in US has developed a novel technology to hold dangerous gases or flood water in tunnels.

The Resilient Tunnel Project (RTP) of S&T has created a huge inflatable cylinder, which is tunnel-shaped having rounded capsule-like ends resembling a large plug. The inflatable cylinder can be sealed with air or water to control flood.

The novel technology that protects important mass transit systems was developed by S&T in association with ILC Dover, producer of NASA space suits and Pacific Northwest National Laboratory, West Virginia University (WVU.

The huge plug can inflate to a length of 32 ft and a width of 16 ft and has the capacity to hold up to 35,000 gal of water. The plug can be stored in a small place within the tunnel and inflates immediately during any disaster when it receives a signal from the command centre in the tunnel system.

However, due to the irregular shape of the tunnel, it cannot be fully covered by the cylindrical plug. To overcome this issue, engineers created the plug with a larger circumference than the tunnel, which provided a tight sealing to the tunnel. The plug must fit the tunnel properly and importantly, must be strong enough to withstand pressure and flexible for packing as well.

After rigorous analysis, the team settled down for a material with three layers, including, the outer webbed Vectran layer, the inner non-webbed Vectran and polyurethane layers. The outer layer is strong and gives shape to the plug, whereas, the inner layers seal water or air.

A unique test tunnel was built at Morgantown, WV, to test the performance of the plug. On the test day, the tunnel was inflated with low pressure air initially. Secondly, air in the tunnel was replaced by water to reach the design pressure and finally, the test tunnel was closed and flooded with water to create a flood condition. The plug was able to sustain the emergency conditions and hence, was a success.

Tunnel and dredging projects to make room for bigger ships in New York Harbor

The project involves building a water tunnel to Brooklyn and dredging New York Harbor to make room for deeper cargo ships to be finished by 2014. That is the same year that larger locks are scheduled to go into operation on the Panama Canal, clearing the way for ships whose cargo capacity is 260 percent as large as the ones that the canal can handle now.

The $250 million, nearly two-mile-long tunnel — officially, a water transmission main siphon — is an infrastructure investment with a rapid payoff for New York, the nation's third-busiest port and allow it to accommodate new megaships.

The Port Authority has set aside $1 billion for the dredging project, which is separate from the cost of the tunnel. The channel would be deepened to approximately 50 feet, from the current depth of 45 feet. The Port Authority and the Army Corps of Engineers will be responsible for the dredging.

The city and the Port Authority are splitting the cost of the tunnel project, with the city's Economic Development Corporation managing the project. The dredging necessitated the replacement of two existing tunnels, one that dates to 1917, the other to 1925. They are 56 and 60 feet below the surface, respectively, and would be too close to the channel bottom after the dredging, officials said. The new tunnel will be 100 feet below the surface.

Like the old tunnels, the new ones will provide only a backup source of drinking water for Staten Island. Staten Island — as do all of the city's boroughs — draws water that originates in reservoirs upstate. Most of the water that ends up in the sinks and tubs of Staten Island gets there through a 42-year-old tunnel from Red Hook, Brooklyn.

If that conduit ever failed, the new tunnel would be able to pump up to 150 million gallons a day, the officials said. Under normal conditions, it would deliver five million gallons a day, or about 10 percent of Staten Islanders' demand for drinking water.

Tunnel below San Francisco Bay

The first tunnel bored beneath San Francisco Bay will carry drinking water five miles from Fremont to San Mateo County. Boring of the $350 million Bay Tunnel is one step that's planned as part of an effort to create a 21-mile stretch of new piping between the East Bay and the Peninsula to ensure that water continues to reach millions of customers after an earthquake.

The project is part of the multibillion-dollar Water System Improvement Program, which aims to overhaul the Hetch Hetchy water system that holds and transports drinking water for 2.5 million Bay Area residents. As part of the program, the San Francisco Public Utilities Commission is replacing and reinforcing water pipes and tunnels throughout a 167-mile network that carries snowmelt from Hetch Hetchy Reservoir in Yosemite National Park west to San Francisco and surrounding cities.

The piping planned beneath the Bay under the WSIP will be part of the fifth major pipeline installed in the Hetch Hetchy system between the East Bay and the Peninsula since the 1920s. The existing four pipelines are aging and could rupture during an earthquake. They were built between 1925 and 1973 using now-outdated construction materials.

The pipes that cross the water leak badly, leading vegetation to flourish at their corroded metal seams. But the ramshackle 1920s-era bridge crosses sensitive wetlands that are protected by federal environmental laws. Those laws effectively prevent water officials from accessing or maintaining the pipeline.

An underwater 9-foot-wide metal pipeline is planned to eventually replace both Bay-crossing pipes, although it's not known whether they will be removed because dismantling efforts could disrupt wetland wildlife.

Tunnel construction efforts using a heavy-duty tunnel-boring machine are expected to begin next year and last until 2015. The tunnel will pass up to 100 feet beneath the Bay floor. Dirt and other fill that's removed from the tunnel as it is bored will be used by an unrelated but adjacent project that aims to restore industrial salt ponds to native marshland, Ortiz said.

South Africa's Gautrain tunnel water issue far from resolved

The issue of excessive water ingress in the tunnel between Park and Rosebank stations on the Gautrain system "remained unresolved", said Gautrain Management Agency (GMA) CEO Jack van der Merwe, following reports by Gautrain operator Bombela that the problem was no longer a big concern.

The opening of the last remaining leg of the 80 km rapid-rail system had been delayed since August 2011, owing to the ingress of water into this section of the tunnel.

Van der Merwe noted that the Gauteng government – through the GMA, which was acting as its agent – was the owner of the Gautrain system and that it had the responsibility to ensure it was constructed and operated according to contractual specifications.

Bombela, in turn, was charged with designing, constructing, operating and maintaining the system for the next 14 years.

He added that a dispute resolution board last year directed Bombela to remedy the situation, so as to meet the specification for tunnel water inflow as set out in the contract signed between the Gauteng government and Bombela.

What this means is that Bombela may be able to manage the excessive quantity of water flowing into the tunnel and provide the train services in the short term, but it has, up to the present time, not provided any credible assurances to the province that the excessive amount of water will not cause irreparable harm to the tunnel itself and the environment around it in the long term.

The Gauteng government has also requested Bombela to develop a revised tunnel rectification plan in order to comply with the water specifications, as instructed by the dispute resolution board.

Current state of the art usage of structural synthetic fibres as a replacement for steel mesh and steel fibres in precast segmental linings

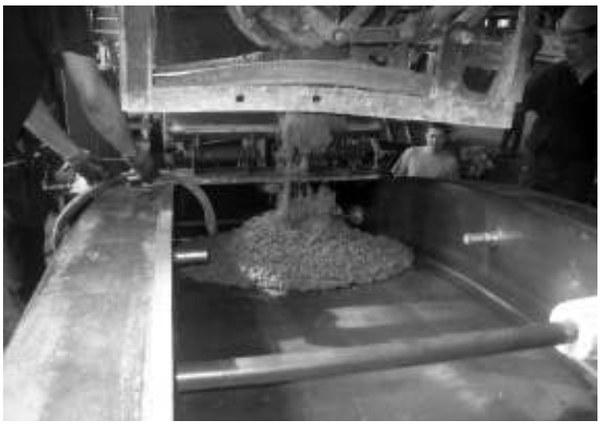
GARRY MARTIN – Tunnelling Manager, Elastoplastic Concrete (EUROPE), Dublin

This article was first published in Concrete Magazine and reprinted here with their kind permission

Structural synthetic fibres offering any real technical performance value, such as Barchip, first came onto the market towards the end of the 1990's and were quickly adopted by firstly the tunnelling industry in Japan in sprayed concrete linings for primary support purposes and then were exported to the mining industry of Australia; where for the last 15 years or so, they have been the reinforcement of choice for over 90% of the concrete used underground there.

Today, Norway has adopted structural synthetic fibres in over 200 kilometres of sprayed concrete linings, including those for several sub-sea tunnels, where the use of steel reinforcement is avoided, due to concerns about durability due to corrosion.

However, it should be noted that structural synthetic fibres are not only limited to primary ground support applications, but have been included in single shell permanent linings such as in the Hindhead tunnel in the UK and cast in situ permanent linings in water tunnels and high-speed rail tunnels in Spain.



However, it is their adoption in the ever growing precast segmental lining sector, where the most significant benefits lie.

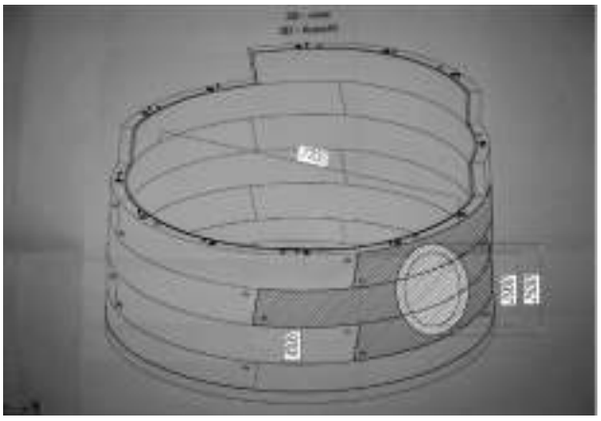
Precast segmental linings have traditionally been manufactured using steel cage; which segment manufacturers freely admit is regarded as a necessary evil, rather than the optimum solution, given the issues surrounding manufacturing hold ups, increased labour requirements, compaction problems and correct placement, amongst other issues that stem from having to use cumbersome cage designs.

Taking all of these impracticalities as a start point, fibre companies realized that there might be a potential to bring the ease of usage that fibre reinforcement brings, either through addition via bags direct into the mixing cycle, or through dosed solutions and thus eliminate many of the negatives associated with using cage reinforcement. However, neither the quality of the fibre product, nor the optimization of dosing nor the ease of usage would be enough on their own to persuade the industry to shift away from steel reinforcement cages if the technical performance was not there to back it up and if said technical performance could not be proven via internationally accepted and transparent means.

The starting point for justifying the performance of any type of fibre concrete is the testing of beams, in accordance with (INSERT STANDARD). These beam test results are a mandatory part of the CE marking of products and provide a fixed term of reference for the performance of the fibre concrete in question, taking into account the classification of the concrete used, the dosage of fibres and the amount of energy that is absorbed in flexure after first crack at a set point of deflection of the beam. This data from beam tests, (which are performed independently at such places as The University of Greenwich in the UK) gives a series of what are known as re3 numbers, (indicating the level of residual flexural strength in the fibre reinforced concrete once it has cracked) which typically increase with the increase of fibre dosage, from around 30 for 2.5kg of Barchip fibres to 70 for 10kg. This number is then used as an input into design programmes and is the same for steel fibre reinforced concretes and for those with structural synthetic fibres. Hence it is possible to compare a given concrete type with a known amount of fibre and based upon the re3 number, be sure

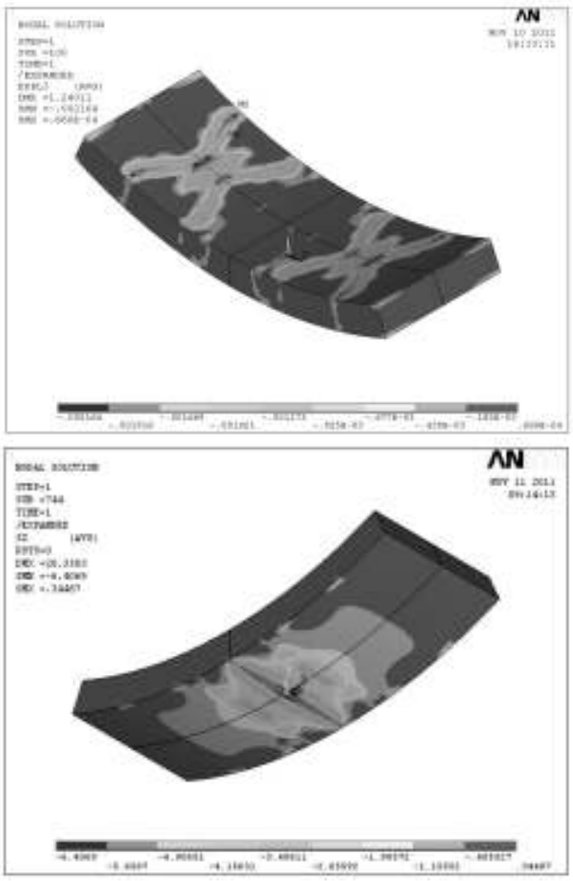
that the level of performance is equivalent. The same applies to beams reinforced with mesh too.

At EPC, we have decided to go one step further and employ finite element analysis, as opposed to the more limited calculations showing only equivalent flexural strength, which use the inputs from the beam tests and can now calculate and show in full transparency, the performance generated by our fibres at every stage of the segment's life cycle, from the stresses generated by de-moulding and transportation, to stacking and to loadings that would be expected at the serviceability state and ultimate limit state for any given segment design. FEA also shows that the substitution of cage for fibres not only provides equivalent performance, but also improves performance levels as fibre reinforced concrete is more resistant to initial micro cracking (leading to higher loads for first crack generation) as well as greater resistance to jacking pressures during placement and the prevention thereby of joint break offs, which lead to ill-fitting seals.



Having proven, using independent testing that there is a transparent level of performance equivalence between steel fibres and structural synthetic fibres at given dosages, and that through the usage of FEA modelling, it can be shown that the fibre reinforced concrete performs not only as well as that reinforced with steel cage, but often surpasses the performance of steel cage, why would the industry want to move away from a material such as steel fibres, which have been around for significantly longer than polymer fibres and which are only recently being used in precast segmental linings? Obviously, for any change to take place, there has to be a big enough driver for it to happen and that driver is the trade off that centres around using a technology that has been tried and tested for a longer period of time, as in the case of steel fibres, but which is known to have potential issues surrounding corrosion and embrittlement, especially when segmental linings are expected to provide a service life in excess of 120 years.

Independent testing has shown that the continuing trend to use higher strength concretes in segmental linings, typically with design strengths that are around 50 MPa, (but which over time can go on to be greater than twice that strength) with increased early age strength gains, so as to aid the productivity of factory segment lines and reduce issues surrounding de-moulding and handling, where it is agreed, the segments are subjected to their



greatest stresses, can cause longer term issues. Such high strength concretes pose a significant problem as the failure mechanism of steel fibres changes from a ductile one to a brittle response as the fibres are snapped rather than pulled and deformed by the matrix surrounding them. That is of course supposing that the steel fibres are still intact anyway and have not been subject to degradation by corrosion, which again in independent testing has shown them to lose up to as much as 50% of their initial capacity as measured at 28 days, when measured again at 90 days in a cracked concrete.

So maybe in these difficult economic times, maybe the right drivers for change exist and now is the time for us to invest in infrastructure that will stand the test of time and not need replacing prior to the specified design life, as is often the case using current materials?

New evidence in Pike River coal mine tragedy

The Pike River Royal Commission of Inquiry was told that the reputation of the New Zealand mines inspectorate was in tatters after the West Coast mine disaster and the role should be outsourced to Australia.

Solid Energy told the commission it wants the inspectorate contracted out to an overseas regulator, preferably from Queensland. That would alleviate the problem of trying to staff the New Zealand unit in direct competition with Australia. Solid Energy owns underground coalmines in Waikato and on the West Coast, including Spring Creek, New Zealand's largest underground mine, near Greymouth.

Tony King, from the Coal Industry Association, said the inspectorate used to be a place where mining professionals were happy to go, but that had changed significantly over the past 20 years. Its reputation needed rebuilding, but he acknowledged it would be hard to match Australia's pay and conditions.

Solid Energy also proposed a senior underground coal inspector take a lead role in any future disaster, noting that at Pike River the police had to `Google' what the Mines Rescue Service was on the night of the disaster, November 19, 2010.

In an aside, the inquiry heard from mining contractor McConnell Dowell, which had its men leave the mine just three minutes before it blew up. The inquiry also heard there were three underground coalmines in the country currently operating and two more in the pipeline – the Terrace at Reefton is due to reopen, and Bathurst plans a partial underground mine at Denniston.

After closing on 4th April the royal commission has since announced it will look at new evidence from former miners. Former Pike River CEO Peter Whitall's lawyer asked the commission to reopen to hear the evidence from former Pike River mine technical staff member Udo Renk and middle managers Terry Moynihan and Greg Borichevsky.

Despite its closing, the findings will not be reported to the Governor General until the end of September.

It is believed that the tragedy was initially caused by a roof collapse which expelled methane gas around the mine, which then ignited due to a spark from the electrical system after the water pumps were turned on. The resulting blast killed 29 men.

According to chairman of the inquiry, Graham Panckhurst, the mine's roof caved in at the goaf; pushing high amounts of methane into the rest of the mine. Pike River was already noted as a particularly gassy coal mine. The mine reportedly exploded soon after Pike River control room officer Daniel Duggan switched on the water pumps, which had been turned off for maintenance.

Prior to the explosion, Duggan told the commission he spoke to who he believed was Scottish miner Malcolm Campbell. Duggan stated that he spoke to the miners to inform them that water pumps were online again after maintenance, and that mining could restart. Only seconds after Campbell reportedly said "Hello Dan, who are you looking for?" Duggan responded and then an unidentified noise is heard. He tried to make contact with other underground, but all intercom and phone communications were lost, along with mine power and gas monitoring equipment.

It is believed that the tragedy was initially caused by a roof collapse which expelled methane gas around the mine, which then ignited due to a spark from the electrical system after the water pumps were turned on. The resulting blast killed 29 men.

Spring Creek Mine forced to stop work after 'incidents'

Work at Solid Energy's Spring Creek site near Greymouth was stopped on February 20 this year when the Department of Labour issued a prohibition notice because of "three recent incidents" at the underground mine.

Solid Energy chief operating officer Barry Bragg said the incidents "should not have happened". The company views these incidents very seriously. We recognise that expectations for underground mining have been raised substantially."

Underground operations at the mine were suspended in May 2011 when a diesel-powered LHD (load, haul, dump) machine caught fire. Work stopped for five months in November 2010 after two coal face heatings and the Pike River disaster. A safety review carried out at Spring Creek at the time identified some improvements, which were implemented.

Work resumes

Solid Energy began a staged resumption of general underground operations again in March, bringing in Australian experts to help.

The current mine manager Greg Duncan was seconded to focus on health and safety systems, and Craig Smith took over as site manager, with Kevin Pattinson taking on the statutory mine manager role, and environmental manager Mark Pizey filling the health and safety role until a permanent appointment is made. Australians were also brought in to work with the mine managers and staff, and corporate health and safety staff from Solid Energy's head office, in Christchurch.

The company expects that when full-scale extraction resumes later in 2012, this new resource block will safely deliver about 2.2 million tonnes of high-value coal over three years.

Gas build up forces Huntly East mine closure

New Zealand miner Solid Energy stopped production at the Huntly East Mine on 21st June after inspectors identified a build-up of lethal gas.

Late last year reports surfaced staff at the same site had put rags over the mine's methane sensors in order to maintain production. The sensors are designed for safety underground and automatically switch off machinery if gas levels reach a certain level.

Work resumed at Huntly East on 25th June when the Department of Labour's High Hazards Unit lifted a prohibition on coal extraction.

Northparkes – Rio Tinto's Mine of the Future

In late June Aker Wirth and Rio Tinto's new innovative tunnel boring system, designed within Rio Tinto's "Mine of the Future" programme, departed from Aker Wirth's production facility near Dusseldorf, Germany, bound for Northparkes Copper Mine in southeast Australia. The arrival of the Mobile Tunnel Miner is scheduled for mid-August when the machine will be made ready for its use in the underground mines.

The machine concept combines the flexibility of a roadheader with the robustness of a TBM. To build this machine knowledge gained from a previous version developed and tested by Aker Wirth in the early nineties was used.

The Mobile Tunnel Miner is very flexible and versatile. Using the undercutting technology it is especially efficient with tunnelling in extremely hard rock (up to max. 300MPa). Another feature of this tunnel boring system is its ability to cut – in addition to circular tunnels – rectangular or horseshoe-shaped cross-sections of up to 6m diameter, eliminating the need to backfill the lower section of the round cross-section.

The machine can be moved flexibly forward with a walking mechanism and backward with a crawler. Aker Wirth engineers employed several swivel joints to attain a

radius of just 30m, which is extremely small for a machine of this size and capacity. The tunnel boring system is equipped with support systems for additional strengthening the tunnel.

Einar Brønlund, CEO of Aker Wirth said, "We will revolutionise safety and efficiency in underground mining with the new Mobile Tunnel Miner. With this tunnel boring system Aker Wirth will play a decisive role in shaping the future of the mining industry."

28 New Zealand gold miners rescued after fire

Twenty-eight miners were rescued from a New Zealand gold mine Tuesday 17TH July after a fire trapped the men underground for up to seven hours.

A truck engine caught fire early in the morning at the Trio mine in the North Island town of Waihi. Mine officials said the ventilation system pumped smoke through the mine and it could be seen coming out the vent shaft.

Initially, 28 men were trapped about 150 metres (500 feet) underground in safety chambers. After more than 5 hours, 13 men taking refuge in two safety chambers were rescued. After seven hours, the remaining men in a third chamber were also rescued. The men were two hours from finishing a 10-hour overnight shift when the fire broke out.

The mine is owned by Denver-based Newmont, one of the world's largest gold producers.

Linda Willoughby, another mine spokesperson, said mine officials were in telephone contact with the trapped

miners throughout their ordeal. Willoughby said the men followed their training after the fire by taking refuge in the underground chambers. Wilson added that many of the miners at first thought the incident was a drill.

CSA-Cobar copper mine extension

CSA Mine is an underground copper mine located in Cobar, Central Western NSW. employing over 350 people operated by Cobar Management Pty Ltd (CMPL) an Australian subsidiary of Glencore International plc Switzerland.

There are exciting times ahead for CMPL with a new deep-level multi-million dollar shaft extension project already approved as well as various other projects that will significantly increase the life of the mine and lower mining costs. CSA Cobar is already the highest grade copper producer and second deepest mine in Australia operating 24 hours seven days a week.

Included in the $100 million extension project are 500-metre extensions to both shafts, new winders, crusher stations, conveyors and ore storages. This massive and important upgrade will transform operations and increase production at the mine from its present 870,000 tonnes of copper ore per annum. In addition to the mine, CMPL also holds an additional 820km2 of tenements in the local Cobar area.

Plans for a new billion dollar gold mine in Waihi

Newmont, the world's second biggest gold miner, plans for a new mine in Waihi which it says at current gold prices could be a billion dollar earner.

To get to the proposed Correnso Mine, the company Newmont will spend hundreds of millions of dollars tunnelling to a depth of 350m beneath east Waihi. However, the company is expecting a legal fight that could stretch into 2014. The proposal will run through the full Resource Management Act process and the company is steeling itself for an appeal to the Environment Court.

Until Correnso was contemplated and the company embarked on two smaller projects, there were signs mining could have ended in the town in just two or three years time.

The capital spend to bore 13.5km of truck-size tunnels is estimated at least $200 million in addition to the $190 million a year the company says it spends on goods, services, rates, taxes and royalties. About a third of that is spent within 30km of Waihi, a town of about 4500.

While Correnso is the big hope, there's a surge of other activity by Newmont. Another $70 million underground mine, Trio, is set to start producing in May. It could produce 200,000oz of gold over two years.

The pit tunnelling plan – an extension of an existing mining permit – has resulted in around 15 appeals to the Environment Court. Outside environmental opponents it's hard to find many who oppose mining in an area where gold was discovered 150 years ago, but the pervading view among residents who are most affected is that it's in the "right place but wrong time".

ERA commits to Ranger 3 Deeps

Energy Resources of Australia will spend $A57 million on a two-year prefeasibility study into the Ranger 3 Deeps development in the Northern Territory.

The funds are on top of the $120 million already committed to build the exploration decline where construction began in May for completion in early 2014.

The study will include 16,000m of drilling in addition to the 35,000m already approved as part of the decline project, with all results to be incorporated into the Pre Feasibility Study.

The deposit already has a resource of 34,000 tonnes of uranium oxide.

The extension of the decline and the installation of a ventilation shaft will be evaluated.

ERA chief executive Rob Atkinson said, "We will continue discussions with the Mirarr through their representatives, the Gundjeihmi Aboriginal Corporation, as well as with the Commonwealth government and Northern Territory government, in relation to this project and the outcomes of the study," he said.

A decision into the underground development is expected to be made in late 2014.

Woodlawn Underground Project

On the February 9th 2012, TriAusMin announced the commencement of a diamond drilling program at the Woodlawn Underground Project. The drilling program was designed to identify extensions to the known ore lenses, below the limit of the previous mining operations. The first of the planned holes has now been completed and final assay results received.

The primary target for the drilling was the continuation down plunge of the significant "B" lens, 100 metres below the base of existing mine workings. Additional plunge extensions of lenses "I" and "D" were also planned to be intersected en route to the B lens target position. The Company reported that I, D and B lenses were intersected successfully with multiple intersections of massive and semi massive base metal sulfides.

The Woodlawn Project is based at the former Woodlawn mine site located 30 kilometres south of Goulburn and 200 kilometres south-west of Sydney, where the company holds two significant poly-metallic resource-based assets; the Woodlawn Underground Project ("WUP") and the Woodlawn Retreatment Project ("WRP").

The WUP involves evaluating the historical underground resource for potential redevelopment of the Woodlawn Mine to access the high-grade ore that remained when the underground mining operations ceased in 1998. In addition, the Company is exploring for new resources on the down plunge extensions of the historically mined lenses. It is TriAusMin's objective to add to this resource through continued exploration and drilling.

When in production, the Woodlawn open pit and underground mine produced approximately 13.4 million tonnes of high grade zinc, lead and copper ore from up to 10 different mineralised lenses.

Ernest Henry Mine's transition underground

Award winning professor Gideon Chitombo has been recognised for his innovations in the mining industry, including his involvement in Ernest Henry Mining's (EHM) transition into the underground phase of their operations.

The EHM site in Cloncurry transitioned from open pit to underground mining in December last year, with Dr Chitombo's research playing a major role in its development.

Underground sub-level caving was one of the concepts implemented on the advice of Dr Chitombo.

Dr Chitombo is majorly involved in investigating the possibility of 'super caves', that allow up to 100,000 tonnes of ore to be safely and economically extracted per day from a single panel. Dr Chitombo said discovering alternative forms of mineral extraction was what he was passionate about. He said the EHM ore body was not being suited to traditional stoping methods, and instead, sub-level caving was implemented. Sub-level caving starts from the above the ore body and is much cheaper, with no need for back-filling as the drilling and blasting goes downward.

The Queensland innovator is based at the WH Bryan Mining and Geology Research Centre for Sustainable Minerals Institute at The University of Queensland, and admitted the resources industry was embarking on a challenging period despite the mining boom.

Dr Chitombo is majorly involved in investigating the possibility of 'super caves', that allow up to 100,000 tonnes of ore to be safely and economically extracted per day from a single panel.

Xstrata to extend Ravensworth coal mine's life

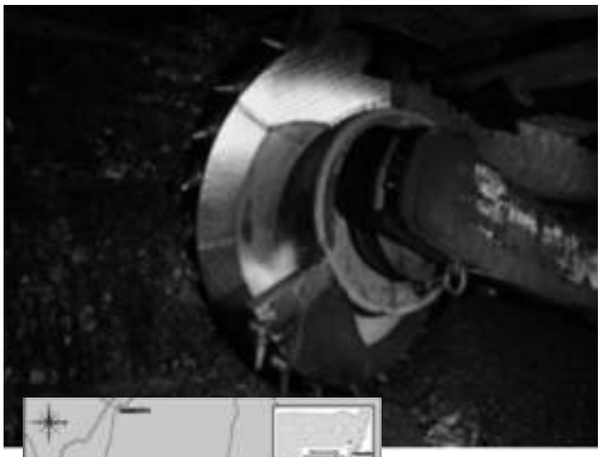
Xstrata has applied to the NSW Department of Planning to extend the lifespan and workforce of its Ravensworth coal mine. Dubbed the "Underground Mine Modification 9", it is part of the miner's gradual development of the Liddell Seam.

According to the miner its objective with the application is to "develop the ongoing underground operations" which will see it change the width, orientation, and location of longwall panels. While it will reduce the number of panels from 19 down to 18, the width of each longwall panel will increase by around 35 metres.

This latest application from Xstrata seeks to modify the existing approved mine plan as well as "install additional surface infrastructure to ensure adequate gas drainage and ventilation", the miner says. This infrastructure includes new pit top facilities; conveyors; tailings pipelines; a substation; RCHPP and RCT; and fuel storage facilities, as well as new fire ventilation shafts and goaf drainage wells. While this will see additional methane gas vented in the early stages levels are predicted to drop soon after, and then stabilise.

As part of this growth it will also expand its workforce from just over 300 employees to a long term average of more than 400, with the occasional peak driving staff numbers above 500.

This latest development of its Hunter Valley underground coal mine comes after it recently announced plans to re-open its closed Blakefield South coal mine, after it was forced to shut the operation down due to underground fires.



Bickham considers underground mine

One of the most controversial mines in recent Hunter history is back on the agenda with exploration to resume at the Bickham site north of Scone.

A proposal for an open-cut mine on the site about 10 kilometres south of Murrurundi was sensationally rejected by the former Labor state government in May 2010. But laws to prohibit open-cut mining on the site did not extend to underground mining and Bickham Coal Company director John Richards says the company has decided to look at an underground mine.

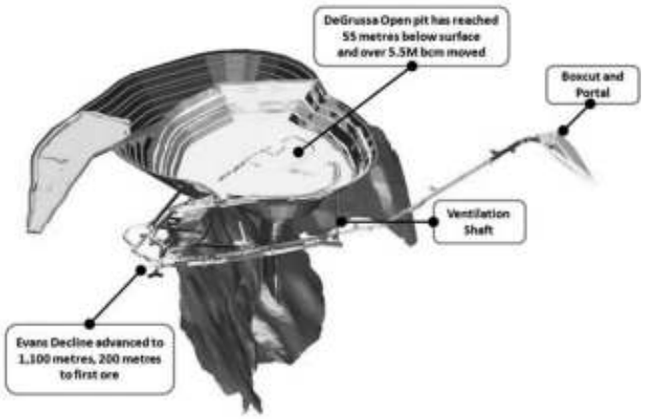
Mr Richards said Bickham was obliged to keep exploring the area as a condition of its exploration licence. He said the company had rejected an underground approach in earlier years but was looking again to see if the coal could be accessed underground using latest technology.

Mr Richards is managing director of the Bloomfield Group which owns the Rix's Creek and Bloomfield open-cut mines and which this week announced a $76million tie-up with Doyles Creek mining proposal owner Nucoal Resources.

Another mine rejected by the former Labor government, the Wallarah 2 underground project near Wyong, has also been revived since the change of government.

DeGrussa copper-gold mine

Sandfire Resources has started mining underground at its DeGrussa copper-gold mine with the first truckload ready for processing. The company began mining its open pit in February 2012 and massive sulphide ores from the longer-life underground mine at DeGrussa in March 2012, Sandfire says the underground development was now progressing beyond 1.5km in depth.



Ulan underground

Ever since the suspension of operations at Xstrata's Ulan coal mine's open cut around four years ago, the miner has been considering possible ways to get the mine running at its full potential again. But Ulan was on the backburner as Xstrata focused more on the growth of its Hunter Valley and Queensland operations.

However an increasing global demand for coal and a strong market price has impelled it to capitalise on Ulan's existing infrastructure and an established local workforce. But it was unsure of how to do this effectively, as nearly a century of work in the region had created a number of significant hurdles. So Xstrata brought in GW Engineers to examine its options for continuing mining at its Ulan operation and the development of Ulan West.

Ulan's age was a major factor, as mining has been carried out in the area for close to 90 years, so it had to deal with an exacting brownfields construction. GW also had to optimise Ulan's longevity while ensuring that operations could be carried out in compliance with Xstrata's environmental management strategy – in particular noise containment. It developed a number of different concepts, considering the viability of each and the individual approvals processes, before coming to an eventual decision – move further underground.

Leighton wins contract at Prominent Hill

Mining contractor Leighton says that it has received a six-year contract worth $1 billion to extend operations at Oz Minerals' Prominent Hill copper-and-gold mine in South Australia.

The work will require Leighton's Thiess subsidiary to hire an additional 170 people over the coming months, bringing the workforce in the open-pit operation to as many as 550, Leighton said in a statement. Thiess, which will mine for Oz Minerals until 2018, was in 2006 hired to construct infrastructure and then mine at Prominent Hill.

Oz Minerals said in mid-December that the Prominent Hill operation had an estimated mineral resource of about 2.68 million metric tons of copper and 6.3 million ounces of gold. The company has plans to develop a second underground mine in conjunction with the open pit.

Lithgow mine's multi-million dollar expansion approved

About 300 jobs in the local coal industry have been saved by the approval of a mine's expansion near Lithgow with the federal government allowing the Springvale Mine to extend its underground operation into an area of 330 hectares.

The mayor of Lithgow, Neville Castle, says the company can work with the 30 conditions placed on the project, including one that stipulates no mining be done under high quality swamps, unless the company can prove it will not negatively impact them. He says the city's economy would have suffered if the expansion was rejected.

"We have in some cases many more conditions for a development application, but in speaking with representatives of the company, some of those conditions are indeed a little bit onerous, but they can work with them and it'll mean that coal can again be being produced in the very near future."

Wolfram expands tungsten mining operations

The first tungsten mine to resume operations in Australia, Wolfram Camp Mining near Dimbulah, is accelerating its exploration program.

Wolfram Camp chief executive officer Gus Phillips said the aim was to increase resources near the current Wolfram Camp 17km northwest of Dimbulah and to expand the current known resources of Bamford Hill, a nearby historical tungsten production area.

Mr Phillips said within the zone an exploration target of 300,000 to 500,000 tonnes had been set in open pit and/or underground mining. "Planned exploration programs at Bamford Hill will target extensions to the known mineralisation, both at depth and along strike, and be incorporated in revised geological and resource modelling," he said. "Future optimisation of selective open pit and/or underground mining at Bamford Hill is anticipated to supplement ore supply and significantly extend the life of the Wolfram Camp project."

The accelerated program follows the official opening of the Wolfram Camp in July 2012 after the division of Deutsche Rohstoff AG of Germany started project development in July last year. It is the first operating Australian tungsten mine for more than 20 years.

Leighton Contractors rebrands

Leighton Contractors has killed off the HWE name and unified its contract mining operations under one brand.

The new brand – Leighton Contractors' Mining Division – would put an end to having two brands servicing the mining sector, its executive general manager Steven Keyser said.

Since the acquisition of HWE Mining in 2006, Leighton Contractors through its Resources Division (now Mining Division) had run under both HWE and Leighton banners. "The sale of some of our HWE Mining operations and associated services to BHP Billiton last September provided the final catalyst for change," Keyser said. "Dual branding was no longer helpful and research in the light of that divestment indicated that we needed to refocus on our place in the mining industry and reshape our brand for future success."

The move to one brand minimises complexity and removes duplication while better reflecting the company's key market focus in open cut and underground mining operations, Keyser said. "We have consolidated all our mining capabilities, experience and expertise under the Leighton Contractors brand as Leighton Contractors' Mining Division," he said. "In turn, this has now concentrated in that one entity all the competence, skill and proficiency amassed previously in both our Resources and HWE Mining entities.

"But while there is a new name and new unity, we will continue to utilise all our fundamental mining qualities, capabilities, experience and values forged over many years. "I am certain this will find comprehensive approval among our clients and potential clients, and across national and international marketplaces, as we focus more strongly than ever on delivering our core mining capabilities and expertise."

St Barbara looks to efficiency

Goldmine St Barbara is to introduce super-haulage trucks and increase underground office space to improve traffic flows in the decline at its Gwalia underground mine near Leonora in Western Australia.

The twin innovations follow a decision not to proceed with plans to sink a shaft. Originally priced at $70 million to $80m, the likely cost of the proposed shaft has increased to more than $100m because of increases in labor and steel costs.

Dugald River

The Dugald RiverProject is a Zinc Mine owned by China Minmetals Corporation, and OZ Minerals Limited, located 85km north-east of Mt Isa. Dugald River produces Zinc along with some Lead, and Silver.

The property is located approximately 30 miles northwest of Cloncurry in Queensland, Australia The deposit is estimated to contain 48 million tonnes of ore, grading 12.1% zinc, 2.1% lead and 44 grams per tonne of silver. Dugald River is amenable to mining with conventional underground mining techniques and high metal recovery rates are expected to be achieved with standard crushing, grinding and floatation processing.

At a capital cost of less than A$500 million and assuming a mining rate of 2 million tonnes per annum, the project is expected to produce 200,000 tonnes zinc, 40,000 tonnes lead and 1.5 million ounces silver per annum in concentrate over a 16 year mine life.

Lady Loretta underground mine

Xstrata Zinc has commenced construction of the new high grade zinc-lead-silver Lady Loretta deposit, 140 kilometres north-west of Mount Isa.

Work is underway to develop the underground services and surface infrastructure of the $246 million project, which is planned to be operational by the end of 2013. The first major milestone for the construction phase was successfully reached in September 2011 with the start of the underground decline.

Lady Loretta is a strategic asset within the Australian zinc portfolio. Its higher grade zinc improves the overall quality of the Mount Isa resource base and increases annual average zinc production from the region by around 20 per cent to 100,000 tonnes. The deposit is well defined. Four feasibility studies and more than 70,000 metres of drilling have identified an unusual and challenging syncline shape to the ore.

A new village will be built over the next two years to accommodate the operational workforce. It will include premium air-conditioned accommodation units, a pool, gym, messing facilities and general store.

The mine will create jobs for up to 230 contractors at peak of construction in 2013, followed by a similar number of permanent operational employees when operational. As a new mining team, Lady Loretta offers a unique opportunity for experienced hard rock miners and professionals to join a mine which by its very nature demands high performance.

Coromandel gold mine closed over safety fears

A small underground gold mine in the Coromandel, has been closed by the Department of Labour after failing to rectify safety problems.

Acting Chief Inspector Mines, Gavin Taylor said the mine, which was non-operational, had failed to comply with section 53 of the underground mining regulations which prohibits the use of electrical equipment that uses oil as a means of arc suppression, cooling or insulation inside the mine.

Taylor also said the mine only has one access and egress from the mine, when regulation requires a minimum of two.

He said he had previously issued a 'do better' notice but upon inspection last month, the decision was taken to close the mine. The mine's owners says it's a small family affair that has been operating safely the 100-year-old mine for 12 years and while it was paying for itself it was not making a fortune.

Rabone said the mine has had up to seven people working in it, including a couple of Canterbury University students, when they had to close.

The mine's owners says it's a small family affair that has been operating safely the 100-year-old mine for 12 years and while it was paying for itself it was not making a fortune.

$100 million mine contract awarded

Barminco Ltd has been awarded a $100 million underground development contract at the Dugald River project. Neil Warburton, Barminco chief executive officer, said the 2.5 year contract at the zinc, lead and silver project encompasses the development of two exploration declines to access and develop the ore body with potential for extension of the term and scope of the contract after the initial development is completed.

He said Barminco maintains a long-standing relationship with Minerals and Metals Group (MMG) providing underground mining services at the Rosebery mine in Tasmania since 2001. Mr Warburton said the addition of MMG's latest Australian project to its contract list reflects Barminco's strategy of maintaining a strong domestic business to support growth aspirations. The Dugald River contract takes the total of Barminco projects in Queensland to four, with other contracts in the region including Mount Gordon Copper Mine, Ernest Henry Copper Mine and Eloise Copper Mine.

Mining stops at Bullant gold project

Mining has been suspended at the Bullant underground gold mine in Western Australia after operator Kalgoorlie Mining Company missed production targets and experienced rising processing costs. The company said the decision to place the mine on care and maintenance followed a detailed operational and financial review of the project. As a result, there will be an immediate reduction in the workforce at the mine, situated 65 kilometres northwest of Kalgoorlie.

Bullant was previously operated by the world's biggest gold miner, Canada's Barrick Gold Mining Corporation. Barrick continued its association with the mine by buying ore from Kalgoorlie Mining for processing at the Canadian miner's nearby Kanowna Bell facilities.

Beaconsfield gold mine finally shuts

More than six months after it was officially announced, the Beaconsfield gold mine has finally closed. In November last year, mine owner BCD Resources announced that it would close the embattled mine.

It explained that "at today's gold price it is not viable to mine below the current depth of 1210 metres".

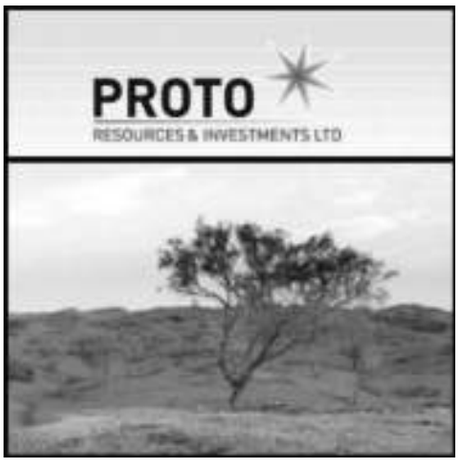
BCD Resources CEO Peter Thompson explained: "Below the current base of the mine, gold mineralisation thins and further development is not viable. This has been confirmed by an independent consultant. The company will continue to review the mining plan and mine life should the gold price continue trending upwards."

This announcement came nearly a year after the mine retrenched close to 100 workers in an attempt to make the mine profitable. Over the weekend the last 40 miners clocked off. The region's mayor Barry Easther said that part of the mine will now be turned into the Beaconsfield Mine and Heritage Centre, to draw tourists. Easther unveiled a 3D model of the mine and the complications of underground mining.

It explained that "at today's gold price it is not viable to mine below the current depth of 1210 metres".

New mine for Beaconsfield

But the Beaconsfield community is set to receive a boost, with Proto Resources confirming work on its Barnes Hill mine will begin by the end of next year. The new Barnes Hill mine would employ 100 people and fill the gap left by the Beaconsfield mine. The $70 million nickel-cobalt-iron Barnes Hill mine is Proto's flagship project, and is expected to last 26 years producing 250,000 tonnes per annum.



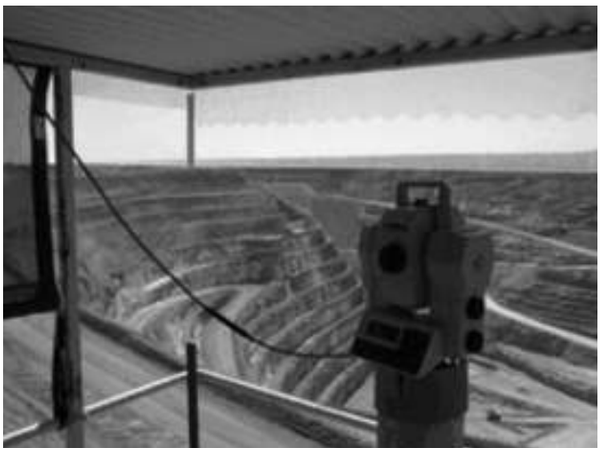
Cock-eyed Bob

At the Cock-eyed Bob deposit, the first gold mineralised banded-iron formation has been intersected underground, at 96 metres along the decline.

Trial underground mining began at Cock-eyed Bob in January, with the aim of demonstrating the potential for long-term production from underground sources at the Randalls project.

Cock-eyed Bob is located 16km east and 13km east, respectively of the Randalls Gold processing facility. Recent drill intercepts support previously announced results, and continue to indicate that high-grade gold mineralisation within the BIFhosted Santa Trend persists at depth with excellent potential for underground extraction. The high-grade BIF-hosted gold deposits at Cock-eyed Bob, Santa and Maxwells continue to emerge as potential future sources of high-grade material for the Randalls Gold Project.

Subject to successful completion of the trial mining exercise, the objective is to progressively develop underground operations at the Cock-eyed, Santa and Maxwells gold deposits to the extent that 50% of the process facilities feed is provided by underground sources at an expected grade of 5–6 g/t gold.



Sunrise to go underground

AngloGold Ashanti says it will be spending over $US800 million on Australian projects in the next two to three years.

AngloGold CEO Mark Cutifani said the expansions aimed to capitalise on predictions the gold price could peak "well over $US2,200" an once in coming years. Cutifani said the $US800 million budget was for expansions to the company's Sunrise Dam mine and Tropicana development, both in Western Australia.

Cutifani said the company was focused on underground mining at Sunrise after depleting the open pit and there was still potential for more exploration at the site.

Anglo to double Moranbah South

AngloAmerican is planning one of Australia's biggest coalmines, which will more than double the expected size of its Moranbah South underground mine. But the trade-off appears to be a two-year delay on operations, which is now not slated to start producing coking coal until 2017.

In documents submitted to the federal Environment Department, Anglo says it plans to export up to 14 million tonnes a year from two underground coalmines at Moranbah South, 150km southwest of Mackay. This would make it close to the nation's biggest export coalmine (underground or open pit) rivalling BHP Billiton's Goonyella and Blackwater mines, which also produce about 14 million tonnes a year.

Anglo's 50 per cent partner in the mine, Exxaro Resources, had previously flagged a mine that would export 6.5 million tonnes of coal a year from 2015. The cost of that mine, according to the latest estimate from the Bureau of Resources and Energy Economics, was $1 billion, meaning a probable $2bn-plus price tag on the new plan.

The project is aiming for a peak production rate of 18 million tonnes a year of mined coal, from which 14 million tonnes of exports would be gathered.

Construction, if approved, is expected to start in 2014.

Ivanhoe Australia Limited

Following the strategic acquisition of the Osborne complex less than 18 months ago, Ivanhoe Australia has developed the Kulthor underground resource and restarted the Osborne underground mine within the scheduled time frame.

With mining at the Osborne and Kulthor underground mines) well underway, work on the Starra 276 decline began in December 2011 with the firing of the first stripping blast. The existing decline at Starra 276 is in excellent condition and is being widened to enable access by larger, more modern haulage trucks. A bypass is also being mined around a tight spiral section of the old decline. The decline development is being undertaken by contract mining, with ore production scheduled to begin in Q1 2013.

The construction of the Osborne-Mount Dore haul road is scheduled to be completed in October 2012. Geophysical analysis within the Osborne-Kulthor region has identified targets that are to be followed up in the current drilling program. One is the Avalon prospect, a substantial, five-kilometre-long magnetic and gravity target that extends more than two kilometres in depth. Avalon is located two kilometres west of Kulthor and, with a coincidental magnetic.

The proposed Osborne Deeps and Kulthor extensions and the bulk of the Avalon prospect are within current Mining Leases and potentially can be accessed from the existing underground development – which would provide substantial capital efficiency should these targets be realised.

Australia's historic opal industry dying off

As the mining boom roars on, a small, historic part of the industry has been forgotten. The vast, arid gem fields of South Australia, New South Wales and Queensland are some of the few places in the world where opals can be found. But this iconic piece of Australian history is being killed off as tourism figures decline and the number of people taking up the opal mining trade plummets.

Kev Phillips has been mining opals in Queensland since the 1980s and says he is struggling to see a future for the industry. "It's a very colourful industry; we've got people from all walks of life, doctors, teachers, immigrants, it's classic," he said. "It's a fantastic sort of industry and it'll be a tragedy to lose this iconic way of life and the people involved. But it is happening." He says it is love not money that moves people to some of the hottest, remote parts of the country to dig for opals. "It's not an occupation, it's a vocation," he said.

He says young people interested in opal mining are now lured away by the fat pay cheques offered by big mining companies. And Mr Phillips says many of the older opal miners have been forced out of business by a mountain of fees and paperwork imposed by state governments. "They've imposed these costs and now we have to just live with them, which is deterring small scale mining from progressing and being a substantial part of the economics of regional Queensland." Mr Phillips, who is also head of the Queensland Small Miners Council, says opal miners have been unfairly restricted by laws aimed at the coal seam gas industry.

He says unless legislation is wound back, the future for all small miners is bleak. "It's not only opal, it's sapphires and small gold miners," he said. "What's happening is the Government is slowly taking away that right in favour of large mining with unionised staff."

Away from the rough mining camps of inland Australia, the opal trade is also struggling on the tourist glitter strips of the coast. Marketed as Australia's national gemstone, opals have always been a hit with overseas visitors. But with tourist numbers dropping since the global financial crisis, the economies of tourist centres like Cairns and the Gold and Sunshine coasts are hurting.

South Australian Mines Emergency Response Competition

Perilya took home the SACOME Perpetual Trophy for Best Team at the South Australian Mines Emergency Response Competition held recently in the Adelaide Hills.

The only interstate team of the seven teams who competed, Perilya from Broken Hill narrowly edged out teams from Kingsgate's Challenger mine, OZ Minerals' Prominent Hill, BHPBilliton's Olympic Dam, UraniumOne's Honeymoon and Terramin's Angas Zine mine on the weekend of 28–29 April, to send the trophy across the border for the first time.

Teams competed in a range of activities including underground rescue, rope rescues, using breathing apparatus, fire fighting, first aid, theory, basic skills and road crash rescue. The event was spread across three different locations including the CFS Training Centre, Brukunga, Hillgroves' Kanmantoo Copper mine and Terramin's Angas Zinc mine at Strathalbyn.

Jason Kuchel, Chief Executive, SACOME, recognises the importance of having such an event in South Australia."This sort of training is vital f or our mine rescue teams. It not only hones their skills, but it is set up as a learning exercise where they can watch other teams and share information", he said. The event is hosted by SACOME and put together by a committee of volunteers from different organisations who help to plan scenarios, organise adjudicators, put the timetable together as well as act as co-ordinators over the two days.

SACOME would like to thank the committee and especially recognise the efforts of Hillgrove Resources and their team for the incredible amount of work put in to make three events happen at the Kanmantoo mine site and Terramin Australia for their use of the Angas Zinc mine for teams to go underground for the search and

rescue event. Len Bately and his team from Fire & Rescue Australia also deserve special mention for their work in planning and providing on-ground support. SACOME would also like to acknowledge all the adjudicators and volunteers who gave up their time to help make the event such a success.

Building on the success of the last three years, SACOME is looking forward to hosting the event again in 2013 which will move back out to a more remote location.

Gold miners escape fire at Fosterville

About 30 miners were forced into rescue chambers when an underground fire broke out in the Fosterville Gold Mine. Two men experienced smoke inhalation during the fire which broke out about 450 metres underground in the mine about 2pm on 6th February.

Authorities believe an underground loader's hydraulic line burst and started the fire. Fosterville Gold Mine general manager Ian Holland said the incident triggered the site's emergency response procedures. "It is a crucial piece of equipment and all these types of machines have automatic fire suppression," he said. "That has been triggered but there was still smoke that came out. Two of our underground crew (were) exposed to some smoke inhalation. We triggered our emergency response plan and everyone else underground in the mine went into rescue chambers."

An Ambulance Victoria spokesman said paramedics treated the two men for smoke inhalation at ground level. He said neither men needed further treatment nor hospitalisation. About 26 miners remained in the rescue chambers until the smoke had cleared.

Mr Holland said night-shift workers started their shifts without delay. He said he was pleased with the organisation's emergency response to the fire. "We have a mine rescue team and we have our own fire fighting facilities – we have our own truck and everything is fitted with fire extinguishers. We dealt with it internally and other agencies responded and they were there to provide additional support."

Dogs join underground mine rescue

Animals have been used for centuries in mining, and until the fairly recent industrial revolution they were a very common sight on site. From pit ponies and mules through to dogs, all of them were used to pull carts in underground coal mines.

Dogs have made their way back onto the mine site through mine rescue. Search and rescue dogs are a common sight at disasters throughout Australia.

From finding Stuart Diver in the Thredbo landslide to aiding police missing person searches and body recovery, dogs have demonstrated time and time again their ability to find people.

Despite this, their use in the mining industry's rescue teams is almost completely unheard of. In fact, until a few months ago there was not anything like it at all. Earlier this year American coal miner Alpha Natural Resources unveiled a world first – Ginny, a Dutch Shepherd that has been specially trained to assist mine rescue teams in locating injured and trapped underground coal miners.

The idea for a mines rescue dog originated back in early 2010 during an Alpha meeting where the company asked employees to recommend ideas to improve its mine site rescue. By December 2102 a plan had come together outlining how the dog would work with mining teams and what it could provide. The dog itself, Ginny, was officially unveiled at the U.S.A. 2012 National Search and Rescue Conference in Nevada.

Bill Dotson, head of Applied K9 Technologies which trained Ginny, said the company used her natural hunting instincts to hunt for missing or trapped miners. While this part was fairly straightforward, the next part, getting her accustomed to operating in underground and open cut coal mines, dealing with heavy machinery and the general noise of mining operations, was much harder. Hartley said that training the dog for the mine site; considering how it would be effective on the mine; and the logistics of moving the dog and keeping it, would be the more difficult aspects.

While the dog is based in West Virginia, America's coal mining heartland, mines are still spread around the state. To overcome this distance issue the dog has been trained to travel by air to sites, either in aircraft or by a helicopter. Effectiveness on the mine itself is the major issue, especially considering the dog would be operating solo in a potentially dangerous mine site. The dog is trained to enter alone and find, then remain, with any injured or trapped miners and bark to draw the rescue teams to the miner.

To overcome many of the issues that the dog would face following an incident, Ginny wears a portable gas detector simulator and is trained to listen for the alarm it sounds when she enters areas with high levels of hazardous gases or low air quality. She is trained to react to the noise and leave the area immediately, which also acts as an early warning system for any rescue crews following her.

Ginny also wears a protective coat that shields her from scratches and scrapes from debris and broken equipment on the ground. The dog is also equipped with a lamp and camera that provides visuals back to her handler and the rest of the rescue team. It is trained to wear safety goggles and a rescue hood, which would be placed over her head in the case of emergency evacuations.

Currently the US Mine Safety and Health Administration (MHSA) is working with the miner on new procedures for the dog's operation on site as well as her equipment.

According to website Mineweb, trainer Bill Dotson has also had enquiries from unnamed Australian government agencies interested in rescue dogs.

According to Hartley, while the idea is interesting, Australia (fortunately) does not have enough significant events to keep the dog occupied or that would make it necessary during its life time, for example "our last major rescue event in Queensland was in 1994," he said.

That is a gap of nearly 20 years, much longer than the average dog's lifespan. He added that "there is no reason a mine rescue dog couldn't be used, and while it's not currently being considered in Queensland that is no reason to say it shouldn't be explored.

Australian company develops 60t u/g articulated mine truck

Australian company Powertrans has developed what is reckoned to be the world's most powerful u/g haul truck with a 60t payload.

A twin-engine, double-articulated mine truck designed and built in Australia is set to establish a new benchmark for underground haulage efficiency according to the developers. The brainchild of Scott McFarlane, Chief Engineer at Brisbane-based Powertrans, the new truck is powered by twin Cummins QSX15 engines.

Powertrans is the company that develops and builds the twin-engine Pit Hauler roadtrains that move large payloads – in excess of 400 t at a time – in mine applications in Western Australia. The new Powertrans underground truck is known as the DAT60 or 'Double Articulated Truck, 60 tonnes' and is the subject of an article in the first edition of the new *Cummins Mining Magazine,* published by Cummins South Pacific. The DAT60 is said to be the most powerful underground hauler on the market today with 1,100 hp available from its 15 litre QSK15 Cummins engines.

"It's all about faster haulage speeds...increased tonnes per kilometre," says Scott McFarlane. He points out the DAT60 was trialled at Newcrest's Cadia Valley Ridgeway mine in NSW and with a payload of 68 t, achieved 15 km/h on a 14% ramp gradient – evidence of its performance. "As underground mines go deeper this kind of performance takes on even greater significance," he says. McFarlane and the Powertrans team have worked closely with specialist underground mining contractor Byrnecut in the development of the DAT60, and Byrnecut has bought the first unit for operation at Newcrest's Telfer gold mine. It is understood that going forward, Byrnecut group affiliate Murray Engineering, which worked with Powertrans throughout the design and testing, will market and sell the truck, with Powertrans manufacturing it and providing ongoing support.

With an engine front and rear and a length of 13.4 m (3.3m high and 3.4m wide), the Powertrans truck is up to 2 m longer than its competitors. However, McFarlane argues that the extra length has no impact on manoeuvrability or swept path because of the double articulation of the DAT60. The Cummins QSX engines are both fitted with compression engine brakes retarding a total of 900 hp – significant braking effort that was fully tested at the Cadia mine with the DAT60 grossing around 108 t. "We tested the fully loaded DAT60 going down into the Cadia mine over a distance of six kilometres and the engine brakes held the truck with the transmissions in second gear," McFarlane points out. The Cummins QSX engines drive through Allison six-speed 4000-series transmissions to Kessler axles. The truck also has an innovative side-tipper devised by Powertrans.

Serviceability is another feature of the DAT60 with plenty of room in the engine bays for routine maintenance. Both engines are cooled by radiators with a 1.3 m^2 frontal area. Powertrans developed its own cab for the DAT60 as well as the custom dash display which incorporates two tachometres for the QSX engines. The cab has both ROPS and FOPS protection. A CAN Bus system is also used to significantly reduce electrical wiring.

Mine dewatering systems from Mono Pumps (Australia)

Mono Pumps mine dewatering pumps have been specifically modified in order to suit the arduous demands of underground mining applications. Mono Pumps (Australia) 's mine dewatering systems are based on rugged E-Range Flexishaft pumps that have been specifically modified to suit the demanding requirements of underground mining.

These mine dewatering pumps are available as a standalone unit, a traveller or a main pump station with multiple pumps. Mono Pumps (Australia) can design and supply dewatering packages with 1000V or 415V drives.

Additional features and benefits of Mono Pump Australia's mine dewatering systems include:

- Halar coated PowerDrive transmission with five year warranty
- standard 316 stainless steel hard chrome plated (HCP) rotor
- resilient, abrasion resistant synthetic rubber stator
- purpose built bearing housing for arduous mining environments with lip seals, lantern ring and continuous greasing facility
- unique gland arrangement which can offer up to three times the life on drive shaft wear; and
- heavy duty mine spec motors.

These mine dewatering pumps are available as a standalone unit, a traveller or a main pump station with multiple pumps. Mono Pumps (Australia) can design and supply dewatering packages with 1000V or 415V drives.

GE buys Australia's Industrea

General Electric Co. agreed to buy Industrea Ltd. for about A$470 million ($466 million) in cash to add mining equipment, technology and services businesses in China and Australia, the biggest exporter of coal and iron ore. The deal values Industrea's shares at A$1.27 ($1.26) each, 48 percent more than Tuesday's close, the Brisbane-based company said in a statement in May.

Buying Industrea will boost General Electric's sales in high growth regions in the $61 billion global mining equipment industry, gaining clients including BHP Billiton Ltd., Xstrata Plc and China Shenhua Energy Co.

"This is a step toward growing our presence in mining and it also grows our manufacturing base not only in the U.S. but in Australia as well," said Lorenzo Simonelli, chief executive officer of GE's transportation unit. "It's a growing marketplace that gives us a further advantage in diversifying our manufacturing footprint that we haven't really had."

GE said it's seeking $6 billion in work contracts out of Australia by the end of this decade as it taps the country's growing role as a supplier of natural resources. Its sales in Australia of equipment for customers ranging from energy producers to mining companies rose 67 percent to almost $3 billion last year, outpacing China and Latin America.

The acquisitions are part of the GE transportation business's expansion into mining equipment as it branches out from locomotives, which use similar technology. Demand for such equipment is growing worldwide as emerging markets seek more raw materials. The unit, which accounted for about 5 percent of $94 billion in industrial revenue last year, already makes motors that power the drive systems of large haulage mining trucks.

Industrea has negotiated the ability to sell its mining services unit separately, with the net proceeds going to shareholders, the company said in the statement. GE will retain the unit if the sale doesn't proceed, it said.

Brisbane leads mining technology charge

Brisbane has emerged as a major innovation hub for the mining services sector as miners look for new technology and solutions to boost productivity.

Underground mining contractor Mastermyne has begun building a dedicated training facility for underground miners which is a short drive from Brisbane's central business district. It will be among the first dedicated underground mining training facilities located within a major capital city.

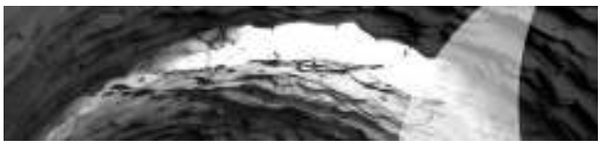
Mastermyne's chief executive Tony Caruso said the program is aimed at industrial electricians looking to move into the mining sector. "The worst of the skills shortage is yet to come and when you see the pipeline of projects that are coming through in Queensland and NSW, that skills shortage is only going to intensify," Mr Caruso said.

Mining technology, services and equipment industry representative group Austmine estimates that the sector exports $3.5 billion a year and has total annual revenue of $12 billion.

Many of the industry's leaders, including mining services groups mineral processing plant specialist Ausenco and coal contractor Sedgman, have opted to call Brisbane home.

Zimi Meka, CEO of engineering and construction firm Ausenco, said the firm is strongly focused on technology and innovation. "Technology and being innovative for me is key," he said. "That's going to keep our industry, the services industry, at the forefront. That's what we strive to do versus just providing more of the same."

Queensland's capital has also attracted the likes of international telecommunications provider Indigo Telecom, which provides voice and data technology to remote and regional areas across Australia. Indigo Telecom Australia's chief David Ruddiman said the company's research and development team is now based in Brisbane. "Around about 60 per cent of our capital expenditure is in research and development," Mr Ruddiman said. He said that Queensland is a growing market for the company's services.



GRANIT

Non-destructive testing of bolts and anchorages

The condition of a bolt or anchor beyond the head-plate is critical to its performance. However, a visual inspection will not provide a reliable evaluation of integrity, nor can it guarantee that a new installation meets its design parametres, on which long term durability and performance depend.

Traditional methods of testing rock bolts and cables commonly used in tunnel construction and mining projects are cumbersome, slow and, worst of all, may interfere with the integrity of the very anchorage they seek to prove. is a safe, reliable, easy to use and award-winning system for testing rock bolts and anchorages where safety and confidence are key issues.

At the 2010 New Civil Engineer (NCE) International Tunnelling awards in London, the Halcrow GRANIT system won the coveted Technical Innovation award. And at the 2011 Tunnels and

Tunnelling International awards GRANIT was highly commended.

How it works

GRANIT tests by sending a series of small controlled impulses through the rock bolt using an electronic solenoid.

Analysis of the captured response reveals defects such as reduced support element length, whether the support element's design or safe working load has been exceeded and potential corrosion issues along the bolt.

GRANIT's key characteristic is its ability to quantify support element bearing loads and identify defects using non-destructive test methods.

Crucial data is obtained without causing damage to the support elements or interface bonds allowing

individual bolts to be repeatedly monitored throughout their life.

Up to 100 support elements can be tested per shift. Once defects have been identified, a remedial program can be devised.

Newcastle's Convict Era Tunnel (c1816) and Brick Culvert (c1850s)

During his presentation at the 2012 National Trust Forum on Innovation and Invention Mr Bill Jordan presented a convict era tunnel dating from around 1816 that lies beneath Church Street, Newcastle. He believes that it is the oldest example of Australian civil engineering works still in use to this day and quite significant.

The convict hewn tunnel was used to drain the water from convict era mines out through the cliff face on south Newcastle Beach. It is still in operation to this day and displays sophisticated hydraulic knowledge in its construction and design.

Under the southern edge of Church Street, Newcastle, running between Newcomen and Watt Streets, outside the Courthouse and Police Station, runs a circular drainage culvert, built from two rings of brickwork. Examination of the bricks and mortar used indicates that it dates from about the middle of the 19th century.

The downstream end of the brick culvert discharges into a hewn rock tunnel, of similar size, which discharges from the cliff face above South Newcastle Beach. The hewn rock tunnel is believed to have been excavated by convict labour around 1816 to provide drainage for one of the first shaft mines established in Newcastle in the grounds of what is now the James Fletcher Hospital.

Sometime around 2008 a robot camera was sent through the tunnel to ascertain the level of maintenance repairs required to the convict structure.

Awakino Tunnel

The Awakino Gorge tunnel, SH3, New Zealand – an unlined single-lane tunnel approximately 50 metres long. According to maori legend, the rock promontory that the tunnel pierces is the remains of the en:Tainui waka.

Parramatta 1820s brick barrel drain

During the construction of the Ferguson Centre at 130 George Street, Parramatta. In 1981 excavation exposed a brick barrel drain from the Convict Lumber Yard, dated to the 1820s. This was the first archaeological site to be placed on display in the Parramatta CBD.

A complete section of the brick barrel drain, built in the 1820s from the Lumber Yard on Macquarie Street (now Arthur Phillip High School) to Parramatta River.

Elizabeth Street drain

Elizabeth Street is the lowest point in the Melbourne central business district, with land rising both to the east and west, and more gradually to the north. Since it is built on top of the historical site of a natural creek, it has suffered numerous floods in Melbourne's history. The Elizabeth Street drain runs from Carlton in the north to the Yarra River in the south, carrying stormwater from the inner northern suburbs and city centre.

Elizabeth Street is located in a small depression formed by the flowing of a creek named William's Creek that flowed into the Yarra. William's Creek was also known as Townend River, because most of the very early settlement was to the west of Elizabeth Street.

In 1840 Elizabeth Street along with Swanston Street was described as "... shallow gullies, with deep and dangerous ruts every 20 yards..." The condition of Elizabeth Street in winter was so bad that it was seriously proposed to establish a punt service to transport goods and passengers. It was reasonably common for pedestrians and horses to become bogged.

Work began on a proper drain in Elizabeth Street in 1841. At that time the inhabitants of Melbourne emptied their waste into cesspits, which were supposed to be properly built and lined, so that wastewater could not escape. However this was not often the case and in the early years before proper sewerage systems were installed, William's Creek was a very unpleasant watercourse. This creek also discharged into the Yarra, which was the town's source of drinking water.

Bid to reopen Albert Park tunnels

Two Aucklanders have their hearts set on re-opening air raid tunnels beneath Albert Park in a bid to preserve some of the city's history. But Auckland Council says the idea is unlikely to see the light of day anytime soon.

Bill Reid has been working on plans to re-open the tunnels for nearly 30 years and last year his quest was caught on film by Mark Howarth in a 10-minute documentary.

Reid and Howarth want tunnel five, which is at the end of Victoria St East, opened and for the first 25m to be excavated to create a museum depicting its history. The tunnels were built in 1942 to act as an air raid shelter for up to 22,000 Aucklanders during World War II. The 3.5km network was built in eight months by 114 men, using no machinery. But by the end of the war the timber supports in the tunnels began to show signs of deterioration so they were filled in with 8.8 million unfired clay bricks. The entrances were sealed in 1946.

Reid and Howarth met with Auckland Council's heritage department last month to put forward their proposal for a museum. However, an Auckland council spokeswoman said there were no plans to reopen the tunnels. Reid believes reopening the tunnels will preserve Auckland's "lost heritage" and the museum would.

Construction of the King William Road tunnel Adelaide 1855

"The progress of the works in connection with the intended bridge over the Torrens, and its southern approach, has been very rapid.

In less than three weeks several thousand cubic yards of earth have been removed, and employed in the formation required by the line of road from the Government domain to the river's edge.

Two massive parallel stone walls intersect this road embankment, and a platform thrown across the opening, leaves the requisite space for a cross road from east to west beneath the approach, which, being a continuation of King William-street, runs due north and south. Large quantities of stone are also being raised from the adjacent quarry ground and deposited near the site of the bridge, where a number of masons are engaged in dressing the material for the abutments on either side of the river. The wall enclosure on the west side of the domain has been partially removed and the available materials will be used on the new line."

THE APPROACH TO THE NEW CITY BRIDGE.—The progress of the works in connection with the intended bridge over the Torrens, and its southern approach, has been very rapid. In less than three weeks several thousand cubic yards of earth have been removed, and employed in the formation required by the line of road from the Government domain to the river's edge. Two massive parallel stone walls intersect this road embankment, and a platform thrown across the opening, leaves the requisite space for a cross road from east to west, beneath the approach, which, being a continuation of King William-street, runs due north and south. Large quantities of stone are also being raised from the adjacent quarry ground and deposited near the site of the bridge, where a number of masons are engaged in dressing the material for the abutments on either side of the river. The wall enclosure on the west side of the domain has been partially removed and the available materials will be used on the new line.

South Australian Register Saturday 6 January 1855 Page 2.

Hundreds tour Otago gorge tunnel

Organised as a fundraiser by the Cromwell Rotary Club, the tour of Brewery Creek downstream tunnel 650 attracted more than 500 visitors this year over two days. "It's been a busy time. We've had everyone from great-grandmothers to babies in arms through the tunnel," tour organiser and Cromwell Rotarian Bill Wilson said.

The tours had been held at Easter for about a decade, usually every second year to coincide with the Warbirds Over Wanaka International Airshow. "It's not just out-of-towners that come through, either. There's a lot of locals who say 'I've never been in these tunnels before and always wanted to see them'."

The 500m tunnel was built in 1990 and was one of the first used for investigation and drainage of the Brewery Creek landslip. It goes under the highway and into a rock face.

During the construction of the Clyde dam, numerous landslips were discovered along the proposed shoreline of Lake Dunstan and major remedial works were carried out at nine sites before the lake was filled.

Those works included a total of 18.5km of tunnels and 78km of drainage drilling. The aim was to offset the effects of lake-filling on the landslips. The tunnels and drain holes were built to drain groundwater within and below the landslip base and limit the rise in groundwater during lake fill. The tunnels were used for geological assessments of the landslips, to remove water, and to install equipment for long-term monitoring of the site.

Durie Hill Elevator Shaft and Tunnel

The Durie Hill Elevator, built to provide transport to and from Durie Hill in Wanganui, is a rare and innovative example of public transport. In 1910 Durie Hill became part of the Wanganui Borough, and the Council faced the problem of providing public transport to the settlement on the hill. A cable car system was initially proposed but found to be too expensive, and eventually an alternative solution, an elevator up through the hill, was agreed upon.

The complex, including elevator and tunnel, was originally designed by Messrs J. Ball and E. Crow and intended to be a public enterprise. However, Wanganui ratepayers were not prepared to take the bear the financial risk of the project, and a private company, the Durie Town Elevator Co., was formed to take over the scheme. The principals of this firm were Col. A. E. Wilson and W. J. Polson. Construction of the elevator began in 1916 by contractors Maxwell and Mann. This included the excavation of a tunnel (205m long, 3m high and 2.7m wide), and an elevator shaft (66m high), ending in a 9.7m flat-topped tower. The tunnel and shaft were lined with reinforced concrete. It was opened on 2 August 1919 by Mrs W. Polson. The maximum fares had been set by the Council at adults 4d up and 2d down, and children 3d up and 1d down. The original fare for twelve trips (six up and six down) was one shilling. Initially the elevator was powered by the tramway electricity supply of 500 volts D.C. When the tramway system was removed from the city, a rectifier was acquired to convert the A.C. current from the national electricity grid to the required 500 D.C.

The construction of the elevator enabled the development of the Durie Hill Garden Suburb in 1920. This suburb was planned by the architect Samuel Hurst Seager, and is considered to be the first modern New Zealand suburb. The elevator continued to be operated by the company until 1 June 1942 when control passed to the Wanganui City Council, which continues to operate the complex today.

The Durie Hill Elevator Shaft and Tunnel was a unique solution to the problems of providing public transport in the days before the motor vehicle was common-place. Its installation enabled the establishment of a new suburb. Today the elevator remains a popular form of transport both for the residents of Durie Hill and for tourists wishing to enjoy the views of the city of Wanganui, the Whanganui River, and beyond.

Mount Tarrengower Tunnelling Company Gold Mine

The Maldon quartz reefing field, although relatively small compared to others in the State, was extraordinary rich in gold. The hardness and heavy mineralisation of the rock mined put the field's mining companies in the vanguard for the use of new technology.

The Maldon quartz reefing field, although relatively small compared to others in the State, was extraordinary rich in gold. The hardness and heavy mineralisation of the rock mined put the field's mining companies in the vanguard for the use of new technology.

This site contains the tunnel or adit excavated by the Mount Tarrengower Tunnelling Company. This company was the first in Australia to use compressed air-driven rock drilling technology. The subsequent widespread adoption of this technology was a milestone in Australian underground mining. The Mount Tarrengower Tunnelling Company commenced mining operations at Maldon in 1865. Their tunnel was designed to cut reefs at a greater depth than any workings in the colony. That ambitious objective was hampered by the hardness of the rock, which made progress by tap and hammer very slow. In 1866, a Low's rock drill, manufactured at St Peter's Iron Works in Ipswich, was introduced. The company nonetheless failed to find payable gold and was wound up in 1870. The fate of the rock-drill is not known.

The Mount Tarrengower Tunnelling Company Gold Mine is of historical, archaeological and scientific importance to the State of Victoria.

The Mount Tarrengower Tunnelling Company Gold Mine is historically and scientifically important as a characteristic example of an important form of gold mining. Gold mining sites are of crucial importance for the pivotal role they have played since 1851 in the development of Victoria. As well as being a significant producer of Victoria's nineteenth century wealth, quartz mining, with its intensive reliance on machinery, played an important role in the development of Victorian manufacturing industry. The Mount Tarrengower Tunnelling Company's Gold Mine is important as a manifestation of this aspect of gold mining.

The Mount Tarrengower Tunnelling Company Gold Mine is a significant historic location where the first compressed air-driven rock drill in Australia was used. Although the technology did not prove successful in that instance, a decade or so later the rock drill revolutionised underground mining in Australia and, in doing so, reversed the fortunes of many a declining goldfield. The rock drill also brought a social cost in the form of the deadly lung disease, phthisis, known euphemistically as 'miners? complaint'.

Wolgan Valley Railway

Following the discovery of kerosene shale at Newness, attention turned to how the processed products could be economically transported to markets. As the Wolgan Valley is hemmed in by sandstone cliffs, this was not easy.

Engineer Henry Deane not only did it, but surprised the sceptics by using standard gauge, thus making the wagons compatible with the main line to Sydney.

The railway route descends through Penrose (now Tunnel) Gorge, passing through two tunnels and sharing a 6m (2o') wide chasm with the creek, before emerging into the Wolgan Valley.

Happy Valley Reservoir Tunnel

Happy Valley Reservoir was built between 1892 and 1897 at a cost of $1.8 million it was the third reservoir constructed in South Australia. It acts as a 'holding pond' for water directed to it from the Clarendon Weir via a five km long underground tunnel.

The 1.8 m diameter tunnel was bored simultaneously from both ends and when meeting had a deviation of 25 mm. Its deepest point underground is 122 m where it passes through a hill. On 7 August 1896 the tunnel's inlet valve was opened by the Governor of South Australia, Sir Thomas Fowl Buxton and the reservoir began filling

The tunnel inlet and outlet, which links Clarendon to the Happy Valley reservoir, are constructed of red brick. The original tunnel is no longer in use, and has been replaced by a newer tunnel adjacent.

The reservoir tunnel was constructed in the period 1892–1897 and built by the SA Engineer-in-Chief's Department. The construction of a reservoir at Happy Valley was the outcome of an 1888 Royal Commission appointed to examine water supply in metropolitan Adelaide. In 1891 Mr Oswald Brown (formerly a hydraulic engineer for SA from 1878 – 1882) was requested to return from England to advise on the matter. On 19 December 1891 he proposed the Happy Valley location and following such the Happy Valley Reservoir Act was assented to. The creation of the Act had the effect of linking, in a legislative sense, the Happy Valley Reservoir with the provision for water catchment at Clarendon where water was diverted by tunnel to Happy Valley.

The tunnel inlet and outlet, which links Clarendon to the Happy Valley reservoir, are constructed of red brick.

Smuggler Tunnels on the Hawkesbury

There have long been stories in the Hawkesbury that the Macquarie Arms Hotel at Windsor, which dates from 1815 in Governor Lachlan Macquarie's time, is reputed to have a tunnel to the Hawkesbury River built for the purpose of smuggling.

R. M. Arndell, in his book *Pioneers of Portland Head*, first published in 1976, recounted that a rumour of an 8ft. x 10ft. brick tunnel was built from the river to Andrew Thompson's store to deliver the casks of "illicitly brewed" rum from Thompson's and Solomon Wiseman's still on Scotland Island into the stores cellars. Arndell reported a similar tunnel which led from another hotel opposite the foot of Baker Street, on the south side of Macquarie Street, to South Creek.

Tales of such tunnels seem to abound for there is also reputed to be a tunnel linking the Macquarie Arms Inn, previously known as the Blight on Arms, at Pitt Town to the Bird in Hand Inn. The exact location of the supposed tunnel, and its purpose, remain a mystery.

Tales of the *"Rum Smugglers' Tunnel"* can be traced back to the early days of the Hawkesbury. It was discussed by George Reeve in the *Windsor and Richmond Gazette of 18th January, 1924*:

Come we now to John Howe's being the trusted clerk for Emancipist Andrew Thompson. I will go back to a period of about 10 months before Thompson's death. It would appear that Thompson's many ventures and interests were growing too fast for him alone to handle. For in the 'Sydney Gazette' of December 3rd, 1809, appears the following advertisement:

A large bricked 8 x 10 conduit or tunnel leading from where Thompson's store site was to the river, parts of which can still be seen by an observant eye is considered to have been constructed specially to draw up the barrels containing the rum which was illicitly manufactured on a wholesale scale on Scotland Island, Thompson's vessels bringing the grog to the foot of Thompson Square, near the old Windsor wharf. This appears to be the real reason for the construction of the underground brick tunnel, which most people erroneously think was a drain to carry away waste water from the old gaol.

Old Sydney sewers – drill and blast tunnels

In the 1950s through to the 1970s many kms of tunnels were excavated across Greater Sydney to create an intense network of sewers to serve to ever expanding urbanisation. Today over 1.3 billion litres of wastewater is collected by a network of 24,000 km of sewers which still includes many kms of these old rock tunnels.

The tunnels are generally either rectangular or arch shaped about 1.2m wide and about 1.7m high with a concrete floor sometimes with a half pipe and low concrete benches about 200 to 500mm high.

The tunnels are mostly in Hawkesbury Sandstone and are generally unlined with fully lined sections through areas of poor ground. Shotcrete or PAM (Pneumatically applied mortar) is generally limited to sections of shale. With the small spans, rockbolts are relatively infrequent, although in some of the larger tunnels with spans up to 2m or more in well bedded strata rockbolts are more frequent with their heads generally protected in by cement mortar.

The tunnels are generally in very good condition. There is strong evidence of half barrels in the roof and shoulders suggesting controlled blasting techniques were used. The tunnels are inspected by Sydney Water on a frequent basis determined by their condition and age.

Manila war tunnel becomes tourist site

The Armed Forces of the Philippines (AFP) have lauded the efforts of the Bases Conversion and Development Authority (BCDA) to transform the Fort Bonifacio Tunnel into a heritage site to honour the nation's unheralded patriots who sacrificed their lives in pursuit of independence and freedom.

Col. Arnulfo Burgos Jr., AFP spokesperson, said that the Fort Bonifacio Tunnel is an underground passageway located in the eastern portion of Bonifacio Global City (BGC) in Taguig. It used to be the main attraction of the old Philippine Army Museum and Library (PAML) which was relocated as a result of the developments made by the BCDA in the area.

According to BCDA, the project of "transforming the war tunnel into a historical site is part of giving back the honour and dignity to the soldiers in the AFP who are the unsung heroes of our republic, continuously serving the Filipino people to maintain peace and order."

The Fort Bonifacio Tunnel was constructed almost simultaneously with the Fort William McKinley (now known as Fort Bonifacio) around 1910 and took almost a decade before being completed. This was prior to Gen. Douglas MacArthur's assumption as the Field Marshal of the Philippine Army, therefore it was not MacArthur who instructed the tunnel's construction. The tunnel served as the main supply depot of the northern and southern operations of the U.S. forces against the Filipino revolutionaries. Most of the tunnel's labourers came from the mining firms in Baguio and Benguet, while the others were Japanese labourers who were later discovered as soldiers spying for the Japanese military.

The original tunnel's length was about 2.24 kilometres with 32 built-in chambers and two passable exits, one leading to Barangay Pembo and the other to Barangay East Rembo. Today only a 730-metre segment of the tunnel remains unaffected, existing underneath the C-5 Road, with its opening near the Market. The tunnel serves as an underground pathway and can be found at the eastern portion of BGC.

The Philippine Army celebrated its 115th founding anniversary on March 22nd 2012. The war tunnel plays an important part in the Army's rich history as it traces its roots to the Filipino revolutionaries who resisted allegiance to foreign rule.

LEGACY OF VINH MOC TUNNELS

One of the entrances to Vinh Moc Tunnels.

Family shelter inside the tunnel.

In February 1966, the North Vietnamese began building a tunnel to transport weapons, equipment and people to South Vietnam. The American forces believed the villagers of Vinh Moc were supplying food and armaments to the North Vietnamese garrison on the island of Con Co which hindered the American bombers on their way to bomb Hanoi. They responded by targeting Vinh Moc with some of the fiercest bombing of the Vietnam War. From all accounts, the Americans dropped more than 9,000 tonnes of bombs on the village in over 1,000 raids.

Rather than flee their ancestral village, the villagers dug a series of tunnels and moved their entire communities underground. They constructed more than 50 tunnels and dumped 6,000 cubic metres of dirt into the sea. For two years, 250 people dug more than 2km of tunnel, which housed all 600 villagers over varying periods, from early 1967 until 1972. They survived, and even prospered in their makeshift underground community. The tunnels were constructed on three levels at depths of 10, 15 and 20 metres, with good ventilation, freshwater wells and, eventually, a generator and lights. Hidden by dense vegetation, escape routes led from the living quarters and emerged just a few metres from the shore.

In 1972, the villagers of Vinh Moc abandoned their underground existence and rebuilt their homes, rejoined by relatives from other parts of the country. No casualties were reported through the fierce years of war, highlighting the great value and significance of the tunnels. The only direct hit was from a bomb that failed to explode; the resulting hole was utilized as a ventilation shaft.

Today, the tunnels of Vinh Moc have become both historical evidence and a tourist destination for those who want to discover a heroic period of Vietnam's modern history, and can be visited on a half-day trip from Hue.

The tunnels have been renovated to make them safer and more comfortable, with wider entrances, higher ceilings, smoother walls and better steps.

A museum at the entrance houses photos of life among the tunnel families, as well as maps of their labyrinths and tools from excavation of the site. One of the most interesting is the Vinh Moc nursery photograph where seventeen children were born underground during the war.

Woman draws water from a well inside the tunnel.

Maternity room.

Children born inside Vinh Moc Tunnels pose for a picture after the war.

ATS Victorian Group Report

Despite the distractions and commitments required for the organisation of this year's Tunnelling Short Course, the Victorian Group has continued to provide a worthwhile and interesting program of technical sessions for the benefit of our members. The technical sessions have continued to draw good crowds, the best example being on a future Melbourne project that was a sell out and standing room only.

Our February session on durability in the tunnelling environment by Frank Papworth and Ike Solomon was very well received, including significant interest from Civil College members. The March session presented by Craig Harrison of McConnell Dowell on the challenges of their Philippines Hydro project was also popular and has subsequently seen a wider audience at other Chapters. April's session was a joint affair between Andrew Banks of Winslow and David Medcalf of John Holland on two pipe jack tunnel projects, clearly a tunnelling methodology that we have not had on our agenda for some time.

An extreme change of scale but also employing some pipe jacking was the May session on the jacked boxes from the Airport Link project, presented by Jeremy Kruger. This proved to be a fascinating presentation with a very lengthy question time. The June session was our annual joint meeting with the AGS on the topic Groundwater Issues relating to tunnelling. The joint speakers were Dr Harry Asche from Aurecon and Mike Dudding from SKM and this night was again well received by very close to a full house. Then July saw a presentation of the geotechnical modelling for the future Melbourne metro project presented by Tony Bennett from Aurecon, Stephen Barrett and Darren Paul from Golders. As mentioned above, the large crowd recognised the desire by industry generally for another major tunnelling project in Melbourne.

The remainder of our technical program for 2012 is well advanced is on schedule for the remainder of the year being as follows.

29th August 2012	Design and Construction of Mined tunnels at Kedron, Airport Link
25th September 2012	Tunnel Visions – Distortions form Around the World (presented by Arnold Dix in conjunction with the Tunnel Short Course)
31st October 2012	Our AGM evening
28th November 2012	Mines of the Future" (Rio Tinto Program)

The Tunnelling Short course organisation is now at the pointy end with a month to go. Sponsorship is full and Registrations are close to the planned target, with the expectation that there will more to come as registrations close. Speaker papers are all on the way and the final administrative arrangements are being undertaken by AusIMM in their usual efficient and professional manner.

Ed Taylor
Victorian Group Chair

ATS WA Chapter Report

This year, the WA Chapter has held 2 technical sessions:

- 18 June – Jurong Cavern Project, Singapore (Matthew Ross, BASF)
- 10 July – Tunnels To And Under Airports (Ted Nye, Mott McDonald), joint session with AGS

The Public Transport Authority of Western Australia **Perth City Link Rail Project** involves lowering the Fremantle rail lines into a 600m long cut and cover tunnel within 1.3m distance above the existing Joondalup line bored tunnels, eventually to be followed by lowering of the Wellington Street Bus Station underground to enable redevelopment of the Perth Rail Yard land for public open space, residential and commercial towers and other civic developments. The first stage of the project, lowering the Perth to Fremantle rail lines and constructing a pedestrian tunnel under the Perth Central Station heritage buildings, platforms and tracks commenced in March 2011 and is being undertaken by the Perth City Link Rail Alliance (John Holland-GHD-PTA), with foundation works in full swing. Project completion is scheduled for mid-2014.

A contract for a 2.0m diameter TBM pipe jack tunnel approximately1.2km long with water depth at the recovery site of around 20m was awarded to Thiess Tunnelling in December 2011 for $60m for the **Wheatstone LNG project**. Construction is due to start on site in May 2013 and be completed by November 2013.

The WA Chapter Committee comprises 7 members (Craig Adamson, Mike Bluck, Richard Douglas, Gary Goodall, Eric Hudson-Smith, Peter McGough and Barry Moore) and meets monthly. The Chapter has over 60 individual members plus 6 company memberships registered in WA.

Eric Hudson-Smith
WA Group Chair

ATS Queensland Group Report

After the opening of the Northern busway on June 18th, the Airport link tunnels, an unprecedented piece of infrastructure for Australia opened on the night of July 24th.

A few weeks later, the first TBM started its long journey on the Legacy Way project.

While the fate of the $8B Cross River Rail project rests, quiet, in the hands of the newly elected state government, a couple of undersea tunnel projects opportunities are further being developed to deliver coal seam gas to Curtis Island in Gladstone.

Technical Activities 2012

Since June, we have held the following technical sessions:

Date	Title	Attendance
June 2012	Specification and Performance of Steel Fibre Reinforced Concrete	70
July 2012	Sydney M2 Motorway Tunnel Widening	65
August 2012	Bulimba Creek Sewer Update	80
September 2012	Managing the O&M at CLEM7	–

The committee is putting all efforts in ensuring a technical presentation every month.

Other Activities

The committee has attended two successful information sessions among geotechnical and civil engineering students at the University of Queensland to promote our tunnelling industry among future professionals.

On October 12, the 3d ATS QLD charity golf event will be held in St Lucia.

Christophe Bragard
Queensland Group Chair

ATS Sydney Group Report

The Sydney Group is having a successful year with attendances at technical meetings slightly up on last year.

Tunnel activity in Sydney is likely to increase significantly with the tender list to be determined shortly for the North West Rail Link.

The Opera VAPS project is well underway and the announcement of the winning tender for the Wynyard Walk project should have been announced by the time you read this.

The widening of the east bound M2 tunnel has been completed with excavation of the west bound tunnel to commence in October. The last technical session of the year will be on this project.

In September 2014, the 15th Australasian Tunnelling Conference will be held in Sydney. So I would again encourage all those potential paper writers and speakers out there to put this in your diary.

Ted Nye
Sydney Group Chair

National Tunnelling Code of Practice

ATS Response to ACCI, April 2012

Context

The Australian Chamber of Commerce and Industry (ACCI) is undertaking an initial scoping exercise on behalf of industry in response to the proposed new National Tunnelling Code of Practice (NTCOP).

ACCI have forwarded a document to the Australasian Tunnelling Society (ATS) which appears to mirror the recently amended Queensland Tunnelling Code of Practice (QTCOP) and requested that ATS provide a response regarding the suitability of this document as the basis for a NTCOP.

Background

In October 2011, the Queensland Chapter of the ATS was contacted by Workplace Health & Safety Queensland (WHSQ) and was invited to comment on a number of proposed amendments to the QTCOP. The original QTCOP was based on a similar document adopted by NSW in 2007.

WHSQ indicated that they had decided to use the national harmonisation process as an opportunity to make some changes to their code at the same time. The ATS response to the initial draft was prepared over a week and identified several key issues of concern including the linking of the QTCOP to the Confined Spaces Code (this link was subsequently removed).

In January 2012 the Queensland Government approved a series of amendments to the code. These changes included areas such as emergency planning, risk management, air quality (including diesel emissions), fire and explosion, communications and a number of other areas affecting construction of underground works. The new QTCOP is now up and running in Queensland. In March 2012 the ATS became aware of a proposal to use the revised QTCOP as the basis for a new NTCOP.

The Australian Chamber of Commerce and Industry (ACCI) is undertaking an initial scoping exercise on behalf of industry in response to the proposed new National Tunnelling Code of Practice (NTCOP).

ATS Response

The ATS strongly supports the proposal to create a National Tunnelling Code of Practice. ATS were heavily involved in the preparation of the original NSW COP in 2006 which was subsequently also adopted by Queensland. This code has operated successfully in Queensland and NSW for the past 5 years and it is entirely appropriate that this document be used as the template for a NTCOP.

It is important that a National Tunnelling COP includes a definition of tunnels and is applicable to all forms of tunnel construction including smaller tunnels for water, sewerage, services and the like. In the opinion of the ATS, some of the recent amendments to the QTCOP have the potential to destabilise the pursuit of a NTCOP due to their contentious nature. The amendments appear to have been made in hasty response to issues arising out of large road tunnels currently being constructed in Brisbane and in a number of instances appear to revert to prescriptive practices common in the underground mining industry. This is an inappropriate basis for a National tunnelling code.

A specific example of a contentious issue within the recent QTCOP amendments is the requirement for escape routes. This inclusion is completely impractical and would preclude a large proportion of all the past and future tunnels from ever being built. Refer the requirement for Escape Routes on page 24:

> *"An alternative escape route for tunnel workers must be available. Examples of escape routes include connected parallel tunnels, return airways or exhaust shafts".*

There are also a number of ambiguous statements regarding the use of self rescuers, refuge chambers, cap lamps and others.

Conclusion

The ATS considers that the creation of a NTCOP would be a positive step for the Australian tunnelling industry and that the NSW and Queensland codes should be used as the templates for this new code.

The ATS also considers that recent amendments to the QTCOP should be isolated from this base document and considered individually as to their suitability for a NTCOP.

The draft Guide for Tunnelling Work can now be viewed on the Safe Work Australia website:

http://www.safeworkaustralia.gov.au/sites/SWA/Legislation/PublicComment/Documents/Fourth-Set-Codes-of-Practice/Guides-4th-set/Tunnelling_Work_Guide.pdf

A further submission was made in June 2012 which included:

1. Individual reviews & comments from various ATS members
2. A marked up version of the document which addresses design issues and suggests rewording

And the following summary:

Australasian Tunnelling Society (ATS)

Response to the Draft Tunnel Guide (version June 2012)

Criteria	Response
Is it helpful and easy to understand	Yes, the Guide is generally helpful and easy to understand. It still contains some repetition which should be addressed at the next opportunity. It also contains numerous spelling and grammatical errors which we assume will be corrected prior to release.
Does it reflects current state of knowledge and technological developments in relation to managing risks associated with tunnelling	Generally yes, however there are two areas where it is clearly deficient: • Use of Tunnel boring machines (TBM's) • Soft ground tunnelling Furthermore it contains incorrect statements about drill & blast, ground freezing and compressed air not being widely used. These methodologies are all used in Australian tunnelling, especially drill & blast.
Does it have an appropriate level of information or is it too detailed	The level of information is generally appropriate. Need to eliminate repetition.
Should it be developed as a code of practice rather than a guide	ATS considers it a retrograde step for the previous Code (NSW & Qld) to now revert to a Guide. Such a move can only lessen its' effectiveness in providing a safe workplace. No explanation has ever been provided to us for why this has occurred.
Does it require additional examples or case studies to provide clarification.	No

We have attached several documents and extracts from various sources within the ATS. It is acknowledged that many of the issues raised cannot be fixed quickly and need to be addressed in the future.

ATS SUBMISSION TO PIKE RIVER ROYAL COMMISSION

INTRODUCTION

The Australasian Tunnelling Society (ATS), operating under the auspices of Engineers Australia and the Institution of Professional Engineers New Zealand, is a learned society which represents the interests of civil engineering construction and other disciplines in the underground environment across the Australasia region and indirectly in New Zealand through the NZ Chapter.

This submission has been prepared by the ATS to represent the views of the tunnelling industry with respect to possible regulatory changes and to highlight the important differences between mining and civil engineering construction activities in the underground environment.

MINING REGULATION AND RECOGNISED PRACTICES

Comparators

New Zealand boasts a proud history of major tunnelling projects covering well over a half century (road and rail tunnels, extensive hydro tunnels, underground power stations; tunnelling on the Tongariro scheme spanned 20+ years between the 1960s and 1980s, the initial Manapouri Hydo scheme the 1960s, Clyde scheme 1980s, Manapouri second tailrace tunnel 1990's).

Whilst the current Mining – Underground Regulations and the Mining Administration regulations consider tunnelling in a civil engineering context, the regulations are in some aspects limited by the methods of tunnelling available at the time of their production. Anecdotal evidence from seasoned practitioners is that prior to the H&S Act, tunnelling was covered under the Tunnel Safety Regulations. Mines were covered under the Mine Safety Regulations. It appears that they may have had their own Acts. The old Mines Inspectorate administered both Mines and Tunnels at that time. In our view, the current regulatory environment does not adequately differentiate between civil engineering tunnelling and underground works and mining underground works. Some overseas jurisdictions have a much larger civil engineering tunnelling industry and as a result have developed specific regulations and codes of practice to administer this section of the industry quite separately from the mining and extractive industries. This differentiation between mining and civil has been further supported by substantial international involvement in areas such as insurance and risk management for civil tunnel construction.

The ATS is concerned that potential significant changes to legislation or mining regulation that eventuate from the findings of the Royal Commission of Inquiry into the Pike River Accident could be applied globally across all underground work. There are likely to be aspects that are not applicable to civil tunnel construction, and these could result in perverse outcomes for the civil engineering and tunnelling industry at a time when New Zealand is seeing increased growth in the use of underground space.

The ATS would therefore propose that in addition to considering practices in Australia, the Royal Commission also considers the following:

1. BS 6164:2011 – Code of Practice for Health and Safety in Tunnelling in the Construction Industry.
2. The Joint Code of Practice for Risk Management of Tunnel Works in the UK (Published by the British Tunnelling Society and the Association of British Insurers) and particularly the subsequent international version published by the International Tunnel Insurance Group (ITIG) and the International Tunnelling Association (ITA).

These documents reflect 'best practice' from one of the world's most mature tunnelling industries with the former being first published in 1982 and the latter having been introduced to the UK tunnelling industry in 2003.

It should also be noted that the Joint Code of Practice for Risk Management of Tunnel Works has subsequently been redrafted in an international form by the ITA and International Tunnel Insurance Group with the intention of providing a document that could be applied internationally, and this document has been applied in NZ in recent projects.

BS 6164 has enjoyed a long history of application and development and has already been incorporated into in the specifications of a number of projects in New Zealand, including the current Waterview Connection Project which is presently the largest tunnel construction project in Australasia.

The MinEx Health and Safety Council also reference BS 6164 in their Industry Code of Practice for Underground Mining and Tunnelling (October 2009) as being "a good guide to sound TBM tunnelling practices". [TBM: tunnel boring machine]

The nature and form of regulatory arrangements

The ATS recognises the opportunity for improvement of the current regulations in New Zealand, and also recognises the need for proper implementation of the regulations in their current form.

The current regulations have already been supplemented with the MinEx Code of practice for Underground Mining and Tunnelling and many tunnelling projects in New Zealand have adopted BS 6164 – Code of Practice for Health and Safety in Tunnelling in the Construction Industry and the ITA/ITIG Code of Practice for Risk Management of Tunnel Works through specification in contract documents. This has been done for a number of reasons, not only to meet perceived gaps in local codes of practice, but also at the request of international insurers.

Mining and civil works have greatly differing design-life requirements. The functionality requirements are totally different. The underground occupancy and people demographics in an operational mine compared to a tunnel under construction differ greatly. The construction methods can be completely different, especially since the advent of mechanical tunnelling using tunnel boring machines TBM's). It is the view of the ATS that the implementation of prescriptive regulation globally across all underground work in New Zealand could result in unintended outcomes in the tunnelling industry that prevent projects from being constructed practically and efficiently.

To illustrate this, three examples are proffered:

Inundation risk as addressed by the current regulations and by modern tunnelling practice. The current regulations address the risk through an assumed open face (mining) excavation method (common to the mining environment). In civil engineering tunnels, the use of a closed face TBM as opposed to conventional "open face" tunnelling is often adopted specifically to mitigate the risk identified in the current Mining – Underground Regulations at Clause 27 (Protection against inundation) negating the stated requirement to provide additional works to ensure the safety of the employees. This is important where TBMs are used to tunnel in conditions that would be unsuitable for conventional "open face" methods that also preclude the development of such additional workings as identified in Clause 27.

Egress Options. The second example touches on risk mitigation through multiple lines of defence; in mining, specifically by providing multiple egress options. In a civil tunnel, which invariably is a conduit providing an underground link between two surface points, having multiple exits is seldom practicable during the construction phase (e.g a tunnel under a lake or harbour). Alternative risk mitigation methods are therefore required.

Gassy Environment. Noxious and explosive gasses are a significant issue in coal mines but are seldom encountered and thus rarely an issue in civil engineering tunnelling.

For the purposes of tunnelling and underground construction for civil engineering, the ATS would prefer to see a '*safety case*' approach applied to regulation that allowed for the project to be assessed as a whole based on the geological conditions and the construction methods to be utilised. This would start with a safety in design approach, currently absent from New Zealand construction regulation, and move into the development of appropriate construction methods taking into consideration the risks associated with the project and applying international best practice to mitigate such risks as described in documents such as the MinEx code of practice and BS 6164. In time it might be appropriate for the New Zealand Industry to develop a more complete code of practice for tunnelling works, however, in most cases existing codes are able to be used within the New Zealand regulatory environment. Where conflict occurs between regulations and an international code the regulation must be followed and this is an approach used on a number of current projects.

It is the view of the ATS that civil tunnelling and underground construction should at least in part have separate trains of regulatory requirements or be regulated separately from mining as is the case in some other jurisdictions.

The establishment of regulatory arrangements

As previously discussed care must be exercised in developing regulations to ensure that they do not unintentionally impact other similar sectors.

In establishing regulatory arrangements it would be the expectation of the ATS that industry consultation with a range of stakeholders would be incorporated and that this would include organisations such as the ATS, the New Zealand Contractors Federation and the Association of Consultant Engineers New Zealand to ensure that appropriate consideration is given to the impact of regulations on tunnelling and underground construction for civil engineering works.

The interaction between mining regulation and recognized practices and other legal requirements

It has been the experience of the ATS that in other jurisdictions professional bodies and learned societies have worked closely with enforcement agencies to develop recognised codes of practice that support the legislative and regulatory requirements of the specific industry sector. With respect to tunnelling and underground work the in the UK, the Health and Safety Executive has representation at committee level within the British Tunnelling Society to work together with the industry to develop best practice.

The resourcing and administration of the regulators of mining law and practice

The establishment of a High Hazards Unit would allow for the introduction of expertise into the Department of Labour in key areas. Whilst the ATS would support greater technical expertise within the Department of Labour, we caution the risk of developing a mining bias which may negatively impact tunnelling and underground construction.

The provision of a unit that is engaged with the tunnelling and underground construction industry is vital in ensuring that best practice for a growing sector of the New Zealand construction market can be developed and implemented appropriately. Utilisation of underground space is becoming increasingly important in order that environmental impacts be minimised and mitigated.

As previously mentioned this is addressed in other jurisdictions by the establishment of industry working groups and close relationships with appropriate specialist bodies.

It should be noted that in other jurisdictions extractive industries and the civil engineering underground industry are often covered by separate regulations due to the significant differences between these industries. Anecdotal evidence suggests this was the practice in New Zealand prior to the Health and Safety Act. If a major

revision of the regulations flows from the extremely sad event under enquiry, it is likely to be beneficial for two streams of regulation to be prepared to cover actual current practices in the two distinct fields.

CONCLUSION

The ATS is dedicated to improving safety in tunnelling and underground construction. It is the concern of this body that any changes in legislation aimed simply at mining, specifically coal mining, may have an adverse impact on other similar industry sectors.

The ATS would encourage the Royal Commission to consider how mining and tunnelling and underground construction vary and to examine the manner in which the civil engineering tunnelling industry is already implementing best practice on recently constructed tunnelling projects within NZ, and within an international market, affected by international best practice imposed not only by legislation, but by codes of practice and principles established by learned societies, field experts and insurers.

NZ South Island West Coast to get mining school

Degrees in mining will be offered by West Coast's Tai Poutini Polytechnic as part of its new School of Mining. The polytechnic has announced it plans to establish the school to boost access to industry training because of an acute shortage of trained professionals in mining nationwide.

''The extractive industry is strong and growing but there is a severe shortage of trained staff and the industry tells us they need this sort of school to meet their training needs,'' polytechnic board chairman Graeme McNally said.

It would start next year (2013) and would offer training at multiple sites around the country, including the West Coast, and would access Australian courses and expertise, particularly for the degree programme.

The move comes at a time when the New Zealand economy increasingly relies on the minerals industry for export earnings. West Coast mining was worth close to a billion dollars to the national economy, employing 5000 people directly and indirectly.

Minerals West Coast manager Peter O'Sullivan said the school was an exciting initiative.

A lack of suitable training for miners was raised as an issue during the royal commission's public hearings last July.

Cross City Tunnel lends a hand in the local community

The Cross City Tunnel is pleased to announce the renewal of its three-year, $375,000 Community Sponsorship Program with local community charities OzHarvest and Circles of Learning.

Extending the partnerships with both charities for another three years takes Cross City Tunnel's support to a six-year partnership in total..

The impact of the Cross City Tunnel's sponsorship on OzHarvest continues to grow, with 155,000 meals delivered in 2012 as a direct result of their investment in Project Woolloomooloo.

Project Woolloomooloo involves OzHarvest collecting high quality, excess food from local restaurants, shops, catering companies and retailers such as Bourke Street Bakery, Harris Farm, Harry's Café de Wheels, local supermarkets and fruit & vegetable shops and delivering it to charities that feed low income families, the homeless and disadvantaged in Woolloomooloo, Darlinghurst, Potts Point and Kings Cross.

Through Circles of Learning, the Cross City Tunnel gifts The Clever Kid Health & Play program to schools and pre-schools in the Inner West and Eastern Suburbs. The program helps develop whole brain learning and raise children's learning abilities and calm behaviour. Up to 500 children will participate in the program through twenty five pre-schools and schools this year.

Cross City Tunnel CEO Ken Dawson said he was extremely pleased to be involved in projects that were making such a practical difference to the lives of so many in the local area.

For further information please contact Lucy Mudd, 0402 106 613.

Atlas Copco to launch underground 'app'

Atlas Copco's Underground Rock Excavation division has launched an 'app' to exploit the proliferation of smart phones, tablets and other hand-held devices.

The app will give customers fast and free access to the company's range of underground face drilling rigs, loaders, trucks and other equipment. Equipment can be viewed in high resolution and from all angles. Users will also be able to access technical data and video, case studies and a social news flow.

The app was available from the Apple App Store from the end of April and from Google Play from the end of May.

THE DAVID SUGDEN YOUNG ENGINEERS WRITING AWARD 2013

SPONSORED BY ATS

Win a chance to attend the 2014 ITA World Tunnel Congress in Iguassu Falls, Brazil with accommodation

- The competition is open to all ATS Members and University Students under 35 years of age (as at 30 June, 2013)
- The task is to write a technical paper on any subject related to tunnelling and underground construction — not less than 2,000 words and not more than 5,000 words.
- Best paper to be judged by the ATS Executive Committee.
- Closing date 30th June 2013
- Winner announced by 31 August, 2013
- The prize includes complimentary conference registration fees and $2,000 towards personal travel and accommodation costs at the ITA World Tunnel Congress to be held in Iguassu Falls, Brazil from 9–14 May 2014.

The winner may also be asked to be part of the ATS National Committee as the Young Engineers Representative.

For more information contact Sheryl Harrington at the ATS Secretariat
Phone 1300 653 113 — Email: sharrington@engineersaustralia.org.au

Five Australian and one NZ tunnel in Top 25 Global Tunnel Projects

The Top 25 Global Tunnel Projects: Project Guide' contains information on the Scope of the top 25 tunnel projects construction projects including project overviews and locations. The report also details project ownership and funding, gives full project descriptions, as well as information on contracts, tendering and key project contacts.

'The Top 25 Global Tunnel Projects: Project Guide' is part of World Market Intelligence's database of 25,000+ construction projects. Our database includes a 10+ year archive of completed projects, full coverage of all global projects with a value greater than $50 million and key contact details for project managers, owners, consultants, contractors and bidders.

WMI's 'The Top 25 Global Tunnel Projects: Project Guide' report utilizes a wide range of primary and secondary sources, which are analysed and presented in a consistent and easily accessible format. WMI strictly follows a standardized research methodology to ensure high levels of data quality and these characteristics guarantee a unique report.

Scope

This report provides details on the global top 25 tunnel projects including:

- Top 25 tunnel projects in infrastructure construction
- Project description, overview and location of each individual project
- Ownership structure, funding status and key funding news for each individual project
- Information on related projects and tendering information
- Key project contact details

Projects include

South Korea-China Underwater Train Tunnel, South Korea-Japan Underwater Train Tunnel, Sacramento-San Joaquin River Delta Conveyance System, Brenner Base Railway, Lyon-Turin Rail Tunnels, Tseung Kwan O-Lam Tin Tunnel, **Melbourne Metro Rail Tunnel**, Gotthard Base Tunnel, Guangzhou-Shenzhen-Hong Kong Express Rail Link, Fehmarn Belt Fixed Link, Circle Line MRT Tunnel, Thames Tideway Tunnel, Silicon Valley Rapid Transit Tunnel, **Footscray-Domain Underground Rail Line**, Bioceanic Aconcagua Corridor, **Melbourne East West Link Road, Sydney City Relief Line, Brisbane Airport Link**, Stockholm Bypass Motorway, **Waitemata Harbour Crossing**, Kungens Kurva-Haggvik Bypass, Stolichnaya to Zabolotnyi's Road Tunnel, Sungai Buloh-Kajang MRT Line, Stockholm City Line.

Xstrata creates first Australian underground training facility

Xstrata Coal has turned its former Baal Bone underground mine into a hands-on training facility. The Lithgow mine has now become the regional training centre, where cleanskins will spend 12 weeks learning mining skills.

According to Xstrata "what's different from more traditional courses is that the trainees not only attend classroom tutorials, they complete familiarisation and operations with the equipment on the surface and then proceed underground to operate the equipment in a 'real-world' environment before they start their fulltime careers".

Mark Bulkeley, Xstrata Coal's Baal Bone health safety and training manager, said the first group of 12 trainees graduated a few weeks ago and are already working at the Ulan West mine. "The feedback we've received from them is that the Baal Bone training facility enabled them to have a better understanding and knowledge before going into production," Bulkeley said.

One of the current trainees, Julie Tiggermann, said it was her first underground mining experience.

"It's a whole new world for me; I expected to and have done the same as the guys, using the same mining equipment, doing the same work. The trainers are great and I've gained experience on Juggernauts, Eimcos, and Shuttle Cars," Tiggerman said. "The courses are also comprehensive and have included mines rescue and Certificate II in Black Coal competency."

Xstrata NSW COO Ian Cribb believes the facility will "support our expansion plans by being able to attract and employ people without previous mining experience but who, importantly, display attitudes that reflect our Xstrata values".

In January last year, the mine was granted a lease expansion to continue longwall mining at Baal Bone until 2014. Xstrata's Ulan mine has also reopened, as the new Ulan West operation in the NSW Central West. There are currently 12 crews on site at Baal Bone.

"I believe turning Baal Bone into a training facility has benefits for Xstrata but also the local community," Bulkeley said. "It provides employments for trainers and assessors so they can stay in the community they call home. It also ensure that the colliery will continue to be an integral part of our community and that critical skills will be kept here.

CONFERENCE AND EVENTS DIARY

Tunnels and Underground Spaces: Sustainability and Innovations
17–20 October 2012 | Montreal (Canada)
http://www.tac2012.ca/

ACUUS 2012 Singapore
7–9 November 2012 – Marina Bay Sands Singapore
"Underground Space Development – Opportunities and Challenges"
http://www.acuus2012.com/

2012 – International Tunnelling Awards Ceremony
29 November 2012 | Toronto (Canada)
http://www.tunnellingawards.com/home

11th Australian Tunnelling Conference
4–5 December 2012 Stamford Plaza Hotel, Sydney
http://www.informa.com.au/conferences/infrastructure-ppp-project-finance/tunnelling-conference/p12r22webpdf

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Infrastructure North Africa
21–22 January Tunis, Tunisia
http://www.infrastructurenorthafrica.com/

International Symposium on Tunnelling and Underground Space Construction for Sustainable Development
18–20 March 2013 | Seoul (Korea)
http://tu-seoul2013.org/

World Tunnel Congress 2013 and 39th ITA General Assembly
May 31 – June 7, 2013 – Geneva (Switzerland)
http://www.wtc2013.ch/home.html

The International Tunnelling Awards are back

– this year in Toronto

There is still time to submit your entries for 2012 – contact anna.grant@emap.com to make sure you don't miss out!

To view all 13 categories and their criteria visit the website. Entries are open to any project, individual, product manufacturer or supplier in the market who can demonstrate innovation and achievement over the last 12 months.

Australasian Tunnelling Society website
www.ats.org.au

ATS Tunnel Database

NEW SOUTH WALES

Project:	City Relief Line		
Client: SMA	**Designer** PB/Arup	**Contractor:**	**Supervising Engineer:**
Scope of work:	5km priority tunnel is proposed to be constructed from Eveleigh to Wynyard, separating western services from inner city trains	**Current status:**	Transport NSW is starting alignment and design studies for the project and will investigate a number of alignment and construction options

Project:	Central Coast Rail Upgrade		
Client: RIC	**Designer** Connell Wagner (Concept) – complete	**Contractor:**	**Supervising Engineer:**
Scope of work:	Hornsby to Hawkesbury. 11.5km twin 8m dia. Rail tunnels.	**Current status:**	EIS complete. Unlikely to proceed in short to medium term

Project:	F3 to M2 Road Tunnel		
Client: RTA and Federal DOTARS	**Designer** SKM (preliminary design)	**Contractor:**	**Supervising Engineer:**
Scope of work:	8km road tunnel to connect the southern end of the F3 Freeway with the M2 Tollroad	**Current status:**	Preferred corridor selected. Preparing the Terms of Reference for development of a concept proposal Construction timetable for the project is yet to be established.

Project:	M5 East tunnel widening		
Client: RTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Provision of additional four new lanes in a driven tunnel next to the existing the M5 East tunnel	**Current status:**	Reference design underway

Project:	M4 East Link		
Client: RTA	**Designer** Connell Wagner	**Contractor:**	**Supervising Engineer:**
Scope of work:	5.5km long, privately funded, road tunnel to connect the eastern end of the M4 Motorway with the CityWest Link.	**Current status:**	On hold awaiting funding

Project:	F6 Transport Corridor		
Client:	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	20-kilometre motorway from the Sutherland Shire to the city Tunnelled section between Port Hacking Road at Sylvania and Loftus	**Current status:**	Economic Impact Study complete Unlikely to proceed in medium term

Project:	Bells Line of Road		
Client: RTA	**Designer** Maunsell	**Contractor:**	**Supervising Engineer:**
Scope of work:	1.2km tunnel to remove 13% grade near Kurrajong	**Current status:**	On Hold

Project:	Busby's Bore Project		
Client: Clean Up Australia	**Designer** KBR	**Contractor:**	**Supervising Engineer:**
Scope of work:	Connection to Busby's Bore and underground water storage in disused St James Railway Tunnel	**Current status:**	Concept design

Project:	Hill M2 Upgrade		
Client: Transurban Group	**Designer** HBO & EMTB in asoociation with T ract Consultants	**Contractor:** Leighton Contractors	**Supervising Engineer:**
Scope of work:	Rock bolting of the existing tunnel. Widening works using an excavator, including widening of the batters (rock walls) on both approaches to the tunnel.· Placement of new electrical and services trenches	**Current status:**	Under construction

Project:	South Sydney Freight Line		
Client: ARTC	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	• 30km single track running parallel to the Main South line between Sefton railway station and Macarthur railway station • Cut and Cover tunnel at Sefton. Required to carry the SSFL underneath the existing Bankstown Line • Underground proposal through Cabramatta Railway Station.	**Current status:**	Tenders currently being reviewed

Project:	City East Cable Tunnel		
Client: EnergyAustralia	**Designer** AECOM	**Contractor:** Theiss	**Managing Contractor**
Scope of work:	3.2km TBM tunnel from Surry Hills to Sydney CBD including connections to existing and proposed substations	**Current status:**	$141 million tender Awarded to Thiess

Project:	Wynyard Pedestrian Tunnel		
Client: Barangaroo Delivery Authority	**Designer** PB	**Contractor:** TBA	**Managing Contractor**
Scope of work:	$286 million pedestrian access to Barangaroo	**Current status:**	Out to Tender

Project:	North West Rail Link		
Client: NSW Gov't Transport Construction Authority (TCA)	**Designer** AECOM	**Contractor:** TBA	**Managing Contractor** TBA
Scope of work:	23km long northwest rail link, which includes 15km of deep, underground twin tunnels stretching from Epping to Kellyville	**Current status:**	Tender expected Q4 2012

Project:	South West Rail Link		
Client: NSW Gov't Transport Construction Authority (TCA)	**Designer** SMEC, KBR, GHD	**Contractor:** John Holland	**Managing Contractor** John Holland
Scope of work:	Rail underpass under Hume Highway (80m long) between Glenfield and Leppington	**Current status:**	Detailed Design

Project:	Pacific Hwy Tintenbah-Ewingsdale Upgrade, St Helena Tunnel		
Client: RTA	**Designer** TBA	**Contractor:** Baulderstone Hornibrook	**Managing Contractor**
Scope of work:	Twin 350m long three lane road tunnels.	**Current status:**	Tender awarded to Baulderstone Hornibrook

Project:	Sydney Opera House Vehicle Access and Pedestrian Safety Project		
Client: RTA	**Designer** ARUP	**Contractor:** John Holland	**Managing Contractor**
Scope of work:	Cavern under Opera House forcourt for loading dock	**Current status:**	Tender awarded to John Holland

Project:	Maldon to Dombarton Rail Link		
Client: RTA	**Designer** TBA	**Contractor:** TBA	**Managing Contractor**
Scope of work:	Long tunnel to provide more direct access to Port Kembla	**Current status:**	$24.5m in federal funding provided

QUEENSLAND

Project:	Airport Link & Northern Busway		
Client: Queensland Government	**Designer** PB Arup	**Contractor:** Thiess/John Holland JV	**Supervising Engineer:**
Scope of work:	$4.3B PPP project. Construction of road tunnels and a busway including Australia's longest road tunnel at 6.7km long	**Current Status:**	Target completion June 2012.

Project:	Legacy Way Tunnel		
Client: Brisbane City Council	**Designer** GHD, URS, Cardno	**Contractor:** Transcity – Acciona, Ghella, BMD Construction	**Supervising Engineer:** GHD
Scope of work:	2 x 4km road tunnels from Toowong to Milton. Additional 550m x 4.8m x 4m Conveyor Tunnel (drill and blast) to transport tunnel spoil into Mt Coot-tha quarry.	**Current Status:**	Radial stacker constructed in Mt Coot-tha Quarry with conveyor connection to TBMs. First TBM started end August 2012.

Project:	East-West Orbital Tunnel		
Client: Brisbane City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel joining Toowong to Everton Park	**Current Status:**	Feasibility study in progress

Project:	East-West Link Tunnel		
Client: Brisbane City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Completion of inner city ring road connecting. 6km from Pacific Highway to East-west Orbital Tunnel (complete 2031).	**Current status:**	Review of traffic demand being completed. Scheduled to be built after 2026 but may be brought forward.

Project:	Toowoomba Bypass		
Client: Queensland Department of Transport and Main Roads (DTMR)	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	42km road costing $1B+ will include 735m twin tube tunnel at top of Great Dividing Range	**Current status:**	Pilot tunnel completed. Project on hold awaiting funding.

Project:	Cross River Rail		
Client: DTMR	**Designer** TBA	**Contractor:**	**Supervising Engineer:**
Scope of work:	A 19km proposed corridor would include a tunnel under the Brisbane River and new stations, running from Salisbury, in Brisbane's south, to Wooloowin, in the north, via Woolloongabba, the CBD and Bowen Hills. $8.2B project.	**Current status:**	Feasibility study is continuing

Project:	Stafford Road Tunnel		
Client: DTMR	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Urban motorway tunnel under Stafford Road to connect the proposed North West Transport Corridor and Inner Orbital with Airport Link	**Current status:**	Planning complete and included in the Western Brisbane Transport Strategy

Project:	Kingsford Smith Tunnel		
Client: Queensland Main Roads	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel to link traffic from the Gateway Motorway and Australia Trade Coast to the Inner City Bypass	**Current status:**	Proposed. Design options developed

Project:	Auchenflower Sewer Upgrade		
Client: Queensland Urban Utilities	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Microtunnelling to install new pipes along Torwood Street, Eagle Terrace, under the railway line into Roy Street and Lang Parade, connecting to the sewer system on Coronation Drive.$9.2M.	**Current status:**	Commenced, Work is due for completion by mid-2012.

Project:	Curtis LNG Project		
Client: Queensland Urban Utilities	**Designer** Arup	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel crossing to Curtis Island. 6kms at 4m diameter.	**Current status:**	Design awardfed to Arup

Project:	Bulimba Creek Trunk Sewer Upgrade		
Client: Queensland Urban Utilities	**Designer** Queensland Urban Utilities	**Contractor:** John Holland	**Supervising Engineer:**
Scope of work:	1.5kn of DN120 pipe jacking 30km of DN800 pipe jacking and 48 manholes	**Current status:**	Under construction

Project:	Wooloongabba Trunk Sewer Upgarde Part B		
Client: Queensland Urban Utilities	**Designer** Queensland Urban Utilities	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	5.5km of sewer pipeline up to 1200mm diameter	**Current status:**	D&C Tenders submitted

WESTERN AUSTRALIA

Project:	Perth Airport Rail Link		
Client: Public Transport Authority	**Designer** AECOM (study)	**Contractor:** N/A	**Supervising Engineer:** N/A
Scope of work:	Twin track electrified passenger heavy rail route from Midland Line near Bayswater Station to a new possible terminal station at High Wycombe. Route to service growing Office and Industrial Park with underground station near current Domestic Terminal. Tunnel options extend under main airport runway to new underground station at International Terminal, continuing eastwards under future runway to High Wycombe (total track length up to 10km, approx half in cut and cover and bored tunnel).	**Current status:**	Pre-feasibility Studies including preferred route identification and preliminary costing, report submitted.

Project:	Woodside Browse Gas Pipeline Shore Crossing		
Client: Woodside	**Designer** Atteris	**Contractor:** TBA	**Supervising Engineer:** N/A
Scope of work:	TBM pipejack or segmentally lined tunnel up to 2km length in up to 20m water depth carrying 3 LNG pipelines onshore.	**Current status:**	Tenders have been submitted and Woodside is currently reviewing.

Project:	The Perth City Link Project		
Client: Public Transport Authority	**Designer** N/A	**Contractor:** JHG-GHD	**Supervising Engineer:** N/A
Scope of work:	Lowering twin Fremantle lines underground in cut and cover tunnel above existing Joondalup line bored tunnels west of Perth Central Station. Includes new pedestrian underpass beneath all tracks and platforms within Perth Central Station. Lowering of Wellington Street Bus Station underground with bus access ramp to west.	**Current status:**	Perth City Link Rail Project Awarded to John Holland-GHD Joint Venture in March 2011. Rail lowering project due for completion in 2014. Bus station lowering project due to follow, with completion by 2016.

Project:	Wheatstone gas pipelines Shore Crossing Tunnel		
Client: Chevron	**Designer** Atteris	**Contractor:** Thiess	**Supervising Engineer:**
Scope of work:	1284m TBM pipejack tunnel to carrying LNG gas pipeline through surf zone and shore crossing into Plant site	**Current status:**	Contract awarded to Thiess Tunnelling in December 2011. Construction on site in May 2013 with completion November 2013. Herrenknecht AVND 2000AB TBM ordered.

VICTORIA

Project:	Melbourne Metro		
Client: DoT	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Stage 1 – new rail tunnel between Dynon in the west and St Kilda Road near Domain with new stations in North Melbourne, Parkville, and St Kilda Road. Satge 2 – linking Domain to the Caulfield corridor	**Current status:**	Under review

Project:	East-West Tunnel		
Client: VicRoads	**Designer** TBA	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential tunnel under Carlton and Royal Park running from the Tullamarine Freeway to the Western Ring Road	**Current status:**	In progress

Project:	WestLink — Stage 1		
Client: LMA	**Designer** Aurecon/AECOM/GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	3.5km tunnel stretching from the ports area to Paramount Road, West Footscray	**Current status:**	On hold

Project:	Northern Sewer Project		
Client: Melbourne Water	**Designer** SKM/Jacobs	**Contractor:** JHG	**Supervising Engineer:**
Scope of work:	Stage 1 – 8km of 1.6m and 2.5m diameter sewer tunnels. Stage 2 – 4.5km and 1.8km diameter sewer tunnels	**Current status:**	Tunnelling complete

Project:	Hoddle Street Tunnel		
Client: Vic Roads	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:** TBA
Scope of work:	Tunnel would run from the Eastern Freeway to Wellington Parade, near the MCG.	**Current status:**	On hold

Project:	Wonthaggi Desaliantion Plant		
Client: Department of Sustainable Energy	**Designer** GHD	**Contractor:** Thiess Degremont	**Supervising Engineer:** TBA
Scope of work:	Desalination plant will include intake and outake tunnels offshore up to 2.5km long	**Current status:**	Tunnelling complete

Project:	Melbourne Main Sewer Replacement		
Client: Melbourne Water	**Designer** GHD	**Contractor:** John Holland	**Supervising Engineer:** Aurecon
Scope of work:	$220 million 2.3km 1.8m diameter new sewer includes six shafts 10–15m deep and 142m crossing of Yarra River	**Current status:**	Tunnelling complete May 2011, project completion in 2012

Project:	Frankston Drainage Improvement Project		
Client: Melbourne Water	**Designer** GHD	**Contractor:** Winslow Infrastructure	**Supervising Engineer:** GHD
Scope of work:	1.5 kilometre 3m OD tunnel with 2.5m dia concrete stormwater pipeline from Monash University to Kananook Creek.	**Current status:**	Complete

Project:	North East Link		
Client: LMA	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Potential road tunnel from Greensborough to Bullen linking the Western Ring Road to the Eastern freeway	**Current status:**	Not before 2018

Project:	Bendigo CBD		
Client: VicRoads	**Designer** GHD	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	A 3.5km road tunnel under the Bendigo CBD	**Current status:**	Proposed

NORTHERN TERRITORY

Project:	Darwin Water Main		
Client: Darwin City Council and the Department of Planning and Infrastructure	**Designer**	**Contractor:** Winslow Infrastructure	**Supervising Engineer:**
Scope of work:	Construction of several major water mains will take place in two stages. Stage 1 includes installing 1.2km of 450mm steel pipe. Stage 2 includes the installation of 9km of 450mm steel water in Darwin's CBD.	**Current status:**	Complete

Project:	Kilgarif Power and Water		
Client: Power and Water	**Designer**	**Contractor:** Sitzler Brothers	**Supervising Engineer:**
Scope of work:	$A4.3M to bore under major road and rail crossings	**Current status:**	Complete

TASMANIA

Project:	Hobart City Tunnel		
Client: Hobart City Council	**Designer**	**Contractor:** TBA	**Supervising Engineer:**
Scope of work:	Tunnel from the Southern Outlet at Davey St to Brooker Ave under West Hobart and North Hobart, and a second stage through the Queen's Domain to the Tasman Bridge.	**Current status:**	Proposed.

NEW ZEALAND

Project:	Homer Tunnel Upgrade		
Client:	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	2 Lane tunnel	**Current status:**	In planning

Project:	Victorai Park Tunnel		
Client: Transit NZ	**Designer** V Formation (Fletcher Construction, Beca Engineering, Higgins Contractors and Parsons and Brinckerhoff)	**Contractor:**	**Supervising Engineer:**
Scope of work:	440m long 2 Lane tunnel	**Current status:**	Complete

Project:	Waterview Connection		
Client: NZTA	**Designer**	**Contractor:** Fletcher/MacConell Dowell/Obayashi	**Supervising Engineer:**
Scope of work:	Linking of Southwestern Motorway (State Highway 20) and the Northwestern Motorway (SH16), including twin three-lane tunnels	**Current status:**	Awarded

Project:	Milford Dart Tunnel		
Client: Milford Dart Co.	**Designer** URS	**Contractor:**	**Supervising Engineer:**
Scope of work:	10.2kms of 5m diameter tunnel for single lane bus route or rail	**Current status:**	In planning

Project:	North Bank Tunnel		
Client: Meridian Energy	**Designer** URS	**Contractor:**	**Supervising Engineer:**
Scope of work:	36kms of 12m diameter headrace tunnel & hydro power station	**Current status:**	In planning

Project:	Britomart rail loop		
Client: Auckland Regional Transport Authority	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	A 3.5km loop linking Britomart with the current western line. Three new underground stations at Aotea Square, Newton and K' Road.	**Current status:**	Planning and conceptual design in progress

Project:	Wellington Northern Corridor		
Client: NZ Transport Agency Board	**Designer** AECOM, Parsons Brinckerhoff and Beca	**Contractor:**	**Supervising Engineer:**
Scope of work:	Four lane expressway from Levin to Wellington Airport including duplication of Mount Victoria and Terrace tunnels.	**Current status:**	In planning

Project:	Tauranga Tunnel		
Client: Local Govt	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Three routes for a road tunnel through the Kaimai Ranges, linking Tauranga with the Waikato.	**Current status:**	Currently being investigated by the NZ Transport Agency

Project:	Central Interceptor Project		
Client: Local Govt	**Designer** AECOM	**Contractor:**	**Supervising Engineer:**
Scope of work:	New sewer tunnel approximately 14 kilometres in length from central Auckland to Mangere Wastewater Treatment Plant	**Current status:**	Design in progress — construction to be completed by 2025

Project:	Nevis Tunnel		
Client: NZ Transport Agency	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel to replace a rockfall-prone stretch of highway at the Nevis Bluff, midway between Cromwell and Queenstown.	**Current status:**	Concept

Project:	Waitemata Harbour		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Potential tunnel route between the central city and the North Shore would cost from $4 to 5.3 billion	**Current status:**	Concept

Project:	Welcome Bay Tunnel		
Client: NZTA	**Designer**	**Contractor:**	**Supervising Engineer:**
Scope of work:	Tunnel or roundabout proposed	**Current status:**	Proposed