West Gate Tunnel Project

Report of Trevor O'Shannessy

1 Introduction

My firm Golder Associates Pty Ltd (Golder) prepared the Technical Report titled West Gate Tunnel Project, Technical Report D – Impact Assessment Ground Movement 1521107-6004-R-Rev0 (Technical Report) which is included as Technical Report D to the Environment Effects Statement (EES) for the West Gate Tunnel Project (Project).

The role that I had in preparing the Technical Report was lead author of the Technical Report and peer review of Appendix A. I also prepared the geological model for the tunnel alignment. Other significant contributors to the Technical Report and their expertise is set out as follows:

- Luke Tkatchyk (Senior Engineering Geologist – Golder Associates), who prepared the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

- Bill Wang (Senior Geotechnical Engineer – Golder Associates), who assisted with preparation the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

- Nimal Nilaweera (Senior Geotechnical Engineer – Golder Associates), who undertook numerical ground movement modelling and assisted in preparation the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

- Jonathan Medd (Principal Hydrogeologist – Golder Associates), who provided the groundwater drawdown predictions that were used to develop the subsidence impacts for the Technical Report.

- Steve Macklin (Principal Engineering Geologist - GHD) who provided external peer review of the Technical Report.

I adopt the Technical Report, in combination with this document, as my written expert evidence for the purposes of the West Gate Tunnel Project Inquiry and Advisory Committee's review of the EES.

2 Qualifications and experience

Appendix A contains a statement setting out my qualifications and experience, and the other matters raised by Planning Panels Victoria 'Guide to Expert Evidence'.

A copy of my curriculum vitae is provided in Appendix B.

3 Further work since preparation of the Technical Report

Since the Technical Report was finalised, I have not undertaken further work in relation to the matters addressed in the Technical Report relevant to the Project.

4 Written Submissions

4.1 Submissions Received

I have read the public submissions to the EES that are relevant to the Technical Report and my area of expertise. These include the following submissions:

29, 92, 123, 255, 278 & 326.

4.2 Summary of Issues Raised

The submissions have raised the following issues relevant to my area of expertise:

- Concerns about potential for alteration/reduction of the existing groundwater table resulting in ground surface subsidence impacting on existing buildings (submission numbers: 29, 278)
- Concerns regarding compensation for building damage, should it occur, due to ground movements associated with the project (submission number: 92, 278)
- Concerns regarding potential ground subsidence in recreational land (i.e. WLJ Croft reserve) underlain by filled ground associated with former quarries (submission number: 123)
- Concerns about potential surface settlement due to tunnelling (submission number: 255)
- General (non-specific) concerns regarding ground movement (submission number 326)

4.3 Response to Issues Raised

Set out below are my comments and response to the issues raised by the written submissions relevant to the area of my expertise.

Concerns about potential for alteration/reduction of the existing groundwater table resulting in ground surface subsidence impacting on existing buildings

Submission numbers: 29, 278

Concerns have been raised by two property owners at the following addresses:

- 8 Bertram Street, Mordialloc (submission 29)
- 3 Beverley Street, Yarraville (submission 278)

The concerns relate to potential ground movement (subsidence) impacts posed by groundwater alteration/reduction.

Submission 29 raised concerns regarding the potential alteration to groundwater conditions that may cause subsidence. The submitters address at 8 Bertram Street, Mordialloc is remote from the Project and will not be affected by potential ground movement (subsidence) impacts posed by Project related groundwater alteration/reduction. As described in Section 7 of the Technical Report, risks associated with subsidence due to groundwater reduction are primarily expected to be localised to major portal locations during construction. These risks have been assessed as Low.

Submission 278 raised concerns that potential construction related groundwater reductions may trigger reactivation or exacerbation of existing building defects. Based on the submission, I understand that the existing building consists of a single story weatherboard house that has experienced previous ground movement issues due to reactive founding soils, which consist of highly reactive (expansive) basaltic soil. This movement has resulted in the owner undertaking rectification works in the form of relevelling and some internal repair.

My understanding from reading the submission is that the owner is concerned about a link between potential lowering of the existing groundwater table and possible shrinkage of reactive founding soils (due to moisture loss), which may cause further ground movement impacts to their house.

In assessing Submission 278 1 have reviewed the position of the water table and geological profile obtained from site investigation borehole information undertaken to support the EES. The nearest

borehole (WD-BH-030) is located approximately 40 m south of the property in Lormer Street, Yarraville and is shown on the geological long section presented in Appendix A (sub-appendix A1) of the Technical Report. This borehole indicates up to 2.2 m thickness of soil including fill and natural clay overlying predominantly slightly weathered to fresh, high to very high strength rock, which extends to approximately 22 m depth below ground surface. The borehole was installed with an open standpipe groundwater well, which indicates the groundwater table is positioned within the basalt rock at a depth of approximately 8.5 m. The basalt rock is insensitive (non-expansive) with respect to moisture change.

Due to the depth and remote position of the existing water table within the basalt rock, a groundwater reduction would not trigger moisture loss and shrinkage movements in the shallow expansive clay founding soil, which directly support the building.

Environmental Performance Requirements (EPRs) have been developed that govern the construction and operation of the West Gate Tunnel Project, which include provisions to minimise ground subsidence risk due to lowering of the water table.

EPR GMP2 addresses the concerns raised in submission 29 and 278.

GMP2 requires Project Co to design the tunnel and portal drainage to minimise adverse changes in groundwater levels during construction and operation. Information provided by Project Co indicates that a range of engineering control measures will be implemented to minimise potential groundwater lowering impacts during construction, these measures include the use of a closed face tunnel boring machine, gasket sealed concrete tunnel lining, secant piled portal structures, in additional to targeted grouting and groundwater recharge measures. The proposed engineering controls would be developed during detailed design and included in the Construction Environmental Management Plan (CEMP) along with specific plans and measures to manage groundwater impacts, which are identified and discussed further in EES Technical Report C (Groundwater).

During operation, the tunnel and portals would be designed as undrained (tanked) structures to minimise groundwater leakage and potential groundwater lowering impacts.

Submission 278 also raised the concern that acquisition of stratum below their property would remove future access to groundwater and geothermal resources, in addition to detrimentally impacting (restricting) potential below ground property extensions. I do not have the expertise to comment on this matter as it relates to land acquisition or stratum title matters and in my opinion is not directly related to ground movement EES matters.

Concerns regarding compensation for building damage should it occur due to ground movements associated with the project (submission number: 92, 278)

For context I have provided a response for each submission which considers the individual property address and potential for project related ground movement to occur as well as project controls (EPRs) which address compensation concerns.

I qualify the above statement by adding that my assessment does not consider potential ground vibration matters raised in submission 278. I do not have the expertise to comment on this matter which has been assessed separately by Technical Report H, Noise and vibration (surface) and Technical Report I, Vibration and regenerated noise (tunnel).

Submission 92 concerns the owner of a property located at 16 Lynch Road, Brooklyn. This property is located to the north of the West Gate Freeway and approximately 2.3 km west of the proposed outbound southern portal. Potential ground movements associated with tunnelling and portal construction works are not expected to affect properties at this distance.

Freeway widening works are planned to occur, which are expected to mainly involve above ground construction. These works are unlikely to generate significant ground movement and any ground movement is likely to be confined to the immediate project corridor within the existing freeway reserve. Potential ground movements associated with above ground freeway widening works are not expected to

affect residential properties such as 16 Lynch Road, which is located approximately 150 metres north of the West Gate Freeway.

EPR GMP3 addresses the concerns raised in submission 92 and 278.

GMP3 requires Project Co to undertake condition surveys for properties and infrastructure identified as being at risk of ground movement damage. This requirement is informed by ground movement analysis which Project Co is required to undertake as part of GMP1 (Geotechnical model and assessment), including the assessment of potential ground movement pathways associated with excavation and dewatering.

Condition surveys of existing structures before and after construction are required under GMP3 and provide a reasonable means of assessing potential ground movement impacts. Condition surveys also provide clarity in the assessment of potential claims for owner and Project Co alike and are commonly carried out for major projects, particularly those requiring significant excavations or tunnelling. In the event that damage is caused by the project, GMP3 requires the damage to be rectified or the landowner compensated. Independent assessment and mediation processes would be required to assess the validity of ground movement damage related claims.

Concerns regarding potential ground subsidence in recreational land (i.e. WLJ Croft reserve) underlain by filled ground associated with former quarries (submission number: 123)

I interpret the concerns raised in section 3.3 of the submission to be associated with exacerbation of existing surface drainage issues and increased flooding risk. I do not have the expertise to comment on this matter which has been assessed separately by Technical Report E, Surface Water.

The submission states that 'ground subsidence is now evident throughout the whole reserve'. I consider this to be caused by compression of the poorly compacted fill placed within the former quarry hole, which has slowly settled over time under self-weight. Such movements, where present, are likely to continue independent of project activities.

The presence of the existing backfilled quarry is identified in Technical Report D, Ground movement (Figure 11).

The Ground movement Technical Report recognises the potential for existing quarries to present a localised ground movement risk with respect to new structures (i.e. new surface loads), which are placed on poorly compacted fill soils. Where such structures are not suitably engineered (for example, by using piles or ground improvement methods) adverse ground movements may occur, which have the potential to damage overlying structures (for example cracking in road asphalt or movement of buried services, etc).

Project Co will be required to provide appropriate ground engineering to mitigate ground movement risks when considering the foundation design of new structures located over the backfilled quarry. Project related construction activity is not expected to affect the surrounding recreational land within WLJ Croft Reserve with respect to exacerbating existing ground movements.

Concerns about potential surface settlement due to tunnelling

Submission number: 255

This submission raised concerns regarding the tunnel depth with respect to minimising potential adverse ground movement impacts. The submission has suggested that the tunnelling depth should be lowered to 32 m depth to provide at least two diameters of ground cover between the tunnel crown and the property address at ground surface.

The property address is located at 188 Stephen Street in Yarraville and contains a single storey weatherboard house.

My assessment indicates that the property is situated above the proposed east bound tunnel and within the tunnel influence zone with respect to potential ground movement. The vertical separation between ground surface and the crown of the proposed tunnel is approximately 27.4 m.

The ground conditions below the property address have been informed by nearby boreholes which were considered in constructing the geological model used in the ground movement predictions. The closest boreholes include WD-BH-031 and WD-BH-033, which are shown on the geological long section presented in Appendix A (sub-appendix A1) of the Technical Report. The geological model and boreholes indicate that the conditions between surface level and the crown of the tunnel predominantly consist of up to approximately 15 m thickness of high to very high strength basalt rock, overlying partially cemented sandy strata.

Based on conservative numerical modelling predictions, and due to the overlying geological conditions described above the property falls within a damage category of slight to negligible, with respect to tunnelling induced ground movement. Some of the conservative assumptions adopted by the modelling include, but are not limited to the following:

- The rock mass behaviour is likely to be stiffer than the model assumes.
- The analysis used to predict potential damage generally underestimates the capacity of existing structures to tolerate ground movement at surface, particularly where construction materials are flexible (for example weatherboard buildings).
- Based on my experience and in my opinion, the tunnelling volume losses used in the numerical modelling are conservative and are likely to overestimate the actual volume loss that can be achieved using good construction practices.

It is my opinion that lowering of the tunnel further to 32 m is unlikely to materially change the ground movement risks presented in the Technical Report, which have been predominantly assessed to be low for the Stephen Street address and for the majority of residential properties within the Yarraville area.

Environmental Performance Requirements (EPR's) have been developed that govern the construction and operation of the West Gate Tunnel Project, which include provisions intended to minimise ground movement related impacts. Project Co will be required to adopt and implement controls consistent with the EPR's designed to minimise the risk of adverse ground movement. These EPRs include requirements for the assessment (GMP1) and monitoring (GMP5) of ground movement occurrence during construction, in addition to implementing property condition surveys, consultation and rectification plans (GMP3) for property identified as being at risk.

General (non-specific) concerns regarding ground movement

Submission number 326

Submission 326 noted that they do not have any expertise to consider ground movement and indicated support for the expertise of Hobsons Bay City Council (HBCC) on this matter, therefore I have not responded further to this submission.

I have reviewed HBCC submission 378, which is referred to within submission 326 above. On review of this submission I have identified one specific mention of ground movement concern contained within section 3.7.3 (Heritage Impacts). The concern raised pertains to an existing Edwardian staff amenities block located on the north side of Simcock Avenue, approximately seventy metres west of Hyde Street / Douglas Parade.

Submission 378 states:

'This building is located on the corner of Simcock Avenue and Douglas Parade and there is potential damage (sic) as a result of vibration or ground movement during construction'

I understand that Project works in proximity to the above building address of 2-4 Simcock Avenue, will mainly be limited to minor surface works such as road asphalting, line marking and intersection upgrades. These activities are not considered significant with respect to potential ground movement pathways and are likely to be similar in nature to routine road maintenance and improvement activities conducted periodically by road authorities.

Based on my understanding of the proposed construction works, Project related ground movement impacts are not expected to occur at the above address.

I qualify the above statement by adding that my assessment does not consider potential ground vibration matters raised in submission 378. I do not have the expertise to comment on this matter which has been assessed separately by Technical Report H, Noise and vibration (surface).

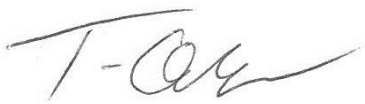
4 Response to IAC's Questions and Further Information Request

Appendix A – Groundwater Information Request (ID: SH1-C).

This request reference Technical Report D (Ground Movement). My understanding of this request is that it pertains to the provision of factual information collected during geotechnical and hydrogeological investigations undertaken by Golder. My company (Golder) has responded to this request and has provided the requested information to the IAC via our client Transurban and the WDA.

Declaration

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.



Trevor O'Shannessy

Date: 01 August 2017

Appendix A Matters Raised by PPV Guide to Expert Evidence

(a) the name and address of the expert;

Trevor O'Shannessy
Building 7, Botanicca Corporate Park,
570-588 Swan Street
Richmond, Victoria 3121

(b) the expert's qualifications and experience;

Trevor has completed a Bachelor of Engineering (Geological Engineering) with honours at the Royal Melbourne Institute of Technology and is a Certified Practising Engineer. Trevor has over 15 years' experience in geotechnical engineering for infrastructure projects including major tunnelling projects.

(c) a statement identifying the expert's area of expertise to make the report;

Trevor has provided expert advice relating geological modelling and geotechnical engineering, including the assessment of ground movement for surface and subsurface civil infrastructure. Specifically, Trevor has provided expert advice for the following major tunnel projects:

- Melbourne Metro. Twin 8 m diameter rail tube tunnels and station caverns. Scoping of procurement stage geotechnical investigations.
- East West Link, investigation, geological modelling and key geotechnical risks for Linking Melbourne Authority for twin 15 m diameter road tunnels.
- Melbourne Main Sewer. Geotechnical investigation, design assessments, instrumentation, construction phase support and ground movement monitoring for 3 m diameter sewer tunnel constructed in variable soft ground, including Coode Island Silt.

Trevor has co-authored and presented peer reviewed international conference papers on tunnelling induced ground movement.

(d) a statement identifying all other significant contributors to the report and where necessary outlining their expertise;

Luke Tkatchyk (Senior Engineering Geologist – Golder Associates), who prepared the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

Bill Wang (Senior Geotechnical Engineer – Golder Associates), who assisted with preparation the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

Nimal Nilaweera (Senior Geotechnical Engineer – Golder Associates), who undertook numerical ground movement modelling and assisted in preparation the report titled, West Gate Tunnel Project Technical Report D, Appendix A – Ground Movement Modelling Prediction – Tunnels and Portals 1521107-211-Rev0.

Jonathan Medd (Principal Hydrogeologist – Golder Associates), who provided the groundwater drawdown predictions that was used to develop the subsidence impacts for the Technical Report.

Steve Macklin (Principal Engineering Geologist - GHD) who provided external peer review of the Technical Report.

(e) all instructions that define the scope of the report (original and supplementary and whether in writing or oral);

The scoping requirements for the EES specify the evaluation objectives and provide the context for the technical studies informing the EES. The relevant evaluation objective for ground movement is:

Land stability – To avoid or minimise adverse effects on land and river bank geomorphic stability from project activities, including tunnel construction and crossings of the Maribyrnong River, Kororoit Creek, Stony Creek and Moonee Ponds Creek.

The Technical Report prepared for ground movement does not address erosional effects associated with waterways (for example, river bed or bank erosion relating to geomorphic stability), which are addressed separately by Technical Report E – Surface water and Technical Report F - Ecology.

The requirements relevant to ground movement are described in the table below:

Aspect	**Scoping requirements**	**Sections in the Technical Report**
Key issues	Potential for project works to cause or lead to reduced ground stability and riverbed and bank erosion that could adversely affect properties, structures, infrastructure, river health or other values.	Sections 6.2, 7.2 & 8.2 Also Technical Report E Surface Water
Priorities for characterising the existing environment	Priorities for characterising the existing environment	Sections 6.1, 7.1, and 8.1
	Identify ground conditions that may be susceptible to instability from proposed project activities (for example, tunnelling, deep excavation, dewatering).	Sections 6.1, 7.1 & 8.1
	Identify properties, assets and infrastructure that may be susceptible to land instability.	Sections 6.3, 7.3 & 8.3
Design and mitigation measures	Identify design and management measures to maintain ground stability where risks of potential instability have been identified.	Sections 6.4, 7.7 & 8.4
Assessment of likely effects	Analyse residual effects on land and water values from project waste streams	Sections 6.5, 7.5 and 8.5 Also Technical Report E Surface Water and Technical Report F Ecology
Approach to manage performance	Describes the principles to be adopted for monitoring programs to identify ground instability and river bed or bank erosion if it occurs during project works, including post construction	Section 10.2 Also Technical Report E Surface Water

Aspect	Scoping requirements	Sections in the Technical Report
	Describes principles of potential contingency actions if adverse ground movement is identified.	Section 10.3

The instructions given to me by Clayton Utz acting on behalf of the WDA, as described in correspondence dated 6 July 2017 including the following work request:

1. Review the public submissions and identify those relevant to your area of expertise (refer section (g), dot point 1 below).

2. Review your Previous Report and identify whether there are any changes to the conclusions of the report arising out of the issues raised by the public submissions or as a consequence of any other relevant matter.

3. Prepare a report that:

    (a) responds to the public submissions relevant to your area of expertise;

    (b) addresses your Previous Report and any changes to the conclusions reached; and

    (c) any other matter that you consider relevant to your area of expertise.

4. Prepare a short (no more than 20 minutes) power point presentation for presenting at the hearing.

5. Attend the hearing to give evidence in relation to your report.

Further instruction was given to me by Clayton Utz acting on behalf of the WDA to review the IAC's Preliminary Matters and Further Information Request and provide a response where relevant. This instruction was described in email correspondence dated 30 July 2017.

(f) the identity of the person who carried out any tests or experiments upon which the expert relied in making this report and the qualifications of that person;

Jonathan Medd provided estimates of groundwater drawdown associated with the construction and operation of the tunnel component of the project (including tunnel portal and dive structures). These estimates were used in the assessment of potential ground movement (subsidence) associated with groundwater lowering. Jonathan was responsible for leading the groundwater investigations for the project and is the author of Technical Report C - Groundwater. Jonathan holds a Bachelor of Science (Hons) and a Master of Environmental Science and Hydrogeology. He has over 24 years' experience in the field of environmental management and impact assessment, specifically in the areas of land contamination, groundwater contamination and groundwater flow management. Jonathan is also an Environmental Auditor of Contaminated Land and Industrial facilities appointed under the *Environment Protection Act 1970*.

Geotechnical laboratories operated by Golder Associates and BTS provided geotechnical testing of soil and rock samples. The results of the laboratory testing, along with in situ test information collected during Golder field investigations was used in the estimation of geotechnical properties and geological modelling and incorporated into the numerical modelling analyses of ground movement.

(g) a statement setting out the key assumptions made in preparing the report;

- All submissions relevant to my area of expertise have been allocated to me by WDA and I have not reviewed any other submissions other than those allocated to me.

- The Technical Report relies on Project Co's tendered design and information gathered within the study area.

- This impact assessment of the West Gate Tunnel Project relies on site investigation data gathered for this project. Due to evolution of the design over time, the data is less detailed in the area of the westbound portal and tunnel that extends approximately one kilometre to the west of the eastbound southern portal.

  It is also expected that Project Co will conduct additional investigations as required to address information gaps in this area of the project in a manner that is specific to its design. This would also be the case for other areas of the project where the level of information gathered is considered sufficient to inform the EES but needs to be supplemented for the detailed design, construction and operational phases.

- In some cases, investigation of specific areas was not possible due to access restrictions posed by existing roads, below-ground infrastructure and third-party property access limitations.

- Interpretation of sub-surface conditions is based on field observations and laboratory test data from widely-spaced sampling locations. The site investigations identify sub-surface conditions only at those points where testing was conducted or samples were taken.

- This assessment is based on conditions that existed when the assessment was conducted. Its findings and conclusions may be affected by the passage of time or by man-made events such as construction on or adjacent to the project area.

- This impact assessment is based on existing geotechnical borehole data. It is possible that additional drilling and sampling works undertaken before construction by Project Co may change some assumptions on the distribution of the sub-surface geological units described in the Technical Report. I do not consider it likely that this will materially affect the findings of the Technical report.

(h) a statement setting out any questions falling outside the expert's expertise and also a statement indicating whether the report is incomplete or inaccurate in any respect.

Except where stated herein, there are no further questions falling outside my area of expertise and I do not have any knowledge that my Report is incomplete or inaccurate.

Appendix B CV

Education

Bachelor of Engineering Geological Hons, RMIT, Melbourne Australia, 2000

Languages

English – Fluent

Golder Associates Pty Ltd - Melbourne

Trevor has over 15 years of experience in civil, mining and water industries.

He has extensive experience in geotechnical investigation, design and contractor supervision. He has led complex geotechnical investigations for tunnels, road and rail projects, tall buildings, dams, open cut mines and numerous other civil engineering structures. Having a wide range of experience, he has worked on geotechnical projects within Australia and internationally in developing countries such as Bangladesh.

His experience extends to engineering of difficult soft ground issues, including tunnelling and shaft support, ground improvement and settlement mitigation.

Trevor has worked with large alliance teams, as well as D&C and traditional owners engineer roles.

Employment History

Golder Associates – Melbourne Australia

Principal Geotechnical Engineer (2015 to Present)

Technical support and leadership roles for major projects being delivered form Golder Associates Melbourne office. Development of water sector geotechnical services. Recent project experience includes assisting Transurban develop their Market Led Proposal for the Western Gate Tunnel Project, technical input to Melbourne Metro rail tunnel and supporting contractors and water authorities with micro-tunnelling services.

GHD – Melbourne Australia

Intermediate to Principal Geotechnical Engineer roles (2002 to 2015)

Career responsibilities have included managing large multidisciplinary teams, mentoring, scoping and carrying out detailed investigations, construction of geological models as well as geotechnical interpretation and design work. Major projects during this time included investigation, design and construction phase support for large diameter sewer tunnels, including Melbourne Main Sewer and Alphington Sewer. Also geotechnical lead for the East-West Link road tunnel project and provided lead and support advice for numerous rail, dam, mining and water infrastructure projects in client facing roles.

Civil Test – Melbourne Australia

Junior Geotechnical Engineer (2000 to 2002)

Geotechnical investigation and reporting for a variety of civil infrastructure projects, land capability assessments and landslide risk assessments. Duties extended to drilling rig operation.

PROJECT EXPERIENCE – TUNNELLING & TRENCHLESS TECHNOLOGY

Western Gate Tunnel Project Victoria, Australia	Geotechnical lead for 6 km length, twin 15.5 m diameter road tunnel reference design. Role involved client advisor for geotechnical investigations, preparation of detailed 2D and 3D ground models as well as technical support. This role also included assessment of tunnelling ground movement to support the Environmental Effects Statement (EES) and tender phase support.
Melbourne Metro Victoria, Australia	$10.9 billion rail project consisting of twin 9 km rail tunnels. Provision of geotechnical project support for reference design & procurement investigation phases. Responsible for scoping $20 million procurement stage investigations for geotechnical, groundwater and contaminated land disciplines. Also responsible for planning and delivering packages for electrical resistivity, thermal resistivity and vibration attenuation studies involving downhole and surface geophysical testing in busy urban environment. Client facing role and technical support provided for field engineering teams.
Anglesea Sewer Outfall Replacement Victoria, Australia	Geotechnical investigation and rig anchoring advice for a 350 mm diameter, 700 m length HDPE sewer outfall pipeline installed by HDD methods below coastal cliff line and offshore. Activities included coastal mapping, desktop studies from aerial photos and drilling of deep on shore boreholes on the existing sea cliffs for assessment of HDD ground conditions.
East West Link Project Victoria, Australia	Stage 1 Geotechnical lead for 4.2 km length, twin 15 m diameter road tunnel reference design. Role involved client advisor for geotechnical investigations, preparation of a detailed ground model as well as technical support. Led multiple experienced teams to successfully complete geophysical surveys, tender phase drilling and detailed hydrogeological testing. The ground models produced were used extensively during the Comprehensive Impact Assessment process and by bidding consortia to identify key ground risks and tailor construction methodology to the varying ground conditions. As part of the deliverables managed the preparation of a consolidated geotechnical database which included hundreds of borehole records from both historical and 2012-2014 drilling programs to allow digital transfer of data to bidders and designers.
Carlton Sewer Upgrade Victoria, Australia	Geotechnical design and site inspection verification of temporary shotcrete shaft support up to 28 m depth in hard basalt rock.
North Yarra Main Sewer Replacement Victoria, Australia	Geotechnical investigation, design and preparation of Baseline Geotechnical Report (GBR) for the construction of a micro tunnelled sewer. The project consists of up to 2.1 km of sewer replacement with an internal diameter of up to 1.5 m, driven through hard basalt rock and soft sedimentary rock, up to 20 m below ground surface.
Warragul Outlet Sewer Victoria Australia	Geotechnical investigation for micro-tunnelled and open trenched sewer project. Included tender assessment and risk work shop role for micro-tunnelling on behalf of the Gippsland Water.
Glenmaggie-Coongulla Sewer Victoria, Australia	Included 800 m length of deep HDD boring under two arms of Lake Glenmaggie. Involved geotechnical investigation and risk workshop advice for design and construction of the preferred HDD trajectory.

Melbourne Main Sewer Replacement Project Victoria, Australia	Geotechnical Investigation, interpretation and design for the construction of the AU $220 Million Melbourne Main Sewer Replacement. The sewer consists of a 2.2 km long tunnel constructed with TBM technology. The tunnel is segmentally lined with an internal diameter of 2.4m. The tunnel is located in a complex and challenging geological setting containing soft saturated sediments of the Yarra Delta Group.
STEP Tunnel Project Abu Dhabi, UAE	Geotechnical assessment and input to tender design for a 4m (ID) TBM tunnel in Abu Dhabi. Tunnel length of approximately 16 km, driven in low strength rock containing solution cavities (karst terrain) and saturated hyper saline groundwater conditions.
Sandgate Avenue Victoria, Australia	Geotechnical investigation, interpretation, design and critical construction phase support. Project involved pipe jack tunnelling for a 2.5m ID pipeline of 1.5 km length in Frankston, including shallow cover tunnelling under an existing highway.
Victorian Desalination Project Victoria, Australia	Geotechnical investigations and analysis for tunnel reference design. Investigations included 1500 m long cored horizontal directionally drilled boreholes, in addition to offshore and onshore drilling and geophysics.
Hallam Valley Main Sewer Victoria, Australia	Geotechnical investigations for a pipe jacked TBM sewer tunnel through saturated alluvial clays and weathered Silurian rock.

PROJECT EXPERIENCE – RAIL

Regional Rail Project Victoria, Australia	Package B – North Melbourne to Footscray. Completion of verification reviews of piled structures and ground improvement for embankment construction within poor ground conditions of Yarra Delta geology.
Westall Rail upgrade Victoria, Australia	Investigations and design for construction of 2.7 km of third track duplication, between Centre Road and Springvale Road. New station platform, a pedestrian bridge structure and rail stabling yards. Included design of a geogrid reinforced track foundation to cope with poor ground conditions and minimise depth of subgrade replacement next to existing rail tracks.
Rail Stabling Facilities Victoria, Australia	Geotechnical investigation and design for new stabling areas at Brighton Beach, Upper Ferntree Gully and Upfield
Sunshine Rail Corridor Victoria Australia	Geotechnical lead for investigations, including borehole drilling, track test pits and on-rail ground penetrating radar for 9 km of proposed track duplication and station upgrades between Footscray and the Western Ring Road. Included live rail work at night under track protection & during short duration track occupations. The project information later got incorporated into the Regional Rail project.
Dandenong Rail Corridor Victoria Australia	Geotechnical lead for investigations, including borehole drilling, track test pits and on-rail ground penetrating radar for proposed track duplication and station upgrades between Dandenong and Caulfield. Included live rail work at night under track protection & during short duration track occupations.

PROJECT EXPERIENCE – ROAD

Webb Dock Road Victoria Australia	Peer review of settlement impacts for BMD contractors due to construction of a light weight fill earth embankment over existing high pressure oil and gas pipeline easement (WAG & APA pipelines).
Ballina Bypass Rest Area NSW Australia	Preliminary geotechnical design options of ground improvement for service station and truck parking development in northern NSW. Involved preliminary designs for ground improvement options on soft compressible soil, including reinforced piled rafts; stone columns; concrete grout columns or surcharge and wick drain improvement methods.
Merchant St Victoria Australia	Design and earthworks supervision of an EPS block and scoria lightweight fill road build-up in docklands Melbourne. To control settlement in site underlain by compressible Coode Island Silt.
Dingley Bypass Victoria Australia	Geotechnical desktop assessment.
Goodwood Junction Adelaide South Australia	Grade separation tender design support.

PROJECT EXPERIENCE – WATER

WesternTreatment Plant Upgrade Victoria Australia	Preliminary geotechnical investigations and design for 50 m diameter tanks and associated plant infrastructure in an area of weak alluvial soils.
Portland Water Treatment Plant Victoria Australia	Geotechnical investigation and design for new waste water facility, including large concrete clarifier tanks and associated infrastructure sited in poor swampy ground conditions with shallow water table conditions. Involved design of deep pre-construction drainage and ground improvement using square impact roller methods to limit settlement serviceability issues.
Tarago Water Treatment Plant Victoria Australia	Geotechnical investigation and design for a large raw water treatment plant. Included plant siting and landslide risk assessment, geotechnical investigations, foundation design and construction verification.
Barossa Dam South Australia	Geotechnical drilling and modelling of abutment stability for existing concrete arch dam. Involved rock mapping and orientated coring for collection and analysis of geo-structural data.
Malmsbury Dam Victoria, Australia	Geotechnical investigations for assessment of downstream piping risk at toe of existing puddle core earth dam. Involved drilling with blow-out preventer casing and continuous sampling of deep lead alluvium situated under a flow of basalt rock. Management of multiple drill rigs and drilling methods whilst working on 'high risk' dam. Construction of detailed geological model.
Eildon Dam Victoria, Australia	$52M dam improvement project involving a 5m embankment raise and spillway upgrade. Responsible for field investigations and drilling program through existing dam crest as well as borrow material investigations.

PROJECT EXPERIENCE – MARINE

Port of Geelong, Lacelles Wharf Victoria, Australia	Lead geotechnical engineer for investigation and analysis of a 300 m wharf extension in Geelong. Included analysis of engineering parameters and modelling of 13 m retained height of embedded sheet pile wall (combi-wall) with dead man anchors. Staged construction sequence modelled including pre-dredge and post dredge berth pocket construction scenarios and potential use of light weight scoria rock fill for land backed reclamation.
Port of Hastings Victoria, Australia	Scoping of geotechnical marine, geophysics and terrestrial investigations. Feasibility study support for dredging and reclamation works.
Royal Yacht Club Williamstown Victoria, Australia	Geotechnical forensic advice relating to collapse of a sheet pile coffer dam. The sheet pile wall was constructed as part of dry cell temporary works for a new concrete boat lift structure.
Bay West (Werribee) Victoria, Australia	Geotechnical desktop assessments for a potential new deep water port in Port Phillip Bay.

PROJECT EXPERIENCE – MINING

Loy Yang Coal Mine Victoria, Australia	Batter inspections, mine dump stability, design of new ash tailings facilities.
Hazelwood Coal Mine Victoria, Australia	Investigation and design of ash tailing dam raise (HAP4A) using insitu ash materials.
Yallourn Coal Mine Victoria, Australia	Eastern ash landfill geotechnical investigations and stability analysis for new mine waste dump and return water pond.
Burnie, Tasmania	Onsite training of geologists for collection of orientated core data for the design of a new iron ore open pit mine.
Phulbari Black Coal Deposit Bangladesh	Geotechnical investigations and supervision of exploration drilling program for the feasibility study of a new black coal mine in Bangladesh. Involved short term overseas trip rotations at a remote location to supervise exploration fieldworks of up to approximately 6-8 weeks duration

PROJECT EXPERIENCE – MISCELLANEOUS

Civil	Civil geotechnical investigations & design (retaining walls, commercial buildings & retained basements, pipelines, large tanks and waste water treatment plants).
Slope Stability	Slope stability landslide risk assessments, Falls Creek, Bulla, Otway coast and Gippsland.
Pavements	Road pavement investigations and design (Flexible and rigid pavements).
Bridges	Bridge pile investigations.
Renewable Energy	Wind turbine and solar array ground investigations.
Legal	Expert witness advice (distressed buildings)

PROFESSIONAL AFFILIATIONS

Chartered Professional Engineer, The Institution of Engineers Australia

(IE Aust MIEAust CPEng)

PUBLICATIONS

Barber, J., O'Shannessy, T. (2012), *Goulburn River Pump Station Geotechnics - Sugarloaf Pipeline Project*, ANZ Conference, Melbourne, Victoria.

Surjadinata, J., O'Shannessy, T., Hull, T. (2011), *Measurement of Tunnelling-induced Soil Movement in Coode Island Silt*, ICAGE 2011 Proceedings of the International Conference on Advances in Geotechnical Engineering Perth, Australia, November 7-9, pages 303-309.

Clark, P., Dixon, M., O'Shannessy, T. (2011), *Soft Ground Tunnelling in Melbourne Investigation and Design of the Melbourne Main Reliever*, 13th Australian Tunnelling Conference, Melbourne, Australia, May 4-7, pages 281-295.