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Report on Numerical Analysis - Sydney Metro

Fiveways Project

Falcon Street, Pacific Highway and Alexander Street, Crows Nest

Prepared for Deicorp Pty Ltd

Project 86645.03

13 May 2025

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Document History

Details

Project No.	86645.03
Document Title	Report on Numerical Analysis - Sydney Metro
Site Address	Falcon Street, Pacific Highway and Alexander Street, Crows Nest
Report Prepared For	Deicorp Pty Ltd
Filename	86645.03.R.002.Rev2

Status and Review

Status	Prepared by	Reviewed by	Date issued
Draft A	Craig Stemp	Charles Marais	4 August 2023
Revision 0	Craig Stemp	Richard Merryfield	30 August 2023
Revision 1	Craig Stemp	Richard Merryfield	11 September 2023
Revision 2	Ernesto Vega	Charles Marais / Peter Hunt	13 May 2025

Distribution of Copies

Status	Issued to
Draft A	Andrew Coleman, Deicorp Pty Ltd
Revision 0	Andrew Coleman, Deicorp Pty Ltd
Revision 1	Andrew Coleman, Deicorp Pty Ltd
Revision 2	Andrew Coleman, Deicorp Pty Ltd

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

Signature	Date
Author	13 May 2025
Reviewer	13 May 2025

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Report on Numerical Analysis for Sydney Metro Fiveways Project
Falcon Street, Pacific Highway and Alexander Street, Crows Nest

1. Introduction

This revised report presents the results of a 3D numerical analysis undertaken by Douglas Partners Pty Ltd (DP) for the proposed Fiveways development considering a reduction in basement levels. The assessment was undertaken in general accordance with Douglas Partners' proposal 86645.05, dated 14 April 2025 and acceptance received from Deicorp Pty Ltd on 15 April 2025.

It is understood that the proposed development will include the demolition of the existing buildings and construction of a mixed-use structure (residential with retail uses) with a 5-level basement.

The numerical analysis has been carried out to assess the potential impact of the proposed development (demolition/excavation and construction of new building) on the Sydney Metro tunnel infrastructure.

The input parameters, model sequence and results are discussed within this report.

2. Site description

The site is triangular and covers approximately 3,300 m^2, located in the suburb of Crows Nest. The site is bounded by Falcon Street, Pacific Highway and Alexander Street (refer Figure 1). The existing surface slopes gradually from west to east along Falcon Street (from RL 99.1 m to RL 96.7 m) and north to south along Pacific Highway (from RL 99.1 m to RL 96.0 m). Along Alexander Street the existing surface slopes towards the south (from RL 96.7 m to RL 96.0 m).

The site is currently occupied by a number of commercial properties, between 2 and 4 levels high, with one property having an existing single level basement.

Dual Sydney Metro tunnels pass beneath the site, as shown in Figure 1, with tunnel crown level understood to be between RL 65 m and RL 63 m (refer "for construction" TfNSW Drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02 attached in Appendix B for further details). The closest cross-passage (XP45) between the two tunnels is shown to be at the northern site boundary. Stantec Survey Drawing 3050-01019-001-002-2 is also attached in Appendix B, which details the tunnel location relative to the site.

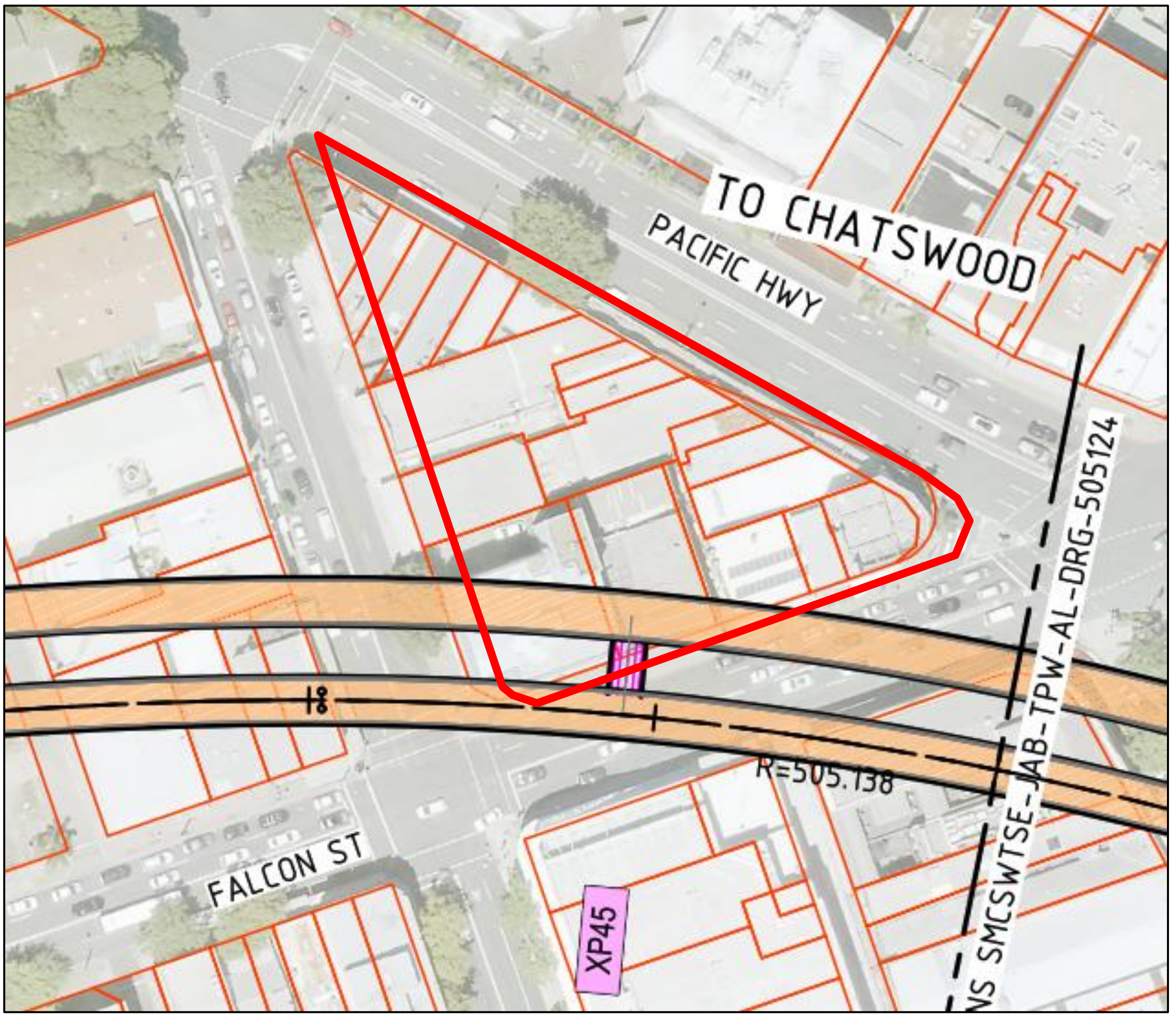

Figure 1: Aerial View of Site with Sydney Metro Tunnel Overlay (note, south up the page)

3. Proposed Development

It is understood that the proposed development will include demolition of the existing buildings on site and construction of a mixed-use structure (residential with retail uses) with a 5-level basement with finished floor level at RL 79.56 and TL 79.61 m (AHD[1] - refer Turner Drawing A-111-003 Rev.A attached in Appendix B).

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[1] Australian Height Datum

The proposed development is understood to be located partly in the Sydney Metro tunnel second reserve, with the dual tunnels (RT01 and RT02) running beneath the northeastern corner of the site (refer TfNSW "for construction" drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02 attached in Appendix B). The tunnels are shown to plunge towards the east with the tunnel crown increasing in depth from approximately RL 65 m to RL 63 m. A cross passage is shown between the two tunnels, located just to the north of the site. Both tunnels are shown to be circular with a diameter of approximately 7.05 m (refer sheet 2 to 4 of drawing 3050-01019-001-002-02, prepared by Stantec attached in Appendix B).

4. Information provided

For the purpose of the assessment, the following documents and information were provided by Deicorp Pty Ltd:

- Drawing titled "PLAN SHOWING RELATIONSHIP OF ROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST", Stantec Drawing No. 3050-01019-001-002-02, dated 5/05/2023.
- Drawing titled "SITE RETENTION PLAN", ABC Consultants Drawing No. 23012-S01.001 Rev 03, dated 9/04/2023.
- Drawing titled "GA PLAN AND LONGITUDINAL SECTION", TfNSW Drawing No. SMCSWTSE-JAB-TPW-AL-DRG-505123 dated 17/05.19.
- Drawing titled "DETAILED EXCAVATION PLAN", Turner Drawing No. A-018-010 Rev A dated 19/03/2025.
- Drawing titled "BASEMENT 05", Turner Drawing No. A-111-003 Rev I dated 4/11/2024.
- Drawing titled "FOUNDATION PLAN", ABC Consultants Drawing No. 23012-S02.001 Rev P5, dated 7/03/2025.
- Drawing with mark-ups titled "FOUNDATION PLAN", ABC Consultants Drawing No. 23012-S02.001 Rev P5, dated 7/03/2025.
- Document summary titled "References for Coordination - Fiveways Crows Nest Assessment - Crows Nest.pdf", Delve Underground.

5. Geotechnical model

The geotechnical model has been based on geotechnical investigations[2] undertaken at the site. The subsurface profile has been divided into four material units as outlined in Table 1.

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[2] Douglas Partners Geotechnical Investigation Report 86645.03.R.001.Rev0, dated 4 July 2023

Table 1: Geotechnical model

Unit	Material Description (Pell's Classification)	Description
A	Fill and Residual Soils	Fill comprising sandy gravel, sandy and clayey soils underlain by residual, low to high plasticity, stiff to hard clay and dense sands.
B	Very Low to Low Strength Shale / Laminite (Ashfield Shale) CLASS IV/III	Shale and laminite bedrock of very low and low strength with some medium strength bands. Mainly highly weathered, then fresh, with extremely weathered bands, highly fractured to slightly fractured.
C	Very Low to Medium Strength Siltstone / Sandstone (Mittagong Formation) CLASS IV/III	Sandstone and siltstone bedrock of generally very low and low strength with medium strength bands, mainly fresh, fractured to slightly fractured.
D	Medium to High and High Strength Sandstone (Hawkesbury Sandstone) CLASS II	Sandstone of medium to high and high strength. Mainly fresh, slightly fractured to unbroken.

Refer Table 2 for underside of the individual units.

The geotechnical investigation (Refer DP Report 86645.03.R.001.Rev2 issued in 2025) and general expected trends in Sydney indicate the following defects could be expected within the rock mass:

- Unit B: Closey bedded (dipping 0° to 5°) with possible highly weathered seams and an orthogonal pair of smooth, planar, steeply dipping (70° to 90°) joint sets, typically striking NNE and ESE, spaced at 0.5 m to 5.0 m. Randomly oriented joints (some slickensided), dipping 20° to 45°, is also common in the shale.
- Unit C: Same as for Unit B, but the orthogonal and randomly oriented joints are smooth to rough.
- Unit D: Thickly bedded, dipping 0° to 20°. An orthogonal pair of rough, planar, steeply dipping (70° to 90°) joint sets, typically striking NNE and ESE and spaced at between 1.0 m to 10 m.

Groundwater monitoring on site indicates the groundwater level ranges from RL 93.1 to RL 86.1 m.

6. Numerical analysis

DP has used FLAC^{3D} to analyse the potential impact of the proposed development on the Sydney Metro tunnel infrastructure. FLAC^{3D} (Fast Lagrangian Analysis of Continua) is a three-dimensional explicit finite difference program for modelling of soil, rock, and structural behaviour. FLAC^{3D} is an analysis and design tool for geotechnical, civil, and mining engineers that can be applied to a broad range of problems in engineering studies. Materials are represented by elements, or zones, which form a grid that is adjusted by the user to fit the shape of the object to be modelled. Each element behaves according to a prescribed linear or non-linear stress/strain laws in response to the applied forces or boundary restraints.

FLAC^{3D} is ideally suited for modelling geomechanically problems that consist of several stages, such as sequential excavation, loading and de-stressing. The explicit Lagrangian calculation scheme and the mixed-discretization zoning technique used in FLAC^{3D} ensure that plastic collapse and flow are modelled accurately. The material can yield and flow, and the grid can deform (in large-strain mode) and move with the material that is represented. The formulation can accommodate large displacements and strains and non-linear material behaviour, even if yield or failure occurs over a large area or if total collapse occurs.

The geometry of the model is based on the information provided by the Deicorp Pty Ltd and their design team. Plots 1 to 3 in Appendix D present the modelled 3D geometry of the Sydney Metro tunnels and proposed development.

6.1 Geotechnical model profile

The surface and rock levels in the model were set up to the approximate surveyed ground levels and rock unit RL's from the investigation (DP, 2025). The simplified geotechnical profile used in the numerical model is provided in Table 2 with unit depth referenced to BH3.

Table 2: Geotechnical Profile for Numerical Model at BH3 Location (DP, 2023)

Geotechnical Unit	Material Description	Depth to Underside of Unit (m)
1	Stiff Clay	3
2	Very Low Strength Shale	16
3	Low Strength Sandstone	18
4	High Strength Sandstone	76 (Model depth)

Groundwater levels are transient in nature and affected by factors such as climatic conditions and will therefore vary with time. For this analysis the groundwater was assumed to be at RL 94 m (on the rock/soil interface).

6.2 Geotechnical material properties

In order to estimate the rock strength parameters, Unconfined Compressive Strengths (UCS) and Intact Elastic Modulus (Ei) testing undertaken during the geotechnical investigation (DP, 2025) was correlated against Axial Point Load Strength values ($Is_{(50)}$) from the borehole cores. UCS correlation values around Sydney generally vary between 16 to 29 times the $Is_{(50)}$. For this analysis a correlation value of 20 was used. Figure 2 shows a plot of inferred and tested UCS values versus the model strength profile adopted.

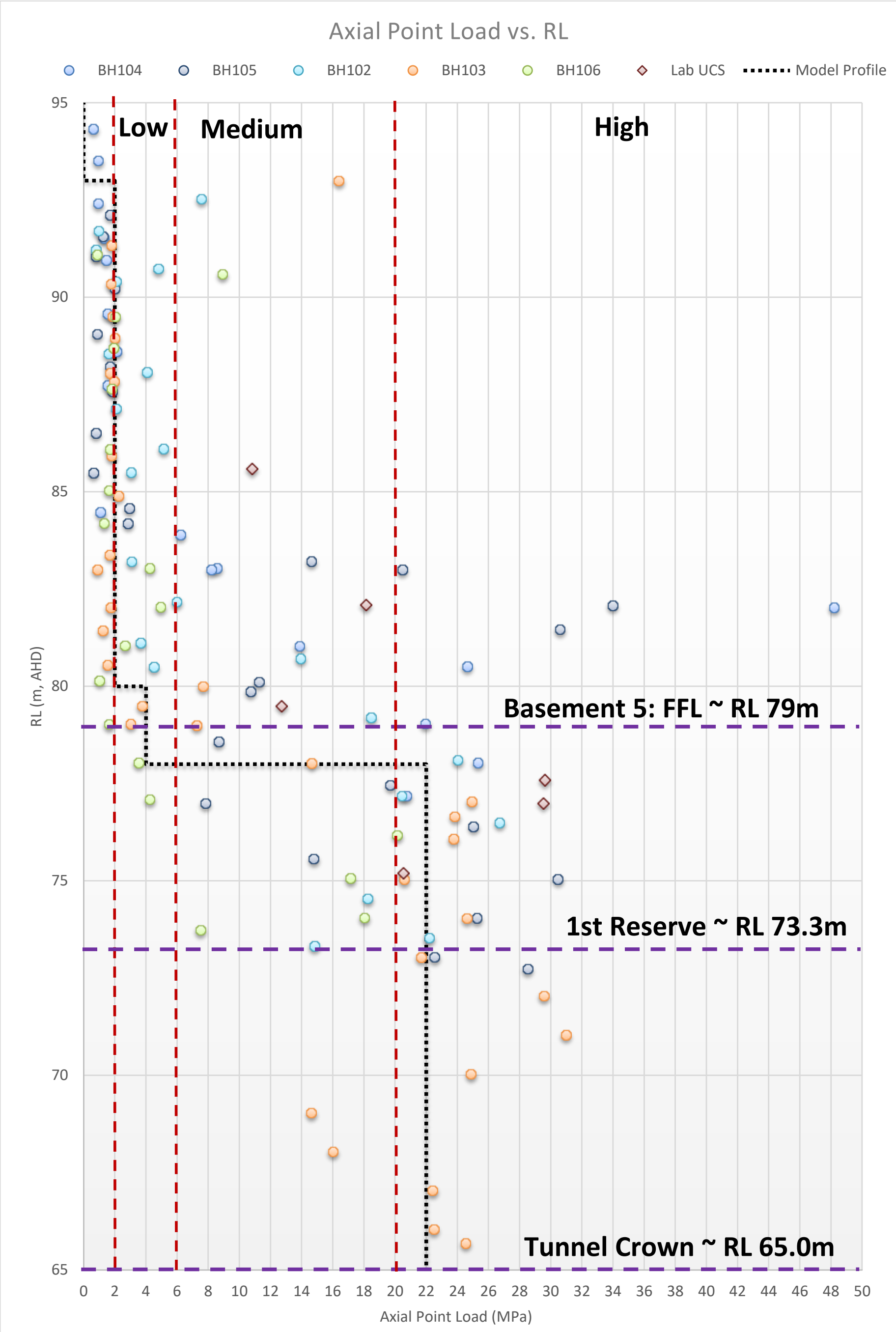

Figure 2: Estimated UCS Vs RL and Adopted Model Strength Profile

The correlation, or Modulus Ratio (MR), between UCS and Ei (secant) varied from 110 to 205. The MR adopted for Unit 4 was 165, based on the median value of test results (refer Table 3). The inferred UCS values, estimated Geological Strength Index range (GSI) and MR were then processed with RocLab by Rocscience to estimate the rock properties, as listed in Table 4. Note that only Unit 4 was modelled as a Mohr Coulomb material. All other units were modelled using an elastic constitutive model.

A sensitivity run was included with rock mass properties and in-situ stress relationships in line with Metro design[3] parameters was used.

Table 3: Results of UCS and Deformation Testing

Bore	Depth (m)	Uniaxial Compressive Strength (MPa)	Tangent		Secant	
			Elastic Modulus (GPa)	Poisson's Ratio	Elastic Modulus (GPa)	Poisson's Ratio
BH102	17.0-17.3	12.7	2.9	0.22	2.6	0.12
BH103	19.1–19.3	29.5	6.4	0.39*	5.1	0.21
BH104	16.2-16.5	29.6	6.3	0.40*	4.6	0.24
BH105	12.5-12.8	10.8	1.6	0.12	1.2	0.07
BH105	16.0-16.3	18.1	1.1	0.42*	2.3	0.31*
BH106	21.6-21.9	20.5	4.4	0.31*	3.7	0.25

* Poisson's ratio values should not be relied upon.

[3] Hochtief Engineering (2018), Appendix G2 Summarized Geotechnical Parameters TD1/3, SMCSWTSE-JHO-TPW-DN-RPT-900010 Rev 00

Table 4: Geotechnical Material Properties

Geotechnical Unit	1	2	3	4
Material	Stiff Clay	Very Low Strength Shale	Low Strength Sandstone	High Strength Sandstone
Constitutive Model	Elastic	Elastic	Elastic	Mohr Coulomb
Pells Class	-	IV	IV	II
GSI	-	40	65	80 (65)
Unit Weight (kN/m3)	20	22	23	24
UCS (MPa)	-	2	4	22
Friction angle (°)	-	-	-	60 (50)
Case 1 - Erm (MPa)	15	200	400	3400 (2000)
Poisson's Ratio	0.3	0.25	0.25	0.2 (0.25)
Cohesion (kPa)	-	-	-	1400 (500)
Tension (kPa)	-	-	-	420 (100)

( ) Bracketed values are sensitivity values in line with Metro design

6.3 In-Situ Stress

The following in-situ stress relationship, adopted from Pells (2002)[4], was used for the high strength sandstone in Geotechnical Unit 4.

σ_1= 1.5 MPa + (2 x σ_3)

σ_2 = 1.0 MPa + (1.2 x σ_3)

σ_3 = γ x H

where,

[4] Pells, P.J.N (2002), Developments in the Design of Tunnels and Caverns in the Triassic Rocks of the Sydney Region, Int J Rock Mech and Min Sci, 39:569-587.

σ_1 = maximum principal stress (north-south direction)

σ_2 = intermediate principal stress (east-west direction)

σ_3 = minor principal stress (vertical)

γ = unit weight = 24 kN/m^3

H = depth below surface (m)

For the very low to low strength units (Unit 2 and 3), a ratio of 1:1 (horizontal to vertical stress) was used. For the soil (Unit 1), a ratio of 0.5:1 (horizontal to vertical stress) was used.

The following in-situ stress relationship, adopted from Hochtief (2018), was used in the sensitivity analysis for the high strength sandstone in Geotechnical Unit 4.

$\sigma 1 = 2.5 \text{ MPa} + (2 \times \sigma 3)$

$\sigma 2 = 0.7. \sigma 1$

$\sigma 3 = \gamma \times H$

6.4 Bedding and Jointing

The bedding and jointing in the geological model have been simplified in a rock mass model (i.e., joints have not been explicitly included). The rock mass properties, however, have been downgraded to account, to some extent, for defects, based on the defects (GSI) observed in the recovered cores (Serviceability Case Properties). For the Sensitivity Case the GSI in accordance with Metro design parameters was used to derive the properties.

6.5 Structural Elements

As the tunnels have been developed in high strength sandstone, well below the excavation, shoring was not explicitly included in the model, with the soils and lower strength rock units modelled as an elastic medium, making it possible to run the model without actually supporting these excavated faces (this allows the material to elastically fully de-stress). Shoring design should, therefore, not rely on the results of this analysis (needs to be assessed separately by the geotechnical and structural engineers).

Structural elements were used in the model to represent the tunnel and cross-passage linings. Details of the structural element properties adopted for the analysis are presented in Table 5. These properties have been provided by Delve Underground (DU). The thickness of the liners varies slightly from the drawings as they are scaled, based on the estimated moment of inertia provided by DU.

The running tunnel linings have been installed after the tunnel excavation has been run to 90% relaxation, in order to be consistent with the TBM design approach (as advised by DU). The cross-passage lining, however, has been installed close to 100% ground relaxation. The liner includes pore pressure but does not include other design loads such as wedge loads, track loads, grout pressures, etc (to be assessed separately by DU).

Table 5: Properties of Elastic Structural Liner Elements (provided by Delve Underground)

Type	Interface Stiffness (GPa/m)		Unit Weight (kN/m³)	Elastic Modulus (GPa)	Poisson's Ratio	Thickness (mm)
	Normal (K_n)	Shear (K_s)				
Running Tunnel	1.0	0.1	25	37	0.2	192
Cross Passage - Section A1	1.0	0.1	25	35	0.2	737 in sidewall 528 in crown 650 in invert
Cross Passage - Section B1	1.0	0.1	25	35	0.2	1380 in sidewall 1250 in crown 800 in invert

6.6 Foundation Loads

Existing building loads for the site have been calculated assuming 10 kPa per floor (as confirmed by ABC Consultants). The total load has been applied as a uniform pressure over the footprint of the buildings.

The footings and cores of the existing building excavations have been explicitly modelled from ABC Consultants Drawing No. 23012-S02.001 Rev P5. For simplicity, all excavations were taken down to 1.5 m below the BEL to RL 77.5 m.

The proposed development loads are shown on the ABC Consultants mark-up Drawing No. 23012-S02.001 Rev P5 attached in Appendix C. The combined loads (G+Q as advised by ABC Consultants) were used to calculate the bearing pressure at the bottom of each footing and cores. The maximum applied pressure per type of footing and core was applied in the model at the bottom of each individual excavation directly on the grid.

6.7 Modelling Geometry

The basement geometry has been based on the external retention boundary in drawing from ABC Consultants S01.001 Site retention Plan Rev 03 issued for construction in 09.04.25.

Sydney Metro infrastructure was based on Metro Drawing SMCSWTSE-JAB-TPW-AL-DRG-505123-02.

The model geometry should be confirmed by Deicorp.

6.8 Modelling Sequence

Two cases were analysed (Serviceability and Sensitivity).

Case 1: Serviceability Rock Mass Properties.

The following sequence was modelled:

<u>Stage 0</u>: Initial Conditions

- Set up geology, geometry, water table and stress conditions prior to any development and run to equilibrium.
- Apply existing building loads and run to equilibrium.
- Reset displacements, excavate the Metro running tunnels to 90% relaxation and install tunnel liners and run to equilibrium.
- Excavate the Metro cross-passage and run to equilibrium.
- Install the Metro cross-passage liner and run to equilibrium.

<u>Stage 1</u>: Proposed Excavation

- Reset displacements, apply construction load, excavate proposed basement and run to equilibrium. Note, the existing building loads were removed in areas that excavation had taken place, simulating demolition and excavation in the same stage.
- Draw the groundwater level down to bulk excavation level and run to equilibrium.

<u>Stage 2</u>: Proposed Construction

- Apply proposed building loads and run to equilibrium.

Case 2: Lower Bound Rock Mass Properties (Sensitivity Run)

Case 2 comprised a sensitivity run with lower bound properties and upper bound in-situ stress presented in line with Metro design parameters. The same sequence used for Case 1 was used for Case 2. The purpose of the sensitivity run is to provide upper bound predictions.

Results are discussed in the sections to follow.

7. Results

The results of the analysis have been presented as plots of induced displacement and stress in the rock mass. Displacement for the tunnel and cross-passage liners have also been provided. Additional structural outputs are available on request. The plots are attached in Appendix D.

The rock mass, and the tunnel and cross-passage liner displacements were reset after Stage 0 (existing conditions). Stage 1 therefore only represents displacement of the rock mass and liners due to the excavation proposed by the current development. Stage 2 Plots represent the cumulative effects of the proposed excavation and building loads. Stresses were not reset and hence predict the total stress within the materials.

Is should be noted that the results are provided in SI units in metres and Pascals, and that:

- Negative stress represents compression, i.e., the most negative stress is the maximum principal stress and the less negative stress is the minimum principal stress.
- Total displacement or 'displacement magnitude' represents the sum of all magnitudes/direction of displacement.
- Certain contour plots have been adjusted to focus on the displacements around the tunnel and have been limited to the values shown.

The cross section shown on the plots was chosen through the intersection between the cross-passage and the Metro tunnels. Plots of other sections and liner outputs are available on request.

The following plots have been included:

- Plots of the 3D geometry modelled (Plots 1 & 2).
- Plot of the geotechnical units and section for analysis (Plot 3).
- Plot of the bearing pressures applied (Plot 4).

Case 1: Serviceability Rock Mass Properties

- Plots of total displacement (including tunnels and cross-passage liners) for Stage 1 and Stage 2 along Section 1 (Plot 5).
- Plots of total displacement and direction of displacement vectors on tunnel and cross-passage liners, in perspective 3D views (Plot 6).
- Plots of minimum and maximum principal stress for Stage 0, Stage 1 and Stage 2 along Section 1 (Plots 7 & 8).

Case 2: Lower Bound Rock Mass Properties (Sensitivity Run)

- Plots of total displacement and direction of displacement vectors on tunnel and cross-passage liners, in perspective 3D views (Plot 9).

Additional plots for Case 2 are available on request.

A summary of the results presenting the displacements and stress around the underground structures is shown in Tables 6 and 7 for Case 1, and Tables 8 and 9 for Case 2.

Serviceability Case (Case 1)

The serviceability model indicated that:

- Maximum rock mass displacement of 1.3 mm, 2.3 mm and 1.4 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 1 – refer Table 6).
- Maximum rock mass displacement of 0.6 mm, 1.3 mm and 1 mm are predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2).
- The liner displacements are similar to that of the rock mass with maximum liner displacements of 0.6 mm, 1.3 mm and 1 mm predicted in RT01, RT02 and cross-passage, respectively (at the end of Stage 2). A maximum angular distortion of 0.05 mm/m was calculated.

- The plots indicate that there is generally a reduction in the maximum and minimum principal stresses in the rock in the vicinity of the crown of the tunnel and cross-passage during the excavation stage (Stage 1- refer Table 7). The maximum principal stress in the rock around the RT01 and cross-passage tunnels reduces by up to 75 kPa. In contrast to these tunnels, the maximum principal stress in the rock around RT02 increases by 185 kPa. The minimum principal stress in the rock around all tunnels reduces by up to 50 kPa.
- During loading (Stage 2) the maximum principal stress in the rock around the crown of the tunnels and cross-passage increased between 50 kPa and 115 kPa, relative to Stage 0. The minimum principal stress increases of up to 45 kPa, relative to Stage 0.

Table 6: Case 1 Results – Predicted Displacements

Underground structure	Maximum Rock Mass Displacement (mm)		Maximum Liner Displacement (mm)	
	Stage 1	Stage 2	Stage 1	Stage 2
RT01	(1.3)	0.6	(1.3)	0.6
RT02	(2.3)	1.3	(2.3)	1.3
Cross-passage	(1.4)	1	(1.4)	1

Values in brackets indicate upward movement; values without brackets indicate downward movement.

Table 7: Case 1 Results – Predicted Stress Change in the Rock Mass in Tunnel Crown

Underground structure	Location	Change in Maximum Principal Stress* (kPa)		Change in Minimum Principal Stress* (kPa)	
		Stage 1	Stage 2	Stage 1	Stage 2
RT01	Crown	75	-50	6	-10
RT02	Crown	-185	-115	50	-45
Cross-passage	Crown	20	-50	30	-40

*change relative to Stage 0; a negative value indicates an increase in compression while a positive value indicates a decrease in compression.

Sensitivity Case (Case 2)

The sensitivity model (Case 2) indicated that:

- At the end of Stage 1 a maximum rock mass displacement of 5.9 mm, 7.1 mm and 6.2 mm are predicted in RT01, RT02 and cross-passage, respectively (refer Table 8).
- At the end of Stage 2 a maximum rock mass displacement of 4.8 mm, 4.6 mm and 4.2 mm are predicted in RT01, RT02 and cross-passage, respectively.
- The liner displacements at the end of Stage 2 are slightly less than the rock mass displacements, with maximum liner displacements of 4 mm, 4.4 mm and 3.1 mm predicted in RT01, RT02 and cross-passage, respectively. A maximum angular distortion of 0.62 mm/m was calculated.
- The plots indicate that the maximum and minimum principal stress in the rock around the crown of the tunnels and cross-passage generally reduce after Stage 1 and Stage 2 (by up to

1.1 MPa, relative to Stage 0 – refer Table 9). The minimum principal stress decreases by up to 530 kPa and 170 kPa, relative to Stage 0, for Stage 1 and Stage 2, respectively.

Table 8: Case 2 Results – Predicted Displacements

Underground structure	Maximum Rock Mass Displacement (mm)		Maximum Liner Displacement (mm)	
	Stage 1	Stage 2	Stage 1	Stage 2
RT01	(5.9)	4.8	(5.4)	4
RT02	(7.1)	4.6	(6.2)	4.4
Cross-passage	(6.2)	4.2	(4.5)	3.1

Values in brackets indicate upward movement; values without brackets indicate downward movement.

Table 9: Case 2 Results – Predicted Stress Change in the Rock Mass in Tunnel Crown

Underground structure	Location	Change in Maximum Principal Stress* (kPa)		Change in Minimum Principal Stress* (kPa)	
		Stage 1	Stage 2	Stage 1	Stage 2
RT01	Crown	680	600	530	-40
RT02	Crown	730	800	195	40
Cross-passage	Crown	1130	1110	235	170

*change relative to Stage 0; a negative value indicates an increase in compression while a positive value indicates a decrease in compression.

8. Comments

The objective of the analysis was to provide estimates of displacements in rock mass and tunnel and cross-passage lining due to the proposed development (basement excavation and foundation loading). The objective was to also provide structural liner outputs to DU for tunnel liner structural assessment.

8.1 Assumptions

The following assumptions, which should be considered when interpreting the results, were made:

- After the segmental lining had been installed, the gap between the tunnel lining and rock mass is grouted. The model, however, assumes a continuous liner rather than a segmental liner. A high normal stiffness, no tensile capacity and low cohesion have been assumed for the interface between the lining and the rock. This results in a relatively immediate lining response to any movement in the rock mass surrounding the tunnel. This also allows for the liner to become detached from the rock mass which should be taken into account when assessing the plots and modelling results.
- In the model, the Metro tunnel lining has been installed after 90% relaxation (stress relief) has occurred. This is done to simulate stress relief and deformation that occurs prior to grouting

the void between the lining and rock mass (as is the case when developing a tunnel with a TBM).

- This study included a sensitivity analysis where the rock properties for Unit 4 were reduced, using the parameters presented by Bertuzzi[5]. A higher locked-in rock mass stress was also used for the sensitivity analysis. It is understood that these properties have been used in the design of the Sydney Metro tunnels for Class II Sandstone. It should be noted that these properties are typical to Metro design properties along the alignment and may not reflect the true changes in the rock in terms of stress change and failure at the specific site. They have, however, been included to provide upper bound outputs for the structural assessment.
- Pressures at the base of footings and cores were applied directly to the grid, calculated from loads and footing dimensions provided by the structural engineer.
- Angular distortion (differential displacement) was estimated over ¼ of the tunnel diameter. The angular distortion may be higher in some localised areas such as where the tunnel liners join the cross-passage liners (DU to carry out independent structurally assessment of the liners).
- This report is not intended to be used to assess the requirements for excavation shoring. DP has assumed that the shoring will be designed separately, adequately braced and anchored back to limit soil movements around the perimeter, design to support the overburden materials and weak rock.
- If additional information that may impact the results of this assessment becomes available at a later stage, or if the design changes in any way (i.e., basement excavation depth, building loading or if additional tunnel information becomes available), then it will be necessary to update the current assessment.

8.2 Displacements and Stresses in the Rock Mass (Case 1 - Serviceability Case)

The analysis indicates that, for the properties and construction sequence modelled, the net displacement within the tunnel linings due to the proposed development will be up to 2.3 mm in Stage 1 and 1.3 mm in Stage 2.

The predicted movements indicate an upward movement during excavation due to stress relief, followed by downward movement due to loading during construction of the new building. The predicted displacements are lower than the allowable movement (10 mm) as outlined in the Sydney Metro Technical guidelines (SMA, 2021).

Demolition of the existing structures is predicted to have almost no effect on the tunnels and has been included as part of Stage 1.

The rock mass displacements and resulting tunnel lining deformation equate to a maximum angular distortion in the lining of 0.05 mm/m for Case 1 (over ¼ of the tunnel diameter) which is also less than the allowable limit (0.5 mm/m) outlined in the Sydney Metro Technical guidelines.

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[5] Bertuzzi, R. (2014). Sydney sandstone and shale parameters for tunnel design. Australian Geomechanics, 49(1), 1–40.

The stress in rock mass does show some minor reduction in stress, however, overall the rock remains in compression (increase of up to 114 Kpa, relative to Stage 0). According to Hoek & Martin (2014)[6], the onset of tensile crackling/spalling of the rock mass starts at approximately 40% to 60% x UCS (uniaxial compressive strength of the rock), i.e., at 8.8 MPa to 13.2 MPa for a 22 MPa sandstone. The maximum predicted principal stress of 5 MPa (for the RT01 Metro tunnel) is still well below this "damage criteria".

8.3 Sensitivity Analysis (Case 2)

The sensitivity analysis was carried out to provide upper bound limits of displacements using Metro tunnel design properties.

The analysis indicates that, for the properties and construction sequence modelled, net displacement within the tunnel linings due to the proposed development will be up to 6.2 mm in Stage 1 and 4.4 mm in Stage 2.

The angular distortion of the tunnel lining was estimated to be 0.62 mm/m for Case 2 (over ¼ of the tunnel diameter), which is slightly higher than the 0.5 mm/m limit.

Plasticity is predicted in the rockmass surrounding the tunnels and beneath the bulk excavation level of the proposed development. This is due to the low strength parameters used in Case 2, which are considered unrealistically low. The results of the sensitivity case should be assessed in the context that they are upper bound and quite conservative, taking into account that the Metro tunnel design properties were derived using a significantly reduced GSI.

Parameters used for Case 1 are considered more in line with those used in Sydney (still incorporating some inherent conservatism) and hence is therefore considered more appropriate for comparison with the Sydney Metro Technical Guidelines (SMA, 2021). Both cases, however, should be considered for the structural assessment.

9. Conclusions

This report presents the results of numerical analysis for a mixed-use development bounded by Falcon Street, Pacific Highway and Alexander Street, Crow Nest, Sydney. The numerical modelling has been based on input loads from the client and parameters obtained from geotechnical assessment. A sensitivity case was carried out to evaluate the proposed development for upper bound conditions based on the original tunnel design parameters.

The predicted values of the displacements for Case 1 are less than the limits stipulated by the Sydney Metro Technical Guidelines (SMA, 2021)[7], which allow total displacements of up to 10 mm and an angular distortion of 0.5 mm/m of 1:2000.

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[6] Hoek, E & Martin, C.D. (2014), Fracture initiation and propagation in intact rock – A review, Journal of Rock Mechanics and Geotechnical Engineering 6 (2014) 287 – 300

[7] SMA. (2021). Sydney Metro Underground Corridor Protection Guidelines Revision - June 2021

From a geotechnical engineering point of view, the modelled serviceability stresses and displacements are likely to be within tolerances that are acceptable for the rock surrounding the rail tunnels and cross-passage. Monitoring should be carried out to confirm that the deformations are as predicted and remain within the tolerances. The predicted rock/lining deformations and lining stresses from the model can be provided to DU for the structural assessment of the tunnel liners.

A mentioned above, it will be necessary to monitor displacement and deformation of the tunnel linings during excavation to confirm that the measured displacements are less than the predicted displacements for the base case (Case 1), and that, if additional movement does occur, it is addressed in a timely manner with suitable adjustments to the excavation sequencing or installation of additional support, as required to reduce such movements. Accordingly, a detailed excavation and monitoring plan should be prepared prior to construction.

10. Limitations

Douglas Partners (DP) has prepared this report for this project at Falcon Street, Pacific Highway and Alexander Street, Crows Nest in accordance with DP's proposal 86645.05.P.002.Rev0. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Deicorp Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and / or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

This report provides specialist advice only and no part of it is considered a Regulated Design under the Design and Building Practitioner Act 2020 (NSW).

The scope of work for this report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of fill of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such fill may contain contaminants and hazardous building materials.

Appendix A

About This Report

About this Report

Introduction

These notes have been provided to amplify Douglas' report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

Douglas' reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, Douglas will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, Douglas cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, Douglas will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, Douglas requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. Douglas would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

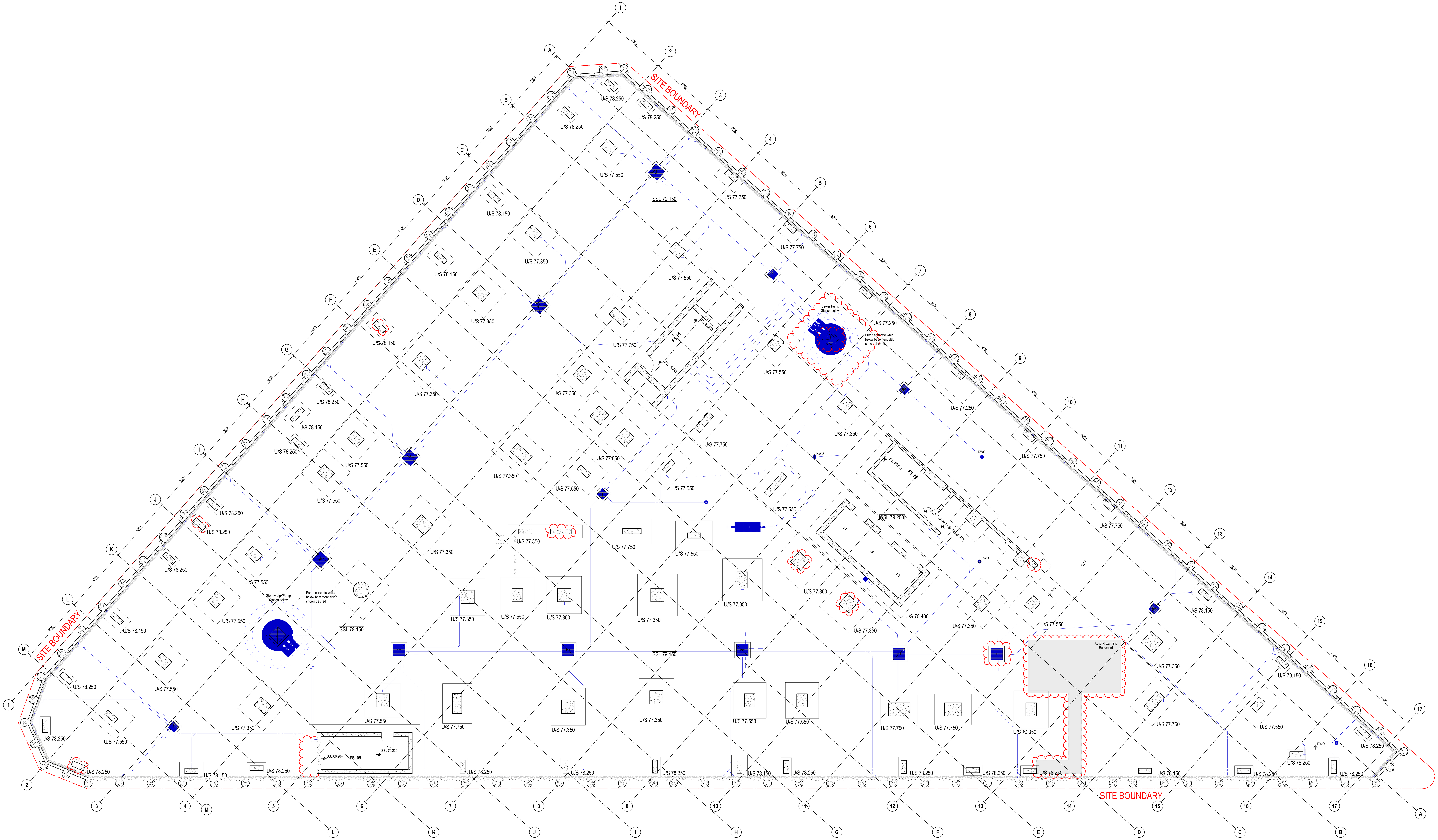
intentionally blank

Appendix B

Drawings

Regulated Design Record				
Project Address:	391/423 Pacific Hwy Crows Nest NSW 2065 Australia			
Project Title:	Fiveways Crows Nest			
Consent No:	SSD-66826207		Body Corporate Reg No: DEP 570	
Drawing Title: Siteworks Detailed Excavation Plan			Drawing No: A-018-010	
Rev	**Date dd.mm.yy**	**Description**	**DP Full Name**	**Reg No**

Non-Regulated



NOTES

 UNLESS NOTED OTHERWISE THIS DRAWING IS NOT FOR CONSTRUCTION. ALL DIMENSIONS AND LEVELS ARE TO BE CHECKED ON SITE PRIOR TO THE COMMENCEMENT OF WORK. INFORM TURNER OF ANY DISCREPANCIES FOR CLARIFICATION BEFORE PROCEEDING WITH WORK. DRAWINGS ARE NOT TO BE SCALED. USE ONLY FIGURED DIMENSIONS. REFER TO CONSULTANT DOCUMENTATION FOR FURTHER INFORMATION.DWG, IFC AND BIMX FILES ARE UNCONTROLLED DOCUMENTS AND ARE ISSUED FOR INFORMATION ONLY.

DLCS Quality Endorsed Company ISO 9001:2015, Registration Number 20476
Nominated Architect: Nicholas Turner 6695, ABN 86 064 084 911

KEY PLAN

DETAILED EXCAVATION PLAN LEGEND

U/S XX.XXX Level to underside of footing

Update Notes:

General Notes:
Dimensions to centre of column unless otherwise noted.

CLIENT
Deicorp
Level 3 161 Redfern Street Redfern NSW 2016

Rev	Date	Approved by	Revision Notes
A	19.03.25	AH	For Coordination

Project Title
Fiveways Crows Nest
391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
Siteworks
Detailed Excavation Plan

Scale	Project No.	Drawn by	North
1:100 @ A0	19073	JC	
Status	Dwg No.	Rev	
For Coordination	A-018-010	A	

TURNER

Level 7 **ONE** Oxford Street
Darlinghurst NSW 2010
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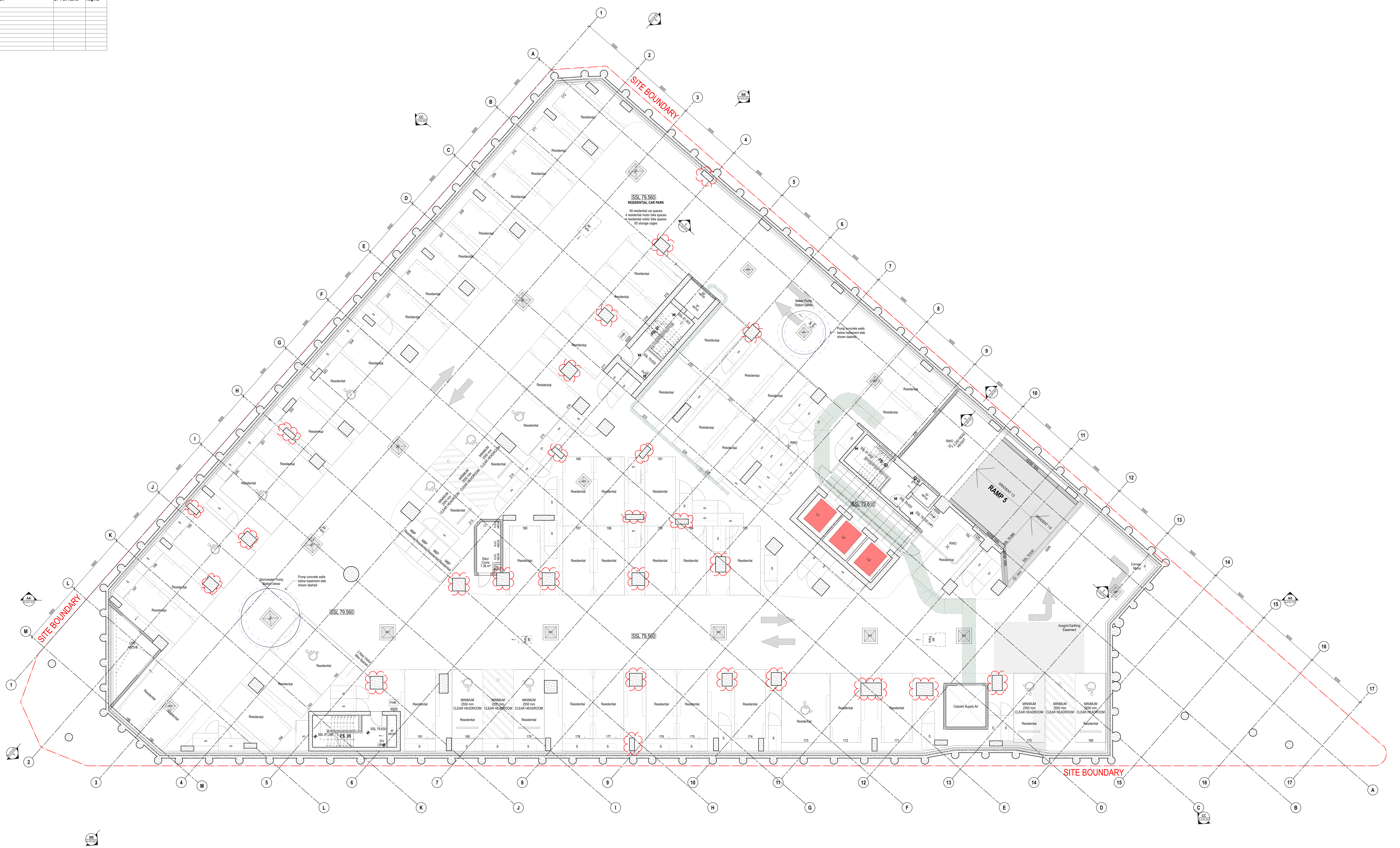
Regulated Design Record				
Project Address:	391/423 Pacific Hwy Crows Nest NSW 2065 Australia			
Project Title:	Fiveways Crows Nest			
Consent No:	SSD-66826207		Body Corporate Reg No: DEP 570	
Drawing Title: 111 GA Plans 1:100 Basement 05			Drawing No: A-111-003	
Rev	Date dd.mm.yy	Description	DP Full Name	Reg No



NOTES

KEY PLAN

GENERAL ARRANGEMENT PLANS LEGEND

CLIENT
Deicorp
Level 3 161 Redfern Street Redfern NSW
2016

Rev	Date	Approved by	Revision Notes
A	04.11.24	AH	For Information
B	18.11.24	AH	For Coordination
C	06.12.24	AH	For Coordination
D	16.01.25	AH	For Coordination
E	06.02.25	AH	For Coordination
F	25.02.25	AH	For Coordination
G	21.03.25	AH	For Coordination
H	03.04.25	AH	For Coordination - CC2
I	16.04.25	AH	For Coordination

NOTE
Drawings updated to align with Hotel MOD DA Drawings issued 15.04.25

Project Title
Fiveways Crows Nest
391/423 Pacific Hwy Crows Nest NSW 2065 Australia

Drawing Title
111 GA Plans 1:100
Basement 05

Scale	Project No.	Drawn by	North
1:100 @ A0	19073	BY/JC/AL	
Status	Dwg No.	Rev	
For Coordination	A-111-003	I	

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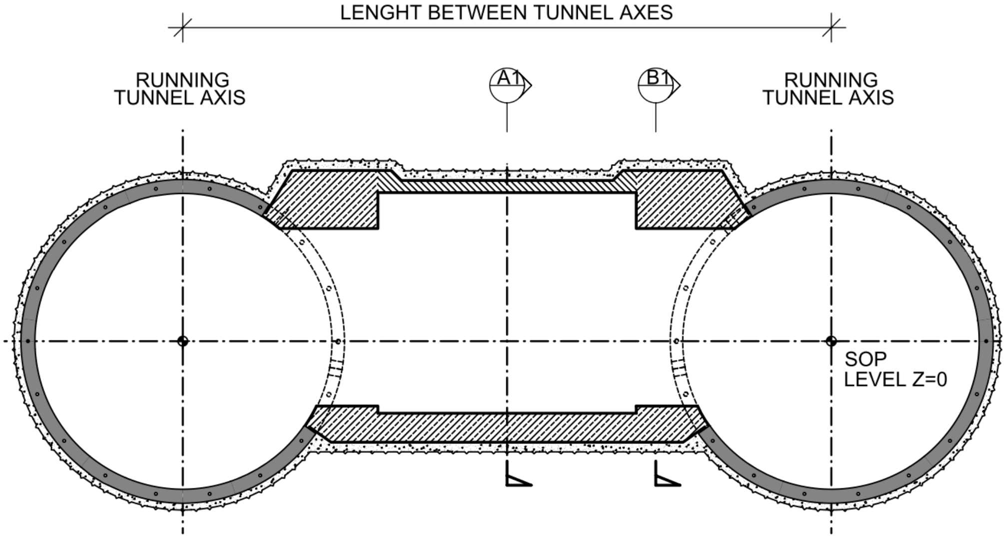


Figure 4-1 Cross Passage without Sump – Longitudinal Section

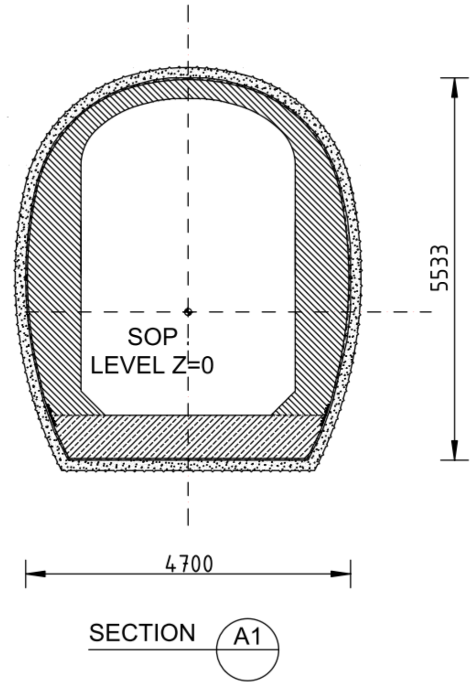


Figure 4-2 Cross Passage without Sump – Regular Section “A1” (middle part)

Hochtief XP Barrel Geometry

6 XP Regular Section "A1" – Plain Concrete (PC)

All description in this Chapter is related to the data in the Appendix H2-1.

6.1 Model Description

The dimensions of a regular cross section are 4700mm (width), ca 5500mm (height). The thickness of the permanent lining varies from 300mm in the vault up to 800mm in the walls. The invert slab is 650mm thick. The shape of the structure in the regular section "A1" is shown in Figure 6-1.

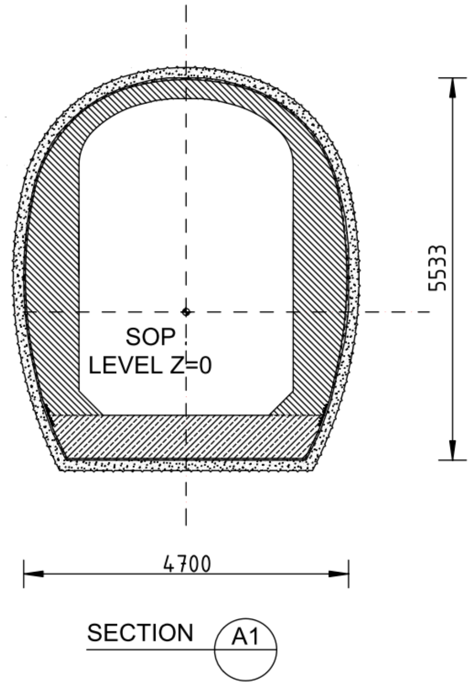


Figure 6-1 Cross Passage without Sump – Regular Section "A1"

The structural calculation of the permanent lining in this section is carried out as 2D task, the dimension in longitudinal direction is b = 1.0m. The structural model in SCIA software, including the support system is shown in Figure 6-2. In order to have the possibility to apply an asymmetric load, the complete lining (left and right symmetric half) structure is modelled. Then the real shape of the structure is replaced by a beam element polygon, the model is divided into 38 elements, some of which with constant thickness (top of vault, invert), some with variable thickness (walls). The centreline always intersects the centre of gravity of a section.

The permanent lining in the vault is cast-in-place plain concrete C40 (beams B1 – B14 and B25 – B38). The variable model thickness (including tolerances 35+5 = 40mm reduction) of the vault changes from 260mm in the top, 760mm in the walls, till 730mm in the lower corner. The invert slab is made of reinforced concrete C40, thickness of 610mm. Permanent lining modulus of elasticity is Ecm = 35.0GPa.

The bedding stiffness is derived from the deformation properties of the surrounding ground material and the excavation dimension acc. the following formula:

7 XP Junction Section “B1” (Collar) - Reinforced Concrete (RC)

All description in this Chapter is related to the data in the Appendix H2-2.

7.1 Model Description

The dimensions of the junction cross section (“Collar”) are 5100mm (width) and 5740mm (height). The thickness of the permanent lining varies – 1250mm in the vault, 1380mm in the walls. The invert slab is 800mm thick. The clearance is 2334 x 3690mm, the position of the inside opening is variable. The shape of the structure in junction section “B1” is shown in Figure 7-1.

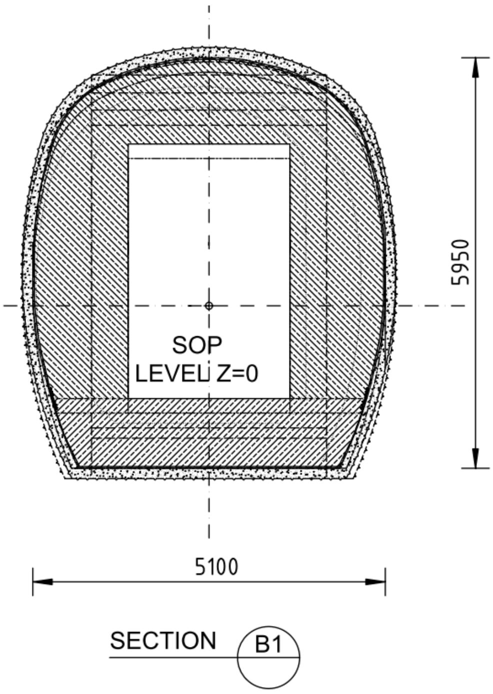


Figure 7-1 Cross Passage without Sump – Junction Section “B1”

The structural calculation of the permanent lining in this section is carried out as 2D task. The variable dimensions of particular beams in longitudinal direction b correspond to the actual shape of the collar structure. The structural model including the support system is shown in Figure 7-2 and Figure 7-3. In order to have the possibility to apply an asymmetric load, the complete lining (left and right symmetric half) structure is modelled. The real shape of the structure is replaced by a beam element polygon, the model is divided into 38 elements, some of which with constant thickness (invert), some with variable thickness (vault, walls). The centreline always intersects the centre of gravity of the sections.

The permanent lining in the whole collar structure is of reinforced concrete C40, steel D500N. The structural model takes into account the fact that the position of the inside opening is variable (due to the running tunnels position) and tolerances (35+5 = 40mm thickness reduction). The resulting model dimensions (thickness) are 1210mm in the top of vault, 1090mm aside in the wall, 700mm in the lower corner. The invert slab is made of reinforced concrete C40, steel D500N, thickness 760mm. The permanent lining modulus of elasticity is Ecm = 35.0GPa.

The bedding stiffness is derived from the deformation properties of the surrounding soil/rock material and the excavation dimension acc. the following formula:

Hochtief XP Material Properties

3.2.9 Materials

The materials used in the construction of the cross passages are identified in Table 3-16.

Table 3-16: Materials

Material	Use	Design Requirement
Sprayed concrete	Temporary support for mined excavations	Minimum cylinder compressive strength = 40MPa
Primary rock bolt (steel).	Temporary support for mined excavations	Ultimate tensile strength = 310kN
Primary rock bolt (Glass Reinforced Plastic)	Temporary support for mined excavations	Ultimate tensile strength = 350kN
Mine mesh	Temporary support for mined excavations	Ultimate wire tensile strength = 500 MPa
Cast in-situ concrete	Permanent lining	Minimum cylinder compressive strength = 40MPa
Blinding concrete	Sealing layers at invert level	Minimum cylinder compressive strength = 10MPa
Steel bar reinforcement	Reinforcement for primary and permanent linings	Minimum yield tensile strength = 500MPa
Steel fibres	Reinforcement for permanent linings if required	Details to be determined by concrete mix design and testing to fulfil DBV Classification F1.6/1.0.
Micro propylene fibre	Reinforcement for permanent linings	Fibre quantities as required by fire testing to achieve the spalling acceptance criteria as defined in the Specification for Cast In-situ Concrete
Waterproofing membranes and geotextiles	Waterproofing for permanent linings	2mm PVC membrane with geotextile to suit requirements from the waterproofing membrane manufacturer or HDPE or VLDPE
Backfill and contact grouting	Backfill behind permanent linings	Minimum cube compressive strength = 40MPa Minimum grouting pressure = 100kPa
Reinjectable grout tubes	Waterproofing for permanent linings	Type Sikafuko Multiple Injections or approved equivalent)
Waterstops	Waterproofing for permanent linings	Type Tricosal AA-320 Tricomer or approved equivalent

Table 3-1 Geotechnical parameters of ground material used in calculations

Unit	Class	γ / γ'	E_{def}	ν	φ_{eff}	c_{eff}
		[kN/m3]	[MPa]	[-]	[º]	[kPa]
Sandstones	SST I-II	24.0 /14.0	2500	0.25	N/A	N/A
Shales	SH I-II	24.0 /14.0	1500	0.25	N/A	N/A

Groundwater levels (GWL) relevant for the calculations (credible worst levels GWL1, typical levels GWL2) are considered acc. Table 3-2 (measured above tunnel axis). Generally, along the project alignment the maximum of the credible worst levels is 53.0m, the maximum of the typical levels is 47.0m, minimum of the typical levels is 8.5m. The important values for design (max GWL1 (blue marked) / max GWL2 (grey marked) / min GWL2 (red marked)) are denoted in the Table 3-2 and summarized as follows:

- for XPs in SST conditions (51.0m /41.0m /8.5m);
- for XPSs (with sump) in SST conditions (53.0m /47.0m /11.5m);
- for XPs in SH conditions (41.0m /35.0m /10.5m);
- the XPS (with sump) in SH conditions (43.5m /36.5m /20.0m).

Table 3-2 Overview of overburden and groundwater levels at Cross Passages locations

XP	RT01 Overburden above Tunnel axis	Rock Mass Class Cross Passage face	Typical GWL above tunnel axis (GWL2)	Worst GWL above tunnel axis (GWL1)
	[m]		[m]	[m]
XP 03	23.5	SH I-II	21.0	23.5
XP 04	33.0	SH I-II	25.0	33.0
XP 05	40.5	SH I-II	32.5	40.5
XP 06	41.0	SST I-II (Mittagong Form.) *)	35.0	41.0
XP 08	40.5	SST I-II *)	35.0	40.5
XP 09	38.5	SST I-II	32.0	38.5
XP 10	37.0	SST I-II	34.0	37.0
XP 11	35.0	SST I-II	27.5	35.0
XP 12	34.0	SST I-II	28.0	34.0
XP 13	34.0	SST I-II	30.0	34.0
XP 14	30.0	SST I-II	20.5	30.0
XP 15	30.5	SST I-II	22.5	30.5

Hochtief XP 45

XP 16	42.0	SST I-II	34.0	42.0
XP 18	42.5	SST I-II	31.5	42.5
XP 19	36.5	SST I-II	20.0	36.5
XP 20	29.5	SST I-II	11.0	29.5
XP 21	31.5	SST I-II	15.5	31.5
XP 23	28.5	SST I-II	14.0	28.5
XP 24	23.0	SST I-II	8.5	23.0
XP 26	26.0	SST I-II	11.0	26.0
XP 27	21.0	SST I-II	12.5	21.0
XP 28	32.0	SST I-II	28.5	32.0
XP 30	43.0	SST I-II	28.5	43.0
XP 31	26.0	SST I-II	34.5	36.0
XP 33	14.0	SST I-II	38.0	39.5
XP 34	30.5	SST I-II	30.5	32.0
XP 35	41.5	SST I-II	41.0	41.5
XP 36	32.0	SST I-II	36.5	38.0
XP 37	50.0	SST I-II	32.5	50.0
XP 38	47.5	SST I-II	26.0	47.5
XP 39	51.0	SST I-II	23.5	51.0
XP 40	38.5	SST I-II	19.5	38.5
XP 42	46.0	SST I-II	35.5	46.0
XP 43	42.5	SST I-II	31.0	42.5
XP 44	34.5	SST I-II	27.0	34.5
XP 45	37.0	SST I-II	19.5	37.0
XP 46	30.0	SST I-II	25.0	30.0
XP 47	31.0	SST I-II	28.5	31.0
XP 48	26.5	SST I-II	22.5	26.5
XP 49	38.0	SST I-II	30.0	38.0
XP 50	34.5	SST I-II	32.5	34.5
XP 52	27.0	SST I-II	27.0	27.0
XP 53	25.0	SST I-II	25.5	25.5
XP 54	25.5	SST I-II	25.5	25.5
XP 55	39.5	SST I-II	29.5	39.5
XP 56	34.0	SST I-II	28.0	34.0
XP 57	27.5	SH I-III and Mittagong Formation	20.0	27.5
XP 58	23.0	SH I-III	10.5	23.0

Hochtief Running Tunnel Geometry

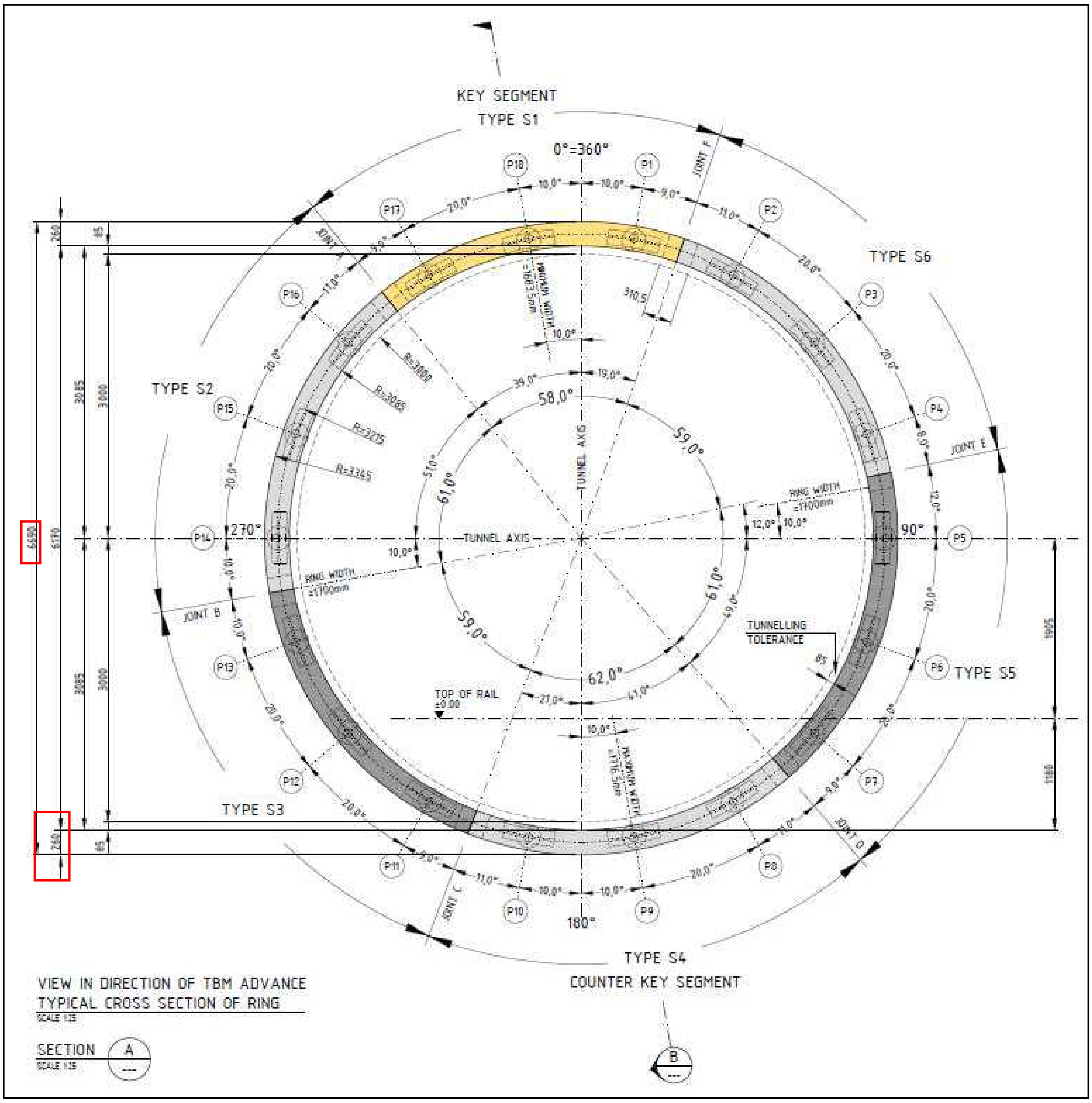


Figure 4-1: Typical ring type, Section A

This leads to defined relevant load combinations and load factors, considering that geotechnical numerical modelling has to be carried out in a complex, statically indetermined system based on unfactored loads and unfactored cautious estimates of rock mass strength.

3.2.9 Materials

The materials to be adopted for this design component are identified in Table 3-15.

Table 3-15: Materials

Material	Use	Design Requirement
Pre-cast concrete	Segmental lining	Minimum characteristic cylinder compressive strength = 50MPa Steel fibre reinforced concrete according to DBV Classification **F1.6/1.0**
Steel fibre	Reinforcement for pre-cast concrete	Details to be determined by concrete mix design and testing to fulfil DBV Classification F1.6/1.0. Calibration of design approaches show that testing can be carried out alternatively according to RILEM TC 162 and test procedure BS EN 14651. Those tests have to check: Minimum residual flexural tensile strength: $f_{R,1}$= 3.0 MPa and $f_{R,4}$= 3.0 MPa at 28 days $f_{R,1}$= residual flexural tensile strength at midspan deflection 0.46 mm, derived from load deflection diagram $f_{R,4}$= residual flexural tensile strength at midspan deflection 3.0 mm, derived from load deflection diagram Minimum characteristic tensile splitting strength: 5MPa at 28 days Limit of Proportionality: $f^{f}_{ct,L}$= 5.2MPa
Steel bar reinforcement	Reinforcement for pre-cast concrete	Minimum yield tensile strength = 500MPa Steel bar reinforcement shall be grade D500N to AS/NZS4671
Polypropylene fibre	Reinforcement for pre-cast concrete	Fibre quantities and type as required by fire testing to allow for a limited spalling due to fire

Hochtief Segmental Grouting Requirements

GENERAL:

G01 ALL DIMENSIONS IN MILLIMETRES (mm) UNLESS NOTED OTHERWISE.

G02 ALL ANGLES ARE IN DECIMAL DEGREES (0-360).

G03 THE DOCUMENTATION REPORT SEGMENTAL LINING TD 1/3 IS PROVIDED IN DOCUMENT SMCSWTSE-JHO-TPW-DN-RPT-900001

G04 SEGMENTAL LINING SPECIFICATION IS PROVIDED IN DOCUMENT SMCSWTSE-JHO-TPW-DN-SPC-941001

TBM TUNNEL:

PRECAST CONCRETE

C01 PRECAST CONCRETE SHALL HAVE A MINIMUM CHARACTERISTIC COMPRESSIVE STRENGTH OF 50MPa (CYLINDER).

C02 PRECAST CONCRETE SHALL CONTAIN STEEL FIBRE REINFORCEMENT AND COMPLY WITH THE FOLLOWING MINIMUM STRENGTHS AT 28 DAYS.
FIBRE CLASS F 1.6 / 1.0 ACCORDING TO DBV GUIDE TO GOOD PRACTICE STEEL FIBRE CONCRETE.
EQUIVALENT TO RESIDUAL FLEXURAL TENSILE STRENGTH ACCORDING TO RILEM TC 162:
f_{R1} = 3MPa & f_{R4}= 3MPa AT 28 DAYS
MINIMUM FLEXURAL TENSILE STRENGTH (LOP)
$f^{f}_{ct,L}$= 5.2MPa AT 28 DAYS

C03 THE REINFORCEMENT STATED IN TABLE 1 APPLIES FOR EACH OF THE SEGMENT TYPES.

C04 STEEL BAR REINFORCEMENT SHALL BE GRADE D500N ACCORDING TO AS/NZS 4671.

C05 FIBRE CLASS F 1.6 / 1.0 HAS TO BE RECONFIRMED FOR ACTUAL STEEL FIBRE TYPE AND QUANTITY BY STANDARD BEAM TESTS ACCORDING TO DBV GUIDE LINE.
ALTERNATIVELY RESIDUAL FLEXURAL TENSILE STRENGTH
f_{R1} = 3MPa & f_{R4}= 3MPa
CAN BE TESTED ACCORDING TO RILEM TC 162.

C06 FIRE TESTING ACCORDING TO RABT-ZTV (RAILWAY) TEMPERATURE CURVE SHALL BE UNDERTAKEN TO DETERMINE THE QUANTITY OF POLYPROPYLENE FIBRE TO BE INCLUDED IN THE CONCRETE FOR FIRE RESISTANCE. THE EXPECTED QUNTITY OF POLYPROPYLENE FIBRE IS 1 TO 2 KG PER CUBIC METRE OF CONCRETE.

HANDLING

H01 HANDLING AND STACKING SHALL BE CARRIED OUT IN ACCORDANCE TO THE DRAWING SMCSWTSE-JHO-TPW-DN-DRG-905008.

TOLERANCES

T01 SEGMENT MANUFACTURING TOLERANCES TO COMPLY WITH CLAUSE 204.4.1 OF THE BTS SPECIFICATION FOR TUNNELLING (2010).

T02 TEST RINGS SHALL COMPLY WITH THE TOLERANCES STATED ON CLAUSE 204.4.2 OF THE BTS SPECIFICATION FOR TUNNELLING.

T03 TUNNEL CONSTRUCTION TOLERANCES SHALL COMPLY WITH CLAUSES 328.1 AND 328.2 OF THE BTS SPECIFICATION FOR TUNNELLING.

T04 MAXIMUM RING ROLL AT LINING INTRADOS = 40mm (0.703°)

T05 DETAILS WILL BE PROVIDED IN A TOLERANCE DRAWING REFER TO SMCSWTSE-JHO-TPW-DN-DRG-905010

EMBEDDED ITEMS

E01 2-3 DOWELS AND 3 SOCKETS SHALL BE INSTALLED AT EACH SEGMENT CIRCUMFERENTIAL JOINT.
(NUMBER OF DOWELS IN STANDARD RING MAY BE REDUCED, 2 INSTEAD of 3)
TYPE: BIBLOCK SYSTEM 84-46-274 DOWEL CONNECTOR 110-160, FIP INDUSTRIALE

E02 EACH SEGMENT SHALL HAVE 1 EMBEDDED GROUT SOCKET WITH AN INTERNAL DIAMETER OF BETWEEN 40mm AND 70mm AND A MAXIMUM EXTERNAL DIAMETER OF 90mm.
TYPE: T142-03P GROUT-LIFTING SYSTEM
FIP INDUSTRIALE OR EQUIVALENT

E03 THE LONGITUDINAL JOINT SHALL HAVE 2No. SPEAR BOLTS WITH A MINIMUM TENSILE STRENGTH OF 75 KN.
TYPE: HH 25 x 300/120 STEEL GRADE 4.6 GALVANISED,
FIP INDUSTRIALE OR SIMILAR APPROVED

E04 EACH LONGITUDINAL JOINT SHALL CONTAIN A 510mm LONG 30mm DIAMETER GUIDANCE ROD.
(FULL DIAMETER RECYCLED PLASTIC ROD BY FIP INDUSTRIALE)

E05 HIGHLOAD PACKERS AT CIRCUMFERENTIAL JOINTS (TRAILING EDGE) d=2mm. SIZE 150x200mm,
TYPE: BITUMINOUS PACKER ELASTAVIP VB, FIP INDUSTRIALE.
(TIMBER PACKERS ARE NOT ALLOWED)

WATERPROOFING GASKETS

W01 ALL JOINTS SHALL CONTAIN THE EPDM GASKET
TYPE: DÄTWYLER M385-66 TOKYO / ANCHORED

GROUTING

G01 CAVITY GROUTING SHALL BE PLACED AT THE ANNULUS BETWEEN THE SEGMENTS AND THE EXCAVATION LINE IN ACCORDANCE WITH THE METHODOLOGY APPROVED BY THE DESIGNERS.

G02 GROUT FOR CAVITY INFILL HAVE THE FOLLOWING MINIMUM STRENGTH:
- COMPRESSIVE STRENGTH AT 28 DAYS: 2 MPa
- FIRST GANTRY: 0.1 MPa

G03 ANNULUS GROUTING SHALL BE CARRIED OUT AT ATMOSPHERIC PRESSURE.
THE CONTRACTOR SHALL MEASURE THE PRESSURE AT THE POINT OF APPLICATION AND ENSURE THAT A MAXIMUM PRESSURE OF 0.5 BAR (50kPa) CANNOT BE EXEEDED BY THE GROUTING SYSTEM.

G04 PROOF GROUTING SHALL BE CARRIED OUT TO A MAXIMUM VALUE OF 2 TIMES THE EXTERNAL WATER PRESSURE BUT NOT EXCEEDING 1.0 BAR (100kPa) ABOVE THE TYPICAL WATER PRESSURE FOR ALL GROUND TYPES EXEPT FOR SHALE TYPE IV OR WORSE.
IN THESE ZONES PRESSURE SHALL NOT EXCEED 0.5 BAR ABOVE THE TYPICAL WATER PRESSURE.

G05 AS A MINIMUM REQUIREMENT ANNULUS GROUTING DEEPLY EMBEDDED IN ROCK CONDITIONS MUST FILL A MINIMUM OF 120° OF THE RING AT THE FIRST RING BEHIND TBM SHIELD, A MINIMUM OF 240° AT THE SECOND RING AND FULLY TO THE CROWN AT THE THIRD RING.
IN ZONES OF POOR GROUND AND IF REQUIRED IN PARTS OF CBD ANNULUS GROUTING OF THE FULL RING WILL BE COMPLETED AS CLOSE TO THE SHIELD AS POSSIBLE.

TBM CYLINDER AND GRIPPERS

L01 IN TD 1/3 DS TBM´S WITH GRIPPERS SHALL BE USED TO TRANSFER TBM LOADS TO SURROUNDING ROCK MASS.
IN TUNNEL SECTIONS WHERE GRIPPERS ARE NOT APPLICABLE THE MAXIMUM FACTORED ULTIMATE CYLINDER LOAD SHALL NOT EXCEED 1,000KN PER RAM SHOE (18,000 KN PER RING)

L02 THE MINIMUM WORKING LOADS APPLIED BY TBM RAMS SHALL NOT BE LESS THAN 200 KN PER RAM.
RAMS SHALL ONLY BE WITHDRAWN OVER THE AREA OF THE RING TO ALLOW ERECTION OF THE NEXT SEGMENT.

L03 THE PRESSURE APPLIED BY THE GRIPPER PADS ONTO THE GROUND SHALL NOT EXCEED 3MPa.
GRIPPERS SHALL NOT BE USED IN
SHALE CLASS III OR WORSE AND SANDSTONE CLASS IV OR WORSE.
REFER TO GEOTECHNICAL DRAWINGS:
SMCSWTSE-JPS-TUS-GE-DRG-105510÷105524 , 105530÷105533
SMCSWTSE-JPS-TUN-GE-DRG-105610÷105620

L04 TBM RAM SHOE DIMENSIONS AND POSITION OF RAM SHOES ARE PROVIDED IN DRAWING:
SMCSWTSE-JHO-TPW-DN-DRG-905012

L05 WHERE BREAKOUT AND EXCAVATION FOR A SHORT CROSS PASSAGE HAS COMMENCED IN THE FIRST TUNNEL PRIOR TO THE TBM FOR THE SECOND TUNNEL REACHING THE CROSS PASSAGE LOCATION, THE GRIPPERS FOR THE TBM IN THE SECOND TUNNEL SHALL NOT BE USED WITHIN +-12 M FROM THE CROSS PASSAGE CENTERLINE.
WHERE BREAKOUT AND EXCAVATION FOR A LONG CROSS PASSAGE (XP23, XP24, XP25, XP26, XP27) HAS COMMENCED IN THE FIRST TUNNEL PRIOR TO THE TBM FOR THE SECOND TUNNEL REACHING THE CROSS PASSAGE LOCATION, THE GRIPPERS FOR THE TBM CAN BE USED IF THE CROSS PASSAGE EXCAVATION FACE STOPS AT LEAST 10.0 M FROM THE FUTURE SEGMENTAL LINING. EARLY EXCAVATION WORKS WITHIN THE CROSS PASSAGE CAN ADVANCE UP TO 3.5 M FROM THE FUTURE LINING OF THE SECOND TUNNEL IF GRIPPERS ARE NOT USED WITHIN +-12 M FROM THE CROSS PASSAGE CENTRELINE.
THIS APPLIES AT ALL CROSS PASSAGES WHERE THE EXPECTED GROUND CONDITIONS ARE ENCOUNTERED.
FURTHER EXCAVATION WORKS ARE ALLOWED WHEN THE SEGMENTAL LINING IN THE SECOND TUNNEL HAS BEEN INSTALLED, ANNULUS GROUTING HAS BEEN COMPLETED AND THE TEMPORARY SUPPORT STRUCTURE IS INSTALLED IN THE SECOND TUNNEL.

TBM TEMPORARY WORKS

M01 THE TBM TEMPORARY WORKS DESCRIBED IN DAN SMCSWTSE-JPS-TPW-GE-DAN-212200
PREDICTED EFFECTS ASSESSMENT-ESR TUNNELS, BELMORE PARK ARE TO BE CARRIED OUT BEFORE THE TBM PASSES THIS AREA.

M02 THE TBM TEMPORARY WORKS DESCRIBED IN SMCSWTSE-JPS-SMP-GE-TWA-502255-00
IMPACT ASSESSMENT OF TBM TUNNELLING ON EASTERN SUBURBS RAIL WAY (ESR) MARTIN PLACE STATION (SMP) SOUTH SHAFT ARE TO BE CARRIED OUT BEFORE THE TBM PASSES THIS AREA.

M03 FOR TBM ANNULUS GROUTING AND OPERATIONAL MODE CONSTRAINTS ADJACENT TO ADITS A5a, A5b, A4e, A4f AND A4g TAIL VOID GROUT PRESSURE AND GRIPPER LOADS TO BE LIMITED TO SUIT CONDITIONS. WMS TO BE SUBMITTED TO DESIGNER.

02

TEMPORARY OPENINGS FOR CROSS PASSAGES:

MATERIALS

N01 TEMPORARY OPENING STRUCTURES TO BE LOCATED WITHIN 4 STEEL BAR REINFORCED SEGMENTAL RINGS TYPE ST3.
(5 RINGS AT CROSS PASSAGE 53)

N02 TEMPORARY OPENINGS FOR CROSS PASSAGES TO BE CONSTRUCTED BY REMOVING AND CUTTING SEGMENTS AS SHOWN ON THE DRAWINGS. THE MAXIMUM CUTTING TOLERANCE TO BE 50mm FROM THE LOCATION SHOWN ON THE DRAWINGS.

N03 SEGMENTAL RINGS AT CROSS PASSAGE TEMPORARY OPENINGS TO CONTAIN SHEAR DOWELS.
TYPE: BIBLOCK SYSTEM 84-46-274 DOWEL CONNECTOR 100-300,
FIP INDUSTRIALE

N04 STEEL MEMBERS FOR TEMPORARY OPENING FRAMES SHALL BE GRADE 350 ACCORDING TO AS/NZS 3678 UNLESS STATED OTHERWISE.

N05 TEMPORARY OPENINGS IN THE SEGMENTAL LININGS AT CROSS PASSAGES SHALL BE SUPPORTED AS ILLUSTRATED ON THE DRAWINGS LISTED IN SMCSWTSE-JHO-TPW-DN-DRG-905001

TABLE 1: SEGMENT TYPES

ST1	STEEL FIBRE	ALL SEGMENTS (EXCEPT ST2+ST3)
ST2	REINFORCEMENT BARS AT LONGITUDINAL JOINTS & STEEL FIBRE	AT SEGMENTAL LINING RINGS FOR AREA WHERE ADDITIONAL BURSTING REINFORCEMENT IS REQUIRED AT THE JOINTS
ST3	STEEL BAR REINFORCEMENT GRADE 500	4 No. RINGS PER TUNNEL PER CROSS PASSAGE OPENING AND WHERE REQUIRED IN RUNNING TUNNEL (5 No.Rings AT XP53)

NOMINAL CONCRETE COVERS FOR SEGMENT TYPES ST2 AND ST3 TO BE AS PER TABLE BELOW

FACE	COVER (mm)
INTRADOS	nom C = 60 mm
EXTRADOS	nom C = 50 mm

DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

FOR CONSTRUCTION

AMD	DESCRIPTION	DESIGNER SIGN./DATE	VERIFIED SIGN./DATE	APPROVED SIGN./DATE
02	NOTES M 01 - M 03 ADDED	FMP 12.04.19	GNM 12.04.19	DNK 12.04.19
01	NOTE L 02 REVISED AND NOTE L 05 ADDED	FMP 14.12.18	GNM 14.12.18	DNK 14.12.18
00	ASSURED FOR CONSTRUCTION	FMP 20.04.18	GNM 20.04.18	DNK 20.04.18

CO-ORDINATE SYSTEM: MGA HEIGHT DATUM: AHD SCALE: NTS

SCALES

IC CERTIFIED - IC CERTIFICATE SMCSWTSE-IC-CER-B2-049

CLIENT

NSW GOVERNMENT Transport for NSW

SERVICE PROVIDERS: ARCADIS, B&G, NAMA, HOCHTIEF, PSM, McMILLEN JACOBS ASSOCIATES

DRAWN	FERDINAND MENGELKAMP	12.04.19
DESIGNED	ERWIN HEYNECK	12.04.19
DRG CHECK	GUIDO NUSSBAUM	12.04.19
DESIGN CHECK	MARCEL PIRAULT	12.04.19
APPROVED	DAMIAN NOWAK	12.04.19

SYDNEY METRO CITY & SOUTHWEST
TSE PROJECT WIDE
DESIGN
TD1&TD3 SEGMENTAL LINING
GENERAL NOTES

FILE No. SHEET: 1 OF 1 A1
STATUS: ASSURED FOR CONSTRUCTION ©
DRG No. SMCSWTSE-JHO-TPW-DN-DRG-905002 02 EDMS No.

DF 801*554

Plotted by P23159 Plot Date & Time 4/10/2019 10:45 File Plotted PWPATH

Excavation Geometries
- DLV Records

Revision	Change	Date	Drawn	Date	Released
D	detail tailskin updated.	10.01.2018	henningj	12.01.2018	henningj
C	updated release.	21.11.2017	henningj	24.11.2017	henningj
B	Updated release.	23.10.2017	henningj	24.10.2017	henningj

General Tolerances

Geometrical product specification (GPS) EN ISO 1101:2013
Edges of undefined shape ISO 13715:2000
Surface specifications according to EN ISO 1302:1992

Drawing type: concept
Project: S-1137
Machine Type: DOUBLE SHIELD

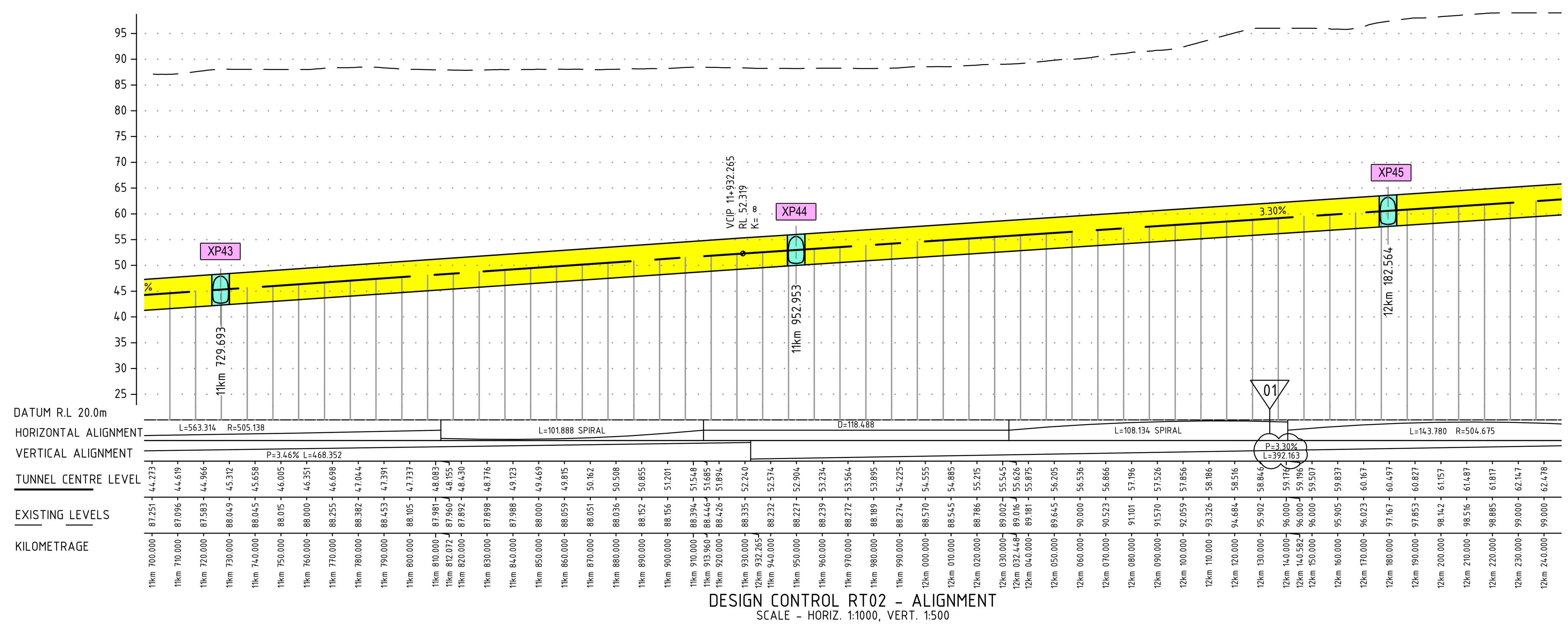
HERRENKNECHT Tunnelling Systems
www.herrenknecht.com

Name: SHIELD MACHINE
SCHILDMASCHINE
OD7010

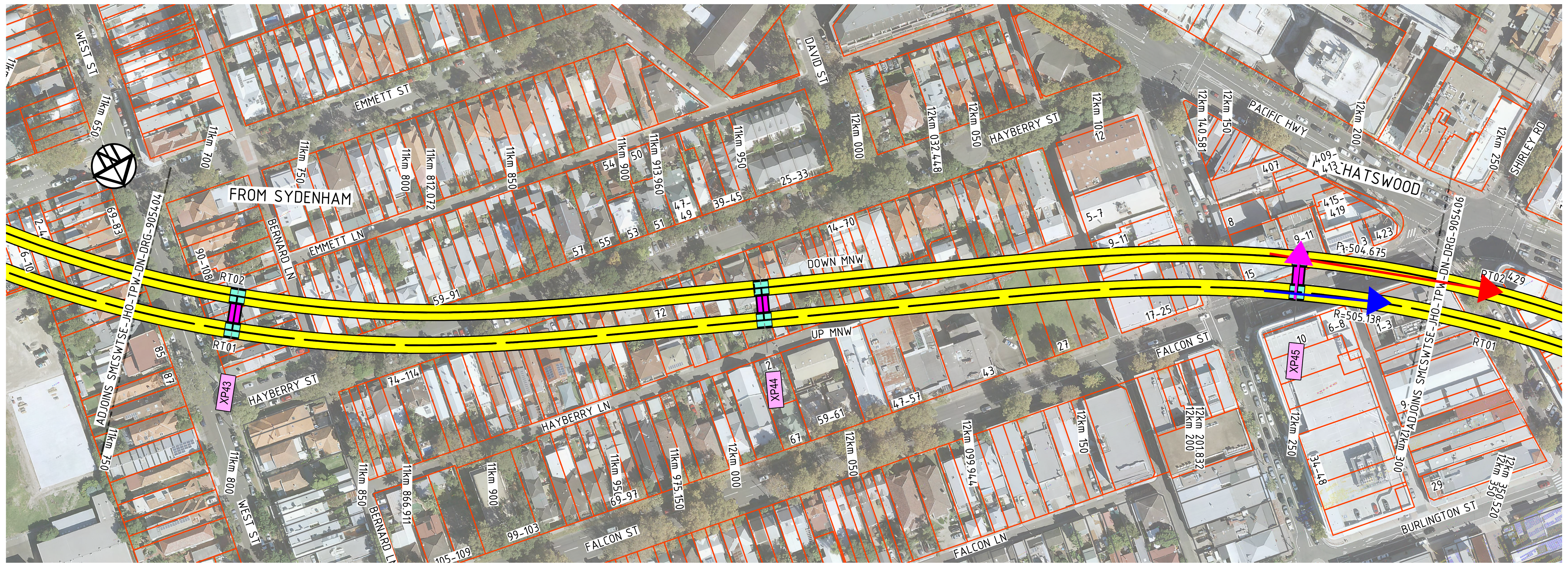
	Date	Name
drawn	23.10.2017	Henninger Jonas
released	24.10.2017	Henninger Jonas

Drawing number	Sheet	Revision	Format
5393-A-001-00	1/1	D	A0S1

Scale	Material no.	Material	Weight	Projection
1:20			kg	



DESIGN CONTROL RT02 - ALIGNMENT
SCALE - HORIZ. 1:1000, VERT. 1:500

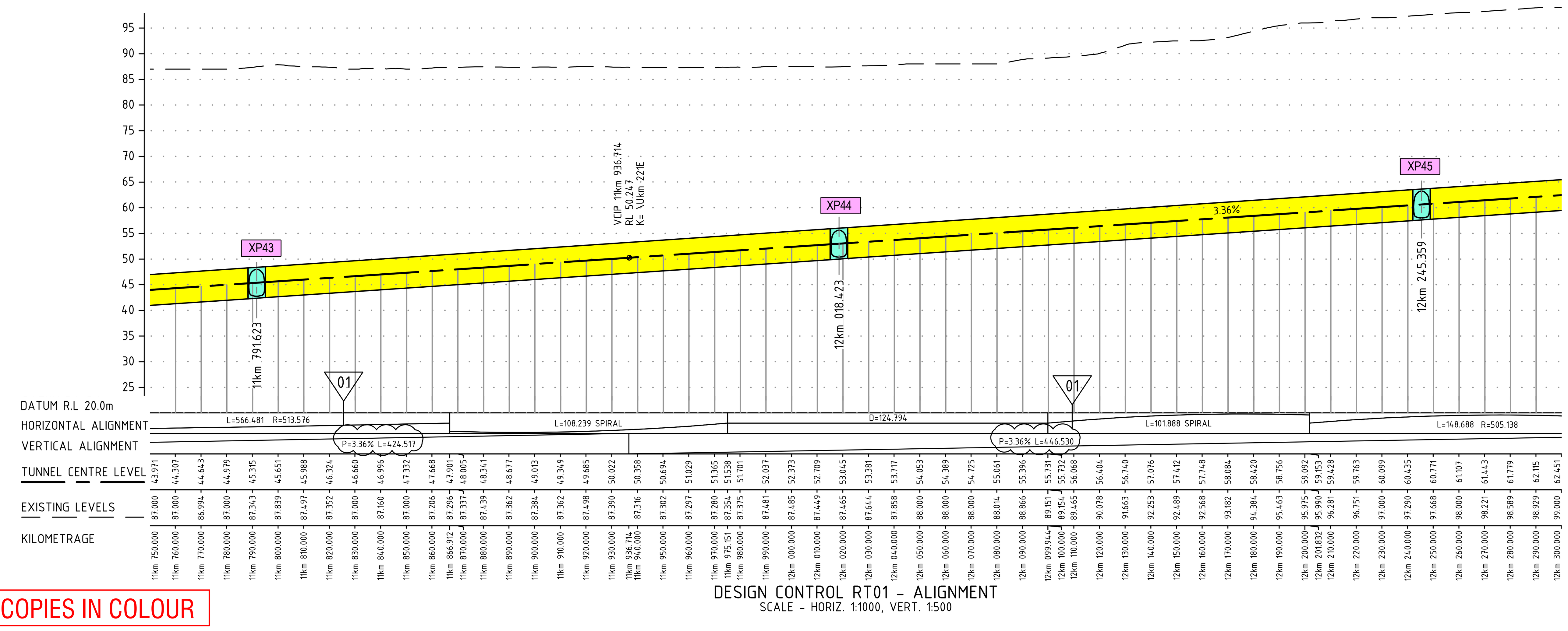


Excavation Sequence - DLV Records

TYPICAL CROSS SECTIONS BASED ON CALCULATION REPORT SMCSWTSE-JHO-TPW-DN-RPT-900003

LEGEND

1.
2.
3.



DESIGN CONTROL RT01 - ALIGNMENT
SCALE - HORIZ. 1:1000, VERT. 1:500

NOTES:

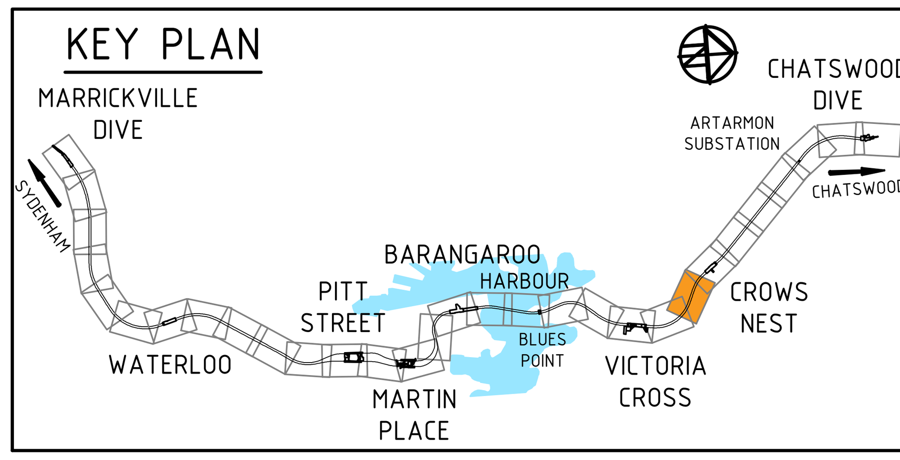
1. ALL DIMENSIONS IN METRES (m) UNLESS STATED OTHERWISE.
2. FOR GENERAL NOTES REFER TO DRAWING SMCSWTSE-JHO-TPW-DRG-905002
3. CHAINAGE AT STATIONS AND DIVES REFER TO SET OUT POINTS ILLUSTRATED IN DRAWINGS SMCSWTSE-JHO-TPW-DRG-905201 ÷ 905202
4. RING ARRANGEMENT AT XP OPENINGS REFER TO DRAWINGS SMCSWTSE-JHO-TPW-DRG-905101 ÷ 905104
5. AN ADDITIONAL FORECAST DRAWING WAS CREATED TO SUMMARISE THE RELEVANT RING TYPES ROUGHLY, BASED ON THE PARTITION OF REINFORCEMENT ZONES AND ZONES OF DIFFERENT RING TAPER. THE FINAL POSITION OF RINGS AT CROSS PASSAGES AND STATIONS/DIVES WILL DEVIATE FROM THE DEFINED SET OUT POINTS. SMCSWTSE-JHO-TPW-DRG-905420
6. THESE OVERVIEW DRAWINGS ARE BASED ON THE ALIGNMENT DRAWINGS SMCSWTSE-JAB-TPW-AL-DRG-505101 ÷ 130 AND SMCSWTSE-JAB-TPW-AL-DRG-505201 ÷ 230

RING TYPES :

- RING TAPER 33mm — PURELY STEEL FIBRE REINFORCED CONCRETE RING TYPES
- RING TAPER 33mm — STEEL FIBRE REINFORCED CONCRETE RING TYPES WITH ADDITIONAL BAR REINFORCEMENT NEXT TO LONGITUDINAL JOINT
- RING TAPER 33mm — CONVENTIONAL BAR/MESH REINFORCED CONCRETE RING TYPES
- TAPER 60mm — LY STEEL FIBRE REINFORCED RETE RING TYPES
- TAPER 60mm — STEEL FIBRE REINFORCED CONCRETE RING TYPES WITH ADDITIONAL BAR REINFORCEMENT NEXT TO LONGITUDINAL JOINT
- RING TAPER 60mm — CONVENTIONAL BAR/MESH REINFORCED CONCRETE RING TYPES

- STUB TUNNEL
- DIVE STRUCTURES
- STATION EXCAVATIONS
- NOZZLE ENLARGEMENTS
- CROSSOVER CAVERN
- STATION SHAFTS
- STATION CAVERNS
- STATION ADITS

KEY PLAN



FOR CONSTRUCTION

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AMD	DESCRIPTION	DESIGNER SIGN./DATE	VERIFIED SIGN./DATE	APPROVED SIGN./DATE
01	REALIGNMENT PACIFIC HIGHWAY	JFR 23.05.19	GNM 23.05.19	DNK 23.05.19
00	ASSURED FOR CONSTRUCTION	JFR 20.04.18	GNM 20.04.18	DNK 20.04.18

CO-ORDINATE SYSTEM: MGA | HEIGHT DATUM: AHD | SCALE: AS SHOWN

SCALES

IC CERTIFIED - IC CERTIFICATE SMCSWTSE-IC-CER-B2-049

CLIENT

NSW GOVERNMENT — Transport for NSW

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SERVICE PROVIDERS: ARCADIS, B&E, NOMA, HOCHTIEF, PSM, JACOBS

DRAWN	JÜRGEN FISCHER	23.05.19
DESIGNED	ERWIN HEYNECK	23.05.19
DRG CHECK	GUIDO NUSSBAUM	23.05.19
DESIGN CHECK	MARCEL PIRAULT	23.05.19
APPROVED	DAMIAN NOWAK	23.05.19

SYDNEY METRO CITY & SOUTHWEST

TSE PROJECT WIDE
DESIGN
TD3 SEGMENTAL LINING OVERVIEW
RING TYPES PLAN AND PROFILE RT01 AND RT02 (5/12)

FILE No. | SHEET: 5 OF 12 | A1
STATUS: ASSURED FOR CONSTRUCTION
DRG No. SMCSWTSE-JHO-TPW-DN-DRG-905405 | 01 | EDMS No.

4.1.1.2 Evaluation of Ground/ Rock Stresses

Ground stress loads have been evaluated using the following methods:

Rock pressures on the segmental lining are evaluated using the longitudinal deformation profile theory. For an unsupported tunnel excavation, ground deformations increase with the distance from excavation face. When the segmental lining is erected and grouted a portion of this deformation (i.e. relaxation) has taken place.

Ground relaxation will reduce the loads on the segmental lining when compared to the initial in situ stress state. This is quantified using finite element calculations in accordance with the method by Vlachopoulos and Diederichs.

Modelling steps are as follows:

<u>Step 1 – Plastic Radius and Maximum Deformation</u>

A model of the expected ground profile with design ground parameters is prepared using finite element software package (Sofistik/Wintube). The model allows for the excavation sequence with gradual stages of core relaxation, which is modelled by applying a reduction of stiffness and ground stresses in the excavation zone. For each relevant tunnel location in rock the excavation face is completely removed and the maximum excavation deformation and the radius of the plastic zone are determined.

<u>Step 2 – Ground Reaction Curve in longitudinal direction</u>

A plot of the relationship between maximum excavation displacement and excavation displacement at variable distance from the tunnel face was generated using the Vlachopoulus and Diederichs method. The deformation that will take place prior to grouting of the segmental lining ring is calculated.

<u>Step 3 – Ground and Structure Interaction</u>

A second finite element model is prepared to model the sequence of construction as follows:

a. Green field stresses are modelled including the locked in in situ stresses prior to excavation and building loads if applicable;

b. The excavation of the tunnel is carried out and the ground is allowed to relax in accordance with Step 2;

c. The lining is installed in the tunnel and the relevant water pressure is applied on the lining. This calculation accounts for the residual, redistributed rock pressure and the water pressure imposes loads on the segmental lining within the FE continuum. Additional loads such as for example track bed loads and metro train operational loads will be applied too.

Step 4 – Sensitivity Analysis

A structural sensitivity check for the most relevant load case and most relevant section with different rock mass parameters is carried out additionally:

Material factors relevant to in situ rock mass are used in accordance with AS4678 Table 5.1(A) (i.e. Φ_{uc} = 0.70 for cohesion (c') and $\Phi_{u\phi}$ = 0.85 for friction angle (tan ϕ')).

Within the Calculation report (Appendix I1) we have carried out additional calculations that consider excavation sequences including the influence of second tunnel excavation to the segmental lining installed before in the first tunnel. This calculations are based on the same principle but they are reflecting the adjacent second tunnel excavation within the same FE-continuum.

4.1.1.3 Axial Force, bending moments and shear forces in the Lining due to Hydrostatic Loads and other "direct -input" loads

The effect of groundwater loads is calculated by applying the external hydrostatic pressure directly as load on the tunnel lining within the continuum model within step 3c. These loads are directly applied onto the beam elements that represent the segmental lining of the tunnel. They are not redistributed within the FE-Continuum as for example the rock loads. The same principle is relevant for Metro Train loads or track bed self-

Hochtief Running Tunnel Ground Stress

5.3 Loads

5.3.1 Permanent loads

5.3.1.1 Self-weight of Segments

The dead load is taken into account based on unit weight of reinforced concrete $\gamma_{concrete}$ = 25 kN/m³.

5.3.1.2 Soft Ground / Rock load

The overburden pressure of soft ground and rock in initial state is derived from the unit weight of soil/ rock layers (green field stresses). Full bulk/submerged unit weight (γ/γ') is adopted when calculating the initial state stresses depending on the level of the ground water table.

Within the 2D-FE continuum models the loads impact on the tunnel lining due to overburden are calculated by the model itself according to the parameters given in chapter 5.2 and the used material law.

High horizontal in situ stresses locked in the rock mass due to morphological effects especially in Sandstone I/II are implemented in the FE Continuum model.

Arching effect is taken into account based on core relaxation and according to longitudinal deformation theory by Vlachopoulos and Diedrichs.

In general the finite element analysis is carried out on characteristic load level to get realistic results due to the deformation and embedding reaction.

Nevertheless in an additional analysis we applied material factors to reduce ground parameters based on AS 4678, Clause 5.2, Table 5.1(A) which are:

Φuc = 0.7 for cohesion

$\Phi u\varphi$ = 0.85 for friction angle $\tan\varphi$

5.3.1.3 Water pressure

The water pressure is considered as hydrostatic load according to the distance to the groundwater level as shown in Figure 5-2. The unit weight is γ_w = 10 kN/m³. Figure 5-3 illustrates the water pressure generated in the FE-model.

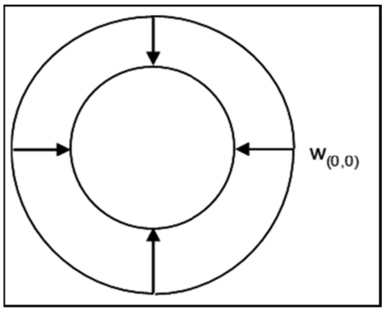


Figure 5-2: Water pressure

5.15.7.2.2. Ground Stress Relaxation

For the assessment of behaviour of the ground surrounding the tunnel, the design analyses consider the effect of ground stress relaxation as the TBM excavation advances, using the convergence-confinement method. The methodology allows estimations of the ground displacement and load sharing between the ground and tunnel lining, as the 'supporting' effect of the tunnel front moves beyond the design section. The longitudinal deformation profiles (LDPs) and the ground reaction curves (GRCs) at critical design sections are determined using RS2 software to create axisymmetric FE modelling assuming 2D plane strain conditions. The LDPs and GRCs are then correlated to derive the anticipated ground relaxation factor.

The ground stress relaxation is a function of ground stiffness, in situ stresses and TBM operating mode. The design has conservatively adopted the ground parameters referred from the GIRs. It is assumed that the TBM will operate in minimum pressure mode (i.e., the minimum operating pressure to maintain the operation of the TBM, which is significantly less than the surrounding pressure) for tunnels excavated in high strength rocks such as SST I, SST II and SST III and GSD (RMUIa, RMUIb and RMUII). The high strength ground limits tunnel longitudinal convergences and allows for higher ground relaxation factor. For tunnels excavated in sensitive areas such as under the Darling Harbour Crossing and Johnston Bay's Crossing, the TBM will operate in ambient pressure mode (i.e., operating pressure to balance the surrounding pressure conditions). Tunnels excavated in rocks with higher initial in situ stresses will typically experience lower ground stress relaxation. Therefore, the ground relaxation factors, λ, calculated for tunnels excavated at the deepest alignment locations within each rock type have been adopted for permanent precast tunnel segments. The following key design considerations have been made for the analysis:

- TBM shield length is assumed to be 13.5m.
- For TBM tunnels excavated in SST I-II rock, the maximum ground cover of 46m is adopted.
- For TBM tunnels excavated in SST III, the ground cover of 30m is adopted.
- For TBM tunnels excavated in GSD (RMUIa, RMUIb and RMUII), the ground cover of 32m is adopted.
- In all cases, the upper bound in situ stress regime in accordance with the GIR listed in Section 5.15.2 has been adopted.

The adopted relaxation factors for TBM tunnel excavation in each rock type are presented in Table 19. More details on the ground stress relaxation analysis are presented in Appendix A.

Table 19: Adopted Ground Relaxation Factors

Rock Type	Ground Stress Relaxation Factor (λ)
SST I	90%
SST II	90%
SST III	90%
GSD (RMUIa, RMUIb and RMUII).	90%

5.15.7.2.3. Rock Wedge Analysis

The program UnWedge (RocScience) was used to determine maximum anticipated rock wedge loading on the lining. Bedding plane and joint data were taken from the GIR mentioned in Section 5.15.2. Data were grouped into zones depending upon consistent bedding and joints over sections of the tunnel. From each zone, critical wedges were determined and the equivalent loads and extents applied to the segmental lining through the beam-spring analysis discussed in Section 5.15.7.2.5. The critical wedges are shown and dimensioned in Figure 11, and are as follows:

- Typical Wedge = 15kPa (non-symmetrical)
- Typical Wedge = 15kPa (symmetrical)
- Exceptional Wedge = 50kPa

Proposed Structural Liner Properties

Table 5: Properties of Elastic Structural Liner Elements

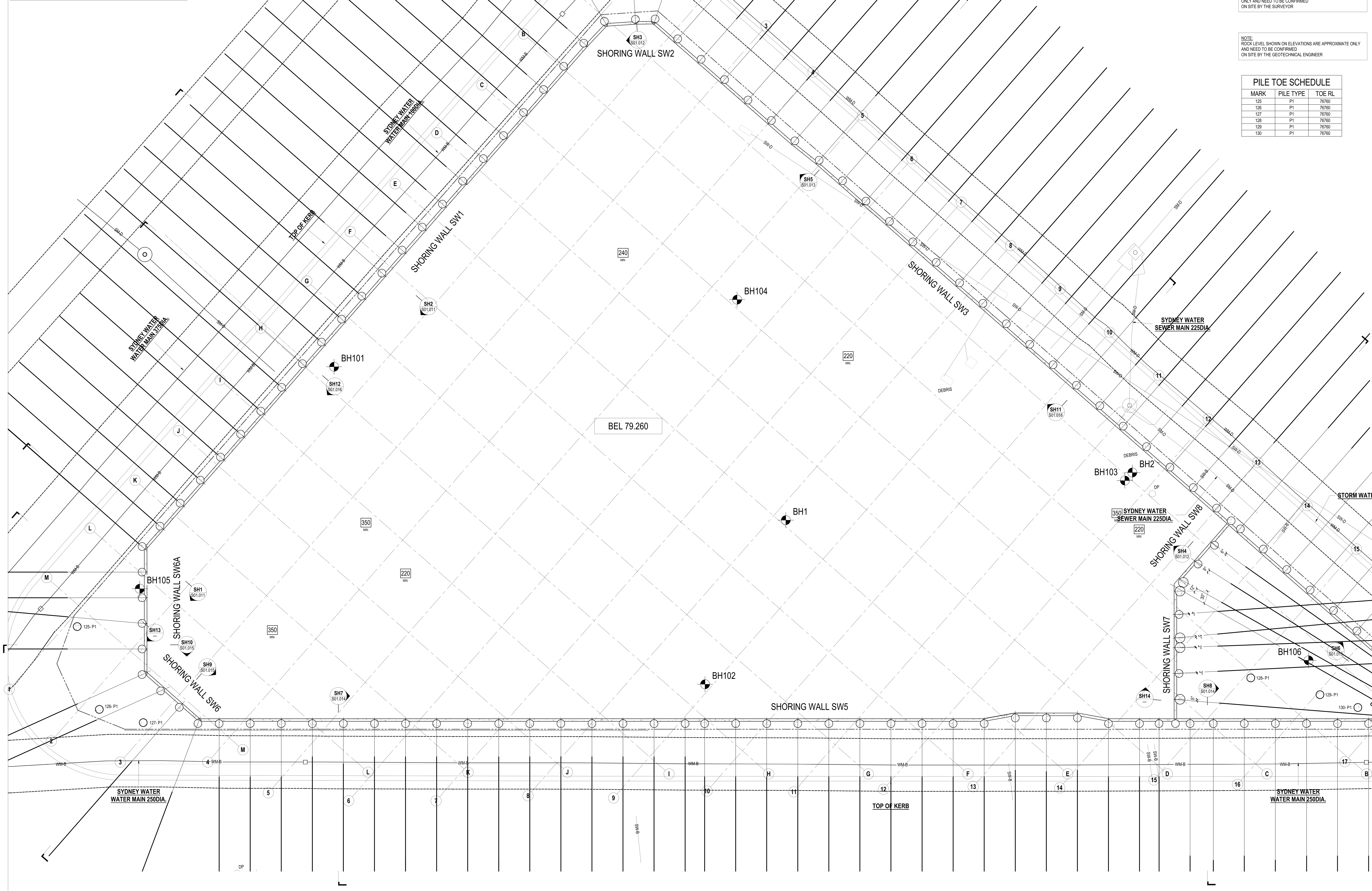
Type	Interface Stiffness (GPa/m)		Unit Weight (kN/m³)	UCS (MPa)	Elastic Modulus (GPa)	Poisson's Ratio	Thickness (mm)
	Normal (K_n)	Shear (K_s)					
Sydney Metro Lines*	1.0	0.1	25	30 [50]	see note 1 25 [37]	0.2	275 [260]
Sydney Metro Cross Passage**	1.0	0.1	25	25 [40]	20 [35]	0.2	300 (assumed on roof, walls and invert) [varies]

*Segmental lined tunnel **flat top tunnel

Note 1. Modelling of the Segmental Lining: Due to the joints between pre-cast segment, typically a reduction in stiffness (more flexible) is used to replicate the minor rotation that will occur at the joints. Assuming a rigid monolithic ring would produce upper bound/conservative bending stresses.

Our recommendation is to reduce the moment of inertia (I) by 45%. The reduction can range between 35 and 50%. 45% is a reasonable value to use for this level of an assessment.

Regulated Design Record				
Project Address:	391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065			
Project Title:	FIVEWAYS CROWS NEST			
Consent No:	SSD-66826207	Body Corporate Reg No:	DEP0000250	
Drawing Title: SITE RETENTION PLAN			Drawing No: S01.001	
Rev	**Date dd.mm.yy**	**Description**	**DP Full Name**	**Reg No**
1	31.10.24	APPROVED FOR CONSTRUCTION	RYAN CAMPBELL	DEP0000027
2	03.12.24	APPROVED FOR CONSTRUCTION	RYAN CAMPBELL	DEP0000027
3	16.04.25	APPROVED FOR CONSTRUCTION	RYAN CAMPBELL	DEP0000027



NOTE:
BULK EXCAVATION LEVELS FOR SLAB ON GROUND ALLOWS FOR SLAB THICKNESS AS NOTED ON BASEMENT PLANS AND A 50mm BLINDING LAYER.
REFER WATER PROOFING CONTRACTORS DETAILS IF ADDITIONAL BLINDING LAYER IS REQUIRED.
REFER BASEMENT PLANS FOR PILE CAPS & FOOTINGS.
HYDRAULIC ENGINEER TO ADVISE ANY ADDITIONAL SUBSOIL DRAINAGE REQUIREMENTS.

NOTE:
GROUND LEVEL SHOWN ON ELEVATIONS ARE APPROXIMATE ONLY AND NEED TO BE CONFIRMED ON SITE BY THE SURVEYOR

NOTE:
ROCK LEVEL SHOWN ON ELEVATIONS ARE APPROXIMATE ONLY AND NEED TO BE CONFIRMED ON SITE BY THE GEOTECHNICAL ENGINEER

PILE TOE SCHEDULE

MARK	PILE TYPE	TOE RL
125	P1	76760
126	P1	76760
127	P1	76760
128	P1	76760
129	P1	76760
130	P1	76760

BULK EARTHWORK NOTES:

GEOTECHNICAL REPORT:
REFER TO GEOTECHNICAL REPORT PREPARED BY DOUGLAS PARTNERS. CONTRACTOR IS TO ENSURE GEOTECHNICAL REPORT RECOMMENDATIONS ARE ADHERED TO.

SITE SURVEY:
THE SITE HAS BEEN SURVEYED BY DAW & WALTON PTY LTD. REFER DRAWINGS FOR DETAILS. THIS IS A COMPILATION OF ENGINEERING AND SITE SURVEY DRAWING, DEPICTING SITE EARTHWORKS OVER THE SURVEY DRAWING.

SPECIFICATION:
THESE NOTES ARE TO BE READ IN CONJUNCTION WITH THE HEAD SPECIFICATION.

EROSION AND SEDIMENT CONTROL:
ALLOW TO SUBMIT AND EROSION AND SEDIMENT CONTROL (ESC) PROGRAM TO COUNCIL FOR ENDORSEMENT PRIOR TO SITE WORKS COMMENCING. THE ESC PROGRAM IS TO COMPLY WITH THE COUNCIL'S EROSION AND SEDIMENT CONTROL STANDARD AND IS TO BE CERTIFIED BY A REGISTERED PROFESSIONAL ENGINEER.

DUST CONTROL:
THE CONTRACTOR IS TO ENSURE THAT THE DUST PREVENTION METHODS HE ADOPTS ARE SUFFICIENT TO MEET THE REQUIREMENTS OF THE ENVIRONMENTAL PROTECTION REGULATION 1998 PART 2A, ENVIRONMENTAL NUISANCE. IT IS THE CONTRACTORS RESPONSIBILITY TO ACQUAINT HIMSELF WITH THE REQUIREMENTS.

SITE SETOUT:
REFER TO ARCHITECTS DRAWINGS FOR THE ACCURATE SETOUT OF ALL BUILDINGS, DRIVEWAYS, PARKING AREAS ETC. NOTE BULK EARTHWORKS PLAN IS INDICATIVE ONLY. CALCULATE AND CUT BATTERS FROM ARCHITECTS PLANS AND SURVEY. CROSSOVER PROFILES TO COUNCIL REQUIREMENTS.

GENERALLY:
PROCEED WITH BULK EARTHWORKS AND SHORING TO PROVIDE A STABLE SUBGRADE AND WORK SPACE FOR THE CONSTRUCTION OF THE PROPOSED DEVELOPMENT. STRIP AND DISPOSE OF TOPSOIL, REDUCE SITE TO LEVELS INDICATED AND DISPOSE OF ALL UNWANTED MATERIAL LEGALLY.

SUPERVISION:
A GEOTECHNICAL ENGINEER IS TO PROVIDE LEVEL 1 SUPERVISION (AS3798) FOR ALL EARTHWORKS DURING THE COURSE OF CONSTRUCTION. AT THE COMPLETION OF THE BULK EXCAVATION CONTRACT, THE GEOTECHNICAL ENGINEER IS TO PROVIDE CERTIFICATION THAT THE WORKS HAVE BEEN CARRIED OUT IN ACCORDANCE WITH BULK EARTHWORKS SPECIFICATIONS.

BULK EARTHWORKS PROCEDURE AND SPECIFICATION:
THE SITE IS TO BE STRIPPED OF TOPSOIL AND UNCONSOLIDATED EXISTING FILL. AT THE COMPLETION OF THE BULK EARTHWORKS, THE CONTRACTOR SHALL PROVIDE TEMPORARY OR PERMANENT DRAINAGE TO ENSURE NO SURFACE WATER IS RETAINED ON THE SITE, OR THAT SURFACE WATER FLOW DETRIMENTALLY SCOURS THE PREPARED BASE.

GEOTECHNICAL ENGINEER NOTES:
EXCAVATION TO BE CARRIED OUT UNDER GEOTECHNICAL ENGINEERS SUPERVISION. GEOTECHNICAL ENGINEER (GE) TO COMMENT ON SUITABILITY OF THE SUBCONTRACTORS METHOD OF EXCAVATION AS REMOVAL PROCEEDS.

HYDRAULICS ENGINEER:
DURING EXCAVATION COORDINATE WITH ALL HYDRAULIC ENGINEERS REQUIREMENTS FOR SEWER, GAS AND STORMWATER LINES.

AS-BUILT DRAWING:
PROVIDE AND AS-BUILT DRAWING PREPARED BY A REGISTERED SURVEYOR TO CONFIRM BULK EARTHWORKS IS COMPLETED TO REQUIRED DIMENSIONS AND LEVELS.

DILAPIDATION REPORT:
THE APPROVED SHORING WALL CONTRACTOR SHALL PREPARE A DILAPIDATION REPORT OF STREET, FOOTPATH AND ROAD FEATURES PRIOR TO INSTALLATION OF SHORING WALL.

COMPACTION NOTES:
COMPACTION BEHIND INTERNAL FORMED RETAINING WALL BY EXCAVATION CONTRACTOR USING HAND HELD RAMMERS TO ACHIEVE 98% MODIFIED DENSITY. COMPACT IN MAXIMUM 300mm THICK LAYERS AT OPTIMUM MOISTURE CONTENT OF ± 3%.

LEGEND:
B.E.L. - DENOTES BULK EXCAVATION LEVEL
E.L. - DENOTES DETAILED EXCAVATION LEVEL

SITE RETENTION PLAN
SCALE 1 : 100

CONSTRUCTION DESIGN

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE.

REV	DATE	REVISION DESCRIPTION	BY
03	09.04.25	ISSUED FOR CONSTRUCTION	PD
02	03.12.24	APPROVED FOR CONSTRUCTION	SF
1	31.10.24	APPROVED FOR CONSTRUCTION	SF
P08	18.10.24	ISSUED FOR PRELIMINARY INFORMATION	SF
P07	27.09.24	ISSUED FOR PRELIMINARY INFORMATION	SF

DEICORP

abc CONSULTANTS
structural & civil engineers
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Web: www.abc-consultants.com.au
Street Address
Suite 2, Level 2
3 Thomas Holt Drive
MACQUARIE PARK, NSW, 2113
Postal Address
PO Box 77
NORTH RYDE BC, NSW, 1670

FIVEWAYS CROWS NEST
391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065

SITE RETENTION PLAN

JOB NUMBER:	DRG NUMBER:		
23012	S01.001		
DESIGNED BY: RC	DATE: June.2024		
DRAWN BY: SF	SCALE: 1:100 @ A0	SIZE: A0	REV: 03

24/04/2025 11:47:34 AM

Regulated Design Record				
Project Address: 391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065				
Project Title: FIVEWAYS CROWS NEST				
Consent No: SSD-66826207		Body Corporate Reg No: DEP0000250		
Drawing Title: FOUNDATION PLAN			Drawing No: S02.001	
Rev	**Date dd.mm.yy**	**Description**	**DP Full Name**	**Reg No**

MISCELLANEOUS NOTES:

REFER TO DRAWING S00.001 FOR GENERAL NOTES.

REINFORCEMENT COVERS		
FOOTING		INTERIOR
ELEMENT	TOP BTM SIDES	50mm 75mm 75mm

FOUNDATION PLAN

SCALE 1 : 100

PRELIMINARY ISSUE

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE.

REV	DATE	REVISION DESCRIPTION	BY
P5	07.03.25	ISSUED FOR PRELIMINARY INFORMATION	SF
P4	20.12.24	ISSUED FOR PRELIMINARY INFORMATION	SF
P03	10.07.24	PRELIMINARY ISSUE	PKP
P2	05.09.23	ISSUED FOR PRELIMINARY INFORMATION	RCL
P1	22.05.23	ISSUED FOR PRELIMINARY INFORMATION	RCL

DEICORP

abc CONSULTANTS structural & civil engineers

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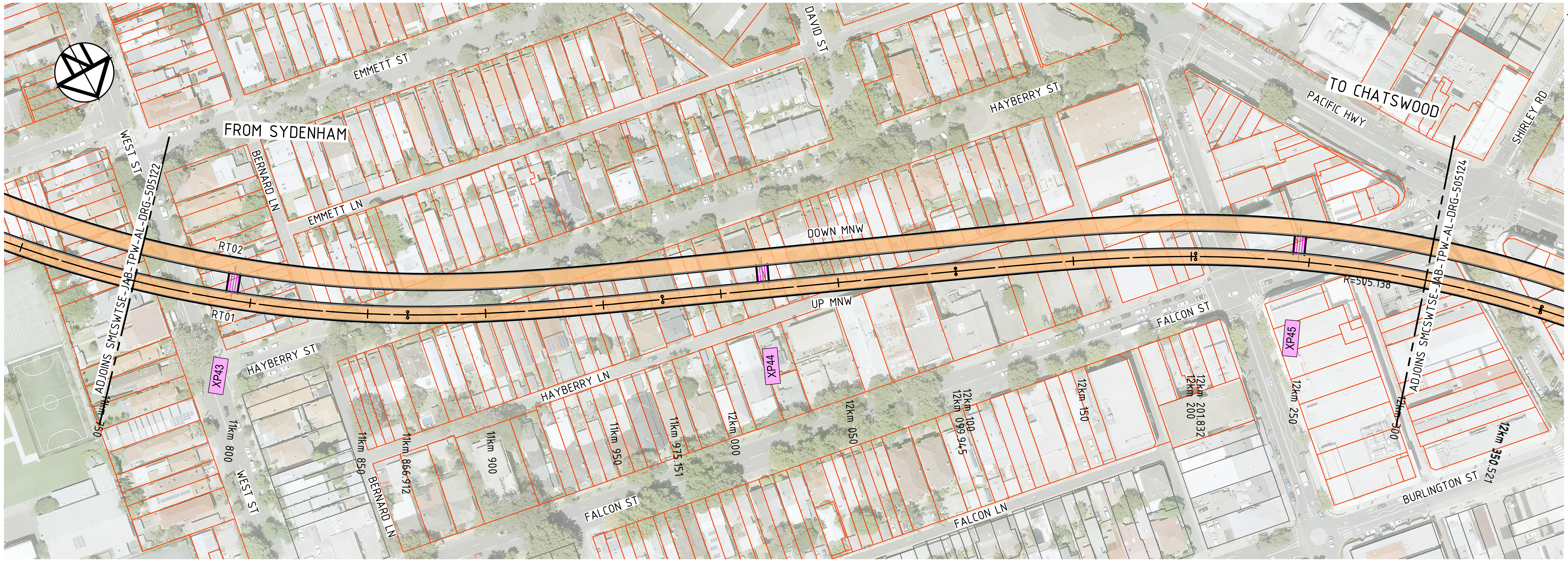
Postal Address
PO Box 77
NORTH RYDE BC, NSW, 1670

FIVEWAYS CROWS NEST
391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065

FOUNDATION PLAN

JOB NUMBER:	DRG NUMBER:		
23012	**S02.001**		
DESIGNED BY: RC	DATE: June.2024		
DRAWN BY: SF	SCALE: 1:1, 1:100 @ A0	SIZE: A0	REV: **P5**

24/04/2025 11:53:51 AM



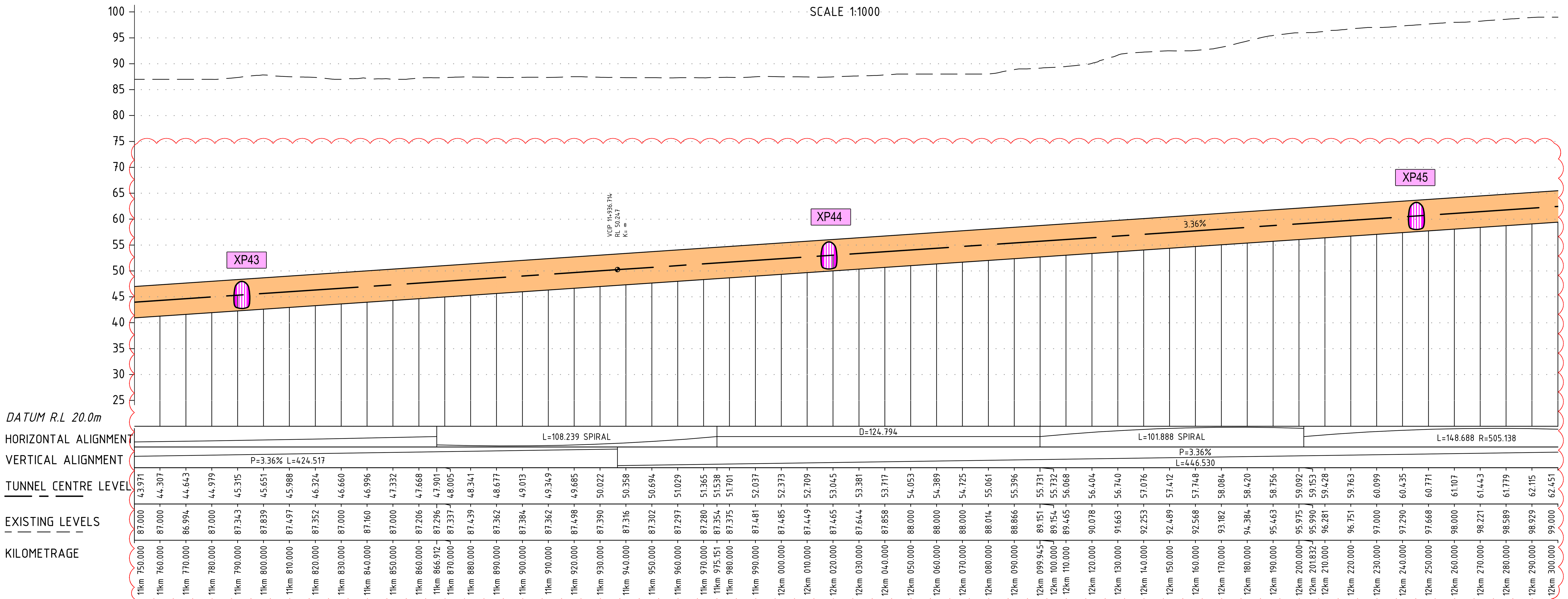
LEGEND

- TUNNEL ALIGNMENT CONTROL LINE
- RUNNING TUNNELS
- CROSS PASSAGES AND CROSS PASSAGES WITH SUMP
- STUB TUNNEL
- DIVE STRUCTURES
- STATION EXCAVATIONS
- NOZZLE ENLARGEMENTS
- CROSSOVER CAVERN
- STATION SHAFTS
- STATION CAVERNS
- STATION ADITS
- SHAFT
- LIFT SHAFTS

CADASTRAL MODEL (BASED ON PR124656-SACM-001-E)

- SURVEY ACCURATE CADASTRAL MODEL
- NEAR SURVEY ACCURATE CADASTRE
- DIGITAL CADASTRAL DATABASE

PLAN
SCALE 1:1000

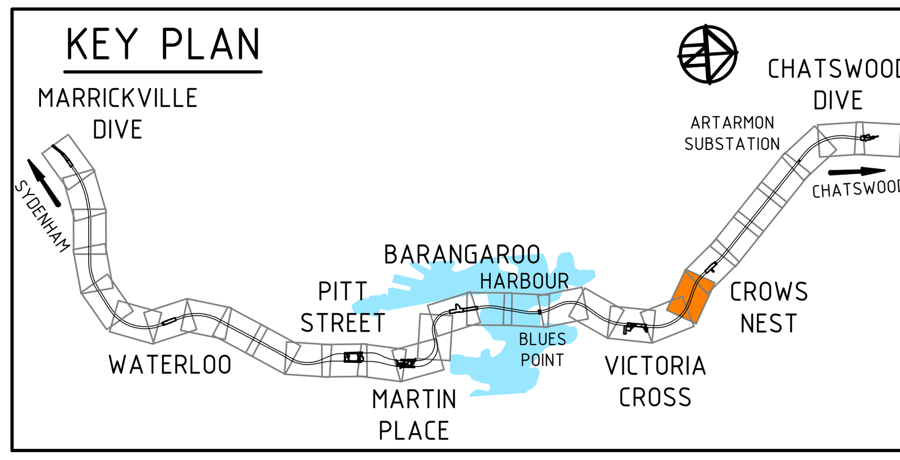


DESIGN CONTROL RT01 - UP MNW
SCALE - HORIZ. 1:1000, VERT. 1:500

NOTE

1. FOR ALL ALIGNMENT NOTES REFER DRAWING NO. SMCSWTSE-JAB-TPW-AL-DRG-505005.

KEY PLAN



DRAWING COLOUR CODED - PRINT ALL COPIES IN COLOUR

FOR CONSTRUCTION

AMD	DESCRIPTION	DESIGNER SIGN./DATE	VERIFIED SIGN./DATE	APPROVED SIGN./DATE
02	AMENDMENTS TO VERTICAL ALIGNMENT DESIGN FOR RT01 AND RT02	17.05.19	17.05.19	17.05.19
01	ASSURED FOR CONSTRUCTION	17.04.19	17.04.19	17.04.19
00	ASSURED FOR CONSTRUCTION	09.01.18	09.01.18	09.01.18

CO-ORDINATE SYSTEM: MGA | HEIGHT DATUM: AHD | SCALE: AS SHOWN

SCALES
SCALE 1:1000 AT A1 SIZE
SCALE 1:500 AT A1 SIZE

IC CERTIFIED - IC CERTIFICATE SMCSWTSE-IC-CER-B2-008

CLIENT
NSW GOVERNMENT
Transport for NSW

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SERVICE PROVIDERS
ARCADIS
HOCHTIEF
PSM
McMILLEN JACOBS ASSOCIATES

DRAWN	E. ESTORES JR.	17.05.19
DESIGNED	TINSW	-
DRG CHECK	F. BATHAN	17.05.19
DESIGN CHECK	N/A	-
APPROVED	D.ROBERTSON	17.05.19

SYDNEY METRO CITY & SOUTHWEST

TSE PROJECT WIDE
ALIGNMENT
GA PLAN AND LONGITUDINAL SECTION
TUNNEL ALIGNMENT CONTROL LINE RT01 - SHEET 23

FILE No. | SHEET: 39 OF 76 | A1
STATUS: FOR CONSTRUCTION
DRG No. SMCSWTSE-JAB-TPW-AL-DRG-505123 | 02 | EDMS No.

NOTES:

1. THE LOCATION OF THE METRO LOT HAS BEEN DERIVED FROM DP1231642
2. THE LOCATION OF THE METRO TUNNELS HAVE BEEN DERIVED FROM 'FOR CONSTRUCTION' DRAWINGS PROVIDED BY TRANSPORT FOR NSW FOR THE SYDNEY METRO CITY & SOUTHWEST PROJECT INDICATING VARIOUS ALIGNMENT COORDINATES AND LEVELS ADJACENT TO THE DEVELOPMENT SITE
3. THE BOUNDARIES OF THE DEVELOPMENT SITE HAVE BEEN DERIVED FROM A PLAN PREPARED BY DAW AND WALTON CONSULTING SURVEYORS TITLED 'DETAIL SURVEY @ PACIFIC HIGHWAY CROWS NEST' DRAFTED 12-04-23, JOB NUMBER 4950-20
4. THE PROPOSED BOREHOLE POINT INDICATED ON THE PLAN AND SECTIONS IS THE CLOSEST PINK PAINT MARK LOCATED ON SITE TO THE METRO TUNNELS

SHORT LINE TABLE

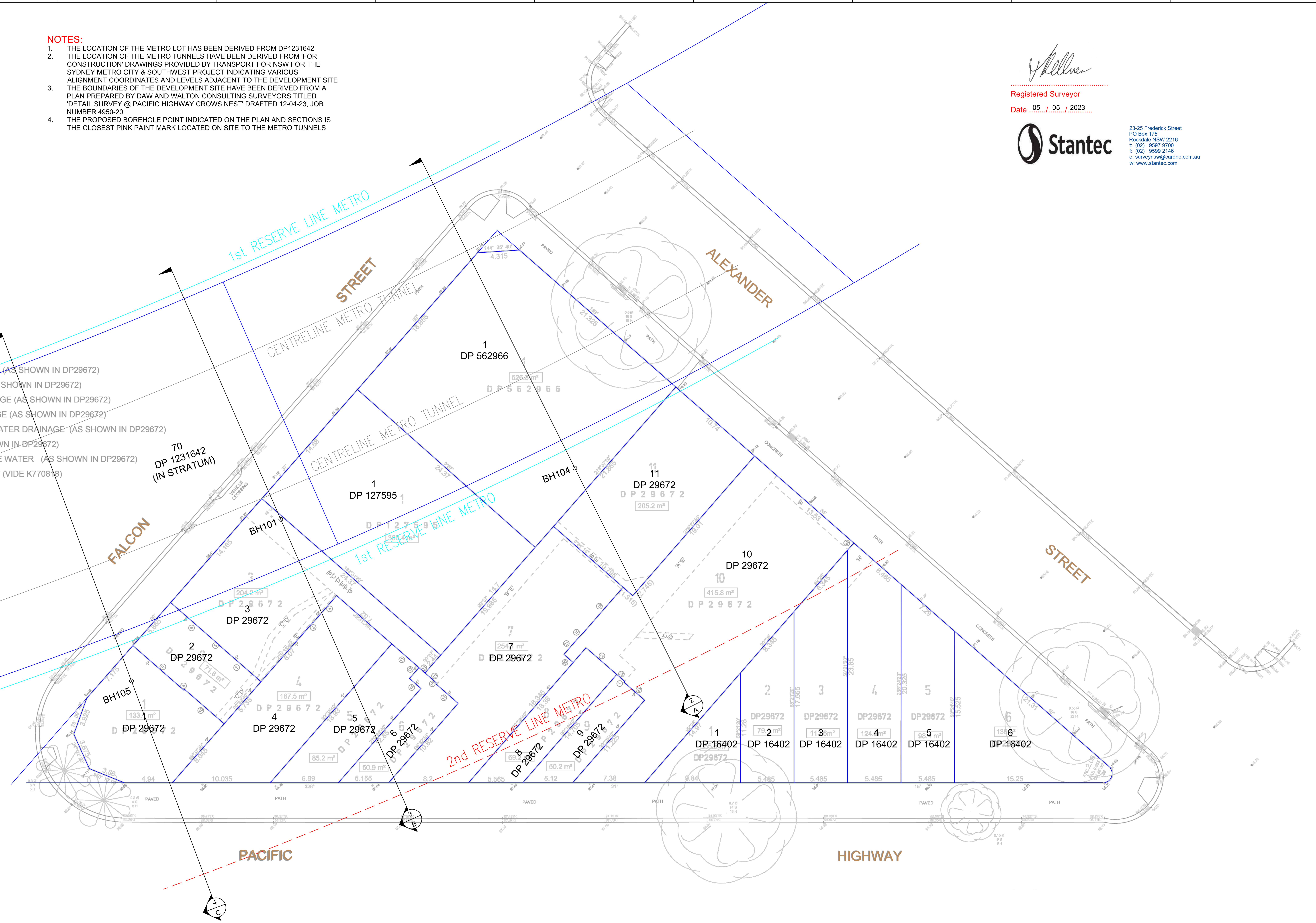
Number	Bearing	Distance
1	189°25'40"	1.07
2	9°25'40"	4.175
3	189°33'40"	0.025
4	99°26'40"	3.685
5	279°25'40"	0.025
6	189°25'40"	6.655
7	189°25'40"	5.66
8	99°33'40"	0.115
9	189°33'40"	6.94
10	189°21'20"	5.38
11	9°31'20"	3.7
12	9°31'20"	0.825
13	99°33'40"	1.48
14	9°22'40"	1.56
15	189°31'20"	1.655
16	99°40'40"	0.11
17	9°40'40"	2.955
18	101°48'40"	1.055
19	99°31'20"	6.115
20	9°31'40"	1.265
21	99°23'40"	2.005
22	99°25'40"	0.115
23	9°25'40"	2.82
24	99°28'	0.975

NOTES:

'A' DENOTES RIGHT OF CARRIAGEWAY (AS SHOWN IN DP29672)
'B' DENOTES RIGHT OF FOOTWAY (AS SHOWN IN DP29672)
'C' DENOTES EASEMENT FOR SEWERAGE (AS SHOWN IN DP29672)
'D' DENOTES EASEMENT FOR DRAINAGE (AS SHOWN IN DP29672)
'E' DENOTES EASEMENT FOR ROOF WATER DRAINAGE (AS SHOWN IN DP29672)
'F' DENOTES RIGHT OF WAY (AS SHOWN IN DP29672)
'G' DENOTES EASEMENT FOR SULLAGE WATER (AS SHOWN IN DP29672)
'H' DENOTES RIGHT OF CARRIAGEWAY (VIDE K770818)
'P' DENOTES 0.23 BRICK PARTY WALL

LEGEND

- GULLY PIT & LINTEL



Registered Surveyor

Date 05 / 05 / 2023

Stantec

23-25 Frederick Street
PO Box 175
Rockdale NSW 2216
t: (02) 9597 9700
f: (02) 9599 2146
e: surveynsw@cardno.com.au
w: www.stantec.com

SCALE 1: 200 @ A1

SCALE 1: 400 @ A3

IMPORTANT NOTE:
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REVISION	DATE	DESCRIPTION	CCAD REF	APPROVED
02	05/05/2023	TITLE BLOCK AMENDED	-	A.K.
01	04/05/2023	ORIGINAL ISSUE	-	A.K.

SCALE: HORZ. 1:200 VERT.

CONTOUR INTERVAL: MAJOR 0.0 MINOR 0.0

A1

HORIZONTAL ORIGIN

COORD. SYSTEM MGA2020

MARK ADOPTED: PM 286
COORDINATES:
E 333 681.947
N 6255 172.989

VERTICAL DATUM

DATUM: AHD

BM ADOPTED: PM 286
RL: 96.802

Stantec

23-25 Frederick Street
PO Box 175
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t: (02) 9597 9700
f: (02) 9599 2146
e: surveynsw@cardno.com.au
w: www.stantec.com

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT

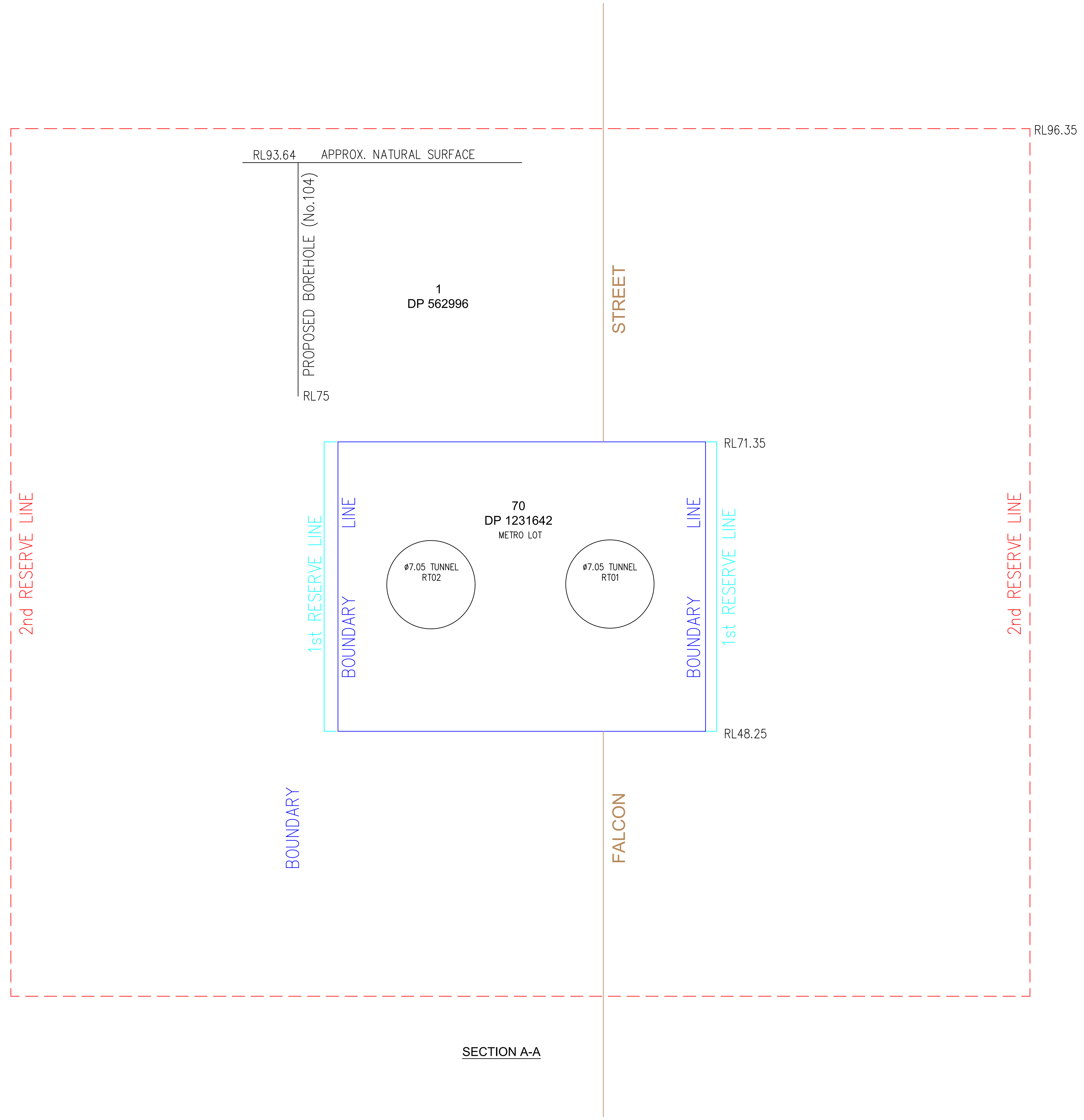
PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 1 OF 1

DRAWING NUMBER 3050-01019-001-002

REV 02



SECTION A-A

NOTES:

1. THE LOCATION OF THE METRO LOT HAS BEEN DERIVED FROM DP1231642
2. THE LOCATION OF THE METRO TUNNELS HAVE BEEN DERIVED FROM 'FOR CONSTRUCTION' DRAWINGS PROVIDED BY TRANSPORT FOR NSW FOR THE SYDNEY METRO CITY & SOUTHWEST PROJECT INDICATING VARIOUS ALIGNMENT COORDINATES AND LEVELS ADJACENT TO THE DEVELOPMENT SITE
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4. THE PROPOSED BOREHOLE POINT INDICATED ON THE PLAN AND SECTIONS IS THE CLOSEST PINK PAINT MARK LOCATED ON SITE TO THE METRO TUNNELS

0 4 6 8 12 16 20
SCALE 1: 200 @ A1

0 8 12 16 24 32 40
SCALE 1: 400 @ A3

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02	05/05/2023	TITLE BLOCK AMENDED	-	A.K.
01	04/05/2023	ORIGINAL ISSUE	-	A.K.

SCALE:
HORZ. 1:200 VERT.
CONTOUR INTERVAL:
MAJOR 0.0 MINOR 0.0

A1

HORIZONTAL ORIGIN
COORD. SYSTEM: MGA2020
MARK ADOPTED: PM 286
COORDINATES:
E 333 681.947
N 6255 172.989

VERTICAL DATUM
DATUM: AHD
BM ADOPTED: PM 286
RL: 96.802

Stantec
23-25 Frederick Street
PO Box 175
Rockdale NSW 2216
t: (02) 9597 9700
f: (02) 9599 2146
e: surveynsw@cardno.com.au
w: www.stantec.com

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

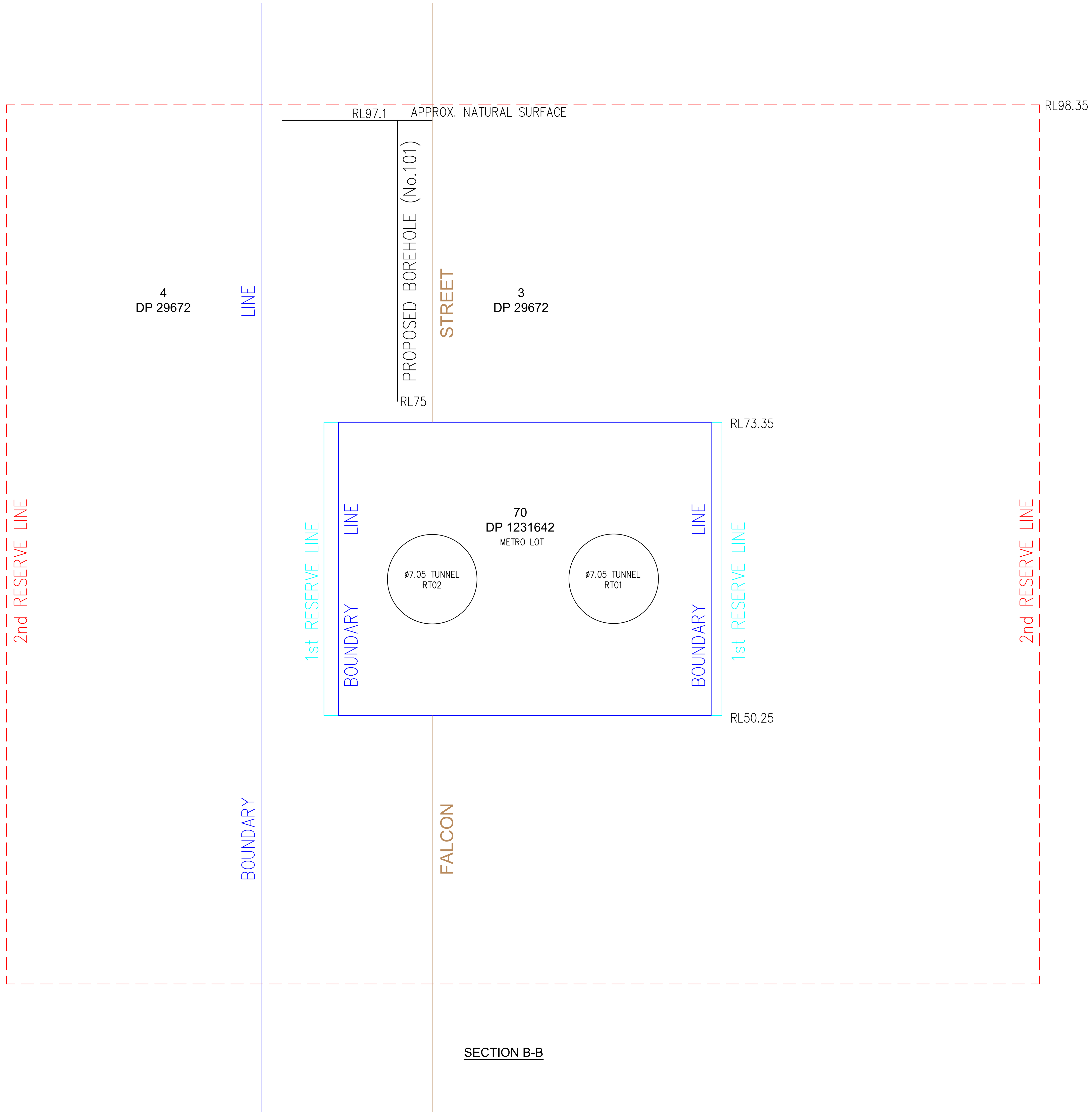
PROJECT: PROJECT

PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 2 OF 1

DRAWING NUMBER	REV
3050-01019-001-002	02



SECTION B-B

NOTES:
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2. THE LOCATION OF THE METRO TUNNELS HAVE BEEN DERIVED FROM 'FOR CONSTRUCTION' DRAWINGS PROVIDED BY TRANSPORT FOR NSW FOR THE SYDNEY METRO CITY & SOUTHWEST PROJECT INDICATING VARIOUS ALIGNMENT COORDINATES AND LEVELS ADJACENT TO THE DEVELOPMENT SITE
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4. THE PROPOSED BOREHOLE POINT INDICATED ON THE PLAN AND SECTIONS IS THE CLOSEST PINK PAINT MARK LOCATED ON SITE TO THE METRO TUNNELS

SCALE 1: 200 @ A1 (0, 4, 6, 8, 12, 16, 20)

SCALE 1: 400 @ A3 (0, 8, 12, 16, 24, 32, 40)

IMPORTANT NOTE:
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02	05/05/2023	TITLE BLOCK AMENDED	-	A.K.
01	04/05/2023	ORIGINAL ISSUE	-	A.K.

SCALE:
HORZ. 1:200 VERT.
CONTOUR INTERVAL:
MAJOR 0.0 MINOR 0.0
A1

HORIZONTAL ORIGIN
COORD. SYSTEM: MGA2020
MARK ADOPTED: PM 286
COORDINATES:
E 333 681.947
N 6255 172.989

VERTICAL DATUM
DATUM: AHD
BM ADOPTED: PM 286
RL: 96.802

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w: www.stantec.com

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT

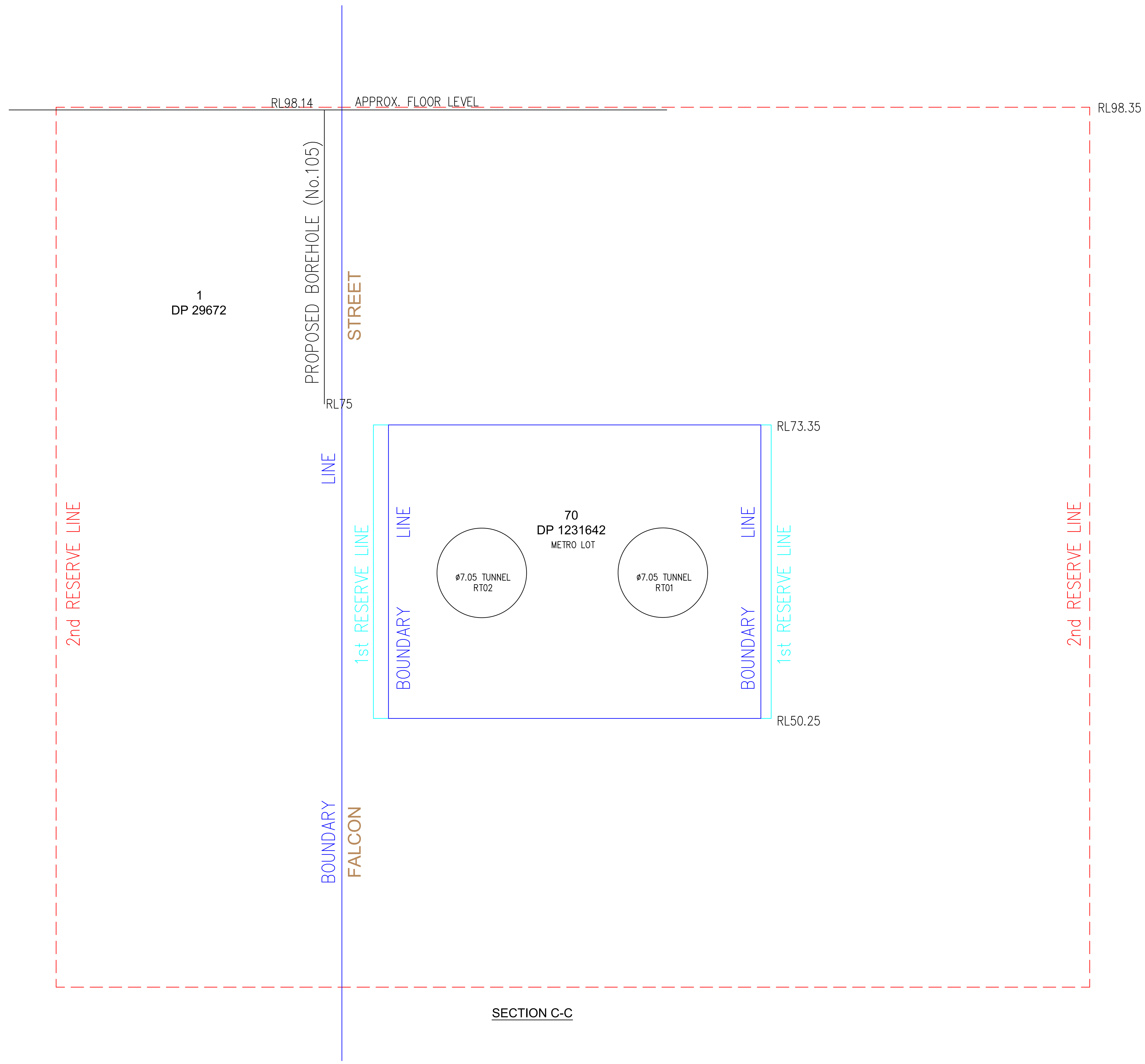
PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 3 OF 1

DRAWING NUMBER	REV
3050-01019-001-002	02

BEFORE YOU DIG
www.byda.com.au



SECTION C-C

NOTES:

1. THE LOCATION OF THE METRO LOT HAS BEEN DERIVED FROM DP1231642
2. THE LOCATION OF THE METRO TUNNELS HAVE BEEN DERIVED FROM 'FOR CONSTRUCTION' DRAWINGS PROVIDED BY TRANSPORT FOR NSW FOR THE SYDNEY METRO CITY & SOUTHWEST PROJECT INDICATING VARIOUS ALIGNMENT COORDINATES AND LEVELS ADJACENT TO THE DEVELOPMENT SITE
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0 4 6 8 12 16 20
SCALE 1: 200 @ A1

0 8 12 16 24 32 40
SCALE 1: 400 @ A3

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01	04/05/2023	ORIGINAL ISSUE	-	A.K.

SCALE:
HORZ. 1:200 VERT.
CONTOUR INTERVAL:
MAJOR 0.0 MINOR 0.0
A1

HORIZONTAL ORIGIN
COORD. SYSTEM MGA2020
MARK ADOPTED: PM 286
COORDINATES:
E 333 681.947
N 6255 172.989

VERTICAL DATUM
DATUM: AHD
BM ADOPTED: PM 286
RL: 96.802

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w: www.stantec.com

SURVEYED	DRAWN	CHECKED	PASSED
L.Z.	A.G.	A.K.	A.K.

PROJECT: PROJECT

PLAN SHOWING RELATIONSHIP OF PROPOSED BOREHOLES TO SYDNEY METRO TUNNELS AT FIVE WAYS, CROWS NEST

CLIENT: DEICORP

SHEET 4 OF 1

DRAWING NUMBER	REV
3050-01019-001-002	02

Appendix C

Structural Loads

Regulated Design Record				
Project Address: 391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065				
Project Title: FIVEWAYS CROWS NEST				
Consent No: SSD-66826207		Body Corporate Reg No: DEP0000250		
Drawing Title: FOUNDATION PLAN			Drawing No: S02.001	
Rev	Date dd.mm.yy	Description	DP Full Name	Reg No

MISCELLANEOUS NOTES:

REFER TO DRAWING S00.001 FOR GENERAL NOTES.

REINFORCEMENT COVERS		
FOOTING		INTERIOR
ELEMENT	TOP BTM SIDES	50mm 75mm 75mm

FOUNDATION PLAN

SCALE 1 : 100

PRELIMINARY ISSUE

NOTE: DO NOT SCALE OFF DRAWINGS. REFER TO ARCHITECTURAL PLANS. VERIFY DIMENSIONS ON SITE.

REV	DATE	REVISION DESCRIPTION	BY
P5	07.03.25	ISSUED FOR PRELIMINARY INFORMATION	SF
P4	20.12.24	ISSUED FOR PRELIMINARY INFORMATION	SF
P03	10.07.24	PRELIMINARY ISSUE	PKP
P2	05.09.23	ISSUED FOR PRELIMINARY INFORMATION	RCL
P1	22.05.23	ISSUED FOR PRELIMINARY INFORMATION	RCL

DEICORP

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FIVEWAYS CROWS NEST
391/423 PACIFIC HIGHWAY CROWS NEST NSW 2065

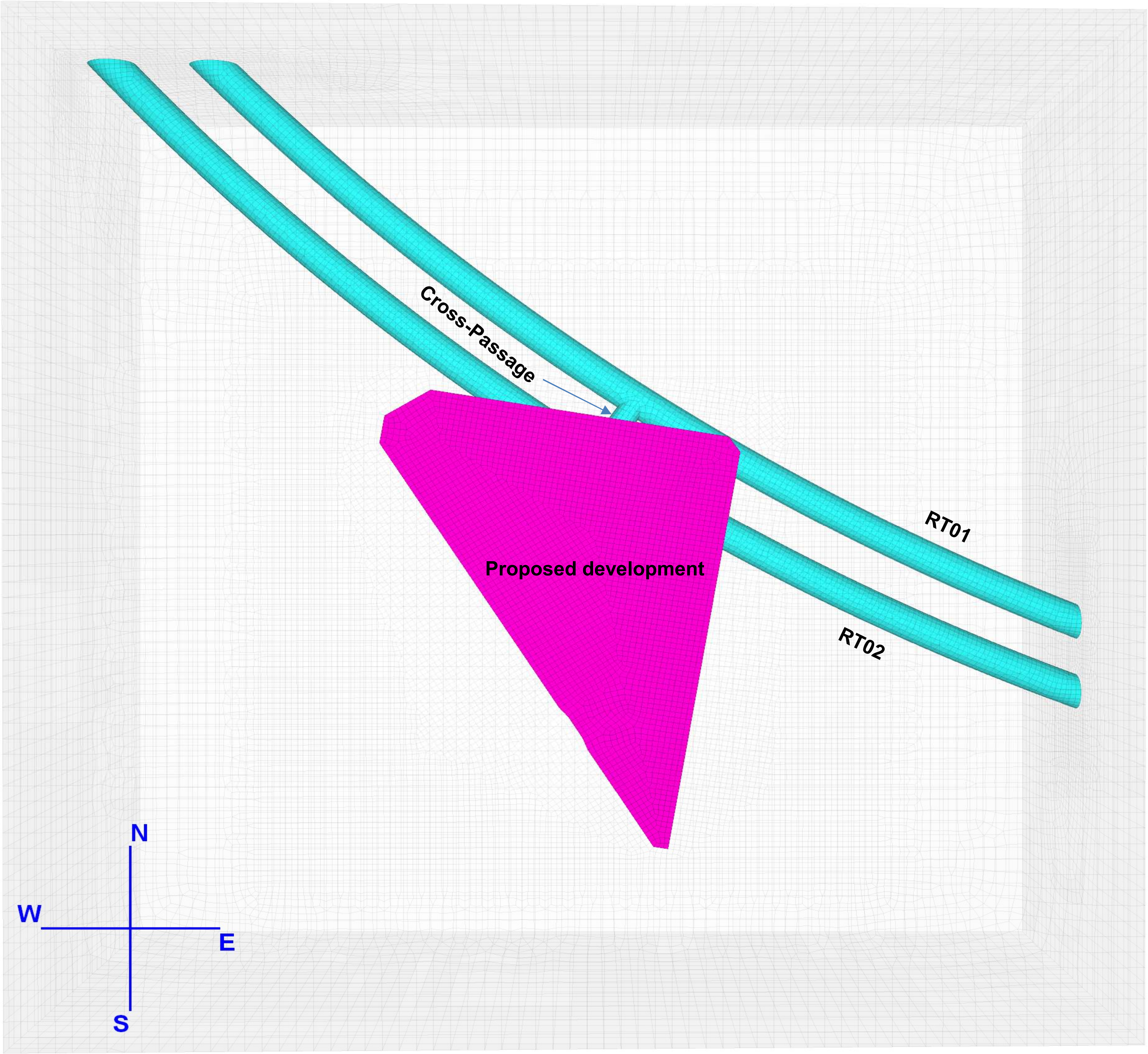
FOUNDATION PLAN

JOB NUMBER:	DRG NUMBER:	
23012	S02.001	
DESIGNED BY: RC	DATE: June.2024	
DRAWN BY: SF	SCALE: 1:1, 1:100 @ A0	SIZE: A0 / REV: P5

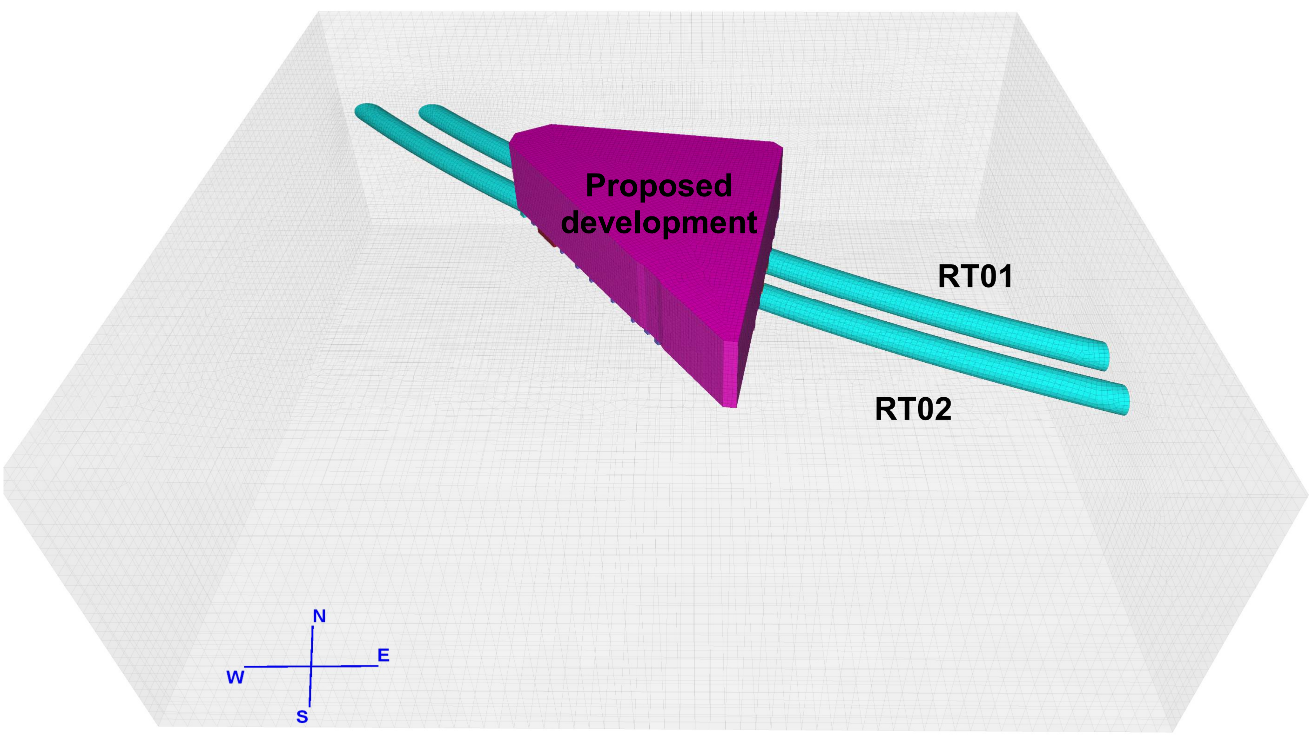
24/04/2025 11:47:35 AM

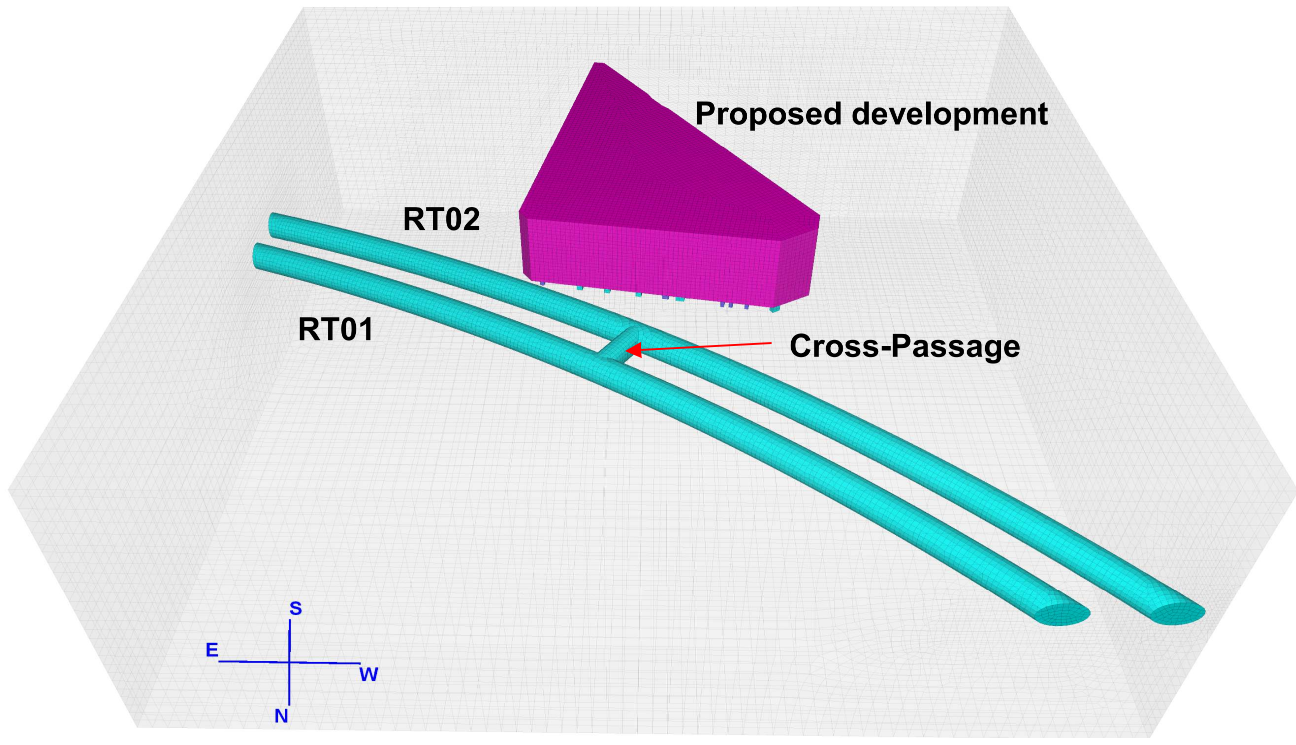
Appendix D

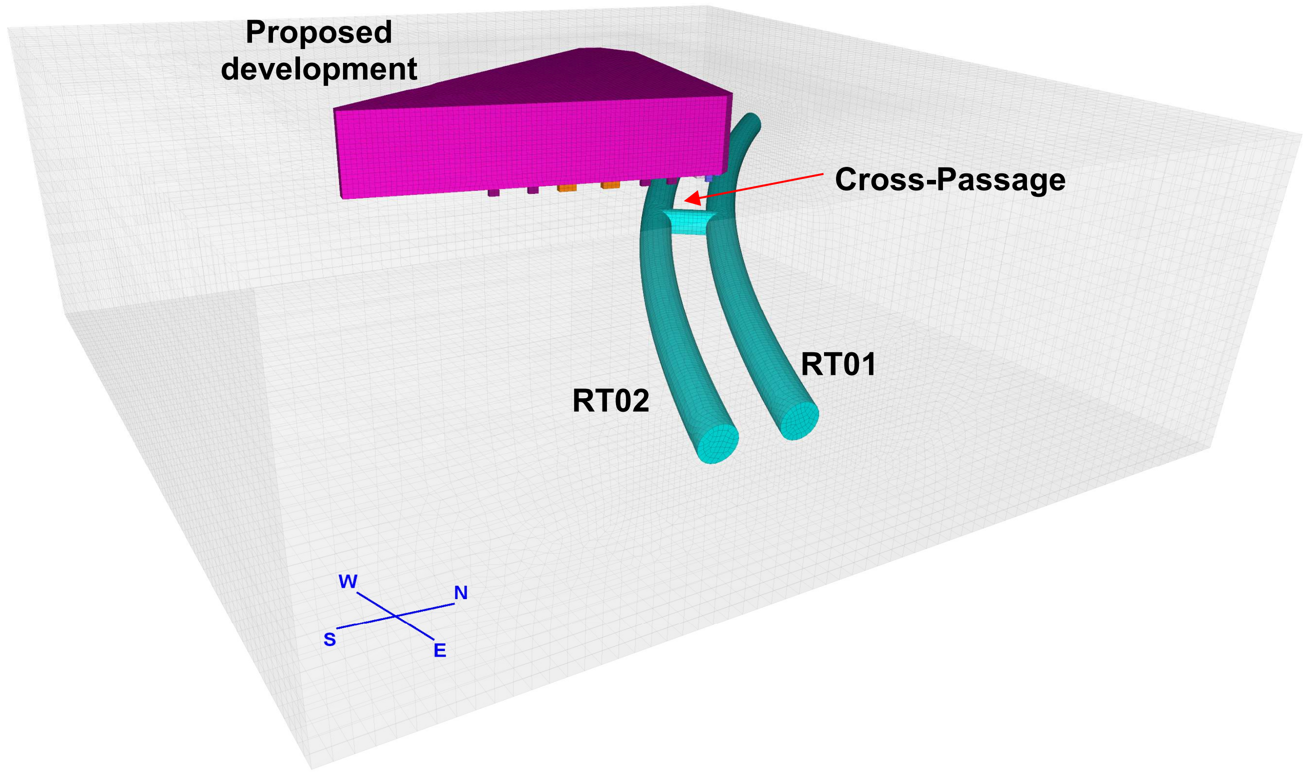
Numerical Analysis Results

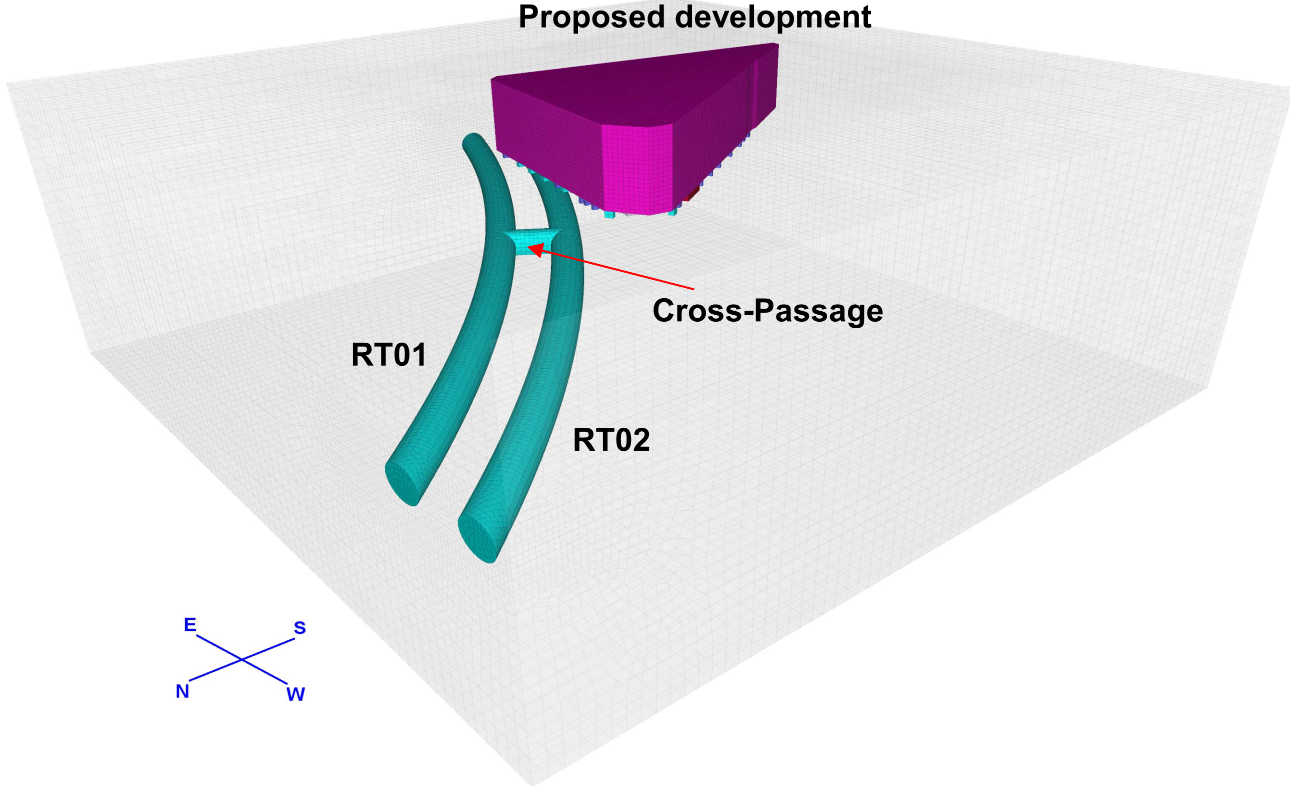


Douglas PARTNERS	CLIENT: Deicorp Pty Ltd	TITLE:	Conceptual Geometry Plot	PROJECT No:	86645.03
	OFFICE: Sydney		3D Numerical Analysis	PLOT No:	1
	DATE: 6 May 2025		Fiveways Project, Crows Nest	REVISION:	2

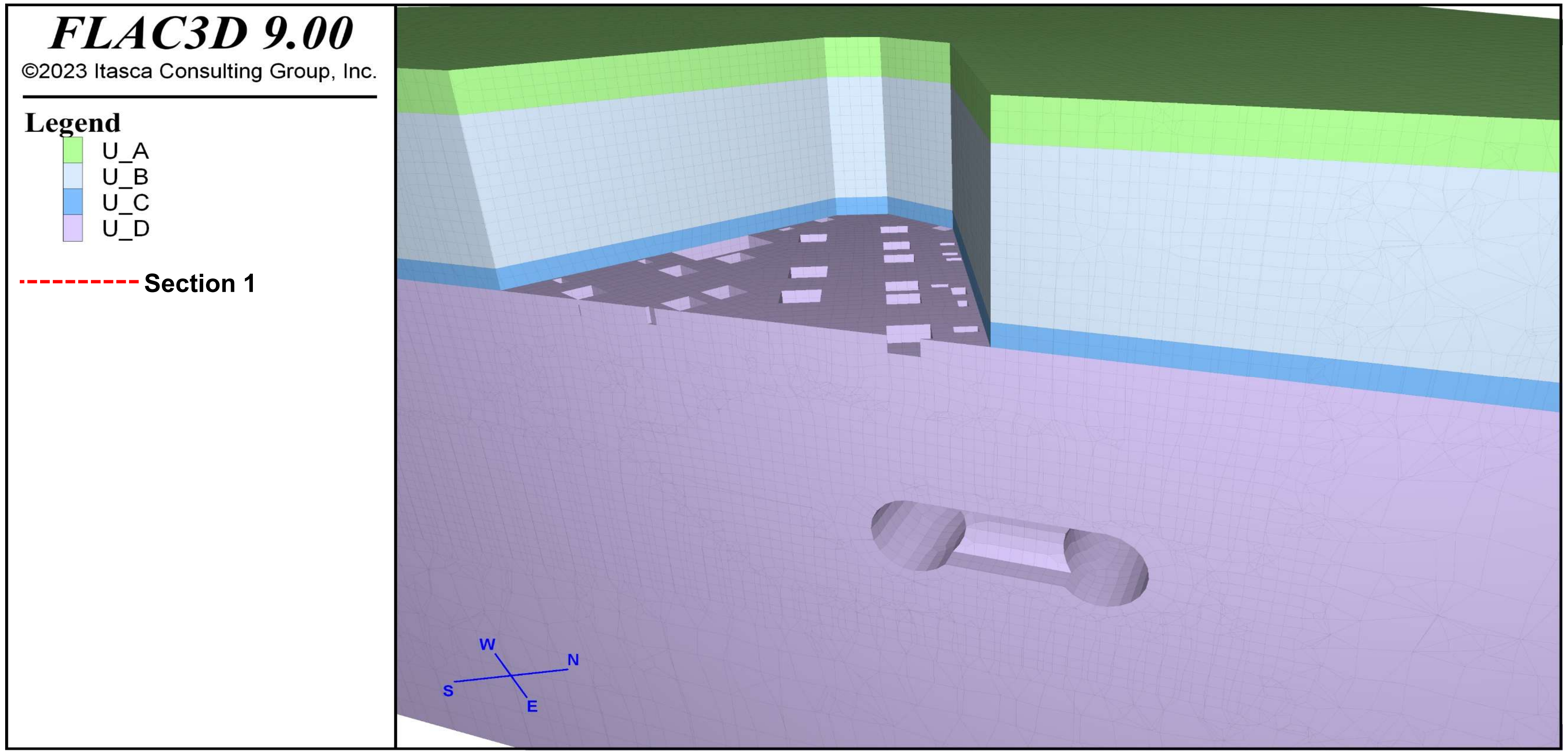


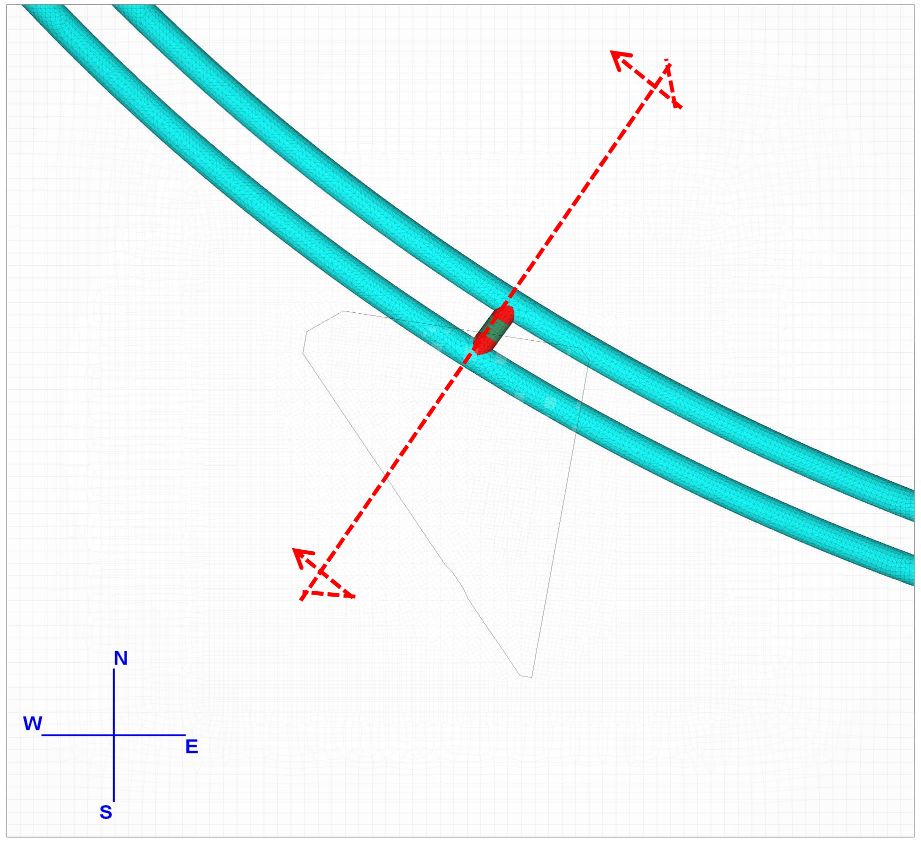






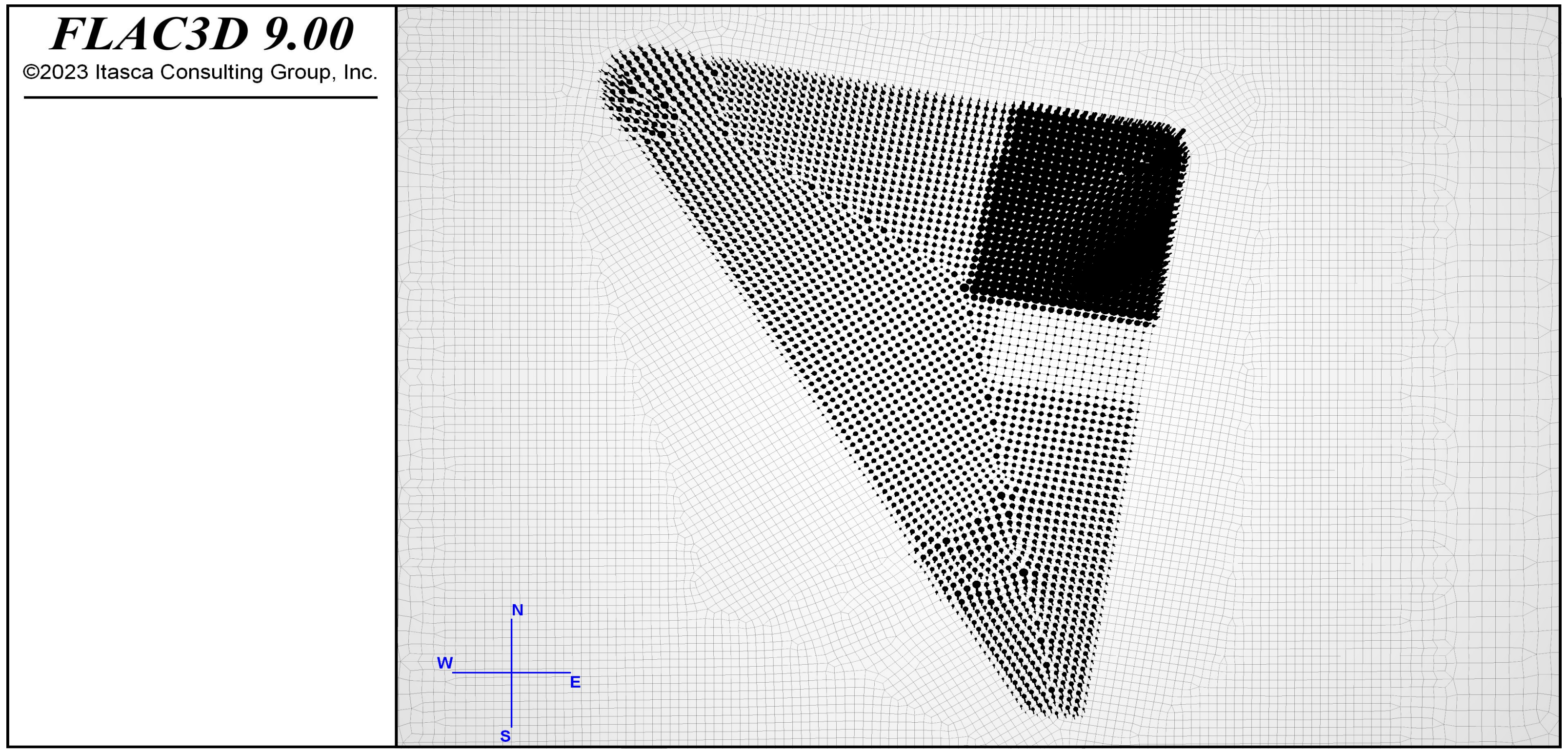
Douglas Partners	CLIENT: Deicorp Pty Ltd	TITLE:	**Perspective Views**	PROJECT No:	86645.03
	OFFICE: Sydney		**3D Numerical Analysis**	PLOT No:	2
	DATE: 6 May 2025		**Fiveways Project, Crows Nest**	REVISION:	2



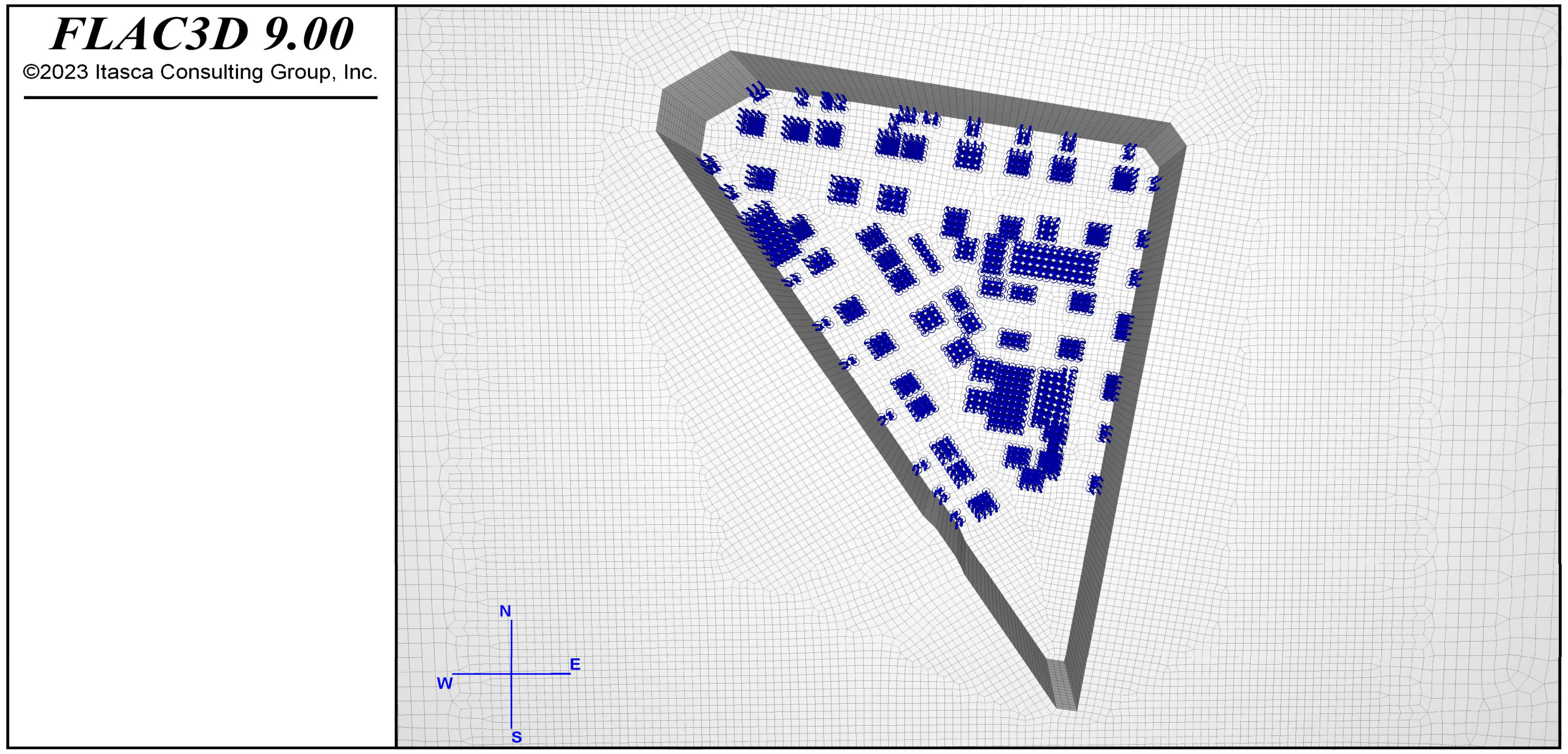


Douglas PARTNERS	CLIENT: Deicorp Pty Ltd	TITLE: **Geotechnical Units and Section for Analysis**	PROJECT No: 86645.03
	OFFICE: Sydney	**3D Numerical Analysis**	PLOT No: 3
	DATE: 6 May 2025	**Fiveways Project, Crows Nest**	REVISION: 2

Existing Buildings



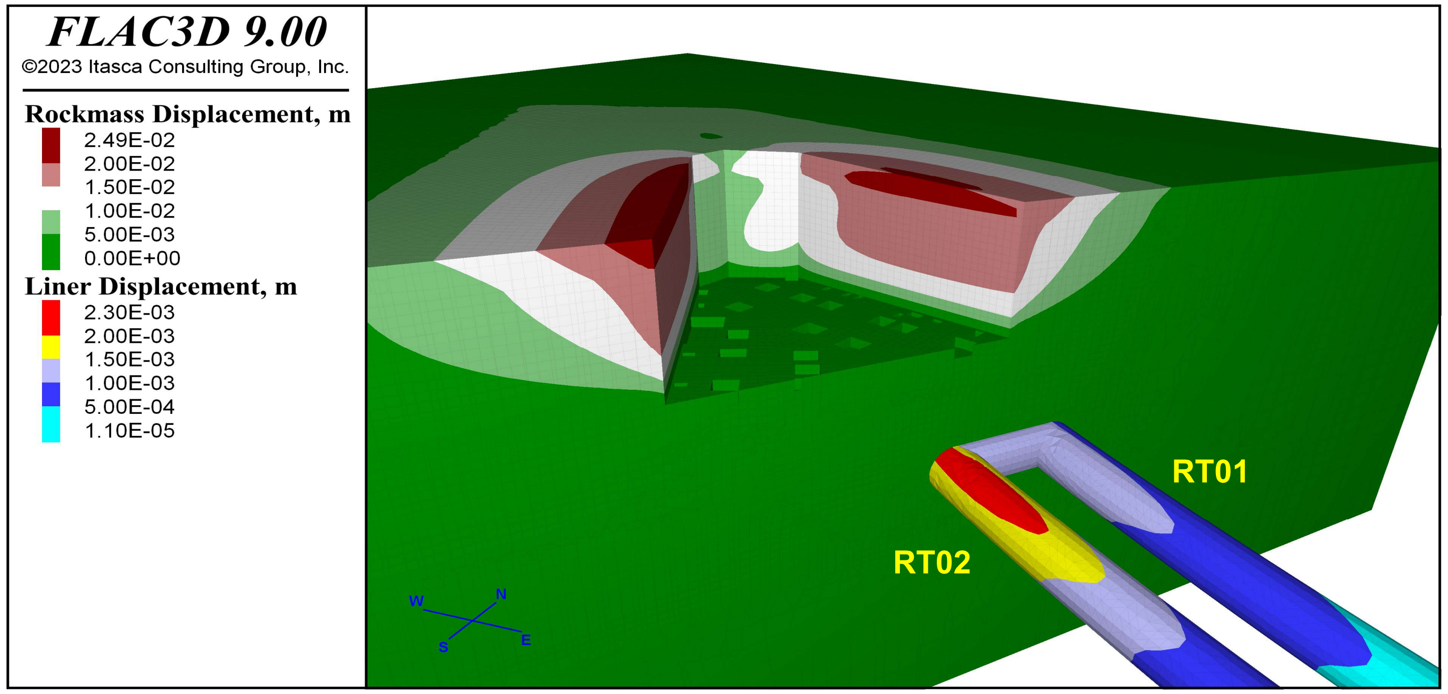
New Footings

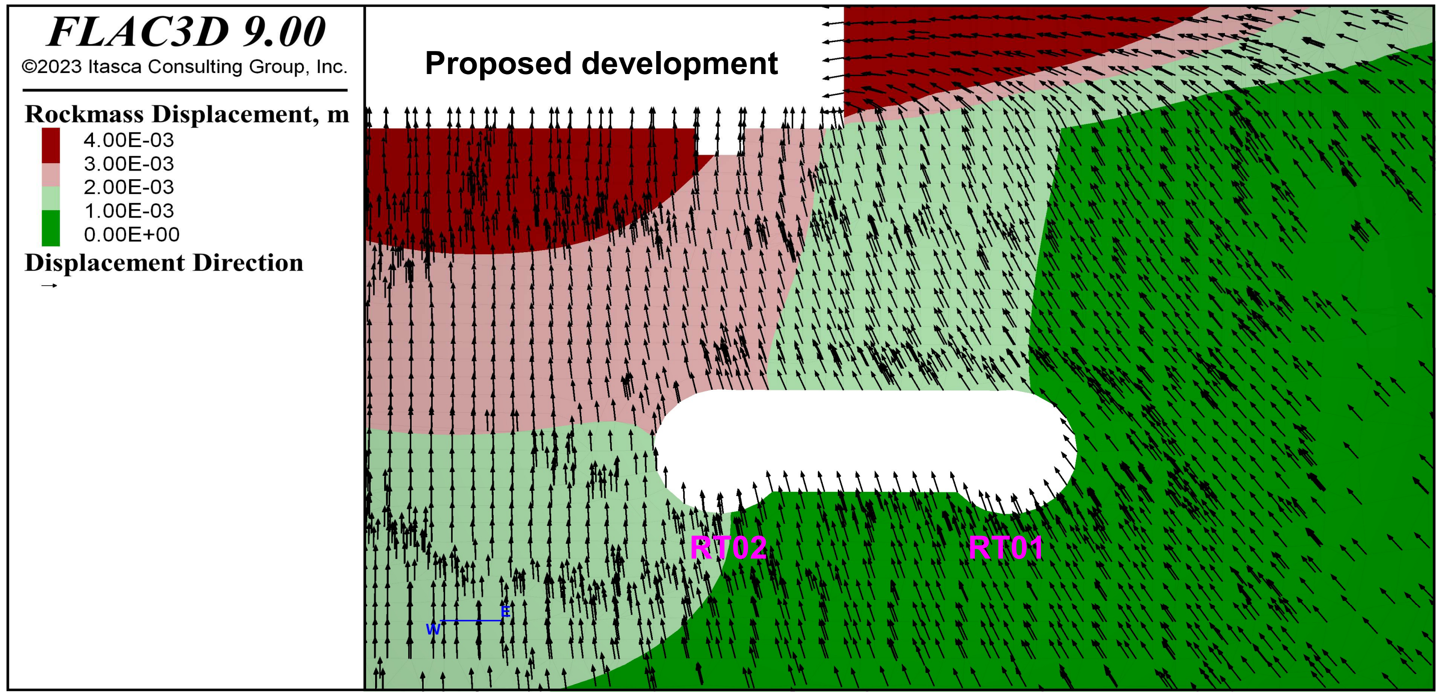


Douglas PARTNERS

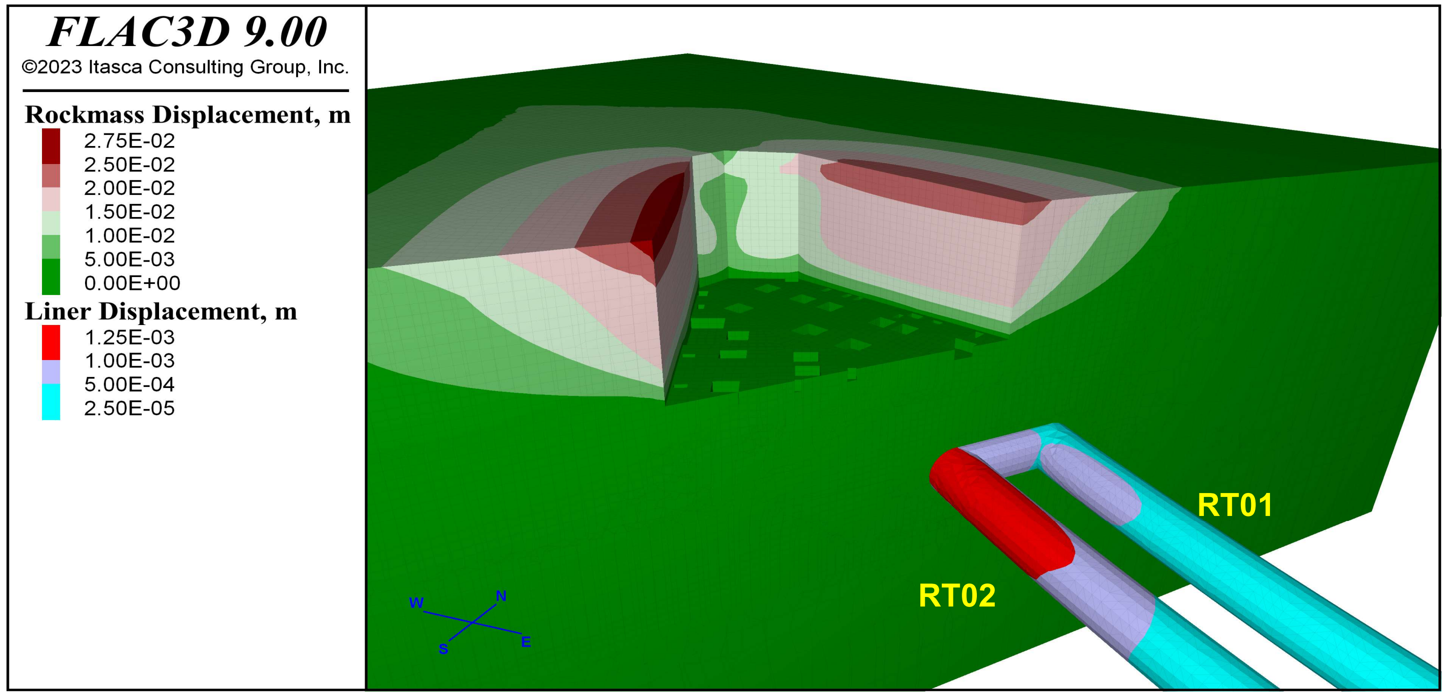
CLIENT: Deicorp Pty Ltd	TITLE: **Bearing Pressures Applied**	PROJECT No:	86645.03
OFFICE: Sydney	**3D Numerical Analysis**	PLOT No:	4
DATE: 6 May 2025	**Fiveways Project, Crows Nest**	REVISION:	2

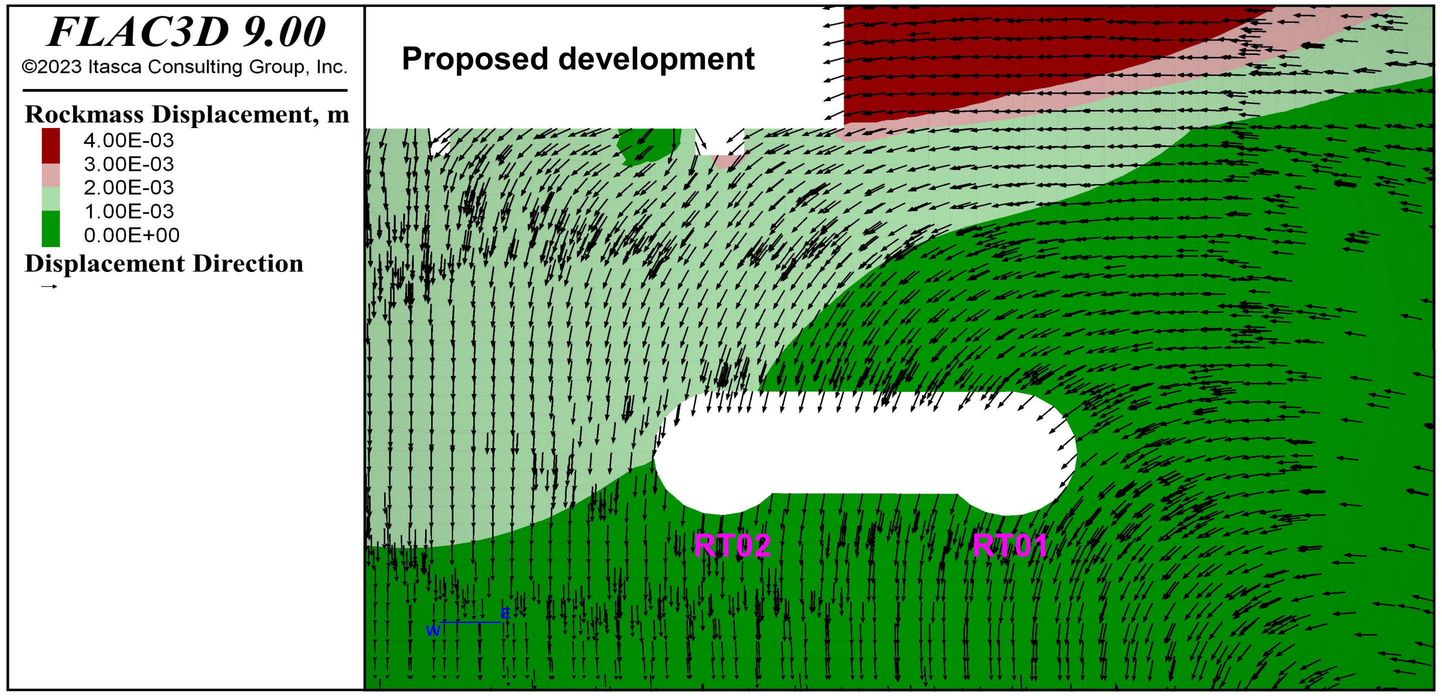
Case 1 - Stage 1 - Perspective View and Section 1 View





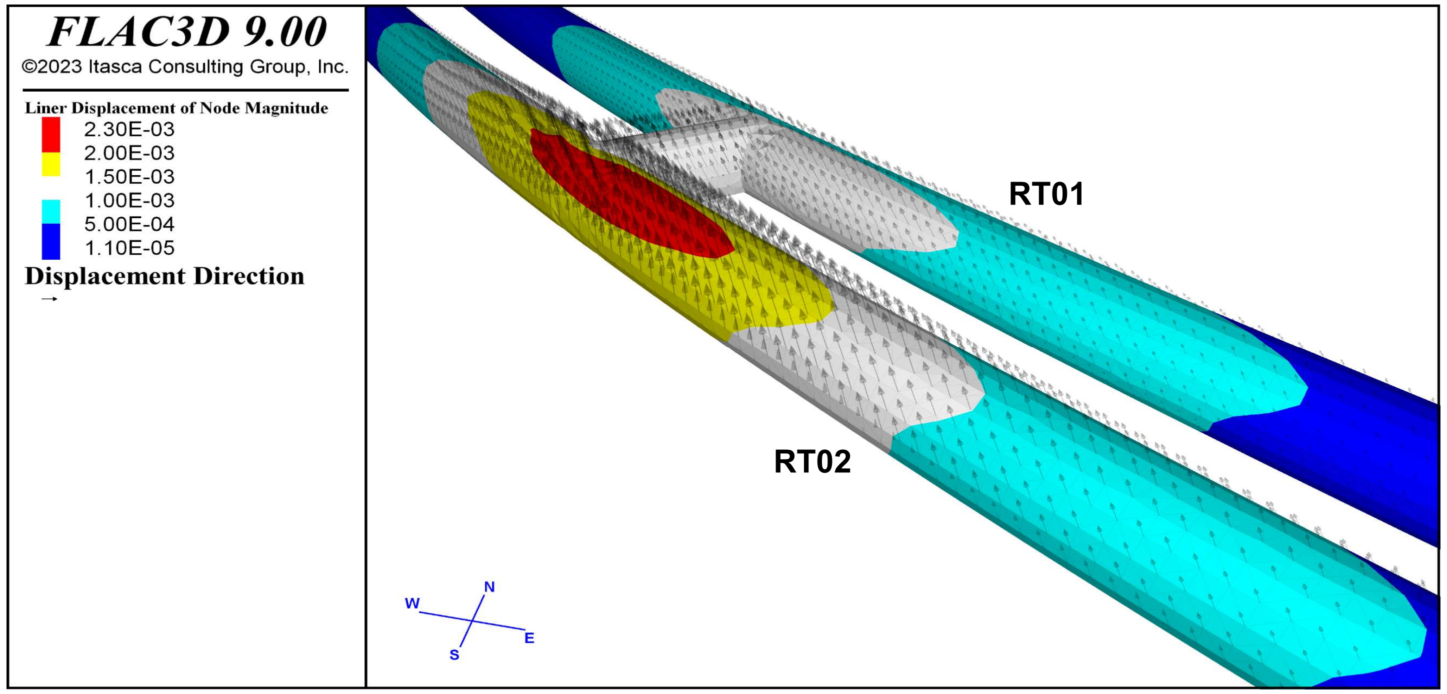
Case 1 - Stage 2 - Perspective View and Section 1 View

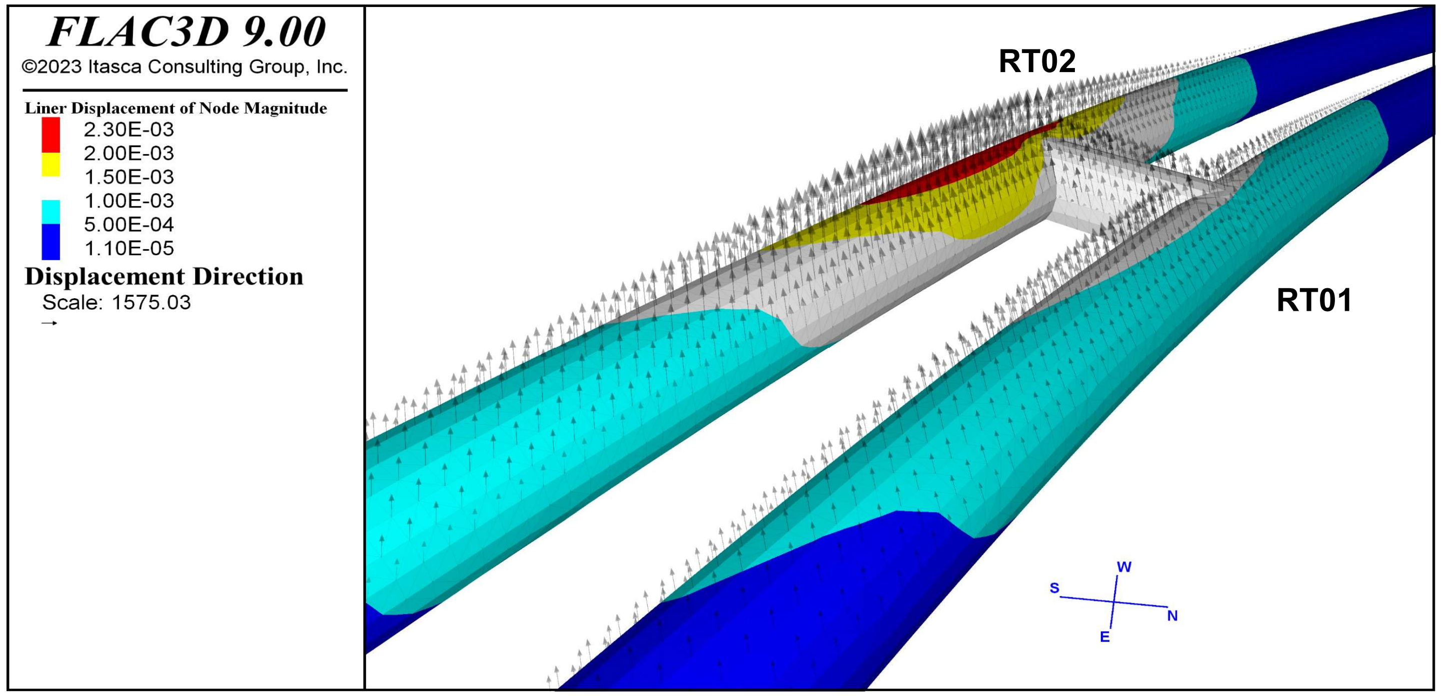




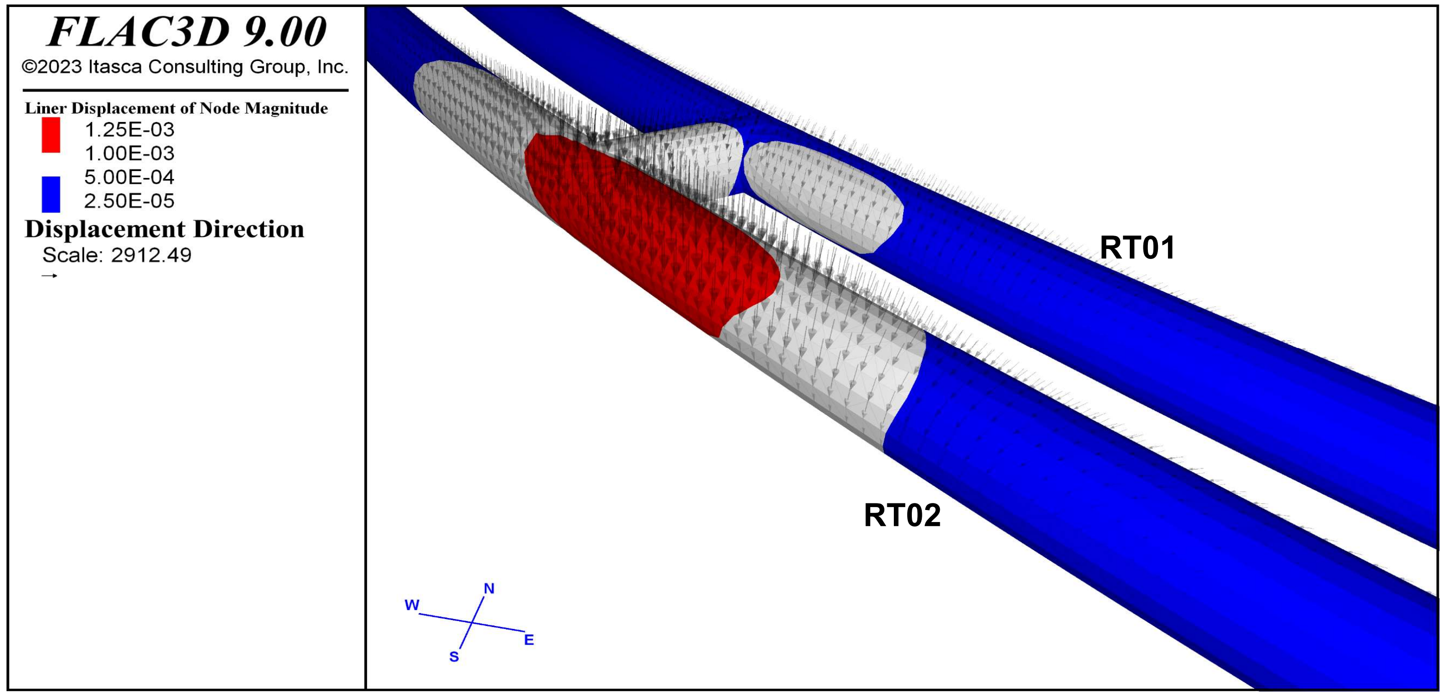
Douglas PARTNERS	CLIENT: Deicorp Pty Ltd	TITLE: **Total Rockmass and Tunnel Liner Displacements (m)**	PROJECT No: 86645.03
	OFFICE: Sydney	**Case 1 - Stages 1 & 2 - Section 1**	PLOT No: 5
	DATE: 6 May 2025	**Fiveways Project, Crows Nest**	REVISION: 2

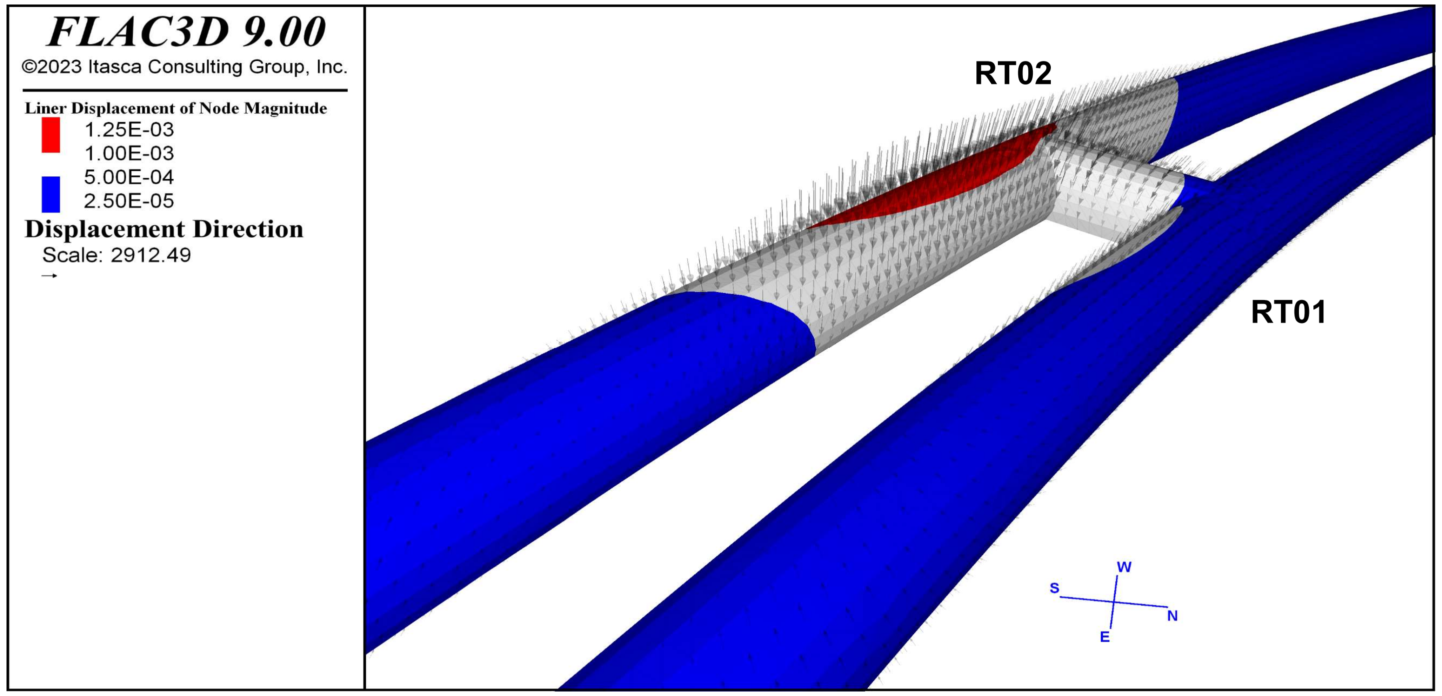
Case 1 - Stage 1 - Perspective Views





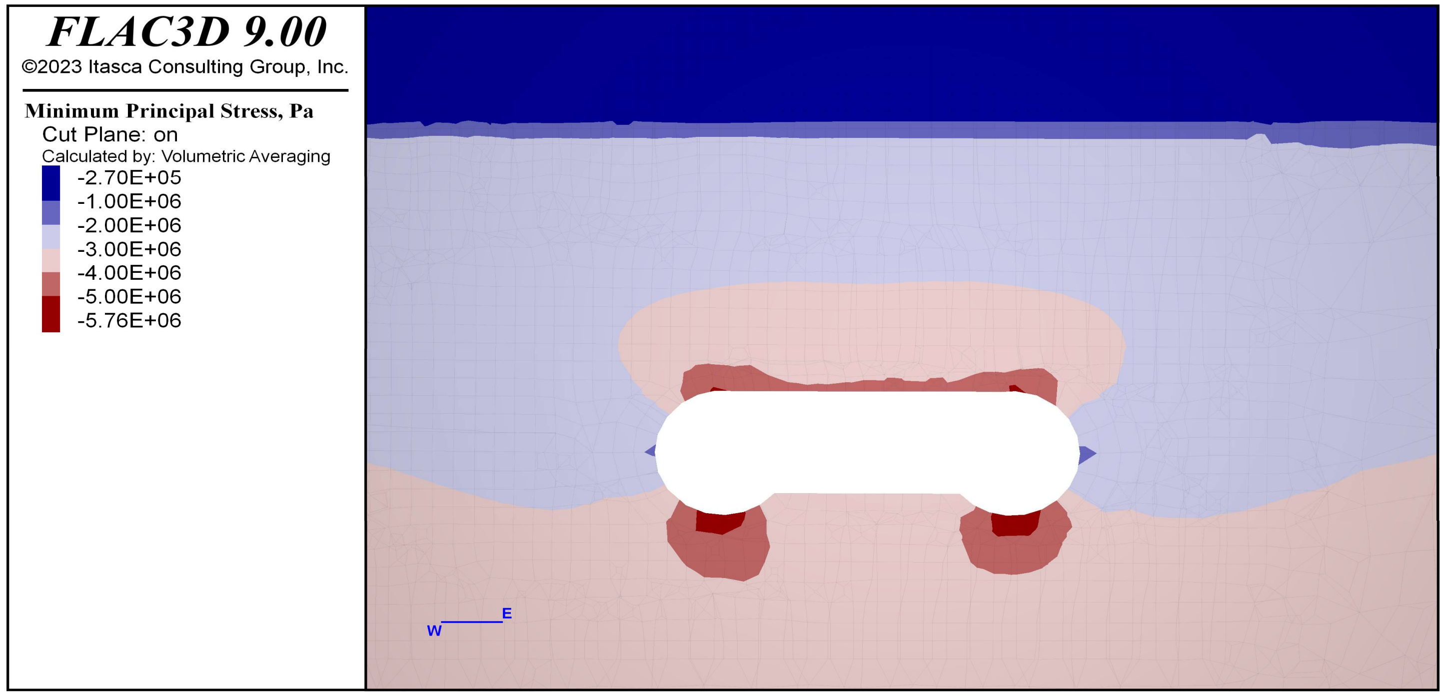
Case 1 - Stage 2 - Perspective Views





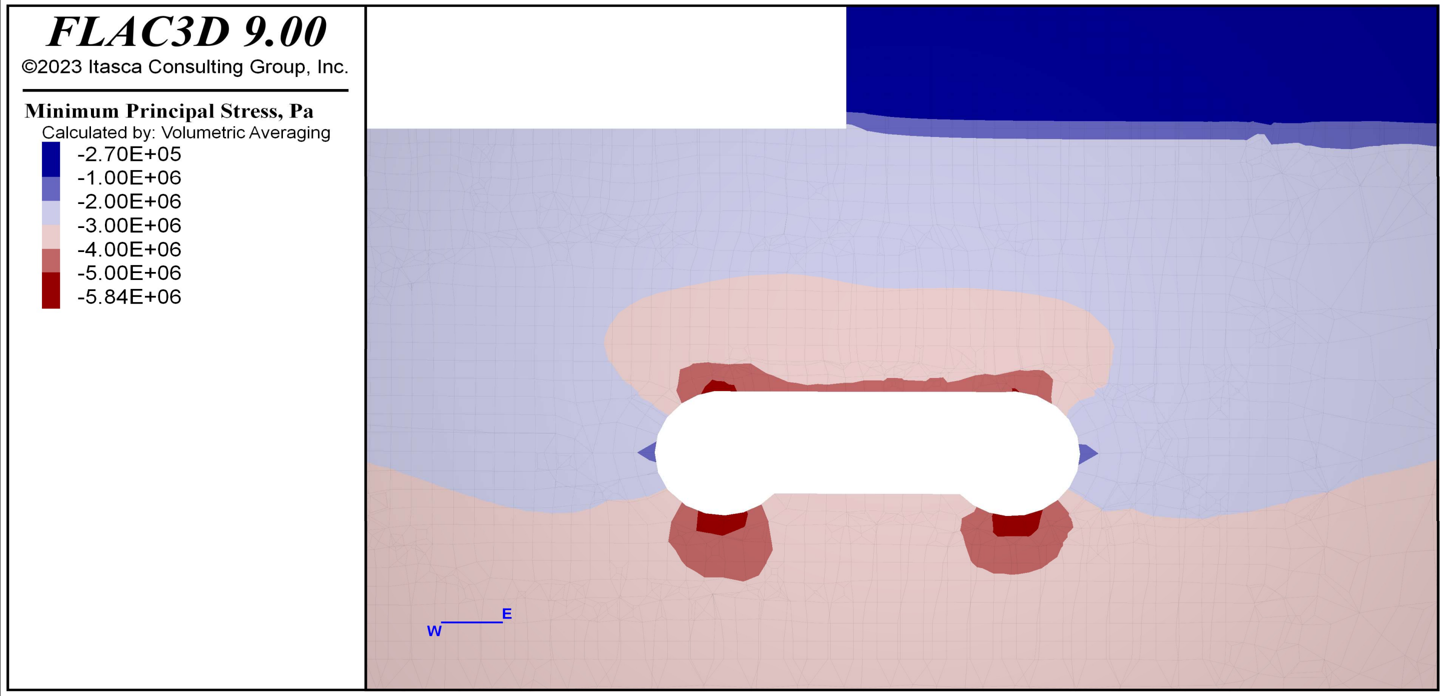
Douglas PARTNERS			
CLIENT: Deicorp Pty Ltd	TITLE: **Total Tunnel Liner Displacements (m)**	PROJECT No:	86645.03
OFFICE: Sydney	**Case 1 - Stages 1 & 2**	PLOT No:	6
DATE: 6 May 2025	**Fiveways Project, Crows Nest**	REVISION:	2

Case 1 - Stage 0 - Section 1

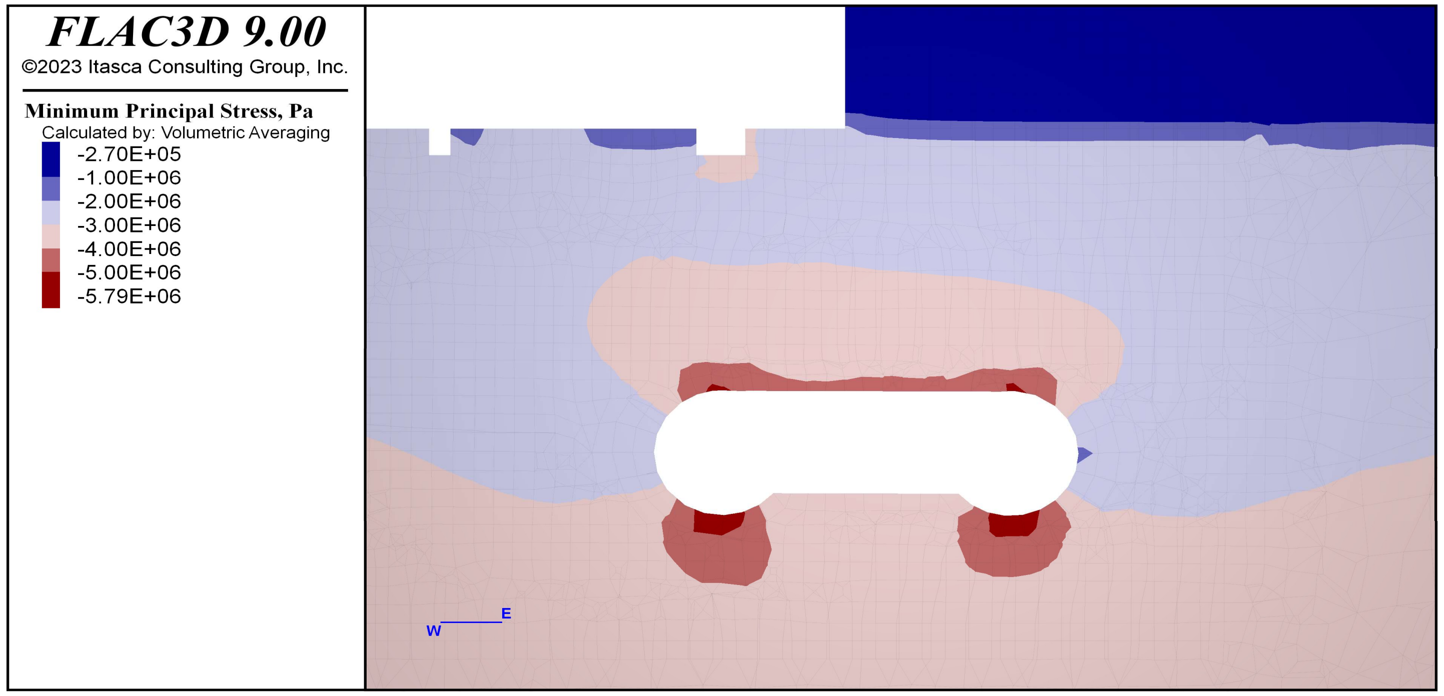


Note:
FLAC3D convention for stress is (-) for compressive stress and (+) for tensile stress. i.e., the most negative stress is the maximum principal stress and the less negative stress is the minimum principal stress

Case 1 - Stage 1 - Section 1

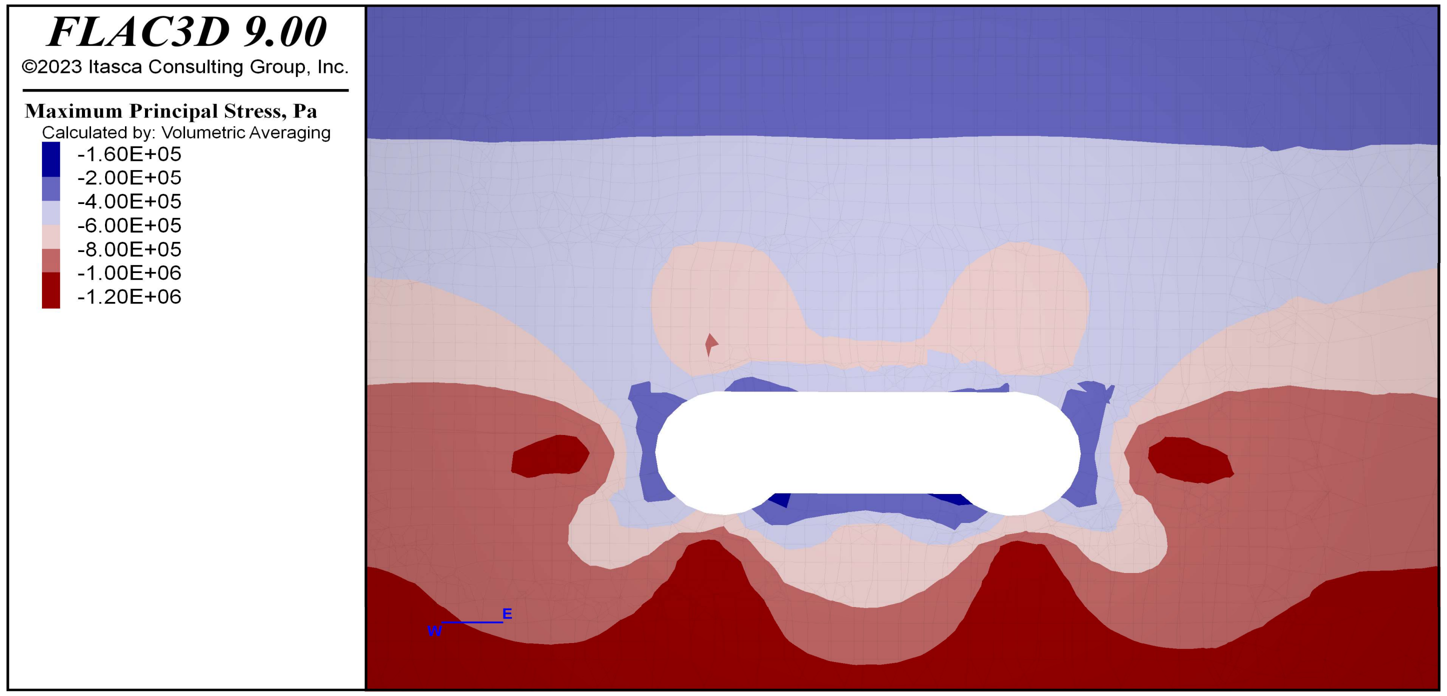


Case 1 - Stage 2 - Section 1



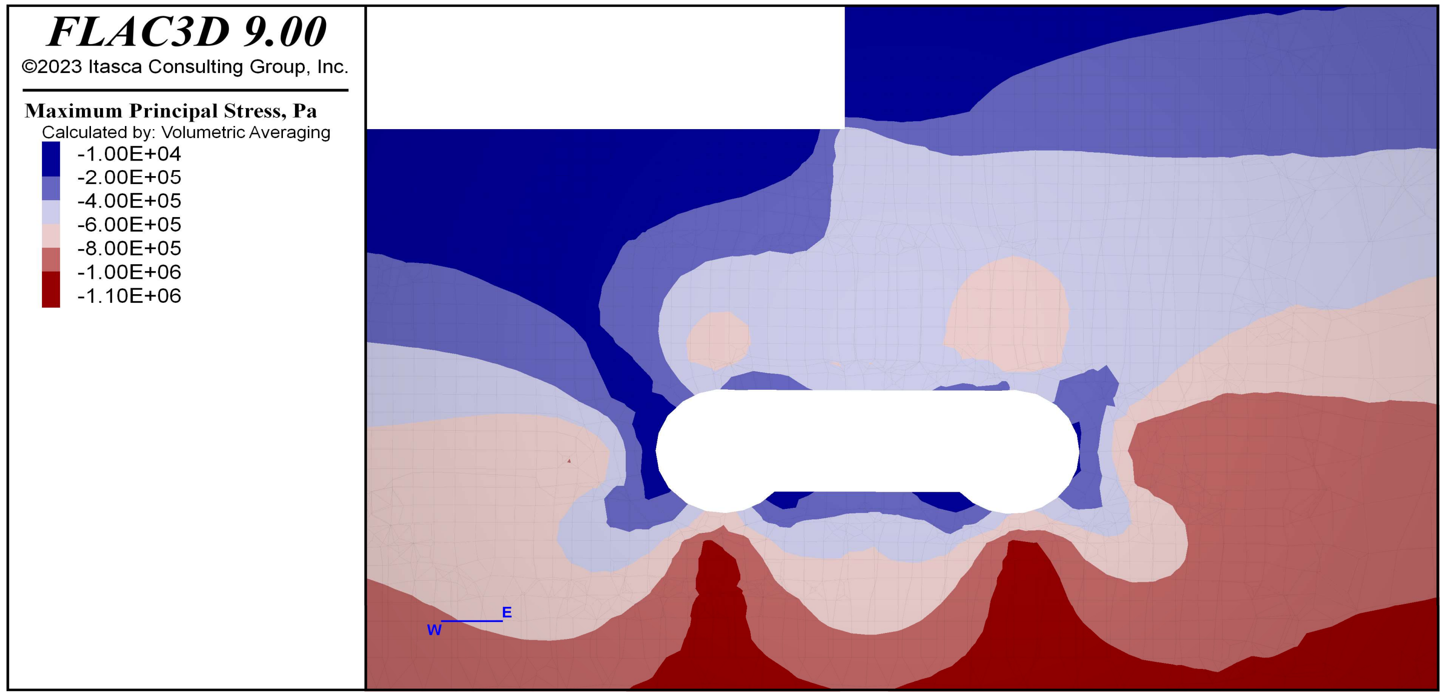
CLIENT: Deicorp Pty Ltd	TITLE:	**Minimum Principal Stress (kPa)**	PROJECT No:	86645.03
OFFICE: Sydney		**Case 1 - Stages 0, 1 & 2**	PLOT No:	7
DATE: 6 May 2025		**Fiveways Project, Crows Nest**	REVISION:	2

Case 1 - Stage 0 - Section 1

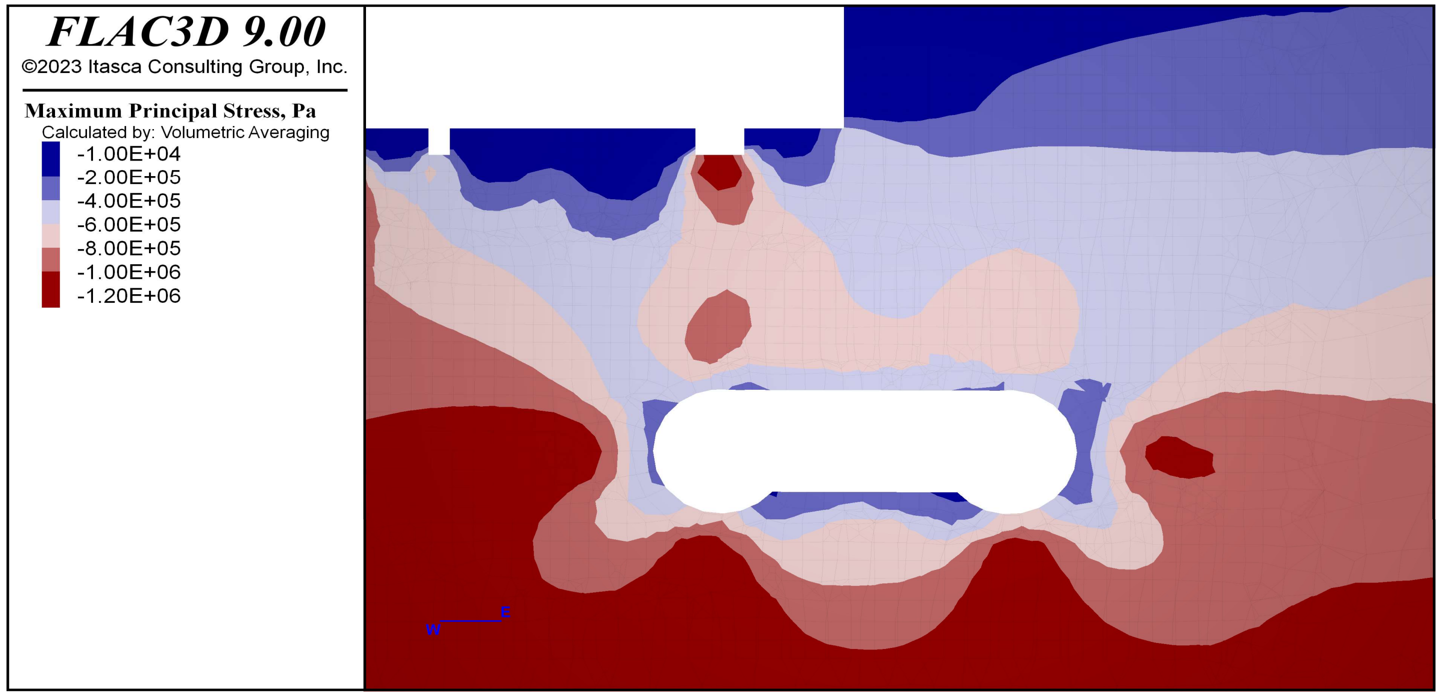


Note:
FLAC3D convention for stress is (-) for compressive stress and (+) for tensile stress. i.e., the most negative stress is the maximum principal stress and the less negative stress is the minimum principal stress

Case 1 - Stage 1 - Section 1

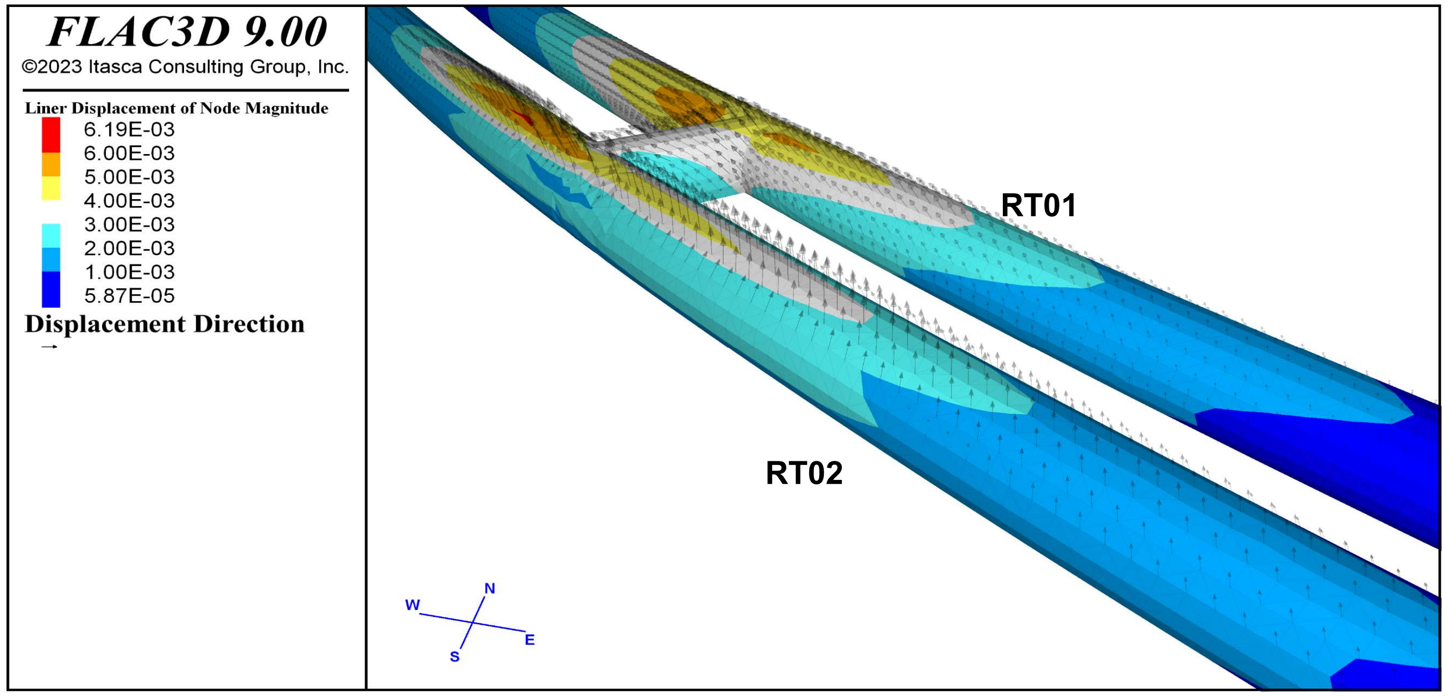


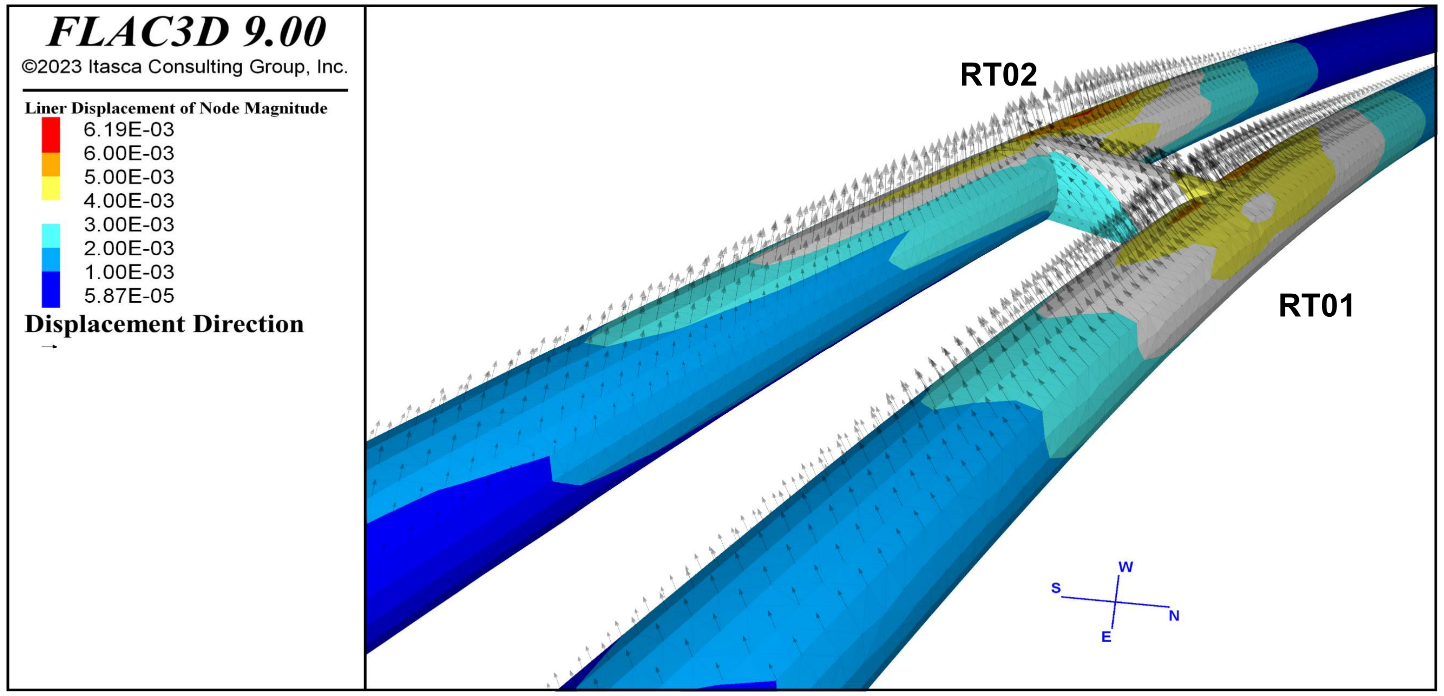
Case 1 - Stage 2 - Section 1



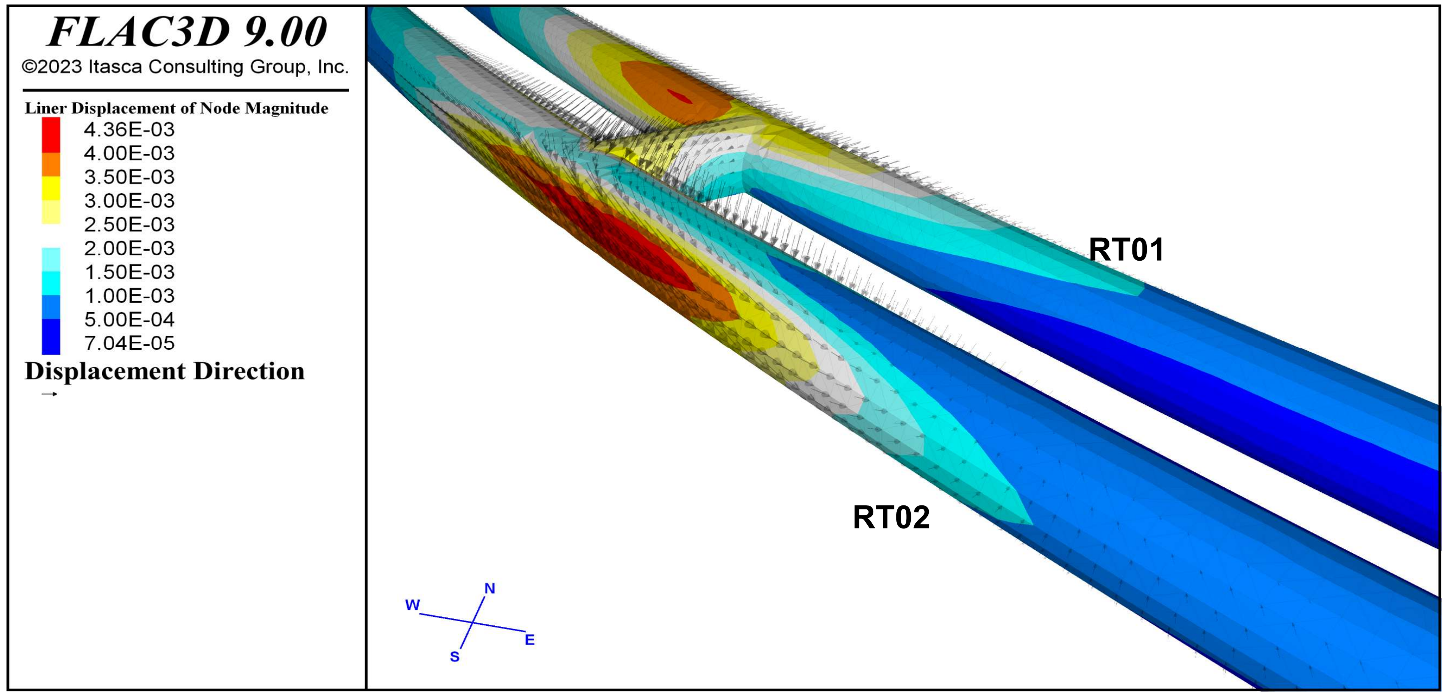
Douglas PARTNERS	CLIENT: Deicorp Pty Ltd	TITLE: **Maximum Principal Stress (kPa)**	PROJECT No: 86645.03
	OFFICE: Sydney	**Case 1 - Stages 0, 1 & 2**	PLOT No: 8
	DATE: 6 May 2025	**Fiveways Project, Crows Nest**	REVISION: 2

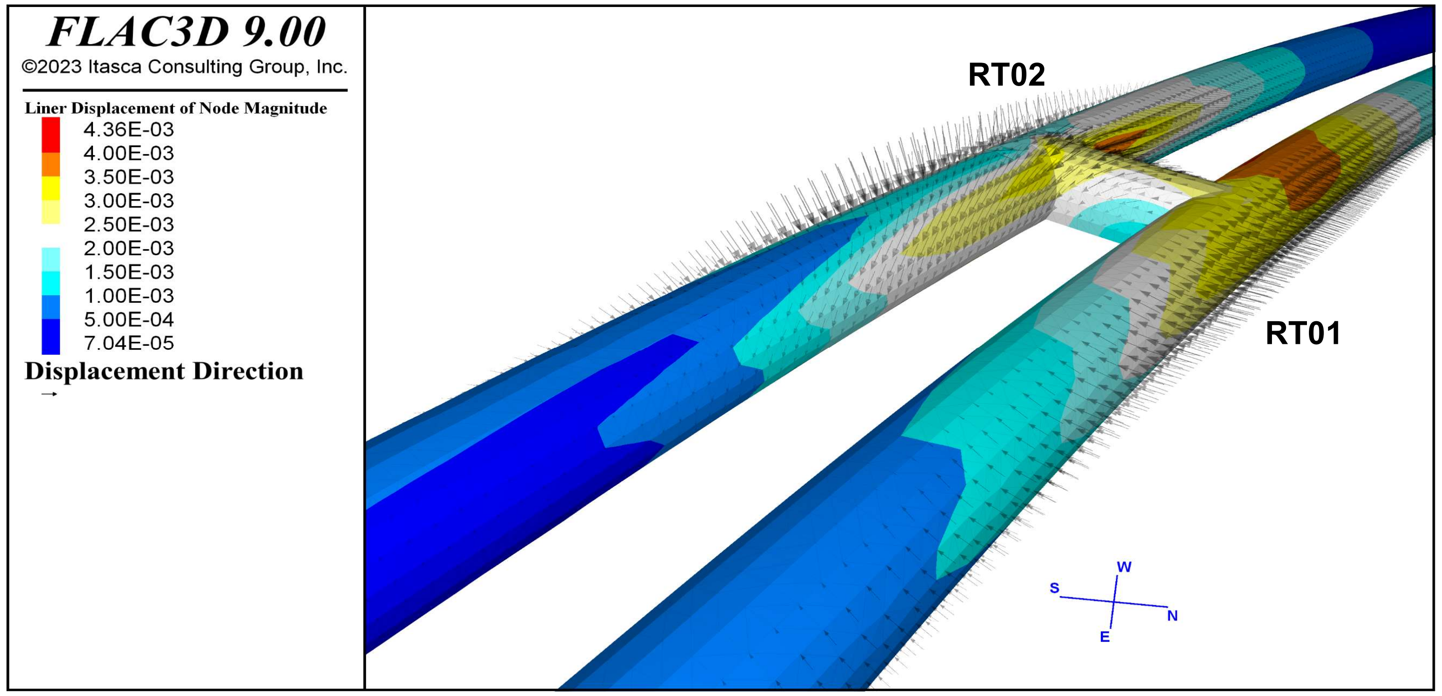
Case 2 - Stage 1 - Perspective Views





Case 2 - Stage 2 - Perspective Views





Douglas PARTNERS			
CLIENT: Deicorp Pty Ltd	TITLE:	**Total Tunnel Liner Displacements (m)**	PROJECT No: 86645.03
OFFICE: Sydney		**Case 2 - Stages 1 & 2**	PLOT No: 9
DATE: 6 May 2025		**Fiveways Project, Crows Nest**	REVISION: 2