

#### **REPORT**

# Metronet - Morley to Ellenbrook Line (MEL)

### Preliminary Dewatering Assessment

Submitted to:

#### **Public Transport Authority**

Public Transport Centre West Parade PERTH WA 6000

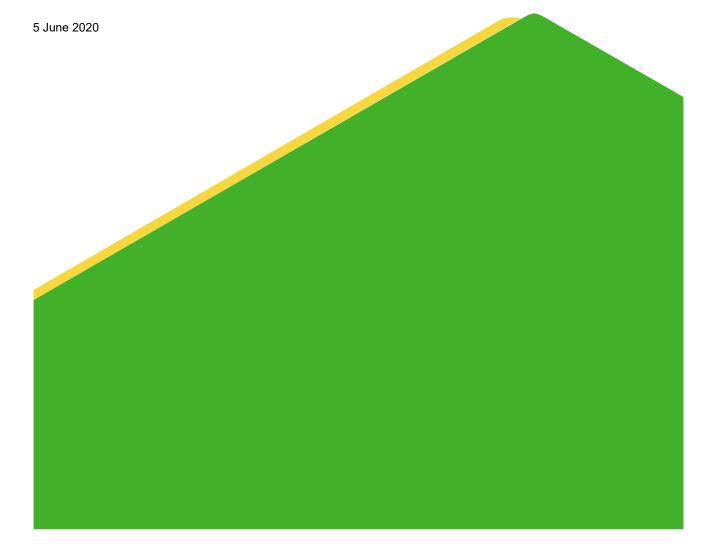
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20145247-003-R-Rev0



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# **Table of Contents**

1.0	INTR	ODUCTION	1
2.0	sco	PE OF WORK	1
3.0	MAL	AGA DIVE STRUCTURE	1
	3.1	Site Description	1
	3.2	Dewatering Requirements	2
	3.3	Groundwater Model	3
	3.3.1	Model Setup	3
	3.3.2	Model Assumptions	3
	3.3.3	Model Scenarios	3
	3.3.4	Groundwater Model Results	4
	3.3.4.	1 Extent of Groundwater Level Drawdown from Dewatering	4
	3.3.4.	2 Dewatering Rates	5
	3.3.4.	3 Mounding Due to Installation of D-walls	5
	3.4	Recommendations	5
4.0	GNA	NGARA AND DRUMPELLIER INTERSECTION	5
	4.1	Site Description	6
	4.2	Dewatering Requirements	6
	4.3	Groundwater Model	7
	4.3.1	Model Setup	7
	4.3.2	Model Scenarios	7
	4.3.3	Model Assumptions	7
	4.3.4	Groundwater Model Results	7
	4.3.4.	1 Extent of Groundwater Level Drawdown from Dewatering	7
	4.3.4.	2 Dewatering Rates	8
	4.4	Recommendations	8
5.0	BEN	NETT BROOK CROSSING	9
	5.1	Site Description	9
	5.2	Dewatering Requirements	10
	5.3	Groundwater Model	10



	5.3.1	Model Setup	10
	5.3.2	Model Assumptions	10
	5.3.3	Model Scenarios	10
	5.3.4	Groundwater Model Results	10
	5.3.4.1	Extent of Groundwater Level Drawdown from Dewatering	10
	5.3.4.2	Dewatering Rates	11
	5.4 F	Recommendations	11
6.0	CONCL	USIONS AND RECOMMENDATIONS	12
7.0	REFER	ENCES	13
8.0	IMPOR	TANT INFORMATION	13
TAE	BLES		
Tab	le 1: Mala	ga Dive Structure Dewatering Requirements	3
Tab	le 2: Exte	nt of Groundwater Level Drawdown for Malaga Dive Structure	4
Tab	le 3: Maxi	mum Modelled Groundwater Level Drawdown (m)	4
Tab	le 4: Exte	nt of Groundwater Level Drawdown for the Gnangara/Drumpellier Site	7
Tab	le 5: Exte	nt of Groundwater Level Drawdown for the Bennet Brook Crossing	11

#### **FIGURES**

- Figure 1: Malaga Dive Structure Model 1 Groundwater Level Drawdown after 1 Year
- Figure 2: Malaga Dive Structure Model 2 Groundwater Level Drawdown after 1 Year
- Figure 3: Cross-sectional Screenshot Model Cross-Section for Model 2
- Figure 4: Gnangara/Drumpellier Site Steady-state Groundwater Model Flow Direction
- Figure 5: Gnangara/Drumpellier Site Model 1 Groundwater Level Drawdown after 1 Month
- Figure 6: Gnangara/Drumpellier Site Model 2 Groundwater Level Drawdown after 1 Month
- Figure 7: Bennett Brook Crossing Groundwater Level Drawdown after 1 Month

#### **APPENDICES**

#### Appendix A

**Provided Concept Design Drawings** 

#### Appendix B

Important Information



#### 1.0 INTRODUCTION

The Public Transport Authority (PTA) has engaged Golder Associates Pty Ltd (Golder) undertake a preliminary dewatering assessment at three areas along the Malaga to Ellenbrook Rail Works section for the Morley to Ellenbrook Line (MEL) Project.

The proposed MEL Project is an approximately 21 km long railway that will connect the existing Midland line in Bayswater to Ellenbrook in Perth's north-eastern suburbs, approximately 22 km north-east of the Perth central business district (CBD). The MEL Project includes new stations at Morley, Noranda, Malaga, Whiteman Park and Ellenbrook, and provision for a future station at Bennett Springs East as well as provision for a future Rail Stabling Facility at Henley Brook.

Golder has also carried out a strategic level hydrogeological assessment along the Malaga to Ellenbrook Rail Works for the MEL project (19132627-010-R-Rev0), where the general hydrogeological data is collated and described, which should be referred to for detailed description of the hydrogeology.

#### 2.0 SCOPE OF WORK

The scope of work involves the preliminary dewatering assessment for the following three areas:

- 1) Malaga Dive Structure
- 2) Gnangara Intersection
- 3) Bennett Brook Crossing

A basic groundwater model was developed using Visual MODFLOW for the three areas for the preliminary dewatering assessment to assess the extent of the groundwater level drawdown from the expected dewatering activities. Model runs were also undertaken to assess if the extent of the groundwater level drawdown can be appropriately controlled through active dewatering discharge management and engineering controls.

The purpose of the preliminary dewatering assessment and groundwater modelling is to assess and model the potential extent of groundwater level drawdown from the dewatering activities for different construction/dewatering scenarios. The information will be used in the Environmental Review Document as part of the environmental approval process. The groundwater modelling results should not be used for design purposes.

#### 3.0 MALAGA DIVE STRUCTURE

The following information was used for the preliminary dewatering assessment and the development of the basic groundwater model (refer to Appendix A for drawings):

- MEL-MNO-ARUP-ST-DRG-3121 to 3124 Rev C provides the proposed invert levels of the D-walls.
- MEL-MNO-ARUP-RS-DRG-0115 Rev C provides the proposed rail level and thereby excavation level.

The geotechnical investigation undertaken by Arup (Arup 2019a) and groundwater study by Golder (Golder 2020) together with our experience from the NorthLink project were utilised to develop the hydrogeological setting at the Malaga Dive Structure.

#### 3.1 Site Description

The Malaga Dive Structure can be described as:

Approximately 450 m long from approximately CH12,940 to CH13,390 where the rail line will dive underneath the southbound lanes of Tonkin Highway and surface before the proposed Malaga Station.



■ The existing ground surface at the dive ranges between RL 33.6 m AHD and RL 32.4 m AHD. The lowest point of the dive structure is at CH13,150 with a rail level of RL 27.52 m AHD, which is approximately 5.0 m below existing ground level at this location.

- D-walls are proposed to be constructed on either side of the dive structure and open ends (i.e. no cross walls at the ends). The toe of the D-walls will range between RL 23.47 m AHD (at the ends) and RL 14.23 m AHD. The internal distance between the walls range between 10.8 m and 11.3 m.
- The top of the raft slab and thickness of the slab has not been provided. It has been assumed that the top of the raft slab is 0.8 m below the rail level and that the slab thickness is 1 m. This means that the required excavation level is 1.8 m below the provided rail level.
- A drainage sump pit will be installed at the lowest point of the tunnel. The invert level of the sump has not been provided, but it has been assumed to be 3 m deep (RL 22.7 m AHD).

Some of the key hydrogeological conditions used to develop the basic groundwater model are:

- The geology at the site consists of:
  - Bassendean Sand extending to about RL 17 m AHD, overlying Guildford Formation extending to around RL -10 m AHD. It is possible that Gnangara Sand is also present below the Bassendean Sand.
  - East of the site towards Bennett Brook the Bassendean Sand becomes thinner and the main geology is Guildford Formation.
  - To the north and west of the dive structure (toward Gnangara Mound) the sand profile becomes thicker and consists of Bassendean Sand and Gnangara Sand (i.e. the Guilford Formation disappears).
- The Arup report describes the Guildford Formation as being variable with some clay layers present. However, based on our experience we do not expect that a continuous clay layer is present to allow for retaining walls to toe into, creating a natural "plug" at depth between the retaining walls.
- The hydraulic conductivity of the Bassendean Sand has been assumed to be 15 m/d and the Guildford Formation 5 m/d. This is based on literature and our experience of transmissivity in the area (Golder 2020).
- Based on information from the NorthLink 2 project, the wet season groundwater level around the dive structure could be around RL 30 m AHD to RL 30.5 m AHD. This is higher than the Design groundwater level of RL 29.29 m AHD provided on the concept design drawings (Appendix A).
- The groundwater flow direction is from northwest toward southeast and east towards Bennett Brook.
- The seasonal groundwater level fluctuations are expected to be around 1 m in this area.

#### 3.2 Dewatering Requirements

Dewatering will be required wherever the groundwater level is higher than the base of the excavation level. Furthermore, it is often necessary to draw the groundwater level down to about 1 m below the excavation level to allow for compaction of soils or removal and replacement of unsuitable founding material.

Table 1 presents a summary of the dewatering requirements for the Malaga Dive Structure based on the provided information.



**Table 1: Malaga Dive Structure Dewatering Requirements** 

Location	Excavation Level	Dewatering Level		ater Level AHD)	Groundwater Level Drawdown (m)		
Location	(m AHD)	(m AHD)	Wet Season	Dry Season	Wet Season	Dry Season	
Dive Structure	25.7 to 30.4	24.7 to 29.4	30.0 to 30.5	29.0 to 29.5	0.9 to 5.8	0.0 to 4.8	
Drainage Sump	22.7	21.7	30.5	30.0	8.8	7.8	

#### 3.3 Groundwater Model

#### 3.3.1 Model Setup

Figure 1 shows the extent of the groundwater model for the Malaga Dive Structure. The model is 3,200 m long (east to west) and 3,500 m wide (north to south), which was chosen to minimise the model boundary effect on the modelled groundwater level drawdown. The grid sizing within the model ranges from 20 m by 20 m (mainly at the model peripheral boundaries) to 2 m by 2 m around the dive structure where dewatering is required, resulting in a total of 463 rows and 376 columns. The model has 9 layers, most of which are mainly to model the different invert levels of the D-walls.

#### 3.3.2 Model Assumptions

Key assumptions used for the groundwater modelling are:

- Dewatering will be required for 1 year.
- The whole dive structure is dewatered at the same time (conservative assumption, because if instead the dive is split up into smaller sections, this may reduce the dewatering duration of each of the sections and thereby the extent of the groundwater level drawdown).
- Retaining walls will be D-walls, which will be installed on both sides of the excavation and will extend to the invert levels provided in MEL-MNO-ARUP-ST-DRG-3121 to 3124 RevC. The hydraulic conductivity of the D-walls was set at 0.001 m/d.
- The hydraulic conductivity is the same horizontally and vertically, i.e. the  $K_h/K_v$  ratio is 1:1 (conservative assumption).
- The groundwater model has been setup to model the wet season groundwater levels, which will result in the greatest groundwater level drawdown.
- Where recharge wells are used, an injection rate of up to around 1 L/s per well was used based on experience from other projects.

#### 3.3.3 Model Scenarios

We have undertaken the following two model runs:

- **Model 1**: D-wall without reinjection of the abstracted water.
- **Model 2**: D-wall with reinjection of the abstracted water. Recharge wells (a total of 110 wells located approximately 10 m apart) was installed around the dive structure (refer to Figure 2 for modelled recharge well locations).



#### 3.3.4 Groundwater Model Results

#### 3.3.4.1 Extent of Groundwater Level Drawdown from Dewatering

Figures 1 and 2 show the modelled groundwater level drawdown after 1 year of construction dewatering of the Malaga Dive Structure while Figure 3 shows a cross-sectional screenshot from Visual MODFLOW for Model 2.

Table 2 summarises the modelled groundwater level drawdown results.

Table 2: Extent of Groundwater Level Drawdown for Malaga Dive Structure

Model No.	Maximum GWL		Extent of Groundwater Level (m)					
	Recharge	Drawdown Outside D-wall (m)	1 m contour	0.5 m contour	0.25 m contour	0.1 m contour		
1	No	4	600	1250	1600	>1750		
2	Yes	2	50	100	200	350		

Table 3 summarises the maximum modelled groundwater level drawdown at different features that could be affected by groundwater level drawdown and indicates:

- Without groundwater level management (Model 1), a groundwater level drawdown of up to 3 m could occur in high-risk ASS areas, under households where shallow reticulation bores could be present (bores could run dry) and at Banksia Woodlands. The groundwater level drawdown would also extend to a Water Corporation bore, two conservation wetlands and other 5C groundwater license users.
- With groundwater level management (Model 2), the groundwater level drawdown could be reduced to less than 0.25 m for all potential impact areas.

Table 3: Maximum Modelled Groundwater Level Drawdown (m)

Impact Areas	Model 1	Model 2
High Risk ASS	3.0	0.25
Banksia Woodland (very good and excellent conditions)	3.0	0.25
Conservation Wetlands	0.6 (UFI 8429) 0.8 (UFI 8418)	0
Water Corporation Bore	0.7 (M40)	0
Households with potential shallow reticulation bore	3.0	0.25
5C Licenses	1.0	0
Contaminated Sites	0	0

The recharge well configurations in Model 2 could be further optimised during the dewatering system design to further reduce the groundwater level drawdown in certain areas. Nevertheless, the purpose of this



groundwater modelling is to conceptually assess if the extent of the groundwater level drawdown can be managed through recharge and engineering means. The Model 2 results indicate that this should be possible with a proper dewatering system design and implementation.

#### 3.3.4.2 Dewatering Rates

The total dewatering rate/volume for the dive would be highly dependent on the construction methodology, construction schedule/sequencing, aquifer conditions (including Kh/Kv ratio), the retaining wall depths and dewatering discharge disposal options. This would all need to be confirmed and investigated during the dewatering system design.

The preliminary groundwater modelling indicates that to lower the groundwater level to the target dewatering level (Model 1), the average dewatering rate could be around 50 L/s with initial dewatering rates of around 100 L/s. However, if the dewatering discharge is recharged back into the aquifer to control the groundwater level drawdown extent (Model 2), then the dewatering rates could almost triple to an average dewatering rate of around 150 L/s with initial rates of around 200 L/s. The reason for this large increase in the dewatering rates is the "recycling" effect of water back into the excavation from the recharge wells. The closer the recharge wells are to the excavation the greater the "recycling" effect and thereby dewatering rates. This would have to be weighed against the allowed extent of groundwater level drawdown as the further away the recharge wells are placed, the lower the dewatering rates, but the greater the groundwater level cone of depression.

#### 3.3.4.3 Mounding Due to Installation of D-walls

The installation of the D-walls to facilitate excavation and construction of the dive structure would create a permanent groundwater flow barrier in the Superficial Aquifer where the walls are aligned obliquely or perpendicular to the groundwater flow direction. This would result in some groundwater mounding against the up-gradient side of the D-walls and some groundwater level drawdown on the down-gradient side of the D-walls. The preliminary groundwater modelling indicates that the groundwater level mounding/drawdown could be less than 0.1 m. The main reason for the limited mounding/drawdown is that the D-walls does not extend to the base of the Superficial Aquifer and does not toe into a low permeability layer, which allows for groundwater to also flow underneath the D-walls. The extent and depth of D-walls, sub-soil profile and aquifer conditions will determine the groundwater mounding/drawdown, which will need to further be investigated during detailed design.

#### 3.4 Recommendations

Based on the preliminary dewatering assessment and groundwater model we provide the following hydrogeological recommendations:

- Drilling of additional boreholes to the base of the Superficial Aquifer to assess the geology at the site and particularly the presence/extent of the fines dominated Guildford Formation.
- Given the potentially high dewatering rates, it is recommended that a pumping test is carried out to obtain a better understanding of the aquifer properties (transmissivity and storage properties) at the dive.
- Install additional monitoring wells at the Malaga Dive Structure to obtain a better understanding of the groundwater levels (minimum and maximum) across the dive site area and potential recharge wells area.

#### 4.0 GNANGARA AND DRUMPELLIER INTERSECTION

The following information was used for the preliminary dewatering assessment and the development of the basic groundwater model:

MEL-MNO-ARUP-ST-DRG-4141 to 4143 RevB for the invert levels of the footings (refer to Appendix A).



MEL-MNO-GOL-EN-REF-0005.0.REF to obtain the possible shape of the Lexia Liquid Waste contamination plume.

The geotechnical investigation undertaken by Arup (Arup 2019b) and groundwater study by Golder (Golder 2020) together with our experience in the areas were utilised to develop the hydrogeological setting at the site.

The purpose of the dewatering assessment is to assess the potential extent of groundwater level drawdown from the dewatering of the footings. The information will be used in the Environmental Review Document as part of the environmental approval process. The results should not be used for design purposes.

#### 4.1 Site Description

Based on the provided information we understand that the rail will go under Drumpellier Drive and Gnanagara Road in a tunnel. Based on the presented concept design with the nominal groundwater level, dewatering of the rail tunnel itself should not be required. However, the deflection wall footings at either end of the rail tunnel would extend into the groundwater table. The dewatering assessment has been based on this concept.

Some of the key hydrogeological conditions used to develop the basic groundwater model are:

- The geology at the site consists of Bassendean and Gnangara Sands extending from around RL 42 m AHD to RL -5 m AHD.
- The hydraulic conductivity of the Bassendean Sand has been assumed to be 15 m/d. This is based on literature and our experience of transmissivity in the area.
- The maximum groundwater level is based on the provided nominal groundwater level of RL 38.4 m AHD provided by Arup on the concept design. Based on our experience in the area, we believe that the current seasonal maximum groundwater level could be higher (perhaps around RL 39.0 m AHD to RL 39.5 m AHD), which would need to be confirmed. If higher, it has been assumed that the rail tunnel level would be raised accordingly, and the concept design would therefore remain the same.
- The groundwater flow direction is from northwest toward southeast.
- The seasonal groundwater level fluctuation is around 1 m.
- A groundwater contamination plume originating from the former Lexia Liquid Waste Disposal Facility (located approximately 1 km northwest of the intersection) is known to be present in the area. Figure 4 shows the shape of the plume as delineated in 2016 by Golder (Golder 2016) and indicates that the delineated plume could be approximately 250 m west of the intersection. It should be noted that the spatial and vertical extent of the plume should be considered indicative only.

#### 4.2 Dewatering Requirements

Dewatering will be required wherever the groundwater level is higher than the base of the excavation level. Furthermore, it is often necessary to draw the groundwater level down to about 1 m below the excavation level to allow for compaction of soils or removal and replacement of unsuitable founding material.

Based on the provided drawings the invert level of the base of the deflection wall footings has been estimated to be RL 38 m AHD, which would result in a dewatering level for the footings of RL 37 m AHD. The required groundwater level drawdown would then be around 1.4 m and 0.4 m during the wet and dry seasons, respectively.

#### 4.3 Groundwater Model

#### 4.3.1 Model Setup

Figure 4 shows the extent of the groundwater model, which is 2,500 m long (northwest to southeast) and 2,000 m wide (southwest to northeast), which was chosen to minimise the model boundary effect on the modelled groundwater level drawdown. The grid sizing with the model ranges from 10 m by 10 m (mainly at the model peripheral boundaries) to 2 m by 2 m around the intersection where dewatering is required, resulting in a total of 422 rows and 387 columns. The model has 3 layers.

#### 4.3.2 Model Scenarios

We have undertaken the following two model runs:

- Model 1: Footing dewatering without recharge/infiltration
- **Model 2:** Footing dewatering with recharge/infiltration the abstracted groundwater has been modelled to be infiltrated back into the aquifer between the dewatering area and the delineated plume

#### 4.3.3 Model Assumptions

Some key assumptions used for the groundwater modelling are:

- Dewatering of the footings will be required for 1 month.
- The four footings will be dewatered at the same time, which is a conservative assumption, because if instead the footings are dewatered separately, this may reduce the interference groundwater level drawdown and thereby the extent of the total groundwater level drawdown.
- The footings will be dewatered using open excavation.
- The K<sub>h</sub>/K<sub>v</sub> ratio is 1:1, which is a conservative assumption.
- For Model 2 the abstracted water is infiltrated back into the aquifer through an infiltration located west of the site (refer to Figure 6 for modelled trench). The modelled infiltration trench is conceptual only, and the length and location would need to be designed during the preparation of the site-specific Dewatering Management Plan.

#### 4.3.4 Groundwater Model Results

#### 4.3.4.1 Extent of Groundwater Level Drawdown from Dewatering

Figure 4 show the current steady-state groundwater model flow direction at the Gnangara/Drumpellier site together with the provided delineated contamination plume from the Lexia Facility. Figures 5 and 6 shows the modelled groundwater level drawdown after 1 month of construction dewatering for Model 1 and Model 2, respectively.

Table 2 summarises the modelled groundwater level drawdown results.

Table 4: Extent of Groundwater Level Drawdown for the Gnangara/Drumpellier Site

Model		E	xtent of Groun	dwater Level (n	1)
Model No.	Recharge	1 m contour	0.5 m contour	0.25 m contour	0.1 m contour
1	No	20	50	200	350
2	Yes	10	30	100	250



The groundwater model results indicate:

At current (steady-state) conditions (i.e. prior to dewatering) the depicted groundwater plume from the Lexia Facility is located to the west of the site and would not reach the footing locations (Figure 4). Particle modelling indicates that a particle at the edge of the plume would flow approximately 9 m in one month.

- Dewatering without groundwater level management through recharge/infiltration will result in the extent of the groundwater level drawdown reaching the depicted plume (around 0.2 m groundwater level drawdown at the depicted eastern edge of the plume) (Figure 5). The groundwater flow direction would slightly change, but a particle from the depicted plume would not reach the dewatering area (the particle would travel 10 m in one month, which is a 10% increase from current conditions).
- Dewatering with groundwater level management through recharge/infiltration could result in the extent of the groundwater level drawdown not reaching the depicted plume, which would result in no change in groundwater flow direction (the particle would travel 9 m in one month, which is similar to current conditions) (Figure 6).
- A Banksia Woodland (classified as in very good condition in the RPS vegetation study RPS (2019)) exists west of the dewatering area. For Model 1 the 0.25 m groundwater level drawdown would extend to the woodland (Figure 5) while for Model 2 the groundwater level drawdown would not extend to the woodland (Figure 6).
- The groundwater level drawdown will not extend to high-risk ASS areas, wetlands or Water Corporation bores.

The infiltration trench configuration would need to be further optimised. Nevertheless, the groundwater modelling indicates that the impact on groundwater level and flow direction at the depicted plume can be minimised through groundwater level management.

#### 4.3.4.2 Dewatering Rates

The total dewatering rate/volume for the site would be highly dependent on the construction methodology, construction schedule/sequencing, aquifer conditions (including K<sub>h</sub>/K<sub>v</sub> ratio) and dewatering discharge disposal options. This would all need to be confirmed and investigated during the dewatering system design.

The preliminary groundwater modelling indicates that for Model 1 the average dewatering rate could be around 20 L/s if the footings are dewatered simultaneously with initial dewatering rates of around 30 L/s to lower the groundwater level to the target dewatering level. However, if the dewatering discharge is recharged back into the aquifer to control the groundwater level drawdown extent (Model 2), then the average dewatering rate could increase to around 25 L/s with initial rates of around 35 L/s (based on the modelled location of the infiltration trench. The increase would depend on the location of the infiltration area). The reason for this increase in the dewatering rates is the "recycling" effect of water back into the excavation from the infiltration. The closer the infiltration trench is to the excavation the greater the "recycling" effect and thereby dewatering rates.

#### 4.4 Recommendations

Based on the preliminary dewatering assessment and groundwater model we provide the following hydrogeological recommendations:

Installation of monitoring wells to allow for measurement of groundwater levels to obtain a better understanding of seasonal maximum and minimum groundwater levels.



#### 5.0 BENNETT BROOK CROSSING

The following information was used for the preliminary dewatering assessment and the development of the basic groundwater model (refer to Appendix A for drawings):

MEL-MNO-ARUP-ST-DRG-3201 to 3202 RevB for the invert levels of the footings.

The geotechnical investigation undertaken by Arup (Arup 2019c) and groundwater study by Golder (Golder 2020) together with our experience from the NorthLink project were utilised to develop the hydrogeological setting at the site.

#### 5.1 Site Description

Based on the provided information we understand that it is proposed to construction a 28 m long bridge (from abutment to abutment) over Bennett Brook. Piles will be installed on either side of Bennett Brook with abutment pile caps. The abutments will be 12.9 m long and 1.5 m wide. The invert level of the base of the pile cap has not been provided but has been estimated to be around RL 13 m AHD based on the provided drawings.

Some of the key hydrogeological conditions for this dewatering assessment are:

- BH015, drilled by Arup, which was drilled 60 m west of Bennett Brook indicates that Bassendean Sand is present to around RL 12 m AHD, overlying Guildford Clayey Sand to RL 10 m AHD, overlying Guilford Clay to end of the borehole at RL 6 m AHD.
- BH016, drilled by Arup, which was drilled 675 m east of Bennett Brook indicates that the Bassendean Sand extends to RL 9 m AHD (end of the borehole).
- The hydraulic conductivity of the Bassendean Sand has been assumed to be 15 m/d, the Guildford Sand to be 5 m/d and the Guilford Clay to be 0.1 m/d. This is based on literature and our experience in the area
- Based on information from the NorthLink 2 and Department of Water and Environmental Regulation (DWER) wells in the area, we would expect that the wet season groundwater level could be around RL 15 m AHD (the invert level of Bennett Brook is about RL 14.5 m AHD at the bridge crossing). However, BH015 is reported by Coffey (Coffey 2019) to have a 2019 wet season groundwater level of only about RL 12.7 m AHD, which is lower than anticipated. This would suggest that the wet season groundwater level could possibly be between RL 13 m AHD and RL 15 m AHD.
- The closest DWER groundwater monitoring wells indicate that the seasonal groundwater level variation is around 1 m, which indicates that the seasonal low groundwater level could be around RL 12 m AHD and RL 14 m AHD.
- Bennett Brook is an ephemeral river, meaning that it does not flow all year round. If it flows during the wet season and is supported by groundwater, we expect that the wet season groundwater level would be at the higher range.
- The local groundwater flow direction in the area is toward Bennett Brook.

No nominal groundwater level was provided on the concept design drawings. For this preliminary dewatering assessment, we have utilised the highest expected wet season groundwater level of RL 15 m AHD (conservative assumption). The groundwater level would need to be confirmed through groundwater level monitoring during the upcoming wet season.



#### 5.2 Dewatering Requirements

Dewatering will be required wherever the groundwater level is higher than the base of the excavation level. Furthermore, it is often necessary to draw the groundwater level down to about 1 m below the excavation level to allow for compaction of soils or removal and replacement of unsuitable founding material.

Based on the estimated abutment invert level of RL 13 m AHD the required dewatering level RL 12 m AHD. The required groundwater level drawdown would then be around 3 m and 2 m during the wet and dry seasons, respectively. During the dry season Bennett Brook would be dry, which could significantly reduce the dewatering rates.

It is noted that if the seasonal maximum groundwater level is only RL 13 m AHD (as suggested by the 2019 groundwater level in BH015), then the required groundwater level drawdown during the wet season is only 1 m, while dewatering may not be required during the dry season.

#### 5.3 Groundwater Model

#### 5.3.1 Model Setup

For the Bennett Brook dewatering assessment, the Malaga Dive model was extended to include the area around Bennett Brook and the observed Guildford Clay layer incorporated into the model as observed in BH015. The model grid was refined by 2 m by 2 m grids in the dewatering area and Bennett Brook was modelled by the river function in MODFLOW.

#### 5.3.2 Model Assumptions

Some key assumptions used for the groundwater modelling are:

- Dewatering will be required for 1 month.
- We have modelled the scenario of the groundwater level of RL 15 m AHD, which would require 3 m of drawdown at the footings.
- The abutments will be dewatered at the same time (conservative assumption).
- The abutments will be dewatered using open excavation.
- The  $K_h/K_v$  ratio is 1:1 (conservative assumption).

#### 5.3.3 Model Scenarios

One model run was undertaken that without recharge/infiltration of the dewatering discharge (worse case scenario).

#### 5.3.4 Groundwater Model Results

#### 5.3.4.1 Extent of Groundwater Level Drawdown from Dewatering

Figure 7 shows the extent of the groundwater level drawdown after 1 month of dewatering together with environmental areas that needs to be considered during dewatering (e.g. Bennett Brook wetland area, conservation wetlands and high-risk acid sulfate soils (ASS) areas).

The groundwater model results indicate that the footings will be located within high-risk ASS areas and within the Bennett Brook wetland area. The Banksia woodland in this area is reported by RPS in their vegetation study (RPS 2019) to be degraded or completely degraded. The groundwater level drawdown will not extend to lots with 5C licenses or Water Corporation bores.

Table 2 summarises the modelled groundwater level drawdown results.



Model		Extent of Groundwater Level (m)					
Model No.	Recharge	1 m contour	0.5 m contour	0.25 m contour	0.1 m contour		
1	No	20	40	75	125		

Table 5: Extent of Groundwater Level Drawdown for the Bennet Brook Crossing

The 0.1 m groundwater level drawdown will extend to the UFI wetland 8728 located northwest of the site. However, it should be noted that since we are modelling the wet season the groundwater level drawdown will be well within normal seasonal variation.

Since the footings will be located within a high-risk ASS area and the Bennett Brook wetland area, the site will be within a high management area. Some management options could be:

- Each footing is dewatered separately.
- The dewatering could be scheduled to be undertaken during the dry season, which would reduce the dewatering requirements.
- Retaining walls could be installed around the footings.
- Infiltration trenches could be installed between UFI 8728 and the dewatering area to reduce groundwater level drawdown toward the wetland and in this ASS area.

#### 5.3.4.2 Dewatering Rates

The total dewatering rate/volume for the site would be highly dependent on the construction methodology, construction schedule/sequencing, aquifer conditions, dewatering discharge disposal options and particularly the aquifer connectivity to Bennett Brook. This would all need to be confirmed and investigated during the preparation of the site-specific Dewatering Management Plan.

The preliminary groundwater modelling indicates that the average dewatering rate if undertaken during the wet season could be around 10 L/s if both abutments are dewatered at the same time with initial dewatering rates of around 20 L/s to lower the groundwater level to the target dewatering level. The dewatering rate would be reduced if the dewatering would be undertaken during the dry season, because of Bennett Brook being dry and less groundwater level drawdown requirement.

#### 5.4 Recommendations

Based on the preliminary dewatering assessment and groundwater model we provide the following hydrogeological recommendations:

- Since there is currently some uncertainty around the groundwater levels near Bennett Brook, we would recommend that groundwater level measurements in BH015 be checked, the wells re-surveyed and a logger be installed in the well. This would allow for a better understanding of the groundwater level elevation, the seasonal groundwater level fluctuations in this area and connectivity with Bennett Brook (i.e. how Bennett Brook is affecting the groundwater levels).
- Possibly install an additional monitoring well to BH015 near Bennett Brook (on the eastern side of Bennett Brook).



#### 6.0 CONCLUSIONS AND RECOMMENDATIONS

The preliminary dewatering assessment at the three dewatering areas indicates:

■ For the Malaga Dive Structure the groundwater modelling indicates that the extend of the groundwater level drawdown from the dewatering of the dive can be minimised through installation of recharge wells and engineering means (installation of retaining walls).

- For the Gnangara/Drumpellier site the groundwater modelling indicates that the impact on groundwater level and flow direction at the depicted plume and nearby Banksia Woodland can be minimised through groundwater level management (construction of an infiltration trench between the dewatering sites and the areas of concern).
- At Bennett Brook Crossing, dewatering will be undertaken within a high-risk ASS area and Bennett Brook wetland area. The groundwater modelling indicates that the 0.1 m groundwater level drawdown will only extend approximately 125 m from the dewatering area. This groundwater level drawdown could be further reduced through infiltration in targeted areas (if required) and by undertaking the dewatering during the dry season.

We recommend that the following be considered:

#### Malaga Dive Structure:

- Drilling of additional boreholes to the base of the Superficial Aquifer to assess the geology at the site and particularly the presence/extent of the fines dominated Guildford Formation.
- Given the potentially high dewatering rates, carry out a hydrogeological pumping test to obtain a better understanding of the aquifer properties (transmissivity and storage properties) at the dive.
- Install additional monitoring wells at the Malaga Dive structure to obtain a better understanding of the groundwater levels (minimum and maximum) across the dive site area and potential recharge wells area.
- Use of retaining walls and recharge wells to minimise the extend of the groundwater level drawdown.

#### Gnangara/Drumpellier Site:

- Installation of monitoring wells to allow for measurement of groundwater levels to obtain a better understanding of seasonal maximum and minimum groundwater levels.
- Installation of an infiltration trench between the dewatering site and the contaminated plume and Banksia Woodland located to the west to control the groundwater level and flow in this area.

#### Bennett Brook Crossing:

- Since there is currently some uncertainty around the groundwater levels near Bennett Brook, we would recommend that groundwater level measurements in BH015 be checked, the well resurveyed and a logger be installed in the well. This would allow for a better understanding of the groundwater level elevation, the seasonal groundwater level fluctuations in this area and connectivity with Bennett Brook (i.e. how Bennett Brook is affecting the groundwater levels).
- Install an additional monitoring well to BH015 near Bennett Brook (on the eastern side of Bennett Brook).
- If possible, undertake the dewatering during the dry season. Infiltration trenches/basins to control the groundwater level in targeted areas could also be adapted, if required.



#### 7.0 REFERENCES

#### **Reference Details**

Arup (2019a). Metronet. Morley – Ellenbrook Line PDP Enabling Works. Morley East to Tonkin Highway Geotechnical Factual Report, Rev A. MEL-MNO-ARUP-GE-RPT-2001\_A DRAFT, 31 July 2019

Arup (2019b). Metronet – Morley – Ellenbrook Line PDP Enabling Works. Ellenbrook – Geotechnical Factual Report, Rev A. MEL-MNO-ARUP-GE-RPT-5001\_A DRAFT, 31 July 2019

Arup (2019c). Metronet – Morley – Ellenbrook Line PDP Enabling Works. Malaga to Whiteman Park – Geotechnical Factual Report, Rev A. MEL-MNO-ARUP-GE-RPT-3001\_A DRAFT, 31 July 2019

Coffey (2019). Draft: Metronet – Morley to Ellenbrook Line, Baseline Hydrology 2018-2019 Annual Report, MEL-MNO-COFF-EN-RPT-0008A.IFR, September 2019

Golder (2016), Lexia Liquid Waste Disposal Facility, Groundwater Monitoring Event, 1649439-003-R-Rev0, June 2016

Golder (2020a). Metronet – Morley to Ellenbrook Line (MEL) Malaga to Ellenbrook Rail Works – Strategic Level Hydrogeological Assessment. 19132627-010-R-Rev0, 29 May 2020

RPS (2020) - Level 2 Flora and Vegetation Surveys

#### 8.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – "Important Information Relating to this Report", which is included in Appendix B of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contact between it and its client.



# Signature Page

**Golder Associates Pty Ltd** 

Allan Lundorf

Principal Groundwater Engineer

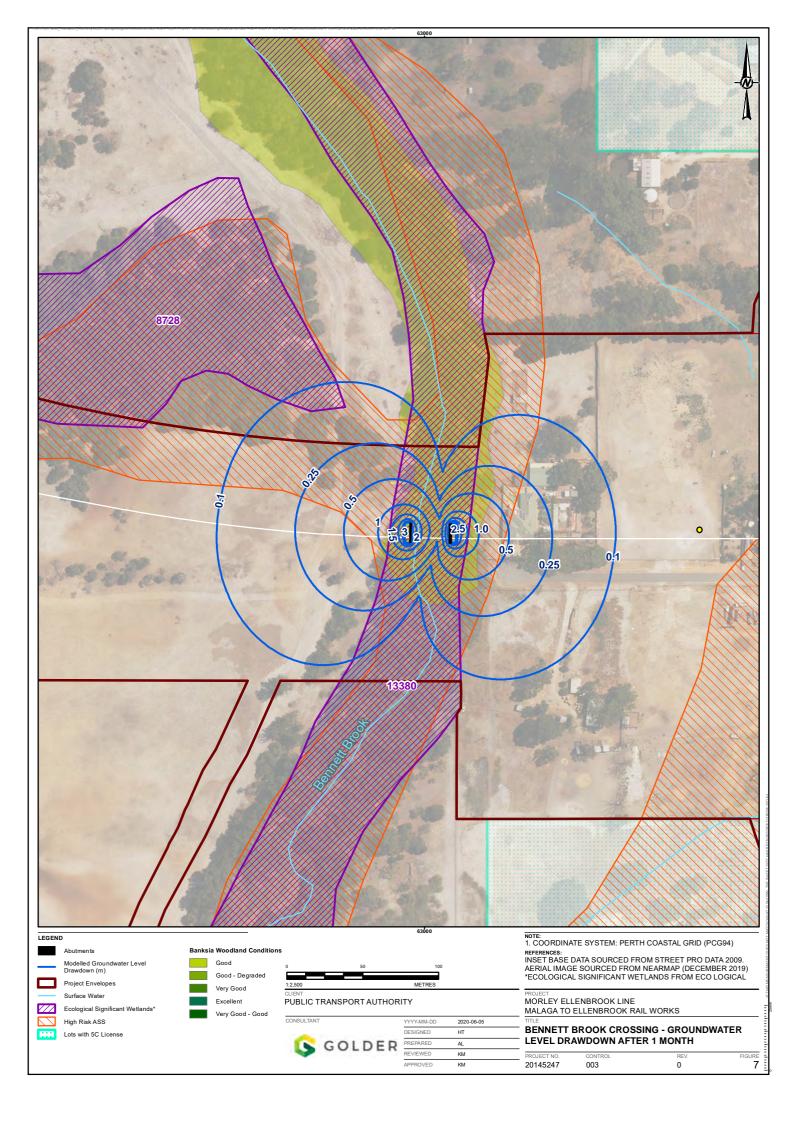
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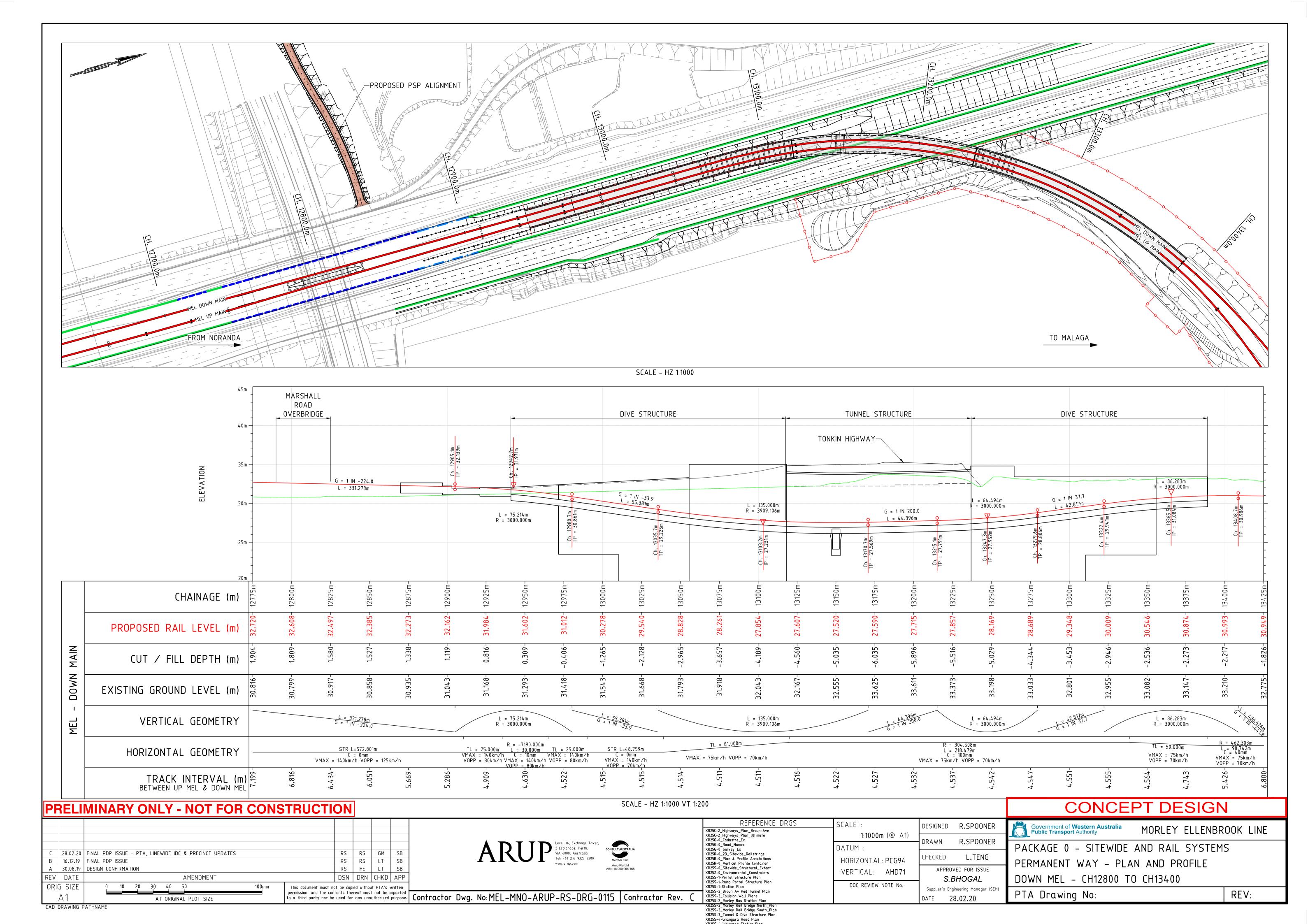
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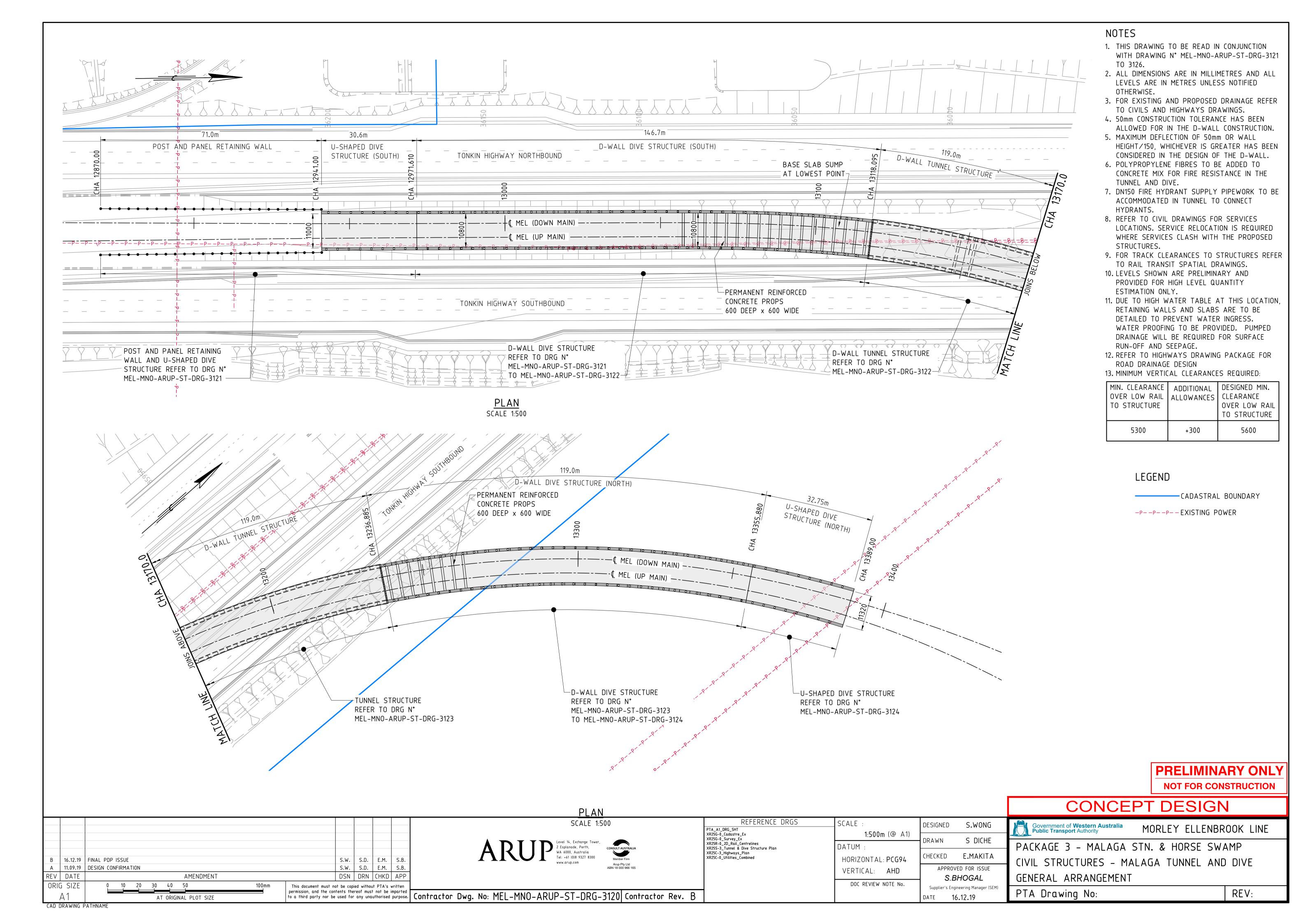


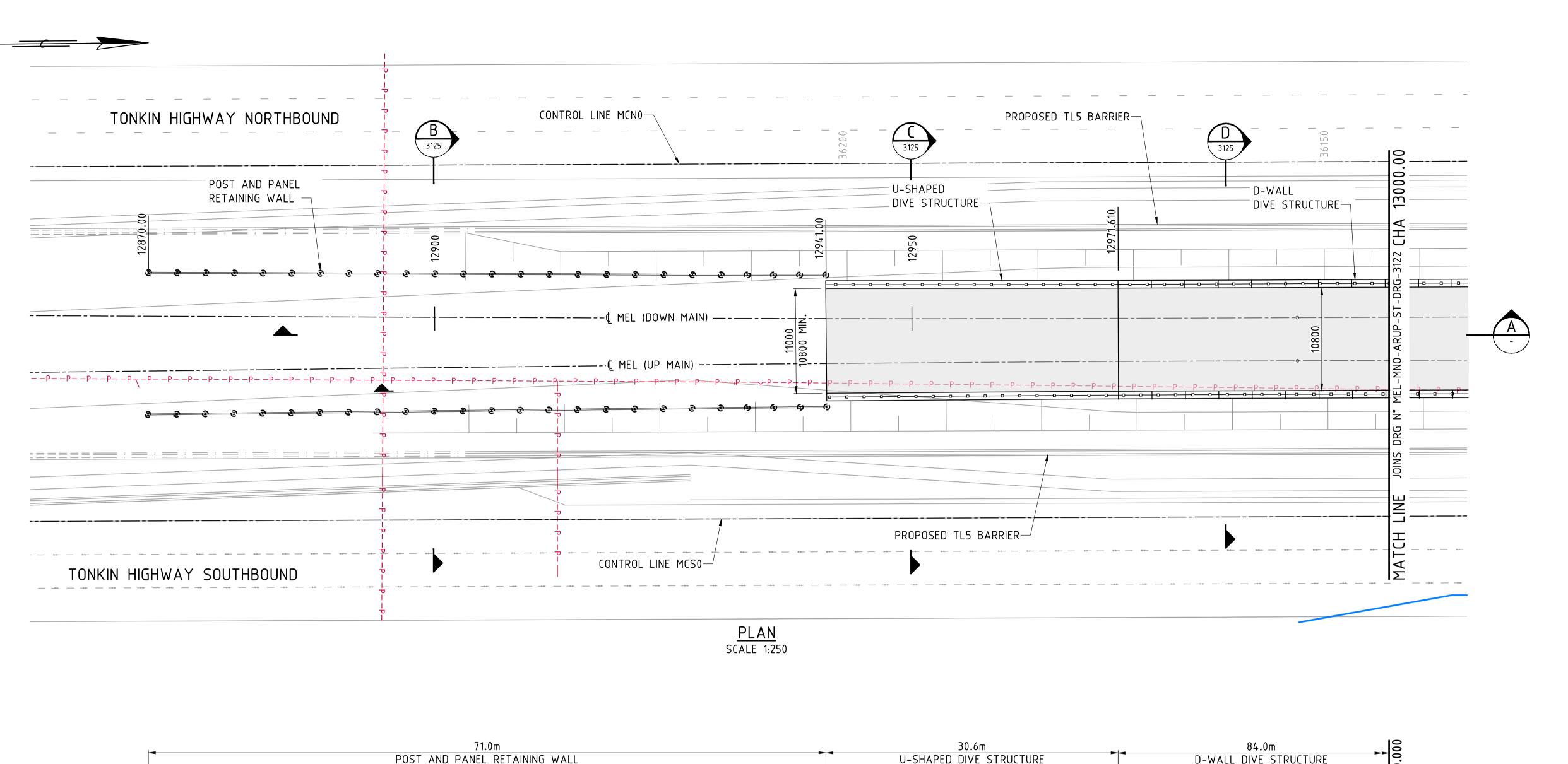


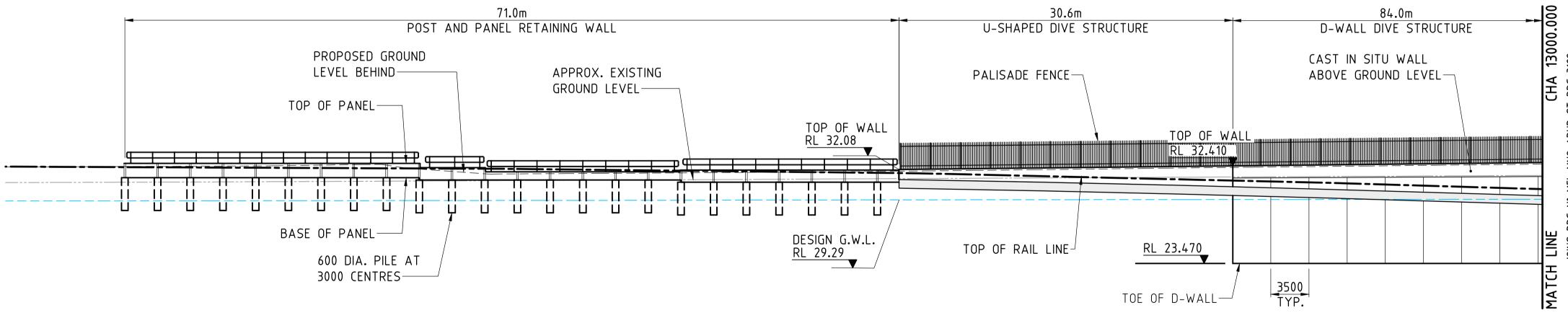
#### **APPENDIX A**

# Provided Concept Design Drawings









SECTION SCALE 1:250

# PRELIMINARY ONLY **NOT FOR CONSTRUCTION**

MORLEY ELLENBROOK LINE

# **CONCEPT DESIGN**

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Tel: +61 (0)8 9327 8300 Member Firm www.arup.com Arup Pty Ltd	XR25G-0_Survey_Ex XR25R-0_2D_Rail_Centrelines XR25S-3_Tunnel & Dive Structure Plan XR25S-3_Structures Sections XR25C-0_Utilities_Combined XR25C-0_Sitewide_Highways_Control	DATUM : HORIZONTAL: PCG94	DRAWN CHECKED	S.DICHE E.MAKITA	PACKAGE 3 - MALAGA STN. & HORSE SWAMP  CIVIL STRUCTURES - MALAGA TUNNEL AND DIVE
ABN 18 000 966 165	XR25C-3_Highways_Plan	VERTICAL: AHD		/ED FOR ISSUE	

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16.12.19

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16.12.19 FINAL PDP ISSUE

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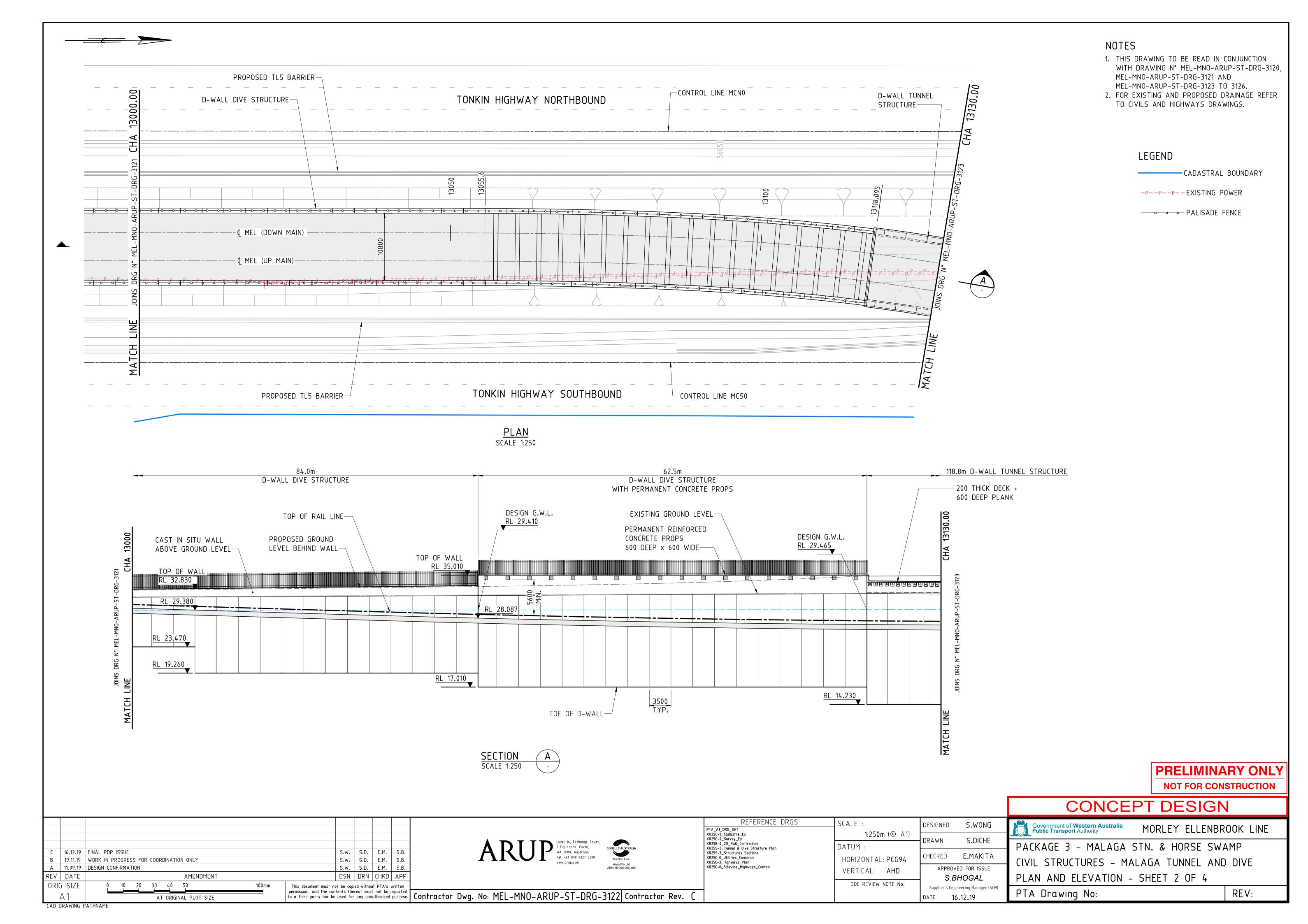
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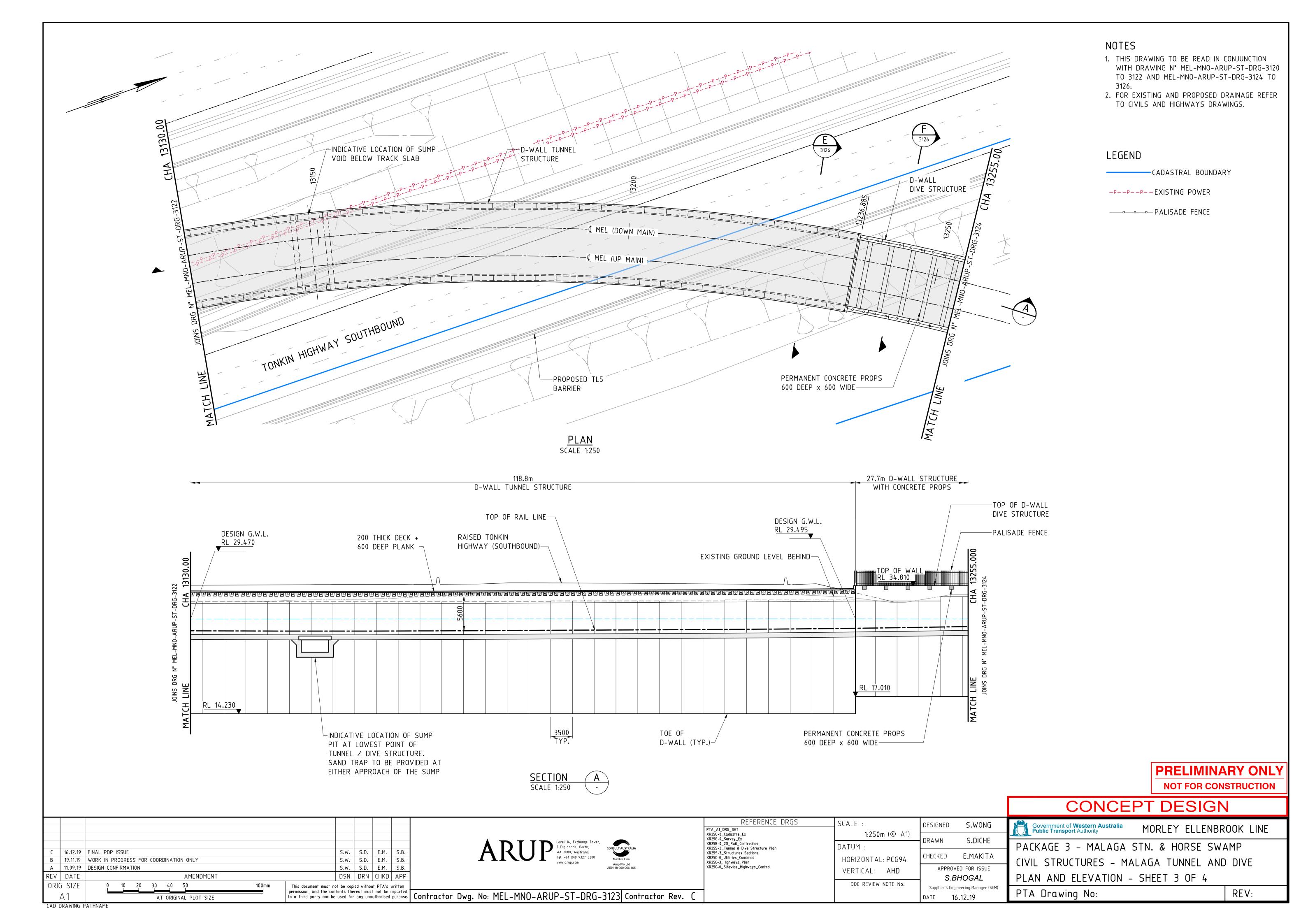
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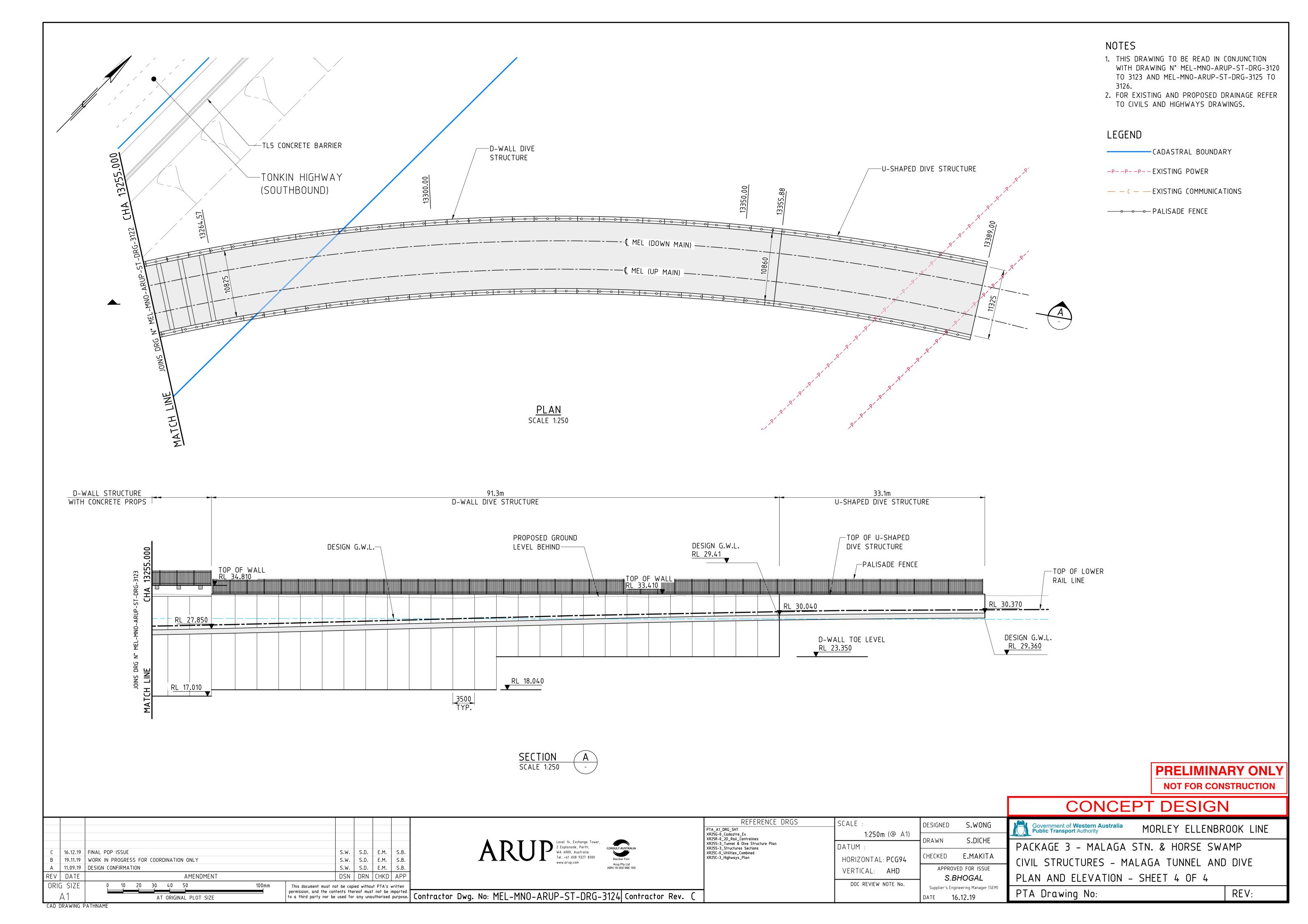
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TONKIN HIGHWAY

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CROSS SECTIONS - SHEET 1 OF 2

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APPROVED FOR ISSUE

S.BHOGAL

Supplier's Engineering Manager (SEM)

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(SOUTHBOUND)

(SOUTHBOUND)

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—PALISADE FENCE

PALISADE FENCE

—CAST IN SITU WALL

ABOVE GROUND LEVEL

-DIAPHRAGM WALLS (TYP.)

-TONKIN HIGHWAY

(SOUTHBOUND)

PROPOSED TL5 BARRIER—

DESIGN G.W.L.

RL 29.235

600mm

DESIGN G.W.L.

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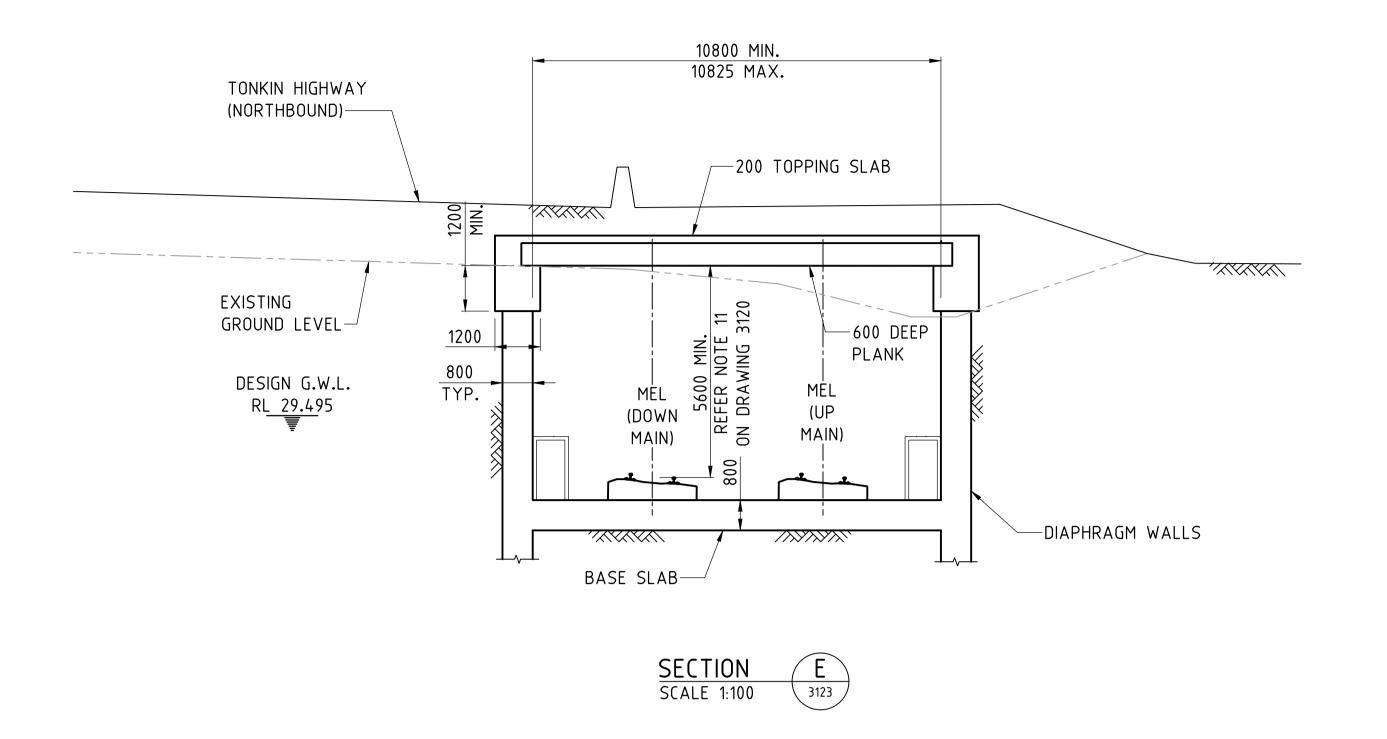
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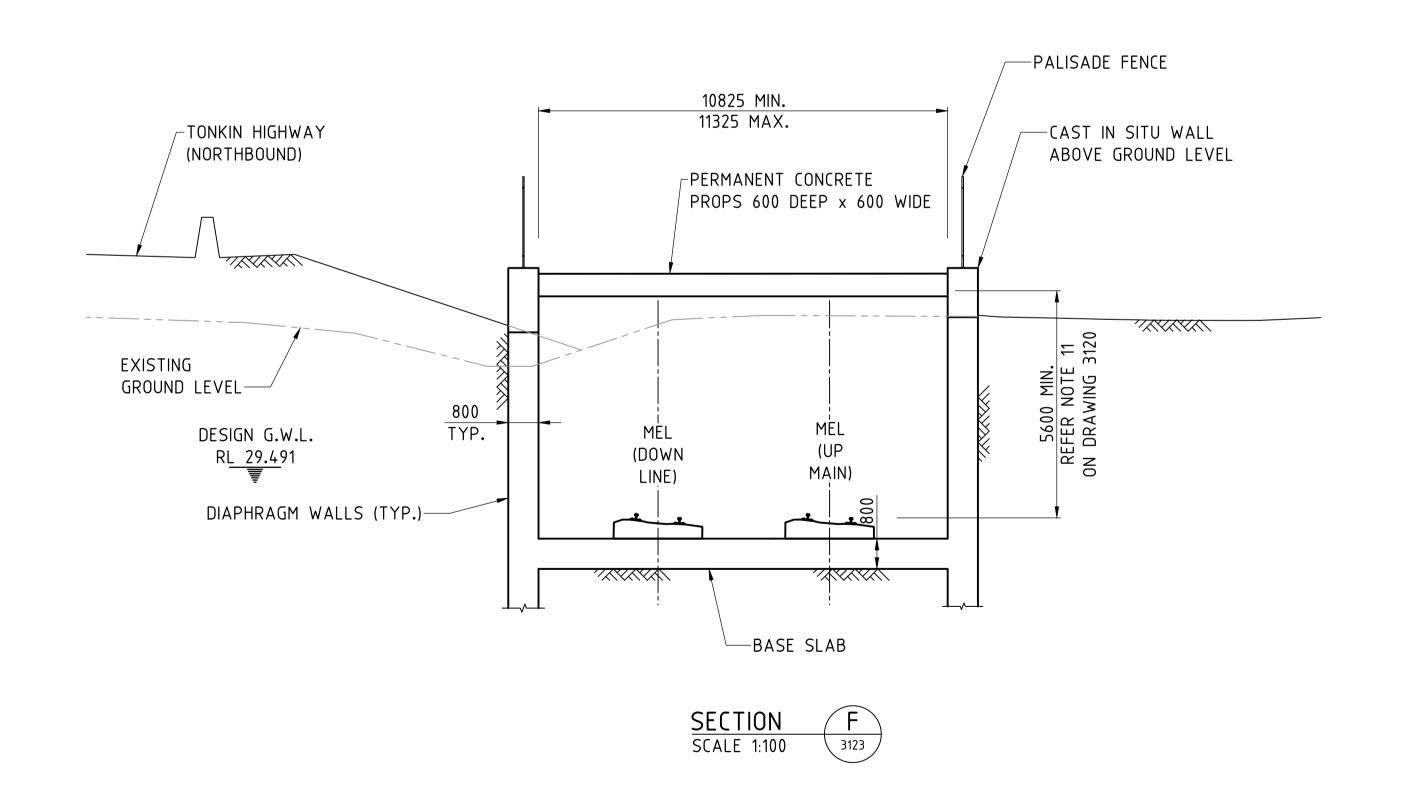
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MORLEY ELLENBROOK LINE

REV:

PACKAGE 3 - MALAGA STN. & HORSE SWAMP
CIVIL STRUCTURES - MALAGA TUNNEL AND DIVE
CROSS SECTIONS - SHEET 2 OF 2

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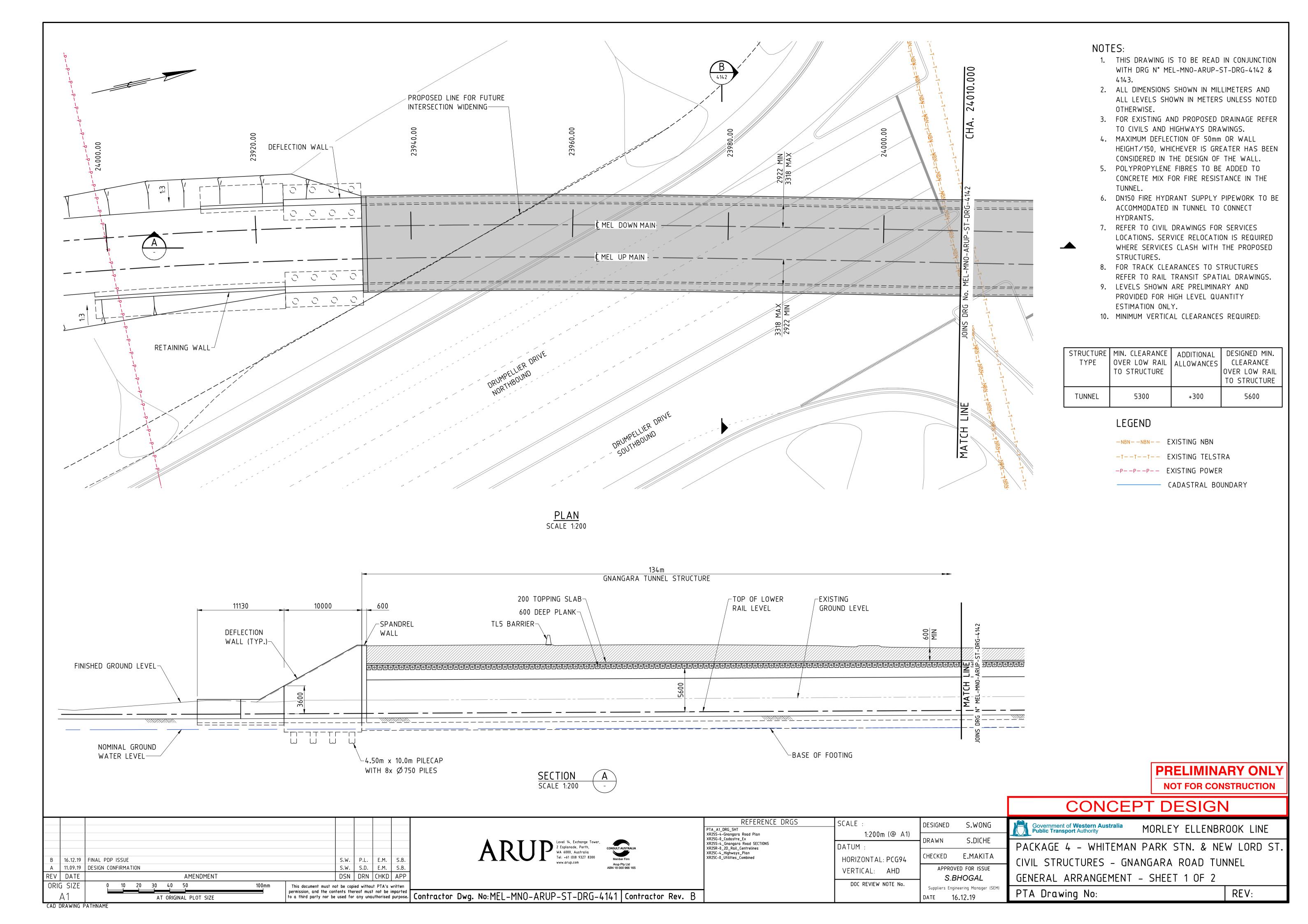
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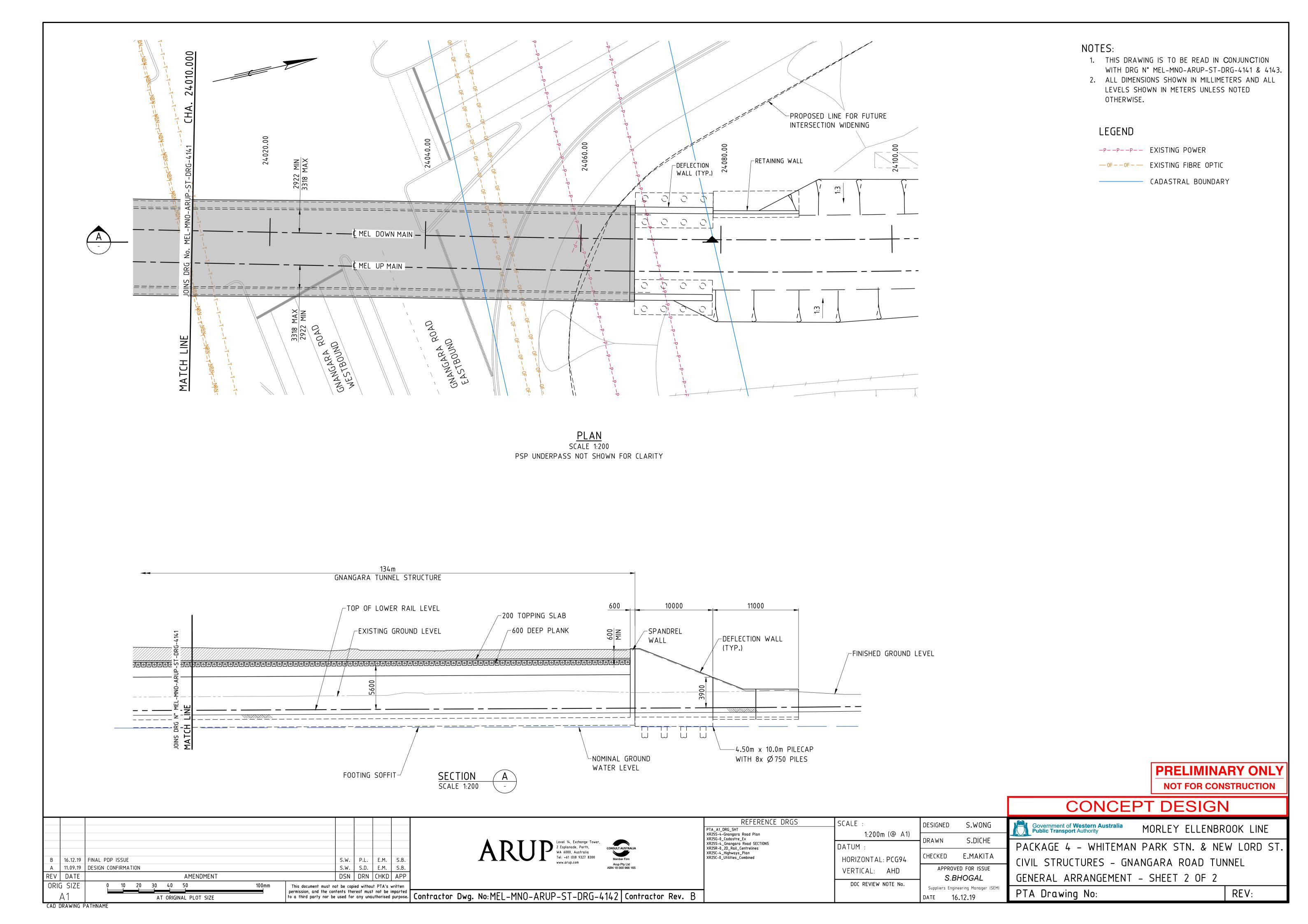
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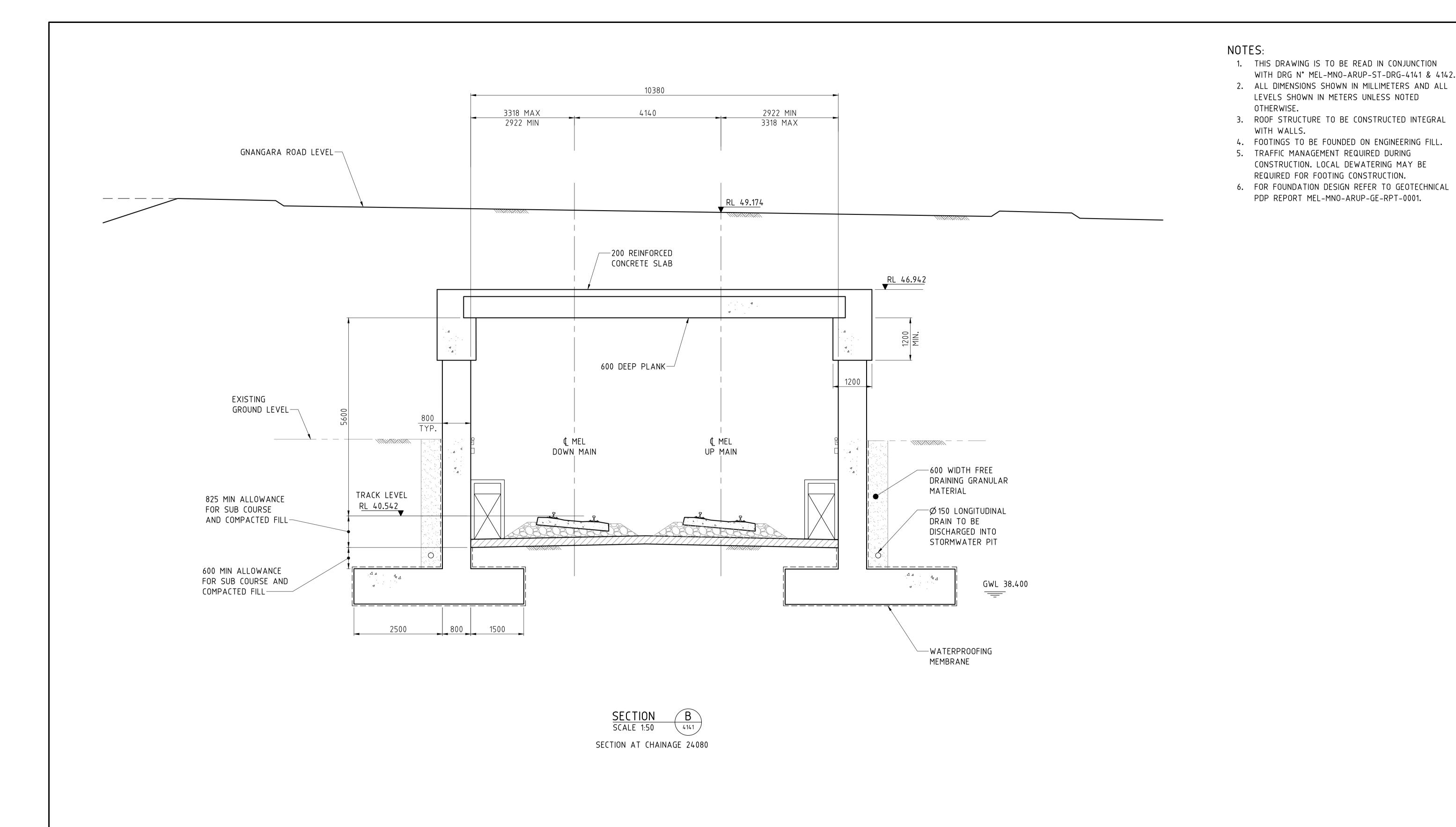
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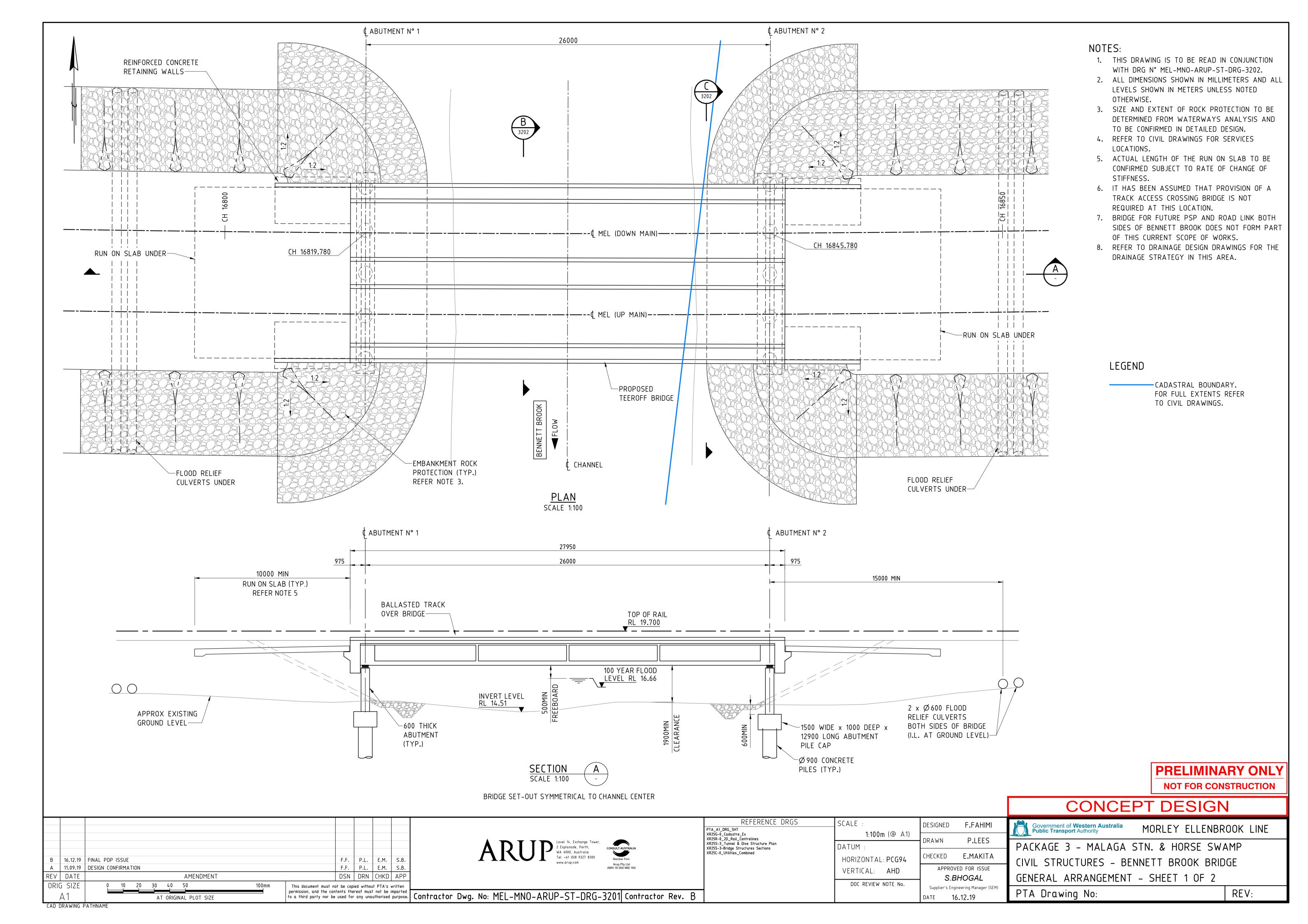
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Government of Western Australia
Public Transport Authority MORLEY ELLENBROOK LINE

PACKAGE 4 – WHITEMAN PARK STN. & NEW LORD ST CIVIL STRUCTURES - GNANGARA ROAD TUNNEL SECTIONS

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**APPENDIX B** 

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