APPENDIX B

Simplified Ground Profiles for TBM and Mined Tunnel Sections

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		4	
Chainage	CH	95+500	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		18.80	m
Top of Rail Level	RL	-13.61	m AHD
Tunnel Centre Level	RL	-11.50	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		22.10	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	7.00	m AHD
Approximate GW Level	RL	-2.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
7.0	2.5	4.5	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
2.5	-1.5	4.0	Tov (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
-1.5	-8.0	6.5	Tvo (RS - EW) - RS	20	13	28					55			0.3		0.60	
-8.0	-17.0	9.0	Tvo (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
-17.0	-25.0	8.0	Tew	20	1	33					95			0.3		0.60	
-25.0	-27.0	2.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-27.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		5	
Chainage	CH	95+660	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		35.61	m
Top of Rail Level	RL	-17.45	m AHD
Tunnel Centre Level	RL	-15.34	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		25.14	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	6.20	m AHD
Approximate GW Level	RL	-3.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
6.2	1.8	4.4	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
1.8	-3.0	4.8	Tov (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
-3.0	-9.0	6.0	Tvo (RS - EW) - RS	20	13	28					55			0.3		0.60	
-9.0	-21.5	12.5	Tew	20	1	33					95			0.3		0.60	
-21.5	-26.0	4.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-26.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		5	
Chainage	CH	95+730	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		42.67	m
Top of Rail Level	RL	-17.69	m AHD
Tunnel Centre Level	RL	-15.58	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		25.18	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	6.00	m AHD
Approximate GW Level	RL	-3.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
6.0	2.0	4.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
2.0	-2.5	4.5	Tov (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
-2.5	-18.5	16.0	Tew	20	1	33					95			0.3		0.60	
-18.5	-28.0	9.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-28.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		5	
Chainage	CH	95+760	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		44.69	m
Top of Rail Level	RL	-17.69	m AHD
Tunnel Centre Level	RL	-15.58	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		26.18	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	7.00	m AHD
Approximate GW Level	RL	-3.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
7.0	3.0	4.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
3.0	-1.0	4.0	Qhi	16	2	23					2	-	-	0.4		0.60	
-1.0	-4.0	3.0	Qpa	18	2	28					10			0.3		0.60	
-4.0	-17.5	13.5	Tew	20	1	33					95			0.3		0.60	
-17.5	-29.5	12.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-29.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		6	
Chainage	CH	96+020	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		40.99	m
Top of Rail Level	RL	-18.63	m AHD
Tunnel Centre Level	RL	-16.52	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		24.12	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	4.00	m AHD
Approximate GW Level	RL	-1.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
4.0	2.0	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
2.0	-10.5	12.5	Qhi	16	2	23					2	20	1	0.4	-	0.60	
-10.5	-20.0	9.5	Qpfu	19	10	25					25	75	0.5	0.3	-	0.70	
-20.0	-25.5	5.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-25.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		6	
Chainage	CH	96+090	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		33.65	m
Top of Rail Level	RL	-17.99	m AHD
Tunnel Centre Level	RL	-15.88	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		20.48	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	1.00	m AHD
Approximate GW Level	RL	-1.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
1.0	0.0	1.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
0.0	-10.0	10.0	Qhi	16	2	23					2	20	1	0.4	-	0.60	
-10.0	-21.0	11.0	Qpfu	19	10	25					25	75	0.5	0.3	-	0.70	
-21.0	-27.0	6.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-27.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		6	
Chainage	CH	96+220	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		18.80	m
Top of Rail Level	RL	-14.83	m AHD
Tunnel Centre Level	RL	-12.72	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		19.32	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	3.00	m AHD
Approximate GW Level	RL	-1.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.0	0.0	3.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
0.0	-6.5	6.5	Qhi	16	2	23					2	20	1	0.4	-	0.60	
-6.5	-10.5	4.0	Qpa	18	2	28					10	30	0.5	0.3		0.60	
-10.5	-19.0	8.5	Qpfu	19	10	25					25	75	0.5	0.3	-	0.70	
-19.0	-21.5	2.5	Qpc	19	0	32					50			0.3		0.60	
-21.5	-24.0	2.5	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-24.0	-31.5	7.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-31.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		8	
Chainage	CH	96+590	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	-13.22	m AHD
Tunnel Centre Level	RL	-11.11	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		18.61	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	3.90	m AHD
Approximate GW Level	RL	-0.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.9	1.5	2.4	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
1.5	-1.5	3.0	Qhi	16	2	23					2			0.4	-	0.60	
-1.5	-3.5	2.0	Qpa	18	2	28					10			0.3		0.60	
-3.5	-4.5	1.0	Qpc	19	0	32					50			0.3		0.60	
-4.5	-10.5	6.0	Tew	20	1	33					95			0.3		0.60	
-10.5	-13.5	3.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-13.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		8	
Chainage	CH	96+860	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	-10.40	m AHD
Tunnel Centre Level	RL	-8.29	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		24.39	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	12.50	m AHD
Approximate GW Level	RL	1.70	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
12.5	10.5	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
10.5	-4.5	15.0	Tov (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
-4.5	-10.5	6.0	Tew	20	1	33					95			0.3		0.60	
-10.5	-13.5	3.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-13.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		9	
Chainage	CH	97+100	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	-7.76	m AHD
Tunnel Centre Level	RL	-5.65	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		26.25	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	17.00	m AHD
Approximate GW Level	RL	7.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
17.0	14.5	2.5	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
14.5	0.5	14.0	Tov (HW - FR) - OV3	24	200	50					1400			0.25		0.60	
0.5	-7.5	8.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-7.5	-13.0	5.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-13.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		9	
Chainage	CH	97+260	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	-6.00	m AHD
Tunnel Centre Level	RL	-3.89	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		21.49	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	14.00	m AHD
Approximate GW Level	RL	9.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
14.0	13.0	1.0	Qpa	18	2	28					10			0.3		0.60	
13.0	5.0	8.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
5.0	-12.0	17.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-12.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		9	
Chainage	CH	97+450	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	-3.02	m AHD
Tunnel Centre Level	RL	-0.91	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		20.51	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	16.00	m AHD
Approximate GW Level	RL	11.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
16.0	15.0	1.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
15.0	14.0	1.0	Qpa	18	2	28					10			0.3		0.60	
14.0	7.0	7.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
7.0	-7.0	14.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-7.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		9	
Chainage	CH	97+680	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.78	m
Top of Rail Level	RL	2.73	m AHD
Tunnel Centre Level	RL	4.84	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		24.76	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	26.00	m AHD
Approximate GW Level	RL	15.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
26.0	22.0	4.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
22.0	17.5	4.5	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
17.5	3.0	14.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
3.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		9	
Chainage	CH	97+850	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.55	m
Top of Rail Level	RL	6.96	m AHD
Tunnel Centre Level	RL	9.07	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		22.53	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	28.00	m AHD
Approximate GW Level	RL	19.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
28.0	24.0	4.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
24.0	20.0	4.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
20.0	6.5	13.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
6.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		11	
Chainage	CH	98+440	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		24.57	m
Top of Rail Level	RL	6.70	m AHD
Tunnel Centre Level	RL	8.81	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		27.79	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	33.00	m AHD
Approximate GW Level	RL	27.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
33.0	30.0	3.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
30.0	28.0	2.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
28.0	10.0	18.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
10.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		11	
Chainage	CH	98+570	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		28.86	m
Top of Rail Level	RL	2.54	m AHD
Tunnel Centre Level	RL	4.65	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		34.95	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	36.00	m AHD
Approximate GW Level	RL	25.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
36.0	31.5	4.5	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
31.5	29.0	2.5	Sud (RS - EW) - RS	22	50	30					80			0.3		1.50	
29.0	16.0	13.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
16.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		11	
Chainage	CH	98+600	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		29.02	m
Top of Rail Level	RL	1.58	m AHD
Tunnel Centre Level	RL	3.69	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		35.91	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	36.00	m AHD
Approximate GW Level	RL	25.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
36.0	32.0	4.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
32.0	28.5	3.5	Sud (RS - EW) - RS	22	50	30					80			0.3		1.50	
28.5	15.5	13.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
15.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		11	
Chainage	CH	99+070	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		16.87	m
Top of Rail Level	RL	-13.45	m AHD
Tunnel Centre Level	RL	-11.34	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		39.94	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	25.00	m AHD
Approximate GW Level	RL	19.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
25.0	22.0	3.0	Sud (RS - EW) - RS	22	50	30					80			0.3		1.50	
22.0	-5.0	27.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
-5.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		11	
Chainage	CH	99+210	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		16.53	m
Top of Rail Level	RL	-16.81	m AHD
Tunnel Centre Level	RL	-14.70	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		40.30	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	22.00	m AHD
Approximate GW Level	RL	13.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
22.0	7.0	15.0	Sud (RS - EW) - RS	22	50	30					80			0.3		1.50	
7.0	-23.5	30.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
-23.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		13	
Chainage	CH	99+570	m

Structure Details
Mined Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.78	m
Top of Rail Level	RL	-16.83	m AHD
Tunnel Centre Level	RL	-14.72	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		40.82	m

Adopted Method of Analysis and Comments
2D FEM. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	22.50	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
22.5	20.5	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
20.5	19.5	1.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.5 - 3.0	
19.5	-7.0	26.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.5 - 3.0	-
-7.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.5 - 3.0	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		13	
Chainage	CH	99+830	m

Structure Details
Mined Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.78	m
Top of Rail Level	RL	-17.96	m AHD
Tunnel Centre Level	RL	-15.85	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		33.95	m

Adopted Method of Analysis and Comments
2D FEM. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	14.50	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
14.5	12.5	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
12.5	3.5	9.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.5 - 3.0	
3.5	-22.0	25.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.5 - 3.0	-
-22.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.5 - 3.0	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		13	
Chainage	CH	100+190	m

Structure Details
Mined Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.78	m
Top of Rail Level	RL	-19.49	m AHD
Tunnel Centre Level	RL	-17.38	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		30.98	m

Adopted Method of Analysis and Comments
2D FEM. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	10.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
10.0	8.0	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
8.0	7.5	0.5	Sud (RS - EW) - RS	22	50	30					80			0.3		0.5 - 3.0	
7.5	-17.0	24.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.5 - 3.0	-
-17.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.5 - 3.0	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		15	
Chainage	CH	100+500	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.77	m
Top of Rail Level	RL	-19.49	m AHD
Tunnel Centre Level	RL	-17.38	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		25.98	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	5.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
5.0	2.0	3.0	Sud (RS - EW) - RS	22	50	30					80			0.3		1.50	
2.0	-22.0	24.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
-22.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		15	
Chainage	CH	100+570	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		15.43	m
Top of Rail Level	RL	-19.41	m AHD
Tunnel Centre Level	RL	-17.30	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		24.40	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	3.50	m AHD
Approximate GW Level	RL	-0.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.5	2.0	1.5	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.50	-
2.0	-7.0	9.0	Qpj	19	10	25					25			0.3		0.70	
-7.0	-10.0	3.0	Qvn	24	200	50					1400			0.25		0.50	
-10.0	-27.0	17.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.50	-
-27.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.50	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+620	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.88	m
Top of Rail Level	RL	-18.72	m AHD
Tunnel Centre Level	RL	-16.61	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		23.21	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	3.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.0	0.0	3.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
0.0	-19.0	19.0	Qvn	26	1300	65	-	-	-	-	15000	-	-	0.2	-	0.5	-
-19.0	-24.0	5.0	Qpfl (Lower)	19	0	32	-	-	-	-	40	-	-	0.25	-	0.6	-
-24.0	-27.0	3.0	Qpg	20	0	35	-	-	-	-	70	-	-	0.2	-	0.6	-
-27.0	-31.0	4.0	Qpc	19	0	32	-	-	-	-	50	-	-	0.25	-	0.65	-
-31.0	-37.0	6.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.2	-	1.5	-
-37.0	below		Sud (SW - FR) - MF1	25	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+660	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.36	m
Top of Rail Level	RL	-18.08	m AHD
Tunnel Centre Level	RL	-15.97	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		15.57	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	-4.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
-4.0	-6.0	2.0	Qra	16	-	-	-	-	-	-	-	-	-	-	-	-	-
-6.0	-10.0	4.0	Qvn	26	1300	65	-	-	-	-	15000	-	-	0.2	-	0.5	-
-10.0	-16.0	6.0	Qpfu (Upper)	19	10	25	-	-	-	-	25	-	-	0.3	-	0.7	-
-16.0	-23.0	7.0	Qpfl (Lower)	19	0	32	-	-	-	-	40	-	-	0.25	-	0.6	-
-23.0	-28.0	5.0	Qpg	20	0	35	-	-	-	-	70	-	-	0.2	-	0.6	-
-28.0	-34.5	6.5	Qpc	19	0	32	-	-	-	-	50	-	-	3	-	0.65	-
-34.5	-40.0	5.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-40.0	below		Sud (SW - FR) - MF1	25	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+700	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.01	m
Top of Rail Level	RL	-17.44	m AHD
Tunnel Centre Level	RL	-15.33	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		14.93	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	-4.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
-4.0	-6.5	2.5	Qra	16	-	-	-	-	-	-	-	-	-	-	-	-	-
-6.5	-9.5	3.0	Qvn	26	1300	65	-	-	-	-	15000	-	-	0.2	-	0.5	-
-9.5	-16.0	6.5	Qpfu (Upper)	19	10	25	-	-	-	-	25	-	-	0.3	-	0.7	-
-16.0	-23.0	7.0	Qpfl (Lower)	19	0	32	-	-	-	-	40	-	-	0.25	-	0.6	-
-23.0	-35.0	12.0	Qvns	26	6000	65	-	-	-	-	25000	-	-	0.2	-	0.5	-
-35.0	-40.0	5.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-40.0	below		Sud (SW - FR) - MF1	25	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+740	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.00	m
Top of Rail Level	RL	-16.80	m AHD
Tunnel Centre Level	RL	-14.69	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		21.29	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	3.00	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.0	0.0	3.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
0.0	-4.0	4.0	Qhi	16	2	23	-	-	-	-	2	-	-	0.4	-	0.6	-
-4.0	-8.0	4.0	Qvn	26	1300	65	-	-	-	-	15000	-	-	0.2	-	0.5	-
-8.0	-20.0	12.0	Qpfu (Upper)	19	10	25	-	-	-	-	25	-	-	0.3	-	0.7	-
-20.0	-23.0	3.0	Qpfl (Lower)	19	0	32	-	-	-	-	40	-	-	0.25	-	0.6	-
-23.0	-32.0	9.0	Qvns	26	6000	65	-	-	-	-	25000	-	-	0.2	-	0.5	-
-32.0	-35.0	3.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-35.0	below		Sud (SW - FR) - MF1	25	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+840	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.00	m
Top of Rail Level	RL	-14.89	m AHD
Tunnel Centre Level	RL	-12.78	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		24.38	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	8.00	m AHD
Approximate GW Level	RL	-1.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
8.0	-1.0	9.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
-1.0	-17.5	16.5	Qhi	16	2	23	-	-	-	-	2	20	1	0.4	-	0.6	-
-17.5	-21.0	3.5	Qpfu (Upper)	19	10	25	-	-	-	-	25	75	0.5	0.3	-	0.7	-
-21.0	-23.5	2.5	Qpfl (Lower)	19	0	30	-	-	-	-	25	75	0.5	0.25	-	0.6	-
-23.5	-24.0	0.5	Qpg	20	0	35	-	-	-	-	60	-	-	0.3	-	0.6	-
-24.0	-28.0	4.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-28.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		16	
Chainage	CH	100+900	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		14.69	m
Top of Rail Level	RL	-12.82	m AHD
Tunnel Centre Level	RL	-10.71	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		19.31	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	5.00	m AHD
Approximate GW Level	RL	-1.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
3.0	-2.0	5.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
-2.0	-18.0	16.0	Qhi	16	2	23	-	-	-	-	2	20	1	0.4	-	0.6	-
-18.0	-25.0	7.0	Qha	18	2	28	-	-	-	-	10	30	0.5	0.3	-	0.6	-
-25.0	-27.0	2.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-27.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		17	
Chainage	CH	101+020	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		21.64	m
Top of Rail Level	RL	-8.62	m AHD
Tunnel Centre Level	RL	-6.51	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		16.61	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	6.50	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
6.5	3.0	3.5	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
3.0	2.0	1.0	Sud (RS - EW) - RS	22	50	30					80			0.3		1.5	
2.0	-6.5	8.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-6.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		18	
Chainage	CH	101+390	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		25.59	m
Top of Rail Level	RL	1.13	m AHD
Tunnel Centre Level	RL	3.24	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		11.36	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	11.00	m AHD
Approximate GW Level	RL	-13.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
11.0	9.0	2.0	Fill	19	0	30	-	-	-	-	10	-	-	0.3	-	0.5	-
9.0	2.0	7.0	Tpb	20	1	35					70			0.3		0.6	
2.0	-2.5	4.5	Sud (RS - EW) - RS	22	50	30					80			0.3		1.5	
-2.5	-48.0	45.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	1.5	-
-48.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		19	
Chainage	CH	102+220	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.94	m
Top of Rail Level	RL	-5.11	m AHD
Tunnel Centre Level	RL	-3.00	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		16.10	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	9.50	m AHD
Approximate GW Level	RL	0.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
9.5	5.5	4.0	Tpb	20	1	35					70			0.3		0.6	
5.5	-2.5	8.0	Sud (RS - EW) - RS	22	50	30					80			0.3		1.5	
-2.5	-28.0	25.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.2.5	-	1.5	-
-28.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	1.5	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	102+580	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.82	m
Top of Rail Level	RL	-5.11	m AHD
Tunnel Centre Level	RL	-3.00	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		16.60	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	10.00	m AHD
Approximate GW Level	RL	-0.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
10.0	0.0	10.0	Tpb	20	1	35					70			0.3		0.60	
0.0	-4.0	4.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-4.0	-31.5	27.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-31.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	102+840	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		12.38	m
Top of Rail Level	RL	-10.97	m AHD
Tunnel Centre Level	RL	-8.86	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		22.26	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	9.80	m AHD
Approximate GW Level	RL	-3.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
9.8	-3.5	13.3	Tpb	20	1	35					70			0.3		0.60	
-3.5	-5.5	2.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-5.5	-30.5	25.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-30.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	103+100	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		13.55	m
Top of Rail Level	RL	-12.16	m AHD
Tunnel Centre Level	RL	-10.05	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		27.95	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	14.30	m AHD
Approximate GW Level	RL	0.60	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
14.3	-4.5	18.8	Tpb	20	1	35					70			0.3		0.60	
-4.5	-6.5	2.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-6.5	-31.0	24.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-31.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	103+200	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		37.24	m
Top of Rail Level	RL	-11.95	m AHD
Tunnel Centre Level	RL	-9.84	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		29.44	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	16.00	m AHD
Approximate GW Level	RL	2.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
16.0	-1.0	17.0	Tpb	20	1	35					70			0.3		0.60	
-1.0	-3.0	2.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-3.0	-28.5	25.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-28.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	103+730	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		12.23	m
Top of Rail Level	RL	-9.48	m AHD
Tunnel Centre Level	RL	-7.37	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		32.97	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	22.00	m AHD
Approximate GW Level	RL	5.00	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
22.0	19.5	2.5	Tpb	20	1	35					70			0.3		0.60	
19.5	17.0	2.5	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
17.0	-15.0	32.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-15.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		21	
Chainage	CH	103+850	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		11.42	m
Top of Rail Level	RL	-8.93	m AHD
Tunnel Centre Level	RL	-6.82	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		28.72	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	18.30	m AHD
Approximate GW Level	RL	5.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
18.3	12.0	6.3	Tpb	20	1	35					70			0.3		0.60	
12.0	10.0	2.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
10.0	-18.5	28.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-18.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		22	
Chainage	CH	104+170	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		11.00	m
Top of Rail Level	RL	-4.73	m AHD
Tunnel Centre Level	RL	-2.62	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		16.32	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	10.10	m AHD
Approximate GW Level	RL	3.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
10.1	-1.5	11.6	Tpb	20	1	35					70			0.3		0.60	
-1.5	-11.5	10.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-11.5	-36.0	24.5	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-36.0	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

Melbourne Metro Rail Project
Ground Profile Assumptions and Input Data for Ground Movement Assessment

Section / Location

SEGMENT		22	
Chainage	CH	104+220	m

Structure Details
TBM Tunnels

Alignment and Tunnel Geometry Assumptions

Centre of Track c/c Distance		10.26	m
Top of Rail Level	RL	-2.98	m AHD
Tunnel Centre Level	RL	-0.87	m AHD
Tunnel Diameter (Excavated)		7.20	m
Top of Rail to Obvert Extrados		5.71	m
Top of Rail to Invert Extrados		1.49	m
Depth to Invert Extrados		16.67	m

Adopted Method of Analysis and Comments
2D FEM. Settlements based on volume loss approach. Geotechnical Design Parameters assumed as below.

Ground Profile and Groundwater Assumptions (Simplified Profile based on Westbound Tunnel Alignment)

Approximate Surface Level	RL	12.20	m AHD
Approximate GW Level	RL	3.50	m AHD

Assumed Geotechnical Units and Design Parameters (refer to GIR Ref. 1525532-061-R for details)

Depth (RL m)		Thickness	Geological Unit / Description	γ'	c'	φ'	S_u	E_u	E'	E_{rm}	E_{50}	E_{ur}	m	υ	p'_o	K_o	k
From	To	m		kN/m^3	kPa	deg	kPa	MPa	MPa	MPa	MPa	MPa	-	-	kPa	-	m/s
12.2	-1.5	13.7	Tpb	20	1	35					70			0.3		0.60	
-1.5	-12.5	11.0	Sud (RS - EW) - RS	22	50	30					80			0.3		0.75	
-12.5	-38.5	26.0	Sud (HW - MW) - MF3	23	150	38	-	-	-	-	300	-	-	0.25	-	0.75	-
-38.5	below		Sud (SW - FR) - MF1	26	650	48	-	-	-	-	2000	-	-	0.2	-	0.75	-

Parameters shown in this table have been used for the ground movement assessment and settlement analysis
"-" not used

Comments and Notes

APPENDIX C

Results of FE Analyses and Indicative Settlement Profiles

Please note this appendix is part of the Ground Movement Assessment Report prepared to support the development of the MMRP Concept Design and should be read in conjunction with that document. The information on which the assessments in this appendix are based is also referenced in that document.

1.0 INTRODUCTION

This document presents results of our preliminary ground movement assessment carried out for tunnels and caverns at selected locations along the proposed alignment. The purpose of this assessment is to assess the potential ground movements induced by underground excavations; to explore the potential impacts on the existing buildings and infrastructure due to construction of tunnels and cavern and to provide information to inform the MMRP Concept Design.

This summary forms a part of our Ground Movement Assessment Report (GMAR) and covers sections within Segments 4, 5, 6, 8, 9, 11, 15, 16, 17, 18, 19, 21 and 22, which are the proposed TBM tunnels, Segment 13 which is the proposed section of mined tunnels, and Segments 12 and 14 which are the proposed mined station caverns.

This summary excludes TBM tunnel section of the Yarra River Crossing below the existing piers and abutments of Princes Bridge. The potential ground movement assessment of the bridge footings due to tunnelling have been assessed separately and the results are discussed in the main text of our GMAR.

This document also excludes an assessment for the potential consolidation settlement triggered by groundwater depressurisation, both during construction and operation. Preliminary assessment of potential consolidation settlement predictions, based on the hydrogeological modelling results and estimates of potential groundwater drawdowns, are discussed in the main report.

2.0 ASSUMPTIONS

2.1 General

Following are assumptions adopted for the purpose of the preliminary ground movement assessment and 2D Plaxis analyses.

- This preliminary assessment of potential ground movement is based on green-field conditions prior to tunnels and caverns excavations. Simplified ground models have been adopted. Existing structures in the vicinity of the tunnels have not been considered.
- The proposed MMRP alignment adopted for this assessment is shown on our Geological Long Section included in the GMAR as Appendix A.
- The adopted ground conditions (presented in attached figures) are based on the Interpreted Geological Setting Report (IGSR). The geotechnical design parameters considered for Plaxis analyses are based on the geotechnical design parameters discussed in IGSR. This document should be read in conjunction with our IGSR.
- For the purpose of preliminary design and soil-structure interaction assessment, the linear elastic perfectly-plastic Mohr-Coulomb (M-C) model was used in Plaxis analyses. As moderate strains are expected (i.e. moderate strains ε ranging from 0.2% to 1%) during construction of TBM tunnels, mined tunnels and caverns, the recommended Secant Modulus (E_{50}) values have been adopted for analyses.
- Groundwater levels adopted for analyses are based on the data shown on geological long sections included in the IGSR. TBM tunnels have been modelled as undrained structures but drained conditions were assumed for mined tunnels and caverns.

2.2 TBM Tunnels

Following are assumptions adopted for the purpose of the preliminary ground movement assessment and 2D Plaxis analyses specific to TBM tunnels.

- Tunnel excavations considered for this assessment assumed:
  - 7.2 m diameter (excavated profile) TBM tunnels; and
  - Staged tunnel excavations (one tunnel at the time); first eastbound tunnel then westbound tunnel.
- The geotechnical design parameters adopted for Plaxis analyses are summarised in Table 5.
- For the purpose of this preliminary assessment a range of K_0 (Major (σ_{h1}) or Minor (σ_{h2})) values between 0.75 and 1.5 have been adopted for TBM tunnel analyses depending on the tunnel orientation. Table 5 presents K_0 values assumed in Melbourne Formation (MF) for each of the tunnel section.
- The preliminary assessment of potential ground movement induced by TBM tunnelling has been carried out using approach based on the tunnel volume loss (VL) parameter ranging between 0.5 and 1.5% aiming at representing variability of geological conditions expected at the tunnel face along the proposed alignment. Lower VL values are generally expected to be achievable in rock and higher VL values being considered for tunnels in soft soils. To provide for initial estimates this range of volume loss values was used in Plaxis and the values presented in Table 1 were considered for the purpose of this preliminary settlement assessment.

Table 1: Volume loss parameters considered for settlement assessment

Ground Conditions at TBM Tunnel Face	Volume Loss – VL (%)
Soft Soil	1.0 / 1.5*
Stiff Soil / Rock (<2D – about twice the tunnel diameter cover or less)	0.5 / 1.0*
Rock (>2D – about twice the tunnel diameter cover or more)	0.5*

* Range of volume loss values of 0.5%, 1.0% and 1.5% have been considered for assessment of TBM tunnel induced settlement and for Plaxis modelling. However, it is expected that volume losses presented in table above are practical and achievable with the use of latest TBMs and techniques currently available in tunnelling industry and may be adopted for preliminary calculations.

2.3 Mined Tunnels

Following are assumptions adopted for the purpose of the preliminary ground movement assessment and 2D Plaxis analyses specific to mined tunnels.

- Tunnel excavations considered for this assessment assumed:
  - Mined tunnels (excavated profile) of approximately 7.5 m span and 7.5 m height.
  - Staged tunnel excavations (one tunnel at the time); first eastbound tunnel then westbound tunnel.
- The geotechnical design parameters adopted for Plaxis analyses are summarised in Table 5.
- In models of mined tunnels, variations of principal horizontal in situ stresses have been considered in Melbourne Formation (MF). The actual in situ stresses will vary depending on depth, in situ stress history and orientation of existing and new structures that is being considered. For the purpose of this preliminary assessment a range of K_0 (Major (σ_{h1}) or Minor (σ_{h2})) values between 0.5 and 3.0 have been adopted for sensitivity analyses.
- Based on the available concept design information, mined tunnels are to be constructed using mining techniques, with the use of road headers and excavations followed closely with rock support in relatively short advance lengths, say 1 to 3m. Construction sequence and rock support assumed for analyses based on the preliminary temporary support design shown indicatively in the design drawings provided by AJM JV.

- The preliminary assessment of potential ground movement induced by mined tunnel excavations has been carried out using 2D Plaxis to assess the effects of staged construction proposed for the mined tunnels between CBD North and CBD South. In the models tunnel excavations were simulated by using a staged approach, where the three-dimensional arching effects were modelled using the *β-method*. The idea is that the initial stress p_k acting around the location where the tunnel is constructed is split into two stages where $(1-\beta)\ p_k$ stress is applied to the unsupported opening followed by a stage where $\beta\, p_k$ is applied to the supported crown and walls. This allows for some convergence of the tunnel prior to installation of support and for preliminary analyses it was assumed that 50% ground relaxation occurs prior to support being installed. It was assumed that staged excavation will have an initial effect on inducing ground movement. The rock support (rock bolts and shotcrete lining) was then introduced in a second stage to restrain the ground movements until equilibrium between the soil stress field and the support elements was achieved.
- It is assumed that the use of robust pre-support in combination with ground improvement measures ahead of excavations will be required for tunnel sections where poor ground is encountered along the alignment. This would likely comprise the use of spiles and/or canopy tubes installed ahead of the excavation face, with grouting as a form of ground improvement if required, and application of relatively thick layer of shotcrete and lattice girders as primary support. It was assumed that the pre-support and ground improvement measures would be designed to keep the effective volume loss due to mined tunnel excavations below 0.5%, to limit the potential surface settlement above mined tunnel.

2.4 Mined Caverns

Following are assumptions adopted for the purpose of the preliminary ground movement assessment and 2D Plaxis analyses for mined caverns.

- Approximately 23 m wide and 19 m high (excavated profile) caverns proposed for both CBD South and CBD North Stations. In consideration of the expected variability of ground conditions, four representative cross sections have been selected for Plaxis analyses at:
  - CBD North: CH99+260m and CH99+480m (approx. cavern invert level RL – 20m AHD); and
  - CBD South: CH100+420m and CH100+460m (approx. cavern invert level RL – 23m AHD).
- The geotechnical design parameters adopted for Plaxis analyses are summarised in Table 6.
- Variations of principal horizontal in situ stresses (Major (σ_{h1}) or Minor (σ_{h2})) have been considered in Melbourne Formation (MF). The actual in situ stresses will vary depending on depth, in situ stress history and orientation of existing and new structures that is being considered. For the purpose of this preliminary assessment a range of K_0 values between 0.5 and 3.0 have been adopted for sensitivity analyses.
- Based on the available concept design information, both caverns are to be constructed using mining techniques, with the use of road headers and excavations followed closely with rock support in relatively short advance lengths, say 1-3m. Construction sequence and rock support assumed for analyses based on the preliminary temporary support design shown indicatively in the design drawings provided by AJM JV.
- The preliminary assessment of potential ground movement induced by caverns constructions has been carried out using 2D Plaxis to assess the effects of staged construction proposed for the caverns. In the models cavern excavations were simulated by using a staged approach, where the three-dimensional arching effects were modelled using the *β-method*. The idea is that the initial stress p_k acting around the location where the cavern is constructed is split into two stages where $(1-\beta)\ p_k$ stress is applied to the unsupported opening followed by a stage where $\beta\, p_k$ is applied to the supported crown and walls. This allows for some convergence of the cavern prior to support application and for preliminary analyses it was assumed that 50% ground relaxation occurs prior to support being installed. It was assumed that

staged excavation will have an initial effect on inducing ground movement. The rock support (rock bolts and shotcrete lining) was then introduced in a second stage to restrain the ground movements until equilibrium between the soil stress field and the support elements was achieved.

- The cavern was assumed to be excavated with rock bolts and shotcrete lining in 8 stages.
- It is assumed that the use of robust pre-support in combination with ground improvement measures ahead of excavations will be required for cavern sections where poor ground is encountered along the alignment. This would likely comprise the use of spiles and/or canopy tubes installed ahead of the excavation face, with grouting as a form of ground improvement if required, and application of relatively thick layer of shotcrete and lattice girders as primary support. It was assumed that the pre-support and ground improvement measures would be designed to keep the effective volume loss due to cavern excavations below 0.5%, to limit the potential surface settlement above mined caverns.

3.0 SUMMARY OF RESULTS

It should be noted that, due to the limited information available at the CD stage, the calculated settlement values are approximate and based on a number of prudently conservative assumptions, including simplified ground profiles and preliminary design geotechnical parameters.

3.1 TBM Tunnels

Table 2 presents estimates of maximum settlements and settlement trough widths (extent of surface settlement trough estimated for settlements > 5mm) expected at surface across the TBM tunnel alignment.

The predictions of potential settlements for a range of volume loss values reported in Table 2 are considered to be reasonable initial estimates based on past tunnelling experience in Melbourne; however, further analyses will be required to refine them going forward as the project develops.

Results of this preliminary assessment indicate that the TBM tunnels excavation induced ground movement may potentially have significant impact on the existing nearby buildings and infrastructure. Building impact assessments should be carried out along the proposed tunnel alignment.

We note that excavations of TBM tunnels at some locations will be undertaken within mixed ground conditions. Highly variable in strength and stiffness ground is expected at the tunnel face ranging from soft to very stiff and/or medium dense to very dense soils to highly weathered to fresh rock materials, in particular with potentially most challenging tunnelling ground encountered within the transition zone when TBM moving from relatively low strength sedimentary soils into likely high strength rock. Therefore, careful control of TBM operation and excavation advance rates will be crucial in achieving lowest practical volume losses at the tunnel face and thus inducing lowermost settlements along the alignment.

Careful construction sequencing and contingency measures should be considered to mitigate the potential for relatively large displacements associated with TBM tunnelling and potential volume loss at tunnel face. Particular attention will need to be given to the TBM advance and face pressure controls design, in combination with contingency measures (i.e. ground improvements, etc.) that are expected to be required in this area, which can be applied prior, during or post tunnel excavations as required.

3.2 Mined Tunnels

Table 3 presents estimates of maximum settlements and settlement trough widths (extent of surface settlement trough estimated for settlements > 5mm) expected at surface across the alignments of caverns.

Predictions of potential settlements for a range of K_0 values in Table 3 are considered to be reasonable initial estimates based on current understanding of in situ stress fields at mined tunnels locations and past experience in Melbourne; however, further analyses will be required to refine them going forward as the project develops.

Results of this preliminary assessment indicate that the mined tunnels excavation induced ground movement (maximum estimated settlements of about 10-15mm) is not expected to have significant impact on the existing nearby buildings and infrastructure. Nevertheless, building impact assessments should be carried out along the proposed tunnel alignment.

We note that excavations of mined tunnels are expected to be undertaken primarily within relatively good ground conditions (i.e. rock mass typically moderately or less weathered). However, it is expected that zones of poorer ground / faulted rock will be encountered in the excavations and probing ahead combined with pre-support and limited excavation advance lengths will be crucial in achieving lowest practical inward displacement and thus inducing lowermost ground movement at surface and/or around existing structures.

Careful construction sequencing and contingency measures should be considered to reduce the potential for undesirable displacements associated with mined tunnel construction. Particular attention will need to be given to the design and construction of connections with caverns, adits and complex junctions where combined effects may result in even larger displacement. Pre-support measures and ground movement controls, in combination with contingency measures (i.e. ground improvements) are expected to be required in a number of areas along the proposed mined tunnels, which may be required to be applied prior, during or post tunnel excavations.

3.3 Mined Caverns

Table 4 presents estimates of maximum settlements and settlement trough widths (extent of surface settlement trough estimated for settlements > 5mm) expected at surface across the alignments of caverns.

The predictions of potential settlements for a range of K_0 values reported in Table 4 are considered to be reasonable initial estimates based on current understanding of in situ stress fields at cavern locations and past experience in Melbourne; however, further analyses will be required to refine them going forward as the project develops.

Results of this preliminary assessment indicate that the cavern excavation induced ground movement (maximum estimated settlements of about 35-40mm) may potentially impact the existing nearby buildings and infrastructure.

Careful construction sequencing and contingency measures should be considered to mitigate the potential for relatively large displacements associated with cavern construction. Particular attention will need to be given to the design and construction of proposed deep shafts, adits and complex junctions where combined effects may result in even larger displacement. Significant pre-support measures and ground movement controls, in combination with contingency measures (i.e. underpinning/strengthening of existing structures, ground improvements, etc.) are expected to be required in a number of areas along the proposed caverns, which may be required to be applied prior, during or post cavern excavations.

We note that excavations of caverns are expected to be undertaken primarily within relatively good ground conditions (i.e. rock mass typically highly weathered or less weathered). However, it is expected that zones of poorer ground / faulted rock will be encountered in the cavern excavations and probing ahead combined with pre-support and limited excavation advance rates will be crucial in achieving lowest possible inward displacement and thus inducing lowermost ground movement at surface and/or around existing structures.

4.0 REMARKS

Sophisticated monitoring of stresses and displacements in a number of the existing structures along the alignment will likely be needed to verify the effectiveness of the control measures implemented for the TBM and mined tunnel and cavern excavations and check that the actual ground displacements are consistent with predicted values.

A structural assessment will need to be undertaken on the impact of the ground movements on the existing structures due to TBM and mined tunnel and cavern excavations.

The existing structures near the proposed TBM tunnels, mined tunnels and caverns, in particular, those with basements and imposing vertical and lateral loads onto the ground may have an influence on the ground movements. These have not been considered in this preliminary assessment.

It should be noted that, based on existing information, inclined weak rock zones may be present along the proposed alignment and tunnelling induced effects can be transmitted in non-vertical directions. Potential for movements in non-vertical directions have not been considered in the preliminary ground movement assessment. As such, these early settlement predictions should be considered as indicative and further studies are recommended to account for complex geological conditions and site specific soil-structure interaction effects.

Further commentary on the significance of these predicted settlements with respect to potential impacts on existing buildings and infrastructure is provided in the AJM JV Ground Movement Impact Assessment (AJM JV, 2016).

Table 2: Summary of Preliminary Ground Movement Assessment Results for TBM Tunnels

Approx. Chainage (m)	Project Segment	Inferred Ground Conditions at Approximate Tunnel Elevation / Tunnel Face	K_0 assumed for MF unit	Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) at Volume Loss (V_L) Eastbound Tunnel Only			Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) at Volume Loss (V_L) Eastbound and Westbound Tunnels		
				0.5%V_L	1.0%V_L	1.5%V_L	0.5%V_L	1.0%V_L	1.5%V_L
				S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$
95+500	4	Stiff Soil / Weathered Rock	0.75	<5mm / -	12mm / 22m	Not expected	6mm / 20m	14mm / 40m	Not expected
95+660	5	Stiff Soil	0.75	6mm / 12m	13mm / 34m	Not expected	6mm / 48m	13mm / 70m	Not expected
95+730	5	Stiff Soil / Weathered Rock	0.75	7mm / 14m	13mm / 34m	Not expected	7mm / 58m	13mm / 76m	Not expected
95+760	5	Stiff Soil / Weathered Rock	0.75	8mm / 17m	19mm / 28m	Not expected	8mm / 62m	19mm / 72m	Not expected
96+020	6	Soft Soil / Stiff Soil	0.75	12mm / 16m	25mm / 56m	37mm / 60m	14mm / 85m	27mm / 94m	39mm / 97m
96+090	6	Soft Soil / Stiff Soil	0.75	12mm / 38m	25mm / 48m	38mm / 52m	12mm / 72m	25mm / 81m	38mm / 85m
96+220	6	Soft Soil / Stiff Soil	0.75	8mm / 20m	19mm / 42m	30mm / 46m	11mm / 42m	28mm / 59m	44mm / 64m
96+590	8	Stiff Soil / Weathered Rock	0.75	13mm / 16m	28mm / 20m	Not expected	14mm / 30m	31mm / 33m	Not expected
96+860	8	Stiff Soil / Weathered Rock	0.75	6mm / 20m	12mm / 42m	Not expected	11mm / 45m	22mm / 60m	Not expected
96+940	8	Stiff Soil / Weathered Rock	0.75	<5mm / -	7mm / 30m	Not expected	7mm / 34m	17mm / 61m	Not expected
97+100	9	Weathered Rock (<2D)	0.75	<5mm / -	8mm / 34m	Not expected	9mm / 42m	17mm / 58m	Not expected
97+260	9	Weathered Rock (<2D)	0.75	<5mm / -	11mm / 24m	Not expected	9mm / 27m	20mm / 40m	Not expected
97+450	9	Weathered Rock (<2D)	0.75	6mm / 12m	13mm / 24m	Not expected	10mm / 30m	21mm / 40m	Not expected
97+680	9	Weathered Rock (>2D)	0.75	7mm / 15m	Not expected	Not expected	12mm / 30m	Not expected	Not expected
97+850	9	Weathered Rock (<2D)	0.75	8mm / 16m	15mm / 26m	Not expected	11mm / 33m	20mm / 43m	Not expected
98+440	11	Weathered Rock (>2D)	0.75	<5mm / -	Not expected	Not expected	6mm / 31m	Not expected	Not expected
98+570	11	Weathered Rock (>2D)	1.50	<5mm / -	Not expected	Not expected	<5mm / -	Not expected	Not expected
98+600	11	Weathered Rock (>2D)	1.50	<5mm / -	Not expected	Not expected	<5mm / -	Not expected	Not expected
99+070	11	Weathered Rock (>2D)	1.50	<5mm / -	Not expected	Not expected	<5mm / -	Not expected	Not expected
99+210	11	Weathered Rock (>2D)	1.50	<5mm / -	Not expected	Not expected	<5mm / -	Not expected	Not expected
100+500	15	Weathered Rock (>2D)	1.50	<5mm / -	Not expected	Not expected	6mm / 22m	Not expected	Not expected
100+570	15	Weathered Rock (<2D)	1.50	<5mm / -	<5mm / -	Not expected	6mm / 16m	12mm / 40m	Not expected

APPENDIX C
Summary of Finite Element Modelling Results for Tunnels and Caverns

Approx. Chainage (m)	Project Segment	Inferred Ground Conditions at Approximate Tunnel Elevation / Tunnel Face	K_0 assumed for MF unit	Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) at Volume Loss (V_L) Eastbound Tunnel Only			Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) at Volume Loss (V_L) Eastbound and Westbound Tunnels		
				0.5%V_L	1.0%V_L	1.5%V_L	0.5%V_L	1.0%V_L	1.5%V_L
				S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$
100+840	16	Soft Soil	1.50	12mm / 34m	23mm / 56m	34mm / 68m	24mm / 48m	46mm / 72m	70mm / 82m
100+900	16	Soft Soil	1.50	8mm / 18m	20mm / 42m	32mm / 56m	10mm / 30m	30mm / 58m	50mm / 72m
101+020	17	Weathered Rock (<2D)	1.50	8mm / 12m	19mm / 18m	Not expected	9mm / 34m	23mm / 40m	Not expected
101+390	18	Stiff Soil / Weathered Rock	1.50	14mm / 10m	27mm / 15m	Not expected	9mm / 34m	26mm / 40m	Not expected
102+220	19	Weathered Rock (<2D)	1.50	<5mm / -	7mm / 16m	Not expected	7mm / 20m	15mm / 34m	Not expected
102+580	21	Stiff Soil / Weathered Rock	0.75	8mm / 12m	24mm / 20m	Not expected	10mm / 26m	27mm / 33m	Not expected
102+840	21	Weathered Rock (<2D)	0.75	<5mm / -	11mm / 24m	Not expected	7mm / 23m	19mm / 38m	Not expected
103+100	21	Weathered Rock (<2D)	0.75	5mm / 6m	12mm / 31m	Not expected	7mm / 35m	15mm / 53m	Not expected
103+200	21	Weathered Rock (<2D)	0.75	5mm / 8m	11mm / 33m	Not expected	6mm / 49m	12mm / 69m	Not expected
103+730	21	Weathered Rock (>2D)	0.75	<5mm / -	Not expected	Not expected	8mm / 31m	Not expected	Not expected
103+850	21	Weathered Rock (>2D)	0.75	<5mm / -	Not expected	Not expected	8mm / 30m	Not expected	Not expected
104+170	22	Stiff Soil / Weathered Rock	0.75	<5mm / -	12mm / 18m	Not expected	7mm / 16m	23mm / 31m	Not expected
104+220	22	Stiff Soil / Weathered Rock	0.75	<5mm / -	13mm / 20m	Not expected	7mm / 13m	24mm / 32m	Not expected

Table 3: Summary of Preliminary Ground Movement Assessment Results for Mined Tunnels

Approx. Chainage (m)	Inferred Ground Conditions at Approximate Tunnel Elevation / Tunnel Face	Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) Eastbound Tunnel Only				Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$) Eastbound and Westbound Tunnels			
		K_0 = 0.5	K_0 = 0.75	K_0 = 1.5	K_0 = 3.0	K_0 = 0.5	K_0 = 0.75	K_0 = 1.5	K_0 = 3.0
		S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$
99+570	SW/FR MF	< 5mm / -	< 5mm / -	< 5mm / -	< 5mm / -	< 5mm / -	< 5mm / -	< 5mm / -	< 5mm / -
99+830	MW/SW MF	8mm / 34m	8mm / 34m	6mm / 32m	<5mm / -	12mm / 58m	11mm / 60m	10mm / 62m	8mm / 68m
100+190	MW/SW/FR MF	6mm / 16m	6mm / 16m	5mm / 10m	<5mm / -	8mm / 40m	8mm / 40m	8mm / 40m	7mm / 42m

Table 4: Summary of Preliminary Ground Movement Assessment Results for Mined Caverns

Approx. Chainage (m)	Cavern	Inferred Ground Conditions at Approx. Cavern Elevation	Estimated Maximum Settlement (S_{max}) and Settlement Trough Width for Settlement ($W_{(s>5mm)}$)			
			K_0 = 0.5	K_0 = 0.75	K_0 = 1.5	K_0 = 3.0
			S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$	S_{max} / $W_{(s>5mm)}$
99+260	CBD North	MF2/MF3	37mm / 130m	35mm / 130m	29mm / 135m	20m / 150m
99+480	CBD North	MF1/MF2	12mm / 52m	11mm / 52m	8mm / 48m	< 5mm / -
100+420	CBD South	MF2/MF3	23mm / 70m	20mm / 70m	16mm / 80m	11m / 90m
100+460	CBD South	MF1/MF2	20mm / 55m	18mm / 58m	15mm / 60m	10m / 70m

Table 5: Preliminary Geotechnical Design Parameters adopted for Plaxis Analyses for TBM and Mined Tunnels (see to notes below)

Geological Unit	Unit Acronym	Description	Unit Weight	Effective Cohesion	Friction Angle	Secant Modulus	Poisson's Ratio	At Rest Earth Pressure Coefficient
			γ (kN/m^3)	c' (kPa)	ϕ' (degree)	E_{50} [1&2] (MPa)	υ (–)	K_o[3] (σ_{h1} or σ_{h2}) (-)
FILL	Fill	Man-made fill	19	0	30	10	0.3	0.5
Coode Island Silt	Q_{hi}	Soft silty CLAY	16	2	23	2	0.4	0.6
Holocene Alluvium	Q_{ha}	Loose clayey SAND	18	2	28	10	0.3	0.6
Newer Volcanics	Q_{vn}	HW/MW (predominantly thin beds below the river)	24	200	50	1400	0.25	0.5
Newer Volcanics	Q_{vn}	SW/FR (predominantly massive, thick beds)	26	750	60	2500	0.2	0.5
Pleistocene Alluvium	Q_{pa}	Firm to stiff silty sandy CLAY, occasional sand lenses	18	2	28	10	0.3	0.6
Fishermens Bend Silt (Upper)	Q_{pfu}	Firm to stiff silty sandy CLAY, occasional sand lenses	19	10	25	25	0.3	0.7
Fishermens Bend Silt (Lower)	Q_{pfl}	Medium dense clayey SAND	19	0	30	25	0.3	0.6
Morey Street Gravels	Q_{pg}	Predominantly granular	20	0	35	60	0.3	0.6
Early Pleistocene Sediments	Q_{pc}	Dense clayey SAND / very stiff silty gravelly CLAY	19	0	32	50	0.3	0.6
Newer Volcanics Swan St Basalt	Q_{vns}	SW/FR	26	1000	65	5000	0.2	0.5
Werribee Formation	T_{ew}	Silty SAND/SAND, SM/SW	20	1	33	95	0.3	0.6
Melbourne Formation Rock, RS	S_{ud}	RS/EW	22	50	30	80	0.3	1.5 / 0.75
Melbourne Formation Rock, MF3	S_{ud}	HW/MW	23	150	38	300	0.25	1.5 / 0.75
Melbourne Formation Rock, MF1	S_{ud}	SW/FR	26	650	48	2000	0.2	1.5 / 0.75

Table 6: Preliminary Geotechnical Design Parameters used for Plaxis Analyses for Mined Caverns (see notes below)

Cavern	Geological Unit	Unit Acronym	Description	Unit Weight	Effective Cohesion	Friction Angle	Secant Modulus	Poisson's Ratio	At Rest Earth Pressure Coefficient
				γ (kN/m^3)	c' (kPa)	ϕ' (degree)	E_{50} (1&2) (MPa)	υ (–)	K_o(3) (σ_{h1} or σ_{h2}) (-)
CBD North	FILL	Fill	Man-made fill	19	0	30	10	0.3	0.5
	Melbourne Formation, MF4	S_{ud}	EW	22	50	30	80	0.3	1.75 / 1.0
	Melbourne Formation, MF3	S_{ud}	HW	23	150	38	300	0.25	1.75 / 1.0
	Melbourne Formation, MF2	S_{ud}	MW	24	400	45	500	0.2	1.75 / 1.0
	Melbourne Formation, MF1	S_{ud}	SW/FR	26	650	48	2000	0.2	1.75 / 1.0
CBD South	FILL	Fill	Man-made fill	19	0	30	10	0.3	0.5
	Melbourne Formation, MF4	S_{ud}	EW	22	50	30	80	0.3	1.5 / 0.75
	Melbourne Formation, MF3	S_{ud}	HW	23	150	38	400	0.25	1.5 / 0.75
	Melbourne Formation, MF2	S_{ud}	MW	24	400	45	700	0.2	1.5 / 0.75
	Melbourne Formation, MF1	S_{ud}	SW/FR	26	650	48	3000	0.2	1.5 / 0.75

1) Use of E_{50} values is recommended for design of caverns, tunnels and very deep retention systems where typically moderate strains (i.e. strains ε ranging from 0.2% to 1%) are expected. Further reduction of modulus values will be required for the analysis of problems where larger strains (ε >1%) may occur.

2) A strain hardening model should be used with caution as the actual modulus values resulting from the model will depend on other parameters such as reference stress, $K_{0,nc}$ etc. The actual modulus values resulting from the input parameters adopted should be checked and verified.

3) The average orientation of principal stresses based on all in situ measurements undertaken to date in Melbourne Formation on the project is about 105° to 130° (Major) / 15° to 40° (Minor). For rock mass, K_0 values are recommended to be adopted for Major (σ_{h1}) or Minor (σ_{h2}) principal horizontal in situ stress ranges for analysis. The actual in situ stresses will vary depending on depth, in situ stress history and orientation of structure that is being considered. Sensitivity analysis is recommended and the input parameters adopted for design should be checked and verified.

APPENDIX D

Indicative Contours of Settlement due to Excavations of Tunnels, Caverns and Open cut Excavations

PLAN

NOTES

1. TUNNELLING INDUCED SETTLEMENT CONTOURS ARE BASED ON THE FOLLOWING ASSUMPTIONS:

GROUND TYPE	VOLUME LOSS (%)	TROUGH WIDTH PARAMETER
SOIL (ALL TYPES)	1.0	0.4
ROCK	0.5	0.6
ROCK (> 2D COVER)	0.5	0.7

2. SETTLEMENT CONTOURS FOR THE STATIONS, SHAFT, CUT & COVER, AND DECLINE STRUCTURES ARE BASED ON WALL DEFLECTIONS CALCULATED FROM FINITE ELEMENT MODELLING.

3. SETTLEMENT CONTOURS FOR THE STATIONS, SHAFT, CUT & COVER, AND DECLINE STRUCTURES ARE SUPERIMPOSED WITH THE TUNNEL SETTLEMENT CONTOURS TO SHOW THE TOTAL MAXIMUM SETTLEMENT FROM ALL CONSTRUCTION WORKS.

4. ESTIMATED CONSOLIDATION SETTLEMENT IS NOT SHOWN. REFER TO DRAWING MMR-AJM-PWAA-DR-NN-500377.

5. ESTIMATED INFLUENCE ZONE IS REPRESENTED BY THE AREA ENCLOSED BY THE 5mm CONTOUR LINES. REFER TO GIS FOR AFFECTED PROPERTY DETAILS. CONDITION SURVEY REQUIRED AND MONITORING PROGRAM TO BE IMPLEMENTED DURING CONSTRUCTION FOR STRUCTURES WITHIN THE INFLUENCE ZONE. EXTENT OF INFLUENCE ZONE MAY INCREASE WHERE COMPRESSIBLE SEDIMENTS ARE PRESENT.

6. TRACK ALIGNMENT SHOWN IS BASED ON TRACK ALIGNMENT VERSION P2.6. STATION EXTENTS SHOWN ARE BASED ON ARCHITECTURAL VERSION 3.9.

7. SETTLEMENT ASSESSMENT AND RESULTING CONTOURS BASED ON TRACK ALIGNMENT VERSION P2.3.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 1 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

N

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture

aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

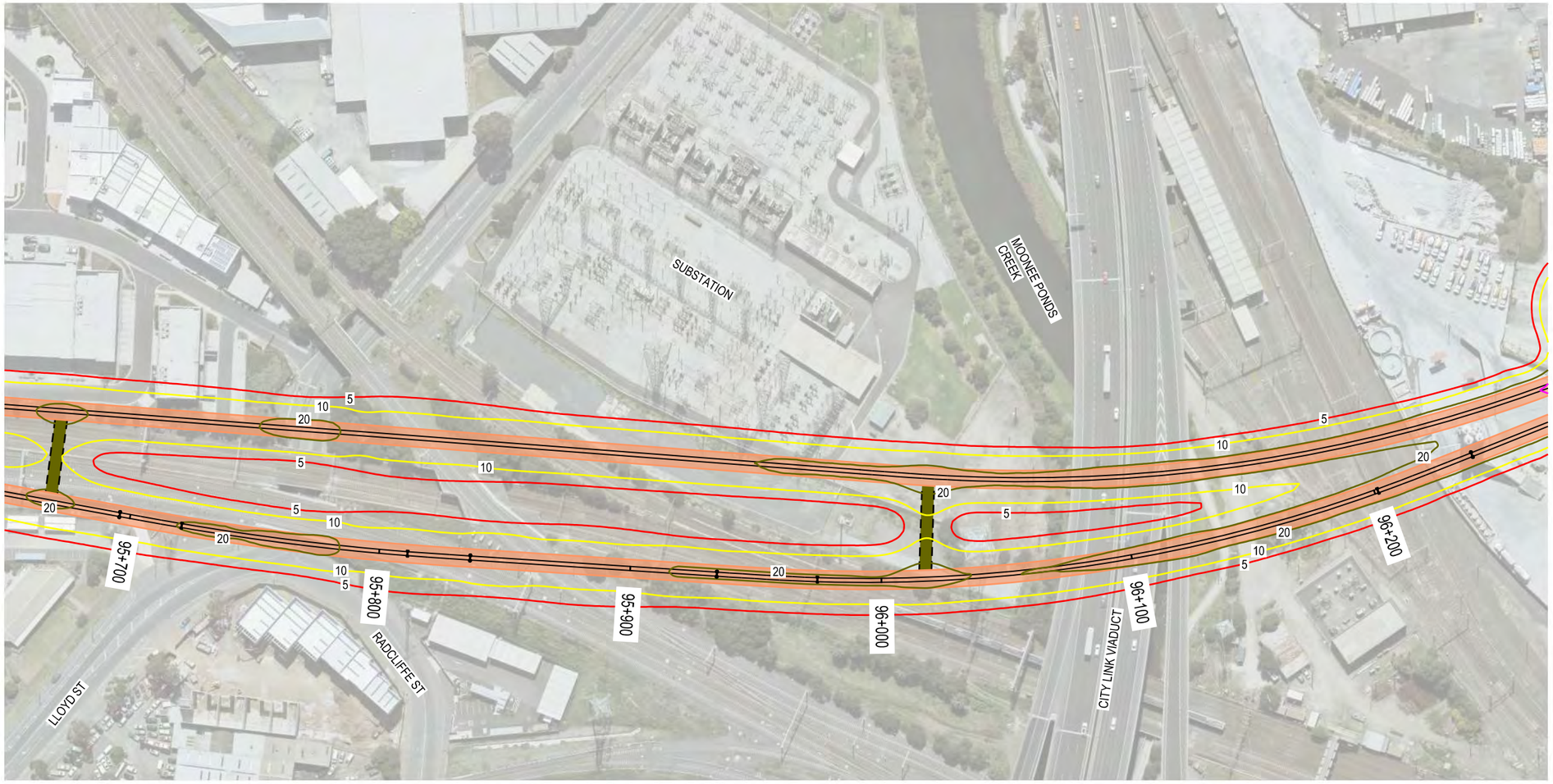
Title
SETTLEMENT CONTOURS
SHEET 2 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

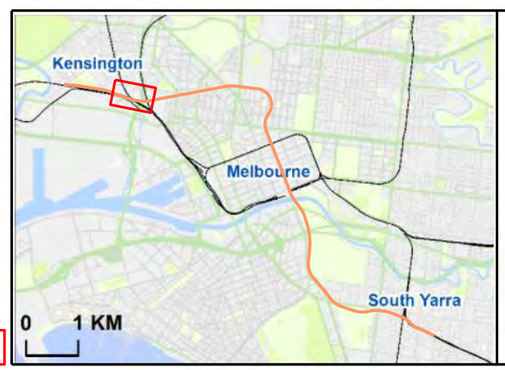
CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

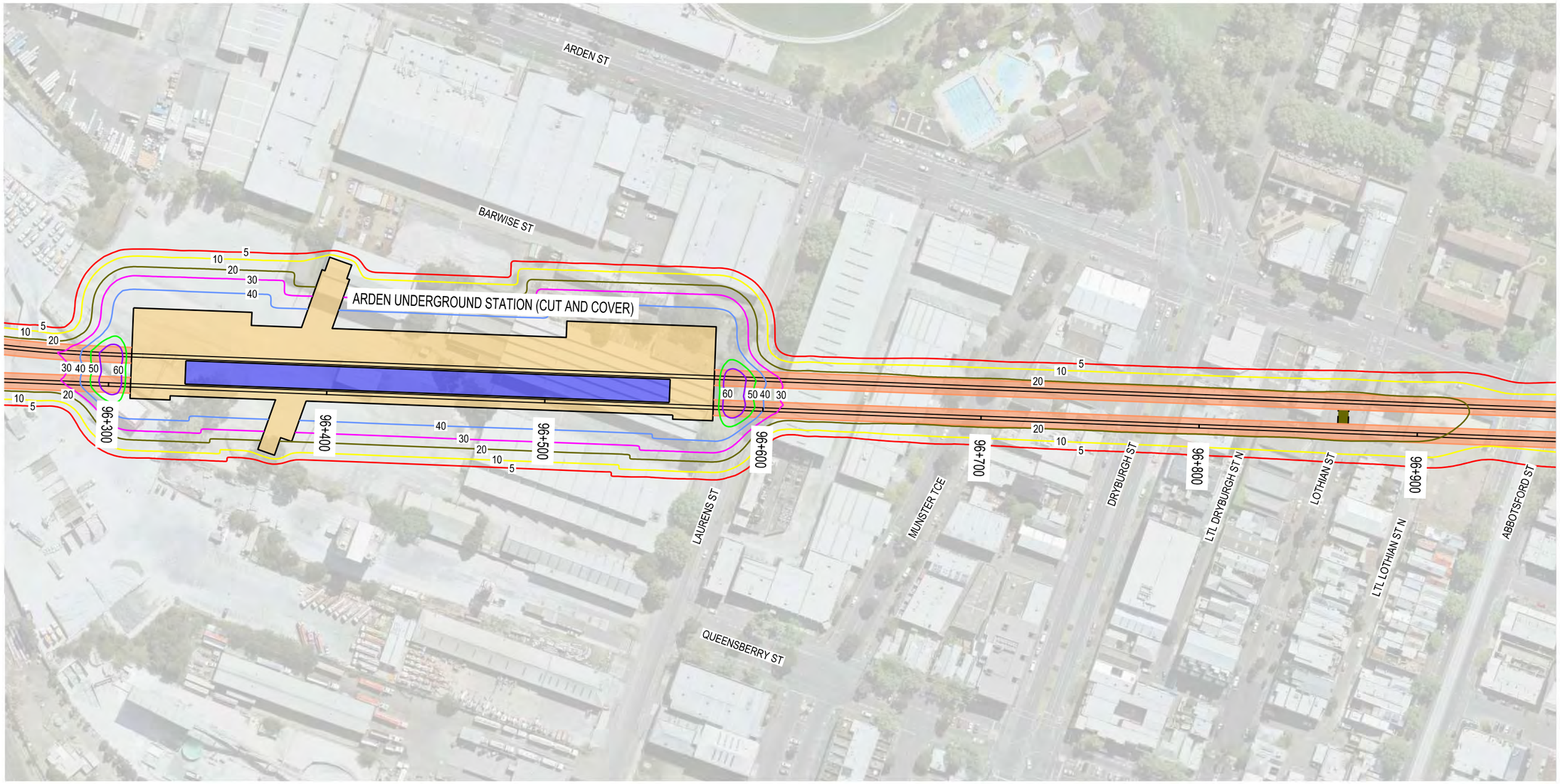
AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title			
SETTLEMENT CONTOURS			SHEET 3 OF 15
Drawing Number			Revision
MMR-AJM-UGAA-DR-NN-500431			P1.1
Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS
SHEET 4 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

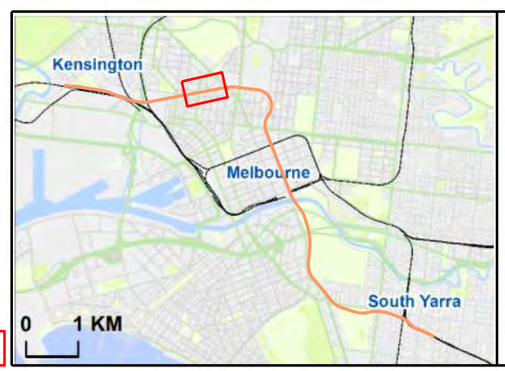
CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture

aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

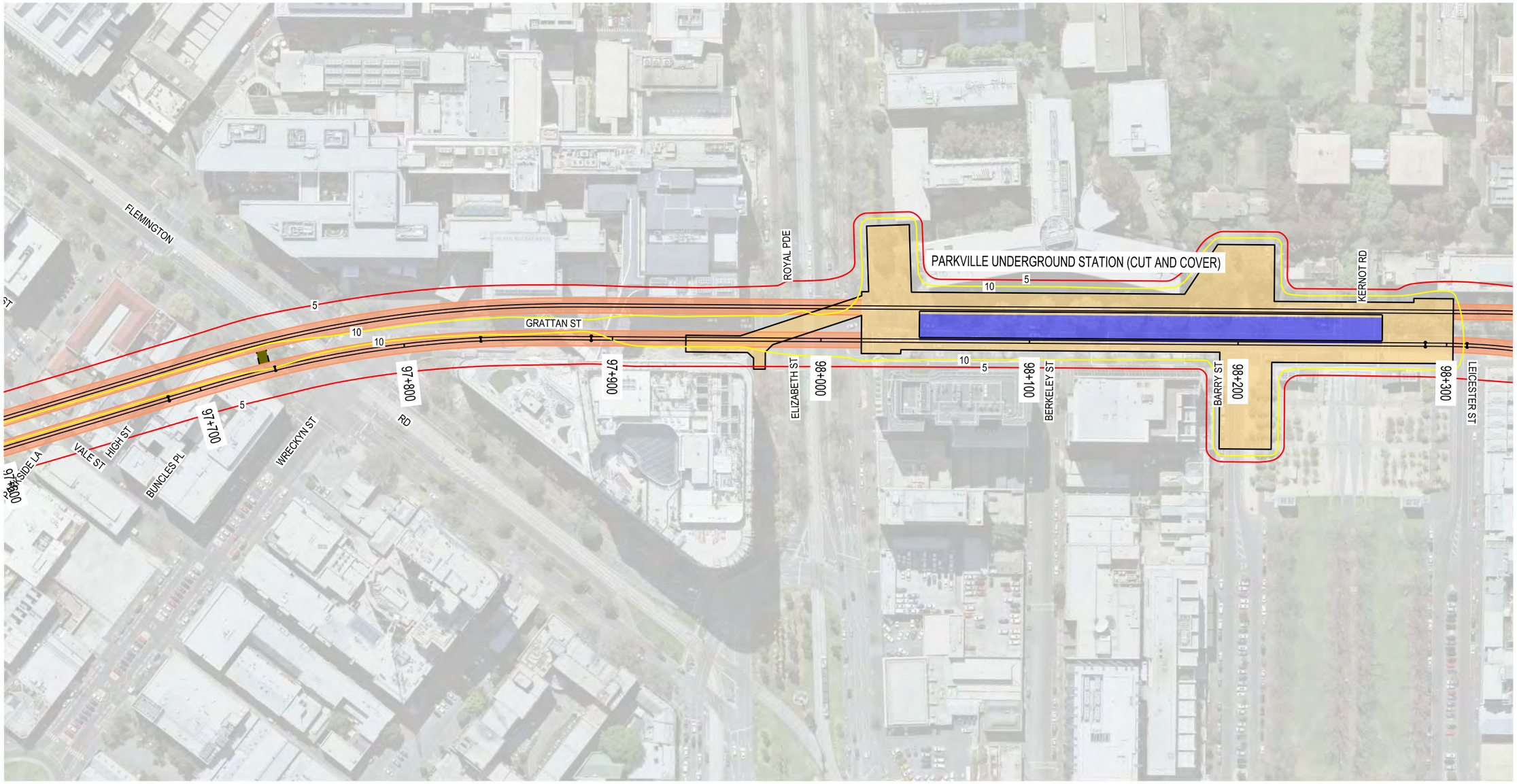
Title
SETTLEMENT CONTOURS
SHEET 5 OF 15

Drawing Number
MMR-AJM-UGAA-DR-NN-500431
Revision
P1.1

Drawn By
N WIJERAYHNE
Approved By
Date
Map Size
A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 6 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

N

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

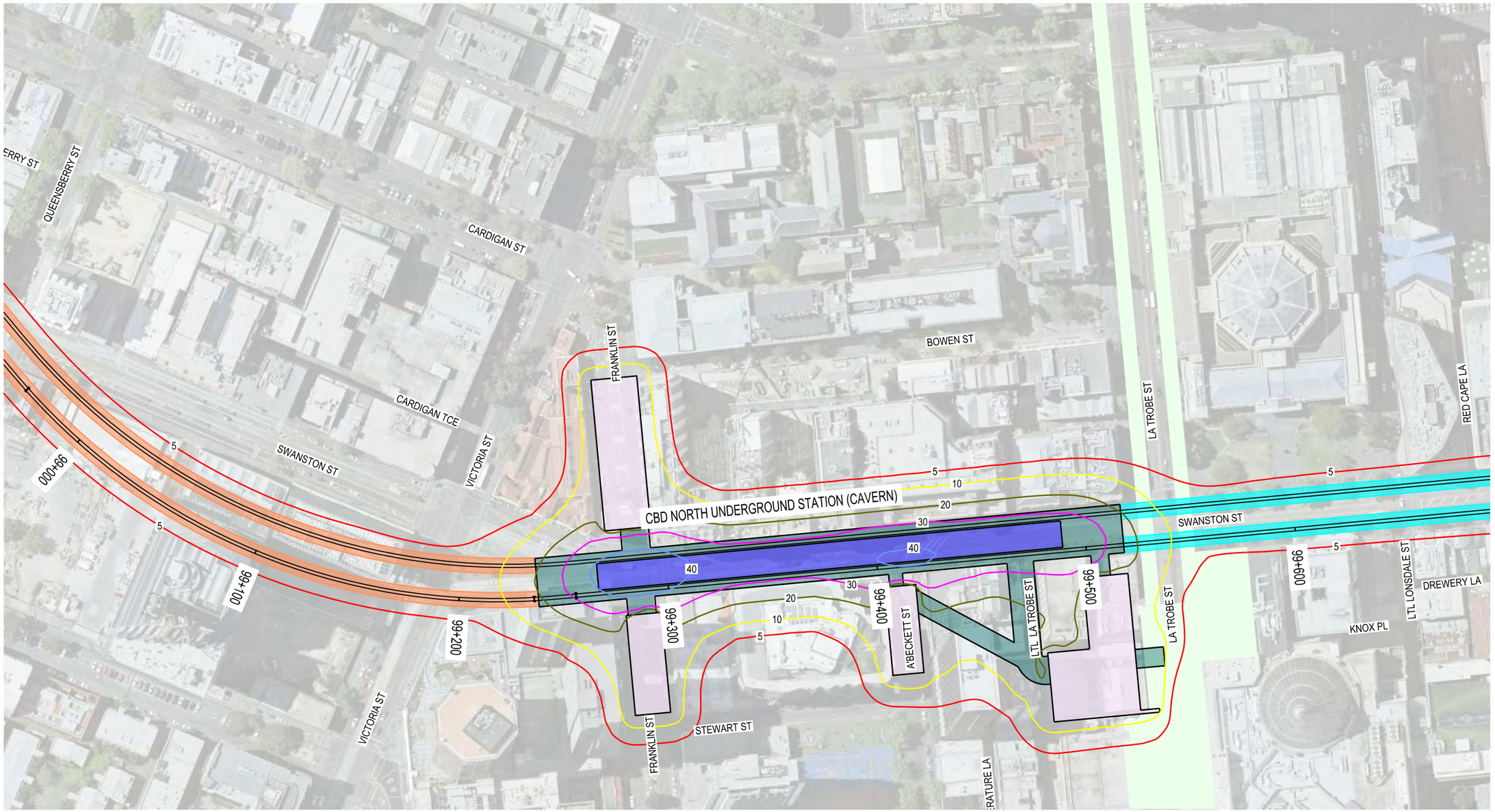
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS
SHEET 7 OF 15

Drawing Number
MMR-AJM-UGAA-DR-NN-500431
Revision
P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

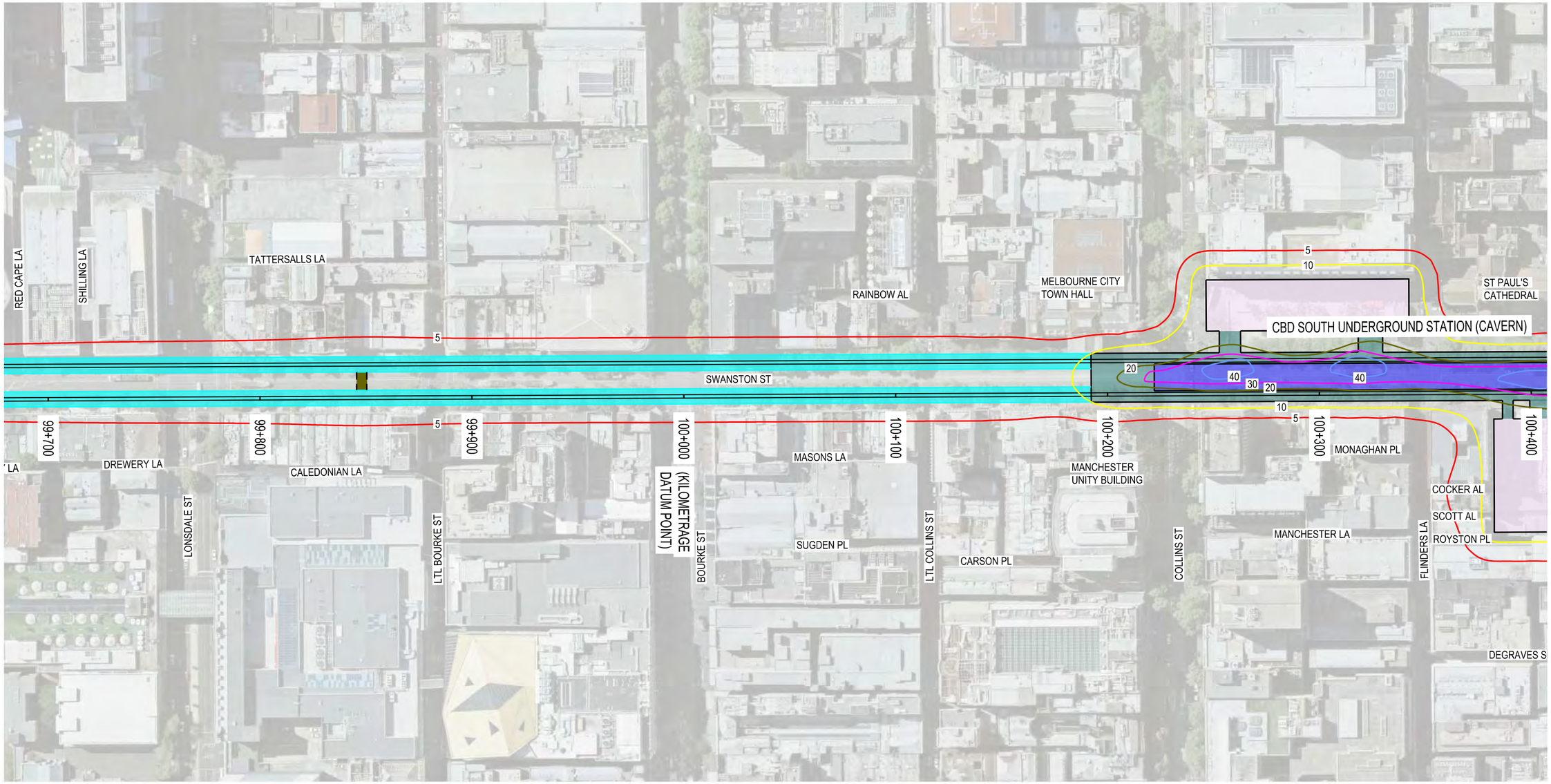
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 8 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture

aurecon JACOBS Mott MacDonald in association with GRIMSHAW

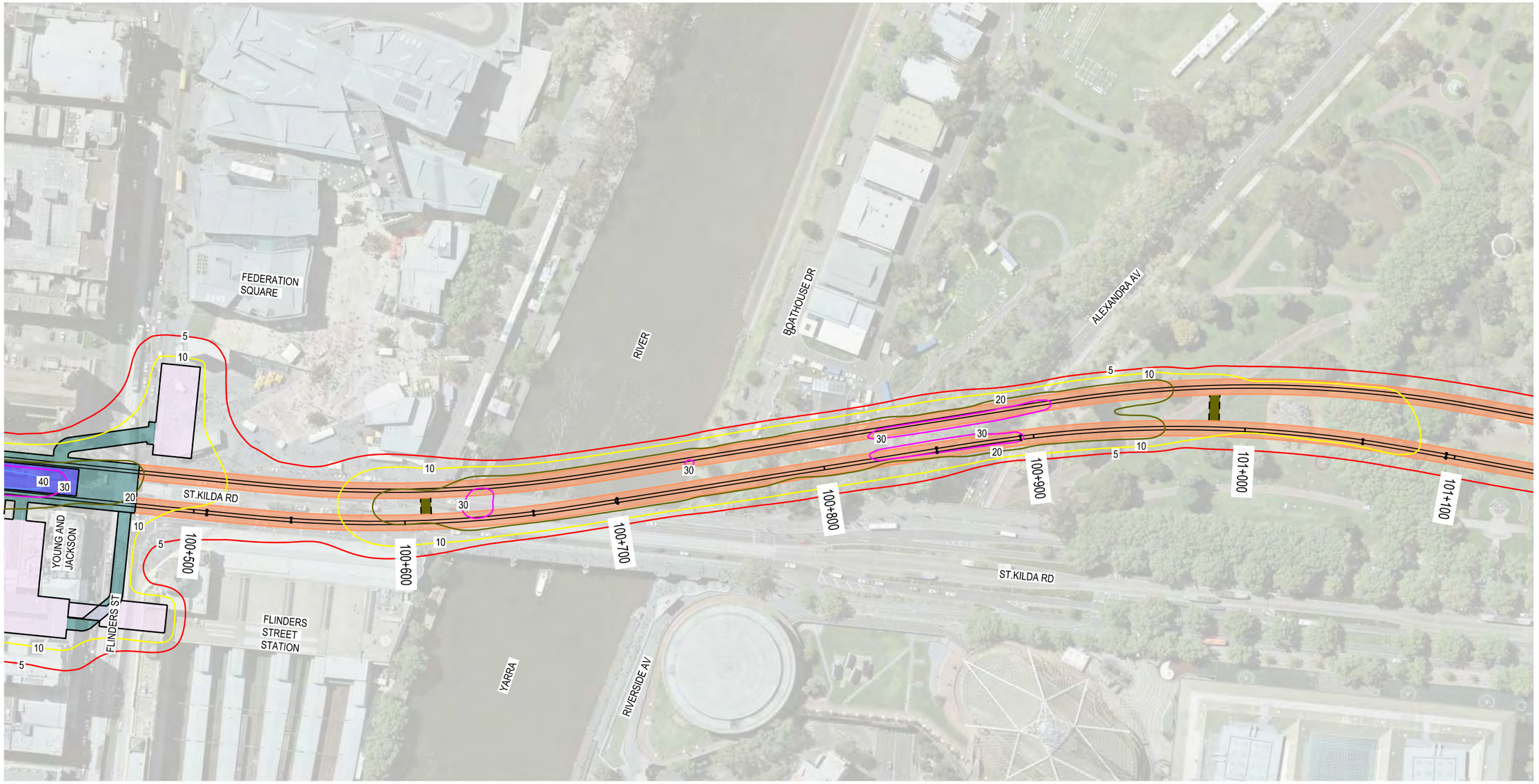
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS
SHEET 9 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.
2. SETTLEMENT AT PRINCESS BRIDGE IS DEPENDENT ON THE QUALITY OF BASALT FORMATION.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

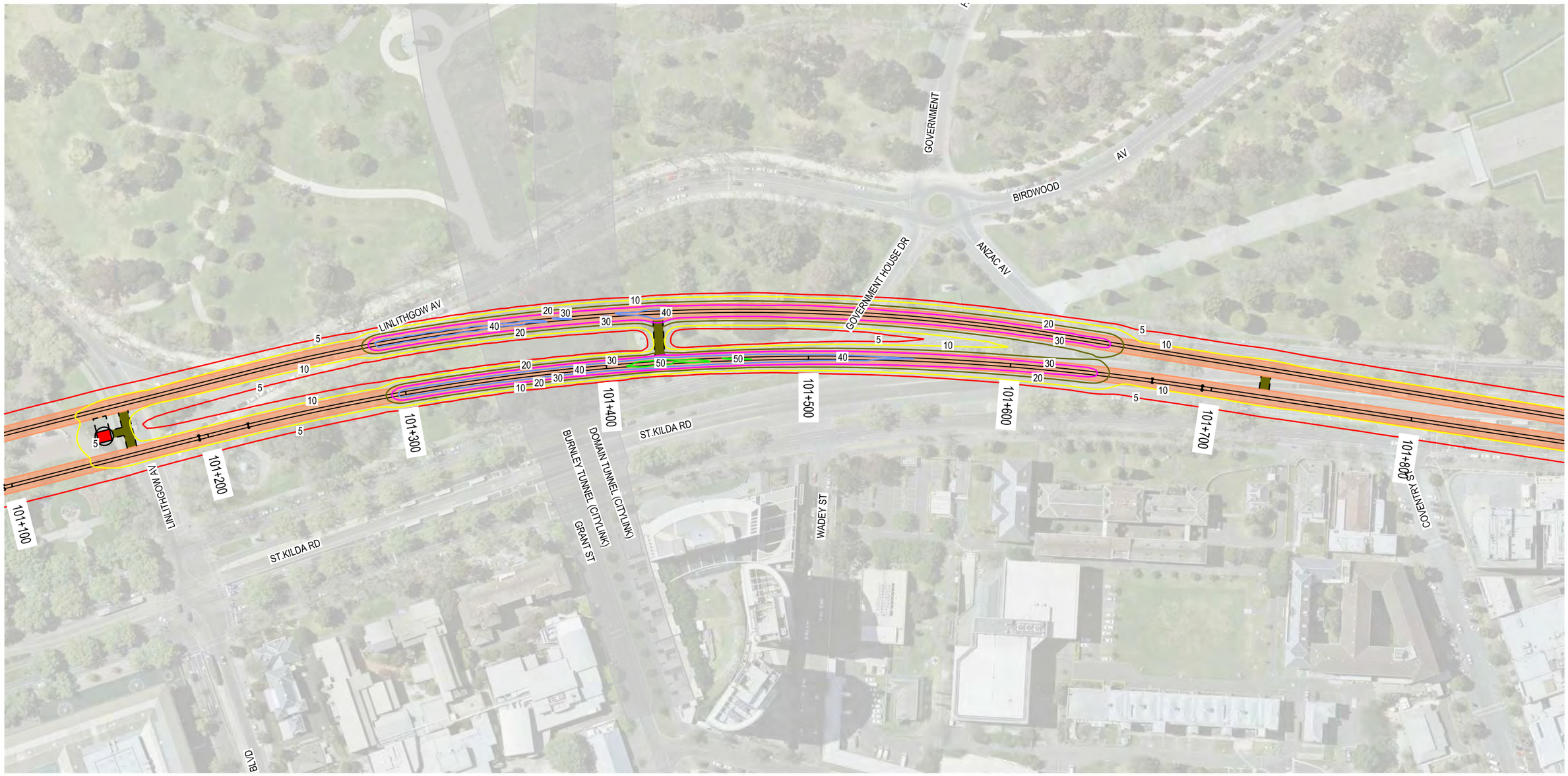
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 10 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

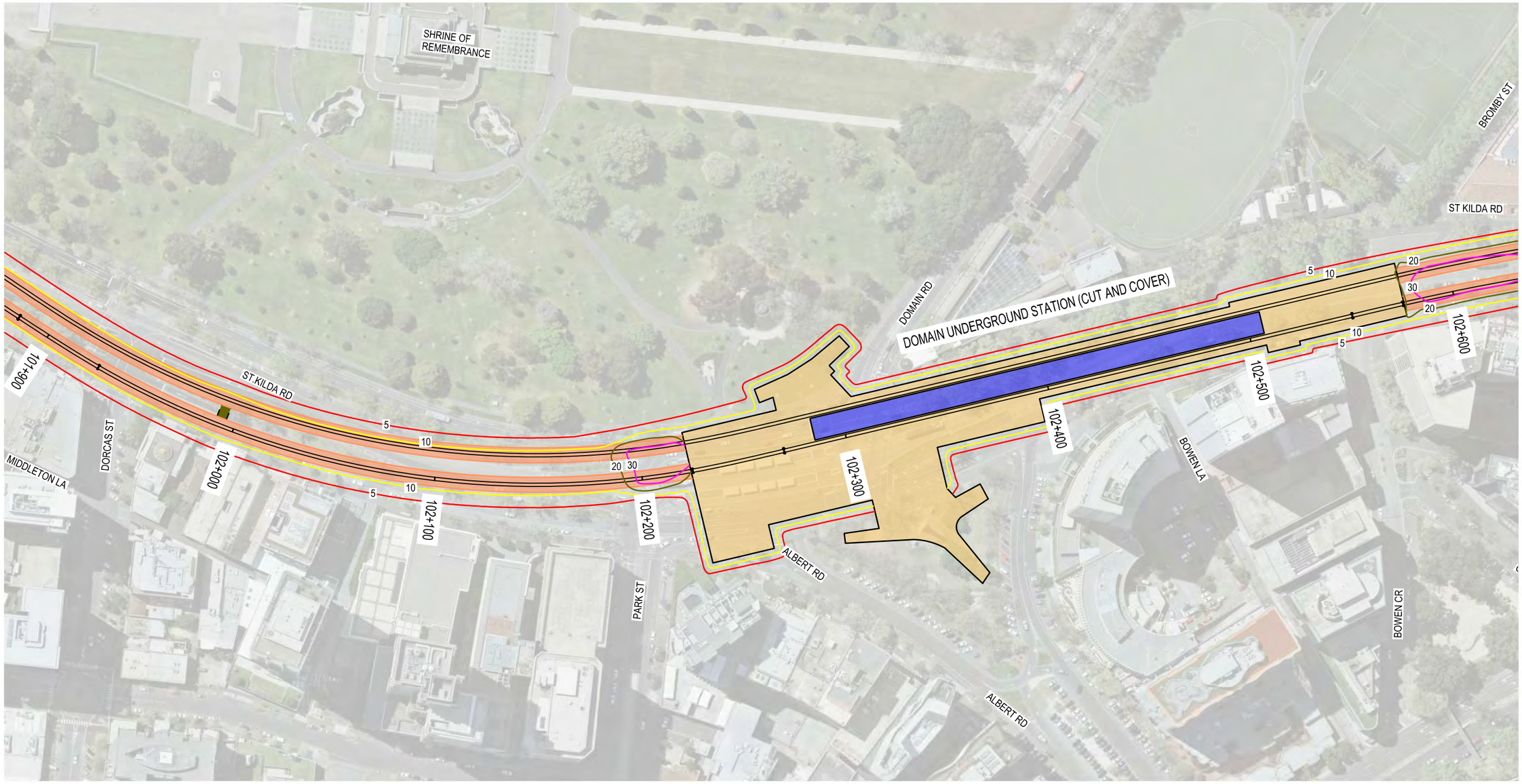
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 11 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS — SHEET 12 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS
SHEET 13 OF 15

Drawing Number			Revision
MMR-AJM-UGAA-DR-NN-500431			P1.1
Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

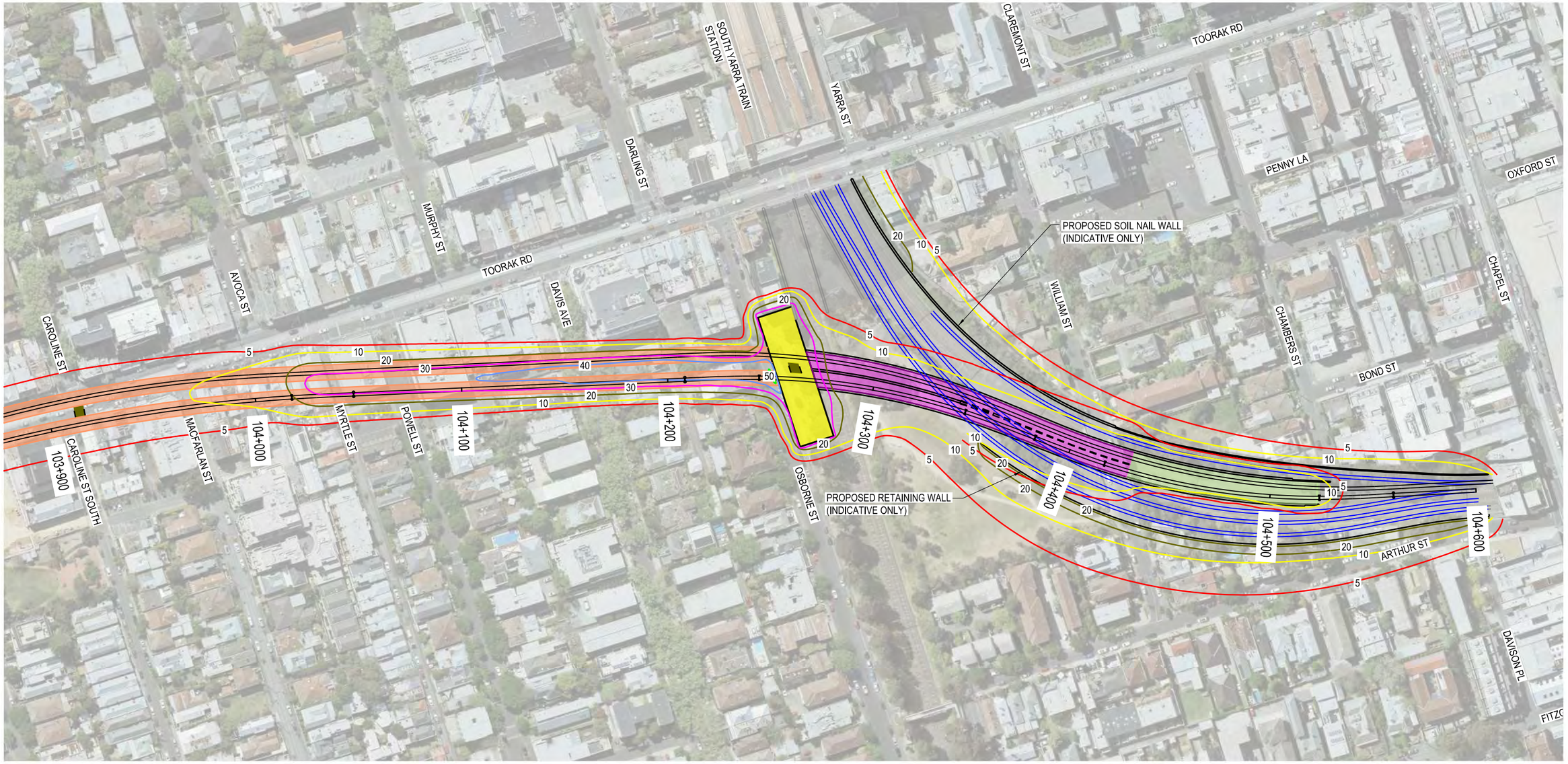
Title
SETTLEMENT CONTOURS — SHEET 14 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

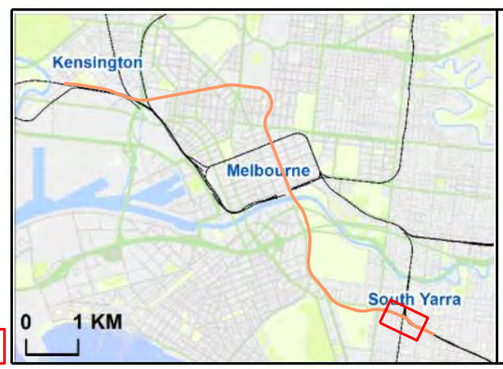
CONCEPT DESIGN: EXCAVATION INDUCED SETTLEMENT CONTOURS

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS
SHEET 15 OF 15

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500431	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERAYHNE			A3

N

0 50 100m

PLAN

NOTES

1. TUNNELLING INDUCED SETTLEMENT CONTOURS ARE BASED ON THE FOLLOWING ASSUMPTIONS:

GROUND TYPE	VOLUME LOSS (%)	TROUGH WIDTH PARAMETER
SOIL (ALL TYPES)	1.0	0.4
ROCK	0.5	0.6
ROCK (> 2D COVER)	0.5	0.7

2. SETTLEMENT CONTOURS FOR THE STATIONS, SHAFT, CUT & COVER, AND DECLINE STRUCTURES ARE BASED ON WALL DEFLECTIONS CALCULATED FROM FINITE ELEMENT MODELLING.
3. SETTLEMENT CONTOURS FOR THE STATIONS, SHAFT, CUT & COVER, AND DECLINE STRUCTURES ARE SUPERIMPOSED WITH THE TUNNEL SETTLEMENT CONTOURS TO SHOW THE TOTAL MAXIMUM SETTLEMENT FROM ALL CONSTRUCTION WORKS.
4. ESTIMATED CONSOLIDATION SETTLEMENT IS NOT SHOWN. REFER TO DRAWING MMR-AJM-PWAA-DR-NN-500377.
5. ESTIMATED INFLUENCE ZONE IS REPRESENTED BY THE AREA ENCLOSED BY THE 5mm CONTOUR LINES. REFER TO GIS FOR AFFECTED PROPERTY DETAILS. CONDITION SURVEY REQUIRED AND MONITORING PROGRAM TO BE IMPLEMENTED DURING CONSTRUCTION FOR STRUCTURES WITHIN THE INFLUENCE ZONE. EXTENT OF INFLUENCE ZONE MAY INCREASE WHERE COMPRESSIBLE SEDIMENTS ARE PRESENT.
6. TRACK ALIGNMENT SHOWN IS BASED ON TRACK ALIGNMENT SHOWN ON DRG. MMR-AJM-PWAA-DR-DD-600191 [P2.3] AND DRG. MMR-AJM-PWAA-DR-DD-600192 [P2.2].

ALTERNATIVE DESIGN OPTION: EXCAVATION INDUCED SETTLEMENT CONTOURS - WESTERN PORTAL

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

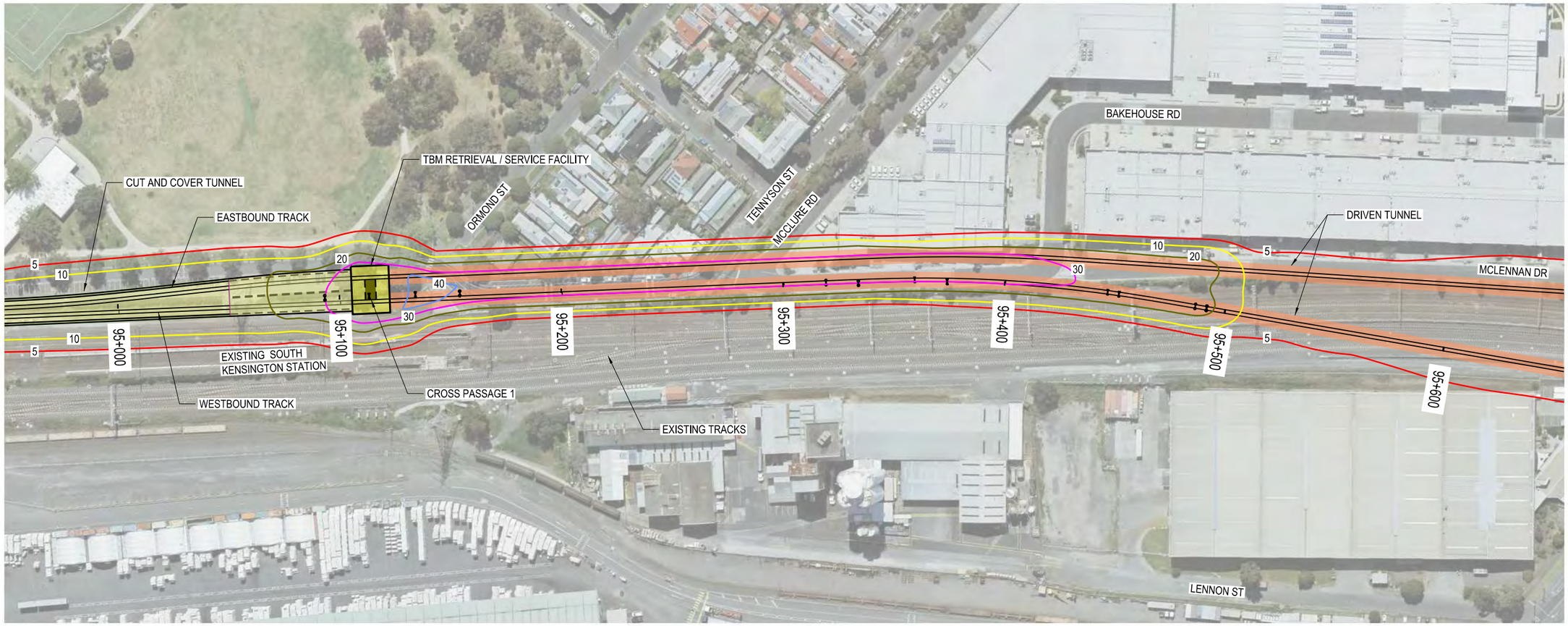
Title
SETTLEMENT CONTOURS
SHEET 1 OF 2

Drawing Number
MMR-AJM-UGAA-DR-NN-500381
Revision
P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500381 SHEET 1 OF 2.

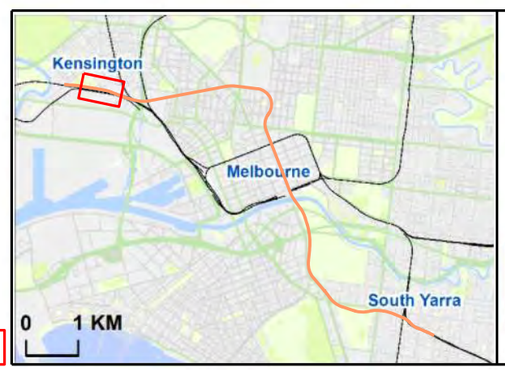
ALTERNATIVE DESIGN OPTION: EXCAVATION INDUCED SETTLEMENT CONTOURS - WESTERN PORTAL

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

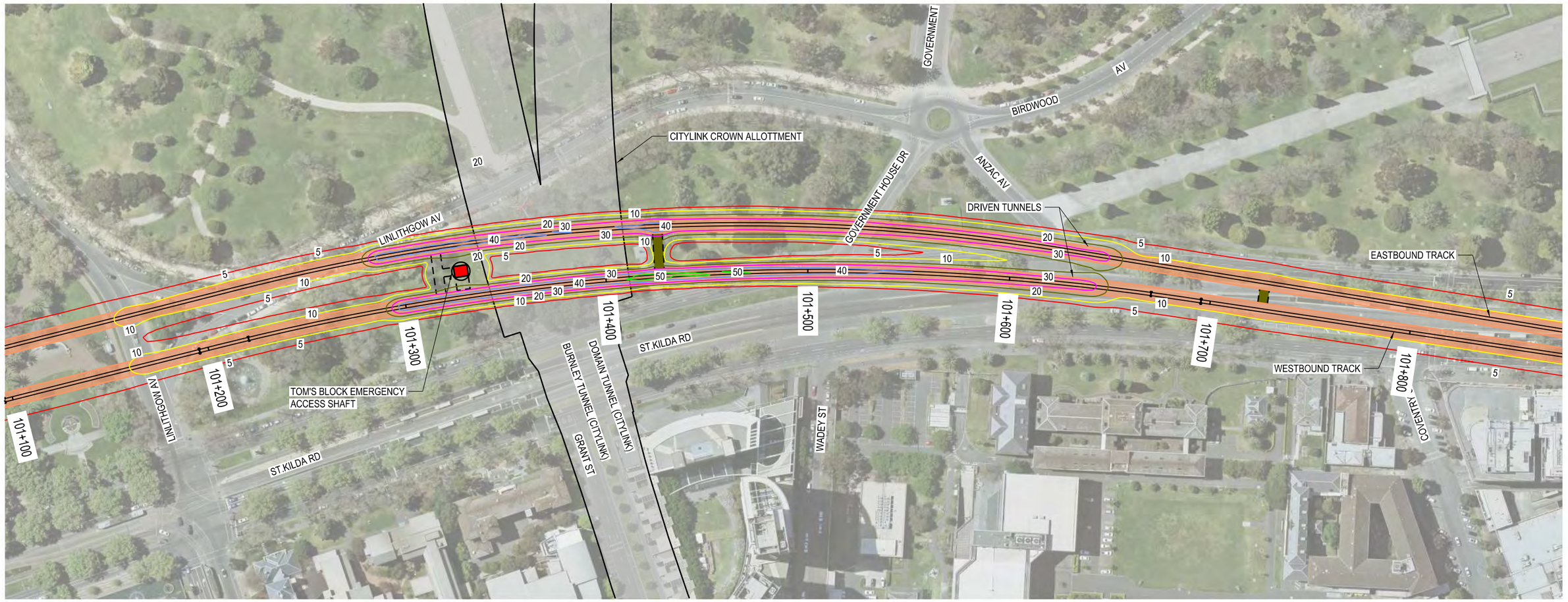
Title
SETTLEMENT CONTOURS — SHEET 2 OF 2

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500381	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

N

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

ALTERNATIVE DESIGN OPTION: EXCAVATION INDUCED
SETTLEMENT CONTOURS - TOM'S BLOCK EMERGENCY ACCESS SHAFT

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS — Mott MacDonald in association with GRIMSHAW

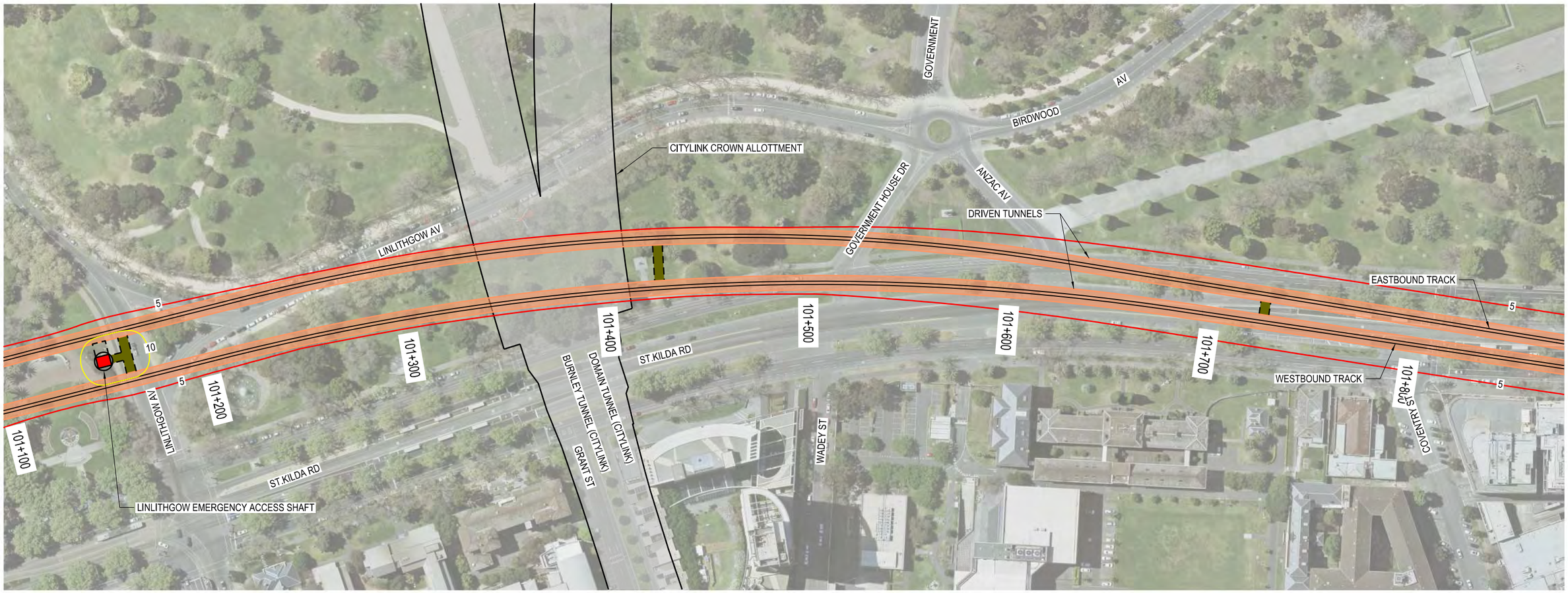
Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500383	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

0 50 100m



PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

ALTERNATIVE DESIGN OPTION: EXCAVATION INDUCED SETTLEMENT CONTOURS - CITYLINK UNDER CROSSING

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500384	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

0 50 100m

PLAN

NOTES

1. FOR NOTES REFER DRG. MMR-AJM-UGAA-DR-NN-500431 SHEET 1 OF 15.

ALTERNATIVE DESIGN OPTION: EXCAVATION INDUCED
SETTLEMENT CONTOURS - FAWKNER PARK EMERGENCY ACCESS SHAFT

LEGEND

- MMRP TRACKS
- TRACKS TO BE REMOVED
- TRACKS TO BE REALIGNED
- RETAINING WALL / VERTICAL WALL
- DIVIDING WALL
- BATTERS
- CUT AND COVER STATION FOOTPRINT
- PLATFORM
- DECLINE STRUCTURE
- TUNNEL - DRIVEN
- TUNNEL - CUT & COVER
- CROSS PASSAGE
- PRECAST CONCRETE RETAINING WALL
- SERVICE FACILITY / TBM RETRIEVAL POINT
- TUNNEL - MINED
- CITY LOOP
- CITYLINK CROWN ALLOTMENT
- EMERGENCY ACCESS SHAFT
- CAVERN STATION ENTRANCE AND PLANT SHAFT (TYP)
- MINED STATION MAIN CAVERN
- 5mm SETTLEMENT
- 10mm SETTLEMENT
- 20mm SETTLEMENT
- 30mm SETTLEMENT
- 40mm SETTLEMENT
- 50mm SETTLEMENT
- 60mm SETTLEMENT
- 70mm SETTLEMENT

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
SETTLEMENT CONTOURS

Drawing Number	Revision
MMR-AJM-UGAA-DR-NN-500385	P1.1

Drawn By	Approved By	Date	Map Size
N WIJERATHNE			A3

0 50 100m

APPENDIX E

Indicative Contours of Consolidation Settlement due to Groundwater Drawdown

MELBOURNE METRO RAIL PROJECT
GROUND MOVEMENT ASSESSMENT
INDICATIVE CONTOURS OF PRIMARY CONSOLIDATION SETTLEMENT DUE TO GROUNDWATER DRAWDOWN

LEGEND

- PROPOSED STATION EXTENT IN PLAN
- CONTROL LINE PROPOSED WESTBOUND RAIL TUNNEL
- CONTROL LINE PROPOSED EASTBOUND RAIL TUNNEL
- INDICATIVE RAIL INFRASTRUCTURE
- RECENT SILT
- COODE ISLAND SILT
- INFERRED EXTENT OF NEWER VOLCANICS (BASALT)

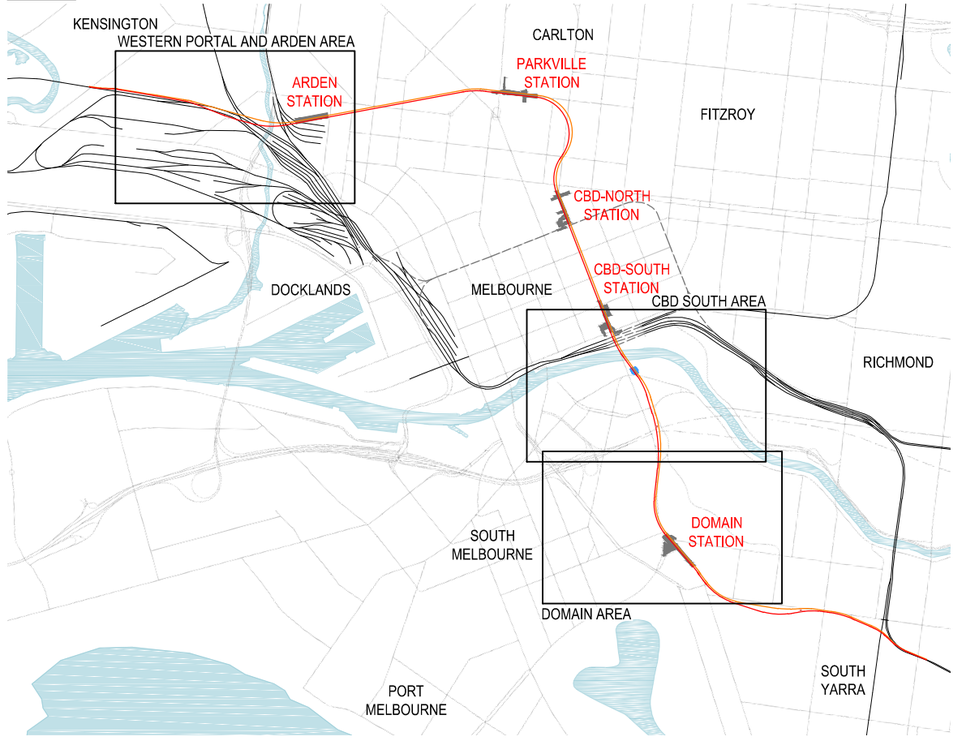
LEGEND INDICATIVE PRIMARY CONSOLIDATION SETTLEMENT

- < 10mm
- 10-20mm
- 20-50mm
- > 50mm

INDICATIVE SETTLEMENT DUE TO CONSOLIDATION OF COODE ISLAND SILT, INDUCED BY GROUNDWATER DRAWDOWN.

FIGURE LIST

KEY MAP



NOTES

1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES TO AHD.
3. ALL CO-ORDINATES ARE IN METRES TO MGA-55.
4. AERIAL PHOTOGRAPH HAS 50% TRANSPARENCY APPLIED.
5. EXISTING STRUCTURES ARE INDICATIVE ONLY.
6. EXTENTS OF INDICATIVE SETTLEMENT DUE TO CONSOLIDATION OF COODE ISLAND SILT ARE BASED ON PRELIMINARY EES GROUNDWATER MODELLING RESULTS.
7. SETTLEMENT ASSESSMENT CONSIDERED THE ESTIMATED MAXIMUM GROUNDWATER DRAWDOWNS RESULTING FROM MMRP WORKS, FOR THE CONSTRUCTION AND OPERATIONAL PHASES FOR THE VARIOUS SCENARIOS CONSIDERED.
8. THESE DRAWINGS SHOULD BE READ IN CONJUNCTION WITH GROUND MOVEMENT ASSESSMENT REPORT BY GOLDER ASSOCIATES FOR MMRP.

REFERENCES

1. TUNNEL ALIGNMENT BASED ON PROPOSED RAIL ALIGNMENT (REVISION 2.3) SOURCED FROM AJM JV, FILE <MMR-AJM-PWAA-M2-DD-D08000-TRACK.DWG> AND <MMR-AJM-PWAA-M2-DD-D08000-PROF.DWG>, RECEIVED BY GOLDER ASSOCIATES 28-10-2015.
2. TUNNEL INFRASTRUCTURE SOURCED FROM AJM-JV FILE <MMR-AJM-PWAA-M2-CS-D05000-TNNL-STR.dwg>, RECEIVED BY GOLDER 16-11-2015.
3. STATION EXTENTS (REVISION 3.3) SOURCED FROM AJM JV, DWG FILE <MMR-AJM-PMAA-M2-DD-D05000_STN_EXTENT.dwg>, RECEIVED BY GOLDER ASSOCIATES 16-11-2015.
4. AERIAL PHOTOGRAPH DATE OF CAPTURE OCTOBER 2014, IMAGE RESOLUTION 10 cm, SOURCED FROM PUBLIC TRANSPORT VICTORIA.
5. TOPOGRAPHY, ROADS AND RAIL DATA SOURCED FROM VICMAP 2013.

PRESENTED CONTOURS DO NOT INCLUDE AN ALLOWANCE FOR SETTLEMENT DUE TO MMRP EXCAVATIONS OR FOR FUTURE CREEP MOVEMENT OF THE COODE ISLAND SILT. FOR CONTOURS OF SETTLEMENT DUE TO MMRP EXCAVATIONS REFER TO DRAWINGS MMR-AJM-UGAA-DR-NN-500431-500445 AND MMR-AJM-UGAA-DR-NN-500381-500385

Note:
Surface works are not shown

NOT FOR CONSTRUCTION

MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture

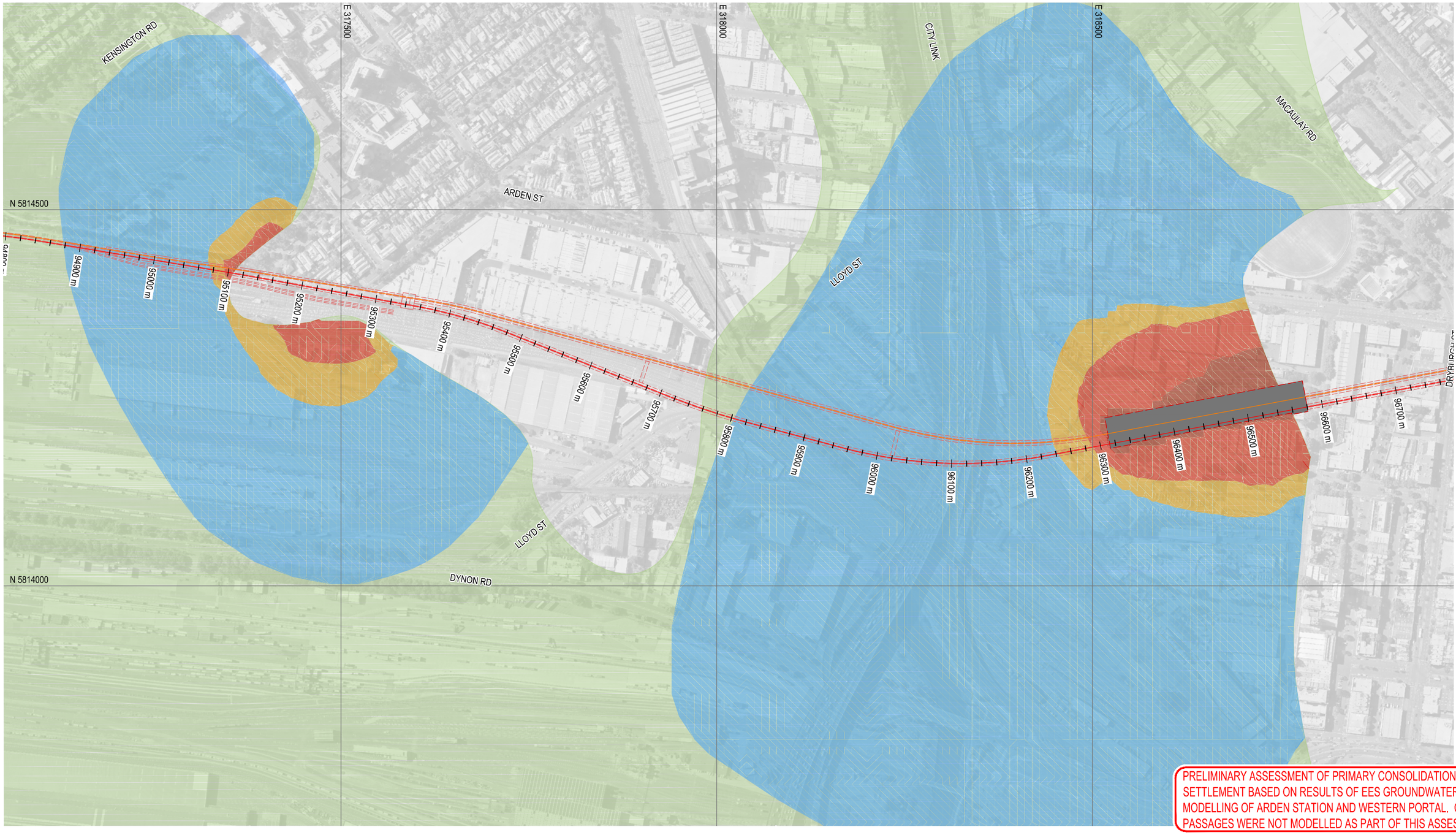
aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
GROUND MOVEMENT ASSESSMENT SHEET 1 OF 4

Drawing Number		Revision
MMR-AJM-PWAA-DR-NN-500377		P1.1
Drawn By	Approved By	Date	Map Size
GOLDER	SLVB	23-03-2016	A3

N



PRELIMINARY ASSESSMENT OF PRIMARY CONSOLIDATION SETTLEMENT BASED ON RESULTS OF EES GROUNDWATER MODELLING OF ARDEN STATION AND WESTERN PORTAL. CROSS PASSAGES WERE NOT MODELLED AS PART OF THIS ASSESSMENT.

LEGEND INDICATIVE PRIMARY CONSOLIDATION SETTLEMENT

< 10mm
10-20mm
20-50mm
> 50mm

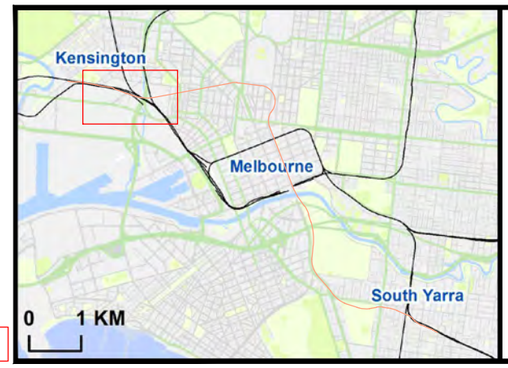
INDICATIVE SETTLEMENT DUE TO CONSOLIDATION OF COODE ISLAND SILT, INDUCED BY GROUNDWATER DRAWDOWN.

NOTES

1. REFER FIGURE MMR-AJM-PWAA-DR-NN-500377-SHEET 1 OF 4 FOR NOTES AND LEGEND.
2. ALL LEVELS ARE IN METRES TO AHD.
3. ALL COORDINATES ARE IN METRES TO MGA-Z55
4. THESE DRAWINGS SHOULD BE READ IN CONJUNCTION WITH GOLDER ASSOCIATES GROUND MOVEMENT ASSESSMENT EES SUMMARY REPORT PREPARED FOR MELBOURNE METRO.

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture
aurecon JACOBS
Mott MacDonald in association with GRIMSHAW

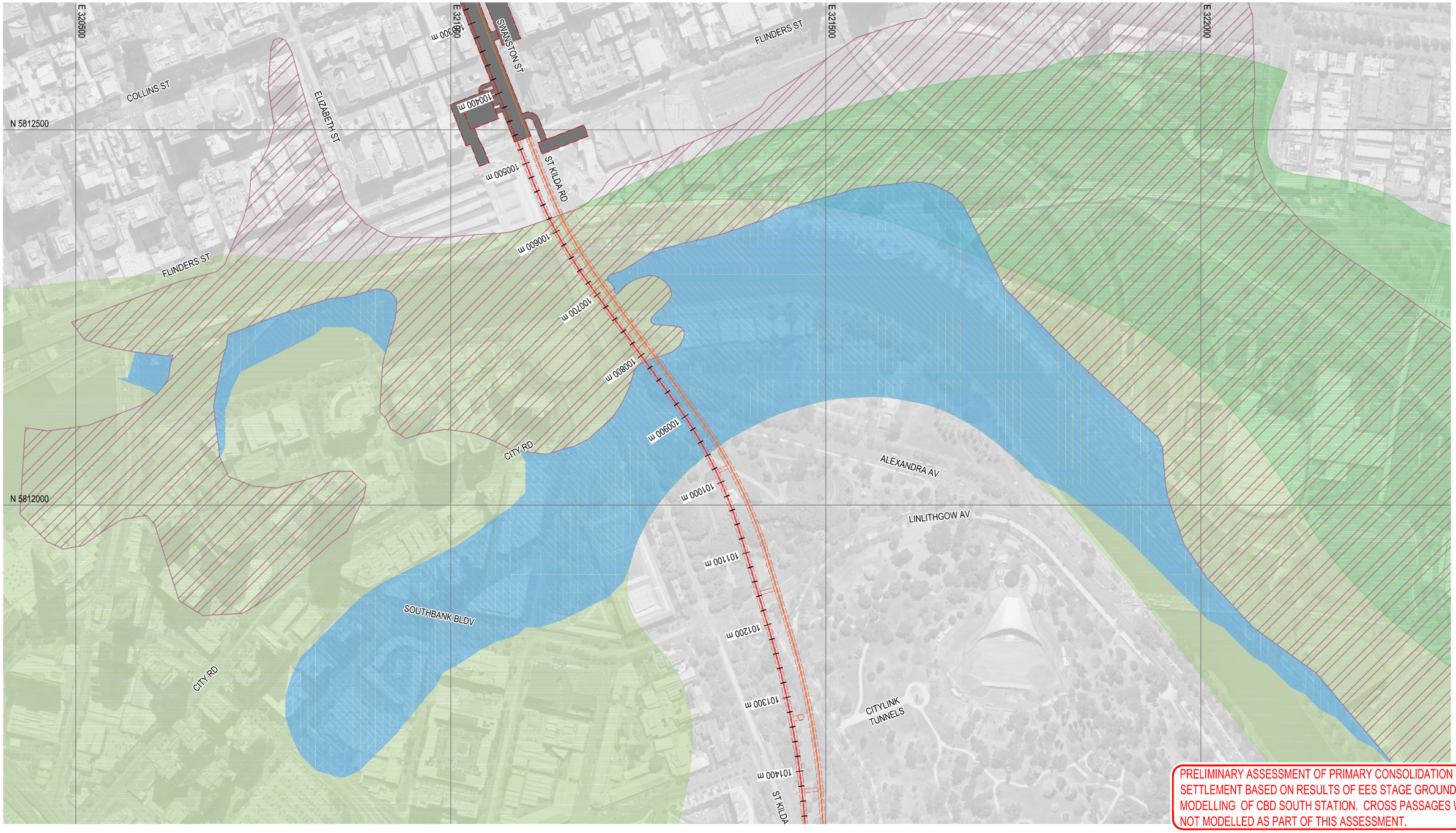
Melbourne Metro Rail Project

Title
GROUND MOVEMENT ASSESSMENT SHEET 2 OF 4

Drawing Number		Revision
MMR-AJM-PWAA-DR-NN-500377		P1.1
Drawn By	Approved By	Date	Map Size
GOLDER	SLVB	23-03-2016	A3

N

0 50 100 150 200 250m



PRELIMINARY ASSESSMENT OF PRIMARY CONSOLIDATION SETTLEMENT BASED ON RESULTS OF EES STAGE GROUNDWATER MODELLING OF CBD SOUTH STATION. CROSS PASSAGES WERE NOT MODELLED AS PART OF THIS ASSESSMENT.

LEGEND INDICATIVE PRIMARY CONSOLIDATION SETTLEMENT

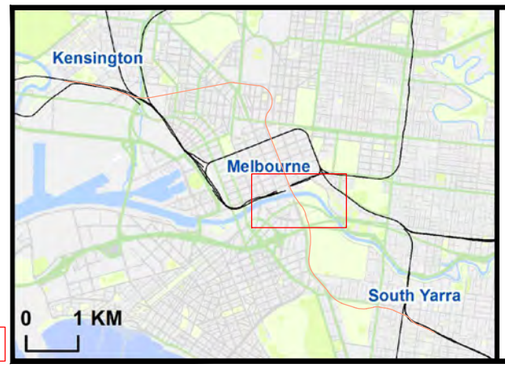
< 10mm 10-20mm 20-50mm > 50mm	INDICATIVE SETTLEMENT DUE TO CONSOLIDATION OF COODE ISLAND SILT, INDUCED BY GROUNDWATER DRAWDOWN.

NOTES

1. REFER FIGURE MMR-AJM-PWAA-DR-NN-500377-SHEET 1 OF 4 FOR NOTES AND LEGEND.
2. ALL LEVELS ARE IN METRES TO AHD.
3. ALL COORDINATES ARE IN METRES TO MGA-Z55
4. THESE DRAWINGS SHOULD BE READ IN CONJUNCTION WITH GOLDER ASSOCIATES GROUND MOVEMENT ASSESSMENT EES SUMMARY REPORT PREPARED FOR MELBOURNE METRO.

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture aurecon JACOBS Mott MacDonald in association with GRIMSHAW

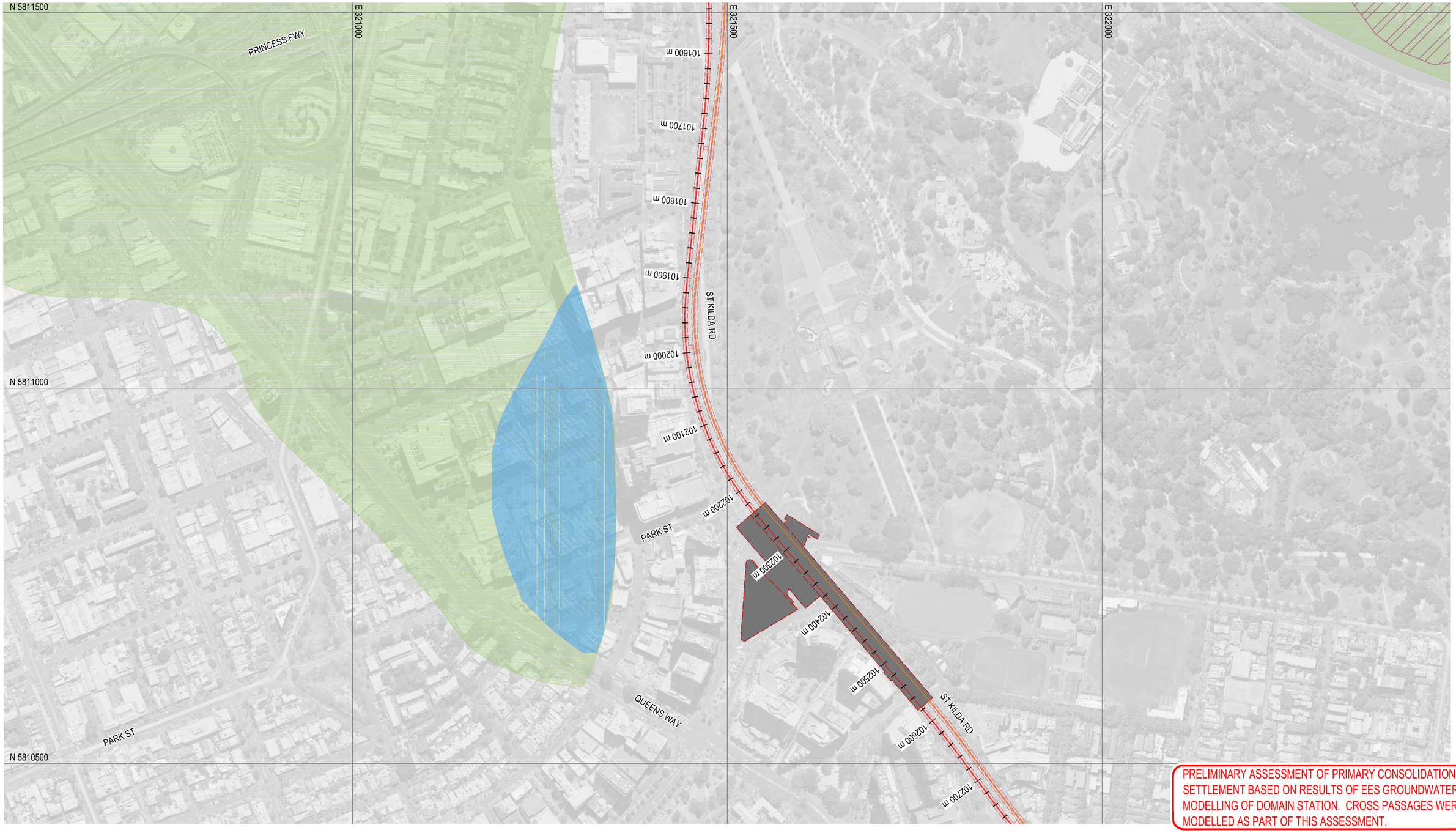
Melbourne Metro Rail Project

Title
GROUND MOVEMENT ASSESSMENT SHEET 3 OF 4

Drawing Number			Revision
MMR-AJM-PWAA-DR-NN-500377			P1.1
Drawn By	Approved By	Date	Map Size
GOLDER	SLVB	23-03-2016	A3

N

0 50 100 150 200 250m



PRELIMINARY ASSESSMENT OF PRIMARY CONSOLIDATION SETTLEMENT BASED ON RESULTS OF EES GROUNDWATER MODELLING OF DOMAIN STATION. CROSS PASSAGES WERE NOT MODELLED AS PART OF THIS ASSESSMENT.

LEGEND INDICATIVE PRIMARY CONSOLIDATION SETTLEMENT

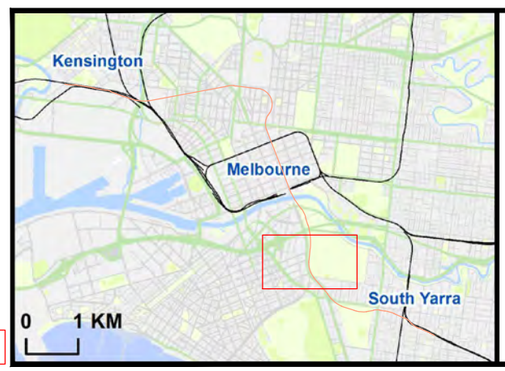
< 10mm 10-20mm 20-50mm > 50mm	INDICATIVE SETTLEMENT DUE TO CONSOLIDATION OF COODE ISLAND SILT, INDUCED BY GROUNDWATER DRAWDOWN.

NOTES

1. REFER FIGURE MMR-AJM-PWAA-DR-NN-500377-SHEET 1 OF 4 FOR NOTES AND LEGEND.
2. ALL LEVELS ARE IN METRES TO AHD.
3. ALL COORDINATES ARE IN METRES TO MGA-Z55
4. THESE DRAWINGS SHOULD BE READ IN CONJUNCTION WITH GOLDER ASSOCIATES GROUND MOVEMENT ASSESSMENT EES SUMMARY REPORT PREPARED FOR MELBOURNE METRO.

Note:
Surface works are not shown

NOT FOR CONSTRUCTION



MELBOURNE METRO RAIL AUTHORITY

AJM Joint Venture — aurecon JACOBS Mott MacDonald in association with GRIMSHAW

Melbourne Metro Rail Project

Title
GROUND MOVEMENT ASSESSMENT SHEET 4 OF 4

Drawing Number	Revision
MMR-AJM-PWAA-DR-NN-500377	P1.1

Drawn By	Approved By	Date	Map Size
GOLDER	SLVB	23-03-2016	A3

N

0 50 100 150 200 250m

APPENDIX F

Limitations

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
Building 7, Botanicca Corporate Park
570 – 588 Swan Street
Richmond, Victoria 3121
Australia
T: +61 3 8862 3500

Golder Associates