

100 Halsey Street

Groundwater and Settlement Effects Report

1101937.1000-RPT-GEO-103

Prepared for: NZCRE 100 Halsey Limited

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1 Introduction

1.1 General

Tonkin & Taylor Ltd (T+T) was engaged by NZ CRE 100 Halsey Limited to conduct geotechnical investigations and analyses for the proposed development at 100 Halsey Street in Wynyard Quarter, Auckland Central.

This report presents the assessment of groundwater drawdown and potential associated settlement effects associated with proposed basement excavation at the site.

The current stage of design was undertaken to support the Fast Track Approvals Act (2024) Substantive Application.

Our work has been undertaken in accordance with our Variation Order dated 20th of August 2026.

1.2 Site description and proposed development

The site is located in the Wynyard Quarter precinct, Auckland and is bounded by Pakenham Street West to the north; Halsey Street to the east; Gaunt Street to the south and; Amey Daldy Park and 55 Gaunt to the west. Additional details on the site location and history are presented in the Geotechnical Assessment Report (GAR) [1].

Five commercial buildings (Buildings B1 to B5) are indicated in the development plans prepared by Peddlethorp[2].



Figure 1.1: Proposed site development.

No basement levels are proposed for Building B1. Buildings B2 and B3 are proposed to have a single basement floor level. Buildings B4 and B5 are proposed to have a two-level basement. Bulk excavation levels will be affected by the foundation design.

[1] T+T (October 2026) *100 Halsey Street – Geotechnical Assessment Report*. T+T ref 1101937.1000-RPT-GEO-101.
[2] Peddlethorp (August 2026). 100 Halsey Street Fast Track Application

Concept level information has been provided by the project structural engineer[3] indicating the between 900 and 1300 mm thick foundation beams or a raft slab with 200 mm allowance for under slab layers. A summary is provided in Table 1.1. The proposed basement plan (for the first level basement) is shown in Figure 1.2, and this has been adopted as the indicative excavation extent for the assessment presented in this report.

The plaza area between the buildings is expected to be around the building threshold levels of RL+3.35 m.

Table 1.1: Summary of proposed floor and excavation levels

Building	Approximate plan area (m^2)	Lowest finished floor level (mRL)	Bulk excavation level (mRL) assumed for groundwater drawdown assessment [3]
B1	1,200	+3.35	Not assessed.
B2	1,600	-0.55	-2.05 *(6 m deep excavation evaluated)*
B3A / B3B	3,400	-0.85	-2.05 *(6 m deep excavation evaluated)*
B4 / B5	2,800	-4.45	-5.65 *(9 m deep excavation evaluated)*

Notes: 1. NZVD2016 datum.

2. Excludes local detailed excavation which may be required for piles, pile caps, lift pits, and subfloor building infrastructure. An average ground elevation of 3.4 mRL assumed for assessment.

3. The base of excavation is estimated based on a slab thickness of 1.0 m for basements B3A/B3B & B4/B5, and 1.3 m for B2 (data centre) based on information provided by the Structural engineer, along with an additional 0.2 m to include a hardfill layer beneath the slab.

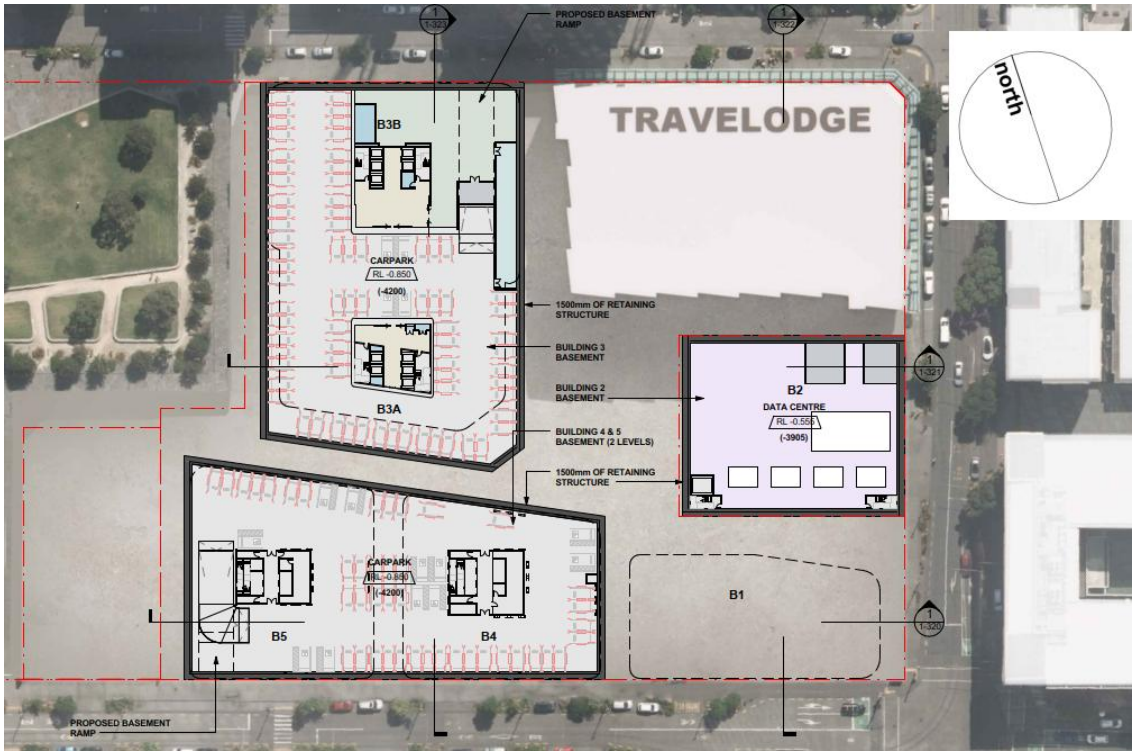


Figure 1.2 Proposed basement plan (extents of the first level basements shown) [source: Peddlethorpe 2/10/2026].

[3] Email: R. van Ballegooy (Holmes) to M. Kent (T+T), 8/9/2026, 3:31pm. *RE: 100 Halsey*.

2 Environmental setting

2.1 Site geology

A summary of site geology relevant to the groundwater assessment is presented here. For a detailed description of the site geology please refer to the GAR.

The site is underlain by historic reclamation fill placed prior to the 1920s. The fill is highly variable comprises of granular basecourse, sands, silts, clays, dredged marine sediments, organics, demolition debris, incinerator ash, gasworks waste and basalt boulders. Numerous historical services and infrastructure may also be present within the near-surface fill.

The reclamation fill generally overlies recent marine sediments comprising loose, shelly silty sand grading to soft to firm silt and clay. The upper sandy portion, typically encountered at approximately 4–7 m below ground level, is expected to be relatively continuous and hydraulically connected to tidal levels, and is therefore of relevance to the groundwater assessment. Marine sediments may be locally underlain by stiffer Pleistocene sandy silt and clay, particularly in the western part of the site.

The underlying East Coast Bays Formation (ECBF) comprises a variable weathering profile of residual soils and highly weathered transitional materials over moderately weathered to unweathered sandstone and siltstone rock. The ECBF rockhead generally deepens westward into an inferred paleochannel, which may contain thicker Pleistocene sediments and/or weathered ECBF materials. Local hard clay layers and deeper weathering or rockhead were encountered in the western part of the site, indicating significant spatial variability in subsurface conditions.

2.2 Hydrogeology

Seasonal groundwater level fluctuations in the order of 1.5 m have been measured within the Western Reclamation[4]. Groundwater is typically expected in the range of 1.5 to 3.0 m below ground level (RL 1.5 to 0.0 m). Monitoring in nearby sites has reported shallower groundwater levels (up to 0.4 m depth) in responses to heavy rainfall events, this has been shown to dissipate relatively quickly and is likely to be controlled by relatively higher permeability services trenches around the site.

Limited groundwater monitoring was undertaken at piezometer installed within the two boreholes carried out at the site. The water levels were recorded continuously over 26 days using electronic loggers. The retrieved data was corrected for barometric pressure recorded within an office building approximately 400 m from the site. As such minor differences from actual site levels may be recorded due to variation in atmospheric conditions between to two locations.

Groundwater head at BH202, positioned near the eastern boundary and closest to the marina, show a clear tidal influence typically varying about 100 to 200 mm. At location BH201, the tidal influence is relatively much lower.

A detailed description of the groundwater conditions at the site is provided in the Geotechnical Assessment Report.

For the assessment undertaken, a groundwater level of 0.7 mRL has been adopted for the site.

[4] Woodward Clyde (NZ) Ltd (July 1996). Soil and Groundwater Contamination Review , Western Reclamation Area Auckland Viaduct. Ref AA245619/0001.

2.3 Built environment

Our review of the built environment surrounding the proposed excavation site is based on our inhouse database and public data sources including LINZ building outlines, Auckland Council underground services data, aerial imagery and Google Street View. The project site and proposed basement excavation is in an area with dense development. Figure 2.1 shows the main built assets in the vicinity which have been considered in the assessment of groundwater drawdown and settlement effects.

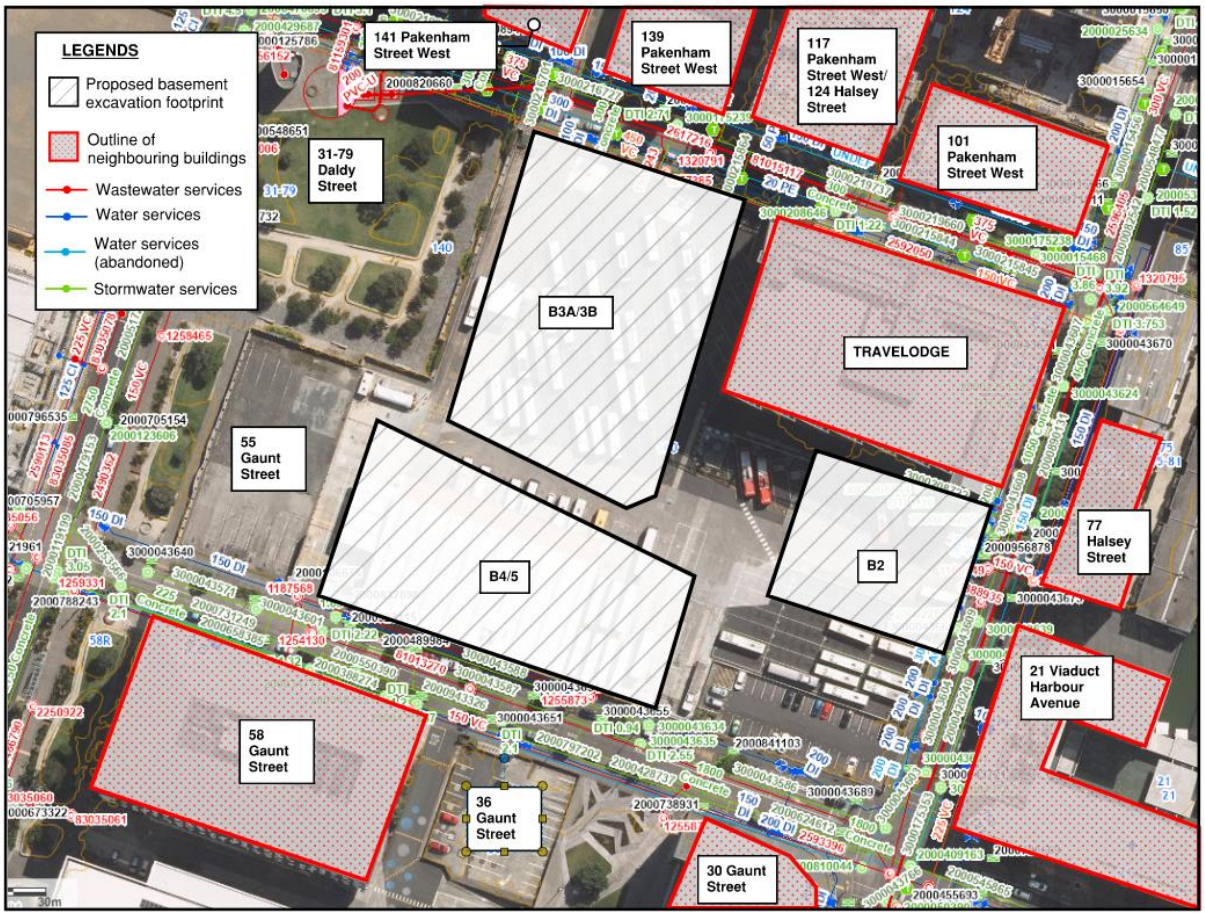


Figure 2.1 Proposed basement excavation location and nearby buildings. Underground utilities from the Auckland Council GIS shown in the background.

2.3.1 Road reserves

The adjacent road reserves typically include segmental concrete pedestrian footpaths flush with the road traffic lanes. Halsey and Gaunt Streets are formed with flexible pavement (asphalt). Pakenham Street West surface is formed of concrete. Surface wate is managed via raingarden soakage areas.

Halsey and Gaunt Streets also include tram lines. These are located about 11 to 15 m from the southern boundary and 10m from the eastern boundary.

Street furniture includes traffic lights and street lighting and signage, bicycle stands, bench seating and rubbish bins. Traffic and street lighting are mounted on flanged anchor-bolt foundations and therefore some releveling is likely to possible to accommodate minor ground movements.

2.3.2 Buried services

A summary of the principal public buried services surrounding the site are summarised in Table 2.1. For simplicity, branching lines such as for raingarden and site connections are excluded. Services indicated as abandoned are excluded.

Table 2.1: Summary of public buried services

Location	Type	Material	Diameter (mm)	Principal alignment to boundary	Nominal distance from boundary (m)
Pakenham St West	Stormwater	Concrete	300 to 750	Parallel	13
		PVC	150	Parallel	15
	Wastewater	PE	400	Parallel	11
		VC	375	Parallel	10
	Water supply	DI	300	Parallel	4
		DI	150	Parallel	18
		PE	20	Parallel	6
Halsey St	Stormwater	Concrete	1050	Parallel	8
		Concrete	225 to 525	Parallel	13
	Wastewater	PE	400	Parallel	10
		U-PVC	225	Parallel	6
		U-PVC	100 to 225	Parallel	5
	Water supply	DI	200	Parallel	3
		DI	150	Parallel	18
Gaunt St	Stormwater	Concrete	1800	Parallel	14
		Concrete	600 to 675	Parallel	8
		Concrete	225 to 375	Parallel	17
		PVC	225	Parallel	3
	Wastewater	U-PVC	150	Parallel	1.8
		CI	150 (connection)	Oblique	3
		U-PVC	250	Parallel	9
		VC	150	Parallel	19
	Water supply	DI	150	Parallel	2.5
		DI	150	Parallel	18

2.3.3 Buildings and previous construction effects

2.3.3.1 100 Halsey Street (Travelodge)

The Travelodge is within the property containing the subject site and comprises a seven-level, 154-room hotel adjoining a multilevel 385-space car-parking building and ground-floor commercial tenancies. Construction included extensive piling and groundworks, a precast-concrete building envelope, and precast beams and floor units within the car park.

2.3.3.2 100 Halsey Street (bus depot)

The existing bus depot located within the subject site includes a lightweight maintenance workshop building with masonry and steel frame construction. It is assumed to be supported on shallow foundations.

A recently installed gantry and bus wash has been installed in the central portion of the site. The gantry structure is supported on piles which are expected to extend to the underlying ECBF rock.

2.3.3.3 141 Pakenham Street West (The Artisan apartment building)

This building comprises an approximately 11-storey reinforced-concrete structure over a common podium and two basement parking levels constructed circa 2016. The structure is supported on cast-in-situ concrete piles extending through the reclamation fill into bedrock. The piles support an in-situ reinforced-concrete basement slab and foundation-beam system, with precast concrete basement perimeter walls.

Prior to basement excavation works the subsoils were stabilised using cement stabilisation to depths below the bulk excavation level. No discernible groundwater drawdown below natural levels occurred during excavation. Groundwater levels within Pakenham St West were typically 1.5 mRL (GWM03).

2.3.3.4 139 Pakenham Street West (Mason Bros building)

This is a 3-storey masonry building supported on driven concrete piles with a slab-on-grade floor. The building was originally built in the 1920's but redeveloped in 2016/17.

2.3.3.5 117 Pakenham Street West / 124 Halsey Street (Beca building)

The portion of the building adjacent to Pakenham St West is understood to have a 2-level basement constructed circa 2022. The basement walls are fully tanked and the foundation consisting of bored concrete piles.

Basement excavations were supported by anchored sheetpiles. Pre-excavation monitoring records (GW2, February - June 2022) adjacent to Pakenham St West showed the groundwater level was generally between 0.4 and 0.6 m RL. During basement construction, a drawdown of 0.5 m was observed for a short period and possibly slightly depressed groundwater levels persisted until the basement was sealed. In general, ground settlements were recorded in the order of 1 to 7 mm. Two monitoring locations (GS7 and GS8) were located on the northern side of Pakenham St West. GS7 recorded about 5 mm settlement while GS8 indicated significant settlement. The monitoring report for the project (T+T ref: 30493.0081) attributed the localised settlement at GS8 to other causes (i.e. largely unrelated to effects due to the basement excavation).

2.3.3.6 101 Pakenham Street West (Lysaght building)

This is a single-story masonry building supported on driven timber pile foundations with a slab-on-grade floor. The original building was constructed in 1920's and refurbished in 2017.

2.3.3.7 77 Halsey Street (Marina apartments)

The building forms part of the multistorey Lighter Quay residential development and includes basement car parking constructed circa 2006. It is likely that the wider development is supported on deep pile foundations and incorporates sheet-pile basement and marina retaining structures, however Council records for the structure has not been specifically reviewed to verify this.

2.3.3.8 21 Viaduct Harbour Avenue (Sofitel)

The Sofitel, part of the Lighter Quay development, is an approximately five-storey hotel over a single basement used for parking, loading and building services constructed circa 2006. Based on the concept design available on T+T records (T+T ref: 19002.007), the basement was proposed as a tanked structure designed to resist groundwater uplift, while the principal building loads are supported on deep pile foundations.

2.3.3.9 30 Gaunt Street (Bayleys building)

Bayleys House is a multistorey commercial building with a deep basement constructed circa 2014. It includes a four-level basement with an approximately 14 m-deep reinforced-concrete diaphragm wall used for basement retention.

2.3.3.10 36 Gaunt Steet (Wilson Parking)

The site is currently an open-air surface car park and does not contain any above ground building structures. A ramp into the neighbouring Baileys building basement is present at the southern portion of the site.

2.3.3.11 58 Gaunt Street (Datacom building)

The Datacom Building is a six- to seven-storey commercial structure with a two-level basement constructed circa 2015/2016. The building is supported on reinforced-concrete piles founded in East Coast Bays Formation rock. The basement excavation was supported using an anchored sheetpile retaining system.

Groundwater levels adjacent to Gaunt St ranged from about 1.2 to 1.9 mRL prior to basement excavations. During basement construction, initial drawdown was observed and appears to have remained slightly depressed at about 300mm below pre-excavation lower bound levels until the basement was sealed.

Ground settlement >10m from the Datacom building, including the northern side of Gaunt St was typically below survey tolerance (+/- 2 mm). A single point (GS-A01) adjacent 55 Gaunt St indicated 3 mm. Within 10m of the Datacom building on the southern side of Gaunt St settlement were reported to range between 6 and 17 mm.

2.3.3.12 55 Gaunt Street (VHHL empty lot)

The site is currently used as an open-air surface car park and does not contain any building structures.

2.3.3.13 31-79 Daldy Street / 140 Pakenham Street West (Amey Daldy Park)

The site comprises a landscaped public park with paved shared surfaces, lawn, and stormwater-management structures. The principal structure is a buried Watercare wastewater pump station enclosed within a cylindrical pavilion, which, based on the Council records is approximately 45 m west of the proposed building 3A/3B basements.

3 Groundwater modelling

3.1 Modelling methodology

3.1.1 Assessment methodology

The groundwater effect of excavation has been assessed using a transient assessment in SEEP/W (GeoStudio 2025.1.1). The SEEP/W model has been used to assess the change in porewater pressures (due to excavation induced drawdown) outside of the excavated region. The resulting increase in effective stress and associated settlement has been calculated separately from SEEP/W using node-wise outputs of the porewater pressure change on a 0.5 m x 0.5 m grid. These outputs are used to perform a depth-wise summation of settlement, using:

$$S = \sum_{i=1}^{n} \left(m_{v,i} \Delta P_i H_i \right)$$

Where, $S = Settlement\ caused\ by\ dewatering\ at\ existing\ ground\ level$

$$Pi = Change\ in\ pore\ water\ pressure$$

$$m_{v,i} = Soil\ compressibility\ in\ node\ i$$

$$Hi = Soil\ thickness\ corresponding\ to\ node\ i, which\ is\ 0.5\ m\ for\ this\ assessment.$$

Representative assessment sections have been selected for the three basements, and simplified ground models have been used to develop an axisymmetric model in SEEP/W which is used to assess the 3-D effect of the excavation on groundwater pressures, with the assumption being that the modelled conditions are symmetrical about the axis of rotation/symmetry (taken as the line through the centre of the excavation).

3.2 Input parameters and assumptions

3.2.1 Construction sequence

We understand the buildings will be completed in the following sequence:

- Stage 1: B1 and B2
- Stage 2: B3a and B3B
- Stage 3: B4 and B5

For the purposes of resource consent groundwater assessment has been undertaken as an envelope of effects beyond the site boundary due to each building basement constructed in sequence. The three basement excavations are evaluated as being independent of one another, with the implicit assumptions/implications being that the building construction is staged with sufficient interval for the groundwater regime to normalize to pre-construction levels. This assumption is consistent with approach outlined within the Draft Construction Management Plan for the development.

Further assessment will be required basement construction occurs concurrently. The level of groundwater drawdown and area affected would be expected to be larger than assessed.

Induced settlement in intersecting zones of influence will be lower for subsequent excavations/groundwater drawdowns (as the soils will be “reloaded” rather than normally consolidated during subsequent drawdowns). As such, with sufficient time between basement construction stages, the estimated drawdown-induced consolidation settlement represents the upper-bound effects.

The effects on newly constructed buildings completed as part of the overall development will need to be considered by the developer. Settlement due to basement construction may have adverse effects within the site boundary and consideration will be required for effects on buildings constructed earlier in the proposed development sequence (e.g. the effects of building B4/5 basement construction on the adjacent building B1).

3.2.2 Wall construction methodology

The excavation support walls for all three basements are assumed to comprise hard–soft secant piles with a nominal diameter of 750 mm to 900 mm with 150mm overlap between adjacent piles. For the drawdown assessment, effective cut-off wall width and modelled with a permeability of 1×10^{-10} m/s. This thickness is expected to represent an average drawdown condition.

In practice, the cut-off wall thickness will vary with depth and location because of set-out offsets and deviation during piling, particularly at greater depths. The actual transmissivity of the secant wall will therefore also vary locations with thinner overlap due to reduced pile verticality or due to drilling 'smear' between the piles will be less watertight. A verticality tolerance of 1:75 is assumed to be achievable and should provide reasonable watertightness to the maximum modelled pile depth of approximately 20 m.

3.2.3 Ground models

3.2.3.1 Basement B2

For the assessment of basement B2, ground stratigraphy as shown in Figure 3.1 and summarized in Table 3.1 has been adopted.

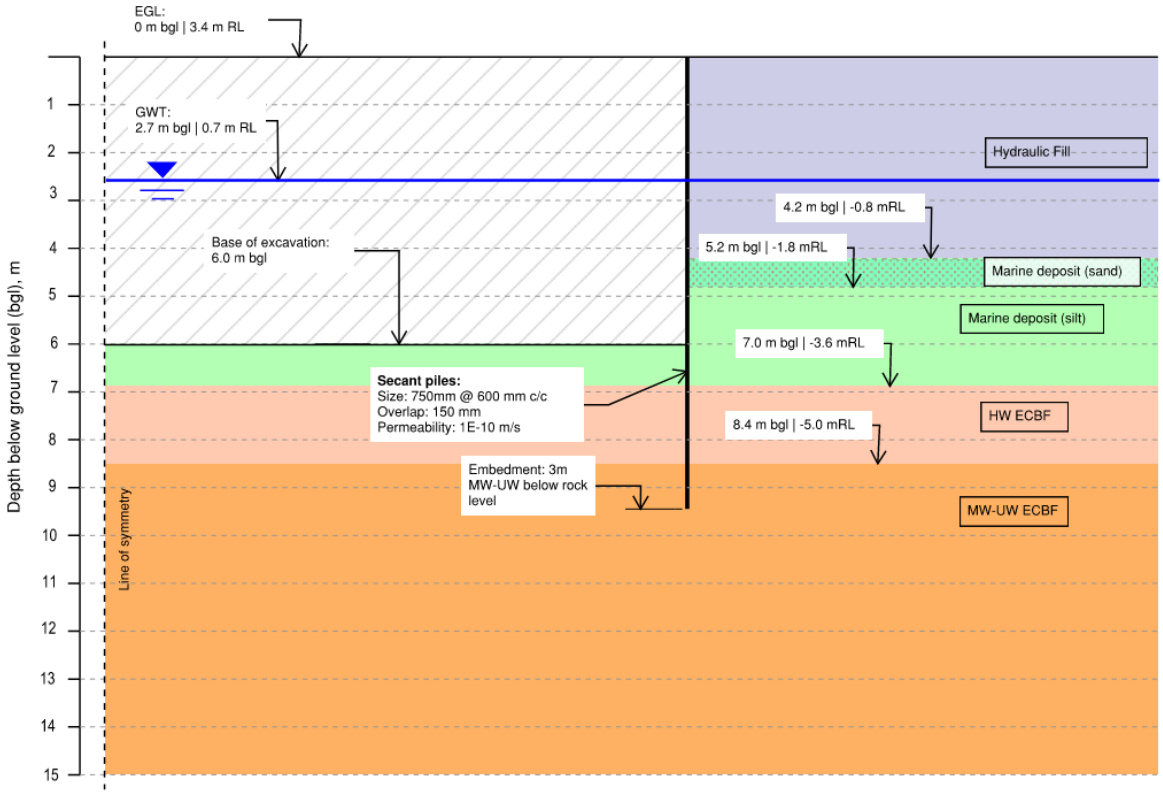


Figure 3.1: Simplified ground model for basement B2.

Table 3.1: Ground stratigraphy adopted for Basement B2

Geological Unit	Top of layer, m bgl	Layer thickness, m
Hydraulic fill	0	4.2
Marine sediments (sand)	4.2	1
Marine sediments (silt)	5.2	1.8
CW-HW ECBF	7	1.4
MW-UW ECBF	8.4	-

3.2.3.2 Basement B3A/B3B

For the assessment of basement B3A/B3B, ground stratigraphy as shown in Figure 3.2 and summarized in Table 3.2 has been adopted.

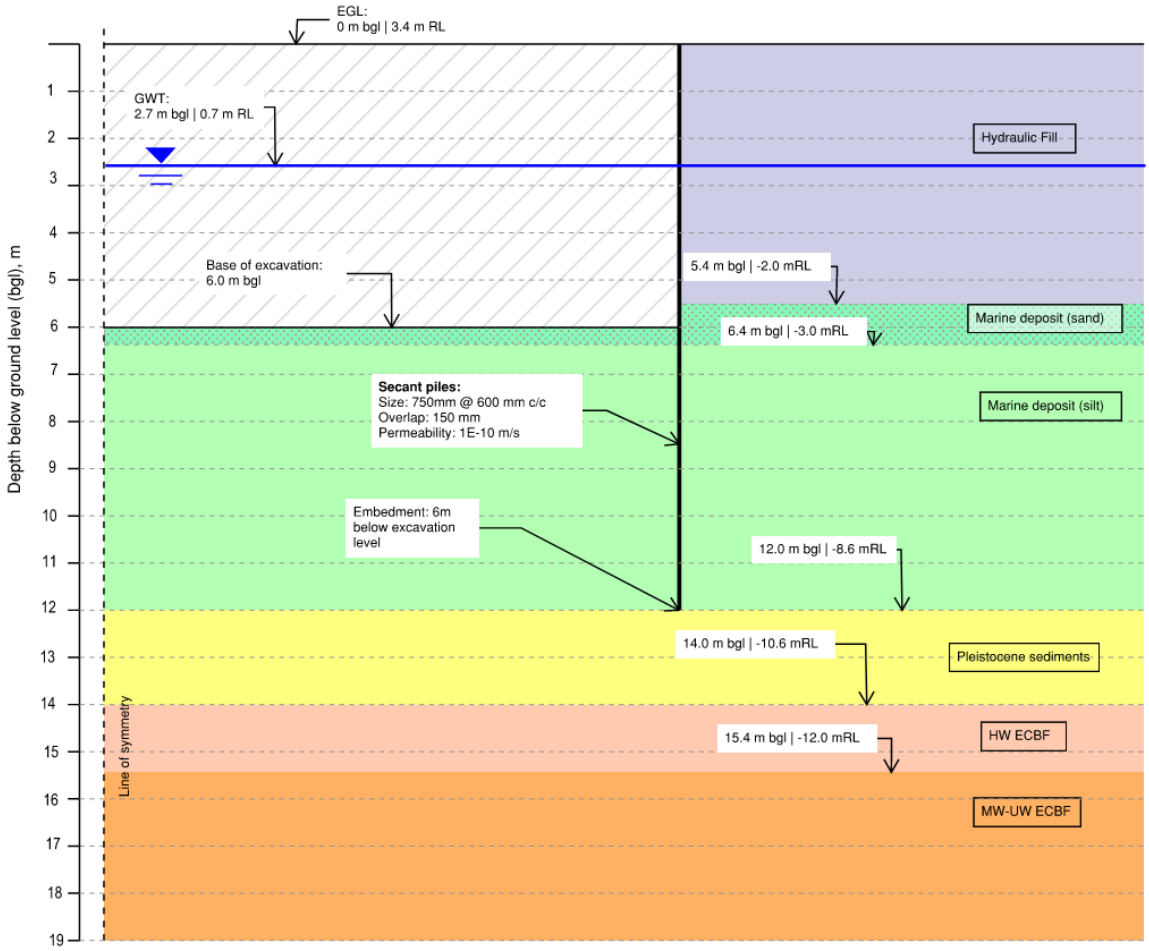


Figure 3.2: Simplified ground model for basement B3A/B3B.

Table 3.2: Ground profile adopted for Basement B3A/3B

Geological Unit	Top of layer, m bgl	Layer thickness, m
Hydraulic fill	0	5.4
Marine sediments (sand)	5.4	1

Geological Unit	Top of layer, m bgl	Layer thickness, m
Marine sediments (silt)	6.4	5.6
Pleistocene sediments	12	2.0
CW-HW ECBF	14	1.4
MW-UW ECBF	15.4	-

3.2.3.3 Basement B4/B5

For the assessment of basement B4/B5, ground stratigraphy as shown in Figure 3.3 and summarized in Table 3.3 has been adopted.

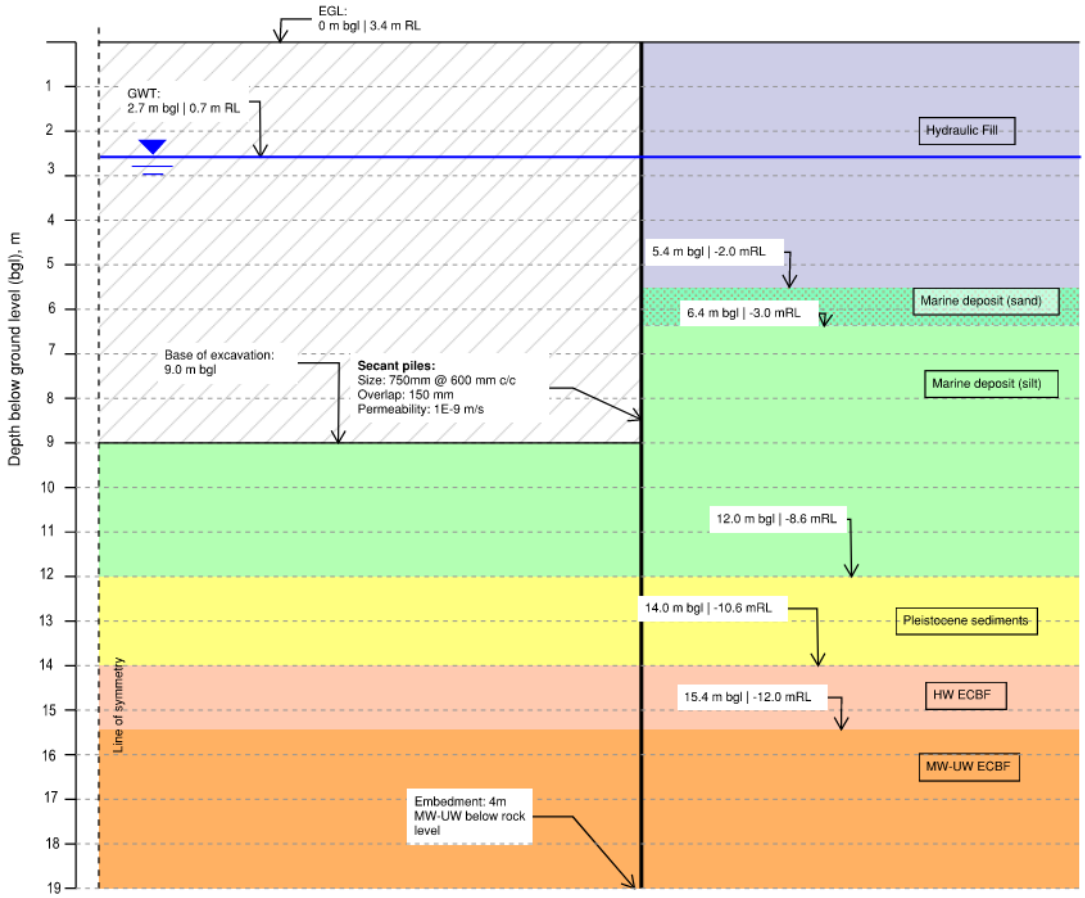


Figure 3.3 Simplified ground model for basement B4/B5.

Table 3.3: Ground profile adopted for Basement B4/B5

Geological Unit	Top of layer, m bgl	Layer thickness, m
Hydraulic fill	0	5.4
Marine sediments (sand)	5.4	1
Marine sediments (silt)	6.4	5.6
Pleistocene sediments	12	2.0
CW-HW ECBF	14	1.4
MW-UW ECBF	15.4	-

3.2.4 Soil parameters

A summary of parameters assumed in the assessment are summarize in Table 3.4.

Table 3.4: Summary of soil parameter adopted in assessment

Geological Unit	Coefficient of volume compressibility, m_v (m^2/MN)	Horizontal permeability, kh (m/s)	kv/kh ratio
Surficial fill (excluding pavement/basecourse layers) [1]	0.1	Not assessed	
Hydraulic fill	1.0	2×10^{-7}	0.5
Marine sediments (sand)	0.3	2×10^{-6}	1.0
Marine sediments (silt)	0.7	2×10^{-7}	0.1
Pleistocene sediments	0.05	2×10^{-7}	0.1
CW-HW ECBF	0.05	2×10^{-7}	0.1
MW-UW ECBF	5.0E-6	5×10^{-7}	0.1

Note: [1] This layer has not been modelled explicitly. This is a surficial layer, that is not clearly delineated in the CPTs. Where encountered, these are typically above the water table, and unlikely to contribute to the effects due to groundwater drawdown.

3.3 Groundwater drawdown and induced settlement

3.3.1 Basement B2

With a secant pile cut-off embedded 3 m into the MW ECBF rock, the drawdown induced settlements is calculated to be approximately 4 mm at the edge of the excavation. This is estimated assuming the dewatering of the basement occurs for a period of 12 months. The estimated drawdown-induced settlement curve at the end of the 12-month period is shown in Figure 3.4.

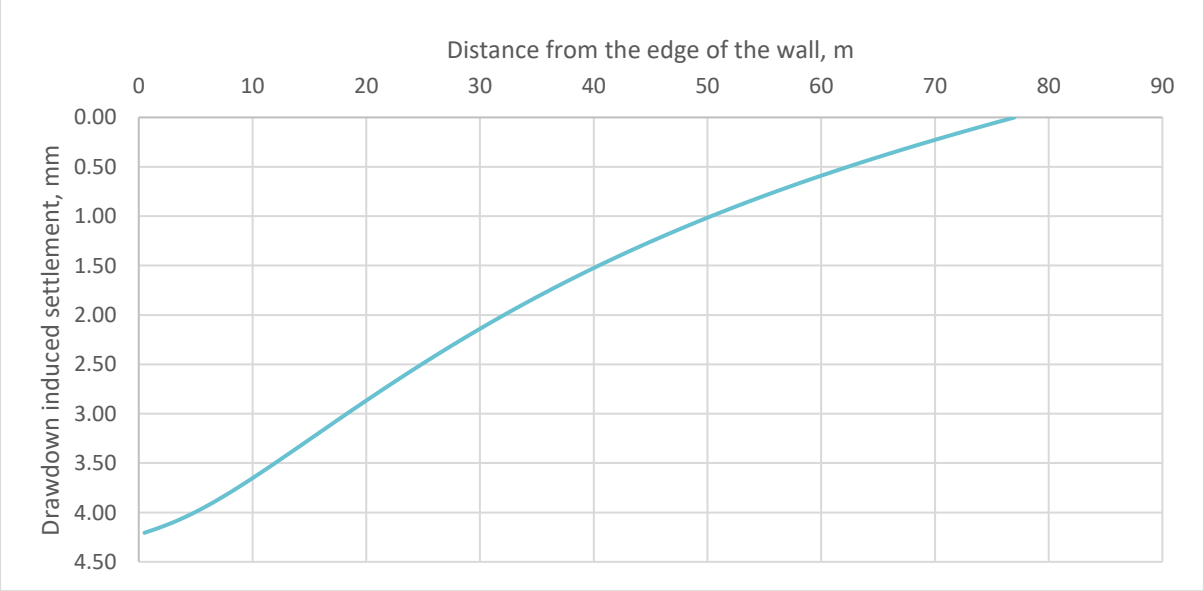


Figure 3.4 Estimated ground settlement due to groundwater drawdown for B2 basement.

Based on the transient SEEP/W modelling, a moderately conservative estimate for water take is between 2 to 20 m3/day with the peak expected at the start of construction and reduces as construction proceeds.

3.3.2 Basement B3A/B3B

With a 6 m deep secant pile cutoff, the drawdown induced settlements is calculated to be approximately 9 mm at the edge of the excavation reducing to 5 mm at approximately 16 m away from the edge of the excavation. This is estimated assuming the dewatering of the basement occurs for a period of 12 months. The estimated drawdown-induced settlement curve at the end of the 12-month period is shown in Figure 3.5.

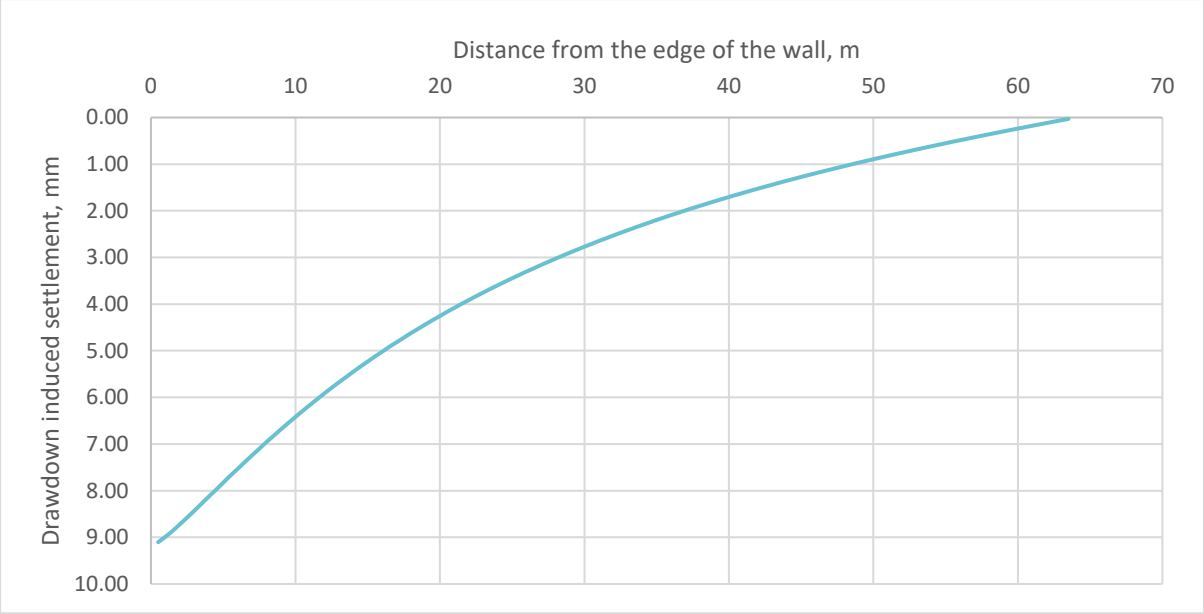


Figure 3.5 Estimated ground settlement due to groundwater drawdown for B3A/B3B basement.

Based on the transient SEEP/W modelling, a moderately conservative estimate for water take is between 5 to 45 m3/day with the peak expected at the start of construction and reduces as construction proceeds.

3.3.3 Basement B4/B5

With secant pile cutoff embedded 4 m into the MW ECBF rock, the drawdown induced settlements is calculated to be approximately 11 mm at the edge of the excavation reducing to 5 mm at approximately 36 m away from the edge of the excavation. This is estimated assuming the dewatering of the basement occurs for a period of 12 months. The estimated drawdown-induced settlement curve at the end of the 12-month period is shown in Figure 3.6.

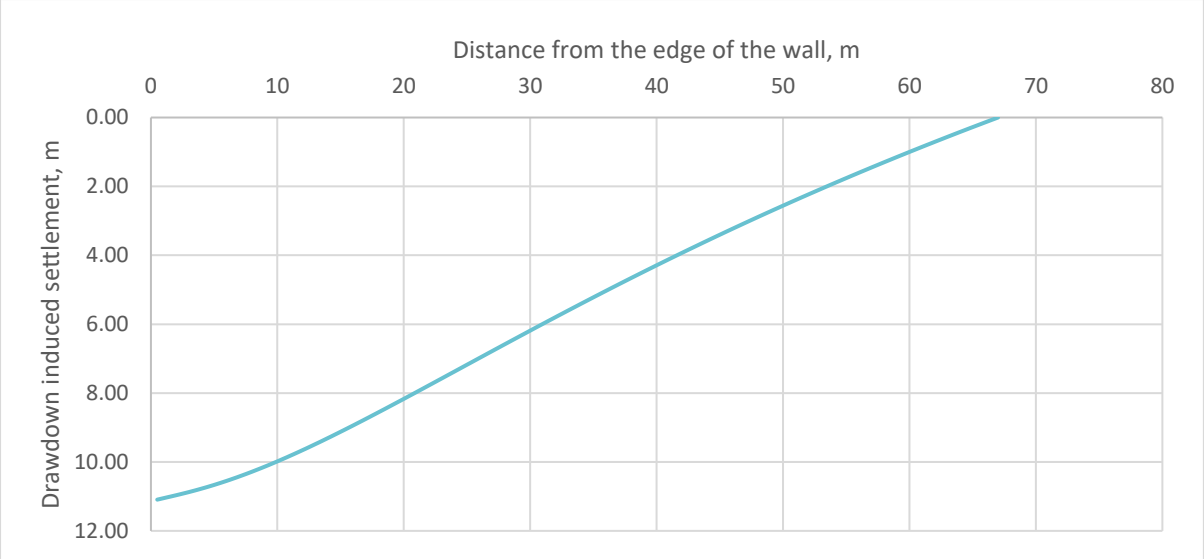


Figure 3.6 Estimated ground settlement due to groundwater drawdown for B4/B5 basement.

Based on the transient SEEP/W modelling, a moderately conservative estimate for water take is between 10 to 60 m3/day with the peak expected at the start of construction and reduces as construction proceeds.

4 Retaining wall deflections and mechanical settlement

The lateral wall displacements for the basement excavations are provided in the retaining wall design report 1101937.1000-RPT-GEO-102. The outward wall deflection along the height of the wall for the three excavations are shown in Figure 4.1 and Figure 4.2. Two construction methods have been evaluated for the wall at B4/B5, and the summary plot shows both these methods.

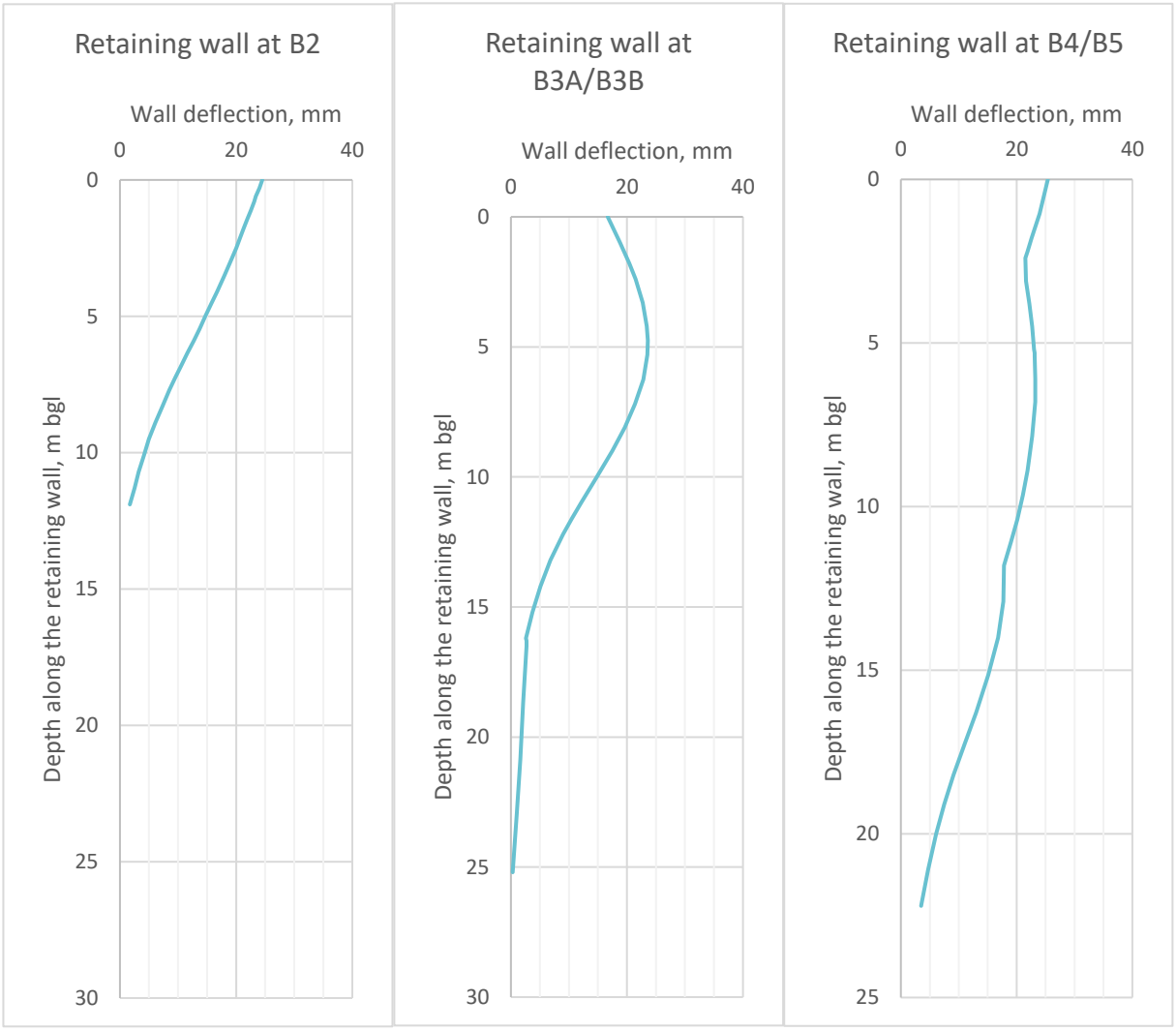


Figure 4.1 Lateral wall displacement calculated for basement excavations.

These displacements have been used to estimate the corresponding ground settlement using Hsieh and Ou (1998) method[5], where the vertical to horizontal displacement ratio (δ_{vm}/δ_{hm}) of 0.85 is adopted. The ground settlement profile estimated for three basement excavations are shown in Figure 4.2.

[5] Hsieh, P.G. and Ou, C.Y., 1998. Shape of ground surface settlement profiles caused by excavation. Canadian geotechnical journal, 35(6), pp.1004-1017.

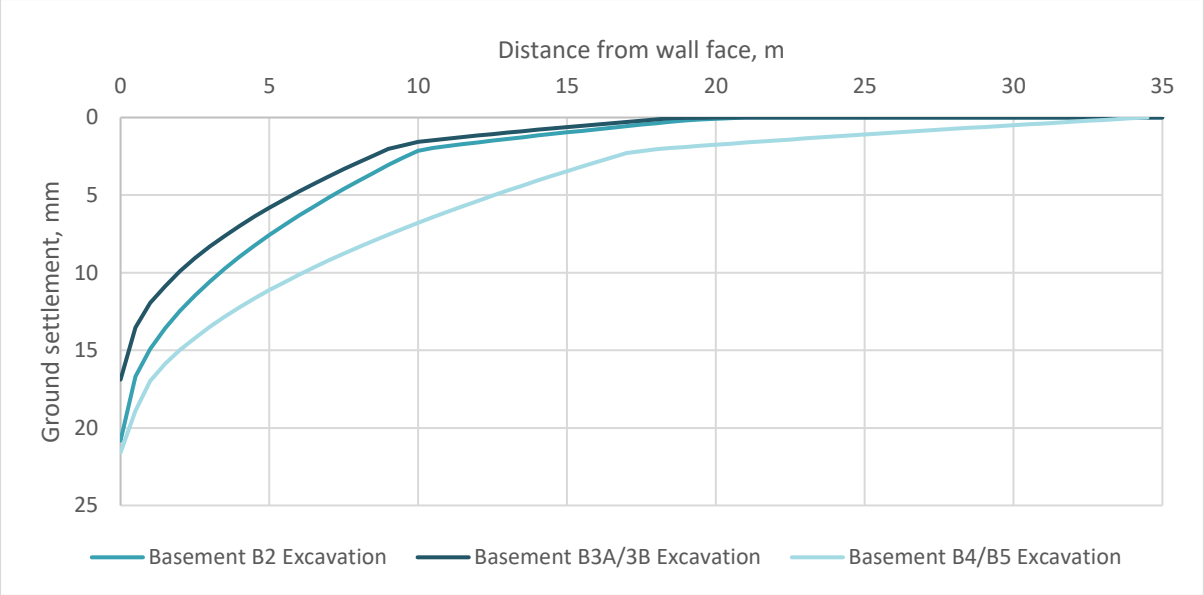


Figure 4.2 Ground settlement calculated for basement excavations.

The resulting ground settlement profile is representative of the settlement expected behind wall under a plane-strain condition, while, as discussed in Section 6.1.2 and Section A 6.5 of CIRIA 760, the corners of the excavation are expected to behave stiffer. To take the effect of stiffer response in the corner into account, the method of estimating the ground settlement at wall corners proposed by Fuentes and Devriendt (2010)[6] has been adopted.

[6] Fuentes, R. and Devriendt, M., 2010. Ground movements around corners of excavations: empirical calculation method. Journal of geotechnical and geoenvironmental engineering, 136(10), pp.1414-1424.

5 Assessment of effects

5.1 Combined groundwater drawdown and wall displacement settlements

The total ground settlement due to the basement construction includes the settlement due to groundwater drawdown (i.e. drawdown induced settlement) and due to wall displacement (i.e. mechanical settlement) during excavation. These settlements have been calculated separately and then combined to estimate the combined settlement for each of the basement excavation.

The assessment undertaken only considers the effects of temporary groundwater drawdown due to dewatering. Following excavation and during installation of the basement slab and permanent walls, the basement will be sealed (i.e. it will be a tanked basement construction). The dewatering operation is expected to be stopped after the completion of the basement, and the groundwater table is expected to return to its pre-construction condition.

For assessing the effects of settlement on neighbouring properties and assets, an envelope of total settlement resulting from the three basement constrictions has been estimated. In preparing this envelop, the following is considered:

- The mechanical settlements from all three excavations are additive.
- Soil that has already undergone drawdown induced settlement (i.e. undergone normal consolidation) will only settle marginally under subsequent drawdown (i.e. will undergo only recompression), provided that the drawdown induced pore water pressure is equal or smaller.

The combined total settlement is presented in Appendix A.

The differential settlement assessed in the vicinity of the proposed basements are:

- Basement B2: Maximum differential settlement of 1:170 at the edge of the wall, reducing to 1:400 within 1.5 m from the edge of the wall, and further reducing to flatter than 1:500 beyond 2.5 m from the edge of the wall.
- Basement B3A/B3B: Maximum differential settlement of 1:130 at the edge of the wall, reducing to 1:350 within 1.5 m from the edge of the wall, and further reducing to flatter than 1:500 beyond 2.5 m from the edge of the wall.
- Basement B4/B5: Maximum differential settlement of 1:220 at the edge of the wall, reducing to 1:250 within 1 m from the edge of the wall, and further reducing to flatter than 1:500 beyond 2.0m from the edge of the wall.

5.2 Assessed effects on neighbouring buildings and properties

The Burland (2012)[7] building damage classification framework is widely referenced for assessing damage risk and establishing preliminary trigger levels for ground movement. This framework has been adopted in this assessment to define preliminary risk categories and associated threshold levels, as summarised in Table 5.1.

[7] 7 Chapter 26 Building response to ground movements, John B.Burland, ICE manual of geotechnical engineering: Volume I. January 2012, 281-296.

Table 5.1: Building damage risk assessment criteria

Risk Category (Burland 2012 & CIRIA 1996)	Total Settlement Range (CIRIA 1996)	Differential Settlement Range (CIRIA 1996)	Description of typical damage (Burland 2012)
1	Less than 10 mm	Less than 1:500	Very Slight: Fine cracks easily treated during normal redecoration. Perhaps isolated slight fracture in building. Cracks in exterior visible upon close inspection. Typical crack widths up to 1 mm.
2	10 to 50 mm	1:500 to 1:200	Slight: Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible, some repainting may be required for weather-tightness. Doors and windows may stick slightly. Typical crack widths up to 5 mm.
3	50 to 75 mm	1:200 to 1:50	Moderate: Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Brick pointing and possible replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired. Typical crack widths are 5 to 15 mm or several greater than 3 mm.
4	Greater than 75 mm	Greater than 1:50	Severe: Extensive repair involving removal and replacement of walls especially over door and windows required. Window and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably. Some loss of bearing in beams. Utility services disrupted. Typical crack widths are 15 to 25 mm but also depend on the number of cracks.

The effects of the combined settlement on the neighbouring buildings/structures are summarized in Table 5.2.

Table 5.2: Summary of settlement effects on neighbouring buildings

Building/structure	Distance to building/structure from proposed development boundary	Likely effects due to settlement
100 Halsey Street (Travelodge)	5 to 10m from B2 and B3A/B3B	Between 10 to 15 mm of settlement and 1:880 differential settlement is expected in the south-east side and north-west corner of the building, which puts the building in risk category of 2 based on Burland (2012), with a slight damage possible. However, since the building is supported on piles, the risk to the superstructure is considered low. Settlement limits to be agreed.

Building/structure	Distance to building/structure from proposed development boundary	Likely effects due to settlement
58 Gaunt Street (Datacom building)	20m south of B4/B5	Combined settlement due to groundwater drawdown and wall deflection is at or below 10mm on the property boundary (at ground surface) with most of the contribution from drawdown induced settlement. Additionally, the differential settlement assessed is flatter than 1:2500. The building has a double level basement, and the settlement at the foundations level is expected to be well within the tolerance. Furthermore, the ground in the immediate vicinity of the building has experienced groundwater drawdown (during its basement construction) to levels lower than that assessed due to the proposed works. This has not explicitly been considered in our assessment, and when considered, the actual settlement at 58 Gaunt Steet property is expected to be lower than assessed in this report. Overall, the settlements effects at this property are assessed to be within tolerance.
100 Halsey Street (bus depot)	Within the development footprint	As buildings B1 and B2 are planned to be constructed first, with the bus depot planned to be removed prior to the construction of B3-B5, the structure will only be affected by the construction of B2 basement. As a result of B2 basement excavation, the total settlement at the bus depot location is expected to be less than 5 mm, and differential settlements are expected to be within tolerance.
55 Gaunt Street (VHHL empty lot)	5 m west of B4/B5	The total settlement within this property boundary is expected to be up to 25 mm, and differential settlement flatter than 1:650. Negligible risk assessed.
31-79 Daldy Street (Amey Daldy Park) / 140 Pakenham Steet West	4 m west of B3A/3B	Up to 25 mm of settlement on the south-easter corner of the property, reducing to less than 10 mm within 6 m from the boundary with proposed development, and further reducing to 5 mm within 20 m. Differential settlement of up to 1:680 is estimated at the boundary with 100 Halsey Street on the eastern side. The settlements are assessed to be within tolerances. Less than 2 mm of settlement is estimated at the Watercare's pump station location north-west of the property, with negligible risk of damage.
141 Pakenham Street West (The Artisan apartment building)	20m north of B3A/B3B	Combined settlement due to groundwater drawdown and wall deflection <10 mm. Negligible risk assessed.
139 Pakenham Street West (Mason Bros building)	20m north of B3A/B3B	
124 Halsey Street (Beca building)	20m north of B3A/B3B	
101 Pakenham Street West (Lysaght building)	40m north-east of B3A/B3B	

Building/structure	Distance to building/structure from proposed development boundary	Likely effects due to settlement
77 Hasley Street (Lighter Quay apartments)	20m east of B2	
21 Viaduct Harbour Avenue (Sofitel)	20m east of B2	
30 Gaunt Street (Baileys building)	30m south-east of B4/B5	
36 Gaunt Steet (Wilson Parking)	20m south of B4/B5	

5.3 Assessed effects on utilities

The damage risk criteria adopted for the effects on these utilities is generally based on O'Rourke and Trautmann (1982)[8] and is summarised in Table 5.3.

Table 5.3: Utilities damage risk assessment criteria

Type of buried pipe	Maximum allowable differential settlement
Brick unlined	1:240
Welded steel pipe	1:120
Cast in-situ concrete	1:170
PVC & HDPE	1:70
Reinforced concrete pipe	1:230
Ductile iron pipe	1:230
Vitrified clay pipe	1:300
Cast iron pipe (diameter category A, smaller diameter pipes up to 200 mm)	1:150
Cast iron pipe (diameter category B, larger diameter pipes greater than 200mm)	1:500

The effects of the combined settlement on the buried services listed in Table 2.1 have been assessed on the basis of the above criteria, and the differential settlement at the location of these services are assessed to be within the tolerance limit.

5.4 Assessed effects on adjoining roads/pavements

The limiting criteria of less than 1(V):200(H) differential settlement, and less than 30 mm total settlement has been adopted based on guidelines provided by New Zealand Transport Agency (NZTA). This criterion is applied to major roads and motorways and is considered conservative for the roads adjoining the proposed developments.

[8] O'Rourke, T D, and C H Trautmann. 1982. Buried pipeline response to tunnel ground movements. In Europipe 82 Conf., Basel, Switzerland, paper 1.

5.4.1 Pakenham St West

The settlements assessed along Pakenham St West (caused mainly due to basement B3A/B3B construction) are:

- Maximum settlement: 25 mm reducing to 20 mm 2 m away from the wall. Between 10-15 mm on the road.
- Maximum differential settlement: Flatter than 1:390 beyond 1 m from the edge of the wall.

Previous settlement from the construction of the Beca building on the northern side of Pakenham St West was reports to be about 5 mm. The cumulative effect of the proposed development is expected to remain within tolerance.

The settlement estimated within the tolerance limit.

5.4.2 Halsey St

The settlements assessed along Halsey St (caused mainly due to basement B2 construction) are:

- Maximum settlement: 23 mm on the sidewalk and 10mm on the road.
- Maximum differential settlement: Flatter than 1:360 beyond 1 m from the edge of the wall.

The settlement estimated within the tolerance limit.

5.4.3 Gaunt St

The settlements assessed along Pakenham St West caused mainly due to basement B4/B5 construction are:

- Maximum settlement: 30mm on the sidewalk and 20mm on the road. Further reducing to 11 mm on the sidewalk on the southern side of Gaunt St.
- Maximum differential settlement: Flatter than 1:430 beyond 1 m from the edge of the wall.

Previous settlement from the construction of the Datacom building on the northern side of Gaunt St was reported to be about 5 mm. On the south side of Gaunt St between 6 and 17 mm was reported. The cumulative effect of the proposed development is expected to remain within tolerance.

Overall, the settlement estimated is within the tolerance limit.

6 Recommended monitoring and contingency measures

6.1 Proposed instrumentation and monitoring

We recommend that construction monitoring of the retaining wall deflections and ground movements is undertaken to check compliance with the design criteria. The monitoring methodology and frequency should be undertaken in accordance with a project specific Monitoring and Contingency Plan.

A draft monitoring location plan has been developed to support the Resource Consent application, and this is provided in Appendix B, and details of the proposed monitoring plan is summarized in the following sections. The monitoring points have been divided into the three stages of project development, where Stage 1 includes construction of buildings B1 and B2, Stage 2 includes buildings B3A and B3B, and Stage 3 includes buildings B4 and B5.

6.1.1 Services condition surveys

Prior to the commencement of dewatering and following completion of dewatering (and within 6 months of completion of construction), a condition survey of potentially affected buried services (refer Table 2.1) shall be undertaken in consultation with the relevant service provider. Since the development of the site is planned in stages, condition survey shall be undertaken as follows:

- Services along Halsey Street to be surveyed prior to construction of B2.
- Services along Pakenham Street West to be surveyed prior to construction of building B3A/B3B.
- Services along Gaunt prior to be surveyed prior to construction of building B4/B5.

Suitable condition surveys are expected to comprise CCTV survey for stormwater and wastewater services and shall include the following but not limited to:

1 Existing levels of aesthetic damage.
2 Existing levels of serviceability damage.
3 Existing levels of structural damage.
4 Photographic/video evidence of (1), (2), and (3) above.

Suitable condition surveys are expected to comprise acoustic leak detection for water supply services.

A condition survey is not required where written evidence is provided to the Council that the owner of that service has confirmed they do not require a condition survey.

6.1.2 Groundwater monitoring

Groundwater level monitoring is intended to provide early identification of groundwater drawdown that could contribute to ground settlement or adversely affect surrounding structures.

Groundwater level monitoring is recommended to be undertaken using automated telemetry instrumentation which allows near-continuous monitoring to be undertaken at 60-minute intervals. The proposed location for groundwater monitoring is shown in Appendix B, where a total of 6 groundwater monitoring locations is proposed, each containing upper and lower monitoring locations/response zones.

Following the installation of the piezometers, pre-excavation groundwater monitoring is to be undertaken to establish the baseline groundwater levels across the site.

The baseline reading shall be taken as the summer low groundwater level (GWL) where possible and recorded before the commencement of construction.

Monitoring should be undertaken at least 3 months prior to bulk excavation until 3 months after completion of dewatering.

Table 6.1: Recommended groundwater monitoring

Development stage	Groundwater monitoring point	Response zone, m bgl	Alert 1 trigger minimum[1], kPa	Alert 2 trigger minimum[1], kPa
1	GW1, GW2	2-5 m 6-9 m	2 10	5 15
2	GW3, GW4	2-5 m 6-9 m	2 10	5 15
3	GW5, GW6	2-5 m 6-9 m	2 10	5 15

Note: [1] Alert levels shall be set prior to basement excavation, based on the pre-construction groundwater levels and the as-built locations of the groundwater monitoring wells.

6.1.3 Retaining wall deflection monitoring

The retaining wall monitoring points are shown in Appendix B and include capping beam monitoring pins at approximately 15 m centres and inclinometer at selected locations, both for monitoring that wall deflection is within the design criteria. The wall inclinometers should be installed within the secant piles which are socketed into ECBF rock.

For establishing a baseline:

- Two baseline surveys shall be undertaken for the monitoring points, and survey (including subsequent ones) shall be accurate up to $\pm$ 2 mm.
- One baseline survey shall be undertaken for the inclinometer.

The monitoring frequency during the different phases of construction shall be:

After commencement of dewatering and until one month after completing of bulk excavation	Fortnightly and at every 2 metres depth excavation or when changes to the propping system are being carried out.
One month following basement excavation and until three months after the completion of dewatering	Monthly

Results of this monitoring are to be compared with the design assumptions and baseline readings. Trigger levels at which actions are required to be undertaken are summarised in Table 6.2. If the Trigger Levels in Table 6.2. are reached, the actions outlined in Section 6.2 shall be carried out.

Table 6.2: Retaining wall displacement trigger levels

Type of monitoring	Development stage	Feature monitored	Monitoring point ID	Alert trigger[1], mm	Alarm trigger[1], mm
Inclinometers	1	Basement wall for B2	IN1, IN2	15	25
	2	Basement wall for B3A/B3B	IN3, IN4	15	25
	3	Basement wall for B4/B5	IN5, IN6	15	25
Wall displacement pins	1	Basement wall for B2	RW1 – RW10	15	25
	2	Basement wall for B3A/B3B	RW11 – RW26	10	20
	3	Basement wall for B4/B5	RW27 – RW42	15	25

Note: [1] Lateral displacement towards excavation.

6.1.4 Ground condition survey

Visual survey/inspection of surrounding ground, pavement and street furniture within 10 m of active works shall be undertaken to monitor any deterioration or cracking, and this shall be undertaken the direction of a suitably qualified engineering professional (SQEP).

Prior to commencement of works, a pre-condition survey shall be undertaken to establish the existing condition of the asset including existing level of damage, and to assess the susceptibility to further movement and damage. The frequency of visual inspection shall be weekly during bulk excavation and reducing to fortnightly following completion of bulk excavation of the basement until completion of dewatering. The assessment shall be typically undertaken by the Contractor. The trigger levels for the visual survey/inspection shall be taken as:

- Alert: Any visual indication of deterioration or cracking by Contractor.
- Alarm: Assessment by Engineer indicates damage likely to worsen.

6.1.5 Ground and building deformation monitoring

The ground and building monitoring points are shown in Appendix B which are intended to monitor and confirm that ground settlements are within the design criteria. For the building monitoring points, marks shall be set as low as practicable on the building on elements in direct connection with the foundation level (i.e. columns or perimeter footings).

At least two baseline surveys shall be undertaken for the monitoring points, and survey shall be accurate up to ± 2 mm.

The monitoring frequency during the different phases of construction shall be:

From commencement of dewatering and until completion of dewatering	Weekly.
After completion of dewatering	Monthly for three months or until such a time following the completion of dewatering that stable measurements are demonstrated, and written approval is granted from the Council.

Results of this monitoring are to be compared with the design assumptions and baseline readings. Trigger levels at which actions are required to be undertaken are summarised in Table 6.3. If the Trigger Levels in Table 6.3. are reached, the actions outlined in Section 6.2 shall be carried out.

Table 6.3: Ground and building deformation trigger levels

Type of monitoring	Development stage	Feature monitored	Settlement marker ID	Total settlement, mm		Differential settlement [1]	
				Alert trigger	Alarm trigger	Alert trigger	Alarm trigger
Building monitoring point	1	Travelodge	BS1 – BS3	5	10	1:700	1:500
	2	141 Pakenham Street West	BS4 – BS5	5	10	1:700	1:500
		139 Pakenham Street West	BS6 – BS7				
		117 Pakenham Street West / 124 Halsey Street	BS8 – BS9				
		101 Pakenham Street West	BS10 – BS11				
		Travelodge	BS12 - BS13	5	10	1:700	1:500
	3	58 Gaunt Street	BS14 – BS17	5	10	1:700	1:500
		30 Gaunt Street	BS18 – BS20				
Ground monitoring points	1	Halsey street	GS1 -GS4	5	10	1:300	1:200
			GS5 – GS8	15	20		
		Bus depot at 100 Halsey Street	GS9 – GS11	15	20		
	2	Pakenham Street West	GS12-GS22	5	10	1:300	1:200
			GS23 - GS27	15	20		
		31-79 Daldy Street / 140 Pakenham Street West	GS28 – GS32	15	20		
	3	Gaunt Street	GS33 – GS41	10	15	1:300	1:200
			GS42-GS48	20	30		
		Building platform at 100 Halsey Street	GS49 – GS50	20	30		
		55 Gaunt Street	GS51 – GS53	15	20		

Note: [1] Differential settlement is measured between two adjacent building/ground monitoring pins.

6.2 Contingency measures

6.2.1 Groundwater contingency measures

In the event of groundwater levels exceeding the monitoring trigger levels, one or more of the following actions may be taken:

1 Review of monitoring results to confirm if groundwater drawdown is being accompanied by ground settlement.
2 Water proofing of any leakages within perimeter retaining walls.
3 Temporary reinjection wells to inject potable water into the ground to mitigate the change in groundwater level (groundwater recharge) while alternative measures are implemented.
4 Where groundwater levels exceed maximum groundwater level triggers contingency measures may include penetration of the perimeter walls to drain elevated groundwater levels while alternative measures are implemented.

6.2.2 Retaining wall deflection contingency measures

In the event of retaining wall deflections exceeding the monitoring trigger levels, a review of the retaining design model shall be carried out to assess the load in the wall and existing props. If required, the following actions may be taken:

1 Assess condition of prop and/or anchor connections/headworks and/or prestress.
2 Install additional props and/or anchors.
3 Place a berm of soil in front of the wall.

6.2.3 Ground and building deformation contingency measures

In the event of ground or building deformation exceeding the monitoring trigger levels, one or more of the following actions shall be taken:

1 Discussions on the situation with the property/service owner that may be affected.
2 Monitor the rate of settlement (assuming that other steps have been undertaken to address the cause)
3 Check public safety is maintained
4 Isolation or underpinning of affected structures/services, and
5 Acceptance and reinstatement of any resultant damage

7 Conclusions and recommendations

The following summarises the groundwater study and settlement assessment for the proposed redevelopment at 100 Halsey Street:

- For a 12-month dewatering period, predicted drawdown-induced settlement at the excavation edge is approximately 4 mm for basement B2, 9 mm for basement B3A/B3B and 11 mm for basement B4/B5, and the total combined settlements (including mechanical settlement due to wall displacement) are 25 mm for B2, 27 mm for B3A/B3B and 39 mm for B4/B5.
- The seepage cut-off is provided by the proposed secant pile wall, which for our assessment are assumed to be embedded 3 m into ECBF rock for basement B2; extended 6 m below the excavation level for basement B3A/3B (where deeper rock levels are expected); and embedded 4 m into ECBF rock for basement B4/B5.
- The secant pile walls should be designed and constructed as low-permeability cut-off walls consistent with the modelling assumptions, including the required pile overlap, verticality control and embedment proposed.
- Estimated groundwater take ranges are 2 to 20 m^3/day for B2, 5 to 45 m^3/day for B3A/B3B and 10 to 60 m^3/day for B4/B5. Peak inflows are expected near the start of dewatering and to reduce as construction proceeds.
- The combined settlement assessment indicates slight damage may be possible based on the total settlement criteria of 10 mm at the north-west and south-east corner of Travelodge, although structural risk is considered low because the building is pile-supported. Settlement limits should be agreed with affected stakeholders.
- Predicted differential settlements for the assessed buried services are within the adopted tolerance criteria.
- Pakenham Street West, Gaunt Street and Halsey Street are also within the adopted road settlement criteria.
- Differential settlement remains within the adopted criterion, and any local pavement effects (typically just adjacent to the walls) are expected to be manageable by targeted repairs.
- Basement construction should be staged, where practicable, to allow groundwater levels to recover between excavations. The assessment should be reviewed if excavations are undertaken concurrently or if the final construction sequence differs from that assessed.
- A construction monitoring and contingency plan should be implemented, including baseline condition surveys, groundwater and wall-movement monitoring, ground and building settlement monitoring, agreed trigger levels, and defined corrective actions. A proposed monitoring plan has been provided.

8 Applicability

This report has been prepared for the exclusive use of our client NZ CRE 100 Halsey Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:



.....

Subrat Subedi
Geotechnical Engineer

Authorised for Tonkin & Taylor Ltd by:



.....

Andrew Hope
Project Director

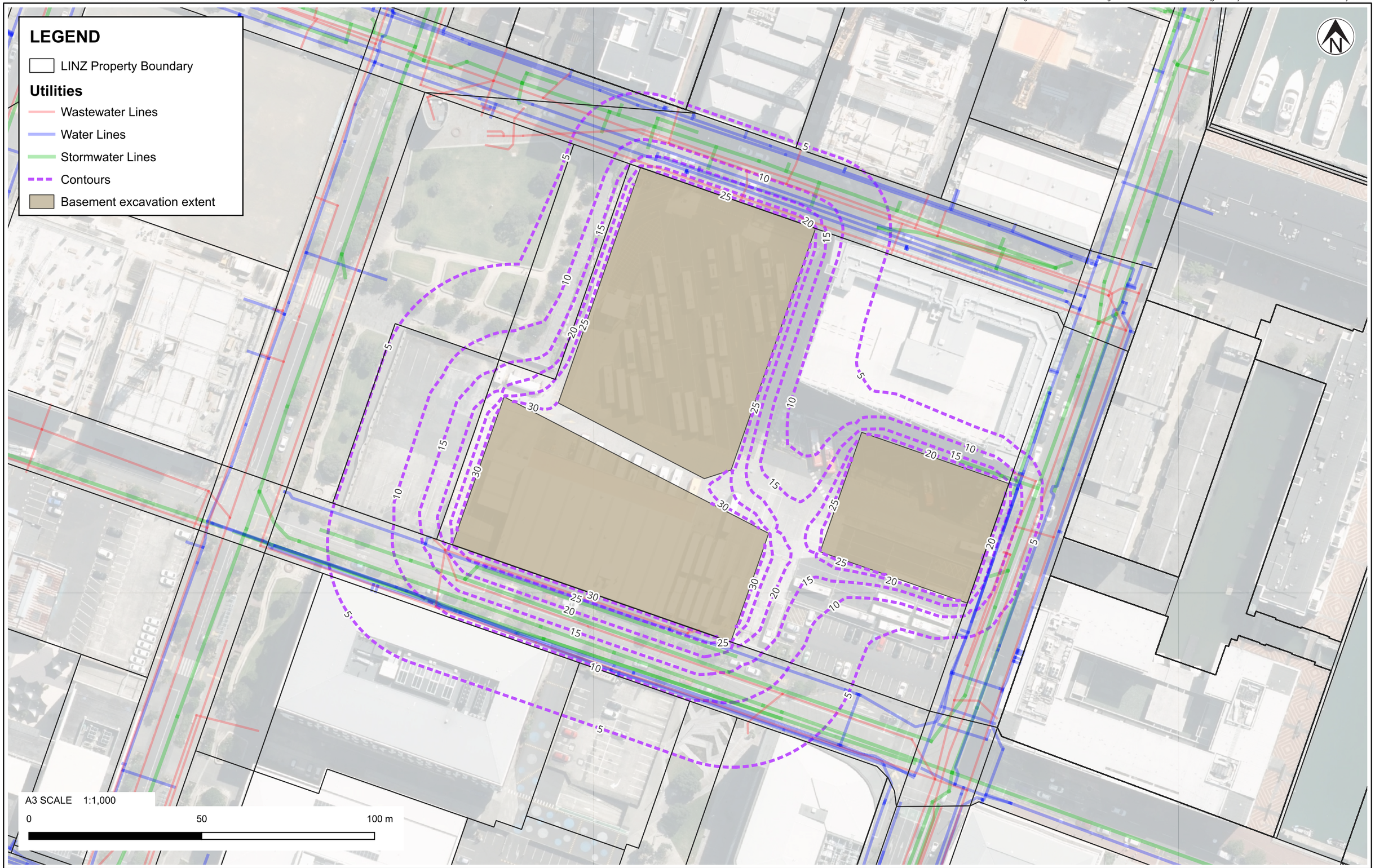
Technical review by Matthew Kent, Senior Geotechnical Engineer.

SSUB

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Appendix A Settlement contour plan

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NOTES:

REV	DESCRIPTION	GIS	CHK	DATE
1	First version	SSUB		10/09/20

LOCATION PLAN

PROJECT No.	1101937.1000	
DESIGNED	SSUB	OCT.26
DRAWN	SSUB	OCT.26
CHECKED		
APPROVED		DATE

CLIENT **NZ CRE 100 HALSEY LIMITED**

PROJECT **100 HALSEY STREET**

TITLE COMBINED GROUNDWATER DRAWDOWN AND RETAINING WALL DEFLECTION INDUCED SETTLEMENT CONTOURS

SCALE (A3) 1:1,000 FIG No. GEO 03 REV 1

Appendix B Groundwater and settlement monitoring plan

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LEGEND

- LINZ Property Boundary

Utilities

- Wastewater Lines
- Water Lines
- Stormwater Lines
- Basement excavation extent

Monitoring points

- Inclinometer (IN)
- Building Settlement (BS)
- Ground Settlement Point (GS)
- Retaining Wall Survey Points (RW)
- Groundwater Point (GW)

Development staging

- Stage 1
- Stage 2
- Stage 3

BS4 BS5 BS6 BS7 BS8 BS9 BS10 BS11 BS12 BS13 BS1 BS2 BS3 BS14 BS15 BS16 BS17 BS18 BS19 BS20

GS13 GS14 GS15 GS16 GS17 GS18 GS19 GS20 GS21 GS22 GS23 GS24 GS25 GS26 GS27 GS28 GS29 GS30 GS31 GS32 GS53 GS52 GS51 GS42 GS43 GS44 GS45 GS46 GS47 GS48 GS49 GS50 GS11 GS10 GS9 GS8 GS4 GS3 GS7 GS6 GS5 GS1 GS2 GS33 GS35 GS36 GS37 GS38 GS39 GS40 GS41 GS34 GS12

GW3 GW4 GW5 GW6 GW2 GW1

RW26 RW11 IN4 RW12 RW13 RW25 RW14 RW24 RW15 IN3 RW16 RW23 RW17 RW22 RW21 RW18 RW20 RW19 RW39 RW40 RW38 RW41 RW37 RW36 RW35 RW34 RW33 RW42 RW27 IN5 RW28 RW29 RW30 IN6 RW31 RW32 RW8 RW9 RW7 RW6 RW5 RW10 IN1 RW1 RW2 RW3 RW4

A3 SCALE 1:1,000

0 50 100 m

NOTES:				PROJECT No.	
				DESIGNED	SSUB OCT.26
				DRAWN	SSUB OCT.26
				CHECKED	
1	Rev 1	SSUB		10/09/20	
REV	DESCRIPTION	GIS	CHK	DATE	LOCATION PLAN / APPROVED / DATE

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CLIENT **NZ CRE 100 HALSEY LIMITED**

PROJECT **100 HALSEY STREET**

TITLE GROUNDWATER AND SETTLEMENT MONITORING PLAN

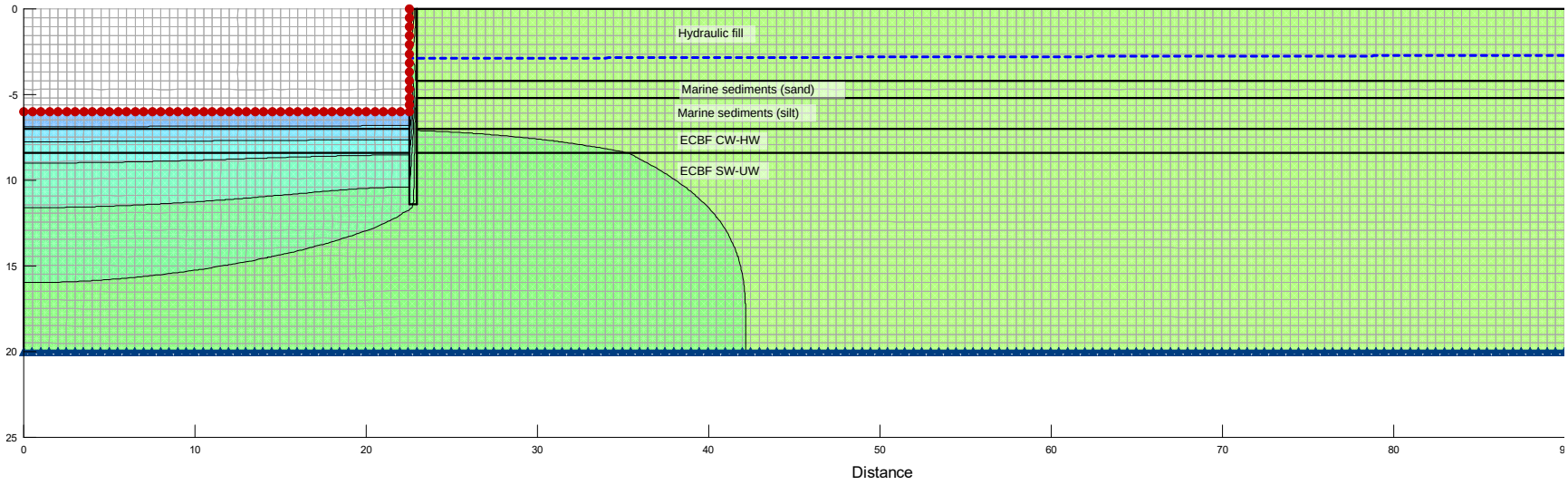
SCALE (A3) 1:1,000 FIG No. GEO 04 REV 1

Appendix C Groundwater drawdown calculation

Analysis Notes:
Method: Transient
Step:Elapsed Time: 365 d

Water Total Head
- -6 - -5.5 m
- -5.5 - -5 m
- -5 - -4.5 m
- -4.5 - -4 m
- -4 - -3.5 m
- -3.5 - -3 m
- -3 - -2.5 m
- -2.5 - -2 m
- -2 - -1.5 m
- -1.5 - -1 m
- -1 - -0.5 m
- -0.5 - 0 m

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Kz'/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressibility (/kPa)
	ECBF CW-HW	Saturated / Unsaturated	CW-MW ECBF	CW-MW ECBF	0.1	1	90	0			
	ECBF SW-UW	Saturated / Unsaturated	ECBF Rock	ECBF Rock	0.1	1	90	0			
	Hydraulic Fill	Saturated / Unsaturated	Hydraulic Fill	Hydraulic Fill	0.5	1	90	0			
	Marine sediments (sand)	Saturated / Unsaturated	Marine sediments (sand)	Marine sediments (sand)	1	1	90	0			
	Marine sediments (silt) / Pleistocene alluvium	Saturated / Unsaturated	Marine sediments (silt)	Marine sediments (silt)	0.1	1	90	0			
	Secant pile (1E-10)	Saturated Only			1	1	90	0	1e-10	0	0



Analysis Description:

Tonkin+Taylor

Project: 1101937.1000 Basement Dewatering 1 year.gsz	
Project Number: 1101937.1000	
A4 Scale: 1:400	
Vertical Exaggeration: 1	
Analysed by: SSUB	Checked By:

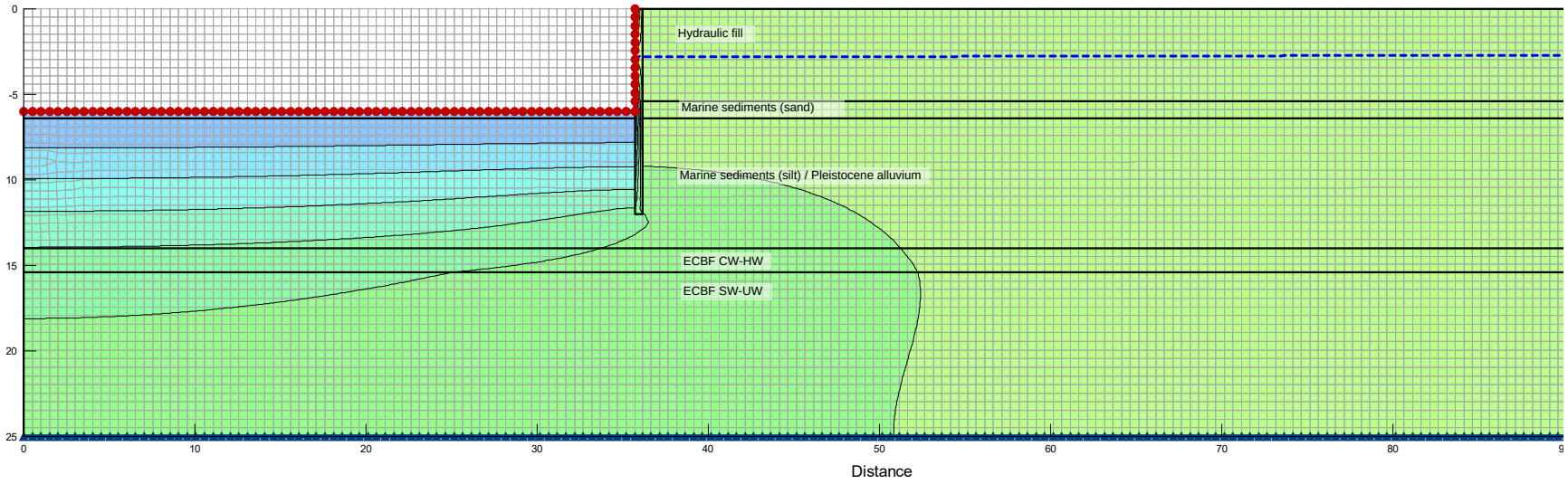
Analysis Case: Basement B2 Excavation

Directory: P:\1101937\1101937.1000\WorkingMaterial\Geotechnical\4. Design\5. Groundwater drawdown assessment\

Analysis Notes:
Method: Transient
Step:Elapsed Time: 365 d

Water Total Head
-6 - -5.5 m
-5.5 - -5 m
-5 - -4.5 m
-4.5 - -4 m
-4 - -3.5 m
-3.5 - -3 m
-3 - -2.5 m
-2.5 - -2 m
-2 - -1.5 m
-1.5 - -1 m
-1 - -0.5 m
-0.5 - 0 m

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Kz'/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressibility (/kPa)
	ECBF CW-HW	Saturated / Unsaturated	CW-MW ECBF	CW-MW ECBF	0.1	1	90	0			
	ECBF SW-UW	Saturated / Unsaturated	ECBF Rock	ECBF Rock	0.1	1	90	0			
	Hydraulic Fill	Saturated / Unsaturated	Hydraulic Fill	Hydraulic Fill	0.5	1	90	0			
	Marine sediments (sand) / Pleistocene alluvium	Saturated / Unsaturated	Marine sediments (sand)	Marine sediments (sand)	1	1	90	0			
	Marine sediments (silt)	Saturated / Unsaturated	Marine sediments (silt)	Marine sediments (silt)	0.1	1	90	0			
	Secant pile (1E-10)	Saturated Only			1	1	90	0	1e-10	0	0



Analysis Description:

Tonkin+Taylor

Project: 1101937.1000 Basement Dewatering 1 year.gsz	
Project Number: 1101937.1000	
A4 Scale: 1:400	
Vertical Exaggeration: 1	
Analysed by: SSUB	Checked By:

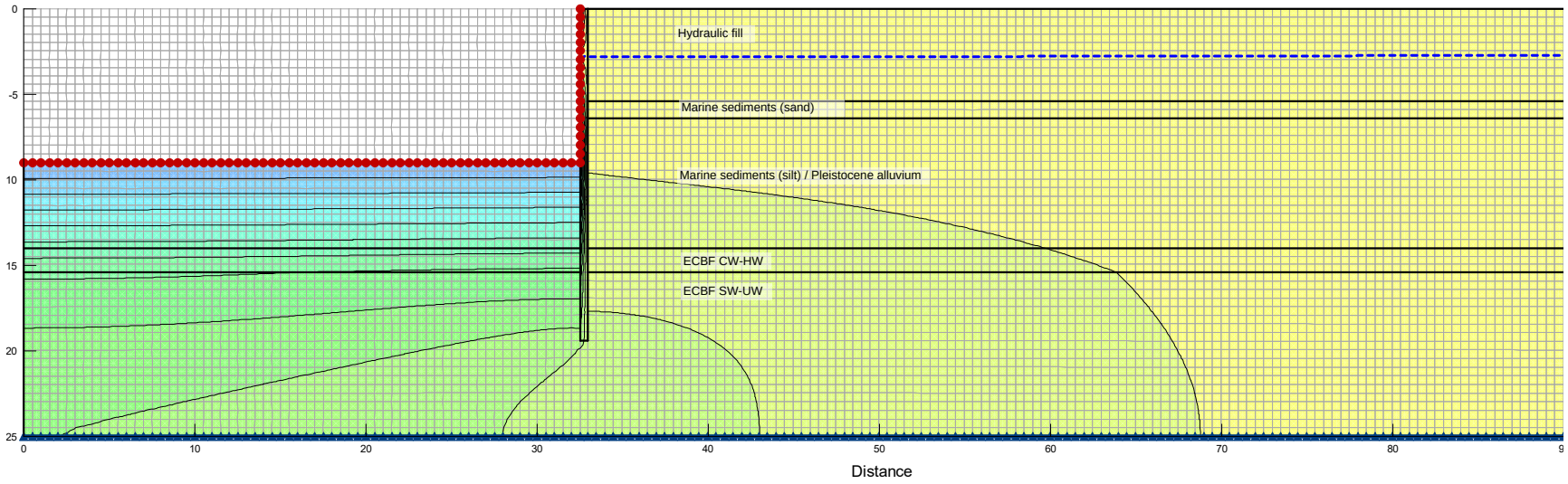
Analysis Case: Basement B3A/3B Excavation

Directory: P:\1101937\1101937.1000\WorkingMaterial\Geotechnical\4. Design\5. Groundwater drawdown assessment\

Analysis Notes:
Method: Transient
Step:Elapsed Time: 365 d

Water Total Head
-9 - -8.5 m
-8.5 - -8 m
-8 - -7.5 m
-7.5 - -7 m
-7 - -6.5 m
-6.5 - -6 m
-6 - -5.5 m
-5.5 - -5 m
-5 - -4.5 m
-4.5 - -4 m
-4 - -3.5 m
-3.5 - -3 m
-3 - -2.5 m
-2.5 - -2 m
-2 - -1.5 m
-1.5 - -1 m
-1 - -0.5 m
-0.5 - 0 m

Color	Name	Hydraulic Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Kz'/Kx' Ratio	Dip Direction (°)	Dip (°)	Sat Kx (m/sec)	Volumetric Water Content	Compressibility (/kPa)
	ECBF CW-HW	Saturated / Unsaturated	CW-MW ECBF	CW-MW ECBF	0.1	1	90	0			
	ECBF SW-UW	Saturated / Unsaturated	ECBF Rock	ECBF Rock	0.1	1	90	0			
	Hydraulic Fill	Saturated / Unsaturated	Hydraulic Fill	Hydraulic Fill	0.5	1	90	0			
	Marine sediments (sand) / Pleistocene alluvium	Saturated / Unsaturated	Marine sediments (sand)	Marine sediments (sand)	1	1	90	0			
	Marine sediments (silt)	Saturated / Unsaturated	Marine sediments (silt)	Marine sediments (silt)	0.1	1	90	0			
	Secant pile (1E-10)	Saturated Only			1	1	90	0	1e-10	0	0



Analysis Description:

Tonkin+Taylor

Project: 1101937.1000 Basement Dewatering 1 year.gsz
Project Number: 1101937.1000
A4 Scale: 1:400
Vertical Exaggeration: 1
Analysed by: SSUB | Checked By:

Analysis Case: Basement B4/B5 Excavation

Directory: P:\1101937\1101937.1000\WorkingMaterial\Geotechnical\4. Design\5. Groundwater drawdown assessment\



Together we create + sustain a better world