The Bays Retaining Walls - Hydrogeological Design Report

SMWSTCTP-AFJ-TBY-GE-RPT-000001 Revision 1

Sydney Metro West – Central Tunnelling Package

DOCUMENT APPROVAL

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C.1	26/11/21	All	[redacted]	CDR / Internal Review – (Stage 3) Stage 2 Secant Pile Solution
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CONTENTS

1. INTRODUCTION

This report provides hydrogeological advice for the design of The Bays Station box, and provides the following:

- An updated hydrogeological conceptual model of the site
- Updated groundwater modelling to estimate the potential groundwater inflows to the station box excavation and mined tunnels, and associated groundwater level drawdown
- Assessment of potential groundwater-related impacts for the site
- Updated discussion of the potential design implications related to the construction of The Bays Station

This issue (Issue E, dated 30 March 2022) has been issued to close-out Sydney Metro comments. There are no outstanding comments relating to hydrogeology to be addressed in comment register SMWSTCTP-AFU-TBY-SN200-ST-COM-003000[B]. As such, no changes have been made to this report since the previous issue (Issue D).

The following additional assessments are included in this report since the previous report (the Stage 3 Secant Pile Solution, dated 8 December 2021) report:

- Potential saline intrusion at The Bays site due to Project works
- Potential contaminant migration at The Bays site due to Project works
- Potential changes to groundwater pH due to activation of (potential) acid sulfate soils at The Bays site due to Project works
- Inclusion of additional packer tests undertaken in AFJV boreholes at The Bays Station site in the analysis of hydraulic conductivity

The scope of this document is limited to the information available at this particular time (January 2022).

1.1 INFORMATION SOURCES

This report has been prepared based on the most up-to-date field investigations and monitoring available at the time of its preparation and thus is based on information provided in:

- AFJV geotechnical investigations at The Bays Station site conducted in September to December 2021, including the following:
    - Drilling of 14 boreholes in the vicinity of the station box and tunnels, with packer testing in 12 of those boreholes
    - "Pump-out tests" in five boreholes. This involved pumping of groundwater from an open borehole for a number of hours. Details and analysis of these tests are provided in Annexure B
    - Groundwater level monitoring in three piezometers during the pump-out tests
- Golder-Douglas Partners (2020), Groundwater Monitoring Report – Stage 2 Locations Sydney Metro West Geotechnical Investigation, report reference 1791865-023-R-GWM Stage 2 Rev1, 20 May 2021
- Golder-Douglas Partners (2021a), Groundwater Monitoring Report – Stage 3 Locations, report reference 1791865-026-R-GWM Stage 3 Rev C, 23 June 2021
- Golder-Douglas Partners (2021b), Factual Contamination Investigation Report – The Bays Sydney Metro West, White Bay Site Investigation, report reference 000013/11868, 21 May 2021
- Senversa (2021), Factual Contamination Investigation Report - The Bays, 21 May 2021

2. PARTICULAR SPECIFICATIONS AND MINISTERS’ CONDITIONS OF APPROVAL

This memorandum considers the Sydney Metro West – Central Tunnel Package Particular Specification Requirements (V7.0) and Ministers’ Conditions of Approval as they pertain to The Bays Station, including:

4.1.7 Groundwater control

(a) The Tunnelling contractor must comply with the following for the drainage of assets:

(ix) The Bays Station Excavation above the soil retention toe level – undrained

(x) The Bays Station Excavation below the soil retention system toe level – drained

(b) The Tunnelling Contractor must assess by modelling the impact on the groundwater table and specify control and monitoring measures to demonstrate compliance with Acceptable Effects.

(c) The Tunnelling Contractor must minimise the impacts of groundwater drawdown and demonstrate from modelling that there are only Acceptable Effects to adjacent structures.

(h) The groundwater seepage within each Station excavation and each Shaft Excavation must not exceed

(i) 50,000 litres in and 24-hour period, measured over any square with an area of 10m2, at any and all locations within the sides and bases of the excavation; and

(ii) the volumes identified below in any 24-hours period:

(G) The Bays Station excavation: 445,000 litres

Ministers’ Conditions of Approval Relevant to this Report

Condition D122: The Proponent must submit a revised Groundwater Modelling Report in association with Stage 1 of the CSSI to the Planning Secretary for information before bulk excavation at the relevant construction location. The Groundwater Modelling Report must include:

(a) for each construction site where excavation will be undertaken, cumulative (additive) impacts from nearby developments, parallel transport projects and nearby excavation associated with the CSSI;
(b) predicted incidental groundwater take (dewatering) including cumulative project effects;
(c) potential impacts for all latter stages of the CSSI or detail and demonstrate why these later stages of the CSSI will not have lasting impacts to the groundwater system, ongoing groundwater incidental take and groundwater level drawdown effects;
(d) actions required after Stage 1 to minimise the risk of inflows (including in the event latter stages of the CSSI are delayed or do not progress) and a strategy for accounting for any water taken beyond the life of the operation of the CSSI;
(e) saltwater intrusion modelling analysis, from estuarine and saline groundwater in shale, into The Bays metro station site and other relevant metro station sties; and
(f) a schematic of the conceptual hydrogeological model.

3. HYDROGEOLOGICAL CONCEPTUAL MODEL

3.1 GEOLOGY

Geological sections at The Bays Station are provided in the Geotechnical Interpretation Report, and show five geological units in the vicinity of the station, including:

- Fill
- Quaternary alluvium

- Residual soils
- Hawkesbury Sandstone
- Great Sydney Dyke

Figure 3-1 shows the interpreted extend of the alluvium and the location of the dyke in relation to the station box.

Fill represents the dominant surficial deposits at The Bays Station. It is highly variable in composition, including reinforced concrete, concrete, gravel, sand and clay. Its thickness varies from approximately 4 m near the center of the station box to less than a metre at the eastern end of the station box.

Quaternary deposits underly Fill deposits at The Bays Station. These are represented by a combination of undifferentiated Holocene and Pleistocene age sediments. The Quaternary deposits are comprised of interbedded sands, silts and clays with discontinuous interbedded lenses of the same material. These have been characterised as alluvium and estuarine deposits within zones of incised sandstone, and are associated with the White Bay palaeochannel. The boundary of the palaeochannel/alluvium is shown in Figure 3-1. The alluvial depth reaches a thickness of up to approximately 17 meters near White Bay Power Station.

The Hawkesbury Sandstone is the basal unit at The Bays Station. The unit was in a fluvial paleo-environment, likely to have been a braided river setting, and as such it is highly stratified. It is ubiquitous across the Sydney Basin and is up to some 300 metres thick. At The Bays Station the unit is characterised by fine to coarse grained sandstone.

The Great Sydney Dyke has been encountered at the eastern edge of the station box. The dyke is a Jurassic or Eocene-age basaltic intrusion into the Hawkesbury Sandstone.

FIGURE 3-1: EXTENT OF ALLUVIUM AND LOCATION OF GREAT SYDNEY DYKE IN THE VICINITY OF THE BAYS STATION (GREAT SYDNEY DYKE IN RED, ALLUVIAL BOUNDARY IN BEIGE)

3.2 HYDROGEOLOGICAL UNITS

Three hydrogeological units are considered to occur at The Bays Station including:

- A surficial unit, comprising Fill and Quaternary deposits (alluvium)
- Residual soils/extremely weathered sandstone
- Hawkesbury Sandstone

3.2.1 SURFICIAL UNIT (FILL, QUATERNARY DEPOSITS AND RESIDUAL SOILS)

Quaternary deposits (alluvium) and fill are considered the surficial aquifer at the site and host the watertable. The fill and alluvium are considered hydraulically connected and groundwater flow will be controlled by the primary permeability of the units with areas of coarse material (gravels and sands) yielding higher permeabilities and finer grained material (silts and clays) yielding lower permeabilities. The thickness of the unit is less than a meter at the eastern extent of the station box, where only a thin layer of fill is present, but thickens to approximately 19 m through the palaeochannel to the west of the station box near White Bay Power Station.

Residual soils/extremely weather rock are generally sandy in nature, having been derived from Hawkesbury Sandstone, and expected to be of relatively high permeability. There is very limited presence of residual soils in the palaeochannel, as the majority of this material is likely to have been eroded.

3.2.2 HAWKESBURY SANDSTONE

The Hawkesbury Sandstone forms the basal aquifer at The Bays Station. Groundwater flow in the sandstone is typically controlled by secondary features such as fractures, joints, shears and bedding planes and effectively acts as a fractured rock aquifer. Areas where the unit is more fractured tend to yield greater permeabilities while more competent sections typically yield low permeabilities.

Review of borehole logs and water pressure (packer) test results indicate the presence of near-horizontal bedding planes across the site that are likely to have dilated due to stress relief. Refer to the Geotechnical Interpretation Report for figures showing these features. Packer test results show that high permeability is associated with these features.

3.2.3 GREAT SYDNEY DYKE

The dyke has been intersected in four reference site boreholes within The Bays area, as well as in outcrop on Sommerville Road and within the cutting on James Craig Road beneath the ANZAC Bridge western abutment.

The projected orientation of the Great Sydney Dyke through the station box, and further northwest into the Balmain area, suggests that the White Bay palaeochannel may have been initiated by the dyke feature parallel to Mullens Street.

The interpreted orientation of the Great Sydney Dyke within The Bays area is shown in Figure 3 1.

The dyke is expected to be subvertical and ranging in width from approximately 4 m to 9 m.

It is comprised of variably weathered dolerite, with soil properties in its upper 4 m and becoming less weathered with depth. The central core of the dyke at depth is likely to be fresh. The contacts with the adjacent sandstone are likely to be irregular and altered, and re-crystalisation of the dyke-country rock contact (baked margin or zone) can be discerned in some of the intersecting boreholes.

The sandstone surrounding the dolerite may be locally more deeply weathered adjacent to the dyke in the uppermost bedrock profile, though borehole logs indicate that the sandstone immediately adjacent to the dyke at depth is fresh, and it may exhibit a higher strength ‘baked margin’ due to the heat from the dyke locally contact metamorphosing the adjacent sandstone (this zone is typically between 0.5 and 1 m thick).

Where the Great Sydney Dyke intersects the station box, the less weathered dolerite rock (the core rock) could be exposed in the basal 10 m to 15 m of the excavation.

Observations and experience of dykes encountered in Sydney suggests that dykes are inherently variable and that, although the approximate orientation and location of the dyke may be relatively well known, the character of the dyke can change over short distances. Dykes can be expected to thicken and thin, bifurcate and recombine, and may exhibit other irregularities governed by the original host rock structure. Photographs of the Great Sydney Dyke in available exposures, as well as available downhole imaging in boreholes that intersect the dyke at White Bay, show a distinct subvertical rock structure that strikes sub-parallel with the main dyke alignment, presumably reflecting the nature of the igneous emplacement. R219_BH240 angled across the dyke shows sandstone country rock between dolerite dykes, indicating a potential for bifurcation, stringer dykes and other irregularities within the White Bay area and station box excavation.

Due to the dyke’s inherent variability, irregular distribution and strongly defined subvertical rock structure, it is possible that it may simultaneously impede and enhance groundwater flow along its length/depth.

Reduced defect spacing is encountered in the dolerite at some locations (R246_BH2103/105 and R219_BH240) but not at others (R246_BH2103/54 and R621_BH05), which could coincide with increased permeability.

Packer test results across the dolerite and adjacent sandstone (boreholes AF_BH01i, R246_BH2103/54 and R219_BH240_NWM) indicate that both dolerite and sandstone in the vicinity of the dyke could show higher permeability than the surrounding sandstone (which often exhibits relatively high permeability) within the palaeochannel.

It is possible that the dyke at the site could act as a conduit to groundwater flow to a greater extent than the surrounding sandstone.

3.3 GROUNDWATER LEVELS AND FLOW

Figure 3-2 and Figure 3-3 show the locations of groundwater monitoring piezometers and vibrating wire piezometers (VWPs) at The Bays Station site.

Figure 3-2 presents the typical depth to the groundwater table, and Figure 3-3 presents the typical elevation of the groundwater table at The Bays Station site. This is based on data considered reliable from the Sydney Metro West (SMW) monitoring locations, supplemented with recent the groundwater monitoring event undertaken by Senversa (2021) in May 2021.

The depth to the watertable ranges between approximately 0.6 metres below ground level (mbgl) and 3.7 mbgl. The elevation of the watertable ranges between approximately 0.3 m AHD and 1.7 m AHD across the site, with generally higher elevations to the west, south and east of the station; and lower elevations to the north, closer to White Bay. This is consistent with inland recharge driving groundwater flow to the north towards White Bay.

Groundwater hydrographs for nested wells at SMW_BH066 and SMW067 have been provided in Annexure A. The deeper bore at SMW_BH066 is screened from 27.2 to 30.2 m depth in the Hawkesbury Sandstone while its shallower counterpart is screened from 2 to 6 m depth in Fill/Quaternary deposits. Likewise, the deeper of SMW_BH067 is screened from 12.5 to 15.5 m depth in the Hawkesbury Sandstone while its shallower counterpart is screened from 2.5 to 6.0 m depth in a shallower section of the Hawkesbury Sandstone.

The hydrographs indicate a weak upward hydraulic gradient at SMW_BH066 with levels in the deeper bore typically ranging between 1.0 and 1.5 m AHD, while those in the shallower bore are typically below 0.5 m AHD. Groundwater levels at SMW_BH067 are similar, with levels typically ranging between 0.5 and 1.5 m AHD in both shallower and deeper wells, though brief sharp increases in groundwater levels to 2.0 m AHD were noted in the shallower well in response to rainfall recharge.

FIGURE 3-2: DEPTH TO WATERTABLE (M BGL) AT THE BAYS STATION SITE

FIGURE 3-3: WATERTABLE ELEVATION (M AHD) AT THE BAYS STATION SITE

3.4 HYDROGEOLOGICAL TEST DATA

Hydrogeological testing has been undertaken in the vicinity of the site, including:

- 151 water pressure (packer) tests in the Hawkesbury Sandstone within about one kilometre of the station box site, including:

    - 136 water pressure (packer) tests in the Hawkesbury Sandstone within the palaeochannel area, of which approximately 82 packer tests were undertaken within 25 boreholes in the vicinity of the station box

- Seven rising/falling head tests in the alluvium in the vicinity of the station box
- Pump-out tests in five open AFJV boreholes, drilled in September and October 2021. Details and analysis of these tests are provided in Annexure B
- Two successful pumping tests undertaken for the Rozelle Interchange project (JHCPB Joint Venture, 2021a) at a location about 700 m west of The Bays Station site and in the same geological setting. One test pumped groundwater from the alluvium for 55 hours (with a typical yield of 45 L/min) and the other test pumped groundwater from the sandstone for 72 hours (with a consistent yield of 20 L/min). A third pumping test in a piezometer screened in sandstone was abandoned as it could not maintain sustainable yield. Groundwater level responses were monitoring in surrounding piezometers screened in both the sandstone and the alluvium

3.4.1 HYDRAULIC CONDUCTIVITY

3.4.1.1 FILL

Hydraulic test data are not available for the fill at the site. Parameter values for the fill have been assumed based on material descriptions, and the data from the WestConnex Rozelle Interchange and Western Harbour Tunnel Enabling Works (RIC) project site. Available data indicates that the horizontal hydraulic conductivity of fill may be between 0.4 m/day and 10 m/day. The fill is expected to be relatively isotropic.

3.4.1.2 ALLUVIUM

Seven rising/falling head tests were conducted at The Bays Station site as part of the Sydney Metro site investigations, and eight were conducted at the RIC site (JHCPB Joint Venture, 2021a).

The tests were conducted in variably sandy, silty, clayey materials; at depths ranging between approximately 2 mbgl and 15 mbgl.

One of the pumping tests completed at the RIC site (JHCPB Joint Venture, 2021a) pumped from the alluvium. The resulting analyses indicated a typical horizontal hydraulic conductivity of between approximately 0.3 m/day and 7 m/day, and a vertical to horizontal hydraulic conductivity ratio of between 0.075 and 0.2, depending on the test analysis method used. JHCPB Joint Venture (2021a) adopted a horizontal hydraulic conductivity value of 0.5 m/day and a vertical to horizontal hydraulic conductivity ratio of 0.2 in their numerical groundwater model.

TABLE 3-1: HYDRAULIC CONDUCTIVITY TEST RESULTS IN ALLUVIUM

Rising/falling head tests	**Horizontal hydraulic conductivity value (m/day)**			
	Minimum test value	**Maximum test value**	**Mean test value**	**Median test value**
Seven at The Bays Station site	0.2	1.7	1.0	1.1
Eight at RIC site	0.06	0.4	0.2	0.2
Pumping test in alluvium	**Horizontal hydraulic conductivity value (m/day)**		**Horizontal to vertical hydraulic conductivity ratio**	
	Minimum value	**Maximum value**	**Minimum value**	**Maximum value**
At RIC site	0.3	0.7	0.075	0.2

Piezometers in which rising/falling head tests were undertaken at The Bays Station site for Sydney Metro were screened across alluvium (and possibly minor residual soils in some locations).

Rising/falling head tests undertaken at the RIC site (JHCPB Joint Venture, 2021a) indicated horizontal hydraulic conductivity values of between 0.5 m/day and 1.5 m/day.

3.4.1.3 SANDSTONE

This section describes the results of permeability testing of the Hawkesbury Sandstone in the vicinity of The Bays Station site.

Fresh Hawkesbury Sandstone with limited defects typically has horizontal hydraulic conductivity values ranging from less than 8.6x10-4 m/day (0.1 Lugeon) to approximately 1.7x10-2 m/day (2 Lugeons). Weathered rock and rock with geological structure (e.g., within fault zones, near dykes) can exhibit hydraulic conductivity values much higher than this.

A ratio of horizontal to vertical hydraulic conductivity equal to 0.1 is considered typical for Hawkesbury Sandstone. Where vertical jointing is present there may be increased vertical connectivity within the sandstone, leading to ratio values closer to 0.5.

3.4.1.3.1 Water pressure (packer) tests

Within the White Bay palaeochannel and the surrounding elevated ground at Rozelle (within about one kilometre of the station box site), 218 water pressure (packer) tests have been completed in the Hawkesbury Sandstone. This includes 171 water pressure (packer) tests in the Hawkesbury Sandstone within the palaeochannel area (i.e., within the alluvial boundary shown in Figure 3-1), of which approximately 119 packer tests were undertaken in 32 boreholes within approximately 200 m of the station box (referred to herein as “at the The Bays Station site”).

Packer test results below 0.1 Lugeons (or reported as zero Lugeons) have been forced equal to 0.05 Lugeons for the purposes of this analysis.

There are five packer test results assessed to have values greater than 100 Lugeons reported. Values above 100 Lugeons may exceed the upper quantification limit of the tests. For the purposes of analysis, these high values are retained. The difference in test statistics values considering values above 100 Lugeons, and in forcing test values above 100 Lugeons to have a test value equal to 100 Lugeons, is minimal.

Statistics for the 48 packer tests conducted outside the palaeochannel, and for the 171 packer tests conducted inside the palaeochannel, are provided in Table 3-2.

Figure 3-4 shows the packer test results (Lugeon value) with depth. Outside the palaeochannel, the hydraulic conductivity tends to reduce with depth. However, at The Bays Station site and within the palaeochannel generally, there is no clear correlation between hydraulic conductivity and depth, with the possible exception that the maximum hydraulic conductivity appears to reduce with depth below about 25 metres below ground level (mbgl).

Figure 3-5 shows the highest Lugeon value of any packer test in a single borehole. There is a clear trend showing high permeability bedrock closer to/within the deeper areas of the palaeochannel, and less permeable bedrock at distance from the deepest part of the palaeochannel. The rock mass permeability of the Hawkesbury Sandstone is controlled by the number and openness of bedrock defects, particularly open bedding plane contacts that have been traced between boreholes at significant lateral distance across the site, and subvertical open joint planes closer to the buried clifflines. It is likely that stress relief of the rock beneath and adjacent to the palaeochannel has enhanced the openness and/or interconnectivity of these features. The Geotechnical Interpretation Report identifies several horizontal bedding planes, in particular, which coincide with high Lugeon packer test results. These bedding planes are interpreted to be present at an average vertical spacing of approximately 3.5 m.

Figure 3-6 shows a histogram of the packer test results (Lugeon values) for all test results inside the palaeochannel and all test results outside the palaeochannel. The histogram suggests that there is a log-normal distribution.

Figure 3-7 shows the log Lugeon value as a linearised normal distribution for all packer tests at The Bays Station site. The median value is 67 Lugeons. This value is very high and is not considered representative of the general rock mass in the palaeochannel.

TABLE 3-2: STATISTICS FOR PACKER TEST RESULTS (LUGEONS)

Statistic	**All locations**	**Inside palaeochannel**	**Outside palaeochannel**	**The Bays Station site**
Number of tests	**219**	**171**	**48**	**119**
Minimum	<1	<1	<1	<1
25th percentile	0.3	0.3	0.3	0.2
Mean	16.5	20.0	3.6	23.4
Median	1.4	1.4	0.7	1.5
Geomean	1.8	2.0	0.9	1.9
75th percentile	11.8	20.0	2.3	20.0
Maximum	>100	>100	26.8	>100

The horizontal hydraulic conductivity of the bulk rock mass in the palaeochannel is generally higher than that across all locations within the subregion. This is to be expected, because the rock closer to the ridgelines (outside the palaeochannel) will not have experienced the stress relief and potential weathering experienced by the rock within the palaeochannel, and is therefore less likely to possess significant water bearing features such as dilated bedding planes and joints.

The horizontal hydraulic conductivity of the bulk rock mass across The Bays Station site is generally higher than that across the whole palaeochannel. This is also to be expected, since the significant water bearing features (such as dilated bedding planes) are likely to be more frequent and extensive in the area closer to White Bay where stress relief may have been greater.

FIGURE 3-4: PACKER TEST RESULTS (LUGEON VALUES) WITH DEPTH BELOW GROUND LEVEL (BGL)

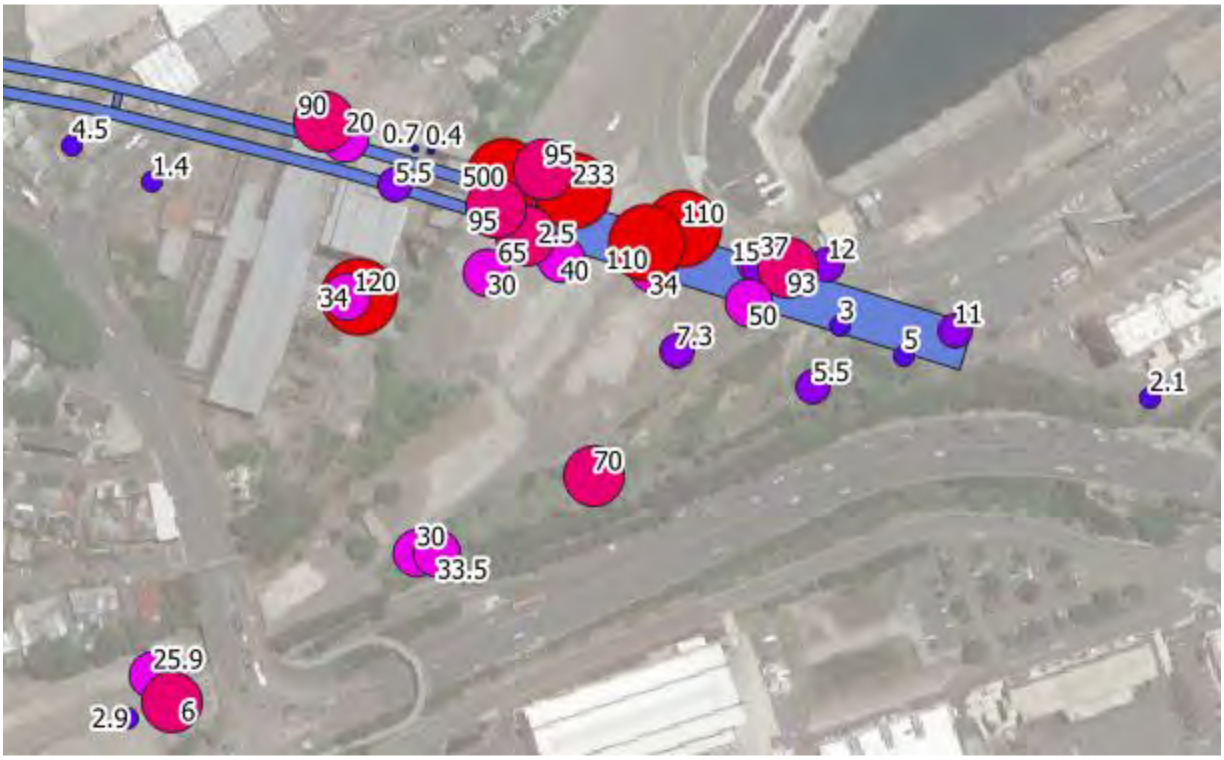


FIGURE 3-5: HIGHEST LUGEON VALUE OF ANY PACKER TEST IN BOREHOLE

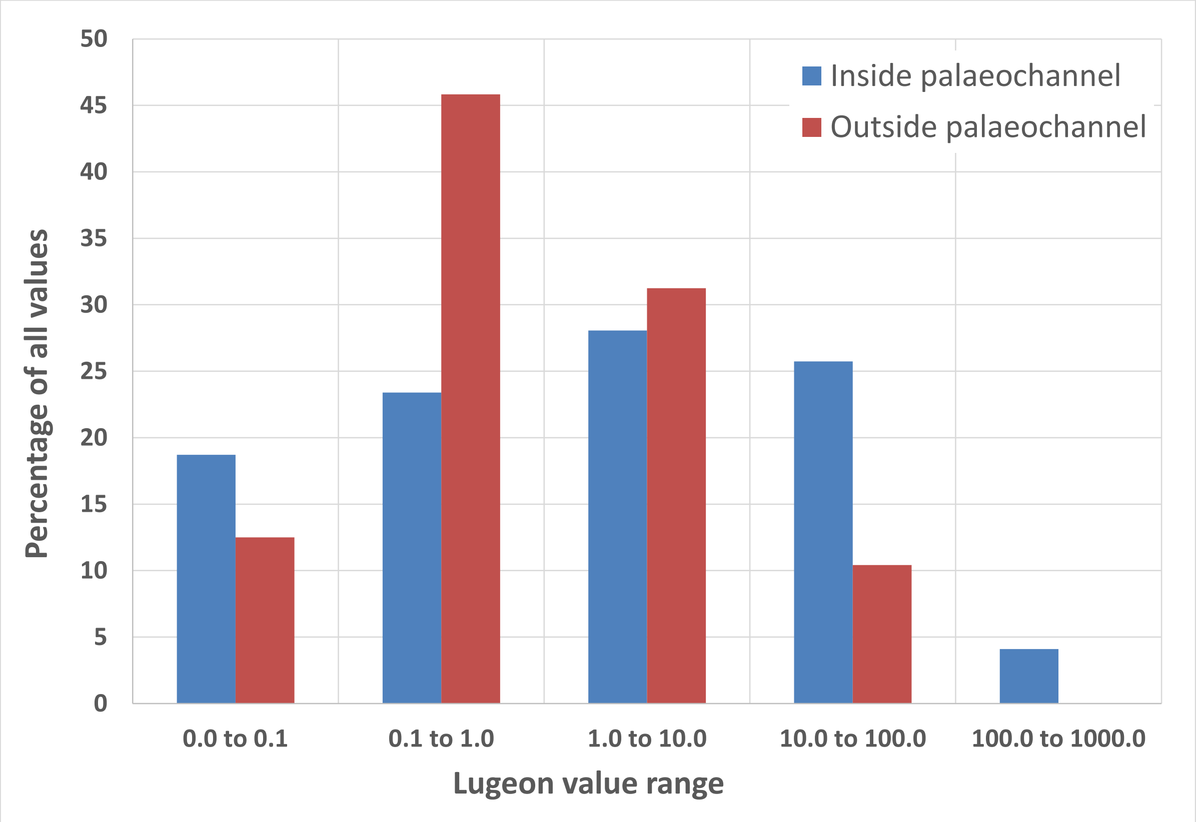
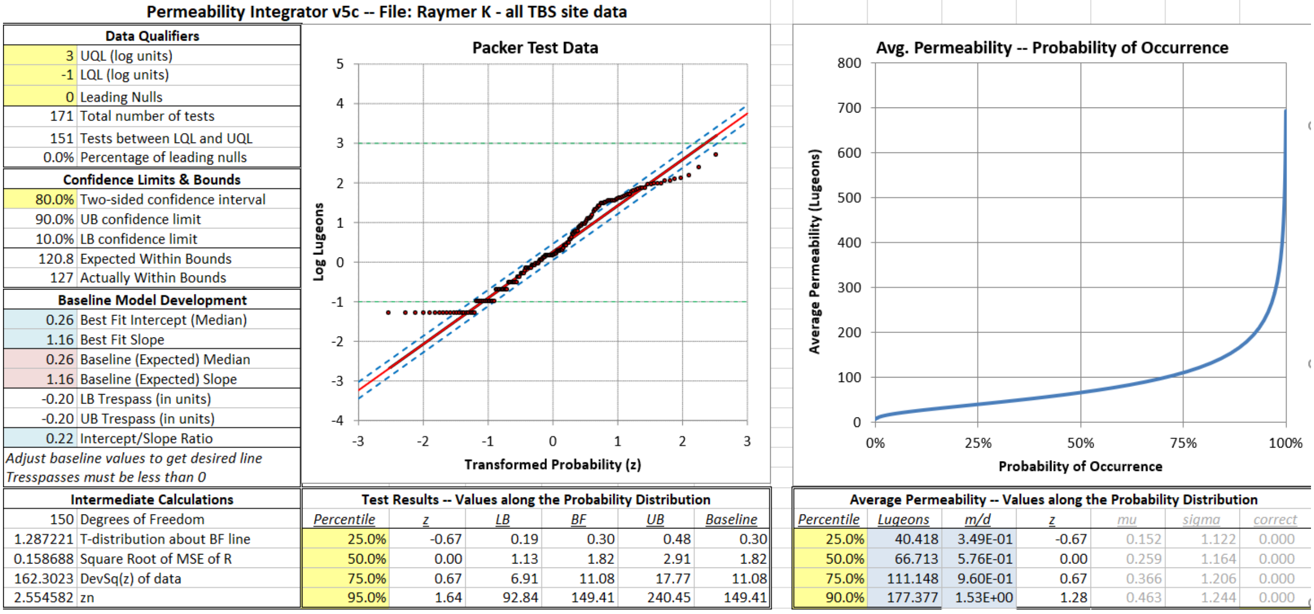


FIGURE 3-6: HISTOGRAM OF LUGEON VALUES FOR TESTS CONDUCTED INSIDE AND OUTSIDE OF THE PALAEOCHANNEL



Permeability Integrator v5c -- File: Raymer K - all TBS site data

Data Qualifiers	
3	UQL (log units)
-1	LQL (log units)
0	Leading Nulls
171	Total number of tests
151	Tests between LQL and UQL
0.0%	Percentage of leading nulls

Confidence Limits & Bounds	
80.0%	Two-sided confidence interval
90.0%	UB confidence limit
10.0%	LB confidence limit
120.8	Expected Within Bounds
127	Actually Within Bounds

Baseline Model Development	
0.26	Best Fit Intercept (Median)
1.16	Best Fit Slope
0.26	Baseline (Expected) Median
1.16	Baseline (Expected) Slope
-0.20	LB Trespass (in units)
-0.20	UB Trespass (in units)
0.22	Intercept/Slope Ratio

Adjust baseline values to get desired line
Tresspasses must be less than 0

Intermediate Calculations	
150	Degrees of Freedom
1.287221	T-distribution about BF line
0.158688	Square Root of MSE of R
162.3023	DevSq(z) of data
2.554582	zn

Test Results -- Values along the Probability Distribution

Percentile	*z*	*LB*	*BF*	*UB*	*Baseline*
25.0%	-0.67	0.19	0.30	0.48	0.30
50.0%	0.00	1.13	1.82	2.91	1.82
75.0%	0.67	6.91	11.08	17.77	11.08
95.0%	1.64	92.84	149.41	240.45	149.41

Average Permeability -- Values along the Probability Distribution

Percentile	*Lugeons*	*m/d*	*z*	*mu*	*sigma*	*correct*
25.0%	40.418	3.49E-01	-0.67	0.152	1.122	0.000
50.0%	66.713	5.76E-01	0.00	0.259	1.164	0.000
75.0%	111.148	9.60E-01	0.67	0.366	1.206	0.000
90.0%	177.377	1.53E+00	1.28	0.463	1.244	0.000

FIGURE 3-7: LOG LUGEON VALUES AS A LINEARISED NORMAL DISTRIBUTION FOR PACKER TESTS AT THE BAYS STATION SITE

3.4.1.3.2 Pump-out tests at The Bays Station site

A description of the pump-out tests, their results, and analysis and interpretation of the results is presented in Annexure B.

Of the test results adopted as valid, the interpreted horizontal hydraulic conductivity values are listed in Table 3-3.

The results of these tests confirm the values indicated by the packer test results. The “all valid” results include all results listed as valid in Annexure B, including those analysed based on the theories of both Theis (1935) and Moench (1984, 1988).

The Moench (1984, 1988) analysis considers a dual-porosity model fractured aquifer system with slab matrix blocks and fracture. It represents a groundwater flow system with sub-horizontal fractures, consistent with the conceptual model of the site in which dilated bedding planes control much of the groundwater flow behaviour.

The results suggest that typical horizontal hydraulic conductivity of between approximately 10 and 25 Lugeons is likely at The Bays Station site.

TABLE 3-3: STATISTICS FOR VALID PUMP-OUT TEST ANALYSIS RESULTS (LUGEONS)

Statistic	All valid analysis results	Valid Moench analysis results
Minimum	1	2
Median	10	7
Mean	22	9
Maximum	81	17

3.4.1.3.3 Pumping tests at the RIC site

JHCPB Joint Venture (2021a) undertook two-dimensional numerical groundwater flow modelling to analyse the results of the pumping tests completed at the RIC site. They estimated the sandstone to have a horizontal hydraulic conductivity of between 6x10-3 m/day (0.7 Lugeons) and 4.3x10-1 m/day (50 Lugeons).

Analysis by JHCPB Joint Venture (2021a) of the pumping test results based on Theis theory yielded a ratio of horizontal to vertical hydraulic conductivity of between 0.17 and 1. Two-dimensional numerical groundwater flow modelling to analyse the results of the pumping tests yielded a value of 0.5, and this value was adopted in their calibrated three-dimensional numerical model.

3.4.1.3.4 Summary

Based on the packer tests, pump-out tests, and pumping tests conducted at the RIC site, it is expected that a typical horizontal hydraulic conductivity of the bulk rock mass across The Bays Station site is likely to range between approximately 10 Lugeons (8.6×10-2 m/day) and 30 Lugeons (2.5×10-1 m/day). A value closer to 20 Lugeons is expected to reflect typical conditions.

However, it is possible that the bulk rock mass across The Bays Station site is much higher (up to 80 Lugeons).

3.4.1.4 DYKE

Six borehole have intersected the Great Sydney Dyke at The Bays Station site. Their locations are shown in Figure 3-8.

Packer tests have been conducted in three of these boreholes (AF_BH01i, R246_BH2103/54 and R219_BH240).

Packer test results range from less than 1 Lugeon to up to 37 Lugeons in the dolerite and surrounding sandstone. The highest values (above 30 Lugeons) are associated with zones where significant core loss is observed. Significant core loss was observed at the margins of the dyke (dolerite) in AF_BH01i and R219_BH240.

Based on the available borehole loss and packer test results, there is no distinct pattern between the geological zone (dolerite core, metamorphosed sandstone at the dyke margin, and surrounding sandstone) and/or weathering showing greater or lesser permeability.

It is possible that the dyke could act as a conduit to groundwater flow, with relatively high Lugeon values (e.g., in excess of 30 Lugeons). However, it is also possible that the dyke has hydraulic conductivity that is consistent with the surrounding sandstone.

FIGURE 3-8: LOCATION OF BOREHOLES INTERSECTING GREAT SYDNEY DYKE AT THE BAYS STATION SITE

3.4.2 STORAGE

3.4.2.1 FILL

Aquifer storage data are not available for the fill at the site. Parameter values for the fill have been assumed based on material descriptions, and the data from the RIC site. Available data indicates that a specific yield of between 0.1 and 0.2 is likely for the fill.

3.4.2.2 ALLUVIUM

Based on the pumping tests completed at the RIC site, JHCPB Joint Venture (2021a) estimated the alluvium to have a specific yield of between 0.04 and 0.15, and a specific storage value of between $9x10^{-6}$ m^{-1} and $2.4x10^{-3}$ m^{-1}. The latter value is unusually high for interbedded clayey-sandy sediments. JHCPB Joint Venture (2021a) adopted a specific yield value of 0.15 and a specific storage value of $1x10^{-4}$ m^{-1} in their calibrated model.

Some of the specific storage values reported by JHCPB Joint Venture (2021a) exceed the upper plausible limit of $1.3x10^{-5}$ m^{-1} calculated by Rau et al. (2018). It is expected that a specific storage value of between approximately $1x10^{-6}$ m^{-1} and $1x10^{-5}$ m^{-1} is likely for the alluvium.

3.4.2.3 SANDSTONE

3.4.2.3.1 Pump-out-tests at The Bays Station site

A description of the pump-out tests, their results, and analysis and interpretation of the results is presented in Annexure B.

Of the test results adopted as valid, the interpreted specific storage values are listed in Table 3-4.

The “all valid” results include all results listed as valid in Annexure B, including those analysed based on the theories of both Theis (1935) and Moench (1984, 1988). The Moench (1984, 1988) analysis considers a dual-porosity model fractured aquifer system with slab matrix blocks and fracture. It represents a groundwater flow system with sub-horizontal fractures, consistent with the conceptual model of the site in which dilated bedding planes control much of the groundwater flow behaviour.

The results suggest that sandstone at The Bays Station site could have specific storage values of between approximately $2x10^{-7}$ and $5x10^{-5}$ m^{-1}.

TABLE 3-4: STATISTICS FOR VALID PUMP-OUT TEST ANALYSIS RESULTS – SPECIFIC STORAGE (M^{-1})

Statistic	All valid analysis results (m^{-1})	Valid Moench analysis results (m^{-1})
Minimum	$1.9x10^{-7}$	$1.2x10^{-6}$
Median	$9.4x10^{-7}$	$1.6x10^{-6}$
Mean	$4.0x10^{-6}$	$4.8x10^{-5}$
Maximum	$1.4x10^{-5}$	$1.2x10^{-5}$

3.4.2.3.2 Pumping tests at the RIC site

Based on the pumping tests completed at the RIC site, JHCPB Joint Venture (2021a) estimated the sandstone to have a specific storage value of between $1x10^{-6}$ m^{-1} and $8.4x10^{-6}$ m^{-1}. JHCPB Joint Venture (2021a) adopted a specific storage values of between $2x10^{-6}$ m^{-1} and $7x10^{-6}$ m^{-1} (for extremely/highly weathered to fresh, respectively) in their calibrated model.

3.4.3 SUMMARY

Table 3-5 provides a summary of the hydrogeological parameter value ranges at The Bays Station site and surrounds.

TABLE 3-5: SUMMARY OF HYDROGEOLOGICAL PARAMETER VALUES AT THE BAYS STATION SITE AND SURROUNDS

Hydrogeological unit	Typical hydraulic conductivity range (m/day)	K_v/K_h range	Specific storage range (m^{-1})	Specific yield range (-)
Fill	0.4 to 10	0.5 to 1	1×10^{-5} to 1×10^{-6}	0.1 to 0.2
Alluvium	0.5 to 1	0.02 to 1	1×10^{-5} to 1×10^{-6}	0.04 to 0.2
Hawkesbury Sandstone within palaeochannel	8.6×10^{-2} to 2.2×10^{-1} (10 to 25 Lugeons)	0.1 to 0.5	$2x10^{-7}$ and $5x10^{-5}$	0.01 to 0.05
Hawkesbury Sandstone outside palaeochannel	4.3×10^{-3} to 3.4×10^{-2} (0.5 to 4 Lugeons)	0.1 to 0.5	$2x10^{-7}$ and $5x10^{-5}$	0.01 to 0.05

Note: K_v/K_h is the ratio of vertical to horizontal hydraulic conductivity.

4. DESIGN GROUNDWATER LEVELS

4.1 REQUIREMENTS

Design groundwater levels have been developed considering, and consistent with, the Particular Specifications, as listed in Table 4-1.

TABLE 4-1 PARTICULAR SPECIFICATIONS RELEVANT TO DEVELOPMENT OF DESIGN GROUNDWATER LEVELS

Particular Specification
1. The following design codes, in order of precedence: a. AS 5100 Bridge Design Series [SM-W-CTP-PS-703]. AS5100.2 requires that variation in groundwater levels shall be taken into account by using design levels based on a return period of 1000 years for the ULS (0.1% AEP) and 100 years for the SLS (1% AEP) b. AS/NZS 1170 Structural Design Actions Series for imposed loads and other actions that are not specified in AS 5100 Bridge Design Series; [SM-W-CTP-PS-704]. AS/NZS1170.1 requires that the hydrostatic pressure shall be the value assuming water level at the ground surface; unless there are groundwater level data available, in which case, a groundwater level with an annual exceedance probability (AEP) of 1 in 50 (2% AEP, or 50 year ARI) shall be adopted c. AS 4678 Earth - retaining structures for ground loadings, for free-standing retaining walls; and [SM-W-CTP-PS-705] d. AS 1657 Fixed Platforms, walkways, stairways and ladders - Design, Construction and installation. [SM-W-CTP-PS-706]
2. The design action resulting from hydrostatic pressure of water acting on surfaces below ground level (Fgw) for all underground structures considers a water level at ground level [SM-W-CTP-PS-910]; or, where information is available, the ground water level with an annual probability of exceedance of 1 in 100. [SM-W-CTP-PS-911]
3. The potential impact of groundwater levels and hydrostatic pressures of floodwater plains or a burst water main where existing or new water utilities are within proximity to the Project Works and Temporary Works [SM-W-CTP-PS-709]
4. Foreseeable differences in groundwater table level between opposite sides of the completed underground structures for the applicable Design Life [SM-W-CTP-PS-711]

5. Civil and structural elements including foundations retaining structures, tunnel portals, tunnel elements, shaft structural elements, and other structural load bearing elements are required to have a design life of 120 years [SM-W-CTP-PS-548]
6. Application of a minimum difference in groundwater level table of 5 m, for the exceptional or temporary load case, to represent a burst water pipe or groundwater flow differential loading condition, unless an alternate value can be demonstrated from hydrogeological analysis. [SM-W-CTP-PS-712]
7. The Tunnelling Contractor must not allow for any reduction in hydrostatic loadings due to localised lowering of groundwater levels *[due to existing drained structures]* in the design of the Works. The reduction of hydrostatic loading due to localised lowering of groundwater levels is permitted in the design of the support of Station Excavations and Station Shaft Excavations that are drained in accordance with the requirements in Section 4.1.7(a). [SM-W-CTP-PS-715]
8. The Tunnelling Contractor must design for the risk of water pressure build-up as a result of blocked drainage. [SM-W-CTP-PS-1030]
9. For the design of tunnels, caverns and adits, consider long term variations in groundwater levels [SM-W-CTP-PS-1389]

4.2 SCENARIOS

Serviceability Limit State (SLS) and Ultimate Limit State (ULS) design groundwater levels have been developed for various scenarios.

Three scenarios are considered:

- The existing condition– this reflects possible groundwater levels under existing conditions (in the absence of excavation dewatering due to Project works), considering potential rises in groundwater level
- The permanent condition for the Project works (SLS and ULS) – this reflects likely groundwater levels after the station structures have been fully excavated and are undergoing (passive) dewatering (recognising Particular Specification SM-W-CTP-PS-715)

4.3 FACTORS POTENTIALLY AFFECTING GROUNDWATER LEVELS

The factors that have been considered as potential causes of future rises in groundwater levels (some of which are discounted as being of negligible impact to the project) include:

- Short term changes
    - High rainfall events
    - Flooding
- Long term changes (over 10-year design life)
    - Sea level rise caused by climate change
    - Prolonged wet periods (long term above average rainfall) and annual seasonal variation

4.3.1 RESPONSE TO RAINFALL

To assess the potential for short term fluctuations in groundwater levels resulting from prolonged and intense rainfall events (e.g., high rainfall over several days), monitoring of water levels at a daily or sub-daily frequency is required. A number of data logger records are available at SMW_BH066, SMW_BH067, SMW_BH724 and SMW_BH725.

Hydrographs for these piezometers are shown in Annexure A.

Records at SMW_BH724 and SMW_BH725 are limited to approximately three months and may be influenced by piezometer development. Records at SMW_BH066 and SMW_BH067 provide longer records with response to rainfall events.

Figure 4-1 below provides groundwater levels monitored in the Hawkesbury Sandstone (BH067_s). This is a shallow bore (screened from 2.5 mbgl to 6.0 mbgl) and has been selected due to its relatively high responsiveness to rainfall and potentially high tides (compared to other bores in the area).

Analysis of groundwater level response to significant rainfall events (in March and August 2019 and in February and July 2020) in this piezometer indicate a clear trend. The July 2020 event in this dataset is an outlier, showing unusually high response, and is a cumulative event of shorter duration than the others.

Figure 4-2 shows the 2019 and February 2020 seven-day-cumulative rainfall events and corresponding groundwater level response.

The Bureau of Meteorology Design Rainfall Data System (2016) (http://www.bom.gov.au/water/designRainfalls) nominates a seven-day (168 hour) 1% Annual Exceedence Probability rainfall event of 490 mm at the site. Based on the groundwater level rise correlation in piezometer SMW_BH068s, this would equate to a groundwater level rise of 1.3 m.

Potential increases in groundwater level due to prolonged wet periods or increased annual average rainfall due to climate change have been considered. However, the results from current models assessing changes in mean annual rainfall due to climate change are highly variable and, as such, do not warrant application in estimation of design groundwater levels. The average of twelve different models predicts a minor increase in mean annual rainfall for Sydney of about 2% by 2030 (NSW Office of Environment and Heritage, 2014). However, half of the models predict a decrease in mean annual rainfall for Sydney by the year 2030. For projections out to the year 2070, the average of twelve different models predicts an increase in mean annual rainfall for Sydney of about 8%. However, four of the 12 models predict either a minor increase (approximately 3%) or decrease in mean annual rainfall for Sydney in the year 2070 (NSW Office of Environment and Heritage, 2014).

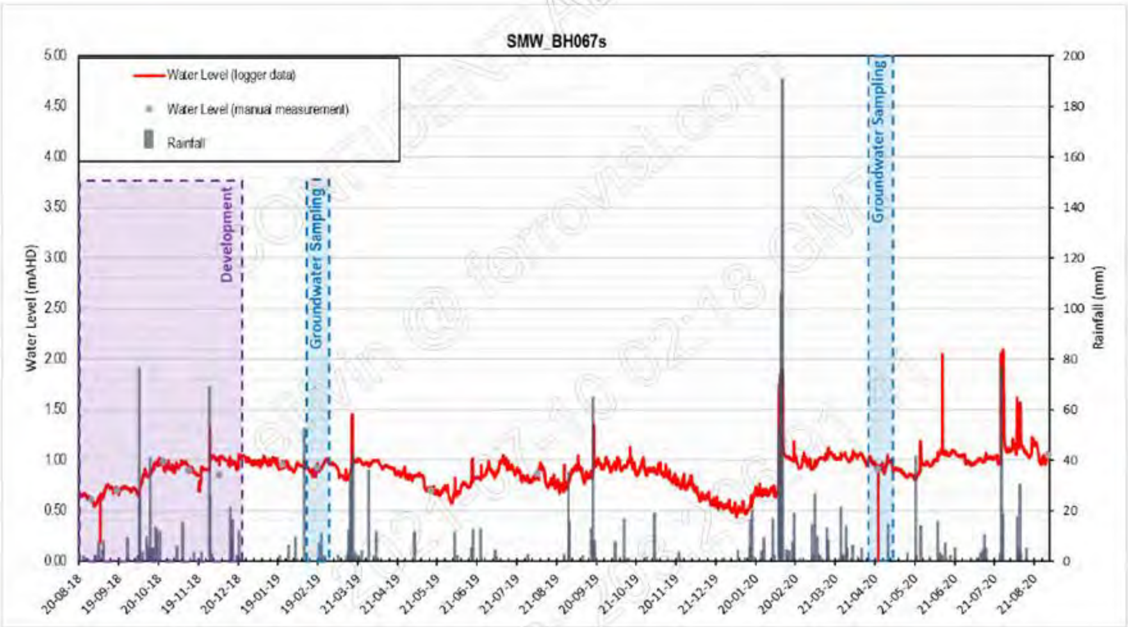


FIGURE 4-1: GROUNDWATER MONITORING IN SMW_BH067_S IN THE UPPER HAWKESBURY SANDSTONE

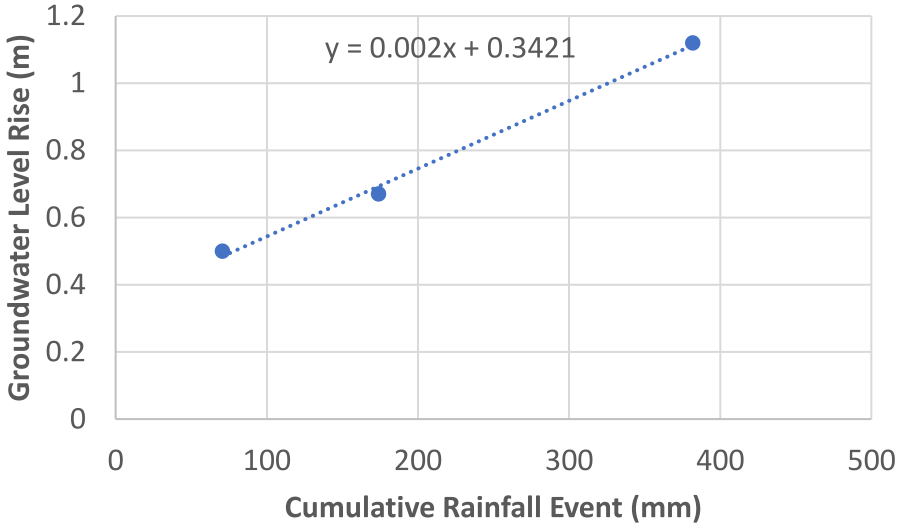


FIGURE 4-2: GROUNDWATER LEVEL RESPONSE TO RAINFALL IN SMW_BH067_S IN THE UPPER HAWKESBURY SANDSTONE

4.3.2 FLOODING

Flooding can cause a temporary rise in groundwater levels as water is transferred into the ground across a wider surface area. The effect of flooding of waterways on groundwater levels is influenced by the duration of the flood event and the hydraulic connection between the surface water and the relevant aquifer(s).

It should be noted that an allowance for flooding in a design groundwater level is only valid if the flood level is at a higher level than the design groundwater level that incorporates the factors considered in the above sections. The duration of highest stream levels associated with significant flood events typically occur for periods ranging from hours to days.

At The Bays Station, alluvial sediments directly overly, and are likely to be in hydraulic connection with, the Hawkesbury Sandstone. It has been conservatively assumed that flooding during a storm surge event could affect groundwater levels.

Note that the design groundwater levels developed here do not consider hydrostatic pressures above ground surface (e.g., related to flood events). Design loading for surface waters will need to be applied separately in design. Refer to the Flood Assessment Report.

4.3.3 SEA LEVEL RISE FROM CLIMATE CHANGE

The dominant effect that future climate change could have on groundwater levels is via sea level rise, which will affect groundwater levels by both driving a higher groundwater level inland, and also by increasing surface water levels in streams and rivers. There is no standard for determining impact on groundwater level from sea level rise.

CoastAdapt (https://coastadapt.com.au/climate-change-and-sea-level-rise-australian-region) reports an estimated sea level rise in the vicinity of Sydney of 0.88 m (90th percentile) in the year 2090 (since 1985-2005 levels), for a Representative Concentration Pathways (RCP) 8.5 (high concentration) scenario.

This is a conservative scenario, with a higher-end estimate of sea level rise and temperature rise due to climate change.

Accordingly, over the 10 year project design life from the year 2024 to 2034, this equates to a sea level rise of approximately 0.1 m.

Given the proximity of The Bays Station to White Bay and Rozelle Bay, and the hydraulic connection between the harbour waters and the surficial hydrogeological unit, a rise in the base level regional groundwater system equivalent to sea level rise can be expected at the site.

4.3.4 PROLONGED WET PERIODS

The potential for long term increases in groundwater levels due to prolonged wetter periods has been considered by examining groundwater hydrographs with long term records in proximity to the project elements. There are very few bores near the project area with long term (decadal) groundwater monitoring data.

The closest well to The Bays site with a long-term monitoring record is bore GW042158, which is located approximately 5 km south east of The Bays Station. The bore is 21 m deep with a depth to watertable ranging from 4 mbgl to 8 mbgl. Based on nearby drilling logs (from bore GW017729), bore GW042158 is likely to lie within Tertiary alluvial sands rather than the underlying Ashfield Shale or Hawkesbury Sandstone. However, monitoring in the bore between 2018 and 2020 indicates a seasonal groundwater level fluctuation in the order of 0.5 m to 1.0 m, which is commensurate with seasonal groundwater level fluctuations observed in the Ashfield Shale and Hawkesbury Sandstone. Given this, it is considered reasonable that groundwater level responses in this bore to provide an indication of long-term trends in the underlying units.

Nearby long-term rainfall monitoring data is available close to GW042158 at the Bureau of Meteorology Station at the Sydney Botanic Gardens (Station 66006), and is shown in Figure 4-3.

Long term trends in rainfall at this station are illustrated in Figure 4-4 . The figure shows the cumulative deviation from mean rainfall between 1900 and 2020, with downward trends reflecting periods of below average rainfall and upward trends reflecting periods of above average rainfall. The figure shows generally below average rainfall between 1900 and 1950, followed by above average rainfall conditions between 1950 and 1980.

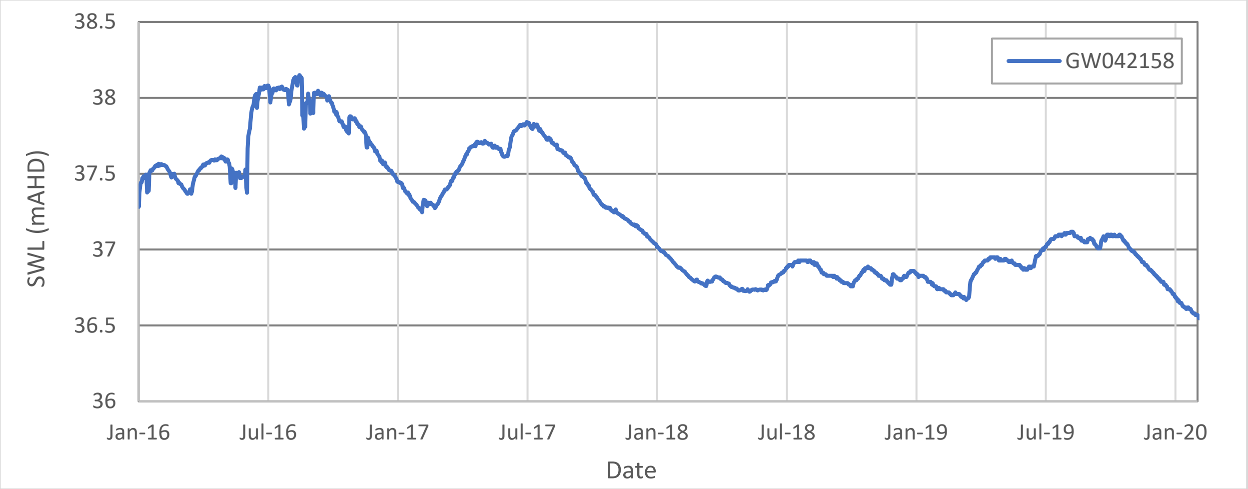


FIGURE 4-3: GROUNDWATER MONITORING AT GW042158 FROM 2017 TO 2020

FIGURE 4-4: CUMULATIVE DEVIATION FROM MEAN MONTHLY RAINFALL AT SYDNEY BOTANIC GARDENS (STATION 66006)

Trends in rainfall and groundwater levels (at bore GW042158) from 1970 to 2020 are illustrated in Figure 4-5. Of interest to the project is the period between 1980 and 1990, when above average rainfall conditions persisted for a decade, yielding a groundwater level increase from of ~2.5 m, from RL ~36.5 m AHD to RL ~39 m AHD. Figure 4-5 suggests that the current groundwater levels observed at The Bays may be close to the minimum observed over the last 50 years, and an increase of 2.5 m is a reasonable estimate of the potential increase in groundwater level from prolonged wet conditions.

However, it is recognised that low lying features in the landscape will control the potential groundwater level rise during prolonged wet periods. As such, it may not be possible for a 2.5 m increase in groundwater to occur, as discharge to the surface would limit the rise. This is also true where groundwater levels are already close to the surface, or areas close to surface water features where groundwater discharge could occur.

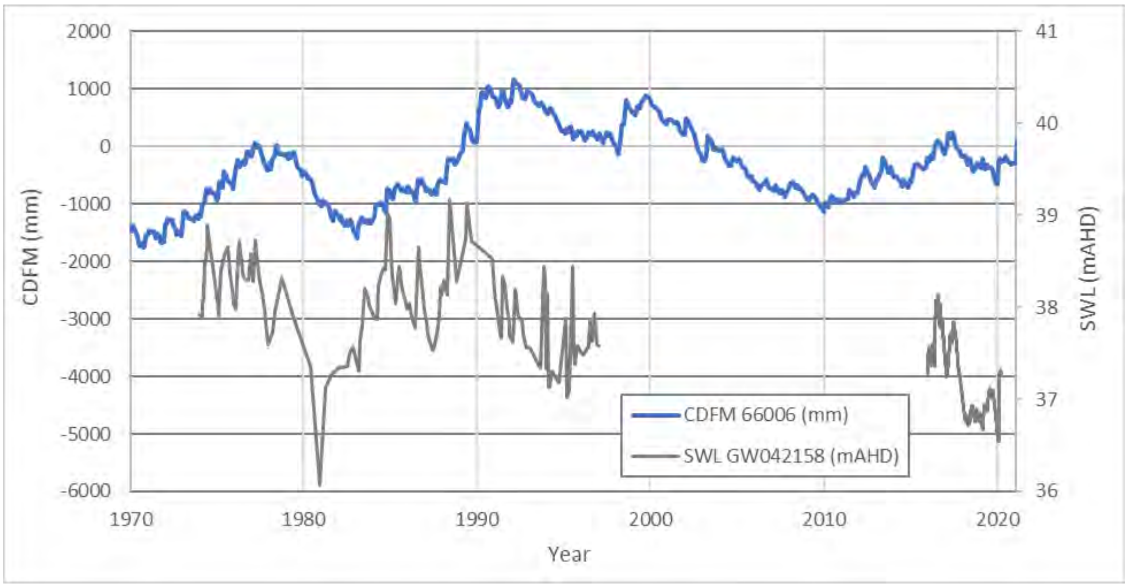


FIGURE 4-5: CUMULATIVE DEVIATION FROM MEAN MONTHLY RAINFALL AT SYDNEY BOTANIC GARDENS (STATION 66006) AND ASSOCIATED GROUNDWATER LEVELS AT BORE GW042158

4.3.5 PROLONGED DRY PERIODS

The limited long term groundwater level records available (refer Figure 4-5), suggest that levels during December 1980, groundwater levels were in the order of 0.5 m below current levels. However, this occurred in response to a 5-year period of below average rainfall conditions and as illustrated in Figure 4-4, such periods have persisted for up to 15 years historically (i.e. between 1935 and 1950). Given this, a groundwater level reduction of 1.5 m could be expected during a prolonged dry period for parts of the alignment further from the bay. However, this is unlikely to be realised at The Bays due to the proximity to White Bay.

4.4 DESIGN GROUNDWATER LEVELS FOR THE BAYS

An Ultimate Limit State (ULS) and a Serviceability Limit State (SLS) design groundwater level are provided below.

4.4.1 SERVICEABILITY LIMIT STATE (SLS)

Based on the above discussion, the SLS design groundwater level for The Bays Station can be estimated by adopting the current observed groundwater levels at SMW_BH066_s and SMW_BH067_s and applying:

- No increase for seasonal variability (as the current level already appears to reflect seasonally high values)
- An increase of 1.3 m due to an extreme rainfall (168 hour 1% AEP) event
- An increase due to climate change induced sea level rise of 0.1 m
- An increase related to long term above average rainfall of 2.5 m

The highest groundwater level elevation based on these increases is an increase of 2.5 m due to long term above-average rainfall. This represents a conservative scenario. If a less conservative scenario is preferred, the rise of 1.3 m due to an extreme rainfall event may be considered.

Accordingly:

- The SLS design groundwater level across the western half of the station box is equal to ground surface, since the groundwater level rise due to a prolonged wet period would potentially raise the groundwater level to ground surface
- The SLS design groundwater level across the eastern end of the station box based is equal to ground surface, since the groundwater level rise due to a prolonged wet period would potentially raise the groundwater level to ground surface

The effects considered above have been summarised in Table 4-2 below.

TABLE 4-2: SUMMARY OF FACTORS AND SLS DESIGN GROUNDWATER LEVELS AT THE BAYS STATION BOX

Area	Surface elevation (m AHD)	Shallowest current groundwater level at box (m bgl)	Rise due to rising sea level (m)	Rise due to prolonged wet period (m)	Rise to due extreme rainfall event (m)	SLS
Western half of box	4.1 (max)	1.9 (SMW_BH066_s)	0.1	2.5	1.3	Ground surface
Eastern half of box	3.5 (max)	1.9 (SMW_BH066_s)	0.1	2.5	1.3	Ground surface

4.4.2 ULTIMATE LIMIT STATE (ULS)

The current groundwater levels observed at SMW_BH066_s and SMW_BH067_s, located within the station footprint, are 3.7 m and 1.9 m below ground surface, respectively.

Based on the above discussion, the ULS design groundwater level for The Bays Station have been developed by considering the following potential increases to the currently observed groundwater levels at SMW_BH066_s and SMW_BH067_s:

- No increase for seasonal variability (as the current level already appears to reflect seasonally high values)
- An increase of 1.3 m due to an extreme rainfall (168 hour 1% AEP) event
- An increase of 0.1 m for climate induced sea level rise effects on groundwater levels
- An increase of 2.5 m for prolonged wet period effects on groundwater levels

The highest groundwater elevation based on these increases is an increase of 2.5 metres due to a prolonged wet period. This represents a conservative scenario. If a less conservative scenario is preferred, the rise of 1.3 m due to an extreme rainfall event may be considered.

Accordingly:

- The surface elevation across the western half of the station box, based on current topographical data, is up to 4 m AHD. Therefore, the shallowest potential groundwater level due to an increase is equal to ground surface
- The ground surface elevation across the eastern half of the station box, based on current topographical data, is up to 3.5 m AHD. Therefore, the shallowest potential groundwater level due to an increase is equal to ground surface

The effects considered above have been summarised in Table 4-3 below.

These design groundwater levels do not consider hydrostatic pressures above ground surface (e.g., related to flood events). Design loading for surface waters will need to be applied separately in design.

TABLE 4-3: SUMMARY OF FACTORS AND ULS DESIGN GROUNDWATER LEVELS AT THE BAYS STATION BOX

Area	Surface elevation (m AHD)	Shallowest current groundwater level at box (m bgl)	Rise due to rainfall (m)	Rise due to rising sea level (m)	Rise due to prolonged wet period (m)	Rise to due extreme rainfall event (m)	ULS*
Western half of box	4.1 (max)	1.9 (SMW_BH066_s)	1.5	0.1	2.5	1.3	Ground surface
Eastern half of box	3.5 (max)	1.9 (SMW_BH066_s)	1.5	0.1	2.5	1.3	Ground surface

*For groundwater only. Does not consider surface waters (e.g., flood events)

4.4.3 MINIMUM WATERTABLE LEVEL

Based on the groundwater modelling undertaken (for the base case mitigated station box and White Bay Power Station scenario) and reported in Section 6.2.2.

The predicted groundwater level drawdown (at the end of Project works in December 2024) around the station box ranges between 4 m and 14 m (refer to Figure 6-8). Adopting a typical watertable level of 2 mbgl, this equates to a minimum watertable level of between 6 mbgl and 16 mbgl.

5. GROUNDWATER QUALITY

Groundwater quality was monitored in over 36 wells and piezometers across The Bays Station site. Monitoring in 15 SMW piezometers was undertaken in 2018, 2020 and 2021. Monitoring in the 21 wells/piezometers was undertaken by Senversa in May 2021.

The pH of groundwater is reported to range between 6.0 and 7.8. Electrical conductivity is reported to range between 751 µS/cm and 48,270 µS/cm. The median electrical conductivity of the 21 monitoring locations noted above is approximately 1,500 µS/cm, significantly below the electrical conductivity of seawater (approximate 50,000 µS/cm).

Figure 5-1 illustrates the groundwater electrical conductivity based on the monitoring noted above. High salinity groundwater is observed in the vicinity of the station box, with higher salinity focused around the central (deeper) part of the palaeochannel.

Figure 5-2 shows the groundwater electrical conductivity with depth (mid-effective screened interval of piezometers for which screen information is available) in the fill/alluvium and in the sandstone. There is no distinct correlation between salinity and depth in the fill/alliuvium. However, there is a distinct correlation between salinity and depth in the sandstone, suggesting the potential presence of a saline wedge. The lateral and depth distribution of salinity data for the sandstone are insufficient to establish the extent of the wedge.

As discussed in the Contamination Assessment Report, there were numerous exceedances of ANZECC/ARMCANZ (2000) trigger levels for 95% protection of marine ecosystems in recent groundwater quality sampling results from groundwater samples collected by Golder/Douglas (2018; 2021) and Senversa (2021). The most common contaminants include arsenic, cobalt, copper, manganese, mercury, nickel, zinc, total recoverable hydrocarbons (C16-C34) fraction, ammonia (as N) and PFAS (perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHxS)).

Dissolved iron concentrations in groundwater within the sandstone are high (e.g., 21.9 mg/L in SMW_BH067, 60 mg/L in SMW_BH724, and 98 mg/L in SMW_BH725). It is possible that iron reducing (and other) bacteria will be active in groundwater, and that groundwater seepage to the excavation may be prone to production of biofilms/sludge. This has the potential to impact on pumping systems. Station excavation pumping and groundwater treatment systems will need to consider the potential for the development of biofilms/sludge.

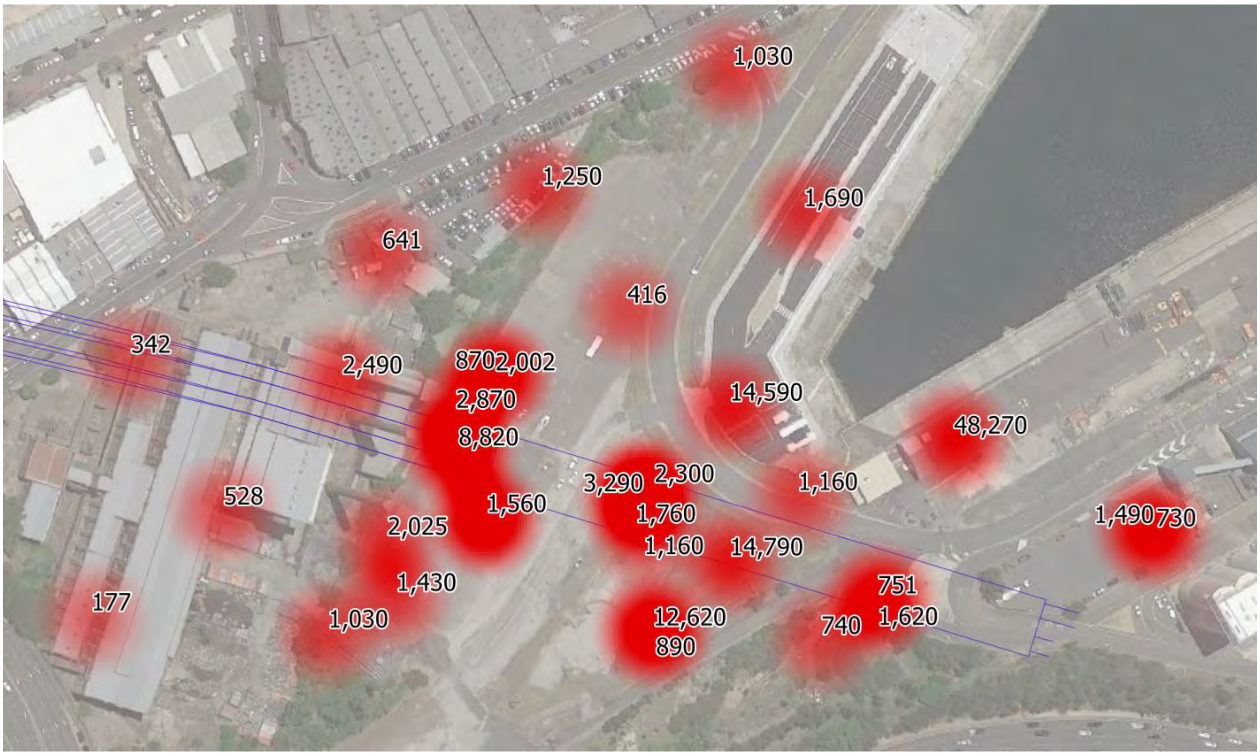


FIGURE 5-1: GROUNDWATER ELECTRICAL CONDUCTIVITY (µS/CM) AT THE BAYS STATION SITE (MOST DATA FROM APRIL/MAY 2021) – VALUES AND HEATMAP THAT REPRESENTS VALUES

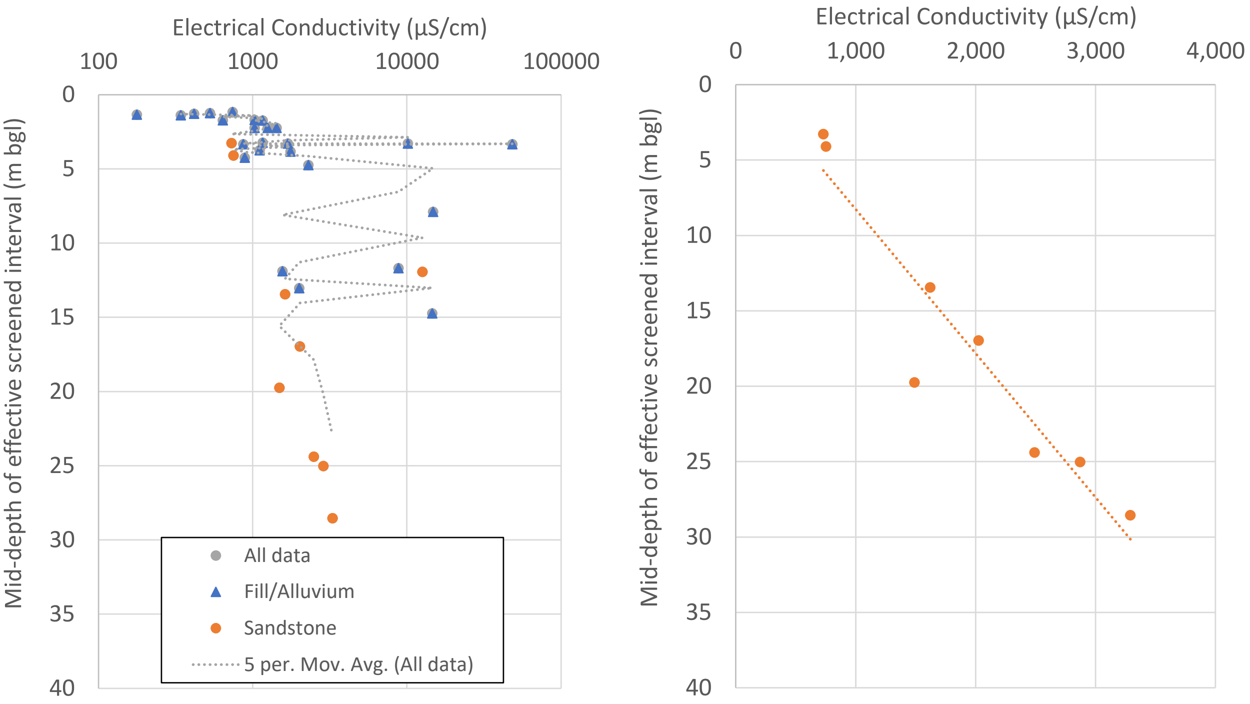


FIGURE 5-2: GROUNDWATER ELECTRICAL CONDUCTIVITY (µS/CM) WITH DEPTH IN FILL/ALLUVIUM AND SANDSTONE AT THE BAYS STATION SITE. DATA FOR THE SANDSTONE ONLY IS SHOWN TO THE RIGHT

6. GROUNDWATER INFLOW AND DRAWDOWN

6.1 MODELLING APPROACH

A three-dimensional numerical groundwater model has been developed for The Bays Station site and surrounds in the MODFLOW-USG software package.

The model permits consideration of:

- Detailed representation of the stratigraphy at the site, based on the geological interpretation
- Representation of the secant piled wall and grouting measures
- The potential influence of tunnelling (west of the station box) on inflows and drawdown, and the relative timing of station box and tunnelling excavations
- The potential impact of other projects, such as the Rozelle Interchange project

Details of the model development, calibration and predictive results are provided in Annexure C.

A summary of the modelled conditions and predictions is provided below.

6.1.1 STATION BOX AND TUNNELLING EXCAVATION STAGING

The station box will be designed to have a soil retaining structure that provides groundwater cut-off through the fill and alluvium. Formerly, a diaphragm wall option was adopted. This has been replaced by a secant piled wall in the current design.

A diaphragm wall is likely to provide improved groundwater cut-off, with minimal leakage, compared to a secant piled wall. The groundwater modelling undertaken assumes that the soil retaining structure is effectively impermeable (it has a very low permeability) and does not leak groundwater into the excavation.

The following station box excavation and tunnel mining schedule has been adopted in the modelling:

- The western 120 m of the station box is excavated between 3 March 2022 and 26 August 2022
- The eastern 110 m of the station box is excavated between 25 March 2022 and 24 November 2022
- Excavation within soils at the station box is assumed to be three times faster than excavation in rock. Average soil and rock thicknesses have been considered in relation to excavation scheduling
- The TBM launch for the northern (up line) tunnel is 20 December 2022. This TBM stops under White Bay Power Station on 21 January 2023, at a distance of 164 m from the western station box wall, and then continues mining from 20 February 2023
- The TBM launch for the southern (down line) tunnel is 20 January 2023. This TBM stops under the White Bay Power Station on 22 February 2023, at a distance of 164 m from the western station box wall, and then continues mining from 21 March 2023
- The tunnels will be constructed using an open-faced TBM with segmental lining erected behind the machine. Groundwater inflows will occur through the tunnel excavation face, and along the tunnel perimeter between the excavation face and where grout is injected behind the tailshield (between the excavation face and the segmental lining). There is an assumed distance of 12 m between the excavation face and the location where the grout is injected

These details are shown in Figure 6-1.

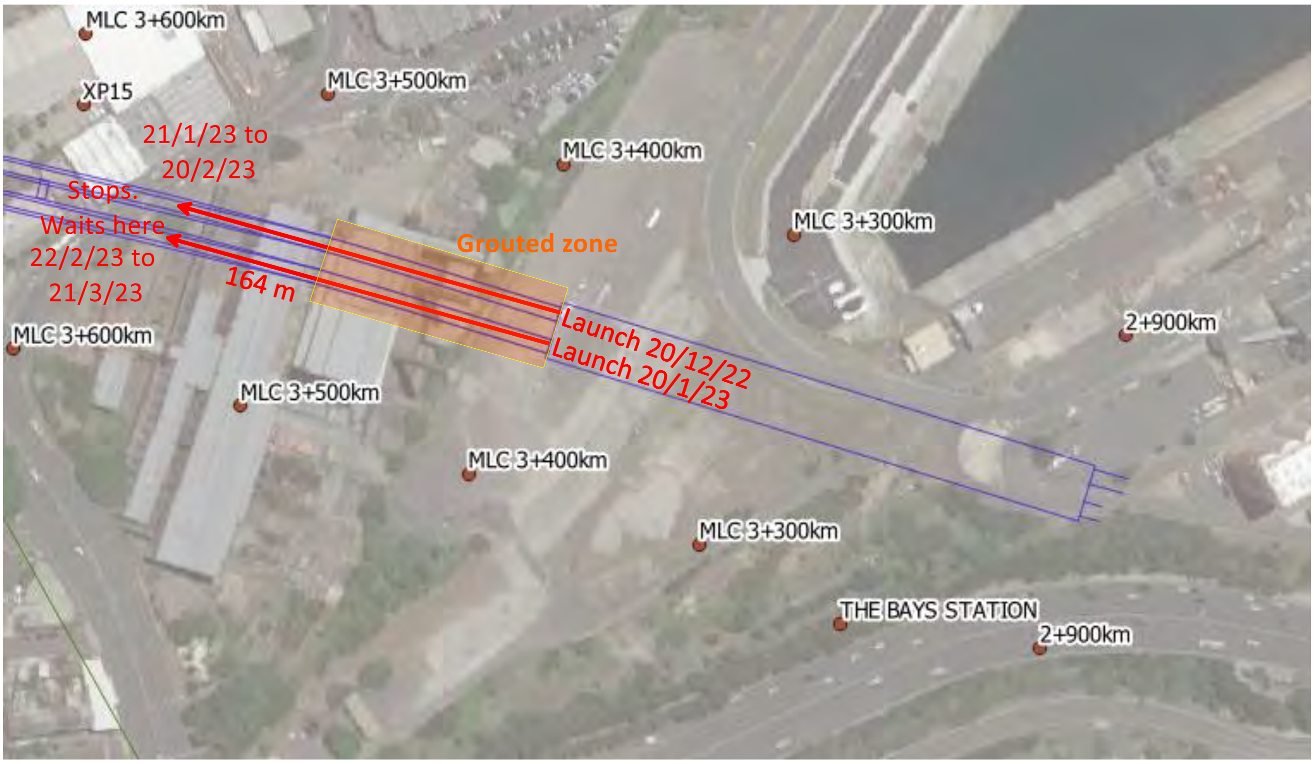


FIGURE 6-1: TIMEFRAMES AND LOCATIONS OF TBM MINING AND GROUTED ZONE AT WHITE BAY POWER STATION

6.1.2 GROUTING

Given the relatively high permeability of the bedrock, grouting of the rock will be undertaken from the ground surface and may also need to be undertaken from the TBM.

Available data indicate that the high permeability rock (or dilated bedding planes with high permeability) are present close to the alluvial boundary / edge of the palaeochannel, and they may be present immediately beyond the alluvial boundary / edge of the palaeochannel. There are no data available to confirm that this is not the case, though additional investigations are currently proposed to explore this. The rock beneath, and in the vicinity of, White Bay Power Station (through which the TBMs will pass) could therefore be of relatively high permeability. For this reason, and given the relatively low rock cover in the tunnels immediately west of the station box, rock in the vicinity of White Bay Power Station is proposed to be grouted.

The model considers the grouted zones consistent with the grouting designs for the station box and White Bay Power Station.

Grouting of the rock at the station box considers a temporary grout curtain around the full perimeter of the station box walls, with the curtain extending to -52 m AHD.

The grouted zone at the White Bay Power Station (WBPS) is shown in plan in Figure 6-1. The grouted zone extends above, below, and laterally (on each side of the tunnels) by one-tunnel-diameter.

For the base case scenario, grouted rock is assumed to have a permeability of 1 Lugeon in the bulk (fresh) grouted rock, and 5 Lugeons in the weathered rock and identified bedding planes.

6.1.3 BASE CASE MODEL PARAMETER VALUES

The model parameter values adopted for the base case scenario are listed in Table 6-1.

TABLE 6-1: ADOPTED BASE CASE SCENARIO MODEL PARAMETER VALUES

Hydrogeological unit	Hydraulic conductivity (m/day)	Ratio of vertical to horizontal hydraulic conductivity (-)	Specific storage (m^{-1})	Specific yield (-)	Recharge (% of mean annual rainfall)
Fill	1	1	$1x10^{-5}$	0.2	4
Alluvium	0.5	0.2	$1x10^{-5}$	0.15	4
Weathered Hawkesbury sandstone / residual soil	0.4	0.2	$2.3x10^{-6}$	0.05	4
Fresh Hawkesbury sandstone rock mass within palaeochannel, and dyke	0.176 (20 Lugeons)	0.1	$3.8x10^{-6}$	0.035	4
Fresh Hawkesbury sandstone dilated bedding planes within palaeochannel	2.66* (308 Lugeons)	1	$3.8x10^{-6}$	0.035	N/A
Fresh Hawkesbury sandstone outside palaeochannel	0.031 (3.6 Lugeons)	0.1	$3.8x10^{-6}$	0.035	4

*The equivalent hydraulic conductivity for a rock block with a (conceptualised) one metre-thick bedding plane feature that has a hydraulic conductivity of 70 Lugeons (slightly higher than the 90th percentile value of site-only packer test results, and slightly above the maximum value of the pump-out tests analysis results) lying within a packer test interval (average 5.8 m interval of all tests at the site), and a bulk rock mass hydraulic conductivity of 20 Lugeons.

6.2 MODEL SCENARIOS AND RESULTS

Steady-state calibration of the 3D numerical groundwater model, and the transient predictive modelling scenarios and results are discussed in the Groundwater Modelling Report (Annexure C). A summary of the predictive results is presented below.

6.2.1 INFLOWS

The Particular Specification requires that groundwater inflows to the station box excavation are limited to:

- 50,000 litres in any 24-hour period (0.58 L/s), measured over any square with an area of 10 m², at any and all locations within the sides and bases of the excavation [Particular Specification SM-W-CTP-PS-1040]
- 445,000 litres in a 24-hour period [Particular Specification SM-W-CTP-PS-104] (5.15 L/s)

The first criterion above relates to small water-bearing features that yield significant inflows over a relatively small area of excavation face. Such features, if encountered, would be grouted during excavation, to reduce the inflows to acceptable limits.

The second criterion above relates to inflows to the entire station box. Inflows to the entire station box excavation were predicted using the 3D numerical model for the “unmitigated” case, i.e., the station box cut-off wall is present, and inflows to the station box excavation occur through the unmodified sandstone bedrock.

Two unmitigated scenarios have been considered for the station box excavation:

- The rock mass within the palaeochannel is 20 Lugeons. This is the base case value, and is discussed in Section 3.4.1.3
- The rock mass within the palaeochannel is 80 Lugeons. This is the highest interpreted horizontal hydraulic conductivity value from the AFJV pump-out test results (refer to Table 3-3), and is above the 90th percentile (equal to 63 Lugeons) of all packer test results in the palaeochannel. It therefore represents scenario under which permeability of the rock in the palaeochannel is closer to the upper bound of what is considered likely

Figure 6-2 shows that the predicted inflow to the station box exceeds the inflow threshold specified in the Particular Specification under unmitigated conditions. For the assessed typical permeability of the rock mass within the palaeochannel (20 Lugeons), peak inflows to the station box are predicted to exceed 12 L/s. If the rock mass within the palaeochannel is highly permeable (80 Lugeons), peak inflows to the station box are predicted to exceed 20 L/s.

Grouting of the rock surrounding the station box is therefore required to limit groundwater inflows to the station box excavation.

Figure 6-2 shows the predicted inflow to the station box for the following mitigated (grouted rock) scenarios:

- Mitigated station box (1 Lugeon rock mass and 5 Lugeons bedding planes): rock around the station box is grouted as outlined in Section 6.1.2. The grouted bulk rock mass has a permeability of 1 Lugeon, and the weathered rock and identified bedding planes have a permeability of 5 Lugeons.
- Mitigated station box (1 Lugeon for all grouted rock): rock around the station box is grouted as outlined in Section 6.2.1,with all grouted rock having a permeability of 1 Lugeon

These mitigated scenarios represent what are considered likely hydrogeological conditions based on available data and characterisation, and rock permeability that is considered likely to be achievable by grouting.

The predicted inflows indicate that grouting of the bulk rock mass to 1 Lugeon, and the weathered rock and identified bedding to 5 Lugeons, for the base case scenario would not meet the inflow threshold.

With the grout curtain achieving a permeability of 1 Lugeon along its full depth, the model indicates that the inflow criterion would be met. The grout curtain will therefore act as a mitigation measure to reduce groundwater inflows to the station box. Combined with localised grouting of significant water-bearing features during excavation, as required, these mitigation measures will help to reduce groundwater inflows to the station box in order to meet the requirements of the Particular Specification.

Tunnelling to the west of the station box also has the potential to impact inflows to the station box.

Figure 6-3 shows the predicted inflows to the station box for the following tunnelling scenarios (all scenarios assume a mitigated station box to 1 Lugeon):

- Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 20 Lugeons (base case scenario), and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualised as a single feature with an equivalent thickness of 1 m and a horizontal hydraulic conductivity of 308 Lugeons (refer to Annexure C)
- Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 80 Lugeons (base case scenario), and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualised as per the bullet point above
- Mitigated WBPS, with rock grouted in the vicinity of WBPS as outlined in Section 6.1.1 (1 Lugeon rock mass, 5 Lugeons for bedding plane features)

These results indicate that, if the rock mass within the palaeochannel has a high permeability and the TBM encounters significant water-bearing features that have not been grouted, inflows to the station box could exceed to inflow criterion.

As there is a potential risk that the TBM will encounter such features during mining, grouting of the rock mass in the vicinity of WBPS is recommended. Grouting of the rock mass in the vicinity of WBPS will serve as an additional mitigation measure, reducing inflows to the TBM and associated groundwater level drawdown.

For the base case scenario, i.e., with mitigated station box (grout curtain rock to 1 Lugeon) and mitigated WBPS scenario (1 Lugeon rock mass and 5 Lugeon bedding planes in vicinity of WBPS), the total predicted groundwater inflow to the station box to December 2024 (i.e., to the end of Project works) is approximately 80 ML.

Groundwater removed from excavated materials will be additional to this. Assuming the specific yield values listed in Table 6-1, an estimated additional groundwater volume of approximately 14 ML will be removed as groundwater within spoil. Based on this, the total expected groundwater take due to station box excavation is expected to be some 94 ML.

For the unmitigated WBPS scenario (Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling), the predicted inflows to a single tube tunnel are typically 1.1 L/s, increasing to up to approximately 1.5 L/s (to the downline/southern tunnel) when the downline/southern tunnel TBM is stationary.

Inflows to a single tube tunnel are predicted to increase to up to 2.4 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 20 Lugeons).

If the rock mass in the palaeochannel is highly permeable (80 Lugeons), the inflows to a single tube tunnel are predicted to increase to up to 4.5 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 80 Lugeons).

The predicted inflows for the mitigated WBPS scenario (Mitigated station box (1 Lugeon) and mitigated WBPS) are significantly lower, with inflows to a single tube tunnel of typically 0.2 L/s in the grouted zone between WBPS and the station box, increasing to up to 1.5 L/s outside the mitigated zone (i.e., to the west of the grouted zone at WBPS).

Groundwater within mined spoil will be additional to the tunnelling inflows predicted above.

Note that the predicted inflows assume that the station box secant piled wall is completely watertight, and that the grouting performance meets the permeability criteria noted throughout this report. Should there be groundwater leakage through the secant piled wall, or the grouting design fail to meet the required permeability, additional inflows will occur.

In addition, it is possible that geological features in the floor of the station box excavation could act as conduits for groundwater flow, including both unidentified features and identified features such as the Great Sydney Dyke. This could lead to greater inflows to the station box than predicted in this report. If such features were encountered, mitigation measures to reduce inflows would include localised grouting of these features from within the excavation.

6.2.2 GROUNDWATER DRAWDOWN

Figure 6-4 shows the predicted drawdown of the watertable in March 2023 for the Mitigated station box (1 Lugeon) with tunnelling and 20 Lugeon rock mass in the palaeochannel for scenarios with both unmitigated and the mitigated rock at WBPS (unmitigated base case and mitigated base case). (There is no explicit water-bearing feature at the tunnel horizon for these scenarios.) This date is when the second (downline/southern tunnel) TBM has completed its period of being stationary and represents the time at which potential drawdown would be maximum in the vicinity of the TBMs and station box.

Watertable drawdown is generally between approximately 1 m and 4 m across the majority of the palaeochannel (where alluvium is present). At the eastern end of the station box, where alluvium pinches out and is not present, predicted watertable drawdown is in the rock and is greater than elsewhere at the site due to the relatively lower permeability of the sandstone.

It should be noted that the pre-construction watertable is located within fill, alluvium or sandstone, depending on location; and the alluvium is therefore not necessarily depressurised equivalent to the watertable drawdown. Depressurisation of deep hydrogeological units will also be greater than depressurisation of shallow hydrogeological units. Drawdown of the watertable will not necessarily reflect the depressurisation of deeper units.

WBPS is sensitive to ground settlement. A significant proportion of the ground settlement predicted in the area is due to groundwater level drawdown. Since it is differential settlement that causes damage to structures, greater differential drawdown (or a greater hydraulic gradient) is of more significance for settlement impacts. Lower hydraulic gradients are therefore more favourable.

The predicted watertable drawdown in the vicinity of WBPS is between approximately 2 m and 4 m for the unmitigated case. This reduces to between approximately 2 m and 3 m for the mitigated case, and the hydraulic gradient across the WBPS is reduced.

It should also be noted that ground conditions in the palaeochannel are variable, and this could also lead to greater differential settlement.

Figure 6-5 shows the predicted watertable drawdown in March 2023 for the Unmitigated rock at WBPS (i.e., no grouting) with a water-bearing feature in the tunnel horizon for palaeochannel rock mass permeability equal to 20 Lugeons and 80 Lugeons.

A cone of depression develops to the west, where the TBMs have been draining groundwater while stationary. A maximum watertable drawdown of 4 m and 7 m, respectively, for the 20 Lugeon and 80 Lugeon palaeochannel rock mass scenarios is experienced in the area at the cessation of the second TBMs' stationary period. Note that the location where the TBMs are stationary is outside the grouted zone, and the permeability of the sandstone at this location in the model is the permeability adopted for the rock mass within the palaeochannel. This is a conservative assumption, as the water-bearing features (such as dilated bedding planes) identified at the site could extend to the west beyond WBPS into the area where the TBMs are stationary.

With a water-bearing feature in the tunnel horizon (20 Lugeon palaeochannel rock mass, consistent with the base case), the predicted watertable drawdown is greater across WBPS, at approximately 4 m, relative to the base case. However, the hydraulic gradient is flatter than the base case. With the palaeochannel rock mass permeability equal to 80 Lugeons, the watertable drawdown across WBPS increases to between 4.5 m and 6.5 m, and the hydraulic gradient is steeper.

These results indicate that greater drawdown is experienced in the vicinity of WBPS if the TBMs encounter (a) water-bearing feature(s), and this greater drawdown increases if the rock mass in the palaeochannel is of higher permeability.

These results suggest that, should the TBM encounter water-bearing features, drawdown in the vicinity of WBPS could be significantly greater during TBM mining. This drawdown is expected to cause significant ground settlement, potentially causing failure of structures at WBPS.

For this additional reason, grouting of the rock mass in the vicinity of WBPS is recommended. If predicted settlement for the mitigated case remains unacceptable, additional mitigation measures will be required.

Figure 6-6 shows the predicted watertable drawdown at the end of CTP project works (December 2024) for the Mitigated station box (1 Lugeon) with tunnelling and 20 Lugeon rock mass in the palaeochannel for scenarios with both unmitigated and mitigated rock at WBPS (unmitigated base case and mitigated base case). This point in time is when the maximum predicted drawdown extent (for this scenario) is experienced during the CTP project works.

Predicted drawdown is similar for both scenarios, because the TBMs are no longer mining in the area, and the groundwater levels have largely recovered from the drawdown induced by the TBMs' mining.

Predicted watertable drawdown in the region is generally between 1 m and 5 m, although it is greater in the sandstone at the eastern end of the station box. In the vicinity of WBPS, the drawdown is between approximately 2.5 m and 4 m.

Figure 6-7 shows the predicted watertable drawdown in December 2024 for the Mitigated station box (1 Lugeon) with unmitigated WBPS and (a) water-bearing feature(s) in tunnel horizon for palaeochannel rock mass at both 20 Lugeons and 80 Lugeons.

The results are similar between the 20 Lugeon case and the basecase, with a slight increase in drawdown associated with the TBM encountering (a) water-bearing feature(s) in tunnel horizon, with between approximately 2.5 m and 4 m drawdown across WBPS. If the palaeochannel rock mass has a higher permeability (80 Lugeons), the drawdown is significantly greater across the eastern portion of WBPS, but the hydraulic gradient is flatter.

The results suggest that the grouting under WBPS does not significantly change the predicted watertable drawdown over the long term for the base case. This is because the TBMs have passed WBPS by this point in time, the tunnels are undrained, and the groundwater level has (partially) recovered in the area.

For the results discussed above, the watertable drawdown generally extends up to some 400 m distance from the station box. At most distant locations, this drawdown is likely to be experienced in the sandstone only. Drawdown is predicted in the vicinity of the WestConnex Rozelle Interchange and Western Harbour Tunnel Enabling Works (RIC) project. Cumulative drawdown with these projects and the Project works is discussed in Section 6.5.

Figure 6-8 shows the predicted drawdown of the watertable in December 2024 (end of Project works) for the Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario and the watertable drawdown predicted two years after excavation by the Environmental Impact Statement (EIS) reported by Sydney Metro (2020). The drawdown predicted for the Project works mitigated scenario is smaller in magnitude than the drawdown predicted in the EIS. This is because the drawdown reported in the EIS does not include the implementation of the mitigation measures (grout curtain around the station box). The drawdown associated with the Project works is predicted to extend to a greater distance than the drawdown reported in the EIS (Amendment Report for The Bays).

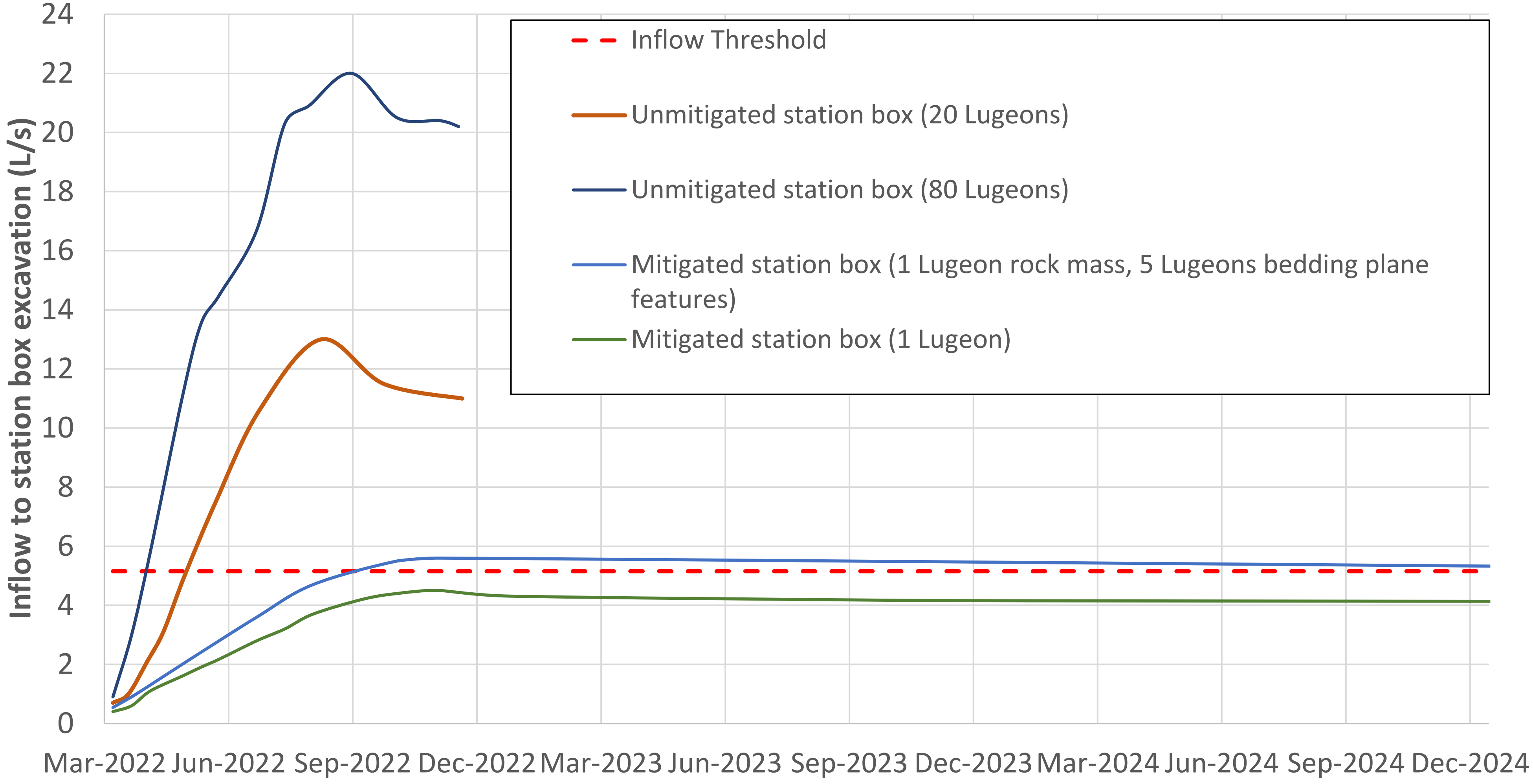


FIGURE 6-2: PREDICTED GROUNDWATER INFLOWS TO STATION BOX EXCAVATION FOR MITIGATED AND UNMITIGATED STATION BOX SCENARIOS

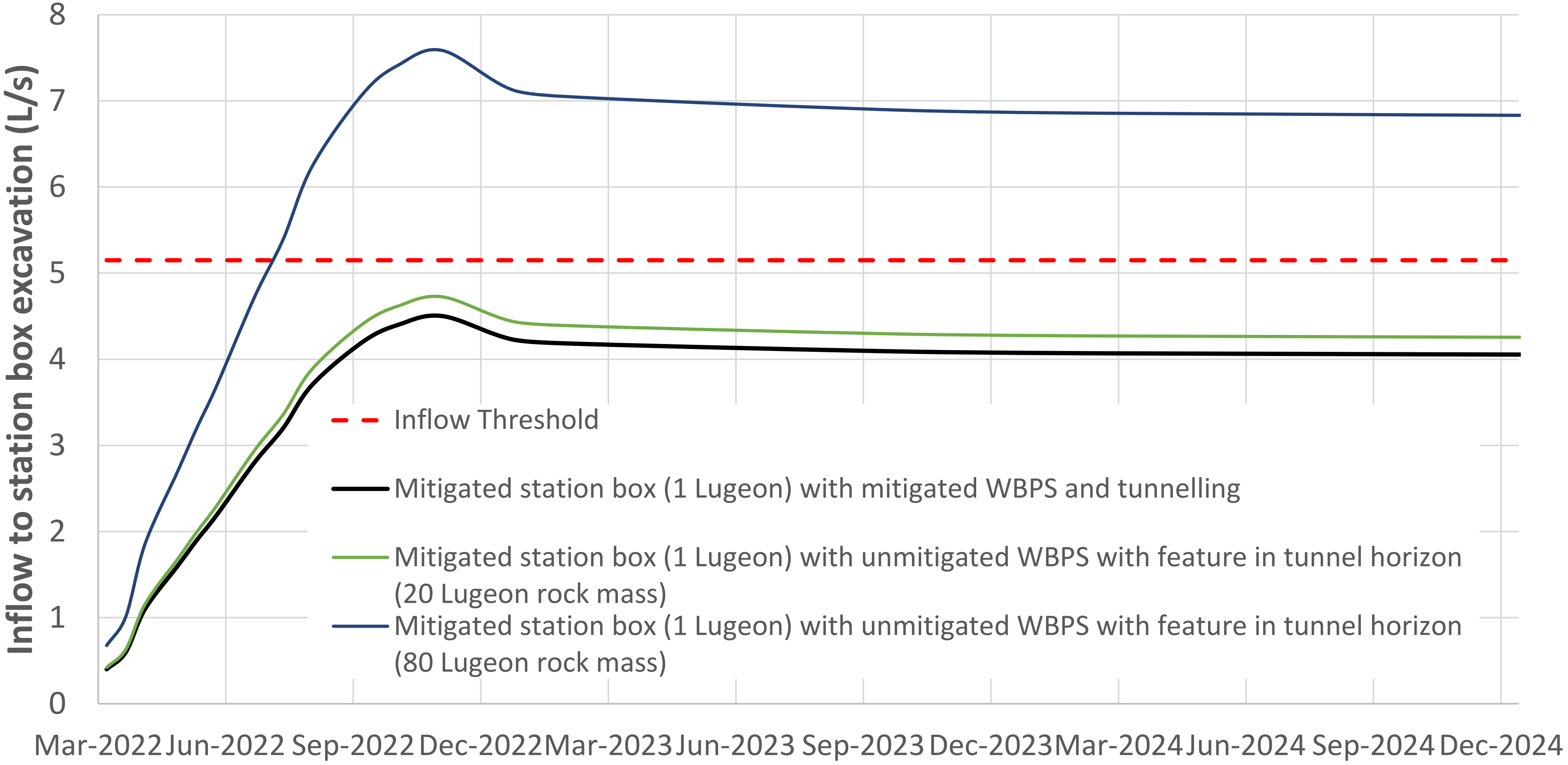


FIGURE 6-3: PREDICTED GROUNDWATER INFLOWS TO STATION BOX EXCAVATION FOR MITIGATED AND UNMITIGATED TUNNELLING SCENARIOS

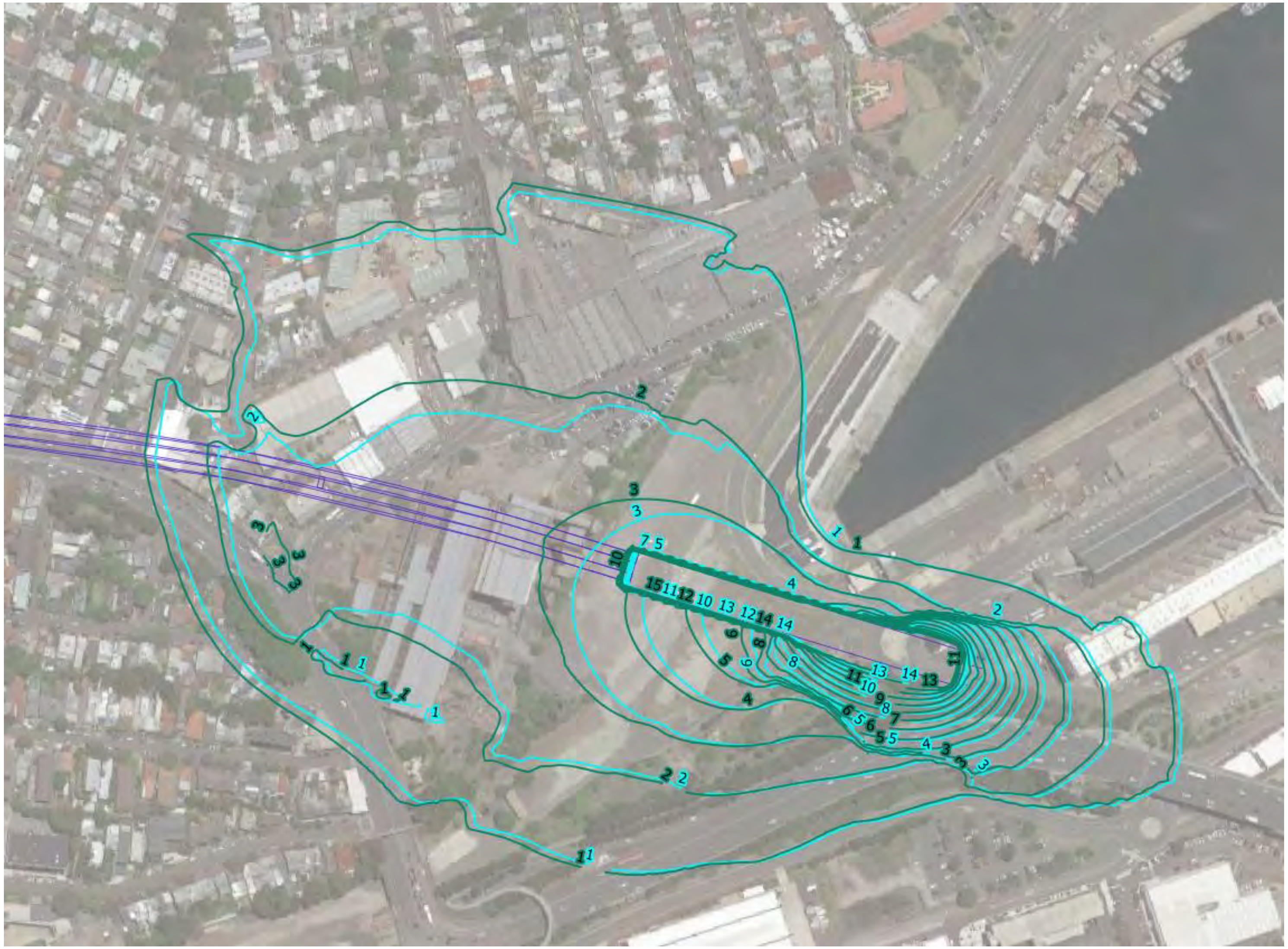


FIGURE 6-4: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO (BLUE) AND MITIGATED STATION BOX (1 LUGEON) AND UNMITIGATED WBPS WITH TUNNELLING SCENARIO (GREEN)

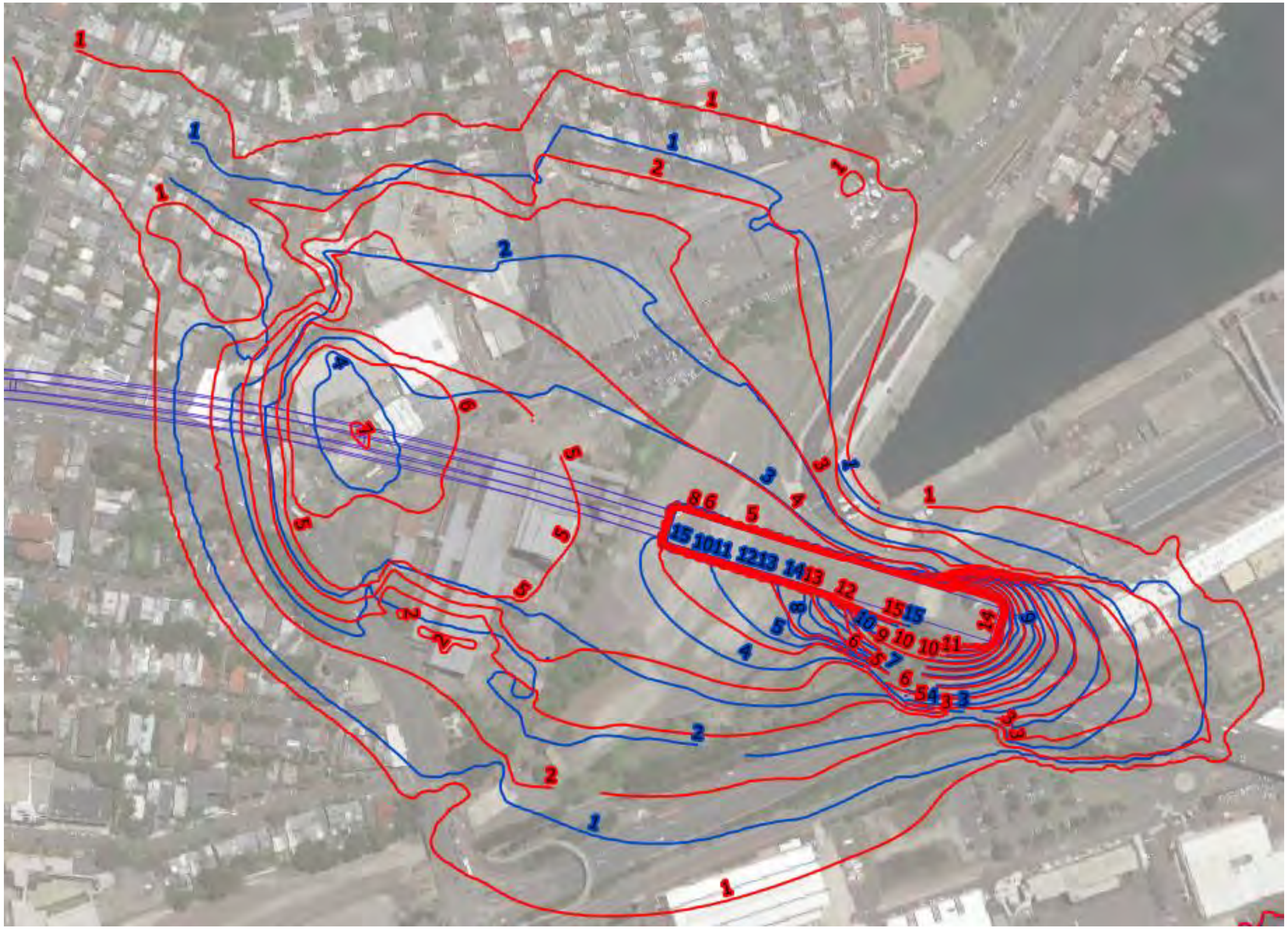


FIGURE 6-5: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR MITIGATED STATION BOX (1 LUGEON) WITH UNMITIGATED WBPS WITH WATER-BEARING FEATURE IN TUNNEL HORIZON AND PALAEOCHANNEL ROCK MASS AT 20 LUGEONS (BLUE), AND UNMITIGATED WBPS WITH WATER-BEARING FEATURE IN TUNNEL HORIZON AND PALAEOCHANNEL ROCK MASS AT 80 LUGEONS (RED)

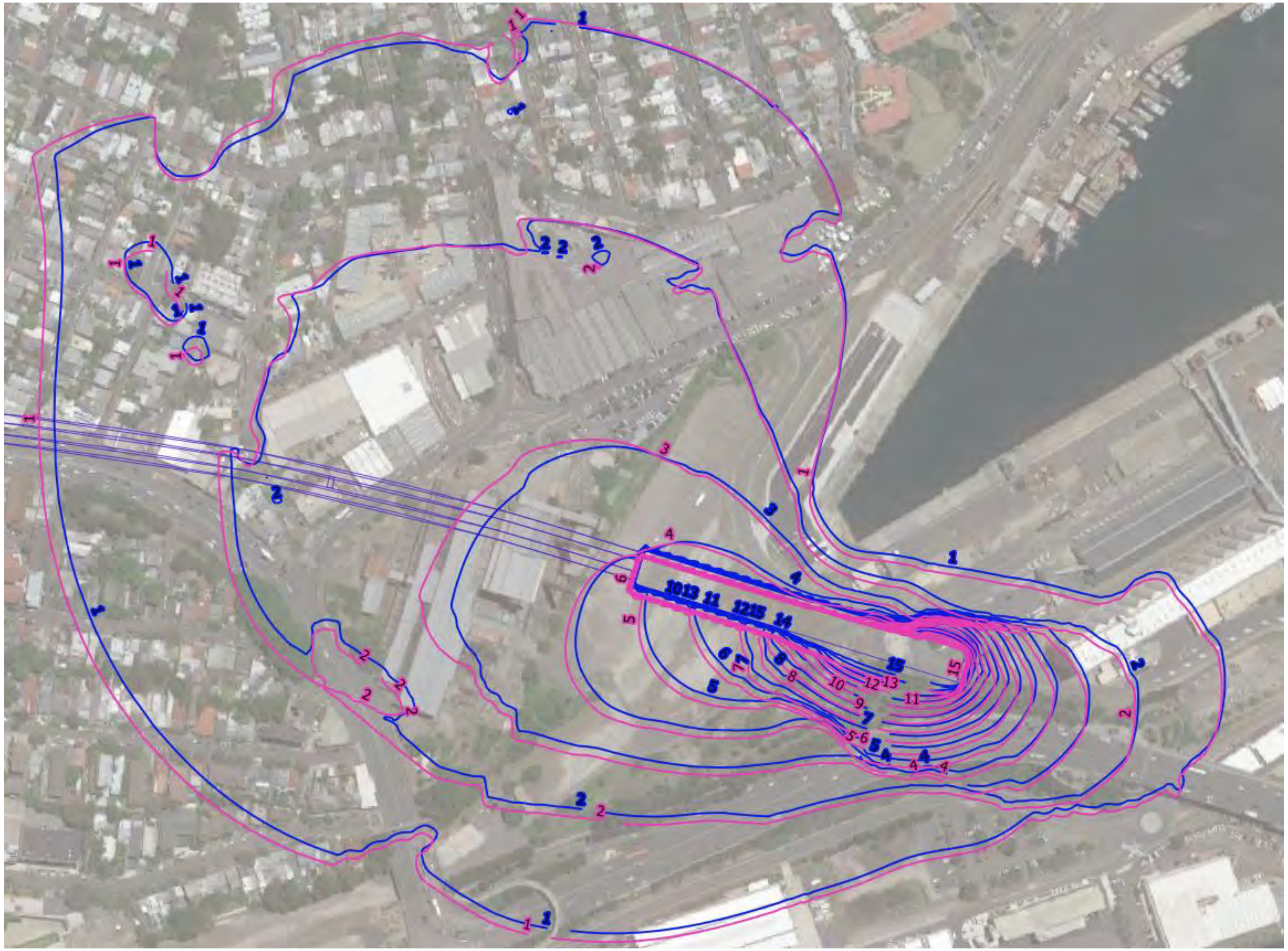


FIGURE 6-6: PREDICTED WATERTABLE DRAWDOWN (METRES) IN DECEMBER 2024 FOR MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO (BLUE) AND MITIGATED STATION BOX (1 LUGEON) AND UNMITIGATED WBPS WITH TUNNELLING SCENARIO (PURPLE)

FIGURE 6-7: PREDICTED WATERTABLE DRAWDOWN (METRES) IN DECEMBER 2024 FOR MITIGATED STATION BOX (1 LUGEON) WITH UNMITIGATED WBPS WITH WATER-BEARING FEATURE IN TUNNEL HORIZON AND PALAEOCHANNEL ROCK MASS AT 20 LUGEONS (GREEN), AND UNMITIGATED WBPS WITH WATER-BEARING FEATURE IN TUNNEL HORIZON AND PALAEOCHANNEL ROCK MASS AT 80 LUGEONS (RED)

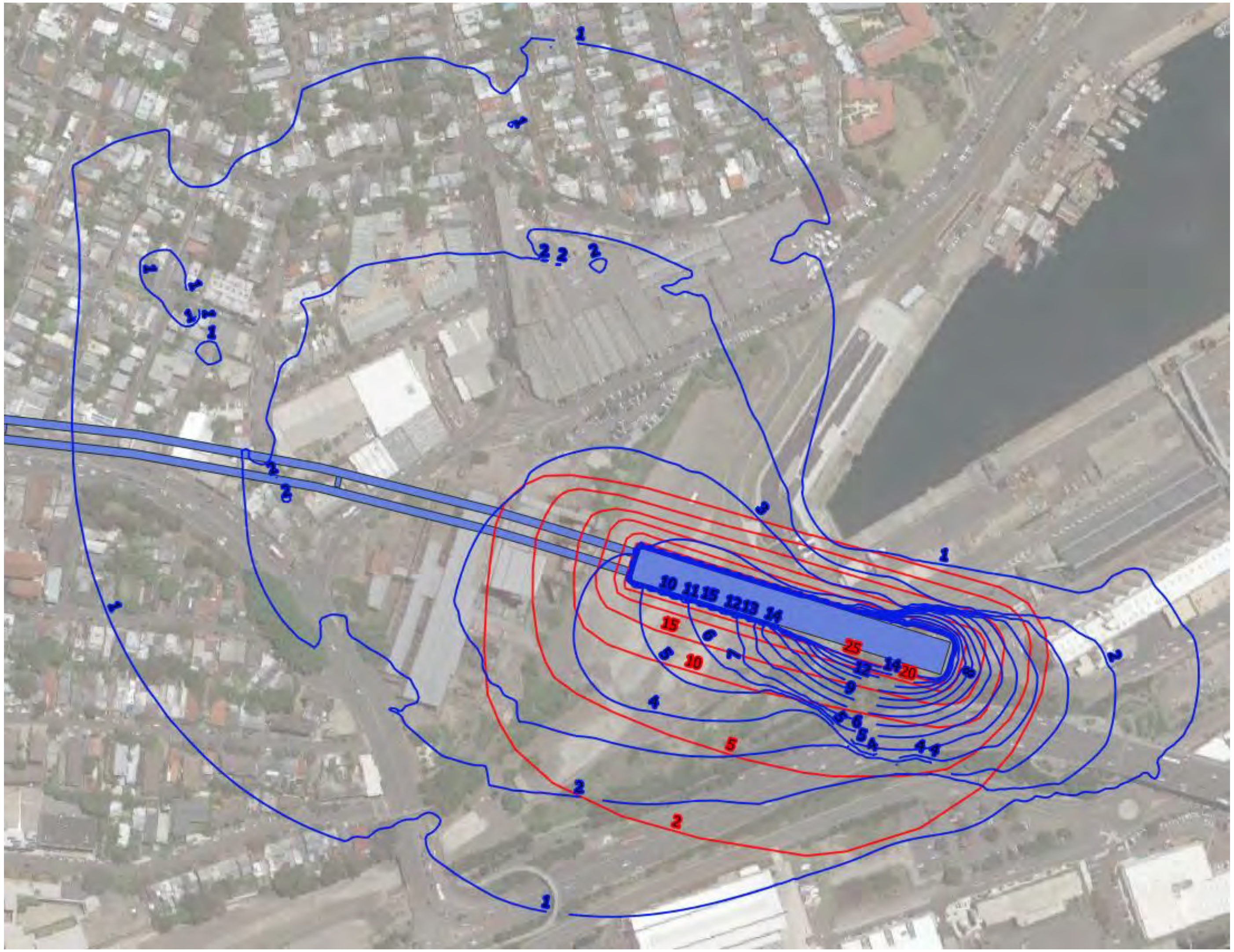


FIGURE 6-8: PREDICTED WATERTABLE DRAWDOWN (METRES) IN DECEMBER 2024 (END OF PROJECT WORKS) FOR MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO (BLUE) AND THE WATERTABLE DRAWDOWN (METRES) PREDICTED TWO YEARS AFTER EXCAVATION BY THE EIS (AMENDMENT REPORT) (RED)

6.2.3 CONTAMINANT MIGRATION

It is anticipated that groundwater in the vicinity of the station box will flow preferentially towards the station box during excavation and dewatering. This has the potential to draw contaminated groundwater into the station box excavation.

Particle tracking modelling was undertaken to assess the potential for contaminants identified within groundwater to enter the station box excavation. Details of the modelling approach are provided in Annexure C of this appendix.

Contamination Assessment Report identifies contaminants in groundwater at the site at concentrations above human health and/or NEPM trigger values, including ammonia, heavy metals, petroleum hydrocarbons, and PFOS. The locations (white dot) of these specific identified contaminants (piezometers/wells) (assumed as at the beginning of Project works in March 2022 based on monitoring data from 2018 to 2021) are shown in Figure 6-9.

Figure 6-9 also shows the predicted migration pathway of these contaminants in groundwater during the Project works due to the flow regime(s) induced by the station box excavation and tunnel mining, and the hydrogeological unit (coloured dot) which the contaminants reach in December 2024, at the end of Project works.

The results suggest that some of the identified contaminants are likely to reach the deeper sandstone units by the end of December 2024. As the modelling approach does not consider potential dispersion and diffusion of contaminants in groundwater, it is possible that contaminant migration could be faster than the results presented here.

Therefore, it is possible that contaminated groundwater may enter the station box excavation during the Project works. Note that the modelled pathways are for identified contaminants in groundwater. It is possible that there are contaminants present in groundwater within soils and rock in the vicinity of the site, and that these (if present) could also enter the station box excavation, potentially within shorter timeframe than the duration of the Project works.

Appropriate construction measures will need to be in place to manage potentially contaminated groundwater seepage to the excavation, and to suitably treat groundwater seepage prior to discharge.

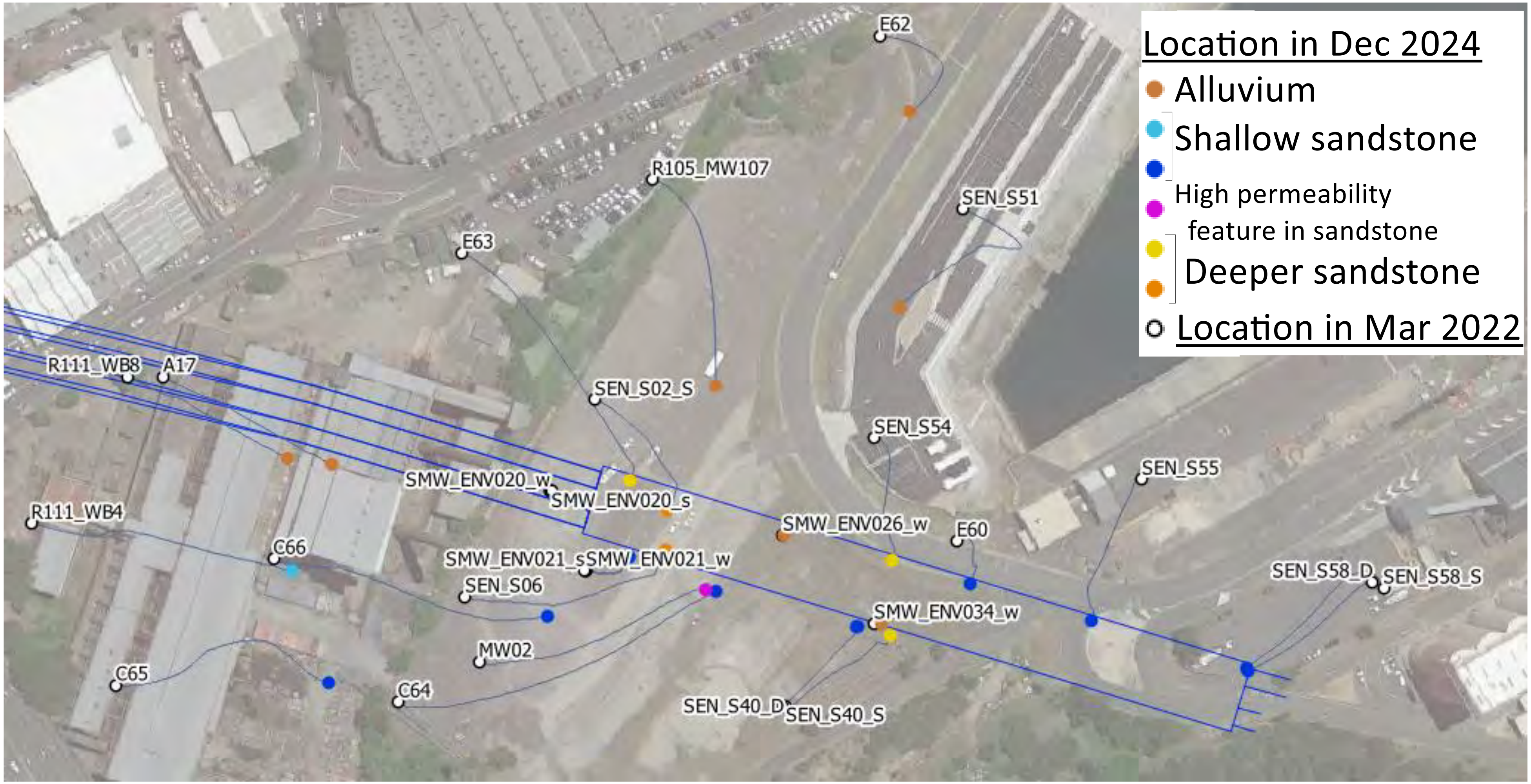


FIGURE 6-9: MIGRATION PATHWAYS OF GROUNDWATER CONTAMINANTS DURING PROJECT WORKS

6.2.4 SALINE INTRUSION

As noted in Section 5, groundwater at the site is currently saline, with electrical conductivities ranging between 751 µS/cm and 48,270 µS/cm, and a median electrical conductivity of approximately 1,500 µS/cm, which is significantly below the electrical conductivity of seawater of approximately 50,000 µS/cm.

Localised drawdown of the groundwater table from dewatering as part of The Bays Station box excavation is expected. It is anticipated that groundwater in the vicinity of the station box will flow preferentially towards the station box during excavation and dewatering. This has the potential to draw saline water from White Bay towards the station box, potentially increasing the salinity of groundwater in the vicinity of the station box.

Solute transport modelling was undertaken to assess the potential extent of saline intrusion during Project works. Details of the modelling approach are provided in Annexure C.

Figure 6-10 shows the predicted intrusion of seawater into the groundwater system in the alluvium in December 2024 (end of Project works) and March 2032 (10 years after station box excavation commenced). Figure 6-11 and Figure 6-12 show the same results for the shallow sandstone (within which the bonded lengths of the ground anchors lie) and the deeper sandstone near excavation floor level.

The modelling predicts significant saline intrusion in the alluvium and the sandstone to the north of the station box. There is some migration of saline waters from Rozelle Bay to the southern wall after 10 years, but the concentrations are very low. During Project works, groundwater salinity is predicted to reach seawater-level concentrations along the northern wall of the station box, and within the sandstone in which the bonded lengths of the ground anchors lie.

This implies that durability design for ground anchors, the retaining wall, and potentially the grout curtain, will need to accommodate saline conditions consistent with seawater (e.g., seawater-level concentrations of chloride and sulfate). This has been considered in the durability design.

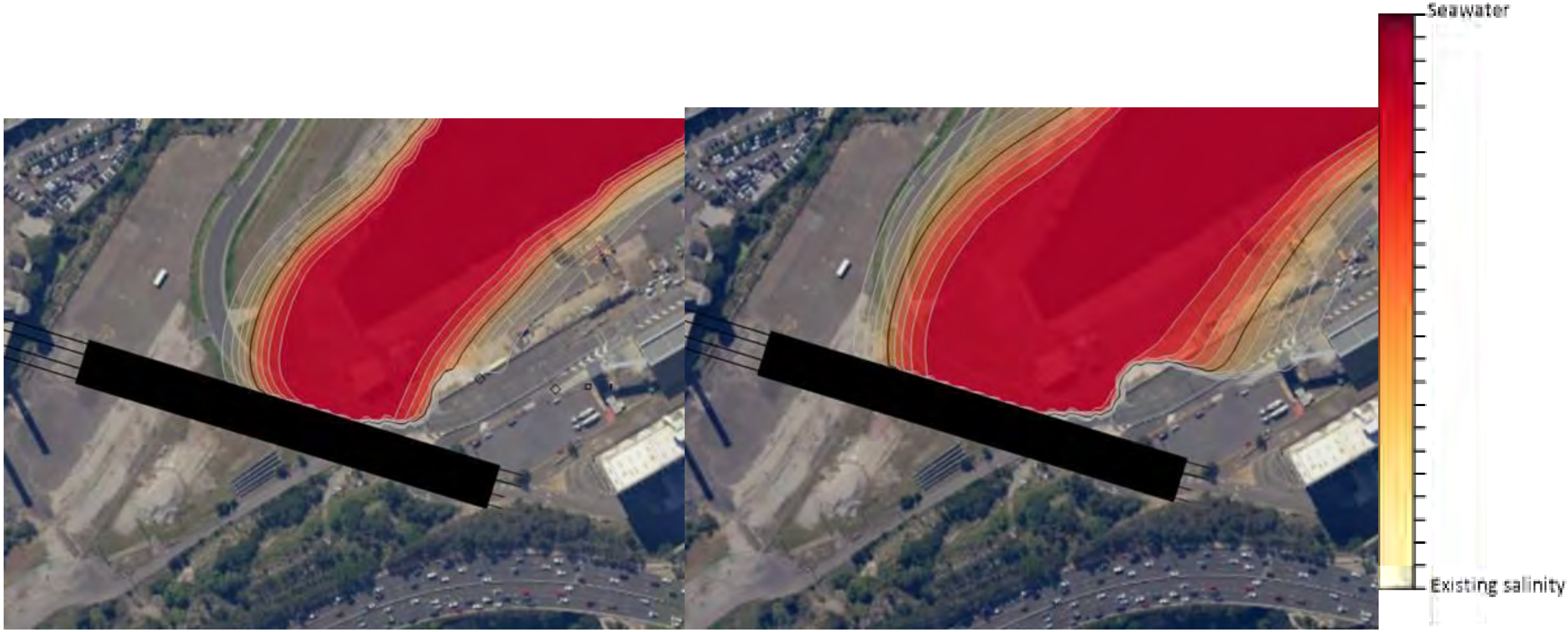


FIGURE 6-10: PREDICTED SALINE INTRUSION IN ALLUVIUM AT DEC 2024 (LEFT) AND AFTER 10 YEARS (MARCH 2032) (RIGHT)

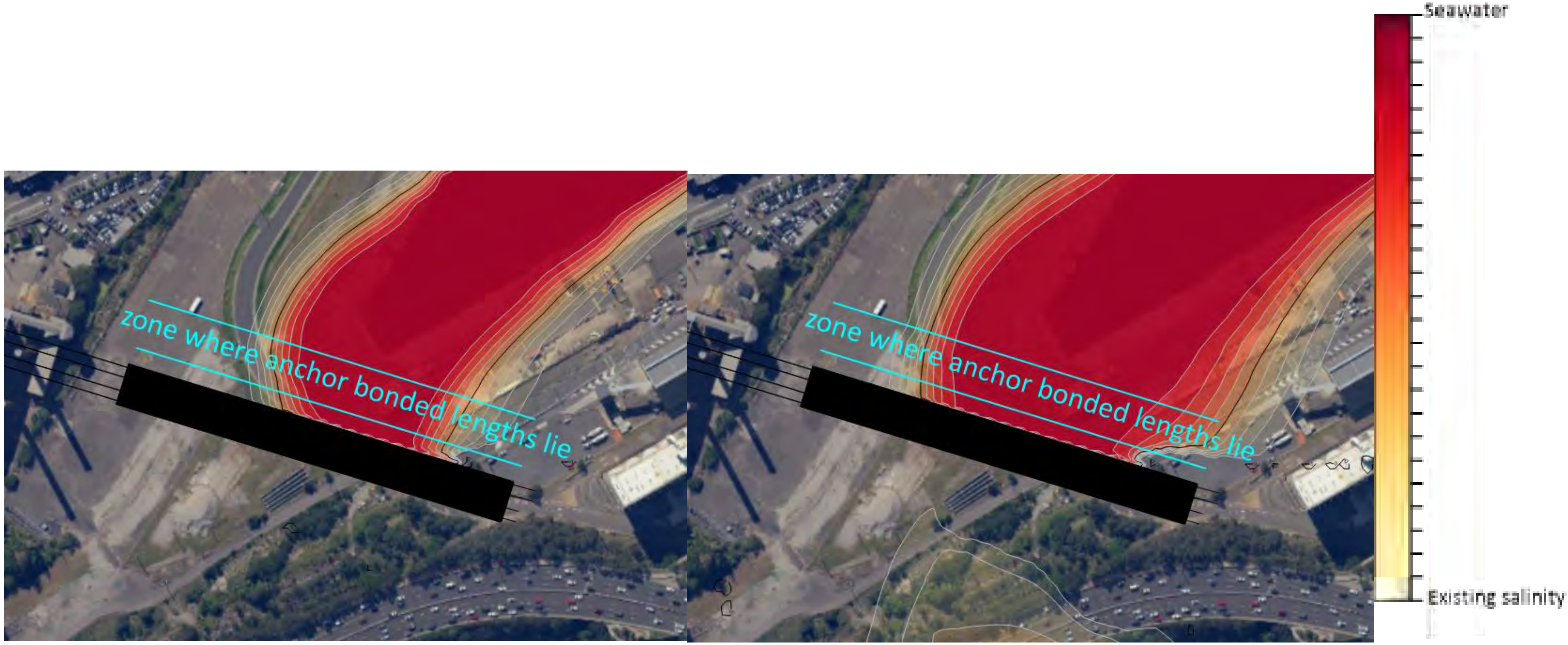


FIGURE 6-11: PREDICTED SALINE INTRUSION IN SHALLOW SANDSTONE AT DEC 2024 (LEFT) AND AFTER 10 YEARS (MARCH 2032) (RIGHT)

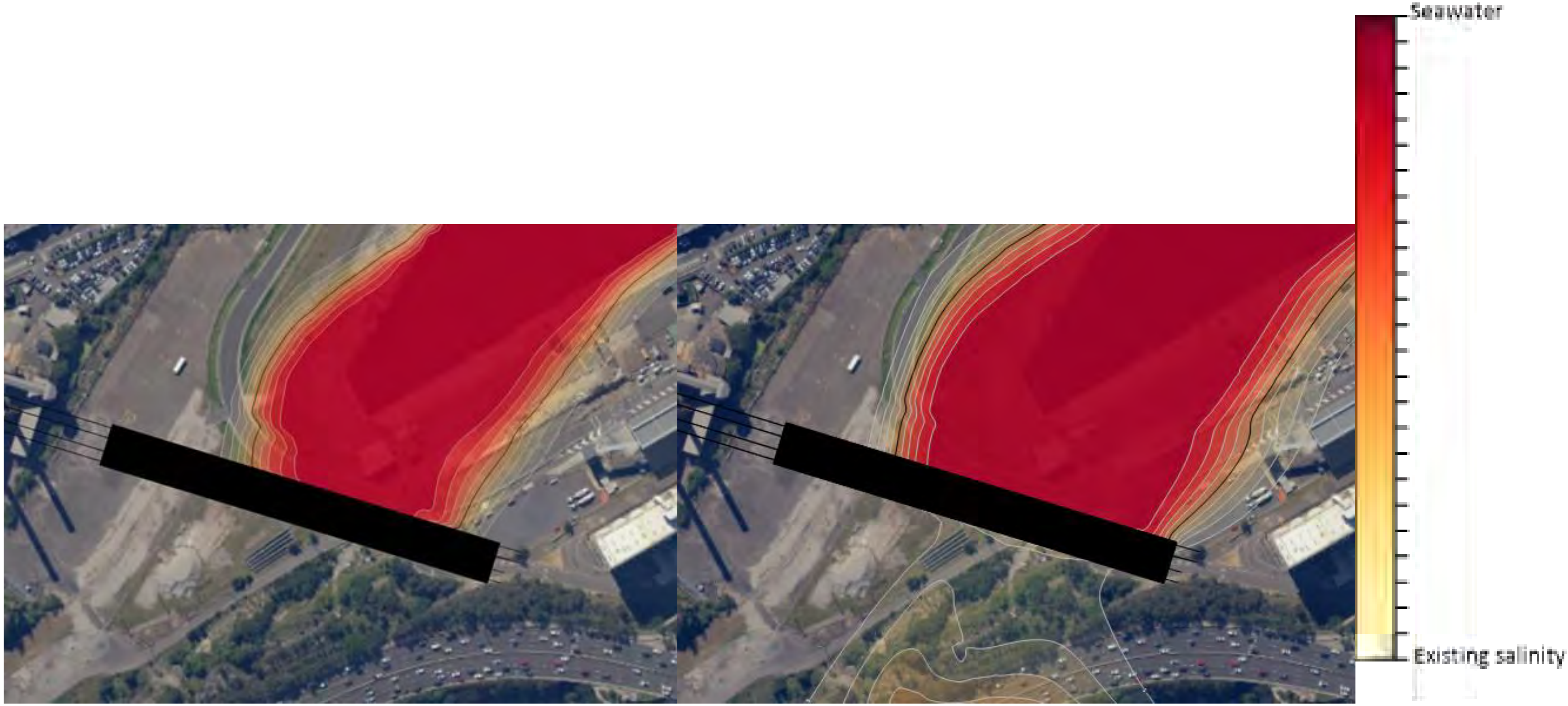


FIGURE 6-12: PREDICTED SALINE INTRUSION IN DEEP SANDSTONE AT DEC 2024 (LEFT) AND AFTER 10 YEARS (MARCH 2032) (RIGHT)

6.3 MODEL UNCERTAINTY ANALYSIS

There is a degree of uncertainty in the modelling results because there is uncertainty in the hydrogeological conditions at The Bays Station site.

Modelling was undertaken to explore the sensitivity of model results to the uncertainty/sensitivity of model inputs (hydrogeological parameter values), and the potential influence on both predicted groundwater level drawdown and inflows.

The hydrogeological parameter values with the greatest uncertainty include:

- Rainfall recharge. Model calibration indicated that a value between approximately 4% and 7% of mean annual rainfall matched existing groundwater levels more accurately. However, the value of 4% adopted in the calibrated predictive model is based on a steady state calibration only where there are no stresses on the system. A lower recharge value may lead to increased groundwater level drawdown. To explore the potential influence of recharge on the modelling results, a modelling scenario with a recharge value of 1% of mean annual rainfall was undertaken
- Alluvium vertical hydraulic conductivity. There is limited test data available to assess the vertical hydraulic conductivity of the alluvium. The modelling has adopted a vertical to horizontal hydraulic conductivity ratio (K_v/K_h) for the alluvium of 0.2. This reflects the fact that the alluvium contains clayey horizons, and is consistent with the conditions modelled by JHCPB Joint Venture (2021a) for the RIC site. A higher value, reflective of more permeable (sandy) material, could lead to increased drawdown. A value of 0.5 was adopted for uncertainty analysis
- Sandstone vertical hydraulic conductivity. There is limited test data available to assess the vertical hydraulic conductivity of the sandstone. The modelling has adopted a vertical to horizontal hydraulic conductivity ratio (K_v/K_h) for the sandstone rock mass of 0.1. This is consistent with the conditions typically adopted for Hawkesbury Sandstone. Furthermore, available information does not indicate the presence of significant sub-vertical fracturing within the palaeochannel that could lead to significant vertical connectivity with the sandstone. However, it is possible that sandstone at the site has a greater value vertical hydraulic conductivity than has been modelled. A conservative vertical to horizontal hydraulic conductivity ratio of 0.5 was adopted for uncertainty analysis
- Sandstone horizontal hydraulic conductivity. A horizontal hydraulic conductivity of 20 Lugeons was adopted for the rock mass within the palaeochannel. A value of 2.4 Lugeons was adopted for the uncertainty analysis. This is the value adopted for the sandstone outside the palaeochannel (the mean value of all packer tests undertaken outside the palaeochannel), and provides a “lower bound” value for the palaeochannel sandstone

Figure 6-13 shows the predicted groundwater inflows to the station box excavation for the various uncertainty scenarios. Figure 6-14 to Figure 6-17 show the predicted drawdown of the groundwater table in 21 March 2023, when the second TBM recommences mining after being stationary under the White Bay Power Station. This represents a point in time when drawdown due to the TBMs is most significant in the vicinity of the White Bay Power Station.

The results show that a reduced recharge or increased vertical hydraulic conductivity of the alluvium do not significantly change the inflows to the station box excavation or the groundwater table drawdown. This suggests that the modelling results are not particularly sensitive to these parameters.

A decrease in the horizontal hydraulic conductivity of the sandstone to 2.4 Lugeons results in a significant decrease in groundwater inflows to the station box excavation, with peak inflows at approximately 2.4 L/s and longer term inflows at approximately 2.2 L/s. The predicted drawdown is significantly lower in magnitude and the hydraulic gradients across the White Bay Power Station area are lower.

An increase in the vertical hydraulic conductivity of the sandstone results in a significant increase in groundwater inflows to the station box excavation and the predicted drawdown is of greater magnitude and extends further. There is significant drawdown associated with the TBM mining in the vicinity of, and to the west of, White Bay Power Station.

6.4 CONSIDERATIONS

The range in predicted groundwater inflows indicates the potential range in inflows to the station box excavation that might be expected for the Mitigated case (grouting curtain around the station box with rock to 1 Lugeon, and grouting under the White Bay Power Station as outlined in Section 6.1.2). These results indicate that the grouting design can meet the inflow criterion.

It should be noted that:

- Surface grouting at the White Bay Power Station may not achieve the same target permeabilities as it does at the station box, due to access constraints. Grouting from the TBMs will serve as a contingency to ensure rock meets the target permeability
- Station box curtain grouting will need to ensure that the grout curtain contacts rock immediately adjacent to the bottom section of the secant piled wall, and that the target permeability is met in this rock, to ensure a continuous groundwater cut-off structure
- Geological features in the floor of the station box excavation (e.g., the Great Sydney Dyke) could act as conduits for groundwater flow, leading to greater inflows than predicted in this report. The dyke potentially presents a significant risk in terms of possible groundwater flow into the station box excavation, as it could act as a conduit for significant groundwater flow. Grouting from within the excavation will serve as a contingency to ensure rock meets the target permeability
- The modelling assumes that the secant piled wall is effectively impermeable. The piles will need to be constructed to ensure the integrity of the piled wall as a groundwater cut-off structure. Sufficient tolerance will be required to ensure there are no gaps between piles, and sufficient pile verticality and pile overlap will be required to ensure the wall is constructed with integrity

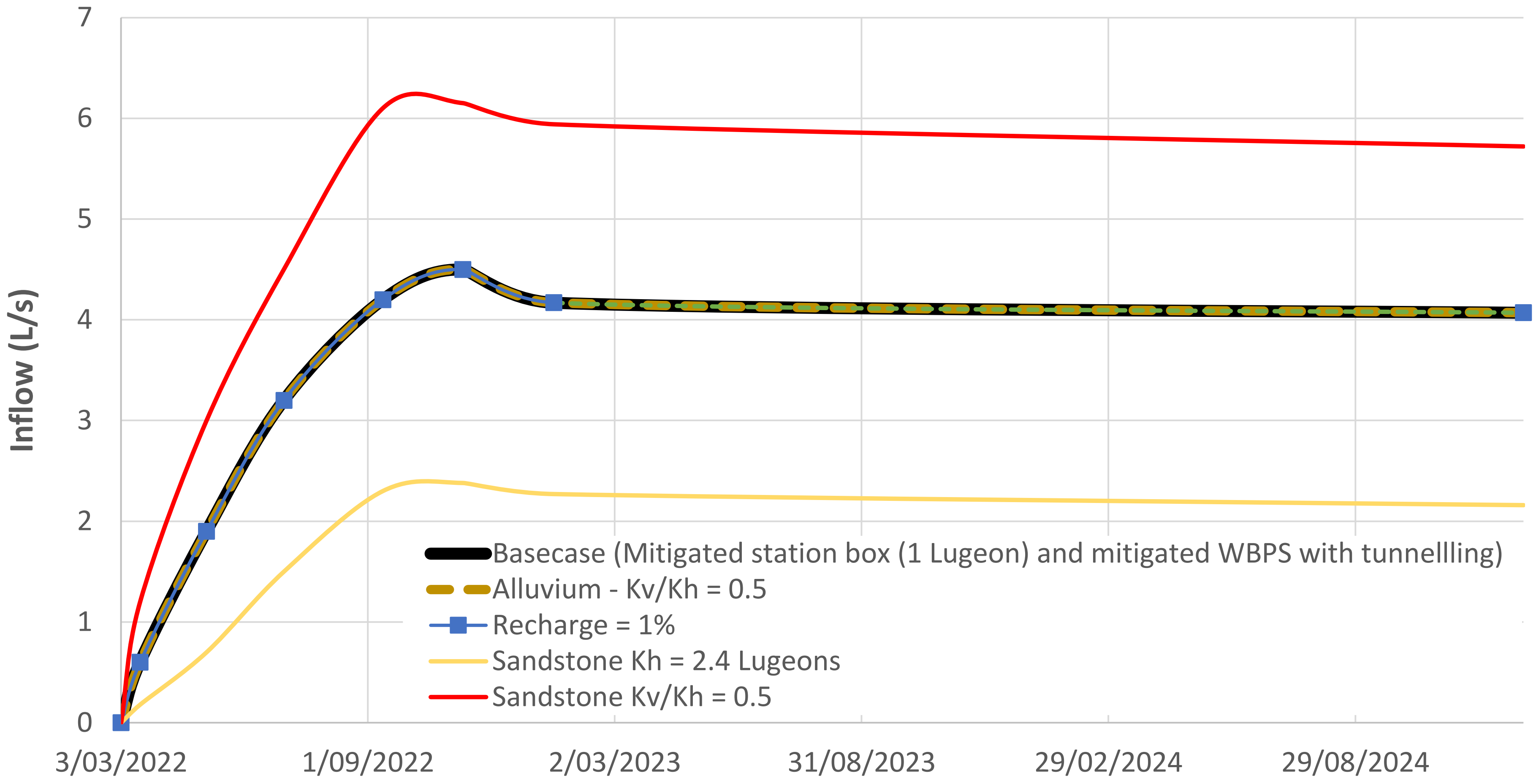


FIGURE 6-13: PREDICTED GROUNDWATER INFLOWS TO STATION BOX EXCAVATION FOR UNCERTAINTY SCENARIOS

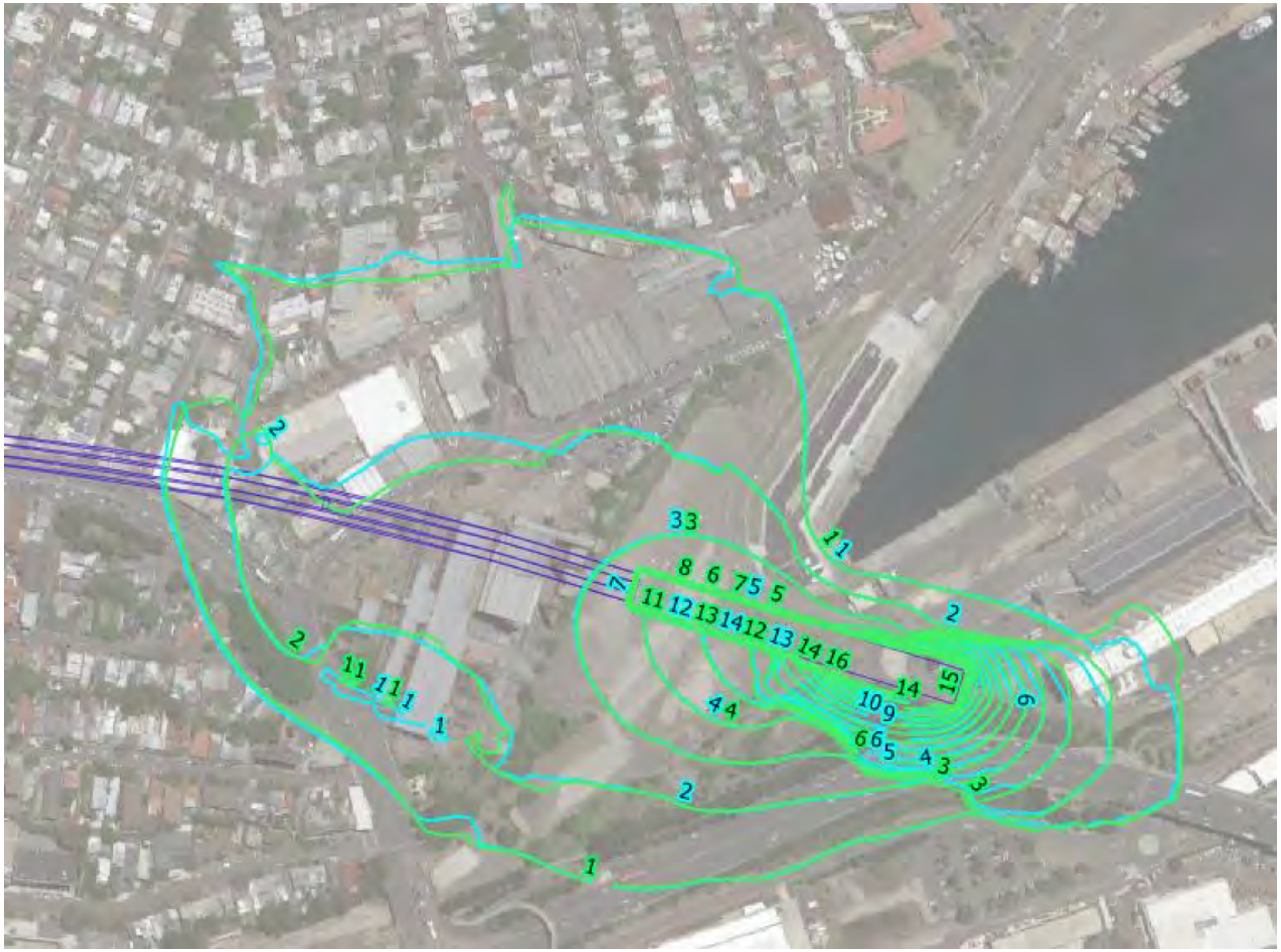


FIGURE 6-14: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR THE BASE CASE (MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO) (BLUE) AND UNCERTAINTY SCENARIO WITH RECHARGE OF 1% (GREEN)

FIGURE 6-15: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR BASECASE (MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO) (BLUE) AND UNCERTAINTY SCENARIO WITH ALLUVIUM K_V/K_H = 0.5 (BROWN)

FIGURE 6-16: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR BASECASE (MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO) (BLUE) AND UNCERTAINTY SCENARIO WITH SANDSTONE HORIZONTAL HYDRAULIC CONDUCTIVITY EQUAL TO 2.4 LUGEONS (GREEN)

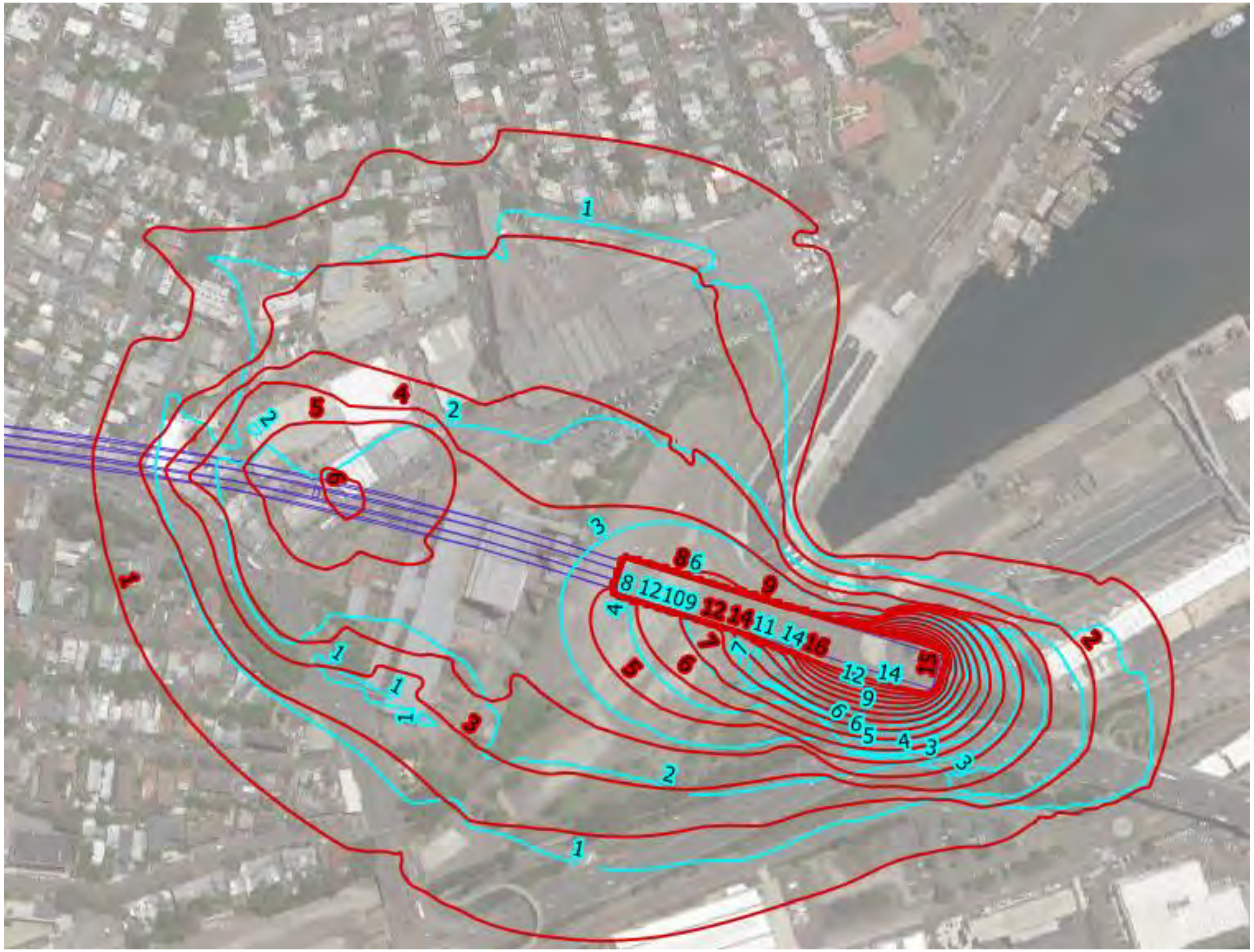


FIGURE 6-17: PREDICTED WATERTABLE DRAWDOWN (METRES) IN MARCH 2023 FOR BASE CASE (MITIGATED STATION BOX (1 LUGEON) AND MITIGATED WBPS WITH TUNNELLING SCENARIO) (BLUE) AND UNCERTAINTY SCENARIO WITH SANDSTONE K_V/K_H = 0.5 (RED)

6.5 CUMULATIVE DRAWDOWN DUE TO OTHER PROJECTS

JHCPB Joint Venture (2021a) modelled the predicted groundwater level drawdown for the RIC project for a ‘design’ case in which tunnel inflows were compliant with the required SWTC inflow criteria for that project. This assumes that, for some lengths of tunnels, inflow controls (e.g., grouting) may have been implemented where inflows otherwise would be exceeded.

JHCPB Joint Venture (2021a) report predicted total groundwater level drawdown for both December 2023 and the long term (steady state). The predicted drawdown for these times is similar in the vicinity of The Bays Station site, with drawdown of up to 2 m predicted within the footprint of White Bay Power Station. Whilst it is total groundwater level drawdown that is reported rather than drawdown of the watertable, JHCPB Joint Venture (2021a) also report their interpreted intersection of the watertable and the top of rock, which lies on the immediate western boundary of the White Bay Power Station. Thus, the total drawdown predicted by JHCPB Joint Venture (2021a) in the vicinity of the White Bay Power Station is expected to be equivalent to watertable drawdown within the sediments.

Figure 6-18 shows the total drawdown predicted JHCPB Joint Venture (2021a) for the RIC project in the long term (steady state).

To date, JTJV has been provided a single monitoring report (dated 6 December 2021) for the RIC project (JHCPB Joint Venture, 2021b). Figure 6-19 shows the groundwater monitoring network reported for the RIC project by JHCPB Joint Venture (2021b). The report shows groundwater levels in monitored piezometers and VWP from mid-September 2021 to early December 2021, with some locations experiencing ongoing groundwater level drawdown while others are experiencing groundwater level recovery during that period. Since groundwater level records for the period prior to this, including pre-construction of the RIC project, are not available; it is not possible to assess the groundwater level drawdown due to the project.

Figure 6-20 shows the cumulative predicted drawdown for the RIC project (long term steady state) (as shown in Figure 6-18) plus the CTP project works (December 2024) for the Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario.

Figure 6-21 shows the cumulative predicted drawdown for the RIC project (long term steady state) (as shown in Figure 6-18) plus the CTP project works in March 2023, when the second TBM recommences mining after being stationary under the White Bay Power Station, for the Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario.

The cumulative drawdown scenarios show that there is potential for significant additional drawdown in the vicinity of the White Bay Power Station due to the RIC project. However, the hydraulic gradient across the footprint of White Bay Power Station is reduced relative to the Project works only scenarios, which may be relatively favourable for differential settlement.

FIGURE 6-18: TOTAL DRAWDOWN (METRES) PREDICTED BY JHCPB JOINT VENTURE (2021A) FOR THE RIC PROJECT IN THE LONG TERM (STEADY STATE)

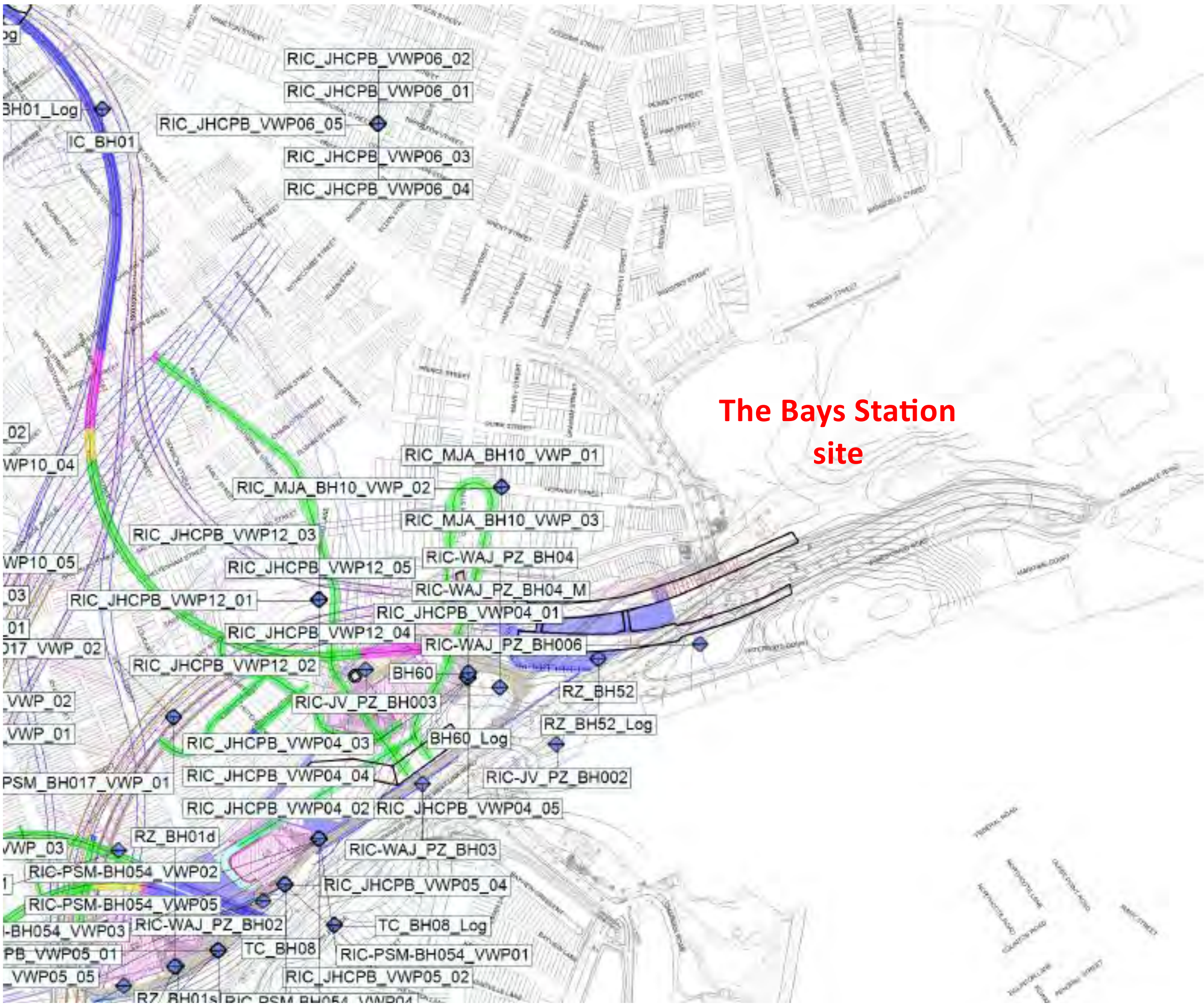


FIGURE 6-19: GROUNDWATER MONITORING NETWORK REPORTED BY JHCPB JOINT VENTURE (2021B) FOR THE RIC PROJECT

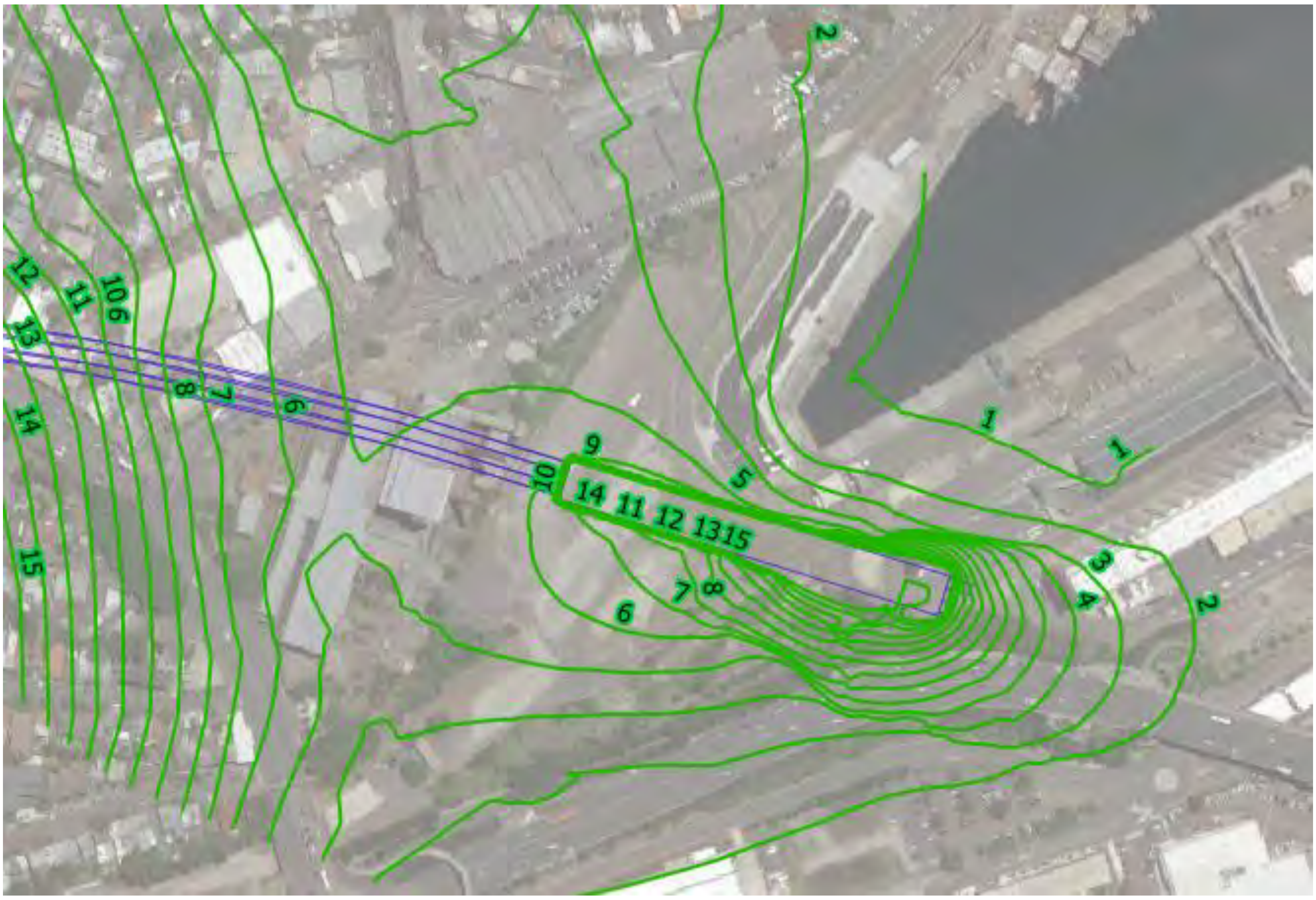


FIGURE 6-20: CUMULATIVE PREDICTED DRAWDOWN (METRES) FOR CTP PROJECT WORKS (DECEMBER 2024) AND THE RIC PROJECT (LONG TERM STEADY STATE) FOR THE CTP MITIGATED BASECASE SCENARIO

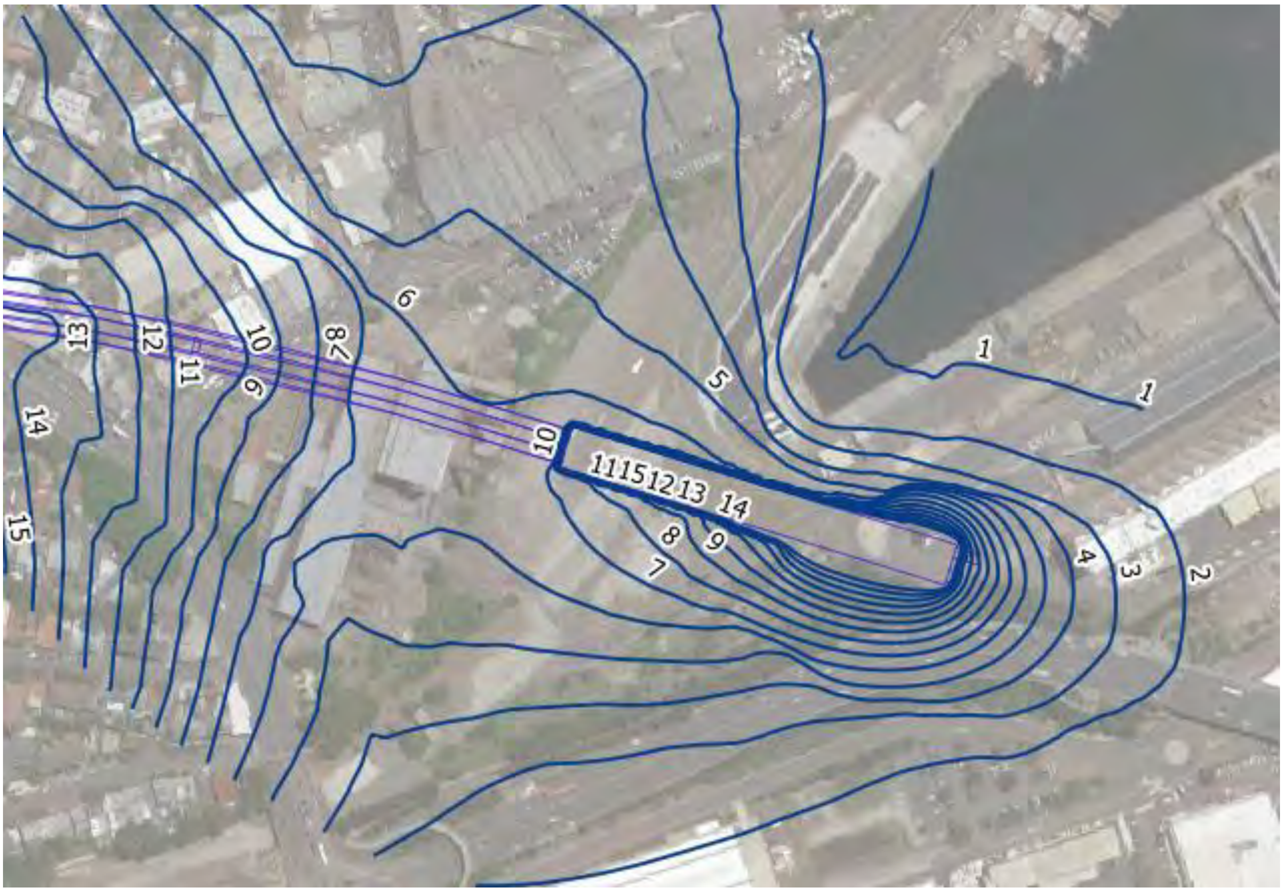


FIGURE 6-21: CUMULATIVE PREDICTED DRAWDOWN (METRES) FOR CTP PROJECT WORKS (MARCH 2023) AND THE RIC PROJECT (LONG TERM STEADY STATE) FOR THE CTP UNCERTAINTY SCENARIO WITH SANDSTONE $K_V/K_H = 0.5$

The cumulative drawdowns presented here are based on predictive modelling only, as groundwater monitoring data for the RIC project is limited, and is for the CTP and RIC projects only.

The cumulative drawdown is a complex interaction between the drawdown induced by the station box excavation and TBM mining for the Project works, the RIC project, and potentially the WHT project.

There is significant uncertainty in the potential cumulative impact of surrounding projects on groundwater at The Bays Station site because:

- Design and construction details for the RIC and WHT project are not available
- The status of excavation and the existing groundwater level drawdown due to other projects, including those from the RIC and WHT projects, are unknown
- The drawdown estimates provided above are based on predictive modelling for the RIC project only, and have not been validated by construction monitoring data
- It is possible that additional drawdown from the WHT project would also extend into The Bays Station site during construction of the WHT project. It is therefore possible that the cumulative drawdown presented above may underestimated potential cumulative drawdown at The Bays Station site.

7. GROUNDWATER-RELATED IMPACTS

7.1 GROUNDWATER RECEPTORS

Groundwater users and groundwater dependent ecosystems have not been identified in the vicinity of The Bays Station. This is consistent with the EIS. As such, there is not expected to be any impact to groundwater users or groundwater dependent ecosystems associated with groundwater inflows to The Bays Station excavation.

7.2 ACID SULFATE SOILS

7.2.1 ACID SULFATE SOILS AND GROUNDWATER LEVEL DRAWDOWN

The Contamination Assessment Report reviews (potential) acid sulfate soils ((P)ASS) test results at The Bays Station site and identifies (P)ASS across the site at depths ranging between 3 mbgl and 19 mbgl.

Figure 7-1 shows the acid sulfate soils tests where peroxide oxidisable sulfur exceeded 0.03% S (in red) and was below 0.03% S (in yellow), as discussed in the Contamination Assessment Report, along with the predicted watertable drawdown (metres) for the Mitigated base case scenario (December 2024).

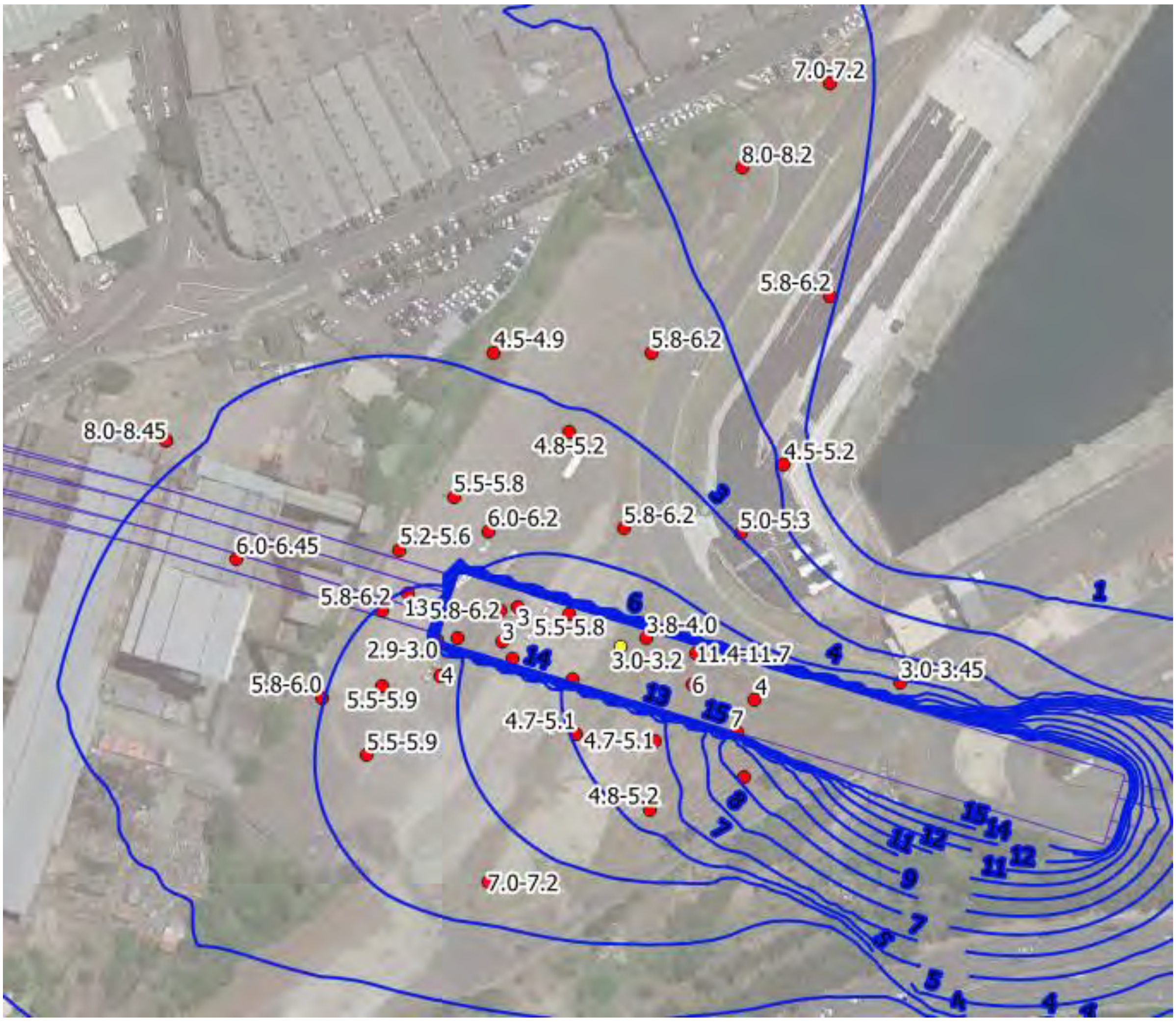


FIGURE 7-1: PEROXIDE OXIDISABLE SULFUR EXCEEDING 0.03% S (IN RED) AND BELOW 0.03% S (IN YELLOW) AND PREDICTED WATERTABLE DRAWDOWN (METRES) FOR THE MITIGATED BASE CASE SCENARIO (DECEMBER 2024)

7.2.2 POTENTIAL IMPACTS

Based on the predicted watertable drawdown at the site for the Mitigated base case scenario in December 2024 (see Section 6.5), there is potential for (P)ASS within approximately 50 m of the station box walls to be activated. This distance increases to approximately 80 m for the potential cumulative drawdown due to the RIC project and the CTP project works.

(P)ASS identified beyond this distance from the station box are deeper than the predicted level of watertable after drawdown and are therefore not expected to be impacted by the Project works.

Activation of (P)ASS has the potential to cause increased acidic conditions in groundwater, with the potential to cause:

- Increased aggressivity of groundwater, potentially impacting in-ground (concrete and steel) structures
- Potential reduction in the pH of groundwater within excavated soils (within the footprint of the station box). Groundwater pH may therefore reduce, potentially impacting the durability of in-ground structures. Spoil materials may therefore require treatment prior to disposal
- Release of contaminants from soils (e.g., bound heavy metals), and reduction in groundwater pH, impacting groundwater quality. In the case that impacted groundwater is drawn into the station box (or tunnel) excavations, additional groundwater treatment may be required

7.2.3 POTENTIAL PH CHANGE DUE TO OXIDATION OF (P)ASS

Available ASS test data for The Bays Station site has used three different laboratory methods, including $pH_{F,}$ pH_{FOX} and pH(Ox). The pH_F measurement is undertaken on a soil:water paste mixture and is a used as an indicator of existing soil acidity and thus, the potential for actual acid sulfate soils (AASS). The pH_{FOX} measurement is undertaken on soil samples mixed in a paste with peroxide and is a used to indicate the pH of a soil following oxidation, and thus, provides an indication of sulfides, otherwise known as potential acid sulfate soils (PASS). The pH(Ox) measurement is undertaken on dried and milled soil samples following addition of peroxide and deionised water, and is used as a precursor to a total peroxide acidity test as part of the SPOCAS detailed ASS assessment.

Both the pH_F and the pH_{FOX} measurements are considered indicative only, and are typically only used for the purpose of decision making regarding the necessity for more detailed ASS analysis. For example, it is widely recognised that the pH_{FOX} measurement tends to overestimate the acid generating potential of soils upon exposure to oxygen, as peroxide is a much stronger oxidant that oxygen; resulting in the oxidation and release of acids (such as humic and fulvic acids bound in organic soil compounds) that would not be released naturally upon drying. While the pH(Ox) measurement is considered more robust than the pH_{FOX} method, it also adopts the use of peroxide as an oxidant. However, unlike the pH_{FOX} method, the drying and milling of the sample during preparation can result in the disaggregation of carbonates and crushing of shells which releases alkalinity that would not typically be available during dewatering. This is illustrated in Figure 7-2, which shows that soil pH(Ox) values (for all available test data at the site) typically exceed pH_{FOX} values due to the liberation of alkalinity during sample preparation for the pH(Ox) test.

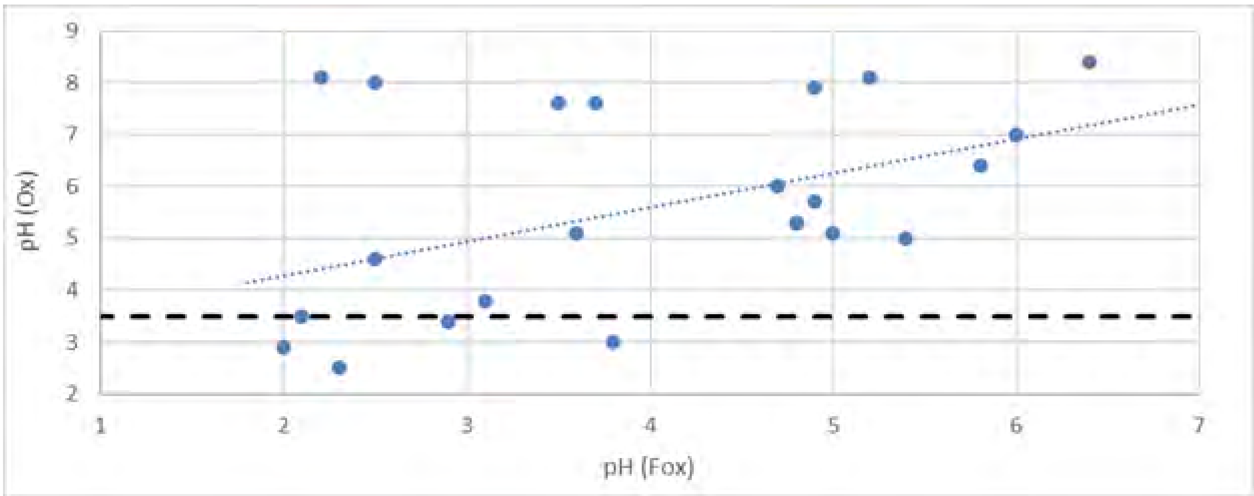


FIGURE 7-2: SOIL PH_{FOX} VS PH(OX) AT THE BAYS STATION SITE

As discussed in the Contamination Assessment Report, the ASS sampling data reviewed does not meet the ASSMAC 1998 guideline requirements, and consequently is not considered a comprehensive acid sulfate soils investigation. Available data is considered suitable for limited characterisation only. Furthermore, due to the significant variations in depth and/or presence of fill and alluvial sediments at the site, it is not possible to correlate the likelihood of ASS/PASS purely by depth. Given this, in order to provide an indication of the likelihood of soil pH falling below 3.5 as a result of dewatering, an assessment has been undertaken based on a statistical (exceedance probability) approach.

The exceedance probability of soil pH for the pH_F, pH_{FOX} and pH(Ox) results for all samples collected from The Bays Station are illustrated in Figure 7-3 below. These data indicate that all soils sampled at The Bays have an existing pH of 5 or greater. However, the data also suggest that following oxidation, the pH may fall below 3.5 in approximately 32% of soils based on pH_{FOX} results, or approximately 10% of soils based on pH(Ox) results (recognising the above discussed limitations of these methods).

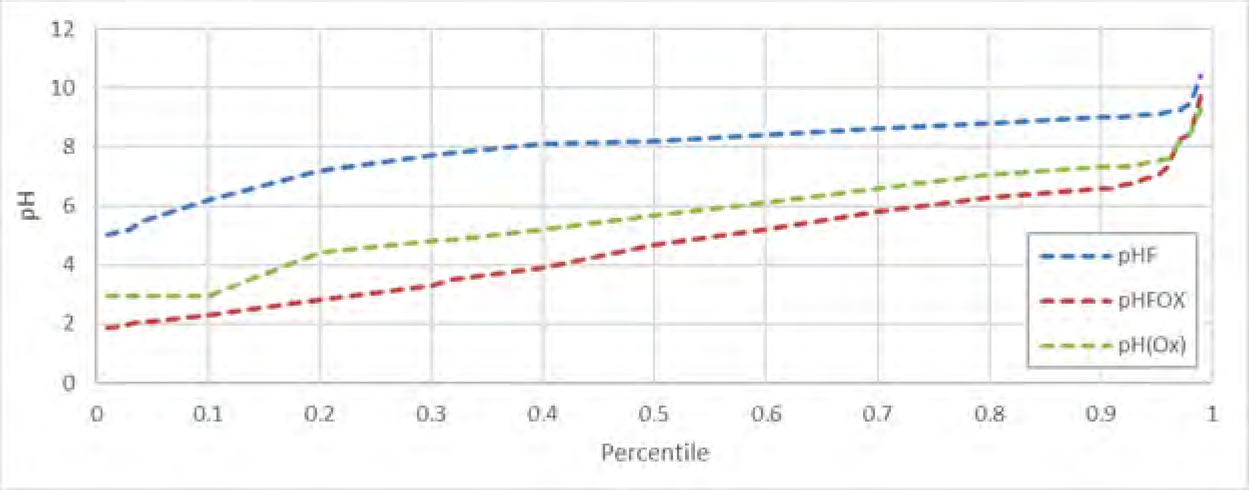


FIGURE 7-3: PH EXCEEDANCE PROBABILITY

Previous experience suggests that pH_{FOX} results tend to overestimate the end-soil pH of oxidised soils that dry in-situ via dewatering by approximately one pH unit. If this were realised for soils at The Bays Station site, then approximately 12% of soils at the site would be estimated to fall below a pH of 3.5, which is more consistent with pH(Ox) results, and provides potential confirmation of a lower proportion of soils (approximately 10%) being at risk of falling below a pH of 3.5 following dewatering.

In summary, while available ASS sampling and testing data is limited and therefore only an indicative assessment in possible, this preliminary assessment suggests that approximately 10% of soils at The Bays Station site appear to be at risk of falling below a pH of 3.5 following dewatering. However, given that the soil testing undertaken to date were not specifically designed to estimate the end-pH of soils upon drying, this assessment is somewhat speculative. Should greater confidence in the assessed reduction in pH due to oxidation of (P)ASS be required, incubation of soils collected from the site in a laboratory environment, with monitoring of soil pH following multiple wetting and drying cycles, is recommended to provide improved estimates of the potential end-point pH of soils due to dewatering.

This assessment is based on limited data collected during various sporadic environmental investigations at the site. The available data are insufficient to support comprehensive assessment of impact to (P)ASS and the development of an Acid Sulfate Soils Management Plan (ASSMP). Additional site investigation will be required to develop an ASSMP. The potential impacts listed above will be considered in the ASSMP.

7.3 CONTAMINANT MIGRATION

As noted in Section 5 and 6.2.3, the Contamination Assessment Report identifies numerous exceedances of ANZECC/ARMCANZ (2000) trigger levels for 95% protection of marine ecosystems at groundwater monitoring locations at The Bays Station site.

Localised drawdown of the groundwater table from dewatering as part of The Bays Station box excavation is expected. It is anticipated that groundwater in the vicinity of the station box will flow preferentially towards the station box during excavation and dewatering.

Groundwater within shallow sediments is expected to be drawn deeper into the sandstone, and has the potential to enter the station box excavation during the Project works. Appropriate construction measures will need to be in place to manage potentially contaminated groundwater seepage to the excavation, and to suitably treat groundwater seepage prior to discharge.

7.4 SALINE INTRUSION

Groundwater modelling predicts significant saline intrusion in the alluvium and the sandstone to the north of the station box during and beyond the Project works. There is some migration of saline waters from Rozelle Bay to the southern wall after 10 years, but the concentrations are very low. During Project works, groundwater salinity reaches seawater-level concentrations along the northern wall of the station box. This implies that durability design for the northern retaining wall, and potentially the northern grout curtain, will need to accommodate saline conditions consistent with seawater (e.g., seawater-level concentrations of chloride and sulfate). This has been considered in the durability design.

7.5 SETTLEMENT AND GROUND MOVEMENT

The groundwater level drawdowns reported in Section 6 have been used in the settlement assessment. Refer to the Settlement Assessment Report.

The settlement assessment considers the following scenarios:

- Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 20 Lugeons (base case scenario), and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualized as a single feature with an equivalent thickness of 1 m and a horizontal hydraulic conductivity of 308 Lugeons. Watertable drawdown in March 2023 / December 2024
- Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 80 Lugeons, and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualized as per the bullet point above. Watertable drawdown in March 2023 / December 2024
- Mitigated base case: Station box and tunnel excavations with grouting of rock at station box (achieving 1 Lugeon) and at power station (1 Lugeon rock mass, 5 Lugeons dilated bedding

planes), as outlined in Section 6.1.1. The greatest absolute watertable drawdown is in December 2024, at the end of Project works

- Sandstone K_v/K_h = 0.5 (vertical to horizontal hydraulic conductivity ratio equal to 0.5): As per the Mitigated base case, but with greater vertical permeability for the sandstone. This scenario shows the most significant differential drawdown in the vicinity of the power station under mitigated conditions in March 2023, when the second TBM has completed its stationary period
- Cumulative drawdown considering the Mitigated base case in December 2024 (above) plus the long-term drawdown predicted by JHCPB Joint Venture (2021) due to the Rozelle Interchange Project

It is important to note that potential cumulative drawdown, due to Project works and surrounding projects such as the Rozelle Interchange and Western Harbour Tunnel Projects, could be greater than the drawdowns predicted for the Project works alone. This has significant implications for potential settlement impacts, with those other projects causing greater potential impact than the Project works alone. Information on other projects is insufficient to assess the cumulative drawdown due to them and the Project works with confidence.

The information has been requested in the RFI's listed in Table 7-1.

TABLE 7-1: LIST OF RFI'S RELATING TO GROUNDWATER INFORMATION FOR ROZELLE INTERCHANGE AND WESTERN HARBOUR TUNNEL PROJECTS

i2CX Reference	SM RFI Reference #	Title
DRFI#0009	SMWSTCTP-AFJ-DRFI-000038	Hydrogeology - Groundwater Monitoring Data
DRFI#0006	SMWSTCTP-AFJ-DRFI-000035	Hydrogeology. Groundwater Monitoring Data from surrounding Projects
DRFI#0011	SMWSTCTP-AFJ-DRFI-000044 SMWSTCTP-AFJ-DRFI-000101 - Follow up SM	Hydrogeology. Information for WHT and Rozelle Interchange projects
DRFI#0023	SMWSTCTP-AFJ-DRFI-000077	Hydrogeology - Groundwater Monitoring Data

8. CONSTRUCTION PHASE MONITORING

Table 8-1 lists proposed groundwater level monitoring locations during construction phase, and Table 8-2 lists the existing groundwater levels based on available monitoring data and trigger thresholds based on the watertable drawdown predicted for the Mitigated base case scenario.

The locations have been selected based on consideration of predicted groundwater level drawdown (for the Mitigated base case scenario) and the locations of assets sensitive to ground settlement, potential groundwater quality-related issues, and monitoring of potential cumulative groundwater level drawdown due to Project works and the Rozelle Interchange Project. Proposed locations have not checked for access or services conflicts.

It is assumed that the existing piezometers listed are accessible and in suitable working order. Note that Sydney Metro has not confirmed which piezometers are operable/decommissioned/destroyed (with the exception of the SMW_BH700 series) – refer to RFI's listed in Table 7-1. In the event that the existing piezometers listed are inaccessible or destroyed, alternative monitoring locations will need to be constructed.

It should also be noted that existing piezometers and open boreholes that would be intersected by the TBM could act as a conduit for groundwater flow into the tunnel excavation. Existing piezometers, open boreholes, or any other in-ground structure that could act as a conduit for groundwater flow into the tunnel excavation, should be grouted prior to TBM mining.

Note that pre-excavation groundwater level monitoring will be required at new monitoring locations to obtain baseline data.

In addition, monitoring of construction groundwater inflow and its water quality should be undertaken.

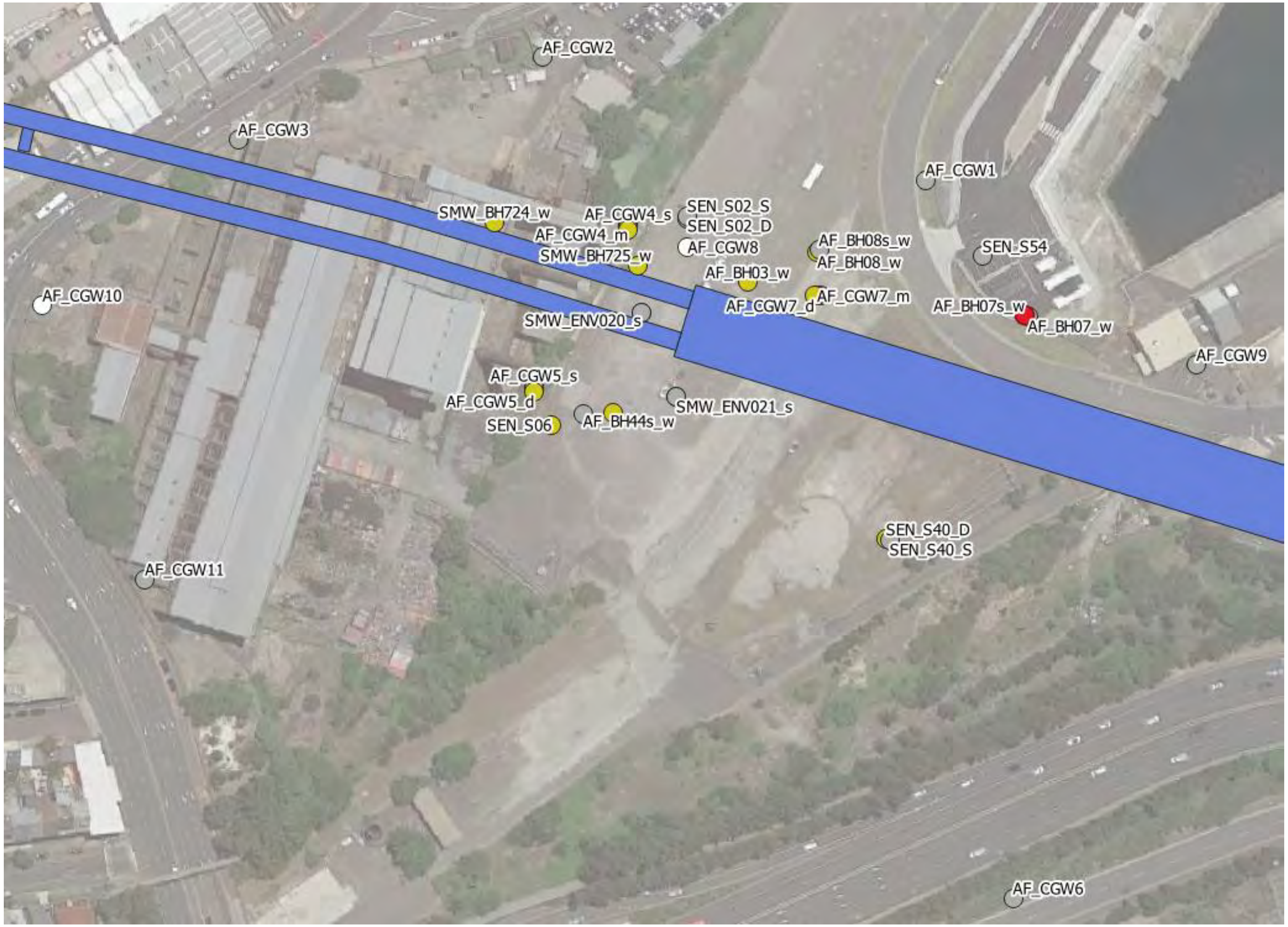


FIGURE 8-1: PROPOSED CONSTRUCTION GROUNDWATER MONITORING LOCATIONS (GREY IN ALLUVIUM, YELLOW IN SANDSTONE, RED IN DYKE, WHITE FOR VWP IN MULTIPLE UNITS)

TABLE 8-1: PROPOSED GROUNDWATER LEVEL MONITORING LOCATIONS DURING CONSTRUCTION PHASE

Location ID	Piezometer / VWP	Existing/ proposed monitoring location	Easting	Northing	Ground surface (m AHD)	Total borehole depth (m bgl)	Depth to monitoring horizon (top) (mbgl)
AF_BH03_w	Piezometer	Existing	331479.5	6251133	5.25	40.15	31
AF_BH07_w	Piezometer	Existing	331569.5	6251123	3.5	7.7	1.96
AF_BH07s_w	Piezometer	Existing	331568.6	6251123	3.46	35	26
AF_BH08_w	Piezometer	Existing	331501.9	6251143	3.45	25.22	22.1
AF_BH08s_w	Piezometer	Existing	331502.4	6251144	3.48	8	2
AF_BH44_w	Piezometer	Existing	331436.3	6251092	3.13	45	37
AF_BH44s_w	Piezometer	Existing	331426.7	6251091	3.13	11	6
AF_CGW1	Piezometer	Proposed	331536.6	6251166	~4	10	TBC
AF_CGW2	Piezometer	Proposed	331413.7	6251206	~3	10	TBC
AF_CGW3	Piezometer	Proposed	331315.9	6251179	~3	Up to 10	TBC
AF_CGW4_s	Piezometer	Proposed	331441.1	6251152	~3	10	3
AF_CGW4_m	Piezometer	Proposed	331441.1	6251151	~3	18	10
AF_CGW4_d	Piezometer	Proposed	331441.1	6251150	~3	32	26
AF_CGW5_s	Piezometer	Proposed	331410.9	6251100	~3	10	3
AF_CGW5_m	Piezometer	Proposed	331410.9	6251099	~3	18	10
AF_CGW5_d	Piezometer	Proposed	331410.9	6251098	~3	32	26
AF_CGW6	Piezometer	Proposed	331564.7	6250936	~4	10	TBC

Location ID	Piezometer / VWP	Existing/ proposed monitoring location	Easting	Northing	Ground surface (m AHD)	Total borehole depth (m bgl)	Depth to monitoring horizon (top) (mbgl)
AF_CGW7_s	Piezometer	Proposed	331502.8	6251129	~3	10	3
AF_CGW7_m	Piezometer	Proposed	331501.8	6251129	~3	18	10
AF_CGW7_d	Piezometer	Proposed	331500.8	6251129	~3	32	26
AF_CGW8	VWP	Proposed	331460.3	6251145	~3	32	VWP sensors in shallow alluvium, deep alluvium, shallow sandstone, and deep sandstone
AF_CGW9	Piezometer	Proposed	331623.6	6251107	~3	10	TBC
AF_CGW10	VWP	Proposed	331253.1	6251126	~7	10	TBC. VWP sensors in shallow alluvium, deep alluvium, shallow sandstone, and deep sandstone
AF_CGW11	Piezometer	Proposed	331286	6251038	~8	10	TBC
SEN_S02_D	Piezometer	Existing	331460.2	6251154	3.11	15.1	11
SEN_S02_S	Piezometer	Existing	331460.1	6251155	3.11	6.2	0.7
SEN_S06	Piezometer	Existing	331416.5	6251088	3.13	20.44	13.5
SEN_S40_D	Piezometer	Existing	331523.9	6251051	3.68	15.2	8.7
SEN_S40_S	Piezometer	Existing	331525.1	6251051	3.6	8	0.5
SEN_S54	Piezometer	Existing	331554.9	6251142	3.59	17.5	12
SMW_BH724_w	Piezometer	Existing	331398.3	6251153	2.12	29.4	19.4

Location ID	Piezometer / VWP	Existing/ proposed monitoring location	Easting	Northing	Ground surface (m AHD)	Total borehole depth (m bgl)	Depth to monitoring horizon (top) (mbgl)
SMW_BH725_w	Piezometer	Existing	331444.2	6251139	2.93	30.05	20
SMW_ENV020_s	Piezometer	Existing	331445.3	6251124	2.94	18.2	2
SMW_ENV020_w	Piezometer	Existing	331445.3	6251124	2.94	18.2	8.4
SMW_ENV021_s	Piezometer	Existing	331456.6	6251097	3.09	14.4	2
SMW_ENV021_w	Piezometer	Existing	331456.6	6251097	3.09	14.4	9.4

Table 8-2: Available recorded groundwater levels and proposed monitoring level thresholds for construction phase

Location ID	Typical pre-construction groundwater level (mbgl)	Lowest pre-construction groundwater level (mbgl)	Predicted drawdown (mitigated basecase scenario in Dec 2024) (m)	Threshold groundwater level (mbgl)	Comment
AF_BH03_w	1.7	Insufficient data	7	8.7	
AF_BH07_w	Insufficient data	Insufficient data	3.5	Insufficient data	
AF_BH07s_w	Insufficient data	Insufficient data	4.8	Insufficient data	
AF_BH08_w	2.2	Insufficient data	4.6	Insufficient data	

AF_BH08s_w	Insufficient data	Insufficient data	3.9	Insufficient data	
AF_BH44_w	No data	No data	3.6	Insufficient data	
AF_BH44s_w	No data	No data	3.8	Insufficient data	
AF_CGW1	No data	No data	3	Insufficient data	
AF_CGW2	No data	No data	3	Insufficient data	
AF_CGW3	No data	No data	2.6	Insufficient data	
AF_CGW4_s	No data	No data	3.7	Insufficient data	
AF_CGW4_m	No data	No data	3.7	Insufficient data	
AF_CGW4_d	No data	No data	4	Insufficient data	
AF_CGW5_s	No data	No data	3.9	Insufficient data	
AF_CGW5_m	No data	No data	3.9	Insufficient data	
AF_CGW5_d	No data	No data	4	Insufficient data	
AF_CGW6	No data	No data	1.5	Insufficient data	
AF_CGW7_s	No data	No data	4.5	Insufficient data	
AF_CGW7_m	No data	No data	4.5	Insufficient data	
AF_CGW7_d	No data	No data	4.5	Insufficient data	
AF_CGW8	No data	No data	4.5, 4.5, 5.5, 7	Insufficient data	
AF_CGW9	No data	No data	2.5	Insufficient data	
AF_CGW10	No data	No data	7 (cumulative with RIC project)	Insufficient data	

AF_CGW11	No data	No data	6 (cumulative with RIC project)	Insufficient data	
SEN_S02_D	2.2	Insufficient data	3.7	5.9	May be destroyed by haul road
SEN_S02_S	2.17	Insufficient data	3.7	5.9	
SEN_S06	2.2	Insufficient data	4	6.2	
SEN_S40_D	3.5	Insufficient data	6.6	10.1	
SEN_S40_S	2.1	Insufficient data	6.2	8.3	
SEN_S54	3.1	Insufficient data	3	6.1	
SMW_BH724_w	1.1	-0.4	3.3	4.4	Likely to require grouting prior to tunnelling Impact from White Bay Power Station surface grouting likely
SMW_BH725_w	1.9	0.4	4.6	6.5	Likely to require grouting prior to tunnelling Impact from White Bay Power Station surface grouting likely
SMW_ENV020_s	Insufficient data	Insufficient data	4.2	Insufficient data	Likely to require grouting prior to tunnelling
SMW_ENV020_w	2.0	Insufficient data	4.2	6.2	Likely to require grouting prior to tunnelling Impact from tunnelling and grouting likely
SMW_ENV021_s	2.2	Insufficient data	4.2	6.4	
SMW_ENV021_w	Insufficient data	Insufficient data	4.2	Insufficient data	Impact from grouting possible

Note: No data/insufficient data means pre-construction groundwater level monitoring is requires to obtain baseline data.

9. SUMMARY

9.1 DESIGN GROUNDWATER LEVELS

The SLS design groundwater level for The Bays Station is equal to ground surface level.

The ULS design groundwater level for The Bays Station is equal to ground surface level.

Note that these design groundwater levels do not include hydrostatic pressure loading due to surface waters (e.g., due to flooding).

The minimum predicted groundwater level around the station box during Project works ranges between 4 m and 14 m. Adopting a typical watertable level of 2 mbgl, this equates to a minimum watertable level of between 6 mbgl and 16 mbgl.

9.2 GROUNDWATER INFLOWS

The Particular Specification requires that groundwater inflows to the station box excavation are limited to:

- 50,000 litres in any 24-hour period (0.58 L/s), measured over any square with an area of 10 m², at any and all locations within the sides and bases of the excavation [Particular Specification SM-W-CTP-PS-1040]
- 445,000 litres in a 24-hour period [Particular Specification SM-W-CTP-PS-104] (5.15 L/s)

The first criterion above relates to small water-bearing features that yield significant inflows over a relatively small area of excavation face. Such features, if encountered, would be grouted during excavation, to reduce the inflows to acceptable limits.

The second criterion above relates to inflows to the entire station box. Three-dimensional numerical modelling of the station box excavation indicates that the proposed grouting design for the station box is likely to meet the inflow criterion if the grout curtain around the station box achieves 1 Lugeon permeability for the grouted rock.

The grout curtain will act as a mitigation measure to reduce groundwater inflows to the station box. Combined with localised grouting of significant water-bearing features during excavation, as required, these mitigation measures will help to reduce groundwater inflows to the station box in order to meet the requirements of the Particular Specification.

Note that the predicted inflows to the station box assumed that there is no groundwater seepage through the secant piled wall, and that the grout curtain meets the permeability criteria noted in this report. In addition, it is possible that geological features in the floor of the station box excavation could act as conduits for groundwater flow, including both unidentified features and identified features such as the Great Sydney Dyke. This could lead to greater inflows to the station box than predicted in this report. If such features were encountered, mitigation measures to reduce inflows would include localised grouting of these features from within the excavation.

Tunnelling to the west of the station box also has the potential to impact inflows to the station box. If the rock mass within the palaeochannel has a high permeability (80 Lugeons) and the TBM encounters significant water-bearing features that have not been grouted, inflows to the station box could exceed to inflow criterion.

For the fully mitigated scenario (Mitigated station box (1 Lugeon) and mitigated WBPS), the predicted inflows to a single tube tunnel are typically 0.2 L/s in the grouted zone between WBPS and the station box, increasing to up to 1.5 L/s outside the mitigated zone (i.e., to the west of the grouted zone at WBPS).

For the unmitigated WBPS scenario (Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling), the predicted inflows to a single tube tunnel are up to approximately 1.5 L/s. This increases to up to 2.4 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 20 Lugeons), and to 4.5 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 80 Lugeons).

As there is a potential risk that the TBM will encounter water-beating features during mining, grouting of the rock mass in the vicinity of WBPS is recommended. Grouting of the rock mass in the vicinity of WBPS will serve as an additional mitigation measure, reducing inflows to the TBMs and associated groundwater level drawdown.

9.3 GROUNDWATER LEVEL DRAWDOWN

For the fully mitigated scenario (base case with permeability of rock mass in the palaeochannel equal to 20 Lugeons, with the grout curtain at the station box to 1 Lugeon, and rock in the vicinity of WBPS grouted as noted above), watertable drawdown of between 1 m and 4 m is generally predicted around the majority of the palaeochannel (where alluvium is present). At the eastern end of the station box, where alluvium pinches out and is not present, predicted watertable drawdown is in the rock and is greater than elsewhere at the site due to the relatively lower permeability of the sandstone.

Drawdown of the watertable is predicted to extend up to some 400 m distance from the station box in December 2024. At most distant locations, and at the eastern end of the station box, this drawdown is likely to be experienced in the fill and/or sandstone only.

The results suggest that, if the rock is not grouted in the vicinity of the tunnels at WBPS, the TBMs encountering significant water-bearing features (such as dilated bedding planes) would likely cause additional drawdown in the vicinity of WBPS relative to the mitigated (grouted case). As there is a potential risk that the TBM will encounter water-beating features during mining, grouting of the rock mass in the vicinity of WBPS is therefore recommended to reduce drawdown and associated ground settlement.

WBPS is sensitive to ground settlement, a significant component of which is induced by groundwater level drawdown (refer to the Settlement Assessment Report). Since it is differential settlement that causes damage to structures, greater differential drawdown (or a greater hydraulic gradient) is of more significance for settlement impacts. Lower hydraulic gradients are therefore more favourable. It should also be noted that ground conditions in the palaeochannel are variable, and this will also lead to greater differential settlement.

The predicted watertable drawdown is between approximately 2 m and 4 m for the unmitigated case (where rock is not grouted at WBPS and the grout curtain is present at the station box). This reduces to between approximately 2 m and 3 m for the fully mitigated base case, and the hydraulic gradient across the WBPS is reduced.

If the sandstone is more permeable than adopted in the base case, particularly in the vertical direction, it is possible that watertable drawdown of up to 6 m could occur in the vicinity of WBPS. This is considered as the “Upper Bound (pessimistic)” scenario in the Settlement Assessment. This would occur at the end of the period in which the second/southern tunnel/downline TBM is lying stationary under the WBPS (March 2024). In addition, the results suggests that, should the TBM encounter water-bearing features, drawdown in the vicinity of WBPS could be greater during TBM mining.

For these reasons, grouting of the rock mass in the vicinity of WBPS is recommended. Note that this is for the TBM mining operations, and is not a requirement for the Project Works (for the station). If predicted settlement for the mitigated case remains unacceptable, additional mitigation measures will be required.

Drawdown is predicted in the vicinity of the WestConnex Rozelle Interchange and Western Harbour Tunnel Enabling Works (RIC) project.

Based on groundwater modelling completed by JHCPB Joint Venture (2021a) for the WestConnex Rozelle Interchange and Western Harbour Tunnel Enabling Works (RIC) project, cumulative drawdown due to the Project works and RIC project is expected. Drawdown of the watertable between the western end of the station box and the White Bay Power Station of up to 6 m is predicted. Drawdown due to the Western Harbour Tunnel (WHT) project would be additional to this. Information on the WHT design and construction project is not available and this additional drawdown cannot therefore be estimated.

There is significant uncertainty in the potential cumulative impact of surrounding projects on groundwater at The Bays Station site because:

- Design and construction details for the RIC and WHT project are not available (RFI's SMWSTCTP-AFJ-DRFI-000038, SMWSTCTP-AFJ-DRFI-000035, SMWSTCTP-AFJ-DRFI-000044 and SMWSTCTP-AFJ-DRFI-000101)
- The status of excavation and the existing groundwater level drawdown due to other projects, including those from the RIC and WHT projects, are unknown. To date, JTJV has been provided a single monitoring report for the RIC project (JHCPB Joint Venture, 2021b) which only covers a three month monitoring period. Since groundwater level records for the period prior to this, including pre-construction of the RIC project, are not available; it is not possible to assess the groundwater level drawdown due to the project
- The drawdown estimates provided above are based on predictive modelling for the RIC project only, and have not been validated by construction monitoring data
- It is possible that additional drawdown from the WHT project would also extend into The Bays Station site during construction of the WHT project. It is therefore possible that the cumulative drawdown presented above may underestimated potential cumulative drawdown at The Bays Station site.

9.4 GROUNDWATER IMPACTS

The estimated groundwater drawdowns associated with inflows indicate that:

- There are no groundwater users or groundwater dependent ecosystems within the predicted zone of watertable drawdown. Groundwater users or groundwater dependent ecosystems will therefore not be affected by the Project works
- There is potential for drawdown of the watertable due to the Project works to activate (potential) acid sulfate soils at the site. This has the potential to increase the aggressivity of groundwater, potentially impacting in-ground (concrete and steel) structures; and release of contaminants from soils (e.g., bound heavy metals), impacting groundwater quality.

Preliminary indicative assessment suggests that approximately 10% of soils at The Bays Station site appear to be at risk of falling below a pH of 3.5 following dewatering. Note that the durability design considers a groundwater pH no lower than 3.5.

This assessment is based on limited data collected during various sporadic environmental investigations at the site. The available data are insufficient to support comprehensive assessment of impact to (P)ASS and the development of an Acid Sulfate Soils Management Plan (ASSMP). Additional site investigation will be required to develop an ASSMP. Should greater confidence in the assessed reduction in pH due to oxidation of (P)ASS be required, incubation of soils collected from the site in a laboratory environment, with monitoring of soil pH following multiple wetting and drying cycles, is recommended to provide improved estimates of the potential end-point pH of soils due to dewatering. The potential impacts listed above should be considered in the ASSMP.

- The migration of contaminated groundwater into the station box presents a risk that should be considered during development of a Construction Environmental Management Plan (CEMP) and a Groundwater Management Plan (GMP) for the site works, including protection of workers and potential treatment of groundwater seepage prior to discharge
- Groundwater within close proximity to the station box is clearly affected by interaction with the waters of White Bay, and it is likely that this zone will become further affected by saline intrusion during Project works. Groundwater modelling predicts saline intrusion towards the station box, with

seawater-level salinity reaching the northern wall of the station box during the Project works. This has been considered in the durability design.

9.5 LIMITATIONS

There are a number of limitations in the assessment, including:

- The 3D numerical groundwater model has not been calibrated to transient conditions because there are insufficient stresses/transient responses in the modelled groundwater system to allow meaningful transient calibration. Groundwater level and inflow monitoring data from the RIC project may permit transient calibration of the model
- The acid sulfate soils assessment is based on limited data collected during various sporadic environmental investigations at the site. The available data are insufficient to support comprehensive assessment of impact to (P)ASS and the development of an Acid Sulfate Soils Management Plan (ASSMP). Additional site investigation will be required to develop an ASSMP. The potential impacts due to activation of (P)ASS listed above will be need to be considered in the ASSMP
- Groundwater monitoring data for the RIC or WHT projects are not available. There is therefore significant uncertainty related to estimated cumulative groundwater drawdown
- There is some uncertainty in hydrogeological parameter values. In particular, the vertical permeability of the alluvium and sandstone. For this reason, uncertainty analysis has been undertaken to cover a range of potential conditions. However, ground conditions can vary over short distances; and the interpretation of ground conditions, and resulting assessment outcomes, are based on the available data only. In addition, as noted above, numerous assumptions have been made regarding the modelling undertaken

10. RECOMMENDATIONS

To reduce the uncertainty in this assessment, the following is recommended:

- To assess potential cumulative groundwater level drawdown impacts with greater confidence, provision of information on the RIC and WHT projects. To date, JTJV has been provided a single monitoring report for the RIC project (JHCPB Joint Venture, 2021b) which covers only a three month monitoring period. To assess cumulative drawdown with confidence, design and construction details for these projects, the status and excavation programmes for these projects, and groundwater monitoring data (levels and quality) for these projects from pre-construction to the present are required
- Potential additional groundwater modelling for The Bays Station site based on the drawdown information for other projects
- Assessment of the potential contaminant migration in groundwater indicates that it is possible that contaminated groundwater will enter the station box excavation during the Project works. The migration of contaminated groundwater into the station box presents a risk that should be considered during development of a Construction Environmental Management Plan (CEMP) and a Groundwater Management Plan (GMP) for the site works, including protection of workers and potential treatment of groundwater seepage prior to discharge
- Additional acid sulfate soils investigations at the site to support comprehensive assessment of impact to (P)ASS and the development of an Acid Sulfate Soils Management Plan (ASSMP)
- Dissolved iron concentrations in groundwater within the sandstone are relatively high. It is possible that groundwater seepage to the excavation may be prone to production of biofilms/sludge. Station excavation pumping and groundwater treatment systems should consider the potential for the development of biofilms/sludge

- To improve confidence in the modelling predictions, transient calibration of the 3D numerical groundwater model using groundwater inflow and level monitoring data (if available) from the RIC project. Should the transient calibration lead to different model parameterization to that adopted in this assessment, revised predictive groundwater modelling will be required
- The lateral extent of water-bearing features (such as dilated bedding planes) at the site is unknown. It is not known whether they extend to the west of WBPS. Additional site investigation around WBPS is proposed to explore this

11. REFERENCES

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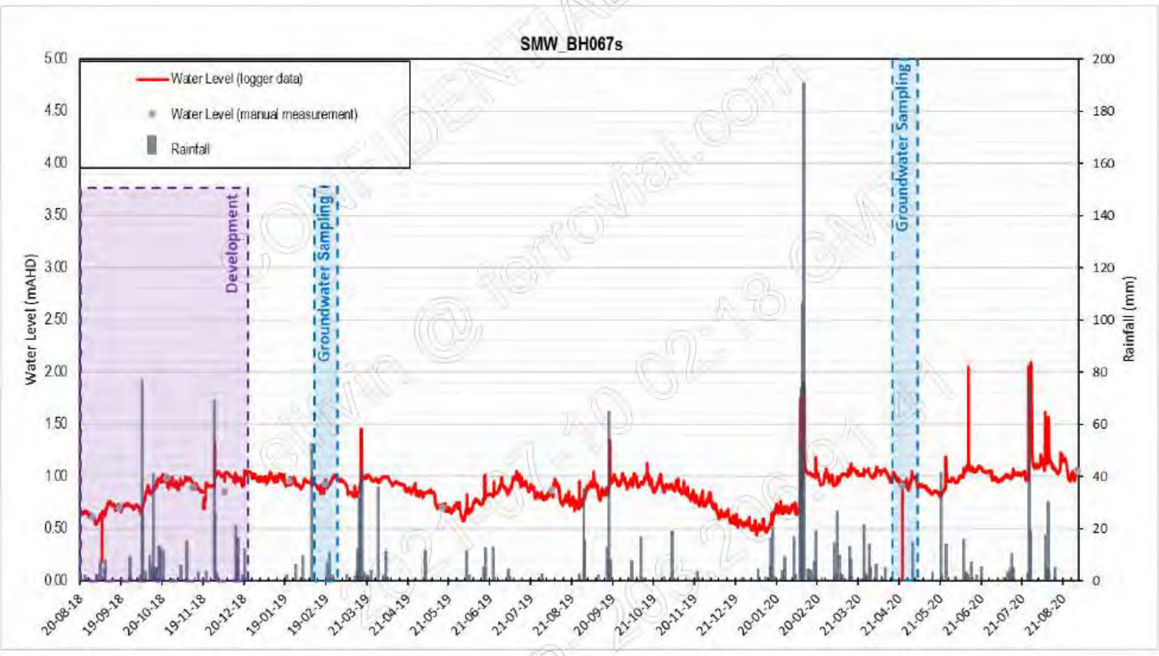
ANNEXES

ANNEXURE A: HYDROGRAPHS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Water Level (logger data)
Water Level (manual measurement)
Rainfall
Development
Groundwater Sampling
Groundwater Sampling
Water Level (mAHD)
Rainfall (mm)
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4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
200
180
160
140
120
100
80
60
40
20
0
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19-09-18
20-10-18
19-11-18
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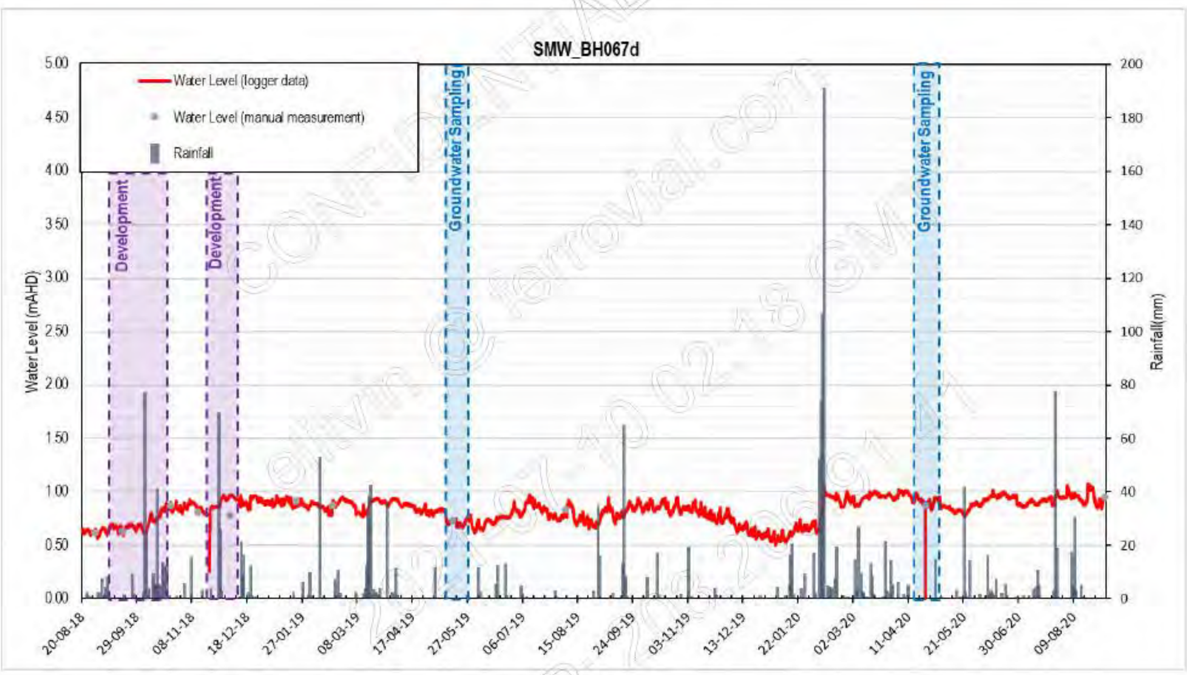
SMW_BH067d
Water Level (logger data)
Water Level (manual measurement)
Rainfall
Development
Development
Groundwater Sampling
Groundwater Sampling
Water Level (mAHD)
Rainfall(mm)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
200
180
160
140
120
100
80
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40
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0
20-08-18
29-09-18
08-11-18
18-12-18
27-01-19
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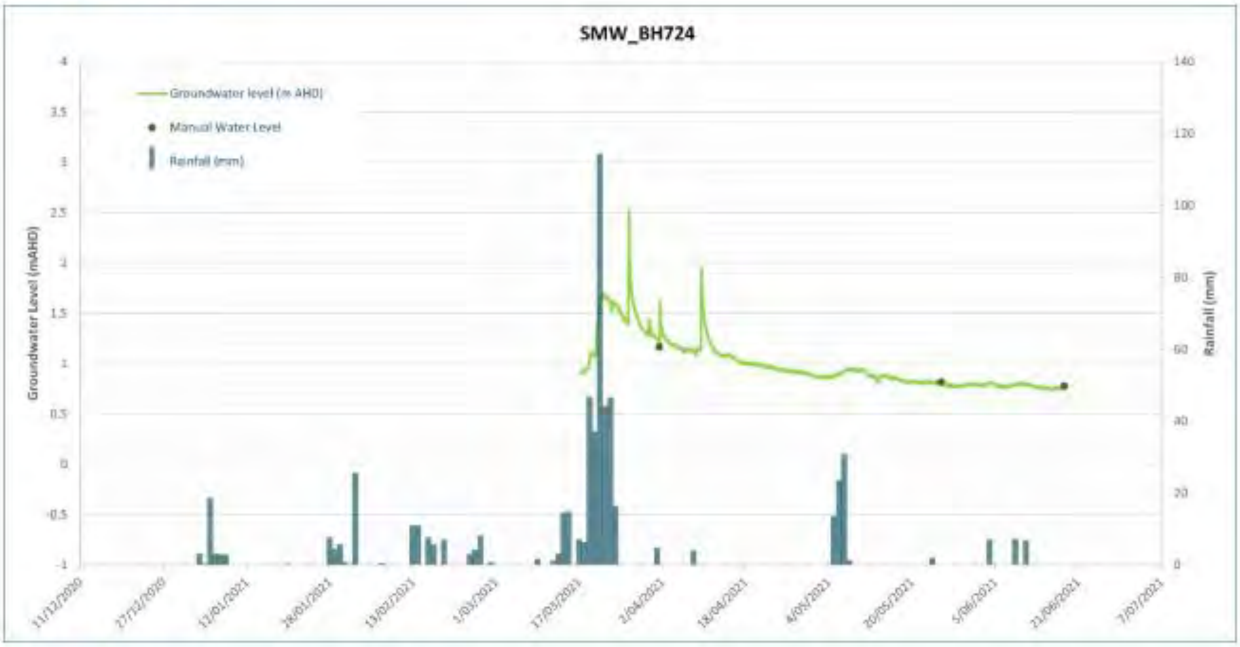
SMW_BH724



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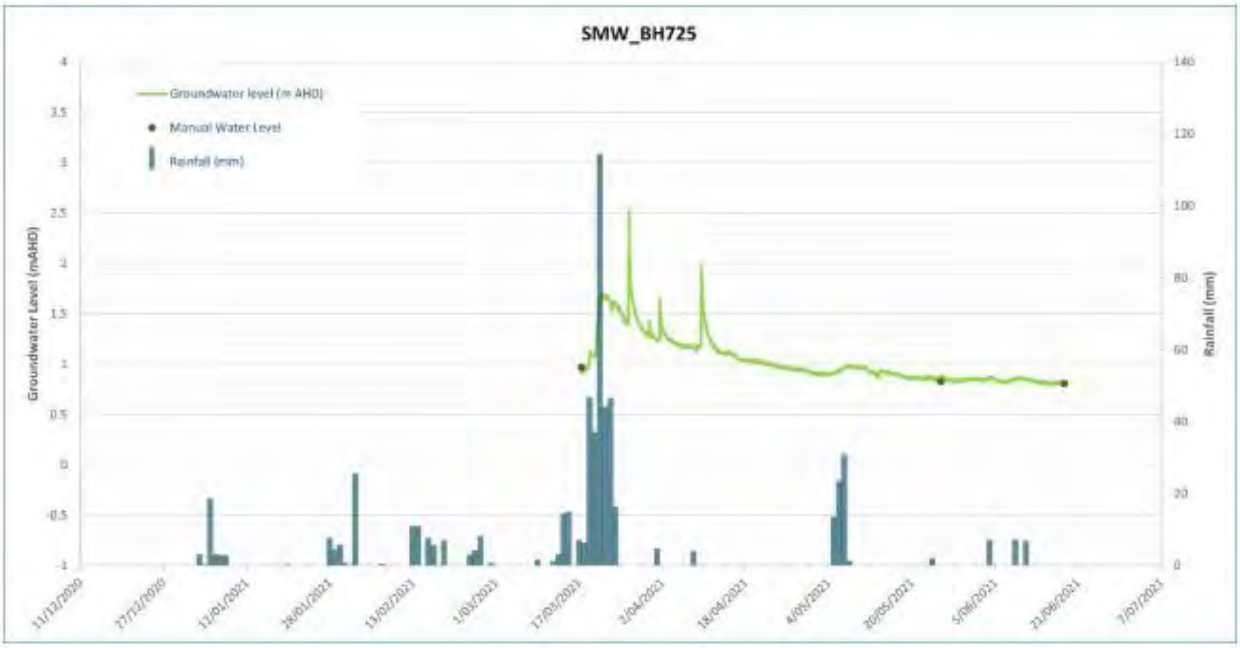

ANNEXURE B: PUMP OUT TESTS

Technical Memo

		Date 24 November 2021
		Document ID SMWSTCTP-AFJ-TBY-SN200-ST-RPT-003000 Appendix-G[C] - Annexure B
From	[redacted]	**Revision** A
Subject	The Bays Station - Groundwater Pump Out Test Analysis	

1. Introduction

This memorandum summarises groundwater pump out tests completed at The Bays Station in October 2021. Douglas Partners were commissioned by Acciona Ferrovial JV to undertake the pump out tests. The test data was analysed and interpretated by Jacobs Typsa JV.

The pump out tests were designed to increase understanding of groundwater flow conditions in the vicinity of the Bays Station, particularly with regards to the continuity of secondary porosity (groundwater flow through bedding planes and fractures) features, and potential groundwater system boundaries.

Noteworthy limitations of the pump out tests include relatively short pumping durations, relatively low pumping rates and generally small associated drawdowns. A higher yield and relatively longer pumping duration could potentially address these limitations.

In spite of the limitations, some insight into the groundwater system behaviour is possible based on the completed testing and analysis.

2. Method

2.1. Pump out test method

Pump out tests were completed in the following open boreholes (Figure 2-1):

- AF_BH02i
- AF_BH03_w and AF_BH04 (separate pump out tests, although some timing overlap)
- AF_BH05i and AF_BH06 (separate pump out tests completed approximately concurrently)

It is noted that AF_BH03_w was completed as a standpipe piezometer. However, at the time of the pump out tests, AF_BH03_w was an open borehole.

Pumping duration ranged from approximately 3.8 to 4.6 hours, with recovery measured overnight. Groundwater level measurements were made by data logger (intervals ranging from 1 second to 5 minutes), supplemented by manual dip measurements. Groundwater level measurements were made in the pumped boreholes and three non-pumped standpipe piezometers, during pumping and recovery.

A summary of the pumped open boreholes is provided in Table 1, including surface elevation, dip and azimuth, open interval in datum of mbgl and mAHD, pump out duration and average pump out test flow rate. It is noted that the open boreholes were cased from ground surface to top of rock, or slightly below top of rock, with the interval below open.

Pumping rates were generally relatively constant and similar to the average flow rate shown in Table 1, except at AF_BH05i, where the pumping rate was variable and ranged from 5.2 L/min to 16.1 L/min; and at BH04, whose average rate changed from 4.2 L/min to 2 L/min about halfway through the pumping interval due to a pump faulting.

Groundwater level measurements were made in the following non-pumped observation piezometers, AF_BH08_w (screened in sandstone), SEN_S02_D (screened in silty sand alluvium) and SEN_S06 (screened in sandstone). Summary details for these observation piezometers are provided in Table 2 and locations are shown in Figure 2-1.

Borehole logs and standpipe piezometer construction logs are provided for the pumped open boreholes and the observation piezometers in Appendix A.

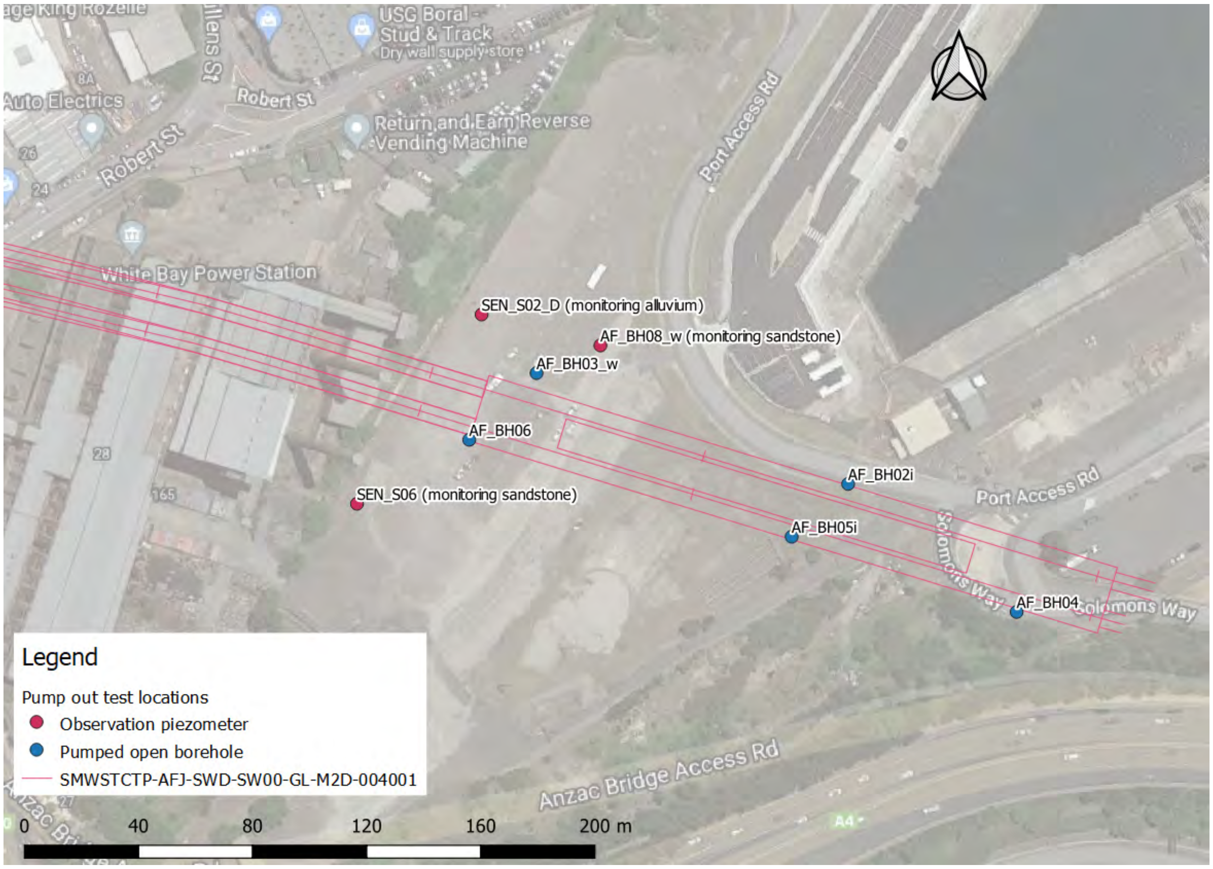

Figure 2-1 Location of pumped open boreholes and observation piezometers

TABLE 1 SUMMARY OF PUMPED OPEN BOREHOLES

Pumped borehole	Surface elevation (mAHD)	Applicable pump out interval and material	Pump out duration (hrs)	Average pump out flow rate (L/min)
Borehole AF_BH02i	3.52	• Inclined borehole • 60° dip, azi 285° TN • Cased from ground surface to top of rock, open from top of rock (12.58 m down hole depth) to total depth of 45.20 m (down hole). • True vertical depth open hole interval: 10.89 to 39.14 mbgl • Open hole interval: -7.37 to -35.62 mAHD • Open hole interval material: sandstone	3.8	18.1
AF_BH03_w	5.25	• Vertical • Cased from ground surface to 18.5 mbgl • Open from 18.5 mbgl to 40.15 mbgl (total borehole depth) • Open from -13.25 to -34.9 mAHD • Open hole interval material: sandstone	3.9	13.9
Borehole AF_BH04	3.89	• Vertical • Cased from ground surface to 1.45 mbgl • Open from 1.45 mbgl to 40.11 mbgl (total borehole depth) • Open from 2.44 to -36.22 mAHD • Open hole interval material: sandstone	3.8	3.6
Borehole AF_BH05i	2.95	• Inclined borehole • 62° dip, azi 277° TN • Cased from ground surface to 0.6 m below to top of rock. Open from 9.1 m (down hole depth) to total depth of 50.25 m (down hole depth). • True vertical depth open hole interval: 8.03 to 44.37 mbgl • Open hole interval: --5.08 to -41.42 mAHD • Open hole interval material – sandstone	4.6	8.8
Borehole AF_BH06	2.95	• Vertical • Cased from ground surface to 15.56 mbgl • Open from 15.56 mbgl to 40.40 mbgl (total borehole depth) • Open from -12.61 to -37.45 mAHD • Open hole interval material: sandstone	4.0	21.9

TABLE 2 SUMMARY OF OBSERVATION STANDPIPE PIEZOMETERS MONITORED DURING PUMP OUT TESTS

Observation standpipe piezometer	Surface elevation (mAHD)	Applicable monitoring interval details
SEN_S02_D	3.11	• Vertical standpipe piezometer • Gravel packed from 11.00 to 15.10 mbgl • Gravel packed from -7.89 to -11.99 mAHD • Gravel pack interval material: silty sand alluvium
SEN_S06	3.13	• Vertical standpipe piezometer • Gravel packed from 13.50 to 20.44 mbgl • Gravel packed from -10.37 to -17.31 mAHD • Gravel pack interval material: sandstone
AF_BH08_w	3.45	• Vertical standpipe piezometer • Gravel packed from 22.10 to 28.10 mbgl • Gravel packed from -18.65 to -24.65 mAHD • Gravel pack interval material: sandstone

2.2. Analysis method

Groundwater level measurements made by data logger were compensated to account for barometric pressure, reduced to the datum of mAHD, and plotted along with manual dip groundwater level measurements and pumping rates. The plots are provided in Appendix B.

Groundwater level drawdown was analysed in AQTESOLV, groundwater pumping test analysis software, as summarised in Table 3. In addition, the trends of the first and second derivatives of drawdown observed at observation piezometer, AF_BH08_w; during pumping at BH02i and BH03_w; and the concurrent pumping at BH05i and BH06, were analysed. Derivative analysis was completed as derivative trends can reveal groundwater system characteristics.

TABLE 3 PUMP OUT TEST ANALYSIS SUMMARY

Pumped borehole	Analysis method	Assumed aquifer thickness (m) value	Comment
Borehole AF_BH02i	Theis (recovery) on the pumped well	28.25 m Open borehole. Top of rock level is -7.37 mAHD. Bottom of borehole is -35.62 mAHD. Therefore, the open hole interval is 28.25 m thick, vertically (borehole dip is 60°).	No concurrent pumping, so no potential for interference from another pump out test. Theis confined aquifer analysis conducted as it is a classical, relatively simple and common analysis method. However, it is noted that of the numerous Theis assumptions, such as radial flow, a homogeneous and isotropic aquifer with infinite areal extent, there is likely to be deviation from these assumptions at the site. Moench analysis also conducted as this solution is appropriate for fractured rock dual porosity groundwater systems, which provides a closer representation of how groundwater flow behaviour at the site has been conceptualised.
	Moench (recovery) on the pumped well		
	Theis (on AF_BH08_w drawdown)		
	Moench (on AF_BH08_w drawdown)		
Borehole AF_BH03_w	Theis (on AF_BH08_w drawdown)	21.95 m Open borehole, vertical. Total borehole depth of 40.15 m less top of sandstone at 18.20 mbgl equals 21.95 m.	Recovery in AF_BH03_w (and observation piezometer AF_BH08_w) impacted by pumping in AF_BH04. As a result, the drawdown at AF_BH08_w during pumping has been analysed as opposed to recovery. Theis and Moench analysis conducted for same reasons as noted for AF_BH02i.
	Moench (on AF_BH08_w drawdown)		
Borehole AF_BH04	Theis (recovery) on the pumped well	36.93 m Open borehole, vertical. Borehole depth of 40.11 m minus equalised standing water level of 3.18 mbgl = 36.93 m. The equilibrium standing water level of 3.18 mbgl resides in sandstone (top of rock is 0.33 mbgl).	Pumping on same day in AF_BH03_w impacted drawdown. Groundwater levels at observation piezometer AF_BH08_w fall before pumping starts in BH04. As a result, the recovery trend of the pumping well has been analysed as there is less potential for interference from pumping at BH03_w. Theis and Moench analysis conducted for same reasons as noted for AF_BH02i.
	Moench (recovery) on the pumped well		
Borehole AF_BH06	Theis (recovery) on the pumped well	24.9 m Open borehole, vertical. Total borehole depth of 40.40 m less top of sandstone at 15.5 mbgl equals 24.9 m.	Potential inference from concurrent pumping at BH05i. Analysis assumes no concurrent pumping in BH05i. AF_BH06 is closer to observation piezometer AF_BH08_w, the piezometer that experienced significant drawdown, compared to BH05i. Analysis conducted to enable comparison to a subsequent analysis which represents the concurrent pumping in BH05i and BH06. Theis and Moench analysis solutions adopted for same reasons as noted for AF_BH02i.
	Moench (recovery) on the pumped well		
	Theis (on AF_BH08_w drawdown)		
	Moench (on AF_BH08_w drawdown)		
Boreholes AF_BH05i and AF_BH06, concurrent pumping	Theis (on AF_BH08_w drawdown)	24.9 m Adopted aquifer thickness of 24.9m, which was also adopted for AF_BH06. Reason for adopting this is because BH06 is closer to the observation piezometer that experienced significant drawdown, BH08_w, compared to the other pumping borehole, BH05i.	Potential for drawdown to have occurred at observation piezometer, AF_BH08_w, due to concurrent pumping at BH05i and BH06. Analysis assumes concurrent pumping at BH05i and BH06. Analysis conducted to enable comparison to analysis of pumping at BH06 which assumed no concurrent pumping at BH05i. Theis and Moench analysis solutions adopted for same reasons as noted for AF_BH02i.
	Moench (on AF_BH08_w drawdown)		

3. Results

Groundwater level drawdown was evident in each borehole that was pumped, and during all pump out tests, in observation piezometer AF_BH08_w. Groundwater level drawdown was not observed in the other observation piezometers, SEN_S02_D and SEN_S06, likely due to the limited pumping durations, relatively low pumping rates and subsequent limited depressurisation.

Observation piezometer AF_BH08_w is offset from pumped locations, AF_BH02i, AF_BH03_w, AF_BH04, AF_BH05i and AF_BH06 by 100 m, 25 m, 170 m, 95 m and 30 m, respectively.

A plot of the first and second derivatives of drawdown observed at observation piezometer AF_BH08_w during pumping at BH02i, BH03_w, and during the concurrent pumping at BH05i and BH06 is provided in Figure 3-1, Figure 3-2 and Figure 3-3, respectively. Interpretation of the derivative plots is provided in Section 4.

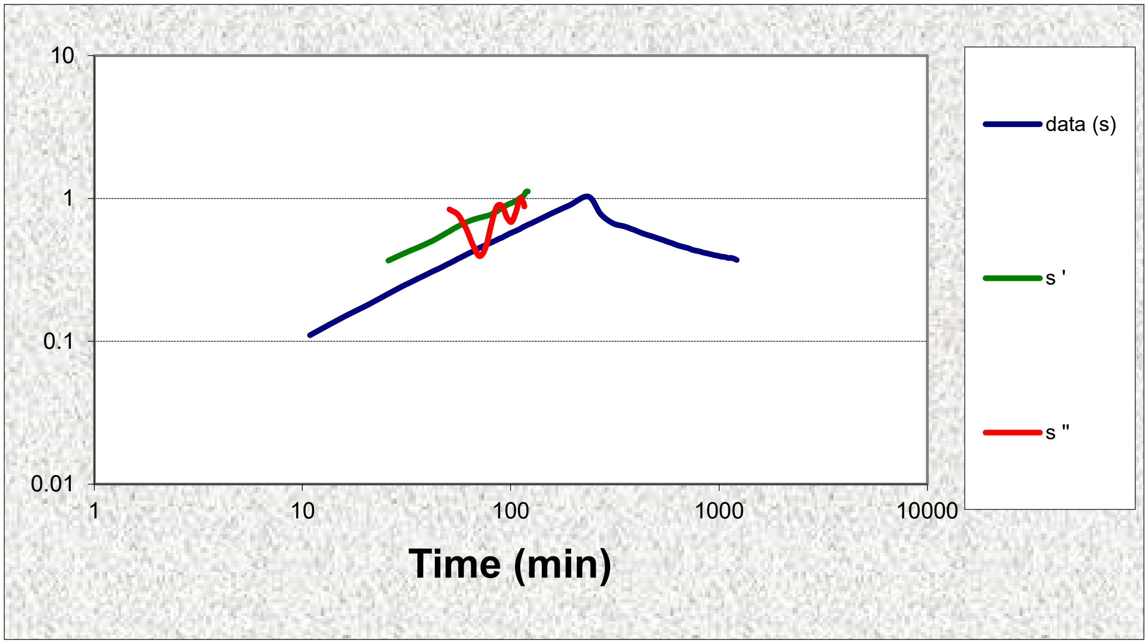

FIGURE 3-1 PLOT OF FIRST (S') AND SECOND (S") DERIVATIVES OF DRAWDOWN OBSERVED AT OBSERVATION PIEZOMETER, AF_BH08_W, DURING PUMPING AT BH02I

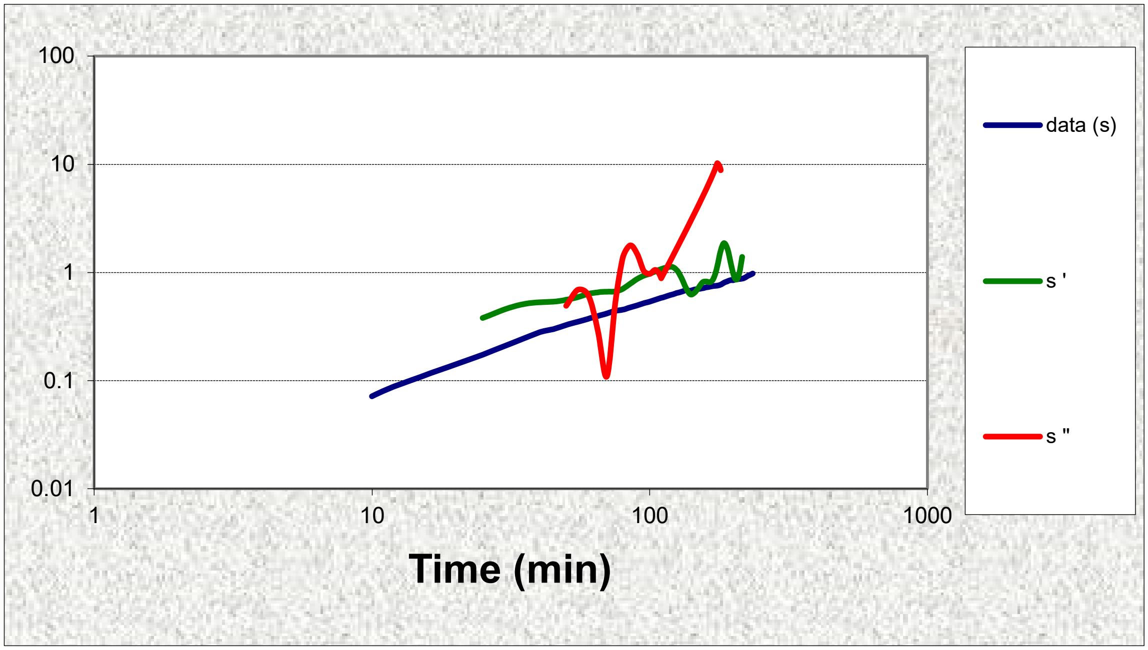

FIGURE 3-2 PLOT OF FIRST (S') AND SECOND (S") DERIVATIVES OF DRAWDOWN OBSERVED AT OBSERVATION PIEZOMETER, AF_BH08_W, DURING CONCURRENT PUMPING AT BH03_W

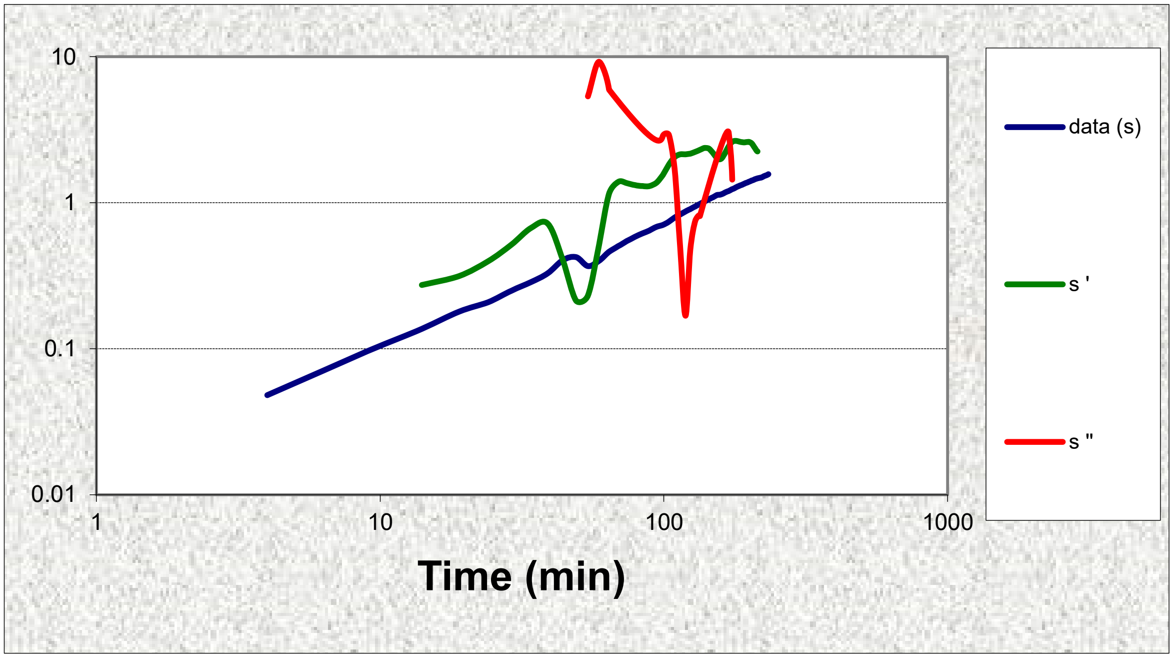

FIGURE 3-3 PLOT OF FIRST (S') AND SECOND (S") DERIVATIVES OF DRAWDOWN OBSERVED AT OBSERVATION PIEZOMETER, AF_BH08_W, DURING CONCURRENT PUMPING AT BH05I AND BH06

Estimated groundwater system hydraulic properties from the Theis and Moench analyses summarised in Table 3 are provided in Table 4. In Table 4, multiple analyses are shown, with adopted analyses shown as bold and justification provided as to why the analyses have been adopted.

Plots of the observed drawdown and matched solutions are provided in Appendix C.

Interpretation of the drawdown trends and estimated groundwater system hydraulic properties are provided in Section 4.

TABLE 4 PUMP OUT TEST ANALYSIS RESULTS

Pumped borehole	Analysis method	Estimated groundwater system hydraulic properties [1]	Comment
Borehole AF_BH02i	**Theis (recovery) on the pumped well**	**T = 19.88 m²/d** **K = 0.70 m/d**	**Adopted as conservative for design and considered representative in the context of available data. Theis analysis is constrained by fewer parameters compared to Moench analysis, which decreases potential for error and non-unique solutions during curve fitting.**
	Moench (recovery) on the pumped well	T = 19.25 m²/d K = 0.68 m/d	Poor curve fit to data.
	Theis (on AF_BH08_w drawdown)	T = 5.49 m²/d K = 0.19 m/d $S = 1.98 \times 10^{-5}$ $Ss = 6.99 \times 10^{-7} m^{-1}$	
	Moench (on AF_BH08_w drawdown)	**T = 1.79 m²/d** **K = 0.06 m/d** $S = 3.36 \times 10^{-5}$ $Ss = 1.19 \times 10^{-6} m^{-1}$	**Adopted as best curve fit to AF_BH08_w observation data**
Borehole AF_BH03_w	**Theis (on AF_BH08_w drawdown)**	**T = 3.70 m²/d** **K = 0.17 m/d** $S = 3.07 \times 10^{-4}$ $Ss = 1.40 \times 10^{-5} m^{-1}$	**Curve fit and results similar for Theis and Moench solutions. Theis adopted as solution because it is constrained by fewer parameters compared to Moench, which decreases potential for error and non-unique solutions during curve fitting.**
	Moench (on AF_BH08_w drawdown)	T = 3.22 m²/d K = 0.15 m/d $S = 2.55 \times 10^{-4}$ $Ss = 1.16 \times 10^{-5} m^{-1}$	
Borehole AF_BH04	Theis (recovery) on the pumped well	T = 0.06 m²/d K = 0.002 m/d	Good straight line fit
	Moench (recovery) on the pumped well	**T = 0.35 m²/d** **K = 0.01 m/d**	**Reasonable curve fit. Adopted as conservative for design and considered representative in the context of available data.**
Borehole AF_BH06	**Theis (recovery) on the pumped well**	**T = 3.11 m²/d** **K = 0.12 m/d**	**Reasonable straight-line fit. Adopted as conservative for design and considered representative in the context of available data. Theis analysis is constrained by fewer parameters compared to Moench analysis, which decreases potential for error and non-unique solutions during curve fitting.**
	Moench (recovery) on the pumped well	T = 1.24 m²/d K = 0.05 m/d	Not a straight-line solution. However, curve fit is relatively straight and does not match late time data.
	Theis (on AF_BH08_w drawdown)	T = 2.48 m²/d K = 0.10 m/d $S = 3.59 \times 10^{-15}$ $Ss = 1.44 \times 10^{-16} m^{-1}$	Results are considered invalid due to extremely (unrealistically) low storage
	Moench (on AF_BH08_w drawdown)	T = 2.34 m²/d K = 0.09 m/d $S = 3.59 \times 10^{-15}$ $Ss = 7.02 \times 10^{-16} m^{-1}$	Results are considered invalid due to extremely (unrealistically) low storage
	Theis (on AF_BH08_w drawdown)	**T = 1.43 m²/d** **K = 0.06 m/d**	**Adopted as conservative for design, without being an excessively high value in the context of available data. Theis analysis is constrained by fewer parameters**

Boreholes AF_BH05i and AF_BH06, concurrent pumping		**S = 4.68 x 10^{-6}** **Ss = 1.88 x 10^{-7} m^{-1}**	**compared to Moench analysis, which decreases potential for error and non-unique solutions during curve fitting.**
	Moench (on AF_BH08_w drawdown)	T = 0.39 m^2/d K = 0.02 m/d S = 4.09 x 10^{-5} Ss = 1.64 x 10^{-6} m^{-1}	

Notes: [1.] T = transmissivity, K = hydraulic conductivity, S = storativity and Ss = specific storage.

The adopted hydraulic conductivity values span over two orders of magnitude, ranging from 0.01 m/d to 0.70 m/d.

The adopted specific storage values are in the order of 10^{-7} to 10^{-5} m^{-1}, with adopted storativity ranging from 10^{-4} to 10^{-6}.

4. Interpretations and conclusion

The derivative analysis indicates the groundwater system behaves as a dual porosity system, with fracture flow occurring, and limited radial flow. The derivative analysis suggests flow within a fracture network that is closed (i.e., flow does not enter the fracture system from outside of the system). This supports the current interpretation that dilated bedding planes and fractures are present within rock in the paleochannel and dominate the flow behaviour of the groundwater system.

The observed drawdown in observation piezometer AF_BH08_w during all pump out tests indicates fracture/bedding parting connectivity between the pumped location and AF_BH08_w. This conclusion is made on the basis of the derivative analysis indicating the groundwater system behaves as a dual porosity system, and because unlike AF_BH08_w, drawdown was not observed at observation piezometer SEN_S06. This is despite SEN_S06 being screened in sandstone and having an offset distance similar or smaller than AF_BH08_w to various pumped locations. However, it is noted that the gravel pack elevation is relatively lower at AF_BH08_w (-18.65 mAHD to -24.65 mAHD) compared to SEN_S06 (-10.37 mAHD to -17.31 mAHD).

Except for the adopted BH02i recovery result, and the adopted result for pumping at AF_BH03_w and observation at AF_BH08_w, the adopted hydraulic conductivity values are considered similar to typical near surface bulk values for Hawkesbury Sandstone. Hewitt (2005) reports a typical near surface bulk hydraulic conductivity for Hawkesbury Sandstone of 0.09 m/d, with bulk hydraulic conductivity decreasing with depth and reported to be about 0.002 m at 50 m depth. Compared to the typical bulk hydraulic conductivity value for Hawkesbury Sandstone at 50 m depth, the adopted hydraulic conductivity values estimated from the pump tests are elevated.

The adopted hydraulic conductivity results for recovery at BH02i and for pumping at AF_BH03_w with observation at AF_BH08_w are considerably higher than the Hewitt (2005) typical near surface bulk value for Hawkesbury Sandstone. This is interpreted to be due to increased fractures and dilated bedding planes that act as conduits for groundwater flow in the vicinity of these boreholes within the palaeochannel at White Bay.

Based on the results of the adopted pump out test analyses, for application in the project's Bay's station numerical groundwater model, recommended lower and upper bounds for hydraulic conductivity are 0.01 m/d and 0.70 m/d, respectively. With respect to specific storage, recommended lower and upper bounds are 1×10^{-7} m^{-1} and 1×10^{-5} m^{-1}, respectively.

References

Hewitt (2005), Groundwater Control for Sydney Rock Tunnels, Previously published in AGS AUCTA Mini-Symposium: Geotechnical aspects of tunnelling for infrastructure projects held in Sydney in October 2005. Revised May 2012.

Appendix A – Borehole and piezometer construction logs

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 1 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020)
SURFACE ELEVATION : 3.52 (mAHD)
ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : ED

DATE STARTED : 14-10-21
DATE COMPLETED : 20-10-21
DATE LOGGED : 14-10-21
LOGGED BY : NB
CHECKED BY : DEM

DRILLING

PROGRESS – DRILLING & CASING: DT; NDD; AD/T; WB; HW Casing
WATER LOSS: 0-5%
DRILLING PENETRATION: H; E
GROUND WATER LEVELS:

SAMPLES & FIELD TESTS
0.60m D 0.70m
1.60m D 1.70m
2.50m D 2.60m
4.00m D 4.10m

DEPTH (m)	RL (m AHD)
0.0	3.5
1.0	2.7
2.0	1.8
3.0	1.0
4.0	0.1
5.0	-0.8
6.0	-1.6
7.0	-2.5
8.0	-3.3

MATERIAL

Depth	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.05m	ASPHALTIC CONCRETE				FILL
0.50m	CONCRETE SLAB				
0.60m	FILL: sandy GRAVEL: dark grey and grey, fine to coarse gravel, sub-angular, igneous, fine to coarse grained sand		M		
1.60m	FILL: COBBLES: yellow-brown, fine to coarse, sub-rounded to sub-angular, sandstone, with fine to coarse grained sand, with sandstone gravel		M		
4.50m	FILL: SAND: yellow-orange and brown, fine to coarse grained sand, trace clay		M W		
8.00m	Clayey SAND: dark grey and brown, fine to medium grained sand, low to medium plasticity clay, with silt, trace charcoal 6.50m: trace shell fragments	SC	W	L to MD	ESTUARINE DEPOSITS

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 2 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020) SURFACE ELEVATION : 3.52 (mAHD) ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

DRILLING						MATERIAL					
PROGRESS											
DRILLING & CASING	WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0 -3.3	▨		Silty CLAY: medium to high plasticity, orange, yellow and pale grey, with fine to coarse grained sand			RESIDUAL SOIL
					9.0 -4.2						
					10.0 -5.0						
WB HW Casing	0-5%	E					CI-CH		w~PL	St	
					11.0 -5.9						
					12.0 -6.8			12.58m			
								Continued as Cored Drill Hole			
					13.0 -7.6						
					14.0 -8.5						
					15.0 -9.3						
					16.0 -10.2						

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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CORED DRILL HOLE LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 3 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

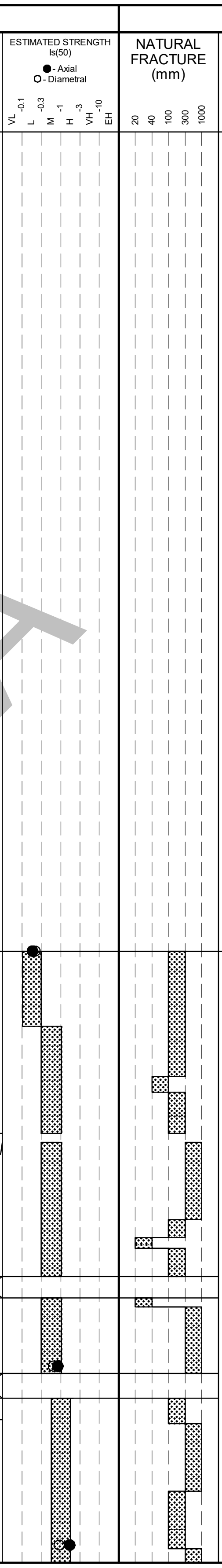
POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020) SURFACE ELEVATION : 3.52 (mAHD) ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DEPTH (m)	RL (m AHD)	DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
8.0	-3.3								
9.0	-4.2								
10.0	-5.0								
11.0	-5.9								
12.0	-6.8								
12.58m		HQ3	0-5%	0% LOSS	75	Is(50) d=0.21 a=0.18	START CORING AT 12.58m SANDSTONE: medium to coarse grained, red-brown and brown, distinct and indistinct bedding at 20-30°	HW	12.70: JT 60° Clay VNR UN RF (12.64-12.78m) 12.80: JT 30° Fe SN UN RF
13.0	-7.6								13.00: XS 5° Clay 30mm 13.28: XS 30° Clay 20mm 13.37: XS 30° Clay 20mm 13.50: XS 20° Clay 40mm 13.60-13.65: XS 50° Clay 50mm 13.66: BP 5° Clay CT PR 4mm
								XW MW	
14.0	-8.5			14.00 20% LOSS	65				14.08: BP 20° Fe SN PR RF 14.18-14.20: BPx2 30° Fe SN PR RF 14.22: JT 5° CN PR RF 14.24: BP 20° Fe SN UN RF
14.40m							CORE LOSS 0.12m (14.40-14.52)		
14.52m							SANDSTONE: medium to coarse grained, pale brown and grey, distinct and indistinct bedding at 10-20°	MW	14.54-14.57: BPx2 5-10° Fe SN PR RF
			10-20%	14.60 10% LOSS	71	Is(50) d=0.62 a=0.81			
14.94m							CORE LOSS 0.14m (14.94-15.08)		
15.0	-9.3								
15.08m							SANDSTONE: fine to medium grained, grey-brown and pale grey, distinct and indistinct bedding at 10-20°	MW SW	15.10: BP 5° Fe SN PR RF 15.22: BP 5° Fe SN PR RF 15.60: JT 60-80° Fe SN UN RF (15.48-15.71m) 15.71: XS 10° Clay 30mm 15.81: BP 10° X VNR PR RF
15.82m							SANDSTONE: medium to coarse grained, pale grey, massive		15.92: BP X VNR PR RF
16.0	-10.2			16.00		Is(50) d=0.88 a=1.64			



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CORED DRILL HOLE LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 4 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

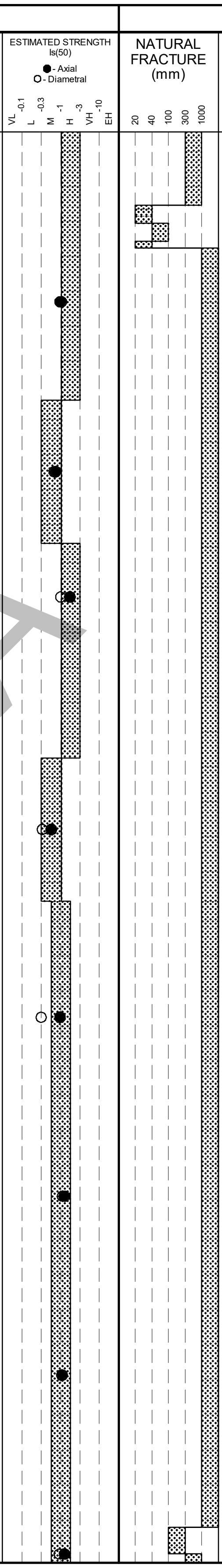
POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020)   SURFACE ELEVATION : 3.52 (mAHD)   ANGLE FROM HORIZONTAL : 59° AT 286° (TN)
RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : ED
DATE STARTED : 14-10-21   DATE COMPLETED : 20-10-21   DATE LOGGED : 14-10-21   LOGGED BY : NB   CHECKED BY : DEM
CASING DIAMETER : HW   BARREL (Length) : 3.00 m   BIT : 4 Step Face   BIT CONDITION : Good

DRILLING

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)
HQ3	10-20%	0% LOSS	91		16.0 -10.2
				Is(50) d=1.02 a=0.93	17.0 -11.0
		17.60			
	0-5%	0% LOSS	100	Is(50) d=0.64 a=0.7	18.0 -11.9
				Packer Test >=70uL; Is(50) d=0.95 a=1.66	
					19.0 -12.8
				Packer Test =35uL; Is(50) d=0.32 a=0.55	20.0 -13.6
		20.60			
		0% LOSS	100	Is(50) d=0.3 a=0.92	21.0 -14.5
		21.60			
		0% LOSS	100	Is(50) d=1.05 a=1.19	22.0 -15.3
				Packer Test =18uL	
				Is(50) d=1.05 a=1.03	23.0 -16.2
				Is(50) d=0.88 a=1.2	24.0 -17.0

MATERIAL

GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering
	SANDSTONE: medium to coarse grained, pale grey, massive *(continued)*	F
	16.40-16.69m: 5% carbonaceous laminations	
	17.16m: siltstone clast, sub-rounded, 30mm	
17.60m	SANDSTONE: fine to coarse grained, pale grey, 5% carbonaceous laminations, distinct and indistinct bedding at 0-10°	
	20.10-24.20m: 5-10% carbonaceous laminations, irregular, distinct and indistinct bedding dipping at 10-40°	



FRACTURES

ADDITIONAL DATA
(joints, partings, seams, zones, etc)
Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

16.41: BP 0-5° UN healed
16.43: JT 40° Fe Clay CT PR RF 4mm
16.47-16.51: BPx3 0-5° Fe SN PR RF
16.61: BP 40° CN PR RF
16.65: BP 40° Clay CT PR 4mm
19.05: BP 20° CU tight
20.30: BP 30° Clay VNR CU RF
23.80: JT 40° CN PR RF
23.95: BP 20° Clay VNR PR 1mm

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CORED DRILL HOLE LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 5 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020) SURFACE ELEVATION : 3.52 (mAHD) ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

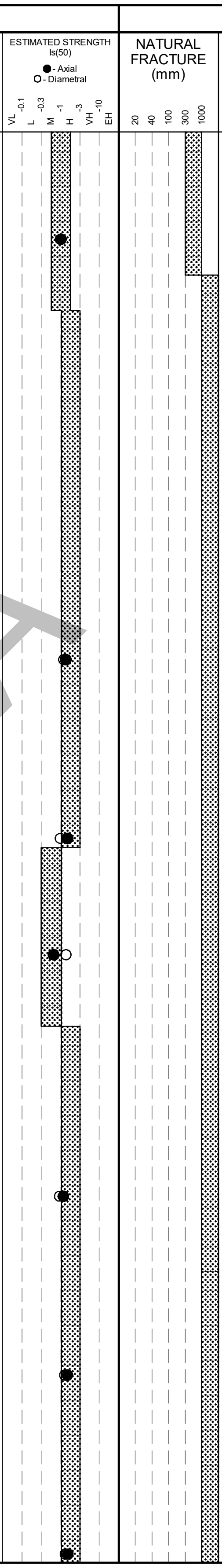
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*
HQ3	0-5%	0% LOSS	100		24.0 *-17.0*
		24.60			
		0% LOSS	100	Is(50) d=0.94 a=0.97	
					25.0 *-17.9*
				Packer Test =18uL Packer Test =26uL	26.0 *-18.8*
	80-100%			Is(50) d=1.15 a=1.3	27.0 *-19.6*
		27.60			
		0% LOSS	100	Is(50) d=0.94 a=1.45	28.0 *-20.5*
				Is(50) d=1.31 a=0.63	
				Packer Test >=93uL	29.0 *-21.3*
				Is(50) d=0.89 a=1.12	30.0 *-22.2*
		30.60			
		0% LOSS	100	Packer Test =0.3uL Is(50) d=1.21 a=1.43	31.0 *-23.0*
				Is(50) d=1.24 a=1.46	32.0 *-23.9*

MATERIAL

GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering
	SANDSTONE: fine to coarse grained, pale grey, 5% carbonaceous laminations, distinct and indistinct bedding at 0-10° *(continued)* 24.20-30.36m: 5% carbonaceous laminations, indistinct, irregular bedding at 10-30°	F
	29.11-29.18m: 30% siltstone clasts up to 40mm diameter	
30.36m	SANDSTONE: fine to medium grained, pale grey, distinct and indistinct bedding at 20-30°	
	From 31.76m: distinct and indistinct bedding at 0-10°	



FRACTURES

CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
	24.85: JT 60° PR tight (24.80-24.90m)
	30.37: BP 40° Clay CT PR 2mm
	31.71: BP 20° Clay VNR PR RF

RevA

RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 SMW CTP - BH.GPJ <<DrawingFile>> 05-Nov-2021 19:15 10.02.00.04 Datgel Tools

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CORED DRILL HOLE LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 6 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020)
SURFACE ELEVATION : 3.52 (mAHD)
ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : ED

DATE STARTED : 14-10-21
DATE COMPLETED : 20-10-21
DATE LOGGED : 14-10-21
LOGGED BY : NB
CHECKED BY : DEM

CASING DIAMETER : HW
BARREL (Length) : 3.00 m
BIT : 4 Step Face
BIT CONDITION : Good

DRILLING

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS
HQ3	80-100%	0% LOSS	100	Packer Test >0.3uL
				Is(50) d=1.51 a=1.84
		33.64		Is(50) d=1.13 a=1.61
		0% LOSS	100	Is(50) d=1.23 a=1.06
				Is(50) d=0.85 a=1.14
				Packer Test =0.3uL
		36.66		
		0% LOSS	100	Is(50) d=1.47 a=1.48
				Is(50) d=1.62 a=0.89
				Is(50) d=0.58 a=1.07
				Packer Test =2uL
		39.66		
		0% LOSS	100	Is(50) d=1.41 a=1.55

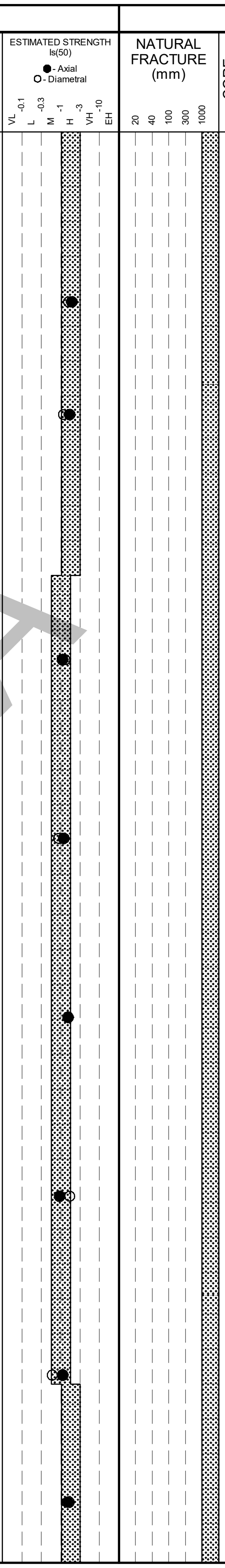
DEPTH (m)	RL (m AHD)
32.0	-23.9
33.0	-24.8
34.0	-25.6
35.0	-26.5
36.0	-27.3
37.0	-28.2
38.0	-29.0
39.0	-29.9
40.0	-30.8

MATERIAL

DESCRIPTION
ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)

Weathering: F

Depth	Description
32.18m	SANDSTONE: medium to coarse grained, pale grey and grey, massive, 15 carbonaceous flecks
33.45m	33.30-33.45m: grey, fine to medium grained sandstone bed, indistinct bedding at 20° SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 20-30°
34.48m	SANDSTONE: medium to coarse grained, pale grey, massive, 1-5% sub-rounded to sub-angular siltstone clasts up to 40mm, <1% siltstone flecks
36.90m	SANDSTONE: fine to medium grained, pale grey, distinct and indistinct bedding at 20-40° 37.20-37.80m: <5% carbonaceous laminations
38.37m	38.27-38.37m: dark grey siltstone band SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 5-20° 38.37-38.60m: 50% dark grey, coarse grained, silty sandstone laminations and beds



FRACTURES

ADDITIONAL DATA
(joints, partings, seams, zones, etc)
Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

33.41: BP 20° Clay CT PR 2mm
36.90: JT 50° X VNR PR RF
38.50: BP 40° X CT PR RF 2mm

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CORED DRILL HOLE LOG

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 7 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N: 6251094.5 (56 MGA2020) SURFACE ELEVATION : 3.52 (mAHD) ANGLE FROM HORIZONTAL : 59° AT 286° (TN)

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING — MATERIAL — FRACTURES

PROGRESS: DRILLING & CASING; WATER LOSS; (CORE LOSS RUN %) DRILL DEPTH; RQD (%); SAMPLES & FIELD TESTS; DEPTH (m) RL (m AHD); GRAPHIC LOG; DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable); Weathering; ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH; NATURAL FRACTURE (mm) 20 40 100 300 1000; CORE; ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

Drilling & casing: HQ3
Water loss: 80-100%
Field tests: Packer Test =2uL

DEPTH (m)	RL (m AHD)
40.0	-30.8
41.0	-31.6
42.0	-32.5
43.0	-33.3
44.0	-34.2
45.0	-35.0
46.0	-35.9
47.0	-36.8
48.0	-37.6

Core loss (run %)	Drill depth	RQD (%)
0% LOSS	42.66	100
0% LOSS	45.20	100

Samples & field tests (approx. depth)
Is(50) d=1.43 a=1.23 (41.0)
Is(50) d=1.14 a=1.27 (42.0)
Is(50) d=1.26 a=1.94 (43.0)
Is(50) d=0.63 a=1.31 (44.0)
Is(50) d=0.66 a=0.66 (45.0)

SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 5-20° *(continued)* — Weathering: F

42.66-42.69m: 30% carbonaceous laminations
42.72-43.24m: fine to medium grained sandstone bed, 5% carbonaceous laminations

43.24-43.52m: grey, fine grained sandstone bed with 10% carbonaceous laminations

43.53m

SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 5-10°

43.83-43.87m: 20% siltstone clasts, sub-rounded, up to 15mm diameter

45.20m

BOREHOLE AF_BH02i TERMINATED AT
45.20 m
Target depth
Hole grouted

Additional data:
- 42.07: BP 30° X VNR PR RF
- 42.42: BP 15° X VNR UN RF
- 43.45: BP 25° X VNR PR RF
- 43.60: BP 10° Clay CT PR RF 2mm

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CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 1 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED
DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : AF_BH02i
FILE / JOB NO : 207139.00
SHEET : 2 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

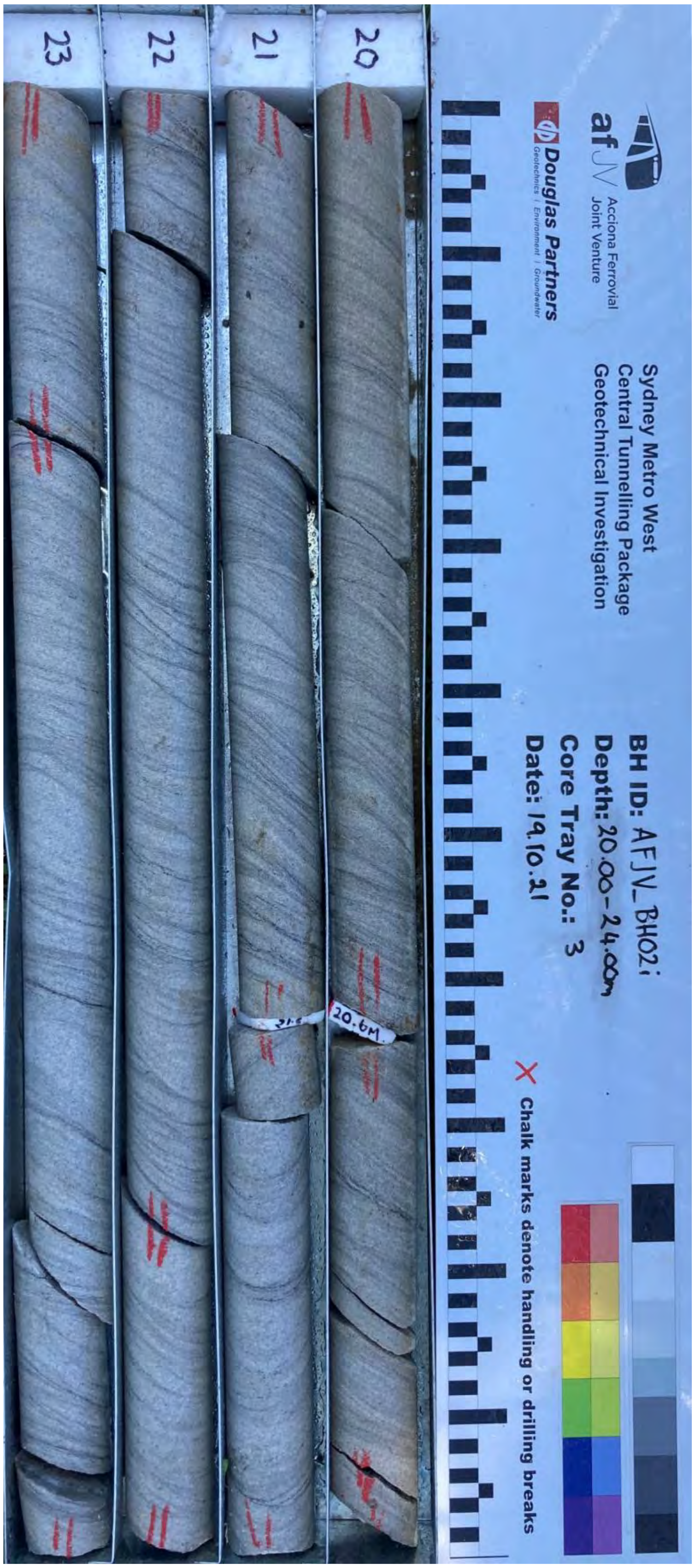
HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 3 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM



CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 4 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 5 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED
DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 6 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED
DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 7 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 8 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED

DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH02i**
FILE / JOB NO : 207139.00
SHEET : 9 OF 9

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331588.8, N:6251093.4 (56 MGA2020) SURFACE ELEVATION : 3.6 (mAHD) ANGLE FROM HORIZONTAL : 59°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : ED
DATE STARTED : 14-10-21 DATE COMPLETED : 20-10-21 DATE LOGGED : 14-10-21 LOGGED BY : NB CHECKED BY : DEM

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 1 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC

DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

DRILLING

PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)
DT (0.00–0.20m)		H (0.00–0.20m)			0.0	5.3
NDD (0.20–0.60m)		F (0.20–1.50m)		0.20m D 0.30m		
DT (0.60m–)				0.60m D 0.70m		
NDD (–1.50m)				0.90m D 1.00m	1.0	4.3
				1.40m D 1.50m		
AD/T (1.50–4.00m)		E (1.50–8.00m)	12-10-21	1.90m D 2.00m	2.0	3.3
			[illegible]-10-21 05-10-21	2.00m SPT 5, 5, 5 N*=10 2.45m		
				2.90m D 3.00m	3.0	2.3
				3.50m SPT 1, 0, 4 N*=4 3.95m		
HW Casing WB (4.00m–)	0-5% (4.00m–)			4.00m U75 4.40m	4.0	1.3
				5.10m U75 5.50m	5.0	0.3
				5.50m SPT 0, 0, 0 N*=0 5.95m		
					6.0	-0.7
				6.60m U75 7.00m		
				7.00m SPT 0, 0, 0 N*=0 7.45m	7.0	-1.7
					8.0	-2.7

MATERIAL

Depth (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.00–0.05m		ASPHALTIC CONCRETE			FILL
0.05–0.17m		CONCRETE SLAB			
0.17–0.42m		FILL: sandy GRAVEL: grey, fine to coarse gravel, fine to medium grained sand	M		
0.42–0.60m		CONCRETE SLAB			
0.60–1.50m		FILL: gravelly SAND: dark grey, fine to medium grained sand, fine to coarse sandstone gravel, trace charcoal, glass and brick			
1.50–2.10m		FILL: gravelly SAND: grey, fine to medium grained sand, fine to coarse sandstone and igneous gravel, trace silt, trace charcoal			2.00: SPT Recovery: 0.45 m
2.10–3.20m	SP	SAND: brown-grey, medium to coarse grained sand, with shell fragments, trace silt	W	L	ESTUARINE DEPOSITS
3.20–4.40m	CL-OL	Peaty CLAY: low to medium plasticity, dark grey, with fine to medium grained sand, trace shell fragments	w~PL	S to F	3.50: SPT Recovery: 0.45 m 3.95: HP =70 kPa
4.40–6.60m	SM	Silty SAND: grey, fine to medium grained sand, trace clay, trace shell fragments	W	VL	4.40: HP =40 kPa 5.50: SPT Recovery: 0.45 m
6.60m–	CH	Silty CLAY: high plasticity, grey	w~PL	VS to S	7.00: HP =50 kPa 7.00: SPT Recovery: 0.45 m 7.45: HP =60 kPa

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 2 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC
DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

DRILLING: PROGRESS — DRILLING & CASING: WB, HW Casing; WATER LOSS: 0-5%; DRILLING PENETRATION: E; GROUND WATER LEVELS

Depth (m) / RL (m AHD): 8.0 / -2.7; 9.0 / -3.7; 10.0 / -4.7; 11.0 / -5.7; 12.0 / -6.7; 13.0 / -7.7; 14.0 / -8.7; 15.0 / -9.7; 16.0 / -10.7

SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
8.10m		CH		w~PL	VS to S	ESTUARINE DEPOSITS
U75 8.50m SPT 7, 14, 12 N*=26 8.95m	8.10m	SP	SAND: pale grey, medium to coarse grained sand, trace silt	W	MD	8.50: SPT Recovery: 0.35 m
9.60m U75 10.00m SPT 0, 0, 0 N*=0 10.45m	9.60m	CI-CH	CLAY: medium to high plasticity, pale grey, with fine to medium grained sand	w~PL	VS to S	10.00: HP =110 kPa 10.00: SPT Recovery: 0.45 m 10.45: HP =60 kPa
11.10m U75 11.50m SPT 0, 0, 0 N*=0 11.95m	11.10m	SM	Silty SAND: pale grey to grey, fine to medium grained sand, trace clay, occasional orange-brown bands	W	VL to L	11.50: SPT Recovery: 0.45 m
12.60m U75 13.00m SPT 11, 20, 25/110mm N*=R 13.41m	12.60m	CH-OH	Peaty CLAY: medium to high plasticity, dark grey	w~PL	S to F	13.00: HP =60 kPa 13.00: SPT Recovery: 0.45 m 13.10: HP =100 kPa
14.10m U75 14.33m SPT 9, 2, 0 N*=2 14.78m	13.10m	SM	Silty SAND: grey, fine to medium grained sand, trace clay	W	MD to D	14.33: SPT Recovery: 0.45 m
	14.60m	CL-CI	Sandy peaty CLAY: low to medium plasticity, dark grey, fine to medium grained sand	w~PL	S to F	14.78: HP =60 kPa
15.60m U75 15.80m SPT 10, 7, 4 N*=11	15.60m	SP	SAND: pale grey, fine to medium grained sand, trace silt	W	MD	15.80: SPT Recovery: 0.45 m

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 3 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC
DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
WB HW Casing	0-5%	E		SPT 10, 7, 4 N*=11 16.25m 17.10m	16.0 *-10.7* 17.0 *-11.7*		SP	SAND: pale grey, fine to medium grained sand, trace silt *(continued)*	W	MD	ESTUARINE DEPOSITS
				U75 17.50m SPT 7, 5, 8 N*=13 17.95m	17.10m 18.0 *-12.7*		SC	Clayey SAND: pale grey mottled grey, fine to medium grained sand			RESIDUAL SOIL 17.50: HP =160 kPa 17.50: SPT Recovery: 0.35 m 17.95: HP =180 kPa
		H		18.60m	18.20m			SANDSTONE: fine to medium grained, mottled pale grey and red-brown, apparently very low strength			BEDROCK 18.60: SPT Recovery: 0.04 m
				SPT 12/40mm HB N*=R 18.64m	18.64m 19.0 *-13.7* 20.0 *-14.7* 21.0 *-15.7* 22.0 *-16.7* 23.0 *-17.7* 24.0 *-18.7*			Continued as Cored Drill Hole			

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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CORED DRILL HOLE LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 4 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

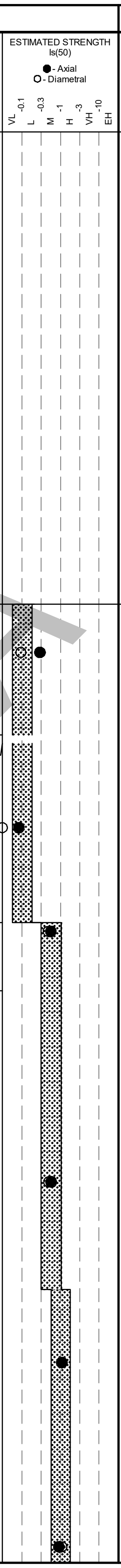
POSITION : E: 331479.5, N: 6251133.4 (56 MGA94)   SURFACE ELEVATION : 5.25 (mAHD)   ANGLE FROM HORIZONTAL : 90°

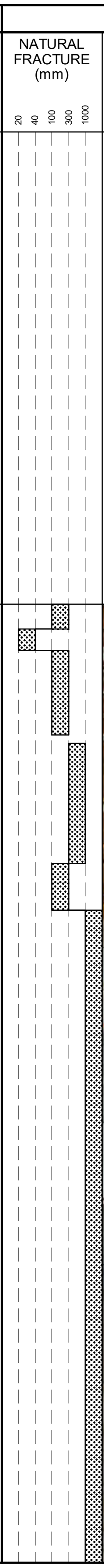
RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : SC

DATE STARTED : 5-10-21   DATE COMPLETED : 10-10-21   DATE LOGGED : 5-10-21   LOGGED BY : BY   CHECKED BY : DEM

CASING DIAMETER : HW   BARREL (Length) :   BIT : 4 Step Face   BIT CONDITION : New

DRILLING: PROGRESS DRILLING & CASING	DRILLING: PROGRESS WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	MATERIAL: DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	FRACTURES: ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
					16.0 -10.7			
					17.0 -11.7			
					18.0 -12.7			
					18.64m	START CORING AT 18.64m		
HQ3	0-5%	0% LOSS	82			SANDSTONE: fine to medium grained, pale grey and red-brown, distinct and indistinct bedding at 0-15°	HW	18.78: XS 0° Clay 5mm 18.90: XS 0° Clay 5mm
				Is(50) d=0.09 a=0.28	19.0 -13.7			19.02: XS 0° 30mm 19.15: XS 10° Clay 5mm 19.27: XS 10° Clay 10mm
							XW	19.37-19.42: XS 50mm
							HW	19.74: XS 30mm
				Is(50) d=0.03 a=0.08	20.0 -14.7			20.09: BP 5° Fe Clay CT PR 2mm
		20.22						
		0% LOSS	78					20.35: BP 0° Clay VNR PR RF
					20.42m	SANDSTONE: fine to medium grained, pale grey, 10-15% siltstone laminations, indistinct bedding at 0-15°	SW	
				Is(50) d=0.46 a=0.54				
		20.81						
		0% LOSS	100				F	
					21.0 -15.7			
				Packer Test >100uL				
				Is(50) d=0.47 a=0.55	22.0 -16.7			21.96: BP 0-15° Clay VNR UN RF
					22.47m	SANDSTONE: fine to medium grained, pale grey, massive, 1% siltstone flecks and siltstone lenticles up to 10mm		
				Is(50) d=1.03 a=1.03	23.0 -17.7			
		23.82						
		0% LOSS	98	Is(50) d=1.03 a=0.87		From 23.89m: 10-15% siltstone laminations, distinct and indistinct bedding at 0-30°		
					24.0 -18.7			





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CORED DRILL HOLE LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 5 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94)
SURFACE ELEVATION : 5.25 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : SC

DATE STARTED : 5-10-21
DATE COMPLETED : 10-10-21
DATE LOGGED : 5-10-21
LOGGED BY : BY
CHECKED BY : DEM

CASING DIAMETER : HW
BARREL (Length) :
BIT : 4 Step Face
BIT CONDITION : New

DRILLING

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)
HQ3	70-80%	0% LOSS	98
		26.73	
	10-20%	0% LOSS	62
		27.66	
		0% LOSS	99
		29.68	
		0% LOSS	98

SAMPLES & FIELD TESTS

Packer Test >100uL

Packer Test =90uL

Packer Test =1uL

SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)
	24.0	-18.7
Is(50) d=0.94 a=0.8	25.0	-19.7
Is(50) d=1.04 a=0.78	26.0	-20.7
Is(50) d=0.56 a=0.69	27.0	-21.7
Is(50) d=2.2 a=2.8	28.0	-22.7
Is(50) d=0.91 a=0.81	29.0	-23.7
Is(50) d=1.03 a=0.89	30.0	-24.7
Is(50) d=1.42 a=1.32	31.0	-25.7
Is(50) d=0.67 a=0.73	32.0	-26.7

MATERIAL

GRAPHIC LOG

DESCRIPTION
ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)

Weathering: F

SANDSTONE: fine to medium grained, pale grey, massive, 1% siltstone flecks and siltstone lenticles up to 10mm *(continued)*

24.29m

SANDSTONE: medium to coarse grained, pale grey, 5-10% siltstone laminations, distinct and indistinct bedding at 0-15°

25.71-26.54m: massive

26.54-27.27m: 10% siltstone laminations and beds up to 40mm, siltstone clasts up to 15mm, indistinct bedding at 0-10°

27.27-27.42m: fine to medium grained bed

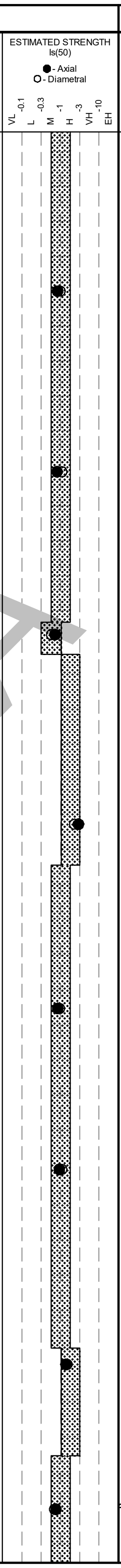
From 27.42m: 10% siltstone and carbonaceous laminations, 1-5% quartz clasts up to 5mm, distinct and indistinct bedding at 0-30°

28.70m

SANDSTONE: medium to coarse grained, pale grey and grey, 10% siltstone laminations, distinct and indistinct bedding at 10-20°

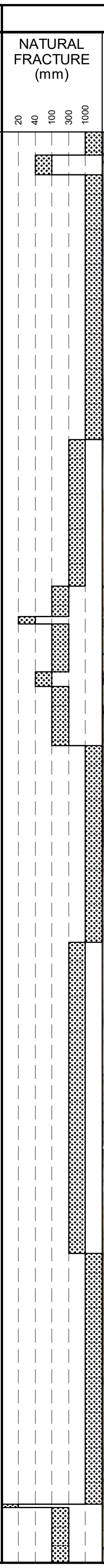
31.24-31.55m: 10-15% irregular siltstone/carbonaceous laminations, 5% quartz clasts up to 5mm, distinct and indistinct bedding at 0-25°

ESTIMATED STRENGTH Is(50)
● - Axial
O - Diametral



FRACTURES

NATURAL FRACTURE (mm)



CORE

ADDITIONAL DATA
(joints, partings, seams, zones, etc)
Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

24.13: BP 5° Clay VNR PR RF
24.24: JT 25° PR tight
25.72: JT 25° X VNR PR RF
26.54: BP 5° Clay VNR PR RF
26.71: BP 5° Clay VNR PR RF
26.75: BP 0-60° Clay VNR IR S
27.02: JT 60° CN PR VR
27.10: JT 30° CN PR VR
27.21: BP 5° CN PR S
27.43: BP 10° Clay VNR PR RF
28.53: BP 5° Clay CT PR 2mm
29.42: BP 20° Clay VNR PR RF
30.27: BP 20° Clay CN PR RF
31.67: BP 0-30° Clay CN IR RF
31.69: BP 0-30° Clay CN IR RF
31.90: CS 20mm

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CORED DRILL HOLE LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 6 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°

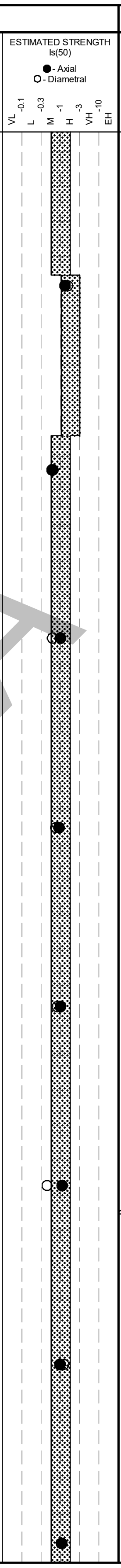
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC

DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

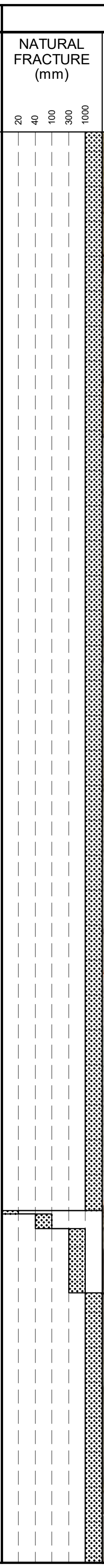
CASING DIAMETER : HW BARREL (Length) : BIT : 4 Step Face BIT CONDITION : New

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	10-20%	0% LOSS	98		32.0 -26.7		SANDSTONE: medium to coarse grained, pale grey and grey, 10% siltstone laminations, distinct and indistinct bedding at 10-20° *(continued)*	F	32.00: BP 0° Clay VNR PR RF
		32.70							
		0% LOSS	100	Packer Test =0uL Is(50) d=1.48 a=1.25	33.0 -27.7				
		33.70							
		0% LOSS	100				From 33.70m: 10-15% siltstone laminations and <1% carbonaceous laminations, distinct and indistinct bedding at 0-25°		33.90: BP 0° Clay VNR PR RF
				Is(50) d=0.62 a=0.58	34.0 -28.7				
				Is(50) d=0.59 a=0.95	35.0 -29.7				
				Is(50) d=0.72 a=0.88	36.0 -30.7				
				Packer Test =1.4uL					36.48: BP 0-10° Clay VNR CU RF
		36.73							
		0% LOSS	98	Is(50) d=0.78 a=0.95	37.0 -31.7				
				Is(50) d=0.43 a=1.06	38.0 -32.7				38.03: BP 20° X VNR PR RF 38.05: BP 20° X VNR PR RF 38.13: BP 0° X VNR PR RF
							38.25-38.49m: fine grained, dark grey, 10% carbonaceous laminations, indistinct bedding at 0-10° 38.49-38.50m: sub-rounded to rounded siltstone clasts up to 20mm.		38.49: BP 0° Clay VNR PR RF
						38.50m	SANDSTONE: medium to coarse grained, pale grey and grey, massive, <5% carbonaceous flecks		
				Is(50) d=1.17 a=0.93	39.0 -33.7				
							From 39.45m: 1-5% siltstone laminations		
		39.73							
		0% LOSS	100	Is(50) d=1.05 a=1.01	40.0 -34.7				

ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral



NATURAL FRACTURE (mm)



CORE

RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH03.GPJ <<DrawingFile>> 15-Oct-2021 16:12 10.02.00.04 Datgel Tools

Douglas Partners
Geotechnics / Environment / Groundwater

CORED DRILL HOLE LOG

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 7 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N: 6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC
DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : BIT : 4 Step Face BIT CONDITION : New

DRILLING						MATERIAL				FRACTURES		
PROGRESS												
DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	▼	40.15	100	↓	40.0 -34.7	∴	40.15m	F				
							BOREHOLE AF_BH03 TERMINATED AT 40.15 m Target depth Groundwater well installed					
					41.0 -35.7							
					42.0 -36.7							
					43.0 -37.7							
					44.0 -38.7							
					45.0 -39.7							
					46.0 -40.7							
					47.0 -41.7							
					48.0 -42.7							

RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH03.GPJ <<DrawingFile>> 15-Oct-2021 16:12 10.02.00.04 Datgel Tools

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CORE PHOTOGRAPHS

HOLE NO : **AF_BH03**
FILE / JOB NO : 207139.00
SHEET : 1 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC
DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

BH ID: AF_BH03
Depth: 18.64 - 22.00m
Core Tray No.: 1
Date: 7.10.21

CORE PHOTOGRAPHS

HOLE NO : AF_BH03
FILE / JOB NO : 207139.00
SHEET : 2 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC

DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

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CORE PHOTOGRAPHS

HOLE NO : **AF_BH03**
FILE / JOB NO : 207139.00
SHEET : 3 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94)
SURFACE ELEVATION : 5.25 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : SC

DATE STARTED : 5-10-21
DATE COMPLETED : 10-10-21
DATE LOGGED : 5-10-21
LOGGED BY : BY
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH03**
FILE / JOB NO : 207139.00
SHEET : 4 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94)
SURFACE ELEVATION : 5.25 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : SC

DATE STARTED : 5-10-21
DATE COMPLETED : 10-10-21
DATE LOGGED : 5-10-21
LOGGED BY : BY
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH03**
FILE / JOB NO : 207139.00
SHEET : 5 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC

DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH03**
FILE / JOB NO : 207139.00
SHEET : 6 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331479.5, N:6251133.4 (56 MGA94) SURFACE ELEVATION : 5.25 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : SC

DATE STARTED : 5-10-21 DATE COMPLETED : 10-10-21 DATE LOGGED : 5-10-21 LOGGED BY : BY CHECKED BY : DEM

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 1 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94)
SURFACE ELEVATION : 3.89 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : EM

DATE STARTED : 6-10-21
DATE COMPLETED : 11-10-21
DATE LOGGED : 6-10-21
LOGGED BY : NB
CHECKED BY : DEM

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
NDD/T		H		0.20m 0.25m D	0.0 3.9	▨		ASPHALTIC CONCRETE			FILL
					0.17m	▨		FILL: sandy GRAVEL: dark grey-brown, fine to coarse gravel, igneous, fine to coarse grained sand	M		
AD/T HW Casing		VH			0.33m	⁘		SANDSTONE: fine to medium grained, pale grey and pale yellow, apparently low strength			BEDROCK
					1.0 2.9						
					1.45m			Continued as Cored Drill Hole			
					2.0 1.9						
					3.0 0.9						
					4.0 -0.1						
					5.0 -1.1						
					6.0 -2.1						
					7.0 -3.1						
					8.0 -4.1						

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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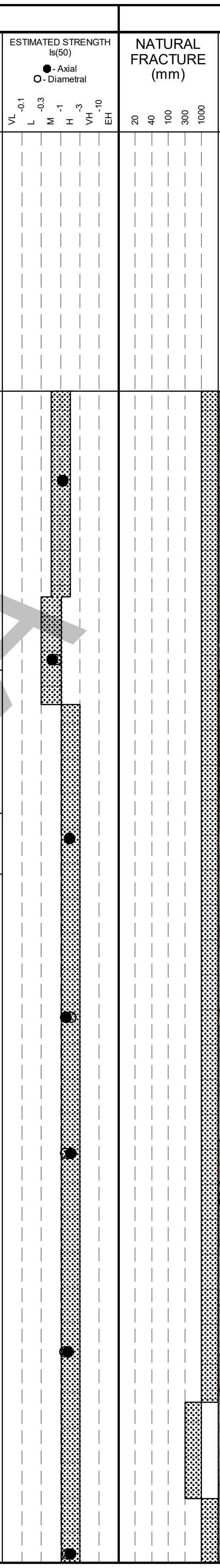
CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 2 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING: PROGRESS DRILLING & CASING	PROGRESS WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	MATERIAL: DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	FRACTURES: ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
					0.0 3.9				
					1.0 2.9				
							1.45m START CORING AT 1.45m		
HQ3	0-5%	0% LOSS	100				SANDSTONE: fine to medium grained, pale grey, massive, 1-5% carbonaceous flecks	F	
				Is(50) d=1.07 a=1.08	2.0 1.9				
	5-10%	2.85 0% LOSS	100						
				Is(50) d=0.75 a=0.58	3.0 0.9		3.01m SANDSTONE: medium to coarse grained, brown and grey, indistinct bedding at 0-20°	MW	3.00: JT 25° CN PR RF
								SW	
				Is(50) d=1.64 a=1.62	4.0 -0.1				
							4.15m SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 10-20°	F	
									4.93: BP 5° Clay VNR PR RF
				Is(50) d=1.77 a=1.31	5.0 -1.1				
	0-5%	5.80 0% LOSS	100	Is(50) d=1.28 a=1.76 Packer Test =4.6uL					
					6.0 -2.1		5.90-6.05m: brecciated, 50% siltstone clasts, sub-rounded to sub-angular, up to 60mm diameter		
				Is(50) d=1.23 a=1.5	7.0 -3.1				7.10: JT 60° Fe SN PR RF (7.00-7.20m)
									7.64: XS 0° Clay 5mm
							7.65m SANDSTONE: fine to medium grained, pale grey, distinct and indistinct bedding at 0-10°		
				Is(50) d=1.41 a=1.72	8.0 -4.1				



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CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 3 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING							MATERIAL		FRACTURES
PROGRESS: DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %)	DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	0-5%	0% LOSS		100		8.0 *-4.1*	SANDSTONE: fine to medium grained, pale grey, distinct and indistinct bedding at 0-10° *(continued)*	F	
			8.85		Packer Test =4.6uL				
		0% LOSS		100	Is(50) d=0.93 a=1.32	9.0 *-5.1*			
									9.26: BP 5° Clay VNR UN RF
			10.05		Is(50) d=1.17 a=1	10.0 *-6.1*			
		0% LOSS		100					
					Is(50) d=1.2 a=1.38	11.0 *-7.1*	11.01m: siltstone clast, sub-rounded, 20mm		
							11.22-11.40m: 10% carbonaceous laminations		11.25: BP 5° X VNR PR RF
						11.60m	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-20°		
					Is(50) d=2.25 a=2.07				11.64: JT 20° CN PR RF
							11.81-11.95m: 40% siltstone clasts up to 70mm		
			11.85						
		0% LOSS		100		12.0 *-8.1*			
					Packer Test =1.2uL				
					Is(50) d=0.91 a=1.38	13.0 *-9.1*			
					Is(50) d=0.41 a=1.58	14.0 *-10.1*			
			14.93						
		0% LOSS		100	Is(50) d=0.92 a=1.06	15.0 *-11.1*			
			16.00		Is(50) d=1.02 a=1.36	16.0 *-12.1*			

ESTIMATED STRENGTH Is(50)
● - Axial
○ - Diametral
VL -0.1 L -0.3 M -1 H -3 VH -10 EH

NATURAL FRACTURE (mm)
20 40 100 300 1000

CORE

RevA

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RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH04.GPJ <<DrawingFile>> 22-Oct-2021 20:53 10.02.00.04 Datgel Tools

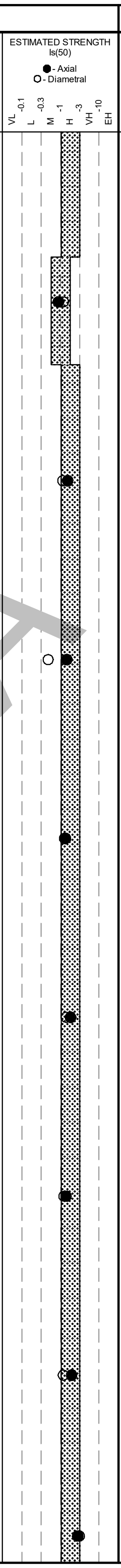
CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 4 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94)   SURFACE ELEVATION : 3.89 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : EM
DATE STARTED : 6-10-21   DATE COMPLETED : 11-10-21   DATE LOGGED : 6-10-21   LOGGED BY : NB   CHECKED BY : DEM
CASING DIAMETER : HW   BARREL (Length) : 3.00 m   BIT : 4 Step Face   BIT CONDITION : Good

DRILLING PROGRESS: DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	FRACTURES ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	0-5%	0% LOSS	100	Packer Test <0.1uL	16.0	-12.1	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-20° *(continued)*	F	
				Is(50) d=1.14 a=0.85	17.0	-13.1			
		17.93							
		0% LOSS	100	Is(50) d=1.09 a=1.46	18.0	-14.1	18.00-18.70m: distinct and disturbed bedding at 0-20°		
									18.49: BP 0° Clay VNR PR RF
				Is(50) d=0.46 a=1.39	19.0	-15.1			
				Is(50) d=1.21 a=1.28	20.0	-16.1			
		21.00							
		0% LOSS	100	Is(50) d=1.34 a=1.75	21.0	-17.1			
		22.00		Packer Test =0.1uL					
		0% LOSS	100	Is(50) d=1.17 a=1.33	22.0	-18.1			
				Is(50) d=1.12 a=1.86	23.0	-19.1	23.07-23.31m: fine to medium grained		
		23.80							
		0% LOSS	100	Is(50) d=2.97 a=2.66	24.0	-20.1			



NATURAL FRACTURE (mm): 20 40 100 300 1000

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CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 5 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

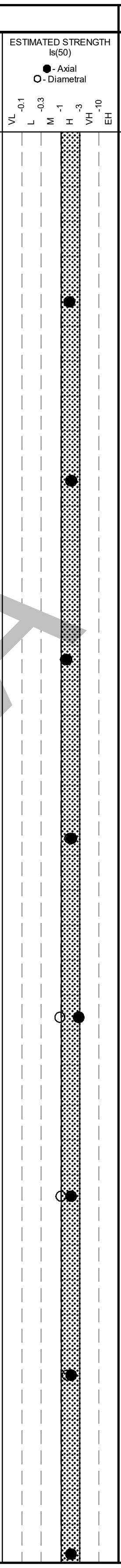
POSITION : E: 331647.9, N: 6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°

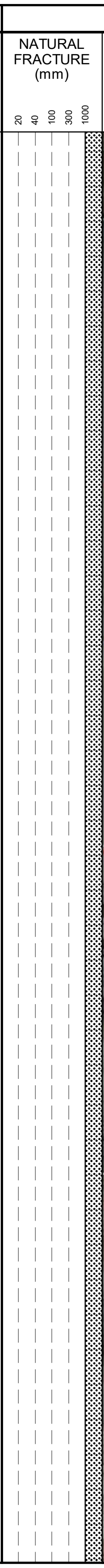
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING						MATERIAL		FRACTURES
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	0-5%	0% LOSS	100		24.0 *-20.1*	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-20° *(continued)* 24.26-24.48m: siltstone inclusions	F	
					24.48m	SANDSTONE: fine to medium grained, pale grey, massive, 1-5% carbonaceous flecks		
				Is(50) d=1.58 a=1.64	25.0 *-21.1*			
				Packer Test =0.1uL Is(50) d=1.74 a=1.84	26.0 *-22.1*			
		26.85						
		0% LOSS	100	Is(50) d=1.28 a=1.37	27.0 *-23.1*			
		28.00		Is(50) d=1.66 a=1.82	28.0 *-24.1*			28.06: BP 0° PR healed
		0% LOSS	100			28.32-28.64m: medium to coarse grained sandstone, 30% siltstone clasts up to 70mm		
					28.64m	SANDSTONE: fine to medium grained, pale grey and grey, distinct and indistinct bedding at 0-10°		
				Is(50) d=0.92 a=2.83	29.0 *-25.1*			
						29.50-30.88m: 5-10% carbonaceous laminations		
		29.83		Packer Test =1.1uL				
		0% LOSS	100	Is(50) d=0.98 a=1.81	30.0 *-26.1*			
						30.88-31.26m: massive		
				Is(50) d=1.43 a=1.81	31.0 *-27.1*			
					31.26m	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-10°, 1-5% carbonaceous laminations		31.44: BP 20° Clay VNR PR RF
				Is(50) d=1.73 a=1.79	32.0 *-28.1*			





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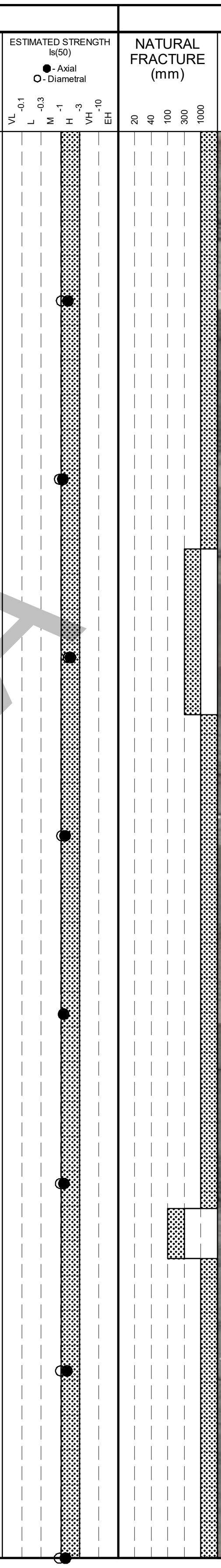
CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 6 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	0-5%	0% LOSS	100	Packer Test =1.1uL	32.0	-28.1	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-10°, 1-5% carbonaceous laminations *(continued)* 32.28-32.62m: 5-10% siltstone clasts, laminations and beds	F	
		32.89 0% LOSS	100	Is(50) d=1.01 a=1.5	33.0	-29.1			
							33.50-33.80m: dark grey, fine grained sandstone, 10% siltstone laminations		
		34.00 0% LOSS	100	Is(50) d=0.91 a=1.11	34.0	-30.1			34.34: BP 5° Clay VNR PR RF
							34.42-35.28m: massive, 1% carbonaceous flecks		
				Is(50) d=1.52 a=1.75	35.0	-31.1			35.27: BP 0° Clay VNR PR RF
		35.84 0% LOSS	100	Is(50) d=1.03 a=1.26 Packer Test =0.4uL	36.0	-32.1			
				Is(50) d=1.15 a=1.16	37.0	-33.1	37.00-38.04m: 5% siltstone laminations and coaly lenticles up to 20mm, 1% fine quartz gravel		
				Is(50) d=0.96 a=1.18	38.0	-34.1			38.04: JT 30° Clay CT PR 3mm 38.32: BP 0° Clay CT PR 2mm
		38.88 0% LOSS	100	Is(50) d=0.97 a=1.41	39.0	-35.1			
					40.0	-36.1			



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Geotechnics / Environment / Groundwater

CORED DRILL HOLE LOG

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 7 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N: 6251049.6 (56 MGA94)   SURFACE ELEVATION : 3.89 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : EM
DATE STARTED : 6-10-21   DATE COMPLETED : 11-10-21   DATE LOGGED : 6-10-21   LOGGED BY : NB   CHECKED BY : DEM
CASING DIAMETER : HW   BARREL (Length) : 3.00 m   BIT : 4 Step Face   BIT CONDITION : Good

DRILLING						MATERIAL				FRACTURES		
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial O - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
▼	▼	40.11	100	▼ Is(50) d=0.9 a=1.3	40.0 *-36.1*	· · · · ·	40.11m		▨ H	▨ 1000	▨	
							BOREHOLE AF_BH04 TERMINATED AT 40.11 m Target depth Hole grouted					

DEPTH (m)	*RL (m AHD)*
40.0	*-36.1*
41.0	*-37.1*
42.0	*-38.1*
43.0	*-39.1*
44.0	*-40.1*
45.0	*-41.1*
46.0	*-42.1*
47.0	*-43.1*
48.0	*-44.1*

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CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 1 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 2 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 3 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94)
SURFACE ELEVATION : 3.89 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : EM

DATE STARTED : 6-10-21
DATE COMPLETED : 11-10-21
DATE LOGGED : 6-10-21
LOGGED BY : NB
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 4 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94)   SURFACE ELEVATION : 3.89 (mAHD)   ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : EM

DATE STARTED : 6-10-21   DATE COMPLETED : 11-10-21   DATE LOGGED : 6-10-21   LOGGED BY : NB   CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 5 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94)
SURFACE ELEVATION : 3.89 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : EM

DATE STARTED : 6-10-21
DATE COMPLETED : 11-10-21
DATE LOGGED : 6-10-21
LOGGED BY : NB
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 6 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 7 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 8 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

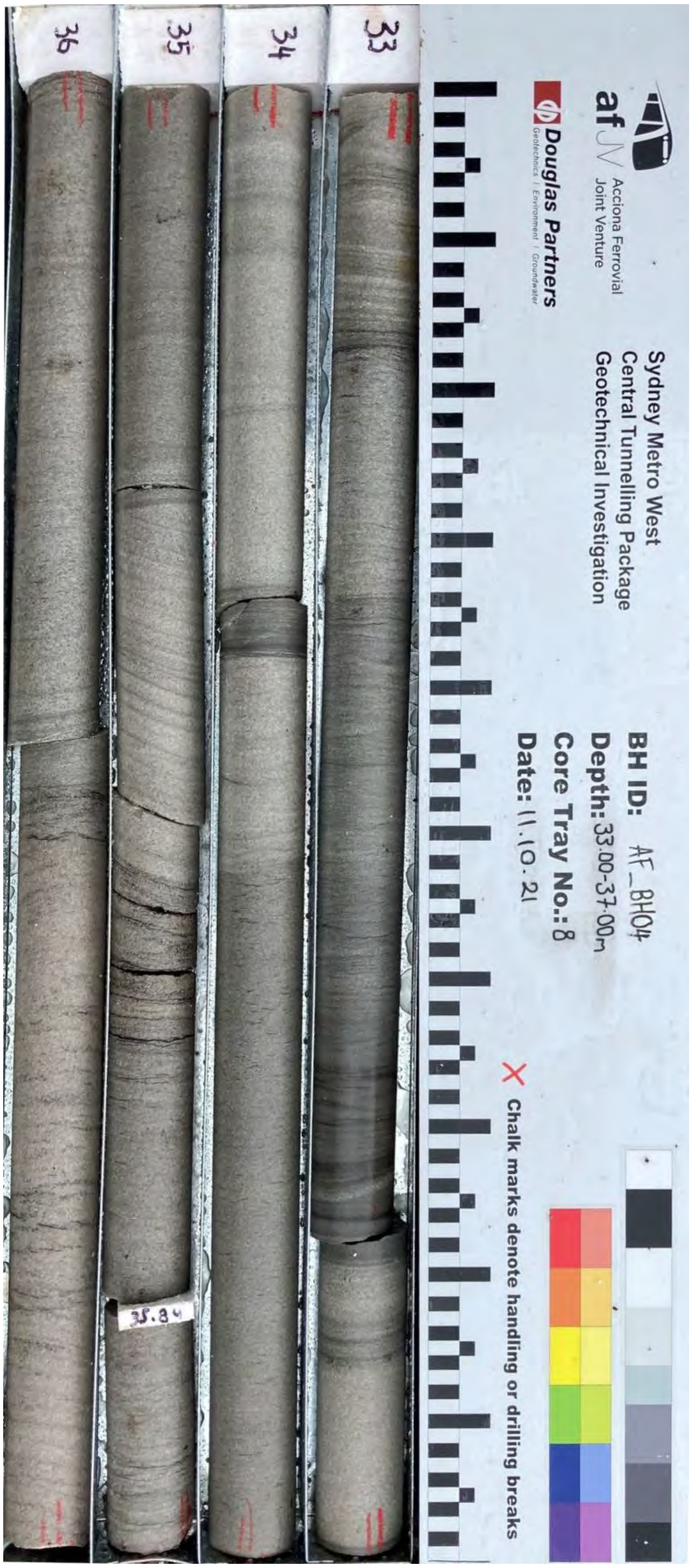
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH04**
FILE / JOB NO : 207139.00
SHEET : 9 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM

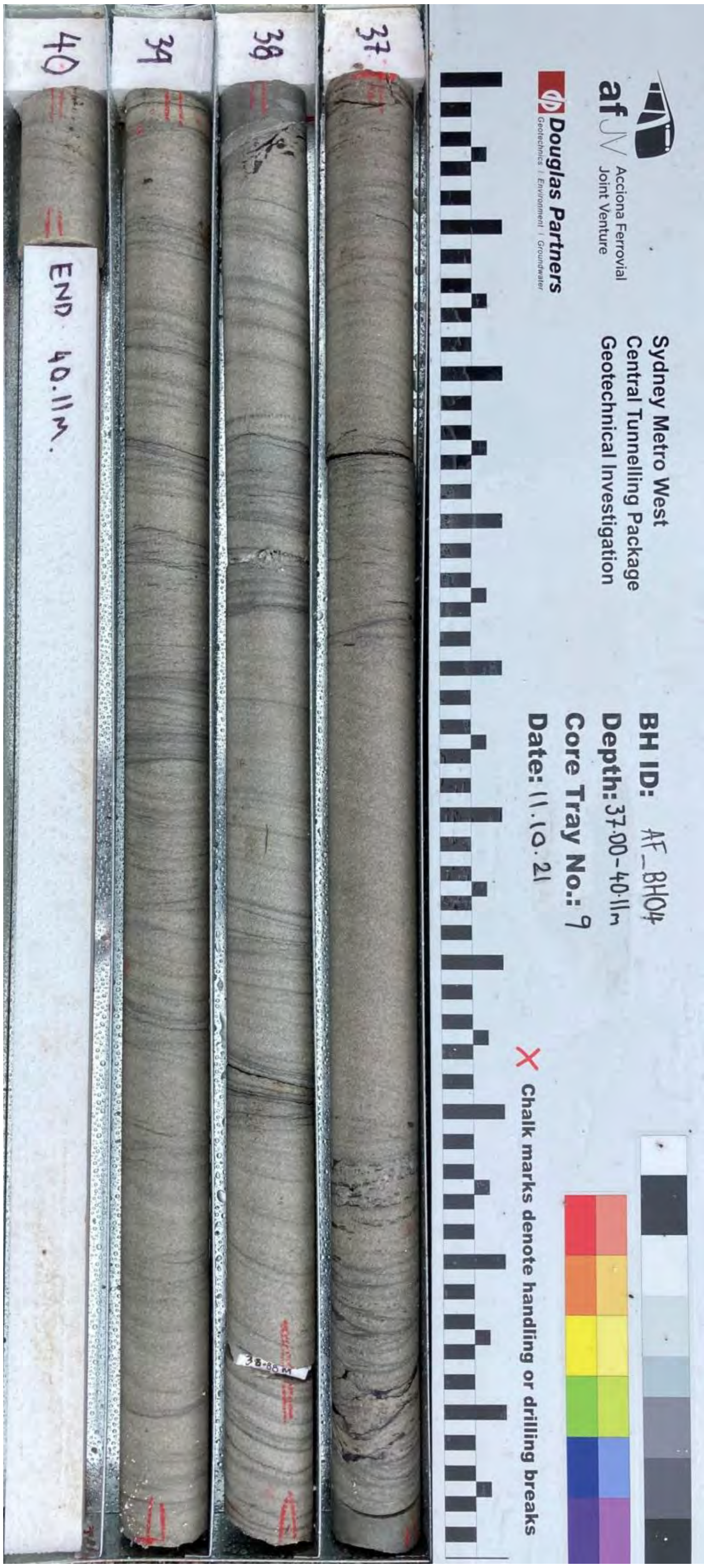


CORE PHOTOGRAPHS

HOLE NO : AF_BH04
FILE / JOB NO : 207139.00
SHEET : 10 OF 10

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331647.9, N:6251049.6 (56 MGA94) SURFACE ELEVATION : 3.89 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 6-10-21 DATE COMPLETED : 11-10-21 DATE LOGGED : 6-10-21 LOGGED BY : NB CHECKED BY : DEM



NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 1 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020)   SURFACE ELEVATION : 2.95 (mAHD)   ANGLE FROM HORIZONTAL : 62° AT 277° (TN)

RIG TYPE : Explora 140   MOUNTING : Truck   CONTRACTOR : Ground Test   DRILLER : SS

DATE STARTED : 1-10-21   DATE COMPLETED : 12-10-21   DATE LOGGED : 1-10-21   LOGGED BY : AD   CHECKED BY : DEM

DRILLING

PROGRESS: DRILLING & CASING	WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS
NDD (0.0–1.5 m) AD/T (1.5–8.0 m) HW Casing (0.0–8.0 m)		F (0.0–2.0 m) E (2.0–8.0 m)	01-10-21 06-10-[illegible]	D 0.10m–0.20m D 0.40m–0.50m D 0.90m–1.00m D 1.40m–1.50m

MATERIAL

DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0–0.10m	2.9	FILL: sandy GRAVEL: pale grey to dark grey, fine to medium gravel, sub-rounded to sub-angular, sandstone and igneous, trace brick fragments		M		FILL
0.10m–0.70m		FILL: gravelly SAND: grey to dark grey, fine to medium grained sand, fine to coarse sandstone and basalt gravel, trace charcoal and steel fibres		M		
0.70m–1.20m	2.1 (1.0)	FILL: SAND: pale brown to brown, fine to medium grained sand, trace charcoal		M		
1.20m–2.00m		FILL: SAND: dark-grey to grey brown, fine to medium grained sand, with shells		M		
2.00m–6.50m	1.2 (2.0), 0.3 (3.0), -0.6 (4.0), -1.5 (5.0), -2.3 (6.0)	SAND: grey to grey-grey brown, fine to medium grained sand, trace shells	SP	W	L to MD	ESTUARINE DEPOSITS
6.50m–8.0	-3.2 (7.0), -4.1 (8.0)	Sandy CLAY: medium plasticity, red-brown to brown, fine to medium grained sand, trace silt	CI	w~PL	St to VSt	RESIDUAL SOIL

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 2 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)

RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS

DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/T HW Casing		E			8.0 *-4.1*	▨	CI	Sandy CLAY: medium plasticity, red-brown to brown, fine to medium grained sand, trace silt *(continued)* 8.50m	w~PL	St to VSt	RESIDUAL SOIL
		H			9.0 *-5.0*	⁘		SANDSTONE: medium to coarse grained, pale grey to red-brown, apparently very low strength 9.10m			BEDROCK
								Continued as Cored Drill Hole			
					10.0 *-5.9*						
					11.0 *-6.8*						
					12.0 *-7.6*						
					13.0 *-8.5*						
					14.0 *-9.4*						
					15.0 *-10.3*						
					16.0 *-11.2*						

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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CORED DRILL HOLE LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 3 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

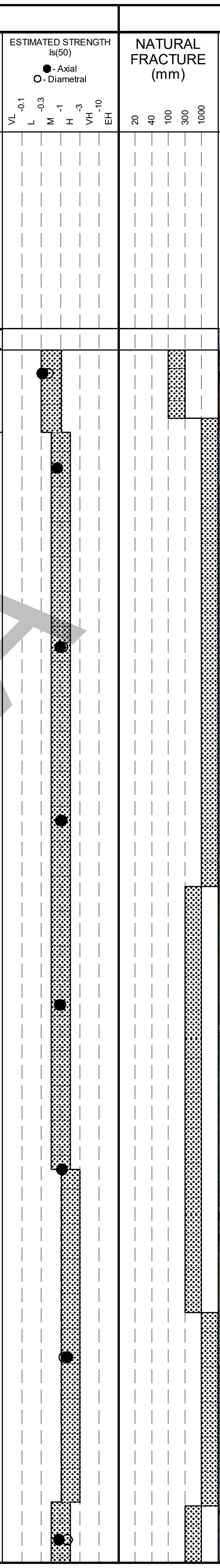
POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)

RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS

DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CASING DIAMETER : HQ/HW BARREL (Length) : 3.00 m BIT : 5 Step Face BIT CONDITION : Good

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, direction]
					8.0 / -4.1			
					9.0 / -5.0	9.10m START CORING AT 9.10m		
HQ3 HQ Casing	0-10%	4% LOSS	91			9.22m CORE LOSS 0.12m (9.10-9.22)		
				Is(50) d=0.46 a=0.32		SANDSTONE: fine to medium grained, pale grey to red-brown	MW	9.32: BP 40° CN IR RF 9.50: BP 30° Fe SN PR RF 9.60: JT 50° Fe PR tight
				Is(50) d=0.79 a=0.78	10.0 / -5.9	9.68m SANDSTONE: medium to coarse grained, pale grey, massive, 1-5% siltstone flecks.	F	
				Is(50) d=1.09 a=0.94	11.0 / -6.8			
		11.85						
		0% LOSS	100	Is(50) d=1.03 a=0.97	12.0 / -7.6	11.95m SANDSTONE: medium to coarse grained, pale grey, regular, distinct and indistinct bedding at 10-30°		12.22: BP 5° X VNR PR RF
				Packer Test <0.1uL Is(50) d=0.96 a=0.91	13.0 / -8.5			13.07: BP 30° X VNR PR RF
				Is(50) d=1.02 a=1.04	14.0 / -9.4			14.05: BP 20° X VNR PR RF 14.60: BP 20° Clay VNR PR RF
		14.87						
	80-90%	0% LOSS	98	Packer Test <0.1 Is(50) d=1.17 a=1.43	15.0 / -10.3			
				Is(50) d=1.43 a=0.86	16.0 / -11.2	15.66m SANDSTONE: medium to coarse grained, pale grey, massive, 1-5% siltstone laminations		15.68: XS 20° Clay 40mm



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CORED DRILL HOLE LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 4 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM
CASING DIAMETER : HQ/HW BARREL (Length) : 3.00 m BIT : 5 Step Face BIT CONDITION : Good

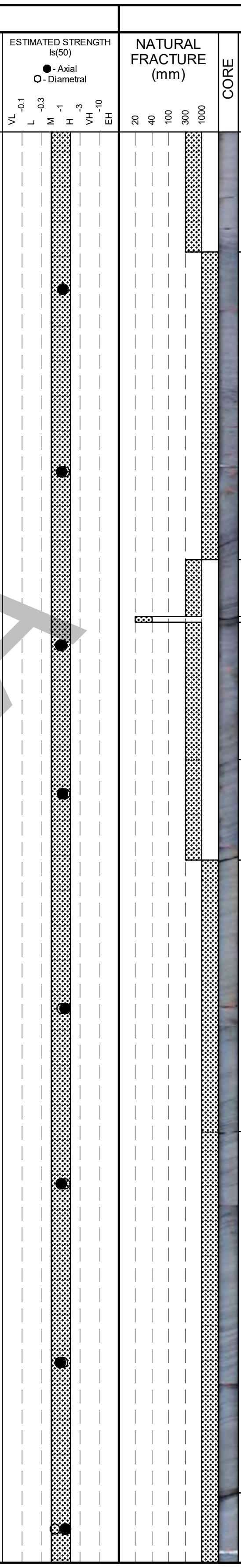
DRILLING

PROGRESS: DRILLING & CASING: HQ3 — HQ Casing; WATER LOSS: 80-90%

(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)
0% LOSS	98		16.0 -11.2
		Is(50) d=1.13 a=1.09	17.0 -12.1
17.87			
0% LOSS	99	Is(50) d=1.2 a=1.01	18.0 -12.9
		Packer Test <0.1uL	
		Is(50) d=1.04 a=0.96	19.0 -13.8
		Is(50) d=1.24 a=1.05	20.0 -14.7
20.90			
0% LOSS	100	Is(50) d=1.03 a=1.25	21.0 -15.6
		Is(50) d=1.25 a=0.99	22.0 -16.5
		Packer Test <0.1uL	
		Is(50) d=1.09 a=0.94	23.0 -17.4
23.93		Is(50) d=0.68 a=1.26	24.0 -18.2

MATERIAL

DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering
SANDSTONE: medium to coarse grained, pale grey, massive, 1-5% siltstone laminations *(continued)*	F
18.00m	
SANDSTONE: medium to coarse grained, pale grey, irregular, indistinct and distinct bedding at 20-30°	
23.70-24.25m: regular and distinct bedding 20-30°	



FRACTURES

ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

16.67: BP 30° Clay VNR PR RF
18.39: BP 40° Clay VNR PR RF
18.71: BP 20° X VNR PR RF
18.74: BP 20° X VNR PR RF
19.51: BP 40° Clay VNR PR RF
20.07: BP 20° Clay CT PR RF 1mm
21.59: JT 5° CN PR RF
23.61: BP 30° X VNR PR RF

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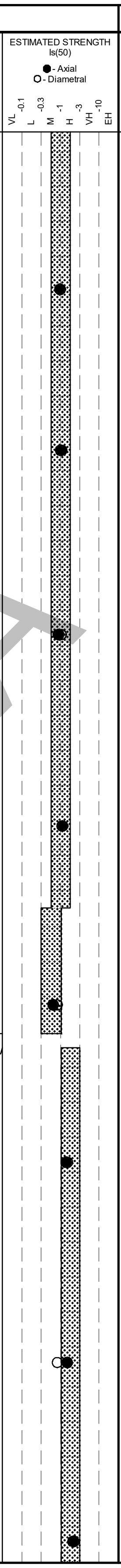
CORED DRILL HOLE LOG

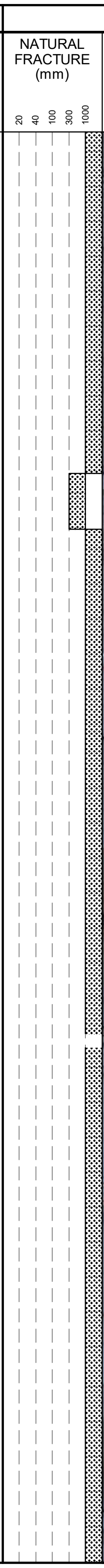
HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 5 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM
CASING DIAMETER : HQ/HW BARREL (Length) : 3.00 m BIT : 5 Step Face BIT CONDITION : Good

DRILLING						MATERIAL			FRACTURES
PROGRESS: DRILLING & CASING / WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering		ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3 HQ Casing 80-90%	0% LOSS	100	Packer Test <0.1uL	24.0 -18.2		SANDSTONE: medium to coarse grained, pale grey, irregular, indistinct and distinct bedding at 20-30° *(continued)*	F		
			Is(50) d=0.96 a=0.93	25.0 -19.1					
			Is(50) d=1.03 a=0.97	26.0 -20.0					25.91: BP 30° X VNR PR RF 26.22: BP 10-20° Clay VNR UN RF
	26.93		Is(50) d=1 a=0.85						
	0% LOSS	96		27.0 -20.9					27.36: BP 20° X VNR PR RF
			Is(50) d=1.1 a=1.06	28.0 -21.8		28.34-28.44m: fine grained, massive sandstone bed			
			Is(50) d=0.79 a=0.62 Packer Test =50uL	29.0 -22.7			XW F		29.04-29.12: XS 20° Clay 80mm
	29.88		Is(50) d=1.47 a=1.34						
	0% LOSS	94		30.0 -23.5	30.05m	SANDSTONE: fine to medium grained, pale grey, massive, 1-5% dark grey siltstone flecks			
			Packer Test =0.3uL Is(50) d=0.79 a=1.43	31.0 -24.4					
						From 31.47m: distinct and indistinct bedding at 10-30°			
					31.80m				
			Is(50) d=1.97 a=2.11	32.0 -25.3					





CORE

CORED DRILL HOLE LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 6 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020)
SURFACE ELEVATION : 2.95 (mAHD)
ANGLE FROM HORIZONTAL : 62° AT 277° (TN)

RIG TYPE : Explora 140
MOUNTING : Truck
CONTRACTOR : Ground Test
DRILLER : SS

DATE STARTED : 1-10-21
DATE COMPLETED : 12-10-21
DATE LOGGED : 1-10-21
LOGGED BY : AD
CHECKED BY : DEM

CASING DIAMETER : HQ/HW
BARREL (Length) : 3.00 m
BIT : 5 Step Face
BIT CONDITION : Good

DRILLING				MATERIAL			FRACTURES
DEPTH (m) RL (m AHD)	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
32.0 -25.3	0% LOSS	94		SANDSTONE: medium to coarse grained, pale grey, irregular, distinct and indistinct bedding at 20-30° *(continued)*	F	32.05: JT 5-10° X VNR PR RF 32.21: BP 10° X VNR UN RF 32.32: BP 20-30° X VNR UN RF
				32.30-32.34m: 40% coaly lenticles, black, up to 20mm thick		
	32.93		Is(50) d=1.29 a=1.42			
33.0 -26.2	0% LOSS	100				
			Is(50) d=1.12 a=1.04			
34.0 -27.1						
				34.30-34.65m: dark grey-brown		
						34.60: BP 30° Clay VNR UN RF
			Is(50) d=1.06 a=0.81			
35.0 -28.0						35.01: BP 30° X VNR PR RF
				35.18-35.25m: 5% siltstone clasts, subrounded, up to 15mm diameter		
				35.60m: siltstone clast, 90mm diameter		
	35.92		Is(50) d=0.54 a=1.51			
36.0 -28.8	0% LOSS	99				36.10: BP 30° X VNR PR RF
			Is(50) d=1.26 a=0.7			
37.0 -29.7						
			Is(50) d=0.97 a=0.35			
38.0 -30.6						
						38.28-38.37: BPx2 30-40° Clay CT PR RF 4mm
	39.00		Is(50) d=1.17 a=1.32			
39.0 -31.5	0% LOSS	99				
			Is(50) d=0.79 a=1.01			
40.0 -32.4						

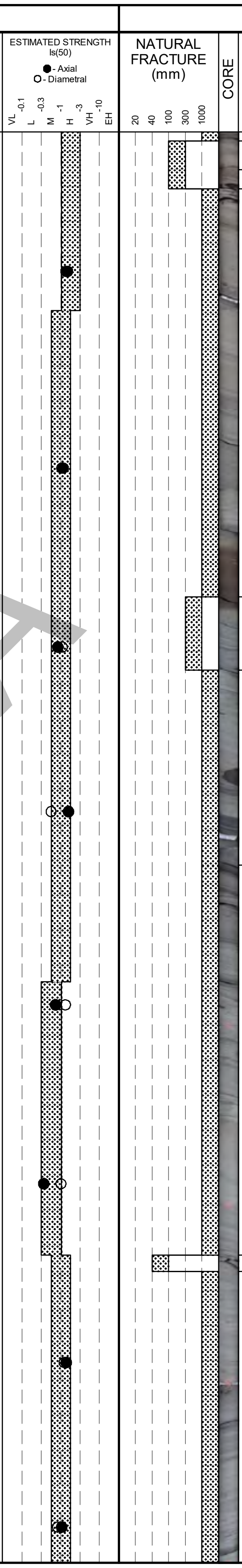
PROGRESS: DRILLING & CASING: HQ3, HQ Casing; WATER LOSS: 80-90%

Packer Test =[illegible]

Packer Test =0.1uL

Packer Test <0.1uL

GRAPHIC LOG



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CORED DRILL HOLE LOG

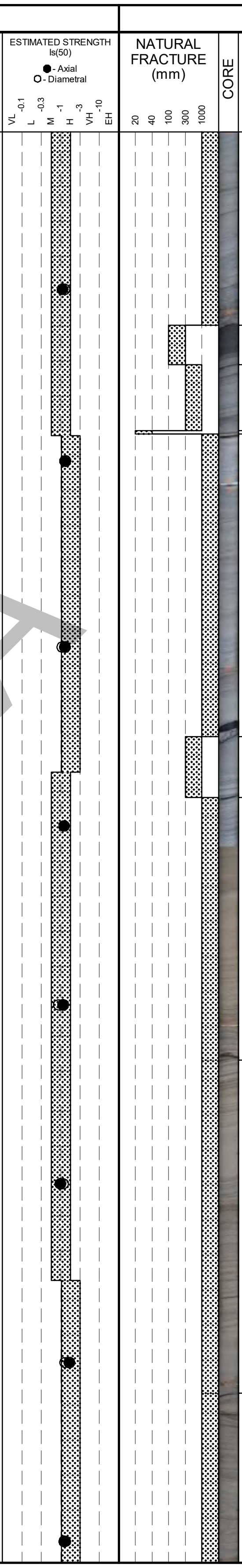
HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 7 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM
CASING DIAMETER : HQ/HW BARREL (Length) : 3.00 m BIT : 5 Step Face BIT CONDITION : Good

PROGRESS: DRILLING & CASING: HQ3, HQ Casing; WATER LOSS: 80-90%

(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
0% LOSS	99		40.0 -32.4		SANDSTONE: medium to coarse grained, pale grey, irregular, distinct and indistinct bedding at 20-30° *(continued)*	F	
		Is(50) d=1.23 a=1.06	41.0 -33.3		41.09-41.24m: fine grained sandstone bed with 1-5% carbonaceous laminations		41.08: BP 20-30° Clay VNR ST RF 41.30: BP 20° CN PR RF
				41.70m	SANDSTONE: medium to coarse grained, pale grey, irregular, indistinct bedding at 5-10°		41.67: BP 15° Clay VNR PR RF 41.69: BP 15° Clay CT PR RF 2mm
41.96		Is(50) d=1.2 a=1.27					
0% LOSS	100	Packer Test <0.1uL	42.0 -34.1				
		Is(50) d=1.03 a=1.23	43.0 -35.0		43.28m: siltstone bed, 40mm thick 43.32-43.40m: 10% siltstone clasts up to 10mm diameter		43.38: JT 60° CN UN RF
				43.58m	SANDSTONE: medium to coarse grained, pale grey, regular, distinct and indistinct bedding at 5-10°		43.72: BP 10° Clay VNR PR RF
		Is(50) d=1.16 a=1.17	44.0 -35.9				
45.00		Is(50) d=0.84 a=1.1					
0% LOSS	100		45.0 -36.8				45.19: BP 10° Clay VNR PR RF
		Packer Test <0.1uL Is(50) d=1.12 a=0.94	46.0 -37.7				
		Is(50) d=1.23 a=1.59	47.0 -38.6	47.05m	SANDSTONE: medium to coarse grained, pale grey, irregular and disturbed, distinct and indistinct bedding at 5-20°		47.05: BP 20° CN PR RF
		Is(50) d=1.26 a=1.18	48.0 -39.4				



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CORED DRILL HOLE LOG

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 8 OF 8

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569.0, N: 6251076.0 (56 MGA2020) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62° AT 277° (TN)
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM
CASING DIAMETER : HQ/HW BARREL (Length) : 3.00 m BIT : 5 Step Face BIT CONDITION : Good

DRILLING						MATERIAL				FRACTURES		
PROGRESS		(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
DRILLING & CASING	WATER LOSS											
HQ3 HQ Casing	80-90%	48.10 0% LOSS 50.25	100	Packer Test <0.1uL Is(50) d=1.41 a=1.34 Is(50) d=1.32 a=1.41	48.0 *-39.4* 49.0 *-40.3* 50.0 *-41.2*		SANDSTONE: medium to coarse grained, pale grey, irregular and disturbed, distinct and indistinct bedding at 5-20° *(continued)* 50.25m	F	● ●			48.94: BP 20° X VNR PR RF
					51.0 *-42.1* 52.0 *-43.0* 53.0 *-43.8* 54.0 *-44.7* 55.0 *-45.6* 56.0 *-46.5*		BOREHOLE AF_BH05i TERMINATED AT 50.25 m Target depth ATV imaging completed Hole grouted					

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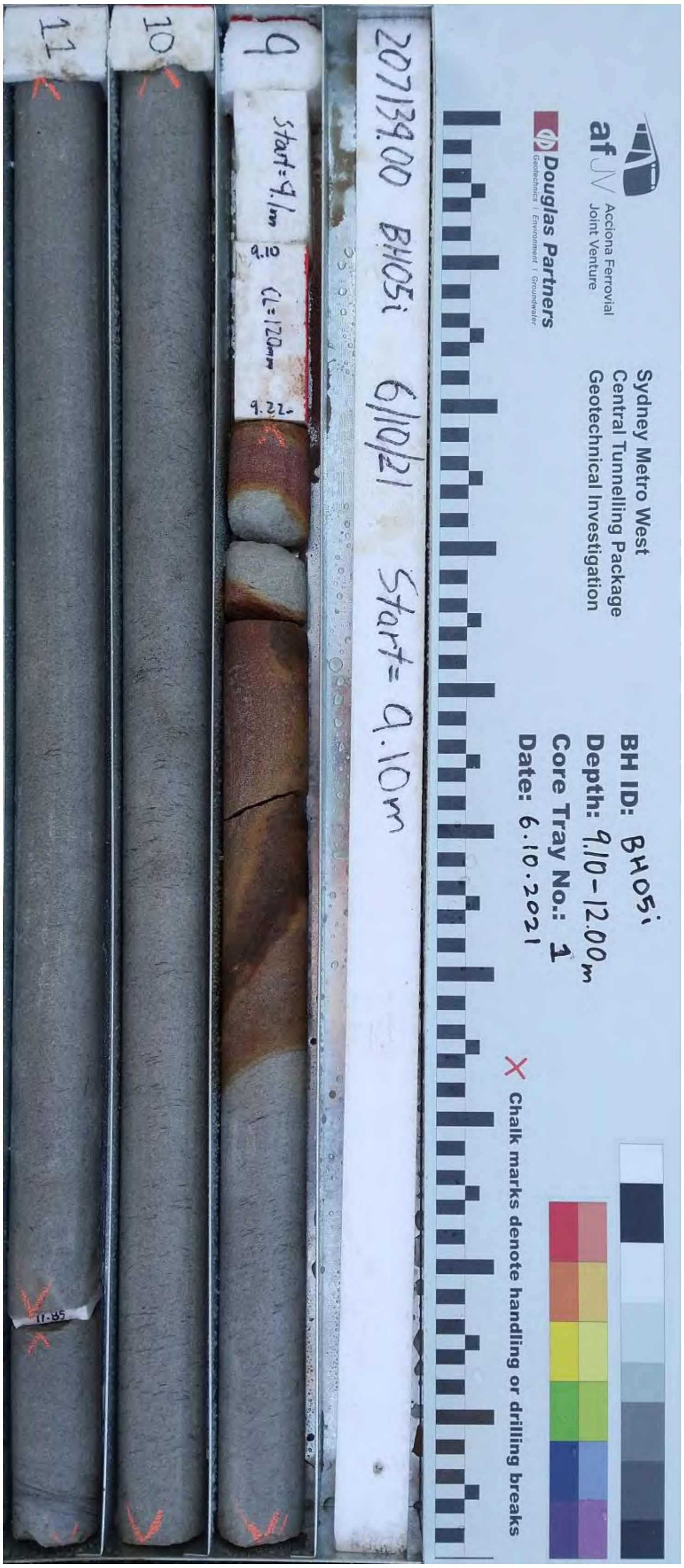
CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 1 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM



CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 2 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94)
SURFACE ELEVATION : 2.95 (mAHD)
ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140
MOUNTING : Truck
CONTRACTOR : Ground Test
DRILLER : SS
DATE STARTED : 1-10-21
DATE COMPLETED : 12-10-21
DATE LOGGED : 1-10-21
LOGGED BY : AD
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 3 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 4 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 5 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 6 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94)
SURFACE ELEVATION : 2.95 (mAHD)
ANGLE FROM HORIZONTAL : 62°

RIG TYPE : Explora 140
MOUNTING : Truck
CONTRACTOR : Ground Test
DRILLER : SS

DATE STARTED : 1-10-21
DATE COMPLETED : 12-10-21
DATE LOGGED : 1-10-21
LOGGED BY : AD
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 7 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 8 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94)
SURFACE ELEVATION : 2.95 (mAHD)
ANGLE FROM HORIZONTAL : 62°

RIG TYPE : Explora 140
MOUNTING : Truck
CONTRACTOR : Ground Test
DRILLER : SS

DATE STARTED : 1-10-21
DATE COMPLETED : 12-10-21
DATE LOGGED : 1-10-21
LOGGED BY : AD
CHECKED BY : DEM

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CORE PHOTOGRAPHS

HOLE NO : AF_BH05i
FILE / JOB NO : 207139.00
SHEET : 9 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°

RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS

DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 10 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 11 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°
RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS
DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM

CORE PHOTOGRAPHS

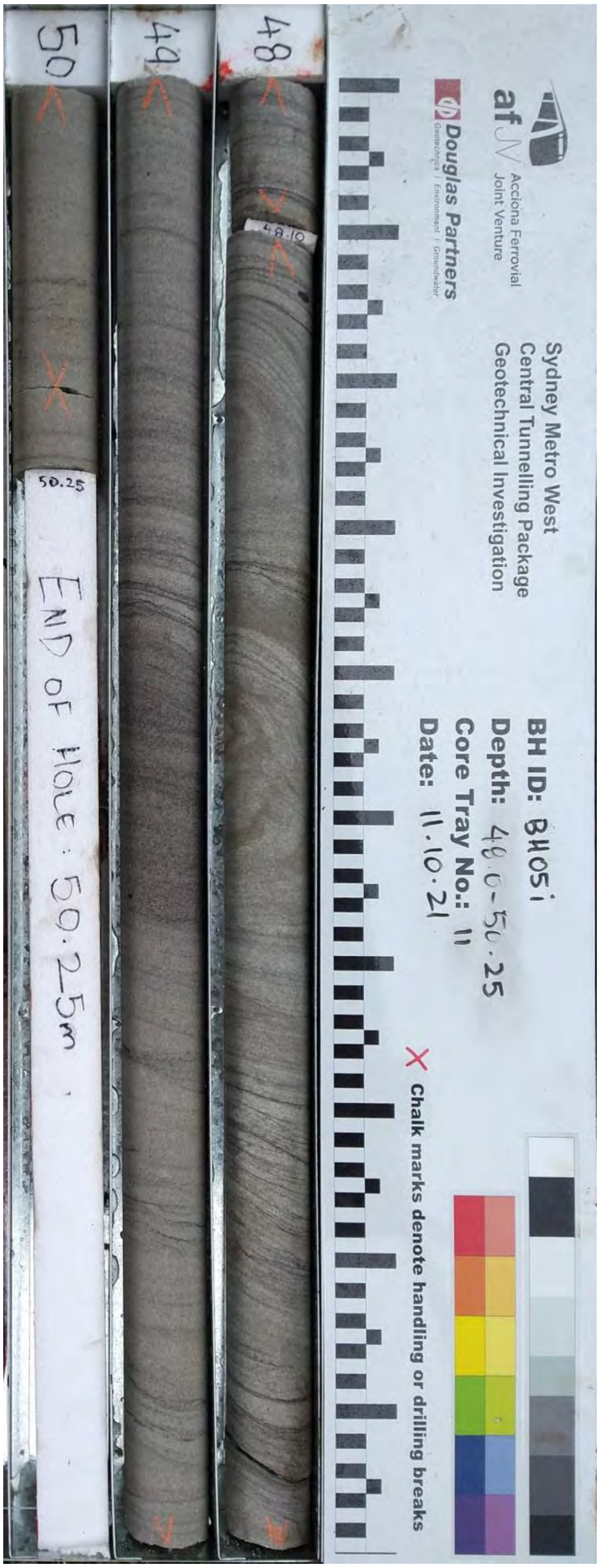
HOLE NO : **AF_BH05i**
FILE / JOB NO : 207139.00
SHEET : 12 OF 12

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331569 , N:6251076 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 62°

RIG TYPE : Explora 140 MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : SS

DATE STARTED : 1-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 1-10-21 LOGGED BY : AD CHECKED BY : DEM



NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 1 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110.0, N: 331455.9 (56 MGA94)   SURFACE ELEVATION : 2.95 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck   CONTRACTOR : Ground Test   DRILLER : GM
DATE STARTED : 6-10-21   DATE COMPLETED : 12-10-21   DATE LOGGED : 6-10-21   LOGGED BY : TM   CHECKED BY : DEM

DRILLING

PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)
DT					0.0	3.0
NDD		F		0.30m D 0.40m 0.60m D 0.70m 0.90m D 1.00m	1.0	2.0
				1.40m D 1.50m		
AD/T		E	3-10-21 14-10-21	1.90m D 2.00m 2.00m SPT 4, 5, 4 N=9 2.45m	2.0	1.0
WB HW Casing	0-5%			2.90m D 3.00m 3.00m U75 3.40m	3.0	0.0
					4.0	-1.1
				4.50m SPT 4, 2, 1 N*=3 4.95m	5.0	-2.1
				5.50m U75 5.90m		
				6.00m SPT 1, 0, 1 N*=1 6.45m	6.0	-3.1
				7.00m U75 7.20m	7.0	-4.1
				7.50m SPT 7, 9, 10 N=19 7.95m	8.0	-5.1

MATERIAL

Depth	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.05m		ASPHALTIC CONCRETE			FILL
0.17m		CONCRETE SLAB			
0.55m		FILL: sandy GRAVEL: grey, fine to coarse gravel, sub-rounded to sub-angular, igneous, fine to coarse grained sand	D to M		
1.80m		FILL: gravelly SAND: dark grey, fine to medium grained sand, fine to medium igneous gravel, trace charcoal, trace brick fragments			
2.80m	SP	SAND: yellow-brown, fine to medium grained sand, trace silt, trace shell fragments	M	L	ESTUARINE DEPOSITS 2.00: SPT Recovery: 0.45 m
7.10m	CH	CLAY: high plasticity, dark grey, trace silt, trace shell fragments	w~PL to w>PL	S to F	3.40: HP =65 kPa 4.50: SPT Recovery: 0.45 m 5.90: HP =60 kPa 6.00: SPT Recovery: 0.25 m
	SP	SAND: pale grey, fine to medium grained sand, trace clay	W	MD	ALLUVIUM 7.50: SPT Recovery: 0.45 m

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 2 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110.0, N: 331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

DRILLING

DRILLING & CASING	WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS
WB HW Casing	0-5%	E (to 15.50m) H (15.50m)	

SAMPLES & FIELD TESTS
9.00m SPT 0, 0, 1 N*=1 9.45m
10.00m U75 10.40m
10.50m SPT 6, 3, 2 N*=5 10.95m
11.50m U75 11.90m
11.90m U75 12.30m
12.30m SPT 1, 1, 3 N*=4 12.75m
13.00m U75 13.40m
13.40m SPT 1, 1, 1 N*=2 13.85m
14.50m U75 14.90m
14.90m SPT 0, 1, 1 N*=2 15.35m
15.50m SPT 30/60mm N=R 15.56m

DEPTH (m)	RL (m AHD)
8.0	-5.1
9.0	-6.1
10.0	-7.1
11.0	-8.1
12.0	-9.1
13.0	-10.1
14.0	-11.1
15.0	-12.1
16.0	-13.1

MATERIAL

Depth	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
to 8.80m	SP	SAND: pale grey, fine to medium grained sand, trace clay *(continued)*	W	MD	ALLUVIUM
8.80m – 12.30m	CL-CI	Sandy CLAY: low to medium plasticity, pale grey, fine to medium grained sand	w~PL	F to St	9.00: SPT Recovery: 0.45 m 9.45: HP =120 kPa 10.40: HP =120 kPa 10.50: SPT Recovery: 0.3 m 10.90: HP =110 kPa
12.30m – 13.40m	SC	Clayey SAND: grey and brown, fine to medium grained sand	W	VL to L	12.30: SPT Recovery: 0.45 m
13.40m – 15.50m	SP	SAND: grey, fine to medium grained sand, trace clay	W	VL to L	13.40: SPT Recovery: 0.32 m 14.90: SPT Recovery: 0.45 m
15.50m – 15.56m		SANDSTONE: apparently very low strength Continued as Cored Drill Hole			WEATHERED MATERIAL 15.50: SPT Recovery: 0 m

See Explanatory Notes for details of abbreviations & basis of descriptions.

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CORED DRILL HOLE LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 3 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110.0, N: 331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING						MATERIAL				FRACTURES		
PROGRESS												
DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
					8.0 *-5.1*							
					9.0 *-6.1*							
					10.0 *-7.1*							
					11.0 *-8.1*							
					12.0 *-9.1*							
					13.0 *-10.1*							
					14.0 *-11.1*							
					15.0 *-12.1*							
							15.56m START CORING AT 15.56m					
HQ3	0-5%	0% LOSS 16.02	100	Is(50) d=0.17 a=0.13 Is(50) d=0.14 a=0.27		· · ·	SANDSTONE: fine to medium grained, orange-brown, distinct and indistinct bedding 0-5°	MW	● ●			
					16.0 *-13.1*							

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CORED DRILL HOLE LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 4 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

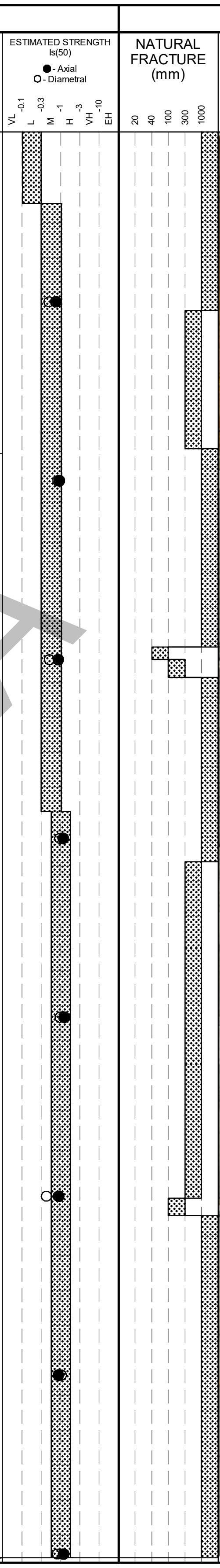
POSITION : E: 6251110.0, N: 331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING

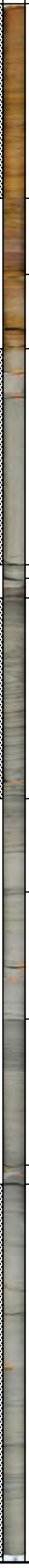
DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)
HQ3	0-5%	0% LOSS	100		16.0 -13.1
				Is(50) d=0.48 a=0.72	17.0 -14.1
		17.90		Packer Test =1.3uL	
		0% LOSS	98	Is(50) d=0.81 a=0.89	18.0 -15.1
				Is(50) d=0.49 a=0.83	19.0 -16.1
				Is(50) d=0.91 a=1.12	20.0 -17.1
		20.92			
		0% LOSS	100	Is(50) d=0.93 a=1.19	21.0 -18.1
				Is(50) d=0.41 a=0.85	22.0 -19.1
				Is(50) d=1 a=0.84	23.0 -20.1
		23.96		Is(50) d=0.79 a=1.14	24.0 -21.1

MATERIAL

Depth	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering
	SANDSTONE: fine to medium grained, orange-brown, distinct and indistinct bedding 0-5° *(continued)*	MW
17.80m	SANDSTONE: medium to coarse grained, pale grey, massive	F
18.87m	SANDSTONE: medium to coarse grained, pale grey, indistinct bedding at 5-10° 19.18-19.50m: disturbed bedding 20.40-21.21m: 1-5% carbonaceous laminations, 1% siltstone flecks, indistinct bedding at 0-5°	
21.21m	SANDSTONE: fine to medium grained, pale grey, indistinct bedding at 5-10°, 5-10% carbonaceous laminations to 22.20m depth 23.40-23.60m: 5% carbonaceous laminations at 0-5°	
23.97m		



FRACTURES



ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

- 17.00: BP 0° Fe SN PR RF
- 17.39: BP 0° Fe SN PR RF
- 17.77: BP 5° X CT PR RF 4mm
- 18.88: XS 5° Clay 10mm
- 18.95: BP 5° Clay VNR PR RF
- 19.05: BP 0° Clay VNR PR RF
- 20.08: BP 0° Clay VNR PR RF
- 20.56: BP 5° X CT PR RF 1mm
- 21.21: BP 5° Clay CT PR RF 4mm
- 21.96: BP 5° X VNR PR RF
- 22.06: BP 5° X VNR PR RF

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RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH06.GPJ <<DrawingFile>> 22-Oct-2021 18:55 10.02.00.04 Datgel Tools

CORED DRILL HOLE LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 5 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

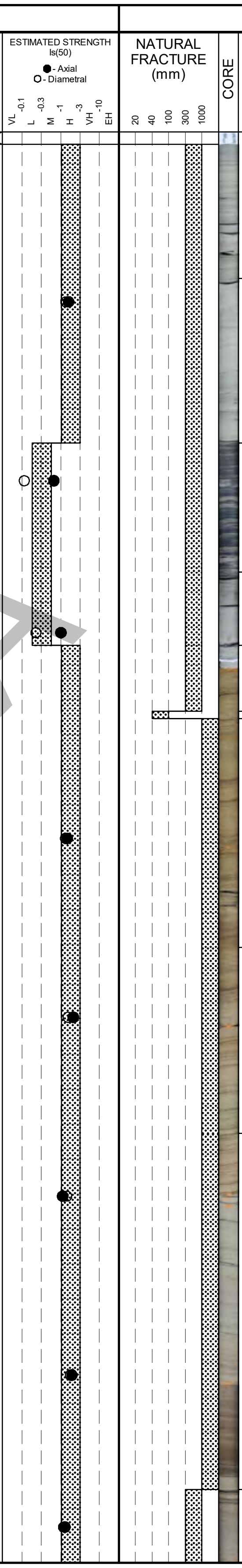
POSITION : E: 6251110.0, N: 331455.9 (56 MGA94)   SURFACE ELEVATION : 2.95 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck   CONTRACTOR : Ground Test   DRILLER : GM
DATE STARTED : 6-10-21   DATE COMPLETED : 12-10-21   DATE LOGGED : 6-10-21   LOGGED BY : TM   CHECKED BY : DEM
CASING DIAMETER : HW   BARREL (Length) : 3.00 m   BIT : 4 Step Face   BIT CONDITION : Good

DRILLING

DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)
HQ3	0-5%	3% LOSS	97		24.0 / -21.1
				Is(50) d=1.29 a=1.53	25.0 / -22.1
	30-40%			Is(50) d=0.11 a=0.64	26.0 / -23.1
		26.92		Packer Test =65uL; Is(50) d=0.22 a=0.97	
		0% LOSS	98		27.0 / -24.1
				Packer Test =13uL; Is(50) d=1.26 a=1.4	28.0 / -25.1
				Is(50) d=1.47 a=2.01	29.0 / -26.1
		29.92			
		0% LOSS	100	Is(50) d=1.38 a=1.07	30.0 / -27.1
				Packer Test =1.3uL; Is(50) d=1.68 a=1.85	31.0 / -28.1
				Is(50) d=1.13 a=1.23	32.0 / -29.1

MATERIAL

Depth	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering
24.07m	CORE LOSS 0.10m (23.97-24.07) *(continued)*	
	SANDSTONE: fine to medium grained, pale grey, indistinct bedding at 0-10°	F
25.74m	INTERLAMINATED SILTSTONE AND SANDSTONE: 70% dark grey siltstone interlaminated with 30% pale grey, fine grained sandstone laminations up to 20mm	
26.87m	SANDSTONE: medium to coarse grained, pale grey, irregular, indistinct bedding at 5-10°, with 5% siltstone laminations to 28.34m	
	29.30-30.70m: irregular, indistinct bedding at 10-20°	
31.50m	SANDSTONE: fine to medium grained, pale grey and grey, distinct and indistinct bedding at 0-10°, 1% carbonaceous laminations, 1% siltstone clasts up to 20mm diameter	



FRACTURES

ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]

24.82: BP 0° Clay VNR CU RF
25.74: XS 0° Clay 5mm
26.46: BP 0° Clay VNR PR RF
26.87: XS 5° Clay 10mm
27.24: BP 10° X VNR UN RF
27.28: BP 5° X VNR UN RF
28.56: BP 0° Clay CT PR RF 2mm
29.60: BP 10° Clay VNR PR RF
31.59: BP 5° X CT UN RF 1mm

RevA

RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH06.GPJ <<DrawingFile>> 22-Oct-2021 18:55 10.02.00.04 Datgel Tools

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CORED DRILL HOLE LOG

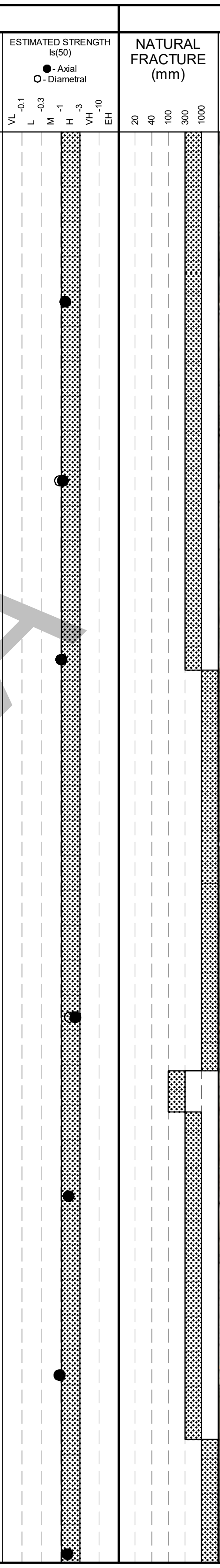
HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 6 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110.0, N: 331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : 3.00 m BIT : 4 Step Face BIT CONDITION : Good

DRILLING: PROGRESS: DRILLING & CASING: HQ3; WATER LOSS: 30-40%

DEPTH (m)	RL (m AHD)	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
32.0	-29.1	0% LOSS	100		SANDSTONE: fine to medium grained, pale grey and grey, distinct and indistinct bedding at 0-10°, 1% carbonaceous laminations, 1% siltstone clasts up to 20mm diameter *(continued)*	F	
							32.42: BP 5° X VNR PR RF
							32.79: BP 5° Clay VNR PR RF
		32.96					
33.0	-30.1	0% LOSS	100	Is(50) d=1.29 a=1.26	32.95-33.70m: disturbed bedding		
33.70m				Packer Test =1.3uL	SANDSTONE: fine to medium grained, pale grey, irregular, distinct and indistinct bedding at 5-10°, with 1-5% carbonaceous laminations and 1-5% siltstone flecks and clasts		
34.0	-31.1			Is(50) d=0.91 a=1.1			
							34.77: BP 5° Clay VNR PR RF
35.0	-32.1			Is(50) d=0.97 a=1.02			35.01: BP 0° Clay VNR PR RF
		35.96					
36.0	-33.1	0% LOSS	100				
							36.20: BP 0-5° X VNR UN RF
37.0	-34.1			Packer Test =1.6uL Is(50) d=1.62 a=2.3			
							37.25: BP 5° Clay VNR PR RF
							37.48: BP 0-5° Clay VNR UN RF
							37.79: BP 5° Clay VNR PR RF
38.0	-35.1			Is(50) d=1.56 a=1.53			
							38.32: BP 0-5° Clay VNR UN RF
		38.90					
39.0	-36.1	0% LOSS	100	Is(50) d=0.88 a=0.91			
							39.31: BP 5° X VNR PR RF
39.71m					SANDSTONE: fine to medium grained, pale grey, massive, <1% carbonaceous laminations		
40.0	-37.1			Is(50) d=1.38 a=1.47			



RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH06.GPJ <<DrawingFile>> 22-Oct-2021 18:55 10.02.00.04 Datgel Tools

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CORED DRILL HOLE LOG

HOLE NO : AF_BH06
FILE / JOB NO : 207319.00
SHEET : 7 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110.0, N: 331455.9 (56 MGA94)   SURFACE ELEVATION : 2.95 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower Scout   MOUNTING : Truck   CONTRACTOR : Ground Test   DRILLER : GM
DATE STARTED : 6-10-21   DATE COMPLETED : 12-10-21   DATE LOGGED : 6-10-21   LOGGED BY : TM   CHECKED BY : DEM
CASING DIAMETER : HW   BARREL (Length) : 3.00 m   BIT : 4 Step Face   BIT CONDITION : Good

DRILLING						MATERIAL				FRACTURES		
PROGRESS												
DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
	30-40%	0% LOSS 40.40	100	Is(50) d=1.29 a=1.01	40.0 -37.1	40.40m	SANDSTONE: fine to medium grained, pale grey, massive, <1% carbonaceous laminations *(continued)*	F	●			
					41.0 -38.1 42.0 -39.1 43.0 -40.1 44.0 -41.1 45.0 -42.1 46.0 -43.1 47.0 -44.1 48.0 -45.1		BOREHOLE AF_BH06 TERMINATED AT 40.40 m Target depth Hole grouted					

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CORE PHOTOGRAPHS

HOLE NO : AF_BH06
FILE / JOB NO : 207139.00
SHEET : 1 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM

DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 2 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM

DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 3 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM

DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 4 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

BH ID: AF_BH06
Depth: 27.00-31.00
Core Tray No.: 4
Date: 11/10/21

× Chalk marks denote handling or drilling breaks

CORE PHOTOGRAPHS

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 5 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM
DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 6 OF 7

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM

DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM

CORE PHOTOGRAPHS

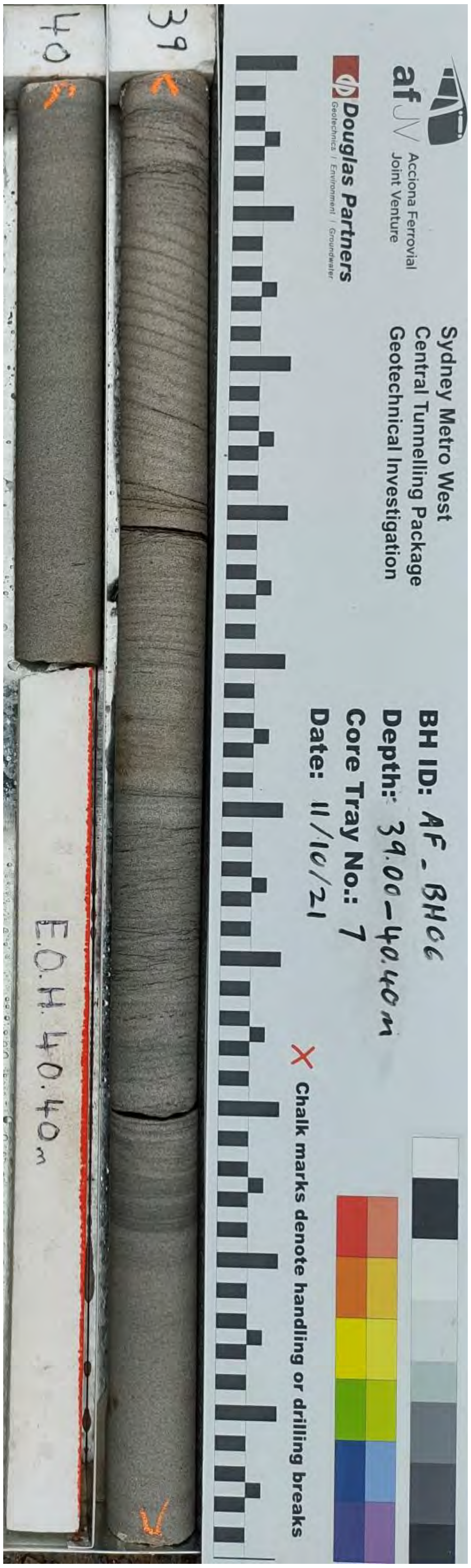
PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

HOLE NO : **AF_BH06**
FILE / JOB NO : 207139.00
SHEET : 7 OF 7

POSITION : E: 6251110 , N:331455.9 (56 MGA94) SURFACE ELEVATION : 2.95 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hydrapower MOUNTING : Truck CONTRACTOR : Ground Test DRILLER : GM

DATE STARTED : 6-10-21 DATE COMPLETED : 12-10-21 DATE LOGGED : 6-10-21 LOGGED BY : TM CHECKED BY : DEM



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BOREHOLE NUMBER S02_D

PAGE 1 OF 2

PROJECT NAME Sydney Metro Detailed Site Investigation

PROJECT NUMBER S18317 **PROJECT LOCATION** White Bay, Sydney, NSW

DATE STARTED 10/3/21 **COMPLETED** 16/3/21 **LOGGED BY** LW and ZS **CHECKED BY** SMS

CONTRACTOR Terratest - Geoprobe **LOCATION (Easting, Northing, Zone)** 331460.68 6251155.41 56H

EQUIPMENT Concrete Core, NDD, Hollow Flight Auger **DIMENSIONS** 150mm **INCLINATION** Vertical

GROUNDWATER NOTES Water Inflow at 2.8 m **CASING LEVEL** 3.000 mAHD **SURFACE LEVEL** 3.110 mAHD

GENERAL NOTES

DRILLING							FIELD MATERIAL DESCRIPTION			SAMPLING	
Method	Core Recovery (%)	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Additional Observations	PID (ppm)	Sample ID & Interval (QA/QC)
CC				3			FILL	FILL: ASPHALT, good condition.			
NDD							FILL	FILL: Sandy GRAVEL, medium to coarse grained, poorly graded, sub-angular gravel, medium to coarse grained, poorly graded, sub-angular sand, black with dark yellow, very dense, wet, anthropogenic material including ballast.			
				2	1		FILL	FILL: Silty SAND, fine to medium grained, poorly graded, sub-rounded sand, low plasticity silt, dark brown to black, dense, moist, anthropogenic material including trace glass fragments and ash.			
HFA								Medium to coarse grained, sub-angular sand, minor shell fragments, dark grey to black, no glass or ash observed.			
				1	2		FILL	FILL: Gravelly SAND, medium grained, poorly graded, sub-rounded to sub-angular sand, fine grained, poorly graded, sub-rounded to sub-angular gravel, dark brown, medium dense, moist.			
		▶						Coarse grained, minor shells, dark yellow, dense.			
				0	3		FILL	FILL: Sandy CLAY, low plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, dark grey, firm, moist, near plastic limit.			
							FILL	FILL: SAND, coarse grained, poorly graded, sub-rounded to sub-angular sand, minor shells, light grey, dense, wet.			
				-1	4		FILL	FILL: Sandy SILT, non-plastic, fine to medium grained, poorly graded, sub-rounded sand, dark brown, dense, wet, wet of liquid limit.			
							FILL	FILL: Sandy CLAY, medium plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, minor shells, dark grey, firm, moist, near liquid limit .			
				-2	5		FILL	FILL: Silty SAND, medium grained, poorly graded, sub-rounded to sub-angular sand, non-plastic silt, minor shells, dark grey, dense, wet.	No odour, no staining		
				-3	6		CI	Sandy CLAY: Medium plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, dark grey, firm, moist, near liquid limit .			
							SM	Silty SAND: Medium grained, poorly graded, sub-rounded to sub-angular sand, non plastic silt, minor shells, dark grey, dense, wet.			
				-4	7					0.2	
				-5	8						
				-6	9					0.3	
					10						

These logs have been prepared for environmental purposes and should not be used for geotechnical design and interpretive purposes senversa

BOREHOLE NUMBER S02_D

PROJECT NAME Sydney Metro Detailed Site Investigation

PROJECT NUMBER S18317 **PROJECT LOCATION** White Bay, Sydney, NSW

DATE STARTED 10/3/21 **COMPLETED** 16/3/21 **LOGGED BY** LW and ZS **CHECKED BY** SMS

CONTRACTOR Terratest - Geoprobe **LOCATION (Easting, Northing, Zone)** 331460.68 6251155.41 56H

EQUIPMENT Concrete Core, NDD, Hollow Flight Auger **DIMENSIONS** 150mm **INCLINATION** Vertical

GROUNDWATER NOTES Water Inflow at 2.8 m **CASING LEVEL** 3.000 mAHD **SURFACE LEVEL** 3.110 mAHD

GENERAL NOTES

DRILLING							FIELD MATERIAL DESCRIPTION			SAMPLING	
Method	Core Recovery (%)	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Additional Observations	PID (ppm)	Sample ID & Interval (QA/QC)
HFA				-7			SM	Silty SAND: Medium grained, poorly graded, sub-rounded to sub-angular sand, non plastic silt, minor shells, dark grey, dense, wet. *(continued)*			
					11						
				-8				No shell fragments.		0.3	
					12						
				-9				Pale grey		0.3	
									No odour, no staining		
					13						
				-10						0.4	
					14						
				-11						0.4	
					15						
				-12						0.4	
								S02_D terminated at 15.10 m bgl Target depth achieved.			
					16						
				-13							
					17						
				-14							
					18						
				-15							
					19						
				-16							
					20						

BOREHOLE NUMBER S06

PAGE 1 OF 3

PROJECT NAME Sydney Metro Detailed Site Investigation

PROJECT NUMBER S18317 **PROJECT LOCATION** White Bay, Sydney, NSW

DATE STARTED 20/4/21 **COMPLETED** 20/4/21 **LOGGED BY** LW **CHECKED BY** VR

CONTRACTOR Terratest - Sonic Rig **LOCATION (Easting, Northing, Zone)** 331417.04 6251088.99 56H

EQUIPMENT Concrete Core, NDD, Sonic **DIMENSIONS** 150mm **INCLINATION** Vertical

GROUNDWATER NOTES Water Inflow at 2.8 m **CASING LEVEL** 3.040 mAHD **SURFACE LEVEL** 3.130 mAHD

GENERAL NOTES

DRILLING

Method: CC, NDD, SON

RL (m): 3, 2, 1, 0, -1, -2, -3, -4, -5, -6

Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

FIELD MATERIAL DESCRIPTION

Classification Symbol	Material Description	Additional Observations
FILL	FILL: ASPHALT, good condition.	No odour, no staining
FILL	FILL: Sandy Silty GRAVEL, medium to coarse grained, poorly graded, sub-angular to angular gravel, medium grained, poorly graded, sub-angular to angular sand, non plastic silt, dark grey, very dense, moist, anthropogenic material including trace asphalt fragments.	
FILL	FILL: Gravelly SAND, medium to coarse grained, poorly graded, sub-angular to angular sand, fine grained, poorly graded, sub-rounded to sub-angular gravel, dark yellow, medium dense, dry.	
FILL	FILL: Silty GRAVEL, coarse grained, poorly graded, sub-angular to angular gravel, non plastic silt, dark grey, very dense, moist.	
FILL	FILL: CONCRETE, good condition.	
FILL	FILL: Sandy GRAVEL, medium to coarse grained, poorly graded, sub-rounded to sub-angular gravel, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, yellow-brown with orange, dense, dry.	Black staining
FILL	FILL: Sandy CLAY, low plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, black mottled yellow, soft, moist, near plastic limit, anthropogenic material including trace ash.	No odour, no staining
FILL	FILL: Clayey SAND, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, low plasticity clay, dark grey mottled white, dense, moist, anthropogenic material including trace ash.	
FILL	FILL: SAND, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, dark orange-brown, dense, moist, trace shell fragments.	
FILL	FILL: Sandy SILT, low plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, dark grey to black, soft, moist, dry of plastic limit, trace organic matter (fur, suspected cow fur).	Black staining
FILL	FILL: Silty SAND, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, non plastic silt, dark grey, dense, moist.	No odour, no staining
FILL	FILL: Silty SAND, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, non plastic silt, dark grey, dense, moist.	
FILL	FILL: Clayey Silty SAND, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, low plasticity clay, dark grey, dense, wet, trace shells and organic matter (fur, suspected cow fur).	
	dark grey to black.	
CH	Sandy CLAY: High plasticity, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, pale grey, soft, moist, near plastic limit.	
	Firm.	
SC	Clayey SAND: Medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, low plasticity clay, pale grey, medium dense, wet.	
CH	Sandy CLAY: High plasticity, medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, pale grey, firm, moist, near plastic limit.	
SC	Clayey SAND: Medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, medium plasticity clay, pale grey, dense, wet.	

SAMPLING

PID (ppm)	Sample ID & Interval (QA/QC)
5.2	S06_0.10 - 0.15
4.6	S06_0.40 - 0.50
1.6	S06_1.10 - 1.30
0.8	S06_2.00 - 2.20
2.7	S06_3.00 - 3.20
2.8	S06_4.00 - 4.20
0.7	S06_5.00 - 5.20
2.2	S06_5.80 - 6.00
0.9	
1.6	
2.7	

1. SENVERSA STANDARD S18317_GINT FILE_20210521.GPJ SENVERSA_GINT.GDT 21/5/21

These logs have been prepared for environmental purposes and should not be used for geotechnical design and interpretive purposes

BOREHOLE NUMBER S06

PROJECT NAME Sydney Metro Detailed Site Investigation
PROJECT NUMBER S18317 **PROJECT LOCATION** White Bay, Sydney, NSW

DATE STARTED 20/4/21 **COMPLETED** 20/4/21 **LOGGED BY** LW **CHECKED BY** VR
CONTRACTOR Terratest - Sonic Rig **LOCATION (Easting, Northing, Zone)** 331417.04 6251088.99 56H
EQUIPMENT Concrete Core, NDD, Sonic **DIMENSIONS** 150mm **INCLINATION** Vertical
GROUNDWATER NOTES Water Inflow at 2.8 m **CASING LEVEL** 3.040 mAHD **SURFACE LEVEL** 3.130 mAHD
GENERAL NOTES

DRILLING							FIELD MATERIAL DESCRIPTION			SAMPLING	
Method	Core Recovery (%)	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Additional Observations	PID (ppm)	Sample ID & Interval (QA/QC)
SON				-7			SC	Clayey SAND: Medium to coarse grained, poorly graded, sub-rounded to sub-angular sand, medium plasticity clay, pale grey, dense, wet. *(continued)*		2.6	
				-8	11					2.9	
				-9	12		SC	Low plasticity clay, pale grey mottled dark orange.		3.2	
				-10	13		CL	Sandy CLAY: Low plasticity, fine to medium grained, poorly graded, sub-rounded to sub-angular sand, dark orange mottled dark yellow, very stiff, moist, near plastic limit.		3.4	
							SANDSTONE	SANDSTONE: Low strength, highly weathered, dark orange with white, indistinct lamination. (Hawkesbury Sandstone).			
				-11	14			Medium strength, moderately weathered, pale orange becoming dark yellow.		5.2	
				-12	15				No odour, no staining	3.4	
				-13	16						
				-14	17						
				-15	18						
				-16	19						
					20						

1. SENVERSA STANDARD S18317_GINT FILE_20210521.GPJ SENVERSA_GINT.GDT 21/5/21

BOREHOLE NUMBER S06

PROJECT NAME Sydney Metro Detailed Site Investigation
PROJECT NUMBER S18317 **PROJECT LOCATION** White Bay, Sydney, NSW

DATE STARTED 20/4/21 **COMPLETED** 20/4/21 **LOGGED BY** LW **CHECKED BY** VR
CONTRACTOR Terratest - Sonic Rig **LOCATION (Easting, Northing, Zone)** 331417.04 6251088.99 56H
EQUIPMENT Concrete Core, NDD, Sonic **DIMENSIONS** 150mm **INCLINATION** Vertical
GROUNDWATER NOTES Water Inflow at 2.8 m **CASING LEVEL** 3.040 mAHD **SURFACE LEVEL** 3.130 mAHD
GENERAL NOTES

DRILLING							FIELD MATERIAL DESCRIPTION			SAMPLING	
Method	Core Recovery (%)	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Additional Observations	PID (ppm)	Sample ID & Interval (QA/QC)
				-17				Medium strength, moderately weathered, pale orange becoming dark yellow. *(continued)*			
								S06 terminated at 20.44 m bgl Target depth achieved.			
					21						
				-18							
					22						
				-19							
					23						
				-20							
					24						
				-21							
					25						
				-22							
					26						
				-23							
					27						
				-24							
					28						
				-25							
					29						
				-26							
					30						

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 1 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N: 6251143.1 (56 MGA94)   SURFACE ELEVATION : 3.45 (mAHD)   ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8   MOUNTING : Track   CONTRACTOR : Rockwell   DRILLER : EM
DATE STARTED : 29-9-21   DATE COMPLETED : 5-10-21   DATE LOGGED : 29-9-21   LOGGED BY : NB   CHECKED BY : DEM

DRILLING

PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS
DT NDD DT HW Casing		H		
NDD		F		0.80m D 0.90m 1.40m D 1.50m
AD/T		E	05-10-21 01-10-21	1.50m SPT 1, 4, 3 N=7 1.95m 2.00m D 2.10m 2.50m U75 2.90m 3.00m SPT 0, 1, 2 N*=3 3.45m 4.00m U75 4.37m 4.40m SPT 1, 1, 3 N*=4 4.85m
WB	0-5%			5.50m SPT 2, 3, 3 N*=6 5.95m 6.50m U75 6.90m 6.90m SPT 0, 0, 0 N*=0 7.35m

DEPTH (m) / RL (m AHD): 0.0 / 3.4; 1.0 / 2.4; 2.0 / 1.4; 3.0 / 0.4; 4.0 / -0.6; 5.0 / -1.6; 6.0 / -2.6; 7.0 / -3.6; 8.0 / -4.6

MATERIAL

Depth	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	CLASSIFICATION SYMBOL	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.05m	ASPHALTIC CONCRETE				FILL
0.10m	CONCRETE SLAB				
0.33m	FILL: sandy GRAVEL: grey-brown, fine to coarse gravel, igneous, fine to coarse sand, trace brick fragments		M		
	CONCRETE SLAB				
0.71m	FILL: gravelly clayey SAND: grey-brown, fine to medium grained sand, fine to coarse igneous gravel, trace charcoal		M		1.50: SPT Recovery: 0 m
2.00m	FILL: sandy CLAY: low plasticity, dark grey, fine to coarse sand, trace ash				
2.50m	Peaty CLAY: high plasticity, dark grey, with shell fragments	CH-OH	w~PL	VS to S	ESTUARINE DEPOSITS 2.90: HP =60 kPa 3.00: SPT Recovery: 0.45 m 3.45: HP =40 kPa
4.00m	SAND: dark grey, medium to coarse grained sand, trace silt, trace shell fragments	SP	W	L	4.37: HP =80 kPa 4.40: SPT Recovery: 0.45 m
5.50m	Sandy CLAY: low to medium plasticity, dark grey-brown, fine to medium sand, trace shell fragments, trace organic matter	CL-CI	w~PL	F	5.50: SPT Recovery: 0.45 m 5.90: HP =100 kPa
6.90m	CLAY: high plasticity, dark grey-brown, trace sand	CH		VS to S	6.90: HP =60 kPa 6.90: SPT Recovery: 0.45 m 7.30: HP =80 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

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Geotechnics / Environment / Groundwater

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 2 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N: 6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 29-9-21 LOGGED BY : NB CHECKED BY : DEM

DRILLING

PROGRESS: DRILLING & CASING: WB, HW Casing; WATER LOSS: 0-5%

DRILLING PENETRATION: E (8.0–12.65 m); F (12.65–16.0 m)

GROUND WATER LEVELS: –

SAMPLES & FIELD TESTS
8.15m U75
8.42m SPT 8, 12, 14 N*=26 – 8.87m
9.65m U75
10.05m SPT 3, 3, 5 N*=8 – 10.50m
11.15m U75
11.55m SPT 7, 11, 11 N*=22 – 12.00m
12.65m U75
13.05m SPT 16, 26, 25 N*=51 – 13.50m
14.15m SPT 17, 10, 2 N*=12 – 14.60m
15.65m U

DEPTH (m)	RL (m AHD)
8.0	-4.6
9.0	-5.6
10.0	-6.6
11.0	-7.6
12.0	-8.6
13.0	-9.6
14.0	-10.6
15.0	-11.6
16.0	-12.6

MATERIAL

Depth to	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY
8.20m	CH	CLAY: high plasticity, dark grey-brown, trace sand *(continued)*	w~PL	VS to S
9.65m	SC	Clayey SAND: pale grey, fine to medium grained sand	W	MD
11.15m	CH	CLAY: high plasticity, dark grey, trace sand	w~PL	St
12.65m	SP	SAND: pale grey, fine to coarse grained sand, trace clay	W	D
13.25m	CH-OH	Peaty CLAY: medium to high plasticity, dark grey, with sand, organic odour	w~PL	St to VSt
14.45m	SP	SAND: pale grey, fine to coarse grained sand	W	D to VD
16.00m	CH-OH	Peaty CLAY: medium to high plasticity, dark grey, trace sand	w~PL	VS to S

STRUCTURE & Other Observations

ESTUARINE DEPOSITS
8.42: SPT Recovery: 0.35 m
10.05: HP =110 kPa
10.05: SPT Recovery: 0.45 m
10.50: HP =140 kPa
11.55: SPT Recovery: 0.45 m
13.05: SPT Recovery: 0.45 m
13.15: HP =110 kPa
14.15: SPT Recovery: 0.35 m
14.60: HP =60 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 3 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N: 6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 29-9-21 LOGGED BY : NB CHECKED BY : DEM

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
WB HW Casing	0-5%	H		16.00m 16.05m SPT 3, 14, 21/100mm HB N*=R 16.45m	16.0 -12.6 17.0 -13.6		SP	SAND: pale grey, fine to coarse grained sand	W	D to VD	ESTUARINE DEPOSITS 16.05: SPT Recovery: 0.34 m
				17.15m SPT 8, 11, 12 N*=23 17.60m 18.65m SPT 10, 13, 13 N*=26 19.10m	18.0 -14.6 19.0 -15.6 20.0 -16.6		CL-CI	17.15m Sandy CLAY: low to medium plasticity, pale grey, fine to medium sand	w~PL	VSt	RESIDUAL SOIL 17.15: SPT Recovery: 0.45 m 17.40: HP =310 kPa 18.65: SPT Recovery: 0.45 m 18.80: HP =380 kPa
				20.15m SPT 20/30mm HB N*=R 20.18m				20.10m SANDSTONE: fine to medium grained, pale orange and pale grey, apparently very low strength 20.30m			WEATHERED MATERIAL 20.15: SPT Recovery: 0.06 m
					21.0 -17.6 22.0 -18.6 23.0 -19.6 24.0 -20.6			Continued as Cored Drill Hole			

See Explanatory Notes for
details of abbreviations
& basis of descriptions.

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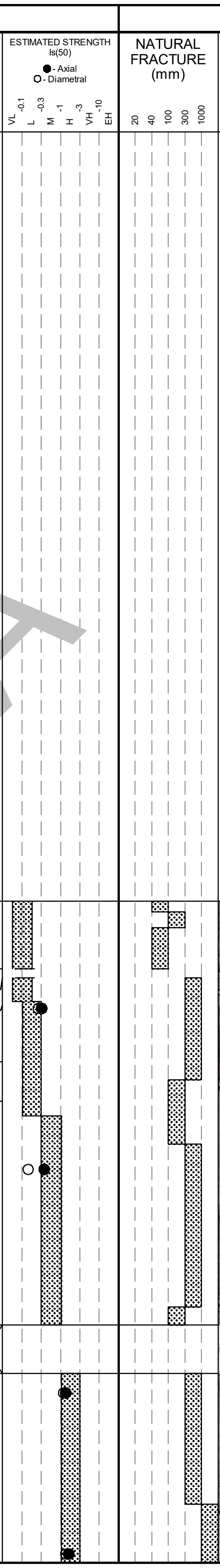
CORED DRILL HOLE LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 4 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N: 6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 29-9-21 LOGGED BY : NB CHECKED BY : DEM
CASING DIAMETER : HW BARREL (Length) : BIT : 4 Step Face BIT CONDITION : Good

DRILLING						MATERIAL					FRACTURES		
PROGRESS: DRILLING & CASING	WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) *RL (m AHD)*	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial ○ - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
					16.0 *-12.6*							
					17.0 *-13.6*							
					18.0 *-14.6*							
					19.0 *-15.6*							
					20.0 *-16.6*		20.30m START CORING AT 20.30m					
HQ3	0-5%	0% LOSS 20.80	0				SANDSTONE: fine to medium grained, pale orange and pale grey, distinct and indistinct bedding at 0-5°	HW XW HW MW				20.36: JT 80° Clay CT IR RF 8mm (20.30-20.45m) 20.45: BP 0° Clay VNR PR RF 1mm 20.52: JT 60° Clay CT IR RF 5mm (20.45-20.60m) 20.60: XS 10mm 20.68-20.73: XS 50mm
		8% LOSS	91	Is(50) d=0.25 a=0.31	21.0 *-17.6*			SW F				21.30: JT 60° Fe VNR PR RF 21.38: JT 60° Clay CT PR 2mm 21.66: JT 70° PR tight
				Is(50) d=0.14 a=0.36								21.94: JT 60-80° IR healed
					22.0 *-18.6*		22.20-22.67m: massive					22.57: JT 70° CN PR RF (22.48-22.67m)
	100%	22.80				22.67m	CORE LOSS 0.27m (22.67-22.94)					
		17% LOSS	83	Is(50) d=1.13 a=1.3	23.0 *-19.6*	22.94m	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-5°	F				
		23.70 0% LOSS	100	Is(50) d=1.29 a=1.54	24.0 *-20.6*							23.67: XS 10mm



RMS LIB 40.3.14.GLB Log RTA CORED DRILL HOLE 4 AF_BH08.GPJ <<DrawingFile>> 08-Oct-2021 18:40 10.02.00.04 Datgel Tools

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CORED DRILL HOLE LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 5 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

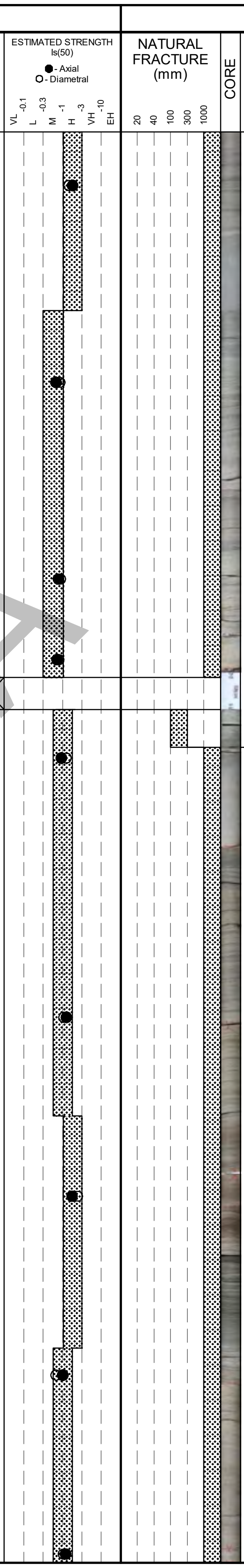
POSITION : E: 331501.9, N: 6251143.1 (56 MGA94)
SURFACE ELEVATION : 3.45 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : EM

DATE STARTED : 29-9-21
DATE COMPLETED : 5-10-21
DATE LOGGED : 29-9-21
LOGGED BY : NB
CHECKED BY : DEM

CASING DIAMETER : HW
BARREL (Length) :
BIT : 4 Step Face
BIT CONDITION : Good

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	MATERIAL: DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	FRACTURES: ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	100%	0% LOSS	100		24.0 -20.6	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-5° *(continued)*	F	
				Is(50) d=1.4 a=1.74				
						24.58-25.00m: massive		
					25.0 -21.6			
				Is(50) d=0.82 a=0.65				
					26.0 -22.6			
				Is(50) d=0.85 a=0.75				
		26.80						
		6% LOSS	94	Is(50) d=0.77 a=0.69	27.0 -23.6			
					27.05m	CORE LOSS 0.18m (27.05-27.23)		
					27.23m	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at at 0-5° 27.23-27.32m: coarse grained	F	
								27.44: BPx2 0-5° CN PR RF
				Is(50) d=1.19 a=0.89	27.47m	SANDSTONE: fine to medium grained, pale grey, massive, 1% carbonaceous flecks		
					28.0 -24.6			
					28.12m	SANDSTONE: medium to coarse grained, pale grey, distinct and indistinct bedding at 0-10°		
				Is(50) d=1.03 a=1.21	29.0 -25.6			
		29.80						
		0% LOSS	100	Is(50) d=2.32 a=1.68	30.0 -26.6			
					30.26m	SANDSTONE: fine to medium grained, pale grey, distinct and indistinct bedding at 0-5° 30.29-30.33m: siltstone bed		
					30.80m	SANDSTONE: medium to coarse grained, pale grey, indistinct bedding at 0-10°, 1-5% carbonaceous laminations and siltstone flecks		
				Is(50) d=0.65 a=0.97	31.0 -27.6			
						31.90-32.17m: 5% siltstone clasts up to 30mm		
				Is(50) d=1 a=1.14	32.0 -28.6			



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CORED DRILL HOLE LOG

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 6 OF 6

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

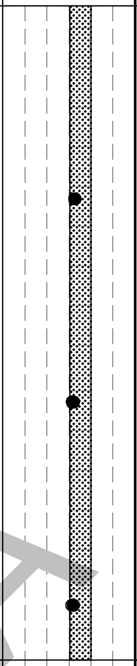
POSITION : E: 331501.9, N: 6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°

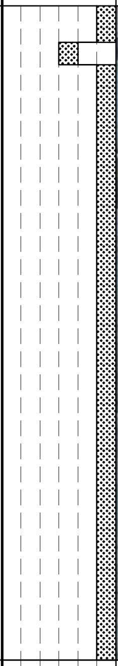
RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 29-9-21 LOGGED BY : NB CHECKED BY : DEM

CASING DIAMETER : HW BARREL (Length) : BIT : 4 Step Face BIT CONDITION : Good

DRILLING						MATERIAL				FRACTURES		
PROGRESS: DRILLING & CASING	PROGRESS: WATER LOSS	(CORE LOSS RUN %) DRILL DEPTH	RQD (%)	SAMPLES & FIELD TESTS	DEPTH (m) RL (m AHD)	GRAPHIC LOG	DESCRIPTION ROCK TYPE : Grain size, Colour, Structure (texture, fabric, mineral composition, hardness alteration, cementation, etc as applicable)	Weathering	ESTIMATED STRENGTH Is(50) ● - Axial O - Diametral VL -0.1 L -0.3 M -1 H -3 VH -10 EH	NATURAL FRACTURE (mm) 20 40 100 300 1000	CORE	ADDITIONAL DATA (joints, partings, seams, zones, etc) Description, apparent dip, infilling or coating, shape, roughness, thickness, other, [true dip, dip direction]
HQ3	100%	0% LOSS	100		32.0 -28.6		SANDSTONE: medium to coarse grained, pale grey, indistinct bedding at 0-10°, 1-5% carbonaceous laminations and siltstone flecks *(continued)* 32.18-32.29m: grey, fine grained, 10% carbonaceous laminations	F				32.18: BP 0° Clay CT PR RF 1mm 32.29: BP 0° Clay CT PR RF 1mm
		32.75										
		0% LOSS	100									
				Is(50) d=1.33 a=1.29	33.0 -29.6		Below 33.00m: distinctly and indistinctly bedded 0-10°					
							Below 33.75m: 5-10% carbonaceous laminations					
				Is(50) d=1.23 a=1.14	34.0 -30.6							
				Is(50) d=1.1 a=1.2	35.0 -31.6							
		35.22					35.22m					
							BOREHOLE AF_BH08 TERMINATED AT 35.22 m Target depth Groundwater well installed					
					36.0 -32.6							
					37.0 -33.6							
					38.0 -34.6							
					39.0 -35.6							
					40.0 -36.6							





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CORE PHOTOGRAPHS

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 1 OF 4

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N:6251143.1 (56 MGA94)
SURFACE ELEVATION : 3.45 (mAHD)
ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjn DB8
MOUNTING : Track
CONTRACTOR : Rockwell
DRILLER : EM

DATE STARTED : 29-9-21
DATE COMPLETED : 5-10-21
DATE LOGGED : 1-10-21
LOGGED BY : NB
CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 2 OF 4

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N:6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjn DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 1-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : **AF_BH08**
FILE / JOB NO : 207139.00
SHEET : 3 OF 4

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N:6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjn DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM

DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 1-10-21 LOGGED BY : NB CHECKED BY : DEM

CORE PHOTOGRAPHS

HOLE NO : AF_BH08
FILE / JOB NO : 207139.00
SHEET : 4 OF 4

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N:6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Hanjn DB8 MOUNTING : Track CONTRACTOR : Rockwell DRILLER : EM
DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 1-10-21 LOGGED BY : NB CHECKED BY : DEM

PIEZOMETER CONSTRUCTION

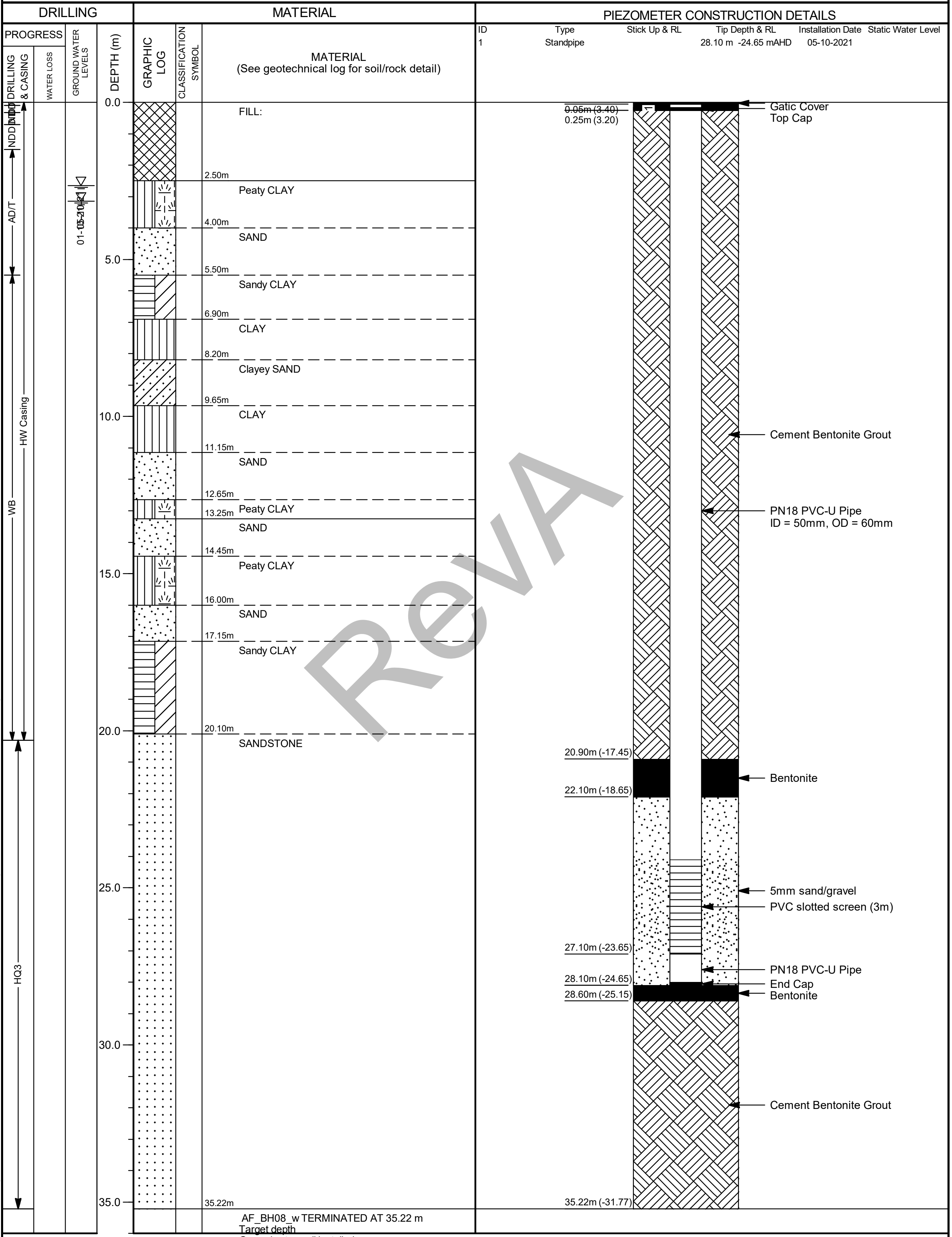
HOLE NO : AF_BH08_w
FILE / JOB NO : 207139.00
SHEET : 1 OF 1

PROJECT : Sydney Metro West - Central Package, The Bays to Sydney Olympic Park
LOCATION : White Bay

POSITION : E: 331501.9, N: 6251143.1 (56 MGA94) SURFACE ELEVATION : 3.45 (mAHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Hanjin DB8 MOUNTING : Track CONTRACTOR : Rockwell

DATE STARTED : 29-9-21 DATE COMPLETED : 5-10-21 DATE LOGGED : 1-10-21 LOGGED BY : NB CHECKED BY : DEM



ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
1	Standpipe		28.10 m -24.65 mAHD	05-10-2021	

AF_BH08_w TERMINATED AT 35.22 m
Target depth
Groundwater well installed

This report of well/VWP installation must be read in conjunction with accompanying notes and abbreviations. The geotechnical log is a summary only and the detailed log should be referred to for strata details and any core loss zones.

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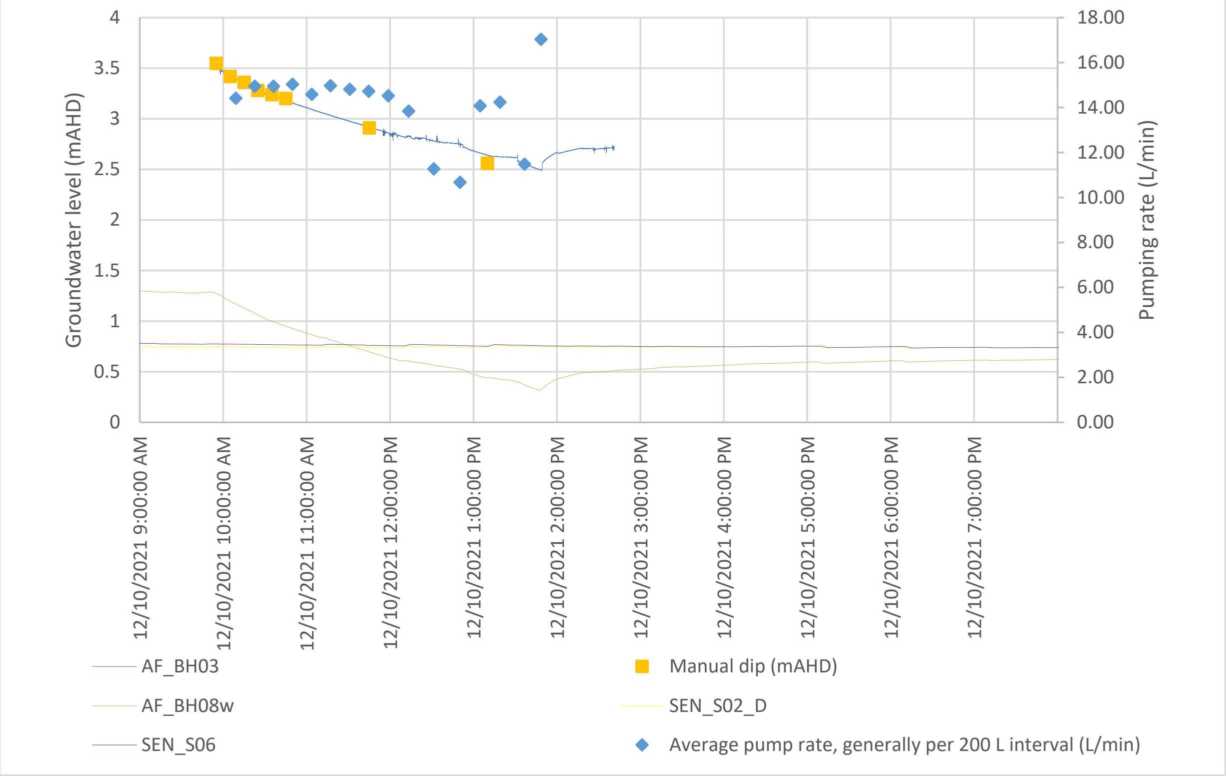
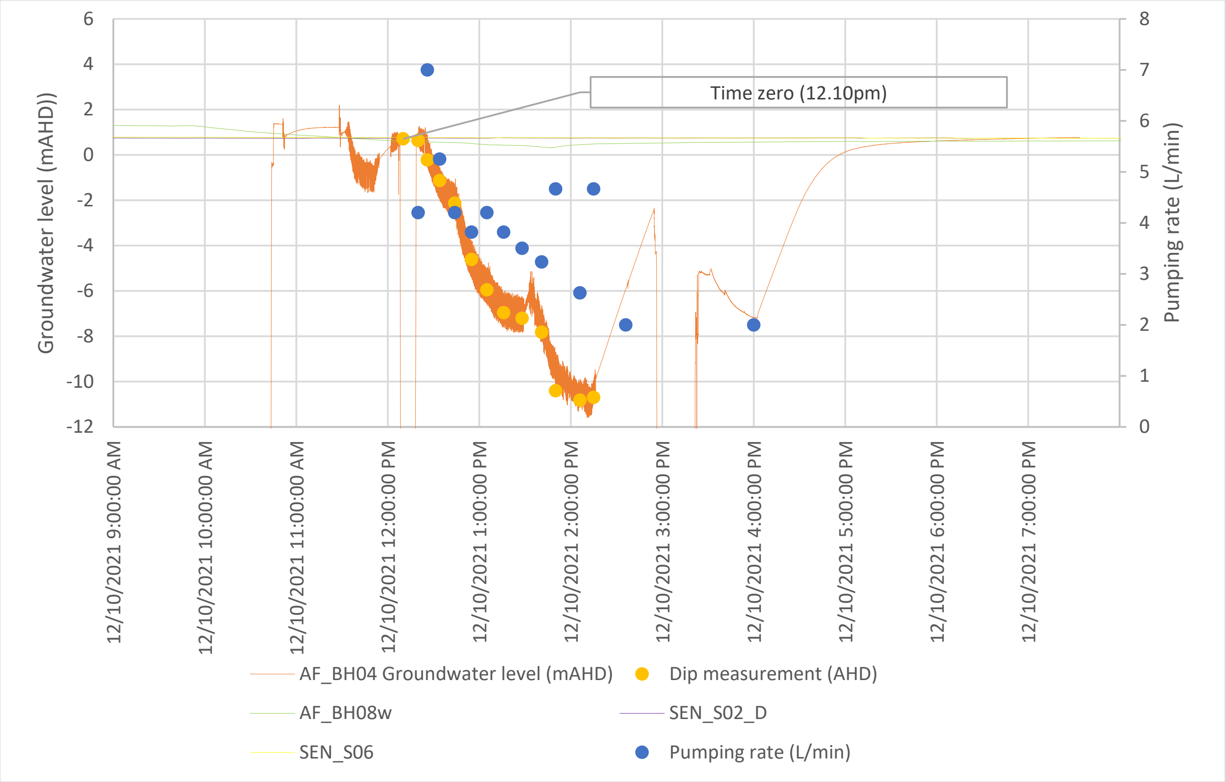
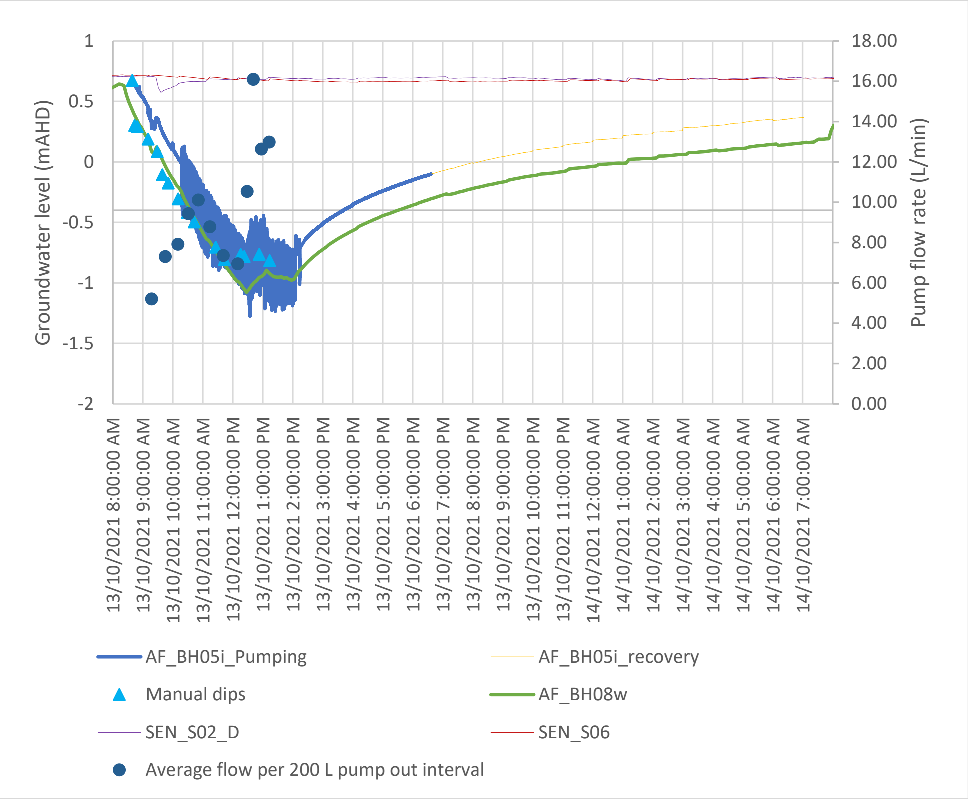
Appendix B – Groundwater level plots during pump out tests



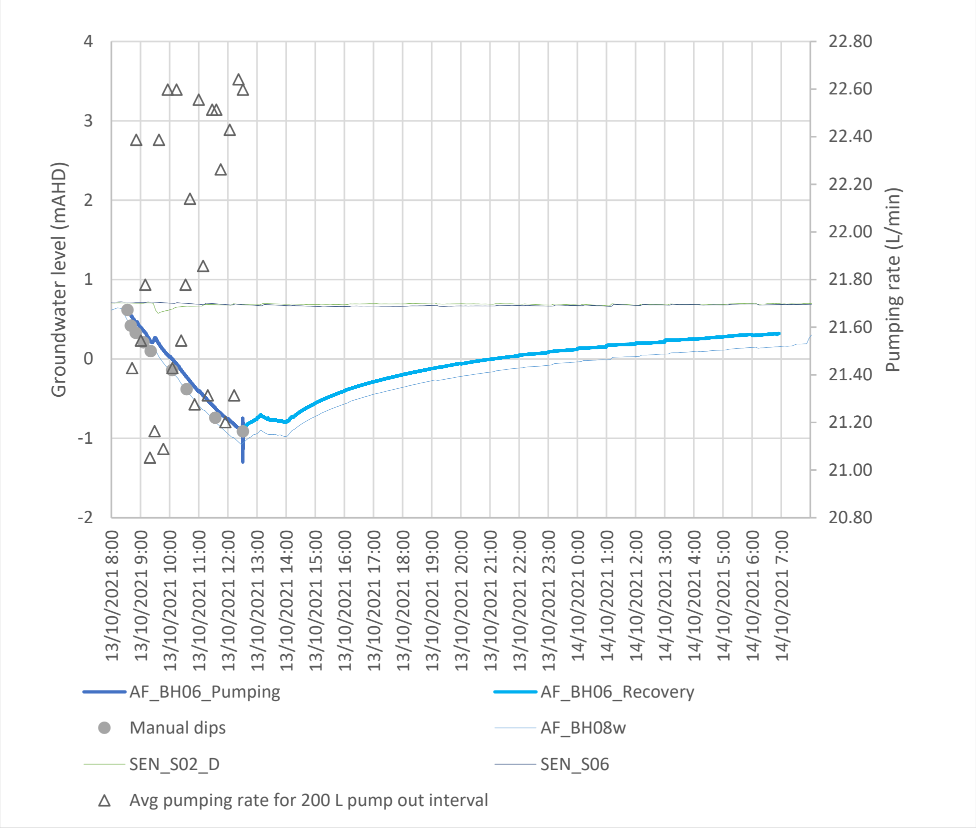
Pumping in AF_BH03_w



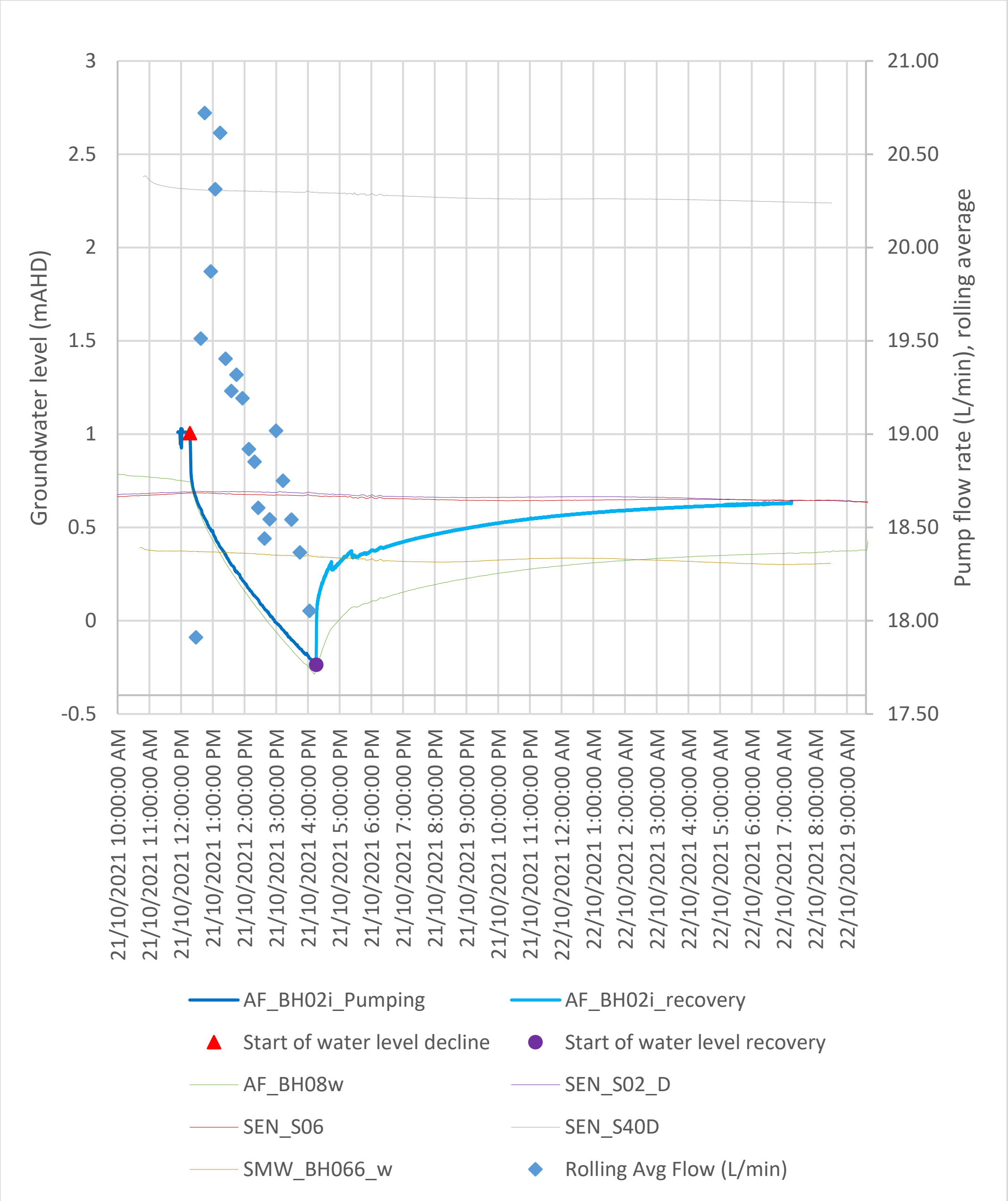
Pumping in AF_BH04



Pumping in AF_BH05i

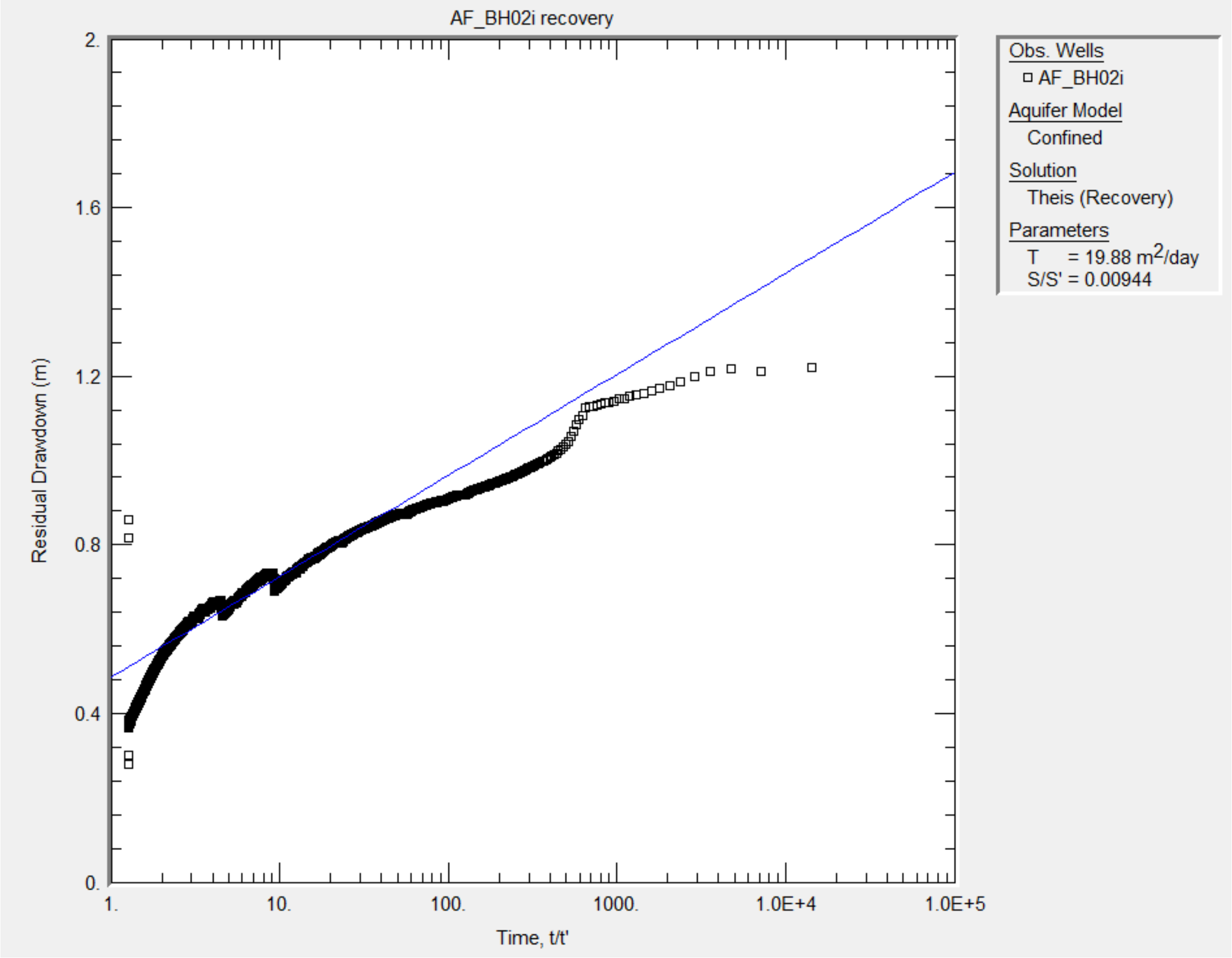


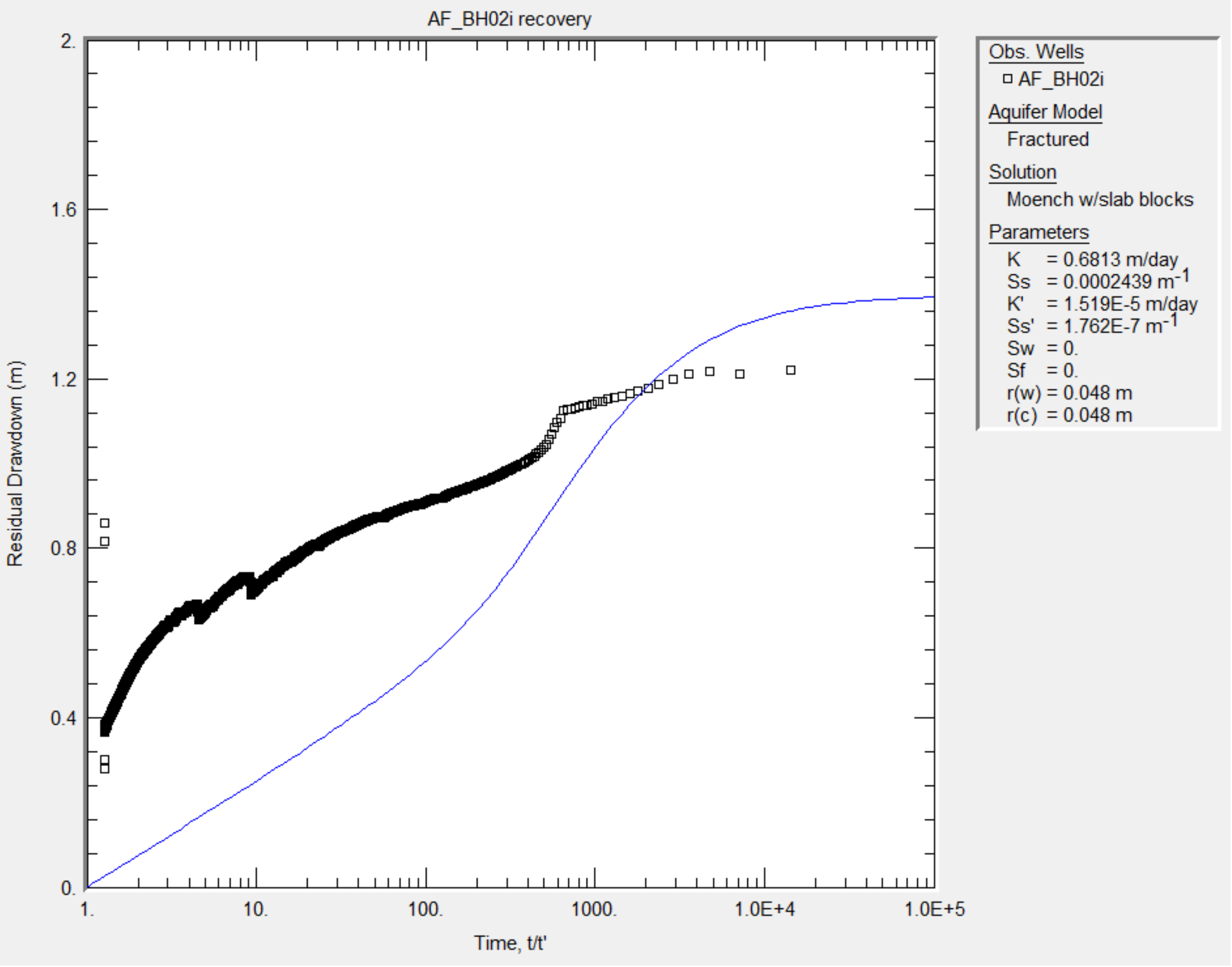
Pumping in AF_BH06

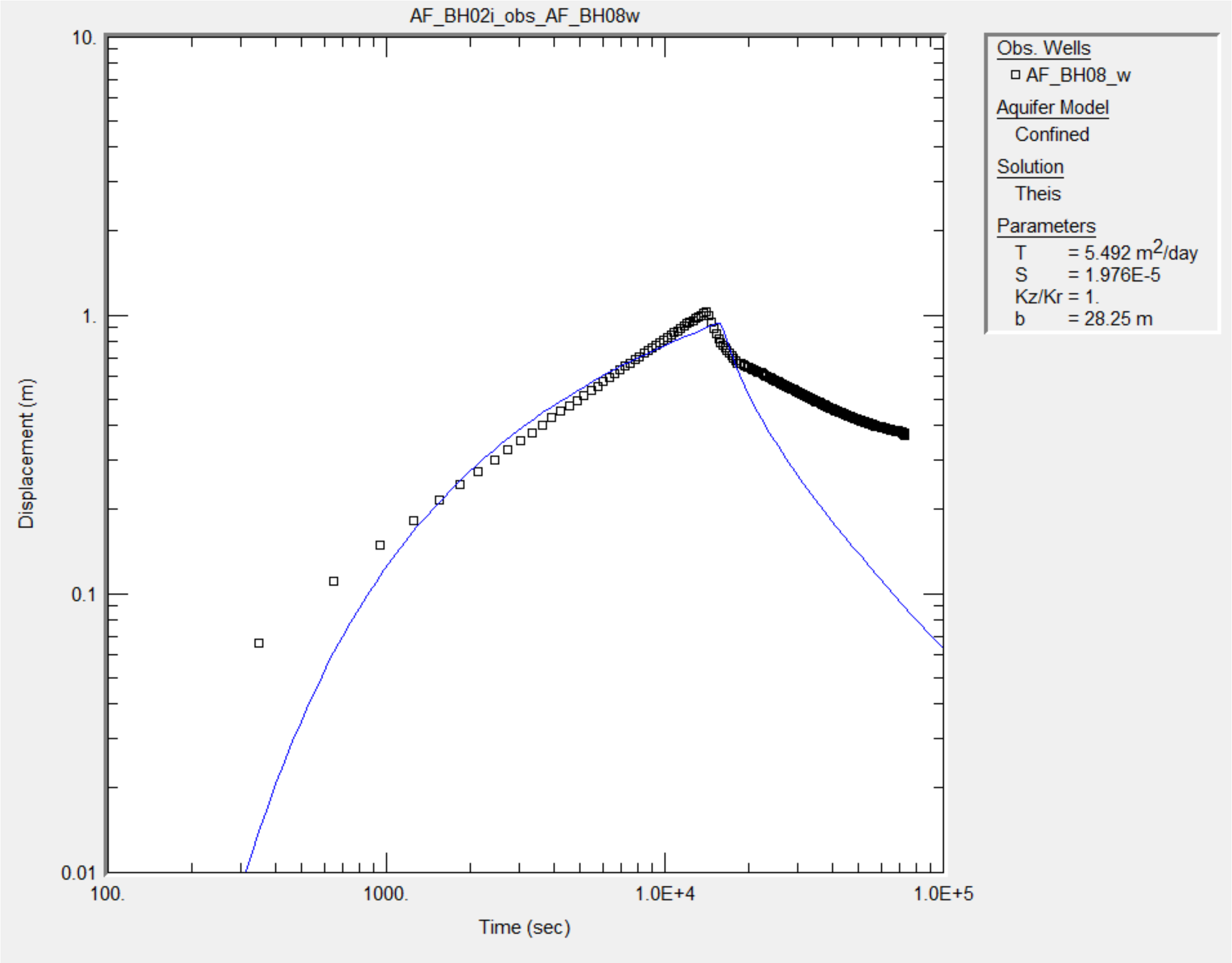


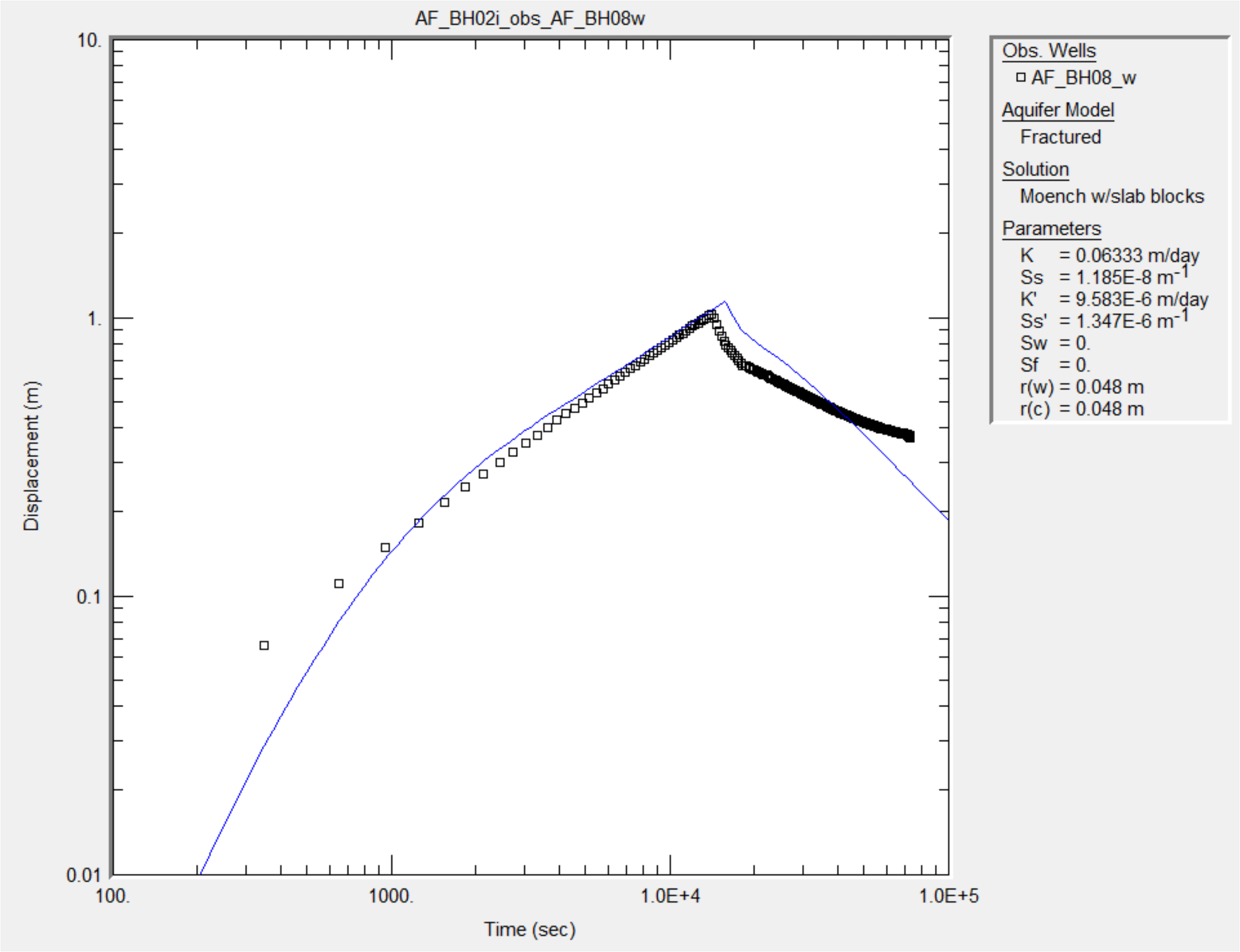
Pumping in AF_BH02i

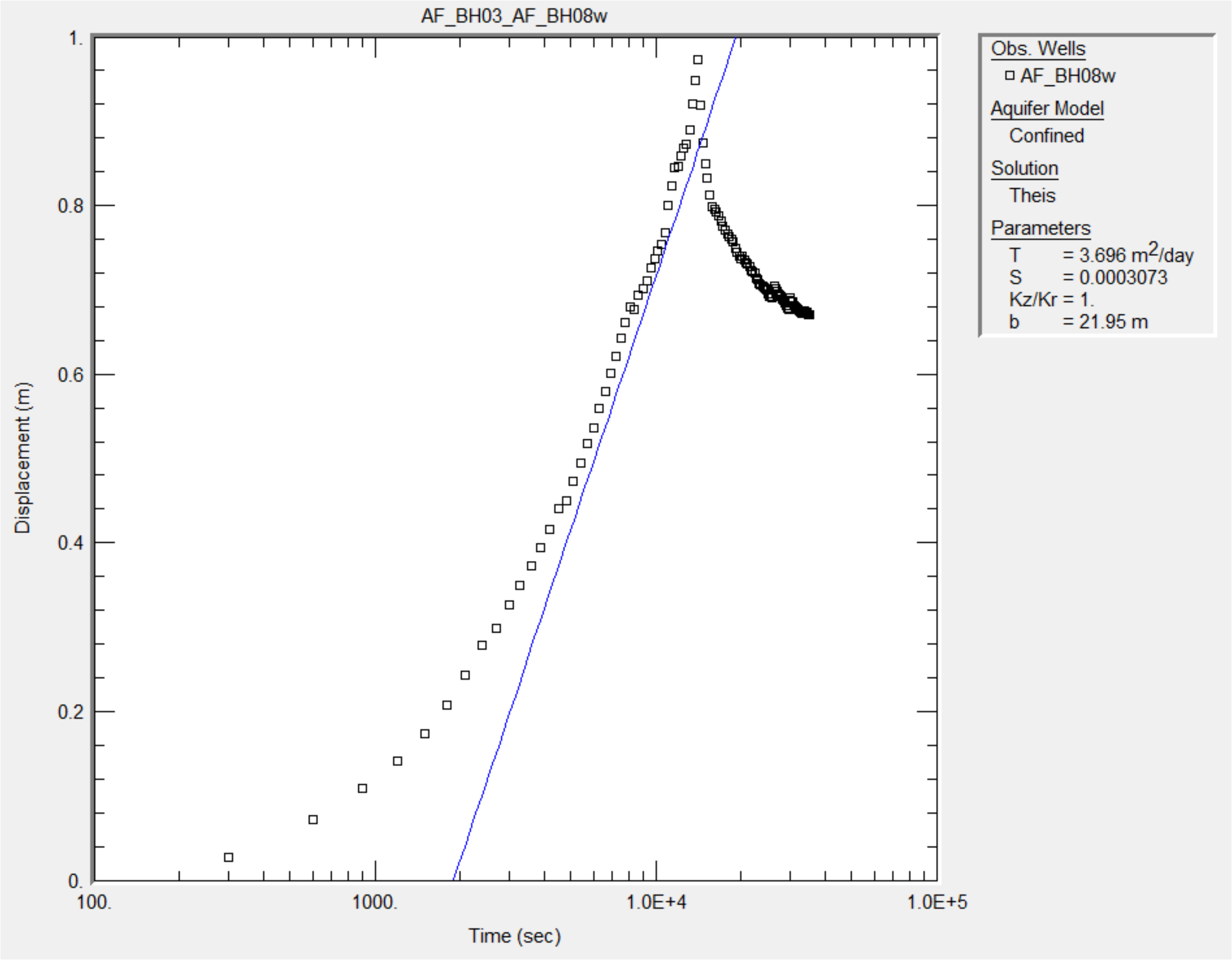
Appendix C – Pump out test drawdown and fitted solutions

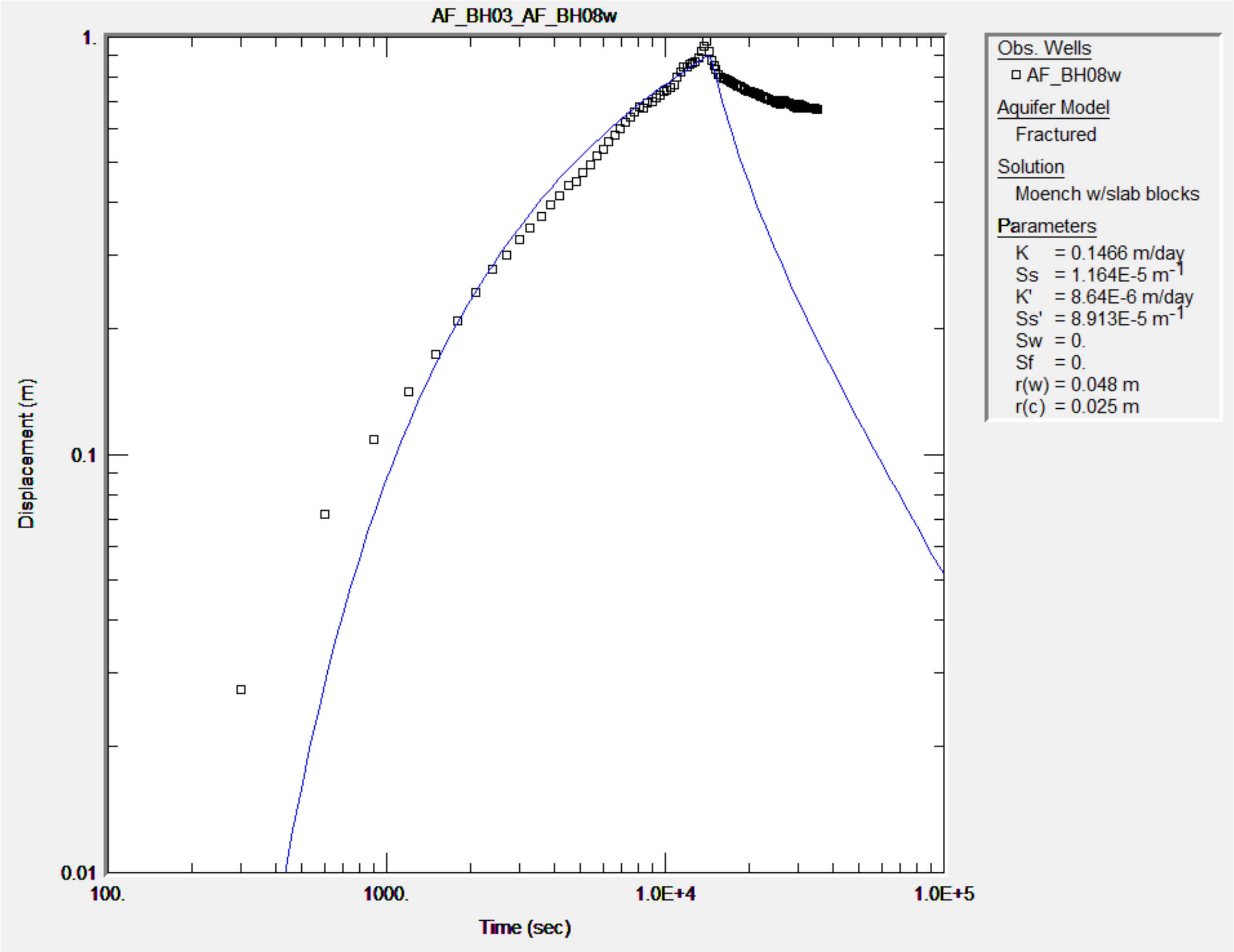


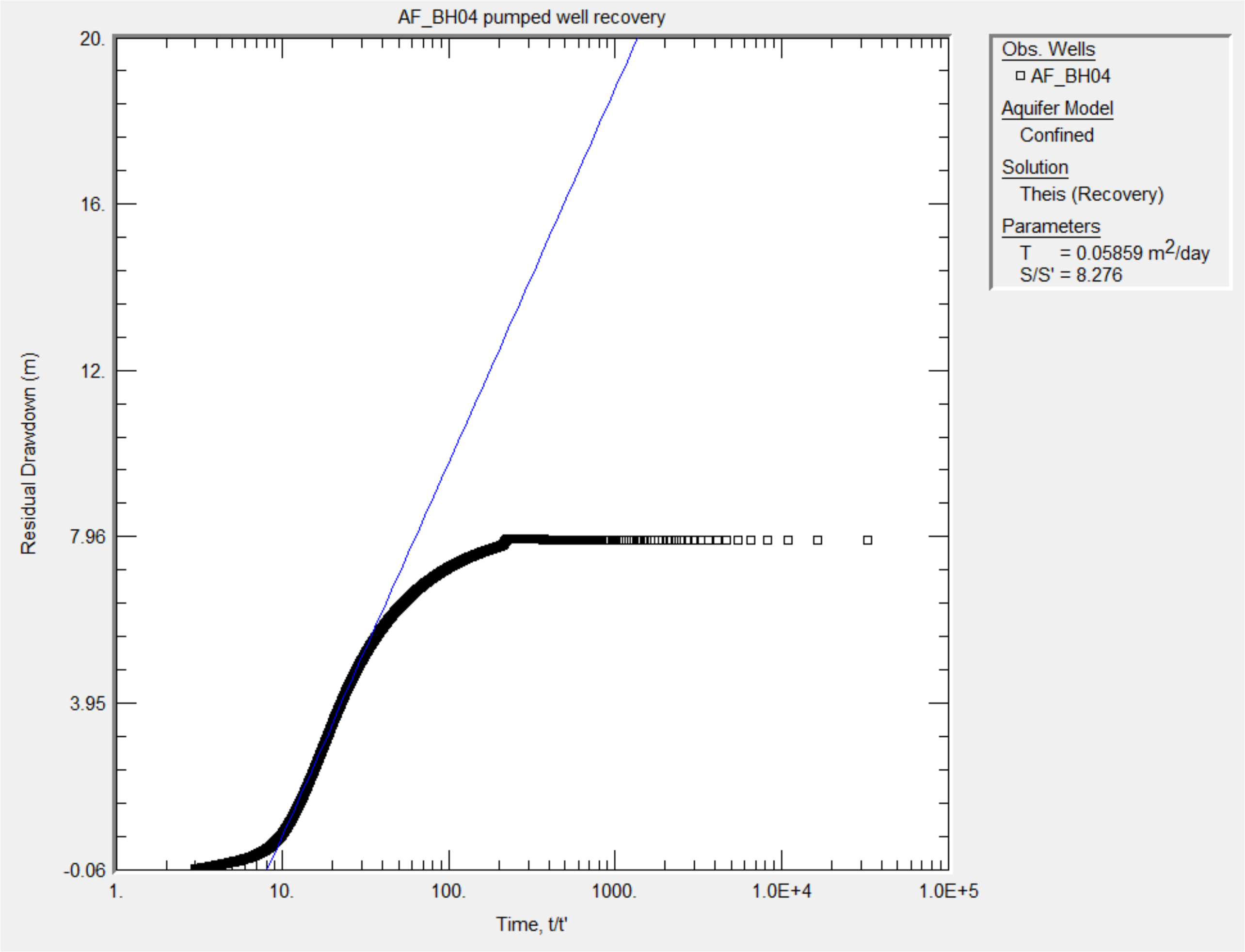

AF_BH02i recovery
2.
1.6
1.2
0.8
0.4
0.
Residual Drawdown (m)
1.
10.
100.
1000.
1.0E+4
1.0E+5
Time, t/t'
Obs. Wells
□ AF_BH02i
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.6813 m/day
Ss = 0.0002439 m-1
K' = 1.519E-5 m/day
Ss' = 1.762E-7 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0.048 m

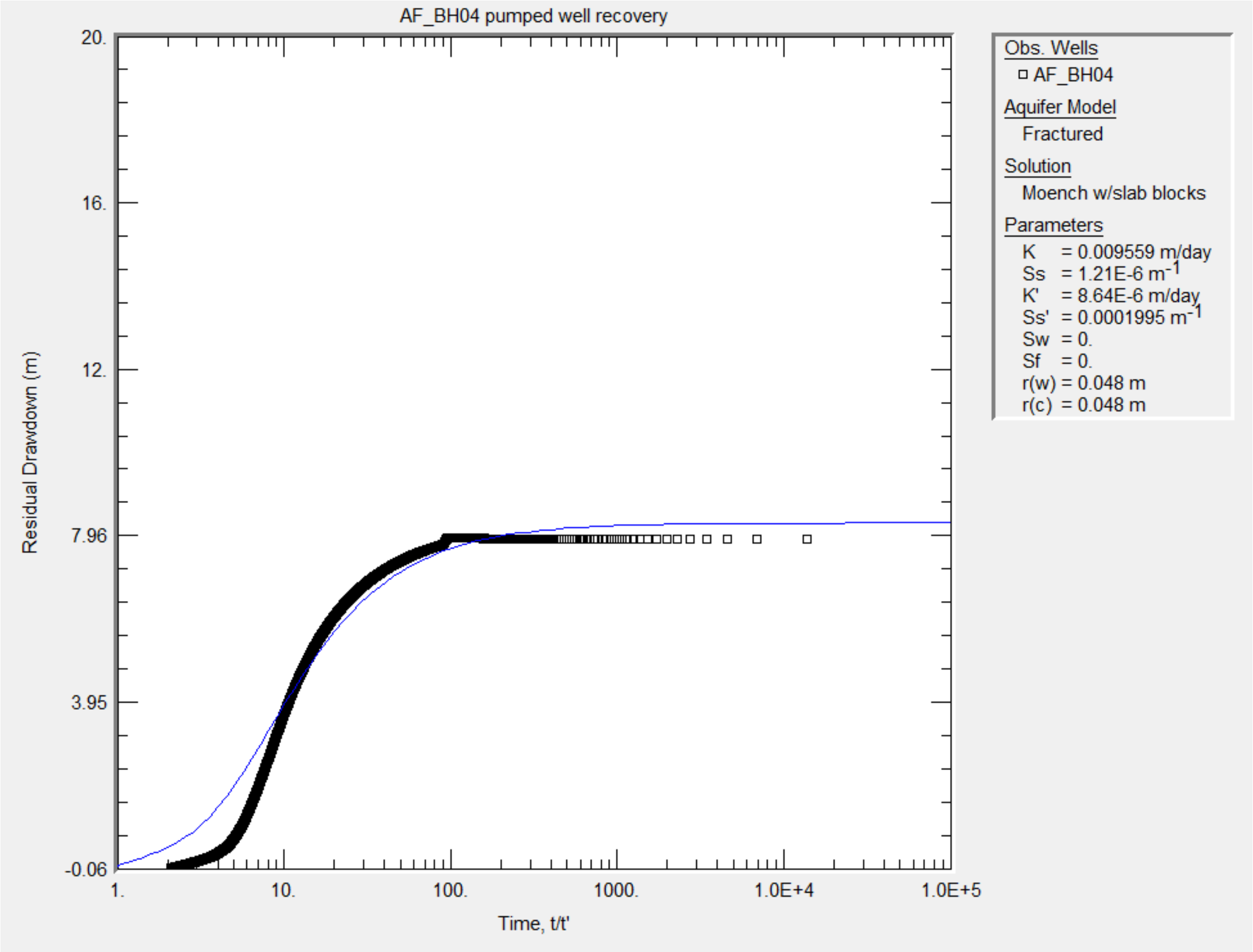

AF_BH02i_obs_AF_BH08w
10.
1.
0.1
0.01
Displacement (m)
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08_w
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.492 m²/day
S = 1.976E-5
Kz/Kr = 1.
b = 28.25 m

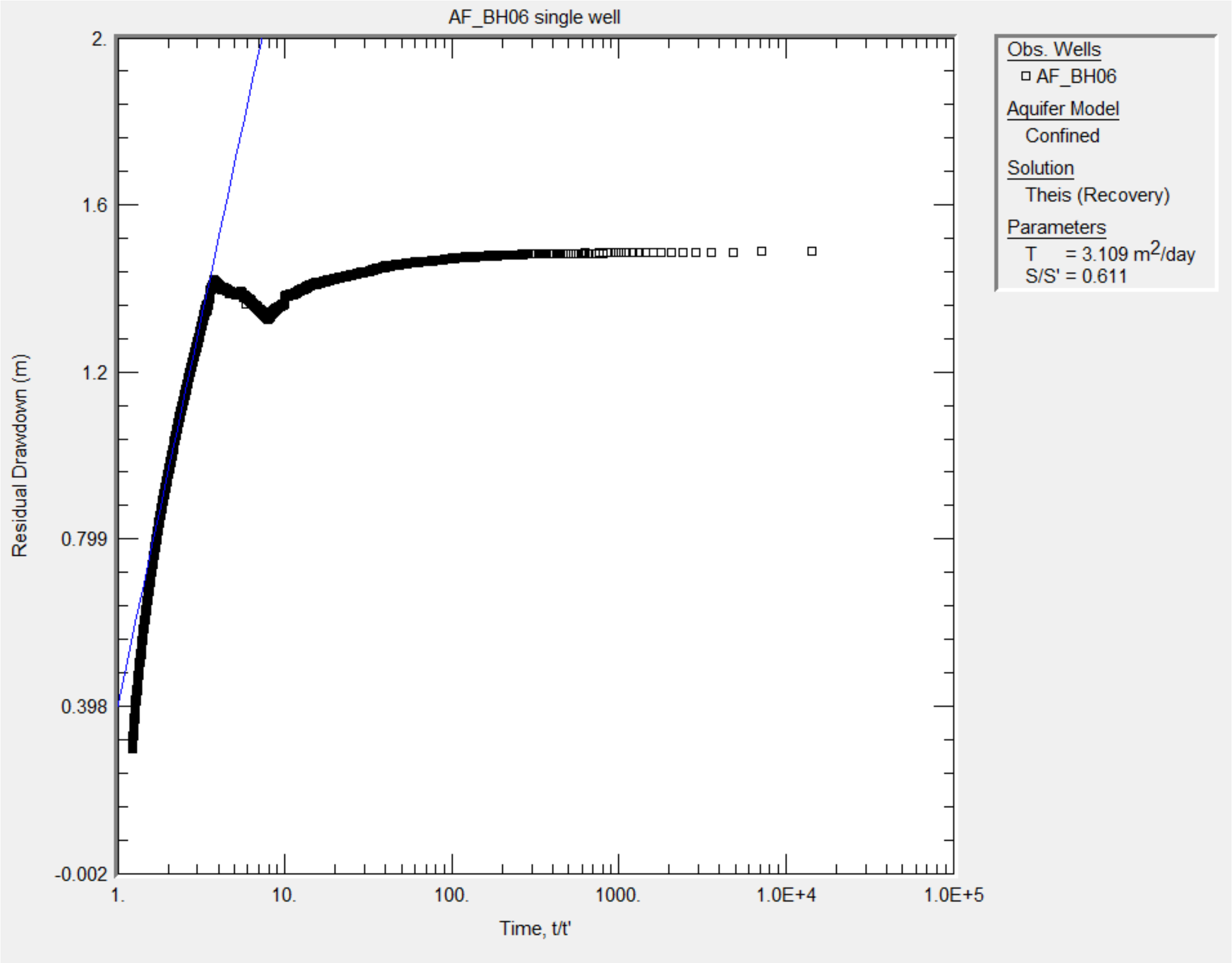

AF_BH02i_obs_AF_BH08w
10.
1.
0.1
0.01
Displacement (m)
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08_w
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.06333 m/day
Ss = 1.185E-8 m-1
K' = 9.583E-6 m/day
Ss' = 1.347E-6 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0.048 m

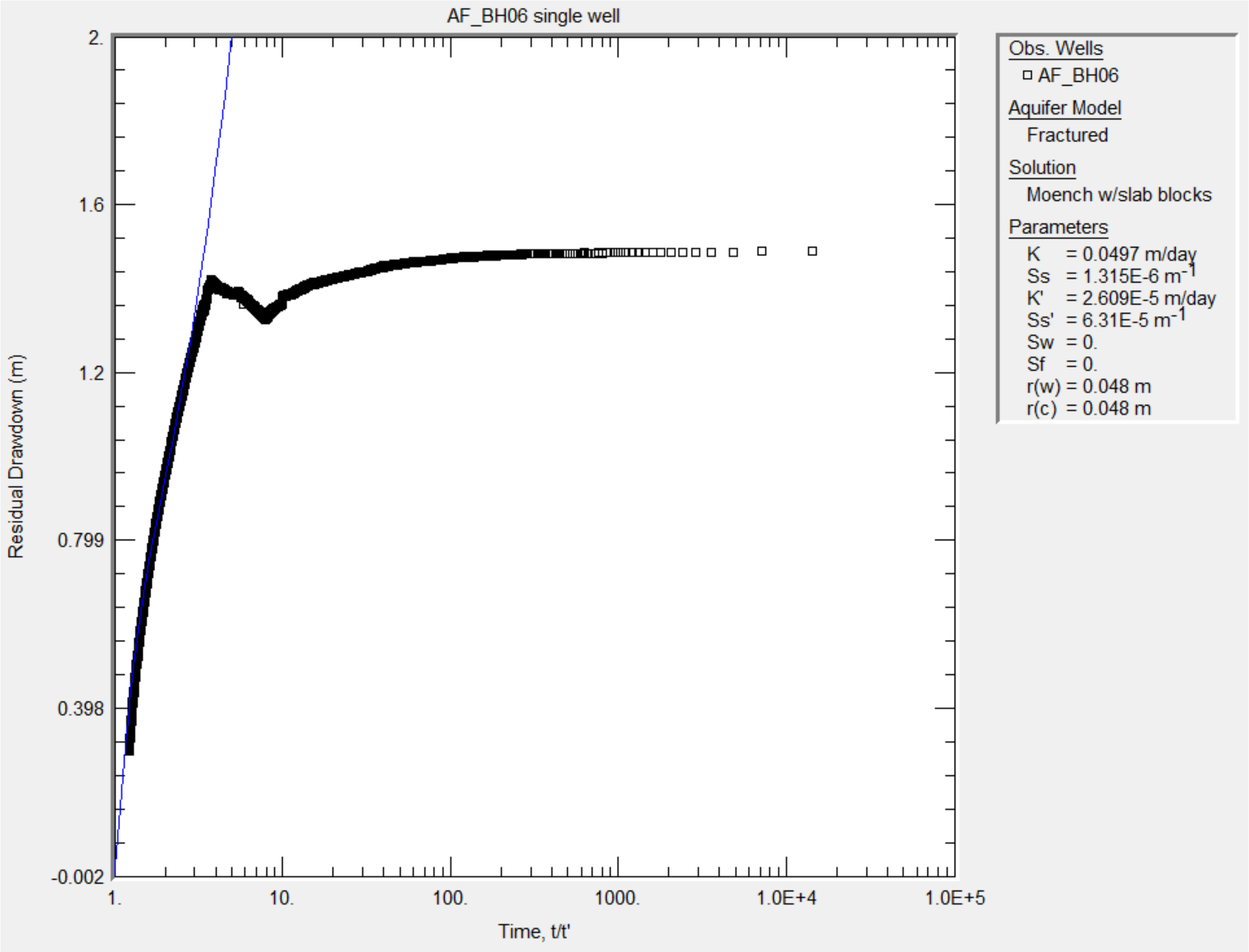

AF_BH03_AF_BH08w
Displacement (m)
0.
0.2
0.4
0.6
0.8
1.
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08w
Aquifer Model
Confined
Solution
Theis
Parameters
T = 3.696 m2/day
S = 0.0003073
Kz/Kr = 1.
b = 21.95 m

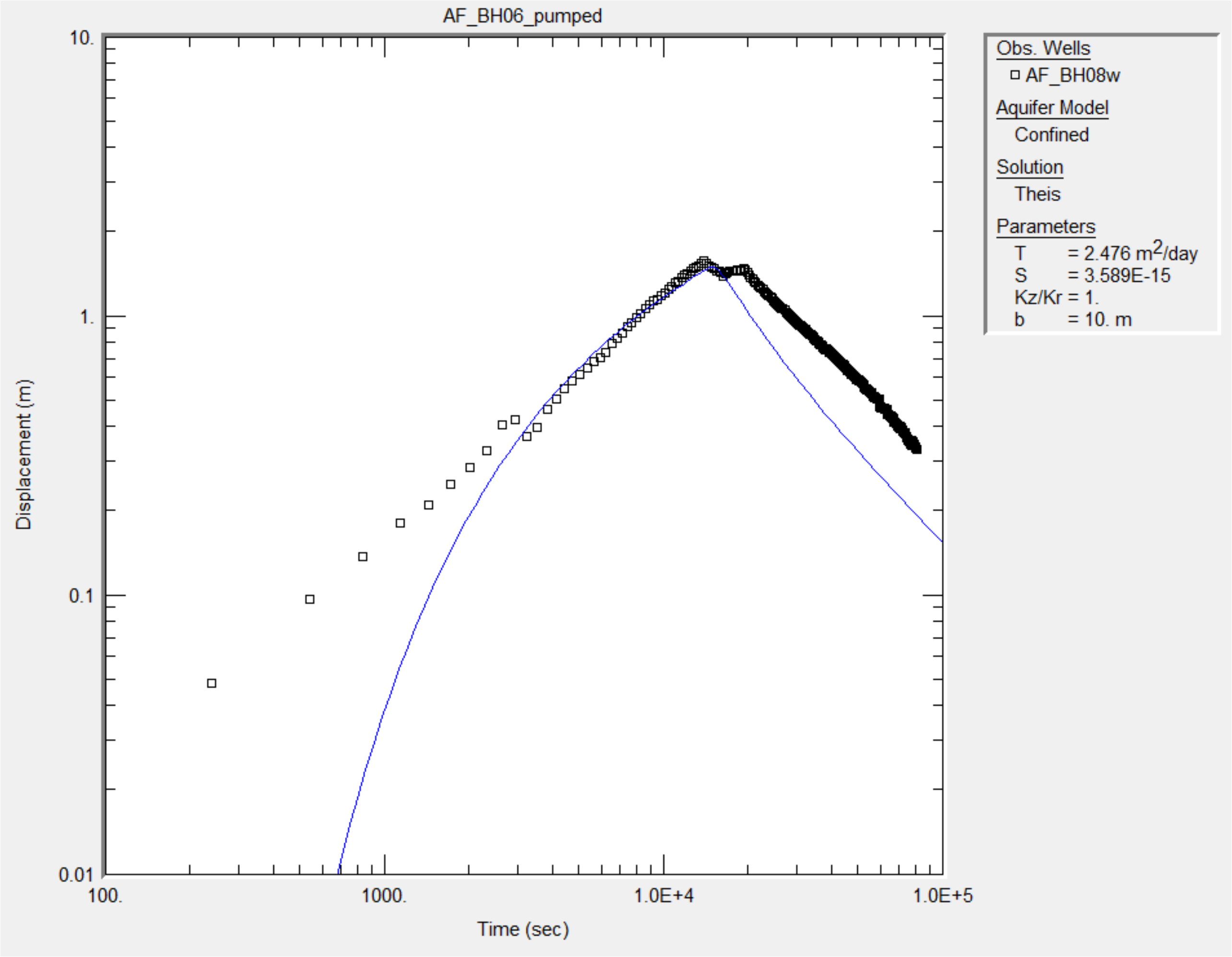

AF_BH03_AF_BH08w
Displacement (m)
1.
0.1
0.01
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08w
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.1466 m/day
Ss = 1.164E-5 m-1
K' = 8.64E-6 m/day
Ss' = 8.913E-5 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0.025 m

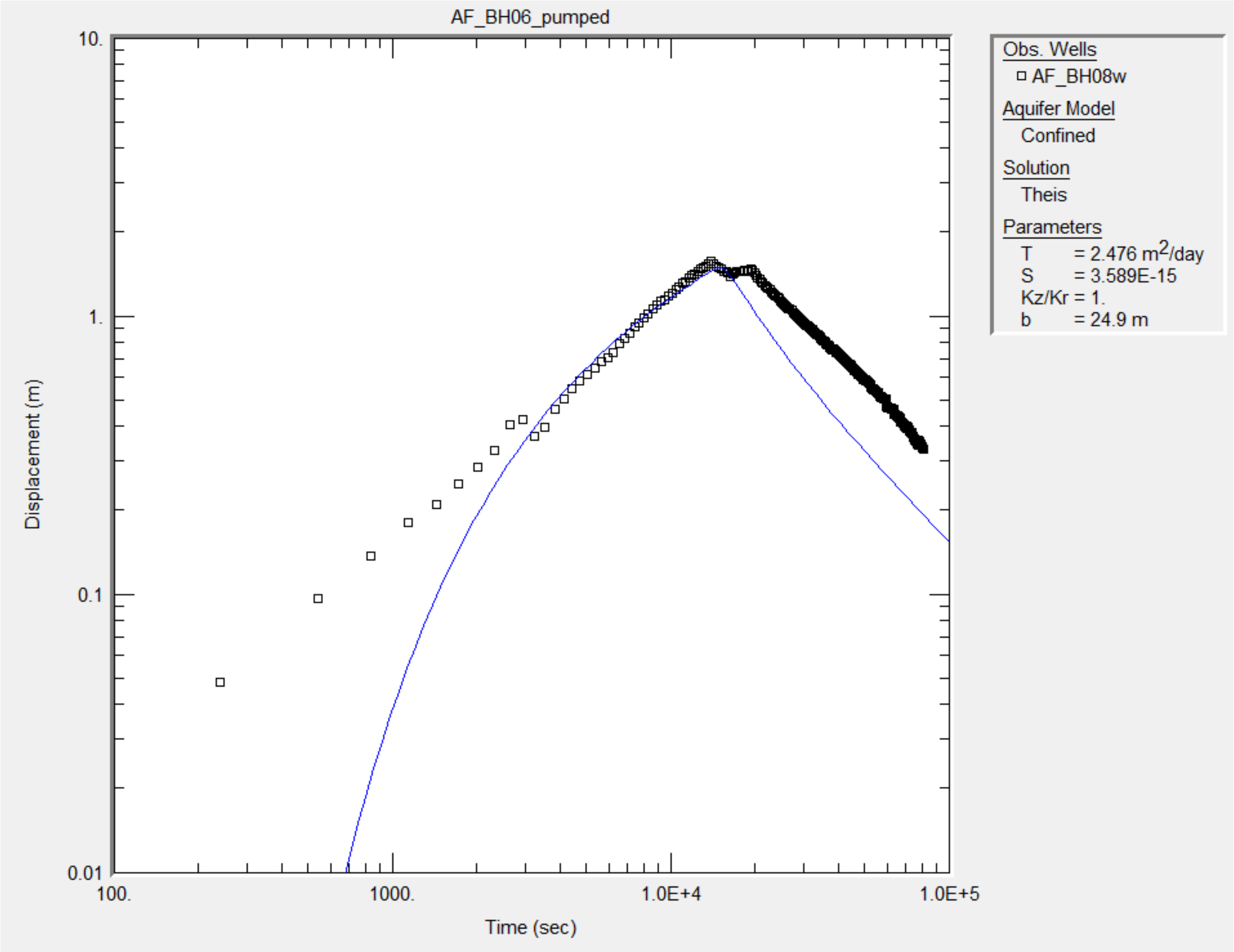

AF_BH04 pumped well recovery
Residual Drawdown (m)
20.
16.
12.
7.96
3.95
-0.06
1.
10.
100.
1000.
1.0E+4
1.0E+5
Time, t/t'
Obs. Wells
□ AF_BH04
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 0.05859 m2/day
S/S' = 8.276

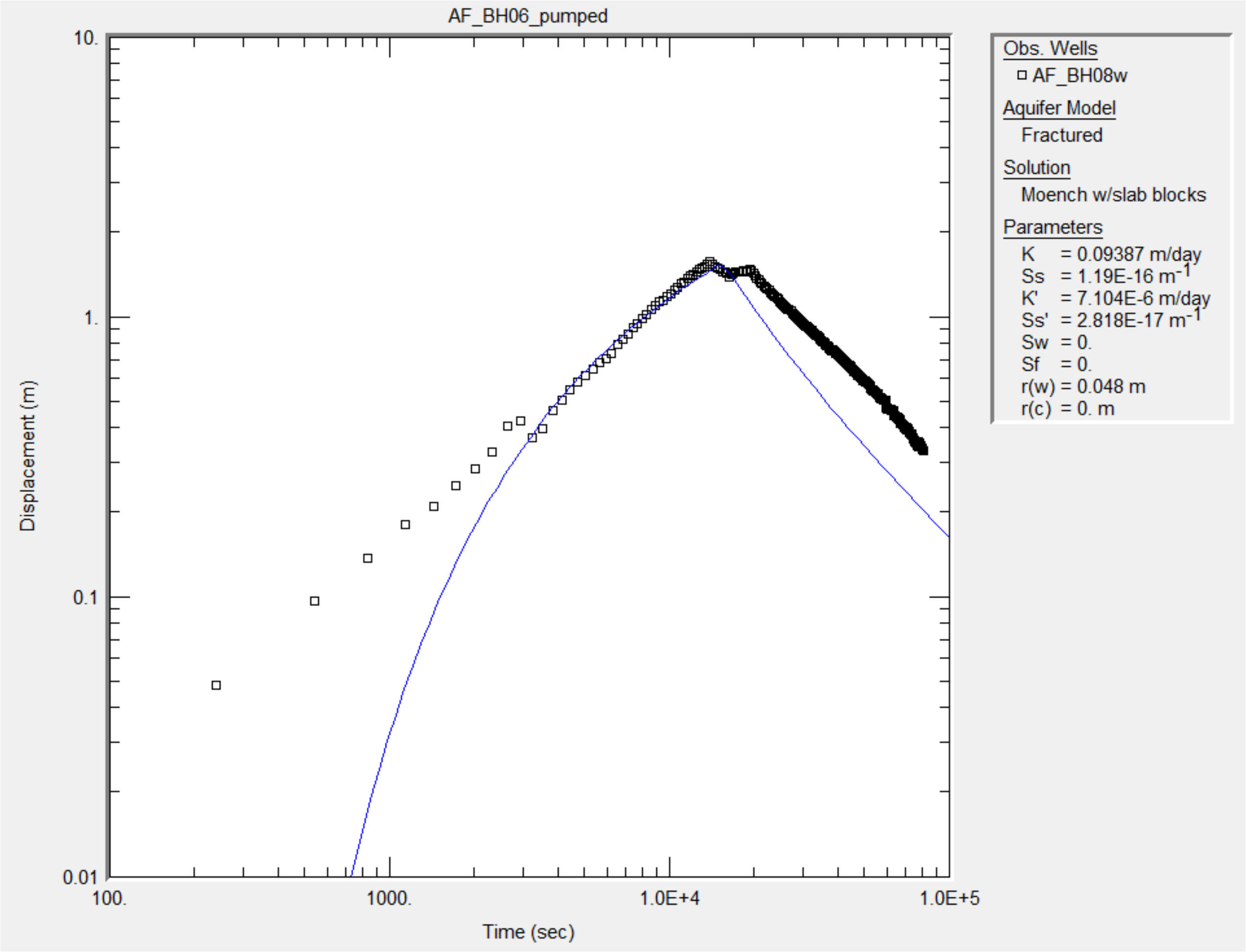

AF_BH04 pumped well recovery
Residual Drawdown (m)
20.
16.
12.
7.96
3.95
-0.06
1.
10.
100.
1000.
1.0E+4
1.0E+5
Time, t/t'
Obs. Wells
AF_BH04
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.009559 m/day
Ss = 1.21E-6 m-1
K' = 8.64E-6 m/day
Ss' = 0.0001995 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0.048 m

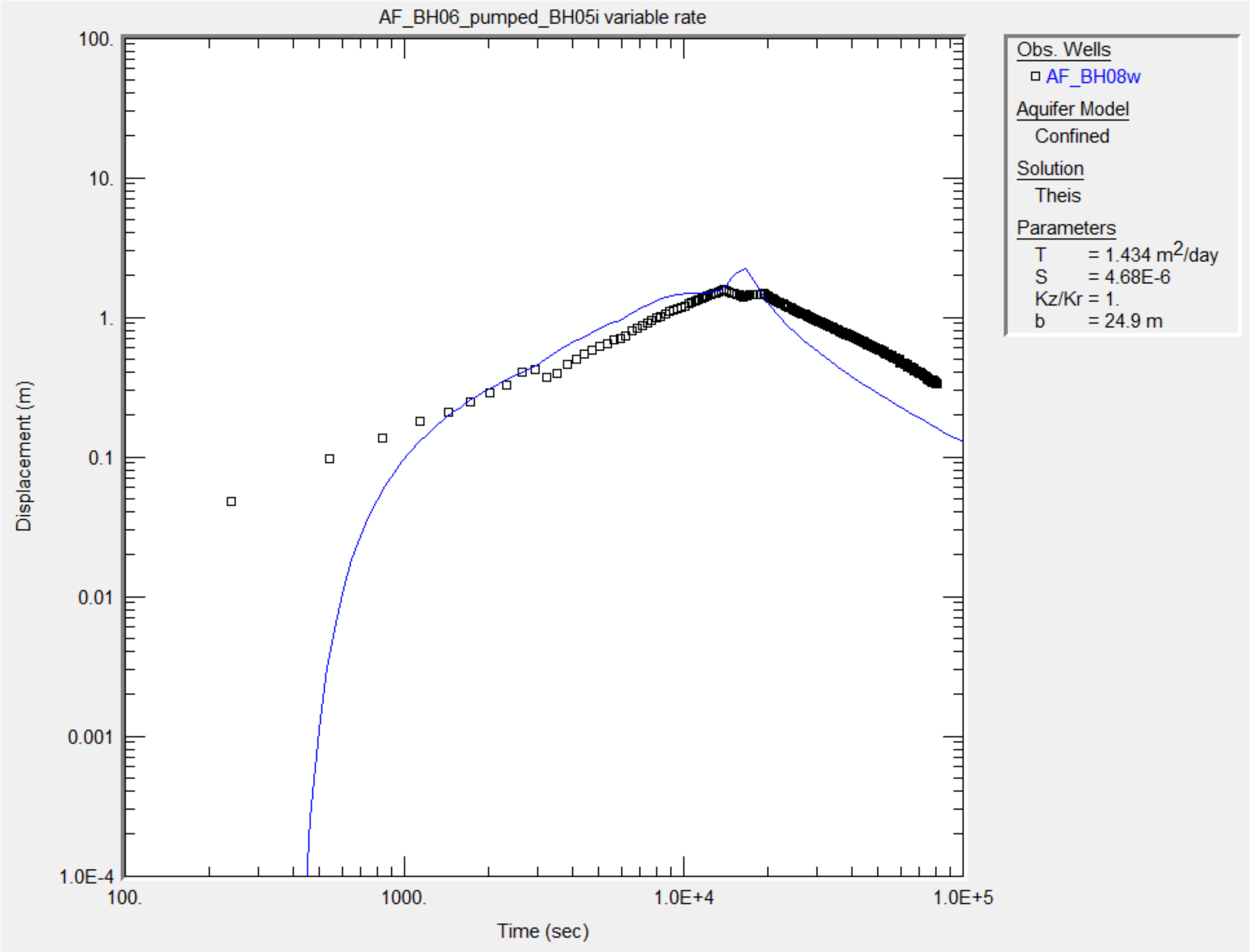

AF_BH06 single well
2.
1.6
1.2
0.799
0.398
-0.002
Residual Drawdown (m)
1.
10.
100.
1000.
1.0E+4
1.0E+5
Time, t/t'
Obs. Wells
□ AF_BH06
Aquifer Model
Confined
Solution
Theis (Recovery)
Parameters
T = 3.109 m2/day
S/S' = 0.611

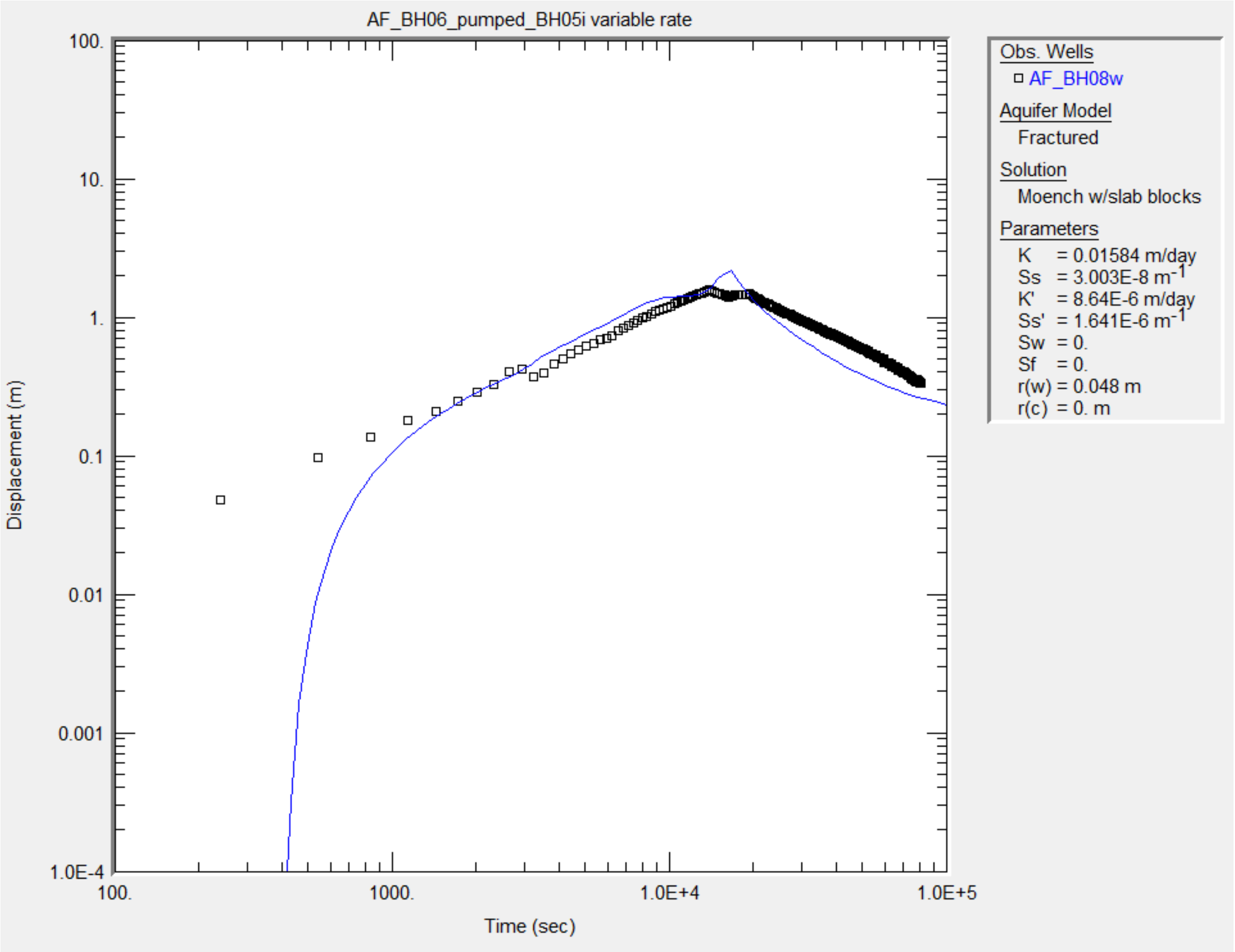

AF_BH06 single well
Residual Drawdown (m)
2.
1.6
1.2
0.799
0.398
-0.002
1.
10.
100.
1000.
1.0E+4
1.0E+5
Time, t/t'
Obs. Wells
□ AF_BH06
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.0497 m/day
Ss = 1.315E-6 m-1
K' = 2.609E-5 m/day
Ss' = 6.31E-5 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0.048 m


AF_BH06_pumped
Displacement (m)
Time (sec)
10.
1.
0.1
0.01
100.
1000.
1.0E+4
1.0E+5
Obs. Wells
□ AF_BH08w
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.476 m2/day
S = 3.589E-15
Kz/Kr = 1.
b = 10. m


AF_BH06_pumped
10.
1.
0.1
0.01
Displacement (m)
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08w
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.476 m²/day
S = 3.589E-15
Kz/Kr = 1.
b = 24.9 m


AF_BH06_pumped
10.
1.
0.1
0.01
Displacement (m)
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08w
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.09387 m/day
Ss = 1.19E-16 m-1
K' = 7.104E-6 m/day
Ss' = 2.818E-17 m-1
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0. m


AF_BH06_pumped_BH05i variable rate
Displacement (m)
100.
10.
1.
0.1
0.01
0.001
1.0E-4
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
AF_BH08w
Aquifer Model
Confined
Solution
Theis
Parameters
T = 1.434 m²/day
S = 4.68E-6
Kz/Kr = 1.
b = 24.9 m


AF_BH06_pumped_BH05i variable rate
Displacement (m)
100.
10.
1.
0.1
0.01
0.001
1.0E-4
100.
1000.
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
□ AF_BH08w
Aquifer Model
Fractured
Solution
Moench w/slab blocks
Parameters
K = 0.01584 m/day
Ss = 3.003E-8 m^{-1}
K' = 8.64E-6 m/day
Ss' = 1.641E-6 m^{-1}
Sw = 0.
Sf = 0.
r(w) = 0.048 m
r(c) = 0. m

ANNEXURE C: GROUNDWATER MODELLING REPORT

Annexure C

Document History and Status

Revision	Date	Description	Author	Checked	Reviewed	Approved
A.1	25/11/2021	Draft Report	[redacted]	[redacted]	[redacted]	[redacted]
B.1	21/1/2022	Draft Report	[redacted]	[redacted]	[redacted]	[redacted]

Contents

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1. Introduction

JTJV has been engaged by Acciona Construction Australia Pty Ltd and Ferrovial Construction (Australia) Pty Ltd Joint Venture to provide hydrogeological advice for the design of The Bays Station box excavation (The Site), including a hydrogeological conceptual model of the site, updated groundwater modelling to estimate the potential groundwater inflows to the station box excavation and associated groundwater level drawdown, and updated groundwater impacts assessment.

Three-dimensional numerical groundwater models were developed for predicting the following, associated with excavation of The Bays Station Box and tunnels:

- Groundwater drawdown
- Inflows to excavations (station box and tunnels)
- The transport of potential contaminants of concern towards excavations
- Potential saline water transport associated with the project

The modelling was designed to meet model confidence Class 1 requirements of the Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012).

This report documents the groundwater model construction, calibration and results of predictions.

2. Conceptual hydrogeological model

The conceptual hydrogeological model is described in *The Bays Retaining Walls - Hydrogeological Design Report (Appendix-G[D])*. A summary of the conceptual hydrogeological model is described in this section.

2.1 Geology

There are five geological units described in the vicinity of the site and surrounding areas namely:

- Fill
- Quaternary alluvium
- Residual soils
- Hawkesbury Sandstone
- Great Sydney Dyke

Fill represents the dominant surficial deposits at site and surrounding areas. It is highly variable in composition, including reinforced concrete, concrete, gravel, sand and clay. Its thickness varies from approximately 4 m near the center of the station box to less than a meter at the eastern end of the station box.

Quaternary deposits (Alluvium) underly fill deposits at the site. Alluvium comprises of interbedded sands, silts and clays with discontinuous interbedded lenses of the same material. These have been characterised as alluvium and estuarine deposits within zones of incised sandstone, and are associated with the White Bay palaeochannel. The boundary of the palaeochannel/alluvium is shown in Figure 2.1. The alluvial depth reaches a thickness of up to approximately 17 meters near White Bay Power Station (WBPS).

Extremely weathered residual soils underlie the alluvium across the majority of the site. These represent weathering of the upper Hawkesbury Sandstone, are characterised by silty, sandy clay; and are typically 2 to 6 m in thickness.

The Hawkesbury Sandstone is the basal unit at the site. The unit was deposited in a fluvial paleo-environment, likely to have been a braided river setting, and as such it is highly stratified. It is ubiquitous across the Sydney Basin and is up to some 300 m thick. At the site the unit is characterised by fine to coarse grained sandstone.

The Great Sydney Dyke has been encountered at the eastern edge of the station box (Figure 2.1). The dyke is a Jurassic or Eocene-age basaltic intrusion into the Hawkesbury Sandstone.

`

Figure 2.1: Location of the alluvium and Great Sydney Dyke in the vicinity of The Bays Station (Great Sydney Dyke in red, alluvial boundary in orange, station and tunnel alignment in purple).

2.2 Hydrogeological units

There are seven hydrogeological units occurring at the site and surrounding areas, namely:

- Fill
- Alluvium and residual soils
- Weathered Hawkesbury
- Fresh Hawkesbury Sandstone underlying the White Bay palaeochannel
- Fresh Hawkesbury Sandstone occurring outside the paleochannel
- Horizontal bedding planes within the Hawkesbury Sandstone
- Great Sydney Dyke

2.2.1 Fill

Fill occurs as the surficial hydrogeological unit over most of the site and surrounding area. The watertable occurs within the fill over a significant portion of the site. The fill is assumed to be hydraulically connected to the underlying alluvium. The average thickness of the fill across the site and surrounding area is approximately two meters. The maximum thickness of the fill of approximately 17 m occurs to the north east of the site, adjacent to Whites Bay.

2.2.2 Alluvium and residual soils

The alluvium occurs beneath the fill or at the surface. The watertable occurs within the alluvium in some areas. As already mentioned, the alluvium and fill are considered hydraulically connected. Groundwater flow within the alluvium is controlled by the primary permeability of the units with areas of coarse material (gravels and sands) yielding higher permeabilities and finer grained material (silts and clays) yielding lower permeabilities. Alluvium is not present at the eastern extent of the station box, but thickens to approximately 19 m through the palaeochannel to the west of the station box near WBPS.

Residual soils are generally sandy in nature, having been derived from Hawkesbury Sandstone, and expected to be of relatively high permeability, comparable to the alluvium.

The model assumes a continuous groundwater profile from the fill/ alluvium to the underlying Hawkesbury Sandstone (i.e. there are no unsaturated zones and perched groundwater systems). This is a reasonable assumption, given the relatively high permeability of the fill and alluvium.

2.2.3 Hawkesbury Sandstone hydrogeological units

The Hawkesbury Sandstone forms the basal groundwater system at the site and is divided into the following four hydrogeological units based primarily on the permeability characteristics:

- Weathered Hawkesbury Sandstone
- Fresh Hawkesbury Sandstone underlying the White Bay palaeochannel
- Fresh Hawkesbury Sandstone occurring outside the White Bay paleochannel
- Horizontal bedding planes within the Hawkesbury Sandstone

The weathered Hawkesbury Sandstone has a higher permeability than the fresh Hawkesbury Sandstone. The weathered zone typically has reduced intact strength and more abundant fractures than the fresher sandstone below. The thickness and permeability of the weathered zone varies considerably from place to place. The various borings in the station box show a range from about 1m to 2m, and up to about 4m nearer the buried cliff lines.

The horizontal hydraulic conductivity of the fresh Hawkesbury Sandstone underlying the White Bay palaeochannel is generally higher than that across all locations within the subregion. This is to be expected, because the rock closer to the ridgelines (outside the palaeochannel) will not have experienced the stress relief and potential weathering experienced by the rock within the palaeochannel. Therefore the sandstone outside the palaeochannel is less likely to possess significant water bearing features such as dilated bedding planes and joints.

The bedding plane horizons within the Hawkesbury Sandstone have been classified into a distinct hydrogeological unit based on a review of borehole logs and water pressure (packer) test results that indicate the presence of near-horizontal bedding planes across the site. Permeability in the Hawkesbury Sandstone occurs mainly along dilated, subhorizontal bedding planes. These bedding planes can be traced for long distances from borehole to borehole. In borehole SMW-BH066, which is inside the station box, there were several such dilated bedding planes; the largest has an aperture of 80 mm and a permeability of greater than 100 Lugeons. The majority of the bedding planes have a thickness of only a few millimeters. The bedding planes are likely to have dilated due to stress relief. The geotechnical interpretation shown in Appendix E indicates that three prominent horizontal bedding plane horizons occur at the site at elevations of -18.5 mAHD, -23.85 mAHD and -29.5 mAHD.

The hydraulic conductivity of the Hawkesbury Sandstone outside the palaeochannel tends to reduce with depth. However, for the Hawkesbury Sandstone within the palaeochannel, there is no clear correlation between hydraulic conductivity and depth, with the possible exception that the maximum hydraulic conductivity appears to reduce with depth below about 25 metres below ground level.

2.2.4 Great Sydney Dyke

The interpreted orientation of the Great Sydney Dyke within The Bays area is shown in Figure 2.1. The dyke is expected to be subvertical and ranging in width from approximately 4 m to 9 m.

There is no evidence that the dyke at the site would act as a conduit to groundwater flow to a greater extent than the surrounding sandstone. However, there is insufficient information to confirm this. For the purposes of this assessment, it has been assumed that the dyke has similar hydrogeological properties as the surrounding sandstone.

Across the Sydney Basin, the dyke is comprised of variably weathered dolerite, with soil properties in its upper 4 m and becoming less weathered with depth. The central core of the dyke at depth is likely to be fresh. The contacts with the adjacent sandstone are likely to be irregular and altered, and re-crystallisation of the dyke-country rock contact (baked margin or zone) can be discerned in some of the intersecting boreholes.

The sandstone surrounding the dolerite may be locally more deeply weathered adjacent to the dyke in the uppermost bedrock profile, though borehole logs indicate that the sandstone immediately adjacent to the dyke at depth is fresh, and it may exhibit a higher strength ‘baked margin’ due to the heat from the dyke locally contact metamorphosing the adjacent sandstone (this zone is typically between 0.5 and 1 m thick).

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Where the Great Sydney Dyke intersects the station box, the less weathered dolerite rock (the core rock) could be exposed in the basal 5 m to 10 m of the excavation.

Observations and experience of dykes encountered in Sydney suggests that dykes are inherently variable and that, although the approximate orientation and location of the dyke may be relatively well known, the character of the dyke can change over short distances. Dykes can be expected to thicken and thin, bifurcate and recombine, and may exhibit other irregularities governed by the original host rock structure. Photographs of the Great Sydney Dyke in available exposures, as well as available downhole imaging in boreholes that intersect the dyke at White Bay, show a distinct subvertical rock structure that strikes sub-parallel with the main dyke alignment, presumably reflecting the nature of the igneous emplacement. R219_BH240 angled across the dyke shows sandstone country rock between dolerite dykes, indicating a potential for bifurcation, stringer dykes and other irregularities within the White Bay area and station box excavation.

Due to the dyke's inherent variability, irregular distribution and strongly defined subvertical rock structure, it is possible that it may simultaneously impede and enhance groundwater flow along its length/depth.

Packer test results across the dolerite and adjacent sandstone (boreholes R246_BH2103/54 and R219_BH240_NWM) do not indicate significantly different permeability than the surrounding sandstone (which often exhibits relatively high permeability) within the palaeochannel.

2.3 Hydraulic properties

2.3.1 Hydraulic conductivity

Table 2.1 presents the hydraulic conductivity values estimated from the project specific investigations and other investigations as summarised in *The Bays Retaining Walls - Hydrogeological Design Report (Appendix-G[B])*.

Table 2.1: Summary of hydraulic conductivity values at The Bays Station site and surrounds

Hydrogeological unit	**Typical hydraulic conductivity range (m/day)**	***Kv/Kh* range (1)**
Fill	0.4 to 10	0.5 to 1
Alluvium	0.5 to 1	0.02 to 1
Weathered Hawkesbury Sandstone	0.13 to 1	
Fresh Hawkesbury Sandstone within palaeochannel	0.001 to 0.216 [10 to 25 Lugeons]	0.1 to 0.5
Fresh Hawkesbury Sandstone outside palaeochannel	4.3×10^{-3} to 3.4×10^{-2} [0.5 to 4 Lugeons]	0.1 to 0.5
Horizontal bedding planes	0.5 to 2.7	0.1 to 0.5

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Hydrogeological unit	Typical hydraulic conductivity range (m/day)	*Kv/Kh* range [(1)]
Great Sydney Dyke	Same as surrounding rock	

Note: (1) K_v/K_h is the ratio of vertical to horizontal hydraulic conductivity.

2.3.2 Storage parameters

Table 2.2 presents the storage parameter values estimated from the project specific investigations and other investigations as summarised in *The Bays Retaining Walls - Hydrogeological Design Report (Appendix-G[B])*.

Table 2.2: Summary of storage parameter values at The Bays Station site and surrounds

Hydrogeological unit	Specific storage range (m^{-1})	Specific yield range (m-1)
Fill	1×10^{-5} to 1×10^{-6}	0.1 to 0.2
Alluvium	1×10^{-5} to 1×10^{-6}	0.04 to 0.2
Hawkesbury Sandstone	$2x10^{-7}$ and $5x10^{-5}$	0.01 to 0.05
Great Sydney Dyke	Same as surrounding rock	

2.3.3 Rainfall recharge

Table 2.2 presents a summary of recharge rates based on a literature review. The recharge rates are provided as a percentage of mean annual rainfall.

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Table 2.3: Summary of recharge rates based on literature review.

Hydrogeological unit	Recharge (% mean annual rainfall)	Source
Botany Sands	3	NSW Office of Water
Alluvium	5	
Hawkesbury Sandstone	3.3	CDM Smith (2015)
Hawkesbury Sandstone	5	EMM (2015)
Hawkesbury Sandstone	2 to 3	GHD (2015)
Hawkesbury Sandstone (paved)	2	HydroSimulations (2015)
	3.5	JCHPB Joint Venture (2021)
	1	Jacobs (2020)
Hawkesbury Sandstone (unpaved)	3	HydroSimulations (2015)
	5	JCHPB Joint Venture (2021)
	3	Jacobs (2020)

2.4 Conceptual hydrogeological model layer surface elevations

The top and bottom surface elevations for the hydrogeological units were inferred from the Leapfrog Geological model developed for the site. The following surfaces were developed:

- **Ground level surface elevation (Top of Layer 1)** – This topographic surface includes bathymetry for submerged areas of the White Bay area within the active cell groundwater model boundary.
- **Base of Fill (Base of Layer 1)** – This surface was constructed primarily based on the base of fill/top of alluvium as mapped in the following:
  - Leapfrog model, and
  - Sydney 1:100,000 geological series sheet.

  The Leapfrog model only covers the site. A constant thickness of 0.5 m was applied outside the area covered by the Leapfrog model. The layer is continued across the entire groundwater model domain because continuous layers are used in the groundwater model and 'pinched out' layers are not explicitly represented.
- **Base of alluvium/top of rock (Base of Layer 2)** – This surface was constructed primarily based on the base of alluvium/top of Hawkesbury Sandstone as mapped in:
  - Leapfrog model, and

  - Sydney 1:100,000 geological series sheet.

  The Leapfrog model only covers the site. A constant thickness of 0.5 m was applied outside the area covered by the Leapfrog model for reasons explained above.

- **Base of Layer 3** – top of fresh Hawkesbury Sandstone based as interpreted in the Leapfrog model and information provided in drill-hole geological logs.

3. Numerical model design and construction

3.1 Modelling software

3.1.1 Groundwater flow modelling

Three-dimensional groundwater flow modelling was carried out using the MODFLOW-USG modelling code. MODFLOW-USG simulates groundwater flow using a generalized control volume finite-difference approach (Panday et al., 2013) The flexible grid design incorporated within MODFLOW-USG, and Quadtree grid refinement was used to focus resolution along key areas of interest including the proposed Bays Box and Whites. The Sparse Matrix Solver (SMS) was used in the numerical simulations.

3.2 Model domain

Figure 3.1 shows the groundwater model domain. Selection of the model domain was based on considering the competing demands of setting boundary conditions far enough away from the proposed project area that they do not influence the simulation result while keeping the model small enough to allow reasonably short simulation times.

The north-eastern boundary is defined by Whites Bay. The eastern and south-eastern model boundaries are defined by Rozelle Bay. The model domain was extended approximately 100 m into Rozelle Bay and 380 m into White Bay to allow the simulation of submarine discharge under baseline conditions as well as providing a reasonable capture zone for inflow from the bays to the proposed project site. The bottom of the model is assigned at a depth of -200 m AHD.

Figure 3.1: Model domain

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3.3 Model layers and hydrogeological units

3.3.1 Overview

The model has been discretised (sub-divided) into eleven vertical layers. Figure 3.2 shows the model layering along a west to east cross that intersects the station box. The cross-section line location is shown in Figure 3.3.

The hydrogeological units represented in the model layers are described in Section 2.2 and summarised in Table 3.1 . The model layering and hydrogeological spatial zonation is primarily based on the conceptual hydrogeological model described in Section 2. There are, however, model layers that have been assigned to the model to facilitate the representation of specific project construction (design) elements as discussed in Section 3.3.7. Details for each of the model layers are presented in Section 3.3.2 to 3.3.6. The MODFLOW-USG layer settings are described in Section 3.3.8.

Table 3.1: Model layers and hydrogeological units.

Hydrogeological unit		Model layer
Fill		1
Alluvium		2
Weathered Hawkesbury Sandstone		2 to 3
Fresh Hawkesbury Sandstone	Paleo-valley	3 to 11
	Outside paleo- valley	3 to 11
Fractured Hawkesbury Sandstone		6 and 8
Dolerite dyke		2 to11

3.3.2 Model layer 1

Model layer 1 is used to represent fill. The fill is continuous across the entire model domain in layer 1 and is assigned a nominal thickness of 0.5 m in areas where it is mapped as absent. Assigning the thin fill layer in areas where the fill is absent is unlikely to have a significant effect on the accurate simulation of the hydrogeological system due to the following reasons:

- The groundwater table depth in areas where the fill is absent generally occurs at depths greater than 0.5 m below the groundwater surface.
- The fill hydraulic conductivity is significantly higher than the hydraulic conductivity of the underlying hydrogeological units. Therefore, the surficial fill will not cause significant restrictions to simulated groundwater recharge to the underlying hydrogeological units.

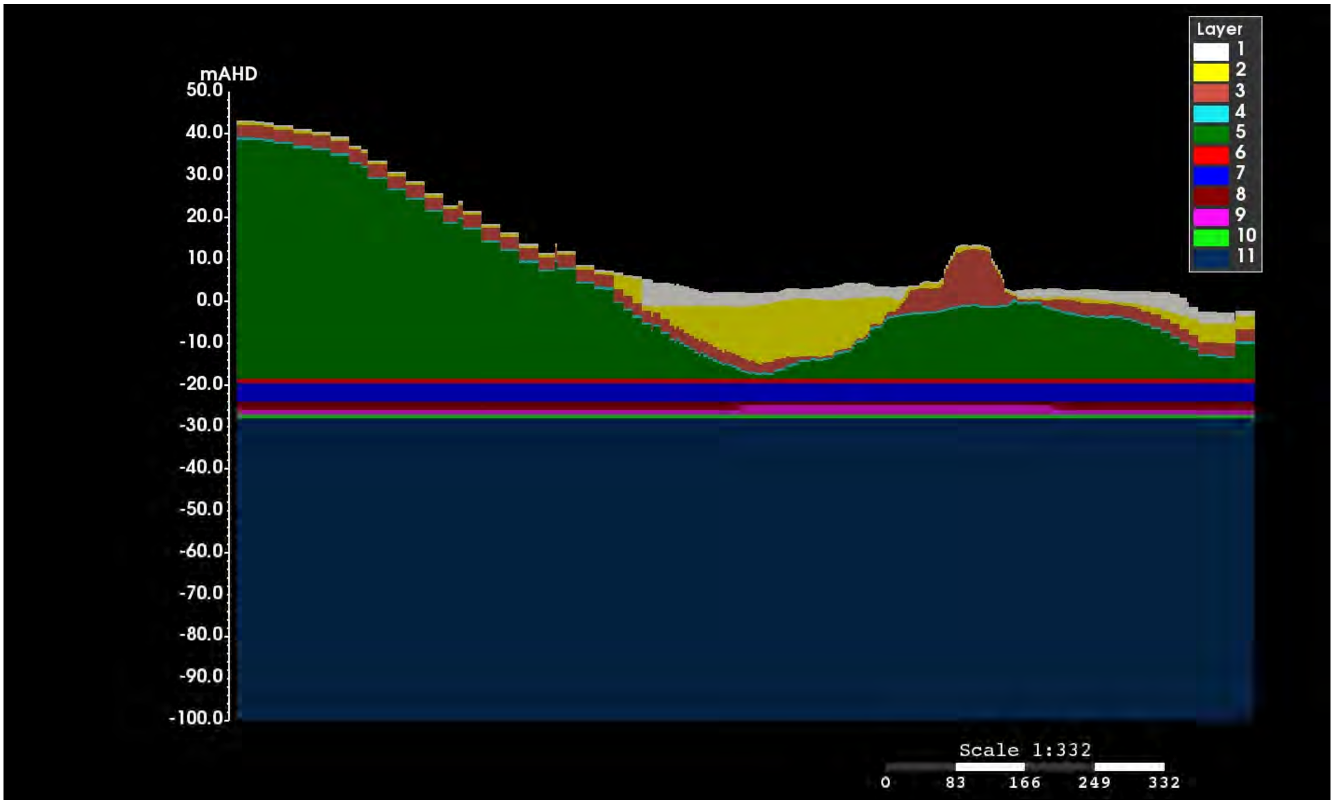

Figure 3.2: West to east cross section showing model layering along line shown in Figure 3.3.

3.3.3 Model layer 2

The hydrogeological units represented in model layer 2 are alluvium (in the paleo-valley), and weathered Hawkesbury Sandstone, outside the paleo-valley (Figure 3.3). The weathered Hawkesbury Sandstone in layer 2 represents the top horizon of the weathered Hawkesbury Sandstone and has a constant thickness of 0.5 m. The Great Sydney Dyke cross-cuts the weathered Hawkesbury Sandstone in model layer 2 (Figure 3.3). However, the dyke does not cross-cut the Alluvium. It has been assumed that the dyke intrusion/extrusion pre-dates the deposition of the alluvium.

3.3.4 Model layer 3

Model layer 3 represents the lower horizon of the weathered Hawkesbury Sandstone. The base of model layer 3 represents the top elevation of the fresh Hawkesbury Sandstone. The dyke cross-cuts the Hawkesbury Sandstone in model layer 3 (Figure 3.4).

3.3.5 Model layer 4,5,7,9,10 and 11

Figure 3.5 shows the hydrogeological units represented in model layer 4,5,7,9,10 and 11. A distinction is made between the fresh Hawkesbury Sandstone underlying the White Bay palaeochannel and fresh Hawkesbury Sandstone acrosss all locations within the subregion based on permeability differences in permeability described in Section 2.2.3. The fresh Hawkesbury Sandstone occurring underlying the palaeochannel was assigned a higher hydraulic conductivity than the sandstone outside the palaeochannel (Section 2.2.3).

3.3.6 Model layer 6 and 8

Layer 6 and 8 are used to represent the horizontal bedding planes within the sandstone underlying the palaeochannel (Figure 3.6). Two prominent bedding planes, were mapped across The Bays Station Box area at elevations of approximately -18.5 m AHD and -23.85 m AHD above the base of the Station box (Section 2.2.3). Model layer 6 and 8 represent these two prominent bedding planes. The maximum inferred thickness of the bedding planes is approximately 80 mm, but in most areas the bedding planes have a thickness of only a few millimeters. A conservative approach has been taken and the bedding planes in layer 6 and 8 are assigned a thickness of 1m. This conceptually represents a number of potential (unidentified) bedding planes in the sandstone.

The fresh Hawkesbury Sandstone outside the paleo-valley in model layer 6 and layer 8 is assigned the same properties as the fractured Hawkesbury Sandstone in model layer 4,5,7,9,10 and 11.

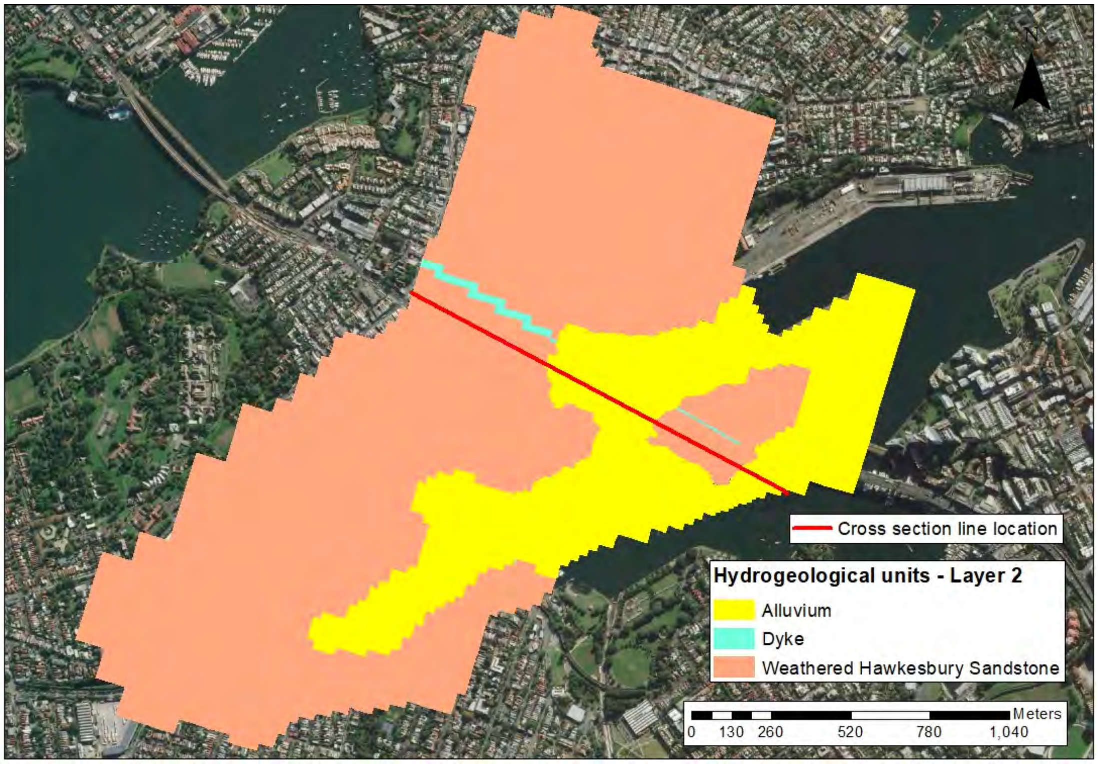

Figure 3.3: Hydrogeological units in model layer 2.

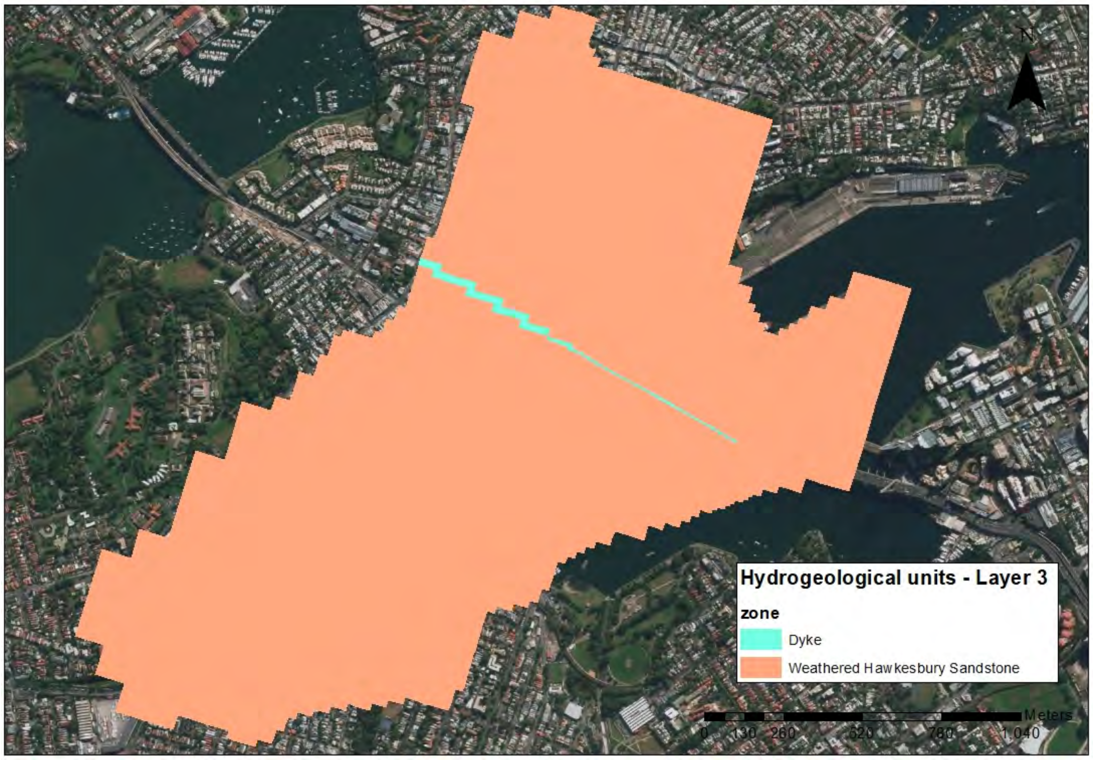

Figure 3.4: Hydrogeological units in model layer 3.

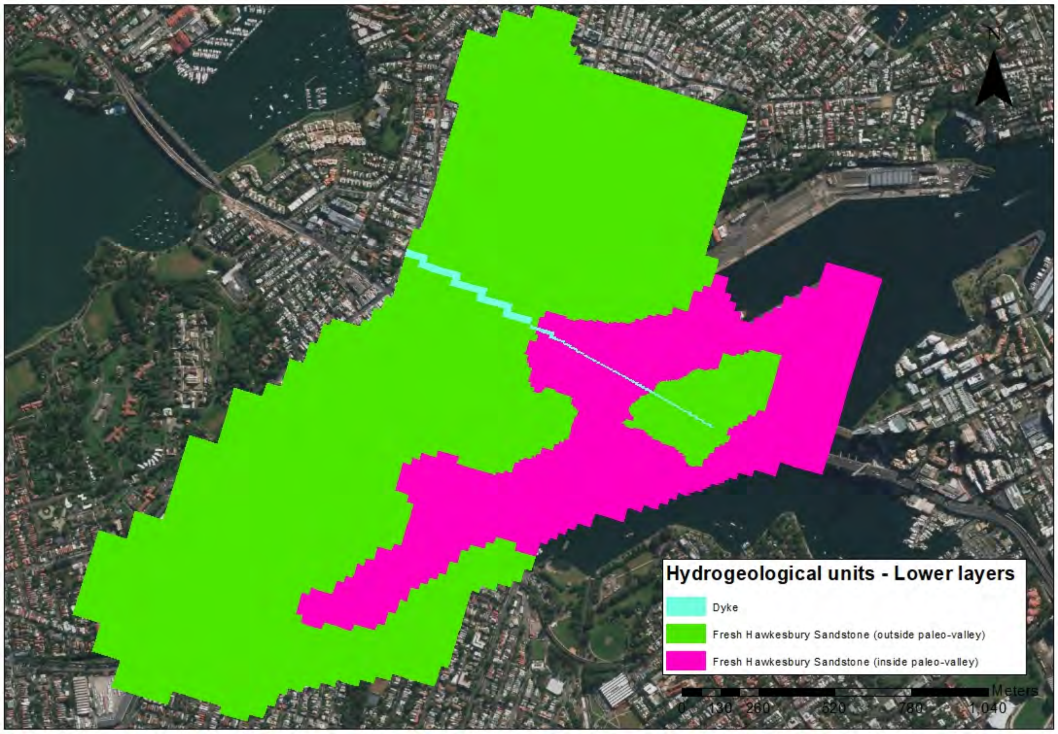

Figure 3.5: Hydrogeological units in model layer 4,5,7,9,10-11.

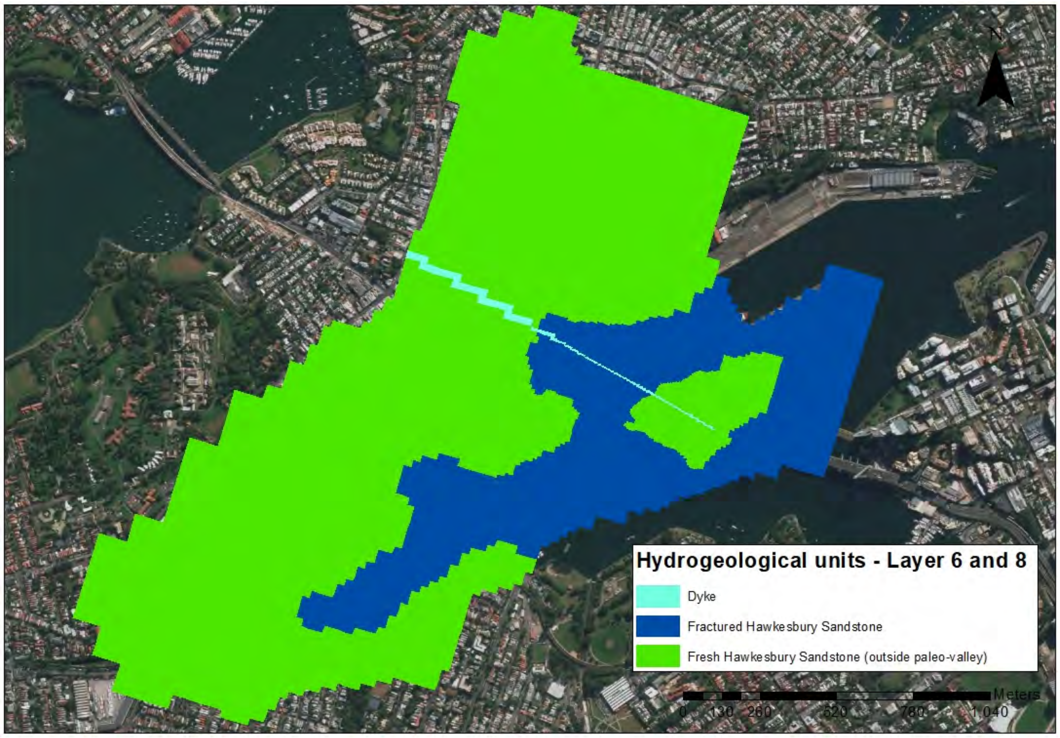

Figure 3.6: Hydrogeological units in model layer 6 and 8.

3.3.7 Representation of project design elements

The following model layer bottom elevations are used to accurately represent key design elements of The Bays Station Box and to constrain the elevation at which inflows to the station box and tunnels are simulated:

- The bottom of model layer 4 coincides with the bottom of the secant-piled wall for The Bays Station Box.
- The bottom of model layer 9 coincides with the bottom of the proposed tunnel from the Bays Station Box
- The bottom of model layer 10 coincides with the bottom of the Bays Station Box.

3.3.8 MODFLOW-USG layer settings

All model layers are simulated as fully convertible between confined and unconfined conditions (Layer type = 4). With this layer type option, when the calculated hydraulic head is below the top of the cell, all the options associated with water -table conditions are implemented. Saturated thickness and transmissivity are recalculated at each iteration based on the water depth of the upstream model cell. For this layer-type option, confined storage coefficient (specific storage × layer thickness) is used to calculate the rate of change in storage if the layer is fully saturated; otherwise specific yield is used.

3.4 Spatial discretisation of model

Quadtree grid refinement was used to refine the model grid in areas along and surrounding the proposed Bays Station Box. Figure 3.7 shows the grid for the active model area and Table 3.2 summarises spatial discretisation information. The smallest model grid length used in the model was 3.125 metres.

Table 3.2: Summary of spatial discretisation information.

Parameter	Value
Minimum grid cell dimension (m)	3.125
Maximum grid cell dimension (m)	100
Number of layers	11
Total number of cells	195,470
Active cells	183,689
Total area (Hectares)	868
Active area (Hectares)	308

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Figure 3.7: Grid for active model area.

3.5 Model parameters

3.5.1 Hydraulic conductivity

Table 3.3 shows the initial hydraulic conductivity values assigned to the model. The hydraulic conductivity values are within the typical value ranges presented in Table 2.1. The initial hydraulic conductivities represent values that are expected to reflect typical conditions.

Table 3.3: Initial hydraulic conductivity values.

Hydrogeological unit		Model layer	Hydraulic conductivity (m/day)		Kv/kh
			Horizontal (Kh)	Vertical (Kv)	
Fill		1	1 [116 Luegons]	1 [116 Luegons]	1
Alluvium		2	0.5 [58 Lugeons]	0.1 [12 Lugeons]	0.2
Weathered Hawkesbury Sandstone		2 to 3	0.4 [46 Lugeons]	0.08 [9 Lugeons]	0.2
Fresh Hawkesbury Sandstone	Palaeochannel	3 to 11	0.176 [20 Lugeons]	0.0176 [2 Lugeons]	0.1
	Outside paleo-channel	3 to 11	0.031 [4 Lugeons]	0.0031 [0.4 Lugeons]	0.1
Horizontal bedding planes (Fractured Hawkesbury Sandstone)		6 and 8	2.666 [309 Luegons]	2.666 [309 Luegons]	1
Great Sydney Dyke		2 to11	0.176 [20 Lugeons]	0.176 [20 Lugeons]	1

3.5.2 Storage parameters

Table 3.4 presents the storage parameters assigned to the model. The storage parameter estimates were within the typical value ranges reported in literature (Table 2.2). The storage parameter values presented in Table 3.4 represent values that are expected to reflect typical conditions.

Table 3.4: Model storage parameters

Hydrogeological unit	Storage parameters	
	Specific storage (Ss) [m^{-1}]	Specific yield (Sy)
Fill	$1x10^{-5}$	0.2
Alluvium	$1x10^{-5}$	0.15
Weathered Hawkesbury Sandstone	$2.3x\ 10^{-6}$	0.05
Fresh Hawkesbury Sandstone	$3.78x10^{-6}$	0.035
Great Sydney Dyke	$3.78x10^{-6}$	0.035

3.6 Model boundary conditions

3.6.1 Rainfall recharge

Recharge is represented in the model using the MODFLOW Recharge (RCH) package. Recharge was assigned to the highest active layer at any location.

Table 3.5 shows the initial rainfall recharge rates assigned to the groundwater model. The initial recharge rates were based on a literature review (Section 2.3.3). Recharge was not applied to open water bodies (White Bay and Rozelle Bay) as these are represented via constant head boundaries. The recharge rates were subsequently adjusted during the model calibration (Section 4.1.2).

Table 3.5: Initial rainfall recharge rates

Hydrogeological unit	Recharge (m/day)	Recharge (% of mean annual rainfall)
Alluvium	$1.3x10^{-4}$	3
Hawkesbury sandstone	$6.7x10^{-5}$	2
Dolerite dyke	$6.7x\ 10^{-5}$	2
White Bay and Rozelle Bay	0	0

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3.6.2 White Bay and Rozelle Bay

White Bay and Rozelle Bay are represented in the model using MODFLOW Constant Head (CHD) boundary conditions. A head of 0.5 m was assigned to the constant head boundaries based on the long-term average water levels recorded at the bays.

3.6.3 Whites Creek

Whites Creek is incised into sandstone. Whites Creek is inundated by daily tides from the Parramatta River. Site inspections undertaken in 2019 and reported in JHCPB Joint Venture (2021) indicated that the creek is concrete-lined but the channel was observed to be in relatively poor condition with some spalling and pervasive cracking. JHCPB Joint Venture (2021) also indicated that cracking was impacting greater than 1% of the channel surface area. Groundwater was observed to be discharging from these cracks, which was taken to imply that when tunnels are constructed and water tables are lowered, saline water from within the channel would leak into the aquifer at high tide.

For the purposes of the groundwater modelling, losses to groundwater from Whites Creek were not considered to be a key feature of the hydrological regime due to the low permeability of the concrete lining. Therefore, MODFLOW Drain (DRN) Boundary conditions were used to represent Whites Creek. The simpler drain boundaries have an advantage (over MODFLOW River Boundary conditions) of having a reduced potential of introducing errors arising from unrealistic losses from the creek.

The drain boundaries were assigned drain elevations approximately equal to the ground surface elevation and drain conductance values between 18 m^2/day and 25 m^2/day depending on the drain length in each model cell. The drain conductance values are based on a hydraulic conductivity for the creek bed material of 1 m/day which is one order of magnitude higher than the conductance applied to Whites Creek in the modelling for the Rozelle Interchange Project (JHCPB Joint Venture, 2021).

3.6.4 No-flow boundaries

No-flow boundaries were assigned outside the margins of the active model domain. The bottom of the model (bottom of model layer 11) is also represented as a no-flow boundary.

4. Model calibration

The model was calibrated for steady state conditions. Calibration was conducted by iterative manual step-wise adjustment of hydraulic conductivity and recharge rates to achieve an acceptable match between simulated and observed heads (groundwater levels).

The 3D numerical groundwater model has not been calibrated to transient conditions because there are insufficient stresses/transient responses in the modelled groundwater system to allow meaningful transient calibration. Groundwater level and inflow monitoring data from the RIC project may permit transient calibration of the model

Calibration head (groundwater level) targets for the steady state model represent average values of head measured at different time periods. The model was calibrated using 13 head targets. The location of the bores used in calibrating the model are presented in Figure 4.1.

Initial hydraulic conductivity estimates assigned to the steady state model during calibration are presented in Section 3.5.1. Initial recharge rates are presented in Section 3.6.1. These initial estimates were adjusted during the model calibration.

Calibration was achieved by qualitatively assessing the match between modelled and observed heads as well as assessing statistical calibration measures.

4.1 Calibrated model parameter values

4.1.1 Calibrated hydraulic conductivity values

Table 4.1 presents the calibrated model hydraulic conductivity values. A reasonable calibration was attained with no modification to the initial hydraulic conductivity values. The model was calibrated for steady state conditions only. As already stated, the 3D numerical groundwater model has not been calibrated to transient conditions because there are insufficient stresses/transient responses in the modelled groundwater system to allow meaningful transient calibration.

Figure 4.1: Calibration target bore locations.

Table 4.1: Calibrated model hydraulic conductivity values

<table>
<tr><th colspan="2" rowspan="2">Hydrogeological unit</th><th rowspan="2">Model layer</th><th colspan="2">Hydraulic conductivity (m/day)</th><th rowspan="2">Kv/kh</th></tr>
<tr><th>Horizontal (Kh)</th><th>Vertical (Kv)</th></tr>
<tr><td colspan="2">Fill</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">Alluvium</td><td>2</td><td>0.5</td><td>0.1</td><td>0.2</td></tr>
<tr><td colspan="2">Weathered Hawkesbury Sandstone</td><td>2 to 3</td><td>0.4</td><td>0.08</td><td>0.2</td></tr>
<tr><td rowspan="2">Fresh Hawkesbury Sandstone</td><td>Paleo-channel</td><td>3 to 11</td><td>0.176</td><td>0.0176</td><td>0.1</td></tr>
<tr><td>Outside paleo-channel</td><td>3 to 11</td><td>0.031</td><td>0.0031</td><td>0.1</td></tr>
<tr><td colspan="2">Horizontal bedding planes (Fractured Hawkesbury Sandstone)</td><td>6 and 8</td><td>2.666</td><td>2.666</td><td>1</td></tr>
<tr><td colspan="2">Great Sydney dyke</td><td>2 to11</td><td>0.176</td><td>0.176</td><td>1</td></tr>
</table>

4.1.2 Calibrated recharge values

Table 4.2 presents the recharge rates assigned to the calibrated model. The recharge rate assigned to the Hawkesbury Sandstone and the dyke was increased from an initial value 2% of mean annual rainfall (MAR) to 4% of MAR. Calibration was attained with no modification to the recharge rate applied to the Alluvium.

Table 4.2: Calibrated model recharge rates

Hydrogeological unit	Recharge (m/day)	Recharge (% of mean annual rainfall)
Alluvium	1.3×10^{-4}	4
Hawkesbury sandstone	1.3×10^{-4}	4
Dolerite dyke	1.3×10^{-4}	4
White Bay and Rozelle Bay	0	0

4.2 Calibration assessment

Figure 4.2 shows the match between simulated groundwater levels (heads) in the calibrated model and observed heads. Qualitatively assessing the match between modelled and observed heads (Figure 4.2), the degree of calibration can be assessed according to how close the plotted points are to the diagonal line from the origin (i.e. along the line y=x that represents perfect calibration). Figure 4.2 shows a good match between simulated heads in the calibrated model and observed heads, except for heads observed in Bore 181A (bore at model layer 4 horizon). Modelled heads at target bore locations in the vicinity of the proposed Bays Box are generally within 1 of observed heads. Modelled heads at all target bore locations, except B181A are within 5 m of observed heads.

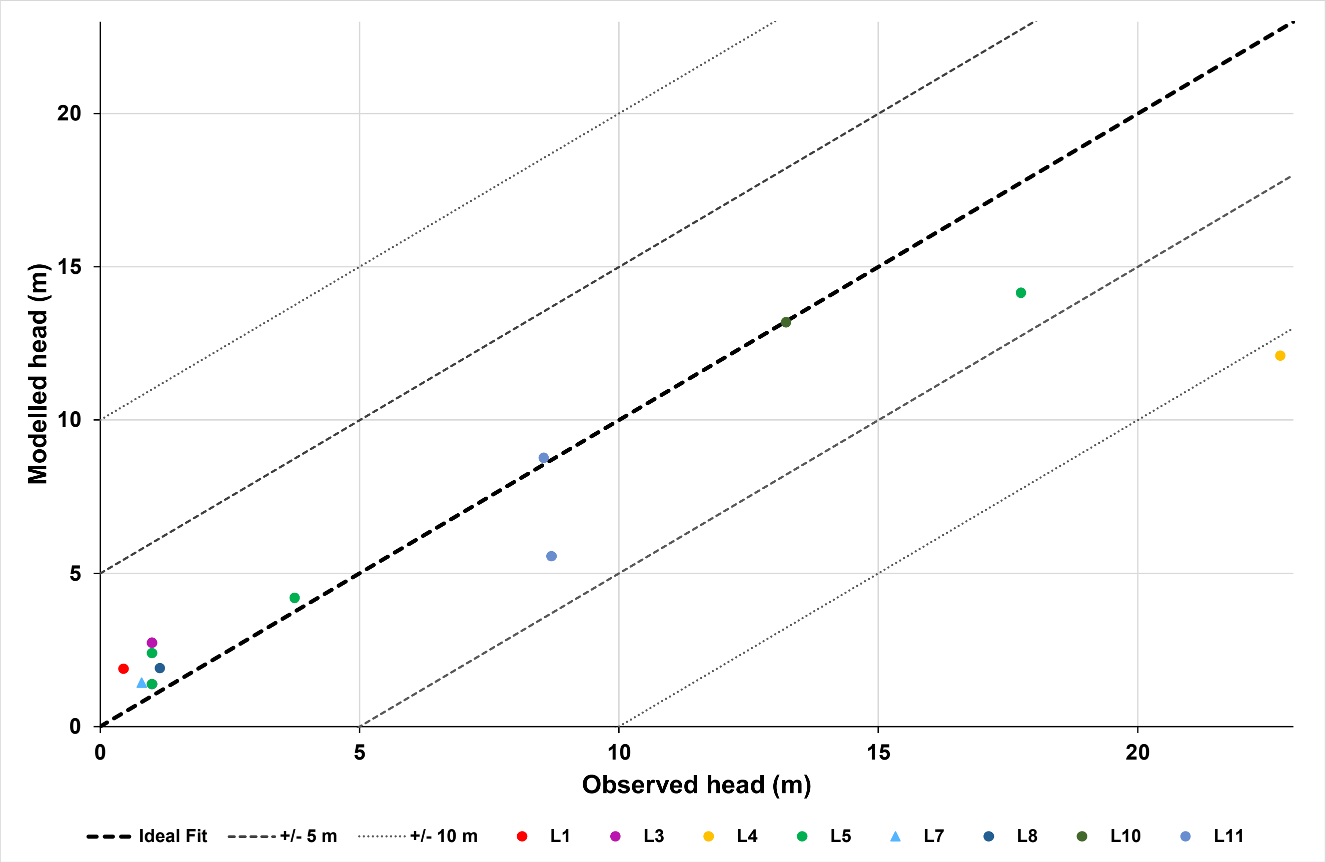

Figure 4.2: Comparison of modelled and observed heads.

Figure 4.3 shows the magnitudes of the head residual errors for the calibration targets. The residual is the difference between the observed and modelled head. A positive residual indicates that the simulated head is less than observed head. A negative residual indicates that the simulated head is higher than the observed head. For multi-level piezometer sites, the average residual error for the monitoring site is presented in Figure 4.3.

The head residual errors for calibration target sites located near the Bays indicate that the modelled heads are all within 1m of the observed heads. Across the model domain, the residual errors for all calibration targets, except bore 181A, are below 4 m.

Figure 4.3: Head residuals for calibration targets

Table 4.3 presents a summary of the calibration statistics for model. The scaled root mean square (scaled RMS) is one of the statistics often used to quantitatively assess the goodness-of-fit between simulated groundwater levels and actual observed groundwater levels. A scaled RMS of less than 0.1 usually indicates a reasonably high degree of model calibration.

Table 4.3 indicates that the scaled RMS error calculated by considering all calibration targets slightly exceeds the 10% threshold. This exceedance is attributed to the relatively poor degree of calibration in the area around Bore 181A. The scaled RMS error reduces to less than 0.1 when the calibration results for Bore 181A are not included in the calculation of the scaled RMS error.

In summary, the model simulates average groundwater levels (heads) across the model with reasonable accuracy, except in the area surrounding Bore 181A. Given that Bore 181A is located a considerable distance from the project area, the level of calibration achieved is considered acceptable for the purposes of this groundwater assessment.

Table 4.3: Calibration statistic summary.

Calibration statistic	Value	
	All calibration targets	Calibration targets excluding Bore 181A
Residual Mean	0.77	0.05
Residual Standard Deviation	3.25	1.62
Absolute Residual Mean	1.91	1.18
Residual Sum of Squares	145	313
RMS Error	3.34	1.62
Minimum Residual	-1.73	-1.73
Maximum Residual	10.65	3.59
Range of Observations	22.30	17.30
Scaled Residual Standard Deviation	0.146	0.093
Scaled Absolute Mean	0.086	0.068
Scaled RMS	0.150	0.09
Number of Observations	13	12

4.3 Calibration sensitivity analysis

Sensitivity analysis was undertaken to:

- Assess the effects of changing model parameter values on the degree (quality) of the model calibration
- identify the parameters that have the greatest influence on model calibration.

Model parameters assessed during the model calibration were recharge and hydraulic conductivity.

4.3.1 Recharge sensitivity analysis

The sensitivity analysis for recharge involved varying the recharge rates applied to the model and assessing the changes to the calibration scaled RMS error. Only one recharge parameter was varied at a time for each sensitivity model run. All the other model parameters were maintained at calibrated model values.

Figure 4.5 shows the scaled RMS errors for varying recharge rates applied to the Hawkesbury Sandstone and Alluvium. The results indicate that the model is more sensitive to changes in the Hawkesbury Sandstone recharge than to changes in the Alluvium recharge. This result is as we would expect given that:

- The Hawkesbury Sandstone covers a substantially larger model area compared to Alluvium. Therefore, from a water balance perspective, changes to the Hawkesbury Sandstone recharge rate (depth in mm/year) will have a significantly larger impact on the overall recharge volume to the model compared to Alluvium recharge rate changes.
- Most of the head observation points (monitoring bores) within or immediately underlying the Alluvium are located in close proximity to the harbour. The harbours are represented in the model using constant head boundaries which constrain groundwater levels simulated in areas adjacent areas.

From the model sensitivity analysis, it was concluded that further refinement of Alluvium recharge through improved or extended calibration would not provide any meaningful improvement in the reliability of the model since the calibration statistics (scaled RMS error) are relatively insensitive to variation of this recharge parameter. Moreover, doing so could lead to assigning physically unrealistic values to the parameters in order to make model results fit the measurements.

Figure 4.4 also indicates that the scaled RMS error exceeds 0.2 when Hawkesbury Sandstone recharge rates below 3% of mean annual rainfall (MAR) and above 9% of MAR are applied to the model. This implies that the model calibration degrades significantly at Hawkesbury Sandstone recharge rates outside the 3% to 9% of MAR range. However, given the non-uniqueness of groundwater models, many different combinations of model inputs can produce calibrated models that match observed heads. Therefore, it is possible to obtain a well-calibrated model with Hawkesbury Sandstone recharge rates outside the 3% to 9% of MAR range.

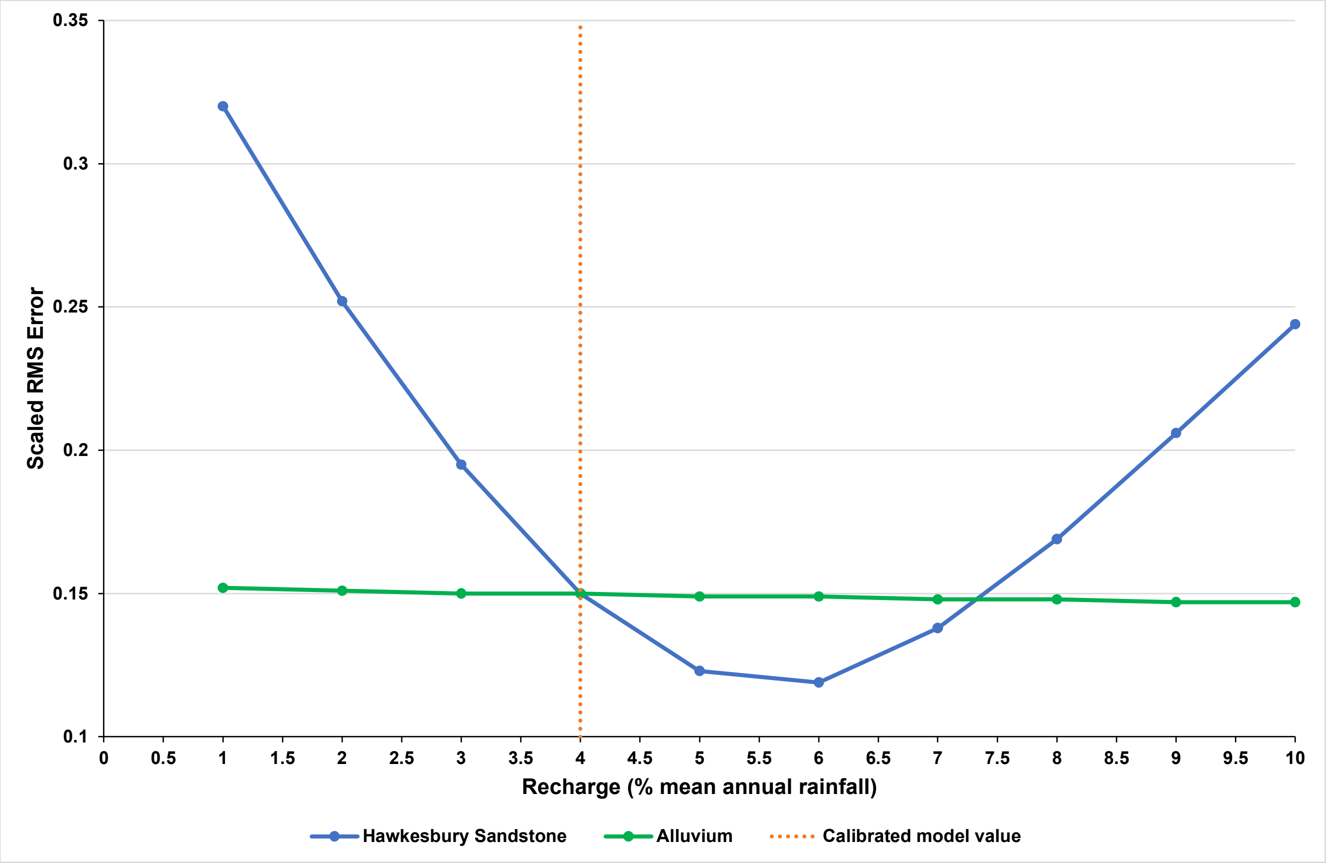

Figure 4.4: Recharge sensitivity analysis based on the scaled RMS error.

Figure 4.5 shows both the scaled RMS error and the residual errors for each calibration target. The scaled RMS error and the residual errors were calculated for varying recharge rates ranging from 2% to 10% of MAR. Initial recharge rates of 2% and 3% of MAR were assigned to the Hawkesbury Sandstone and the Alluvium respectively, based on the literature review (Section 2.3.3). For the other sensitivity scenarios, the Hawkesbury Sandstone and the Alluvium were assigned the same recharge rates.

Figure 4.5 shows relatively low residual errors for recharge rates up to 10% of MAR at calibration target locations in and around the proposed Bays Box area (SMW_BH066_s, SMW_BH067_s, SMW_BH724_w, SMW_BH725_w and SMW_BH066_w). Figure 4.5 also shows that the calibrated model (with recharge of 4% of MAR applied to both the Hawkesbury Sandstone and the Alluvium) is associated with the following:

- low residual errors for calibration targets located in and around the proposed Bays Box area
- a reasonably low scaled RMS error of 0.15

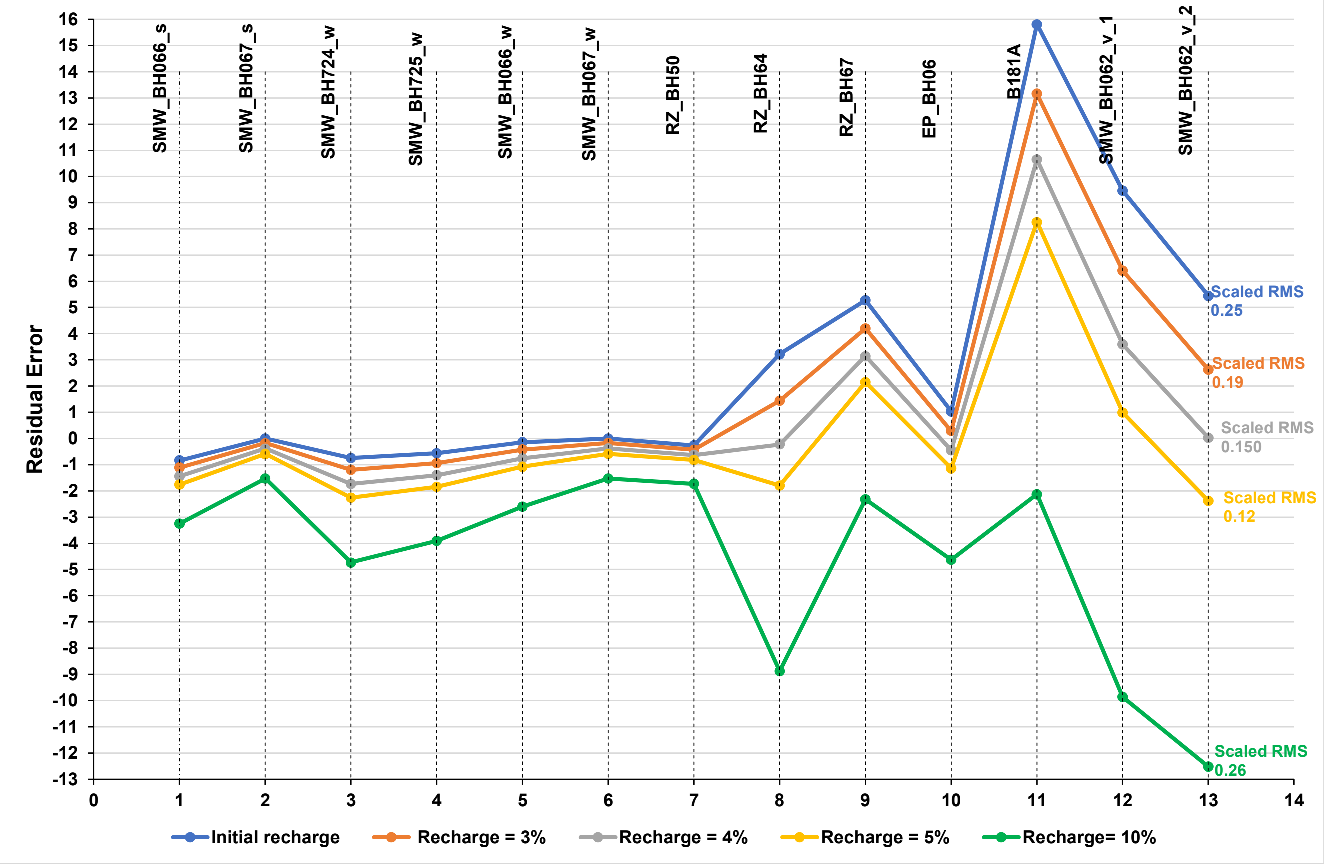

Figure 4.5: Recharge sensitivity analysis including residual errors.

4.3.2 Hydraulic conductivity sensitivity analysis

Hydraulic conductivity values were varied by up to 20 times from calibrated model values. The results of the sensitivity analysis presented in Figure 4.6 to Figure 4.8 indicate that the highest model sensitivity is associated with changes in the hydraulic conductivity for the Hawkesbury Sandstone outside the paleo-valley. The model is not very sensitive to changes in Alluvium hydraulic conductivity and the hydraulic conductivity assigned to the Hawkesbury Sandstone inside the paleo-valley.

For the Hawkesbury Sandstone outside the paleo-valley, Figure 4.7 indicates that the scaled RMS error exceeds 0.2 when the hydraulic conductivity for the sandstone is reduced below 0.005 m/day or increased above 0.05 m/day. This implies that the model calibration degrades significantly when the sandstone hydraulic conductivity is outside the 0.005 to 0.05 m/day range. However, given the non-uniqueness of groundwater models, many different combinations of model inputs can produce calibrated models that match observed heads. Therefore, it is possible to obtain a well-calibrated model with the sandstone hydraulic conductivity outside the 0.005 to 0.05 m/day range.

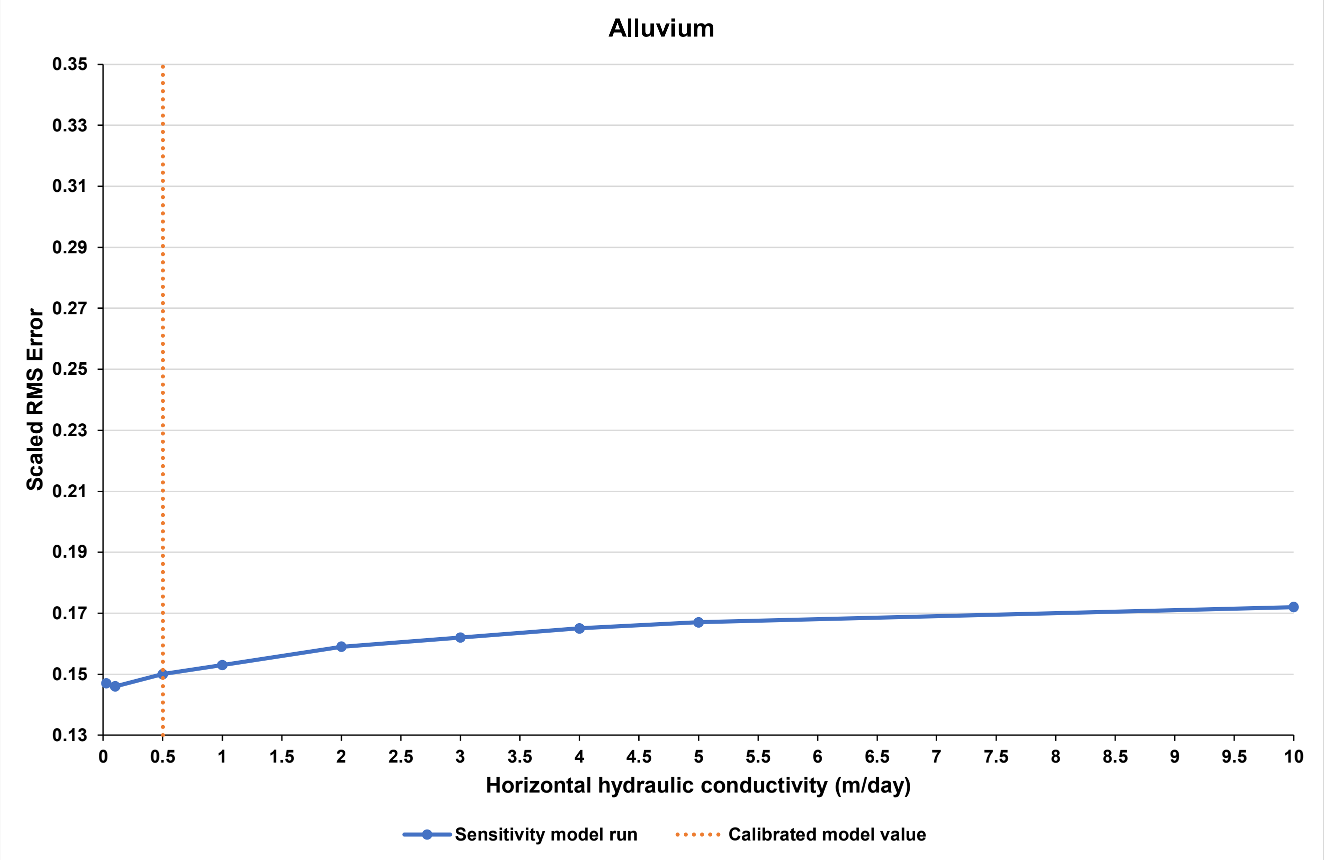

Figure 4.6: Sensitivity analysis results - Alluvium

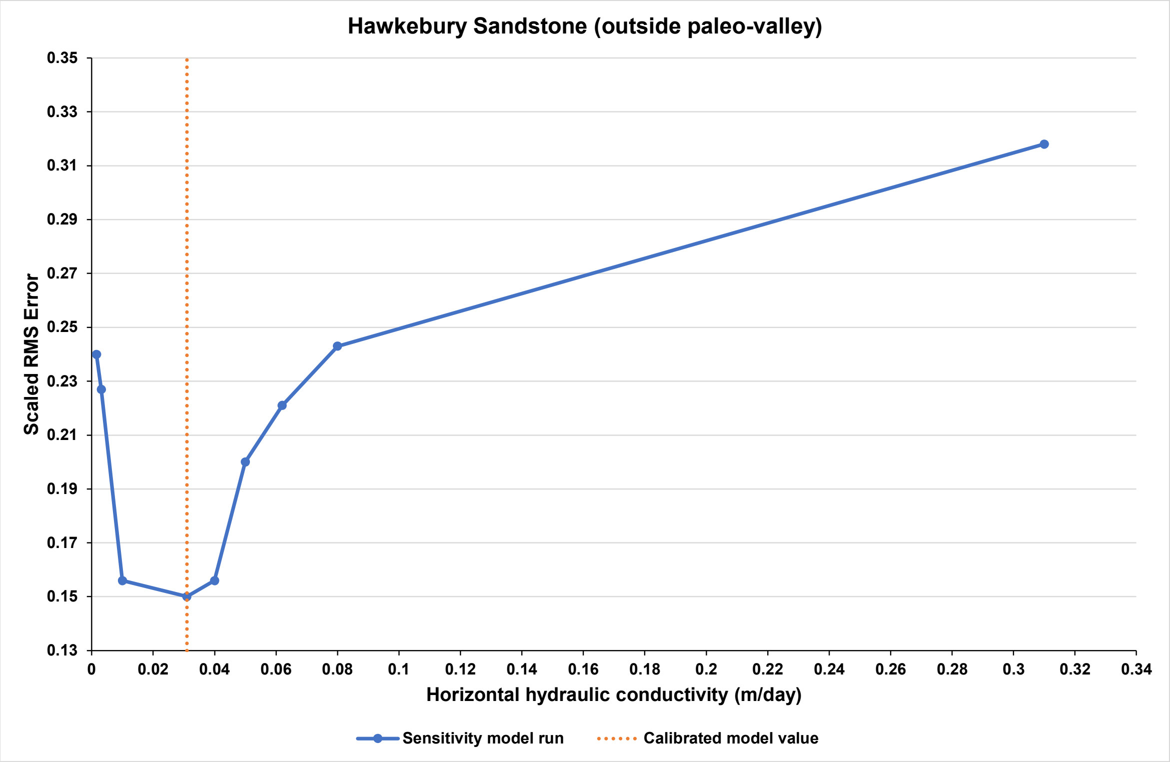

Figure 4.7: Sensitivity analysis results - Hawkesbury Sandstone (outside paleo-valley)

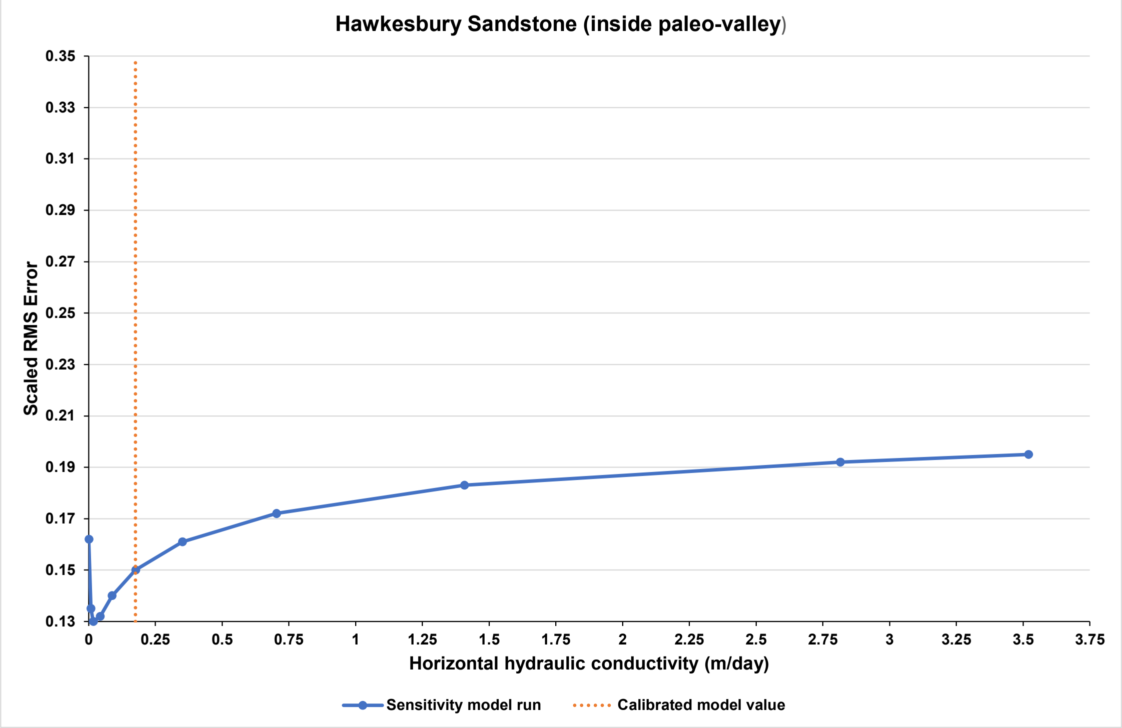

Figure 4.8: Senstivity Analysis- Hawkesbury Sandstone (inside paleo-valley).

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4.4 Calibrated model water balance

Table 4.4 presents the water balance for the steady state model. The only simulated inflow to the groundwater system is rainfall recharge. Rainfall-recharge contributes the largest proportion of inflows to the modelled groundwater system. Simulated recharge assigned to the model is net recharge (gross recharge minus evapotranspiration). The largest proportion of simulated groundwater discharge occurs through outflows along the bays.

Table 4.4: Model water balance - steady state model.

Component	Inflow (m^3/day)	Outflow (m^3/day)
Rainfall recharge	379	
Constant head (Bays)		279
Drains (Whites Creek)		100
TOTAL	379	379
PERCENTAGE ERROR	0%	

5. Predictive flow modelling approach

5.1 Predictive groundwater flow modelling

Predictive modelling was carried out to simulate the following:

- Groundwater inflows into the Bays Station box and tunnels located to the west of the station box.
- The magnitude and extent of groundwater drawdown.

A predictive transient groundwater flow model was developed, based on the calibrated steady state model. The predictive transient groundwater model was setup to simulate groundwater conditions up to the end of CTP works (the end of December 2024), approximately 768 days after completion of The Bays Station Box excavation.

Table 5.1 summarises the model stress periods used in the predictive model simulations. Seven-day long stress periods were applied for the duration of The Bays Station Box excavation period. Stress periods ranging from 2 to 5 days were applied for the duration of the tunnel excavation period. Shorter stress period durations were used for simulating the tunnel excavation period in order to provide more accurate spatial and temporal representation in the model of the advance of the drained open tunnel excavation face. A single 651-day long stress period, broken down into five timesteps, was used to simulate groundwater conditions following station box excavation leading to the establishment to re-establishment of steady-state conditions.

Table 5.1: Stress period summary for predictive model.

Simulation period	Dates	Number of stress periods	Duration of each stress period	Timesteps per stress period
Bays Station Box construction	3/03/2022 to 24/11/2022	38	7 days	3
Pre-tunnel excavation	24/11/2022 to 20/12/2022	3	7 days	3
Tunnel excavation	20/12/2022 to 21/03/2023	41	2 to 5 days	3
Post construction	21/03/2023 to 31/12/2024	1	651	5

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For each stress period, a time-step multiplier of 1.2 was used to calculate the increase in model time-step length from one time-step to another.

Two predictive model scenarios of the numerical groundwater model were run. One scenario represented the "Project Case" in which the proposed Bays Station Box and the TBM tunnel excavation are simulated. The other scenario referred to as the "Null Case" does not include simulation of The Bays Station Box and the TBM tunnel excavation. Groundwater drawdown was estimated by subtracting simulated "Project Case" groundwater levels from "Null Case" groundwater levels.

5.2 Simulation of inflows to Station Box

5.2.1 Station Box excavation staging

Table 5.2 provides information on proposed excavation progression in soil (fill, alluvium and residual soils) for the western and eastern parts of The Bays Station Box. Table 5.3 provides information on the excavation progression in rock. The progression of excavation in soil is faster in soil compared to rock. Table 5.2 and Table 5.3 indicate that the overall excavation rate in the western part of the box will be faster than in eastern part due to the thicker soil thickness in the west compared to the east.

Table 5.2: Excavation advance rates in soil.

Part of Box	Length (m)	Excavation dates		Excavation days	Average Soil thickness (m)	Excavation Rate (m/day)
		Start	End			
Western	120	3/03/2022	16/04/2022	44	16	0.36
Eastern	110	25/03/2022	5/04/2022	11	4	0.36

Table 5.3: Excavation advance rates in rock.

Section	Length (m)	Excavation dates		Excavation days	Average rock thickness (m)	Excavation Rate (m/day)
		Start	End			
Western	120	16/04/2022	26/08/2022	132	16	0.12
Eastern	110	5/04/2022	24/11/2022	233	28	0.12

5.2.2 Model representation of station box inflows

MODFLOW Drain (DRN) boundary conditions were used to simulate inflows to The Bays Station Box. The deepening of the excavation over time is simulated by progressively lowering the drain elevations assigned to the DRN cells over time. Stress periods applied to the model for the station excavation period each have a duration of seven days.

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5.2.3 Drain conductance

A DRN cell conductance value of 100,000 m^2/day was assigned to the model to simulate inflows to The Bays Station Box. The drain conductance was applied based on the conservative approach recommended by Zaidel et al. (2010), which is applicable when the dimensions of the excavation are comparable to the numerical model cell sizes. Zaidel et al. (2010) recommends assigning artificially high conductance values at drain cells, which are at least 2 orders of magnitude higher than the MODFLOW hydraulic conductance term (i.e., the product of hydraulic conductivity and cell cross-section areas divided by average distance between the nodes). Numerical experiments undertaken by Zaidel et al. (2010) indicated that applying drain conductance values of this magnitude generally results in negligible simulated flow resistance and that computed head at the location of an active drain node was always very close to the specified drain elevation. A drain conductance of 100,000 m^2/day is more than 2 orders of magnitude higher than the MODFLOW hydraulic conductance term for any model cell containing a tunnel drain.

A high-level sensitivity analysis performed for the preliminary predictive model runs indicated that, above a certain threshold drain conductance value, the simulated excavation inflows are insensitive to the drain conductance value assigned to the model. During the preliminary predictive model runs, similar predicted excavation inflows were obtained using drain conductance values of 100 m^2/day and 100,000 m^2/day.

5.3 Simulation of inflows to TBM tunnels

5.3.1 Tunneling staging

The tunnel boring machines (TBM) will launch from the western portion of The Bays Station box. Table 5.1 presents the Tunnel Boring Machine (TBM) excavation time staging. Information provided by the contractor indicates that excavation of the North Tunnel and South Tunnel will progress as follows:

- **North tunnel**: TBM launched on 20 December 2022 and tunneling continues for 164 m until 21 January 2023. Excavation pauses on 21 January 2023 and resumes on 20 February 2023.
- **South tunnel**: TBM launched on 20 January December 2023 and tunneling continues for 164 m until 22 February 2023. Excavation pauses on 22 February 2023 and resumes on 21 March 2023

The tunnels will be constructed using an open-faced TBM with segmental lining erected behind the machine. Groundwater inflows will occur through the tunnel excavation face, and along the tunnel perimeter between the excavation face and where grout is injected behind the tailshield (between the excavation face and the segmental lining). There is an assumed distance of 12 m between the excavation face and the location where the grout is injected. The rate of tunnel excavation is expected approximately 5.1 m/day

5.3.2 Model representation of tunnel inflows

DRN boundary conditions were used to simulate inflows to the moving 12 m open excavation face. The model stress periods for the period between 20 December 2022 and 21 March 2023 are setup to

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provide an accurate representation of the progression of the drained 12 m tunnel open excavation face (Table 5.1).

A DRN cell conductance value of 100,000 m^2/day was assigned to the model to simulate inflows to the tunnel open excavation face based on the approach described in Section 5.2.3.

The model does not simulate tunnel inflows after 21 March 2023, when the tunnelling re-starts after the TBM in the South Tunnel has been idle and sitting under the power station. This means that the tunnel excavation is not simulated after 21 March 2023 (i.e. final stress period). As a result, the predicted drawdown for the final model stress period does not include drawdown due to groundwater inflows to the tunnel. The implications of this approach are discussed in the predicted drawdown results section (Section 6)

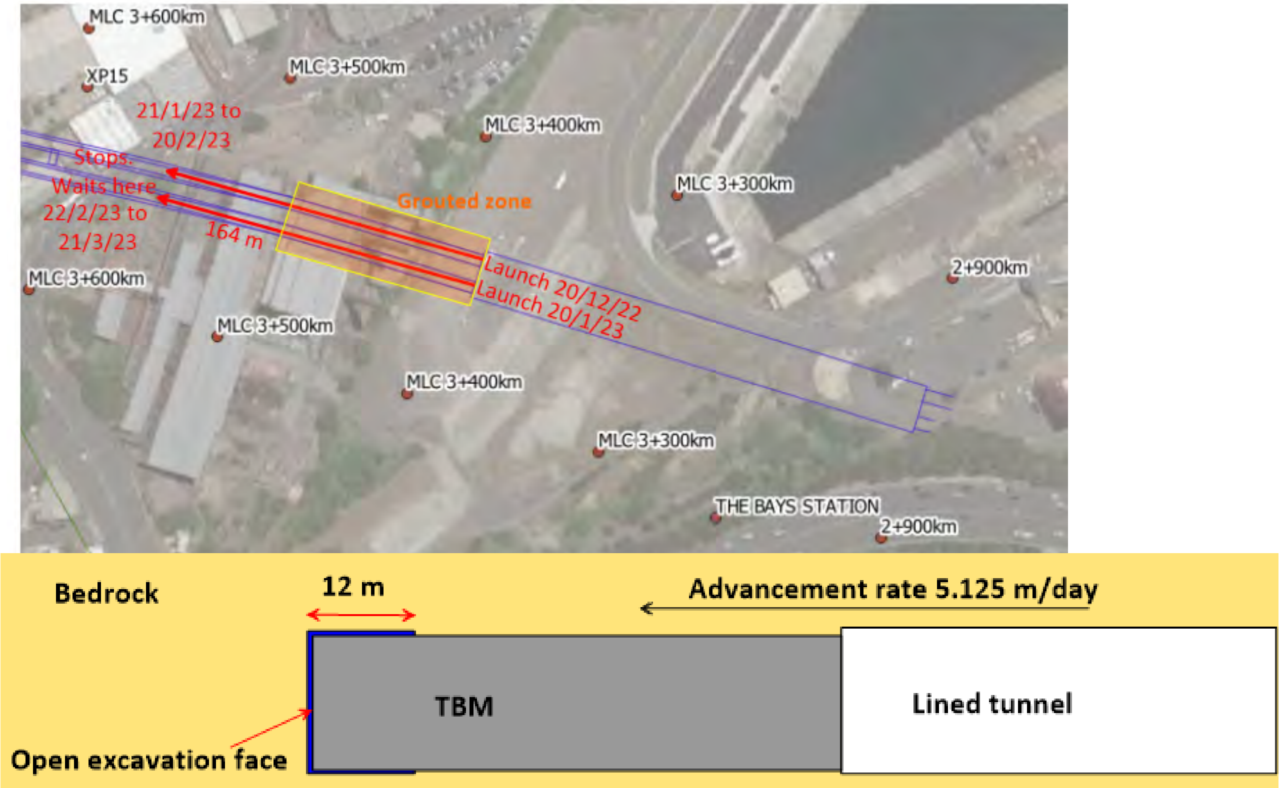

Figure 5.1: Tunnelling staging

5.4 Simulation of secant-piled wall

The Bays Station Box design considered for this assessment consists of a retention system comprising a cast in place reinforced secant-piled wall which is embeded into the fresh Hawkesbury Sandstone. One of the purposes of the Secant-piled wall is to minimize the groundwater inflow into the excavation

The Secant-piled wall will be constructed through the full thickness of the soil and weathered Hawkesbury Sandstone around the excavation, except where the rock is shallow. The toe of the Secant-piled wall will be at a minimum elevation of -18.5 m AHD at the western end of the Station Box and -16.5 AHD at the eastern end of the Station Box. The toe elevation of the drain is higher towards the eastern end of the Station Box where the depth to the top of the fresh Hawkesbury Sandstone is shallower.

The Bays Station Box secant-piled wall was simulated using the MODFLOW Horizontal Flow Barrier (HFB) package. HFB boundaries are used to simulate vertical low-permeability features that impede the horizontal flow of groundwater (USGS, 2021). The key assumption underlying the HFB Package is that the width of the barrier is negligibly small in comparison with the horizontal dimensions of the cells in the grid. Barrier width is not explicitly considered in the Package but is included implicitly in a hydraulic characteristic defined barrier hydraulic conductivity divided by barrier width. HFBs are assumed to have zero storage capacity.

Figure 5.2 shows the location of HFB boundaries around the station box. The Secant-piled wall is absent along some sections in the eastern half of the station Box, where the fresh Hawkesbury Sandstone outcrops at the ground surface. Where, the HFB boundaries are present, they are assigned from ground surface (model layer 1) to layer 4. Elevations assigned to the bottom of layer 4 in the model coincide with the bottom of the Secant-piled wall as specified in the designs (Section 3.3.7).

The HFB boundaries are assumed to be impermeable and are assigned a hydraulic conductivity of 1× 10^{-12} m/day and a thickness of one meter.

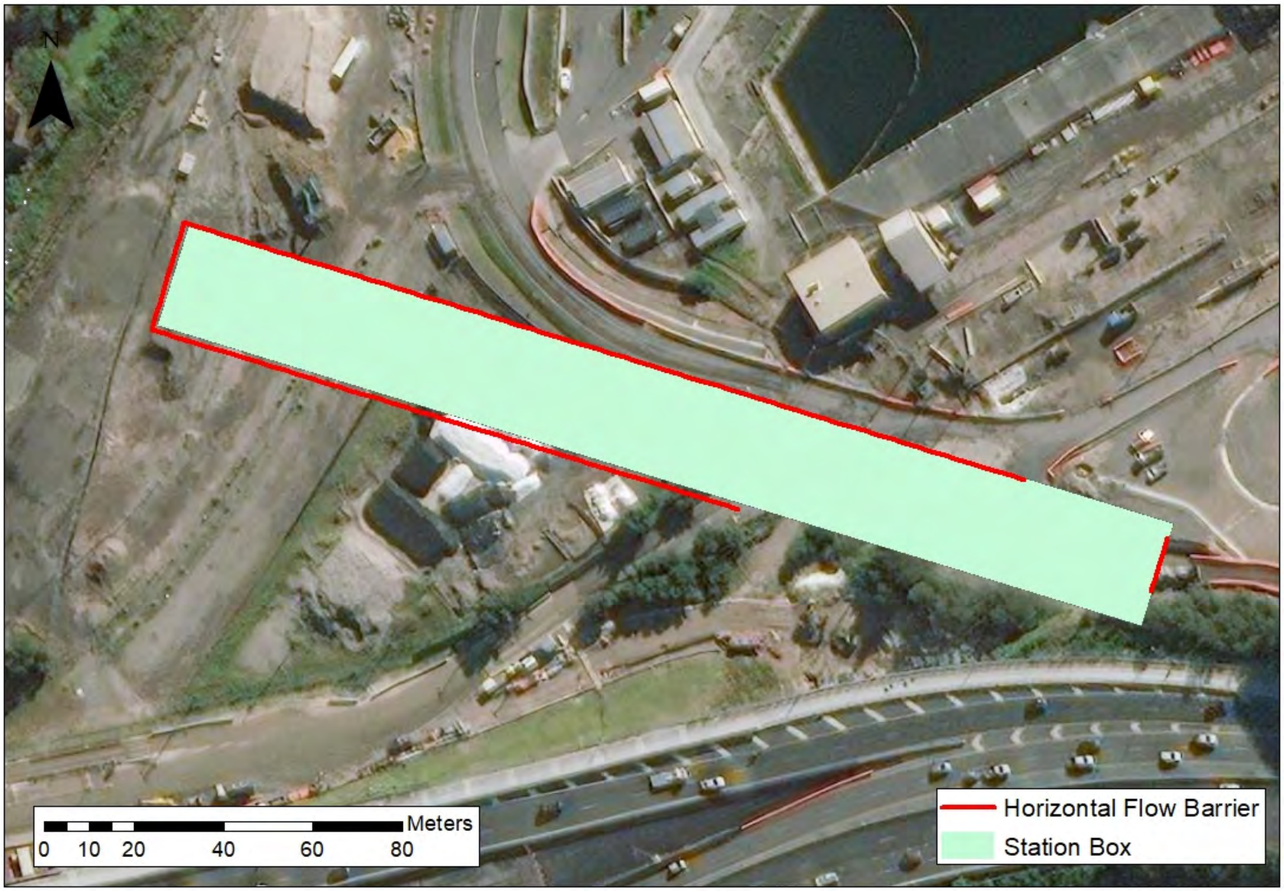

Figure 5.2: MODFLOW Horizontal Flow Barrier boundary locations.

5.5 Simulation of Station Box grouting design.

Given the relatively high permeability of the bedrock, pre-excavation grouting from the surface will be used to control groundwater inflows to the excavation for The Bays Station excavation. Figure 5.3 shows a cross-sectional view of the proposed Station Box grouting scheme. The grout will be applied to a depth of approximately 24 m below the base of the Station Box (elevation of -52 m AHD).

The following grouting targets have been adopted:

- Bulk rock will be grouted to reduce the hydraulic conductivity to approximately 1 Lugeon (8.6 x 10^{-3} m/day)
- Dilated bedding planes will be grouted to reduce the hydraulic conductivity to approximately 5 Lugeons (4.3 x 10^{-2} m/day).

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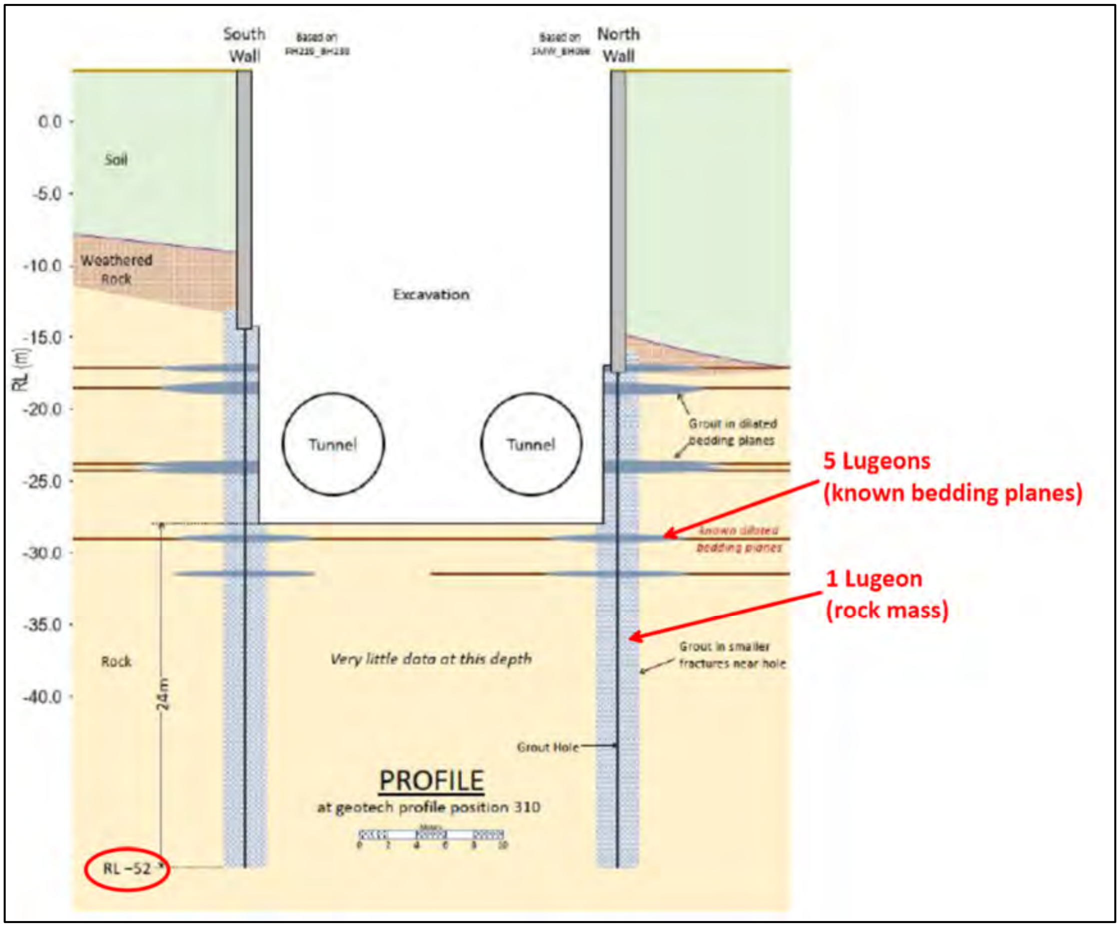

Figure 5.3: Station Box grouting design.

The grouting scheme was simulated in the model by reducing the hydraulic conductivity for model cells along the perimeter of the Station Box to the design hydraulic conductivity. Typical grout layout in the model layers is shown in Figure 5.4. The grout curtain was simulated mainly in model layer 5 to layer 11, below the Secant-piled wall. The grout curtain was, however, also simulated in model layer 1 to 4 in areas where the Secant-piled wall is absent (Figure 5.2).

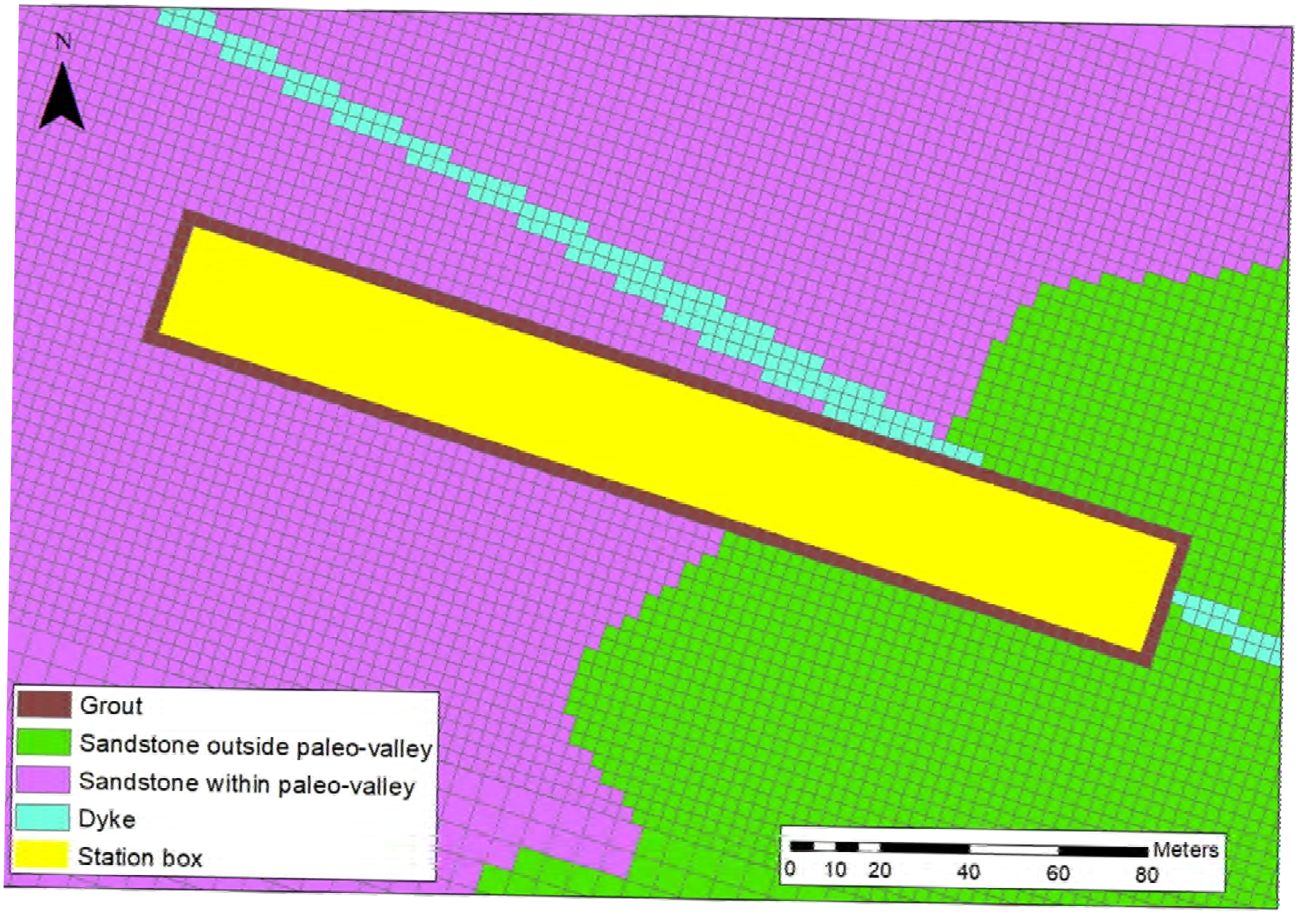

Figure 5.4: Typical grout layout in model layer.

Two grouting schemes with varying grout hydraulic conductivity for the bedding planes were simulated (Table 5.4). For scenario 1, hydraulic conductivity of 5 Lugeons (4.3 x 10^{-2} m/day) was assigned to the grout represented in model layer 6 and 8. For Scenarios 2, both the bulk rock and the bedding planes were simulated with a hydraulic conductivity of 1 lugeon (8.6 x 10^{-3} m/day).

Table 5.4: Simulated grouting scenarios

Grouting Scenario	Bulk rock		Bedding planes	
	Grouted hydraulic conductivity		Grouted hydraulic conductivity	
	Lugeons	m/day	Lugeons	m/day
1	1	$8.6x10^{-3}$	5	$4.3x10^{-2}$
2	1	$8.6x10^{-3}$	1	$8.6x10^{-3}$

5.6 Simulation of TBM Grouting design for White Bay Power Station.

The tunnel boring machines (TBM) will launch from the western portion of The Bays Station box. The following scenarios have been simulated:

- Pre-excavation grouting will be carried out in the area surrounding the proposed TBM tunnel drives extending some 130m out from The Bays Station box and extending beneath the former White Bay Power Station (WBPS).
- No pre-excavation grouting in the area surrounding the tunnels

The pre-grouting scenario is being considered because the tunnel drives in this White Bay Power Station area have limited rock cover and underlie some 20m of saturated alluvial soils and fill material. The aim of the grouting is to reduce groundwater inflows through the rock and reduce the risk of dewatering/depressurising the overlying saturated alluvium that can lead to settlement of the surface and deformation of the power station foundations that are understood to found within the alluvium.

Figure 5.5 presents the proposed grouting scheme for the tunnels. The grouted zone will extend on all sides of the tunnels a distance equivalent to the diameter of one tunnel. The tunnel diameter of approximately 7 m was represented in the model by two refined model cells (model cell length = 3.125 m)

The fresh Hawkesbury Sandstone will be grouted to achieve a hydraulic conductivity of 1 lugeon (8.6 x 10^{-3} m/day). The weathered Hawkesbury Sandstone and bedding planes will be grouted to achieve a hydraulic conductivity of 5 lugeons (4.3 x 10^{-2} m/day).

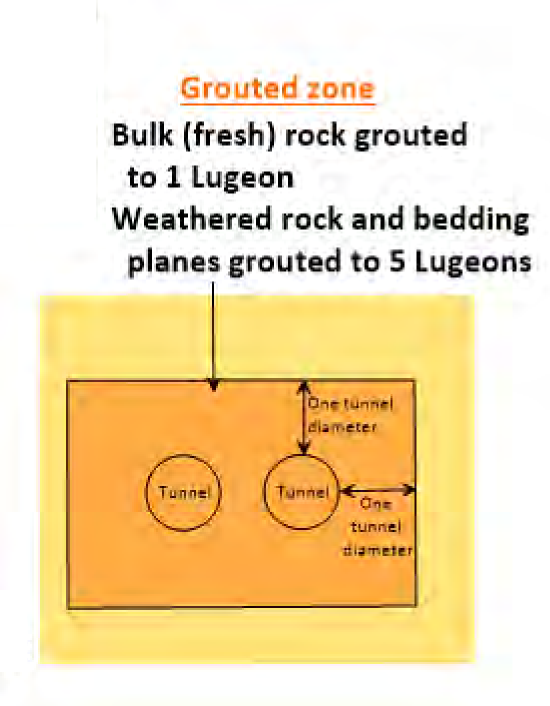

Figure 5.5: Grouting scheme around TBM tunnels

6. Predictive flow modelling results

6.1 Predictive modelling scenarios

The following predictive scenarios were run:

- **Unmitigated station box scenarios**: For the unmitigated scenarios, it is assumed that the station box cut-off wall is present, but inflows to the station box excavation occur through the unmodified sandstone bedrock. The following two unmitigated scenarios have been considered:
    - The hydraulic conductivity of the Hawkesbury Sandstone underlying the palaeochannel is 20 Lugeons (0.173 m/day). This is the base case value based on the calibrated model values (Table 4.1).
    - The hydraulic conductivity of the Hawkesbury Sandstone underlying the palaeochannel is 80 Lugeons (0.691 m/day). This is the highest interpreted horizontal hydraulic conductivity value from the pump-out tests carried out for this project and is above the 90th percentile (equal to 64 Lugeons) of all packer test results in the palaeochannel. It therefore represents scenario under which permeability of the rock in the palaeochannel is closer to the upper bound of what is considered likely.
- **Mitigated station box base case**: Bulk rock grouted to reduce hydraulic conductivity to 1 lugeon (0.009 m/day). Bedding planes grouted to reduce hydraulic conductivity to 5 lugeons (0.043 m/day). No grouting simulated along the TBM tunnel alignment. The TBM tunneling and associated groundwater inflows are not simulated.
- **Mitigated station box (1 Lugeon)**: Same as “Mitigated base case” except bedding planes grouted to reduce hydraulic conductivity to 1 lugeon.
- **Mitigated station box (1 Lugeon) with mitigated WBPS and tunneling**: Same as “Mitigated station box (1 Lugeon)” except:
    - The TBM tunneling and associated groundwater inflows are simulated, and
    - Grouting is simulated along the first 130 m length of the TBM tunnel alignments adjacent to the station box. The grouting is described in Section 5.6.
- **Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling**: Same as “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” except, grouting beneath the WBPS is not simulated.
- **Mitigated Station box (1 Lugeon) and unmitigated WBPS (80 Lugeon rock mass):** Unmitigated WBPS with a high permeability feature within the tunnel horizon (Model layer 9). The Feature is 1 m thick and has a hydraulic conductivity of 308 Lugeons (2.661 m/day). The hydraulic conductivity of the fresh Hawkesbury Sandstone in the Palaeochannel is 80 Lugeons (0.691 m/day). An

equivalent hydraulic conductivity is applied to the model layer through which tunnel passes (Model layer 9), which has the high permeability feature.

- **Mitigated Station box (1 Lugeon), unmitigated WBPS (80 Lugeon rock mass) and CHBC:** Same as the "Unmitigated WBPS - 80 Lugeons" scenario, except the constant head boundary conditions (CHBC) representing the bays (White Bay and Rozelle Bay) have been applied to all the model layers. For all the other scenarios above, the CHBC are applied only to the top model layer. Applying the CHBC to all model layers results in a higher degree of simulated hydraulic connectivity between the lower model layers and the bays.

- **Mitigated station box (1 Lugeon), unmitigated WBPS (20 Lugeon rock mass) and CHBC:** Same as the "Unmitigated WBPS - 80 Lugeons, CHBC" scenario, except the hydraulic conductivity applied to the fresh Hawkesbury Sandstone in the palaeochannel is 20 Lugeons (0.173 m/day). This is the base case value based on the calibrated model values (Table 4.1).

6.2 Predicted inflows to Station Box excavation

The Particular Specification requires that groundwater inflows to the station box excavation are limited to 445,000 litres in a 24-hour period (5.15 L/s).

Figure 6.1 presents the predicted inflows for the following scenarios:

- **Unmitigated station box (20 Lugeons)**: It is assumed that the station box cut-off wall is present, but inflows to the station box excavation occur through the unmodified sandstone bedrock. The Hawkesbury Sandstone underlying the palaeochannel is 20 Lugeons (0.173 m/day). This is the base case value based on the calibrated model values (Table 4.1).

- **Unmitigated station box (80 Lugeons)**: It is assumed that the station box cut-off wall is present, but inflows to the station box excavation occur through the unmodified sandstone bedrock. The hydraulic conductivity of the Hawkesbury Sandstone underlying the palaeochannel is 80 Lugeons (0.691 m/day). This is the highest interpreted horizontal hydraulic conductivity value from the pump-out tests carried out for this project and is above the 90th percentile (equal to 64 Lugeons) of all packer test results in the palaeochannel. It therefore, represents scenario under which permeability of the rock in the palaeochannel is closer to the upper bound of what is considered likely.

- **Mitigated station box basecase**: Bulk rock grouted to reduce hydraulic conductivity to 1 lugeon (0.009 m/day). Bedding planes grouted to reduce hydraulic conductivity to 5 lugeons (0.043 m/day). No grouting simulated along the TBM tunnel alignment. The TBM tunneling and associated groundwater inflows are not simulated.

- **Mitigated station box (1 Lugeon)**: Same as "Mitigated basecase" except bedding planes grouted to reduce hydraulic conductivity to 1 lugeon.

Figure 6.1 shows that the predicted inflow to the station box exceeds the inflow threshold specified in the Particular Specification under unmitigated conditions. For the assessed typical permeability of the rock mass within the palaeochannel (20 Lugeons), peak inflows to the station box are predicted to exceed 12 L/s. If the rock mass within the palaeochannel is highly permeable (80 Lugeons), peak inflows to the station box are predicted to exceed 20 L/s.

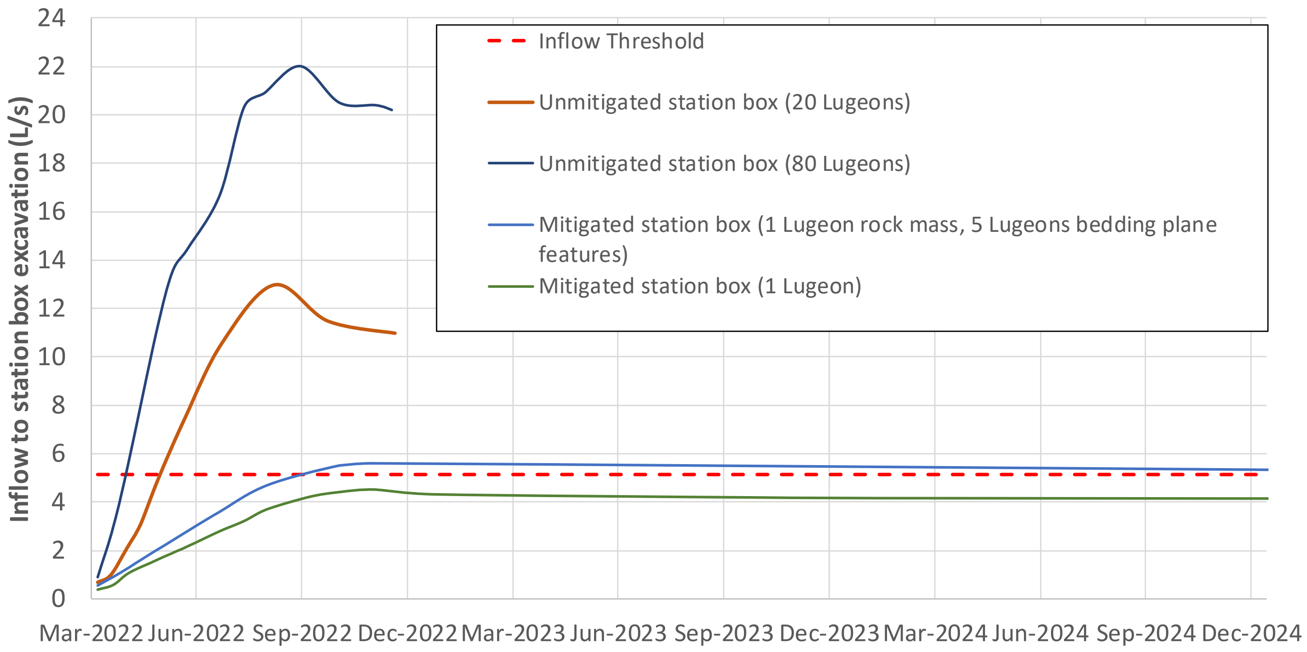

Figure 6.1: Predicted groundwater inflows to station box excavation for mitigated and unmitigated station box scenarios.

Figure 6.1 also shows that grouting of the bulk rock mass to 1 Lugeon, and the weathered rock and identified bedding to 5 Lugeons, for the base case scenario would not meet the inflow threshold. With the grout curtain achieving a permeability of 1 Lugeon along its full depth, the model indicates that the inflow criterion would be met.

Figure 6.2 shows the predicted inflows to the station box for the following tunnelling scenarios (all scenarios assume a mitigated station box to 1 Lugeon and that TBM tunnel excavation is occurring):

- **Mitigated station box (1 Lugeon) with mitigated WBPS and tunneling**. Grouting (mitigation) is simulated along the first 130 m length of the TBM tunnel alignments adjacent to the station box in the WBPS area. Rock grouted in the vicinity of WBPS as outlined in Section 5.6 (1 Lugeon rock mass, 5 Lugeons for bedding plane features). The fresh Hawkesbury Sandstone underlying the palaeochannel is assigned hydraulic conductivity of 20 Lugeons (basecase scenario).

- **Mitigated station box (1 Lugeon), unmitigated WBPS (20 Lugeon rock mass) and CHBC**: Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 20 Lugeons (basecase scenario), and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualized as a single feature with an equivalent thickness of 1 m and a horizontal hydraulic conductivity of 308 Lugeons (refer to Annexure C). The constant head boundary conditions (CHBC) representing the bays (White Bay and Rozelle Bay) have been applied to all the model layers. For all the scenarios previously described, the CHBC are applied only to the top model layer. Applying the CHBC to all model layers results in a higher degree of simulated hydraulic connectivity between the lower model layers and the bays.

- **Mitigated station box (1 Lugeon), unmitigated WBPS (80 Lugeon rock mass) and CHBC:** Unmitigated WBPS in which the rock mass in the palaeochannel has a horizontal hydraulic conductivity of 80 Lugeons, and there are water-bearing features (dilated bedding planes) within the tunnel horizon. The features are conceptualized as per the bullet point above. The constant head boundary conditions (CHBC) representing the bays (White Bay and Rozelle Bay) have been applied to all the model layers.

These results presented in Figure 6.2 indicate that, if the rock mass within the palaeochannel has a high permeability and the TBM encounters significant water-bearing freatures that have not been grouted, inflows to the station box could exceed to inflow criterion.

For the basecase scenario, i.e., with mitigated station box (grout curtain rock to 1 Lugeon) and mitigated WBPS scenario (1 Lugeon rock mass and 5 Lugeon bedding planes in vicinity of WBPS), the total predicted groundwater take by the station box to December 2024 is approximately 80 ML

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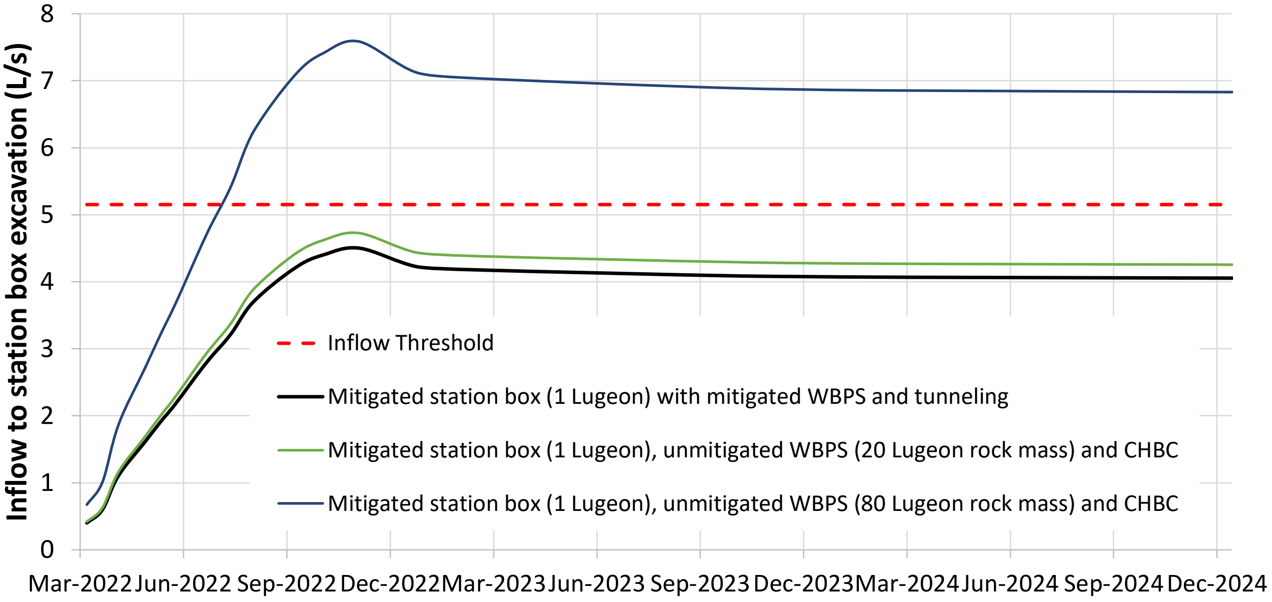

Figure 6.2: Predicted groundwater inflows to station box excavation for mitigated and unmitigated tunneling scenarios.

6.3 Predicted inflows to TBM tunnels

For the unmitigated WBPS scenario (Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling), the predicted inflows to a single tube tunnel are typically 1.1 L/s, increasing to up to approximately 1.5 L/s (to the downline/southern tunnel) when the downline/southern tunnel TBM is stationary.

Inflows to a single tube tunnel are predicted to increase to up to 2.4 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 20 Lugeons).

If the rock mass in the palaeochannel is highly permeable (80 Lugeons), the inflows to a single tube tunnel are predicted to increase to up to 4.5 L/s if rock in the vicinity of the WBPS is not grouted and the TBM encounters significant water-bearing features (WBPS unmitigated, palaeochannel rock mass is 80 Lugeons).

The predicted inflows for the mitigated WBPS scenario (Mitigated station box (1 Lugeon) with mitigated WBPS and tunneling) are significantly lower, with inflows to a single tube tunnel of typically 0.2 L/s in the grouted zone between WBPS and the station box, increasing to up to 1.5 L/s outside the mitigated zone (i.e., to the west of the grouted zone at WBPS)

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6.4 Predicted drawdown

Figure 6.3 shows the predicted watertable in March 2023 for the Mitigated station box (1 Lugeon) with tunnelling for scenarios with both unmitigated and the mitigated rock at WBPS. This date is when the second (downline/south tunnel) TBM has completed its period of being stationary and represents the time at which potential drawdown would be maximum in the vicinity of the TBM's and station box.

Figure 6.4 shows the predicted watertable drawdown in March 2023 for the following scenarios

- unmitigated WBPS with water-bearing feature in tunnel horizon and a rock mass hydraulic conductivity of 20 Lugeons "*Mitigated station box (1 Lugeon), unmitigated WBPS (20 Lugeon rock mass) and CHBC* " scenario (green)

- unmitigated WBPS with water-bearing feature in tunnel horizon and a rock mass hydraulic conductivity of 80 Lugeons "*Mitigated station box (1 Lugeon), unmitigated WBPS (80 Lugeon rock mass) and CHBC* " scenario (red)

The scenarios with a water bearing feature encountered during TBM tunelling (Figure 6.4) have greater simulated drawdown in the vicinity of WBPS compared to scenarios where the water bearing feature is not encountered (Figure 6.3).

Figure 6.4 also shows that the drawdown increases if the rock mass in the palaeochannel is of higher permeability.

Figure 6.5 shows the predicted watertable drawdown for the same scenarios shown in Figure 6.3 at a later time (December 2024). The Central Tunneling Project (CTP) works end in December 2024. Therefore, this drawdown of the watertable represents the maximum predicted drawdown extent for this scenario during the CTP project works. It should be noted that the pre-construction watertable is located within fill, alluvium or sandstone, depending on location; and the alluvium is therefore not necessarily depressurised equivalent to the watertable drawdown.

Figure 6.6 shows the predicted watertable drawdown in December 2024 for the following scenarios

- unmitigated WBPS with water-bearing feature in tunnel horizon and a rock mass hydraulic conductivity of 20 Lugeons "*Mitigated station box (1 Lugeon), unmitigated WBPS (20 Lugeon rock mass) and CHBC* " scenario (green)

- unmitigated WBPS with water-bearing feature in tunnel horizon and a rock mass hydraulic conductivity of 80 Lugeons "*Mitigated station box (1 Lugeon), unmitigated WBPS (80 Lugeon rock mass) and CHBC* " scenario (red)

Figure 6.6 indicates that greater drawdown is experienced in the vicinity of WBPS if the TBM encountered a water-bearing feature, and this greater drawdown increases if the rock mass in the palaeochannel is of higher permeability.

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The results indicate that the grouting under WBPS does not significantly change the predicted watertable drawdown over the long term. This is because the TBM's have passed WBPS by this point in time, the tunnels are undrained, and the groundwater level has (partially) recovered in the area.

In March 2023, the predicted watertable drawdown gradient across the WBPS is less than it is in December 2024, due to the cumulative effect of the two TBM's at different locations.

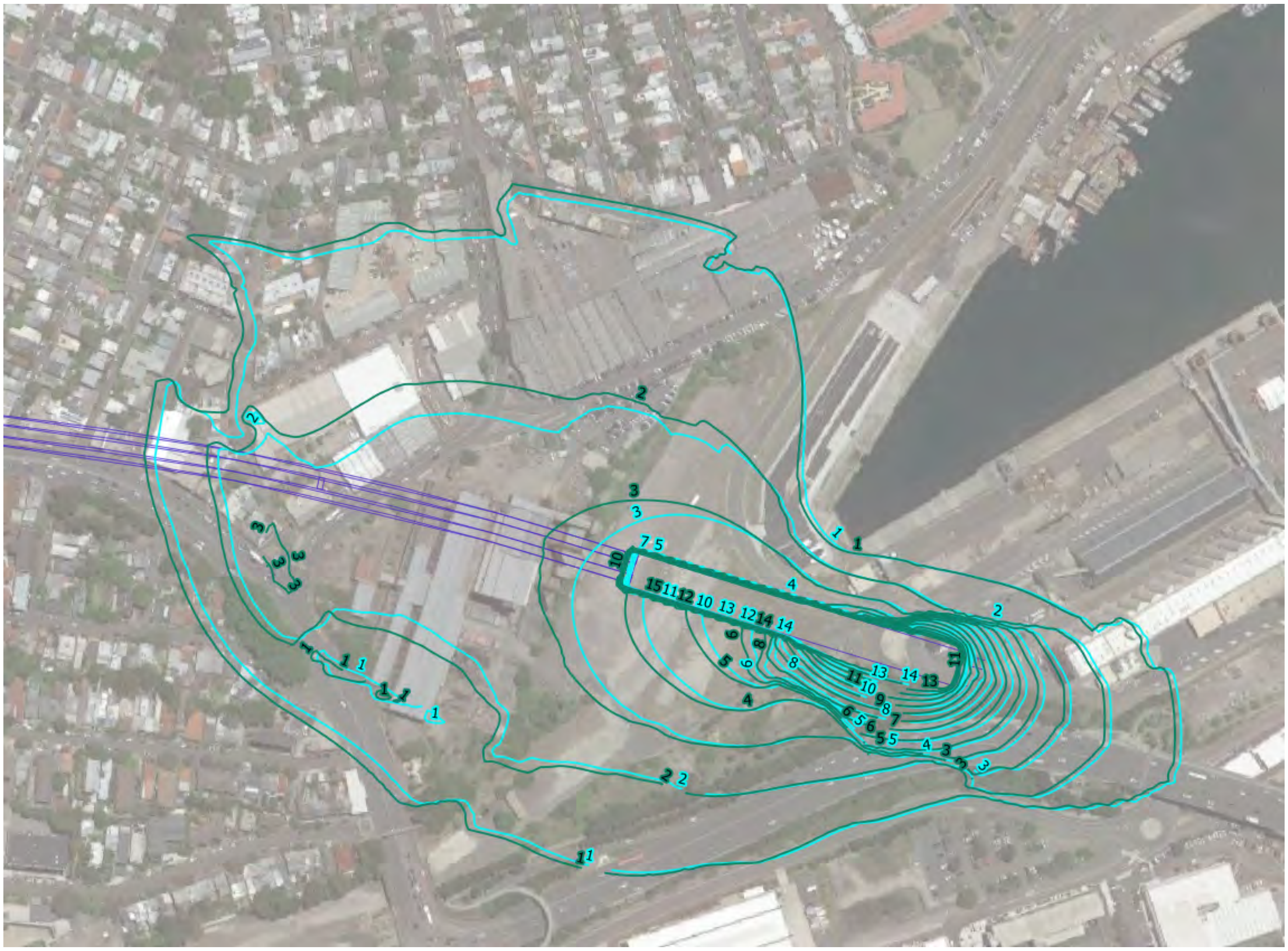

Figure 6.3: Predicted watertable drawdown (metres) in March 2023 for "Mitigated station box (1 Lugeon) with mitigated WBPS and tunneling" scenario (blue) and "Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling" scenario (green)

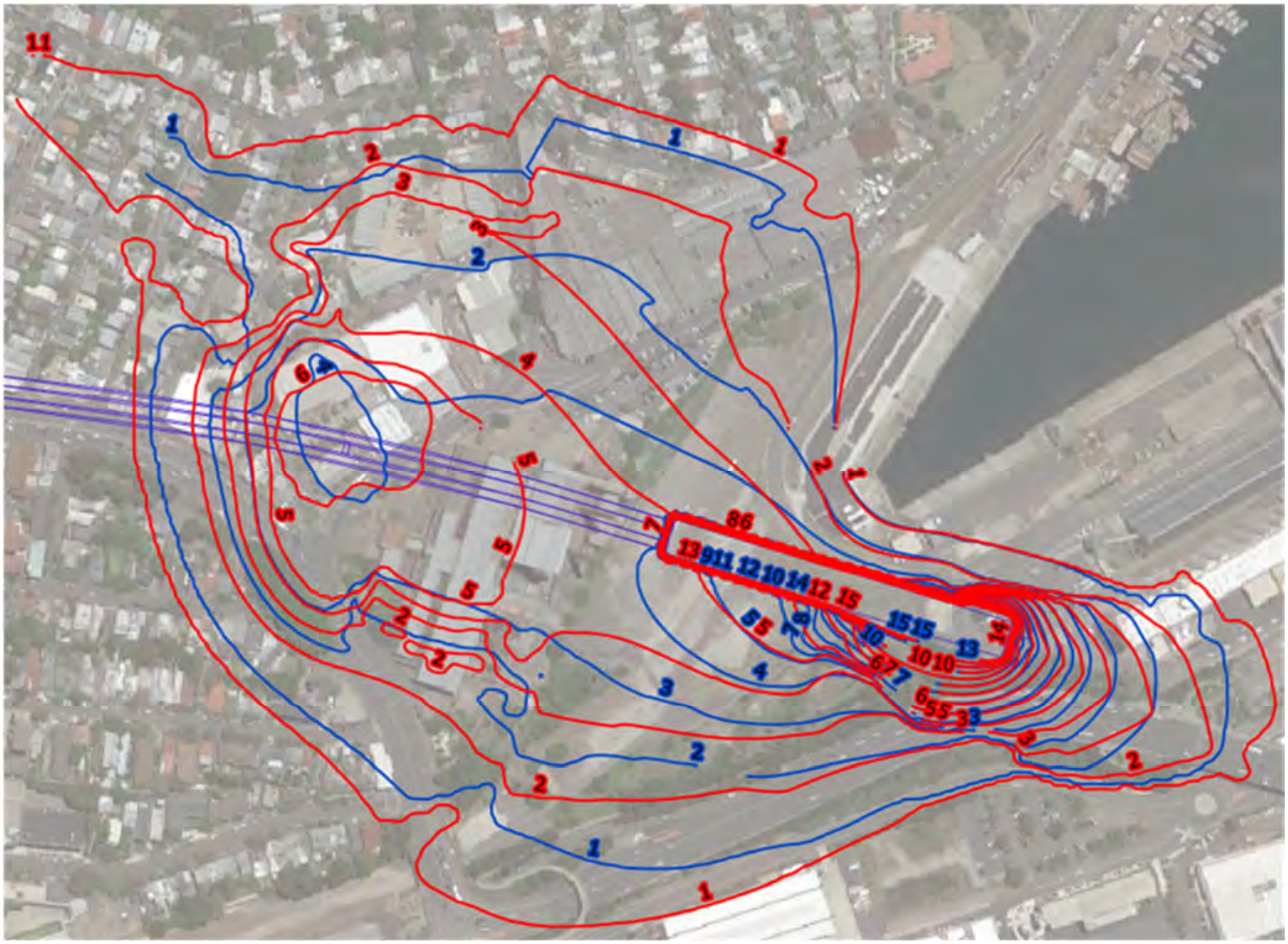

Figure 6.4: Predicted watertable drawdown (m) in March 2023 for "Mitigated station box (1 Lugeon), unmitigated WBPS (20 Lugeon rock mass) and CHBC" scenario (blue) and "Mitigated station box (1 Lugeon),unmitigated WBPS (80 Lugeon rock mass) and CHBC" scenario (red)

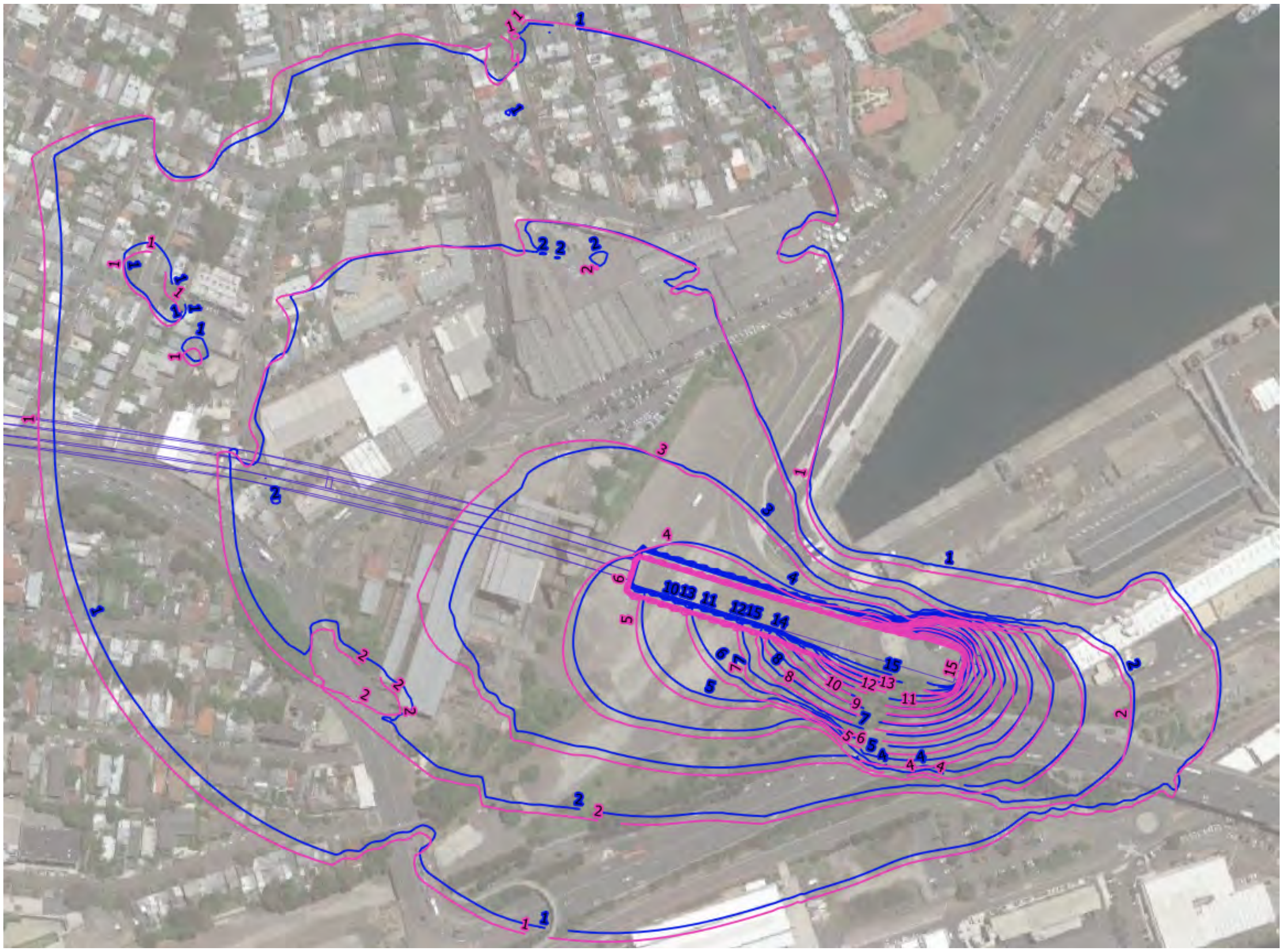

Figure 6.5: Predicted watertable drawdown (m) in December 2024 for "Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling" scenario (blue) and "Mitigated station box (1 Lugeon) and unmitigated WBPS with tunnelling scenario" (purple)

Figure 6.6: Predicted watertable drawdown (m) in Dec 2024 for "Mitigated station box (1 Lugeon) unmitigated WBPS (20 Lugeon rock mass) and CHBC" (green) and "Mitigated station box (1 Lugeon),unmitigated WBPS (80 Lugeons rock mass) and CHBC" scenario (red)

7. Uncertainty analysis – groundwater flow modelling

7.1 Uncertainty analysis methodology

The purpose of the uncertainty analysis was to assess the sensitivity of model predictions to varying the parameter values assigned to the predictive base case model. The "Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling" scenario (Section 6.1) was considered as the predictive base case model for the purposes of uncertainty analysis.

The following parameters were assessed during the uncertainty analysis:

- **Rainfall recharge:** Model calibration indicated that a value between approximately 4% and 7% of mean annual rainfall matched existing groundwater levels more accurately. However, the value of 4% adopted in the calibrated predictive model is based on a steady state calibration only where there are no stresses on the system. A lower recharge value may lead to increased groundwater level drawdown. To explore the potential influence of recharge on the modelling results, a modelling scenario with a recharge value of 1% of mean annual rainfall was undertaken. The lower recharge rate assessed for the uncertainty analysis is considered to be at the lower bound of the plausible recharge range for the geological formations occurring within the Sydney Basin.

- **Vertical hydraulic conductivity anisotropy ratio (*Kv/Kh*) for the fresh Hawkesbury Sandstone**: There is limited test data available to assess the vertical hydraulic conductivity of the fresh Hawkesbury Sandstone. The modelling has adopted a vertical to horizontal hydraulic conductivity ratio (K_v/K_h) for the sandstone rockmass of 0.1. This is consistent with the conditions typically adopted for Hawkesbury Sandstone. Furthermore, available information does not indicate the presence of significant sub-vertical fracturing within the palaeochannel that could lead to significant vertical connectivity with the sandstone. However, it is possible that sandstone at the site has a greater value vertical hydraulic conductivity than has been modelled. A conservative vertical to horizontal hydraulic conductivity ratio of 0.5 was adopted for sensitivity analysis.

- **Kv/Kh for Alluvium**: There is limited test data available to assess the vertical hydraulic conductivity of the alluvium. The modelling has adopted a vertical to horizontal hydraulic conductivity ratio (*Kv/Kh*) for the alluvium of 0.2. This reflects the fact that the alluvium contains clayey horizons and is consistent with the conditions modelled by JHCPB Joint Venture (2021) for the RIC site. A higher value, reflective of more permeable (sandy) material, could lead to increased drawdown. A value of 0.5 was adopted for sensitivity analysis.

- **Hydraulic conductivity for the fresh Hawkesbury Sandstone underlying the palaeochannel**: The horizontal hydraulic conductivity applied to the fresh Hawkesbury Sandstone was decreased from 0.176 m/day (approximately 20.3 lugeons) to 0.021 m/day (approximately 2.4 lugeons). The vertical hydraulic conductivity was reduced to 0.0021 to maintain a Kv/Kh of 0.1. The horizontal hydraulic conductivity of 0.176 m/day was based on the arithmetic mean of hydraulic conductivity values estimated based on project specific packer test results. The horizontal hydraulic conductivity value of 0.021 m/day assessed for the uncertainty analysis is based on the geometric mean value based on the packer test results. The geometric mean of packer test based hydraulic conductivity estimates is widely considered to be a conservative estimate of bulk rock hydraulic conductivity.

7.2 Uncertainty analysis results

7.2.1 Inflows to station box

Figure 7.1 shows the predicted inflows to the station box for the uncertainty analysis scenarios. The uncertainty analysis results indicate that:

- Predicted inflows are insensitive to increasing Alluvium Kv/Kh from 0.2 to 0.5
- Predicted inflows are insensitive to reducing the rainfall recharge from 4% to 1%
- Reducing the hydraulic conductivity for the fresh Hawkesbury Sandstone within the paleo-valley to 0.021 m/day (approximately 2.4 lugeons) reduces the predicted inflows to the station box by approximately 50%.
- Increasing Kv/Kh for the fresh Hawkesbury Sandstone from 0.1 to 0.5 increases the predicted inflows to above 5.15 after July 2022. As previously mentioned, the Kv/Kh ratio of 0.5 was based on the value applied to the groundwater assessment for the Rozelle Interchange project (JHCPB Joint Venture, 2021). It should be noted, however, that site specific investigations do not indicate the occurrence of significant vertical fracturing within the sandstone, which would result in rather high Kv/Kh ratio of 0.5, which is atypical of ratios commonly applied for investigations in the Sydney Basin. This suggests that inflows predicted with a fresh Hawkesbury Sandstone Kv/Kh of 0.5 are likely to be overly conservative.

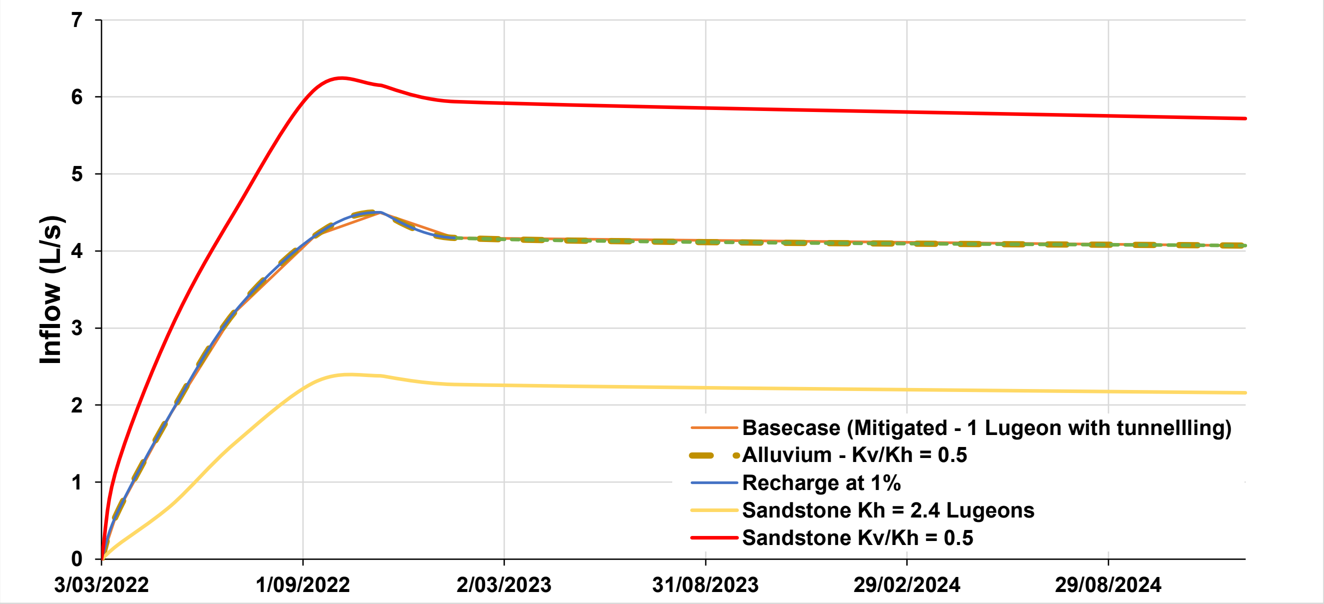

Figure 7.1: Uncertainty analysis results - station box inflows

7.2.2 Inflows to TBM tunnels

Table 7.1 presents the predicted peak inflows to the North Tunnel and South Tunnel for the uncertainty analysis scenarios. A comparison of the predicted inflows from the uncertainty analysis scenario models to the inflows predicted from the "Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling" indicates the following:

- Predicted peak inflows for the North Tunnel and South Tunnel are insensitive to increasing Alluvium Kv/Kh from 0.2 to 0.5.
- Predicted peak inflows for the North Tunnel and South Tunnel are insensitive to reducing the rainfall recharge from 4% to 1%.
- Reducing the hydraulic conductivity for the fresh Hawkesbury Sandstone within the paleo-valley to 0.021 m/day (approximately 2.4 lugeons) reduces the predicted peak inflows by:
    - Approximately 40% for the North Tunnel, and
    - Approximately 80% for the South Tunnel.
- Increasing Kv/Kh for the fresh Hawkesbury Sandstone from 0.1 to 0.5 increases the predicted peak inflows for both the North Tunnel and South Tunnel by over 200%.

Table 7.1: Uncertainty analysis results - inflow to tunnels

Scenario	**Predicted inflow (L/s)**	
	North Tunnel	**South Tunnel**
Base Case “Mitigated – 1 Lugeon with tunnelling”	1.53	1.07
Alluvium Kv/Kh = 0.5	1.53	1.07
Fresh sandstone Kv/Kh = 0.5	3.34	2.48
Recharge = 1%	1.50	1.06
Fresh sandstone in paleo-valley Kh = 2.4 lugeons	0.89	0.20

7.2.3 Predicted water table drawdown

The uncertainty analysis presented in this section is based on drawdown predicted on 21 March 2023 which represents the period of maximum modelled drawdown associated with tunnel inflows. Excavation of the South Tunnel resumes on this day after the 27 day pause in tunnelling in the South Tunnel. The date is 117 days after the completion of excavation for The Bays Station Box (Section 5).

The predicted water table drawdown for each of the uncertainty analysis scenarios was compared to the predicted drawdown for the base case model. The “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario (Section 6.1) is used as the base case model for the uncertainty analysis reported here.

The results of the uncertainty analysis indicate the following:

- Predicted water table drawdown for the Alluvium Kv/Kh = 0.5 scenario is very similar to predicted drawdown for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario” (Figure 7.2). This suggests that the predicted drawdown is not particularly sensitive to changes in the Alluvium Kv/Kh value.

- Predicted water table drawdown for the recharge = 1% scenario is very similar to predicted drawdown for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario (Figure 7.3). This suggests that the predicted drawdown is not particularly sensitive to changes in recharge.

- For the scenario with sandstone Kv/Kh = 0.5, the predicted extent (lateral and vertical) of the drawdown affected area is larger than predicted extent for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario (Figure 7.4). The area with simulated drawdown of more than 1 m extends up to 380 m from the station box for the uncertainty analysis scenario compared to 360 m for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scnenario. The predicted drawdown beneath the Power Station of approximately 5 m for the uncertainty analysis scenario model run is almost double the drawdown predicted for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario.

- For the scenario with sandstone within the paleo-valley with Kh = 2.4 lugeons, the predicted extent of the drawdown affected area is much smaller than predicted extent for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario (Figure 7.5). The area with simulated drawdown of more than 1 m extends up to 180 m from the station box for the uncertainty analysis scenario compared to 360 m for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario. The predicted drawdown beneath the Power Station of approximately 1 m for the uncertainty analysis scenario model run is almost half the drawdown predicted for the “Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling” scenario.

Figure 7.2: Predicted watertable drawdown (metres) in March 2023 for basecase (Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario) (blue) and sensitivity scenario with alluvium Kv/Kh = 0.5 (brown)

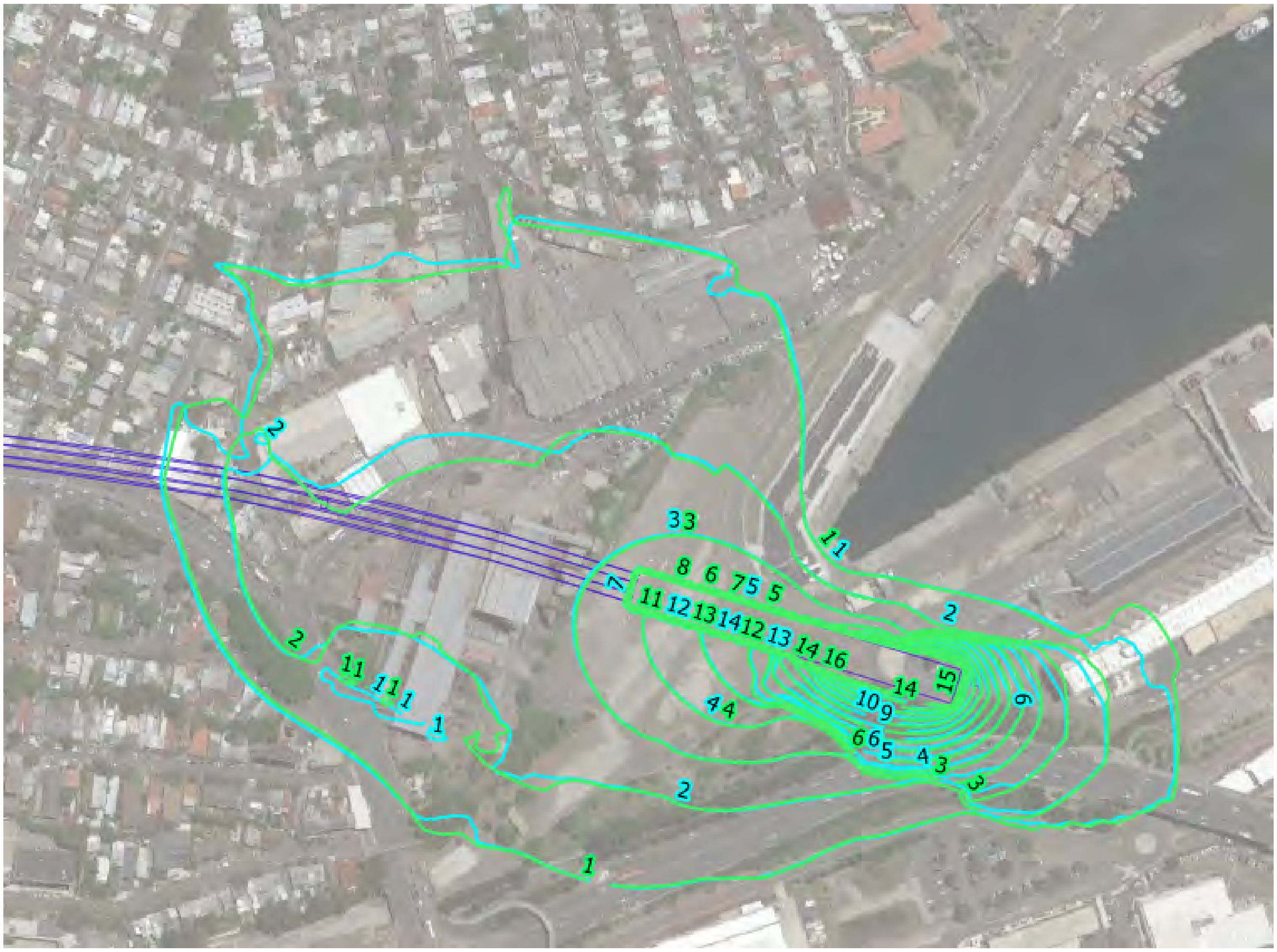

Figure 7.3: Predicted watertable drawdown (metres) in March 2023 for the basecase (Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario) (blue) and sensitivity scenario with recharge of 1% (green)

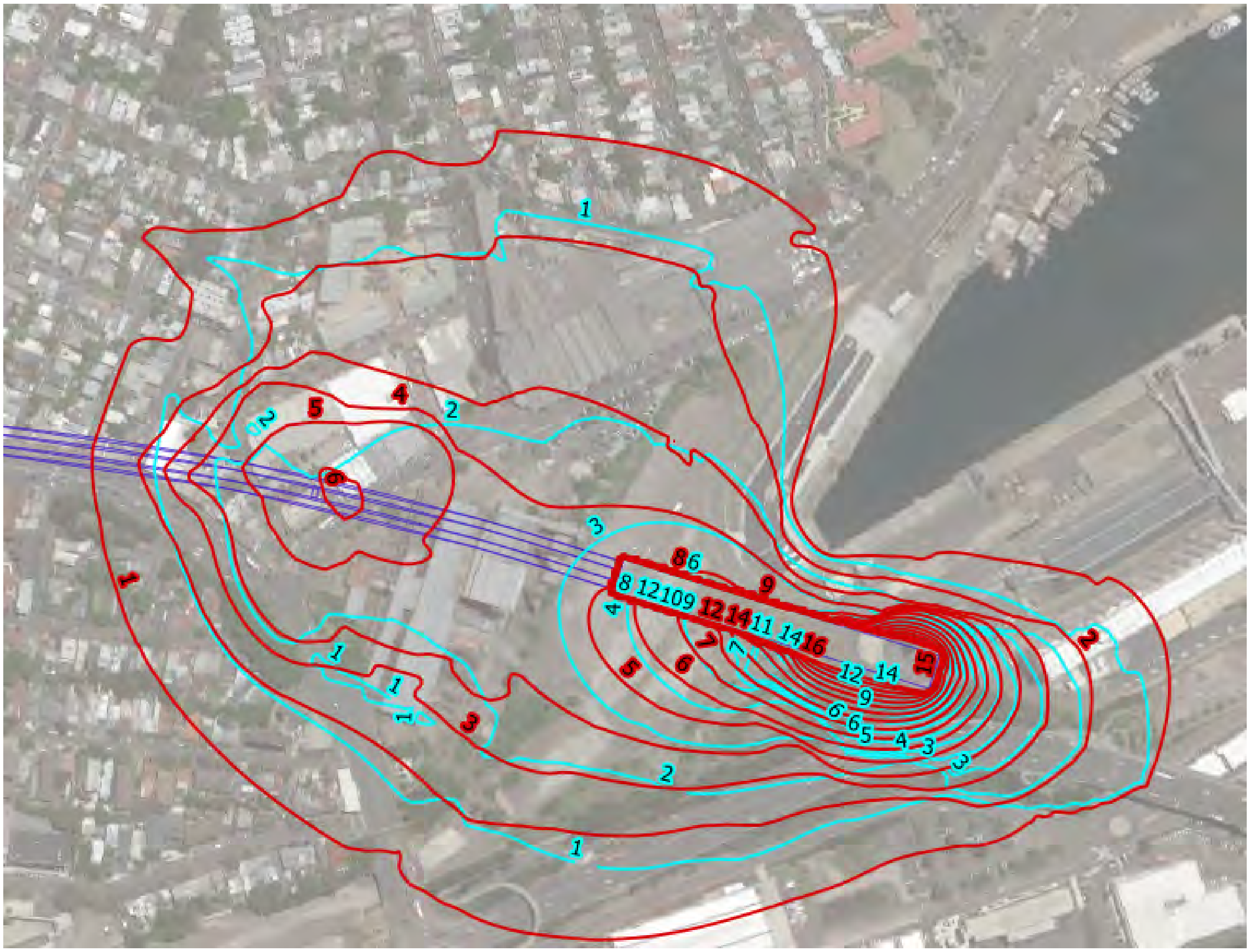

Figure 7.4: Predicted watertable drawdown (metres) in March 2023 for basecase (Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario) (blue) and sensitivity scenario with sandstone Kv/Kh = 0.5 (red)

Figure 7.5: Predicted watertable drawdown (metres) in March 2023 for basecase (Mitigated station box (1 Lugeon) and mitigated WBPS with tunnelling scenario) (blue) and sensitivity scenario with sandstone horizontal hydraulic conductivity equal to 2.4 Lugeons (green)

8. Particle tracking

8.1 Particle tracking methodology

Particle tracking analysis was carried out to assess migration pathways (pathlines) of potential contaminants towards the station box excavation.

Particle tracking analysis was used to compute flow paths for imaginary “particles” transported through the simulated groundwater system. It is assumed that the transport of the “particles” mimics the advective transport of potential contaminants in the groundwater system. Advective transport is the movement of particles that occurs due to groundwater flow. Particle-tracking was used to compute advective transport of particles only. Other processes that can affect and attenuate contaminant transport including dispersion, diffusion, density effects and chemical reactions were not considered during the particle tracking analysis.

The mod-PATH3DU particle tracking post-processing package (Version v1.1) was used to compute flow paths from the MODFLOW-USG groundwater flow models.

The Waterloo semi-analytical particle tracking method (Ramadham 2015), which is incorporated in mod-PATH3DU, was used to calculate the local velocity at particle locations for use in simulation of the advection of particles. The Waterloo method calculates advective flow based on Darcy’s Law using Equation 8.1.

$$v = \frac{K\,\partial h}{\theta \partial x} \qquad \text{[Equation 8.1]}$$

Where v = advective flow velocity (L/T)

K = hydraulic conductivity (L/T)

θ = effective porosity (-)

$\frac{\partial h}{\partial x}$ = hydraulic gradient in the direction of flow (L/L)

All the terms (parameters) in Equation 8.1, except effective porosity, are obtained from the solution of the MODFLOW-USG groundwater flow models. Effective porosity in geological formations is variable. Table 8.1 shows literature values for effective porosity reported for different geological formations.

Table 8.1: Effective porosity for different geological formations

Type of material	**Permeability**	**Effective porosity (%)**	**Source**
Unconsolidated sedimentary	high	30 to 35	Van Drecht et. al. (2003)
	low	15 to 20	
Consolidated sedimentary	high	20	
	low	10	
Igneous and metamorphic rock	medium	5	
	low	2	
Gravelly sand		17 (1) 25 to 32 (2)	Stephens et. al. (1998)

(1) Based on tracer tests

(2) Based on laboratory tests

Table 8.1 indicates that the typical effective porosity range for unconsolidated sediments is between 15% and 35%. However, for the purposes of this assessment, an effective porosity of 10% was applied to the alluvium and fill to simulate conservative (relatively long) particle travel distances.

Similarly, a conservative effective porosity of 5% was applied to the Hawkesbury Sandstone. Table 8.1 indicates that the typical effective porosity range for consolidated sedimentary rocks is between 10% and 20%.

Figure 8.1 shows the location of particle starting locations assigned to the model. The particles were assigned at locations where potential contaminants were detected in groundwater samples.

The particles were tracked forward in time for a period from the proposed start date of excavation of The Bays Station Box, in March 2022, for 1,034 days to 31 December 2024. The end date of the particle tracking simulation coincides with the proposed completion date of all activities associated with excavation of The Bays Station Box.

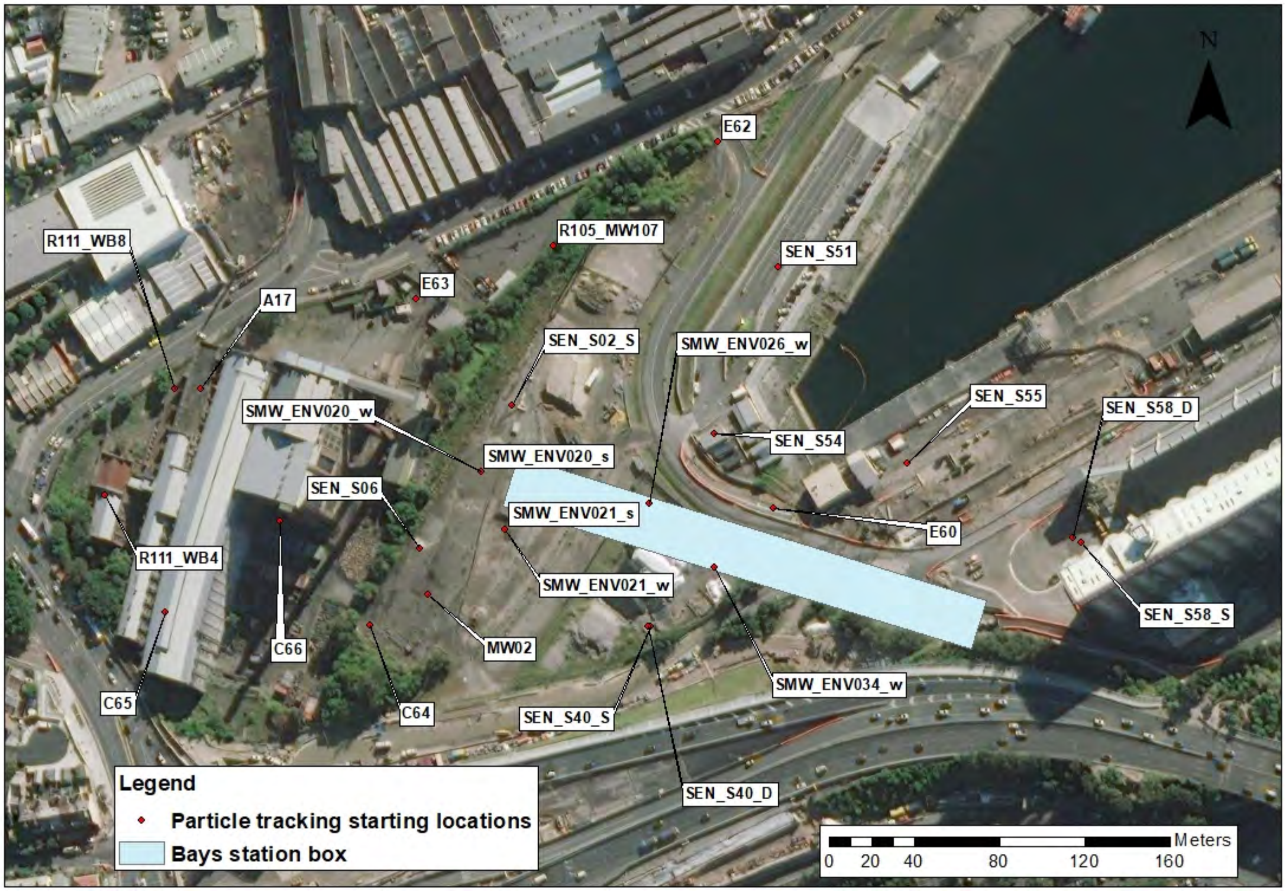

Figure 8.1: Particle starting locations

8.2 Particle tracking results

Figure 8-2 shows the predicted migration pathway of the particles in groundwater during the CTP works due to the flow regime(s) induced by the station box excavation and tunnel mining, and the hydrogeological unit (coloured dot) which the contaminants reach in December 2024, at the end of CTP works.

The results suggest that some of the identified particles are likely to reach the deeper sandstone units by the end of December 2024. As the modelling approach does not consider potential dispersion and diffusion of contaminants in groundwater, it is possible that contaminant migration could be faster than the results presented here for representative particles.

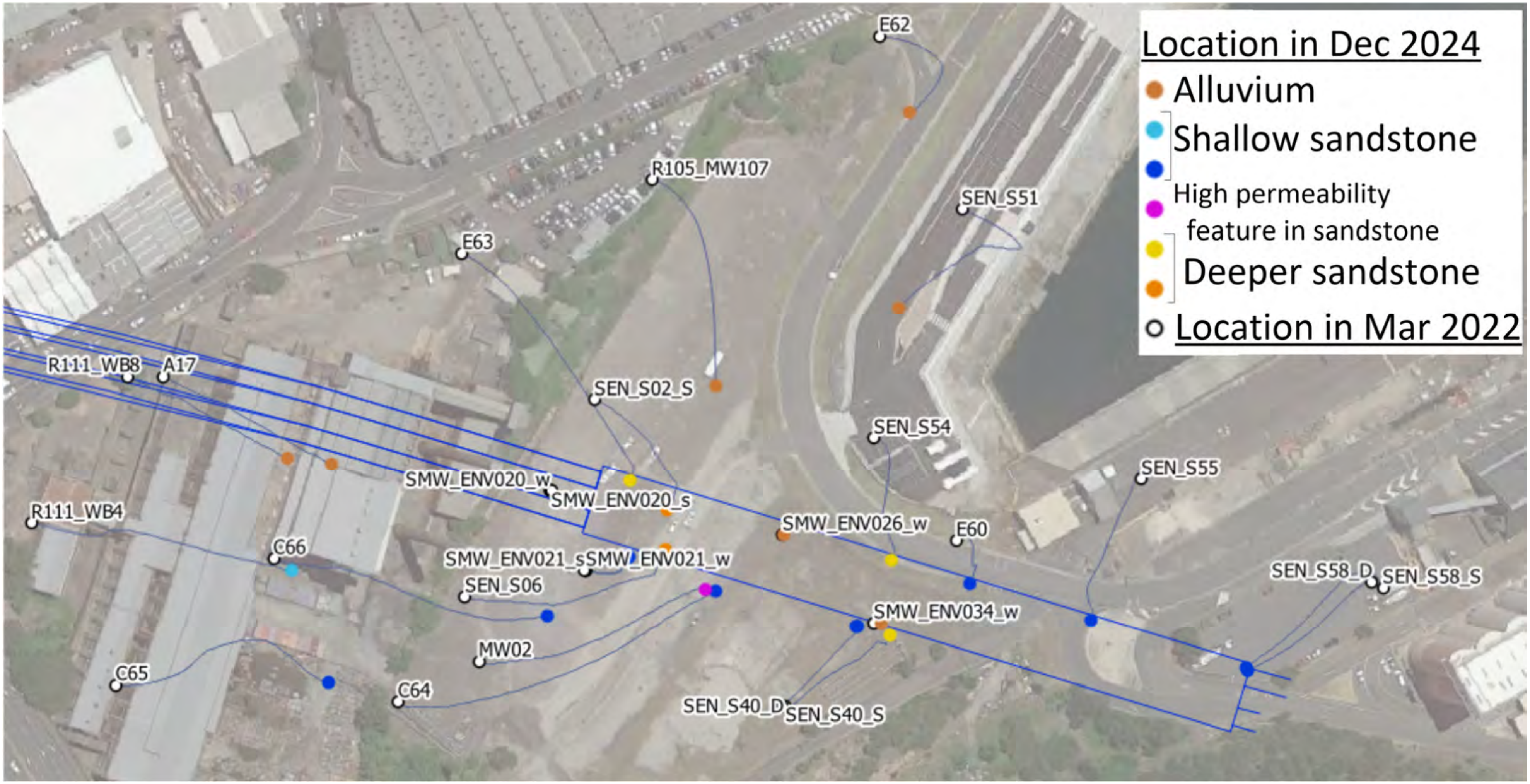

Figure 8-2: Particle tracking during CTP works

9. Saline water transport modelling

9.1 Overview of saline water transport modelling

Saline water transport associated with excavation of The Bays Station Box was simulated using MODFLOW-USG Transport. MODFLOW-USG Transport was used to simulate saline water transport in the same run as the flow model. This was implemented through a Block-Centred Transport (BCT) Package and a Prescribed Concentration Boundary (PCB) Package (Panday, 2017). The BCT Package was used to simulate three-dimensional advective-dispersive transport (which includes diffusion) of saline water in the subsurface using an unstructured grid, control Volume Finite Difference (CVFD) framework. The Prescribed Concentration Boundary (PCB) Package was used in conjunction with the BCT Package to simulate constant saline water concentration boundary conditions in the MODFLOW-USG transport simulation. Density dependent flow was not simulated.

The time stepping provided in the MODFLOW-USG adaptive time stepping (ATS) was used to guide transport time-stepping (ESI, 2020) for the transient transport simulations. The ATS settings included an initial time step of 0.01 days, which was increased by a factor of 1.2 up to a maximum of 200 days. The Total Variation Diminishing (TVD) scheme was used to control numerical dispersion in the advection term. The dispersion terms were formulated implicitly for components along the principal axes.

The saline water transport modelling was run in conjunction with the "*Mitigated station box (1 Lugeon) with mitigated WBPS and tunneling*" groundwater flow modelling scenario which includes the following features:

- Base case model with bulk rock and bedding planes around The Bays Station Box grouted to reduce hydraulic conductivity to 1 lugeon (0.009 m/day).
- The TBM tunneling and associated groundwater inflows are simulated
- Grouting is simulated along the first 130 m length of the TBM tunnel alignments adjacent to the station box

The saline water transport modelling was carried for the period from the proposed start date of excavation of the Bays Station Box, in March 2022, for 10 years to March 2032.

9.2 Dispersion and diffusion coefficients for solute transport modelling

Inputs for longitudinal dispersivity, transverse dispersivity and diffusion assigned to the BCT package are described in this section.

The longitudinal dispersivity is scale-dependent (i.e. increases with flow distance). Schluze-Makuch (2005) provide Equation 9.1 for estimating the longitudinal dispersivity:

$\alpha = c(L)^m$ [Equation 9.1]

Where,

α= longitudinal dispersivity (m).

c= parameter characteristic for the longitudinal dispersivity for a geological medium (m).

L= flow distance (m).

m = scaling exponent.

For computer simulations, the flow distance (L) is considered to be the horizontal distance between the solute source and a sink (Schluze-Makuch, 2005). The minimum source to sink distance from the bays to the excavation box is approximately 50 m.

Schluze-Makuch, 2005 recommend the following values for sandstone:

c = 0.92 m

m = 0.01

A longitudinal dispersivity of approximately 1 m was calculated based on Equation 9.1 and the parameter values provided above.

The transverse dispersivity is commonly set to be equal to 30% of the longitudinal dispersivity (Lovanh et.al., 2000). Therefore, a transverse dispersivity of 0.3 m was assigned to the advection-dispersion solute transport simulation.

A diffusion coefficient of 1 x 10^{-6} m^2/s was assigned to the model based on values assigned to similar hydrogeological units in the modelling for the adjacent Western Harbour Tunnel Project (Jacobs 2020).

9.3 Prescribed Concentration Boundary Conditions and initial Concentrations

Constant concentration boundary conditions were assigned to the bays (White Bay and Rozelle Bay) in all model layers to represent the seawater salt concentration. An arbitrary constant concentration of 50 mass units/m^3 was assigned to the constant concentration boundaries to represent seawater salt concentration. Initial salt concentrations of 0 mass units/m^3 were assigned to all other model cells.

Post-processing was used to convert the simulated changes in arbitrary salt concentrations into actual saltwater concentrations.

9.4 Results

Figure 9-1 shows the predicted intrusion of seawater into the groundwater system in the alluvium in December 2024 (end of CTP works) and March 2032 (10 years after station box excavation commenced). Figure 9-2 shows the same results for the deeper sandstone near excavation floor level.

The modelling predicts significant saline intrusion in the alluvium and the sandstone to the north of the station box. There is some migration of saline waters from Rozelle Bay to the southern wall after 10 years, but the concentrations are very low. During CTP works, groundwater salinity reaches seawater-level concentrations along the northern wall of the station box.

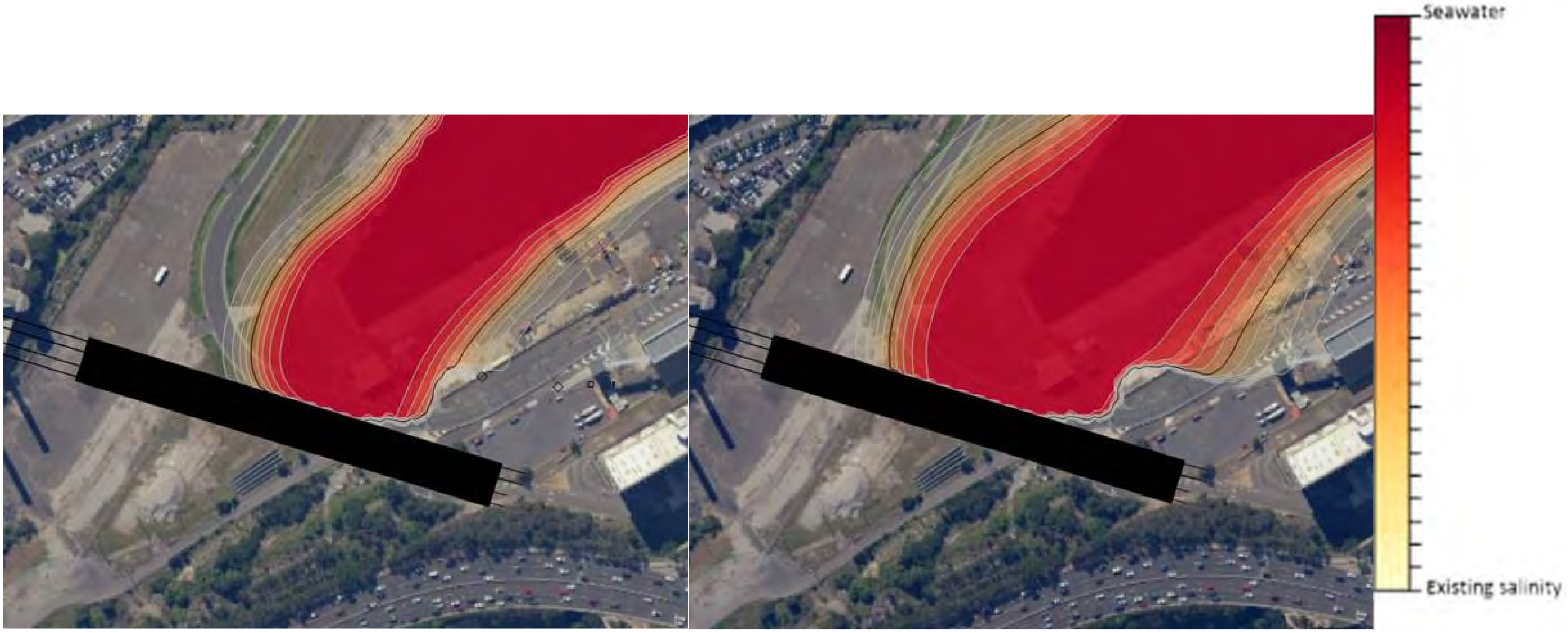

Figure 9-1: Predicted saline intrusion in alluvium at Dec 2024 (left) and after 10 years (March 2032) (right)

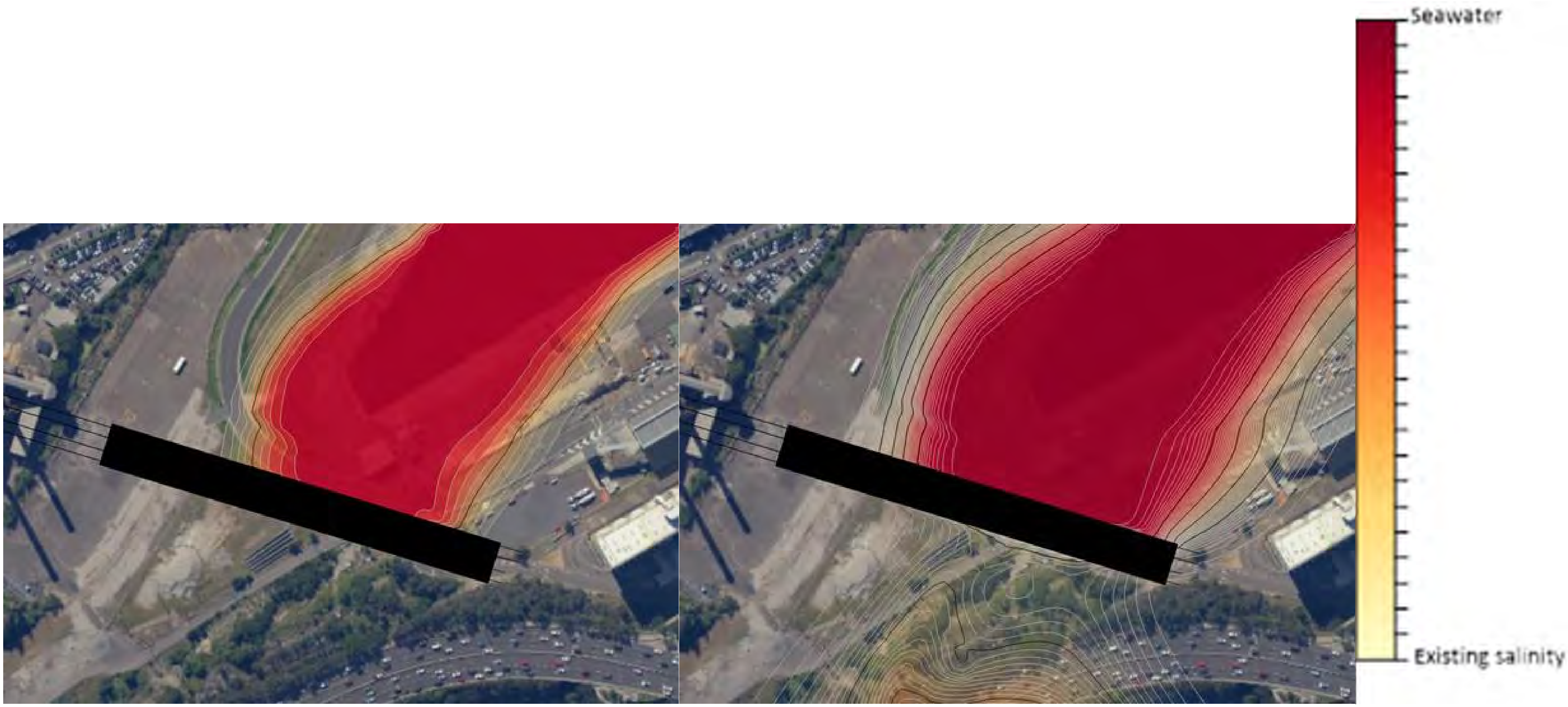

Figure 9-2: Predicted saline intrusion in deep sandstone at Dec 2024 (left) and after 10 years (March 2032) (right)

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