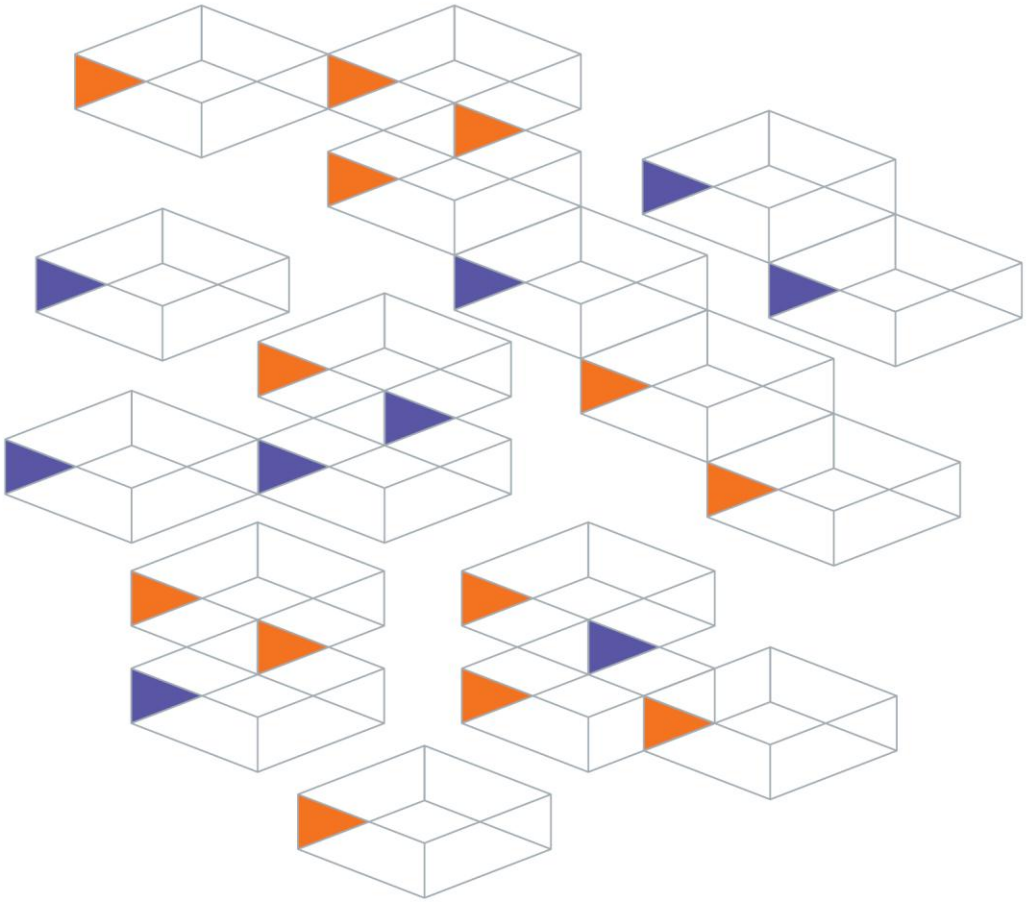
Mirvac

Harbourside Darling Harbour

Preliminary Groundwater Assessment Report

27 September 2016



Boundaries
are set by those
who are afraid
to push them

This page has been left intentionally blank

Harbourside Darling Harbour

Prepared for
Mirvac
Level 26, 60 Margaret St
Sydney NSW 2000

Prepared by
Coffey Geotechnics Pty Ltd
Level 19, Tower B, 799 Pacific Highway
Chatswood NSW 2067 Australia
t: +61 2 9406 1000 f: +61 2 9406 1002

27 September 2016

Document authorisation

Our ref: GEOTLCOV25340AA-AE

For and on behalf of Coffey

Ross Best
Senior Principal

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
Rev 2	Minor update	27/09/2016	BR	RJB	RJB
Rev 1	Revised for two-level basement, services floatation, flood study input	12/07/2016	BR	PT, PS	BR
Rev 0	First issue	19/02/2016	BR	RJB	BR

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Rev 2	1	PDF	Lachlan Attiwill	27 Sep 2016
Rev 1	1	PDF	Steve McFarlane	12 Jul 2016
Rev 0	1	PDF	Lachlan Attiwill	19 Feb 2016

Table of contents

Figures

Appendices

1. Introduction

Coffey Corporate Services Pty Ltd (Coffey) was engaged by Mirvac to prepare a preliminary groundwater assessment for the proposed redevelopment of the Harbourside Shopping Centre, which is situated on the western foreshore of Darling Harbour.

Our Preliminary Groundwater Assessment was first undertaken consistent with a proposal submitted by Coffey dated 18 November 2015 (Coffey reference GEOTLCOV25340AA-AB). That assessment considered a single level basement.

We understand that since issue of that report, a two-level basement is now proposed for the development.

This revised Preliminary Groundwater Assessment considers a two-level basement, and provides:

- A preliminary hydrogeological model for the site based on available data from surrounding sites, including discussion of rock mass permeability
- Discussion of groundwater cut-off to permit excavation
- Estimates of the long-term (steady state) groundwater inflow to the construction excavation under various conditions
- Consideration of the impact of flooding on groundwater
- Potential uplift pressures for design of surrounding services.

2. Proposed development

This report supports a State Significant Development Application (SSDA) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

Mirvac Projects Pty Ltd (Mirvac) is seeking to secure approval to establish concept proposal details for the redevelopment of the Harbourside Shopping Centre (Harbourside), including a new retail shopping centre, residential apartment tower and substantial public domain improvements.

The project supports the realisation of the NSW State Government's vision for an expanded 'cultural ribbon' spanning from Barangaroo, around to Darling Harbour and Pyrmont. The project importantly will add further renewed diversity in tourism and entertainment facilities to reinforce Sydney's CBD being Australia's pre-eminent tourist destination.

2.1. Background

Mirvac acquired Harbourside, a key location within the Darling Harbour precinct, in November 2013. Harbourside, which was opened in 1988 as part of the Bicentennial Program, has played a key role to the success of Darling Harbour as Australia's premier gathering and entertainment precinct.

Despite its success, with an annual pedestrian visitation of around 13 million people, Harbourside is now outdated and in decline. The building lacks a quality interface to the Darling Harbour public domain and Cockle Bay and does not integrate well with the major transformation projects underway and planned for across Darling Harbour.

Harbourside is at risk of being left behind and undermining the significant investment being made in Darling Harbour that will see it return to the world stage as a destination for events and entertainment.

Accordingly, Mirvac are taking a carefully considered and staged approach to the complete revitalisation of the site and its surrounds.

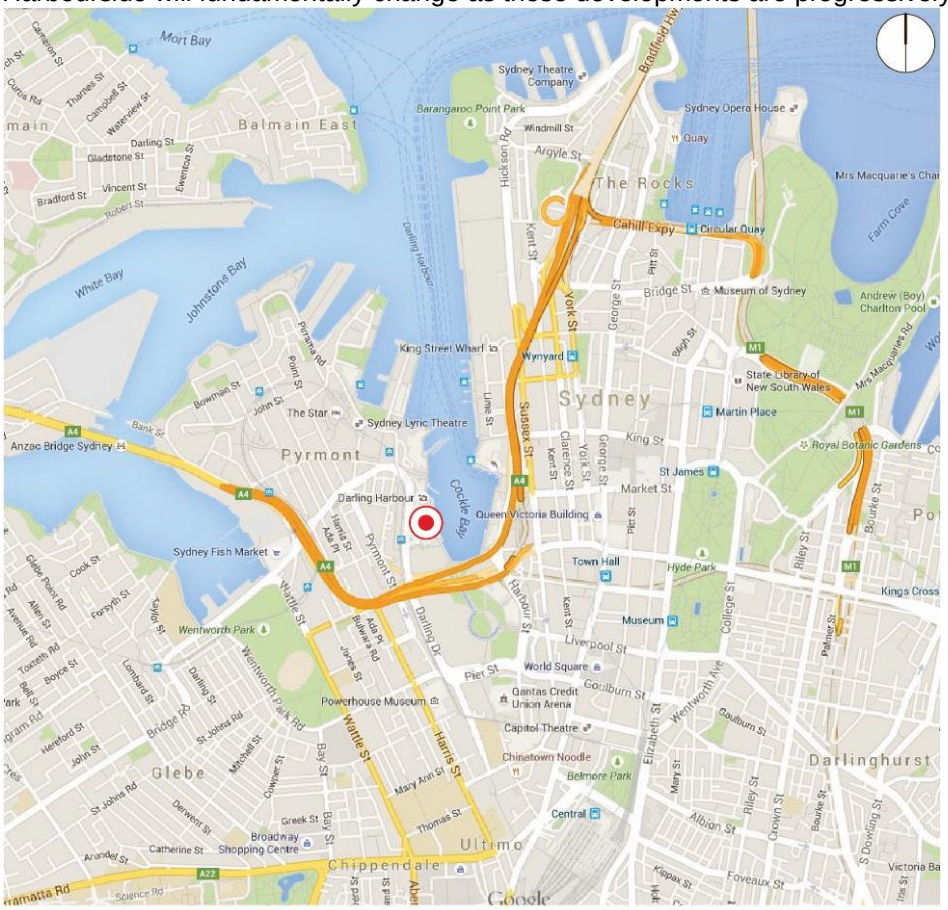
2.2. Site Description

The Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

More generally the site is bound by Pyrmont Bridge to the north, the Sydney International Convention, Exhibition and Entertainment Centre Precinct (SICEEP) to the south, Darling Drive and the alignment of the Light Rail to the west and Cockle Bay to the east.

A locational context area plan and location plan are provided at Sketch 1 below.

The Darling Harbour precinct is undergoing significant redevelopment as part of the SICEEP, Darling Square, and IMAX renewal projects. The urban, built form and public transport / pedestrian context for Harbourside will fundamentally change as these developments are progressively completed.



The Site

Sketch 1 – Location Context Area Plan

2.3. Overview of Proposed Development

- The proposal relates to a staged development application and seeks to establish concept proposal details for the renewal and re-imagining of Harbourside.
- The concept proposal establishes the vision and planning and development framework which will be the basis for the consent authority to assess future detailed development proposals.
- The Harbourside site is to be developed for a mix of non-residential and residential uses, including retail and restaurants, residential apartments, and open space.
- The Concept Proposal seeks approval for the following key components and development parameters:
- Demolition of existing site improvements, including the Harbourside Shopping Centre, pedestrian bridge links across Darling Drive, obsolete monorail infrastructure, and associated tree removal;
- A network of open space areas and links generally as shown within the Public Domain Concept Proposal, to facilitate re-integration of the site into the wider urban context;
- Building envelopes;
- Land uses across the site, non-residential and residential uses;
- A maximum total Gross Floor Area (GFA) across the Harbourside site of 87,000m2 for mixed use development (non-residential and residential development);
- Basement car parking;
- Car parking rates to be utilised in subsequent detailed (Stage 2) Development Applications);
- Urban Design and Public Realm Guidelines to guide future development and the public domain; and
- Strategies for utilities and services provision, drainage and flooding, and ecological sustainable development.

A more detailed and comprehensive description of the proposal is contained in the Environmental Impact Statement (EIS) prepared by JBA.

2.4. Planning Approvals Strategy

The Site is located within the Darling Harbour precinct, which is identified as a State Significant Site in Schedule 2 of State Environmental Planning Policy (State and Regional Development) 2011. As the proposed development will have a capital investment exceeding $10 million, it is declared to be State Significant Development (SSD) for the purposes of the Environmental Planning and Assessment Act 1979 (EP&A Act), with the Minister for Planning the consent authority for the project.

This State Significant Development Application (DA) is a staged development application made under section 83B of the EP&A Act. It seeks approval for the concept proposal for the entire site and its surrounds.

More specifically this staged DA includes establishing land uses, gross floor area, building envelopes, public domain concept, pedestrian and vehicle access and circulation arrangements and associated car parking provision.

Detailed development application/s (Stage 2 DAs) will accordingly follow seeking approval for the detailed design and construction of all or specific aspects of the proposal in accordance with the approved staged development application.

The Department of Planning and Environment provided the Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development on 30 August 2016. This report has been prepared having regard to the SEARs as relevant.

Figure 1 shows the location of the proposed development.

Information describing the proposed development (provided by Mirvac) is provided in Appendix A.

3. Hydrogeological conditions

3.1. Stratigraphy

Our preliminary geotechnical assessment report (reference GEOTLCOV25340AA-AD, 19 February 2016) described the geology, site history and stratigraphy at the site.

In summary, ground conditions at the site comprise:

- Fill, up to 8 m thick, and comprising variably clayey sand and gravel, with sandstone and shale cobbles, concrete, coal, brick and timber fragments, overlying
- Estuarine and alluvial sediments, up to 7 m thick, and comprising clayey sands, silts and clays. Organic/peaty clay horizons may be present, possibly corresponding to an area where mangrove swamps once existed, overlying
- Thin residual soils (less than 1 m thick) in some locations but generally absent, overlying
- Extremely to highly weathered sandstone that is highly fractured or fragmented, with frequent zones of clay seams; grading to high strength and fresh at greater depth.

Figure 2 shows interpreted top of rock contours as presented in our preliminary geotechnical assessment and the locations of three sections through the site. The sections are provided in Appendix B and show interpreted ground conditions. The proposed finished floor level of a two-level basement is some 3 m below the finished floor level of the single-level basement shown on these sections.

3.2. Groundwater levels

3.2.1. Available data

Details of the existing harbour wall at the site are unknown, and the hydraulic connection between groundwater at the site and harbour waters is uncertain. The wall may prevent flow between groundwater and harbour waters, in which case groundwater levels behind the wall might trypically be higher than harbour water level; or there may be strong hydraulic connection between groundwater and harbour waters, in which case groundwater levels behind the wall would vary in accordance with the tides (with lag time) but the average level would be approximately mean sea level.

The groundwater table at the site is expected to experience variation due to tidal influence (assuming some hydraulic connection exists).

Tide levels vary between approximately -0.8 m AHD and 1.1 m AHD (based on low and high tides reported by Roads and Maritime Services for Fort Denison). Groundwater levels at the site could be as high as the Highest Astronomical Tide of 1.1 m AHD, but are expected to typically be lower, perhaps in the range of 0 m AHD to 1 m AHD. Groundwater levels in the west of the site, where sandstone is elevated, may be higher.

Geotechnical investigation by Coffey (2013) at the Sydney International Exhibition and Entertainment Precinct's ICC Hotel, immediately to the west of the southern portion of the proposed development, observed groundwater levels between 0.4 m AHD and 0.7 m AHD at the time of investigation (May 2013).

Geotechnical investigation by Douglas Partners Pty Ltd (2013) at the Sydney Convention and Exhibition Centre, to the immediate south of the site, observed the groundwater table there in September 2013 at depths of between 1.6 m and 5.5 m below ground level (-2.4 m AHD to 1.7 m AHD), with an average reported of about 0 m AHD.

3.2.2. Sea level rise

The NSW Office of Environment and Heritage (formerly Department of Environment, Climate Change and Water NSW (2010)) nominate design still water levels for 2050 and 2100 incorporating projected sea level rise for a 50 year recurrence interval of approximately 1.8 m AHD and 2.3 m AHD, respectively. These levels allow for all components of elevated ocean water levels experienced over this timeframe (including tides, meteorological influences and other water level anomalies); however, they exclude wave setup and wave run-up influences. They are relevant to where full oceanic tidal conditions are expected, and this may not be the case at the site, particularly to the west. We recommend groundwater monitoring at the site to confirm levels and hydraulic connection to harbour waters.

3.2.3. Flood conditions

A flood study completed by Arcadis Australia Pacific Pty Ltd (2016) provides flood levels predicted by WMAwater Pty Ltd, who completed a flood study for Sydney City Council. Results of the flood modelling completed by WMAwater Pty Ltd are included in the report by Arcadis and nominate a flood level of approximately 3.3 m AHD and 4.3 m AHD for a 100 year Average Recurrence Interval event and a Probably Maximum Flood (PMF), respectively.

These levels appear to be relevant to the north west and south west of the proposed development. Coffey understands that Arcadis recommend more detailed flood modelling of the area. For the purposes of this assessment, we assume the nominated flood levels are generally relevant to the development site.

The hydraulic conductivity of fill at the site, and the extent to which surface water to infiltrate the ground, is unknown. However, fill at the site comprises clayey sand and gravel and is expected to have relatively high hydraulic conductivity.

Additional ground testing and analysis is required to estimate the response of groundwater pressures to flood conditions.

For the purposes of this report, we make the conservative assumption that flood waters can readily infiltrate the fill, such that hydrostatic conditions under a PMF event are consistent with a PMF level of 4.3 m AHD.

3.3. Aquifer properties

There are no data available on the hydraulic properties of the fill, estuarine/alluvial sediments or sandstone bedrock at the site.

Packer test data from other site in the region shows that the hydraulic conductivity of shallow sandstone can range between approximately 0.001 m/day and 1 m/day.

3.4. Groundwater flow

It is expected that groundwater (beyond the zone of tidal influence) flows in an easterly direction, towards Cockle Bay. Within the tidal zone, groundwater flow would likely exhibit complex flow behaviour.

4. Groundwater management during construction

Based on our ground model, and assuming the lowest floor level of the proposed basement lies at approximately -3 m AHD, the excavation is expected to extend through the fill and into across the site sandstone.

We understand the basement is proposed to be tanked, with waterproofing to prevent groundwater ingress into the basement structure.

Groundwater cut-off will be required to prevent groundwater entering the basement excavation during construction.

The cut-off wall would comprise a combination of diaphragm and secant pile walls.

For diaphragm walls, consideration should be given to the excavatability through the fill, the keying-in to the sandstone, and the amount of space required to manage the bentonite, steel cages and concrete for the wall construction. Allowances should also be made for localised grouting at completion of the construction.

For secant pile walls, construction equipment may be able to penetrate through obstructions in fill. The verticality of such piles is important to ensure the desired groundwater cut-off performance of the wall is achieved.

5. Inflow assessment

We have assessed anticipated groundwater inflows to the basement, assuming the presence of a secant pile or diaphragm cut-off wall that penetrates the underlying rock and runs the full perimeter of the basement excavation.

Assessment of steady state groundwater inflows was undertaken using analytical methods based on the theory presented by Polubarinova-Kochina (1952) for confined flow under an impervious structure.

The inflow assessment assumes:

- A groundwater level of 1 m AHD in the vicinity of the site under existing conditions
- During a flood, a flood water level of 4.3 m AHD, with groundwater under hydrostatic conditions
- The cut-off wall extends from ground surface to some 1.5 m into Class III (or Class I or II) sandstone, the top of Class III sandstone is , and the wall is essentially impermeable
- Based on material descriptions (borehole logs) and our knowledge of conditions in the area, we assume the hydraulic conductivity of the sandstone underlying the toe of the cut-off wall (i.e., the Class III or better sandstone) is some 0.5 m/day

- Surface water does not enter the excavation.

Based on these assumptions, a conservative estimate of long-term (steady state) inflow to the basement has been estimated for both the mean groundwater level condition and the flood condition. These are provided in Table 1.

Additional allowance would need to be made for dewatering of direct rainfall and/or surface water entering the excavation.

It is possible that groundwater inflows to the excavation could be reduced by extending the cut-off wall into deeper (fresher) sandstone. However, in-situ hydraulic conductivity data on sandstone are required to confirm this.

There is significant uncertainty in this assessment, particularly because the hydraulic conductivity of ground is unknown and direct measurements of groundwater level are not available at the site. We recommend site investigation to assess the hydraulic conductivity of the sediments and shallow rock at the site. Our inflow assessment should be revised once in-situ results have been obtained.

Table 1: Estimated Groundwater Inflow to Excavation

Condition	Estimated Inflow (L/s)
Mean groundwater level	Up to 15
Probable maximum flood (with groundwater under hydrostatic conditions with flood waters)	Up to 25

6. Preliminary design water levels and uplift pressures

In the absence of site-specific groundwater monitoring data, we assess that a typical groundwater level in the fill surrounding a tanked basement development could be as high as sea level (1.1 m AHD).

Under flood conditions, groundwater levels in the fill surrounding a tanked basement development could be high as high as flood level (4.3 m AHD at PMF level).

Considering a lowest basement floor level of -3.1 m AHD, a tanked basement would need to be designed for an uplift pressure of 42 kPa under typical conditions and 73 kPa under flood conditions.

These design groundwater levels are based on limited available information in the locale, may be reduced subject to site-specific monitoring data.

Based on these groundwater levels, services surrounding the development would need to be designed/modified for the uplift pressures nominated in Table 2 in order to avoid floatation.

We have not received any information regarding the nature of proposed or existing services in the vicinity of the development site. Our nominated uplift pressures assume the services are sealed and do not permit groundwater ingress.

Measures adopted to resist the uplift/buoyancy forces should provide adequate factor of safety.

Table 2: Design Uplift Pressures for Surrounding Services

Elevation of Base of Service Structure (m AHD)	Design Uplift Pressure (kPa)	
	Typical Condition (Groundwater level at 1.0 m AHD)	Flood Condition (PMF Level of 4.3 m AHD)
0.0	10	43
1.0	N/A	33
2.0	N/A	23
3.0	N/A	13

7. Uncertainty and recommendations

There is limited data relating to hydrogeological conditions at the site, and therefore significant uncertainty in our assessment.

To reduce this uncertainty, we recommend site investigation prior to detailed design to confirm groundwater levels at the site, and to assess the hydraulic conductivity of the sediments and rock at the site.

Our inflow assessment may be revised once in-situ results have been obtained.

We recommend review of potential impacts of the development (including impacts on potential acid sulfate soils and groundwater quality) once the concept design has been confirmed for the development.

8. Limitations

This report is based on limited data that is not specific to the site. Subsurface conditions can change over relatively short distances. For these reasons, there is significant uncertainty in our assessment. The attached document entitled “Important Information about Your Coffey Report” presents additional information on the uses and limitations of this report.

9. References

Arcadis Australia Pacific Pty Ltd (2016), Flooding, Stormwater and WSUD for Stage 1 DA, Habourside Shopping Centre, Report prepared for Mirvac, 18 March 2016.

Coffey Geotechnics Pty Ltd (2013), Geotechnical Investigation Report for SSDA6, Sydney International Exhibition and Entertainment Precinct - ICC Hotel, report reference GEOTLCOV24303AH-AH Rev 1, 26 August 2013.

Douglas Partners Pty Ltd (2013), Report on Additional Geotechnical Investigation, Darling Harbour Live, Sydney Convention and Exhibition Centre, Darling Harbour, Report Prepared for Lend Lease Building Pty Ltd, Project 72959.01, October 2013.

Polubarinova-Kochina, P.Ya. (1952), Theory of the Motion of Ground Water Gostekhizdat, Moscow, in Harr, M.E., Groundwater and Seepage, McGraw-Hill Book Company, New York, 1962.

State of NSW and Department of Environment, Climate Change and Water (2010), Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments, Available at www.environment.nsw.gov.au, ISBN 978 1 74232 922 2, DECCW 2010/760, August 2010.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

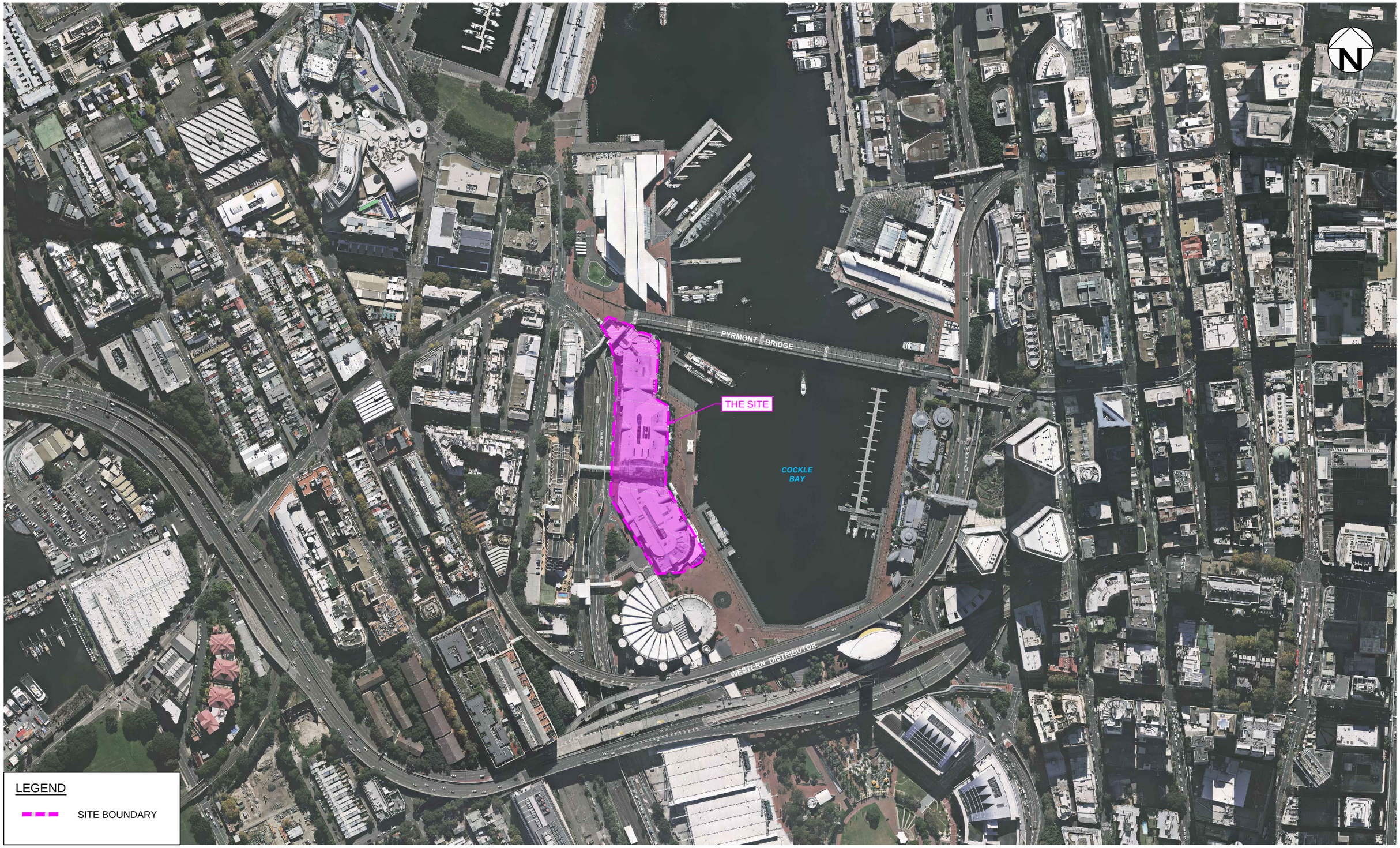
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE	MF	STP	18/02/16

50 0 50 100 150 200

Scale (metres) 1:4000

drawn	MF / AW
approved	STP
date	18 / 02 / 16
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

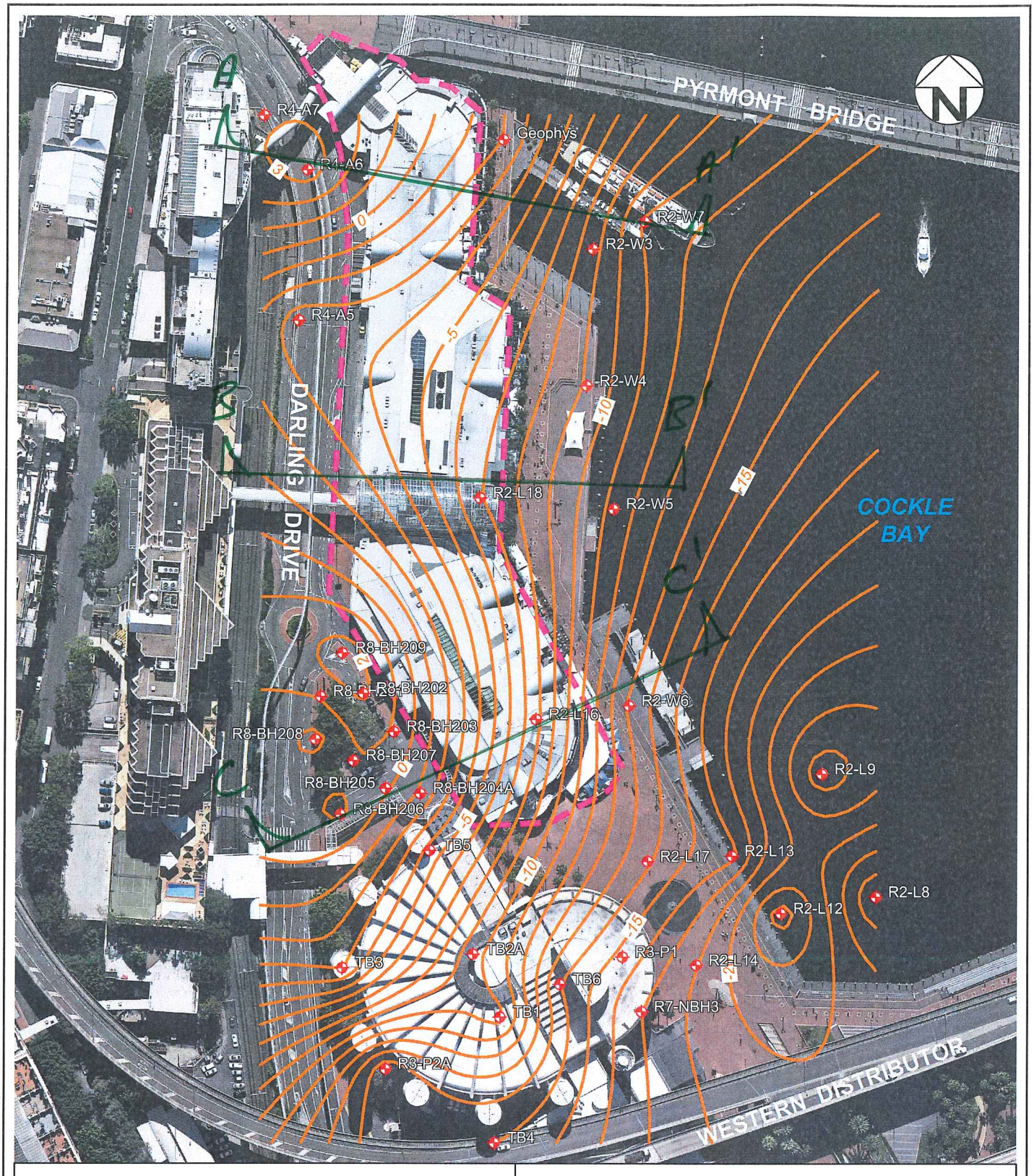
client: MIRVAC

project: PRELIMINARY GEOTECHNICAL ASSESSMENT REPORT
HARBOURSIDE DARLING HARBOUR, SYDNEY, NSW

title: SITE LOCATION PLAN

project no: GEOTLCOV25340AA-AD | figure no: FIGURE 1 | rev: A

PLOT DATE: 18/02/2016 4:14:31 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\GEOTLCOV25\GEOTLCOV25340AA HARBOURSIDE REDEVELOPMENT\CAD\GEOTLCOV25340AA-AD.DWG



LEGEND

- PREVIOUS BOREHOLE LOCATION
- SITE BOUNDARY
- -10 TOP OF ROCK CONTOURS (m)

20 0 20 40 60 80 100

Scale (metres) 1:2000

DRAFT

drawn	MF / AW
approved	-
date	17 / 02 / 16
scale	AS SHOWN
original size	A4

coffey
A TETRA TECH COMPANY

client: MIRVAC

project: PRELIMINARY GEOTECHNICAL ASSESSMENT REPORT
HARBOURSIDE DARLING HARBOUR, SYDNEY, NSW

title: TOP OF ROCK CONTOUR PLAN

project no: GEOTLCOV25340AA-AD | figure no: FIGURE 2 | rev: A

PLOT DATE: 17/02/2016 4:34:34 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\GEOTLCOV25340AA HARBOURSIDE REDEVELOPMENT\CAD\GEOTLCOV25340AA-AD.DWG

Appendix A - Development Plans

© FRANCIS-JONES MOREHEN THORP PTY LTD 2016 ABN 28 101 197 219

ENV 1

ENV 2

60,800

22,999

97,600

13,273

48,600

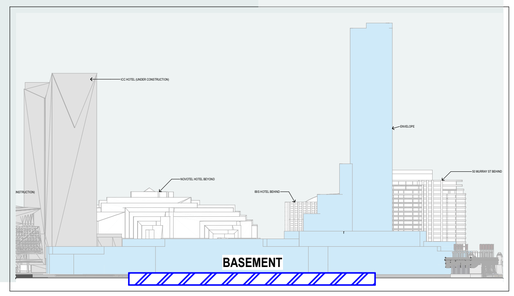
ENV 1

ENV 2

BOUNDARY LEGEND

LOT BOUNDARY

WATERFRONT & PYRMONT BRIDGE SETBACKS



fjmt
francis-jones morehen thorp

Envelope Plan - Basement

Mirvac - Harbourside

DRAFT

0 5 10 20m

1:500 @ A1

14/09/2016

For Information

SSDA1-102

Appendix B – Interpreted Ground Conditions

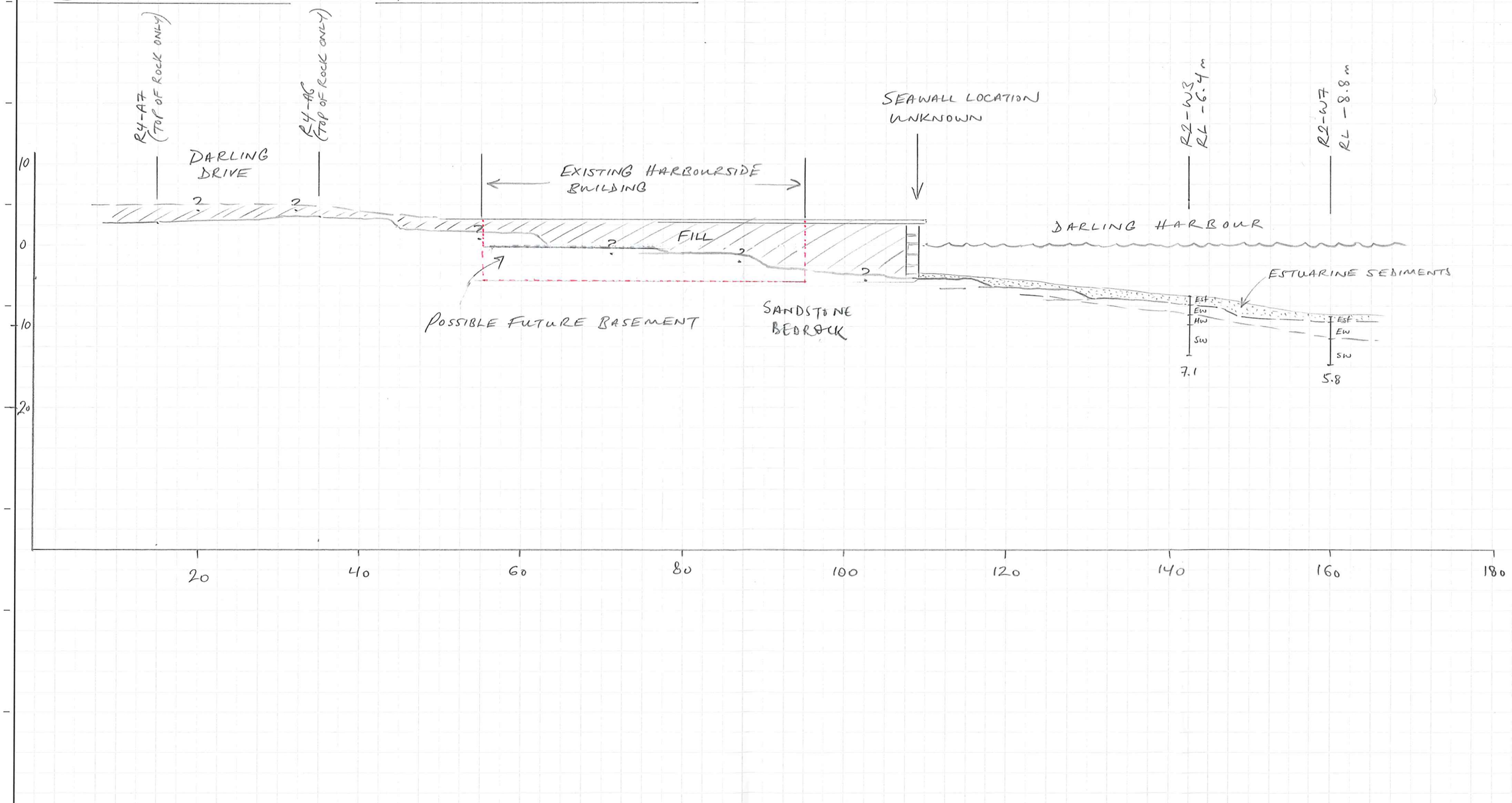
coffey

Computations

project no: GEOTLCOV25340AA sheet 1 of 3

client: MURVAL
office: CHATS
principal:
date: 13/7/2016
project: HARBOURSIDE
by: MF/PS
location:
checked:

SECTION A - A' 1:500 NATURAL SCALE



64210 / 07-06

coffey

Computations

project no: GEOTLCOV25340AA

sheet 2 of 3

client: MIRVAC

office: CHATS

principal:

date: 18/02/2016

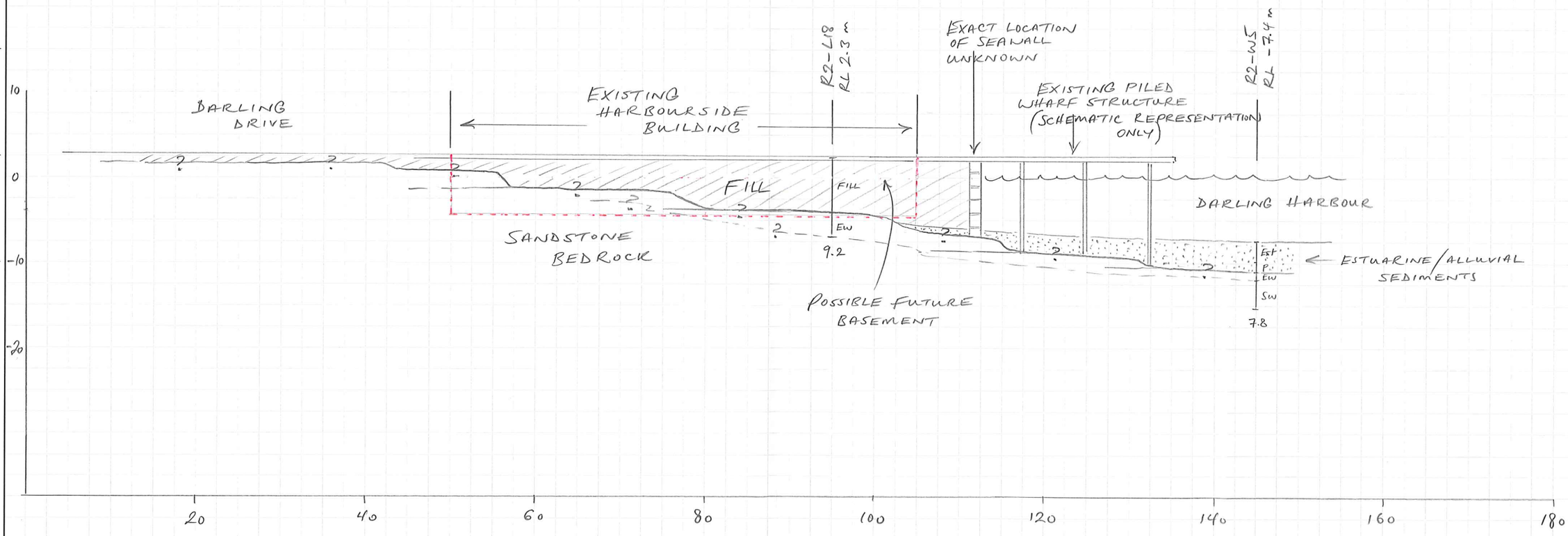
project: HARBOURSIDE

by: MF / PS

location:

checked:

SECTION B–B' 1:500 NATURAL SCALE



64210/07-06

coffey

Computations

project no: GEOTLCOV25340AA

sheet 3 of 3

client: MIRVAC

office: CHATS

principal:

date: 13/07/2016

project: HARBOURSIDE

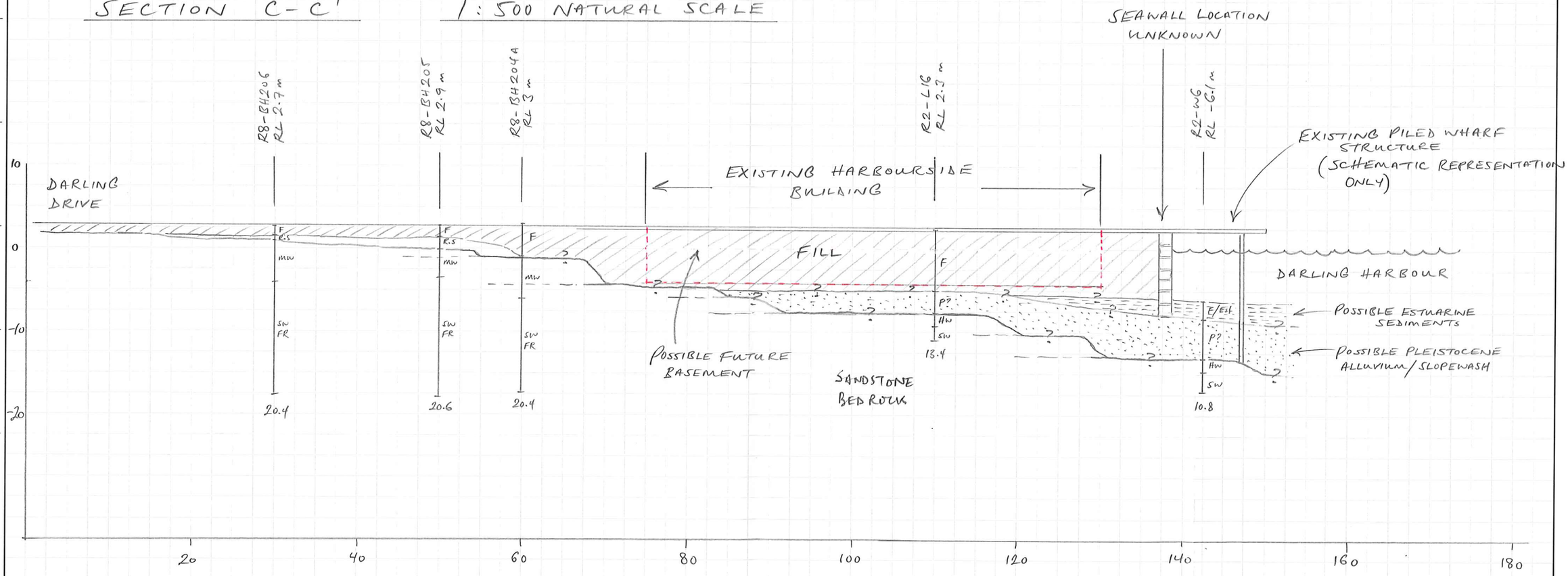
by: MF/PS

location:

checked:

SECTION C-C'

1:500 NATURAL SCALE



This page has been left intentionally blank