BESIX Watpac

Barangaroo Station

Water Discharge Impact Assessment

SEPTEMBER 2021

CONFIDENTIAL

Question today

Imagine tomorrow

Create for the future

Barangaroo Station
Water Discharge Impact Assessment

BESIX Watpac

WSP
Level 15, 28 Freshwater Place
Southbank VIC 3006

Tel: +61 3 9861 1111
Fax: +61 3 9861 1144
wsp.com

REV	DATE	DETAILS
00	29 September 2021	Final issue

	NAME	DATE	SIGNATURE
Prepared by:	[redacted]	29 September 2021	[redacted]
Reviewed by:	[redacted]	29 September 2021	[redacted]
Approved by:	[redacted]	29 September 2021	[redacted]

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

This document may contain confidential and legally privileged information, neither of which are intended to be waived, and must be used only for its intended purpose. Any unauthorised copying, dissemination or use in any form or by any means other than by the addressee, is strictly prohibited. If you have received this document in error or by any means other than as authorised addressee, please notify us immediately and we will arrange for its return to us.

Table of contents

List of tables

List of figures

List of appendices

Abbreviations

AHD	Australian Height Datum
ANZECC/ARMCANZ, 2000	Australian Water Quality Guidelines for Fresh and Marine Water Quality
ANZECC 2000	Australian and New Zealand Guidelines for Fresh and Marine Water Quality ANZECC 2000
ANZG 2018	Australian and New Zealand Guidelines for Fresh and Marine Water Quality ANZG 2018
CSSI	Critical State Significant Infrastructure
DCP	Barangaroo South - District Cooling Plant
DO	Dissolved Oxygen
EC	Electrical conductivity
EIS	Sydney Metro city & Southwest Environmental Impact Statement
EPL	Environmental Protection Licence
ESCP	Erosion and Sediment Control Plan
EVs	Environmental Values
HIR	Hydrogeological interpretative report
JGCPBBG	John Holland, CPB and Gheller
MSL	mean sea level
NSW WQO	NSW Water Quality Objectives
NWQMS	National Water Quality Management Strategy
OEH	NSW Office of Environment and Heritage
PAH	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
POEO Act	Protection of the Environment Operations Act 1997 POEO Act (EPA NSW 1997)
SHWQIP	Sydney Harbour Water Quality Improvement Plan (Greater Sydney Local Land Services, 2015)
SWQMP	Surface Water Quality Monitoring Program
TfNSW	Transport for NSW
TRH	total recoverable hydrocarbons
TSE	Tunnel and Excavation Contractor

TSS	Total Suspended Solids
WDIA	Water Discharge Impact Assessment
WTP	Water Treatment Plant

1 Introduction

1.1 Project Background

WSP has been commissioned by BESIX Watpac to provide building and specialist services for the Barangaroo Station Construct Only Works Contract. Transport for NSW (TfNSW) has committed to the temporary works and construction phase works of Barangaroo Station following a Stage 3 certified Metron Design stage package.

The Tunnel and Excavation Contractor (TSE) is a JV between John Holland, CPB and Gheller (JGCPBBG), who are scoped to deliver the excavation and construction of the station box structure. The TSE Contractor has been responsible for the management of groundwater, surface water and construction water within the Barangaroo Station site (the project). Within the construction site for the project, the TSE Contractor commissioned a Water Treatment Plant (Barangaroo WTP), which is currently treating groundwater and surface water, collected on site via a system of pits and pumps.

When the TSE Contractor finish their works and hand the site over to BESIX Watpac, the station box lid will be cast and fully tanked up to level B3. The scope of the proposed BESIX Watpac construction works include:

- Station fitout works including secondary structural elements
- Third party works including Hickson Road construction, public domain works, utilities and landscaping
- Interface works including the provision of facilities, plant and equipment for Interface Contractor.

BESIX Watpac has engaged WSP to prepare a Water Discharge Impact Assessment (WDIA) for the discharge and water quality from the Barangaroo WTP. BESIX Watpac are seeking to validate the requirements set out under the CSSI Conditions of Approval (E-107) to maintain the *NSW Water Quality Objectives* and if modifications or improvements to the performance of the Barangaroo existing WTP is required to treat collected runoff from the project. The Barangaroo Station project indicative site boundary is shown in Figure 1.1.

Figure 1.1 Barangaroo Station project (indicative site boundary) *Sourced: TSE EPL Premise Map*

1.2 Scope of study

The definition for phases used throughout this report are:

- *Typical case* conditions – refers to groundwater inflows collected from the B3 depressurisation drain and the Northern Shaft, to Barangaroo WTP (i.e. dry weather event).
- *Worst-case* conditions – refers to surface water and groundwater flows generated at the project (i.e wet weather events).

The scope of the WDIA includes:

- Critical State Significant Infrastructure (CSSI) Sydney Metro City & Southwest Chatswood to Sydenham Conditions of Approval
- Sydney Metro - Water Discharge & Reuse Procedure
- BESIX Watpac Soil & Water Management Procedure – Barangaroo Station
- Review of legislation and guidelines relevant to water quality discharge at the site
- Review and analysis of available surface water quality data at Sydney Harbour to determine environmental value
- Analysis of Barangaroo WTP effluent data and groundwater quality data against relevant guidelines and discharge criteria.
- Estimation of surface water and groundwater flow for construction stage including proposed discharge volumes under *typical case conditions* and *worst-case conditions*.

- Characterise the expected WTP discharge quality (for both chemical and physical parameters) under *typical case conditions* and *worst-case conditions* and potential impacts to receiving waters.
- Recommend monitoring and discharge criteria for the construction works.

2 Legislation and Policy

2.1 Commonwealth

2.1.1 NATIONAL WATER QUALITY MANAGAMENT STRATEGY

The National Water Quality Management Strategy (NWQMS) is a joint approach by the Australian and New Zealand governments to improving water quality in waterways. The NWQMS provides guidelines for setting water quality objectives to sustain current or likely future environmental values for water resources. Guidelines relevant to the project include:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018); and
- Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000).

2.1.2 *Australian and New Zealand guidelines for fresh and marine water quality (ANZECC guidelines);*

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality have recently been updated to incorporate new science and knowledge developed over the past 20 years (ANZG 2018). The ANZEG 2018 together with the ANZECC 2000 guidelines provide a:

- framework for conserving ambient water quality in natural water resources (rivers, lakes, estuaries and marine waters);
- guidance to understand the current health of the waterways in the vicinity of the project;
- list a range of environmental values assigned to a described waterbody; and
- long-term (default) trigger values for various levels of protection which have been considered when describing existing water quality and key indicators.

The site is in the *Southeast Coast* drainage division of ANZEG 2018 guidelines. At the time of this report, the Southeast Coast guideline was not published.

2.2 State

2.2.1 *Protection of the Environment Operations Act 1997*

The EPA, as the regulatory authority, provides licensing for projects with direct impact on water bodies based on some of the considerations established in Chapter 3, Section 45 of the Protection of the Environment Operations Act 1997 - POEO Act (EPA NSW 1997).

2.2.2 *Protection of the Environment Administration Act 1991*

This Act establishes the EPA, Board of the EPA and community consultation forums. The Act’s purpose is to protect, restore and enhance the quality of the environment and reduce risks to human health. It defines obligations and responsibilities for managing activities that may cause environmental harm.

2.2.3 *NSW Water Quality Objectives*

The NSW Water Quality Objectives (WQO) are the agreed environmental values and long-term goals for NSW’s surface water (DECCW, 2006). The WQO describe:

- community ***values*** and uses (for example healthy aquatic ecosystem, water suitable for recreation or drinking water) for NSW waterways;
- a range of water quality ***indicators*** to assess whether the current condition of the waterway supports these values and uses; and
- recommended guideline levels determined by environmental values.

The project is in the Sydney Harbour and Parramatta River Lower Estuary catchment. Based on this classification, nominated environmental values (EVs) include the protection of aquatic ecosystems, protection of visual amenity and protection of primary and secondary contact recreation.

The NSW WQO and ANZG 2018 / ANZECC 2000 guidelines recommend trigger values for the EVs. Guideline trigger values are the criteria used for concentrations that, if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response.

2.3 Regional

2.3.1 Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.

The Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 covers all the waterways of the Harbour, the foreshores and entire catchment. The planning principles for land within the Sydney Harbour Catchment Regional Environmental Plan as relevant to this assessment are:

- Environmental Objectives: Guidelines for Water Management: Sydney Harbour and Parramatta River Catchment (published in October 1999 by the Environment Protection Authority), such action to be consistent with the guidelines set out in Australian Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000)
- Development is to improve the water quality of urban runoff, reduce the quantity and frequency of urban runoff, and prevent the risk of increased flooding and conserve water.

2.3.2 Sydney Harbour Water Quality Improvement Plan

The Sydney Harbour Water Quality Improvement Plan (Greater Sydney Local Land Services, 2015) (SHWQIP) was developed by Greater Sydney Local Land Services and NSW Office of Environment and Heritage (OEH) in coordination with a range of stakeholders. The main objective of the SHWQIP is to *identify threats to water quality in the Harbour and its tributaries and to set targets for pollutant load reductions (in terms of total nitrogen, total phosphorus, suspended sediment and pathogens) required to protect the condition and values of the Sydney Harbour, its tributaries, estuaries and waterways*.

Catchment load and estuary condition targets have been developed using scenario options for both the management of stormwater and improvements in sewer overflow performance. These targets are based on assumptions of feasible change developed in scenarios:

- 70% WSUD applied to infill redevelopment and 10% retrofit of existing areas.
- Improving sewer overflow performance to limit overflows to no more than 40 events in 10 years.

The proposed Barangaroo Station is in the sub-catchment of Darling Harbour. The targets for Darling Harbour are TN-25%, TP -37%, TSS -45%, Enterococci -41% and Faecal coliforms -43%.

2.3.3 Pollution in Sydney Harbour: sewage, toxic chemicals and microplastics

The NSW Parliamentary Research Service Briefing Paper No. 03/2015 by Daniel Montoya describes the type and location of pollution in Sydney Harbour, with reference to water quality, dioxins, heavy metals and sediment toxicity, and microplastics.

Sydney Harbour has been classified as very severely modified by heavy metal contamination. In total, 1,900 tonnes of copper, 3,500 tonnes of lead and 7,300 tonnes of zinc have been found in Sydney Harbour sediments. Stormwater is the most significant contemporary source of heavy metal contamination in Sydney Harbour. Copper concentrations in stormwater almost always exceed the guidelines, zinc concentrations frequently exceed guidelines and arsenic, chromium and lead concentrations exceed guidelines on occasion. Sydney Harbour has some of the highest recorded sediment concentrations of heavy metals in Australia.

Research published in 2013 evaluated the heavy metal contamination of Sydney Harbour by examining the degree to which the sediments have become enriched by heavy metals. Rozelle & Blackwattle Bays were very severely modified for copper, lead and nickel. All embayment locations, as well as Sydney Harbour as a whole, were classified as very severely modified by heavy metal contamination.

2.4 Planning Conditions

2.4.1 Conditions of Approval

The Transport for NSW Minister for Planning granted Conditions of Approval for the Critical State Significant Infrastructure (CSSI) Sydney Metro City & Southwest Chatswood to Sydenham in 2017(Conditions of Approval). The key planning condition relevant to this WDIA is Condition E107, which states:

The CSSI must be constructed and operated so as to maintain the NSW Water Quality Objectives where they are being achieved as at the date of this approval, and contribute towards achievement of the NSW Water Quality Objectives over time where they are not being achieved as at the date of this approval, unless an EPL in force in respect of the CSSI contains different requirements in relation to the NSW Water Quality Objectives, in which case those requirements must be complied with.

2.4.2 Revised Environmental Mitigation Measures

The key condition of the Revised Environmental Mitigation Measures relevant to the WDIA is ID SWC4, which states:

Discharges from the construction water treatment plants would be monitored to ensure compliance with the discharge criteria in an environment protection licence issued to the project.

2.5 Guidelines and Relevant Reports

Additional Design Standards and Codes, Technical Publications and Guidelines not referenced as above and relevant to this design package are

REFERENCE	TITLE
City & Southwest Project Delivery	Chatswood to Sydenham Construction Environmental Management Framework
City & Southwest Project Delivery, July 2019	Chatswood to Sydenham – Staging Report
Sydney Metro Integrated Management System	Water Discharge & Reuse Procedure (SM-17-00000098)
Centre for Environmental Contaminants Research, CSIRO Land and Water, 2009	Development Of Guidelines For Ammonia In Estuarine And Marine Water Systems
Landcom, 2004	Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (known as the Blue Book Volume 2)

BESIX Watpac, July 2021	Soil & Water Management Procedure (SMCSWSBR-BWC-SBR-EM-PRO-000031)
JHCPBG, March 2020	Water Reuse and Discharge Management Procedure (SMCSTSEJCG-TPW-EM-MPR-003002)
JHCPBG	Surface Water Treatment Quality Monitoring Program (SMCSWTSE-JCG-TPW-EM-RPT-097238)
Aquatic Engineering Australia Pty Ltd, May 2019	Sydney Metro 15 l/s Water Treatment Plants – Operation and Maintenance Manual (P35-15LPS)
JHCPBG, June 2017	Water Reuse and Discharge Management Procedure (SMCSWTSE-JCG-TPW-EN-MPR-003002)
Worley Parsons, September 2012	Barangaroo South – District Cooling Plant (DCP), Harbour Heat Rejection System Thermal Water Marine Ecological Impact Assessment

3 Methodology

3.1 Overview

It is a requirement to protect the waterways from pollutants generated by the project, that may have the potential to negatively impact on the health of the receiving environment.

Poor water quality has a negative impact on the health of our ecosystems, recreational activities and other activities, and so water quality guidelines (ANZG 2018 / ANZECC 2000) are used to guide water quality management. The guidelines identify different uses and activities for waterways (e.g. drinking, swimming, crop use) and appropriate water quality values for uses and activities. They enable water management to be tailored to different waterway environmental conditions and different water uses.

Application of the ANZG 2018 / ANZECC 2000 guidelines are used to identify catchment and waterway-specific water quality management goals for different potential pollutants (trigger values). The methodology for assessing construction phase water quality impacts, as outlined in the ANZG 2018 / ANZECC 2000 guidelines, is illustrated in Figure 3.1.

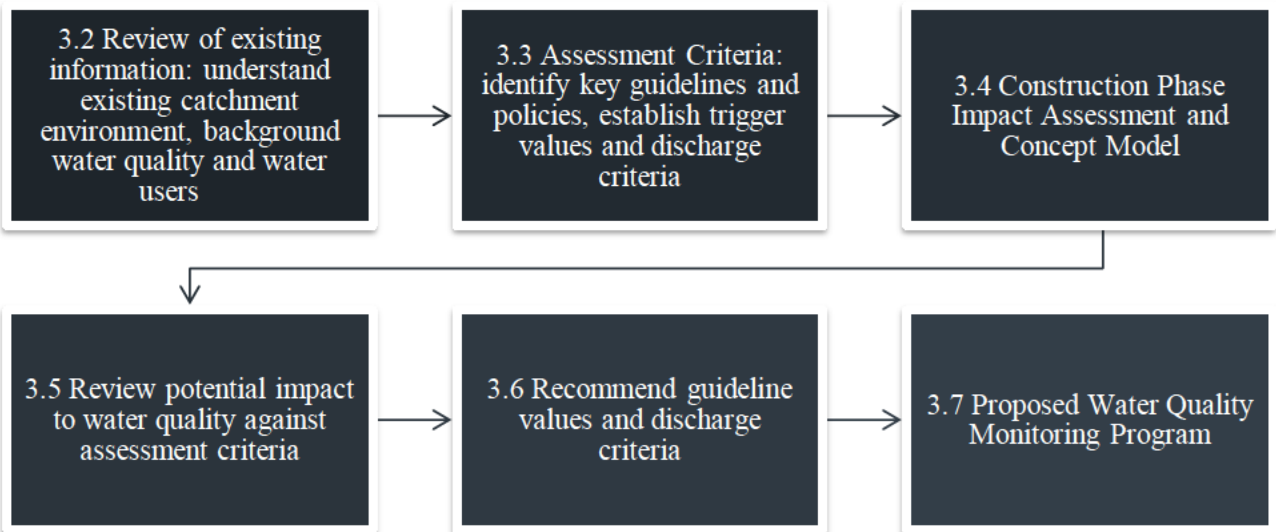


Figure 3.1 Key steps in construction water quality impact assessment – application of ANZECC (2000) Guidelines

Together with the scope of works (refer to Section 1.2), this WDIA has incorporated the ANZG 2018 / ANZECC 2000 methodology for assessing construction phase water quality impacts, as outlined in the following sections.

3.2 Existing Conditions

The desktop assessment involves a review of available information relevant to the Barangaroo WTP discharge, groundwater quality data and the receiving surface water environment in Sydney Harbour. A summary of key sources reviewed to provide context for the existing surface water conditions for the Project is provided in Table 3.1. These documents provided key information to identify environmental values, water quality objectives and development of site-specific water quality objectives where required.

Table 3.1 Key data sources

REFERENCE	BRIEF OVERVIEW	RELEVANT PROJECT DATA
Stormwater and Flooding Management Plan Project: Sydney Metro City & Southwest – TSE Works Document No.: SMCSWTSE-JCG-TPW-DN-PLN-002032	Details how John Holland CPB Ghella (JHCPBG) will manage stormwater and flooding during the Design and Construction of Sydney Metro City & Southwest Tunnel and Stations Excavations Works Project.	Identifies potential flood impacts to the project and specifies required flood mitigation measures.
Site Specific Erosion and Sediment Control Plans (BESIX Watpac)	Layout plans showing flow paths and erosion and sediment control to be implemented for the project.	Provides an understanding of the existing drainage infrastructure at the project.
Indicative TSE current & BESIX WATPAC project boundaries discharging runoff to Barangaroo WTP.	Sketch highlighting project boundaries of the current TSE project and proposed BESIX WATPAC project boundary.	Provides an understanding of changes to the surface water flow regime from the TSE contractor and BESIX WATPAC contractor.
Controlled Water Overflow Management Strategy Project: Sydney Metro City & Southwest – TSE Works Document No.: SMCSWTSE-JCG-TPW-DN-RPT-097233	A risk assessment and strategy how JHCPBG will manage surface water overflows once the 5-day 85 percentile rainfall depth is exceeded.	Provides the design rainfall event applied to estimating the current construction runoff rate at the project.
Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works August 2017 to January 2018 January 2018 to June 2018 July 2018 to December 2018 January 2019 to June 2019 July 2019 to December 2019 July 2020 to December 2020 January 2021 to July 2021	The SWQMP is being implemented in accordance with Condition C9 of the Project Planning Approval.	Provides a baseline and construction water quality monitoring for Sydney Harbour (station reference: SW-B-01). This data will provide the current water quality of the existing receiving water environment.
Construction Soil, Water and Groundwater Management Plane (CSWGMP) Project: Sydney Metro City & Southwest – TSE Works Document No.: SMCSWTSE-JCG-TPW-EM-PLN-002014	Details how John Holland CPB Ghella (JHCPBG) will minimise and manage impacts on soil, water and groundwater during the Design and Construction of Sydney Metro City & Southwest Tunnel and Stations Excavations Works Project.	Provides an overview of the frequency of water quality monitoring and parameters to be monitored for stages: — *Pre-construction* Baseline phase August 2017 – February 2018. — *Construction*

REFERENCE	BRIEF OVERVIEW	RELEVANT PROJECT DATA
		Monitoring every 3 months plus 4 wet weather monitoring events undertaken within a 12 month period. — *Post works completion* Continuation of the 3 monthly monitoring until handover.
TSE EPL Premise Map Sydney Metro City & Southwest Barangaroo Station and Precinct	Indicative site boundary and premised area	Establishing the existing conditions of the project and area subject to EPL discharge criteria.
Aquatic Engineering Recorded Barangaroo WTP discharge rate for the period May, June and July 2021	Continuous flow measurements at the discharge of the Barangaroo WTP	Data used to establish existing flow conditions at the site.
Environmental Protection Licence (EPL 20971)	States project discharge must comply with criteria specified in Condition L2.8.	Refer to Section 3.3.1
Barangaroo WTP Monitoring Results from Q4 2018 to Q2 2020 (reference: SMCSWSBR-BWC-CRFI-000064-02-BN)	Monthly water quality monitoring for EPL parameters Quarterly water quality monitoring for the NSW WQO and ANZECC chemical suite	Data used to establish background compliance with EPL and NSW WQO trigger values.
Sydney Metro Barangaroo Station Civil Engineering Drawings (METRON) Stormwater Drainage Plan Sheet 8 (Drawing No: SMCSWSBR-MET-SBR-CE-DWG-012008 Rev 1) Stromwater Drainage Longitudinal Section Sheet 1 (Drawing No: SMCSWSBR-MET-SBR-CE-DWG-012101 Rev 1)	Barangaroo WTP outfall pipe layout plan and longitudinal section	Barangaroo WTP outfall pipe invert levels incorporated into plume dispersion model.

The Barangaroo WTP effluent data and groundwater quality monitoring data was reviewed against NSW Water Quality Objective criteria and EPL (Licence 20971) conditions.

3.2.1 Existing flow and Volume Estimation

3.2.1.1 Surface Water

A review of measured discharge data from the Barangaroo WTP from May 2021 to July 2021 is presented in Section 4.3.1.

An understanding of the existing surface water collection network was based on information provided by BESIX Watpac (refer to Section 3.2). An estimation of surface water volume and flow to Barangaroo WTP for construction stage was based procedures outlined in the *NSW Government's Managing Urban Stormwater: Soils and Construction, 2004* (*Blue Book*).

Surface water at the project is collected via a series of pits and pumped to the WTP for treatment. The capacity of the pits and the rate and frequency of pumping was not available at the time. The recommendations from the Blue Book are that storage capacity should be re-established within 4 to 5 days following the storm event. Hence, a conservative estimate of assuming all rainfall runoff will be collected and discharged within 72 hrs after conclusion of the rainfall event. While the stored volume and the pumping rates of the discharge may vary from storm to storm, such a simplified approach is considered as conservative (as it assumes discharge of the entire collected water volume) and sufficient to assess the water quality impact.

3.2.1.2 Groundwater

A discussion of existing groundwater conditions is presented in Section 4.3.3.

3.3 Assessment Criteria

The WDIA identifies appropriate water quality impact assessment criteria. By applying the legislative and policy frameworks described in Section 2, together with a review of the water quality monitoring data supplied by BESIX Watpac (refer to Appendix C), criteria for the Barangaroo WTP discharge was developed.

Setting trigger values for projects involving works in or near receiving water environments involves the following process:

- Trigger values are first identified for long-term aspirational goals for water quality, which tend to be the most stringent values based on all relevant environmental values;
- The existing water quality in the waterways is then determined from monitoring data and the waterways ecosystem conditions are classified in accordance with the ANZG (2018) / ANZECC (2000) guidelines;
- As assessment is then made as to whether the long-term aspirational goals are currently being met, and if not, whether the relevant activity would influence achieving them; and
- For temporary activities that won't influence achieving long term aspirational goals, monitoring data based site specific trigger values that reflect the existing water quality rather than the long-term goals are established that indicate whether a management response is required in relation to the activity. These trigger values for construction activities may be different to the trigger values based on long term aspirational goals.

3.3.1 Water Quality Objectives

Water quality trigger values are the criteria used to identify if there is a potential environmental problem in the receiving water environment. If the water quality concentration is outside the allowable range/value for a particular environmental value, there is potential risk to that environmental value. There are two types of contaminants classified in ANZG 2018 / ANZECC 2000, namely physical and chemical stressors and toxicants. The method for defining the default trigger values is different for each:

- Physical and chemical stressors (Section 3.3 of ANZG 2018) are:
  - Naturally occurring physical and chemical stressors (e.g. nutrients and pH) can cause serious degradation of aquatic ecosystems when ambient values are too high or too low; and
  - The default trigger values for physical and chemical stressors are based on ANZG 2018 / ANZECC 2000 guideline trigger values.
- Toxicants (Section 3.4 of ANZEG(2018)):
  - Chemical contaminants that have the potential to exert toxic effects at concentrations that might be encountered in the environment.
  - The trigger values for toxicants depend on the level of protection required.

— For bioaccumulative toxicants, stringent protection levels for species protection is considered appropriate. Bioaccumulative toxicants include polychlorinated biphenyls (PCBs), some pesticides, lead, cadmium, mercury, dioxins, furans, benzo(a)pyrene, hexachlorobenzene and chlorobenzenes.

Aquatic ecosystem is the primary environmental value for this project. The objectives adopted for the protection of aquatic ecosystems is *to maintain and enhance the ecological integrity of freshwater and estuarine ecosystems, including biological diversity, relative abundance and ecological processes*.

The objective of the protection of aquatic ecosystems will also protect against secondary contact recreation and / or primary contact recreation environmental values, since aquatic ecosystems are generally more sensitive to changes to the aquatic environment.

3.3.2 Level of Species Protection

In ANZG 2018 / ANZECC 2000, the 'level of protection' is defined as *the degree of protection afforded to a water body based on its ecosystem condition (current or desired health status of an ecosystem relative to the degree of human disturbance).* In ANZG 2018/ANZECC 2000, level of protection only applies to aquatic ecosystems. The selected level of protection is to:

- Maintain the existing ecosystem condition, or
- Enhance a modified ecosystem by targeting the most appropriate level of condition.

Typically, the level of protection for a region is decided through a process of stakeholder involvement. The ecosystem condition and associated levels of protection form a subjective approach to viewing the continuum of disturbance across ecosystems. Levels of protection could apply according to the anticipated capacity of an ecosystem to readily recover from impact if contamination is to be of short duration. The 3 categories of ecosystems conditions in the ANZG 2018 / ANZECC 2000 are:

- **High conservation or ecological value systems**

  Effectively unmodified or other highly valued ecosystems, typically occurring in national parks and conservation reserves, or in remote and inaccessible locations. This category applies 99% species protection for toxicants.

- **Slightly to moderately disturbed systems**

  Ecosystem in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. This category applies 95% species protection for toxicants, or 95% species protection for highly bioaccumulating toxicants.

- **Highly disturbed systems**

  Measurably degraded ecosystem of lower ecological value. Examples are shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture. This category 80% or 90% species protection for toxicants is acceptable.

Currently the existing discharge from Barangaroo WTP is compared against the **slightly to moderately disturbed system category**, with corresponding water quality guideline trigger values for 95% species protection of aquatic ecosystems for physical and chemical stressors and toxicants.

The default trigger values for physical and chemical stressors and toxicants values are provided in Appendix A.

3.3.3 Site specific Trigger Values

This section describes project specific trigger values applied for monitoring of the Sydney Harbour during construction, and in the period after construction.

A Surface Water Quality Monitoring Program (SWQMP) is ongoing to identify potential impacts of the TSE Works on surface water quality. The SWQMP is being implemented in accordance with Condition C9 of the Project Planning Approval. The purpose of water quality monitoring is to identify if a trigger investigation is required and to ensure site processes and procedures are effective.

3.3.3.1 Sydney Harbour Monitoring Station

Water quality monitoring is being conducted in Sydney Harbour quarterly together with up to four wet weather sampling events within a 12 month period (station reference: SW-B-01). Station SW-B-01 receives water from the project as well as the surrounding urban catchment and influences from Sydney Harbour. The location of the station is presented in Figure 3.2.

Figure 3.2 Location of Sydney Harbour Monitoring Station (SW-B-01) and Barangaroo WTP Sampling Point (BN-3)

The 80th percentile baseline value from the monitoring data is being implemented as the project specific trigger value. The trigger values have been determined based on water quality data collected from August 2017 to January 2018. The surface water monitoring parameters and 80th percentile baseline values for Sydney Harbour (station SW-B-01) are presented in Table 3.2.

Table 3.2 Baseline 80th percentile trigger values

PARAMETER	TRIGGER VALUE
pH[1]	7.7 / 8.0
Dissolved Oxygen (DO mg/l)[2]	6.3

PARAMETER	TRIGGER VALUE
Dissolved Oxygen (DO %)[2]	88.7
Turbidity (NTU)	1.6
Oil and Grease	5.0
Conductivity (µS/cm)	53.0/52.0
Total Suspended Solids (TSS: mg/L)	10.4
Iron (mg/L)	0.03
Manganese (mg/L)	0.008

1. Lab/Field tests
2. 20 percentile baseline

It is noted a reduced metals suite of Iron and Manganese were selected for analysis based on a groundwater risk base approach. For DO, the 20 percentile baseline value was adopted as a decrease in DO is representative of environmental degradation.

3.3.3.2 Barangaroo WTP Effluent

Water quality monitoring of the Barangaroo WTP effluent is carried out prior to discharge for EPL parameters (refer to Table 3.3) and quarterly for the NSW WQO and ANZECC physical and chemical stressors and toxicant suite. Samples are taken from the stormwater pit directly adjacent to the Barangaroo WTP (station BN-3), refer to Figure 3.2. Water quality monitoring results were provided from Q4 2018 to Q2 2021 and are presented in Appendix C.

It is noted monitoring results provided prior to September 2020 were from the decommissioned Barangaroo WTP which was located at the project and had a treatment capacity of 50 l/s. While effluent quality results from the decommissioned Barangaroo WTP are not representative of the current treatment capacity, the results are included to provide an understanding of the history of water quality discharge from the project.

The physical and chemical stressors and toxicants monitored at the discharge from Barangaroo WTP are compared to the ANZG 2018 / ANZECC 2000 guidelines trigger values for 95% species protection of aquatic ecosystems.

3.3.3.3 EPL Discharge Criteria

The Barangaroo WTP is discharging treated water to Sydney Harbour in accordance with the project's Environmental Protection Licence (EPL 20971), which nominates discharge criteria for key pollutants, as presented in Table 3.3.

Table 3.3 Barangaroo WTP discharge criteria (EPL 20971 condition L2.8)

PARAMETER	UNIT	DISCHARGE CRITERIA
pH	pH units	6.5 – 8.5
Total Suspended Solids	mg/l	50
Oil and Grease	Visible	Not visible

Once the project is handed over by the TSE contractor to BESIX Watpac, the project will no longer be required to operate under the EPL (Licence 20917).

3.4 Construction Phase Water Discharge Impact Assessment

3.4.1 Estimated Flow and Volume for Project

An understanding of the proposed surface water collection network was based on information provided in the BESIX Watpac *Soil & Water Management Procedure*. An estimation of surface water volume and flow to Barangaroo WTP for this project's construction stage was based procedures outlined in the *NSW Government's Managing Urban Stormwater: Soils and Construction, 2004* (*Blue Book).*

Groundwater modelling of base case conditions and sensitivity simulations provided a conservative estimation of groundwater flow anticipated to occur during the construction stage of this project, refer to Appendix G.

The anticipated flow and volume estimation under *typical case* and *worst-case* conditions for this project's construction stage, were assessed against the treatment capacity of the Barangaroo WTP, refer to Section 5.1.

3.4.2 Water Quality Assessment – Plume Dispersion Modelling

The construction water quality impact assessment aims to identify and assess the mixing processes occurring between the effluent discharges at Barangaroo WTP and the receiving water environment at Sydney Harbour. Near-field plume dispersion modelling simulates this mixing process to produce an estimate of the plume dilution and dispersion along both the vertical and horizontal plane.

The near-field plume dispersion assessment was performed using VISJET software, developed by a team of researchers led by Professor Joseph Lee (University of Hong Kong). VISJET simulates the initial mixing of single or multiple buoyant discharges of an ocean outfall into an ambient current, which represents the receiving water body. The VISJET software has been applied to projects in Australia and at Sydney Harbour including the Barr South project.

The aim of the plume dispersion modelling is to identify the required horizontal and vertical mixing of pollutants within Sydney Harbour to achieve the ANZECC trigger values for 95% species protection of aquatic ecosystems.

The plume dispersion modelling inputs, assumptions and results are presented in Section 5.2.

3.5 Discharge and Water Quality Monitoring Criteria for Construction Stage

The guideline values and discharge criteria identified in Section 3.3 have been reviewed together with the modelling outcome in Section 5.2. The recommended discharge criteria, to ensure the water quality impact is within the acceptable limits, is presented in Section 6.2.

Water quality monitoring has also been proposed based on the findings of the assessment, considering the current water quality monitoring locations and data collected. The proposed water quality monitoring regime for the project is presented in Section 6.1.

4 Existing Conditions

4.1 Existing Water Environment

The existing surface water environment conditions is based on a review of available reports, monitoring data, layout plans and publications, listed in Section 3.2 and Table 3.1.

4.1.1 Surface Water Catchment

The Barangaroo Station site is located within the Sydney Harbour / Parramatta River catchment. The project is located on the waterfront surrounded by high rise development on Hickson Road. The *Sydney Metro city & Southwest Environmental Impact Statement* (EIS), identifies the Barangaroo Station site to be located within the city area catchment. This catchment is described as fully developed (heavily urbanised), with surface water generally collected by stormwater networks (point source discharge).

The *Stormwater Flooding Management Plan* presumes that when capacity of the drainage network discharging runoff to Barangaroo is reached, overtopping of the rock wall along the eastern boundary of the project will occur and runoff will discharge onto Hickson Road.

There are no regional flooding issues identified at the project. In terms of local flooding, the station excavation is situated at a crest and all areas surrounding the station fall away from the proposed excavation.

No watercourses will be directly impacted or modified by the TSE works. Wharf modification works will be undertaken at the Barangaroo / Darling Harbour.

4.1.2 Receiving Surface Water Quality Monitoring

A review of the Sydney Metro City & Southwest – TSE Works biannual Surface Water Quality Monitoring Program from August 2017 to June 2021.

Exceedance of parameters above the 80th percentile baseline values (refer to Section 3.3.3.1 and Table 3.2) were recorded during the monitoring period at Sydney Harbour. A summary of the exceedances noted in the monitoring reports with the reported conclusions are presented in Table 4.1.

Table 4.1 Reported Parameter exceedances at Sydney Harbour monitoring station SW-B-01

MONITORING REPORT DATE	PARAMETERS REPORTED TO EXCEED 80 PERCENTILE BASELINE	REPORTED CONCLUSION
January 2021 to June 2021	Turbidity Total Suspended Solids	Barangaroo WTP was discharging in compliance with the project EPL and was not the cause of elevated turbidity and TSS concentrations recorded in Sydney Harbour. Runoff from the surrounding environment is likely the cause of excess TSS recorded.
July 2020 to December 2020	Turbidity TSS	Sampling of discharge water from the WTPs found levels to be in accordance with the assessment requirements and no exceedances of water quality can be attributed to the TSE works.
July 2019 to December 2019	pH	The results disregarded for the monitoring period due to potential cross contamination in the laboratory.
	Turbidity Oil & Grease	There were no elevated turbidity levels recorded during discharge from projects water treatment plants and the elevated levels recorded are considered to be associated with other local area industry and construction works.

MONITORING REPORT DATE	PARAMETERS REPORTED TO EXCEED 80 PERCENTILE BASELINE	REPORTED CONCLUSION
January 2019 to June 2019	Turbidity Oil & grease	The investigation of the trigger action plan found there was no discharge prior to or during the sampling from the relevant Sydney Metro site, other local area construction works and industry have been considered the l kely cause of the elevated oil and grease levels. The exceedances of surface water oil and grease are therefore considered to be associated with external sources.
July 2018 – December 2018	pH	The investigation of the trigger action plan found there was no discharge prior to or during the sampling from the relevant Sydney Metro site, other local area construction works and industry have been considered the likely cause of the elevated oil and grease levels. The exceedances of surface water oil and grease are therefore considered to be associated with external sources.
January 2018 – June 2018	No exceedance	Water quality results were found to be influenced by external factors within the catchment and surrounding areas including industrial and construction discharges not associated with the TSE works.

The water quality monitoring highlights Sydney Harbour (station SW-B-01) exceeds the 80th percentile baseline trigger values for Turbidity, TSS, Oil & Grease and pH over the monitoring period from July 2018 to June 2021. The monitoring reports conclude the water quality at this monitoring station is influenced by surrounding residential and industrial sites, as well as other construction sites. It is not possible to identify the exact influence on water quality, however investigations found no direct association to the Barangaroo WTP and the Sydney Harbour (station SW-B-01) exceedance parameters.

The full suite of surface water monitoring results for Sydney Harbour (station SW-B-01) is presented in Appendix B.

4.1.2.1 Marine Environment of Receiving Water

A description of the existing marine environment at Barangaroo is provided based on a review of the *Barangaroo South – District Cooling Plant (DCP), Harbour Heat Rejection System, Thermal Water Marine Ecological Impact Assessment* by Worley Parsons, September 2012 (2012 DCP Thermal Water Marine Ecological Impact Assessment).

Protected Areas and Aquatic Vegetation

The Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 Zoning Map (Harbour REP) covers all waterways and foreshores of the Port Jackson estuary (Sydney Harbour) and its catchment. The Barangaroo project is located adjacent to waters zoned W1 Maritime Waters under the Harbour REP. No Environmental Protection Zones are in the immediate vicinity of the project with the closest site being near Berrys Bay approximately 2.5 km to the NNW of the project.

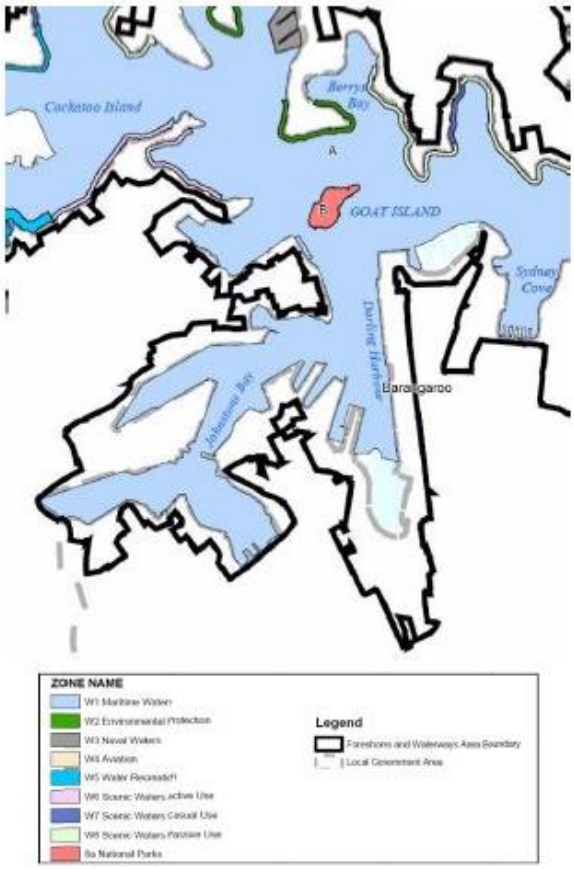


Figure 4.1 Sydney Harbour Mixing Zone excerpt Study area from Harbour REP (source 2012 DCP Thermal Water Marine Ecological Impact Assessment)

Extensive mapping of the aquatic vegetation in Sydney Harbour has been undertaken by the NSW Department of Primary Industries (DPI) (Fisheries). The estuarine vegetation maps indicate that seagrass, mangroves and saltmarsh do not occur in the vicinity of the project area. No seagrasses were observed during spot dives or video transects undertaken at the site by WorleyParsons in 2010. No mangroves or areas of saltmarsh were observed at, or near, the study area.

Marine Habitats

The benthic habitat in Darling Harbour adjacent to Barangaroo was surveyed video (WorleyParsons 2010a). Considerable bioturbation was evident across the entire site, presumably from burrowing organisms, such as polychaete worms and crustaceans.

No aquatic vegetation was observed by divers or was reported on the underwater video transects.

Benthic Infauna

Diver coring was used to collect benthic infauna samples adjacent to Barangaroo and at nearby reference sites. A diverse range of benthic marine organisms was identified in sediments from Barangaroo, Berrys Bay and Snails Bay including polychaete worms, amphipods, crustaceans (e.g. crabs, shrimps, isopods), ascidians (sea squirts), cnidarians, brittle stars, bivalves (e.g. clams) and gastropods (marine slugs).

Sessile Invertebrates

Intertidal and subtidal hard substrate habitats in Sydney Harbour support a diverse assemblage of sessile organisms including colonial and solitary ascidians, bryozoans, sponges, polychaete worms, bivalves and barnacles (Bulleri et al. 2005). Rock oysters were found on the hard caisson walls at the study site.

Mobile Marine Fauna

Mobile marine fauna such as fish, sharks (e.g. bull sharks) and marine mammals (e.g. fairy penguins) are known to occur in the area.

Fish species commonly occurring in Sydney Harbour include yellowfin bream (Acanthopagrus australis), tarwhine (Rhabdosargus sarba), snapper (Chrysophrys auratus), mullet (Family: Mugilidae), dusky flathead (Platycephalus fuscus), sand whiting (Sillago ciliate), leatherjackets (Family: Monocanthidae), luderick (Girella tricuspidata) and largetooth flounder (Pseudorhombus arsius) (Cardno Ecology Lab 2009).

Threatened and Protected Species

Searches of the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife (for species listed under the TSC Act 1995), the DSEWPC Protected Matters Search Tool (for species listed under the EPBC Act 1999) and Schedules of the NSW FM Act 1994 were undertaken to determine whether any species, populations and matters of national / international significance occured in the vicinity of the site.

In WorleyParsons (2010a), a summary of the habitat required by each of these species and their likelihood of occurrence at the study site is provided. Of the species listed, the only one with any likelihood of occurring in the vicinity of the proposed development is the Little Penguin. However, no areas listed as Little Penguin Critical Habitat under the Harbour REP 2005 occur in the area. Furthermore, due to the high level of boating activity and lack of suitable important habitats (e.g. for feeding, breeding or sheltering) at Barangaroo, it is highly unlikely that any species of threatened fauna listed under the TSC Act 1995 or EPBC Act 1999, which have the potential to occur in the harbour, would utilise the study area.

4.1.3 Groundwater Environment

The following groundwater quality information for Barangaroo was obtained from Section 9.7.8 of the hydrogeological interpretative report (HIR) (PSM, 2018):

Following completion of the contiguous pile wall, groundwater flowing into the excavation is unlikely to be significantly impacted by contamination at the nearby gasworks and likely of similar quality and geochemistry to that sampled from wells SRT_BH034, SRT_BH035, SRT_BH071, SRT_BH072 and SRT_BH073.

With time, inflows (particularly along the western and northern margins of the excavations) may become increasingly saline and with similar (or equivalent) geochemistry and salinity of seawater (that is TDS concentration of 36,000 mg/L, chloride concentration of 19,000 mg/L, and sulfate concentration of 2,700 mg/L).

The quality of likely inflows to the TSE from fracture sets in the Hawkesbury Sandstone may also be influenced by past activities at the former Barangaroo gasworks to the south of the excavation and the reclaimed land to the west. Predictive groundwater flow modelling suggests that only 69 kL/day (of the predicted total of 225 kL of daily inflow) is expected to be groundwater discharging from the Hawkesbury Sandstone. Hence concentrations of contaminants from this flux are likely to be diluted in the excavation by seawater derived from the fill material. In excavations for the nearby Star City Casino basement increased seepage was encountered through the Luna Park Fault Zone, requiring more concentrated drainage provision (Speechley et al 2004).

Iron and manganese-enriched groundwater from the Hawkesbury Sandstone may also be encountered. This groundwater, which is typically saline, highly reducing and mobile in both major and minor structures, usually has high concentrations of dissolved iron and manganese which form oxyhydroxide complexes when exposed to oxygen-rich environments. These oxyhydroxides form the orange, brown and ochre staining on sandstone walls and exposures. They frequently block drainage systems, are a corrosion hazard, and can be costly to treat.

It should further be noted that should any significant fracturing associated with any minor structures (such as bedding plane partings and joints) or unidentified major structures be encountered in the bedrock, then inflows could be much higher than anticipated and these may be contaminated as a result of proximity to the gasworks.

Seawater intrusion at Barangaroo was obtained from Section 5.4.4 of the HIR (PSM, 2018):

The intrusion of seawater along the foreshore of the Central Business District is a growing influence on the local quality of groundwater. The local setting at Darling Harbour (Barangaroo) is not natural. There has been landform (both excavation and infill) changes that most likely altered the natural groundwater and seawater environments. There has been land reclamation by filling with crushed sandy and gravelly sandstone, with inclusions of cobbles, boulders, building rubble, steel, ash slag, concrete and charcoal. The reclamation extends into deeper water, with fill overlying silty alluvium.

Based on experience in the Barangaroo area:

- *Intuitively seawater would predominantly saturate the land reclamation profiles. This relates to landform, but may also indicate comparatively high-transmissivity of the fill material. High transmissivity fill would enhance tidal efficiency and intrusion of seawater.*
- *Groundwater with chemistry typical of seawater (sodium concentrations of about 10,000 mg/L, sulphate concentrations of 1,900 mg/L and chloride about 19,000 mg/L) has been identified in groundwater monitoring wells SRT_BH080 and SRT_BH080A installed on the western side of Hickson Road in Barangaroo.*
- *The water table in the reclamation profile responds to tides and storm surge.*

4.2 Project Drainage Layout

The project area comprises hardstand surfaces, sealed roads, stockpiles of materials and large station boxes. Surface water runoff is therefore classified as dirty and is managed by overland flow paths and underground pipes that convey water to a series of sumps. The sumps temporarily store water before pumping the collected surface water to the Barangaroo WTP for treatment.

The current Barangaroo WTP was commissioned by the TSE Contractor in September 2020 and is managed by Aquatic Engineering Pty Ltd. The Barangaroo WTP has a nominal treatment capacity of 15 l/s and treats both surface water and groundwater generated within the project. The Barangaroo WTP has been primarily designed to treat water to meet the discharge criteria set in the EPL (Licence 20971).

The Barangaroo WTP treatment system processes include pre-treatment (water collection and initial solids removal), coagulation (pH control & oxidant dosing), flocculation, clarification (sludge to Sludge Holding Tank and filter press), post pH correction and media filtration. The outlet from Barangaroo WTP comprises twin 1050 mm diameter pipes, which discharge effluent by gravity directly into the artificial bay and towards Sydney Harbour. A layout and long section of the Barangaroo WTP outlet is presented in Appendix D.

Other erosion and sediment control measures at the project include sediment fences, sandbags, spill kits, bunds, fish tanks and protection over drains. The ESCP is presented in Appendix E.

4.3 Existing Flow Estimation

4.3.1 Measure Discharge from Barangaroo WTP

Discharges flow rates from the Barangaroo WTP for the period May, June and July 2021 was provided by Aquatic Engineering. Table 4.2 shows a summary of the dataset.

Table 4.2 Aquatic Engineering Barangaroo WTP recorded discharge

DATA	MAY 2021	JUNE 2021	JULY 2021	MEAN FLOW RATE (L/S)
Average flow rate (l/s)	2.54	2.55	2.56	2.55

DATA	MAY 2021	JUNE 2021	JULY 2021	MEAN FLOW RATE (L/S)
Maximum flow rate (l/s)	8.61	5.26	3.94	5.94
Minimum flow rate (l/s)	1.66	1.52	2.03	1.74

4.3.2 Estimated Existing Surface Water Discharge – TSE Construction Stage

An estimation of surface water volumes to the Barangaroo WTP using procedures outlined in the *Managing Urban Stormwater: Soils and Construction (Blue Book),* NSW Department of Housing, 2004 was carried out. A conservative approach of estimating volumetric runoff based on a Type D/F sediment basin volume was applied. It is assumed that all rainfall runoff will be collected and discharged within 72 hrs after conclusion of a rainfall event. Table 4.3 presents a summary of the estimated project surface water volume.

Table 4.3 Design volume of construction runoff from the project based on Type D/F sediment basin

PARAMETER	VALUE	REFERENCE
Site Area		
Total catchment area (ha)	3.08	TSE EPL Premise Map and Indicative TSE current project boundary discharging runoff to Barangaroo WTP (supplied by BESIX Watpac).
Rainfall Data		
Design number of rainfall days	5	Recommended values from Section 6.3.4 of the *Blue Book* Table 6.3 on pages 6-24 and 6-25 The *Controlled Water Overflow Management Strategy* (JHCPBG) refers to sites adequately accommodating this design rainfall depth without overflows occurring.
Design rainfall percentile	85	
Design rainfall depth (mm)	38.8	
Sediment basin Design Criteria & Volume (Type D/F basins only)		
Volumetric runoff coefficient (Cv)	1	Table F2, Appendix F of *Blue Book* It is noted the highest (i.e. the most conservative value) from Table F2 is Cv = 0.79. Considering the condition of the existing TSE construction site value was selected, considering the current hardstand areas at the project.
Sediment basin Volume (m^3)	1195	Section 6.3.4(i) for calculation
Estimated Discharge		

PARAMETER	VALUE	REFERENCE
All collected surface water discharged following a rainfall event (hours)	72	Conservative assumption based on Section 6.3.4 of the *Blue Book*
Required discharge rate from the project (l/s)	**4.61**	

4.3.3 Estimated Existing Groundwater Flow – TSE Construction Stage

The current depressurisation system at the project is working at station box level B6. There is not enough data available to estimate the existing (pre handover) groundwater inflow. However, groundwater inflow during existing conditions is expected to be higher than when BESIX Watpac take over construction for the project. This is because the depressurisation system under existing project conditions is dewatering from a deeper level (level B6) than the BESIX Watpac construction stage (level B3). Therefore, the depressurisation system will need to remove less groundwater during the BESIX Watpac construction stage.

Additionally, groundwater levels are expected to have reduced somewhat over time from the dewatering activities; with lower groundwater levels, there is less groundwater to remove.

4.4 Existing Water Quality

4.4.1 Groundwater Quality

A description of the groundwater monitoring network, provided within the HIR (PSM, 2018), and bore location plan is shown in Appendix G.

Groundwater quality data was provided in Excel format. Note most of the laboratory reports have not been sighted and some concentrations may be recorded incorrectly. A brief summary of some of the results, from the HIR network, are as follows:

- Some elevated concentrations for at least one of the piezometers at the former gasworks (MW3 and MW15), including ammonia, polycyclic aromatic hydrocarbons (PAH) and volatile organics.
- Electrical conductivity (EC) is elevated for the piezometers in the fill, at 30,000 to 41,000 µS/cm. The pH is near neutral, at 6.8-8.2.
- Groundwater within the fill has low metal concentrations, with some detections of total recoverable hydrocarbons (TRH) and volatile organics.
- For the Hawkesbury Sandstone:
  - pH ranges from 5.8 to 9.0. The higher pH may be due to grout contamination, as Hawkesbury Sandstone groundwater is typically slightly acidic to neutral.
  - The EC is variable, from 388 µS/cm (SRT_BH035) to 46,000 µS/cm (SRT_BH080).
  - Iron and manganese are typically elevated.
  - There is some contamination evident, with detections of TRH and volatile organics.

The groundwater quality for the network outside the HIR, can be summarised as follows:

- pH ranging from 3.5 to 12.0. Again, the higher pH may be due to grout contamination, as Hawkesbury Sandstone groundwater is typically slightly acidic to neutral.
- Oil and grease was detected at some locations, with the highest concentration at SBR-SBX_7 at 27 mg/L.
- Total dissolved solids were relatively low, up to 450 mg/L.

- Metals concentrations were mostly low except for iron and manganese which were generally elevated.
- Volatile organics, phenols, TRH and PAH were generally not detected. The main exception was low detection of TRH at SBR_SRKFN and SBR_SBX_STH.

4.4.2 Barangaroo WTP Effluent Quality

Water quality monitoring of the Barangaroo WTP effluent is carried out monthly for EPL parameters and quarterly for the NSW WQO and ANZECC physical and chemical stressors and toxicant suite. The water quality samples represent the treated surface water and groundwater quality from the project.

Monthly water sampling data indicates the Barangaroo WTP is consistently compliant with EPL conditions for pH, TSS and Oil & Grease.

A comparison of the quarterly physical and chemical stressors and toxicants from the Barangaroo WTP effluent against the NSW WQO aquatic species 95% protection trigger values show exceedances for Ammonia, Copper, Cynaide, Lead and Zinc. The Lead and Cynaide exceedances occurred once during the operation of the now decommissioned Barangaroo WTP. While a Cyanide exceedance also occurred on the day of commissioning of the Barangaroo WTP. The level of exceedances was relatively minor and within the tolerance of the lower range aquatic species 90% protection trigger values.

Exceedances of Copper and Zinc occurred during the operation of both the now decommissioned Barangaroo WTP and the current Barangaroo WTP. However, the exceedances of Copper and Zinc were within tolerance of the lower range of aquatic species 80% protection trigger values.

There is a persistent exceedance of Ammonia in the effluent from the Barangaroo WTP (both from the now decommissioned Barangaroo WTP and the current Barangaroo WTP). Ammonia levels meet the aquatic species 80% protection trigger values, except for two sampling events in September 2020, where ammonia concentrations were greater than the 80% protection trigger values. Ammonia concentrations for Quarter 1 and Quarter 2 of 2021 comply with the aquatic species 95% protection trigger values.

5 Construction Phase Water Discharge Impact Assessment

5.1 Water Management During BESIX WATPAC Construction

5.1.1 Proposed Site Drainage

The management of surface water runoff within the project boundary is not changing, except at the station box.

Currently at the station box, direct rainfall is collected in sumps and pumped to the Barangaroo WTP for treatment. When the TSE Contractor finish their works and hand the site over to BESIX Watpac, the station box lid will be cast and fully tanked up to level B3.

From the top of the station box lid, the proposed surface water drainage will establish a new stormwater collection network of drains, sumps and pumps that will collect and direct runoff to the Barangaroo WTP. While new drainage infrastructure is proposed on the station box lid, there is no increase in total surface area or surface water regime within the project boundary.

The current erosion and sediment control measures will continue to operate as per the ESCP, refer to Appendix E.

When BESIX Watpac takeover the site, a review of surface water management will be carried out. A potential option to investigate treating portions of the surface water and total groundwater at the Barangaroo WTP will be investigated and assessed accordingly. Surface water may be discharged offsite without passing through the WTP, if water quality monitoring results indicate compliance to discharge criteria and ANZG 2018 / ANZECC 2000 criteria can be achieved.

5.1.2 Proposed Surface Water Flow Estimation

No change is proposed to the surface water catchment area contributing runoff to the Barangaroo WTP during the BESIX Watpac construction phase. Also, the proposed BESIX Watpac changes to the management of the surface water runoff does not impact the estimated volume presented in Table 4.3. The anticipated design volume and required discharge rate for the BESIX Watpac construction stage is therefore unchanged from the existing TSE conditions at 1195 m^3 and 4.61 l/s, respectively.

5.1.3 Proposed Groundwater System

With BESIX Watpac taking over the station box site, it is predicted the volume of groundwater to be treated once the depressurisation system is operating at level B3 will be less than the existing project conditions (before from B6 as an open box). This is because the pumps on B6 will be decommissioned and the depressurisation system will be pumping from a shallower depth at B3 instead, while strip drains will divert seepage to the WTP.

5.1.4 Groundwater Modelling

A technical memorandum detailing the numerical groundwater modelling undertaken to estimate groundwater seepage inflows into the Barangaroo B3 depressurisation system of the Station Cavern and the Northern Shaft, is presented in Appendix G. Groundwater flow estimates are provided for the base case (*typical case*) and a sensitivity analysis (*worse case)* to inform the proposed required treatment capacity of the Barangaroo WTP.

Modelled groundwater inflows for the *base case* into the B3 depressurisation drain are 0.6 L/s and into the Northern Shaft 0.5 L/s.

Given the need to have the capacity of the wastewater treatment plant sufficient to allow for large groundwater inflows, a sensitivity analysis that increased the hydraulic conductivity in the Hawkesbury Sandstone by 1 order of magnitude was included in the groundwater modelling. This sensitivity analysis takes into account the impact of the Luna Park Fault Zone in relation to the Northern Shaft. It is recommended the higher groundwater inflow estimate from this sensitivity analysis is applied to the *worse-case* flow condition to the Barangaroo WTP. The following are the recommended groundwater inflow rates from the sensitivity analysis:

- B3 depressurisation drain inflow rate of 1.6 L/s (138.3 kL/day), and
- the Northern Shaft inflow rate of 4.6 L/s (394.5 kL/day)).

It should also be noted that there is some uncertainty in the location and hydraulic properties of the Luna Park Fault Zone in relation to the Northern Shaft. Based on a comparison with the measured peak seepage inflows of 369 kL/day (BESIX Watpac provided spreadsheet "Groundwater Results – Barangaroo"), it can be assumed that the higher hydraulic conductivity scenario for the Northern Shaft has sufficiently captured this uncertainty in inflows.

Another note should be made regarding the waterproofing. Although this is assumed to create an impermeable barrier to groundwater flow, some minor leakage may be expected.

For details on the groundwater modelling assumptions, inputs and conclusions, refer to the technical memorandum *Barangaroo - Modelled groundwater inflows into B3 depressurisation system and Northern Shaft* in Appendix G.

5.1.5 Estimated Total Flow

The estimated *typical-case* flow conditions to the Barangaroo WTP during construction is 1.1 l/s (total groundwater *base case* flow). This total flow estimate is within the range of outflows measured at the Barangaroo WTP during May, June and July 2021. During these months the project was affected by small rainfall events, therefore, Barangaroo WTP outflow rates are representative of *typical-case* conditions.

The *worse-case* flow conditions to the Barangaroo WTP is the combined estimated surface water construction flow rate of 4.61 l/s and the sensitivity scenario groundwater flow of 6.2 l/s, to give a total existing flow of 10.81 l/s. While the estimated flow rate during construction is higher than the existing project flow rate, there is adequate capacity at the Barangaroo WTP to treat this estimated flow.

5.2 Water Quality Impact Assessment

5.2.1 Proposed Water Quality

The management of surface water quality from the project will continue to be controlled using the erosion and sediment control measures as per the ESCP, refer to Appendix E. Considering the scope of the proposed BESIX Watpac construction works, the quality of surface water collected from the site will remain similar to the existing conditions.

Similarly, the proposed changes to the management of groundwater and surface water collected at the station box is not likely to impact on the quality of inflow to the Barangaroo WTP.

Under the *worse-case* flow conditions, the combined total flow to the Barangaroo WTP is estimated at 10.81 l/s. This *worse case* flow estimation is much greater than the *typical-case* flow at 1.1 l/s and the current metered flows recorded at the Barangaroo WTP (refer to Table 4.2). If the *worse-case* flow condition did occur during the BESIX Watpac construction period, the treatment capacity at Barangaroo WTP is designed to cater for such flow conditions, with a nominal treatment capacity of up to 15 l/s.

5.2.2 Plume Dispersion Modelling

A comparison of the quarterly physical and chemical stressors and toxicants from the Barangaroo WTP effluent against the NSW WQO aquatic species 95% protection trigger values show exceedances for Ammonia, Copper, Cynaide, Lead and Zinc. Plume dispersion modelling has been carried out to identify if horizontal and vertical mixing of pollutants within Sydney Harbour can achieve the NSW WQO and ANZECC 2018 95% species protection of aquatic ecosystems values.

Table 5.1 summarises the highest pollutant reduction threshold for parameters that exceeded the 95% species protection of aquatic ecosystems trigger values. The target pollutant reduction is based on monitoring results taken from the current Barangaroo WTP (since September 2020).

Table 5.1 Target pollutant reduction

Pollutant	Maximum Measured Pollutant Concentration	Date	NSW Water Quality & ANZECC (2000) Level of protection (95% species) (mg/l)	Target pollutant reduction
Ammonia (mg/l)	2.6	17/09/2020 (commission of WTP)	0.91	65%
Cyanide (mg/l)	0.006	17/09/2020 (commission of WTP)	0.004	33%
Copper (mg/l)	0.004	19/02/2021	0.0013	68%
Zinc (mg/l)	0.026	19/02/2021	0.015	44%

5.2.3 Modelling Inputs and Assumptions

Table 5.2 provide a summary of the outfall geometry, effluent characteristics and ambient conditions adopted in the near-field modelling. A description of the assumptions adopted in the estimation of the water depth above the outfall, effluent flow rates and ambient current velocities is provided in the following sections.

Table 5.2 Modelling Inputs

Parameter	Value
Outfall Geometry	
Water depth above the outfall	3.25 m (high tide scenario) 0.66 m (low tide scenario)
Diameter	1.05 m
Horizontal angle	90°
Vertical angle	0°
Effluent Characteristics	
Temperature	24 °C
Salinity	0.05 ppt (freshwater)
Flow rate	15 l/s (rainfall event) 5.94 l/s (maximum during dry season) 2.55 l/s (average during dry season) 1.74 l/s (minimum during dry season)
Receiving Water Body Conditions	
Salinity	35 ppt (saltwater)
Temperature	24 °C

Parameter	Value
Current velocity	0.03 m/s (from hydrodynamic model of Sydney Harbour) 0.10 m/s (sensitivity test)

5.2.3.1 Water Depth Above Outfall

The water depth above the outfall was estimated by considering the tide levels recorded at Fort Denison tide gauge from May 1914 to June 2021. The tide levels were downloaded from the Bureau of Meteorology website on 16th July 2021. A Fort Denison gauge zero of 0.925 m was adopted to convert the tide levels to Australian Height Datum (AHD).

The water depth above the outfall was estimated from the invert level of the outfall pipe cross-section centre of -1.775 mAHD. A summary of the tide levels and estimated water depths for different tide scenarios in provided in Table 5.3.

Table 5.3 Statistics of tide levels recorded at Fort Denison tide gauge

Type	Tide level (m above gauge zero)	Tide level (mAHD)	Water depth above outfall (m)	Recording date
Maximum tide level	2.400	1.475	3.250	1:00pm 25/05/1974
Minimum tide level	-0.190	-1.115	0.660	5:00pm 19/08/1982
Mean Sea Level (MSL)	0.937	0.012	1.787	N/A

It is worth noting that the minimum tide level at Fort Denison was recorded on 19th August 1982, i.e. during one of Australia's most severe drought of the 20th century.

5.2.3.2 Effluent Flow Rate

The measured flow rates from Barangaroo WTP is representative of *typical-case* conditions for the project. Therefore, the mean flow rate measured data from the Barangaroo WTP for the period May, June and July 2021 (refer to Table 4.2, Section 4.3.1).

While the *worse-case* flow condition is estimated at 10.81 l/s, a conservative approach of modelling the nominal treatment capacity of Barangaroo WTP of 15 l/s was applied.

5.2.3.3 Sydney Harbour Current Velocities

The action of current velocities in the receiving water body improve the effluent dilution, while also producing spreading of the effluent discharges in the horizontal plane.

The current velocities at the project were estimated on the basis of the results produced by the 3D hydrodynamic model of Sydney Harbour developed by Worley Parsons and adopted in the far-field modelling described in the *Thermal Water Marine Ecological Impact Assessment* report performed for the *Barangaroo South - District Cooling Plant (DCP), Harbour Heat Rejection System* (WP, 2012).

The hydrodynamic model results predicted current velocities of 0.03 m/s at the DCP outfall located into Pyrmont Bay, and current velocities of 0.77 m/s (i.e. 1.5 knots) along the main channel of Sydney Harbour south of Blues Point. A comparison between the DCP outfall and the station construction site outfall location is shown in Figure 5.1.

Given that the DCP outfall is located far into Pyrmont Bay in a more sheltered position, when compared to the location of the Barangaroo WTP outfall, current velocities greater than 0.03 m/s can potentially occur at the Barangaroo WTP outfall. However, the current velocities at the Barangaroo WTP outfall location are not expected to reach the upper end value of 0.77 m/s observed in the main Sydney Harbour channel because the outfall is in a more sheltered position within Pyrmont Bay.

Figure 5.1 Comparison between construction site outfall and DCP outfall locations

With these premises, the ambient current velocities adopted for the plume dispersion model can be summarised as follows:

- Current velocities of 0.03 m/s were adopted to simulate the plume fate in Sydney Harbour in accordance with the values estimated by the 3D hydrodynamic model. Current velocity correlates to the percentage of pollutant dilution in the receiving water, i.e. the lower the current velocity, the lower the pollution dilution. Due to the location of Barangaroo WTP outfall, the current velocity is likely to be higher than the more sheltered part of Pyrmont Bay. By applying the lower velocity from Pyrmont Bay to the plume dispersion model, this represents a conservative scenario.
- Sensitivity test simulations assuming current velocities of 0.1 m/s were also carried out to estimate more favourable effluent dilution conditions.
- In all scenarios, the direction of the ambient currents was assumed to be parallel to the coast, i.e. perpendicular to the outfall pipe.

5.2.4 Modelling Results

The scenarios tested in the plume dispersion model are presented in Table 5.4.

Table 5.4 Plume Dispersion Model Scenarios

FLOW RATE (L/S)	VELOCITY (M/S)	TIDE LEVEL	DISTANCE FROM OUTFALL TO ACHIEVE POLLUTION REDUCTION TO ANZECC 2018 95% SPECIES PROTECTION (M)
1.74	0.1	High Tide / Low Tide	0.11 / 0.11
	0.03	High Tide / Low Tide	0.04 / 0.04
2.55	0.1	High Tide / Low Tide	0.14 / 0.14
	0.03	High Tide / Low Tide	0.04 / 0.04
5.94	0.1	High Tide / Low Tide	0.15 / 0.15
	0.03	High Tide / Low Tide	0.06 / 0.4
15	0.1	High Tide / Low Tide	0.18 / 0.17
	0.03	High Tide / Low Tide	0.07 / Dilution reaches maximum of 58.7%

The pollutant reduction along the horizontal and vertical plane in the high tide scenario is shown in Figure 5.2 and Figure 5.3, respectively.

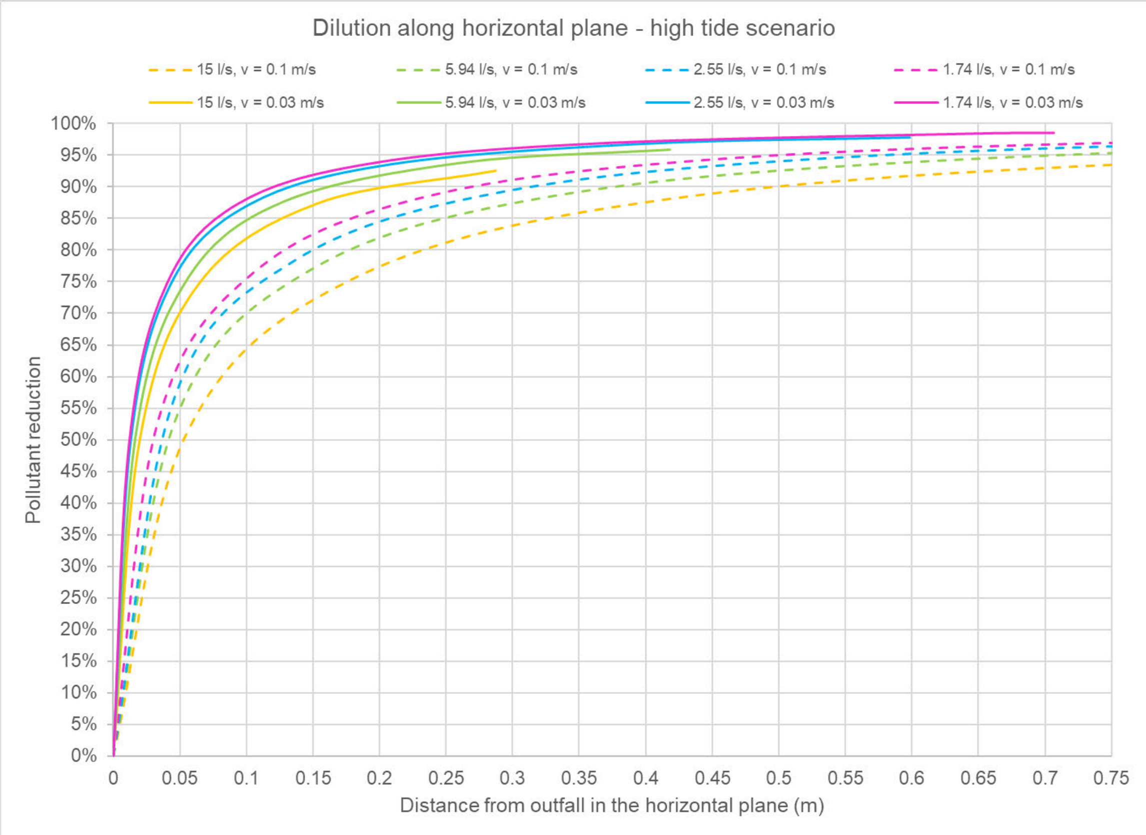


Figure 5.2 Pollutant reduction along the horizontal plane in the high tide scenario

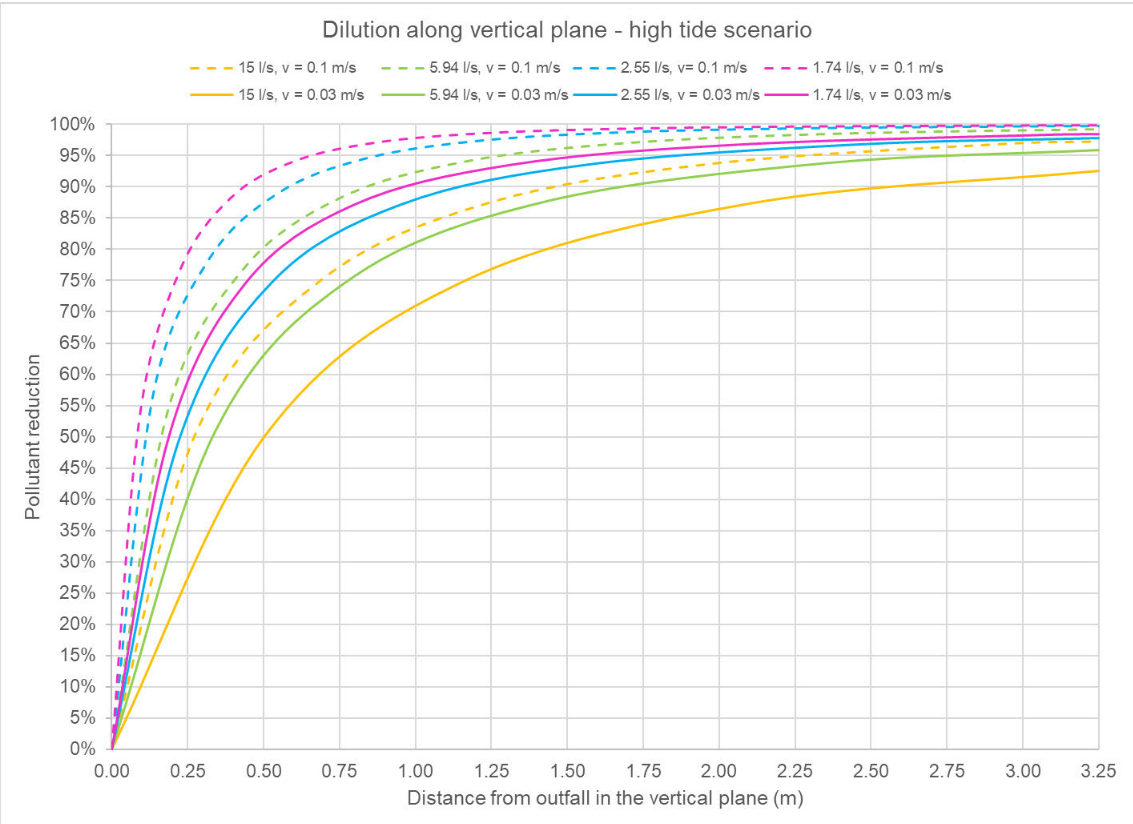


Figure 5.3 Pollutant reduction along the vertical plane in the high tide scenario

The pollutant reduction along the horizontal and vertical plane in the low tide scenario is shown in Figure 5.4 and Figure 5.5 respectively.

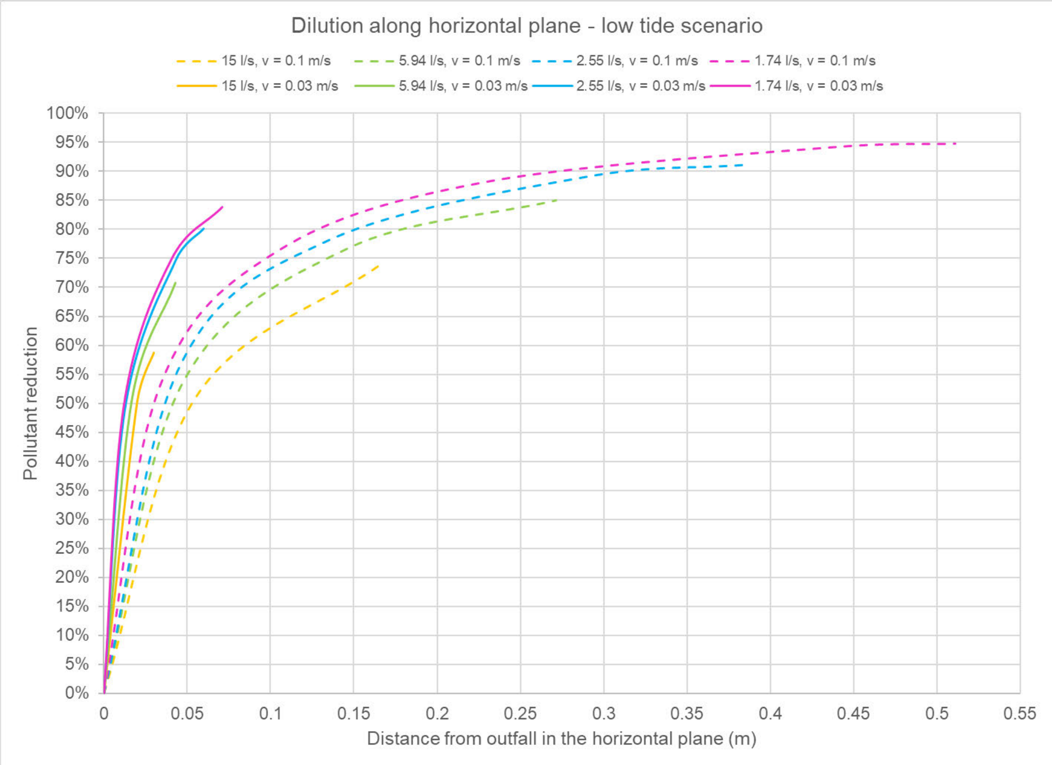


Figure 5.4 Pollutant reduction along the horizontal plane in the low tide scenario

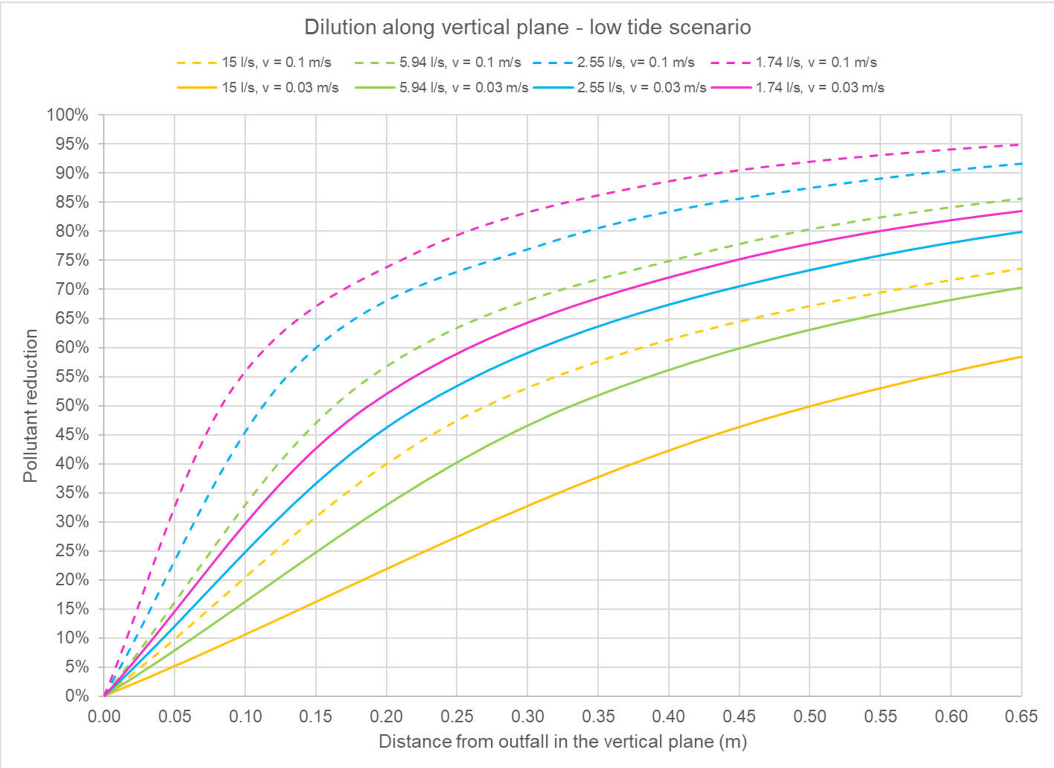


Figure 5.5 Pollutant reduction along the vertical plane in the low tide scenario

The key results from the near-field modelling can be summarised as follows:

- In all the analysed tide scenarios, a pollutant reduction higher than 68% is achieved within 0.15 m from the outfall for all the analysed flow rates and ambient current velocities, with the only exception of the low tide scenario characterised by a flow rate of 15 l/s and current velocities of 0.03 m/s.
- In the high tide scenario, a pollutant reduction of 68% is achieved in less than 1 m from the outfall in the vertical direction for all the analysed effluent flow rates and ambient current velocities.
- In the low tide scenario, a pollutant reduction higher than 68% is achieved in the vertical direction before the plume hits the water surface for all the analysed effluent flow rates and ambient current velocities, with the only exception of the scenario characterised by 15 l/s flow rate and current velocities of 0.03 m/s.
- A maximum pollutant reduction of 58.7% is achieved when considering a low tide scenario with an effluent flow rate of 15 l/s and current velocities of 0.03 m/s. However, it is worth noting that the minimum tide level was recorded during one of Australia's most severe droughts of the 20th century. Therefore, the probability of the combined occurrence of a significant rainfall event (i.e. a 15 l/s flow rate) and a low tide level of -1.115 mAHD is extremely low.

5.2.5 Discussion of Results

The near-field modelling results show that pollutants are diluted to achieve ANZG (2018) / ANZECC (2000) 95% protection aquatic species within 0.15 m from the outfall in the horizontal plane and within 1 m from the outfall in the vertical plane, in most of the *typical case* and *worse-case* simulated scenarios characterised by different tide levels, effluent flow rates and ambient current velocities.

The target pollutant reduction was not achieved only in the *worse-case* scenario characterised by low tide levels, 15 l/s flow rates (i.e. significant rainfall event) and ambient current velocities of 0.03 m/s. However, the probability occurrence of this scenario is extremely unlikely due to:

1. High concentrations of contaminants are associated with dry days when inflow rates would represent typical-case conditions (groundwater inflow only)
2. The 15 l/s inflow rate would only occur with a significant rainfall event, during which surface water would provide dilution of contaminates prior to inflows reaching the WTP
3. Significant rainfall events are usually accompanied by strong winds and storm tides rather than the lowest tide level recorded in the past 107 years.

6 Recommendations

6.1 Proposed Water Quality Monitoring Frequency

It is anticipated the current construction water quality monitoring program will continue, in accordance with the *Planning Condition C9* of the Project Planning Approval, dated 9 January 2017 and the procedures set out in the *Water Reuse and Discharge Management Procedure.*

The sampling frequency will continue to be undertaken at Sydney Harbour (SW-B-01), Groundwater monitoring locations and at the discharge of the Barangaroo WTP (sampling point BN_03). The monitoring frequency has increased to establish if there is a trend in the levels of the physical, chemical and toxicant parameters. The recommended monitoring frequency is:

Sydney Harbour (SW-B-01)

Surface water sampling will continue to be carried out in accordance with the Soil and Water Management Plan at the following frequencies:

- Monthly for the same suite of physical, chemical and toxicants as currently being monitored at this station plus ammonia, cyanide, copper and zinc.
- Up to four wet weather sampling events within a 12 month period (when at least 38.8 mm of rain is received in the catchment in any 5 day period).

Barangaroo WTP

Surface water testing will continue to be carried out on the Barangaroo WTP effluent at the following frequencies:

- Prior to discharge offsite
- Following significant inclement weather events > 20 mm in 24 hours.
- Quarterly monitoring of the full suite of physical and chemical stressors and toxicants
- Monthly monitoring for ammonia, cyanide, copper and zinc.

Groundwater Monitoring

Groundwater sampling will continue to be carried out in accordance with the Construction, Soil, Water and Groundwater Management Plan at quarterly intervals.

6.2 Discharge Criteria for Construction Stage

BESIX Watpac are required to operate in accordance with planning condition E107 which states the project must maintain the NSW Water Quality Objectives where they are being achieved and contribute towards the achievement of the NSW Water Quality Objectives over time where they are not being achieved.

Sydney Harbour has been classified as very severely modified by heavy metal contamination (refer to Section 2.3.1). Water quality monitoring at Sydney Harbour (Station SW-B-01) concluded water quality in Sydney Harbour was influenced by runoff the surrounding residential and industrial sites, as well as other construction sites adjacent to harbour.

Based on the available information, Sydney Harbour water quality is in a deteriorated condition and the objective for water quality discharge from the Barangaroo Station is that it contributes toward the achievement of the NSW Water Quality Objectives over time.

A review of the marine environment receiving waters at Darling Harbour (WorleyParsons 2012), concluded due to the high level of boating activity and lack of suitable important habitats (e.g. for feeding, breeding or sheltering) at Barangaroo, it is highly unlikely that any species of threatened fauna listed under the TSC Act 1995 or EPBC Act 1999 would utilise the study area. The artificial bay where the mixing zone is occurring is likely to be less ecologically sensitive than Darling Harbour.

Considering the scope of the proposed BESIX Watpac construction works, the quality of surface water and groundwater collected from the site for *typical-case* conditions will remain similar to the existing conditions. Under the *worse-case* flow conditions, the anticipated inflows to the Barangaroo WTP is much greater than flows currently being recorded onsite. However, the Barangaroo WTP has adequate treatment capacity (at 15 l/s) to cater for such an elevated flow condition.

The current discharge from Barangaroo WTP generally achieves the ANZG (2018) / ANZECC (2000) guidelines trigger values for 95% species protection of aquatic ecosystems for toxicants, with the exception of the ammonia, cyanide, copper and zinc.

The results from the near field plume dispersion modelling demonstrates adequate dilution to achieve the ANZG (2018) / ANZECC (2000) guidelines trigger values for 95% species protection of aquatic ecosystems occurs within less than 1 m from the outfall for all tested scenarios, expect the low tide scenario characterised by a flow rate of 15 l/s and current velocities of 0.03 m/s. The extent of the predicted mixing zone is shown as a yellow dot in Figure 6.1.

Figure 6.1 The approximate extent of mixing zone shown by red line to achieve 95% species protection criteria

Given the small extent of the mixing zone and the location of the outfall adjacent to the artificial bay, it's unlikely aquatic biological diversity will be adversely affected within the mixing zone.

Considering the condition of the marine environment at the WTP outlet, we recommend the ANZG 2018 / ANZECC 2000 ecological condition of *highly disturbed system* is adopted. The attributes of this category agree with the current site conditions at the artificial harbour including *sections of harbours serving coastal cities, urban streams receiving road* *and stormwater runoff*. For this category 80% or 90% species protection for toxicants is acceptable. However, as the discharge from the WTP is achieving ANZG (2018) / ANZECC (2000) guidelines trigger values of 95% species protection of aquatic ecosystems for toxicants other than ammonia, copper, cyanide and zinc. We are recommending only copper, cyanide and zinc toxicants are monitored against the 80% species criteria.

BESIX Watpac are not required to operate in accordance with the EPL (Licence 20971) however, it is recommended effluent from the Barangaroo WTP continue to be tested prior to offsite discharge for the parameters:

- Turbidity between 0.5-10 NTU (NSW WQO default trigger value).
- pH between 6.5 and 8.5
- Oil and grease – not visible.

It is recommended the quarterly monitoring continue throughout the BESIX Watpac construction stage of the project and monthly monitoring be carried out for ammonia, copper, cyanide and zinc Monitoring results should be assessed against:

- Turbidity trigger value of 0.5-10 NTU (NSW WQO default trigger value).
- Ammonia trigger value of 2 mg/l (based on performance of Barangaroo WTP).
- the ANZG (2018) / ANZECC (2000) guidelines trigger values of 80% species protection of aquatic ecosystems for copper, cyanide and zinc.
- the ANZG (2018) / ANZECC (2000) guidelines trigger values of 95% species protection of aquatic ecosystems for all other toxicants.

If BESIX Watpac decided to discharge surface construction water separately, the above criteria should be applied.

6.3 Proposed Response Action for Exceedances of Surface Water Quality

A risk-based approach to investigate water quality will be implemented in the event of:

- a surface water sampling exceedance being recorded against the recommended trigger values presented in Section 6.2 or
- a 20% greater than previous result being recorded. Monitoring against previous results will determine if there is a trend in the deterioration of water quality.

The following items will be reviewed as part of the investigation:

- Climate data including rainfall data leading up to and during the sampling event
- Construction activities taking place on site and the implementation of the ESCP
- Contact laboratory to discuss sample testing and possible re-run of sample.
- Review of WTP operations and daily sampling and flow records
- Conduct unscheduled water quality monitoring

The results of the investigation may result in further action including changes to the monitoring programme, modifications to certain construction activities, changes to WPT processes or consultation and reporting with the relevant government regulatory.

7 Conclusions

Sydney Harbour Environmental Value

Research published by the NSW Parliamentary Research Service Briefing Paper No. 03/2015 by Daniel Montoya, described Sydney Harbour has been classified as very severely modified by heavy metal contamination. Reference was made to sediments that have become enriched with copper, lead and zinc.

Bi-annual surface water sampling at the Sydney Harbour station (SW-B-01), carried out from Jan 2018 to June 2021 by JGCPBG, also noted exceedances of Turbidity, Total Suspended Solids, Oil & Grease and pH above the 80% percentile baseline value. These reports concluded that when such exceedances occurred, the water quality in Sydney Harbour was influenced by runoff the surrounding residential and industrial sites, as well as other construction sites adjacent to harbour. There has been no recorded incident of discharges from the project impacting on water quality at Sydney Harbour station (SW-B-01) during this monitoring period.

It is recommended a precautionary approach of continuing to monitor water quality at Sydney Harbour and compare results against the baseline values throughout the BESIX Watpac construction phases.

Estimation Total Construction Flow

During construction the estimated *typical-case* and *worse-case* flow conditions to the Barangaroo WTP is 1.1 l/s (groundwater modelling *base case* scenario) and 10.81 l/s (combined surface water and groundwater sensitivity scenario), respectively.

While the estimated *worse-case* flow rate during construction is higher than the existing conditions flow rate, there is adequate capacity at the Barangaroo WTP (nominal treatment capacity of 15 l/s) to treat this estimated flow.

Barangaroo WTP Effluent Water Quality

Water quality monitoring results since the commissioning of Barangaroo WTP in September 2020, show compliance with EPL criteria (pH, TSS, Oil and Grease) is consistently being achieved prior to offsite discharge.

A comparison of the quarterly toxicant stressors from the Barangaroo WTP effluent show exceedances for Ammonia, Copper, Cyanide, and Zinc when compared to the ANZG (2018) / ANZECC (2000) guidelines trigger values for 95% species protection of aquatic ecosystems. No baseline values for these heavy metals were established at the Sydney Harbour station (SW-B-01). The exceedances of Copper, Cyanide and Zinc were within tolerance of the lower range of ANZG (2018) / ANZECC (2000) 80% protection aquatic species trigger values.

There is a persistent exceedance of Ammonia in the effluent from the Barangaroo WTP (both from the now decommissioned Barangaroo WTP and the current Barangaroo WTP). Although it is noted Ammonia concentrations for Quarter 1 and Quarter 2 of 2021 did comply with the aquatic species 95% protection trigger values.

The near-field modelling results show that pollutants are diluted to achieve ANZG (2018) / ANZECC (2000) 95% protection aquatic species within 0.15 m from the outfall in the horizontal plane and within 1 m from the outfall in the vertical plane, in most of the *typical case* and *worse-case* simulated scenarios characterised by different tide levels, effluent flow rates and ambient current velocities.

The target pollutant reduction was not achieved only in the *worse-case* scenario characterised by low tide levels, 15 l/s flow rates (i.e. significant rainfall event) and ambient current velocities of 0.03 m/s. However, the probability occurrence of a significant rainfall event with the lowest tide level recorded in the past 107 years is very low, being the significant rainfall events usually accompanied by strong winds and storm tides.

Considering the results of the near field plume dispersion modelling, modifications or upgrades to the Barangaroo WTP are not required for this next stage of project construction.

Monitoring and Discharge Criteria for the Construction Works.

BESIX Watpac are not required to operate in accordance with the EPL (Licence 20971) however, it is recommended effluent from the Barangaroo WTP continue to be tested prior to offsite discharge for the parameters:

— Turbidity between 0.5-10 NTU (NSW WQO default trigger value).

— pH between 6.5 and 8.5

— Oil and grease – not visible.

It is recommended the quarterly monitoring continue throughout the BESIX Watpac construction stage of the project and monthly monitoring be carried out for ammonia, copper, cyanide and zinc. Monitoring results should be assessed against

— Turbidity trigger value of 0.5-10 NTU (NSW WQO default trigger value).

— Ammonia trigger value of 2 mg/l (based on performance of Barangaroo WTP).

— the ANZG (2018) / ANZECC (2000) guidelines trigger values of 80% species protection of aquatic ecosystems for copper, cyanide and zinc.

— the ANZG (2018) / ANZECC (2000) guidelines trigger values of 95% species protection of aquatic ecosystems for all other toxicants.

8 Limitations

This Report is provided by WSP Australia Pty Limited (*WSP*) for BESIX Watpac (*Client*) in response to specific instructions from the Client and in accordance with WSP's proposal dated 6th July 2021 and agreement with the Client dated 13th July 2021 (*Agreement*).

8.1 Permitted Purpose

This Report is provided by WSP for the purpose described in the Agreement and no responsibility is accepted by WSP for the use of the Report in whole or in part, for any other purpose (*Permitted Purpose*).

8.2 Qualifications and Assumptions

The services undertaken by WSP in preparing this Report were limited to those specifically detailed in the Report and are subject to the scope, qualifications, assumptions and limitations set out in the Report or otherwise communicated to the Client.

Except as otherwise stated in the Report and to the extent that statements, opinions, facts, conclusion and / or recommendations in the Report (*Conclusions*) are based in whole or in part on information provided by the Client and other parties identified in the report (*Information)*, those Conclusions are based on assumptions by WSP of the reliability, adequacy, accuracy and completeness of the Information and have not been verified. WSP accepts no responsibility for the Information.

WSP has prepared the Report without regard to any special interest of any person other than the Client when undertaking the services described in the Agreement or in preparing the Report.

8.3 Use and Reliance

This Report should be read in its entirety and must not be copied, distributed or referred to in part only. The Report must not be reproduced without the written approval of WSP. WSP will not be responsible for interpretations or conclusions drawn by the reader. This Report (or sections of the Report) should not be used as part of a specification for a project or for incorporation into any other document without the prior agreement of WSP.

WSP is not (and will not be) obliged to provide an update of this Report to include any event, circumstance, revised Information or any matter coming to WSP's attention after the date of this Report. Data reported and Conclusions drawn are based solely on information made available to WSP at the time of preparing the Report. The passage of time; unexpected variations in ground conditions; manifestations of latent conditions; or the impact of future events (including (without limitation) changes in policy, legislation, guidelines, scientific knowledge; and changes in interpretation of policy by statutory authorities); may require further investigation or subsequent re-evaluation of the Conclusions.

This Report can only be relied upon for the Permitted Purpose and may not be relied upon for any other purpose. The Report does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment, divestment, financial commitment or otherwise. It is the responsibility of the Client to accept (if the Client so chooses) any Conclusions contained within the Report and implement them in an appropriate, suitable and timely manner.

In the absence of express written consent of WSP, no responsibility is accepted by WSP for the use of the Report in whole or in part by any party other than the Client for any purpose whatsoever. Without the express written consent of WSP, any use which a third party makes of this Report or any reliance on (or decisions to be made) based on this Report is at the sole risk of those third parties without recourse to WSP. Third parties should make their own enquiries and obtain independent advice in relation to any matter dealt with or Conclusions expressed in the Report.

8.4 Disclaimer

No warranty, undertaking or guarantee whether expressed or implied, is made with respect to the data reported or the Conclusions drawn. To the fullest extent permitted at law, WSP, its related bodies corporate and its officers, employees and agents assumes no responsibility and will not be liable to any third party for, or in relation to any losses, damages or expenses (including any indirect, consequential or punitive losses or damages or any amounts for loss of profit, loss of revenue, loss of opportunity to earn profit, loss of production, loss of contract, increased operational costs, loss of business opportunity, site depredation costs, business interruption or economic loss) of any kind whatsoever, suffered on incurred by a third party.

Bibliography

WorleyParsons (September 2012). Barangaroo South - District Cooling Plant (DCP), Harbour Heat Rejection System Thermal Water Marine Ecological Impact Assessment. Prepared on behalf of Lend Lease for the Barangaroo redevelopment works (reference: 301015-02234-17-EN-REP-001).

PSM (October 2018). Hydrogeological interpretative report – Post-AFC. Prepared on behalf of the John Holland CPB Ghella Joint Venture (JCG), for the Sydney Metro Project (reference SMCSWTSE-JPS-TPW-GE-RPT-110003-01).

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for Freshwater and Marine Water Quality. Volume 1: The Guidelines (Chapters 1-7), s.l.: Australian and New Zealand Environment and Conservation Council.

DECC (2008). Managing Urban Stormwater: Soils and Construction. Volume 2D: Main Road Construction. Department of Environment and Climate Change, Sydney.

Landcom (2004). Managing Urban Stormwater: Soils and Construction. Volume 1. NSW Government, Sydney.

City & Southwest Project Delivery (July 2019). Chatswood to Sydenham – Staging Report. City & Southwest Project Delivery (reference: 20190702 SM C&SW C2S Staging Report v6.0.docx)

City & Southwest Project Delivery (March 2017). Chatswood to Sydenham Construction Environmental Management Framework. Prepared on behalf of NSW Government Transport for NSW.

CSIRO Land and Water, (2009). Development Of Guidelines For Ammonia In Estuarine And Marine Water Systems. Centre for Environmental Contaminants Research, CSIRO Land and Water. (Marine Pollution Bulletin 58 (2009) 1472-1476)

BESIX Watpac (July 2021). Soil & Water Management Procedure. BESIX Watpac (reference:SMCSWSBR-BWC-SBR-EM-PRO-000031)

JHCPBG (March 2020). Water Reuse and Discharge Management Procedure. John Holland, CPB and Gheller (report reference: SMCSTSEJCG-TPW-EM-MPR-003002)

Aquatic Engineering Australia Pty Ltd (May 2019). Sydney Metro 15 l/s Water Treatment Plants – Operation and Maintenance Manual. Aquatic Engineering Australia Pty Ltd (report reference: P35-15LPS)

NSW Parliamentary Research Service (March 2015). Pollution in Sydney Harbour: sewage toxic chemicals and microplastics Briefing Paper No 03/2015 by Daniel Montoya. NSW Parliamentary Research Service.

SIMS (2014). Sydney Harbour A Systematic Review of the Science 2014. Sydney Institute of Marine Science Technical Report.

Local Land Services (June 2015). Sydney Harbour Water Quality Improvement Plan. Local Land Services.

JHCPBG (June 2017). Water Reuse and Discharge Management Procedure. John Holland, CPB and Gheller (report reference: SMCSWTSE-JCG-TPW-EN-MPR-003002)

JHCPBG (June 2017). Stormwater and Flooding Management Plan Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-DN-PLN-002032)

JHCPVG (December 2019). Monitoring and Protection Plan Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-CN-PLN-002036)

JHCPBG (September 2017). Controlled Water Overflow Management Strategy Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-DN-RPT-097233)

JHCPBG (May 2018). Surface Water Quality Monitoring Program August 2017 to January 2018 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097238)

JHCPBG (July 2018). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works January 2018 to June 2018 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097252)

JHCPBG (January 2019). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works July 2018 to December 2018 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097401)

JHCPBG (July 2019). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works January 2019 to June 2019 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097417)

JHCPBG (January 2020). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works July 2019 to December 2019 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097440)

JHCPBG (January 2021). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works July 2020 to December 2020 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097486)

JHCPBG (July 2021). Bi- Annual Surface Water Quality Monitoring Program Project: Sydney Metro City & Southwest – TSE Works January 2021 to July 2021 Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-RPT-097501)

JHCPBG (March 2018). Construction Soil, Water and Groundwater Management Plane (CSWGMP) Project: Sydney Metro City & Southwest – TSE Works. John Holland, CPB and Gheller (Document No.: SMCSWTSE-JCG-TPW-EM-PLN-002014)

EPL (March 2021). Sydney Metro City & southwest Tunnels and Excavation Works Locations Between Chatswood Railway Station and Sydenham Railway Station. Licence No. 20971. Licensee: John Holland Pty Ltd. NSW Environment Protection Agency.

Appendix A

ANZG 2018 / ANZECC 2000 guidelines trigger values

Table A.1 ANZG 2018 / ANZECC 2000 guidelines trigger values for 95% and 80% species protection of aquatic ecosystems

PARAMETER	NSW WATER QUALITY & ANZECC (2000) LEVEL OF PROTECTION (95% SPECIES) (MG/L)	NSW WATER QUALITY & ANZECC (2000) LEVEL OF PROTECTION (80% SPECIES) (MG/L)
Ammonia (as N)	0.91	1.7
Chromium (hexavalent)	0.0044	0.085
Chromium (trivalent)	0.0274	0.0906
Cyanide (total)	0.004	0.014
Turbidity	0.5 - 10 NTU	0.5 - 10 NTU
Cadmium	0.0055	0.036
Chromium	0.0274	0.0906
Copper	0.0013	0.008
Lead	0.0044	0.012
Mercury	0.0004	0.0014
Nickel	0.07	0.56
Zinc	0.015	0.043
Endosulfan I	0.00001	0.00005
Endrin	0.000008	0.00002
Pentachlorophenol	0.022	0.055
Phenol	0.4	0.72
Naphthalene	0.07	0.12
1.1.2-Trichloroethane	1.9	18
Benzene	0.7	1.3

Appendix B

Sydney Harbour (Station SW-B-01) Water Quality

		Field						Lab						
	Analyte	Temp	pH	Electrical Conductivity	Turbidity	DO	DO	pH	Electrical Conductivity	Oil & Grease (LLE)	Total Suspended Solids	Iron - Total	Manganese Total	Flow/Tide
Monitoring Parameters	Units	oC	pH Units	mS/cm)	NTU	mg/L	%	pH Units	mS/cm)	(LLE)	mg/L	mg/L	mg/L	
	Estuarine (LL)		**7.0**		**0.5**			**7.0**						
	Esturaine (UL)		**8.5**		**10.0**			**8.5**					**0.08**	
	EPL 20971 (LL)		**6.5**					**6.5**						
	EPL 20971 (UL)		**8.5**					**8.5**			**50.0**			
	Baseline 80%ile	N/A	7.7	53.0	1.6	N/A	N/A	8.0	52.0	5.0	10.4	0.03	0.01	
	Baseline 20%ile	*N/A*	*N/A*	*N/A*	*N/A*	*6.3*	*88.7*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	
	Standard Dev	3.3	0.7	1.9	1.7	1.1	15.5	0.1	1.2	0.0	4.8	0.1	0.0	
	Max Value	25.4	9.3	54.8	6.2	9.2	119.1	8.1	52.0	5.0	22.0	0.3	0.0	
	Min Value	14.2	6.0	48.3	0.0	5.0	63.3	7.8	49.0	5.0	5.0	0.0	0.0	
Baseline dataset	24/08/2017	15.2	7.6	50.8	0.0	8.4	105.2	8.0	50.0	5.0	5.0	*0.02*	0.01	Outgoing
	06/10/2017	18.3	7.6	50.0	*6.2*	8.0	115.0	8.0	52.0	5.0	10.0	*0.03*	0.01	Outgoing
	25/10/2017	21.0	7.7	49.9	0.0	8.3	115.6	8.0	52.0	5.0	*12.0*	*0.03*	0.01	Incoming
	22/11/2017	21.3	7.7	*53.0*	0.5	*6.3*	*88.7*	7.8	49.0	5.0	10.0	*0.04*	0.01	Incoming
	06/12/2017	20.8	7.8	*53.1*	0.0	6.6	92.7	8.0	49.0	5.0	10.0	*0.03*	0.01	Incoming
	30/01/2018	25.4	7.7	*53.4*	0.0	*6.2*	*85.0*	8.0	52.0	5.0	10.0	*0.04*	0.01	Outgoing
2018 Q1	29/03/2018	23.4	*8.2*	*53.1*	*2.4*	7.4	109.5	*8.1*	50.0	5.0	*22.0*	*0.03*	0.01	Outgoing tide
2018 Q2	31/05/2018	17.1	*8.1*	*53.2*	0.1	*5.0*	*63.3*	7.8	.	<5	<5	*0.05*	<0.01	
Post Rainfall	07/06/2018	15.8	8.0	51.5	0.4	7.1	90.4	8.0	50.0	<5	<5	<0.01	0.04	Low tide
2018 Q3	22/08/2018	14.2	*9.3*	*54.8*	0.0	7.4	93.8	8.0	.	<5	<5	*0.04*	<0.01	Clear odourless, calm
Post Rainfall	05/10/2018	17.3	*8.1*	48.3	0.5	9.2	119.1	8.0	.	<5	<5	*0.27*	<0.02	Outgoing
2018 Q4	22/11/2018	20.6	**6.0**	49.5	0.0	7.9	109.0	8.0	52.0	<5	<5	*0.04*	<0.01	
2019 Q1	22/03/2019	23.58	**5.88**	46.8	0.5	*5.61*	*79.2*	8	49	< 10	3.4	< 0.05	< 0.005	High tide, moderate swell. pH probe faulty
2019 Q2	31/05/2019	17.71	*8.14*	*54.1*	0	7.12	95.6	8	51	*15*	*14*	< 0.05	< 0.005	Low tide, clear
Post Rainfall	26/06/2019	16.47	*8.09*	46.6	0	8.3	98.9	8	*53*	*17*	*40*	< 0.25	< 0.025	Clear, odourless
2019 Q3	09/08/2019	15.21	*9.07*	45.5	0.3	14.7	180.4	**2.5**	*57*	*17*	*11*	< 0.05	< 0.005	Low tide, no debris
Post Rainfall	30/08/2019	14.44	7.85	47.3	0.4	8.46	103	7.8	52	< 10	*12*	< 0.05	< 0.005	Clear water, odourless, high tide
2019 Q4	11/10/2019	18.13	7.91	40.6	*2.2*	6.31	*82.1*	*8.1*	*54*	*23*	4.9	< 0.05	< 0.005	Clear, high tide
Post Rainfall	11/02/2020	24.33	7.72	17.3	*20.8*	8.41	108.3	7.6	15	< 10	*38*	*0.45*	*0.016*	Brown, slight turbid, high tide
2020 Q1	12/03/2020	21.56	*8.33*	36.7	*6.6*	9.1	117.5	6.9	49	<10	<5	*0.06*	0.007	
2020 Q1 WTP - BN	12/03/2020	.	.	.	.	.	.	6.6	.	<10	2.2	<0.05	<0.005	Barangaroo WTP
2020 Q2	19/06/2020	15.46	*8.34*	45.8	*3.3*	9.25	113	7.8	44	< 10	*26*	< 0.05	0.005	Lowtide, clear, odourless
2020 Q2 WTP - BN	19/06/2020	.	.	.	.	.	.	7.1	25	<10	*11*	*1*	**0.64**	Barangaroo WTP
Post Rainfall	17/07/2020	14.66	*8.01*	52.6	*12.2*	6.47	*81.4*	7.9	47	< 10	**400.0**	< 0.05	< 0.005	Clear, odourless, lowtide
2020 PR WTP - BN	17/07/2020	.	.	.	.	.	.	7.6	31	<10	**120.0**	*1.3*	**4.60**	Barangaroo WTP (not discharging)
2020 PR WTP - BN	30/07/2020	.	.	.	.	.	.	7.7	.	<10	*17*	*1.2*	**2.80**	Barangaroo WTP
2020 Q3	25/09/2020	17.54	*8.08*	51.3	*4.4*	10.2	134.5	7.9	50	< 10	8.2	< 0.05	< 0.005	Clear, odourless, high tide
2020 Q3 WTP - BN	25/09/2020	.	.	.	.	.	.	8	.	< 10	*42*	*0.73*	**0.32**	Barangaroo WTP
2020 Q4	20/11/2020	21.06	*8.15*	50.1	0	8.99	125.8	8	50	< 10	*31*	< 0.05	< 0.005	Clear, odourless high tide, WTP not discharging
2020 Q4 WTP - BN	20/11/2020	.	.	.	.	.	.	.	.	.	.	.	.	Barangaroo WTP (not discharging)

Appendix C

Barangaroo WTP Effluent quality data Q4 2018 to Q2 2021

	SBR_COMM_41	SBR_COMM_42
	17-09-20	21-09-20
	(mg/L)	(mg/L)
Ammonia (as N)	2.6	1.7
Chloride	9300	9200
Chromium (hexavalent)	< 0.005	< 0.005
Chromium (trivalent)	< 0.005	< 0.005
Cyanide (total)	0.006	< 0.005
Oil & Grease (HEM)	< 10	< 10
pH (at 25Â°C)	7.5	7.7
Total Suspended Solids Dried at 103â€“105Â	68	13
Turbidity	9	2
Alkali Metals		
Calcium	300	360
Alkalinity (speciated)		
Bicarbonate Alkalinity (as CaCO3)	110	59
Carbonate Alkalinity (as CaCO3)	< 10	< 10
Hydroxide Alkalinity (as CaCO3)	< 20	< 20
Total Alkalinity (as CaCO3)	110	59
Heavy Metals		
Aluminium	0.11	< 0.05
Aluminium (filtered)	0.1	< 0.05
Arsenic	< 0.001	< 0.001
Arsenic (filtered)	< 0.001	< 0.001
Cadmium	< 0.0002	< 0.0002
Cadmium (filtered)	< 0.0002	< 0.0002
Chromium	< 0.001	< 0.001
Chromium (filtered)	< 0.001	< 0.001
Copper	0.002	< 0.001
Copper (filtered)	0.002	< 0.001
Iron	1.5	0.29
Iron (filtered)	1.2	0.27
Lead	< 0.001	< 0.001
Lead (filtered)	< 0.001	< 0.001
Manganese	1.4	0.51
Manganese (filtered)	1.2	0.45
Mercury	< 0.0001	< 0.0001
Mercury (filtered)	< 0.0001	0.0001
Nickel	0.002	0.001
Nickel (filtered)	0.002	< 0.001
Zinc	0.049	0.018
Zinc (filtered)	0.036	0.01
Organochlorine Pesticides		
4.4'-DDD	< 0.0001	< 0.0001
4.4'-DDE	< 0.0001	< 0.0001
4.4'-DDT	< 0.0001	< 0.0001

a-BHC	< 0.0001	< 0.0001
Aldrin	< 0.0001	< 0.0001
Aldrin and Dieldrin (Total)*	< 0.0001	< 0.0001
b-BHC	< 0.0001	< 0.0001
Chlordanes - Total	< 0.001	< 0.001
d-BHC	< 0.0001	< 0.0001
DDT + DDE + DDD (Total)*	< 0.0001	< 0.0001
Dieldrin	< 0.0001	< 0.0001
Endosulfan I	< 0.0001	< 0.0001
Endosulfan II	< 0.0001	< 0.0001
Endosulfan sulphate	< 0.0001	< 0.0001
Endrin	< 0.0001	< 0.0001
Endrin aldehyde	< 0.0001	< 0.0001
Endrin ketone	< 0.0001	< 0.0001
g-BHC (Lindane)	< 0.0001	< 0.0001
Heptachlor	< 0.0001	< 0.0001
Heptachlor epoxide	< 0.0001	< 0.0001
Hexachlorobenzene	< 0.0001	< 0.0001
Methoxychlor	< 0.0001	< 0.0001
Toxaphene	< 0.01	< 0.01
Vic EPA IWRG 621 OCP (Total)*	< 0.001	< 0.001
Vic EPA IWRG 621 Other OCP (Total)*	< 0.001	< 0.001
Dibutylchlorendate (surr.)	75	INT
Tetrachloro-m-xylene (surr.)	71	82
Phenols (Halogenated)		
2.4.5-Trichlorophenol	< 0.01	< 0.01
2.4.6-Trichlorophenol	< 0.01	< 0.01
2.4-Dichlorophenol	< 0.003	< 0.003
2.6-Dichlorophenol	< 0.003	< 0.003
2-Chlorophenol	< 0.003	< 0.003
4-Chloro-3-methylphenol	< 0.01	< 0.01
Pentachlorophenol	< 0.01	< 0.01
Tetrachlorophenols - Total	< 0.03	< 0.03
Total Halogenated Phenol*	< 0.01	< 0.01
Phenols (non-Halogenated)		
2.4-Dimethylphenol	0.005	< 0.003
2.4-Dinitrophenol	< 0.03	< 0.03
2-Cyclohexyl-4.6-dinitrophenol	< 0.1	< 0.1
2-Methyl-4.6-dinitrophenol	< 0.03	< 0.03
2-Methylphenol (o-Cresol)	< 0.003	< 0.003
2-Nitrophenol	< 0.01	< 0.01
3&4-Methylphenol (m&p-Cresol)	< 0.006	< 0.006
4-Nitrophenol	< 0.03	< 0.03
Dinoseb	< 0.1	< 0.1
Phenol	< 0.003	< 0.003
Total Non-Halogenated Phenol*	< 0.1	< 0.1
Phenol-d6 (surr.)	41	79

Polycyclic Aromatic Hydrocarbons		
Acenaphthene	< 0.001	< 0.001
Acenaphthylene	< 0.001	< 0.001
Anthracene	< 0.001	< 0.001
Benz(a)anthracene	< 0.001	< 0.001
Benzo(a)pyrene	< 0.001	< 0.001
Benzo(b&j)fluoranthene	< 0.001	< 0.001
Benzo(g.h.i)perylene	< 0.001	< 0.001
Benzo(k)fluoranthene	< 0.001	< 0.001
Chrysene	< 0.001	< 0.001
Dibenz(a.h)anthracene	< 0.001	< 0.001
Fluoranthene	< 0.001	< 0.001
Fluorene	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	< 0.001	< 0.001
Naphthalene	0.002	0.002
Phenanthrene	< 0.001	< 0.001
Pyrene	< 0.001	< 0.001
Total PAH*	0.002	0.002
p-Terphenyl-d14 (surr.)	88	98
2-Fluorobiphenyl (surr.)	75	86
Total Recoverable Hydrocarbons - 1999 NEPM Fractions		
TRH C10-36 (Total)	< 0.1	0.4
TRH C10-C14	< 0.05	< 0.05
TRH C15-C28	< 0.1	0.2
TRH C29-C36	< 0.1	0.2
TRH C6-C9	0.12	< 0.02
Total Recoverable Hydrocarbons - 2013 NEPM Fractions		
Naphthalene	< 0.01	< 0.01
TRH >C10-C16	< 0.05	< 0.05
TRH >C10-C16 less Naphthalene (F2)	< 0.05	< 0.05
TRH >C10-C40 (total)*	< 0.1	0.2
TRH >C16-C34	< 0.1	0.2
TRH >C34-C40	< 0.1	< 0.1
TRH C6-C10	0.12	< 0.02
TRH C6-C10 less BTEX (F1)	0.12	< 0.02
Volatile Organics		
1.1.1.2-Tetrachloroethane	< 0.001	< 0.001
1.1.1-Trichloroethane	< 0.001	< 0.001
1.1.2.2-Tetrachloroethane	< 0.001	< 0.001
1.1.2-Trichloroethane	< 0.001	< 0.001
1.1-Dichloroethane	< 0.001	< 0.001
1.1-Dichloroethene	< 0.001	< 0.001
1.2.3-Trichloropropane	< 0.001	< 0.001
1.2.4-Trimethylbenzene	< 0.001	< 0.001
1.2-Dibromoethane	< 0.001	< 0.001
1.2-Dichlorobenzene	< 0.001	< 0.001
1.2-Dichloroethane	< 0.001	< 0.001

1.2-Dichloropropane	< 0.001	< 0.001
1.3.5-Trimethylbenzene	< 0.001	< 0.001
1.3-Dichlorobenzene	< 0.001	< 0.001
1.3-Dichloropropane	< 0.001	< 0.001
1.4-Dichlorobenzene	< 0.001	< 0.001
2-Butanone (MEK)	0.1	0.011
2-Propanone (Acetone)	0.019	< 0.001
4-Chlorotoluene	< 0.001	< 0.001
4-Methyl-2-pentanone (MIBK)	< 0.001	< 0.001
Allyl chloride	< 0.001	< 0.001
Benzene	0.002	0.003
Bromobenzene	< 0.001	< 0.001
Bromochloromethane	< 0.001	< 0.001
Bromodichloromethane	0.002	< 0.001
Bromoform	< 0.001	< 0.001
Bromomethane	< 0.001	< 0.001
Carbon disulfide	< 0.001	< 0.001
Carbon Tetrachloride	< 0.001	< 0.001
Chlorobenzene	< 0.001	< 0.001
Chloroethane	< 0.001	< 0.001
Chloroform	0.01	< 0.005
Chloromethane	< 0.001	< 0.001
cis-1.2-Dichloroethene	< 0.001	< 0.001
cis-1.3-Dichloropropene	< 0.001	< 0.001
Dibromochloromethane	< 0.001	< 0.001
Dibromomethane	< 0.001	< 0.001
Dichlorodifluoromethane	< 0.001	< 0.001
Ethylbenzene	< 0.001	< 0.001
Iodomethane	< 0.001	< 0.001
Isopropyl benzene (Cumene)	< 0.001	< 0.001
m&p-Xylenes	< 0.002	< 0.002
Methylene Chloride	< 0.001	< 0.001
o-Xylene	< 0.001	< 0.001
Styrene	< 0.001	< 0.001
Tetrachloroethene	< 0.001	< 0.001
Toluene	< 0.001	< 0.001
Total MAH*	< 0.003	0.003
trans-1.2-Dichloroethene	< 0.001	< 0.001
trans-1.3-Dichloropropene	< 0.001	< 0.001
Trichloroethene	< 0.001	< 0.001
Trichlorofluoromethane	< 0.001	< 0.001
Vic EPA IWRG 621 CHC (Total)*	0.01	< 0.005
Vic EPA IWRG 621 Other CHC (Total)*	0.01	< 0.005
Vinyl chloride	< 0.001	< 0.001
Xylenes - Total	< 0.003	< 0.003
Toluene-d8 (surr.)	75	92
4-Bromofluorobenzene (surr.)	74	103
BTEX		
Benzene	0.002	0.003

Ethylbenzene	< 0.001	< 0.001
m&p-Xylenes	< 0.002	< 0.002
o-Xylene	< 0.001	< 0.001
Toluene	< 0.001	< 0.001
Xylenes - Total	< 0.003	< 0.003
4-Bromofluorobenzene (surr.)	74	103
Monocyclic Aromatic Hydrocarbons		
Benzene	0.002	0.003
Ethylbenzene	< 0.001	< 0.001
Isopropyl benzene (Cumene)	< 0.001	< 0.001
m&p-Xylenes	< 0.002	< 0.002
o-Xylene	< 0.001	< 0.001
Styrene	< 0.001	< 0.001
Toluene	< 0.001	< 0.001
Total MAH*	< 0.003	0.003
Xylenes - Total	< 0.003	< 0.003
Toluene-d8 (surr.)	75	92
4-Bromofluorobenzene (surr.)	74	103

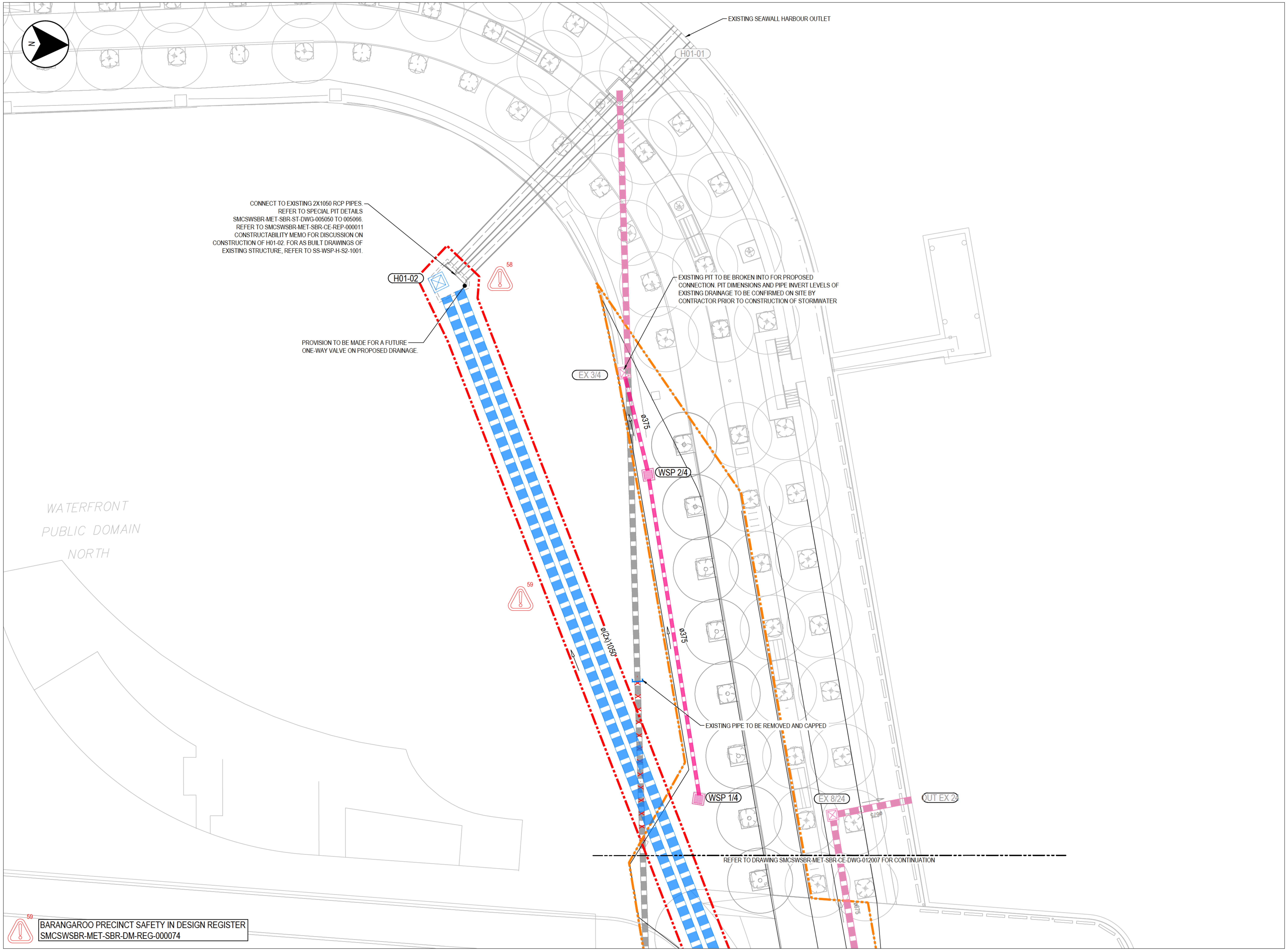
Monitoring Point	Identifier	Date Sampled	Event Based Monitoring (Y/N)	Parameter/ Criteria/ Measured Value								Statement of Compliance	Comments
				pH (Min)	pH (Max)	pH (6.5 - 8.5)	Total Suspended Solids (50 mg/L)	Turbidity (Min)	Turbidity (Max)	Turbidity (35 NTU)	Oil & Grease (None Visible)		
2	BN_03	1/12/2020 to 30/12/2020	N	6.9	8.5	7.3		0.1	16.4	1.9	Nil	Compliant	
2	BN_03	11/01/21 – 31/01/21	N	7.1	8.1	7.3		0.32	7.48	0.73	Nil	Compliant	
2	BN_03	01/02/21 – 28/02/21	N	7.21	7.96	7.25		0.27	20.92	1.42	Nil	Compliant	
2	BN_03	01/03/20021 - 31/03/2021		6.7	7.8	7.4		0.1	27.5	1.4	Nil	Compliant	
	BN_03	01/04/20021 - 30/04/2021		7.1	8.2	7.4		0.05	2.8	0.6	Nil	Compliant	
	BN_03	01/05/20021 - 31/05/2021		6.61	7.93	7.3		0.25	8.84	0.86	Nil	Compliant	
	BN_03	01/06/20021 - 30/06/2021		6.5	8.5	7		0.06	39	2.14	Nil	Compliant	

JHCPBG	Discharge Criteria / ANZECC Value/EPL	Q4 2018	Q1	Q2	Q3	Q3(2)	Q4	Q1	Q2	Q3	Q3	Q4	Q1	Q2
Report ID		633135	642457	662637	667515	678936 (v2)	694537	701281	722997	745667	745975	756753	775206	801157
SYDNEY METRO 2	(mg/L)	14-12-18	26-02-19	25-06-19	24-07-19	23-09-19	18-12-19	10-02-20	01-06-20	22-09-20	23-09-20	13-11-20	19-02-21	07-06-21
		(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Ammonia (as N)	1.2	0.9	0.62	0.39	0.64	1.8	0.14	0.25	1.7	1.7	2	1.4	0.88	0.74
Chloride	-				2300		31	1300	9500	10000	18000	9300	10000	11000
Chromium (hexavalent)	0.02	<0.005	<0.005	< 0.005	< 0.005	0.01	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	<0.005
Chromium (trivalent)	0.0486	<0.005	<0.005	< 0.005	< 0.001	<0.001	-	0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.005	<0.005
Cyanide (total)	0.007	<0.005	<0.05	0.007	< 0.005	<0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	<0.005
Oil & Grease (HEM)	None visible	<10	<10	23	< 10	<10	23	15	< 10	< 10	< 10	< 10	< 10	<10
pH (at 25Â°C)	6.5-8.5	7.4	7.4	7.4	6.8	7.5	7.9	7	7.1	8.3	7.8	7.4	7	7.2
Total Suspended Solids Dried at 103â€“105Â°C	50	<5	38	10	5.1	<1	< 5	19	30	6.2	8.6	6.2	46	4.6
Turbidity	33	1.7	9.4	3.6	< 1	<1	< 1	2.5	6.5	4.1	3.3	1.5	< 1	<1
Alkali Metals														
Calcium	-				540		17	100	930	360	430	460	390	500
Alkalinity (speciated)	-													
Bicarbonate Alkalinity (as CaCO3)	-	36	27	31	24		76	31	79	48	98	72	38	44
Carbonate Alkalinity (as CaCO3)	-		<10	< 10	< 10		< 10	< 10	< 10	56	< 10	< 10	< 10	<10
Hydroxide Alkalinity (as CaCO3)	-		<20	< 20	< 20		< 20	< 20	< 20	< 20	< 20	< 20	< 20	<20
Total Alkalinity (as CaCO3)	-	62	27	31	24	35	76	31	79	100	98	72	38	44
Heavy Metals														
Aluminium	-			< 0.05	< 0.05	0.08	< 0.05	0.5	0.16	< 0.05	< 0.05	< 0.05	0.07	<0.05
Aluminium (filtered)	-			< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Arsenic	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Arsenic (filtered)	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	<0.001
Cadmium	0.014	<0.0002	<0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.0002
Cadmium (filtered)	0.014	<0.0002	<0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	<0.0002
Chromium	0.0486	<0.001	<0.001	0.003	0.002	0.008	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Chromium (filtered)	0.0486	<0.001	<0.001	< 0.001	0.002	0.007	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Copper	0.003	<0.001	0.004	0.002	0.002	< 0.001	0.93	<0.001	< 0.001	0.001	< 0.001	< 0.001	0.004	<0.001
Copper (filtered)	0.003	0.001	0.1	0.001	< 0.001	< 0.001	1	<0.001	< 0.001	0.001	< 0.001	0.001	0.003	<0.001
Iron	-		0.46	0.29	0.11	< 0.05	< 0.05	0.4	1.4	0.71	0.87	0.3	0.11	0.08
Iron (filtered)	-		0.3	0.24	0.06		< 0.05	< 0.05	0.94	0.55	0.7	0.06	0.09	<0.05
Lead	0.0066	<0.001	<0.001	< 0.001	< 0.001	<0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Lead (filtered)	0.0066	<0.001	0.005	< 0.001	< 0.001	<0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Manganese	2.5		3.5	2.3	0.046	0.19	< 0.005	0.22	1.8	0.55	0.89	0.44	0.3	1.5
Manganese (filtered)	2.5		3.6	2.5	0.038		< 0.005	0.19	1.7	0.47	0.78	0.38	0.32	1.4
Mercury	0.0007	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.0001
Mercury (filtered)	0.0007	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	<0.0001
Nickel	0.2	0.003	0.002	0.004	0.002	0.002	0.002	0.001	0.005	0.002	0.001	0.004	0.002	<0.001
Nickel (filtered)	0.2	0.004	0.019	0.004	0.002	0.001	0.002	<0.001	0.005	0.002	0.001	0.005	0.001	<0.001
Zinc	0.023	<0.005	0.008	0.005	0.016	<0.005	0.14	0.009	0.022	0.027	0.013	< 0.005	0.026	0.016
Zinc (filtered)	0.023	<0.005	0.11	0.005	0.015	<0.005	0.15	<0.005	0.008	0.02	0.009	0.008	0.018	0.013
Organochlorine Pesticides														
4.4'-DDD	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
4.4'-DDE	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
4.4'-DDT	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
a-BHC	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Aldrin	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Aldrin and Dieldrin (Total)*	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
b-BHC	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Chlordanes - Total	-	<0.0001	<0.0001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.002
d-BHC	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
DDT + DDE + DDD (Total)*	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Dieldrin	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endosulfan I	0.00002	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endosulfan II	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endosulfan sulphate	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endrin	0.00001	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endrin aldehyde	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Endrin ketone	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
g-BHC (Lindane)	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Heptachlor	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Heptachlor epoxide	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Hexachlorobenzene	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0001
Methoxychlor	-	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002
Toxaphene	-	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.001	< 0.001	< 0.001
Vic EPA IWRG 621 OCP (Total)*	-	<0.0001	<0.0001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.002
Vic EPA IWRG 621 Other OCP (Total)*	-	<0.0001	<0.0001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	< 0.002
Dibutylchlorendate (surr.)	-	114	71	94	118	64	120	57	81	80	130	140	91	68
Tetrachloro-m-xylene (surr.)	-	64	INT	63	112	65	85	70	62	75	99	118	69	100
Phenols (Halogenated)														
2.4.5-Trichlorophenol	-	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
2.4.6-Trichlorophenol	-	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
2.4-Dichlorophenol	-	<0.003	<0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
2.6-Dichlorophenol	-	<0.003	<0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
2-Chlorophenol	-	<0.003	<0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
4-Chloro-3-methylphenol	-	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pentachlorophenol	0.033	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tetrachlorophenols - Total	-	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Total Halogenated Phenol*	-	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenols (non-Halogenated)														
2.4-Dimethylphenol	-	<0.003	<0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
2.4-Dinitrophenol	-	<0.03	<0.03	< 0.03	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
2-Cyclohexyl-4.6-dinitrophenol	-	< 0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
2-Methyl-4.6-dinitrophenol	-	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
2-Methylphenol (o-Cresol)	-	<0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
2-Nitrophenol	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
3&4-Methylphenol (m&p-Cresol)	-	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006		< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
4-Nitrophenol	-	<0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03		< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Dinoseb	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenol	0.52	<0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Total Non-Halogenated Phenol*	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenol-d6 (surr.)	-	48	53	44	70	28	43		79	50	59	81	55	25
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Acenaphthylene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Anthracene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chrysene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluoranthene	-	<0.001	<0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Fluorene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	0.09	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001
Phenanthrene	-	<0.001	<0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Pyrene	-	<0.001	<0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total PAH*	-	<0.001	<0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001
p-Terphenyl-d14 (surr.)	-	90	101	102	95	79	108	64	67	82	108	95	82	70
2-Fluorobiphenyl (surr.)	-	68	84	85	98	56	77	65	57	83	97	100	91	69
Total Recoverable Hydrocarbons - 1999 NEPM Fractions														
TRH C10-36 (Total)	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.02	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1
TRH C10-C14	0.05	<0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.1	< 0.05	<0.05
TRH C15-C28	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH C29-C36	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH C6-C9	-	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.1	< 0.02	< 0.02

Total Recoverable Hydrocarbons - 2013 NEPM Fractions														
Naphthalene	0.09	<0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
TRH >C10-C16	-	<0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C10-C16 less Naphthalene (F2)	-	<0.05	<0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C10-C40 (total)*	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C16-C34	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C34-C40	-	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TRH C6-C10	-	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TRH C6-C10 less BTEX (F1)	-	<0.02	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Volatile Organics														
1.1.1.2-Tetrachloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.1.1-Trichloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.1.2.2-Tetrachloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.1.2-Trichloroethane	5.8	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.1-Dichloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.1-Dichloroethene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2.3-Trichloropropane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2.4-Trimethylbenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2-Dibromoethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2-Dichlorobenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2-Dichloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.2-Dichloropropane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.3.5-Trimethylbenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.3-Dichlorobenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.3-Dichloropropane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
1.4-Dichlorobenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2-Butanone (MEK)	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	0.009	0.008	< 0.001	< 0.001	< 0.001
2-Propanone (Acetone)	-	< 0.001	< 0.001	< 0.001	0.002	< 0.001		<0.005	< 0.2	< 0.001	< 0.001	< 0.001	0.003	< 0.001
4-Chlorotoluene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
4-Methyl-2-pentanone (MIBK)	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Allyl chloride	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Benzene	0.9	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001
Bromobenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bromochloromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bromodichloromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bromoform	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bromomethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Carbon disulfide	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Carbon Tetrachloride	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chlorobenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chloroethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chloroform	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chloromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1.2-Dichloroethene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
cis-1.3-Dichloropropene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromochloromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dibromomethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dichlorodifluoromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iodomethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Isopropyl benzene (Cumene)	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylenes	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Methylene Chloride	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
o-Xylene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Styrene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Tetrachloroethene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total MAH*	-	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
trans-1.2-Dichloroethene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
trans-1.3-Dichloropropene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Trichloroethene	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Trichlorofluoromethane	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vic EPA IWRG 621 CHC (Total)*	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Vic EPA IWRG 621 Other CHC (Total)*	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Vinyl chloride	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Xylenes - Total	-	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Toluene-d8 (surr.)	-	82	121	117	125	79		117	89	79	88	89	91	123
4-Bromofluorobenzene (surr.)	-	83	122	115	131	80		100	118	66	121	76	98	133
BTEX														
Benzene	0.9						< 0.001		< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	-						< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylenes	-						< 0.002		< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	-						< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	-						< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Xylenes - Total	-						< 0.003		< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
4-Bromofluorobenzene (surr.)	-						117		118	66	121	76	98	123

Appendix D

Barangaroo WTP – Outlet Pipe Layout Plan & Longitudinal Section

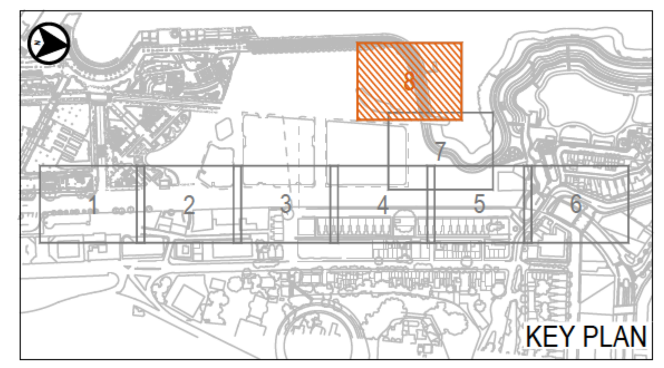


LEGEND

- HICKSON ROAD WORKS EXTENTS
- FORESHORE REINSTATEMENT EXTENTS
- EXTENT OF STATION BOX
- STORMWATER DRAINAGE PIPE BY CITY OF SYDNEY COUNCIL (ULTIMATE DESIGN)
- TRENCH DRAIN
- STORMWATER DRAINAGE PIT AND SUBSURFACE PIT EXTENT BY CITY OF SYDNEY COUNCIL (ULTIMATE DESIGN)
- STORMWATER DRAINAGE PIPE (INTERIM DESIGN)
- STORMWATER DRAINAGE PIT AND SUBSURFACE PIT EXTENT (INTERIM DESIGN)
- STORMWATER DRAINAGE BY INSW
- STORMWATER DRAINAGE BY SYDNEY METRO
- B-A0.03 — PIT NUMBER
- SS — SLOTTED PVC SUBSOIL DRAINAGE. REFER TO CoS DETAIL 7.2.10
- SS — uPVC SUBSOIL DRAINAGE COLLECTOR PIPE. REFER TO COS DETAIL 7.2.10
- FP — SUBSOIL FLUSHING POINT. REFER TO CoS DETAIL 7.2.10
- EXISTING STORMWATER DRAINAGE PIPE
- EXISTING STORMWATER DRAINAGE PIT
- EXISTING STORMWATER DRAINAGE BY INSW
- DRAINAGE CAPPING. REFER TO DRAWING SMCSWSBR-MET-SBR-CE-DWG-012300 FOR DETAILS
- X X X — STORMWATER PIPE TO BE REMOVED AND DEMOLISHED
- TREE. REFER LANDSCAPE ARCHITECT DRAWINGS SMCSWSBR-MET-LA-DWG-000001 TO 000709 FOR SPECIES AND DETAILS
- RD — 150mm x 100mm x 6mm GALVANISED RHS ROAD DRAINAGE. CONNECT TO KERB AS PER CoS DETAIL 1.1.14
- SO — 200mm x 200mm x 6mm RHS SWALE OUTLET TO CONNECT TO SWALE AT MIN 1% GRADE. FOR PIT CONNECTION REFER TO CoS DETAIL 7.2.11.
- STRATA VAULT TREE PIT CELL EXTENT
- STRATA VAULT TREE PIT STABILISED COLLAR EXTENT
- RETAINING WALL, REFER TO LANDSCAPE DWG SMCSWSBR-MET-SBR-LA-DWG-000623 AND STRUCTURAL DRAWING SMCSWSBR-MET-SBR-ST-DWG-005121.
- BOLLARDS. FOR DETAILS, REFER TO LANDSCAPE ARCHITECT DRAWINGS SBR-MET-SBR-LA-000640.

NOTES:

1. CONTRACTOR TO CONFIRM LOCATIONS AND INVERTS OF ALL PIPES. FOR SOURCES OF INFORMATION ON EXISTING PIPES REFERE TO GENERAL NOTES SMCSWSBR-MET-SBR-CE-DWG-010011 & 010012 FOR DBYD AND SURVEY REFERENCE DOCUMENTS.
2. EXISTING PITS TO BE ADJUSTED TO SUIT DESIGN SURFACE LEVELS. PIT LIDS TO BE REPLACED TO SUIT LANDSCAPE ARCHITECTS PAVEMENT DETAILS. REFER TO SMCSWSBR-MET-SBR-CE-DWG-011001 TO 011007 SITEWORKS PLANS AND LANDSCAPE DRAWINGS SMCSWSBR-MET-SBR-LA-DWG-000301 TO SMCSWSBR-MET-SBR-LA-DWG-000312.
3. FOR ADDITIONAL DRAINAGE INFORMATION, REFER TO:
   - SMCSWSBR-MET-SBR-CE-REP-000008 APPENDIX X FOR STORMWATER DRAINAGE CATCHMENT PLAN
   - SMCSWSBR-MET-SBR-CE-DWG-012101 TO 012110 STORMWATER DRAINAGE LONGITUDINAL SECTION
   - SMCSWSBR-MET-SBR-CE-DWG-012501 - STORMWATER DRAINAGE PIT SCHEDULE
   - SMCSWSBR-MET-SBR-ST-DWG-005050 TO 005071 FOR PIT DETAILS
   - SMCSWSBR-MET-SBR-CE-DWG-012300 FOR TYPICAL STORMWATER DRAINAGE DETAIL



FOR CONSTRUCTION

REV.	BY	DATE	DESCRIPTION	APPD.
0	PBGS	18/06/2021	HICKSON ROAD REVISED EXTENTS AFC ISSUE	
1	PBGS	02/07/2021	AFC UPDATES	GD

SCALES

0 2 4 6 8m

1 : 200 FULL SIZE A1

CLIENT

SERVICE PROVIDERS

The information shown on this drawing is for the purposes of the Sydney Metro Project only. No warranty is given or implied as to its suitability for any other purpose. The Service Providers accept no liability arising from the use of this drawing and the information shown thereon for any purpose other than the Sydney Metro Project.

DRAWN	P.B.G.SANTOS	02/07/2021
DESIGNED	F.AHMAD	02/07/2021
DRG CHECK	J.HEYDON	02/07/2021
DESIGN CHECK	J.HALL	02/07/2021
APPROVED	A.MOHAMAD	02/07/2021

SYDNEY METRO

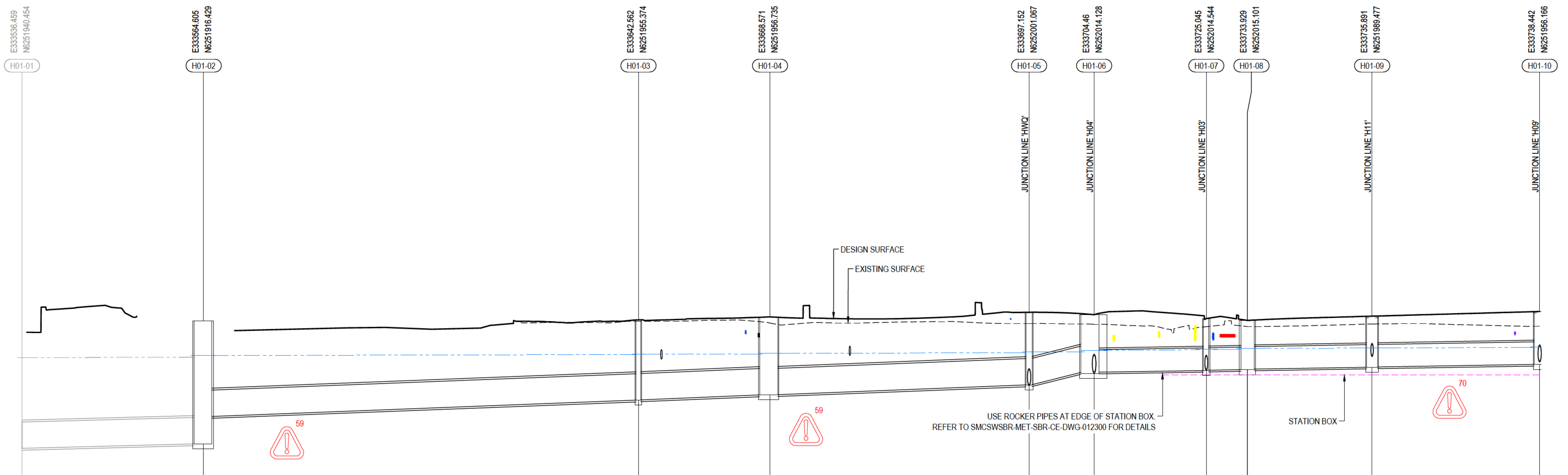
BARANGAROO STATION
CIVIL ENGINEERING
STORMWATER DRAINAGE PLAN
SHEET 8

STATUS:STAGE 3 DESIGN | SHEET 8 OF 8 | ©

DRG No. SMCSWSBR-MET-SBR-CE-DWG-012008 | REV. 1

A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing. | ALT. DRG No. SMCSWSBR-MET-SBR-CE-DWG-012008 1

100mm AT FULL SIZE Plot Date: 02/07/21 - 16:42 Cad File: C:\pw_working\au\pw05\d0121682\SMCSWSBR-MET-SBR-CE-DWG-012008.dwg



LEGEND

- LV ELECTRICAL
- HV ELECTRICAL
- POTABLE WATER
- IRRIGATION
- COMMS
- GAS
- SEWER
- STORMWATER (ULTIMATE DESIGN)

NOTES:

1. ALL STORMWATER PIPES TO BE RUBBER RING JOINT EXCEPT WHERE SPECIFIED AS FLUSH JOINT (FJ).
2. REUSED EXISTING CONDUITS TO BE INSPECTED AND REPLACED IF NECESSARY.
3. FOR ROAD CROSS SECTION DRAWINGS REFER SMCSWSBR-MET-SBR-CE-DWG-011211 - 011233.
4. FOR PAVEMENT INFORMATION, REFER TO SMCSWSBR-MET-SBR-CE-DWG-017001 TO 017021.
5. FOR UTILITY COORDINATION INFORMATION, REFER TO SMCSWSBR-MET-SBR-CE-DWG-014001 TO 014607.
6. FOR STORMWATER DRAINAGE INFORMATION, REFER TO SMCSWSBR-MET-SBR-CE-DWG-012001 TO 012501.
7. FOR SPECIAL PIT DETAILS, REFER SMCSWSBR-MET-SBR-ST-DWG-005050 TO 005066.
8. FOR PIT SCHEDULE REFER SMCSWSBR-MET-SBR-CE-DWG-012501.
9. FOR STORMWATER DRAINAGE TYPICAL DETAILS REFER SMCSWSBR-MET-SBR-CE-DWG-012300.
10. DRAINAGE MODEL INFO:
    - SCALES: HORI 1:500 VERT 1:100
    - DRAINS MODEL LOCATION: PW:\\MOTT-AU-PW.BENTLEY.COM: MOTT-AU-PW-05\DOCUMENTS\CSW DETAIL DESIGN\BARANGAROO STAGE 2 AND 3\50 DESIGN\CIVIL ENGINEERING\20 DISCIPLINE WORKING DOCUMENTS\26 DRAINAGE DESIGN\02 STORMWATER\DRAINS\MODELS\PROPOSED MODELS\
    - DRAINS MODEL NAME: SMCSWSBR-REDESIGN_PROPOSED_ARR2019_ULTIMATE.DRN
    - DRAINS VERSION: 2020.043 (64 BIT) - 11 SEPT 2020
    - DESIGN STORM: 20YR ARI AR&R2019

	H01-01 to H01-02	H01-02 to H01-03	H01-03 to H01-04	H01-04 to H01-05	H01-05 to H01-06	H01-06 to H01-07	H01-07 to H01-08	H01-08 to H01-09	H01-09 to H01-10
FLOW (m^3/s)	1.186	1.185	1.185	1.184	1.041	0.875	0.752	0.742	0.7
VELOCITY (m/s)	0.72	0.72	0.72	0.72	0.73	0.74	0.64	0.66	0.69
PIPE SIZE & CLASS	Ø(2x)1050 RCP Class 4	Ø(2x)1050 RCP Class 4	Ø(2x)1050 RCP Class 4	Ø(2x)1050 RCP Class 4	Ø(2x)1050 RCP Class 4	Ø(2x)900 RCP Class 4 FJ	Ø(2x)900 RCP Class 4 FJ	Ø(2x)900 RCP Class 4 FJ	Ø(2x)900 RCP Class 4 FJ
GRADE (%)	0.5%	0.75%	0.75%	0.75%	3.7%	0.3%	0.3%	0.3%	0.3%
Length	L=36.228	L=86.704	L=26.226	L=51.664	L=12.973	L=22.359	L=8.207	L=24.859	L=33.409

Datum R.L -21.00

	H01-01	H01-02	H01-03	H01-04	H01-05	H01-06	H01-07	H01-08	H01-09	H01-10
DEPTH TO INVERT	1.050 / 1.050	4.903 / 3.810	3.196 / 3.186	3.109 / 3.099	2.893 / 2.883	2.303 / 2.293	2.066 / 2.056	1.961 / 1.939	2.034 / 2.024	2.110
20YR ARI H.G.L LEVEL	1.315 / 1.320	1.332 / 1.400	1.439 / 1.450	1.465 / 1.490	1.511 / 1.540	1.550 / 1.600	1.625 / 1.640	1.640 / 1.690	1.698 / 1.700	1.721 / 1.740
INVERT LEVEL	-2.300 / -2.300	-2.120 / -1.027	-0.377 / -0.367	-0.170 / -0.160	0.227 / 0.237	0.724 / 0.734	0.801 / 0.811	0.836 / 0.858	0.933 / 0.943	1.043
PROPOSED LEVEL	-1.250	2.783	2.819	2.938	3.121	3.027	2.867	2.797	2.967	3.153
EXISTING LEVEL	-1.250	2.783	2.764	2.691	2.673	2.646	2.548	2.552	2.654	2.560
CHAINAGE	0.000	36.228	122.932	149.158	200.822	213.794	236.154	244.360	269.220	302.629

1

LINE H01

59

BARANGAROO PRECINCT SAFETY IN DESIGN REGISTER
SMCSWSBR-MET-SBR-DM-REG-000074

FOR CONSTRUCTION

REV.	BY	DATE	DESCRIPTION	APPD.
0	PBGS	18/06/2021	HICKSON ROAD REVISED EXTENTS AFC ISSUE	
1	PBGS	02/07/2021	AFC UPDATES	GD

SCALES
0.5 0 0.5 1 1.5m
1 : 50 FULL SIZE A1
2 0 2 4 6 8m
1 : 200 FULL SIZE A1

CLIENT
NSW GOVERNMENT
sydney METRO

The information shown on this drawing is for the purposes of the Sydney Metro Project only. No warranty is given or implied as to its suitability for any other purpose. The Service Providers accept no liability arising from the use of this drawing and the information shown thereon for any purpose other than the Sydney Metro Project.

SERVICE PROVIDERS
METRON

DRAWN	P.B.G.SANTOS	02/07/2021
DESIGNED	F.AHMAD	02/07/2021
DRG CHECK	J.HEYDON	02/07/2021
DESIGN CHECK	J.HALL	02/07/2021
APPROVED	A.MOHAMAD	02/07/2021

SYDNEY METRO
BARANGAROO STATION
CIVIL ENGINEERING
STORMWATER DRAINAGE LONGITUDINAL SECTION
SHEET 1

STATUS:STAGE 3 DESIGN | SHEET 1 OF 10 | ©

DRG No. SMCSWSBR-MET-SBR-CE-DWG-012101 | REV. 1

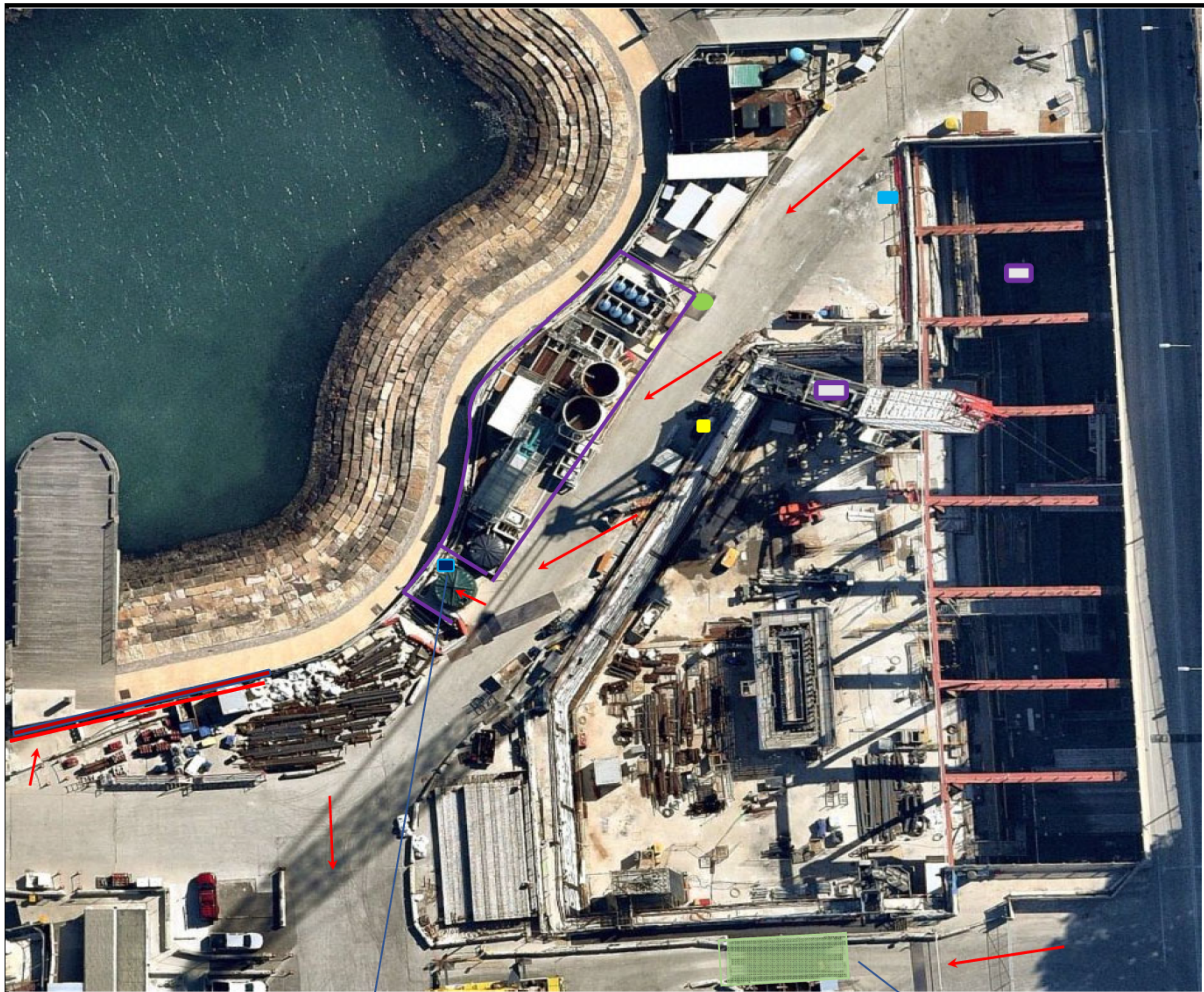
A1 Original | Co-ordinate System: MGA Zone 56 | Height Datum: A.H.D. | This sheet may be prepared using colour and may be incomplete if copied | NOTE: Do not scale from this drawing. | ALT. DRG No. SMCSWSBR-MET-SBR-CE-DWG-012101 1

Cad File: C:\pw_working\au\pw05\d0121682\SMCSWSBR-MET-SBR-CE-DWG-012101.dwg
Plot Date: 02/07/21 - 16:44
100mm AT FULL SIZE

Appendix E

Erosion and sediment control plan

PROGRESSIVE EROSION AND SEDIMENT CONTROL PLAN:



Sump collects surface runoff and pumps to WTP.

Site exit gate. Gate manned during standard working hours. Area to be swept

INSTRUCTIONS:

In wet weather all vehicles to have tires washed

1. Minimise disturbance to only that necessary and try to retain existing sealed surfaces wherever possible.
2. Install all relevant erosion and sediment controls as shown on the drawing at left.
3. Note that stabilised construction exits do not need to be installed if existing sealed driveways are used for site egress.
4. De-watering is to be undertaken in accordance with regular site requirements.
5. Dust suppression using water will be undertaken as necessary to minimise the risk of dust.
6. Stockpiling will be undertaken in accordance with Blue Book Detail SD4-1 and Detail C.
7. As much as possible, contain drilling slurry in accordance with Detail A.
8. Sweep local roads as necessary to remove soil/rocks.
9. All erosion and sediment control measures will be monitored and cleaned out or replaced as necessary.
10. Refer to the Hold Point for dewatering requirements.
11. All erosion and sediment control measures will be inspected weekly and before/after significant rain.

Note that this is a Progressive ESCP and so only shows controls and instructions relevant to this particular parcel of work.
Note that SD refers to Blue Book Standard Details, which are attached overpage.

LEGEND

Red line	Sandbags
Red/blue line	Coir log bund
Blue square	Stormwater Inlet (Protected)
Blue/red arrows	Water flow (blue = clean; red = dirty)
Yellow square	Spill Kit
Dark blue square	Sump
Purple box	Fish tank
Green rectangle	Wheel bath
Green circle	Sealed drain
Orange circle	Protected drain
Purple line	WTP Bund Wall

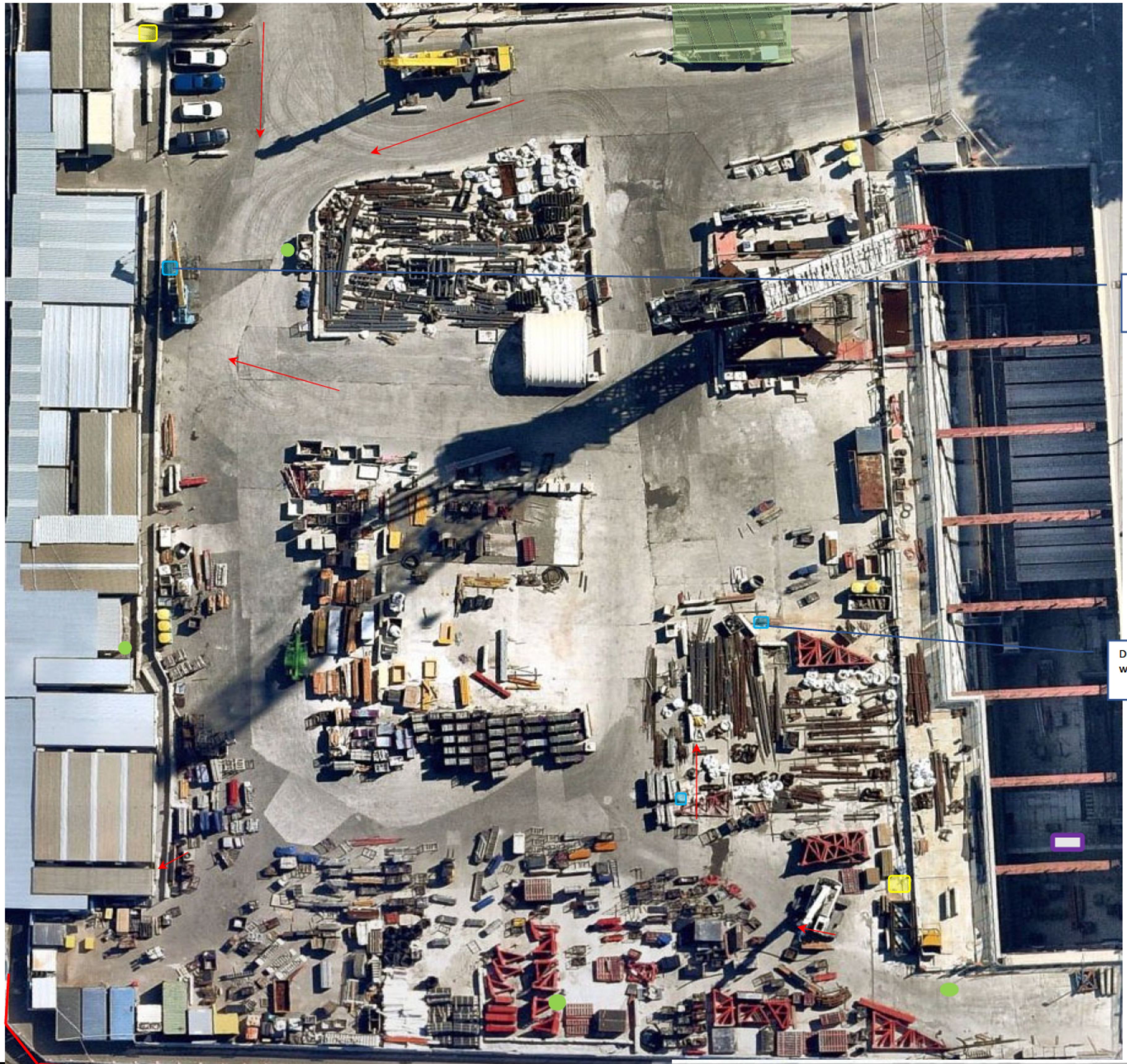
This plan is designed to meet best-practice requirements for this Project.

LOCATION	Barangaroo
DESCRIPTION	SBX Works, Foreshore Reinstatement
DRAWING	REV 15
DATE	01/02/2021

Hold Point for Erosion and Sediment Control	Hold Point for Discharge or Reuse of Site Water
Erosion and Sediment Control Plans (ESCPs) will be developed for each area prior to the commencement of works and will be approved by the Site Superintendent prior to use.	Reuse or de-watering of any detained water onsite must be done in accordance with the project dewatering procedures.

[redacted]

PROGRESSIVE EROSION AND SEDIMENT CONTROL PLAN:



INSTRUCTIONS:

1. Minimise disturbance to only that necessary and try to retain existing sealed surfaces wherever possible.
2. Install all relevant erosion and sediment controls as shown on the drawing at left.
3. Note that stabilised construction exits do not need to be installed if existing sealed driveways are used for site egress.
4. De-watering is to be undertaken in accordance with regular site requirements.
5. Dust suppression using water will be undertaken as necessary to minimise the risk of dust.
6. Stockpiling will be undertaken in accordance with Blue Book Detail SD4-1 and Detail C.
7. As much as possible, contain drilling slurry in accordance with Detail A.
8. Sweep local roads as necessary to remove soil/rocks.
9. All erosion and sediment control measures will be monitored and cleaned out or replaced as necessary.
10. Refer to the Hold Point for dewatering requirements.
11. All erosion and sediment control measures will be inspected weekly and before/after significant rain.
12. Wheel washed to be implemented during and after rain events to prevent tracking

Note that this is a Progressive ESCP and so only shows controls and instructions relevant to this particular parcel of work.
Note that SD refers to Blue Book Standard Details, which are attached overpage.

LEGEND

	Coir Log
	Sandbags
	Stormwater Inlet (Protected)
	Jersey Barrier
	Stabilised exit
	Spill Kits
	Sump
	Wheel Wash
	ATF
	Water flow (blue = clean; red = dirty)
	Sealed drains
	Protected drain
	Fish tank

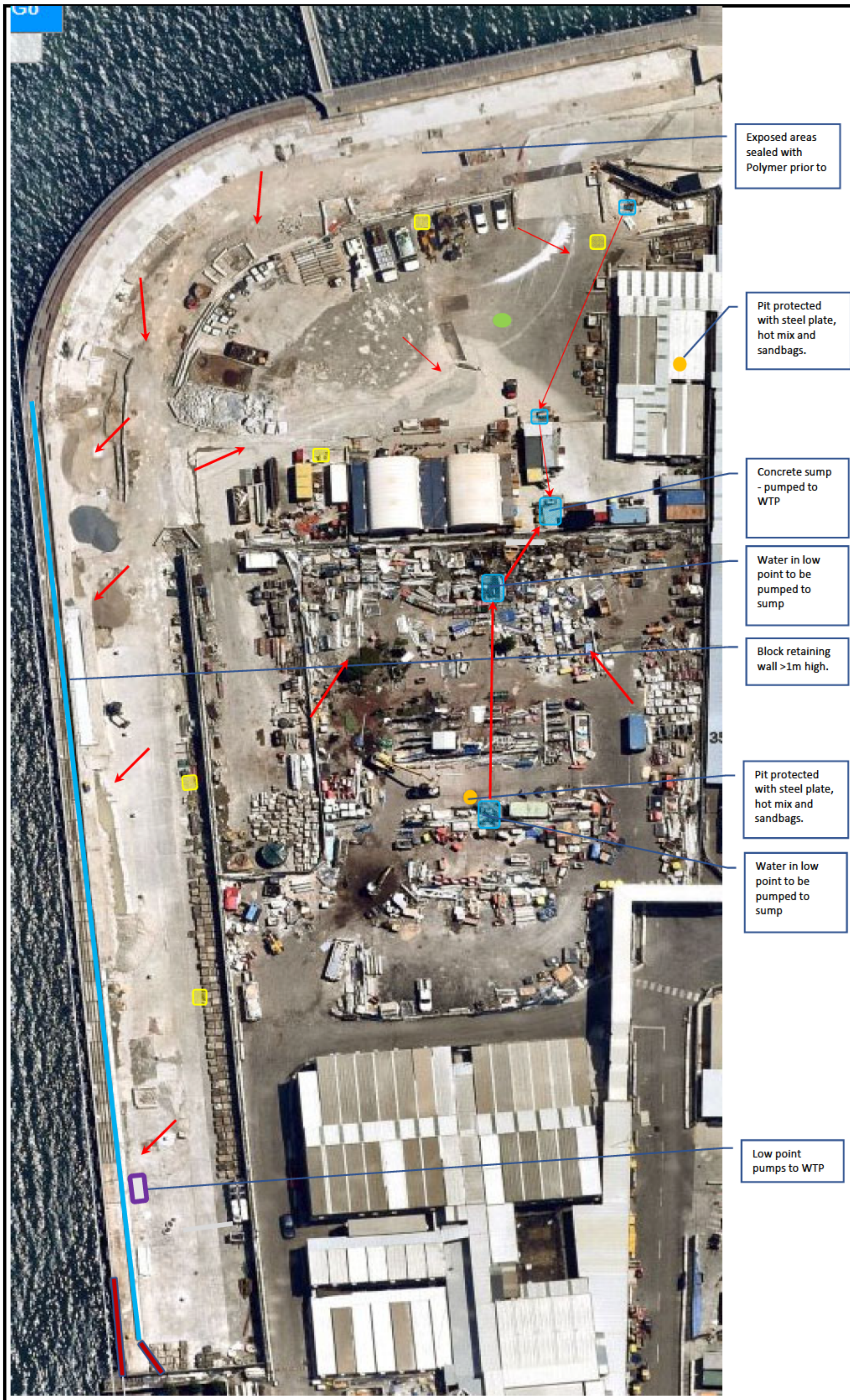
This plan is designed to meet best-practice requirements for this Project.

Hold Point for Erosion and Sediment Control	Hold Point for Discharge or Reuse of Site Water
Erosion and Sediment Control Plans (ESCPs) will be developed for each area prior to the commencement of works and will be approved by the Site Superintendent prior to use.	Reuse or de-watering of any detained water onsite must be done in accordance with the project dewatering procedures

[redacted]

LOCATION	Barangaroo		
DESCRIPTION	SBX Works		
DRAWING		REV	15
DATE	01/02/2021		

PROGRESSIVE EROSION AND SEDIMENT CONTROL PLAN:



INSTRUCTIONS:

1. Minimise disturbance to only that necessary and try to retain existing sealed surfaces wherever possible.
2. Install all relevant erosion and sediment controls as shown on the drawing at left.
3. Note that stabilised construction exits do not need to be installed if existing sealed driveways are used for site egress.
4. De-watering is to be undertaken in accordance with regular site requirements.
5. Dust suppression using water will be undertaken as necessary to minimise the risk of dust.
6. Stockpiling will be undertaken in accordance with Blue Book Detail SD4-1 and Detail C.
7. As much as possible, contain drilling slurry in accordance with Detail A.
8. Sweep local roads as necessary to remove soil/rocks.
9. All erosion and sediment control measures will be monitored and cleaned out or replaced as necessary.
10. Refer to the Hold Point for dewatering requirements.
11. All erosion and sediment control measures will be inspected weekly and before/after significant rain.

Note that this is a Progressive ESCP and so only shows controls and instructions relevant to this particular parcel of work.

Note that SD refers to Blue Book Standard Details, which are attached overpage.

LEGEND

	Sediment Fence
	Jersey Barriers - sealed
	Sandbags
	Coir Logs
	Hoarding (Sealed Base)
	Spill kit
	Water flow (blue = clean; red = dirty)
	Bund Wall
	Fish tank
	Block work wall
	Protected drain
	Sump
	Sealed drain

This plan is designed to meet best-practice requirements for this Project.

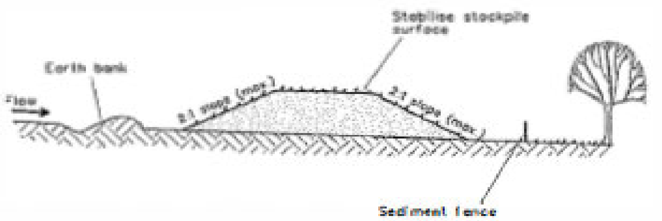
Hold Point for Discharge or Reuse of Site Water

Reuse or de-watering of any detained water onsite must be done in accordance with the project dewatering procedures.

[redacted]

LOCATION	Barangaroo		
DESCRIPTION	SBX works, Foreshore reinstatement		
DRAWING		REV	15
DATE	01/02/2021		

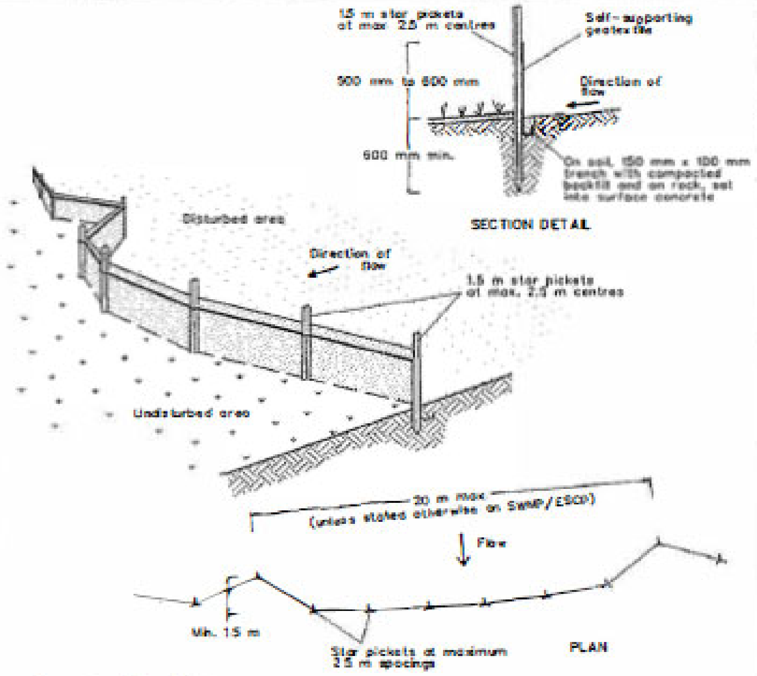
Standard details reproduced from Landcom (2004).



Construction Notes

1. Place stockpiles more than 2 (preferably 5) metres from existing vegetation, concentrated water flow, roads and hazard areas
2. Construct on the contour as low, flat, elongated mounds.
3. Where there is sufficient area, topsoil stockpiles shall be less than 2 metres in height.
4. Where they are to be in place for more than 10 days, stabilise following the approved ESCP or SWMP to reduce the C-factor to less than 0.10.
5. Construct earth banks (Standard Drawing 5-5) on the upslope side to divert water around stockpiles and sediment fences (Standard Drawing 6-8) 1 to 2 metres downslope.

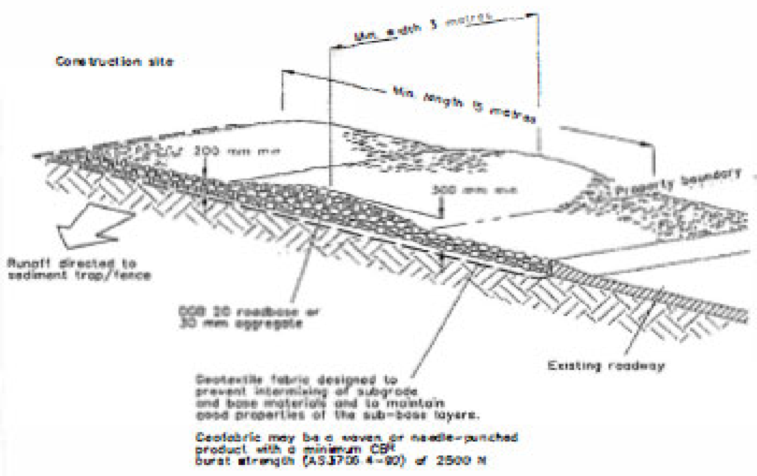
STOCKPILES **SD 4-1**



Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE **SD 6-8**



Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200-mm thick pad over the geotextile using road base or 30-mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS **SD 6-14**

Appendix F

Barangaroo Station Groundwater Quality

MEMO

TO: [redacted]

FROM: [redacted]

SUBJECT: **Barangaroo Station groundwater quality**

OUR REF: PS124220-WAT-MEM-001 RevA

DATE: **28 July 2021**

1. GROUNDWATER QUALITY AS DESCRIBED IN THE HYDROGEOLOGICAL INTERPRETATIVE REPORT

The following groundwater quality information for Barangaroo was obtained from Section 9.7.8 of the hydrogeological interpretative report (HIR) (PSM, 2018):

Following completion of the contiguous pile wall, groundwater flowing into the excavation is unlikely to be significantly impacted by contamination at the nearby gasworks and likely of similar quality and geochemistry to that sampled from wells SRT_BH034, SRT_BH035, SRT_BH071, SRT_BH072 and SRT_BH073.

With time, inflows (particularly along the western and northern margins of the excavations) may become increasingly saline and with similar (or equivalent) geochemistry and salinity of seawater (that is TDS concentration of 36,000 mg/L, chloride concentration of 19,000 mg/L, and sulfate concentration of 2,700 mg/L).

The quality of likely inflows to the TSE from fracture sets in the Hawkesbury Sandstone may also be influenced by past activities at the former Barangaroo gasworks to the south of the excavation and the reclaimed land to the west. Predictive groundwater flow modelling suggests that only 69 kL/day (of the predicted total of 225 kL of daily inflow) is expected to be groundwater discharging from the Hawkesbury Sandstone. Hence concentrations of contaminants from this flux are likely to be diluted in the excavation by seawater derived from the fill material. In excavations for the nearby Star City Casino basement increased seepage was encountered through the Luna Park Fault Zone, requiring more concentrated drainage provision (Speechley et al 2004).

Iron and manganese-enriched groundwater from the Hawkesbury Sandstone may also be encountered. This groundwater, which is typically saline, highly reducing and mobile in both major and minor structures, usually has high concentrations of dissolved iron and manganese which form oxyhydroxide complexes when exposed to oxygen-rich environments. These oxyhydroxides form the orange, brown and ochre staining on sandstone walls and exposures. They frequently block drainage systems, are a corrosion hazard, and can be costly to treat.

It should further be noted that should any significant fracturing associated with any minor structures (such as bedding plane partings and joints) or unidentified major structures be

Level 27, 680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001

Tel: +61 2 9272 5100
Fax: +61 2 9272 5101
www.wsp.com

encountered in the bedrock, then inflows could be much higher than anticipated and these may be contaminated as a result of proximity to the gasworks.

Seawater intrusion at Barangaroo was obtained from Section 5.4.4 of the HIR (PSM, 2018):

The intrusion of seawater along the foreshore of the Central Business District is a growing influence on the local quality of groundwater. The local setting at Darling Harbour (Barangaroo) is not natural. There has been landform (both excavation and infill) changes that most likely altered the natural groundwater and seawater environments. There has been land reclamation by filling with crushed sandy and gravelly sandstone, with inclusions of cobbles, boulders, building rubble, steel, ash slag, concrete and charcoal. The reclamation extends into deeper water, with fill overlying silty alluvium.

Based on experience in the Barangaroo area:

— *Intuitively seawater would predominantly saturate the land reclamation profiles. This relates to landform, but may also indicate comparatively high-transmissivity of the fill material. High transmissivity fill would enhance tidal efficiency and intrusion of seawater.*

— *Groundwater with chemistry typical of seawater (sodium concentrations of about 10,000 mg/L, sulphate concentrations of 1,900 mg/L and chloride about 19,000 mg/L) has been identified in groundwater monitoring wells SRT_BH080 and SRT_BH080A installed on the western side of Hickson Road in Barangaroo.*

— *The water table in the reclamation profile responds to tides and storm surge.*

2. GROUNDWATER MONITORING NETWORKS

The groundwater monitoring network provided within the HIR (PSM, 2018) is shown in Appendix A (first image).

As provided in Section 9.6.5 of the HIR (PSM, 2018), the groundwater monitoring network includes the following:

— SRT_BH072A, which was installed along the alignment of Barangaroo and screened in residual soils (gravel and sands).

— SRT_BH034, SRT_BH035, SRT_BH071, SRT_BH072, SRT_BH073 and SRT_BH080, which were installed along the alignment of Barangaroo and screened across Class I and Class II Hawkesbury Sandstone.

— MW3 and MW15, which were installed at the former Barangaroo gasworks (Millers Point gasworks) to the south of Barangaroo and screened across residual soils and Hawkesbury Sandstone respectively.

— piezometers (not specified in Section 9.6.5 of the HIR, however understood to be SRT_BH080A, JCG_BH1110 and JCG_BH1111) installed in the reclaimed lands to the west of Barangaroo.

Groundwater quality data is also available outside the HIR, with the network also shown in Appendix A (second image). The network comprises:

— Deep piezometers along the perimeter of the station (assumed to be screened within the Hawkesbury Sandstone), BRBH04, BRBH10, BRBH15 and BRBH17.

— Shallow piezometers also positioned along the perimeter of the station, BRBH01, BRBH03, BRBH05, BRBH06, BRBH09, BRBH12, BRBH14 and BRBH21. It is not known whether the shallow piezometers are screened within fill, residual soils or the Hawkesbury Sandstone.

Note the “BH” in the piezometer name may be presented as “MW”, for example BHBH15 and BRMW15. Additionally, data for all the network is not available.

A further groundwater monitoring network, outside the HIR, to the east of Barangaroo, is provided in Appendix A (third image). The network, where data is available, comprises 36HR_MW01, 36HR_MW02, 36HR_MW03, BN_GW, SBR_SBX_2, SBR_SBX3, SBR_SBX4, SBR_SBX5, SBR-SBX_7, SBR-SBX_8, SBR_SRKFN, SBR_SBX_STH and SBR_SBX. The entire network is not shown in the location image.

Note the piezometer prefix may be labelled as 36HR or HR36. Geological information is not known.

3. GROUNDWATER QUALITY

Groundwater quality data is provided in Excel format. Note most of the laboratory reports have not been sighted and some concentrations may be recorded incorrectly.

A brief summary of some of the results, from the HIR network, are as follows:

- Some elevated concentrations for at least one of the piezometers at the former gasworks (MW3 and MW15), including ammonia, polycyclic aromatic hydrocarbons (PAH) and volatile organics.
- Electrical conductivity (EC) is elevated for the piezometers in the fill, at 30,000 to 41,000 µS/cm. The pH is near neutral, at 6.8-8.2.
- Groundwater within the fill has low metal concentrations, with some detections of total recoverable hydrocarbons (TRH) and volatile organics.
- For the Hawkesbury Sandstone:
  - pH ranges from 5.8 to 9.0. The higher pH may be due to grout contamination, as Hawkesbury Sandstone groundwater is typically slightly acidic to neutral.
  - The EC is variable, from 388 µS/cm (SRT_BH035) to 46,000 µS/cm (SRT_BH080).
  - Iron and manganese are typically elevated.
  - There is some contamination evident, with detections of TRH and volatile organics.

The groundwater quality for the network outside the HIR, can be summarised as follows:

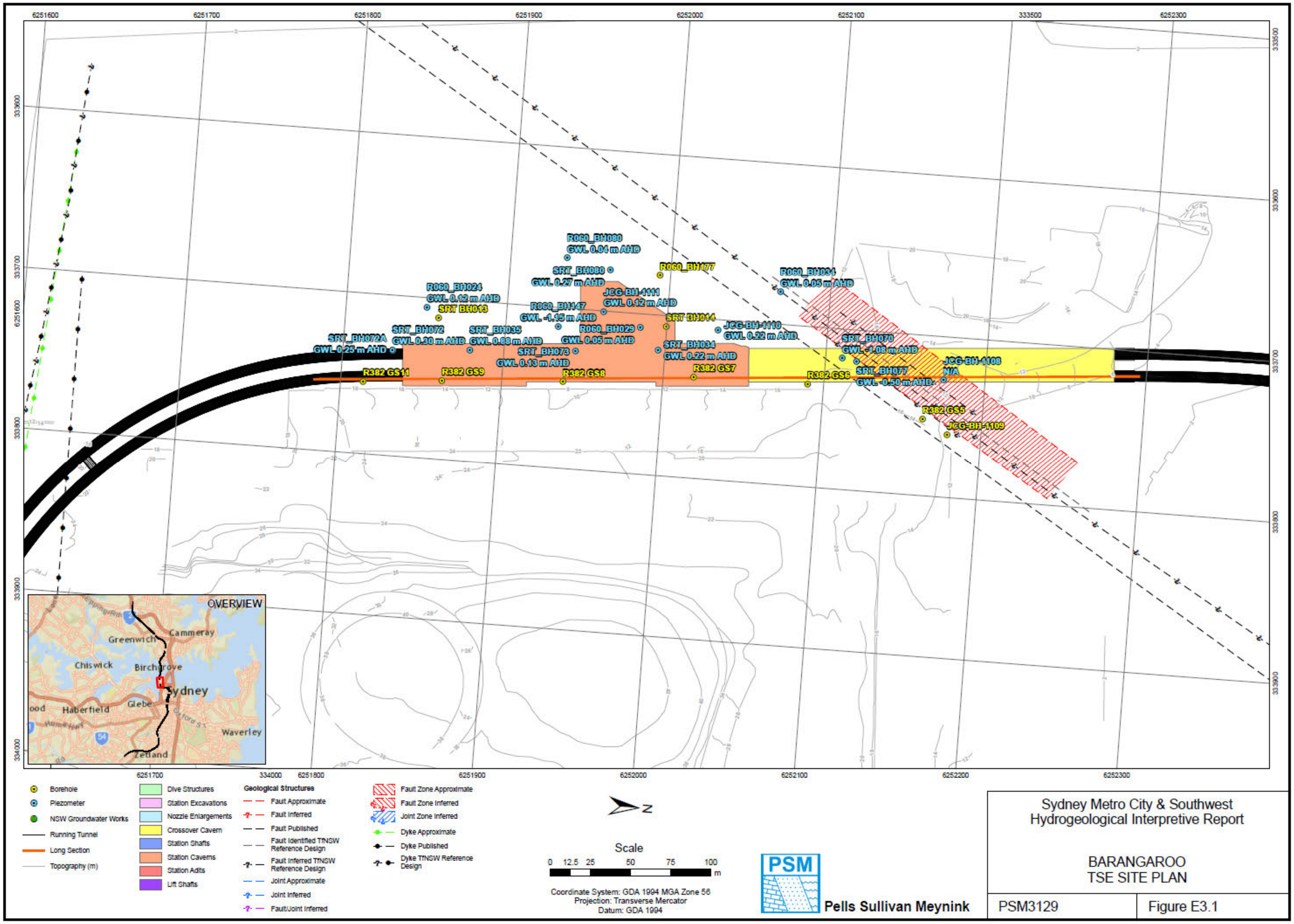
- pH ranging from 3.5 to 12.0. Again, the higher pH may be due to grout contamination, as Hawkesbury Sandstone groundwater is typically slightly acidic to neutral.
- Oil and grease was detected at some locations, with the highest concentration at SBR-SBX_7 at 27 mg/L.
- Total dissolved solids were relatively low, up to 450 mg/L.
- Metals concentrations were mostly low except for iron and manganese which were generally elevated.
- Volatile organics, phenols, TRH and PAH were generally not detected. The main exception was low detectedion of TRH at SBR_SRKFN and SBR_SBX_STH.

References

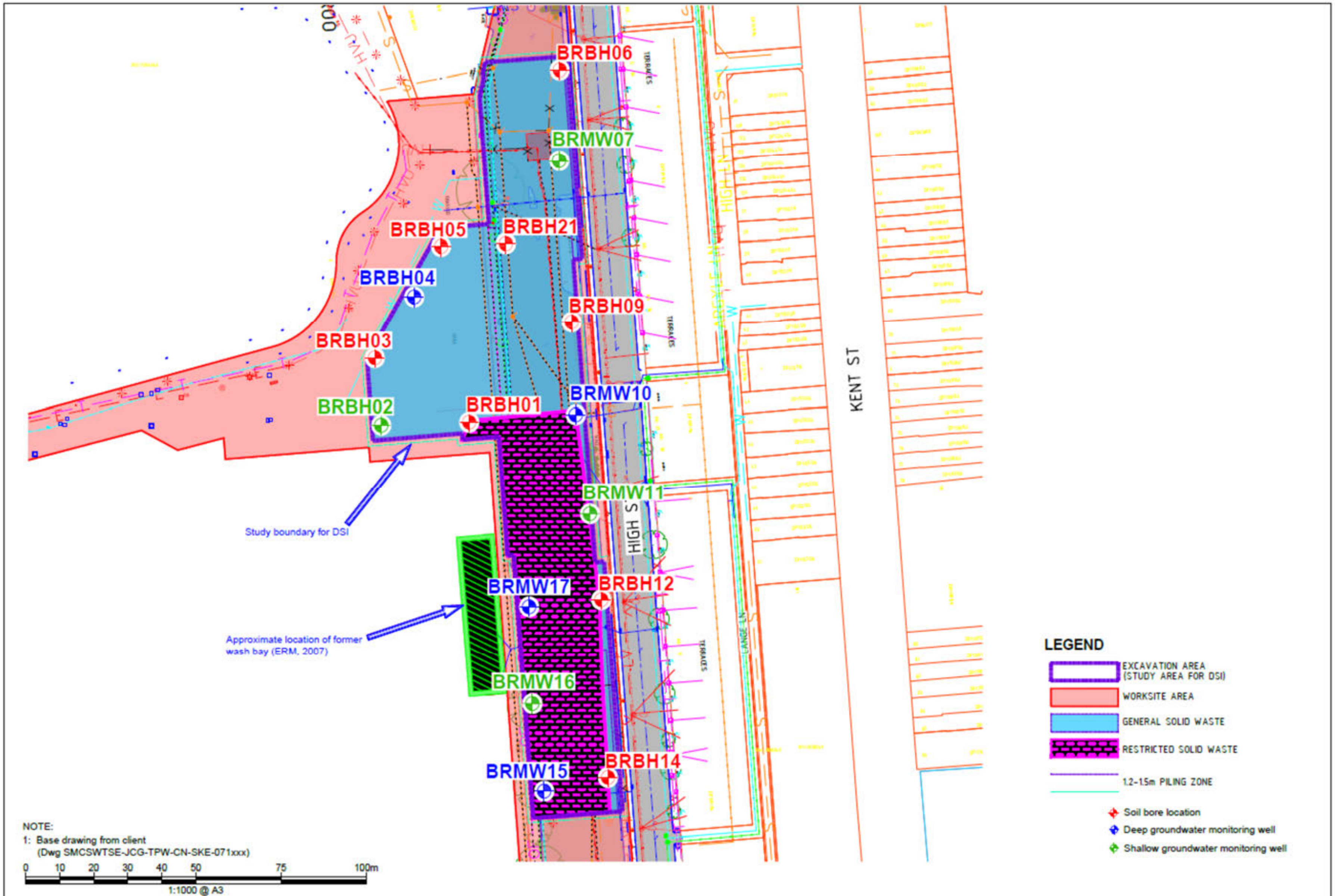
PSM (2018). Hydrogeological interpretative report – Post-AFC. Prepared on behalf of the John Holland CPB Ghella Joint Venture (JCG), for the Sydney Metro Project, reference SMCSWTSE-JPS-TPW-GE-RPT-110003-01, dated October 2018.

Appendix A – Groundwater monitoring network (figures)

APPENDIX A GROUNDWATER MONITORING NETWORK (FIGURES)

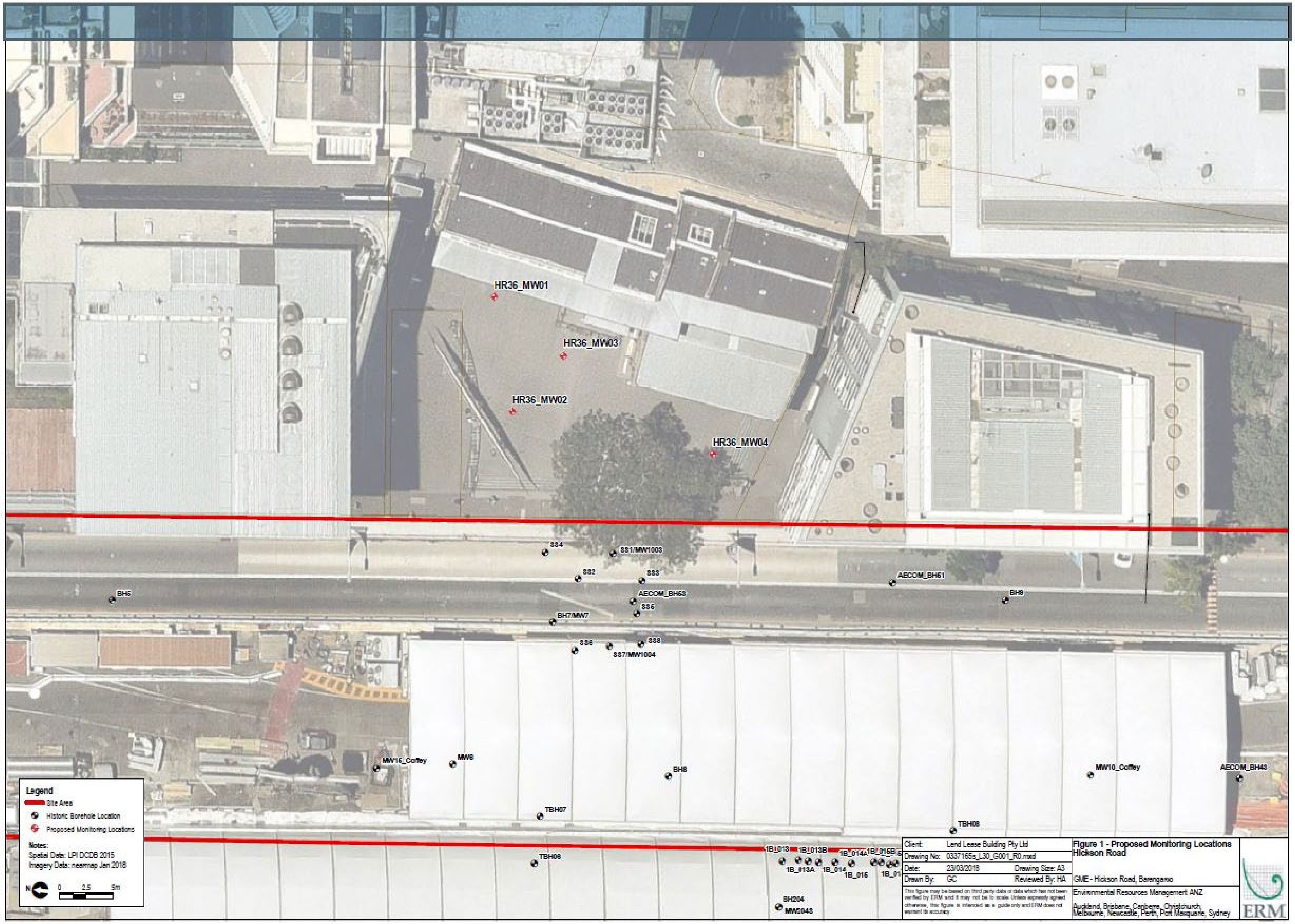


From hydrogeological interpretative report (PSM, 2018)



Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: John Holland CPB Ghella JV	TITLE: **In Situ Filling Waste Classification**	PROJECT No: 85608.08
	OFFICE: Sydney — DRAWN BY: PSCH	**Sydney Metro City & South West, Tunnel and Station Works**	DRAWING No: 3
	SCALE: 1:1000 @ A3 — DATE: 23.1.2018	**Proposed Barangaroo Station, Hickson Road, BARANGAROO**	REVISION: 0

From spreadsheet "Groundwater Results – Barangaroo"



From spreadsheet “Groundwater Results – Barangaroo”

Appendix G

Barangaroo – Modelled Groundwater Inflows into B3 Depressurisation System and Northern Shaft

MEMO

TO:	[redacted]
FROM:	[redacted]
SUBJECT:	**Barangaroo - Modelled groundwater inflows into B3 depressurisation system and Northern Shaft**
OUR REF:	PS124220-WAT-MEM-001 RevA
DATE:	**12 August 2021**

1 INTRODUCTION AND BACKGROUND

This memo details the numerical groundwater modelling undertaken to estimate groundwater seepage inflows into the Barangaroo B3 depressurisation system of the Station Cavern and the Northern Shaft. The estimates are required to inform capacity of a new on-site wastewater treatment plant.

A Hydrogeological Interpretive Report (HIR) was prepared by Pells Sullivan Meynink (PSM), on behalf of the John Holland CPB Ghella Joint Venture (JCG), for the Sydney Metro Project in 2018 (PSM, 2018). This report includes details of the modelling undertaken for the construction and operation of the Barangaroo Station. The conceptual and numerical model design from the HIR has been adopted for the numerical models undertaken to estimate groundwater seepage to the B3 depressurisation system (section 5) and the Northern Shaft (Section 6).

Hand-drawn conceptual drawings were included in the HIR (PSM, 2018), titled 'Sydney Metro – Barangaroo station Groundwater Depressurisation' and dated 4/2/2019. The conceptual drawings include the following design assumptions, hydrogeological parameterisation and groundwater seepage rate information:

— Predicted groundwater inflows of 57 kL/day (0.66 L/s) into the station excavation for 12 months after construction (assumes pile wall/jet grout is impermeable, and pressure grouting of rock below piles extends to RL -30 m Australian Height Datum (AHD) and achieves a permeability of <0.0001 m/day).

— Sensitivity analysis of hydraulic properties of the class I/II sandstone long-term seepage rates of up to 277 kL/day (2.7 L/s).

— Extrapolated steady-state seepage estimated at 81.7 kL/day (0.95 L/s).

2 OBJECTIVE AND SCOPE

The primary objective of the work is to estimate the groundwater inflow rates into the depressurisation drain at RL -12.7 (B3 level) of the Station Cavern and into the Northern Shaft.

Level 27, 680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001

Tel: +61 2 9272 5100
Fax: +61 2 9272 5101
www.wsp.com

To meet the objective, the following was undertaken:

- Conceptualise the groundwater flow systems in the vicinity of the Station Cavern and Northern Shaft.
- Develop uncalibrated 3D numerical groundwater models of the B3 depressurisation system and Northern Shaft.
- Undertake sensitivity analysis for certain model parameters.

3 METHODOLOGY

Numerical modelling was carried out using MODFLOW-USG and the Groundwater Vistas Version 8 user interface. MODFLOW-USG (Panday et al., 2013) utilises a control-volume finite difference approach (CVFD) and is well suited to model seepage inflows in which precise water balance estimates are important. MODFLOW-USG allows for refined and unstructured grids, and variably saturated flow conditions.

The model geometry is based on the geology and geometry of the site provided in the HIR (PSM, 2018).

The hydraulic properties utilised are based on the values used in the HIR numerical model (discussed in Section 5.1.1).

The geology and geometry of the site were simplified to a level appropriate for the model objectives. The following key rationalisations of the site were applied:

- An average thickness of 5 m was used to simulate fill material that is present on the harbour side of the model (for the B3 depressurisation system only).
- The bedrock of the site was simplified to a single host rock geology.
- The model geometry has been simplified to allow efficient modelling. For the B3 depressurisation system, a coarser grid outside the area of interest and a more refined grid at the cavern site was used.

4 CONCEPTUALISATION

A summary of the key aspects of the conceptual hydrogeological site model consists of the following (further details are provided in the HIR (PSM, 2018)):

- The topography ranges from approximately 44 mAHD in the east to 0 mAHD in the west (Sydney Harbour).
- Groundwater levels follow the topography and are shallow, ranging from approximately 8.5 mAHD in the east to 0 mAHD at Sydney Harbour.
- Saturated fill material exists on the harbourside (ranging from 0.5-12.5 m in thickness), west of Hickson Road, with underlying Hawkesbury Sandstone. The fill deposits consist of sand, gravel and sandy gravel with building rubble, charcoal, bricks, concrete and sandstone fragments.
- Hawkesbury Sandstone outcrops to the east of Hickson Road. Class II/I Hawkesbury Sandstone dominates at Barangaroo and comprises of fresh bedrock with widely spaced defects. It is characterised by a massive fabric, with limited defects and very low effective transmissivity.
- Known structural features includes the Luna Park Fault Zone, which is a sub-vertical, north-north east striking zone of significant shearing and closely spaced jointing and

faulting. Comparatively higher groundwater seepage has previously been noted adjacent to the Luna Park Fault Zone. The fault zone was not shown to intercept the Station Cavern, however it may intersect the Northern Shaft.

- The primary recharge mechanism is through direct rainfall recharge to fill and the Hawkesbury Sandstone outcrop, with additional recharge sources, such as runoff and recharge to the Hawkesbury Sandstone via vertical leakage through the fill deposits.
- Groundwater discharges to the Sydney Harbour.

Figure 4.1 shows a conceptual hydrogeological long-section of the Barangaroo site developed by PSM (2018).

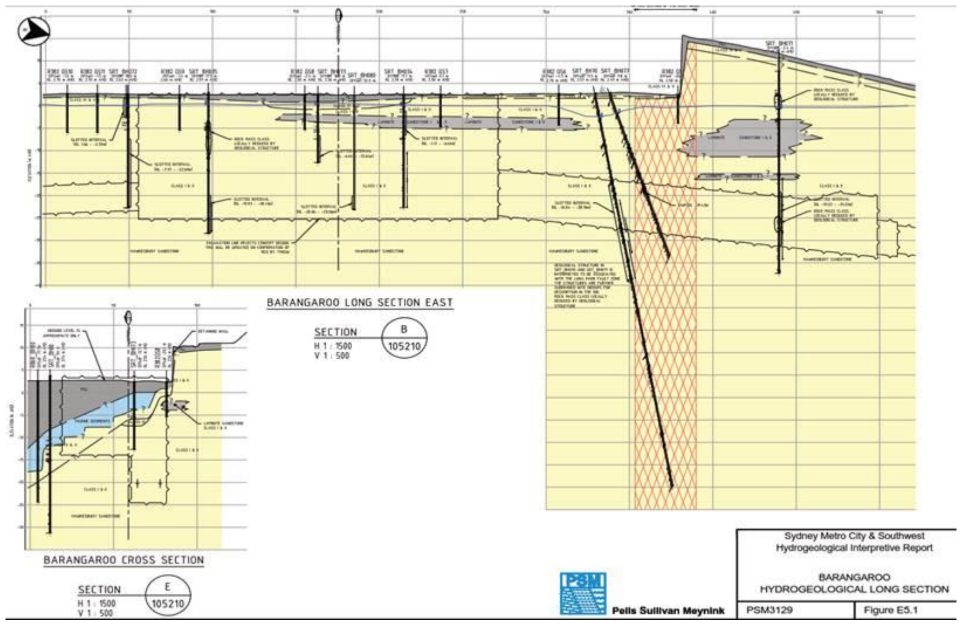


Figure 4.1 Barangaroo hydrogeological long-section (PSM, 2018)

5 B3 DEPRESSURISATION SYSTEM

Figure 5. shows the cavern design drawings with the depressurisation system indicated with a red line and the waterproofed wall of very low permeability indicated with a green line.

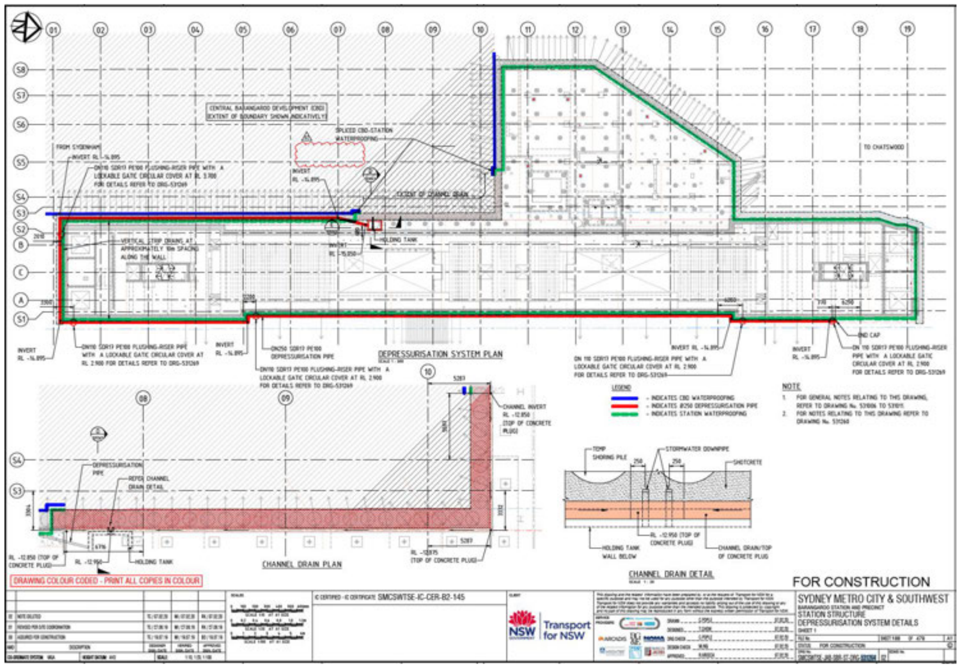


Figure 5.1 Station structure and depressurisation system (Drawing SMCSWTSE-JAB-ST-DRG-5312164, provided by BESIXWatpac)

5.1 MODEL SETUP

5.1.1 MODEL DESIGN

MODEL GEOMETRY

The model domain is 300 m by 400 m. The major hydrostratigraphic units are represented by two model layers. The model cell size is 10 x 10 m over most of the model domain, however the cell size has been refined using quad-tree refinement to 0.625 m x 0.625 m in the Station Cavern area of interest. Cells outside the model domain are defined as inactive. The total number of active model cells after refinement is 49,904.

The model domain, model grid and inactive (no-flow) cells are shown in Figure 5.2. For information regarding no-flow cells, refer to Section 5.1.2.

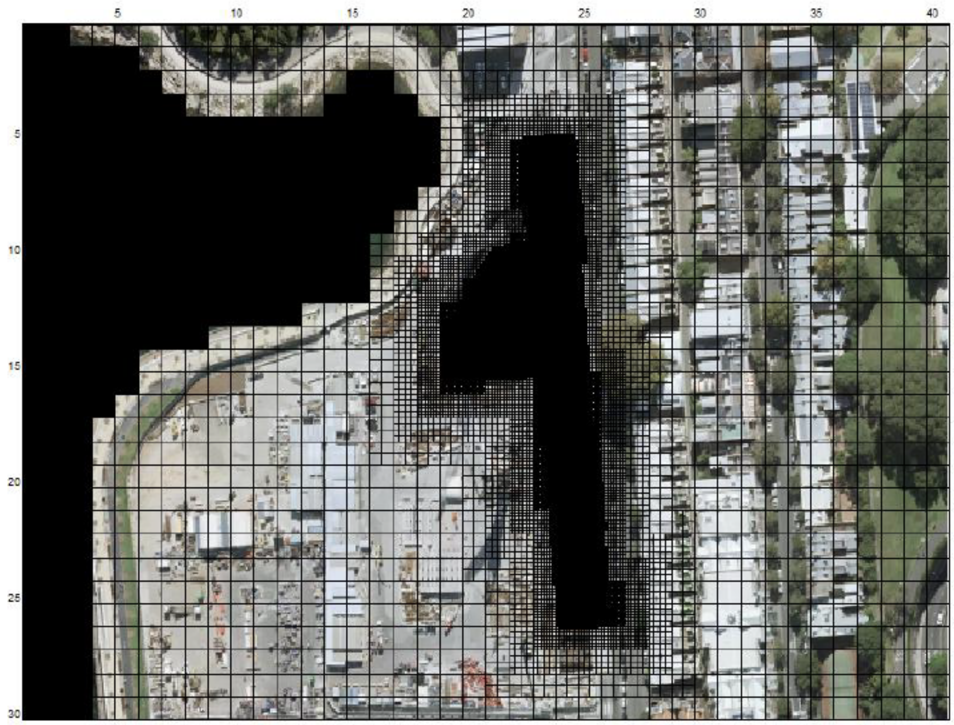


Figure 5.2 Model domain, model grid and no-flow cells (in black)

MODEL LAYERS AND HYDRAULIC PROPERTIES

The groundwater system and hydrogeological units were represented by two model layers as summarised in Table 5.1.

Digital Elevation model (DEM) data from June 2020 (NSW Government's Spatial Services, 2021) was used for the top elevation of the model. The elevation in the Station Cavern area was set to RL 2.5 mAHD. The thickness of layer 1 (fill) was set to 5 m across the model domain. Fill properties were assigned to the west of Hickson Road and Hawkesbury Sandstone properties were assigned on the western side, consistent with the surface geology map (Department of Regional NSW, 2020). Layer 2 extended to a depth of -32.7 mAHD (20 m below the base of B3) and Hawkesbury Sandstone properties were assigned to the entire layer.

Table 5.1 Model layers and hydraulic properties

LAYER	GROUNDWATER RESOURCE UNIT	LITHOLOGY	HYDRAULIC CONDUCTIVITY (HORIZONTAL/VERTICAL) IN METRES PER DAY	SPECIFIC YIELD
1	Fill	Anthropogenic unconsolidated material	10 / 10	0.2
2	Hawkesbury Sandstone	Class I/II sandstone	$1x10^{-2}$ / $5x10^{-3}$	0.05

No geological faults have been incorporated into the groundwater flow model, however a sensitivity run has been included to simulate potential higher hydraulic conductivity in Hawkesbury Sandstone.

BOUNDARY CONDITIONS

Initial heads were set at 1 m below the surface. Surface drainage and evapotranspiration were not included in the model.

Aquifer recharge was applied to the model using the MODFLOW recharge package (RCH). Rainfall recharge was applied uniformly. The average rainfall recharge applied in the model is 9.99 x 10^{-4} m/day (3% of average annual rainfall (1,215 mm)) as per the PSM model.

A MODFLOW constant head boundary (CHB) of 0 mAHD was applied to the Sydney Harbour side of the model (dark blue cells on Figure 5.3) and a MODFLOW general head boundary (GHB) of 8.5 mAHD was applied to the eastern boundary of the model and set at a distance of 10 m (light blue cells on Figure 5.3). The conductance of the general head boundary is based on the hydraulic conductivity of geological material in the adjacent model cell.

A MODFLOW drain boundary was used to simulate the depressurisation drain. The drain elevation was set at the B3 basement level of -12.7 mAHD in layer 2 and 0.1 m above the base of the model cells in layer 1. The extent of the depressurisation drain is shown in red on Figure 5.1 and in yellow on Figure 5.3. A drain conductance of 100 m^2/day was assigned.

No flow (inactive) cells were assigned outside the model domain (beyond the CHB) and inside the cavern area to simulate the 'void' surrounded by a waterproof wall (indicated in black on Figure 5.3).

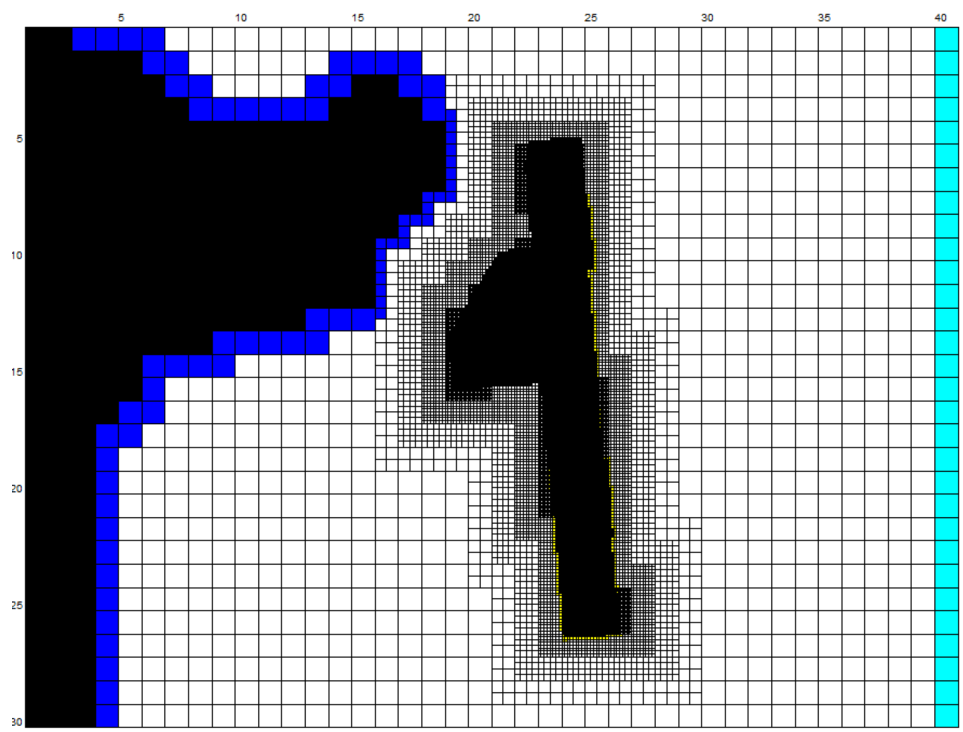


Figure 5.3 Model boundaries

SIMULATION PERIOD

The model was run in steady state for 1000 days.

5.1.2 MODEL CALIBRATION - PRE-CONSTRUCTION

The model was not calibrated as the model parameters were adopted from the HIR, however steady state groundwater levels, before the depressurisation drain and Station Cavern void were incorporated in the model (pre-construction), did correspond to the initial heads modelled by PSM. The modelled groundwater flow direction is consistent with topography and observed groundwater levels, with groundwater discharging to Sydney Harbour.

The model has a mass balance error of 0.0%, which is below the accepted threshold of 1% (Barnett et al., 2012).

5.2 MODEL RUNS AND PREDICTIONS

After the pre-construction (initial) uncalibrated model, the cavern void and depressurisation drain were added to the model. The base case model converges with an acceptably small convergence error and the model is numerically stable i.e. the simulated results are mathematically sound. The model has a mass balance error of 0.0%, which is below the accepted threshold of 1% (Barnett et al., 2012).

Figure 5.4 shows the simulated drawdown in layer 2 (Hawkesbury Sandstone).

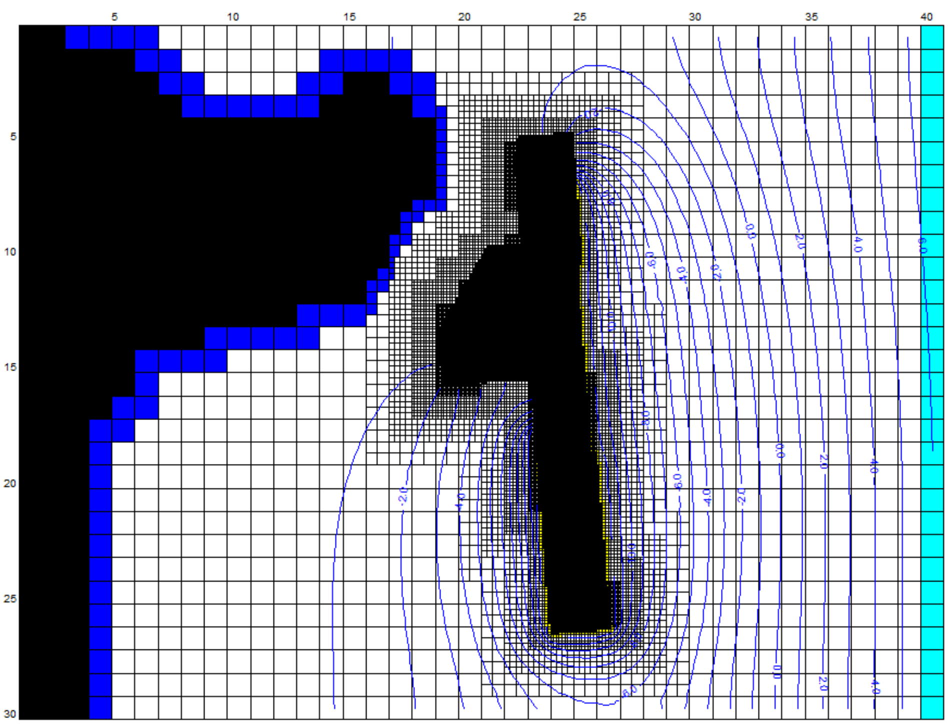


Figure 5.4 Simulated drawdown (base case) in layer 2 (Hawkesbury Sandstone)

Table 5.2 shows the modelled groundwater inflows into the depressurisation drain for the base case as well as the following sensitivity runs:

- increase hydraulic conductivity in Hawkesbury Sandstone by one order of magnitude
- increase recharge by 5%
- increase recharge by 10%.

Table 5.2 Model runs and outputs

MODEL RUN	MODELLED FLOW RATE INTO DEPRESSURISATION DRAIN (KL/DAY)		
	LAYER 1 (FILL)	LAYER 2 (HSST)[1]	TOTAL
Base case	26.4	27.0	53.4 (0.6 L/s)
Increase K[2] in Hawkesbury Sandstone by 1 order of magnitude	0.8	137.5	138.3 (1.6 L/s)
Increase recharge by 5%	26.5	27.1	53.6 (0.6 L/s)
Increase recharge by 10%	26.5	27.2	53.7 (0.6 L/s)

1. HSST = Hawkesbury Sandstone.
2. K = hydraulic conductivity.

6 NORTHERN SHAFT MODEL

A separate 3D uncalibrated model was set up to simulate inflows into the Northern Shaft (dimensions: 30 m deep, 10 m wide, 16 m long).

The simplified 1-layer model was set up with an extent of 200 by 200 m and a uniform grid with 1 m spacing. The same hydraulic properties of the Hawkesbury Sandstone as used in PSM (2018) and provided in section 5.1.1 were applied, as well as the same uniform recharge (3%; section 5.1.1). The model was run in steady state for 1000 days.

CHBs were assigned to the eastern and western model boundaries. Hydraulic heads were assigned at 5.5 m below ground level (bgl) in the east and 7.5 mbgl in the west, based on the initial heads map from PSM (2018).

To simulate inflows into the Northern Shaft, a MODFLOW drain boundary was assigned at a drain elevation of 30 m below ground level with a width of 16 m and a length of 10 m as per the shaft's dimensions. The drain conductance was set at 100 m^2/day.

Simulated drawdown for the base case scenario for the Northern Shaft is shown in Figure 6.1.

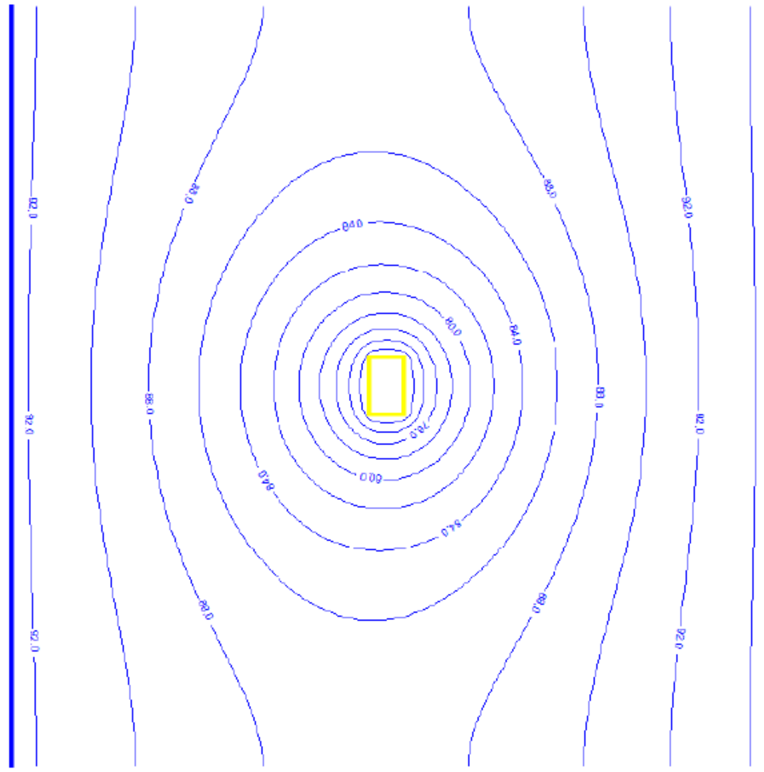


Figure 6.1 Simulated drawdown at the Northern Shaft (northern shaft shown in yellow)

Table 6.1 shows the modelled groundwater inflows into the Northern Shaft for the base case as well as the following sensitivity runs:

— increase hydraulic conductivity in Hawkesbury Sandstone by one order of magnitude

— increase recharge by 5%

— increase recharge by 10%.

Table 6.1 Model runs and outputs

MODEL RUN	MODELLED FLOW RATE INTO NORTHERN SHAFT (KL/DAY)
Base case	40.5 (0.5 L/s)
Increase hydraulic conductivity in Hawkesbury Sandstone by 1 order of magnitude	394.5 (4.6 L/s)
Increase recharge by 5%	40.6 (0.5 L/s)
Increase recharge by 10%	40.6 (0.5 L/s)

7 DISCUSSION

The modelled groundwater inflows are within the expected range indicated in Section 1. Modelled groundwater inflows for the *base case* into the B3 depressurisation drain are 0.6 L/s and into the Northern Shaft 0.5 L/s.

Sensitivity analysis indicates that an increase in recharge of up to 10% has a negligible effect on groundwater inflows, while increasing the hydraulic conductivity of the Hawkesbury Sandstone bedrock by one order of magnitude increases groundwater flows into the B3 depressurisation drain to 1.6 L/s and the Northern Shaft to 4.6 L/s.

Given the need to have the capacity of the wastewater treatment plant sufficient to allow for large and unforeseen groundwater inflows, it is recommended the larger inflow rates be considered (that is, B3 depressurisation drain inflow rate of 1.6 L/s (138.3 kL/day) and the Northern Shaft inflow rate of 4.6 L/s (394.5 kL/day)).

It should also be noted that there is some uncertainty in the location and hydraulic properties of the Luna Park Fault Zone in relation to the Northern Shaft. Based on a comparison with the measured peak seepage inflows of 369 kL/day (BESIXWatpac provided spreadsheet “Groundwater Results – Barangaroo”), it can be assumed that the higher hydraulic conductivity scenario for the Northern Shaft has sufficiently captured this uncertainty in inflows.

Another note should be made regarding the waterproofing. Although this is assumed to create an impermeable barrier to groundwater flow, some minor leakage may be expected.

8 REFERENCES

— Barnett et al (2012). Australian groundwater modelling guidelines, Waterlines report, National Water Commission, Canberra.

— NSW Government’s Spatial Services, a unit of Department of Customer Service (2021). Digital Elevation model (DEM), Capture date: 2020-06-14.

— Panday, S., Langevin, C. D., Niswonger, R. G., Ibaraki, M., & Hughes, J. D. (2013). MODFLOW–USG Version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation. U.S. Geological Survey.

— Pells Sullivan Meynink (PSM) (2018). Hydrogeological Interpretive Report (HIR), on behalf of the John Holland CPB Ghella Joint Venture (JCG), for the Sydney Metro Project.

— State of New South Wales and Department of Regional NSW (2020). Geological Survey of NSW, NSW Seamless Geology version 2.

9 MODEL ASSUMPTIONS AND LIMITATIONS

This Report is provided by WSP Australia Pty Limited (WSP) for BESIXWatpac (Client) in response to specific instructions from the Client and in accordance with WSP's proposal and agreement with the Client (Agreement).

9.1 MODEL ASSUMPTIONS

The groundwater flow model simulates a simplified version of a complex geological and hydrogeological system. This simplification is required to allow the model to be run and utilised within a reasonable timeframe. Further, the model assumptions that were incorporated were deemed appropriate and acceptable given the purpose of the model (i.e. to develop a model to simulate inflows into the B3 depressurisation system and the Northern Shaft). In this context, the assumptions made are considered to be conservative in respect of the scale of the groundwater impacts that are predicted (i.e. the assumptions, when compounded, would tend to overestimate the scale of the impact).

A summary of the assumptions incorporated into the model, and their resulting limitations, include:

— The model is based on the conceptual hydrogeological model in Section 4.

— The groundwater model has drawn on groundwater level and hydraulic property data available for the Sydney Metro project for Barangaroo Station (PSM, 2018), which is considered to provide a good indication of values as these are located in the same hydrogeological environment.

— The number of layers within the model has been limited to two. Vertical discretisation of the model layers is deemed appropriate and reasonable for the purpose of determining the likely groundwater seepage inflows.

9.2 PERMITTED PURPOSE

This Report is provided by WSP for the purpose described in the Agreement and no responsibility is accepted by WSP for the use of the Report in whole or in part, for any other purpose (*Permitted Purpose*).

9.3 QUALIFICATIONS AND ASSUMPTIONS

The services undertaken by WSP in preparing this Report were limited to those specifically detailed in the Report and are subject to the scope, qualifications, assumptions and limitations set out in the Report or otherwise communicated to the Client.

Except as otherwise stated in the Report and to the extent that statements, opinions, facts, conclusion and / or recommendations in the Report (*Conclusions*) are based in whole or in part on information provided by the Client and other parties identified in the report (*Information),* those Conclusions are based on assumptions by WSP of the reliability, adequacy, accuracy and completeness of the Information and have not been verified. WSP accepts no responsibility for the Information.

WSP has prepared the Report without regard to any special interest of any person other than the Client when undertaking the services described in the Agreement or in preparing the Report.

9.4 USE AND RELIANCE

This Report should be read in its entirety and must not be copied, distributed or referred to in part only. The Report must not be reproduced without the written approval of WSP. WSP will not be responsible for interpretations or conclusions drawn by the reader. This Report (or sections of the Report) should not be used as part of a specification for a project or for incorporation into any other document without the prior agreement of WSP.

WSP is not (and will not be) obliged to provide an update of this Report to include any event, circumstance, revised Information or any matter coming to WSP's attention after the date of this Report. Data reported and Conclusions drawn are based solely on information made available to WSP at the time of preparing the Report. The passage of time; unexpected variations in ground conditions; manifestations of latent conditions; or the impact of future events (including (without limitation) changes in policy, legislation, guidelines, scientific knowledge; and changes in interpretation of policy by statutory authorities); may require further investigation or subsequent re-evaluation of the Conclusions.

This Report can only be relied upon for the Permitted Purpose and may not be relied upon for any other purpose. The Report does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment, divestment, financial commitment or otherwise. It is the responsibility of the Client to accept (if the Client so chooses) any Conclusions contained within the Report and implement them in an appropriate, suitable and timely manner.

In the absence of express written consent of WSP, no responsibility is accepted by WSP for the use of the Report in whole or in part by any party other than the Client for any purpose whatsoever. Without the express written consent of WSP, any use which a third party makes of this Report or any reliance on (or decisions to be made) based on this Report is at the sole risk of those third parties without recourse to WSP. Third parties should make their own enquiries and obtain independent advice in relation to any matter dealt with or Conclusions expressed in the Report.

9.5 DISCLAIMER

No warranty, undertaking or guarantee whether expressed or implied, is made with respect to the data reported or the Conclusions drawn. To the fullest extent permitted at law, WSP, its related bodies corporate and its officers, employees and agents assumes no responsibility and will not be liable to any third party for, or in relation to any losses, damages or expenses (including any indirect, consequential or punitive losses or damages or any amounts for loss of profit, loss of revenue, loss of opportunity to earn profit, loss of production, loss of contract, increased operational costs, loss of business opportunity, site depredation costs, business interruption or economic loss) of any kind whatsoever, suffered on incurred by a third party.

[redacted]
Associate hydrogeologist

[redacted]
Principal hydrogeologist and Groundwater Team Manager