WALSH BAY ARTS AND CULTURAL PRECINCT

STATE SIGNIFICANT DEVELOPMENT APPLICATION

SSDA 8671

APPENDIX 13:

INTEGRATED WATER MANAGEMENT PLAN

Walsh Bay Arts and Cultural Precinct – Integrated Water Management Plan

Contents

1. Objectives of the report

1.1 Introduction

The NSW Government is committed to development of a public arts and cultural precinct at Walsh Bay. Infrastructure NSW is acting on behalf of the client, Arts, Screen and Culture Division in preparing a State Significant Development Application for the Walsh Bay project (Walsh Bay Arts and Cultural Precinct 'WBACP').

This SSDA will seek approval for the construction and operation of Pier 2/3 and Wharf 4/5 for arts and cultural uses with complementary commercial and retail offerings to activate the precinct.

The site generally comprises Pier 2/3, Wharf 4/5, and Wharf 4/5 Shore Sheds. The site has a street frontage to Hickson Road. The site is part of the Walsh Bay area, which is located adjacent to Sydney Harbour within the suburb of Dawes Point.

The Scope of the Project is as follows:

Pier 2/3

- The adaptive re-use providing for new arts facilities including performance venues for the Australian Chamber Orchestra, Bell Shakespeare and Australian Theatre for Young People.
- Retaining a large heritage commercial events/art space for events such as Sydney Writers Festival, Biennale of Sydney and a wide range of commercial and artistic events.
- A series of stairs, external lift and balconies designed as a contemporary interpretation of the original gantries reflecting the precinct's former industrial heritage.
- Modifications to the roof.

Wharf 4/5 (including Shore Sheds)

- Refurbishment of the ground floor arts facilities and its associated Shore Sheds for Bangarra Dance Theatre, Sydney Dance Company, Sydney Philharmonia, Gondwana and Song Company.
- New commercial retail opportunities.
- A series of stairs, external lifts and balconies designed as a contemporary interpretation of the original gantries reflecting the precinct's former industrial heritage.
- Modifications to the roof.
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1.2 Purpose of this Report

Jacobs has been engaged by Infrastructure NSW (INSW) to undertake an Integrated Water Management Plan in accordance with the Secretary's Environmental Assessment Requirements (SEARs), issued 1 September 2017. The SEARs and Stage 1 State Significant Development Application (SSDA) Concept Approval Conditions of Consent relevant to this specialist paper and where they have been addressed in the report are summarised in Table 1.

Table 1: Summary of SEARs relevant to this specialist working paper

SEARs No.	SEARs requirement	Where addressed
13	Water, Drainage, Stormwater and Groundwater Prepare an Integrated Water Management Plan, detailing stormwater and wastewater management, including any re-use and disposal requirements, drainage concept for the site, demonstration of water sensitive urban design and any water conservation measures, and identification of any appropriate water quality management measures. Detail potential impacts on groundwater (if any).	This Working Paper
20	Flooding, Climate Change and Sea Level Rise Address the potential risks from flooding, wave movements and sea level rise on the development and detail any proposed mitigation measures.	• Drainage concept – provided in Sections 6.3.1. • Potential flooding risks – discussed in Section 6.3.2. • Potential impacts on groundwater environment – discussed in Section 7. • Potential wave movements and sea level rise risks discussed in Maritime Impact Assessment Working Paper.

1.3 Report structure

This Working Paper is the Integrated Water Management Plan that will be used to support the preparation of the EIS required under Part 4.1 of the EP&A Act. The structure of the report is summarised in Table 2.

Table 2: Report structure

Section reference	Section heading	Description
1	Objectives of report • Introduction • IWCM context • Report structure	Outlines the objectives, context and structure of the Integrated Water Management Plan.
2	Site and Project Description • The Site and surrounds • The Project	Provides an overview of the Project Site and the Project itself.
3	Site Analysis • Catchment content • Existing services • Design standards • Design criteria • Ecological Sustainable Development principles	Provides an overview of aspects of the Site and Project design specific to the Integrated Water Management Plan.
4	Assessment requirements	Sets out the drivers for the work undertaken in the development of the integrated water management strategy
5	Integrated Water Management Plan development • Options assessment • Key assumptions • Integrated water management options and preferred option	Provides an overview of the approach, outlines the key assumptions, the process of the development of the strategy and provides the water balance modelling results.
6	Final Integrated Water Management Plan • Water Supply • Wastewater management • Stormwater and drainage	Outlines the final Integrated Water Management Plan proposed for the Project, including the WSUD elements incorporated. Also outlines the potential flooding risks.
7	Groundwater • Existing groundwater environment • Potential groundwater impacts	Provides an overview of the existing groundwater environment and outlines the potential impacts to groundwater from the WBACP redevelopment.
8	References	

1.4 Existing Conditions

Integrated Water Cycle Management (IWCM) is the integrated management of water supply, sewerage and stormwater services within a whole of catchment context. The three components of urban water – potable water, sewage and stormwater – share common issues, as well as individual problems. IWCM promotes the holistic management of these services, which saves resources and improves outcomes for the environment. The integration of the systems is demonstrated pictorially in Figure 1.

In considering the opportunities for IWCM in the redevelopment of the WBACP, it is acknowledged that the WBACP is dealing with an unconventional catchment environment. The "catchment" is entirely impervious and consists of over-water concrete wharves and impervious roof areas, and runoff from the catchment proceeds immediately to the harbour receiving water environment. The environment is also highly constrained, both from a space perspective, where infrastructure for managing the water cycle is required to occupy over-water space and a heritage perspective, where significant changes to the structure and facades of the built environment need to be consistent with the heritage values of the precinct.

Nonetheless, there are still many opportunities to improve water cycle outcomes in terms of reducing the amount of water imported to the site, reducing the volume of wastewater to be exported from the site and improving the quality of stormwater runoff. These options will be explored in this investigation.

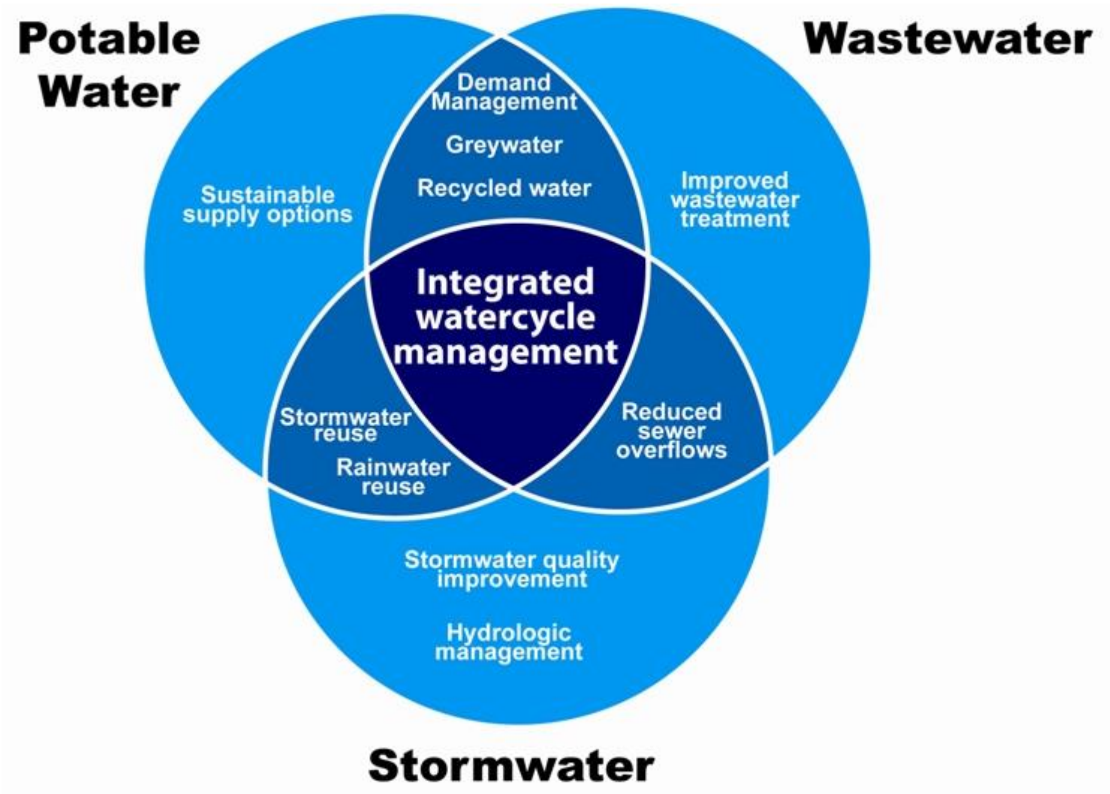

Figure 1: Principles of IWCM showing the links between potable water, sewage and stormwater

2. Site and Project Descriptions

2.1 The Site and surrounds

The Walsh Bay Arts and Cultural Precinct (WBACP) (the "site") generally comprises Pier 2/3, Pier 4/5 and its shore sheds which make up Wharf 4/5, as well as the adjoining waterway. The site has a street frontage to Hickson Road. The site is shown in Figure 2. The site is part of the Walsh Bay area which is located adjacent to Sydney Harbour within the suburb of Dawes Point. The site is located within the City of Sydney Local Government Area.

Walsh Bay is strategically located to the north of Sydney's CBD in the vicinity of major tourist destinations including the Sydney Harbour Bridge, the historic areas of Millers Point and The Rocks, Circular Quay and the Sydney Opera House. The Barangaroo redevelopment precinct is located immediately to the south-west.

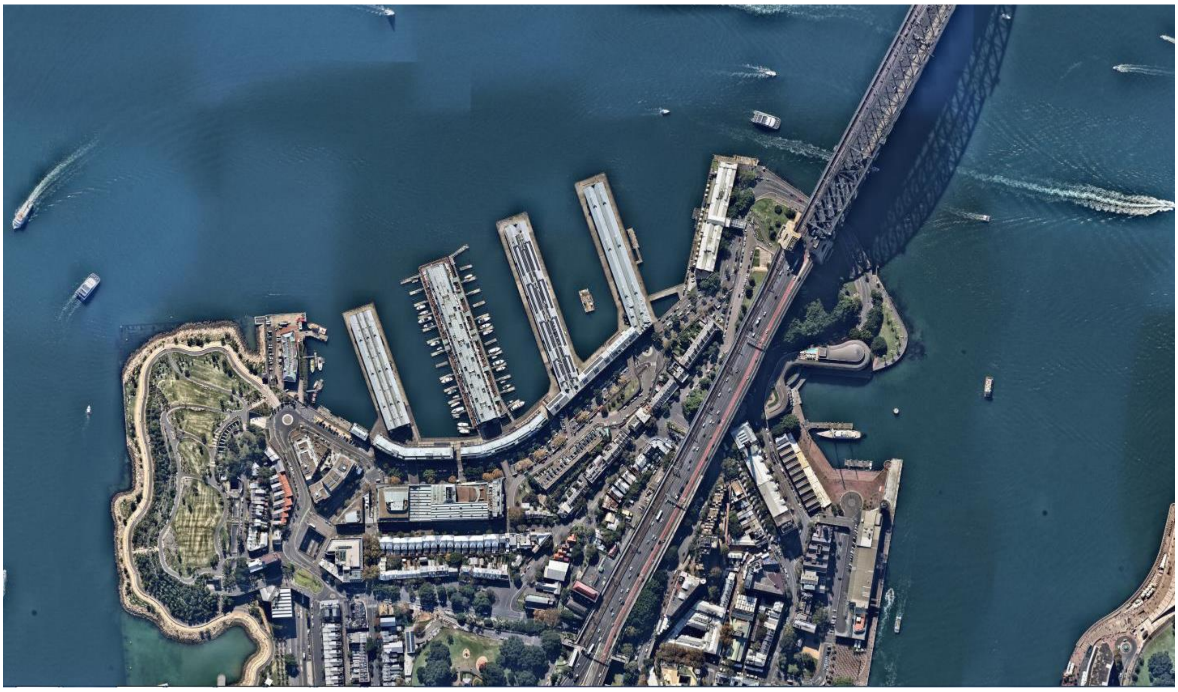

Figure 2: Aerial view of the site (Source: www.nearmap.com)

Pier 2/3 is legally described as Lot 11 in DP 1138931 and Wharf 4/5 is legally described as Lot 65 in DP 1048377. The total area for these lots is 18,090sqm.

The land owner of the site is the Roads and Maritime Services (RMS). Both Pier 2/3 and Wharf 4/5 are occupied under various lease arrangements with Create NSW (formerly Arts NSW), Department of Justice, primarily for arts and cultural uses.

The area of water that the project proposes to build over is also owned by RMS. Its land title description is Lot 12 in DP 1138931.

Walsh Bay comprises ten berths constructed between 1908 and 1922 for international and interstate shipping. These are collectively known as the Walsh Bay Wharves. The Walsh Bay Wharves Precinct is listed as an item on the State Heritage Register.

The Walsh Bay Wharves comprise the following:

- Pier One which contains the Sebel Pier One Sydney Hotel;

- Pier 2/3 the last remaining undeveloped pier (has previously received approval for cultural uses, temporary arts events and some commercial events);
- Wharf 4/5 which is occupied by the Sydney Theatre Company (STC), the Australian Theatre for Youth Program (ATYP), Sydney Dance Company (SDC), Bangarra Dance Theatre and the choirs comprising Gondwana, the Song Company and Sydney Philharmonia;
- Pier 6/7 which has been redeveloped for residential apartments and associated boat marina;
- Pier 8/9 which has been redeveloped for office uses; and,
- Shore sheds aligning Hickson Road which contain a range of commercial activities, including restaurants, bars, shops and offices.

2.2 The Project

The combined Pier 2/3, Wharf 4/5 application will seek consent for the following:

<u>Early works</u>
Early construction works comprising infrastructure upgrades, demolition, hazmat removal and sub structure works.

<u>Pier 2/3</u>

- Internal alterations and reconfiguration to provide for the following:
  - Performance venues;
  - Rehearsal rooms, production workshops, back of house facilities and offices;
  - Function spaces, bars, cafes and foyer spaces extending onto external gantry platforms (balconies) providing breakout space for internal foyers and allowing views of outdoor performances;
  - Construction of some mezzanine spaces for offices and back of house facilities;
  - Upgrading of some walls to meet the requirements of Section J of the BCA;
  - Removal of some storey posts and beams to facilitate internal reconfiguration/new uses; and
- Retention of a large proportion of the ground floor in its existing ‘raw’ heritage state for venue commercial hire and continuation of events and festivals including Sydney Writers’ Festival and Biennale. External alterations and additions comprising:
  - Raised roofs within central valley of Pier 2/3;
  - New balconies and external stairs for fire egress;
  - Installation of glazing in existing cargo sliding doors and other solid panels on the eastern, western and northern elevations to allow for views into and out of the building. The glazing is to be installed mostly consistent with the building’s exisiting chequerboard pattern.
  - Raising of the floor level on the eastern side by introducing a new raised deck and continuous set of stairs beyond the existing column line.
  - External lift western side of Pier 2/3
  - Installation of solar photovoltaic panels to roof.

- Installation of roof plant platform in roof valley.

Wharf 4/5

- Internal alterations and reconfiguration to the Bangarra Dance Theatre (BDT) tenancy to provide for the following:
    - Upgrade of the main rehearsal and performance spaces to provide improved daylight and natural ventilation;
    - Upgraded foyer/exhibition space along the eastern frontage;
    - Improved office space at mezzanine level including a new lift;
    - Provision of a function space at ground level of the northern end of wharf;
    - New entrance to BDT and new glazing in bays of sliding cargo doors, opening up the foyer and main studio to Wharf 4 apron.
- Minor internal alterations and additions to the SDC tenancy comprising:
    - Reducing the existing workshop space to create a fifth dance studio; and
    - Upgrading office and reception areas.
- External alterations and additions to SDC tenancy comprising:
    - Raising of the timber wharf deck adjoining the SDC café and opening of the facade with new glazing.
- External fabric alterations around the Sydney Theatre Company (STC) tenancy comprising:
    - Improved street entry at Hickson Road involving relocation of the stairs to allow for an improved landing and point of arrival to the STC;
    - New ‘gantry’ balconies, stairs and lifts mid-wharf and at the end of the wharf to provide for improved accessibility and compliance with fire engineering solutions;
    - Minor amendments to the existing façade to accommodate new entries and exits along the wharf; and
- Lifting the roof valley above the workshop roof to allow for flexibility in set design and above Wharf 1 theatre to improve the audience viewing experience.

Wharf 4/5 Shore Sheds

- Relocation of choir rehearsal spaces;
- Creation of new commercial tenancies at ground and mezzanine levels;
- Creation of a plant and services room and switch room; and
- Provision of office space at ground level.

3. Site analysis

3.1 Catchment context

The site is adjacent to, and is in part suspended above, Walsh Bay which forms part of Sydney Harbour. The site is predominantly sealed, covered in concrete footpaths, over which surface water generated by rainfall runs directly into the harbour. Hence, the WBACP does not utilise the City of Sydney's stormwater network to dispose rainfall runoff from the site.

The WBACP is accessible from Hickson Road which may be subject to flooding during storm events where flows exceed the capacity of the stormwater pipes. Flood behaviour on Hickson Road was assessed by BMT WBM for the City of Sydney in 2014 as part of the study entitled "*City Area Catchment Flood Study"*.

3.2 Existing services

3.2.1 Pier 2/3

The existing Pier 2/3 building is provided with water and drainage services. The building is provided with an existing roof drainage system currently utilising valley gutters and box gutters which are directed to the down pipes on the western elevation (Arup, 2016a).

3.2.2 Wharf 4/5

The existing building on Wharf 4/5 is fully serviced with hydraulic services. This includes an approximately 12 year old rainwater collection system with a storage capacity of 100 kilolitres. The rainwater system performs well with the only issue being the need for regular maintenance to clear out stormwater debris (Arup, 2016a).

The rainwater collection system is described in more detail in Section 6.1.3.

According to the water bills received from July 2015 to July 2016, Wharf 4/5 currently uses approximately 16 kilolitres of potable water per year.

3.3 Design standards

The stormwater drainage network will be designed generally in accordance with the following standards and guidelines:

- *Australian Rainfall and Runoff* (2016);
- *NSW Floodplain Development Manual* (2005);
- Relevant City of Sydney Council Policies;
- *AS3500.3: Plumbing and Drainage – Stormwater Drainage* (2013);
- *Managing Urban Stormwater – Harvesting and Reuse* (2006);
- *Managing Urban Stormwater – Soils and Construction Volume 1, 4th Edition* (2004).

3.4 Design criteria

According to Arup (2016a), the hydraulic system for the WBACP will meet the design criteria provided in Table 3 in accordance with industry practice.

Table 3: Design criteria for relevant hydraulic services system components (source: Arup, 2016)

Item	Parameter
Rain water intensity	270mm/hr– 5min 1:100 year event for internal box gutters. External eaves gutters will be provided to cater for a 1:20 year event.
Working velocities in water services pipes	Max 2.4m/s depending on noise sensitivity of area
Maximum operational water pressure	500kPa
Minimum operational water pressure	250kPa
Cold water average supply temperature	10ºC
Velocities within drainage systems	Self-cleansing velocities between 0.75m/s and 1.5l/s

3.5 Sustainability Framework

A Sustainability Framework has been completed for the Concept Design phase of the WBACP (Arup, 2016b). The Framework outlines seven key principles for addressing environmental sustainability in the design and function of the WBACP:

- Energy and carbon
- Collecting, minimising and re-using water
- Sustainable materials
- User comfort and wellbeing
- Sustainable transport
- Sustainable in operation
- Social and community engagement.

The ESD strategy for water outlined in the Sustainability Framework involves the responsible reduction of potable water consumption, and where possible increasing the quality of water in the surrounding harbour (Arup, 2016). The following design recommendations were made in the Framework as part of the ESD strategy for water:

- Specification of water efficient fixtures to all fittings (including retrofits), for example:
  - 3 L/half flush, 4.5L/ full flush toilets
  - 1 L/flush urinals
  - 4.5 L/min taps
  - 7.5 L/min showers.
- Provision of a harbour heat rejection system.
- Provision for a rainwater tank and infrastructure to Pier 2/3 to facilitate the potential installation of a storage tank
- Use of solar hot water.

4. Assessment requirements

The plan for integrated water management considers operation of a sustainable and activated cultural and creative precinct with variable performer, staff and visitor levels during the day and evening. The development of an integrated water management plan for the redevelopment requires the consideration of all sources of water and all uses of water in a total catchment context. As such an integrated water management plan will consider the management of the three streams of the water cycle:

- Water supply.
- Wastewater.
- Stormwater.

In considering a redevelopment such as the WBACP, there are no specific legislative or regulatory requirements that relate to the integrated water management plan, although there are requirements that relate to the development of infrastructure in each of the three water streams above. Therefore this working paper will not be considering any specific requirements.

It is however understood that any modification of land use through redevelopment may have adverse environmental impacts relating to the water cycle. For the proposed WBACP which is a relatively low-intensity, urban redevelopment on the water these are:

- The concentrated demand for water leads to the requirement to import potable water onto the site.
- The concentrated point-source generation of wastewater leads to highly polluted and nutrient-laden volumes of water that is unsuitable for discharge to the environment without treatment.
- The coverage of the site with significant amounts of impervious surface results in:
  - Increases to the volume and intensity of stormwater runoff.
  - Increases to the pollutant and nutrient content of stormwater discharges due to the accumulation of litter and urban fallout on surfaces.

In current best practice water cycle management, it is appropriate to examine each of these impacts and examine a range of integrated water management options before arriving at a preferred integrated water management strategy.

5. Integrated Water Management Plan development

5.1 Overview of approach

5.1.1 Options considered

The IWCM options have been assessed in two stages:

1) Coarse screening of available options – where options that are considered unfeasible due to site constraints are ruled out from further consideration; and

2) Water balance assessment of short listed options.

The site constraints considered in the coarse screening include:

- Small site footprint – limited space for landscaping, onsite treatment facilities and storage areas, etc.
- Location – sited in a highly developed urban landscape on a busy working harbour.
- High heritage values associated with the site.

Most “at source” Water Sensitive Urban Design (WSUD) options will not be practical due to cost, space and heritage considerations. Specific options not considered include:

- Stormwater Quality Improvement Devices for existing wharf areas – these would require either large numbers of devices to capture runoff from multiple points or the re-profiling of wharf surfaces to re-direct runoff. The wharf structure would also require modification to allow servicing from the wharf.
- Engineered wetlands or biofiltration facilities – these options require significant areas of open water and/or vegetation that cannot be practically provided.

In the development of the integrated water management plan, there were a range of options that were considered. These are set out in Table 4 below.

Table 4: Outline and course screening of potential water cycle management options

Water Cycle Management Option	Target Issue	Other Benefits	Potential Limitations	Considered as an IWCM Option
Water efficient fixtures and appliances	Reducing water use	• Reduces water and energy (hot water and water pumping) usage • Reduces the need for water system amplification • Reduces the volume of exported wastewater	• None	Yes
Waterless Urinals	Reducing water use	• Reduces water and energy (water pumping) usage • Reduces the need for water system amplification • Reduces the volume of exported wastewater	• Maintenance	Yes
Recycled wastewater for non-potable uses: • Cooling towers • Toilet/urinal flushing • Irrigation	Reducing water use	• Reduces the volume of exported wastewater	• Cost and footprint for on-site wastewater treatment facilities	No
Roof water harvesting	Reducing water use	• Improves stormwater quality • Reduces stormwater runoff	• Space for location of storages	Yes
Stormwater harvesting	Reducing water use	• Reduces stormwater runoff • Improves stormwater quality	• Limited storage space on site • Difficulty in capturing runoff from wharf areas	No

Water Cycle Management Option	Target Issue	Other Benefits	Potential Limitations	Considered as an IWCM Option
Green Roofs	Improving stormwater quality	• Mitigates urban heat island effect	• Heritage issues • Maintenance • Interaction with roof-top solar systems	No
Engineered wetlands	Improving stormwater quality	• Mitigates urban heat island effect • Improves public open space and amenity	• Land area required	No
At-source WSUD: • Drainage swales • Biofiltration swales • Infiltration trenches • Permeable pavings • Gross Pollutant Traps	Improving stormwater quality	• Improves stormwater quality • Reduces stormwater runoff • Mitigating heat island effect from roads and buildings	• Cost Land area available	Yes – but limited capacity to implement options – see explanation above.

5.1.2 Water balance modelling approach

To undertake the water balance comparison the Jacobs IWMSim model (an integrated water cycle water balance model) was used. The model:

1) Is designed to simulate the operation of all parts of an integrated water system including water demands (seasonal and non-seasonal), wastewater flows (dry weather and wet weather) and stormwater flows.

2) Utilises actual water and wastewater system data to generate demands and flows, so that the supply and demand patterns so critical to understanding urban water balances are precisely simulated.

3) Uses a unique monte-carlo simulation of large numbers of virtual water uses. Each group of users has specified “end-uses” of water that can be supplied from either the potable supply, rainwater, recycled wastewater or recycled stormwater. Each virtual user exhibits individual probabilistic behaviour driven by varying water use behaviour.

Stormwater flows are generated within IWMSim using the SimHyd hydrological model. The overall structure of the model is shown in Figure 3.

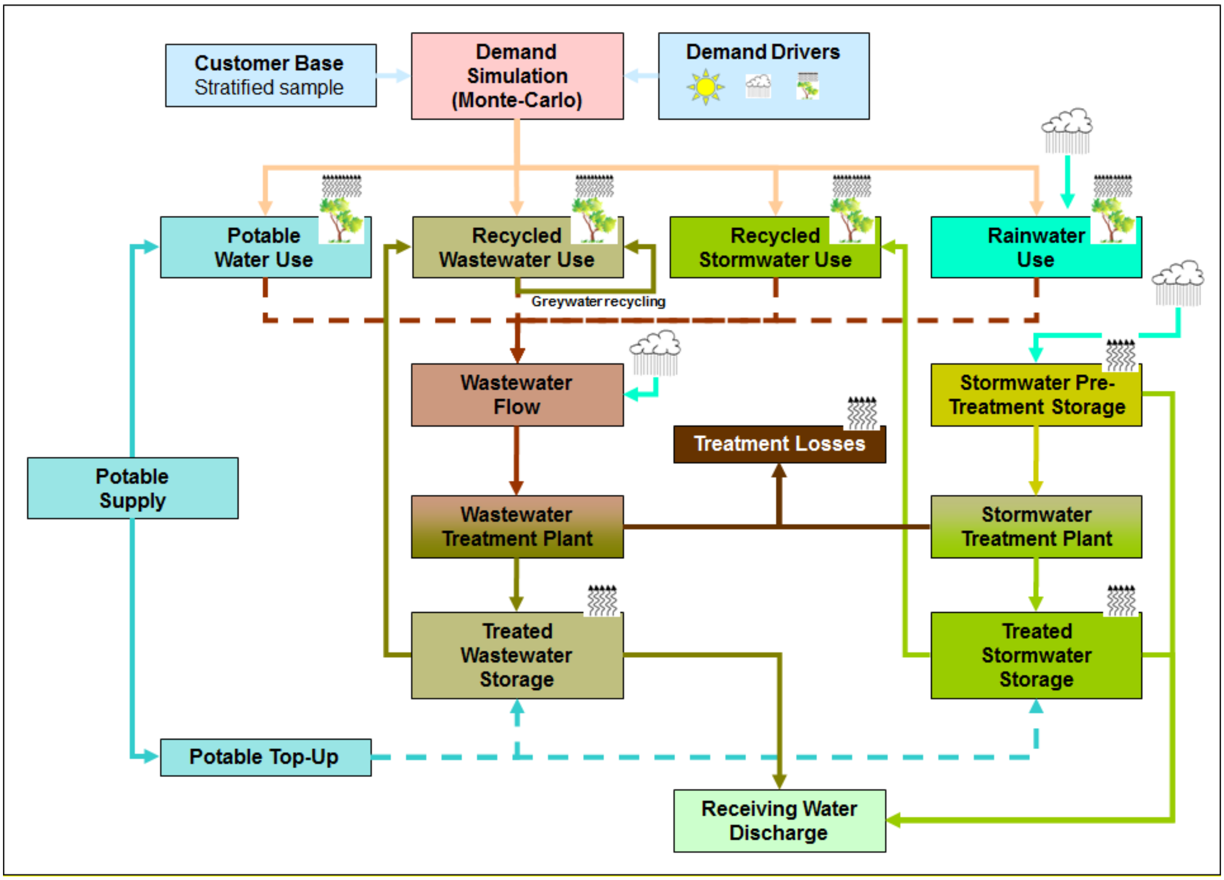

Figure 3: IWMSim model structure

Water uses in the model are divided into those generating wastewater flows, and those not. Each water use is assigned a demand pattern.

5.2 Key assumptions

As mentioned above, the development of a water cycle requires the consideration of all sources and uses of water. To do this, estimates of different water end uses are required for the WBACP.

A number of steps were undertaken to generate these water use demands:

1) WBACP peak populations were provided for patrons, staff and performance participants. These three population types were further disaggregated into different occupant categories:

   - permanent staff
   - performers
   - performance support staff
   - performance visitors
   - dance studio visitors
   - function staff
   - function visitors.

   and the following parameters were set for each occupant category:

- an average demand factor, which was generated based on a specific time-period in the week i.e. Monday to Friday (day); Friday and Saturday (night); Saturday and Sunday (day); and Sunday to Thursday (night).
- the daily water use per person was calculated based on the estimates of the frequency of different types of water use of water efficient fixtures (toilets, urinals, hand basins and showers) provided in Section 3.5, as well as the application of the Best practice guidelines for water efficiency in clubs (Sydney Water, 2009).

2) The daily water demands for the different occupant categories were generated for each day of the week from peak population numbers (provided), as well as the average demand factor and daily water use per person estimated above.

The total daily water demands for each day of the week are shown in Table 5.

Table 5: Total typical daily water demand by week day[1]

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Weekly
Pier 2/3								
Daily water demand (L)	29,027	29,027	29,027	29,027	42,124	61,376	48,279	267,885
% of demand	10.8%	10.8%	10.8%	10.8%	15.7%	22.9%	18.0%	100.0%
Pier 4/5								
Daily water demand (L)	15,537	15,537	15,537	15,537	13,945	13,820	15,412	105,324
% of demand	14.8%	14.8%	14.8%	14.8%	13.2%	13.1%	14.6%	100.0%
Shore Sheds								
Daily water demand (L)	24,247	24,247	24,247	24,247	43,780	58,599	39,066	238,435
% of demand	10.2%	10.2%	10.2%	10.2%	18.4%	24.6%	16.4%	100.0%
Total WBACP								
Daily water demand (L)	68,810	68,810	68,810	68,810	99,849	133,796	102,757	611,644
% of demand	11.9%	11.9%	11.9%	11.9%	15.8%	20.2%	16.3%	100.0%

The daily average water demands for different water uses (i.e. toilets, urinals, hand basins, showers, catering and laundry) were generated for the different occupants at the site based on the varying daily water demand throughout the week. The total daily average water demands for each water use are shown in Table 6.

[1] These figures are for typical day to day operation and do not include the impact of special events

Table 6: Total daily average water demand by water use[2]

	Toilets	Urinals	Hand Basin	Shower	Catering	Laundry	Total
Pier 2/3							
Daily water demand (L)	13,970	1,963	4,967	921	16,448	200	38,469
% of demand	36.3%	5.1%	12.9%	2.4%	42.8%	0.5%	100%
Pier 4/5							
Daily water demand (L)	4,485	450	1,595	2,138	6,379	400	15,446
% of demand	29.0%	2.9%	10.3%	13.8%	41.3%	2.6%	100%
Shore Sheds							
Daily water demand (L)	13,514	2,290	4,805	-	13,454		34,062
% of demand	39.7%	6.7%	14.1%	0.0%	39.5%	0.0%	100%
Total WBACP							
Daily water demand (L)	31,969	4,702	11,367	3,059	36,281	600	87,978
% of demand	36.3%	5.3%	12.9%	3.5%	41.2%	0.7%	100%

The water balance modelling was based on all the built structures which contained permanent water services within the redevelopment, including Pier 2/3, Pier 4/5 and the Shore Sheds. The public domain area was excluded due to the lack of water services present.

Additional water balance assumptions are outlined in Table 8 below.

Table 8: Additional water balance modelling assumptions

Parameter	Value Used
Roof area – Pier 2/3 (m^2)	5,500
Roof area – Pier 4/5 (m^2)	5,745
Rainwater tank size - Pier 2/3 (kL)	85
Rainwater tank size - Wharf 4/5 (kL)	100.2

Total WBACP water use breakdowns for occupant categories and water uses are provided in Figures 4 and 5, respectively.

[2] These figures are for typical day to day operation and do not include the impact of special events

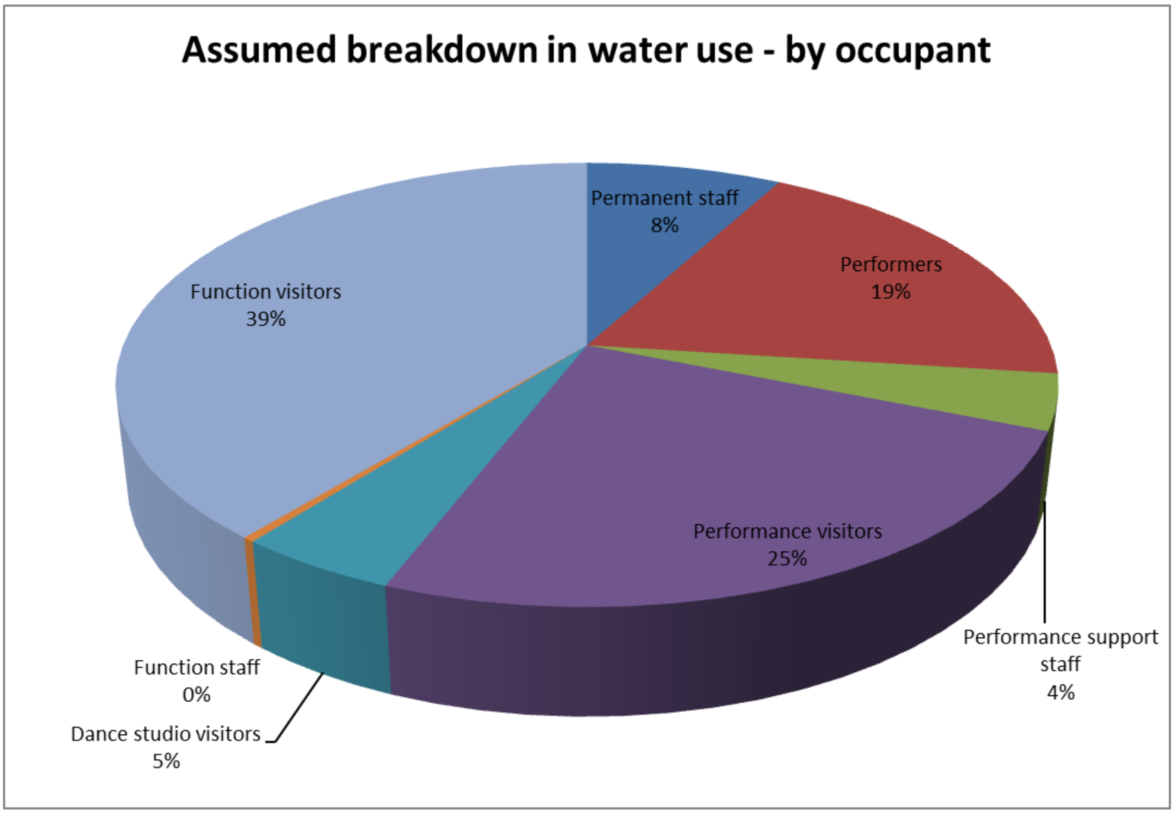

Figure 4: Assumed breakdown in total WBACP water use - by occupant

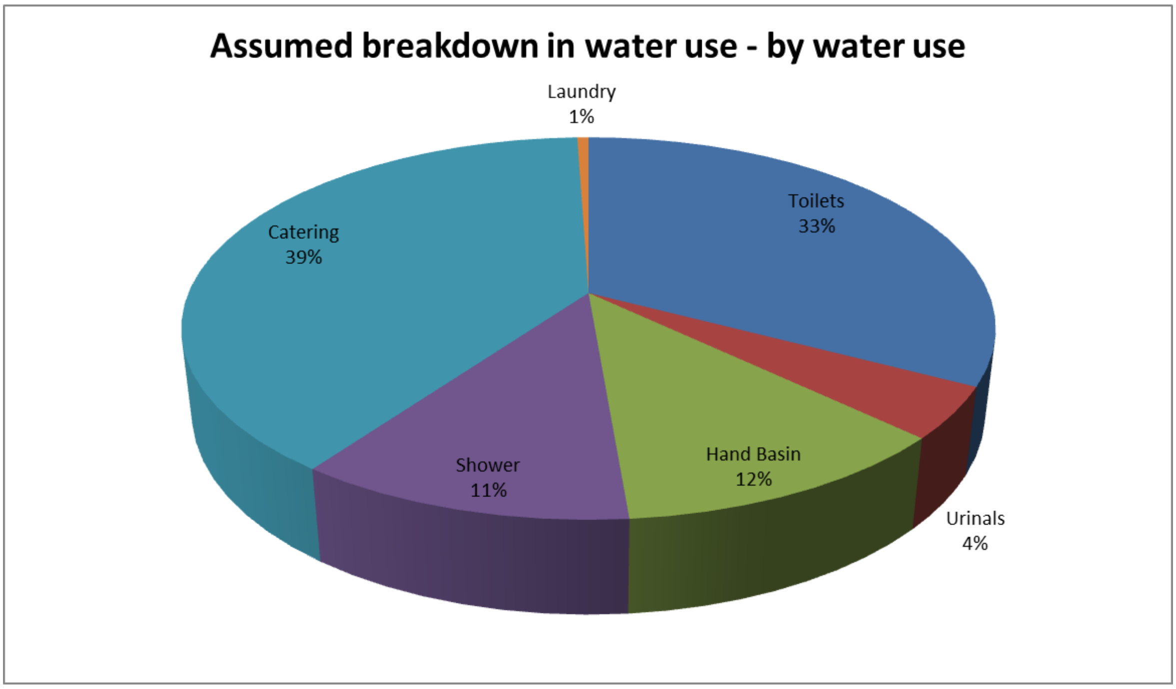

Figure 5: Assumed breakdown in total WBACP water use - by water use

5.3 Integrated water management options and preferred option

The list of potential integrated water management options considered in the water balance modelling are shown in Table 9. The standard redevelopment scenario includes the use of water efficient fixtures and appliances such as low flush toilets and urinals and flow-regulated kitchen rinse nozzles and bathroom taps. Where dishwashing and clothes washing machines are utilised, these are assumed to be water efficient.

Table 9: Potential water cycle management options

Water Cycle Management Option	Scenario 1 – Standard Redevelopment	Scenario 2 – Rainwater Harvesting on Wharf 4/5 only (existing)	Scenario 3 – Rainwater Harvesting on Pier 2/3 and Wharf 4/5	Scenario 4 – Rainwater Harvesting on Wharf 4/5 only and Waterless Urinals in new Pier 2/3 facilities	Notes
Water efficient fixtures and appliances	Yes	Yes	Yes	Yes	Standard approach in modern building design
Waterless Urinals	No	No	No	Yes: (new Pier 2/3 facilities only)	May be part of a package of more water efficient fixtures and appliances.
Roof water harvesting	No	Yes: Toilet and urinal flushing in Wharf 4/5 only	Yes: Toilet and urinal flushing in Pier 2/3 and Wharf 4/5	Yes: Toilet and urinal flushing in Wharf 4/5 only	Preferred over stormwater harvesting due to better water quality and reduced need for treatment.

Water balance outcomes were modelled using the IWMSim model outlined above. Summary results are provided in Table 10 below.

Scenario 3 (rainwater harvesting on Pier 2/3 and Wharf 4/5) is the preferred approach due to the maximisation of rainwater reuse onsite, reduction in stormwater runoff (and improvement in its quality) and the reduced need for imported potable water. However, if the installation of a rainwater harvesting system on Pier 2/3 is considered unfeasible due to cost, it is recommended that waterless urinals be installed in the new Pier 2/3 facilities (Scenario 4). The installation of waterless urinals will help reduce potable water demand and wastewater flows.

Table 10: Water cycle water balance outcomes

Parameter	Scenario 1 – Traditional Redevelopment	Scenario 2 – Rainwater Harvesting on Wharf 4/5 only (existing)	Scenario 3 – Rainwater Harvesting on Pier 2/3 and Wharf 4/5	Scenario 4 – Rainwater Harvesting on Wharf 4/5 only and Waterless Urinals in new Pier 2/3 facilities
Potable Water Demands				
Potable Water Demand (kL/a)	37,755	38,178	33,212	35,462
% Reduction in Potable Water Demand	0% (basecase)	4%	12%	6%
Wastewater Flows				
Wastewater Flows (kL/a)	37755	37755	37755	37,038
% Reduction in Wastewater Discharge	0% (basecase)	0%	0%	2%
Rainwater System				
Rainwater Demand (kL/a)	0	1,796	9,727	1,796
Rainwater Storage Size (kL)	N/A	100.2	185.2	100.2
Reliability of Rainwater Supply	N/A	88%	47%	88%
Volume of stormwater runoff (kL/a)	22,492	20,916	17,950	20,916
Reduction in stormwater runoff (%)	0% (basecase)	7%	20%	7%

6. Final Integrated Water Management Plan

6.1 Water Supply

6.1.1 Potable water

The WBACP redevelopment is targeting reducing potable water consumption, which will be achieved through:

- Use of efficient water fittings (for potable and non-potable water uses); and
- Collection of rainwater from the Pier 2/3 (if feasible) and Wharf 4/5 roofs and reticulation back through the building for non-potable water uses.

The reduction in use of potable water will be subject to further design development.

From the water balance modelling, an estimated 13% reduction in potable water demand is expected if these measures are implemented within the WBACP redevelopment.

6.1.2 Non-potable water

The non-potable water supply will continue to be supplemented with rainwater from the Wharf 4/5 roof, as well as the addition of rainwater from the Pier 2/3 roof. This will be treated and distributed via a separate system to flush toilets and urinals within these wharves.

Non-potable water use will be subject to further design development.

6.1.3 Rainwater harvesting and re-use

Rainwater is currently collected from the roof of Wharf 4/5 and stored in a 100.2 kilolitre tank located under the wharf. This has been very successful to date. It is proposed that a similar system will be implemented in the redesigned Pier 2/3. At present the incorporation of harvesting remains an option dependant on the evaluation of cost.

The design intent of the rainwater harvesting system on Wharf 4/5 is summarised as follows:

- Stormwater from the wharf roof drains to the rainwater harvesting tank located underneath the wharf structure via rainwater outlets and downpipes.
- The capture of roof fallout using a first flush device prior to entering the tanks.
- Rainwater surcharged from the tanks is discharged into Sydney Harbour.

The system within Wharf 4/5 will be augmented as required to meet the needs of the changed fit outs, with major alteration not expected (Arup, 2016a).

6.2 Wastewater management

The redeveloped Pier 2/3 will be provided with a sanitary drainage system in accordance with the plumbing code of Australia, AS3500.2 and Sydney Water requirements (Arup, 2016a).

All bathroom amenities and sanitary fixtures will be drained to the Sydney Water sewer in Hickson Road.

Ground level drainage from the northern end of the pier will be connected via a gravity sanitary drainage system to a sewer pump station under the pier in accordance with AS3500.2. This reflects Wharf 4/5 as gravity draining to Hickson Road from this end is not possible.

Sewer pump pits will be provided with chamber vents complying with the requirements of AS3500.2. The sewer drainage system will be provided with an overflow relief gully in accordance with AS3500.2.

The drainage system within Wharf 4/5 and the Shore Sheds will be augmented as required to meet the needs of the changed fit outs (Arup, 20167).

6.3 Stormwater and drainage

6.3.1 Rainwater harvesting and re-use

A schematic of the stormwater drainage concept is shown in Figure 6.

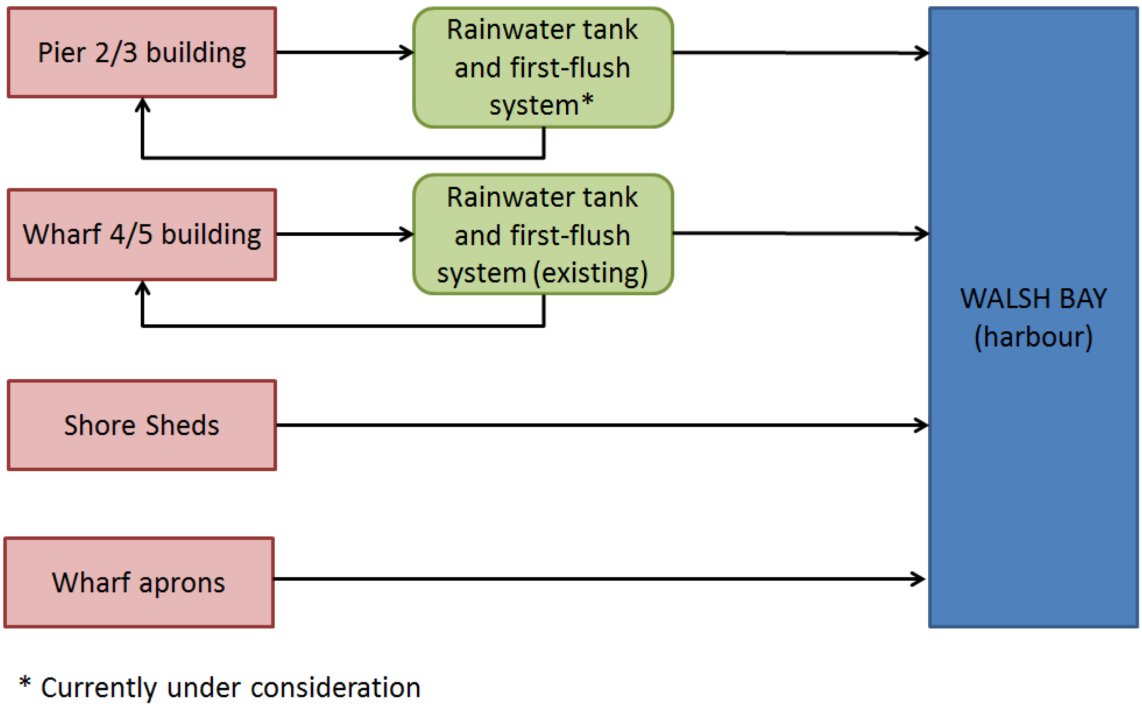

Figure 6: Proposed stormwater drainage concept for the WBACP

6.3.2 Flooding risks

The site is located within the City Area drainage catchment, and therefore included in the Sydney City Area Catchment Flood Study (BMT WBM, 2014). This study incorporates all sources of flooding, i.e. rainfall and tidal, in a single model. It also considers the impact of potential climate change scenarios (design rainfall intensities and sea level rise) on design flood conditions.

While the WBACP site itself is not subject to mainstream flooding, sections of Hickson Road adjacent to the Shore Sheds are identified as problem areas in relation to flood inundation.

BMT WBM (2014) states that:

"*Whilst there is a relatively small and localised catchment contributing flow to Hickson Road in the Walsh Bay area, modelling shows that flooding occurs in the 5 year ARI design event. Furthermore, responses received during the community consultation exercise indicated that flooding has occurred here in the past. At this location the roadway is relatively flat and does not* *promote efficient drainage. Flooding is relatively shallow with depths less than 0.20m, but these depths may still impede pedestrian and vehicle access and possibly inundate car parks*."

The 1% Annual Exceedance Probability (AEP), otherwise referred to as the 100 year Average Recurrence Interval (ARI) flood is generally used as a reference flood for land use planning and control. From the design flood mapping provided at Appendix A of BMT WBM (2014), the following flood conditions were modelled in the sections of Hickson Road adjacent to the Shore Sheds for a 100 year ARI event:

- Peak Flood Depths – up to 0.1 metres (indicating that overland flows will be contained within the road reserve)
- Peak Flood Levels – up to 3.47 mAHD (noting that the building ground floors and wharf apron elevations are approximately 3.44 and 3.4 mAHD, respectively)
- Peak Flood Velocities – up to 1.0 m/s.

BMT WBM (2014) identifies the WBACP as an indirectly flood affected area in the 2 year ARI event and as a Low Flow Island in the 5% AEP event. A Low Flow Island is defined in the *Floodplain Risk Management Guideline - Flood Emergency Response Planning Classification of Communities* (DECC, 2007) as follows:

"*The flood island is lower than the limit of flooding (i.e. below the probable maximum flood) or does not have enough land above the limit of flooding to cope with the number of people in the area. During a flood event the area is isolated by floodwaters and property will be inundated. If floodwater continues to rise after it is isolated, the island will eventually be completely covered. People left stranded on the island may drown and property will be inundated*".

The guideline identifies that Rescue/Medivac and evacuation will be required for Low Flood Island.

Considering that the WBACP has multiple floors and Hickson Road is subject to low hydraulic hazard up to and including the Probable Maximum Flood event, it is considered appropriate to designate the WBACP a High Trapped Perimeter (HTP). A HTP Area is defined in DECC (2007) as:

"*The inhabited or potentially inhabited area includes enough land to cope with the number of people in the area that is higher than the limit of flooding (i.e. above the probable maximum flood). During a flood event the area is isolated by floodwater and property may be inundated. However, there is an opportunity for people to retreat to higher ground above the probable maximum flood within the area and therefore the direct risk to life is limited. The area will require resupply by boat or air if not evacuated before the road is cut. If it will not be possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs*."

According to BMT WBM (2014), the impacts of future climate change may lead to a wide range of environmental responses in receiving waters such as Sydney Harbour. The study identified that the following changes may influence flood behaviour within the Sydney City Area Catchment:

- Increase in ocean boundary water level (sea level rise)
- Increase in rainfall intensity.

Sea level rise risks associated with the WBACP are detailed in Maritime Impact Assessment Working Paper. This paper also outlines the potential risks associated with wave and tidal movements.

BMT WBM (2014) adopted the following projections to undertake the rainfall-related climate change scenario modelling:

- increased design rainfall intensities of up to 30%, in accordance with the *Floodplain Risk Management Guideline - Practical Consideration of Climate Change* (DECC, 2007).

The results of the climate change modelling in the vicinity of the WBACP, taken from the design flood mapping provided at Appendix A of BMT WBM (2014), are provided in Table 11. These indicate that under these rainfall-related climate change scenarios, flooding will not occur within the WBACP.

Table 11: Flood level impacts due to an increase in rainfall intensity in the vicinity of the WBACP (Source: BMT WBM, 2014)

<table>
<tr><th>Design Flood</th><th>Increase in 1% AEP rainfall intensity</th><th>Adopted Sydney Harbour peak water level (mAHD)</th><th>Changes in peak flood levels</th></tr>
<tr><td rowspan="3">1% AEP</td><td>10%</td><td>1.38 (5% AEP Harbour Level)</td><td rowspan="3">Along Hickson Road adjacent to Shore Sheds:
• areas that were dry now wet
• areas of no change in impact
• increases in flood depths of up to 0.1 metres
WBACP site:
• no impact</td></tr>
<tr><td>20%</td><td>1.38 (5% AEP Harbour Level)</td></tr>
<tr><td>30%</td><td>1.38 (5% AEP Harbour Level)</td></tr>
</table>

The WBACP site is currently impervious and will remain impervious. As stated in Arup (2014), Wharf 4/5 and the Shore Sheds comprise fit out works only, and therefore there are no proposed changes to entrance thresholds. Pier 2/3 will be subject to flows from rainfall falling directly on the site only, and therefore entrances will not be subject to flooding.

It is assumed that no construction or operational activities are proposed along Hickson Road as part of the WBACP project, therefore the project will have negligible impacts on existing flood behaviour. Construction materials are not to be stored along Hickson Road.

7. Groundwater

A marine and groundwater assessment of the WBACP was completed by Jacobs SKM in 2014 (Jacobs SKM, 2014). The results of the investigation have been incorporated into this Integrated Water Management Plan to advise the potential impacts on the groundwater environment as a result of the WBACP redevelopment.

7.1 Existing groundwater environment

Walsh Bay is located on bedrock consisting of Hawkesbury Sandstone (Britton, 1996). Overlying the sandstone locally, the marine sediments in Walsh Bay are layers of surficial silts and clayey silts over older marine sediments consisting of interbedded clays, sands and clayey sands.

The Hawkesbury Sandstone is a recognised aquifer and elsewhere across Sydney provides a source of potable groundwater, though it often has elevated levels of iron (up to 300 ppm) and manganese (up to 15 ppm), decreasing its palatability.

Numerous investigations around Sydney Harbour indicate that the groundwater of the Hawkesbury Sandstone is located close to ground surface and hence discharges to the estuary. However, in the immediate offshore vicinity of the WBACP, sediments in the estuary are dominated by muds, with little sand and gravel (West, 2008). The high proportion of mud suggests that this area is not a prominent area of groundwater discharge and this is supported by a number of local investigations that report a strong correlation between groundwater levels and tidal influences. Further, the shallow groundwater in the area are all highly saline, generally up to seawater composition, indicating the influence of seawater intrusion in the immediate area.

A large movement to reclaim land at multiple foreshore sites along the banks of Sydney Harbour, including Walsh Bay, occurred between 1922-2002. The materials used for reclamation mainly consisted of dredging spoils from the estuary, demolition rubble, construction materials and domestic and industrial wastes but varied with location and few records exist (Birch, 2006). With such materials characterising soil profiles, contaminants resting dormant may be activated and mobilised by tidal pumping or rainwater percolation (Suh, 2003).

Above the Hawkesbury Sandstone, the fill provides an enhanced hydraulic conductivity (greater than 50 m/day compared to less than 0.03 m/day for the Hawkesbury Sandstone) through which contaminants in the fill materials may be preferentially transported around the area. The shallow, low gradient groundwater system is strongly dependent on tidal forcing and flow can change direction depending on tidal heights. Therefore, while dominate flow would generally be towards the harbour, during high tides flow may reverse towards the south.

7.2 Potential groundwater impacts

Potential groundwater impacts that may occur due to the WBACP redevelopment identified in Jacobs SKM (2014) are summarised in Table 12.

No additional groundwater impacts have been identified as a result of design updates following the concept design phase. The majority of design updates are related to internal fit-outs or on-wharf additions that would not impact groundwater. There are no additional design changes that are expected to impact groundwater users, quality, direction or flow rates.

Due to the unlikelihood of impacts on groundwater, sampling of groundwater was considered unnecessary. It was also considered unnecessary for a Groundwater Environmental Management Plan to be prepared due to the low risk nature of the proposed activities to be undertaken.

Table 12: Potential groundwater impacts due to the WBACP redevelopment (Source: Jacobs SKM, 2014)

Impact	Assessment	Likelihood of impact
• Contamination of groundwater of decline in quality	Groundwater impacts are expected to be minimal provided the appropriate standard controls are in place to contain spills and leakages during construction. The project does not include the extraction of groundwater. The nearest groundwater users (greater than three kilometres) will not be impacted. No Groundwater Dependent Ecosystems occur within or near the Project Site.	Unlikely
• Penetration of groundwater sources		
• Impacts to groundwater users		
• Change in groundwater flow direction and rates		

8. Conclusion and Management Recommendations

2.1 Water Cycle Management

In current best practice water cycle management, it is appropriate to examine a range of water cycle management options before arriving at a preferred water cycle management strategy. The water cycle management strategy focusses primarily on water balance rather than water quality outcomes. Water cycle management options considered a range of options for conserving water and utilising recycled roof water as alternative sources for meeting demand.

Due to its maximisation of rainwater reuse onsite, reduction in stormwater runoff and the minimisation of the need for imported potable water, Scenario 3 (rainwater harvesting on Pier 2/3 and Wharf 4/5) is the preferred water cycle management scenario. However, if the installation of a rainwater harvesting system on Pier 2/3 is considered unfeasible it is recommended that waterless urinals be installed in the new Pier 2/3 facilities (Scenario 4). The installation of waterless urinals will help reduce potable water demand and wastewater flows.

2.2 Flooding

While the WBACP site itself is not subject to mainstream flooding, sections of Hickson Road adjacent to the Shore Sheds are identified as problem areas in relation to flood inundation.

No construction or operational activities are proposed along Hickson Road as part of the WBACP project, therefore the project will have negligible impacts on existing flood behaviour. Construction materials are not to be stored along Hickson Road.

The WBACP site is currently impervious and will remain impervious. Pier 2/3 will be subject to flows from rainfall falling directly on the site only, and therefore entrances will not be subject to flooding. There are no proposed changes to entrance thresholds at Wharf 4/5 and the Shore Sheds.

2.1 Groundwater

Groundwater impacts are expected to be minimal provided the appropriate standard controls are in place to contain spills and leakages during construction.

The project does not include the extraction of groundwater. The impact on groundwater due to the installation of additional and replacement pilings is considered negligible in context of the overall hydrogeological regime.

Due to the unlikelihood of impacts on groundwater, sampling of groundwater is considered unnecessary. It is also considered unnecessary for a Groundwater Environmental Management Plan to be prepared due to the low risk nature of the proposed activities to be undertaken.

9. References

Arup (2016a) *Walsh Bay Arts Precinct – Building Services Phase 1 Concept Review*. Prepared for Infrastructure NSW.

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