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Amcor Botany Paper Mill

OVERLAND FLOW MANAGEMENT REPORT

- Final Report
- Version E
- September 2012



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SKM derived the data in this report from a variety of sources. The sources are identified at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. SKM has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose of the project and by reference to applicable standards, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report.

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Executive Summary

Amcor are redeveloping the western side of the Botany Mill site in Matraville, including construction of a New Paper Mill on the south-western corner of the site (referred to as the Project B9, DoP Application No. 05_0120). Additional works, including the upgrade of McCauley Street, which runs along the western side of the site, have also been approved for construction. The road upgrade is necessary to cater for increased heavy vehicle traffic during operation of the New Paper Mill.

Upon completion of the Project B9, excess land in both the western and eastern portions of the site may be cleared (i.e. buildings demolished) and either sold for development by others or retained by Amcor. At this stage no decision has been made on the future use of excess land.

Previous studies have been undertaken to investigate flood risk relating to the Amcor site redevelopment. However, these studies investigated flooding in the western and eastern portions of the site separately, and were primarily used as the basis for setting floor levels in the New Paper Mill buildings. The need to manage overland flows through the site have since been identified from a recent flood impact assessment for the proposed noise wall along Australia Avenue using recently acquired topographic data. These overland flows originate from external local catchments to the north-east of the site. Additionally, mainstream flooding occurs in the creek which drains the catchment to the north-east of the Amcor Botany site, henceforth referred to as Eastern Creek (also known as Bunnerong Creek). Eastern Creek passes through culverts underneath the eastern end of the Amcor Botany site, draining an area of approximately 250ha to the north and east of the site.

The overland and mainstream flooding affecting the Amcor site was assessed in an integrated two-dimensional hydraulic model called TUFLOW, which represented flooding in both the eastern and western portions of the site together. Modelling results for the pre-development case indicated that, in the western portion of the site, overland flows from sub-catchments to the north of the north-west corner of the site would flow onto the site from Australia Avenue in the vicinity of Purcell Park. These flows would then run south-west through the site, onto Botany Road and then through Port Botany to Botany Bay. These flows would be obstructed from flowing off-site to Botany Road by the B9 building in the post-development case.

In the predevelopment case of eastern portion of the site, overland flows from the "Hangar" catchment in the vicinity of Partanna Avenue would travel towards the site and then be deflected to the south-east by an existing brick wall and buildings to Eastern Creek. Both the overland flow and the mainstream creek flow would be conveyed under the Amcor site by existing culverts and discharged to Bunnerong Canal before flowing to Botany Bay. The post-development case is likely to involve demolition of most of these existing buildings in the eastern portion of the site, thus



allowing overland flows to enter the site in this location. A number of alternative options to manage these overland flows through the site are available.

A comprehensive options identification and assessment process was undertaken to identify a reasonable and feasible solution to manage overland flows from the western portion of the catchment. These options are described in detail in Section 5.2.2. The outcome of the options identification and assessment process concluded that the only reasonable and feasible option for conveying overland flows from the western catchment was to use a combination of on-site floodways and McCauley Street to convey flows from the western catchment towards Botany Bay.

The on-site floodway is would comprise of a 0.6m deep, 17m wide (top-width) channel. The on-site floodway is designed to intercept flows entering the site off Australia Avenue and discharge the flows onto McCauley Street at the new site exit opposite Raymond Avenue. Flows will then be conveyed down McCauley Street to Botany Road, where they are also discharged in the pre-development case.

To ensure that existing properties on McCauley Street and Raymond Avenue are not adversely impacted by the increased flows in McCauley Street, the footpath and driveways on the western side of McCauley Street and the crest of Raymond Avenue will be raised by up to 400mm to form a floodway channel. This floodway will ensure that flows up to the 1 in 100 Annual Exceedance Probability (AEP) event will be retained in the road corridor. The footpath modification will extend to just before the third driveway south of Raymond Avenue, located 80m from the intersection. Beyond this location, McCauley Street is lower than the adjacent properties and forms a channel-like profile in the pre-development case, hence modification of the footpath to contain flows is not required. On the eastern side of McCauley Street the floodway will extend laterally onto the Amcor site.

Flood depths on the existing properties will not increase in the 1 in 100 AEP event as a result of these proposed works. Vehicle access to the properties with modified driveways has been validated using Australian Standard vehicle profiles. Some modifications to property drainage arrangements would be required to ensure that site drainage is not impacted by the floodway works. Flooding conditions in McCauley Street in the 1 in 100 AEP event have been reviewed, and there will be no major risk to pedestrian safety in the post-development conditions. Appropriate flood signage could be installed at a number of locations along McCauley Street, Botany Road and Raymond Avenue to manage flood risk to pedestrians. There is a minor risk of damage to vehicles due to flows in McCauley Street, which would be managed through appropriate signage, warning motorists of the risk of flooding in extreme events.



In the eastern section of the site, there are several options for managing overland flows including extending the brick wall (or similar) to transfer the flows directly into Bunnerong Creek upstream of the Amcor site as is currently the case or constructing an on-site floodway.



1. Introduction

1.1. Overview

The Amcor Botany Mill is located on the northern side of Botany Road in Matraville. Amcor are redeveloping the western side of the site, including construction of a New Paper Mill on the south-western corner of the site (referred to as the Project B9, DoP Application No. 05_0120).

Department of Planning and Infrastructure has provided Project Approval and construction of the New Paper Mill is in progress. Additional works, including the upgrade of McCauley Street, which runs along the western side of the site, have also been approved for construction. The road upgrade is necessary to cater for increased heavy vehicle traffic during operation of the New Paper Mill.

Upon completion of the Project B9, excess land in both the western and eastern portions of the site may be cleared (i.e. buildings demolished) and either sold for development by others or retained by Amcor. At this stage no decision has been made on the future use of excess land.

Previous studies have been undertaken to investigate flood risk relating to the Amcor site redevelopment. However, these flooding studies were primarily used as the basis for setting floor levels in the New Paper Mill buildings. The need to manage overland flows through the site have since been identified from a recent flood impact assessment for the proposed noise wall along Australia Avenue using recently acquired topographic data, including ground survey and LiDAR.

This study has therefore been prepared by SKM on behalf of Amcor to assess the existing case flooding behaviour and to develop strategies for managing flooding on the site and adjacent properties in the developed case, in the 1 in 100 Annual Exceedance Probability (AEP) event. Objectives of this study include:

- To update previous flood studies prepared for the Amcor site and reassess the existing flooding behaviour, based on more accurate topographic data;
- To assess developed case flooding using the most recent information on ultimate case development;
- To develop options for managing overland flows through and adjacent to the site; and
- To assess the impacts to flooding conditions on the adjacent residential and industrial properties in the developed case.



2. Background

2.1. Description of Catchment

The Amcor site and roads in the surrounding area are shown in **Figure 2-1**. Flooding from a number of local catchments affects the Amcor Botany site and adjacent areas, as shown in **Figure 2-2**. Overland flows enter the site across its north-eastern boundary from two local catchments to the north-east of Australia Avenue, and an additional local catchment located in the Moorabin/Partanna Avenue area (referred to as the “Hangar” catchment), flowing towards the south-west to Botany Road. Overland flows also occur in McCauley Street to the north of Australia Avenue, and in Raymond Avenue. These flows are conveyed along McCauley Street south-west, towards Botany Road.

Mainstream flooding occurs in the creek which drains the catchment to the north-east of the Amcor Botany site, henceforth referred to as Eastern Creek (also known as Bunnerong Creek). Eastern Creek passes through culverts underneath the eastern end of the Amcor Botany site, draining an area of approximately 250ha to the north and east of the site.

Mainstream flooding also occurs in the Sydney Water Channel (Bunnerong Main Drain), located to the west of McCauley Street and Raymond Avenue, approximately 180m to the west of the Amcor site. The Channel drains a large catchment to the north of the site, including areas of Matraville, Eastgardens and Maroubra.

2.2. Previous Studies

Hydrologic and hydraulic modelling previously undertaken by SKM were used as the basis in this current study. The previous studies were:

- *Amcor Botany – Eastern Creek Flood Study* (SKM, May 2009). This study investigated mainstream flooding from Eastern Creek in addition to the local catchments flowing onto the site between Eastern Creek and Purcell Park. Hydrologic modelling was undertaken in XP-RRAFTS, while hydraulic modelling was conducted with a 2D TUFLOW model, using 2m contour topographic data.
- *Amcor Botany – Western Side Flood Study* (SKM, December 2008). This study investigated the impact of mainstream flooding on the site from the Sydney Water Channel using a HEC-RAS hydraulic model and flows previously published by Bewsher Consulting (2004). Local overland flooding from the Purcell Park local catchments, McCauley Street and Raymond Avenue were also investigated using a DRAINS hydrologic model and a HEC-RAS hydraulic model, although the scope of the hydraulic modelling was limited to determining flood levels in McCauley Street for the purpose of setting finished floor levels of the B9 buildings.



■ Figure 2-1 Amcor Site and Surrounding Area



■ Figure 2-2 Local and Mainstream Catchments





2.3. Consultation with Council

For this round of flood modelling, a meeting was held with Randwick City Council on 24 February 2012 to present preliminary modelling of existing and developed case flooding and to discuss potential overland flow management options. The preliminary flood modelling focussed on flow conveyance through the western portion of the site and impacts on adjacent properties. The option of conveying external flows in a floodway through the north-western corner of the site to McCauley Street, and utilising McCauley Street as a floodway, was discussed.

The extent of the flood modelling has subsequently been expanded at Council's request to assess flooding behaviour and impacts in the Eastern Creek floodplain, the Hangar catchment and the low-lying areas along Botany Road, including properties adjacent to the sag at the Botany Road and McCauley Street intersection.

Council also indicated acceptable levels of flood impact on adjacent properties to be:

- Residential properties: no increase in the 1 in 100 AEP peak flood levels;
- Commercial/industrial properties: 30mm increase in the 1 in 100 AEP peak flood levels.

2.4. Update of Flood Modelling

The previous hydrologic and hydraulic modelling was updated for the purposes of this study. In summary, the updates made to the modelling included:

- Development of an integrated model to assess Eastern Creek and western side flooding, to cater for the possibility of interflow between catchments;
- The use of updated topographic data - The previous studies utilised a Digital Elevation Model (DEM) derived from 2m contour data. Ground survey of the site and adjacent areas indicated inaccuracies in this DEM in key locations. Hence, LiDAR data (captured in 2008, typical accuracy +/- 0.15m) was obtained to represent the wider study area not covered by ground survey. The current study therefore utilised ground survey, site design surface levels (developed case) and LiDAR.
- Recent information on the ultimate development conditions on site - In addition to incorporating the final design of the B9 Project in the model, it is assumed that a number of buildings and facilities will eventually be removed to facilitate the sale of excess land. The ultimate development case site layout is indicated in **Appendix A**.

The updated hydrologic and hydraulic modelling is discussed in **Section 3 and 4**.



3. Update of Hydrologic Modelling

3.1. Sub-Catchment Delineation

The hydrologic models developed for the previous Amcor flood studies were utilised in this study. XP-RAFTS was used in the *Eastern Creek Flood Study* (SKM, 2009) to model the eastern area catchments. DRAINS was used in the *Western Side Flood Study* (SKM, 2008) to model the western area catchments, in addition to the catchments on the Amcor site. Sub-catchment boundaries were reviewed and updated as necessary according to the LiDAR data.

The DRAINS model catchments were further allocated to suit key drainage points in the study area, such as the site boundary along Australia Avenue and the sag point in Raymond Avenue. The adopted model sub-boundaries are shown in **Figure 3-1**. The sub-catchments in the DRAINS model and the XP-RAFTS model are indicated with different symbols.

3.2. Hydrologic Parameters

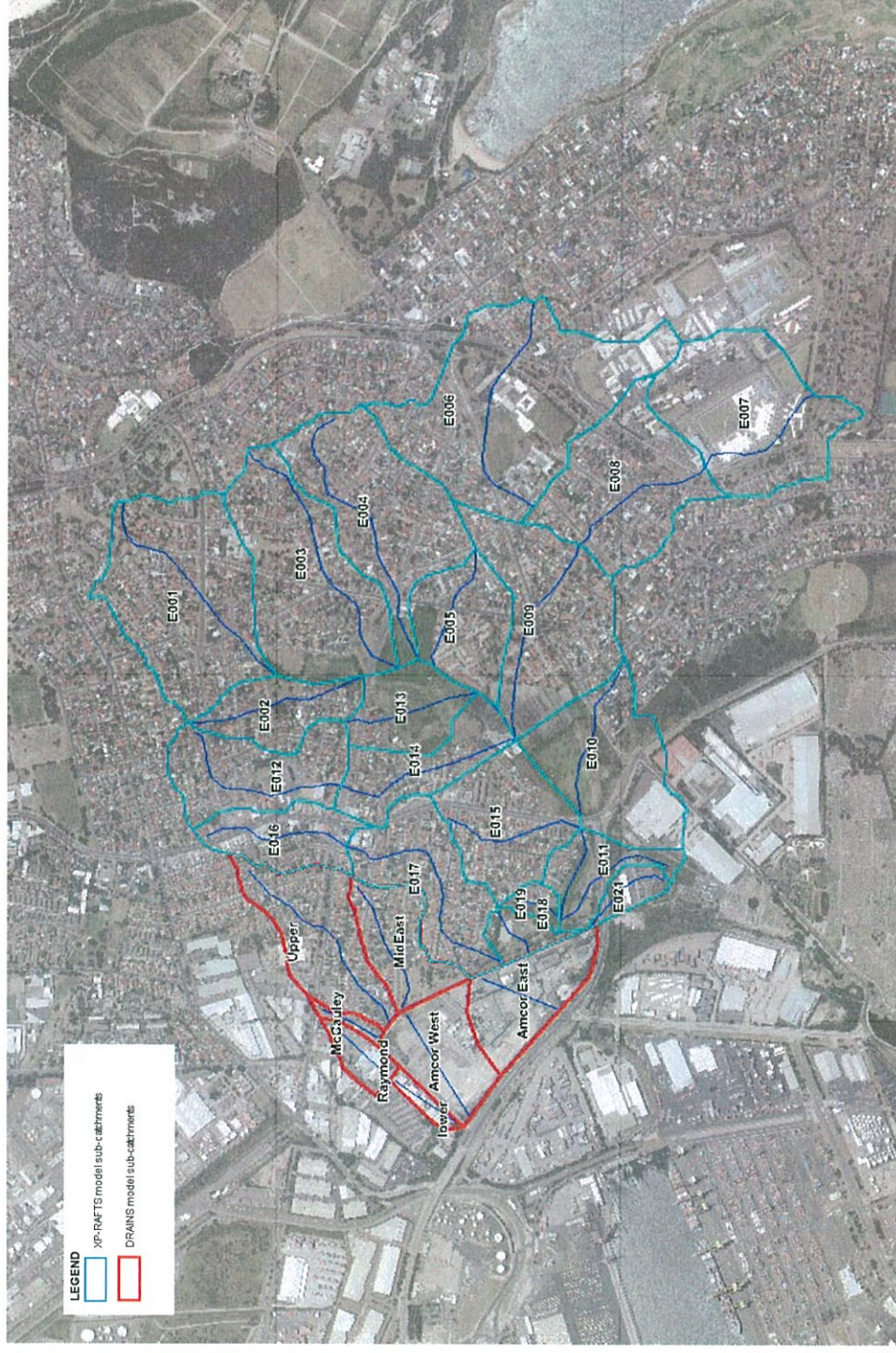
Model inputs and parameters, including design rainfall intensities and rainfall losses, were maintained from the previous hydrologic modelling. The adopted hydrologic parameters are summarised in **Table 3-1**.

■ **Table 3-1 Hydrological Parameters for Impervious and Pervious Catchments**

Parameter	Impervious Area*	Pervious Area
DRAINS Model		
Depression Storage (mm)	1	5
Soil Type	-	2 (Moderately well drained sandy soil)
Antecedent Moisture Condition (AMC)	-	3 (Relatively wet initial soil conditions prior to the storm)
XP-RAFTS Model		
Initial Loss (mm)	1.5	15.0
Continuing Loss (mm/hour)	0.0	1.5
PERN Roughness Factor	0.020	0.040

* The impervious areas were modelled in the DRAINS model as Paved Areas. The sub-catchments were assumed to have zero Supplementary Area.

■ Figure 3-1 Hydrologic Model Sub-Catchments





The DRAINS and XP-RAFTS models were run for a range of storm events and flow hydrographs at key locations extracted for input into the updated 2D TUFLOW hydraulic model, which is described in **Section 4**. Peak flows during the 1 in 100 AEP event at each sub-catchment outlet are given in **Appendix B**.

Note that both the DRAINS and XP-RAFTS models do not represent the stormwater drainage network and therefore are considered conservative approaches to estimating catchment flows.



4. Update of Hydraulic Modelling

4.1. Extent and Topography

An integrated eastern and western area TUFLOW model was developed for the existing and developed cases based on LiDAR data, ground survey and site design surface level data. Ground survey was obtained for the Amcor site in May 2011 (pre-development case), McCauley Street, Raymond Avenue and Purcell Park (on Australia Avenue). Three industrial properties on the western side of McCauley Street, to the south of Raymond Avenue, were also surveyed, as these properties were identified as being potentially impacted by overland flooding and have ground level undercover car parking areas which are not picked up by the LiDAR data.

The model extent is shown in **Figure 4-1**. It includes a section of the Eastern Creek in addition to the existing culverts under Bunnerong Road and the eastern end of the Amcor site and a section of Bunnerong Canal as 1D features.

The TUFLOW model was set up with a 2m grid cell size, which is an appropriately small cell size to define overland flow behaviour.

4.2. Boundary Conditions

4.2.1. Inflow Boundaries

Flow hydrographs from the DRAINS and XP-RAFTS hydrologic models were input at the locations indicated in **Figure 4-1**. These locations included:

- Inflows into Eastern Creek;
- Local catchment inflows upstream of the Amcor site;
- The local catchment inflows from areas to the west of the Amcor site; and
- Local flows generated on the Amcor site.

LEGEND

- TULLOW Model Domain (Red outline)
- Downstream Boundary (Blue line)
- 1D Network Creek (Blue line)
- 1D Network Culvert (Blue line)
- Site Boundary (Yellow outline)
- Inflow (White arrow)
- Outflow (Blue arrow)

Inflows:

- Eastern Creek Inflow
- Bunnings Canal Inflow
- Amcor East Inflow
- Amcor West Inflow
- McCauley Lower Inflow
- McCauley Upper Inflow
- Raymond Inflow
- Australia Inflow
- Purell Inflow
- Hangar Inflow

Outflows:

- Bunnings Canal Outflow
- Amcor Culvert
- Port Botany Outflow (Free Outfall)
- McCauley Water Channel Outflow (Free Outfall)
- Bunnings Canal Outflow (MWHNS tailwater level)



4.2.2. Downstream Water Level Boundaries

The downstream water level boundaries are shown in **Figure 4-1**. These include:

- Bunnerong Canal: A Mean High Water Spring (MHWS) level of 0.68m AHD in Botany Bay was adopted as a fixed water level boundary, consistent with the *Eastern Creek Flood Study Report* (SKM, 2009).
- Port Botany outflows: The outflows of Port Botany overland flows are not influenced by the Botany Bay tailwater levels, as the Port surface elevations are approximately 2m higher than the MHWS level. A free flowing outlet was therefore assumed.
- Outflows to Sydney Water Channel: Review of the *Western Side Flood Study Report* (SKM, 2008) indicates that the 1 in 100 AEP flood level in the Channel would be confined within the Channel, and hence overland drainage from Raymond Avenue would not be tailwater affected. A free flowing outlet was therefore assumed.

4.3. Channel and Floodplain Roughness

Separate Manning's "n" friction factors have been used for the one and two dimensional parts of the model. For the creek waterway, a constant Manning's "n" value of 0.07 has been assumed, in order to represent the overgrown banks and channel of the waterway. A value of 0.02 has been used for the culverts, in the absence of any information about the interior condition of the culverts.

For the two-dimensional model, Manning's "n" values have been assigned to floodplain regions according to whether they are predominantly residential housing ($n = 0.060$), green areas ($n = 0.040$) or roads and paved areas ($n = 0.025$).

4.4. Representation of Buildings

Buildings in the TUFLOW model domain on and off the site are treated as solid impermeable objects in the hydraulic modelling. This means that it has been assumed there is no possibility flow will pass through or be stored within the buildings. The buildings on the Amcor site differ in the pre- and post-development cases, and are shown in **Figure 4-2**. Buildings off site are also shown.

The three industrial properties on the western side of McCauley Street have undercover car parking areas which would potentially convey overland flows, and hence only the ground-level building footprints, which were surveyed, are blocked out.



■ Figure 4-2 Pre- and Post-Development Case Buildings





4.5. Representation of Fencing

Flood flow across the site is affected by a brick wall which runs along a section of the north-east boundary of the site. This wall will act as a barrier to flood flow in the existing case. Other fencing along the north-east boundary is comprised of Colourbond fencing, which is assumed to collapse under the weight of floodwaters. Fencing on residential properties is also assumed to be Colourbond fencing.

4.6. Stormwater Drainage

The TUFLOW model was developed primarily to represent overland flow behaviour only. Stormwater network data, both on and off the site and in both the pre- and post-development cases was typically not represented in the modelling. However, in areas where the omission of stormwater drainage was likely to give overly conservative peak water levels, pit and pipe data was included in the TUFLOW model. This is the case at the Raymond Avenue sag, where the sag and adjacent properties are on relatively flat terrain, and the modelling results are likely to overstate the degree of impacts to these properties. Pipe survey was not available at the two sag pits at this location, hence, the typical minimum pipe size of 375mm diameter and minimum grade of 0.5% was assumed. An outlet pipe length of 20m was assumed, with pipe outlet tailwater condition assumed to be 0.3m above the pipe invert (i.e. pipe outlet is not flowing freely). The two 2.4m lintel/grated kerb inlet pits were assumed to be 50% blocked.



5. Flood Modelling Results

5.1. Pre-Development Case

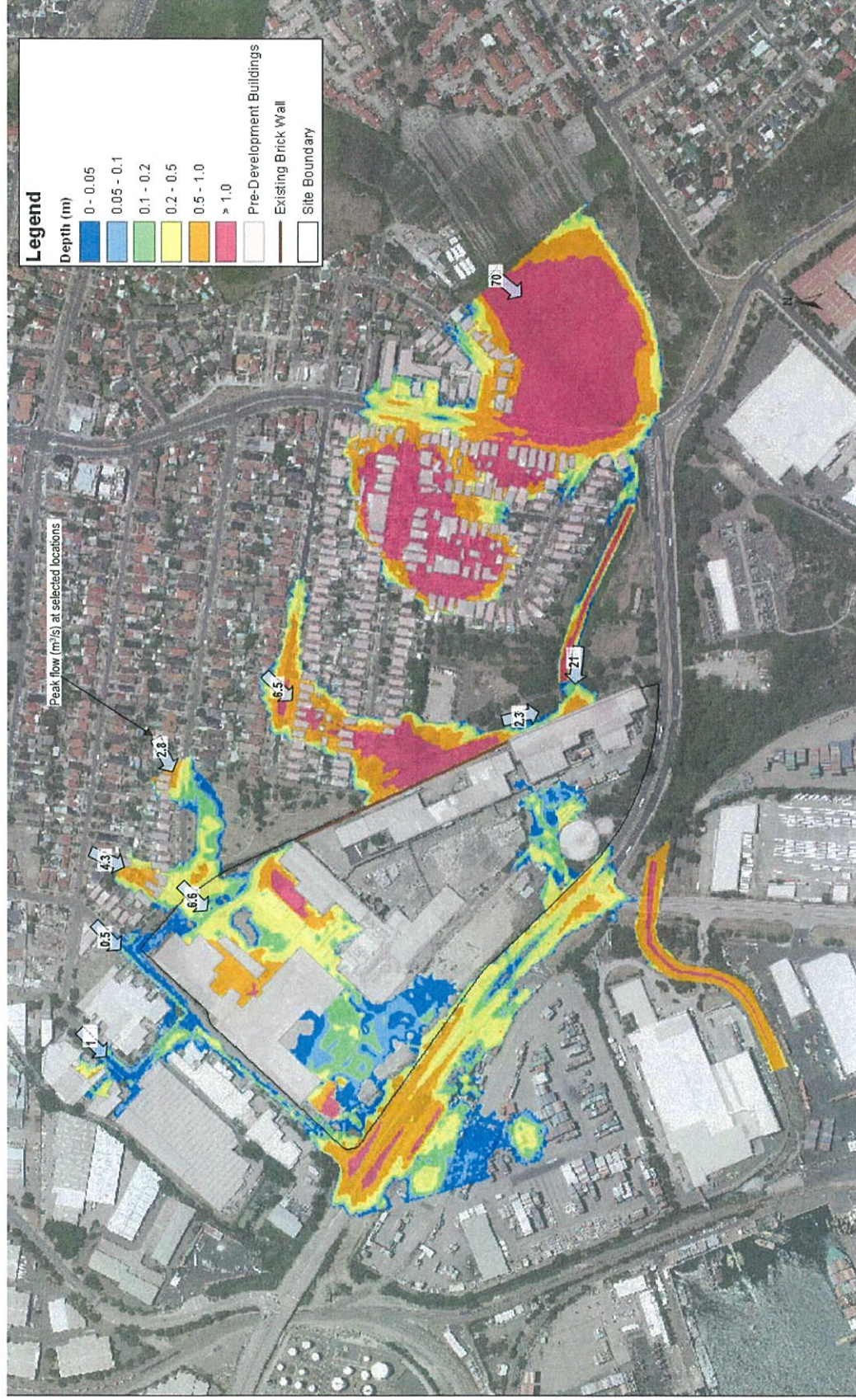
The hydrologic and hydraulic models were run for the 1 in 100 AEP storm event for a range of storm durations from 25 minutes to 2 hours. The TUFLOW model results for the pre-development case are presented as maximum flood depths in **Figure 5-1**. Peak flows at selected locations are also indicated. Key findings on the flood behaviour include:

- Overland flows from Australia Avenue enter the north-west corner of the site and flow towards Botany Road through the pre-development buildings. Approximately $6.6\text{m}^3/\text{s}$ peak flow enters the site at this location.
- Runoff enters the Raymond Avenue sag from the Raymond Avenue catchment and from upper McCauley Street, and then spills back into McCauley Street and flows down to Botany Road. Some flows in Raymond Avenue discharge into the Sydney Water Channel through existing industrial properties. The sag pits intercept and discharge a peak flow of $0.18\text{m}^3/\text{s}$.
- Overland flows from the Hangar Catchment will pond behind the existing brick wall, before overflowing into the Eastern Creek catchment. The flows will run along the wall and the outside of the B8 building before entering the Eastern Creek.
- Floodwaters in Eastern Creek are contained within its floodplain without overflowing into the Amcor site. The existing culverts under the Amcor site have sufficient capacity to convey the 1 in 100 AEP flows.
- Overland flows reaching Botany Road pond in the sag at the McCauley Street intersection, before overflowing into Port Botany.

A number of options were investigated to manage these overland flows through the site.

The pre-development case flooding affects a number of properties in the study area outside of the Amcor site. Properties of particular interest in the assessment and design of the proposed flow management options are the residential properties located on Australia Avenue near McCauley Street, and the industrial properties at the McCauley Street and Raymond Avenue intersection, including the corner properties known as the “Sydney Seafarer’s Centre” (30 McCauley Street), and Maroubra Building Supplies (26-28 McCauley Street).

Figure 5-1 Peak 1 in 100 AEP Flood Depths, Pre-Development Case.





5.2. Post-Development Case

5.2.1. Overview

External overland flows enter the site in two locations:

- Western area: Flows enter from the sag in Australia Avenue, 80m from the McCauley Street intersection; and
- Eastern area: Flows enter around the eastern end of the brick wall, approximately 120m from Eastern Creek along the eastern site boundary when the B7 and B8 buildings removed.

These flow paths convey flow through the site independently of each other, and hence the overland flow management options for each catchment are described separately.

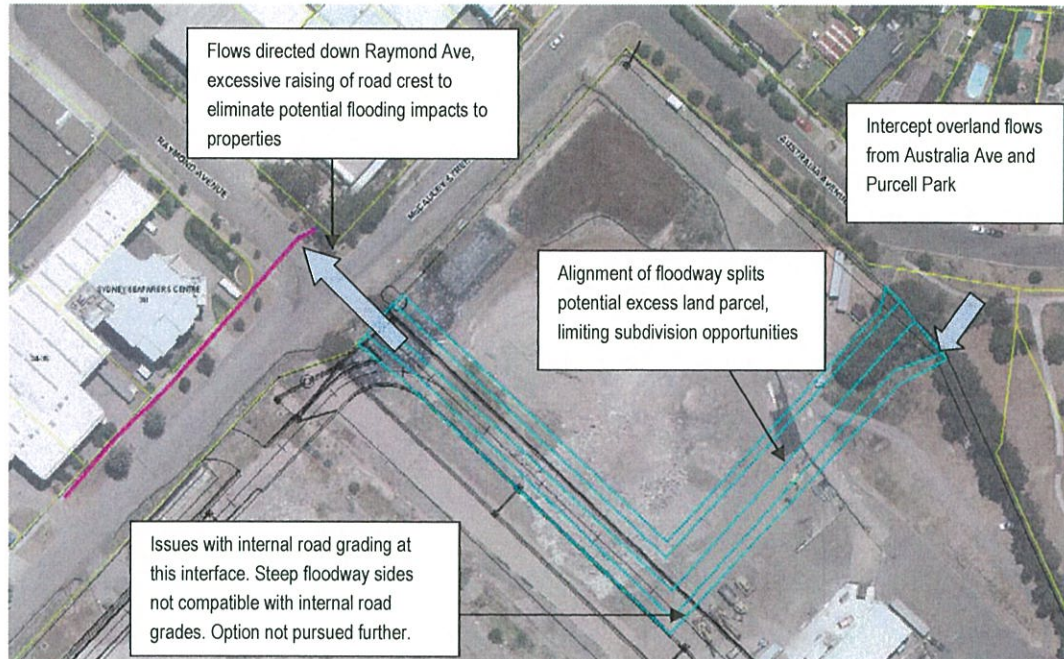
5.2.2. Options Assessment and Development – Western Area

A comprehensive options development and assessment process was undertaken to identify a reasonable and feasible option to convey floodwaters and minimise flooding impacts on commercial and residential areas. The focus of the options development and assessment was the Western area as this area is most constrained and is currently being developed. The Eastern area is not being modified as part of the New Paper Mill development and there are potentially a number of reasonable and feasible options to manage flood waters in this area.

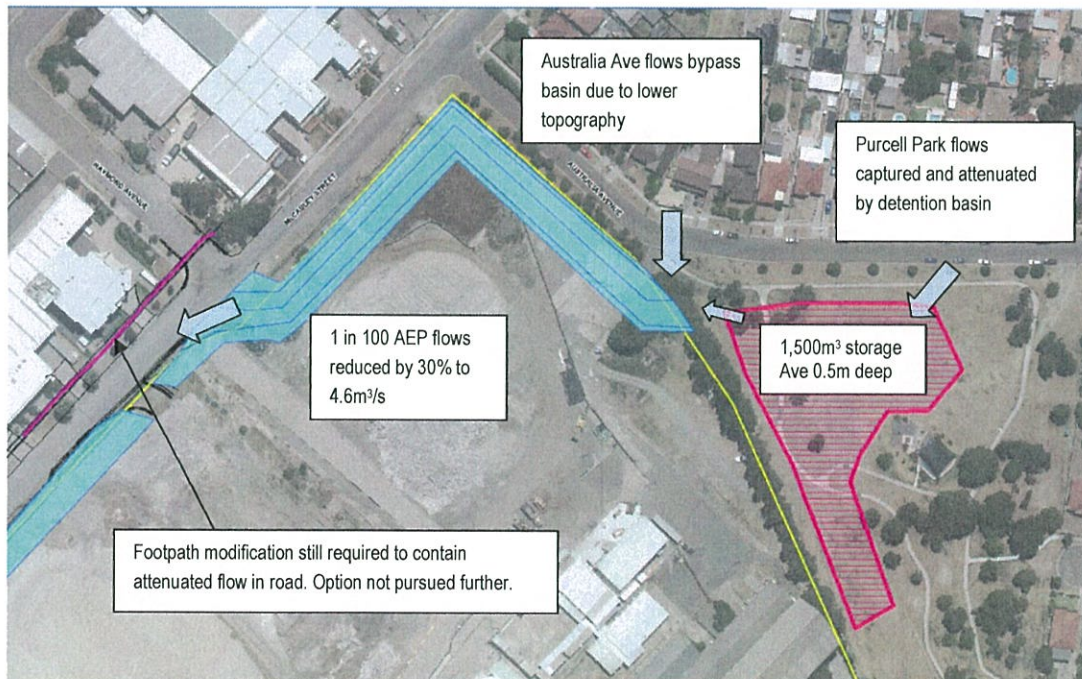
Several alternative designs to manage upstream overland flows were assessed including:

- Alternative on-site floodway alignment, running southward from Australia Avenue then westward to McCauley Street. Refer to **Figure 5-2**. This alignment would have directed flows into Raymond Avenue instead of down McCauley Street, which would have required excessive raising of the McCauley Street footpath and Raymond Avenue levels. This is similar to the preferred option, however would require additional works and would restrict the site subdivision in the future. Additionally, the relatively steep sides of the floodway channel are not compatible with the flat acceptable grades for the internal road where they interface. As it provided no additional benefits to the preferred option it was not considered further.
- Provision of flood detention storage in Purcell Park. Refer to **Figure 5-3**. Approximately 1,500m³ of detention storage could be provided in Purcell Park with moderate-impact earthworks to 25% of the park area, while retaining the existing playground and landscaping features. This results in a 30% reduction in peak 1 in 100 AEP event flows in McCauley Street. Further reductions in peak flow are not practical as more than half the flow arriving at Australia Avenue bypasses the detention basin, due to the topography. This option would also still require the formation of a floodway in McCauley Street to manage flows, similar to the preferred option, and hence the area of works and disturbance would be significantly greater than for the preferred option. This option was therefore not considered further.

■ **Figure 5-2 Alternative on-site floodway alignment**



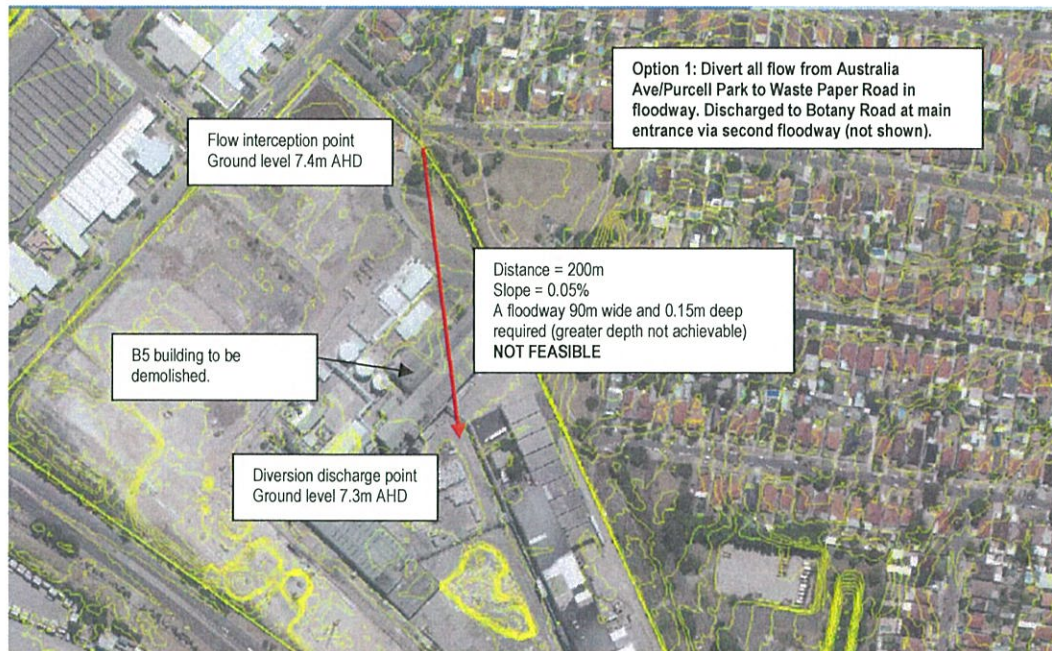
■ **Figure 5-3 Alternative option: Purcell Park flood detention**



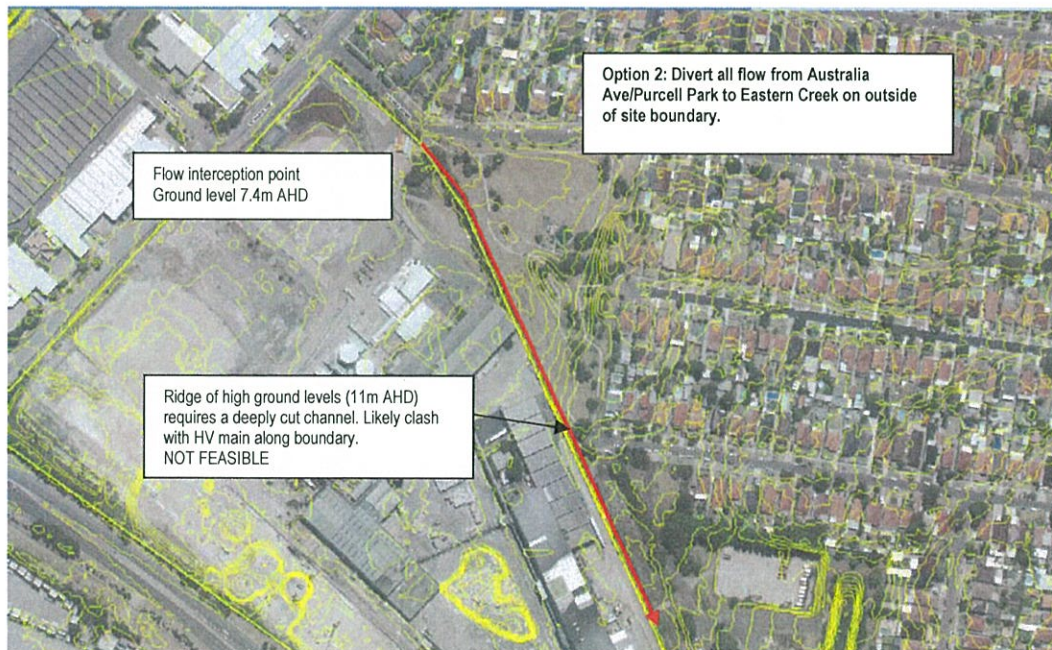


- Lowering of McCauley Street levels immediately to the south of Raymond Avenue to form a floodway and increase flow capacity. The road levels between and up to 140m south of Raymond Avenue would be lowered by up to 400mm and would eliminate the need for raising the western footpath to form a channel-profile. However, this option deviates significantly from the approved road design and would have resulted in significant relocations of existing utilities and driveways, prolonged disruption to traffic on McCauley Street and would have similar flow conditions within the street when compared to the preferred option. This option was not considered further.
- Culverts to intercept and discharge overland flows to the Sydney Water Channel or to Port Botany. This option was dismissed as clashes with major utilities and major disruption to private properties would have occurred.
- Culverts or floodways to intercept and convey overland flows from the western side of the site to the eastern side of the Amcor site, namely transferring flows from one sub-catchment to another. Different options for transferring all or some of the western flows were assessed, as illustrated in **Figure 5-4** to **Figure 5-6**. While technically feasible, transferring any portion of the western flows was not considered practical due to the significant distance and the topography. The ground levels between where the western and eastern flows enter the site are similar (flat grades of less than 0.1%). Further, there is a significant area of higher ground between the two locations which would require a wide deep channel to be constructed. Consequently, there are likely to be conflicts between the channel, existing utilities and a number of the buildings that are to be retained. Additionally, the overland flow channel for the eastern portion would have to be deepened and widened substantially to accommodate the western flows, and this larger channel would not tie in to the levels of other major features such as the access road to the wastepaper yard, off Botany Road opposite Bumborah Point Road. Because of these issues transferring flows from the western to the eastern sub-catchment is not feasible.

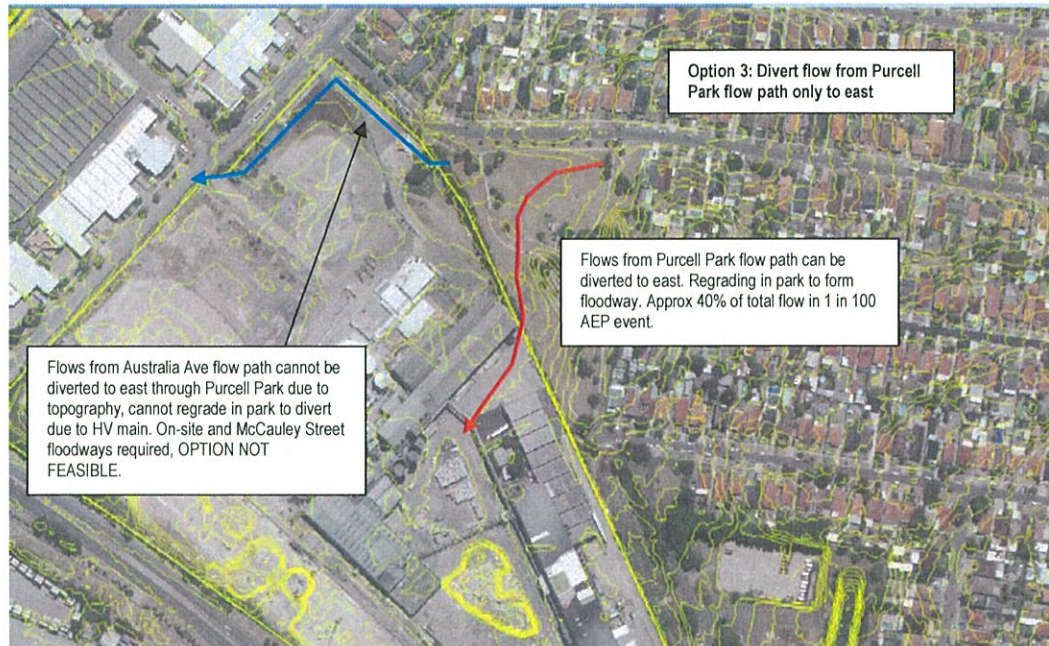
■ **Figure 5-4 Alternative option: Divert flows from western to eastern sub-catchment (Option 1)**



■ **Figure 5-5 Alternative option: Divert flows from western to eastern sub-catchment (Option 2)**



- **Figure 5-6 Alternative option: Divert flows from western to eastern sub-catchment (Option 3)**



5.2.3. Overland Flow Management – Western Area

The overland flows in this portion of the site would flow towards the south-west as per the pre-development case, but are blocked from flowing to Botany Road by the B9 building, which is currently being constructed.

Overland flows up to and including the 1 in 100 AEP event through and around the site in the Western Area would be managed with the works described below and in **Figure 5-7**.

Construction of floodway through north-west corner of site

The overland flows will be intercepted by a formalised floodway channel as they enter the site off Australia Avenue. The floodway runs parallel to the existing site boundary, and tails-out at the proposed site entrance on McCauley Street, at the Raymond Avenue intersection. The floodway invert will tie in with the approved McCauley Street design levels at the kerb line.

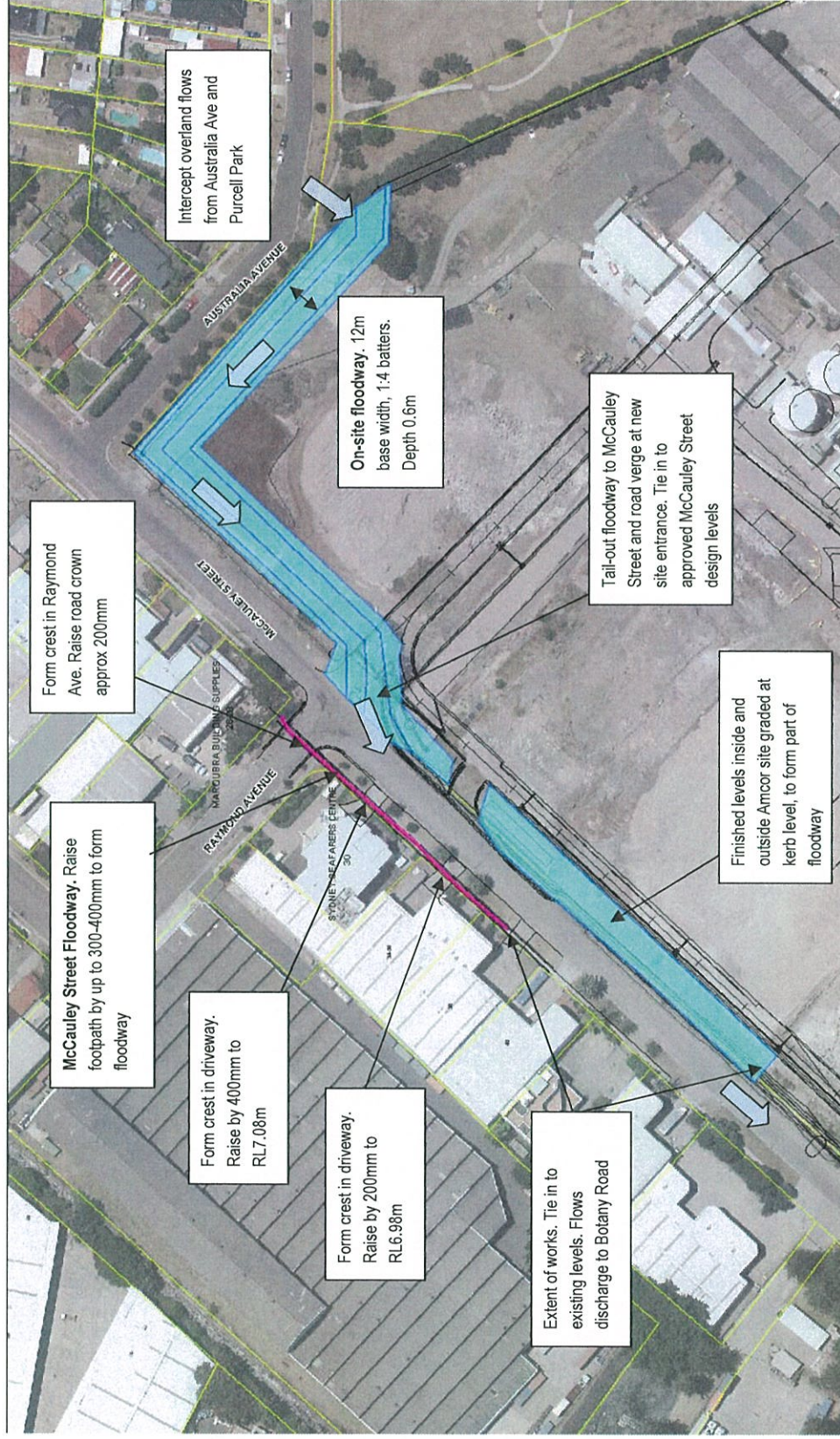
The floodway will have the following typical dimensions:

- Batter slopes 1:4 approximately.



- Channel depth 0.6m. A greater channel depth cannot be achieved due to the shallow change in elevation between the upstream and downstream ends of the channel (0.2m change in elevation).
- Base width 12m, top width 17m.
- Longitudinal slope 0.1%. The achievable slope is restricted by the flat terrain.
- Base lining will be short grass. Batter slopes are assumed to be lightly vegetated.

■ Figure 5-7 Western Area floodway





Formation of a floodway in McCauley Street

The on-site floodway discharges flows to McCauley Street for conveyance to its current endpoint at the Botany Road sag. Given the flat terrain in this area, the floodway would be formed by raising a section of the footpath on the western side of McCauley Street, in addition to forming a crest in Raymond Avenue, to contain the flows in McCauley Street. The footpath levels will be raised by 300 – 400mm, and surface levels in Raymond Avenue raised by 150 – 200mm.

The footpath modification would extend to just before the third driveway south of Raymond Avenue, located 80m from the intersection. Beyond this location, McCauley Street is lower than the adjacent properties and forms a channel-like profile in the pre-developed case, hence modification of the footpath is not required.

The floodway will extend laterally onto the Amcor site, such that a proportion of the total flow will be conveyed within the Amcor site. On the eastern side of McCauley Street, the road verge and the area on the site between the site boundary and the parallel access road will be graded to the same level as the kerb, for a distance of 120m to the south of the Finished Product Store exit ramp. This surface grading will provide additional conveyance of flows on the Amcor site and will reduce the amount of flow conveyed in McCauley Street. The design of the access road cannot be lowered to use it as a part of the floodway, as the finished level of the access road is fixed by the B9 building footings, site stormwater and other services, which have already been installed. The extent and nature of the works are illustrated in **Figure 5-7**. The proposed landscaping along and inside the site boundary at this location will not need to be modified or deleted as a part of the floodway option.

5.2.4. Proposed Overland Flow Management – Eastern Area

It is anticipated that several buildings in the eastern portion of the site will be demolished in the ultimate development case, including the B7 and B8 buildings. The external overland flows will enter the site at the end of the brick wall, in the vicinity of the B8 building, assuming that the existing brick wall is retained in its current form.

The post-development case ground levels are proposed to be similar to the existing levels around B7 and B8 (approximately 7.5m AHD). There are several potential options for managing external overland flows in this area.

The preferred option is to convey all or some of the flood flows further east to the culvert beneath the Amcor site, thus maintaining the pre-development case flow behaviour. This would be achieved by extending the existing brick wall along the B8 building frontage, thus maintaining the pre-development flow path from the Hangar Catchment to Bunnerong Creek when the B8 building is demolished. This option has the advantage of reducing overland flow levels within the Amcor site and also at the Botany Road and Bumborah Point Road intersection as flows would be discharged



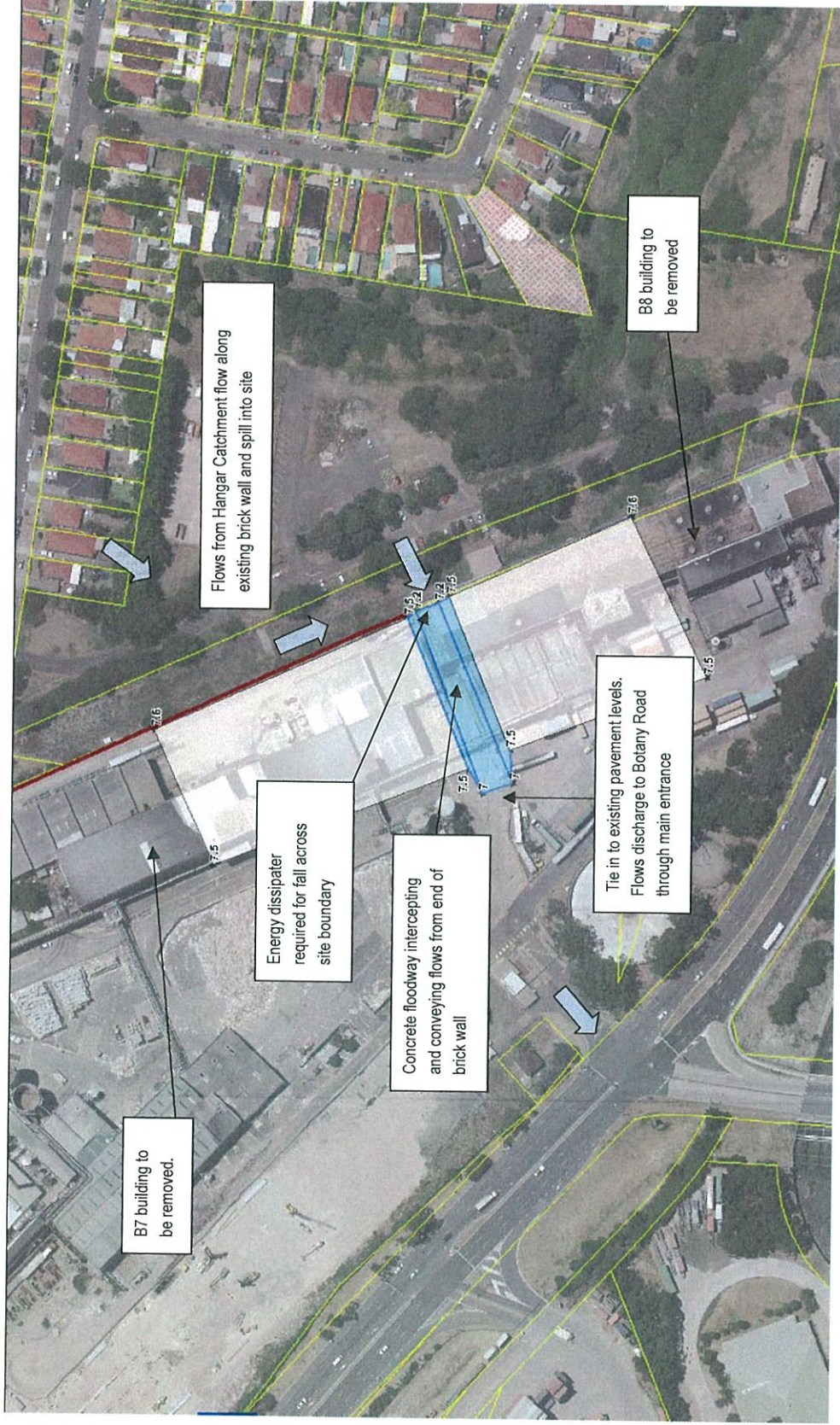
downstream of this intersection into Bunnerong Canal. This option may be preferable to RMS and Sydney Ports as it does not result in additional flooding of this key port access location.

Another option is to construct a floodway channel to intercept and convey the flows entering the site to the Amcor site main entrance. The potential floodway will have the following typical dimensions to convey up to and including the 1 in 100 AEP event flows (See **Figure 5-8**):

- Batter slopes 1:5 approximately.
- Channel depth 0.4m.
- Base width 12m, top width 16m.
- Longitudinal slope 0.3%.
- Base lining will be concrete.

A decision on the final solution for conveying overland flows from the Eastern catchment will be made before the demolition of the B7 and B8 buildings. It is to be noted that the demolition of the B7 and B8 buildings are not part of the approved New Paper Mill project.

■ Figure 5-8 Location of Proposed Flow Management Options, Eastern Area





5.2.5. Post-Development Case Flood Behaviour

The TUFLOW model results for the post-development case are presented as maximum flood depths in **Figure 5-9**. The impact of the proposed works on flood levels is shown in **Figure 5-10**.

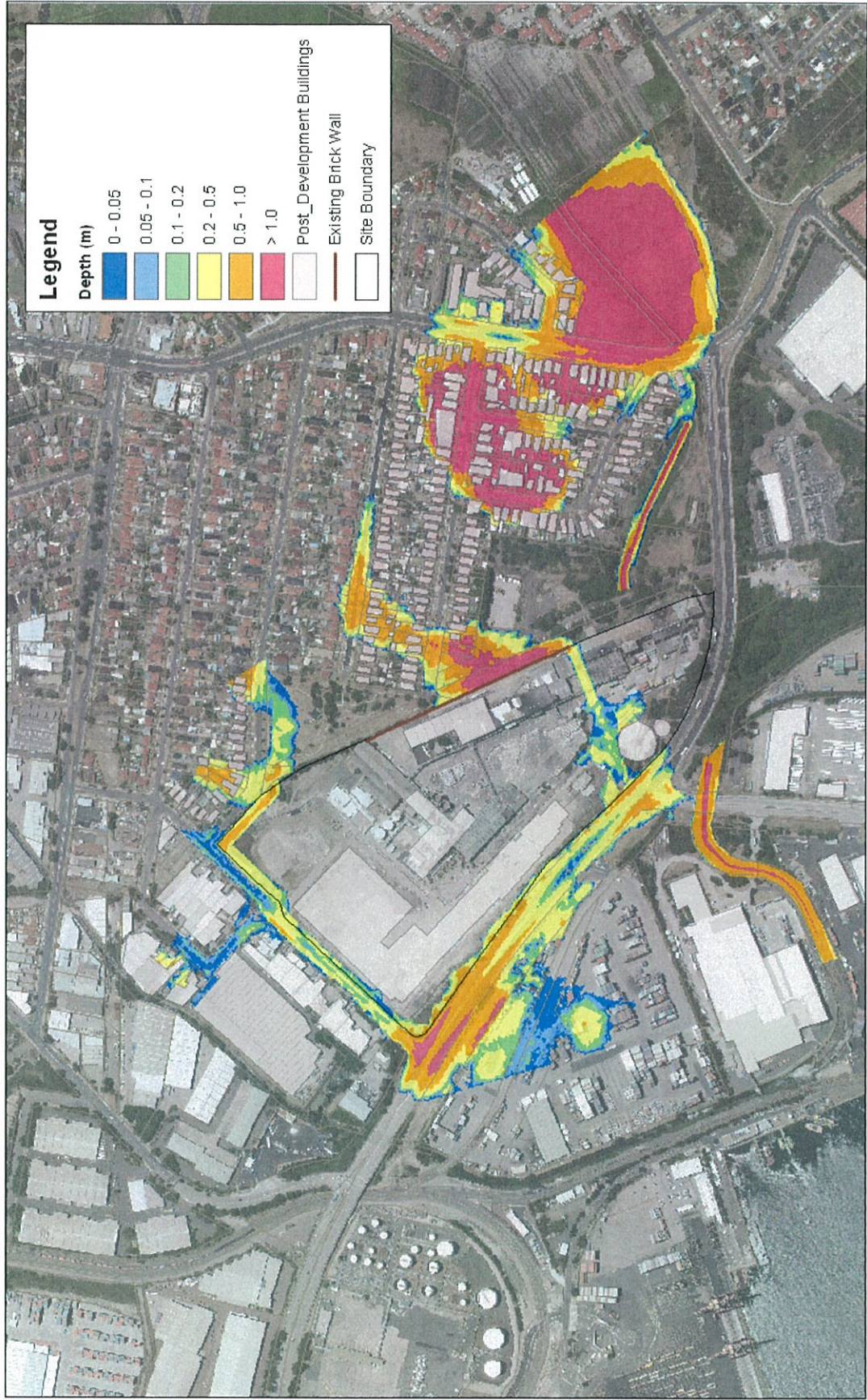
5.2.5.1. Western Area

The following outcomes will occur in the 1 in 100 AEP flood event in the western area:

- There will be no increase in the peak flood levels on any residential properties;
- There will be minor increases in flooding on a limited number of industrial properties on McCauley Street, but these impacts are localised and limited to fringe flooding on the property boundaries.
- Flows will be contained in the on-site floodway with minimum 100mm freeboard. Peak flows will be $6.6\text{m}^3/\text{s}$.
- Flows will be contained in the McCauley Street floodway with zero freeboard on the western footpath, which maintains the pre-development case conditions as the footpath is inundated in the pre-development case. Depths of flow on the footpath will be 10mm at the Sydney Seafarers Centre and up to 50mm at 38 McCauley Street. Peak flows will be $6.8\text{m}^3/\text{s}$. It should be noted that there would be freeboard for properties at 42 and 44-46 McCauley Street.
- A significant proportion of the total McCauley Street floodway flow (up to 30%) is conveyed in the part of the floodway within the Amcor site itself.
- There would be a reduction in flooding on the Sydney Seafarers Centre property, as the flood level in the Raymond Avenue sag is also reduced by preventing McCauley Street runoff from entering Raymond Avenue.
- The post-development case flooding does not encroach on any buildings on McCauley Street which are not currently flood affected. This includes all properties south of the Sydney Seafarers Centre.
- There will be increased flood depths in McCauley Street in the post-development case, though the depth of flow will be typically limited to 0.3m in the gutter. There would be localised areas where depths will be up to 0.7m, namely in the slight depression in the gutter on the western side of McCauley Street, just south of Raymond Avenue.
- Average flow velocities in McCauley Street will increase from 0.6 to 1.4m/s. Maximum velocities will stay the same at 3.7m/s.

There will therefore be no significant flood impacts to existing properties. There will be impacts to flood conditions in McCauley Street, though the risk to public safety can be managed. This is discussed in **Section 6**.

Figure 5-9 Peak 1 in 100 AEP Flood Depths, Post-Development Case





■ Figure 5-10 Change in Peak 1 in 100 AEP Flood, Post-Development Case (with on-site floodway conveying all flows)





5.2.5.2. Eastern Area

There are several options to manage overland flows from the Eastern catchment. The preferred option would be to extend the brick wall (or similar) and transfer the overland flow into Bunnerong Creek upstream of the Amcor site. This option does not require the construction of a floodway and would not result in increased flooding of Botany Road and the Botany Road/Bumborah Road intersection.

The other option involves the construction of an on-site floodway. The post-development case modelling results for an on-site floodway indicate the following outcomes for the 1 in 100 AEP flood event in the eastern area:

- There would be a reduction in flood levels of 300mm on residences in Partanna Avenue, as the removal of the B8 building will allow flows onto the site, with less build-up of floodwater behind the brick wall.
- Flows will be contained in the on-site floodway with approximately 100mm freeboard. Peak 1 in 100 AEP flows will be $2.7\text{m}^3/\text{s}$. Typical flow velocities are 1m/s.
- Flows will exit the Amcor site at the main entrance on Botany Road, and flow to the north-west along Botany Road to the sag at the McCauley Street intersection. Maximum flow velocities at the main entrance would remain at similar values of 3.1m/s.
- Flooding in Botany Road will increase up to 50mm mainly as a result of the Eastern Area floodway flows, which are currently discharged to Eastern Creek and subsequently Bunnerong Canal.

The final option for managing flows from the Eastern catchment would be considered prior to the demolition of the B7 and B8 buildings.



6. Validation of Proposed Design

6.1. Western Area

There are a number of flood risk and design issues relating to the proposed Western Area flow management works which have been considered in this assessment. These are discussed below.

Flood Level Impacts on the Amcor Site and Facilities

There will be some changes to flow patterns and flood levels affecting the Amcor site, including the B9 building, though these impacts are within acceptable limits. The Finished Product Store will be constructed with a finished floor level of 7.5m AHD. Peak flood levels in McCauley Street in the 1 in 100 AEP event will be 7.07m AHD. The maximum flood level adjacent to the Finished Product Store building will be 7.19m AHD, at a location at the outlet of the proposed on-site floodway channel. Peak flood levels would also be greater than 300mm below the Paper Machine building floor level further down McCauley Street. Hence, the prescribed 300mm freeboard above the 1 in 100 AEP flood level will be maintained.

Flood Level Impacts on External Properties

Flood levels in residential properties will not increase as a result of the works. Council's flood impact criterion for residential properties is therefore achieved.

Flood levels on industrial properties typically do not increase by more than 10mm. Three industrial properties become affected by fringe flooding as a result of the proposed works, but this is limited to shallow depths less than 20mm immediately on the property boundaries, which is considered a negligible impact on the flood affectation of these properties and is unlikely to affect the buildings. These properties are 34-36, 38 and 42-44 McCauley Street. Council's flood impact criterion for industrial properties is therefore achieved.

Impact on Driveway Access

Two driveway cross-overs on McCauley Street will be affected by the footpath raising along the western side of McCauley Street, namely the Sydney Seafarers Centre (30 McCauley Street) and the adjacent property (34-36 McCauley Street). Sections of the driveways will be modified to tie in to the raised footpath levels. Concept design of the proposed works on these driveways is shown in **Appendix C**.

A vehicle vertical clearance check was undertaken for the modified driveway profiles using Australian Standard typical car profiles. The driveway for the Sydney Seafarers Centre has the steepest change in grades out of the two driveways. There is a potential grounding issue at the kerb crossing for non-standard vehicles with low clearances, assuming that the vehicle enters and exits at a right-angle to the kerblines. However, vehicles typically enter and exit driveways diagonally, which allows the vehicles to enter and exit without grounding. Also there is an alternative access to



the Seafarers Club on Raymond Avenue and therefore vehicles that have low clearances would be able to access the club without grounding. Therefore, the proposed works will not impact on the accessibility of the affected properties.

Depths of flooding during the pre-development 1 in 100 AEP flood in the Botany Road sag are greater than 1m depth and would not permit cars to access McCauley Street from Botany Road.

A minor increase in flood depths is expected in the Botany Road sag (approximately 40mm) in the post-development case, which does not translate to an exacerbation of the trafficability of McCauley Street during storm events, as McCauley Street is already cut-off from Botany Road during storm events

The risk to southbound traffic on McCauley Street from north of Raymond Avenue can be managed by the provision of floodway warning signage and flood depth indicators.

Pedestrian Safety in McCauley Street

Recent research has produced a set of guideline values defining the flow conditions which pose varying degrees of hazard to pedestrians standing within these flows. The guidelines indicate the flow conditions posing a Low, Moderate and High Hazard to pedestrian stability. "Low Hazard" is defined as being where stability is uncompromised for persons standing in these flow conditions.

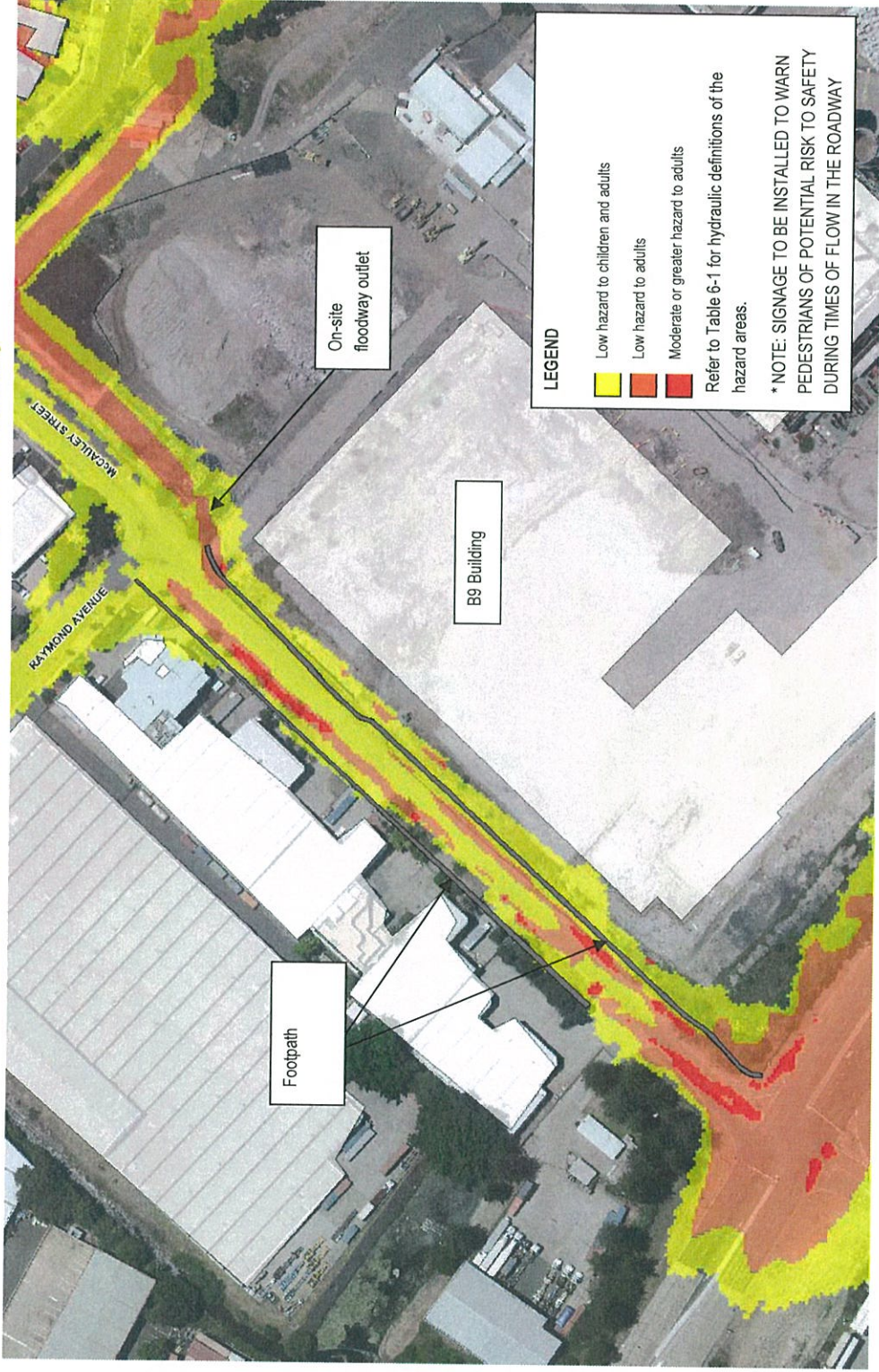
The Low Hazard areas for pedestrians in the 1 in 100 AEP event in McCauley Street are shown in **Figure 6-1**. The hazard areas for pedestrians are presented by the categories as described in **Table 6-1**.

■ **Table 6-1 Threshold Values for Pedestrian Stability Flow Hazard Areas***

Flow Hazard Description	Velocity x Depth value (m²/s)	Upper limit for depth (m)	Upper limit for velocity (m/s)
Low Hazard for adults and children (Yellow Area)	< 0.4	0.5	3.0
Low Hazard for adults (Orange Area)	< 0.6	1.2	3.0
Moderate Hazard and higher for adults	> 0.6	> 1.2	> 3.0

* Refer to **Figure 6-1** for mapping of these hazard areas.

■ Figure 6-1 Pedestrian Stability Flow Hazard Areas in Proposed McCauley Street Footway



SINCLAIR KNIGHT MERZ



The figure shows that the areas where the flows present a moderate or greater hazard to adult pedestrians (red areas) are localised and are limited in extent to the gutter. The areas where the flows are a moderate or greater hazard to children (orange and red areas) are more extensive, however, given that this is an industrialised area and that the road does not link up the nearby residential area to any parks or community facilities, it is highly unlikely for children to be pedestrians in this part of McCauley Street. The large orange area at the McCauley Street/Botany Road intersection is due to excessive depths, which are present in the pre-development case.

The existing and proposed footpaths on McCauley Street are typically low hazard areas in the post-development case (yellow areas), hence there is low hazard to adult and children pedestrians on the footpaths. A localised section of the eastern footpath at the Amcor site entrance has a VxD product of 0.4 – 0.6, which presents a low hazard to adults.

It should also be noted that the pedestrian footpath on the western side of McCauley Street would be above the 1 in 100 AEP event. This footpath would be the most trafficked as it fronts the commercial premises along McCauley Street. The eastern footpath along the Amcor site would only be used by pedestrians accessing their vehicles parked along this side of McCauley Street.

To mitigate the risk to the public from the areas in McCauley Street with a moderate (or higher) flow hazard, it is proposed that appropriate signage and depth indicators will be installed at a number of locations along McCauley Street, Botany Road and Raymond Avenue. The signage should state that flood flows may occur in McCauley Street, and that flows may be a risk to pedestrian safety. This will prompt pedestrians to immediately move to the footpath when McCauley Street begins to convey flow.

Damage to Vehicles in McCauley Street

Draft interim criteria proposed in Engineers Australia (2011) indicate that small vehicles would be stable in flows up to a VxD product of 0.3, in which case a large area of McCauley Street would experience flows exceeding this criterion in the post-development case. In the pre-development case there are only localised areas of $VxD > 0.3$. Therefore, there is a risk of damage to vehicles in McCauley Street during a flood event in the post-development case, with this risk being higher than in the existing case.

It is proposed that signage in McCauley Street be installed that warns drivers that the road is a floodway and that flows in the road may cause damage to vehicles, in addition to the installation of flow depth indicators. Drivers will therefore be made aware of the risk to their property if they choose to use the road or park their cars on McCauley Street. The other option would be to remove parking in affected areas of McCauley Street.



Property Drainage

Modifications to property drainage on the Sydney Seafarers Centre, 34-36 and 38 McCauley Street will be required to assist with stormwater drainage on these properties, as the elevated flood levels in McCauley Street in the post-development case may hinder the capacity of the pipe drainage on these properties. The following modifications are proposed:

- Seafarers Centre: Abandon existing drainage connection from sump pit in driveway to McCauley Street. Install a new connection to pit in Raymond Avenue.
- 34-36 McCauley Street: Abandon existing drainage connection from sump pit in driveway to McCauley Street. Install a new connection to pit on 38 McCauley Street, retaining existing connection to McCauley Street pit.

The drainage modifications are illustrated on **Figure 6-2**.

Note on McCauley Street Upgrade Design

The approved road upgrade design for McCauley Street will be retained. Additional minor adjustments are proposed to tie in with the raised Raymond Avenue crest, and beyond the kerb-line for the Amcor site access at the Raymond Avenue intersection. The existing approved kerb levels in McCauley Street will be retained. Modification of the kerbs on both corners of Raymond Avenue is proposed.

■ Figure 6-2 Proposed property drainage modifications





6.2. Flood Evacuation

The overland flow management works will change the flood behaviour on and around the Amcor site, which may affect existing routes for evacuation of properties in case of emergency. This is discussed below.

The Amcor Site

The McCauley Street evacuation route will be cut off for both standard vehicles and pedestrians during flood events in the post-development case. Access via the main entrance for standard vehicles is also likely to be cut off due to excessive flood depths on Botany Road. Pedestrians could evacuate the site to the high ground on the eastern side of Purcell Park and ultimately Australia Avenue. Those in the eastern corner of the site could evacuate to Botany Road, east of the main entrance. Access gates at these locations would need to be installed.

A potential option for vehicular evacuation of the Amcor site is by semi-trailer trucks, which are likely to be on site at all times due to the proposed 24 hour operation of the upgraded Amcor site. A potential evacuation route would be via the main entrance and east-bound along Botany Road.

Industrial Properties along McCauley Street and Raymond Avenue

Vehicle access via McCauley Street would be cut off for the industrial properties to the south of Raymond Avenue in the post-development case. Pedestrian evacuation would be possible along the western footpath on McCauley Street in the 1 in 100 AEP event, as the footpath would only be flooded to a shallow depth with a low VxD product (refer to **Section 6.1**).

Vehicle access and evacuation can potentially be undertaken via the private laneway behind the industrial properties on McCauley Street, although there is a gate restricting access from Raymond Avenue.

The flood evacuation route for industrial properties on and to the north of Raymond Avenue would not be impacted by the flow management works.

Residential Properties around Amcor Site

Flood evacuation routes for the residential properties to the north and east of the Amcor site would not be impacted by the works, as the works would occur downstream of the properties. The likely evacuation routes for these properties would be uphill, away from the changed flood behaviour.



6.3. Loss of Access to Site

There is likely to be temporary loss of access to the Amcor site during flood events in the pre-development case, both along McCauley Street and through the main entrance on Botany Road, which may cause disruption to operations. Access to McCauley Street and the main entrance will become restricted due to flooding in Botany Road of up to 1m in the 1 in 100 AEP event.

The works may result in an increased frequency in the loss of access to the site, since flooding in Botany Road will increase slightly in the post-development case. Further investigation is required to determine the frequency of the site access being cut off, by analysing the flood conditions in more frequent events than the 1 in 100 AEP event.



7. Conclusions

The works discussed in this report have been developed to manage overland flows in the 1 in 100 AEP storm through and around the Amcor site. These include:

- An on-site floodway through the north-west corner of the site, discharging into McCauley Street.
- Creation of a floodway in McCauley Street by raising a section of the western footpath and creating a hump in Raymond Avenue. This floodway will convey flows to their current outlet at the Botany Road sag.
- An on-site floodway in the eastern portion of the site to intercept flows entering the site from the Hangar Catchment, discharging the flows to Botany Road at the Amcor site main entrance.
- An alternative to the eastern on-site floodway is to extend the existing brick wall along the B8 building frontage, thus maintaining the pre-development flow path from the Hangar Catchment to Bunnerong Creek when the B8 building is demolished.

The works will have no significant impact to flooding in the 1 in 100 AEP event on residential and industrial properties. The required level of freeboard above flood level to the finished floor levels of proposed buildings on the site will be maintained.

Modified property driveway configurations as a part of the proposed works have been reviewed, and there will be no significant impacts to the accessibility of the affected properties.

Flow conditions in McCauley Street have been reviewed, and it is considered that there will be no significant risk to pedestrian safety in the post-development flow conditions. There is a risk of damage to vehicles due to flows in McCauley Street, which needs to be managed through appropriate signage.

Modifications to property stormwater drainage for three industrial properties on McCauley Street are likely to be required to mitigate any drainage impacts due to the flow management measures.



8. References

Institute of Engineers Australia (2001) *Australian Rainfall and Runoff*. Editor-in-Chief D.H. Pilgrim.

Engineers Australia (2010) *Australian Rainfall and Runoff Revision Project 10 Stage 1: Appropriate Safety Criteria for People*. AR&R Report Number P10/S1/006, April 2010. Editor: Dr James Ball

Engineers Australia (2011) *Australian Rainfall and Runoff Revision Project 10 Stage 2: Appropriate Safety Criteria for Vehicles*. AR&R Report Number P10/S2/020, February 2011. Editor: Dr James Ball

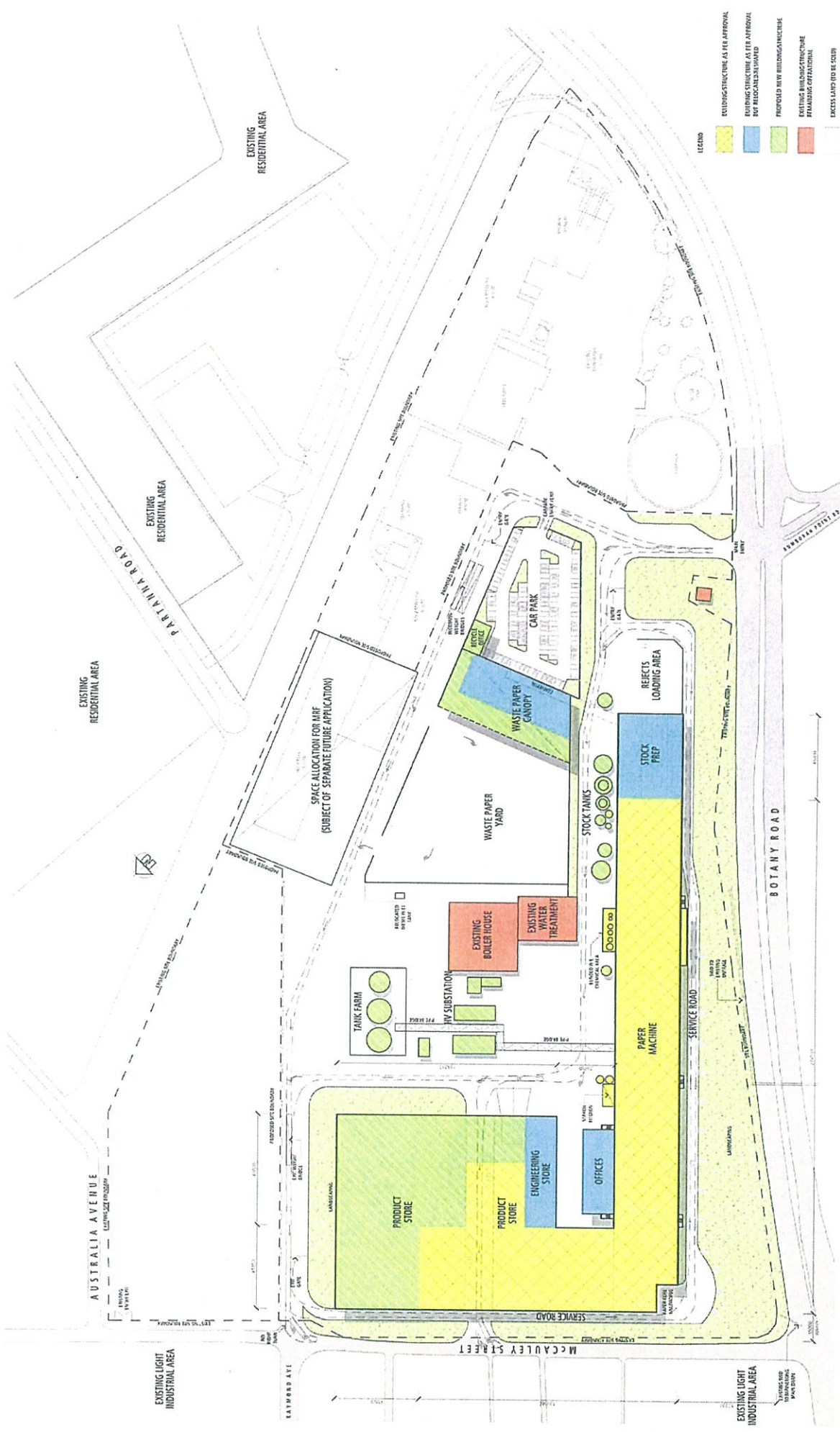
NSW Government (2005) *Floodplain Development Manual*.

Sinclair Knight Merz (2008) *Ancor Botany – Western Side Flood Study*. Prepared for Ancor.

Sinclair Knight Merz (2009) *Ancor Botany – Eastern Creek Flood Study*. Prepared for Ancor.



Appendix A Ultimate Development Case Site Layout



AMCOR MODIFICATION TO APPROVED DA LAYOUT

CNR BOTANY ROAD & MCCAULEY STREET, MATRIVILLE NSW

09117 TP01c



NOTE: DIMENSIONS APPROXIMATE ONLY, INCLUDING 1000MM PRODUCT STORE LAYOUT

WATSON YOUNG ARCHITECTS / INTERIORS

NO	REV	REASON	DATE	BY	CHK
1	01	ISSUED FOR PERMIT	10/10/20	WY	WY
2	02	ISSUED FOR PERMIT	10/10/20	WY	WY
3	03	ISSUED FOR PERMIT	10/10/20	WY	WY
4	04	ISSUED FOR PERMIT	10/10/20	WY	WY
5	05	ISSUED FOR PERMIT	10/10/20	WY	WY
6	06	ISSUED FOR PERMIT	10/10/20	WY	WY
7	07	ISSUED FOR PERMIT	10/10/20	WY	WY
8	08	ISSUED FOR PERMIT	10/10/20	WY	WY
9	09	ISSUED FOR PERMIT	10/10/20	WY	WY
10	10	ISSUED FOR PERMIT	10/10/20	WY	WY

OCT 09

DATE

SCALE

1:1000

1:2000



Appendix B Hydrologic Model Results



■ Table B-1 Peak Flows at Sub-Catchment Outlets, 1 in 100 AEP Flood Event

Sub-Catch	Area (ha)	Peak flow (m ³ /s)	Sub-Catch	Area (ha)	Peak flow (m ³ /s)
XP-RAFTS			DRAINS		
E001	22.2	11.6	Lower	1.11	0.7
E002	6.9	3.7	Upper	11.27	4.3
E003	20.2	9.6	MidEast	6.85	2.8
E004	18.0	9.7	Amcor_West	7.78	4.2
E005	9.0	5.1	Amcor_East	8.50	4.3
E006	29.2	12.1	McCauley	0.83	0.6
E007	18.6	8.6	Raymond	2.28	1.1
E008	16.3	7.9			
E009	17.4	8.3			
E010	14.7	9.4			
E011	5.2	2.7			
E012	10.8	6.4			
E013	7.0	2.0			
E014	8.0	3.1			
E015	11.4	4.9			
E016	6.7	4.2			
E017	11.1	5.3			
E018	2.1	1.4			
E019	1.3	0.7			
E020	0.2	0.1			
E021	2.1	1.4			
E022	16.3	11.9			
E030	5.5	2.6			



Appendix C Concept Details of Modification to Driveways at 30 and 34-36 McCauley Street



Figure C-1 Driveway Modification – Sydney Seafarers Centre

