Memo

Subject	Moorebank Intermodal Site Stormwater and Flood Conditions November 2017
Author	Richard McManus and Mark Wainwright
Distribution	Department of Planning
Date	16 November 2017

Dear Heather,

We have undertaken a review of Stormwater Quantity and Quality documents associated with the MPE and MPW sites. The review is presented in the following sections:

- Proposed consent conditions for Water and WSUD.
- Specific comments on the reports in meeting the SEARs and REMMs have been identified in the tables in Section 2 of this report. All comments raised in this section should be addressed.
- Review of specific issues within the reports relating to stormwater quantity management is outlined in Section 4.
- Review of specific issues within the reports relating to stormwater quality management is outlined in Section 5.
- Consistency with NSW Government Plans and Policies in Section 6.

If you have any queries about this memo, please feel free to contact me to discuss.

Yours Sincerely,

Richard McManus

T 02 8094 9703

M 0413 609 722

Suite 6, Level 1, 2-12 Foveaux St, Surry Hills NSW 2010

1 Proposed Consent Conditions for the MPE Stage 2 Application – Water and WSUD

The following are suggested consent conditions and proposed to address the deficiencies in the Water related reports prepared for the MPE and MPW sites, as subsequent information provided to the Department.

1.1 Soil and Water Management Plan

B1. *Prior to the commencement of early works, fill importation or any other surface disturbance, the Applicant must prepare a Soil and Water Management Plan to the satisfaction of the Secretary and include:*

- *(a) Measures to verify the properties of fill imported to the site*
- *(b) Plans showing limits of clearing, filling and other earthworks and vegetation to be retained and protected*
- *(c) Plans showing temporary access points and haul roads within the site for fill stockpiling and placement*
- *(d) Plans showing the location of stockpiled fill and other materials and storage areas;*
- *(e) Measures to minimise dust, erosion and prevent migration of soil offsite and migration into constructed and natural drainage lines;*
- *(f) Details on design and maintenance of temporary stormwater drainage infrastructure including sediment basins and temporary diversion channels around temporary work obstructions to allow low and normal flows to safely bypass the work areas and to separate clean and dirty water flows;*
- *(g) Details of existing stormwater infrastructure to be maintained, including proposed upgrades, and design and maintenance of proposed new infrastructure;*
- *(h) Confirmation that agreement has been obtained:*
  - *i. to discharge stormwater through adjacent sites;*
  - *ii. for any necessary upgrade works to be constructed;*
  - *iii. for undertaking maintenance activities; and*
  - *iv. evidence that an easement has been obtained to discharge water through adjacent sites;*
- *(h) Confirmation that the stormwater drainage systems in adjacent sites are designed, or can be upgraded to accept flows from the MPE site, including provision of scour protection at discharge points; and*
- *(i) Demonstrate that stormwater leaving the site meets the design water flow and water quality criteria in Section 1.1.2.*

1.1.1 Erosion and Sediment Control Plan

B2. *An Erosion and Sediment Control Plan*

- *(a) must be prepared by an appropriately-qualified person.*
- *(b) be prepared in accordance with Volume 1 of Managing Urban Stormwater: Soils and Construction ('the Blue Book') (Landcom 2004), Managing Urban Stormwater: Soils and Construction − Installation of Services, Volume 2A (OEH 2008) and Managing Urban Stormwater: Soils and Construction – Main Road Construction, Volume 2D (OEH 2008). The plan must consider likely stages of the works and provide for appropriate control of sediment and erosion for each stage. This Plan shall show:*
  - *(i) location and extent of all necessary sediment and erosion control measures for the site*
  - *(ii) catchment plan*
  - *(iii) sediment basin(s) locations including details showing how runoff from the entire site will be directed to the sediment basin(s)*
  - *(iv) All relevant details and calculations of the sediment basins including sizes, depths, flocculation, outlet design, all relevant sections, pump out systems, and depths*
  - *(v) all details of basement and other excavation pump out and dewatering treatment systems including flocculation and any proposed discharge from the site from dewatering and pump out systems*
  - *(vi) identification and management of any stormwater run-on to the site from adjacent sites*
  - *(vii) location of any temporary stockpiles (soil, spoil, top soil or otherwise) and accompanying sediment and erosion control measures*

(viii) location and details of all vehicle wash down bays and associated erosion and sediment control measures such as earthen bunds

(ix) A daily and weekly site inspection checklist consistent with IECA Best Practice Erosion and Sediment Control documents

(c) be implemented prior to the start of each stage of the project (and any substages) and be updated as relevant to changing early works; fill importation, stockpiling and placement, and construction activities.

1.1.2 Stormwater Management Plan

B3. *An amended Stormwater Water Management Plan must be prepared by a suitably qualified person and independently reviewed to ensure it meets the following criteria:*

(a) Flooding

(i) Demonstrate no impact on flood levels / extents on Anzac Creek due to filling MPE

(ii) Demonstrate no impact on flood levels / extents on the Georges River Creek due to filling MPW

(b) Drainage

(i) convey flows from low order events (up to and including the 10% AEP event from the main part of the site, and up to and including the 2% AEP event for the rail access connection corridor) within the formal drainage system, with lows from rarer events (up to the 1% AEP event) conveyed in controlled overland flow paths.

(ii) show the location and width of controlled overland flow paths.

(iii) provide levels to AHD confirming building floor levels are a minimum of 150 mm above the maximum design flow path levels.

(c) Water quantity

(i) On site detention is to be provided to attenuate peak flows from the development such that both the:

- *1 in 1-year ARI event post development peak discharge rate is equivalent to the pre-development (un-developed catchment) 1 in 1-year ARI event*
- *1 in 100-year ARI event post development peak discharge rate is equivalent to the pre-development (un-developed catchment) 1 in 100-year ARI event*

(ii) no stormwater discharges to the Defence Joint Logistics Unit (DJLU) site

(iii) all onsite detention basins to have maximum batter slopes of 1V:4H

(iv) demonstrate that onsite detention basins are within common areas.

(d) Connection to natural creeks

(i) onsite detention basin outlets to natural drainage lines are to be constructed of natural materials to facilitate natural geomorphic processes and to include vegetation as necessary (gabion baskets and gabion mattresses are not acceptable).

(e) Stormwater Quality

(i) have stormwater quality treatment train comprised of gross pollutant traps and biofiltration / bioretention systems to

- *Reduce the average annual load of total nitrogen by 45% compared to a base case if there were no treatment systems in place*
- *Reduce the average annual load of total phosphorus by 65% compared to a base case if there were no treatment systems in place*
- *Reduce the average annual load of total suspended solids by 85% compared to a base case if there were no treatment systems in place*

(ii) all stormwater quality elements are to be modelled in MUSIC as per the NSW MUSIC Modelling Guide.

(iii) all stormwater quality elements are to be installed upstream of stormwater detention basins.

(iv) the area of biofiltration / bioretention systems is to be at least 1% of the catchment draining to the system, to ensure there is no short-circuiting of the system.

(v) bioretention systems which are greater than 1,000m^2 in area, are to be divided into cells with no individual cell greater than1,000m^2.

(vi) all filter media used in stormwater treatment measures must:

- *be loamy sand with an appropriately high permeability under compaction and must be free of rubbish, deleterious material, toxicants, declared plants and local weeds, and must not be hydrophobic;*
- *have a hydraulic conductivity = 100-300 mm/hr, as measured using the ASTM F1815-06 method*
- *have an organic matter content less than 5% (w/w).*

1.1.3 Stockpile Management Plan

B4. *The Stockpile Management Plan must be consistent with Volume 1 of Managing Urban Stormwater: Soils and Construction ('the Blue Book') (Landcom 2004), Managing Urban Stormwater: Soils and Construction – Installation of Services, Volume 2A (OEH 2008) and Managing Urban Stormwater: Soils and Construction – Main Road Construction, Volume 2D (OEH 2008). This Plan shall show:*

(a) Details on and the location of fill sorting, crushing and stockpiling
(b) Details of erosion and sediment control downslope of the stockpiles
(c) Plans and details on the progressive formation of stockpiles, placement and stabilisation of placed fill
(d) Stockpiles not to exceed more than 10m in height with stockpiles over 4m in height to be benched, slopes to be a maximum of 1V:3H.
(e) Monitoring of stockpile moisture content and stockpile watering
(f) Stabilisation of stockpiles if not worked on for more than 10 days
(g) Stabilisation of placed fill if construction does not commence within 10 days.

B5. *The amended numerical models are to be submitted to the Secretary.*

1.1.4 Water Quality Monitoring Plan

B6. *A Stormwater Quality Monitoring Program must be prepared in consultation with OEH prior to operation and must be implemented for 5 years following completion of construction to monitor performance of the stormwater treatment system in relation to the ANZECC guidelines.*

1.1.5 Stormwater Infrastructure Operation and Maintenance Plan

B7. *Conversion of any construction stage sediment and erosion control measures into stormwater quality treatment elements must only occur once the civil works (roads and drainage) have been completed for the site to ensure the treatment measure is compromised by sediment runoff.*

B8. *Any subsequent development in the catchment, including but not limited to warehousing, must control sediment runoff such that it does not impact on the effectiveness of the stormwater treatment elements. At the completion of any such construction over 1ha in the catchment, the design engineer(s) responsible for the construction drawings of the stormwater treatment measures are to certify that the system is operating in accordance with the construction drawings or, where modified, this has not adversely affected the performance of the system. All stormwater infrastructure must be constructed in accordance with the Stormwater Management Plan approved by the Secretary and properly maintained on an ongoing basis.*

B9. *Works as Executed drawings signed off by the design engineer(s) responsible for the construction drawings of the stormwater treatment measures are to be provided to the Secretary. The engineer is to certify that the system has been constructed in accordance with the construction drawings or, where modified, this has not adversely affected the performance of the system.*

B10. *A Stormwater Infrastructure Operation and Maintenance Plan must form part of the OEMP required under condition C4 and must be implemented for the life of the assets and include:*

(a) the entity responsible for management and maintenance of the assets
(b) quarterly inspections and inspections after major rainfall events
(c) schedule for routine checking, cleaning and servicing of all devices/ systems in accordance with the manufacturer's and/or designer's recommendations.
(d) records of all maintenance activities undertaken
(e) results of water quality monitoring
(f) investigation, management and mitigation of water quality guideline exceedances
(g) annual independent auditing

B11. *Prior to operation, evidence is to be provide to the Secretary that a maintenance contract is in place with a reputable and experience maintenance contractor.*

B12. *The annual independent audit must be undertaken by a suitably qualified WSUD professional. The audit is to verify the condition of the treatment system(s), verify and document that the system(s) is working as intended, verify the system(s) has been cleaned adequately, verify there is no excessive build-up of material in the system(s) and identify any issues with the treatment system(s) which require rectification for the system(s) to adequately perform its intended function.*

B13. *A quarterly maintenance report and annual independent audit report is to be provided to the Secretary following completion of construction and must include the results of inspections, management and maintenance actions and water quality monitoring.*

3 Compliance of the Stormwater and Flooding Environmental Assessment with the REMMS and SEARs

Specific comments on the reports in meeting the SEARs and REMMs have been identified in the following tables. all issues raised in the comments section (ie column 3 below), should be addressed by the proponent.

3.1 Review of the Secretary's Environmental Assessment Requirements for MPW

SEARS No	SEARS	Report Section / Comment
8a	assess impacts on surface and groundwater flows, quality and quantity, with particular reference to any likely impacts on dragonfly species listed under the *Fisheries Management Act 1994*, the Georges River and Anzac Creek;	Sections 4 & 5: Quantity Section 6: Quality ('Groundwater' and 'impacts on dragonfly species' are not addressed in this report. Refer to biodiversity assessment regarding dragonfly) NOT ADDRESSED – there is no reference to the ecological needs of the Georges River or ANZAC Creek.
8b	assess flooding impacts and characteristics, to and from the project, with an assessment of the potential changes to flooding behaviour (levels, velocities and direction) and impacts on bed and bank stability, through flood modelling, including: i. hydraulic modelling for a range of flood events; ii. description, justification and assessment of design objectives (including bridge, culvert and embankment design); iii. an assessment of afflux and flood duration (inundation period) on property; iv. consideration of the effects of climate change, including changes to rainfall frequency and/or intensity, including an assessment of the capacity of stormwater drainage structures; and v. relevant provisions of the NSW Floodplain Development Manual 2005.	Sections 4 & 5 (no bridge) PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.
8c	assess effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas, water dependent fauna and flora	Section 6 NOT ADDRESSED – Section 6 presents no assessment of downstream rivers wetlands, flora or fauna, nor the hydrologic, geomorphic needs of those systems. Specifically, there is no consideration of geomorphic flows
8d	describe any mitigating effects of the proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options;	Section 6 PARTIALLY ADDRESSED – specific comments on modelling is contained in Sections 4 and 5 of this memo.
8e	identification of proposed monitoring of hydrological attributes;	Section 6.

SEARS No	SEARS	Report Section / Comment
		NOT ADDRESSED
8f	address drainage issues associated with the development / site, including the incorporation of Water Sensitive Urban Design measures, stormwater and drainage infrastructure such as on-site detention systems to ensure peak discharges and flow velocities post development shall not exceed existing peak flows and velocities;	Section 5: Quantity Section 6: Quality PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.
8g	undertake an assessment of surface water quality during construction (including reference to water quality objectives for the relevant catchment where objectives have been determined), including an identification of works that may impact water quality, and a summary of proposed monitoring and mitigation measures in accordance with Managing Urban Stormwater – Soils & Construction Volume 1 2004 (Landcom) and Volume 2 (DECC 2008);	Section 6 NOT ADDRESSED – only limited information provided.
8h	consideration of stormwater quality and management (including monitoring) during operation of the site with the objective of maintaining or improving existing water quality taking into account the Water Quality Objectives	Section 6 PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.
8i	consider whether the existing sewerage system can cater for the proposal and whether environmental performance of the existing system will be impacted;	Sewerage is not addressed in this report - provide technical report section where this has been comprehensively addressed
8j	identify and assess the soil characteristics and properties that may impact or be impacted by the project, including acid sulfate soils, salinity, erodibility, unstable or unsuitable ground and unrippable rock; and	Soil characteristics are not addressed in this report – provide technical report section where this has been comprehensively addressed
8k	include a bulk earthworks strategy detailing the volume of spoil to be extracted from the site, planned reuse and amount of material to be imported.	Bulk earthworks strategy is not addressed in this report – provide technical report section where this has been comprehensively addressed

3.2 Review of the REMMS - MPW

REMMS	REMM	Report Section / Comment
9A	A soil and water management plan (or equivalent) would be developed before work begins in the conservation area. This plan would include erosion and sediment control plans (ESCPs) and procedures to manage and minimise potential environmental impacts associated with developing this area.	EW Design Dwg PARTIALLY ADDRESSED – limited information provided.
9B	Site compounds, stockpiling areas and storage areas for sensitive plant, equipment and hazardous materials would be located above an appropriate design flood level, which would be determined based on the duration of the construction works.	EW Sections 5.3 & 5.4 NOT ADDRESSED – See detail provided on REMMS 9N, 9O, 9P, 9Q and 9S.
9E	For all site works, provide temporary diversion channels around temporary work obstructions to allow low and normal flows to safely bypass the work areas.	C Design Drawing NOT ADDRESSED – there is limited information on diversion channels, and staging.
9F	The potential effects of various flood events on construction phase works would be further investigated during detailed design and preparation of the Stage 2 SSD approval(s).	DD Section 5
9K	The following staging process would be considered to be implemented when constructing surface water drainage infrastructure: • Biofiltration and detention basins that form part of the proposed stormwater management strategy would be excavated at the first phase of development, with the intention that the excavated basins would be used as temporary construction phase sedimentation basins. Once these construction phases become operational, these temporary construction phase sedimentation basins could be developed into the permanent biofiltration and detention basins. • During the relevant phase of development, all major stormwater pipes and culverts (600 mm diameter and larger) and main channels and outlets would be installed. Minor drainage and upstream systems would then be progressively connected to the major drainage elements during each phase of construction as required.	C Design Drawing NOT ADDRESSED - No detail is provided on how temporary construction phase sedimentation basins would be converted into biofiltration and OSD basins.
9L	A soil and water management plan (or equivalent) would be developed before land was disturbed that would include erosion and sediment control plans (ESCPs) and procedures to manage and minimise potential environmental impacts associated with construction of the Project. The ESCP(s) for the Project would be prepared in accordance with Volume 1 of Managing Urban Stormwater: Soils and Construction ('the Blue Book') (Landcom 2004), Managing Urban Stormwater: Soils and Construction − Installation of Services, Volume 2A (OEH 2008) and Managing Urban Stormwater: Soils and Construction – Main Road Construction, Volume 2D (OEH 2008). The ESCP(s) would be established before the start of each construction phase and would be updated as relevant to the changing construction activities.	C Design Drawings PARTIALLY ADDRESSED – Limited detail is provided on erosion and sediment control plans (ESCPs)
9N	Vehicles and machinery would be properly maintained to minimise the risk of fuel/oil leaks.	C Design Drawings NOT ADDRESSED – Limited detail is provided on REMMS 9N, 9O, 9P, 9Q and 9S.
9O	Routine inspections of all construction vehicles and equipment would be undertaken for evidence of fuel/oil leaks.	
9P	All fuels, chemicals and hazardous liquids would be stored within an impervious bunded area in accordance with Australian Standards and NSW Environment Protection Authority guidelines.	

9Q	Emergency spill kits would be kept onsite at all times. All staff would be made aware of the location of the spill kits and trained in their use.	
9S	Construction plant, vehicles and equipment would be refuelled offsite, or in designated re-fuelling areas located at least 50 metres from drainage lines or waterways.	
9U	A stormwater management plan (or equivalent) would be developed in accordance with the detailed design. This includes the requirement to control the rate of stormwater runoff so that it does not exceed the pre-developed rate of runoff.	DD - Section 5 ADDRESSED – further comments on modelling are contained in Section 4 and 5 of this memo.
9V	The stormwater system would be designed such that flow from low order events (up to and including the 10% AEP event from the main part of the site, and up to and including the 2% AEP event for the rail access connection corridor) would be conveyed within the formal drainage systems. Flows from rarer events (up to the 1% AEP event) would be conveyed in controlled overland flow paths.	
9W	The onsite detention system proposed would detain flow and control discharge rates to the Georges River equal to predevelopment discharge rates.	DD Section 5 ADDRESSED – further comments on modelling are contained in Section 4 and 5 of this memo.
9X	A stormwater treatment system would be implemented, incorporating sedimentation and bio-filtration basins upstream of the stormwater detention basins.	DD, C Section 6 & Design Drawings NOT ADDRESSED – Stormwater treatment systems (bioretention systems) have been designed in the base of the OSD basins, NOT upstream of OSD basins. This is further discussed in Section 5 of this document.
9Y	Use of onsite infiltration would be incorporated into the design through the distribution of swale drains and rain gardens across the Project site.	DD Section 6 & Design NOT ADDRESSED – There are no infiltration systems, swales or raingardens proposed across the development site, only as part of the OSD basins.
9Z	A number of other stormwater management opportunities would be considered during development of the detailed design in accordance with Liverpool City Council's Development Control Plan Part 2.4 Development in Moorebank Defence Lands and other relevant policies, including: • polishing water runoff using dry creek gravel beds with macrophyte plants; • using drainage swales to slow down stormwater runoff and increase onsite infiltration; • collecting roof rainwater for re-use onsite; • installing gross pollutant traps (GPTs) at the outlets of the pipe system before discharge into the sedimentation basins; and • incorporating impervious surfaces and vegetated areas into the design to increase sub-surface water flow during rain events and to reduce the discharge of stormwater pollutants.	DD Section 6 & Design Drawings NOT ADDRESSED – the following have not been considered. • using drainage swales to slow down stormwater runoff and increase onsite infiltration; • incorporating impervious surfaces and vegetated areas into the design to increase sub-surface water flow during rain events and to reduce the discharge of stormwater pollutants.

3.3 Review of the Secretary's Environmental Assessment Requirements for MPE

7. An assessment of soil and water impacts for the site. The assessment shall:		
a)	assess impacts on surface and groundwater flows, quality and quantity, with particular reference to any likely impacts on Georges River and Anzac Creek;	NOT ADDRESSED – there is no reference to the ecological needs of the Georges River or ANZAC Creek.
b)	assess flooding impacts and characteristics, to and from the project, with an assessment of the potential changes to flooding behaviour with particular emphasis on local stormwater flooding (levels, velocities, extents and direction) and impacts on bed and bank stability, through flood modelling, including: i. hydraulic modelling for a range of flood events; ii. description, justification and assessment of design objectives (including bridge, culvert and embankment design); iii. an assessment of afflux and flood duration (inundation period) on property; iv. consideration of the effects of climate change, including changes to rainfall frequency and/or intensity, including an assessment of the capacity of stormwater drainage structures; and v. relevant provisions of the *NSW Floodplain Development Manual 2005*.	PARTIALLY ADDRESSED – specific comments on modelling is contained in Sections 4 and 5 of this memo.
c)	assess effects to downstream rivers, riparian vegetation, wetlands, estuaries and floodplain areas, water dependent fauna and flora (including Ground Dependent Ecosystems);	NOT ADDRESSED – Section 6 presents no assessment of downstream rivers wetlands, flora or fauna, nor the hydrologic, geomorphic needs of those systems. Specifically, there is no consideration of geomorphic flows
d)	describe any mitigating effects of the proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options;	Section 6 PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.
e)	identification of proposed monitoring of hydrological attributes;	
f)	include a detailed and consolidated site water balance;	NOT ADDRESSED
g)	address drainage issues associated with the development / site, including the incorporation of Water Sensitive Urban Design measures, stormwater and drainage infrastructure such as on-site detention systems to ensure peak discharges and flow velocities post development shall not exceed existing peak flows and velocities;	PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.
h)	undertake an assessment of surface water quality during construction (including reference to water quality objectives for the relevant catchment where objectives have been determined), including an identification of works that may impact water quality, and a summary of proposed monitoring and mitigation measures in accordance with Managing Urban Stormwater – Soils & Construction Volume 1 2004 (Landcom) and Volume 2 (DECC 2008);	NOT ADDRESSED – only limited information provided.
i)	consideration of stormwater quality and management (including monitoring) during operation of the site with	PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo.

	the objective of maintaining or improving existing water quality taking into account the Water Quality Objectives;	
j)	consider whether the existing sewerage system can cater for the proposal and whether environmental performance of the existing system will be impacted;	Sewerage is not addressed in this report - provide technical report section where this has been comprehensively addressed
k)	identify and assess the soil characteristics and properties that may impact or be impacted by the project, including acid sulfate soils, salinity, erdodibility, unstable or unsuitable ground and unrippable rock;	Soil characteristics are not addressed in this report – provide technical report section where this has been comprehensively addressed
l)	include a bulk earthworks strategy detailing the volume of spoil to be extracted from the site, planned reuse and amount of material to be imported;	Bulk earthworks strategy is not addressed in this report – provide technical report section where this has been comprehensively addressed

3.4 Review of the Revised Statement of Commitments proposed by SIMTA – MPE

Biodiversity – Riparian	Comments
• Water quality and quantity issues will be managed during the construction phase through the implementation, inspection and maintenance of best practice soil and water management techniques which will be defined in the CEMP for sedimentation and erosion control during construction.	Limited information provided. Recommended consent conditions proposed.
• Water quality and quantity issues will be managed during the operation phase through the implementation, inspection and maintenance of Water Sensitive Urban Design (WSUD) measures such as rainwater tanks, grass filter strips, swales and bio retention.	PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo. Recommended consent conditions proposed.
Stormwater and Flooding	
• The Proponent will incorporate stormwater quantity and quality management measures into the detailed applications in accordance with the objectives and performance standards outlined in the Stormwater and Flooding Environmental Assessment report and including o Preparation of a Soil and Water Management Plan (SWMP) and Erosion and Sediment Control Plan (ESCP) for both the construction and operation phases. o implementation of management plan strategies prior to commencement of the staged construction phase o Monitoring and review performance of sediment and water control structures during construction and operation phases	PARTIALLY ADDRESSED – specific comments on modelling are contained in Sections 4 and 5 of this memo. Recommended consent conditions proposed.
• The proponent commits to providing a multi-cell culvert (with Elevated 'dry' cells and recessed 'wet' cells) to facilitate aquatic and terrestrial fauna movement in accordance with Witheridge (2003) and Part 7 (Division 3) of the Fisheries Management Act works (including the 1994 (FM Act).	All culverts should be constructed of natural materials to facilitate natural geomorphic processes. These systems should include vegetation as necessary. Gabion baskets and gabion mattressing is not acceptable. Recommended consent conditions proposed.

4 MPE and MPW Stormwater quantity management systems

This section of our review outlines our comments on the proposed drainage and stormwater detention systems proposed for the development. Our appreciation of the proposed stormwater quantity management systems and key comments on these elements are detailed in Table 1.

The key specific issues and recommendations on the proposed minor and major drainage system include:

1. Updated catchment plans for the pre-development and post development conditions should be provided by the applicant for the MPW and MPE sites. These catchment plans should clearly show labelled site contours at an appropriate interval to enable the defined sub-catchments to be confirmed.
2. The report indicates that the existing concrete lined channel through the MPW site is proposed to be modified by replacing the existing channel with a vertical sided 15m wide x 3.3m deep concrete channel (with a deeper lower flow section 2.4m wide x 5.1m deep). The channel is proposed to be enclosed for some sections through the MPW site and an open channel for others. It is considered that introducing a concrete lined drainage channel in an urban area with vertical sides up to 5.1m high is inconsistent with current practice and not appropriate in an urban area. Whilst fencing is proposed along the sides of the channel, it is unclear how the inlet to the channel downstream of Moorebank Avenue would be managed to prevent community access. It is unclear how the proposed 155m wide floodway across Moorebank Avenue would transition to the proposed deep vertical side channel without creating an elevated risk to the community.

The key specific issues and recommendations on the proposed on-site detention (OSD) system include:

3. The reports for MPW and MPE should clearly state the OSD objectives that have been adopted and provide discussion on how the adopted objectives address flood mitigation in the local, Anzac Creek and Georges River catchments.
4. The reports should discuss the adopted catchment gradients and impervious fractions for each sub-catchment modelled in DRAINS.
5. The MPE report indicates that existing flood storage is available within the MPE site. The MPW site is also likely to include existing local flood storage, although it is also unclear how this has been considered. The report should outline how this existing flood storage has been considered within the pre-development DRAINS models.
6. The MPE and MPW reports outline DRAINS modelling results for the PMF based on adopted PMP intensities. The reports should confirm how the PMP intensities were derived (or where these were adopted from).
7. The peak flow comparisons summarised in the Table 5-2 and Table 4-2 of the MPW and MPE reports respectively requires clarification. The applicant should confirm if the corresponding peak inflows and outflows presented in these tables are for the same design storm duration. The basin IDs adopted in the tables for MPW also appears to differ from the IDs in Appendix B of that report, and this makes review of the results challenging. In some circumstances, the peak flows summarised in Table 5-2 and Table 4-2 of the MPW and MPE reports appears to differ from the flows presented in the Appendices. The applicant should provide clarification on these issues.
8. Table 5-2 and Table 4-2 of the MPW and MPE reports respectively do not summarise the estimated pre-development flows at each basin site. It is therefore not possible to confirm from the provided results the estimated performance of each basin in relation to pre-development flows. The applicant should include the estimated pre-development flows at each basin site in these tables.
9. The proposed basins would have vertical concrete side walls containing stormwater up to depths of 3m in a 100-year ARI event. The applicant should outline how the proposed basin configurations have considered community safety and the financial sustainability of long-term operation and maintenance for these potentially oversized basins.
10. Proposed Basins 5 and 6 would have a maximum storage volume of approximately 60 ML and maximum water depth greater than 3m with vertical walls. The proposed basins should be assessed for consideration as “prescribed" dams under the Dams Safety Act 1978. The requirements of the NSW Dam Safety Committee for dam design should also be considered at this stage to ensure that

sufficient land is available in the development layout to position appropriately configured basins. It is considered that these requirements should be considered at this stage to avoid compromises on basin design later when the development footprint has progressed further.

More detailed comments are provided in Table 1 below.

Table 1 *Comments on proposed stormwater quantity management systems*

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
OSD objectives and targets	The report outlines that development of the site (without mitigation) has the potential to cause adverse flood impacts without provision of on-site detention and improved drainage from Moorebank Avenue through MPW to the Georges River. Comments and recommendations: *The report provides no clear statement on the adopted objectives or targets for the OSD basins. Whilst a range of flooding events have been modelled, the report does not clearly outline what the critical flooding events are for the downstream areas that may be impacted by increased flows from the development. For example, it is unclear if the OSD basins are being sized to focus on flood mitigation in the local catchments or the Georges River.* *The Georges River Flood Study (DLWC and LCC, 2000) identified that the critical duration event for the Georges River is the 36-hour event. It is considered likely that design flows during short duration events for the MPW site would not be as critical for downstream flooding. As the basins are primarily located adjacent to the Georges River with no development planned between the basin outlets and the river, the benefits of detaining short duration events that do not influence flooding behaviour in the Georges River would be of limited benefit. Focusing on mitigation of longer duration events could potentially assist with reducing the required detention storage and enable a more integrated and improved design for the basins.* • *The MPW and MPE reports should clearly state the adopted OSD objectives and targets.* • *Discussions should be held with Liverpool City Council to define requirements for all aspects of the Stormwater and Flooding Reports.*	*Similar comments and recommendations as for MPW, that it is unclear if the OSD basins are being sized to focus on mitigating flooding in the local catchments, Georges River, and/or Anzac Creek. The Anzac Creek Floodplain Risk Study and Management Plan (BMT WBM, 2008) identified that the critical duration event for flooding in the Anzac Creek catchment was associated with the 9-hour event.*
Pre-development sub-catchments	Drainage sub-catchments for the MPW site primarily comprise land to the west of Moorebank Avenue draining to the Georges River. A low north-south ridge through the adjacent MPE site directs runoff from the western portion of this site (approximately 50% of the site) in a westerly direction towards Moorebank Avenue. Moorebank Avenue grades in a northerly direction conveying runoff from the eastern side of Moorebank Avenue to an existing concrete lined open channel through the MPW site. An additional piped stormwater drainage line collects stormwater from	The eastern portion of the MPE site drains to Anzac Creek. The western portion of the MPE site drains to an existing channel in the MPW site that discharges to the Georges River.

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
	Moorebank Avenue towards the southern extents of MPE and conveys this centrally through the MPW site. An existing 25 ha sub-catchment comprising the southern extents of the MPW site currently drains into the headwaters of Anzac Creek to the east. Comments and recommendations: *The contours shown on the catchment plan for MPW are unclear for the purposes of confirming the pre-development sub-catchment areas adopted by the applicant. Confirmation of the adopted sub-catchment extents would require clearer catchment plans to be provided by the applicant. Our comments assume that the pre-development sub-catchments provided by the applicants have been defined appropriately.*	It was estimated that there is currently approximately 10,500 m^3 of flood storage within the MPE site. The post development site would drain similarly to the pre-development site and further discussion on this is provided below. Comments and recommendations: *Similar comments and recommendations as MPW apply to MPE*
Post-development sub-catchments	The MPW site would be drained to a series of OSD basins (Basins 3a, 4, 5, 6 and 8) to manage flooding hydrology from five separate local catchments. The proposed basin locations are shown on Figure 5-2 in the report. The proposed re-grading of the southern portion of the MPW site would direct an additional 15 ha of land to proposed Basins 6 and 8 that drain to the Georges River, with an equivalent reduction in catchment area draining to Anzac Creek through proposed Basin 3a. With the exception of the southern portion of MPW land, it is our understanding from the provided information that the pre-and post-development catchment areas draining to Anzac Creek and the Georges River will be similar. Comments and recommendations: *Similar to the pre-development sub-catchments, a clear catchment plan showing the proposed finished surface grading was not provided by the applicant for the MPW site. Our comments assume that the post development sub-catchments draining to each basin have been defined appropriately by the applicant.*	The MPE site sub-catchments would be drained to four OSD basins (Basins 1, 2, 9 and 10) to manage flooding for separate sub-catchments. Basins 1 and 2 drain to Anzac Creek, and Basins 9 and 10 to the Georges River (initially through MPW). The proposed basin locations are shown on Figure 4-8 in the report. The north-eastern portion of MPE drains to proposed Basin 1 prior to discharging across the eastern site boundary through an existing box culvert into a channel in the adjacent DNSDC site. The south-eastern portion of MPE drains to proposed Basin 2 that discharges to the east into an existing minor tributary of Anzac Creek. Basins 9 and 10 would manage runoff from the western portion of the MPE site that currently drains to Moorebank Avenue prior to discharging through a culvert into the existing concrete lined channel located within the MPW site. Comments and recommendations: *Similar comments and recommendations to the post development sub-catchments for the MPW site apply to this site.*
OSD modelling software	The applicant has evaluated the OSD requirements utilising DRAINS software (and specifically the XP-RAFTS module). Pre-development and post development models were developed to analyse the local catchment flood hydrology for the site. Comments and recommendations: *The modelling software applied to evaluate flood detention requirements for the site is considered appropriate for this application.*	Comments and recommendations: *Similar approach and comments as for the MPW site.*

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
Model input parameters	XP-RAFTS impervious and pervious area rainfall-runoff input parameters adopted in the DRAINS flood hydrology models are summarised in the report. The report does not clearly summarise the estimated catchment gradients and impervious fractions adopted within the pre-development or post development models. Comments and recommendations: *It is considered that the report should include a summary of the adopted catchment gradients and impervious fractions for each sub-catchment in the main report. The DRAINS models should also be provided for review.* *It was identified in the report for MPE that significant floodplain storage exists within that site. It is envisaged that existing local floodplain storage would also exist in the MPW site, although it is unclear if these areas have been accounted for in the pre-development model (as was indicated for MPE).* • *The report should include a summary of the adopted catchment gradients and impervious fractions for each sub-catchment in the main report.* • *The DRAINS models should also be provided for review.* • *The approach adopted for considering existing flood storage in the pre-development MPW site should be explained by the applicant.*	Comments and recommendations: *A similar modelling approach to the MPE site was adopted for the MPE site and similar comments on the approach apply to the MPE site.* *The report identifies there is an estimated 10,500 m^3 of existing flood storage within the MPE site that will presumably be reduced post development following regrading. The report indicates that this existing flood storage has been accounted for in the pre-development model, but it is unclear how this has been modelled.*
Modelled design events	Event-based hydrologic modelling was completed for design storm durations ranging from 5 minutes to 36 hours, and average annual recurrence intervals (ARI's) of 2, 5, 10, 20 and 100 years. The 15 minute and 6-hour duration PMP events, and 30 and 36 hour 'extreme events' (assumed to be 5 x 100-year ARI) were also modelled. Additional sensitivity model runs were completed considering increased rainfall intensities under predicted climate change conditions. Details of the adopted rainfall intensities for each design storm event are provided in Appendix B of the report. Comments and recommendations: *The range of design storm durations and frequencies assessed in evaluating OSD requirements is considered appropriate for managing local and regional flooding. Whilst design intensities for ARI's up to 100 years are summarised in Appendix B, the report should outline where the PMP intensities were derived from and what range of PMP events were considered.*	Comments and recommendations: *Similar approach and comments as MPW, with the exception that the 30 and 36 hour 'extreme events' were not modelled, presumably as these events would be represented appropriately by the PMP events.*

<table>
<tr><th>Stormwater element</th><th>MPW report (Arcadis, 2016a)</th><th>MPE report (Arcadis, 2016b)</th></tr>
<tr><td></td><td>

- *The MPW report should outline how the PMP intensities were derived and what range of PMP events were considered for the hydrologic modelling.*

</td><td></td></tr>
<tr><td>OSD peak discharge modelling results</td><td>

The estimated post development peak OSD basin inflows, outflows and water depths for the MPW basins are summarised in Table 2-2 (of this report). The post development results have been sourced from Table 5-2 in the MPW report.

Table 4-2 ***Summary of modelled OSD basin performance for 100-year ARI event (Arcadis, 2016a)***

OSD Basin ID	Peak pre-development inflow (m^3/s)	Peak post development inflow (m^3/s)	Peak post development outflow (m^3/s)	Peak water depth (m)[1]
3A	?	3.3	0.8	0.9
4	?	1.9	0.3	0.5
5	?	22.8	2.6	2.6
6	?	27.2	4.3	2.3
8	?	8.2	0.9	2.7

1. Raingarden in base of OSD basins extended detention depth of 0.3m additional to this.

Comments and recommendations:

The results summarised in Table 5-2 of the report (and summarised in Table 4-2 above) suggest that the proposed OSD basins would reduce peak discharges by approximately 80 to 90% at each basin site. Although, it is unclear from the report if the corresponding peak inflows and outflows presented are for the same design storm duration (which is typically how flows would be reported) or for different storm durations. It is also unclear how the results in Appendix B correspond with the results presented in Table 5-2 as it appears the same basins have been assigned different basin names/IDs.

Table 5-2 does not include estimates of pre-development peak flows that could be compared with the indicated detention basin performance. The magnitude of the estimated flow mitigation would typically significantly exceed that required by individual basins to demonstrate the development would not increase peak discharges

</td><td>

The estimated post development peak OSD basin inflows, outflows and water depths for the MPE basins are summarised in Table 4-3. The peak post development results were sourced from Table 4-2 in the report. The peak pre-development inflows were sourced from Appendix B in the report for the same storm duration as the post development outflow (assuming OSD basin IDs are the same).

Table 4-3 ***Summary of modelled MPE OSD basin performance for 100-year ARI event (Arcadis, 2016b)***

OSD Basin ID	Peak pre-development inflow (m^3/s)	Peak post development inflow (m^3/s)	Peak post development outflow (m^3/s)
1	3.2	14.5	1.8
2	3.0	8.1	1.7
9	12.5[1]	7.0	0.9
10		25.1	3.1

1. Sub-catchments for Basins 9 and 10 considered as one combined catchment in the pre-development model.

Comments and recommendations:

The results summarised in Table 4-3 indicate that the proposed OSD basins would typically reduce the peak post development discharges by approximately 80 to 90% at each basin site (and by more than 40% when compared to the pre-development discharge). Similarly, to MPW, comparison of peak discharges is only relevant for the same design storm duration and it is unclear if the post development inflows and outflows presented are for the same design storm duration.

Review of the results presented in Appendix B indicates that shorter duration events generally have a higher degree of mitigation. It is considered that the magnitude of mitigation indicated would exceed that required to demonstrate the development would not increase peak discharges in the local catchment and regionally along the Georges River and Anzac Creek. This is in addition to the diversion of approximately 15

</td></tr>
</table>

<table>
<tr><th>Stormwater element</th><th>MPW report (Arcadis, 2016a)</th><th>MPE report (Arcadis, 2016b)</th></tr>
<tr><td></td><td>from pre-development conditions (if flows presented are for the same event). Although, without pre-development flow estimates at each basin this is not possible to confirm.

It also appears that the existing and proposed flows at specific flow comparison locations within the site summarised in Table 5-1 of the report differ to those presented in Appendix B for the same location.

• It is considered that the peak flow comparison in the report is currently confusing and should be clarified by the applicant by providing a response to the following key issues:
  ○ if the corresponding tabulated peak inflows and outflows presented are for the same or different design storm durations.
  ○ how the results in Appendix B correspond with the results presented in Table 5-2 as it appears the same basins have been assigned different basin names/IDs.
• pre-development and post development flows at specific flow comparison locations within the site summarised in Table 5-1 of the MPW report differ to those presented in Appendix B for the same location.</td><td>ha of existing Anzac Creek catchment to the Georges River due to proposed re-grading of the southern portion of the MPW site.

Similarly, to MPW, it is considered that the peak flow comparison in the report is currently confusing and should be clarified by the applicant.</td></tr>
<tr><td>OSD proposed storage volume</td><td>Table 5-2 in the report includes a summary of the catchment areas and proposed active storage volumes (i.e. available OSD storage volume above the water quality extended detention water level) for each OSD basin. These areas and volumes are presented in Table 4-4 along with calculated storage ratios (m^3/ha) for each basin. Table 4-4 indicates that on average the OSD basins have a proposed active storage volume of approximately 1000 m^3/ha of contributing catchment.
Table 4-4 Summary of proposed OSD basin storage volumes (Arcadis, 2016a)
<table>
<tr><th>OSD</th><th>Sub-catchment Proposed (ha)</th><th>Active storage volume (m^3)</th><th>Storage (m^3/ha)</th></tr>
<tr><td>3A</td><td>8.1 (or 11.8?)</td><td>3,500</td><td>432</td></tr>
<tr><td>4</td><td>3.3</td><td>3,400</td><td>1030</td></tr>
<tr><td>5</td><td>56.0</td><td>62,800</td><td>1121</td></tr>
<tr><td>6</td><td>66.8</td><td>58,100</td><td>870</td></tr>
<tr><td>8</td><td>18.5</td><td>20,100</td><td>1086</td></tr>
<tr><td>Totals</td><td>152.7</td><td>147900</td><td>969 (mean)</td></tr>
</table></td><td>Table 4-2 in the report includes a summary of the catchment areas and proposed active storage volumes (i.e. available OSD storage volume above the water quality extended detention water level) for each OSD basin. These areas and volumes are presented in Table 4-5 along with calculated storage ratios (m^3/ha) for each basin. Table 4-5 indicates that on average the OSD basins have a proposed active storage volume of approximately 800 m^3/ha of contributing catchment.
Table 4-5 Summary of proposed OSD basin storage volumes (Arcadis, 2016b)
<table>
<tr><th>OSD Basin ID</th><th>Sub-catchment Proposed (ha)</th><th>Active storage volume (m^3)</th><th>Storage (m^3/ha)</th></tr>
<tr><td>1</td><td>29.0</td><td>27400</td><td>945</td></tr>
<tr><td>2</td><td>16.2</td><td>16600</td><td>1025</td></tr>
<tr><td>9</td><td>11.9</td><td>8000</td><td>672</td></tr>
<tr><td>10</td><td>42.2</td><td>24000</td><td>569</td></tr>
<tr><td>Totals</td><td>99.3</td><td>76000</td><td>803 (mean)</td></tr>
</table></td></tr>
</table>

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
	It is our experience that the OSD storage requirement for development in similar parts of western and south-western Sydney is typically less than 500 m³/ha. The proposed OSD storages are therefore more than double the typical volume. It is considered that this may be a reason the estimated magnitude of the flow mitigation achieved for each basin is so high. Comments and recommendations: *Whilst the provision of oversized OSD detention basins may provide additional mitigation for downstream flooding above that typically applying to new development in this area, there will also be significantly higher costs associated with future operation and maintenance of oversized OSD basins. It will be important that the organisation ultimately responsible for maintenance of the OSD basins is aware of the likely additional costs, and would be able to allocate on-going sustainable funding for maintenance of these facilities into the future.* • *The applicant should outline the reasons why the proposed OSD basin sizes appear to have more than double the volume of storage compared to basins in similar council areas.*	Comments and recommendations: *Similarly, to the OSD basins in MPW, there is likely to be benefits for downstream flooding above that which typically would apply to new development, although unsustainable costs associated with future operation and maintenance of the oversized OSD basins may also be incurred by the ultimate owner of the basins.*
OSD performance during extreme events	The OSD basins have been modelled to mitigate impacts during PMF and other extreme events and results are presented in Tables 5-1 and 5-2 in the report. Basins 5 and 6 are proposed with a maximum storage volume of approximately 60 ML each and maximum water depth greater than 3m. Basins 5, 6 and 7 are proposed with vertical walls and water depths up to 3m in a 100-year ARI event. Comments and recommendations: *OSD basins should be designed to mitigate flows for a range of flooding events up to Council's flood planning event that we understand is the 1% AEP (or 100-year ARI) design event. During events exceeding Council's flood planning event, the OSD basins should function primarily to safely manage flows without increasing risks to the community or damage/failure of the basin structures.* *The NSW Dam Safety Committee recommendations on flood retarding basins should be addressed for all proposed basins to ensure that any consequence of failure of individual or combined basins on the downstream community is considered closely during initial*	Comments and recommendations: *Similar comments as for the MPW site.*

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
	planning and design. It is unclear from our review if these requirements have been considered. • *The applicant should confirm that the NSW Dam Safety Committee recommendations on flood retarding basins have been considered in determining the required footprint for the basins in the development layout.*	
General community safety	Comments and recommendations: *The basins as proposed would need to be surrounded by acceptable barriers (e.g. secure fencing) to prevent access by to the community (since the basins are currently proposed with vertical walls up to 3m high).* *The basins would also require an unobstructed inlet to enable overland flows to drain to the basins during events up to the 100-year ARI. It is unclear how this would be achieved whilst also preventing community access to the basins.* *It is considered that this would not be a desirable outcome from urban design or community safety perspectives.* • *The applicant should confirm how OSD basins that are over 3m high would be surrounded by acceptable barriers to prevent access by to the community.*	Comments and recommendations: *Similar comments as for the MPW site.*
Maintenance	Comments and recommendations: *It is unclear how the raingardens in the base of the OSD basins will be accessed for maintenance considering the perimeter basin walls will be vertical and up to 3m high with a 1(v):6(h) embankment slope at the overflow weir.*	Comments and recommendations: *Similar comments as for the MPW site.*
Existing major stormwater drainage system	The report indicates that there are currently two main formed major drainage flowpaths through the MPW site. The larger of these drainage flowpaths is an existing concrete lined channel that conveys runoff from a high proportion of the MPE site and Moorebank Avenue road reserve to the Georges River. It appears that lower sections of the concrete channel have collapsed due to what appears to be an active head cut in the channel. The other drainage flowpath conveys a small portion of existing development north of the MPE site through the northern extents of the MPW site. Comments and recommendations: *The report indicates that the existing major drainage outlets from the MPW site have insufficient capacity to convey major flows from the existing site due to existing blockages or capacity constraints. Current flood storage available upstream of the*	The north-eastern portion of the MPE site drains to an existing box culvert into a channel in the adjacent DNSDC site. It was identified by the applicant that the existing box culvert was 100% blocked by sediment and other debris during a recent inspection. The south-eastern portion of the MPE site drains through a smaller culvert across the eastern site boundary and under Greenhills Road into an existing minor tributary of Anzac Creek. There is currently informal flood detention storage provided in the MPE site upstream of the two outlets draining to the east. The western portion of the MPE site currently grades to the eastern side of Moorebank Avenue where runoff would be collected and drained to the north towards an existing culvert crossing Moorebank Avenue. This culvert discharges into an existing concrete

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
	existing major drainage outlets within the MPE site also appears to provide significant local flood attenuation. *The inlet to the existing culvert under Moorebank Avenue is covered by square steel mesh grates. Downstream overland flowpaths are also partially blocked by existing security fencing. It is envisaged that these measures were in place for security reasons, but would also be highly prone to blockage with potential for significant flooding impacts on upstream land. Removal of these barriers is likely to improve upstream overland flows.*	lined channel within the MPW site. There also appears to be significant informal flood storage available on the eastern side of Moorebank Avenue upstream of the culvert. Comments and recommendations: *Similar comments as for the MPW site.*
Proposed major stormwater drainage system	The report indicates that the existing concrete lined channel through the MPW site is proposed to be modified by replacing the existing channel with a 15m wide x 3.3m deep concrete channel (with a deeper lower flow section 2.4m wide x 5.1m deep). The channel is proposed to be enclosed (i.e. a culvert) for some sections through the MPW site and an open channel for others. The channel is proposed to have vertical walls at each side and fencing along the sides of the channel. The modified channel would extend from Moorebank Avenue through the MPW site to the Georges River. Comments and recommendations: *It is considered that the planned modified channel through the MPW site is not appropriate in its current proposed configuration. It is considered that introducing a concrete lined drainage channel in an urban area with vertical sides up to 5.1m high is not consistent with current practice. Whilst fencing is proposed along the sides of the channel, it is unclear how the inlet to the channel downstream of Moorebank Avenue would be managed to prevent community access. It is also unclear how the proposed 155m wide floodway across Moorebank Avenue would transition to the proposed deep vertical side channel without creating an elevated risk to the community.* *It is considered that concentration of all future west draining runoff from the MPE site (and a significant proportion of the MPW site) along this one major drainage pathway creates an elevated risk to the community. It is considered that a more appropriate design outcome would be to distribute the flow through the MPW site between several parallel major drainage channels or modify the proposed channel to be wider with battered embankments, vegetation and a more natural creek form that is more representative of current practice. The current proposed highly engineered channel is considered a poor design outcome for this site considering the potential that exists for providing a functioning urban stream in this area that appropriately considers*	The report indicates that Moorebank Avenue is proposed to be raised by 2m with the MPE also filled. The applicant has indicated that further modelling is to be completed using TUFLOW to finalise the Moorebank Avenue channel, culvert and downstream channel configuration. The report also indicates that some regrading and drainage works would be required along the southern MPE site boundary and drainage works would need to be undertaken in properties adjacent to MPE. Comments and recommendations: *Due to the scale of the filling works proposed, it is considered that completion of TUFLOW modelling will be important to assess any potential impacts on neighbouring properties that will remain at current levels. This will be important particularly for existing land located north on the MPE site on the eastern side of Moorebank Avenue.* *Drainage works required in the adjacent property to achieve the intent of the proposed OSD and drainage strategy should be agreed with the adjacent property owner at this stage to ensure that appropriate consents and easements will be in place. If these agreements are not in place, this may require time consuming negotiations and possibly legal action that could significantly delay the development.* *Major drainage works within the existing channel in the MPW site would also need to be completed prior to development in the MPE site. Further comments on this channel are provided in the section of MPW.*

Stormwater element	MPW report (Arcadis, 2016a)	MPE report (Arcadis, 2016b)
	hydrology, hydraulics, geomorphology, habitat and community safety. The current proposal for this waterway appears to focus on providing an efficient engineered hydraulic solution. • *The MPW site will feature a single concrete lined drainage channel in an urban area with vertical sides up to 5.1m high, which is not consistent with current practice. The applicant should consider distributing the flow through the MPW site between several parallel major drainage channels or modifying the proposed channel to be wider with battered embankments, vegetation and a more natural creek form that is more representative of current practice.* • *Furthermore, the proposed edge treatment of the channel of the OSD provides no softened green edge through vegetation growth. This edge condition of the detention bank sits adjacent to the proposed 5 metre noise wall, adjacent to the internal roadway.* • *TUFLOW modelling should be completed to assess potential drainage impacts on neighbouring properties*	
Minor stormwater drainage system	The report provides limited detail on the existing minor drainage systems within the MPW site. Although, it appears there are several existing piped stormwater drainage lines collecting runoff from the western side of Moorebank Avenue with one minor piped drainage system constructed through the MPW site. Details of these minor systems were unclear from the available survey data. Comments and recommendations: *Whilst details on these existing minor drainage systems are unclear, it is expected that regrading of the MPE and MPW sites and Moorebank Avenue will render many of these systems redundant. Although, it will be important for the applicant to demonstrate that all site areas can be graded to the proposed major drainage pathways to ensure that no trapped low points or unplanned major overland flowpaths are formed as development proceeds.* • *Confirmation of any significant existing minor drainage systems in the MPW site should be provided.*	The report provides limited details on existing minor drainage systems within the MPE site. Details of these minor systems were unclear from the available survey data. Comments and recommendations: *Similar comments for MPW site apply to the MPE site*

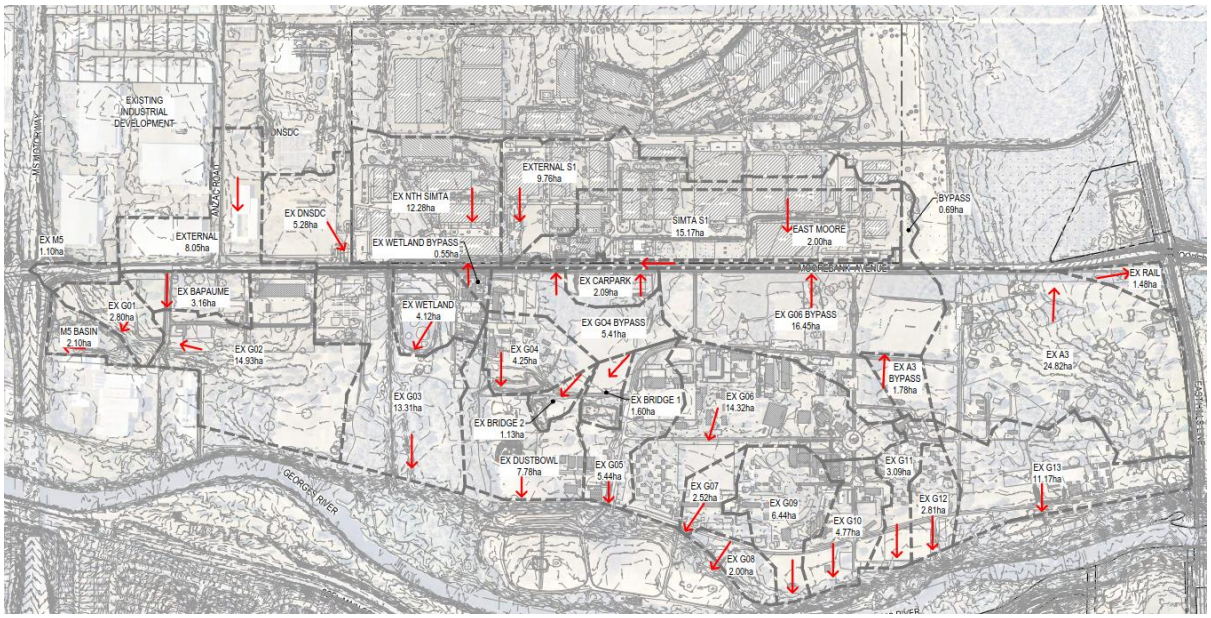

Figure 4-1 *MPW pre-development sub-catchment plan (Arcadis, 2016a)*

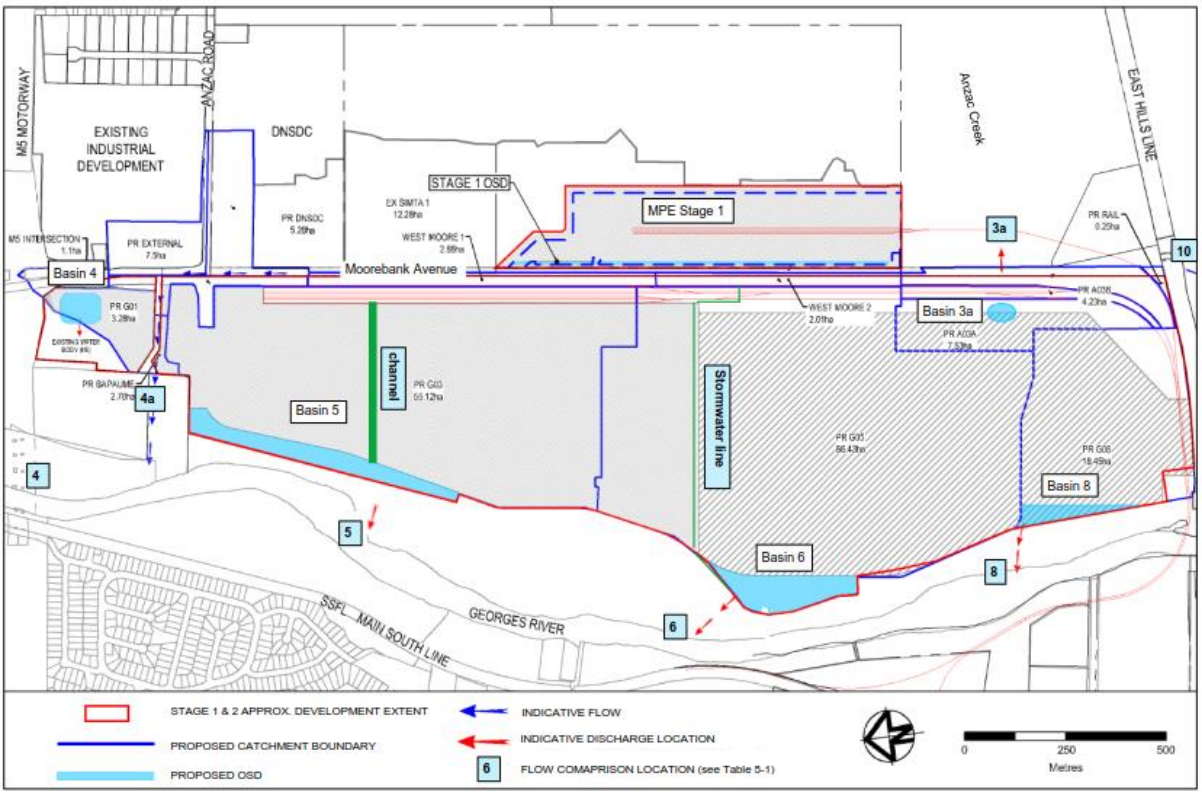

Figure 4-2 *MPW post development sub-catchment plan showing proposed detention basin locations (Arcadis, 2016a)*

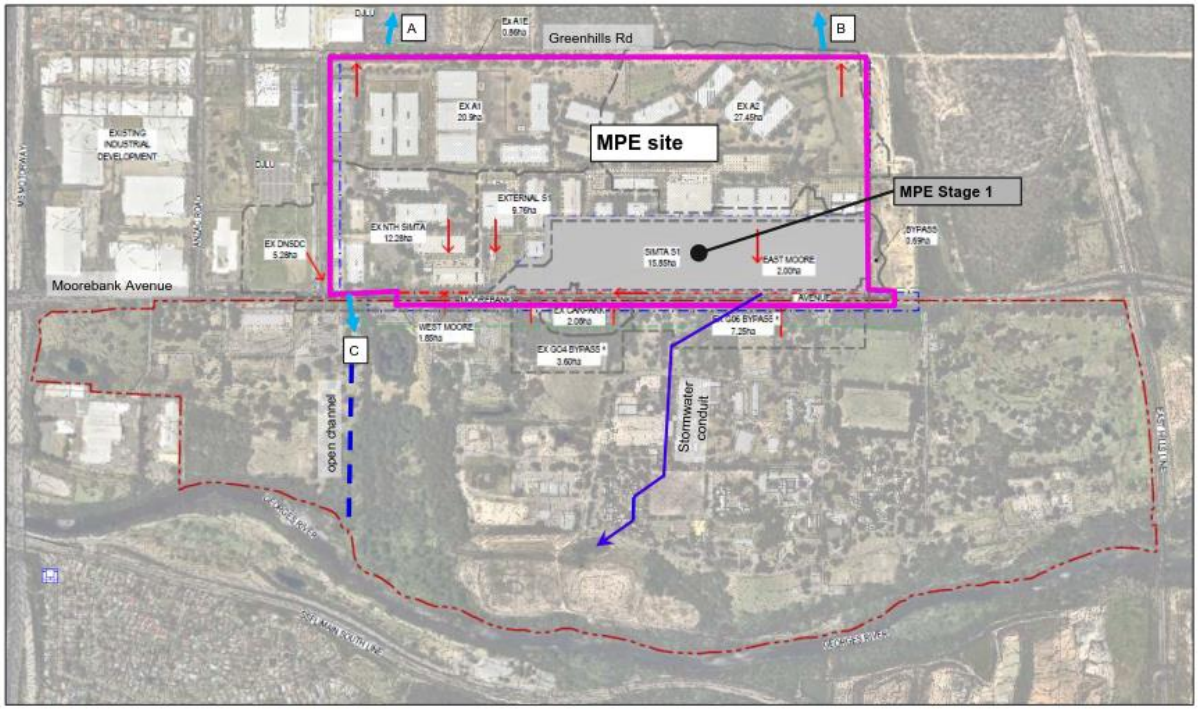

Figure 4-3 *MPE pre-development sub-catchment plan (Arcadis, 2016b)*

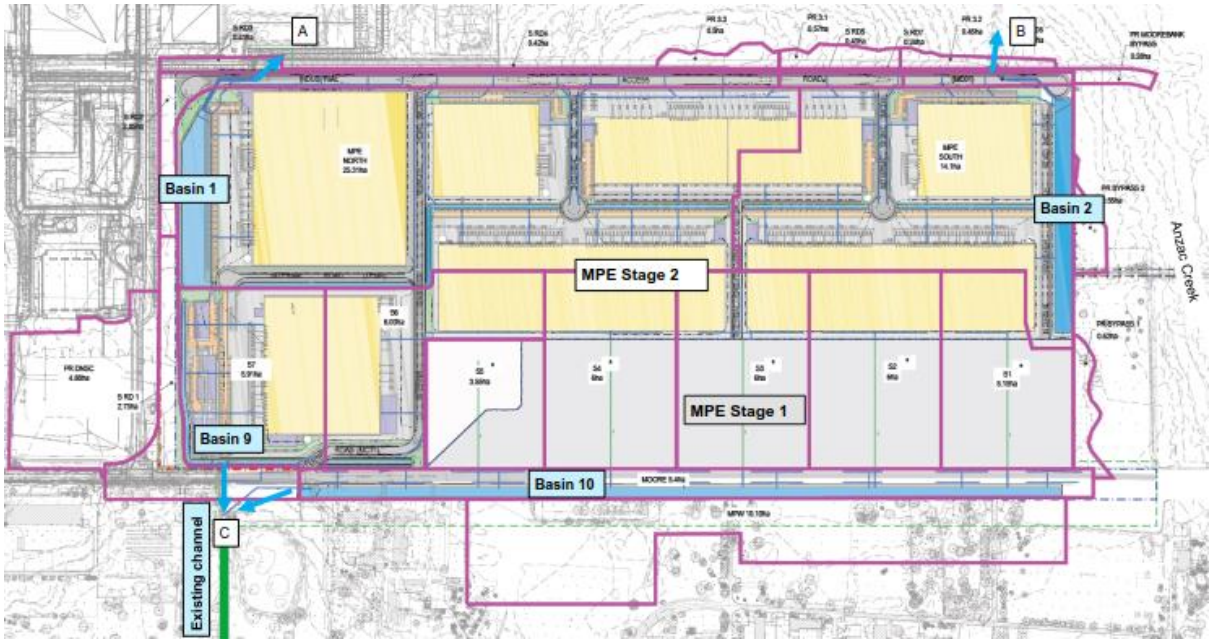

Figure 4-4 *MPE post development sub-catchment plan showing proposed detention basin locations (Arcadis, 2016b)*

5 Stormwater Quality Systems – MPE and MPW

Review of the stormwater quantity management for MPE and MPW is outlined in this section. The key issues relating to water quality for both the MPE and MPW sites are the location of the treatment systems and the modelling parameters used for the proposed treatment systems.

Both the MPE and MPW reports state that that the key objectives for stormwater quality management for the Proposal(s) include:

- Maintain or improve existing water quality.
- To protect the aquatic environment of the downstream waterways including the Georges River.
- Prevent bed and bank erosion and instability of waterways.
- Provide sufficient flows to support aquatic environments and ecological processes.
- Incorporate a Water Sensitive Urban Design (WSUD) approach.

5.1 Stormwater Quality / Performance Targets

The water quality strategy for both the MPE and MPW sites includes two key treatment measures to meet the performance targets:

1. Gross Pollutant Traps (GPTs)
2. Rain gardens (Bioretention systems).

The SEARs require the development to take into consideration of stormwater quality and management (including monitoring) during operation of the site with the objective of maintaining or improving existing water quality taking into account the Water Quality Objectives (MPW SEAR 8h / MPE SEAR 7i). Both the MPE and MPW reports have identified three performance standards as shown in the following copied table.

Of the targets adopted for the studies, the Georges River Estuary CZMP (2013), is consistent with the Botany Bay and Catchment Water Quality Improvement Plan developed by the Sydney Metropolitan CMA (2011), and appropriate for this study.

Both the MPE and MPW reports suggest that the SEARs require the adoption of NorBE (Neutral of Beneficial Effect) as required by the SEARS. This is a misunderstanding by the consultant, of the SEARs requirements, which calls for "stormwater quality and management……. with the objective of maintaining or improving existing water quality taking into account the Water Quality Objectives" (MPW SEAR 8h / MPE SEAR 7i). NorBE is not required or appropriate for this site.

5.2 MUSIC Modelling

The size of the proposed stormwater treatment systems has been determined by modelling the development through the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). MUSIC is an industry standard water quality model developed by Monash University and eWater (http://ewater.org.au/products/music/). The sizing of treatment systems is based on treating the runoff from the development to meet performance standards.

The MUSIC model uses a range of assumptions, which the consultants have based on the SCA (Sydney Catchment Authority's) Using MUSIC in Sydney's Drinking Water Catchment. It is not clear why the consultant did not use the NSW MUSIC modelling Guidelines. While most of the parameters and assumptions are consistent with guidance provided by NSW, the main inconsistency in the approach for both the MPE and MPW sites is the parameters for orthophosphate as shown in Table 5-1.

.

Table 5-1: Discrepancies in modelling from ARCADIS reports and SCA / NSW MUISC Modelling Guide Recommendations.

Parameter	ARCADIS Reports	SCA / NSW MUISC Modelling Guide Recommendations	Comment
Bioretention – Orthophosphate Content of Filter Media (mg/kg)	9 mg/kg	40 mg/kg	Orthophosphate Content of Filter Media (mg/kg) is calibrated to other parameters in the MUSIC model and the algorithms therein. The use of a low value of ortho-phosphate has the potential to decrease the size of the bioretention system to a size which has the potential to be overloaded, especially in this case where the bioretention systems are in the base of the OSD basins, and there is no by-pass. The consultant has *suggested that to meet the water quality targets a bioretention systems is generally in the range of 0.5 to 2% of the total catchment area. This is considered to be a typical range for urban catchments in Sydney.* The consultant has also *suggested that the approach for bioretention sizing is in accordance with best practice.* It is recommended that a minimum size of 1% of the catchment draining to the bioretention systems is applied.

The modelling has been used to determine the size of the stormwater treatment systems to meet the targets for MPE and MPW. For MPW Table 5-2 shows that the proposed treatment systems which are located in the OSD basins are typically approximately 25% of the total surface area of the detention basin and approximately 1% of the upstream catchment.

Table 5-2: OSD and Water Quality Systems MPW

BASIN	Storage Surface Area (m2)	OSD			Water Quality	
		Invert Level (mAHD)	Height (m)	Total Volume (m3)	Filter Area m2	Filter Area as % of OSD surface area
3A / 10	4,000	15	0.9	3,500	1000	25.0%
4	7,100	11	0.5	3,400	400	5.6%
5	24,000	11.3	2.6	62,800	5800	24.2%
6	25,000	11.6	2.3	58,100	6000	24.0%
8	7,500	11.8	2.7	20,100	2000	26.7%
Total Storage				147,900	15,200	

The MUSIC modelling has informed the proposed strategy for MPE as outlined in Table 5-3 and Figure 5-1. The stormwater treatment systems are in the base of the OSD systems. The stormwater treatment systems are between 0.7% and 2.3% of the catchments draining to the locations, with treatment system A01 being three times as large as system A02.

Table 5-3: Water Quality Systems MPE

Treatment Name	Catchment (ha)	Treatment filter (m2)	Treatment as % of Catchment
A-01	15.0	3,500	2.3%
A-02	27.6	1,800	0.7%
G04	12.2	1,900	1.6%
G06	14.0	2,000	1.4%

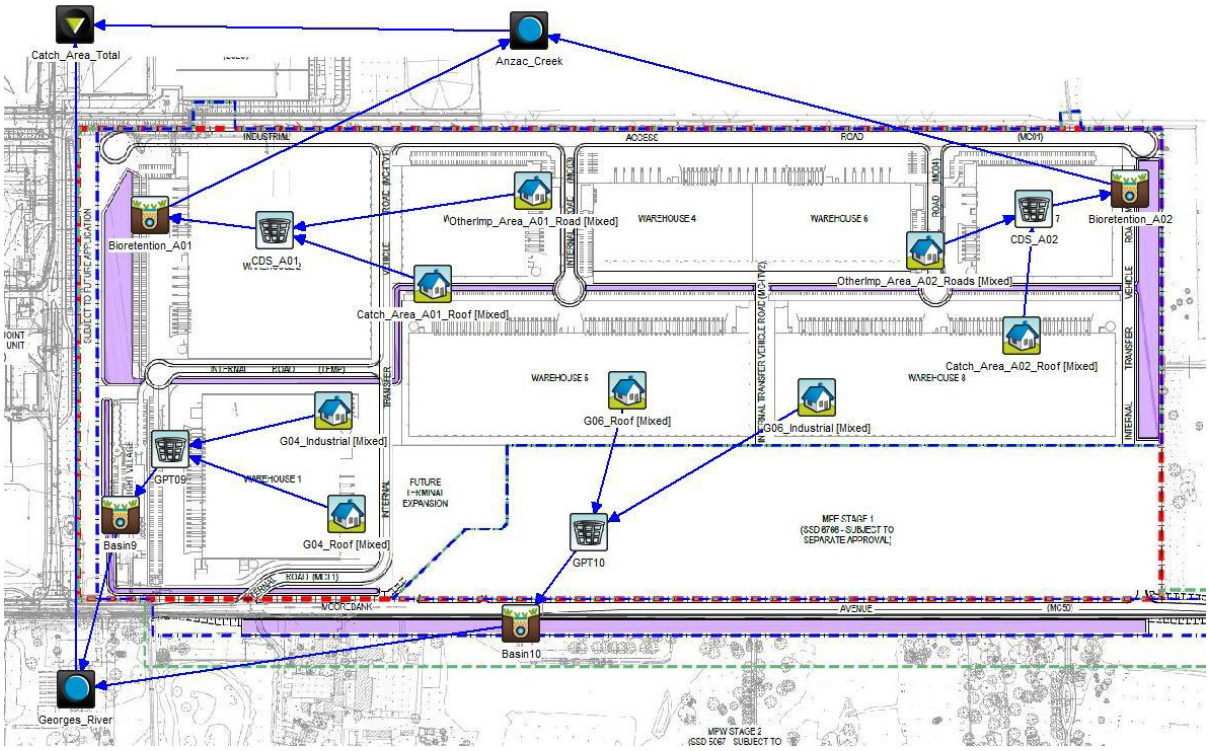

Figure 5-1: MPE stormwater modelling layout.

5.3 Location of Stormwater Quality Treatment Systems

Both the MPE and MPW reports states that "Rain gardens are proposed in the base of the stormwater basins" (Section 6.2). This is further detailed in the drawings, which show a typical stormwater basin in the base of an Onsite Detention system (a cross-section is shown in the following image). This is contrary to the MPW REMMs which require "A stormwater treatment system would be implemented, incorporating sedimentation and bio-filtration basins **upstream** of the stormwater detention basins" (MPW REMM 9X).

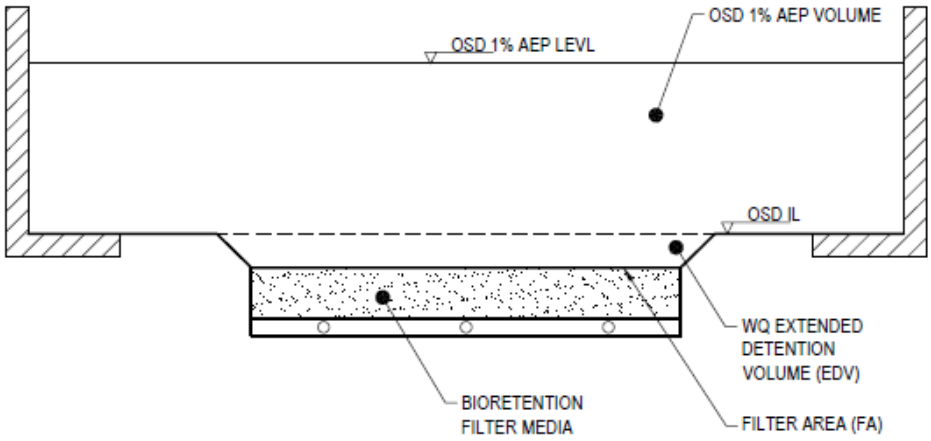

Figure 5-2: Stormwater Basin Typical Detail, showing bioretention system in the base of the Stormwater OSD Basin. Note the depth of water above the bioretention filter media.

It is not recommended, nor is it good practice, for stormwater treatment systems to be in the base of large OSD systems, due to:

- *potential for these systems to be scoured with all the flows from the upstream catchment, and unusually large volumes of sediment settling on top of the systems.*

- *potential for these systems to be smothered with sediment.*
- *the fact that these systems will be the lowest point of the OSD basin, as well as the lowest outlet for water means that they will receive greater flows than they can be designed for.*

5.4 Required Water Quality Approach

The REMMs and SEARS for Moorebank require water quality treatment systems to be integrated across the development site, as defined by the following provisions:

- A stormwater treatment system would be implemented, incorporating sedimentation and bio-filtration basins upstream of the stormwater detention basins (MPW REMM 9X)

- Use of onsite infiltration would be incorporated into the design through the distribution of swale drains and rain gardens across the Project site (MPW REMM 9Y)

- Stormwater management opportunities would be considered (consistent with) Liverpool City Council's Development Control Plan, including (MPW REMM 9Z):

    - polishing water runoff using dry creek gravel beds with macrophyte plants;

    - using drainage swales to slow down stormwater runoff and increase onsite infiltration;

    - collecting roof rainwater for re-use onsite;

    - installing gross pollutant traps (GPTs) at the outlets of the pipe system before discharge into the sedimentation basins; and

    - incorporating pervious surfaces and vegetated areas into the design to increase sub-surface water flow during rain events and to reduce the discharge of stormwater pollutants.

- consideration of stormwater quality and management (including monitoring) during operation of the site with the objective of maintaining or improving existing water quality taking into account the Water Quality Objectives (MPW SEAR 8h / MPE SEAR 7i)

The integration of water quality elements into the landscape is consistent with the contemporary and accepted practice of Water Sensitive Urban Design (WSUD). A water sensitive approach to urban planning supports more sustainable, resilient, productive and liveable cities. This is achieved in-part by more effectively integrating a broad range of urban water considerations into strategic planning and masterplanning, and by identifying how water can enhance environmental, social and economic outcomes.

5.4.1 Consistency with DCP, Part 2.4 Development in Moorebank Defence Lands

The Liverpool Development Control Plan 2008, Part 2.4 Development in Moorebank Defence Lands includes setbacks via landscape and parking controls. These setbacks would be appropriate areas for stormwater treatment elements and with the controls including:

S3.4 Landscaping – Controls

1. Landscape frontages should be a minimum depth as indicated below:

    - Moorebank Avenue 18 m

    - Local Road Frontages 7.5 m

S 3.6 Car Parking and Access – Controls

1. Car parking at grade or below buildings should not dominate any site. Where car parking occurs in the open and on-grade it should incorporate a 2.5m wide landscape bay for tree planting, with a minimum of 6 - 8 cars in a row to reduce the visual impact of parked cars.

An example of a bioretention system in a setback is provided in Figure 5-3.

Figure 5-3: Example of bioretention system in setback area of an Industrial development.

5.5 Recommended Stormwater Treatment Consent Conditions

To address the above issues the following stormwater quality consent conditions are proposed:

(i) have stormwater quality treatment train comprised of gross pollutant traps and biofiltration / bioretention systems to

- *Reduce the average annual load of total nitrogen by 45% compared to a base case if there were no treatment systems in place*
- *Reduce the average annual load of total phosphorus by 65% compared to a base case if there were no treatment systems in place*
- *Reduce the average annual load of total suspended solids by 85% compared to a base case if there were no treatment systems in place*

(ii) all stormwater quality elements are to be modelled in MUSIC as per the NSW MUSIC Modelling Guide.

(iii) all stormwater quality elements are to be installed upstream of stormwater detention basins.

(iv) the area of biofiltration / bioretention systems is to be at least 1% of the catchment draining to the system, to ensure there is no short-circuiting of the system.

(v) bioretention systems which are greater than 1,000m^2 in area, are to be divided into cells with no individual cell greater than1,000m^2.

(vi) all filter media used in stormwater treatment measures must:

- *be loamy sand with an appropriately high permeability under compaction and must be free of rubbish, deleterious material, toxicants, declared plants and local weeds, and must not be hydrophobic;*
- *have a hydraulic conductivity = 100-300 mm/hr, as measured using the ASTM F1815-06 method*
- *have an organic matter content less than 5% (w/w).*

6 Consistency with NSW Government Plans

An approach which integrates water quality management through a site is consistent with the followings NSW Government Plans:

- Sydney Water and the Greater Sydney Commission have identified the following WSUD planning principles for Sydney:
    - Promote development that protects, maintains or restores waterway health and the community's environmental values and uses of waterways
    - Promote integrated water cycle management that holistically considers and drives investment in sustainable water supply, reuse, wastewater, and stormwater infrastructure.
    - Promote development that fosters the relationship between water, landscapes and urban living, to enhance human and social wellbeing and promote community co-design and governance in urban water strategies
- The Greater Sydney Commission has developed water related priorities and actions within the Draft South-West District Plan, namely:
    - Sustainability Priority 2: Maintain and improve water quality and waterway health
    - Action S4: Improve the management of waterways in Priority Growth Areas for improved management of riparian corridors, with the objective of stabilising banks, maintaining water quality, protecting woodland corridors, cooling the urban environment, improving amenity and providing habitat for native species and ecological communities.
    - Important project 3 to deliver Sydney's Green Grid in the District - Georges River Parklands and Chipping Norton Lakes Enhancing the Georges River as a regional open space and active transport corridor, as well as protecting and enhancing the wetlands, ecological communities and improving stormwater management from surrounding development.
- Metropolitan Water Plan (NSW Metropolitan Water 2017), Outcome 3: Our urban communities are more liveable and resilient. the Metro Water Plan identifies the need for waterway health, maintenance of recreational areas and the amenity of our waterways. More recently, the water industry has recognised the strong connection between providing access to safe, green open space and the physical health of our communities. Water in the landscape, as a deliberate element in the design of our cities, can provide an effective and potentially efficient means of providing urban cooling and reducing the impacts of heat stress, as outlined in Figure 6-1.

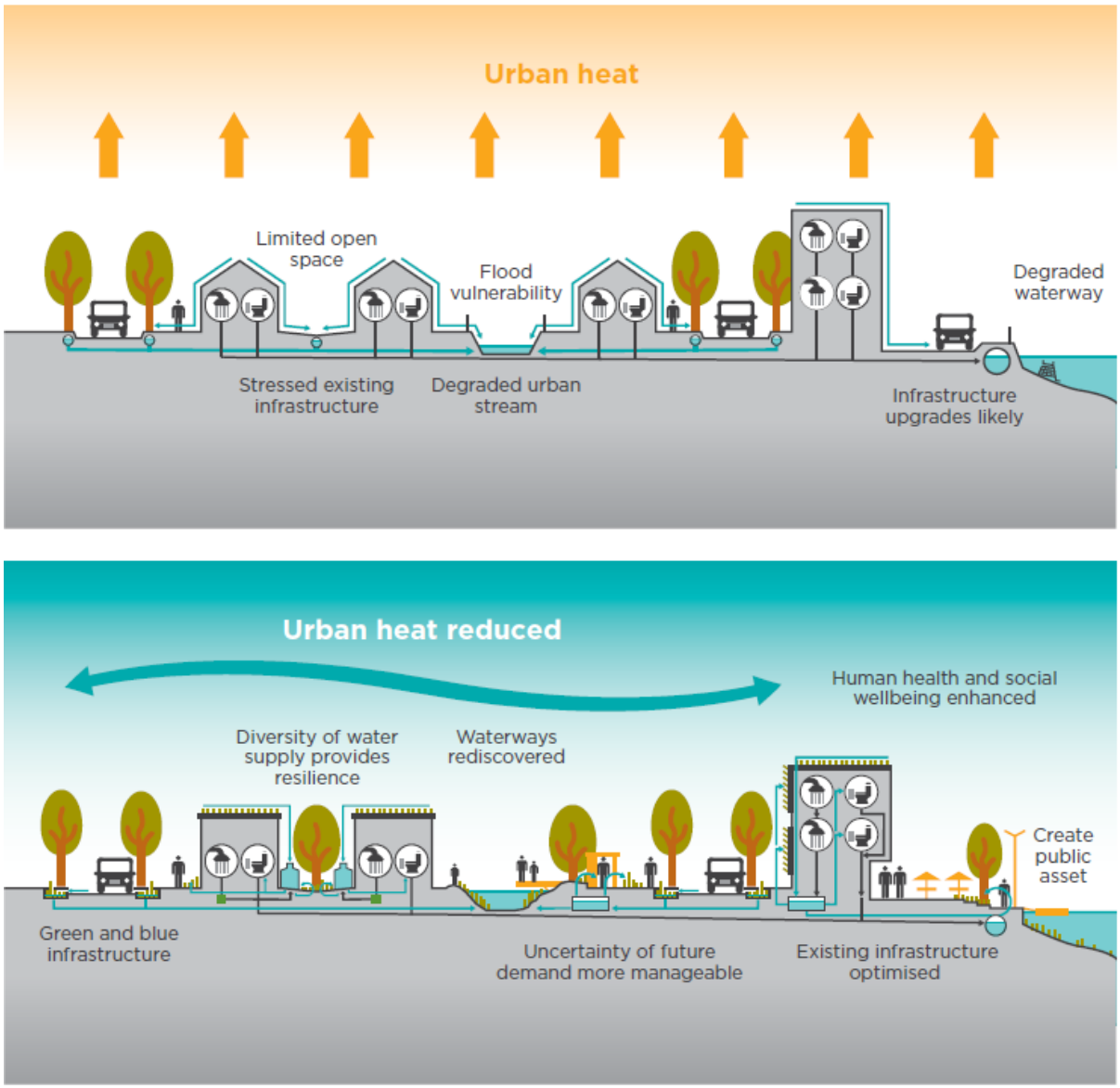

Figure 6-1: Benefits of a WSUD approach to urban planning (NSW Metropolitan Water 2017).

6.1.1 Case Studies of Water Quality Management Elements Integrated Across Industrial Sites.

Three case studies of stormwater treatment systems integrated into industrial sites is presented as examples of how stormwater treatment systems can be integrated into large sites. The examples include:

1. Woolworths Distribution Centre, Warnervale (Constructed ~2007).
2. West Huntingwood, Industrial Estate (Constructed ~2011).

6.1.1.1 Woolworths Distribution Centre, Warnervale (Constructed ~2007).

In 2006, the 14-ha development site was subdivided into two industrial lots and one residual parcel (including land to protect the sensitive environmental attributes of the locality). The selection of WSUD elements for the site is outlined in the Figure 3-4.

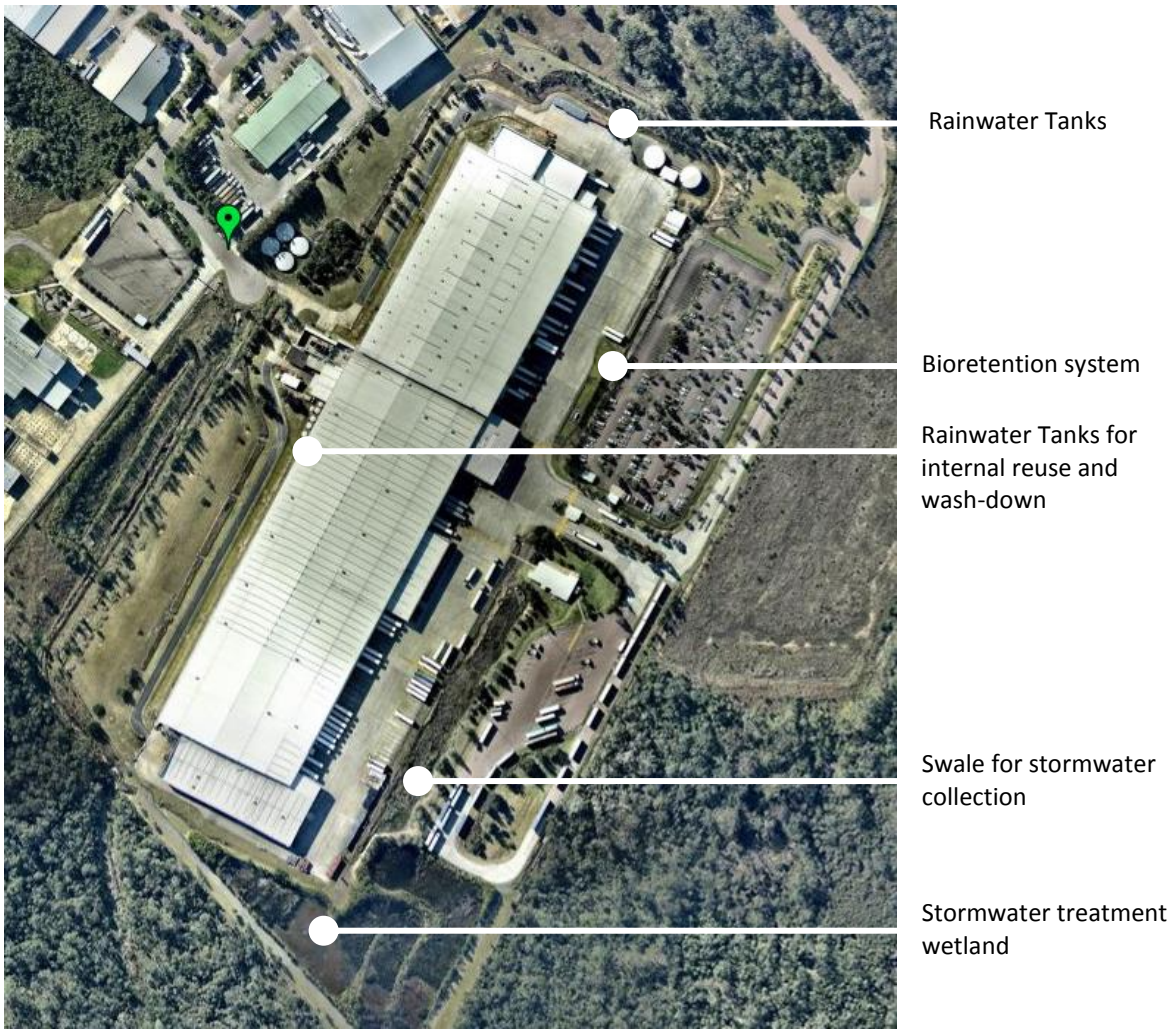

Figure 6-2: Woolworths Warnervale Industrial Site (Nearmap 2017).

6.1.1.2 West Huntingwood, Industrial Estate (Constructed ~2011).

The West Huntingwood Industrial Estate is immediately adjacent to Eastern Creek, and the development was required to manage water quality and flows to minimise the impact on the creek. Stormwater from the whole industrial complex is discharged to a series of swales around the site and then into bioretention systems, wetlands and ponds, prior to discharge to Eastern Creek.

Figure 6-3: West Huntingwood Industrial Site (Nearmap 2017).