

# Addendum to Integrated Water Cycle Management Strategy, Mixed Use Urban Development at West Culburra, NSW



**Prepared for Sealark Pty Ltd**

Report No: 1203365JR10

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**Without Prejudice**

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## Executive Summary

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### Overview

This report provides an addendum to the Integrated Water Cycle Management Strategy (**IWCMS**) supporting a proposed concept plan for a mixed-use urban development (the **Proposal**) located to the west of the village of Culburra Beach on the NSW South Coast. Matters covered by this report are summarised below. The IWCMS outlined a comprehensive strategy for water management for the Proposal that will be implemented in future development applications and included:

1. Review of available literature, relevant standards and guidelines.
2. Development of a site-specific water management strategy with eight specific water management objectives.
3. Development of an ecologically sustainable concept water management scheme that would deliver a neutral or beneficial impact on receiving waters, dependent ecosystems and the commercial aquaculture.
4. Modelling and auditing of the performance of the concept stormwater management scheme against a range of criteria demonstrating a neutral or beneficial impact.
5. Assessment of the potential impact of the concept stormwater management scheme on groundwater resources and any groundwater dependent ecosystems.
6. Assessment of likely demands for water and sewerage services, including a detailed risk assessment of the sewer system and development of a range of risk management principles and guidelines.
7. Assessment of construction staging and soil and water management requirements.
8. Development of an environmental monitoring program to be undertaken prior to construction works, during construction and during the operational phase of the development.

This report has been prepared on a **without prejudice** basis and has been produced within the context of appeal proceedings in the NSW Land & Environment Court in matter 28149 of 2019 (the **Proceedings**). The report is in response to a request for further information and clarification in respect of matters identified in a memorandum prepared by the NSW Department of Planning, Industry and Environment's (the **Department**) water quality experts Mr Tony Weber and Mr Martin Giles, dated 30 March 2021 (the **TWMG Memo**). These include five specific requests for further information and two additional areas which were raised more generally in the TWMG Memo. The response to each issue respectively is summarised below.

### Issue 1 – Supply of MUSIC Model

The MUSIC model(s) relied upon in the IWCMS will be provided for further review as part of this addendum to the IWCMS.

### Issue 2 - Justification of Exfiltration Rate

The adopted exfiltration rate of 0.25 mm/hour at Biobasins A, B and C and stormwater ponds (for MUSIC model D-T2 where exfiltration is included) is considered acceptable because:

1. It appropriately balances groundwater pollution risks against the benefits that are to be gained through implementing a groundwater recharge system.
2. It represents good practice as part of an overall water sensitive urban design (**WSUD**) approach to the stormwater management system.
3. It satisfies the following engineering and environmental performance criteria:
  - a. The rate is less than substratum permeability.
  - b. The rate is physically achievable.
  - c. The rate is physically verifiable.
  - d. The rate achieves a reduction in stormwater runoff volume.
  - e. The rate does not lead to excessive pollutant loss.
  - f. The rate does not lead to nuisance groundwater level changes.
  - g. The rate does not impact on groundwater quality.

### Issue 3 - Biobasin Water Supply

At Biobasins A, B and C, high inflows are diverted to stormwater ponds for detention, further treatment and re-use, whilst low flows directly flow to the Biobasin. Overflows from the stormwater ponds, if and when these occur, are then returned to the Biobasins. Interrogation of the MUSIC model prepared for the Proposal indicates that sufficient water will be delivered to the Biobasins to ensure that plant survival and Biobasin function are maintained, noting:

1. There will be a consistent baseline supply of water to each Biobasin to ensure basins do not dry, with only around 5 % of the total inflow diverted to the stormwater ponds.
2. The total water volume supplied to each Biobasin is significant because this also includes overflows from the stormwater ponds.
3. Equivalent rainfall depths over each Biobasin basin are each substantially higher than average annual rainfall, indicating appropriate hydrological operating conditions.

## Issue 4 - Surface Water Hydrology

Supplementary interrogation of the MUSIC model prepared for the Proposal has shown that the proposed stormwater system will largely mimic / replicate current hydrological conditions. This is particularly the case where some stormwater exfiltration is incorporated into the design of stormwater treatment structures, this being recommended as part of the preferred stormwater management approach. The following is noted:

1. There will not be any increase in 'runoff days' if exfiltration is included in the design and the frequency of medium volume (1-4 ML/day) and larger volume (> 4 ML/day) flows from the site to the 100 m forested estuary buffer will remain essentially unchanged.
2. Developed condition hydrographs closely mimic / replicate existing conditions. Developed conditions hydrograph peaks are often lower due to the detention capacity of the proposed stormwater ponds, with rising limbs slightly elevated and falling limbs slightly depressed. Including exfiltration further beneficially reduces peak flow rates and flow rates.
3. Surface water quality monitoring between 2018 and 2020 demonstrates that urban runoff will contain salt levels around 4-5 times higher than current conditions. Estuary mass balance modelling indicates that the very minor increase in freshwater volume released to estuary will not have the effect of reducing estuarine salinity.
4. More detailed modelling of water quality in receiving waters was therefore not considered necessary because site runoff frequency and magnitude analysis demonstrated that there would be no material changes to the surface water runoff regime from the site to the estuary.

## Issue 5 - Pathogen Control

A detailed pathogen transformation model was prepared for the Proposal based on the IWCMS MUSIC model which was re-run at a daily time step. The modelling approach consisted of extracting inflows and outflows to stormwater management structures, mixing concentrations at convergent flow points, and transforming pathogen levels within structures. The pathogen model was run for a range of parameter assumptions so that outcome variability could be assessed.

Modelling results demonstrated that: pathogen concentrations contained in stormwater runoff will receive significant treatment prior to release to the 100 m forested estuary buffer; will be considerably lower than 'natural' or background pathogen levels currently contained in runoff generated by the existing forest; and will not compromise oyster aquaculture water quality objectives within the Crookhaven River estuary. The following is noted:

1. Irrespective of the modelling scenario or statistic considered, pathogen concentrations in treated stormwater will be significantly lower than those under existing conditions. This outcome satisfies the Neutral or Beneficial Effect (**NorBE**) test.

2. In terms of the impact of the development on oyster aquaculture, reduced site stormwater pathogen concentration levels will deliver an improvement in oyster growing water quality conditions within the estuary.
3. Modelling of peak pathogen loads to the estuary during extreme runoff events, as well as mass balance modelling of pathogen concentrations within the nearshore estuary environment adjacent to the estuary, indicates that pathogen concentrations are expected to decrease because of the Development. This demonstrates that the pathogen risk profile of the estuary will decrease as a consequence of the Proposal and that the OISAS<sup>1</sup> pathogen water quality objectives will not be compromised by the Proposal.
4. The proposed stormwater treatment train provides an important and effective barrier to pathogens potentially contained in runoff arriving at the Estuary.

## Issue 6 - Management of Stormwater Infrastructure

A range of modifications and additions have been documented in respect of the management of stormwater infrastructure. These are detailed in Section 6 and summarised as follows:

1. **Water Quality Monitoring** – Monitoring obligations have been separated into three discrete periods including: pre-construction, during construction and operational. The pre-construction monitoring period has been extended to a minimum of 18 months and is proposed to start on consent. Further details for installing monitoring systems within Biobasins are also provided.
2. **Corrective Actions** – Trigger events for corrective actions have been modified to include triggers during construction and during operational phases of the development. Where previously trigger events were defined as trigger values being exceeded in 2 out of 3 consecutive sampling events, these have been reduced to any 2 consecutive exceedances. Further detail in respect of corrective actions has been provided, including responsibility for action, a detailed scope of action, and the timing for when actions are to be completed.
3. **Hand-over of Structures** – A range criteria have been developed which are to be satisfied prior to hand-over of stormwater infrastructure to Shoalhaven City Council.
4. **Design of Future Stages** – It is acknowledged that design of stormwater treatment measures in stages later than stage 1, will be confirmed based on the performance of treatment measures built in prior stages.

## Issue 7 - Construction Phase Management

During construction of the stormwater quality management infrastructure, the Proposal will traverse through an initial period where full water quality control of the site will not be available. During that phase, prior to the completion of internal roads and development of any dwellings or other structures, the key water quality management concern will be

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<sup>1</sup> NSW Oyster Industry Sustainable Aquaculture Strategy, prepared by the NSW Government, dated 2006 (the **OISAS**).

that the works site is managed to minimise ground disturbance areas and mitigate any sediment generation.

To ensure appropriate water quality outcomes during construction, specific performance criteria have been developed for the Proposal (see below), including associated acceptable solutions required to achieve the performance criteria (refer to Table 21).

1. Work will not cause erosion and / or siltation.
2. Work will not have an adverse impact on receiving waters from increased concentrations and loads of sediment.
3. Work will not detrimentally impact on Oyster Aquaculture activities.
4. Work will not detrimentally impact on Coastal wetlands and other sensitive environmental receptors.

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# 1 Introduction

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## 1.1 Overview

This report provides an addendum to, and should be read in conjunction with, the Integrated Water Cycle Management Strategy prepared by Martens & Associates dated 17 November 2020 (the **IWCMS**) in support of a proposed concept plan for a mixed-use urban development (the **Proposal**) located to the west of the village of Culburra Beach located on the NSW south coast.

The IWCMS outlined a comprehensive strategy for water management for the Proposal that will be implemented in future development applications and included:

1. Review of available literature, relevant standards and guidelines to determine the local and regional environmental setting, and assessment of key water management issues and concerns.
2. Development of a site-specific water management strategy with eight specific water management objectives aimed at protecting and preserving local waterways and receiving environments.
3. Development of an ecologically sustainable concept water management scheme that would deliver a neutral or beneficial impact on receiving waters, dependent ecosystems and the commercial aquaculture.
4. Modelling and auditing of the performance of the concept stormwater management scheme, which included stormwater treatment, retention and re-use, against a range of criteria demonstrating a neutral or beneficial impact.
5. Assessment of the potential impact of the concept stormwater management scheme on groundwater resources and any groundwater dependent ecosystems.
6. Assessment of likely demands for water and sewerage services, including a detailed risk assessment of the sewer system and development of a range of risk management principles and guidelines.
7. Development of staging and soil and water management requirements to ensure water quality objectives are met during Proposal construction.
8. Development of an environmental monitoring program to be undertaken prior to construction works, during construction and during the operational phase of the development.

This report has been prepared on a **without prejudice** basis and has been produced within the context of appeal proceedings in the NSW Land & Environment Court in matter 28149 of 2019 (the **Proceedings**). The report is in response to a request for further information and clarification in respect of several matters identified in a memorandum prepared by the NSW Department of Planning, Industry and Environment's (the **Department**) water experts Mr Tony Weber and Mr Martin Giles dated 30 March 2021 (the **TWGM Memo**).

## 1.2 Matters Identified for Further Clarification

The TWMG Memo identifies a number of matters for further information or clarification. Some matters are specifically listed as items requested for further information (Issues 1-5), whilst other matters were raised more generally within the TWMG Memo and raised during discussions with the Department's experts (Issues 6-7). An outline of further issues considered in this report is provided in Table 1.

We note that estuary salinity mass balance impact modelling is included in this report at Section 4.3.2. However, more detailed modelling of water quality in receiving waters was not considered necessary because the site runoff frequency and magnitude analysis (Issue 4) demonstrated that there would be no material changes to the surface water runoff regime from the site to the estuary.

**Table 1:** Matters raised in TWMG Memo further considered in this report.

Issue	Issue Source	Description	Reference
1	TWGM Memo Requested Information	Supply of the MUSIC model(s) relied upon in the IWCMS for further review.	Provided with this report.
2	TWGM Memo Requested Information	Justification of the IWCMS adopted exfiltration rate.	Section 2.
3	TWGM Memo Requested Information	Review amount of water reaching bioretention basins.	Section 3.
4	TWGM Memo Requested Information	Further quantification of site runoff frequency and magnitude.	Section 4.
5	TWGM Memo Requested Information	More detailed justification of pathogen removal rates.	Section 5.
6	TWGM Memo comments on contentions 1(a), 1(w), 1(x), 14(b), 14(c).	Further details in the management of stormwater quality infrastructure including water quality monitoring, trigger events, corrective actions, handover of structures and design of future stages.	Section 6.
7	TWGM comments on contention 1(s)	Construction phase management performance criteria.	Section 7.

## 1.3 Expert Witness Guidelines

The author has read Part 31 of Division 2 of the *Uniform Civil Procedure Rules 2005*, Schedule 7 of the *Uniform Civil Procedures Rules 2005* and understands his obligations to the Court and agrees to abide by the rules in Part 31 and Schedule 7, as well as the Land and Environment Court expert witness policies. This report has been prepared in accordance with the Expert Witness Guidelines.

## 2 Exfiltration Rates

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### 2.1 Adopted Rates

Exfiltration represents the transmittance of water from stormwater management infrastructure to underlying substrata, and in some cases to underlying groundwater. This typically occurs in many stormwater systems unless specific measures are implemented to restrict the downward movement of water, such as placing impermeable liners<sup>2</sup> within the conveyance or detention systems. It is on this basis that care must be taken to ensure that any loss of stormwater through the conveyance system does not pose a material risk to the groundwater system. Exfiltration is therefore generally not relied upon as a means of causing the loss of large stormwater pollutants loads, but rather is primarily used to reduce runoff volumes.<sup>3</sup>

In order to investigate the potential benefits and risks of enabling some low-level exfiltration within the stormwater system, stormwater quality modelling for the Crookhaven River catchments presented in the IWCMS<sup>4</sup> included results for two exfiltration scenarios:

1. No exfiltration from stormwater conveyance system. This was simulated by MUSIC model D-T1 and assumed all stormwater structures were constructed with impermeable liners.
2. 0.25 mm/hr (6mm/d) from Biobasins A, B and C and stormwater ponds. This was simulated by MUSIC model D-T2 and assumed that the selected stormwater structures were lined with a compacted clay capable of achieving the design exfiltration rate.

### 2.2 Justification for Rates

The adopted exfiltration rate for model D-T2 where exfiltration is incorporated has been selected based on a criteria described in Table 2, these being developed in response to site and receiving environment conditions. Table 2 also includes an accompanying assessment of these criteria in respect of the Proposal. The adopted rates are considered acceptable because they appropriately balance groundwater pollution risks against the benefits that are to be gained through implementing a groundwater recharge system, and good practice as part of an overall water sensitive urban design (**WSUD**) approach to the stormwater management system.

On this basis, incorporation of some form of low level exfiltration into the design of stormwater management structures is the preferred approach, provided that the rates do not exceed the maximum rate adopted in this assessment.

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<sup>2</sup> Such as concrete, HDPE and compacted clays.

<sup>3</sup> MUSIC Guideline p 47.

<sup>4</sup> Refer to Table 22 and Table 27 of IWCMS.

**Table 2:** Criteria for exfiltration rate selection.

Exfiltration Rate Selection Criteria	Comment and Assessment
<p>1. Be less than substratum permeability</p>	<p>This criterion is satisfied because:</p> <ol style="list-style-type: none"> <li>1. Average substratum saturated hydraulic conductivity (<b>K<sub>sat</sub></b>) at the site was assessed through extensive geotechnical testing and found to be 21.3 mm/hr.<sup>5</sup></li> <li>2. The adopted 0.25 mm/hr is around two orders of magnitude below this, therefore satisfying this selection criteria.</li> </ol>
<p>2. Be physically achievable</p>	<p>This criterion is satisfied because the nominated rate is physically achievable. The following is noted:</p> <ol style="list-style-type: none"> <li>1. The design rate of 0.25 mm/hr equates to 6.9x10<sup>-8</sup> m/s.</li> <li>2. These design exfiltration rates are readily achieved through standard civil and geotechnical engineering construction methods such as compaction of a good quality clay or construction in conjunction with a geotextile liner such as 'Bentofix'.</li> </ol>
<p>3. Be verifiable</p>	<p>This criterion is satisfied because the adopted exfiltration rate can and would be verified through a variety of means including:</p> <ol style="list-style-type: none"> <li>1. <i>In-situ</i> permeability testing of placed compacted clay liner materials</li> <li>2. Geotechnical engineering inspection of any liner or stormwater management infrastructure to ensure that construction methods and outcomes are spatially uniform and consistent with the design.</li> <li>3. Installation of any geosynthetic products are in accordance with the manufacturer's specification.</li> </ol>
<p>4. Achieves a reduction in stormwater runoff volume</p>	<p>This criterion is satisfied because:</p> <ol style="list-style-type: none"> <li>1. Average annual stormwater runoff volumes under developed conditions are reduced from 116 ML/year to 101 ML/year,<sup>6</sup> this representing a reduction of 15 ML/year or around 13%.</li> <li>2. Whilst this is not a large volume in comparison to the total remaining stormwater volume, it nevertheless demonstrates a real benefit in reducing net stormwater flow volumes to the receiving environment.</li> </ol>
<p>5. Does not lead to excessive pollutant loss</p>	<p>This criterion is satisfied because large pollutant loads are not released to the substratum or groundwater below the stormwater management system,<sup>7</sup> and there is no material reliance on the removal of pollutants via exfiltration. Specifically:</p> <ol style="list-style-type: none"> <li>1. In terms of Total Phosphorus (<b>TP</b>) would cause around 1.04 kg/year TP to be directed to the substratum, this being 13% of the total residual load under zero exfiltration conditions, but only 1.8 % of the actual TP load generated by the development.</li> <li>2. In terms of Total Nitrogen (<b>TN</b>) would cause around 9.30 kg/year TN to be directed to the substratum, this being around 12 % of the total residual load under zero exfiltration conditions, but only 2.0 % of the actual TN load generated by the development.</li> </ol>

<sup>5</sup> Refer to Table 20 of IWCMS.

<sup>6</sup> Refer to Table 24 of the IWCMS.

<sup>7</sup> Refer to Table 22 and Table 27 of the IWCMS.

Exfiltration Rate Selection Criteria	Comment and Assessment
<p><b>6.</b> Does not lead to nuisance groundwater level changes</p>	<p>This criterion is satisfied because:</p> <ol style="list-style-type: none"> <li>1. The volume of stormwater infiltrated annually is low compared to the area of land receiving.</li> <li>2. Detailed groundwater modelling has been undertaken to examine the potential effect of exfiltration within the Proposal area. Results<sup>8</sup> indicate that there are no material impacts on groundwater levels that would cause nuisance in terms of bringing groundwater significantly closer to the surface.</li> <li>3. Enabling recharge causes groundwater levels to marginally rise in areas close to and downslope of the recharge structures. This to some degree compensates for the reduced flow rates experienced in upper portions of the Concept Plan where recharge on balance is reduced due to urbanisation</li> <li>4. Changes in groundwater levels do not affect any existing groundwater bores or users.</li> </ol>
<p><b>7.</b> Does not impact on groundwater quality</p>	<p>This criterion is satisfied because:</p> <ol style="list-style-type: none"> <li>1. Exfiltrated stormwater is generally similar to or better than existing groundwater quality, particularly in terms of mean, 75<sup>th</sup> percentile and maximum concentrations.<sup>9</sup></li> <li>2. Detailed groundwater pollutant transport (advection / dispersion) modelling demonstrated that pollutants exfiltrated to the groundwater system are not likely to result in travel distances of more than 25 m before reaching background concentrations.<sup>10</sup> Exfiltration at the nominated 0.25 mm/hr rate will therefore not impact on any groundwater dependent ecosystems or groundwater users.</li> </ol>

<sup>8</sup> Refer to Map 37 for groundwater Head changes and Map 35 for groundwater Head sections.

<sup>9</sup> Refer to Table 46 of the IWCMS which compares net MUSIC exfiltration water quality with observed groundwater quality data.

<sup>10</sup> Refer to Table 45 and Maps 38, 39 and 40 of the IWCMS.

## 3 Biobasin Water Supply

### 3.1 Modes of Operation

Biofiltration basins (**Biobasins**) are designed to be operated in one of two general hydrologic modes.

1. Hydrologic Mode 1 – All upstream in-flow is directed to the Biobasin. Outflow is either via a pipe or an overflow weir.
2. Hydrologic Mode 2 – High flows are diverted via a flow diversion structure(s) to a stormwater pond for detention, further treatment and re-use, whilst low flows are directed immediately to the Biobasin. Overflows from the stormwater pond, if and when these occur, are then returned to the Biobasin for further treatment prior to discharge.

Table 3 outlines the mode of operation for each Biobasin, indicating that only Biobasins A, B and C operate in hydrologic mode 2. High flow bypass rates vary from to 10 L/s (Biobasins B and C) to 20 L/s (Biobasin A).<sup>11</sup> The following discussion is concerned with these Biobasins only.

**Table 3:** Biobasin hydrologic modes of operation.

Operating Hydrology	Biobasin Location and ID
Hydrologic Mode 1	Western catchment (Crookhaven): 1, 2, 3
	Central catchment (Crookhaven): D
	Eastern catchment (Crookhaven): 6
	Southern catchment (Lake Wollumboola): 7
Hydrologic Mode 2	Western catchment (Crookhaven): A
	Central catchment (Crookhaven): C
	Eastern catchment (Crookhaven): B

### 3.2 Hydrologic Performance

The MUSIC model was interrogated to obtain average annual outflow rates from each of the Biobasins A, B, C. These values provide a conservative estimate of water application rates to the management structure and can be converted to equivalent rainfall depths by dividing by basin area.<sup>12</sup>

Results are provided in Table 4 and indicate that sufficient water will be provided to the Biobasins to ensure that plant survival and Biobasin function are maintained. The following is noted:

<sup>11</sup> Refer also to Table 12 of IWCMS.

<sup>12</sup> Refer to Table 11 of IWCMS for Biobasin areas (A=6,000 m<sup>2</sup>, B = 3,000 m<sup>2</sup>, C = 2,000 m<sup>2</sup>).

1. Given that low flows will always be delivered to the Biobasins, there will be a consistent baseline supply of water to each Biobasin to ensure basins do not dry out because only around 5% of the total potential inflow will be diverted to the stormwater ponds.<sup>13</sup>
2. The total water volume supplied to each Biobasin is significant because this also includes overflows from the stormwater ponds.
3. Equivalent rainfall depths over each Biobasin basin are each substantially higher than average annual rainfall, indicating appropriate hydrological operating conditions.

**Table 4:** Summary of water supply to each Biobasin.

Biobasin ID	Average Hydrological Conditions	No Exfiltration	With Exfiltration
A	Annual Flow (ML/year)	73.2	63.7
	Equivalent Rainfall Depth (mm/year)	12,200	10,610
B	Annual Flow (ML/year)	28.4	24.7
	Equivalent Rainfall Depth (mm/year)	9,467	8,230
C	Average Flow (ML/year)	12.8	11.1
	Equivalent Rainfall Depth (mm/year)	6,400	5,530

### 3.3 Supplementary Support Measures

Whilst modelling has demonstrated that Biobasins A, B and C will receive sufficient water to ensure plant survival and on-going performance, it is possible that a backup direct irrigation system could be included in the ongoing Biobasin management scheme (for Biobasins A, B and C only) which would irrigate stormwater contained within the stormwater ponds directly over vegetation within the Biobasin. This, although not considered necessary, may be useful in periods of extended dry or drought conditions. It may also be beneficial in providing a temporary water source during the vegetation establishment phase of the project.

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<sup>13</sup> Refer to Table 26 of IWCMS which indicates that flows < 10 L/s represent around 95 % of the forecast stormwater flow rates generated by the development draining to the Crookhaven River catchment.

## 4 Surface Water Hydrology

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### 4.1 Flow Volumes and Frequencies

With reference to Section 4.5.3 of the IWCMS, annual stormwater volumes are predicted to slightly increase following development. The increase is in the order of 10 % when comparing the developed condition to existing conditions, assuming some exfiltration within the larger stormwater treatment structures (MUSIC model D-T2).<sup>14</sup> This increase was previously further considered in Table 25 and Diagram 12 of the IWCMS in terms of the distribution of flows released by the development to the 100 m forested estuary buffer, which indicated that following development, flow rate distributions will closely match present day conditions.

To provide further information in terms of the distribution of surface flows leaving the Proposal footprint and entering the 100 m forested buffer following development, MUSIC models PD-LC (pre-development conditions based on existing land cover), D-T1 (developed conditions assuming no exfiltration) and D-T2 (developed conditions assuming exfiltration) were re-run at a daily time step (rather than 6 minute time step) to simplify the data output and computational requirements. Results are provided in Table 5 and Diagram 1. The following general observations are made in respect of these analyses:

1. The number of zero flow days decreases if no exfiltration is incorporated into the stormwater system design (model D-T1) but increases to levels similar to and slightly higher than existing conditions if exfiltration is provided as part of the stormwater train (model D-T2). This supports the inclusion of some low level exfiltration into the design of future stormwater structures.
2. Irrespective of the modelled scenario, site runoff is characterised by the majority of stormwater flow being low volume and occurring in the low flow category of < 1 ML/day. If no exfiltration is undertaken (model D-T1), then the frequency of these lower flows increases, but where exfiltration is included (model D-T2), there is a further reduction in the occurrence of low flows.
3. In the case of other low flow rates say between 1-4 ML/day, the frequency of these events is slightly increased by around 2% after development if no exfiltration is undertaken, this being reduced to an increase of around 1% (4-5 days/year) if exfiltration is included in the stormwater scheme.
4. In the case of higher flows > 4 ML/day, the frequency of these events is effectively unchanged where the modelling includes exfiltration.

In summary, modelling investigation have found that the proposed stormwater system will largely mimic current hydrological conditions. This is particularly the case where some stormwater exfiltration is incorporated into the design of stormwater treatment structures as denoted in MUSIC model D-T2. Results indicate that there will not be an increase in 'runoff days' if exfiltration is included in the design, and that the frequency of medium

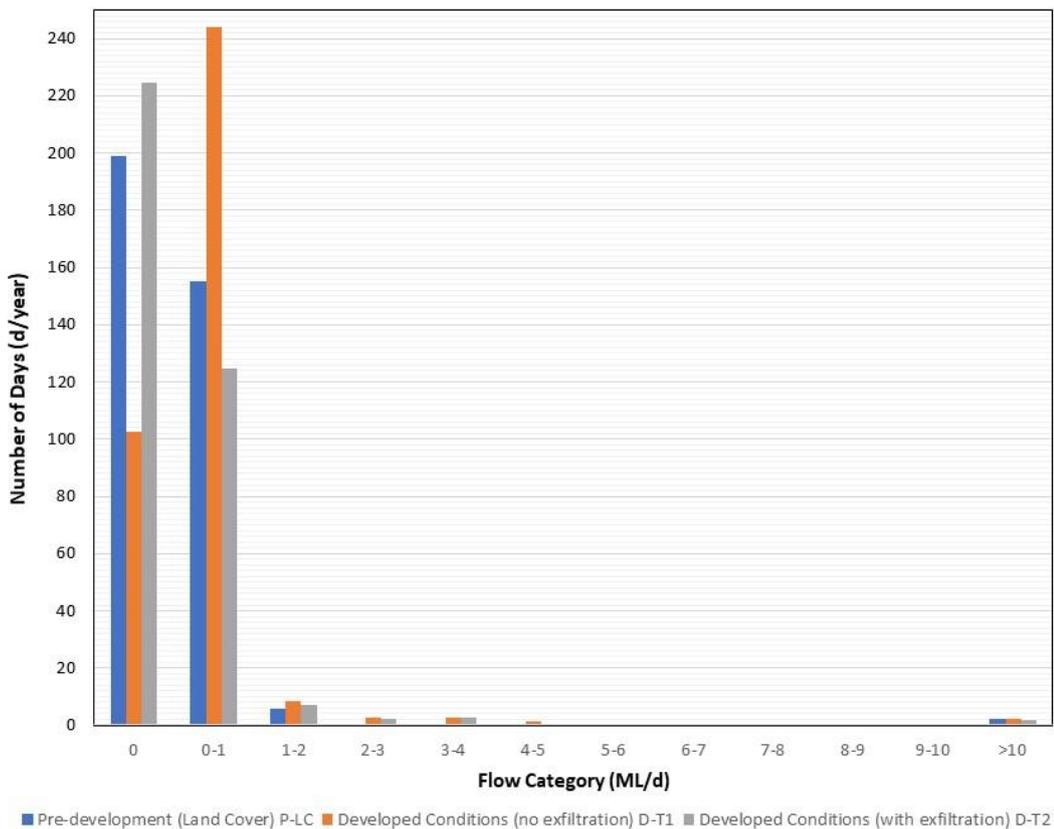
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<sup>14</sup> Refer to Table 24 in IWCMS and compare results for PD-LC1 or PD-LC2 with D-T2.

volume (1-4 ML/day) and larger volume (> 4 ML/day) flows from the site to the 100 m forested estuary buffer will remain essentially unchanged.

**Table 5:** Distribution of stormwater flow volumes to 100 m forested buffer to estuary.

Daily Flow Volume (ML/d)	Pre-Development (PD-LC)		Developed No Exfiltration (D-T1)		Developed With Exfiltration (D-T2)	
	% Time	Days/yr	% Time	days/yr	% Time	days/yr
No Flow	54.5%	199.0	28.0%	102.4	61.5%	224.4
< 1	42.5%	155.1	66.8%	244.0	34.2%	124.7
1-2	1.6%	5.8	2.3%	8.2	1.9%	7.0
2-3	0.2%	0.6	0.7%	2.7	0.6%	2.1
3-4	0.2%	0.7	0.7%	2.6	0.7%	2.6
4-5	0.1%	0.2	0.3%	1.2	0.1%	0.4
5-6	0.1%	0.2	0.1%	0.2	0.1%	0.4
6-7	0.1%	0.3	0.1%	0.2	0.1%	0.3
7-8	0.1%	0.2	0.1%	0.4	0.1%	0.2
8-9	0.1%	0.2	0.1%	0.3	0.2%	0.6
9-10	0.1%	0.4	0.2%	0.6	0.1%	0.4
>10	0.6%	2.2	0.6%	2.2	0.5%	1.8



**Diagram 1:** Occurrence of daily stormwater flow volumes under existing and developed conditions.

## 4.2 Hydrographs

Further investigation of the potential impact of the Proposal on flow regimes was undertaken through a detailed examination of hydrographs under average, wet and dry year conditions. With reference to Table 16 of the IWCMs, the following representative years were taken from the MUSIC model run data:<sup>15</sup>

1. Average year: 1966 (1,024 mm rain)
2. Wet year: 1969 (1,468 mm rain)
3. Dry year: 1968 (464 mm rain)

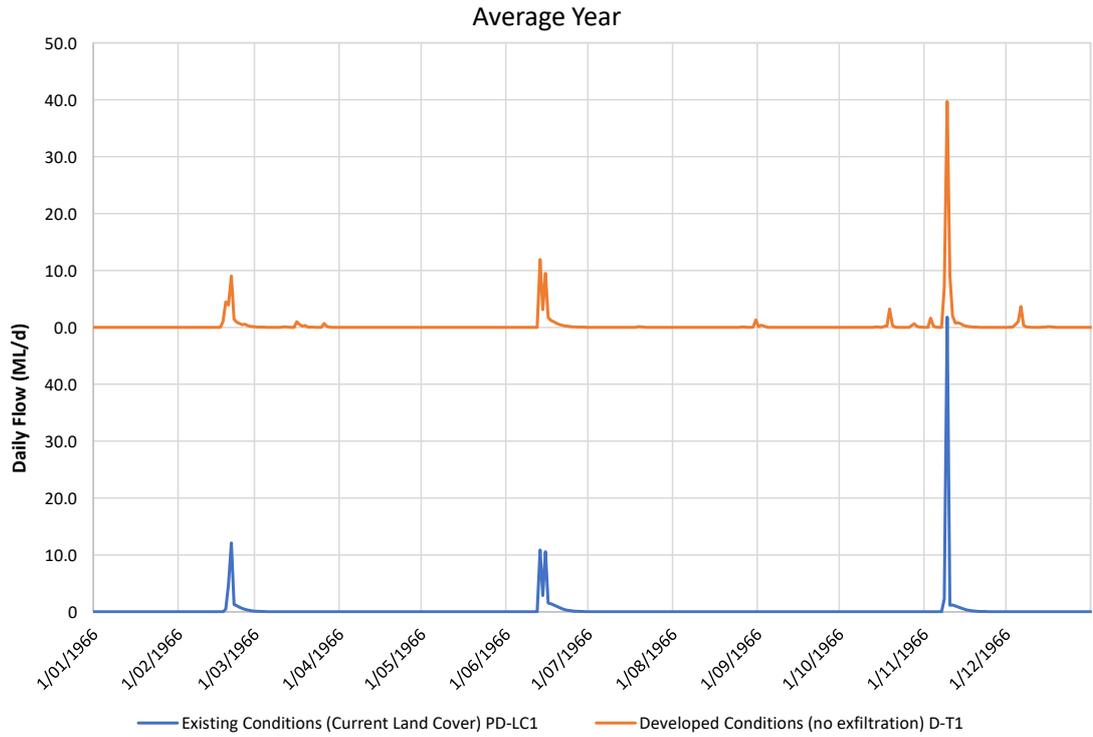
Existing and developed conditions hydrograph comparisons have been plotted for an average rainfall year (Diagram 2 no exfiltration, Diagram 3 with exfiltration), a wet year (Diagram 4 no exfiltration, Diagram 5 with exfiltration), and a dry year (Diagram 6 no exfiltration, Diagram 7 with exfiltration). The following is observed:

1. There is a general similarity in the form and occurrence of hydrographs between existing and developed conditions. The most notable features are that peak flow rates are typically reduced following development (due to the attenuation with stormwater ponds) and that the occurrence of smaller runoff events (say 1-4 ML/d) is slightly increased (particularly where no exfiltration is assumed within the stormwater system), this reflecting the flow frequency analysis given in Table 5.
2. The effect of exfiltration within the stormwater treatment train is to generally further depress peak flow rates (likely due to pond storage volumes being slightly reduced at the on-set of stormwater inflows), and generally cause minor reductions in hydrograph rising and falling limb levels. A more detailed comparison is provided in Diagram 8.
3. More detailed comparisons of existing and developed conditions (with exfiltration) hydrographs of example storms within average rainfall, wet and dry years are provided in Diagram 9, Diagram 10 and Diagram 11. These show:
  - a. During dry and average rainfall years (Diagram 11 and Diagram 9), whilst the overall shape and volume are generally consistent with existing conditions, developed condition hydrographs maintain slightly lower peaks and have higher rising limbs and lower falling limbs.
  - b. In wet years, hydrograph peaks and general shape are largely consistent with existing conditions.

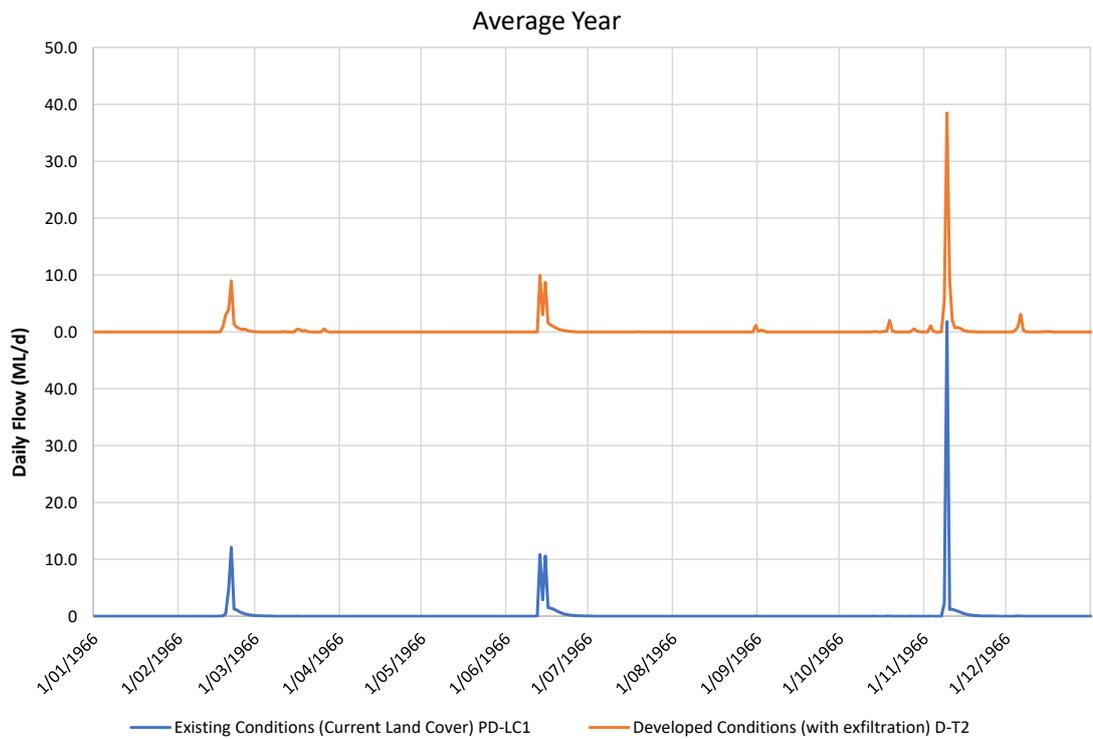
In summary, developed condition hydrographs closely mimic existing conditions. In general, the frequency of overland flows is largely unchanged, although there is a slight frequency increase in lower order flows of between 1-4 ML/day. Developed conditions hydrograph peaks are often lower due to the detention capacity of the proposed stormwater ponds, with rising limbs slightly elevated and falling limbs slightly depressed. Including exfiltration further beneficially reduces peak flow rates and flow rates.

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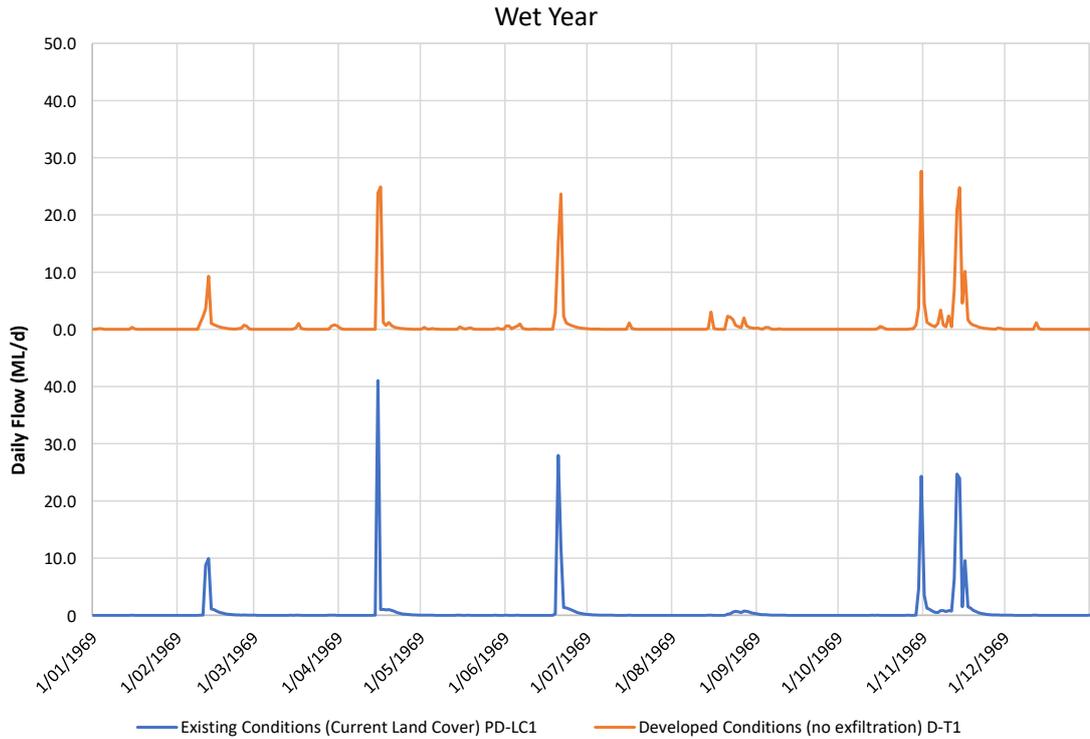
<sup>15</sup> Using the daily time step runs produced as part of the data analysis presented at Section 4.1.



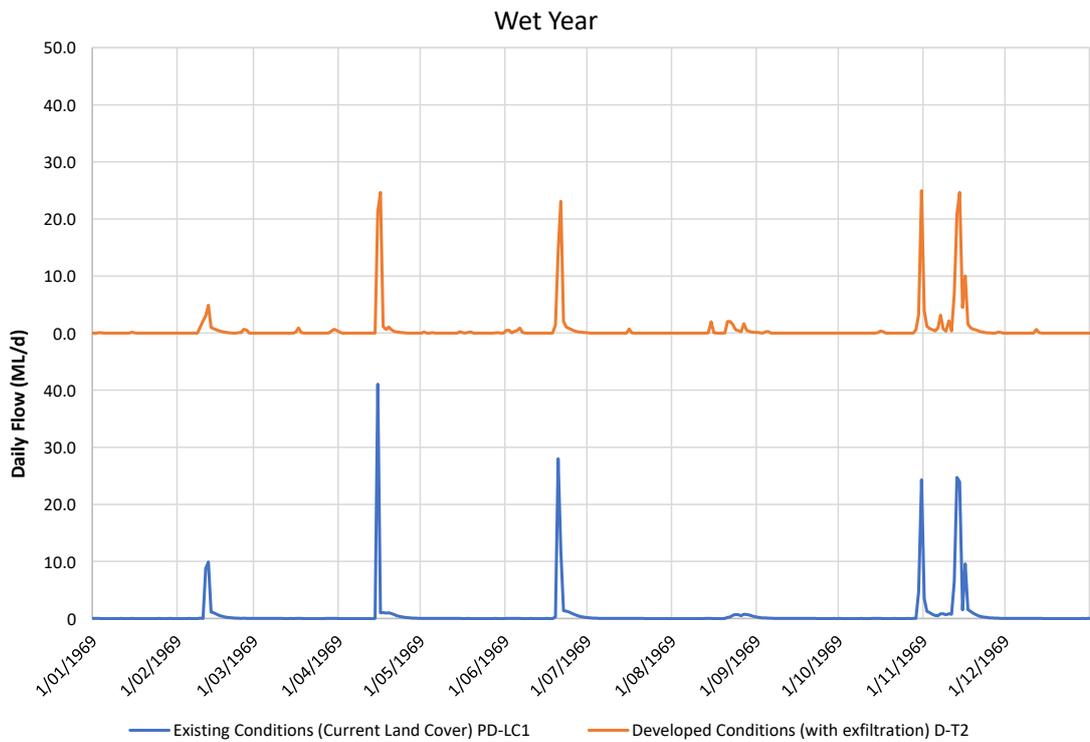
**Diagram 2:** Comparison of average rainfall year existing and developed (no exfiltration) condition hydrographs.



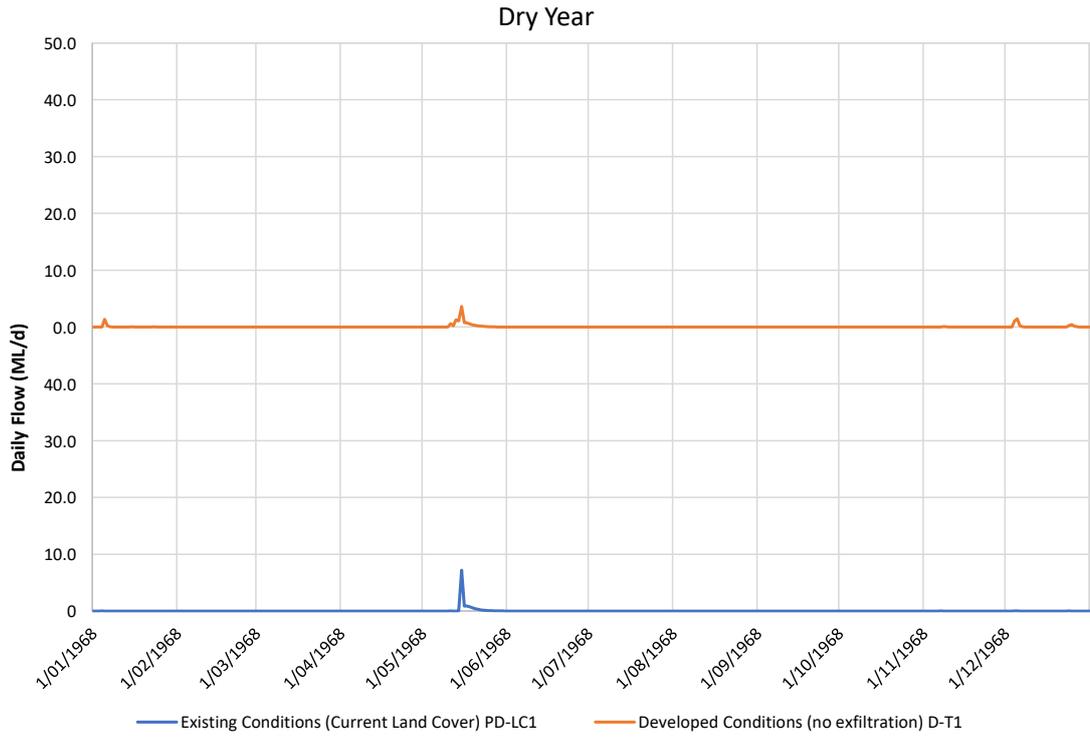
**Diagram 3:** Comparison of average rainfall year existing and developed (with exfiltration) condition hydrographs.



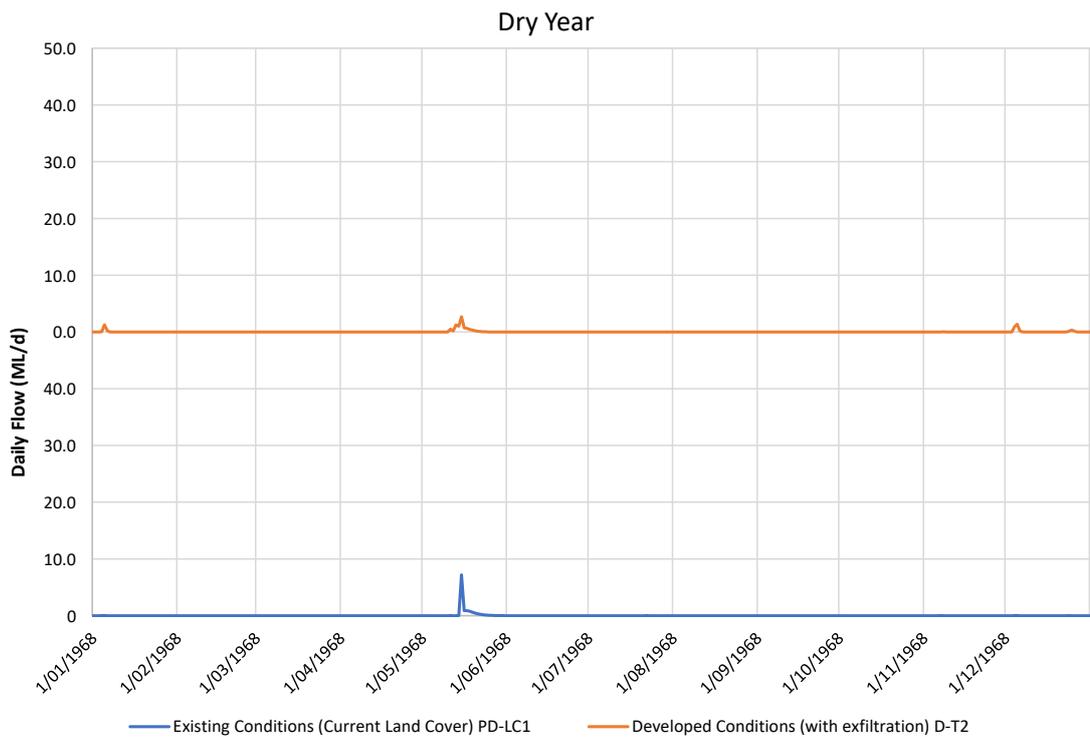
**Diagram 4:** Comparison of wet year existing and developed (no exfiltration) condition hydrographs.



**Diagram 5:** Comparison of wet year existing and developed (with exfiltration) condition hydrographs.



**Diagram 6:** Comparison of dry year existing and developed (no exfiltration) condition hydrographs.



**Diagram 7:** Comparison of dry year existing and developed (with exfiltration) condition hydrographs.

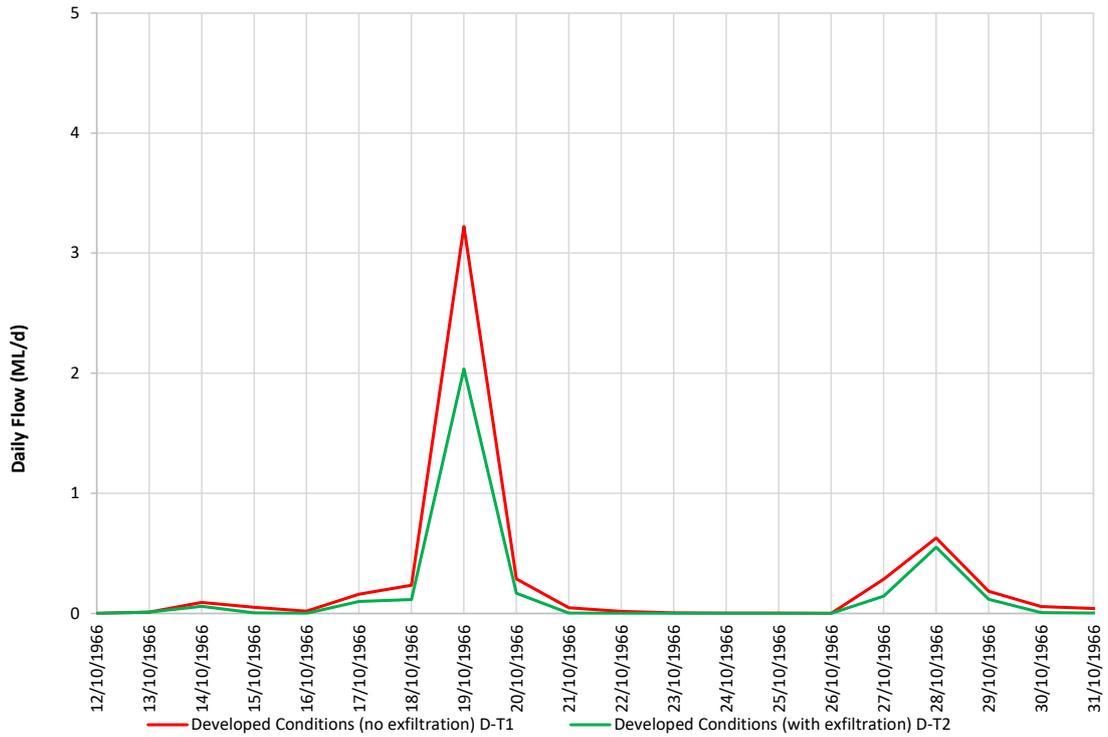


Diagram 8: Developed condition hydrographs showing impacts of including exfiltration.

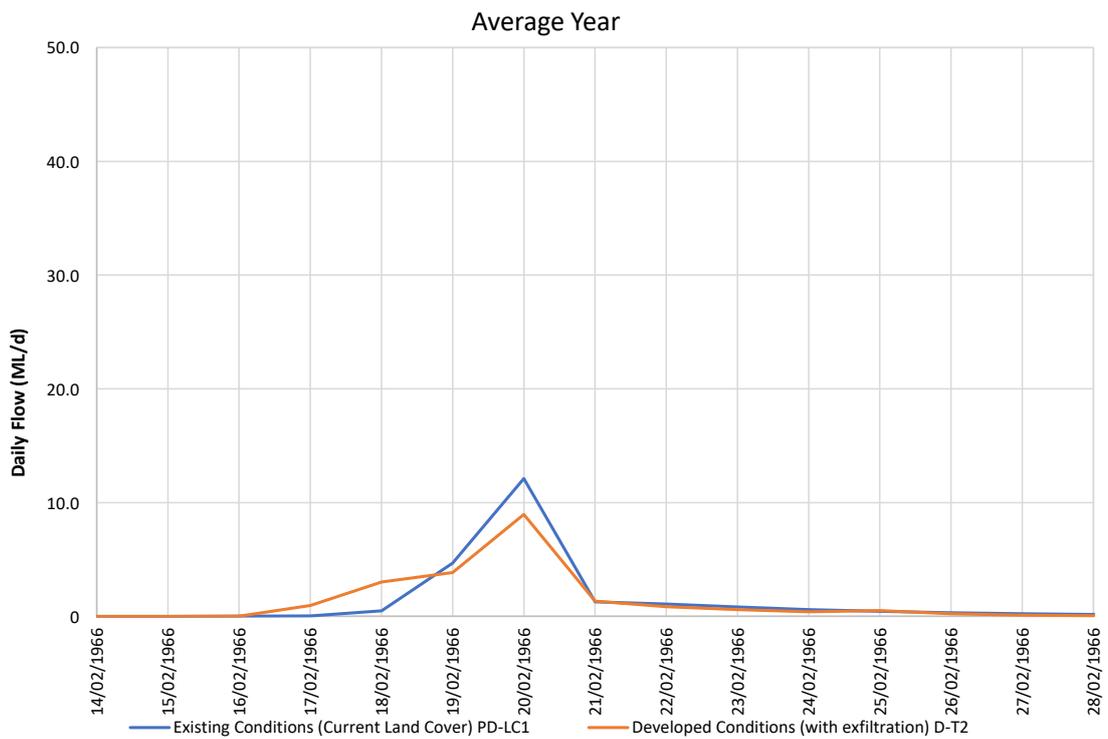
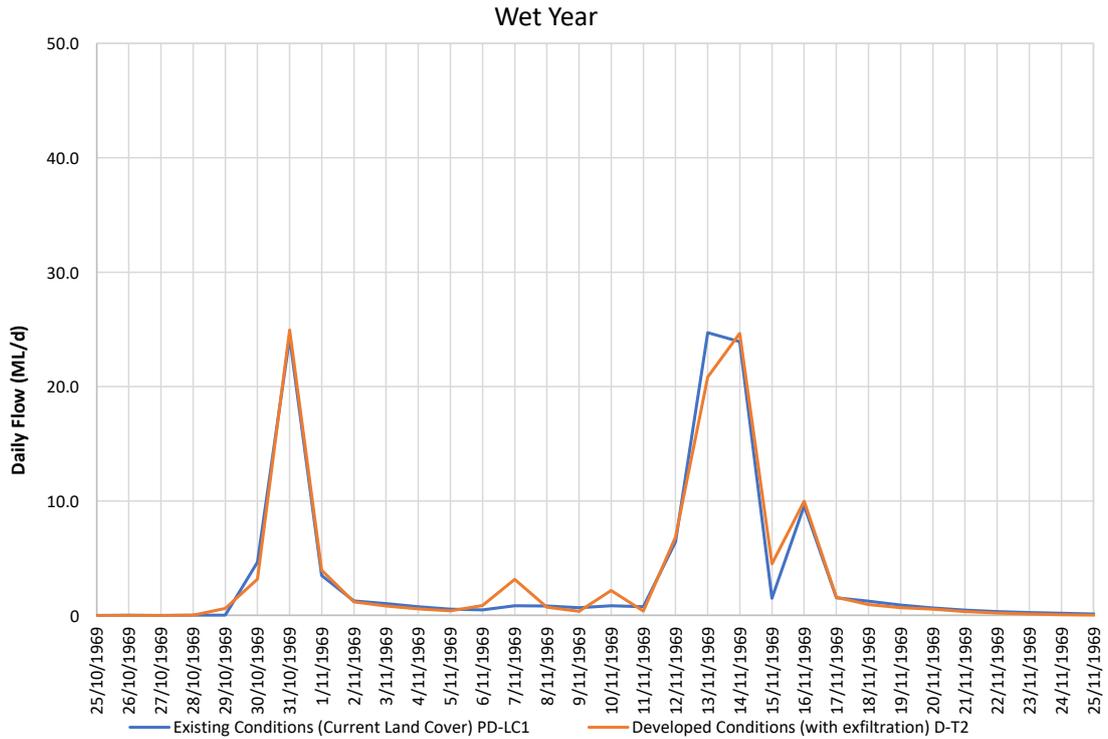
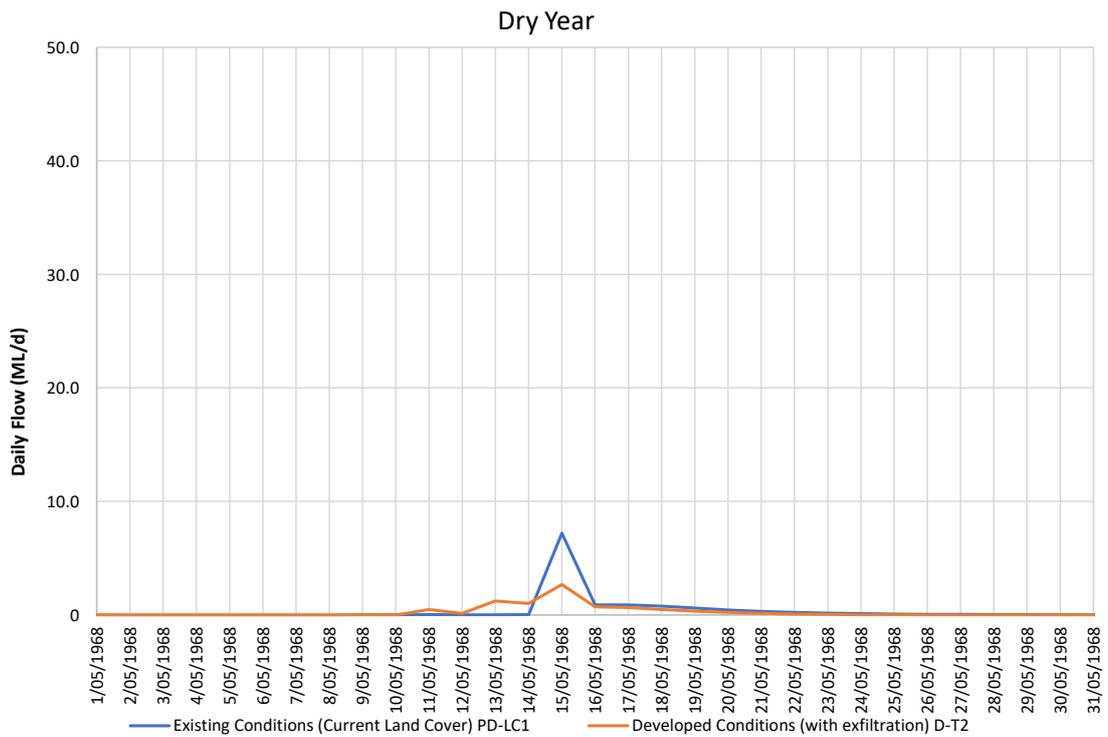


Diagram 9: Detailed average rain year hydrograph comparison of existing and developed conditions (with exfiltration).



**Diagram 10:** Detailed wet year hydrograph comparison of existing and developed conditions (with exfiltration).



**Diagram 11:** Detailed dry year hydrograph comparison of existing and developed conditions (with exfiltration).

## 4.3 Salinity Impacts

### 4.3.1 Runoff Salinity Levels

With reference to Section 3.1.6.3 of the IWCMS, surface water runoff quality from three existing land-use types has been monitored at a number of locations between November 2018 and July 2020. Expanded salinity monitoring data summaries have been produced in Table 8 which includes additional percentile data. Data indicate that elevated salinity levels are consistently contained in urban runoff compared to agricultural or forest runoff.

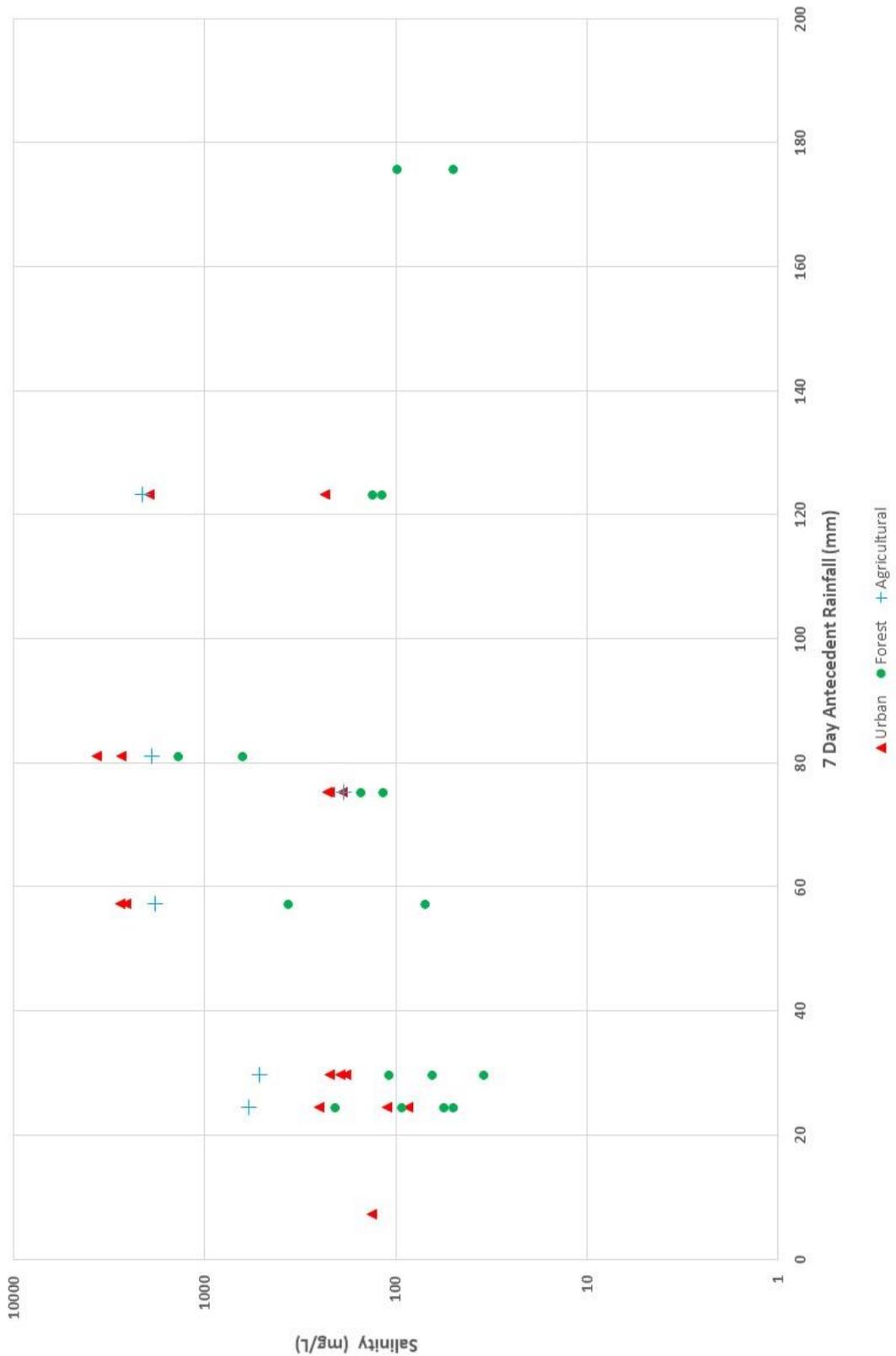
**Table 6:** Summary of land-based salinity (given in  $\mu\text{S}/\text{cm}$  and  $\text{mg}/\text{L}$ ) monitoring.

Statistic	Urban		Agricultural		Forest	
	Salinity ( $\mu\text{S}/\text{cm}$ )	Salinity ( $\text{mg}/\text{L}$ )	Salinity ( $\mu\text{S}/\text{cm}$ )	Salinity ( $\text{mg}/\text{L}$ )	Salinity ( $\mu\text{S}/\text{cm}$ )	Salinity ( $\text{mg}/\text{L}$ )
Mean (average)	1,543	988	1,854	1,187	342	219
90 <sup>th</sup> percentile	4,315	2,762	3,135	2,006	738	472
95 <sup>th</sup> percentile	4,685	2,998	3,233	2,069	1,223	783
99 <sup>th</sup> percentile	5,537	3,544	3,311	2,119	1,965	1,258

We note that all surface water samples were collected during or immediately following wet weather. Plots of runoff salinity concentration versus 24 hr and 7 day antecedent rainfall totals are provided in Diagram 12 and Diagram 13. These do not reveal any identifiable trend in salinity concentration as a function of incident rainfall and indicate that adopting a mean concentration is reasonable for modelling purposes. The following is observed from these data:

1. The rainfall versus salinity plots show that urban runoff consistently contains higher salt concentrations than runoff from forested catchments or agricultural land.
2. Monitoring shows that mean urban runoff salinity is approximately 4-5 times higher than runoff from forested catchments, noting:
  - a. This is a logical outcome given that salt laden wind deposits salt directly on urban surfaces which are then readily subject to direct runoff during rainfall.
  - b. By contrast, salt deposition in forest areas can occur within the vegetation and can be bound within the soil, thus reducing the potential for elevated salt levels in runoff.
3. The monitoring therefore supports the proposition, even assuming a margin of error, that the minor increase in freshwater volume released to the estuary will not have the effect of reducing estuarine salinity (see Section 4.3.2 for further exploration of the issue of salinity changes in the estuary).





### 4.3.2 Salinity Changes In Estuary

The potential impact of increased runoff entering the Crookhaven River estuary was tested through modelling of annual and daily estuary tidal prism mass balances assessed between the western site boundary and confluence with the Shoalhaven River. Analyses and results are presented in Table 7. The following is observed:

1. The Proposal's contribution to annual tidal flows with the Crookhaven River estuary is extremely small at around 0.006%.
2. Modelling demonstrates that there is not likely to be any change to average annual salinity levels within the Crookhaven River estuary arising out of the Proposal. On a daily basis, salinity is similarly expected to be unchanged.
3. Modelling outcomes remain consistent even for lower assumed urban runoff salt concentrations of say 500 or 200 mg/L. This is because site runoff only provides a very small contribution to the tidal prism and other catchment inflows.

**Table 7:** Assessment of increased runoff volume on estuary salinity.

Impact Assessment	Existing	Developed	Comment
<u>Background Data</u>			
Tidal Prism (m <sup>3</sup> )	2,106,221	2,106,221	Volume between MHW and MLW d/s of western Site boundary.
Typical Estuary Salinity (mg/L, no-flood)	27,500	27,500	Mid-range value based on IWCMS Section 3.2.3.
Site Runoff Volume (ML/year)	95.9	101.0	Assumes exfiltration scenario (D-T2). Refer to Table 24 in IWCMS.
Site Percent Days no Runoff	55%	62%	Assumes exfiltration scenario (D-T2) in Table 5.
Site Runoff Salinity (mg/L)	219	988	Assumes existing=forest and developed = urban in Table 6.
Site Annual Salt Load (tonnes/year)	21.0	99.8	Average annual total loads based on monitoring data.
Site Daily Salt Load (kg/d)	126	710	Average salt contribution during site runoff days only.
<u>Annual Mass Balance Assessment</u>			
Tidal Volume (ML/year)	1,537,637	1,537,642	Two tide cycles/day + additional flow volume from site.
Salt load in Tidal Prism (tonnes/year)	42,282,408	42,282,486	Mass brought to estuary each day + additional salt load from site.
Resultant salinity (mg/L)	27,498	27,498	Calculated based on salt mass per unit volume.
<u>Peak Daily Mass Balance Assessment</u>			
Tidal Volume (m <sup>3</sup> /day)	4,213,019	4,213,161	Volumes includes 2 tidal cycles + site runoff contributions on runoff days
Salt Load in Tidal Prism (kg/day)	115,842,281	115,842,865	Loads include site loads on runoff days only
Resultant Salinity (mg/L)	27,496	27,495	Calculated based on salt mass per unit volume.

## 4.4 System Performance

Based on these supplementary investigations, the hydrologic performance of the proposed stormwater system can be summarised as follows:

1. The proposed stormwater system will largely mimic current hydrological conditions. This is particularly the case where some stormwater exfiltration is incorporated into the design of stormwater treatment structures (which is recommended). Results indicate that there will not be any increase in 'runoff days' if exfiltration is included in the design, and that the frequency of medium volume (1-4 ML/day) and larger volume (> 4 ML/day) flows from the site to the 100 m forested estuary buffer will remain essentially unchanged.
2. Developed condition hydrographs closely mimic existing conditions. In general, the frequency of overland flows is largely unchanged, although there is a slight frequency increase in lower order flows of between 1-4 ML/day. Developed conditions hydrograph peaks are often lower due to the detention capacity of the proposed stormwater ponds, with rising limbs slightly elevated and falling limbs slightly depressed. Including exfiltration further beneficially reduces peak flow rates and flow rates.
3. Surface water quality monitoring between 2018 and 2020 demonstrates that urban runoff will contain salt levels around 4-5 times higher than current conditions. Estuary mass balance modelling indicates that the very minor increase in freshwater volume released to estuary will not have the effect of reducing estuarine salinity.
4. More detailed modelling of water quality in receiving waters is therefore not considered necessary because site runoff frequency and magnitude analysis demonstrated that there would be no material changes to the surface water runoff regime from the site to the estuary.

## 5 Pathogen Control

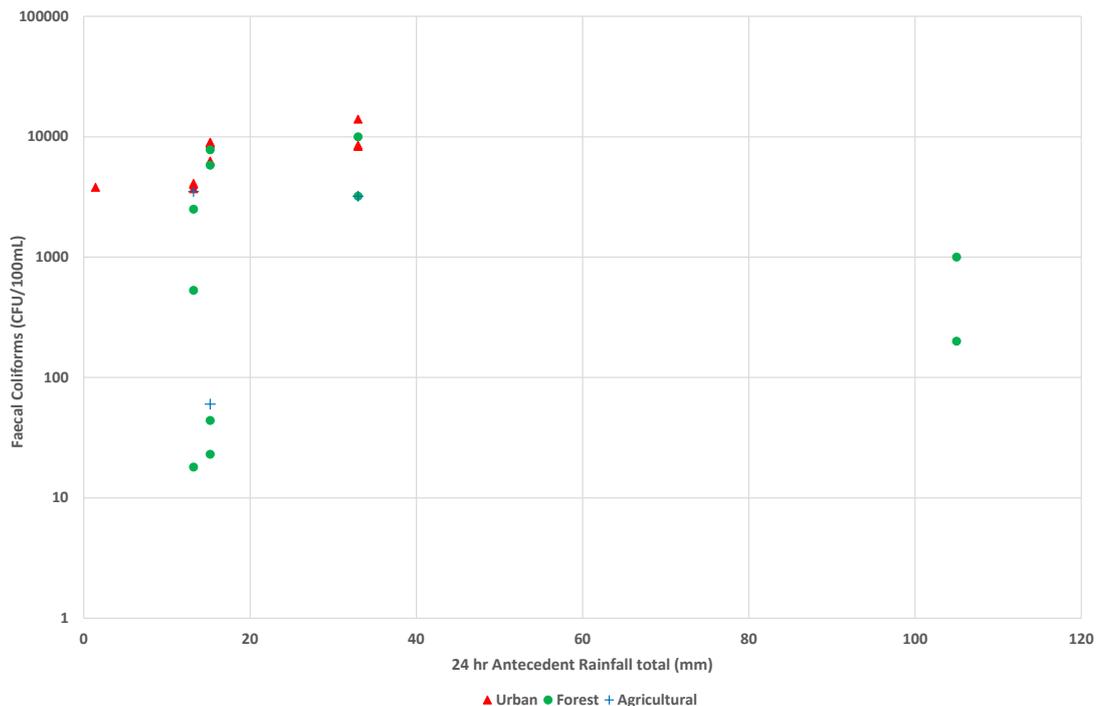
### 5.1 Existing Water Quality

With reference to Section 3.1.6.3 of the IWCMS, surface water runoff quality from three existing land-use types has been monitored at a number of locations between November 2018 and July 2020. Faecal Coliform monitoring data summaries have been reproduced in Table 8, including additional percentile data. Data indicate that pathogens are contained in surface runoff irrespective of land-use.

**Table 8:** Summary of land-based Faecal Coliform (CFU/100mls) monitoring.

Statistic	Urban	Agricultural	Forest
Mean (average)	7,070	2,253	2,829
90 <sup>th</sup> percentile	9,500	3,440	7,800
95 <sup>th</sup> percentile	11,750	3,470	8,900
99 <sup>th</sup> percentile	13,440	3,494	9,780

All surface water samples were collected during or immediately following wet weather. Plots of concentration versus 24 hr and 7 day antecedent rainfall totals are provided in Diagram 14 and Diagram 15. These do not reveal any identifiable trend in concentration as a function of incident rainfall and indicate that adopting a mean concentration is reasonable for modelling purposes.



**Diagram 14:** Faecal Coliform concentration as a function of 24 hour antecedent rainfall total.



### 5.3 Pathogen Removal Model

A detailed model of pathogen removal was developed based on the more conservative results of the developed case (D-T1) MUSIC model (no exfiltration assumed to occur at stormwater structures and higher runoff volumes are predicted). The general modelling approach undertaken is summarised as follows:

1. MUSIC model D-T1 was re-run at a daily time step (rather than 6 minute time step) to simplify the model computational requirements.
2. A range of daily hydrologic data were extracted from the MUSIC D-T1 model including:
  - a. Biobasin inflows / outflows. In the case of Biobasins A, B and C, this included both low flows and stormwater pond overflows.
  - b. Direct inflows to stormwater ponds.
  - c. Stormwater pond daily storage volumes.
  - d. Stormwater pond discharge flows.
3. Pathogen concentrations were transformed within the stormwater treatment train in accordance with the governing functions described in Table 9. Specifically:
  - a. In the case of Biobasins, nominated log removal rates were applied to selected outflows.
  - b. In the case of stormwater ponds, concentrations were determined on the basis of mixing with inflows and modelled daily pathogen decay.
4. Adopted pathogen removal rate coefficients are described in Table 10 noting:
  - a. In respect of LR, four modelling scenarios were considered.
  - b. In respect of  $t_{0.5}$ , two modelling scenarios were considered.
5. In total, eight modelling scenarios were undertaken. For each scenario, the following statistics were evaluated:
  - a. Mean (average)
  - b. 90<sup>th</sup> percentile
  - c. 95<sup>th</sup> percentile
  - d. 99<sup>th</sup> percentile
6. Modelled stormwater pathogen concentrations released to the 100 m forested estuary buffer were compared to existing forest runoff.

**Table 10:** Adopted pathogen removal function coefficients.

Coefficient	Comment																									
$C_0$	<ol style="list-style-type: none"> <li>If upstream of any other stormwater structure, <math>C_0 = 7,000</math>.</li> <li>If downstream of a stormwater structure <math>C_0 =</math> upstream structure outflow concentration.</li> </ol>																									
LR	<p>Given that LR is expected to vary between 1-2,<sup>18</sup> four modelling scenarios were considered:</p> <ol style="list-style-type: none"> <li><u>LR Scenario 1</u> – Uniform LR applied to all Biobasin flows.</li> <li><u>LR Scenario 2</u> – As per Scenario 1, but LR=1.5 applied to pipe flow in Biobasins A, B and C where flows are regulated by diverting high flows to stormwater ponds.</li> <li><u>LR Scenario 3</u> – Uniform LR applied to all Biobasin pipe flows, LR=0 applied to all Biobasin weir flows.</li> <li><u>LR Scenario 4</u> - As per Scenario 3, but LR=1.5 applied to pipe flow in Biobasins A, B and C where flows are regulated by diverting high flows to stormwater ponds.</li> </ol> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Scenario</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> </tr> </thead> <tbody> <tr> <td>Biobasins 1,2,3,6,7,D pipe flow</td> <td>LR=1</td> <td>LR=1</td> <td>LR=1</td> <td>LR=1</td> </tr> <tr> <td>Biobasins 1,2,3,6,7,D weir flow</td> <td>LR=1</td> <td>LR=1</td> <td>LR=0</td> <td>LR=0</td> </tr> <tr> <td>Biobasins A,B,C pipe flow</td> <td>LR=1</td> <td>LR=1.5</td> <td>LR=1</td> <td>LR=1.5</td> </tr> <tr> <td>Biobasins A,B,C weir flow</td> <td>LR=1</td> <td>LR=1</td> <td>LR=0</td> <td>LR=0</td> </tr> </tbody> </table>	Scenario	1	2	3	4	Biobasins 1,2,3,6,7,D pipe flow	LR=1	LR=1	LR=1	LR=1	Biobasins 1,2,3,6,7,D weir flow	LR=1	LR=1	LR=0	LR=0	Biobasins A,B,C pipe flow	LR=1	LR=1.5	LR=1	LR=1.5	Biobasins A,B,C weir flow	LR=1	LR=1	LR=0	LR=0
Scenario	1	2	3	4																						
Biobasins 1,2,3,6,7,D pipe flow	LR=1	LR=1	LR=1	LR=1																						
Biobasins 1,2,3,6,7,D weir flow	LR=1	LR=1	LR=0	LR=0																						
Biobasins A,B,C pipe flow	LR=1	LR=1.5	LR=1	LR=1.5																						
Biobasins A,B,C weir flow	LR=1	LR=1	LR=0	LR=0																						
$t_{0.5}$	<p>Two rates were considered:</p> <ol style="list-style-type: none"> <li><math>t_{0.5} = 1.2</math> days based on the work by the NSW Sydney Catchment Authority<sup>19</sup> and others.<sup>20</sup></li> <li><math>t_{0.5} = 2.0</math> days, taken as an upper envelope value.</li> </ol>																									

## 5.4 Modelling Pathogen Levels in Runoff

Modelling results are provided in Table 11, which provides summary statistics for the simulation period on the basis of including zero discharge days, and Table 12, which provides summary statistics for only days where stormwater is released to the 100 m forested estuary buffer (this being around 70% of the year for MUSIC model D-T1).

<sup>18</sup> Chandasena, K. K. G. I., Deletic, A., Ellerton, J. and McCarthy, D.T. (2011) *Removal of Escherichia coli in Stormwater Biofilters*, 12<sup>th</sup> International Conference on Urban Drainage, Porto Alegre/Brazil, p 6.

<sup>19</sup> See WaterNSW (2015) *Wastewater Effluent Model*, as described in WaterNSW (2015) *Neutral or Beneficial Effect on Water Quality Assessment Tool*, Consultants and Consultant Administrators; and Martens & Associates (2011) *Technical Update of the Development Assessment Module (DAM) – Final Report*, prepared on behalf of the Sydney Catchment Authority.

<sup>20</sup> See for example: Vinten, A.J. A, Douglas, D. R, Lewis D. R., Aitken, M. N and Fenlon (2004) Relative risk of Surface Water Pollution by E. coli Derived from Faeces of Grazing Animals Compared to Slurry Application, *Soil Use and Management* 20, 13 – 22, at p 19 who reported a half-life of 1.2 days for E. coli at 15° temperature; Sobratee, N. , Mohee, R., Driver, M.F. and Mudhoo, A. (2007) Survival Kinetics of Faecal Bacterial Indicators in Spent Broiler Litter Composting, *Journal of Applied Microbiology* 104 (2008) 204–214, at p 209 report a half-life of 1.4 days for Faecal Coliforms; Kimberly, L. A., Whitlock, J. E. and Harwood, V. J (2005) Persistence and Differential Survival of Faecal Indicator Bacteria in Subtropical Waters and Sediments, *Applied Environmental Microbiology* 71(6) 3041 – 3048, report half-life as low as 0.3 days for Faecal Coliforms in freshwater; Blaustein, R. A., Pachepsky, Y., Hill, R. L., Shelton, D. R. and Whelan, G. (2013) *Escherichia coli* Survival in Waters: Temperature Dependence, *Water Research* 47(2), 569–578, reported in a review of various data sources, an average E. coli half-life of around 0.75 days for non-saline river water at 20°.

**Table 11:** Modelled stormwater pathogen release concentrations (CFU/100mls) to 100 m buffer (includes zero discharge days).

t <sub>0.5</sub> (days)	Percentile	Existing Forest	Developed Conditions (Model D-T1)			
			LR Scenario 1	LR Scenario 2	LR Scenario 3	LR Scenario 4
1.2	Mean	2,829	132	47	135	48
	90 <sup>th</sup>	7,800	308	111	317	114
	95 <sup>th</sup>	8,900	461	206	507	210
	99 <sup>th</sup>	9,780	700	221	700	221
2.0	Mean	2,829	133	48	135	49
	90 <sup>th</sup>	7,800	308	111	317	114
	95 <sup>th</sup>	8,900	461	206	507	210
	99 <sup>th</sup>	9,780	700	221	700	221

**Table 12:** Modelled stormwater pathogen release concentrations (CFU/100mls) to 100 m buffer (excludes zero flow days).

t <sub>0.5</sub> (days)	Percentile	Existing Forest	Developed Conditions (Model D-T1)			
			LR Scenario 1	LR Scenario 2	LR Scenario 3	LR Scenario 4
1.2	Mean	2,829	181	65	185	66
	90 <sup>th</sup>	7,800	342	127	354	134
	95 <sup>th</sup>	8,900	700	221	700	221
	99 <sup>th</sup>	9,780	700	221	700	249
2.0	Mean	2,829	182	65	185	66
	90 <sup>th</sup>	7,800	342	127	354	134
	95 <sup>th</sup>	8,900	700	221	700	221
	99 <sup>th</sup>	9,780	700	221	700	249

## 5.5 Pathogen Levels in Estuary

### 5.5.1 Peak Pathogen Loads

Potential changes to peak pathogen loads received at the Crookhaven River estuary from Development runoff were assessed using the following approach:

1. Representative peak runoff events were selected from annual hydrographs under average, wet and dry year conditions (refer to Diagram 2, Diagram 4 and Diagram 6).
2. Total runoff event pathogen load for each selected event under existing conditions was determined as the product of total event runoff volume and the mean pathogen runoff concentration assuming a forested land cover (2,829 CFU/100mls).

- Total runoff event pathogen load for each selected event under developed conditions was determined as the product of total event runoff volume and the highest 90<sup>th</sup> percentile predicted pathogen concentration in runoff (assuming no exfiltration within the stormwater management system) as described in Table 12 (354 CFU/100 mls).

Outcomes of the analysis are summarised in Table 13 which indicate that total pathogen loads from the Development under extreme rainfall conditions will be reduced as a result of the Proposal when compared to existing conditions.

**Table 13:** Modelled peak runoff event pathogen loads to estuary.

Annual Runoff Event	Statistic	Existing Forest	Developed Conditions (Model D-T1)
Average Year (8-11/11/1966)	Volume (ML)	56.4	57.9
	Pathogen load (CFUx10 <sup>9</sup> )	1,597	205
Wet Year (14-17/4/1969)	Volume (ML)	43.1	50.0
	Pathogen load (CFUx10 <sup>9</sup> )	1,220	177
Dry Year (14-17/5/1968)	Volume (ML)	9.0	6.2
	Pathogen load (CFUx10 <sup>9</sup> )	144	13

### 5.5.2 Nearshore Pathogen Levels

The potential impact of increased runoff entering the Crookhaven River estuary was tested through modelling of annual and daily estuary tidal prism pathogen mass balances assessed for the nearshore oyster lease area in the vicinity of the Proposal which would potentially receive direct runoff from the Development. Diagram 16 shows the nearshore component of the estuary over which tidal prism was calculated, this being determined to be approximately 613 ML.

Modelling analyses and results are presented in Table 14. The following is observed:

- On an annual and peak daily basis, baseline pathogen concentrations are expected to decrease within the nearshore estuary environment adjacent to the Development because of the measures implemented within the Proposal's stormwater management system.
- Modelling demonstrates that OISAS<sup>21</sup> pathogen water quality objectives (90<sup>th</sup> percentile < 43 CFU/100mls) will not be compromised or detrimentally impacted by the Proposal.
- The pathogen risk profile of the estuary is expected to decrease as a consequence of the Proposal.

<sup>21</sup> NSW Oyster Industry Sustainable Aquaculture Strategy, prepared by the NSW Government, dated 2006 (the **OISAS**).



**Diagram 16:** Nearshore oyster lease area in vicinity of Proposal.

**Table 14:** Assessment of increased runoff volume on nearshore estuary pathogen levels.

Impact Assessment	Existing	Developed	Comment
<u>Background Data</u>			
Nearshore tidal prism (m <sup>3</sup> )	613260	613260	Volume between MHW and MLW downstream as shown in Diagram 16
Estuary baseline pathogen (CFU/100mls, non-flood)	4.4	4.4	Estimated to achieve average estuary values in IWCMS Tables 5 & 6.
Site runoff volume (ML/year)	95.9	101	Assumes exfiltration scenario (D-T2). Refer to Table 24 in IWCMS.
Site percent days no runoff	55%	62%	Assumes exfiltration scenario (D-T2) in Table 5
Site runoff pathogen concentration (CFU/100ml)	2,829	354	Assumes existing=forest and developed=max 90th %ile Table 12
Site annual pathogen load (CFUx10 <sup>9</sup> /year)	2,713.0	357.5	Annual total loads
Site daily peak pathogen load (CFUx10 <sup>9</sup> /day)	16.34	2.54	Contribution during runoff days only
<u>Annual Mass Balance Assessment</u>			
Tidal Volume (ML/year)	447,776	447,781	Two tide cycles/day + additional flow volume from site
Pathogen load in Tidal Prism (CFUx10 <sup>9</sup> /year)	22,410.9	20,055.5	Number brought to estuary each day + additional load from site
Resultant pathogen concentration (CFU/100mls)	5.0	4.5	Calculated based on pathogen concentration per unit volume
<u>Peak Daily Mass Balance Assessment</u>			
Tidal Volume (m <sup>3</sup> /day)	1,227,097	1,227,239	Volumes includes 2 tidal cycles + site runoff contributions on runoff days
Pathogen Load in Tidal Prism (CFUx10 <sup>9</sup> /day)	70.30	56.51	Loads include site loads on runoff days only
Resultant Pathogen concentration (CFU/100ml)	5.7	4.6	Calculated based on pathogen concentration per unit volume

## 5.6 System Performance

In summary, modelling demonstrates that: pathogen concentrations contained in stormwater runoff will receive significant treatment prior to release to the 100 m forested estuary buffer; will be considerably lower than 'natural' or background pathogen levels currently contained in runoff generated by the existing forest; and will not compromise oyster aquaculture water quality objectives within the Crookhaven River estuary. The following is noted:

1. Irrespective of the modelling scenario or statistic considered, pathogen concentrations in treated stormwater will be significantly lower than existing conditions. This outcome satisfies the Neutral or Beneficial Effect (**NorBE**) test.
2. In terms of the impact of the development on oyster aquaculture, Table 11 is more relevant (particularly LR scenarios 2 and 4 which include the benefit derived by improved flow control through the larger Biobasins A, B and C) as oyster growing criteria are given on the basis of oyster growth over an entire year. Data demonstrate that stormwater releases will contain much lower pathogen concentration levels than overland flow currently discharged to the estuary. This will ensure that there will be an improvement in oyster growing water quality conditions within the estuary.
3. Modelling of peak pathogen loads to the estuary during extreme runoff events, as well as mass balance modelling of pathogen concentrations within the nearshore estuary environment adjacent to the estuary, indicates that pathogen concentrations are expected to decrease because of the Development. This demonstrates that the pathogen risk profile of the estuary will decrease as a consequence of the Proposal and that the OISAS<sup>22</sup> pathogen water quality objectives will not be compromised by the Proposal.
4. The proposed stormwater treatment train provides an important and effective barrier to pathogens potentially contained in urban runoff arriving at the Estuary.

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<sup>22</sup> NSW Oyster Industry Sustainable Aquaculture Strategy, prepared by the NSW Government, dated 2006 (the **OISAS**).

## 6 Management of Stormwater Infrastructure

### 6.1 Water Quality Monitoring

The following amendments and additions are provided for the Water Quality Monitoring Program provided at Section 9 of the IWCMS in response to the TWMG Memo (refer to Table 1).

#### 6.1.1 Monitoring Periods

In respect of the timing and frequency of monitoring recommended to be undertaken, this is further clarified in Table 15. These requirements update those specified in Section 9.3 of the IWCMS.

**Table 15:** Summary of monitoring periods and frequency.

Monitoring	Pre-Construction	During Construction	Operational
Surface Waters	Begin on grant of consent. Monthly for 18 months minimum prior to construction including at least 2 wet weather events.	Monthly during construction of any stage.	3 monthly and following any sewage overflow event for 2 years after completion of stage and then review frequency.
Stormwater Infrastructure Water Quality	n/a	Monthly during construction of any stage.	3 monthly and following any sewage overflow event for 2 years after completion of stage and then review frequency. 2 wet-weather events per year for 2 years after completion of stage and then review frequency.
Stormwater Infrastructure Condition <sup>23</sup>	n/a	Monthly during construction of any stage.	3 monthly and following any sewage overflow event for 2 years after completion of stage and then review frequency. 2 wet-weather events per year for 2 years after completion of stage and then review frequency.
Groundwater Systems	Begin on grant of consent. Monthly for 18 months minimum prior to construction.	Monthly during construction of any stage.	3 monthly for 2 years and then review frequency.
Shell Fish Sites	Begin on grant of consent. Monthly for 18 months minimum prior to construction.	Monthly during construction of any stage.	3 monthly and following any sewage overflow event for 2 years after completion of stage and then review frequency.
Photo Monitoring Sites	Begin on grant of consent. Monthly for 18 months minimum prior to construction.	Monthly during construction of any stage.	3 monthly and following any sewage overflow event for 2 years after completion of stage and then review frequency.

<sup>23</sup> Refer to Table 57 of IWCMS for monitoring requirements.

### 6.1.2 Biobasin Monitoring

In order that effective and efficient monitoring can be undertaken at all Biobasins constructed within the site, it will be a mandatory requirement that:

1. Each Biobasin shall include a suitably designed sump within the outlet flow path that will permanently hold water sufficient to enable water quality sampling during both dry and wet weather flow conditions.
2. Each Biobasin water quality monitoring location shall be included in the general maintenance program to ensure that it is free from debris and sediment and capable of being used for monitoring.

## 6.2 Corrective Actions

### 6.2.1 Trigger Events

Trigger events are the conditions required to initiate corrective actions. These have been summarised in accordance with the type of monitoring undertaken, and the phase of development, being either construction or operational. Updated trigger events are provided in Table 16.

**Table 16:** Summary of trigger events requiring corrective action.

Monitoring	During Construction	Operational
Surface Waters	Interim trigger value exceeded any two consecutive samplings	Interim trigger value exceeded any two consecutive samplings.
Stormwater Infrastructure Water Quality	On trigger value exceeded.	Interim trigger value exceeded any two consecutive samplings.
Stormwater Infrastructure Condition	On trigger event having occurred.	On trigger event having occurred.
Groundwater Systems	Interim trigger value exceeded any two consecutive samplings	Interim trigger value exceeded any two consecutive samplings
Shell Fish Sites	Interim trigger value exceeded any two consecutive samplings	Interim trigger value exceeded any two consecutive samplings
Photo Monitoring Sites	On trigger event having occurred.	On trigger event having occurred.

### 6.2.2 Corrective Actions

In respect of corrective actions, the following is proposed:

1. Corrective actions will commence once a trigger event has occurred.
2. The responsibility for corrective actions will be as outlined in Table 17, which includes the construction of stormwater infrastructure.
3. Preliminary details and timing of corrective actions will be as outlined in Table 18. Further corrective actions may also be specified in response to more detailed designs at the development application phase for each future development stage.

**Table 17:** Responsibility for corrective actions.

Phase	Description	Responsibility
1	During subdivision construction	Developer
2	During establishment of water quality management structures	Developer
3	Operational phase – before Council handover	Developer
4	Operational phase – after Council handover	Council

**Table 18:** Summary of corrective actions following trigger event.

Location	Corrective Action	Timing of Action
Surface Waters	<ol style="list-style-type: none"> <li>1. Determine if changes in water quality are attributable to development in the concept plan area. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Undertake additional water quality sampling to confirm trigger event.</li> <li>b. Review available historical aerial photographs and examine for condition of vegetation communities and presence of any new pollutant sources.</li> <li>c. Inspect stormwater infrastructure for damage or other performance problems.</li> <li>d. Inspect catchment for potential pollutant sources.</li> <li>e. Undertake additional water quality sampling at stormwater structures and any other identified locations to determine if these are likely source.</li> </ol> </li> <li>2. If the water quality observations are deemed to be attributable to development in the Concept Plan area, then implement any necessary remediation works or improvement works to the water cycle management system. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Remove from the water cycle infrastructure any accumulated sediment and degraded vegetation as required.</li> <li>b. Repair the water cycle infrastructure as required, including for example areas of soil erosion, leaks, liner damage, overflow weir damage, flow distribution irregularities.</li> <li>c. Reinstate an establishment phase for any repaired infrastructure so as to ensure that vegetation is properly established and repairs are satisfactory.</li> <li>d. Seek independent advice from a professional engineer for design improvements if this is considered to be beneficial. Implement any recommendations.</li> <li>e. Update water quality monitoring protocols including sampling locations and frequency.</li> </ol> </li> </ol>	Complete investigation and works with 3 months of trigger event
Stormwater Infrastructure Water Quality	<ol style="list-style-type: none"> <li>1. Determine if the changes in water quality are out of the ordinary or expected performance range or cannot be readily explained by an obvious incident. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Undertake additional two water quality samples (1 week apart) to confirm trigger event.</li> </ol> </li> </ol>	Complete investigation and works within 3 months of trigger event

Location	Corrective Action	Timing of Action
	<ul style="list-style-type: none"> <li>b. Inspect stormwater infrastructure for damage or other performance problems.</li> <li>c. Inspect catchment for potential pollutant sources.</li> </ul> <p>2. If the water quality observations are deemed to be out of the ordinary, then implement any necessary remediation works or improvement works to the water cycle management system. This may include the following actions:</p> <ul style="list-style-type: none"> <li>a. Remove from the water cycle infrastructure any accumulated sediment and degraded vegetation as required.</li> <li>b. Repair the water cycle infrastructure as required, including for example areas of soil erosion, leaks, liner damage, overflow weir damage, flow distribution irregularities.</li> <li>c. Reinstate an establishment phase for any repaired infrastructure so as to ensure that vegetation is properly established and repairs are satisfactory.</li> <li>d. Seek independent advice from a professional engineer for design improvements if this is considered to be beneficial. Implement any recommendations.</li> <li>e. Implement a testing regime (in addition to the approved water quality monitoring program) to confirm that water quality compliance issues have been resolved.</li> </ul>	
Stormwater Infrastructure Condition	<ul style="list-style-type: none"> <li>1. Assess cause and extent of degraded water cycle management infrastructure. This may include the following actions:               <ul style="list-style-type: none"> <li>a. Inspect catchment for causes of degraded condition (e.g. uncontrolled sediment release, broken water main, excessive vehicle traffic over stormwater infrastructure etc).</li> <li>b. Professional engineer to undertake a detailed inspection of infrastructure. This may require engagement of other specialists such as geotechnical engineers, plumber, landscape consultants etc.</li> <li>c. Review available historical aerial photographs and examine for condition of vegetation communities and presence of any new pollutant sources.</li> </ul> </li> <li>2. Prepare and enact an infrastructure rectification plan. This may include the following actions:               <ul style="list-style-type: none"> <li>a. Remove from the water cycle infrastructure any accumulated sediment and degraded vegetation as required.</li> <li>b. Repair the water cycle infrastructure as required, including for example areas of soil erosion, leaks, liner damage, overflow weir damage, flow distribution irregularities.</li> <li>c. Reinstate an establishment phase for any repaired infrastructure so as to ensure that vegetation is properly established and repairs are satisfactory.</li> <li>d. Seek independent advice from a professional engineer for design improvements if this is considered to be beneficial. Implement any recommendations.</li> </ul> </li> </ul>	Complete investigation and works within 1-2 months of trigger event

Location	Corrective Action	Timing of Action
Groundwater Systems	<ol style="list-style-type: none"> <li>1. Determine if the changes in groundwater level or water quality are attributable to development in the Concept Plan area. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Undertake a detailed inspection of the relevant groundwater monitoring bore(s) to determine if the bore has been damaged or become cross contaminated with surface water.</li> <li>b. Undertake additional groundwater sampling at the affected bore(s) to confirm trigger event.</li> <li>c. Redrill an adjacent bore and monitor concurrently for 1 month with the affected bore to confirm trigger event.</li> <li>d. Review available historical aerial photographs and examine for condition of vegetation communities and presence of any new pollutant sources.</li> <li>e. Inspect stormwater infrastructure for damage or other performance problems.</li> <li>f. Inspect catchment for potential pollutant sources.</li> <li>g. Undertake additional water quality sampling at stormwater structures and any other identified locations to determine if these are likely source.</li> </ol> </li> <li>2. If the groundwater level or water quality observations are deemed to be attributable to development in the Concept Plan area, then implement any necessary remediation works or improvement works to the water cycle management system. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Repair the water cycle infrastructure as required, including for example areas of soil erosion, leaks, liner damage, overflow weir damage, flow distribution irregularities.</li> <li>b. Reinstate an establishment phase for any repaired infrastructure so as to ensure that vegetation is properly established and repairs are satisfactory.</li> <li>c. Seek independent advice from a professional engineer for design improvements if this is considered to be beneficial. Implement any recommendations.</li> <li>d. Seek independent advice from a professional engineer for any groundwater remedial works if this is considered necessary.</li> <li>e. Update monitoring protocols including sampling locations and frequency.</li> </ol> </li> </ol>	Complete investigation and any works within 4 months of trigger event
Shell Fish Sites	<ol style="list-style-type: none"> <li>1. Determine if changes in quality are attributable to development in the concept plan area. This may include the actions list under 'Surface Waters' above.</li> <li>2. If the quality observations are deemed to be attributable to development in the Concept Plan area, then implement any necessary remediation works or improvement works to the water cycle management system. This may include the actions list under 'Surface Waters' above.</li> </ol>	Complete investigation and works with 3 months of trigger event
Photo Monitoring Sites	<ol style="list-style-type: none"> <li>1. Determine if changes observed are attributable to development in the concept plan area. This may include the following actions:               <ol style="list-style-type: none"> <li>a. Review available historical aerial photographs and examine for the condition of vegetation communities</li> </ol> </li> </ol>	Complete investigation and works with 4 months of trigger event

Location	Corrective Action	Timing of Action
	<p>and presence of activities that may have caused the observed changes.</p> <ol style="list-style-type: none"> <li data-bbox="555 398 1161 454">b. Inspect stormwater infrastructure for damage or other performance problems.</li> <li data-bbox="555 465 1169 573">c. Inspect catchment and other estuarine or foreshore areas for potential sediment or pollutant sources, or factors that may have affected hydrology (e.g. floods, channel diversions, flow obstructions etc).</li> <li data-bbox="555 584 1190 640">d. Engage a professional ecologist to investigate the cause of observed change(s).</li> </ol> <p data-bbox="501 651 1190 759">2. If the changes observed are deemed to be attributable to development in the Concept Plan area, then implement any necessary remediation works or improvement works. This may include the following actions:</p> <ol style="list-style-type: none"> <li data-bbox="555 770 1161 853">a. Remove from the water cycle infrastructure any accumulated sediment and degraded vegetation as required.</li> <li data-bbox="555 864 1153 972">b. Repair the water cycle infrastructure as required, including for example areas of soil erosion, leaks, liner damage, overflow weir damage, flow distribution irregularities.</li> <li data-bbox="555 983 1177 1066">c. Reinstatement an establishment phase for any repaired infrastructure so as to ensure that vegetation is properly established and repairs are satisfactory.</li> <li data-bbox="555 1077 1177 1160">d. Seek independent advice from a professional engineer for design improvements if this is considered to be beneficial. Implement any recommendations.</li> <li data-bbox="555 1171 1190 1254">e. Engage a professional ecologist to determine the extent of damage or vegetation impacted and prepare and enact a remediation plan for affected area.</li> <li data-bbox="555 1265 1102 1326">f. Update monitoring protocols including sampling locations and frequency.</li> </ol>	

### 6.3 Hand-over of Structures

It is intended that all stormwater treatment structures will be handed over to Council for long-term ownership, control and maintenance. This will occur only when it has been shown in respect of individual elements, that these structures have demonstrated that the quality of water will not typically exceed defined trigger values and the element is operating satisfactorily.

Each element of the stormwater treatment system should not be handed over to Shoalhaven City Council until the criteria in Table 19 have been achieved.

**Table 19:** Hand-over criteria for stormwater quality infrastructure.

Element	Hand-over Criteria
Biobasins	<ul style="list-style-type: none"> <li data-bbox="584 1861 1299 1890">• Operational water quality criteria satisfied for at least 12 months.</li> <li data-bbox="584 1901 991 1930">• No trigger events in past 3 months.</li> <li data-bbox="584 1942 1366 1971">• Any accumulated sediment and gross pollutants have been removed.</li> </ul>

	<ul style="list-style-type: none"> <li>• All flow control structures are operational and flow distribution within structure is satisfactory to ensure operation.</li> <li>• Condition of vegetation is satisfactory to ensure Biobasin is operating satisfactorily. This includes no vegetation dieback or excessive growth.</li> <li>• No evident damage to structure.</li> <li>• Any previously initiated rehabilitation works have been completed and fully established.</li> <li>• Professional engineer to certify that the Biobasin will, on hand-over, deliver water quality that would not exceed defined trigger values and is operating satisfactorily.</li> </ul>
Stormwater Ponds	<ul style="list-style-type: none"> <li>• No trigger events in past 3 months.</li> <li>• Any accumulated sediment and gross pollutants have been removed.</li> <li>• All flow control structures are operational and flow distribution within structure is satisfactory to ensure operation.</li> <li>• No evident damage to structure.</li> <li>• Any previously initiated rehabilitation works have been completed and fully established.</li> <li>• Professional engineer to certify that the stormwater pond will, on hand-over, perform in accordance with the approved design.</li> </ul>
Irrigation Scheme	<ul style="list-style-type: none"> <li>• No trigger events in past 3 months.</li> <li>• All electrical equipment is operational and in accordance with design parameters.</li> <li>• All flow control structures, including pumps, manifolds, intake structures, delivery lines and irrigation elements are operational and satisfactory to ensure operation.</li> <li>• No evident damage to infrastructure.</li> <li>• Any previously initiated rehabilitation works have been completed and fully established.</li> <li>• Professional engineer to certify that the irrigation scheme will, on hand-over, perform in accordance with the approved design.</li> </ul>

## 6.4 Design of Future Stages

In accordance with concept plans prepared by Allen Price & Scarratts as contained in Annexure P of the IWCMS, the development will proceed in a number of discrete stages. All future development will be the subject of a separate development application to Shoalhaven City Council. In order that the best possible water quality outcomes can be achieved by the Proposal, the following is recommended:

1. A development application for any development proposed by the approved concept plan must incorporate a stormwater management system that is consistent with the IWCMS and demonstrates that it has a neutral or beneficial effect on downstream receiving waters.
2. The design of stormwater treatment measures in stages later than stage 1, should be confirmed based on the performance of treatment measures built in prior stages.

## 7 Construction Phase

### 7.1 Overview

During construction of the stormwater quality management infrastructure, the Proposal will traverse through an initial period where full water quality control of the site will not be available. During that phase, prior to the completion of internal roads and development of any dwellings or other structures, the key water quality management concern will be that the works site is managed so as to minimise ground disturbance areas and mitigate any sediment generation. Further information in relation to construction phase management practices has been provided below in response to the TWMG Memo (refer to Table 1).

### 7.2 Guidelines

Guidelines relevant for managing construction related water quality impacts are outlined in Table 20.

**Table 20:** Applicable guidelines for managing construction related water quality impacts.

Guideline	Section	Comment / Performance Requirements
Landcom (2004) Managing Urban Stormwater: Soils and Construction Volume 1 ( <b>Blue Book</b> )	1.6	<ul style="list-style-type: none"> <li>• Sets out general principles and engineering design specifications for erosion and sediment control measures.</li> <li>• General principles: <ul style="list-style-type: none"> <li>○ Investigate soil to ensure proper design of control measures.</li> <li>○ Integrate site constraints with design.</li> <li>○ Minimise disturbed area at any one time.</li> <li>○ Conserve topsoil for later site rehabilitation.</li> <li>○ Control water flow from top of, and through development area.</li> <li>○ Rehabilitate disturbed land quickly.</li> <li>○ Maintain control measures appropriately during construction phase.</li> </ul> </li> </ul>
Healthy Estuaries for Healthy Oysters Guidelines, NSW Department of Primary Industries 2017 ( <b>Healthy Estuaries Guideline</b> )	2.9	<ul style="list-style-type: none"> <li>• Control runoff during construction.</li> <li>• Erosion and sediment control measures to be designed in accordance with the Blue Book.</li> <li>• Suspended solids &lt; 75 mg/L in Oyster growing areas.</li> <li>• High priority for compliance inspections.</li> </ul>
NSW MUSIC Modelling Guidelines, produced by BMT WBM on behalf of NSW Local Land Services Greater Sydney, prepared August 2015 ( <b>MUSIC Guideline</b> )	6.6	<ul style="list-style-type: none"> <li>• Construction phase sediment basins should be sized in accordance with the Blue Book.</li> </ul>

Guideline	Section	Comment / Performance Requirements
NSW Oyster Industry Sustainable Aquaculture Strategy, prepared by the NSW Government, dated 2006 (OISAS)	3.4	<ul style="list-style-type: none"> <li>Suspended solids &lt; 75 mg/L in Oyster growing areas.</li> </ul>
Shoalhaven City Council Development Control Plan 2014, chapter G2: Sustainable Stormwater Management and Erosion / Sediment Control as commenced on 12 February 2020 (SDCP)	5.2.1	<ul style="list-style-type: none"> <li>Erosion and sediment control measures to be designed in accordance with the Blue Book.</li> <li>Where vegetation exists, retain buffer zones along boundaries where practicable, particularly those adjacent to creeks.</li> <li>Performance criteria:               <ul style="list-style-type: none"> <li>Work will not cause erosion and/or siltation.</li> <li>Work will not have an adverse impact on receiving waters from increased concentrations and loads of sediment.</li> </ul> </li> </ul>

### 7.3 Performance Criteria

On the basis of the above guidelines, specific performance criteria have been developed for the construction phase(s) of the project. These are described in Table 21 and include associated acceptable solutions required to achieve the performance criteria.

**Table 21:** Construction phase performance criteria (erosion and sediment control).

Performance Criteria		Acceptable Solutions
P1	Work will not cause erosion and / or siltation.	P1.1. Where vegetation exists, retain buffer zones along boundaries where practicable, particularly those adjacent to creeks or drainage gullies. P1.2. Minimise as far as possible the total extent of disturbed areas at any one time. P1.3. Minimise the number of locations where construction stormwater runoff is concentrated. P1.4. Control water flow from top of, and through the development area. P1.5. Rehabilitate and revegetate disturbed areas as soon as practicable.
P2	Work will not have an adverse impact on receiving waters from increased concentrations and loads of sediment.	P3.1. Professional engineer to design control measures in accordance with the Blue Book. P3.2. Professional engineer to certify that any sediment and erosion control plan design has been in accordance with the Blue Book, any relevant consent conditions and meets the performance criteria and acceptable solutions outlined in this document. P3.3. Professional engineer to inspect control measures following installation and certify that measures have been implemented in accordance with approved plans. P3.4. Professional engineer to routinely audit the performance of erosion and sediment control measures during

Performance Criteria		Acceptable Solutions
		<p>construction on a minimum 3 monthly basis and following heavy rainfall events and make recommendations for improvements and specific maintenance measures.</p> <p>P3.5. Maintain control measures appropriately during construction phase in accordance with Blue Book requirements. Clean and repair all control measures as required to ensure on-going performance compliance.</p> <p>P3.6. A log-book must be kept during the operational phase of all sediment and erosion control measures. The log book should document the date and time of any inspections, observations made during the inspection, recommendations for remedial works, and a sign-off for when such works were completed and who completed the works.</p> <p>P3.7. Erosion and sediment control measures should not adversely impact on existing stormwater management measures.</p>
P3	Work will not detrimentally impact on Oyster Aquaculture activities.	<p>P3.1. Implement water quality monitoring program during construction works.</p> <p>P3.2. Retain erosion and sediment control measures until all construction works are fully rehabilitated.</p> <p>P3.3. Design control measures so that average site discharge sediment concentrations from disturbed areas, including sediment ponds, are &lt; 75 mg/L (or less as required by the Blue Book) for events up to the 1 in 10 year storm.</p>
P4	Work will not detrimentally impact on SEPP14 wetlands and other sensitive environmental receptors	<p>P4.1. No construction work to be undertaken in 100 m buffer to SEPP14 wetlands.</p> <p>P4.2. Implement water quality monitoring program during construction works.</p> <p>P4.3. Retain erosion and sediment control measures until all construction works are fully rehabilitated.</p>