Robert Bird Group
Member of the Surbana Jurong Group

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Reference: CR:KG LTR/C 19005C

24th February 2020

Lendlease Building Pty Ltd
Level 3, 2 King Street
BOWEN HILLS QLD 4006

Dear Sirs

RE: TWEED VALLEY HOSPITAL – RESPONSE TO SUBMISSIONS FOR STATE SIGNIFICANT DEVELOPMENT

Robert Bird Group has considered the responses received to the submission for State Significant Development Part 2 (SSD2) relating to the civil engineering design and provides the following additional information to address those responses.

Stage 2 SSD – 10353 EIS Submission:

Tweed Shire Council (TSC):

Stormwater Management

Comment: The SMEC Hydrology Assessment recommends various modifications to the Stormwater Management at the time of the report. The RBG SWMP appears to have been updated to incorporate the SMEC recommended modifications, but the design drawings pre-date the SMEC report. It is unclear if/when the SMEC recommendations are to be incorporated into the current design. Recommend this be conditioned with a typical condition referring to the SWMP and Hydrology Assessment.

Response: The SMEC Hydrology Report, Section 2.4.1.3 states measures that could be implemented to more closely match pre-development flow rates in the very minor storm events (>1 event per year) under the title “Recommendation”, although SMEC have since clarified that there is negligible benefit to doing this in relation to the wetland ecology and the flows as shown in Table 7 are compliant with the standard TSC requirements – refer to SMEC Response to Submissions (Appendix B) and revised EIS Report (Appendix C). Adopting these measures would be more costly to implement and would increase the maintenance requirements for the basins. Given that there is no real benefit to be achieved from implementing changes to the outflow rates in very minor storms, it is therefore not proposed to adopt these measures in the design.

Comment: The SWMP and associated Hydrologic Assessment do not provide any information on the changes to the Cudgen Road external catchments. Robert Bird Group drawings 350 and 351 show the catchments significantly reduced, however drawings 300-302 show increased impervious area. The impact of the development on stormwater discharges to adjacent private land must be quantified to confirm no worsening.

Response: Comment noted. Substantiation that stormwater flows will not be worsened by the development will be provided following completion of the detailed design of these areas. Based on initial assessment, controlling the stormwater discharge to ensure it is no worse than existing in the design storm events is expected to be readily achievable.

Department of Planning, Industry and Environment (DPIE)

Comment: The submitted plans indicate that the amended building envelope for the hospital and the car park would result in modifications to the volume of cut and fill that was previously approved under the Stage 1 works. Having regard to the above, an amended plan should be provided that identifies the modifications to the cut and fill volumes and the need for any further retaining walls (or variation to the heights of the retaining walls) within the site.

Response: The earthworks quantities have been refined as we have developed the design of the stage 1 and 2 works, including optimising road levels, retaining walls and batter slopes. Drawings showing the cut and fill depths and retaining wall profiles are provided as annexures to this letter. The current design results in approximately 12,000m^3 of material to be removed and disposed off-site.

Comment: Greater effort should be given to reducing the stormwater volumes entering the basins, such as including more storage and reuse of runoff and more use of swales and raingardens in suitable locations.

Response: A 400KL rainwater reuse tank will be provided to collect and store rainwater from the hospital roof to use for irrigation and cooling tower. It is estimated by the hydraulic consultant that reusing stormwater for this purpose will reduce the total stormwater discharge by approx. 17ML per year on average. RBG have considered provision of infiltration devices such as swales and raingardens to further reduce the site runoff, however, geotechnical advice has been received which confirms that doing so would increase the risk of slope slip failure on the steep batters around the site due to waterlogged subsoil – refer to Morrison Geotechnic letter (Appendix A). For this reason, infiltration devices cannot be provided and the bio-detention basins will have an impermeable liner as shown in updated drawing RBG-CV-DWG-RIE-86-310.

Comment: The recommendations outlined in the SMEC report for refinements to the basin outflow design and for greater channel infiltration to ensure stormwater discharge is managed to reduce impacts on the wetland should be incorporated into final engineering designs and documentation.

Response: The SMEC Hydrology Report, Section 2.4.1.3 states measures that could be implemented to more closely match pre-development flow rates in the very minor storm events (>1 event per year) under the title "Recommendation", although SMEC have since clarified that there is negligible benefit to doing this in relation to the wetland ecology and the flows as shown in Table 7 demonstrate that the flows are less than the existing flows in the 20% AEP event and significantly less in the 1% AEP event (as required under TSC development control plan). As such, it is not currently proposed to adopt these measures.

Comment: The Department's Independent Consultant has reviewed the stormwater drainage information and provided the following comments:

- **Targets** – It is unclear what water quality targets have been adopted by Robert Bird Group (RBG) for the development. RBG has indicated that WSUD measures have been provided to comply with OEH's target of 'no increase in the natural annual average load of nutrients and sediments' but no estimate of natural loads has been completed or comparison provided. Comparisons are currently made with Council's load-based targets and a 'no increase over pre-development conditions' target.

Response: The MUSIC model has been updated and a natural (bush/forest) sub-model has been created as well as the pre-development and post-development sub-models. It has also been updated to include the proposed 400KL rainwater reuse tank. The results obtained from the updated models are shown in **Table 1**.:

Table 1: MUSIC model results

Mean Annual Load	Natural state (bush / forest)	Pre-development (agriculture)	Post Development (without treatment)	Post Development (with treatment)
Flow (ML/Yr)	63.7	69.6	113	99.6
Total Suspended Solids (kg/yr)	3,750	19,000	25,000	2,880
Total Phosphorus (kg/yr)	4.23	21.7	58.6	13.7
Total Nitrogen (kg/yr)	48.4	127	355	134
Gross Pollutants >5mm (Kg/yr)	0	388	2080	0.033

The music model demonstrates compliance with the TSC development control plan requirement to reduce the post development flows by the following reduction targets (compared with post development loads without treatment). Suspended solids 80%, Phosphorus 60%, Nitrogen 45%, gross pollutants 90%. It also demonstrates a significant overall improvement in water quality compared with the modelled pre-development state (other than a very small increase in nitrogen) .We note that the MUSIC model has only accounted for a reduction in total flows of approx. 11ML for the rainwater tank (compared to the 17ML calculated by the project hydraulic engineer)

- **Flow regime analysis** – SMEC has estimated impacts from discrete storm events on the wetland only. The consent conditions require consideration of changes to flow regimes over a much longer time period to include consideration of seasonal changes to wetland hydrology (and wetland ecology). We understand that the consent authority (and other government agencies) is interested in how the additional estimated 36 ML/yr (50 – 14 ML/yr harvested) of additional runoff volume is distributed into the wetland over the year. Based on estimates by SMEC, an individual 4 EY event would only contribute approximately 0.2 ML/yr of additional inflow (i.e. approximately 0.5% of the total estimated increase).

Response: Refer to SMEC Response to Submissions (Appendix B)

- **Rainfall-runoff modelling** – The commercial land-use rainfall-runoff parameters adopted from the 2018 WBD guidelines appear to be erroneous The 2018 WBD guidelines recommend a field capacity parameter value of 80mm which exceeds the soil storage capacity of 18mm. The field capacity value should always be significantly lower than soil storage capacity. In addition, the recommended daily recharge rate is zero. This parameter value should be greater than zero to enable shallow groundwater recharge to occur. It is expected that adoption of these parameters for all pervious surfaces is likely to be resulting in a significant over-estimate of runoff volumes from pervious surfaces with the site. It is recommended that rainfall-runoff parameters outlined in the 2015 NSW MUSIC modelling guidelines be adopted for this site rather than the WBD parameters. The MUSIC rainfall-runoff parameters are primarily influenced by the characteristics of the soils within a site (as outlined in the 2015 NSW guidelines) rather than the land use (WBD guidelines).

RBG Response: The MUSIC model has been updated to use the parameters of the 2015 NSW guidelines (WBD parameters had originally been adopted as required by the TSC development control plan). Please refer to the above results table.

- **MUSIC models** – Review of the MUSIC models would be required to comment further on the modelling approach and model outcomes. The following MUSIC models would be required to complete our review.
  - Robert Bird Group models – Pre-development and post development MUSIC models that the results presented in Table 5.2 in Section 6.4 of their report 19005-RBG-ZZ-XX-RP-CV-87-001 (Issue E, 19/9/19) are based on.
  - SMEC models - Pre-development and post development MUSIC models that the results presented in Figure 2 and Table 11 of their report 3002721 (Rev 2 dated 15/8/19) are based on.

RBG Response: A copy of the updated RBG MUSIC model is attached to this correspondence.

Transport for NSW

Comment: Condition B22 (e) and (f) in Schedule 2 of the Concept Approval requires the Stage 2 application to provide:

- details of design of the proposed new bus stops on Cudgen Road prepared in accordance with relevant guidelines;
- details of pedestrian access between the hospital and the proposed bus stop within the indented bus bay on Cudgen Road in accordance with the relevant disability access standards and guidelines.

Drawings (i.e. Main Entrance – General Arrangement Plan) are provided as appendix to the Environmental Impact Statement (EIS) and Traffic Impact Assessment (TIA) report that illustrate the location of the proposed new bus stops on Cudgen Road. However, it is not evident that the details of design as required in the above two conditions are adequately presented in the EIS and its associated documentation.

Details of the proposed new bus stops should be included in the drawings in support of the EIS documents to demonstrate the adequacy of the design and reference be made to the bus capable infrastructure guidelines and DDA compliance.

It is recommended that the proponent be conditioned to undertake an independent Detailed Design Road Safety Audit (RSA, refer to NSW Centre for Road Safety Guidelines for Road Safety Audit Practices) of the proposed pedestrian facility improvements and bus stop arrangement on Cudgen Road, prior to issue of construction certificate. The proposed design shall address any deficiencies identified within the RSA.

RBG Response: Further detail has been added to the civil engineering drawing RBG-CV-DWG-RIE-87-301 to show the intended layout of the bus stops, including the position and size of the bus shelters and the provision of tactile pavements for DDA compliance. This drawing should be read in conjunction with the architectural response to submissions and architectural drawings. The layout generally satisfies the requirements of TfNSW Guidelines for Public Transport Capable Infrastructure, the State Transit Authority Bus Infrastructure Guide and DDA compliance however, due to site constraints the westbound bus stop has been placed in advance of the traffic signals stop line. RBG note the above recommendation regarding Road Safety Audits.

We trust that the above information is helpful in resolving the above queries.

Yours faithfully

ROBERT BIRD GROUP PTY LTD

Appendix A

Geotechnical Advice

Brisbane | Gold Coast | Maroochydore
Unit 1, 35 Limestone Street (PO Box 3063), Darra Q 4076 **P** (07) 3279 0900 **F** (07) 3279 0955
ABN: 51 009 878 899
www.morrisongeo.com.au

Job No. GE19/150
Ref: 24822
Author: Davor Dragun and Robert Maxwell

3rd December 2019

LendLease
771 Cudgen Road
Cudgen 2487 NSW

RE: <u>CLARIFICATION ON GENERAL DRAINAGE COMMENTS – TWEED VALLEY HOSPITAL – CUDGEN ROAD, KINGSCLIFF</u>

This letter provides clarification on the general drainage comments presented in the geotechnical investigation reports carried out for the site.

The work was commissioned by LendLease (the Client).

It is understood that the Client has been requested to reduce stormwater flows from the site by reusing stormwater and by construction of infiltration trenches, raingardens and/or removing liners from the existing sediment basins when they are converted to bio-detention basins.

Morrison Geotechnic have previously carried out a preliminary geotechnical investigation including the slope stability assessment (Job Number: GE18/144 Rev 2 – September 2018) and proposed sediment basins assessment (Job Number: GE18/216 – November 2019) for the above site. Those two investigations have been reviewed and considered in assessment of this letter.

Upon review of the investigations carried out, the natural clay soils encountered on the site are permeable and susceptible to loss of strength at elevated moisture contents. If adopted, the infiltration trenches are expected to have affect onto the sloping grounds on the site resulting in possible instability associated with slips, creep or erosion. The same/similar would be expected if liners are removed from sediment basins.

In summary, all sloping grounds on the site should have suitable drainage system(s) installed to maintain long term stability and to prevent slips, creep or erosion. Discharging onto the sloping areas should not be permitted at any time.

Please do not hesitate to contact this office if you require any further information.

Yours faithfully,

<u>D DRAGUN (RPEQ 16310)</u>
For and on behalf of
MORRISON GEOTECHNIC PTY LTD

Appendix B
SMEC RtS

LTR-001-Queries-Response_Rev0
13 February 2020

Lendlease
Level 3, Kings Gate, 2 King Street, Bowen Hills
QLD 4006 Australia

Dear Lendlease,

RE: Tweed Valley Hospital - TSA-RFI-000206: Re: SSD 2 - Response to Submissions

In reference to your emails on the other 11 November 2019, please find below our responses to the Department of Planning, Industry and Environment (DPIE) queries letter (reference DOC19/876417) regarding stormwater and impacts on coastal wetland. In addition to the above request a response to flow regime analysis dated 21/11/2019.

Based on comments provided by Biodiversity Conservation Division (DPIE), this letter has been updated and the following conclusions have been made:

- Stormwater volumes entering the basin cannot be further reduced than 17 ML due to geotechnical risks. Please refer Table 1, reference number 1a for more information
- The impact of refining the basin outflow design for the more frequent wetting events (1EY, 4EY and 50% AEP) have minimal benefit and is not necessary for the protection of the wetland. Please refer Table 1, reference number 1b for more detail.

Table 1: SMEC Response (reference DOC19/876417)

REF NO.	BIODIVERSITY CONSERVATION DIVISION (BCD) COMMENT	SMEC RESPONSE
1a	Greater effort should be given to reducing the stormwater volumes entering the basins, such as including more storage and reuse of runoff and more use of swales and raingardens in suitable locations.	As per SMEC recommendations, a 400KL rainwater reuse tank was modelled to collect and store rainwater from the hospital roof to use for irrigation and cooling tower. The results showed that the reusing stormwater will reduce the total stormwater discharge by approximately by 17ML per year on average. RBG confirmed that the other SMEC recommendation for use of infiltration treatment devices such as infiltration trenches, swales, rain gardens and permeable pavements etc could not be implemented due slope slip failure on the steep batters around the site due to waterlogged subsoil. Because of the geotechnical risks, infiltration devices will not be feasible. Also, the recommendation to remove the basin liner will not be feasible due to the same geotechnical risks mentioned above. The stormwater volumes entering the basin will not be further reduced than the existing limitation stated above of 17ML per year.

REF NO.	BIODIVERSITY CONSERVATION DIVISION (BCD) COMMENT	SMEC RESPONSE
1b	The recommendations outlined in the SMEC report for refinements to the basin outflow design and for greater channel infiltration to ensure stormwater discharge is managed to reduce impacts on the wetland should be incorporated into final engineering designs and documentation.	The basins were designed to cater 1% AEP (100 year ARI) major event and 20% AEP (20 year ARI) minor event in accordance with the basin design criteria. As per section 2.4.1.3 of Coastal Wetland Assessment (SMEC, August 2019), SMEC carried out additional model runs for frequent events such as 1EY, 4EY and 50% AEP and recommendations were provided to incorporate multiple outlets. However, as part of SMEC assessment more frequent events were evaluated to quantify the impact of the increase in flows to the wetland. Section 3.3 of Coastal Wetland Assessment (SMEC, August 2019) stated that the development site has minimal impact on coastal wetland levels, and effectively only fills the local depressions. Therefore, refining the basin outflow design for the 1EY, 4EY and 50% AEP would have minimal benefit and is not necessary for the protection of the Wetland According to the report (Morrison Geotech – Clarification on General Drainage Comments – Tweed Valley Hospital – Cudgen Road, Kingscliff), the groundwater in the existing condition is connected to the wetland and therefore adding infiltration provides limited practical benefit.
1c	Following the above actions 1(a) and 1(b), the SMEC report should be revised to better demonstrate that the impact of more frequent wetting events will be negligible or can be satisfactorily mitigated.	Based on comments provided by Department of Planning, Industry and Environment (BCD) on the 7th November 2019, the sections 2.2 MUSIC Model Review, 3.4 Groundwater and 3.4.1 Recommendation of the SMEC report dated 31st January 2020 have been updated to demonstrate the item 1a and 1b above.
1d	Regular routing maintenance of the bioretention systems and Enviropod should be included in an operational procedures plan.	n/a for SMEC
1e	A condition of consent be included to ensure there is an emergency procedure in place to prevent contamination spills (such as diesel or other fuels) entering the sensitive receiving environment.	n/a for SMEC

Ecologist Response to flow regime analysis

Question:

Flow regime analysis – SMEC has estimated impacts from discrete storm events on the wetland only. The consent conditions require consideration of changes to flow regimes over a much longer time period to include consideration of seasonal changes to wetland hydrology (and wetland ecology). We understand that the consent authority (and other government agencies) is interested in how the additional estimated 36 ML/yr (50 – 14 ML/yr harvested) of additional runoff volume is distributed into the wetland over the year. Based on estimates by SMEC, an individual 4 EY event would only contribute approximately 0.2 ML/yr of additional inflow (i.e. approximately 0.5% of the total estimated increase).

SMEC Response:

Seasonality

The Northern NSW area has a strongly seasonal rainfall pattern with the majority of rainfall falling over the summer and early Autumn period. The nearest meteorological station (Coolangatta Airport) is located approximately 17Km north of the site and this location received approx. 45% of its annual rainfall over a 4-month period between December and the end of March (BoM, 2020). Distribution of rainfall at the hospital site can be expected to be similar.

Rainfall volumes are similarly distributed with the Coolangatta Station averaging about 52 days a year with > 10mm of rain and 16 days with rainfall > 25mm (BoM, 2020). The vast majority of these events occur in the warmer months.

The increase in storm water discharge volumes associated with the hospital development will be distributed in line with this seasonal rainfall pattern. Larger volumes of stormwater will be present during the higher rainfall periods (Summer/Autumn) and lesser volumes during the Winter and Spring period. The treatment options proposed will not alter this pattern and more water will reach the wetland area in the warmer period when vegetative growth is at its most peak and many species (both fauna and flora) are actively reproducing.

Vegetation and Hydroperiod

A predominant factor in the ecological makeup and function of wetlands is the duration of hydroperiod. The coastal wetland adjacent to the hospital site is a forested wetland. Forested wetlands are defined as naturally flooded or saturated areas that support an important component of woody vegetation adapted to poorly aerated and/or saturated soil (Lugo et al. 1990).

The community within the mapped extent of the coastal wetland has previously been identified as predominately being Broad-leaved Paperbark (Melaleuca quinquenervia) Closed Forest to Woodland (TSC LGA Mapping, 2012). While Broad leaved paperbark cannot survive permanent inundation, they do have adaptations such as fibrous or adventitious roots around their lower trunk that are thought to function as breathing roots, helping the tree to survive during long periods of submersion (McJannet, 2008). Similarly the composition and diversity of the mid and understorey will vary with latitude and the length of time the swamp contains water, but can typiclly include shrubs such as quinine berry Petalostigma pubescens, and Banksia sp. on the margins; sedges such as soft twigrush Baumea rubiginosa, Lepironia articulata and bogrush Schoenos breviofolius; saw-sedges such as Gahnia sieberiana; reeds such as the common reed Phragmites australis; other grasses such as Ischaemum spp., swamp rice grass Leersia hexandra, blady grass Imperata cylindrica and saltwater couch Sporobolus virginicus (DERM, 2010).

The composition of this community is primarily determined by the frequency and duration of waterlogging and the texture, salinity nutrient and moisture content of the soil, and latitude. The composition and structure of the understorey is influenced by grazing and fire history, changes to hydrology and soil salinity and other disturbance, and may have a substantial component of exotic grasses, vines and forbs (NSW OEH, 2019).

An assessment of flow depth increase due to 36ML/year was carried out and the results are shown in Tabl*e 2*. Given these factors the addition of approximately 4 to 11cm of additional inflow from the developed site during significant events for parts of the wetland, is unlikely to result in any significant structural change to the dominant floristics of this community.

It is noted that flooding from Tweed River (BMT, 2018) indicates inundation depths for the wetland of approximately 2m for the 5% AEP event and 3m for the 1% AEP event. This suggests that the existing, long established, coastal wetland area has proved resilient throughout numerous inundation event well in excess of anything likely to result from the inflows from the proposed development.

Tabl*e 2: Summary of flow depth calculations*

DISCRIPTION	BIODIVERSITY AND CONVERATION DEPARTMENT (BCD) COMMENT	UNITS
Wetland area	30.7	ha
	307000	m^2
Flow increase	36	ML/yr
	36000	m^3/s

DISCRIPTION	BIODIVERSITY AND CONVERATION DEPARTMENT (BCD) COMMENT	UNITS
Increase in depth of water if 36ML at one time a year	11	cm
Increase in depth of water if 36ML at two times a year	6	cm
Increase in depth of water if 36ML at three times a year	4	cm

Summary:

The existing, long established, coastal wetland area has proved resilient throughout numerous inundation event well in excess of anything likely to result from the inflows from the proposed development. Therefore, it is unlikely to result in any significant structural change to the coastal wetland (dominant floristics of this community) due to annual flow increase of 36ML/yr.

Reference:

BMT (2018), Tweed Valley Hospital – Flooding and Coastal Hazards Assessment, Ref R.B22945.003.02.docx

BoM (2019), Bureau of Meteorology Climate Data Online. http://www.bom.gov.au/climate/data/

DERM (2010), Wetland Management Profile, Coastal and Subcoastal Tree Swamps. Queensland Wetlands Program

Greencap (2019), Biodiversity Development Assessment Report – Tweed Valley Hospital. Greencap Pty Ltd, Brisbane.

TSC, (2012), Tweed Shire Council Tweed LGA Vegetation Mapping.

Lugo, AE, Brown, S and Brinson, MM. 1990. “Concepts in wetland ecology”. In Ecosystems of the world 15: Forested wetlands, Edited by: Lugo, AE, Brinson, MM and Brown, S. 53–85. Amsterdam: Elsevier.

If you have any queries or wish to discuss the submission further, please do not hesitate to contact myself on (02) 9925 5408 or Matt.Box@smec.com.

Yours sincerely,

Matthew Box

Manager – Water Resources Sydney

Appendix C

SMEC Revised EIS Report

SMEC
Member of the Surbana Jurong Group

local people
global experience

Final

Tweed Valley Hospital Hydrology Assessment

Reference No.
Prepared for **Lendlease**
31 January 2020

SMEC INTERNAL REF. 3002721

Document Control

Document:	Final
File Location:	X:\projects\3002721\04 reports
Project Name:	Tweed Valley Hospital Hydrology Assessment
Project Number:	3002721
Revision Number:	Rev 3

Revision History

Revision No.	Date	Prepared by	Reviewed by	Approved for Issue by
Rev 1	13 August 2019	Nilmini Pannipitiya, Donald Carroll	Norm Mueller	
Rev 2	15 August 2019	Norm Mueller, Jon Alexander	Norm Mueller	
Rev 3	31 January 2020	Nilmini Pannipitiya Jon Alexander	Matt Box	Matt Box

Issue Register

Distribution List	Date Issued	Number of Copies
Lendlease	31 January 2020	1- pdf
Robert Bird Group	31 January 2020	1- pdf

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Important Notice

This report is confidential and is provided solely for the purposes of Lendlease as a review of the RBG Stormwater Management Plan basins and associated hydrology components. This report is provided pursuant to a Consultancy Agreement between SMEC Australia Pty Limited ("SMEC") and Lendlease, under which SMEC undertook to perform a specific and limited task for Lendlease. This report is strictly limited to the matters stated in it and subject to the various assumptions, qualifications and limitations in it and does not apply by implication to other matters. SMEC makes no representation that the scope, assumptions, qualifications and exclusions set out in this report will be suitable or sufficient for other purposes nor that the content of the report covers all matters which you may regard as material for your purposes.

This report must be read as a whole. The executive summary is not a substitute for this. Any subsequent report must be read in conjunction with this report.

The report supersedes all previous draft or interim reports, whether written or presented orally, before the date of this report. This report has not and will not be updated for events or transactions occurring after the date of the report or any other matters which might have a material effect on its contents or which come to light after the date of the report. SMEC is not obliged to inform you of any such event, transaction or matter nor to update the report for anything that occurs, or of which SMEC becomes aware, after the date of this report.

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EXECUTIVE SUMMARY

This report has been undertaken for Lendlease to assesses the hydrology impact of the proposed Tweed Valley Hospital development on the adjacent coastal wetland

The existing site was agricultural and horticultural land immediately adjacent to a coastal wetland with a small dam in the north west corner of the site. The proposed development utilises Water Sensitive Urban Design structures to control peak flows and improve water quality of discharge from site.

Central to the review is the Robert Bird Group (RBG) Stormwater Management Plan, which has been used as a base to undertake the assessment. The water quality (MUSIC) and water quantity (DRAINS) models were reviewed for suitability and then used to provide information relating to discharges into the coastal wetland. The stormwater design incorporates four basins to capture and treat development site rainfall runoff.

This report shall feed back into the ongoing design and submissions related to the overall water and ecological impact of the hospital development.

Key findings of the review are as follows:

- The proposed RBG stormwater management reduces 1% AEP (100 year Average Recurrence Interval) peak flows from the development to below existing levels for the whole of site, and with minor basin modification, the 20% AEP for all basins. This reduction of peak 1% and 20% peak flows to below existing levels is a design requirement
- During frequent rain events (more frequent than the 20% AEP) the developed stormwater discharge is above existing levels. The impact of increased and more frequent flows on the wetland is assessed as minimal benefit and is not necessary for the protection of the Wetland
- Stormwater management for the site incorporates 400 KL rainwater tanks and re-use of rainwater for irrigation
- The annual flow volumes for the current design are higher post development than pre development. The stormwater volumes entering the basin will not be further reduced than the 17ML per year as the use of infiltration treatment devices such as infiltration trenches, swales, rain gardens and permeable pavements etc could not be implemented due slope slip failure on the steep batters around the site due to waterlogged subsoil. Because of the geotechnical risks confirmed by RBG.
- According to the report dated 3rd December 2019 (Morrison Geotech – Clarification on General Drainage Comments – Tweed Valley Hospital – Cudgen Road, Kingscliff), the groundwater in the existing condition is connected to the wetland and therefore adding infiltration provides limited practical benefit.
- Infilling of the existing dam was assessed for a range of flood events and found to have no material impact on wetland flood levels, except a minor local affect for the frequent 4EY (four exceedance per year on average), due to the runoff filling in the local depressions
- Ecological impact from development outflows and more frequent wetting events has been assessed as having minimal impact, with the change in flood level being very small (<50mm), especially when compared to existing frequent flood inundation from Tweed River
- The increase in frequent flows and improved water quality through reduction of sediment load and nutrients, may be of ecological benefit to the wetland species
- The existing, long established, coastal wetland area has proved resilient throughout numerous inundation event well in excess of anything likely to result from the inflows from the proposed development. Therefore, it is unlikely to result in any significant structural change to the coastal wetland (dominant floristics of this community) due to annual flow increase of 36ML/yr

Based on comments provided by Department of Planning, Industry and Environment (DPIE) on the 7th November 2019, the following sections of the report have been updated

  - 2.2 MUSIC Model Review, 3.4 Groundwater and 3.4.1 Recommendation

1 Introduction

1.1 Purpose

The purpose of this report is to undertake a desktop review of the Stormwater Management Plan for the Tweed Valley Hospital undertaken by Robert Bird Group, and then extend the hydrology modelling to assess hydrological impacts on the adjacent coastal wetland from the stormwater measures.

The report also considers the impact of infilling an agricultural dam in the north western corner of the site.

The RBG Stormwater Management Plan does not include detailed components of the stormwater design and this review scope does not undertake an assessment of detailed design of the proposed water quality basins or stormwater network, rather to confirm that the RBG MUSIC water quality modelling and DRAINS water quantity modelling of the stormwater network are consistent with the Stormwater Management Plan in terms of hydrological aspects affecting the coastal wetland.

1.2 Scope

The scope of work incorporates the following:

- Desktop review of the RBG Stormwater Management Plan
- Hydrological assessment of the potential change to the downstream coastal wetland, due to the development
- Dam decommissioning (infilling) option assessment

In accordance with the proposal, the following steps were undertaken to review the hydrological impact of the development:

1. Review supplied background documentation relevant to the stormwater and water quality outputs to the wetland;
2. Develop a hydrologic model to determine the peak discharge for the 50%, 20% and 1% Annual Exceedance Probability (AEP) events, and compare to the pre-development case;
3. Develop a two-dimensional (2D) hydraulic model to determine the effect of the dam decommissioning option provided by RBG (existing and developed scenarios);
4. Assess the impact of changes in flow regimes on the wetland and communicate the outcomes for ecological assessment; and
5. Provide information for Input into the RBG Design Report and Design Drawings.

2 Review of Stormwater Management

2.1 Methodology

A desktop review was undertaken of the Stormwater Management Plan developed by Robert Bird Group. The review was assessed against standard industry practise and the requirements indicated to satisfy the respective draft conditions of consent from the NSW Department of Planning and Environment for Section B3.b.ii, and iii.

2.1.1 Summary of stormwater treatment

- The pre-development site was used for agriculture (mainly horticulture) with associated soil disturbance and potential for increased pollutant loads such as sediment and nutrients discharging into the coastal wetland. Previous site discharge had no significant water quality treatment that we are aware of, apart from a portion draining into an existing dam.
- The post development case aims to improve runoff water quality through the use of water sensitive urban design structures such as bio-retention systems and gross pollutant traps. Capture and re-use of rainwater is proposed with roof runoff rainwater tanks (400ML) and recycling for on-site irrigation.

2.2 MUSIC model review

Proposed water quality treatment design is tested using a comparison of pre and post development condition modelled using the industry standard MUSIC model (eWater, 2018).

The MUSIC model assesses the conceptual design of Water Sensitive Urban Design (WSUD) components and is the standard specified by most development codes in eastern Australia. Parameters to be used in each model are usually specified within design guidelines, however most are reasonably consistent unless site specific data is available.

No site specific water quality data has been provided for the Tweed area, and therefore the Tweed Shire Council Design Specifications and Queensland Urban Drainage Manual (2013) are relevant, with MUSIC pollutant parameter data in accordance with Water by Design MUSIC Modelling Guidelines (Nov, 2018) being the latest guideline, and considered applicable as used by RBG.

Rainfall data for the RBG MUSIC model was based on the data available for download from the eWater on-line Rainfall Data Tool (eWater, 2019). Data on the website has been assessed by eWater as suitable for MUSIC modelling of WSUD options. The recommendation by OEH is to assess data of 20 years minimum, however this length of record was not available at the 6-minute time increment recommended for this size site. A longer period of data (2003-2017) was obtained from the Bureau of Meteorology Climate Data Online (BoM, 2019), via purchase.

Table 1 shows the data available from a check of the Bureau of Meteorology database. The first site is the eWater MUSIC available data set which is under nine years in length. A second nearby site was found at Coolangatta with just over 14 years of data, and a third site at Gold Coast Seaway having 19 years of record (but 38km away), however it had several data gaps that significantly limit its use. Therefore, the Coolangatta site 040717 was used for analysis, being a longer period than Coolangatta Bowls, and also more recent and continuous.

Table 1: Available rainfall data for MUSIC modelling

Site	Data Start- Finish	Annual Rainfall	Comment
040052 Coolangatta Bowls (9.9km from site)	9/1972-6/1981	1934	MUSIC website data
040717 Coolangatta (12.2 km from site)	9/2003-1/2018	1438	Good quality recent data set, also used in this review
040764 Gold Coast Seaway (38.4 km from site)	3/2000-7/2019	1163	Significant data gaps and reasonable distance away

The MUSIC model catchment review is included with the DRAINS model review in the next section.

MUSIC model water quality objectives set by Tweed Shire Council (TSC, D7, 2016) are for the following pollutant load reductions:

Total Suspended Solids (TSS)	80%,
Total Phosphorous (TP)	60%
Total Nitrogen (TN)	45%
Gross Pollutants	90%

Analysis using alternative recent rainfall data from 2003-2017 was undertaken for comparison and results shown in Figure 1 (1972-1981 data) and Figure 2(2003-2017 data). The basins in the model are lined which reduces infiltration.

	Pre-development Annual Load	Post-development Annual Load (Untreated)	Post-development Annual Load (Treated)	% Reduction	TSC Target
Total Flow	78.7	136	134	1.7	N/A
TSS	29,900	32,200	5,580	82.7	80%
TP	31,500	71.6	21.3	70.3	60%
TN	183	429	201	53.2	45%
GP	415	2100	0.054	100	90%

Figure 1: Water Quality (MUSIC modelling) results copied from RBG (2019), MUSIC 1972-1981 data

	Sources		Residual Load		% Reduction	
	Pre	Post	Pre	Post	Pre	Post
Flow (ML/yr)	90.6	142	90.6	140	0	1.41
Total Suspended Solids (kg/yr)	35600	33800	35600	7000	0	79.3
Total Phosphorus (kg/yr)	37.2	75.2	37.2	26.4	0	64.9
Total Nitrogen (kg/yr)	207	454	207	236	0	48
Gross Pollutants (kg/yr)	412	1930	412	0.19	0	100

Figure 2: Water Quality (MUSIC modelling) results screenshot using more recent BoM 2003-2017 data

The results support the RBG (2019) assessment for pollutant load reduction to the required levels for TP and TN, however the TSS reduction using 2003-2017 data is shown as being just under the 80% level at 79.3%. This reduction could be easily improved to 80% with slight design modification, if required.

With regard to the mean total annual flow volume from site, this is shown as increasing by just over 50% from pre-development (90.6ML/yr) to post development (140 ML/yr) for 2003-2017 data. This is similar to, but lower than the 70 % increase indicated in RBG (2019, Table 5.2) annual load assessment of 78.7 ML/yr pre-development to 134 ML/yr post development using 1972 to 1981 data. The reason for the large increase is that the development has a significant area that has become impervious (roofs, carparks, roads, paths) compared to the original agricultural land that readily allowed infiltration. An option for reducing this is discussed later.

In terms of changes to total pollutant load, Total Suspended Solids (TSS) and Total Phosphorus (TP) are reduced below pre-development levels, while Total Nitrogen has increased by approximately 14% (207 kg/yr to 236 kg/yr). This result is consistent with an increase in TN found by the RBG assessment using 1972-1981 data. Again, this increase in total load can be reduced with some design modification. It is noted that the Landscape proposal in the SSD 9575 approval drawings included potential rain gardens.

Reducing the post development flow volumes to pre-development levels is difficult without a significant increase in storage, and mechanisms of transferring this to groundwater, which would also likely make its way to the adjacent wetland over a delayed period.

The impact on the wetland water levels is minimal and discussed later in the dam filling option, Section 4.
The ecological impact of this has been assessed in Section 5.

Following submission of revision 02 of this report to DPIE, the department requested changes to the design MUSIC model (RBG model). The model has been updated to include the following changes and has been provided to SMEC for review:

- Commercial land use run-off parameters from 2018 Water By Design guidelines have been amended in respect of rainfall run-off and field capacity values. The updated model adopts the parameters as outlined in the 2015 NSW Music modelling guidelines.
- Rainfall data has been updated to use the 10 year (01/1989 to 12/1998) 6-minute rainfall data from the Elanora rainfall station (40609), obtained from the e-Water online rainfall Data Tool.
- A "natural" (bush/forest) sub-model has been created as well as the pre-development and post-development sub-models for comparison with the natural state.
- A proposed 400KL rainwater reuse tank has been included in the model.

The following results have been obtained from the updated mode (refer Table 2)l:

Table 2: MUSIC modelling results (December 2019)

Mean Annual Load	Natural state (bush / forest)	Pre-development (agricultural land use)	Post-development (without treatment)	Post-development (with treatment)
Flow (ML/Yr)	63.7	69.6	113	99.6
Total Suspended Solids (kg/yr)	3,750	19,000	25,000	2,880
Total Phosphorus (kg/yr)	4.23	21.7	58.6	13.7
Total Nitrogen (kg/yr)	48.4	127	355	134

The updated MUSIC model demonstrates compliance with the TSC development control plan requirement to reduce the post development flows by the following reduction targets (compared with post development loads without treatment). Suspended solids 80%, Phosphorus 60%, Nitrogen 45%, gross pollutants 90%. It also demonstrates a significant overall improvement in water quality compared with the modelled pre-development state (other than a very small increase in nitrogen). It is noted that the MUSIC model has only accounted for a reduction in total flows of approximately 11ML for the rainwater tank (compared to the 17ML calculated by the project hydraulic engineer).

2.3 Reducing post development flow volume

A 400KL rainwater reuse tank was modelled to collect and store rainwater from the hospital roof to use for irrigation and cooling tower. The results showed that the reusing stormwater will reduce the total stormwater discharge by approximately by 17ML per year on average.

Using the recommended MUSIC model parameters indicates that reducing post development annual flow volume to pre-development levels is not feasible due to geotechnical limitations on use of range of other water quality treatment devices such as infiltration trenches, raingardens and permeable pavements etc (refer Morrison Geotech – Clarification on General Drainage Comments – Tweed Valley Hospital – Cudgen Road, Kingscliff). The stormwater volumes entering the basin will not be further reduced than the existing limitation stated above of 17ML per year.

2.4 DRAINS model review

2.4.1.1 Model Parameters

A review of model parameters used for both MUSIC and DRAINS models was carried out as part of the review process to check consistency of the modelling data.

Table 3 and Table 4 show the model parameters used by RBG (2019) DRAINS and MUSIC models.

Table 3: RBG DRAINS model parameters for basins

	Basin A	Basin B	Basin C	Basin D
Total Catchment (ha)	7.385	0.3	1.44	3.41
% Impervious	60	50	85	50
% Pervious	40	50	15	50

Table 4: RBG MUSIC model parameters for basins

	Basin A	Basin B	Basin C	Basin D
Total Catchment (ha)	6.77	0.21	1.25	3.30
% Impervious	62	26	65	25
% Pervious	38	74	35	75

The SMEC review confirmed that the parameters used in the MUSIC models were more accurate, hence the DRIAN model parameters were changed to replicate MUSIC model parameter.

ARR2019 data hub parameters for the Tweed Hospital Site was downloaded in August 2019 based on the latitude and longitudes shown in Table 5.

Table 5: Co-ordinate details used for ARR2019 Data hub request

	Requested	Nearest grid cell
Latitude	28.2639	28.2625
Longitude	153.5655	153.5625

The rainfall intensity parameters used by RBG were compatible with the data extracted by SMEC.

2.4.1.2 Modelling Methodology and results

The development of the RBG DRAINS models was carried out using Horton/ILSAX type hydrological model with less abbreviated data for time of concentration of 5 mins for each basin. The Table 6 shows the individual outflow from each basin.

Table 6: RBG DRAINS model runs with 2016 - ILSAX

Basin	Catchment Area (ha)	1% AEP Flow (m^3/s)		20% AEP Flow (m^3/s)		50% AEP Flow (m^3/s)		1EY (m^3/s)		4EY (m^3/s)	
		EXST	DEV	EXST	DEV	EXST	DEV	EXST	DEV	EXST	DEV
Basin A	6.77	4.45	1.61	3.09	1.41	1.44	1.13	1.24	0.67	0.56	0.35
Basin B	0.21	0.19	0.18	0.13	0.12	0.06	0.06	0.05	0.05	0.03	0.03
Basin C	1.25	1.11	0.44	0.68	0.38	0.36	0.27	0.30	0.25	0.15	0.12
Basin D	3.30	2.40	1.17	1.75	0.99	0.83	0.61	0.70	0.54	0.33	0.29

SMEC developed a XP-RAFTS hydrology model to verify the DRAINS flows. ARR2016 Initial Continuous Loss (IL/CL) method was adopted for both the XPRAFTS and the DRAINS modelling.

Table 7 shows the individual outflow from each basin. The results revealed that the developed flows for the 1% AEP event are reduced to below existing levels. However, for frequent events 50% AEP (Basins A and B), and all basins in the 1EY and 4EY events are significantly higher than the existing flows. It is expected these outflows could be reduced to pre-development levels for each basin through additional modifications to the outlet design.

Table 7: SMEC DRAINS model runs with 2016 IL/CL numbers used for rafts modelling.

Basin	Catchment Area (ha)	1% AEP Flow (m^3/s)		20% AEP Flow (m^3/s)		50% AEP Flow (m^3/s)		1EY (m^3/s)		4EY (m^3/s)	
		EXST	DEV	EXST	DEV	EXST	DEV	EXST	DEV	EXST	DEV
Basin A	6.77	2.97	1.61	1.13	1.22	0.53	*0.65*	0.39	*0.54*	0.06	*0.26*
Basin B	0.21	0.12	0.14	0.05	0.07	0.02	*0.04*	0.02	*0.03*	0.00	*0.01*
Basin C	1.25	0.71	0.43	0.32	0.30	0.12	*0.24*	0.10	*0.20*	0.01	*0.10*
Basin D	3.30	1.75	1.12	0.80	0.73	0.30	*0.47*	0.23	*0.40*	0.03	*0.12*

A further assessment was carried out by SMEC to assess the combined flows at the outlet downstream of the dam for the development as a whole. Table 8 shows the combined outflows downstream of the dam. The results confirmed that the developed flows are greater than the existing flows for the 50% AEP, 1EY and 4EY rainfall events.

Refer Appendix A for hydrographs extracted from the DRAINS model for comparison.

Table 8: SMEC DRAINS model runs with 2016 IL/CL – Combined flows at the outlet.

Rainfall Event	Catchment Area (ha)	AEP OutFlow (m^3/s)	
		EXISTING	DEVELOPED
1% AEP	11.53	4.10	2.70
20% AEP	11.53	2.30	2.10
50% AEP	11.53	0.70	*1.20*
1EY	11.53	0.65	*1.10*
4EY	11.53	0.10	*0.30*

2.4.1.3 Recommendation

The developed flows for the more common 50% AEP, 1EY and 4EY rainfall events are greater than the existing outflows. The impact of increased and more frequent flows on the wetland is assessed as minimal benefits. Therefore, refining the basin outflow design for the 1EY, 4EY and 50% AEP would have minimal benefit and is not necessary for the protection of the Wetland.

3 Coastal Wetland Assessment

3.1 Rainfall data assessment

As indicated in the previous section, the 6 minute rainfall data for MUSIC has a maximum term of approximately 14.7 years, from May 2013 to Jan 2018. To consider 20 years' worth of data, daily rainfall records are required. Site 04717 Coolangatta (~12 km from the site) was used which contains data from December 1982 to 2019, with a 17 month gap from January 1993 to end June 1994. (25 years continuous from 1994).

A summary of the rainfall data statistics is shown in Table 9 below. It shows that there is no significant difference whether considering the rainfall from 1982, or from 1994, noting that the days of rainfall have reduced. Therefore, daily data from 1994 and continuous data from 2003 for MUSIC modelling is supported.

Table 9: Summary of min 20 years rainfall data, site 04717 Coolangatta.

Statistic	1982-2018 -data gap 1/1993-6/94 (35 yrs)	1994-2019 (25 yrs)
Total days data	12,869	9,171
Average dry days between rain	4.79	4.80
Days of rainfall >1mm	3469 (27.1%)	2436 (18.9%)
Average rainfall (on a rainday (>0.2)	11.56 mm	11.46 mm
Average rainfall when >1mm per rainday,	14.6 mm	14.7 mm
Average rainday duration >1mm	2.29 days	2.28 days
Max days without any rain	54 (2012)	54 (2012)

3.2 Increase in flow to wetland from development

Frequent events (more frequent than the 50% AEP) have been shown by the MUSIC modelling to increase the annual flow volume to the wetland by approximately 50%. For the high flow events of 20% AEP and 1% AEP, the proposed bio-retention basins by RBG have been shown to reduce peak flow to below the existing level for the site overall.

The basin outlets are designed with scour protection (from the RBG SWMP), however a detailed design was not yet available. The outlet channel is straight forward to design to reduce scour potential, particularly where the outflow channel connects to the wetland.

As an example, using Manning's formula, for a peak 1% AEP discharge of 1.61 m^3/s from Basin A, assuming a maximum channel depth of 0.3m, slope of 1% and maximum velocity of 1m/s, the flow could be accommodated with a 5m wide base width, 1:4H side slope, rock channel (n=0.045).

The channel from the basin to the outlet point could be made narrower and deeper, with flow slowed down and spread out where it discharges to the wetland. The other basins have smaller outflows and would require smaller channels as a result. The channels could also be designed for additional infiltration as discussed in the groundwater, Section 3.4. RBG confirmed that the infiltration trenches are not feasible doe to geotechnical risks.

3.3 Comparison of pre and post development flows to wetland

A comparison of flow discharge from the developed bio-retention basins was undertaken in the DRAINS model review (Section 2.3) with hydrographs provided in Appendix A.

It was shown that for the more frequent events the developed flow and volumes exceeded the existing case.

Determining the impact on the coastal wetland is made difficult by the very flat nature of the area and the disconnected low flow points.

The coastal wetland is flooded on a regular basis from the Tweed River (BMT, 2018) with a 5% AEP flood depth of approximately 2m (correlating to RL 2.5-3.0 m AHD) and 1% AEP flood depth of approximately 3.0 m

Outflow from the 4EY and 1EY events from the development site, although higher than the existing flows, effectively only fill some of the localised depressions. This is shown in the later dam filling assessment, Section 4.

Table 10: Approximate flood levels in the wetland for frequent events.

Minor flood Event (development site only)	Estimated Water level m AHD
Existing dam water level (at time of RBG survey)	0.27
Surrounding ground level	0.6-0.8
4EY (avge 4 exceedances per year)	0.6
1EY (avge 1 exceedance per year)	0.7
20% AEP	0.75

The results from the table indicate that outflow from the development site has minimal impact on coastal wetland levels, and effectively only fills the local depressions. The assessment only considers the impact from the development site, as a worst case or conservative assessment.

It should be recognised that if a rain event occurs on the development site then it will also very likely occur on the wetland and therefore the rise in water level could actually be much more significant. There are no initial or continuing rainfall losses when rainfall occurs directly onto a water surface, and therefore the water level increase to the wetland may be higher than due to discharge from the development.

It is noted that the frequency of minor runoff events into the wetland may increase significantly due to the development, however the change in wetland flood level is expected to be less than 50mm from these events, and return to normal level within a day or so, if connectivity between wetland depressions and the natural outlet remain.

3.4 Groundwater

Geotechnical assessment by Wood and Grieve (W&G, 2018), indicates the site material to be Silty Clay overlaying basalt at depth. At the lower end of site permeability percolation tests (Bore Hole 22 and 23) were undertaken to depths of 0.5m within the proposed bio-retention area.

The results are shown in Table 11 and indicate high permeability values. The testing shows than rainfall readily infiltrates into the ground in the lower elevations of the site.

Table 11: Permeability values (taken from W&G, 2018)

Test number	Borehole 22 (Permeability (mm/hr)	Borehole 23 (Permeability (mm/hr)
Test 1	670.3	203.5
Test 2	83.5	60.9
Test 3	149.0	77.6
Average of Test 2 and 3	116.3	69.3

The result for Test 1 appears very high and may be a result of other issues. Therefore, to be conservative the lowest average permeability of 69 mm/hr was used for testing in the MUSIC model to assess the impact of infiltration. MUSIC model representative infiltration rates for medium clay are 0.36-3.6mm/hr, or up to 36mm/hr for sandy clay.

The W&G geotechnical report indicated that seepage may occur at the natural soil/weathered rock interface, especially following rain events, and that the groundwater level is dependent on rainfall, subsurface material and permeability of the ground, and proximity and type of vegetation.

Given the slope of the site is perpendicular to, and direct connected to the wetland, it is expected that any infiltration on site in pre and post development conditions would be a source of groundwater inflow to the wetland.

According to the report (Morrison Geotech – Clarification on General Drainage Comments – Tweed Valley Hospital – Cudgen Road, Kingscliff), the groundwater in the existing condition is connected to the wetland and therefore adding infiltration provides limited practical benefit.

RBG confirmed that the other SMEC recommendation for use of infiltration treatment devices such as infiltration trenches, swales, rain gardens and permeable pavements etc could not be implemented due slope slip failure on the steep batters around the site due to waterlogged subsoil. Because of the geotechnical risks, infiltration devices will not be feasible.

Also, the recommendation to remove the basin liner will not be feasible due to the same geotechnical risks mentioned above.

Therefore, the MUSIC model is run with the basins lined and water recycling via 400KL rainwater tank (from RBG). Refer Table 12 for the flow volumes.

Table 12: Flow Volumes (including rainwater tank)

Infiltration option tested (using 2003-2017 data)	Pre-development flow volume ML/yr average	Post Development flow volume ML/yr average
Current stormwater model with the four basins lined and water recycling via 400KL rainwater tank	63.7	99.6

3.4.1 Recommendation

The use of infiltration treatment devices such as infiltration trenches, swales, rain gardens and permeable pavements etc could not be implemented. The stormwater volumes entering the basin will not be further reduced than the volumes mentioned in Table 12. The existing, long established, coastal wetland area has proved resilient throughout numerous inundation event well in excess of anything likely to result from the inflows from the proposed development. Therefore, it is unlikely to result in any significant structural change to the coastal wetland (dominant floristics of this community) due to annual flow increase of 36ML/yr.

4 Dam filling options

4.1 Methodology

A TUFLOW hydrodynamic model was built for the purposes of assessing the flood level and flow impacts of the proposed dam infilling. The outlet flow from each of the four basins was extracted from the DRAINS model and utilised as inflows in the TUFLOW model. The TUFLOW model DEM was on a 2 metre grid resolution based off the provided survey and sourced LiDAR data. To model the dam infill an elevation of 0.3 mAHD was assumed for the surface level of the dam.

A rain on grid model of the existing case was modelled to determine flow paths surrounding the wetland and the dam. It was determined that very minor flows from the wetland reach the dam and therefore only the proposed development basin outflows were considered for this assessment.

4.2 Option 1: Impact of filling the dam to match surrounding ground level

The dam filling option has been assessed based on the Basin outflow for the two extremes of discharge, being the 1% AEP and 4EY events.

Figure 3 and 4 below show the difference in peak flood levels for the 4EY and 1% AEP event respectively. The grey shading indicates an impact of less than 10mm.

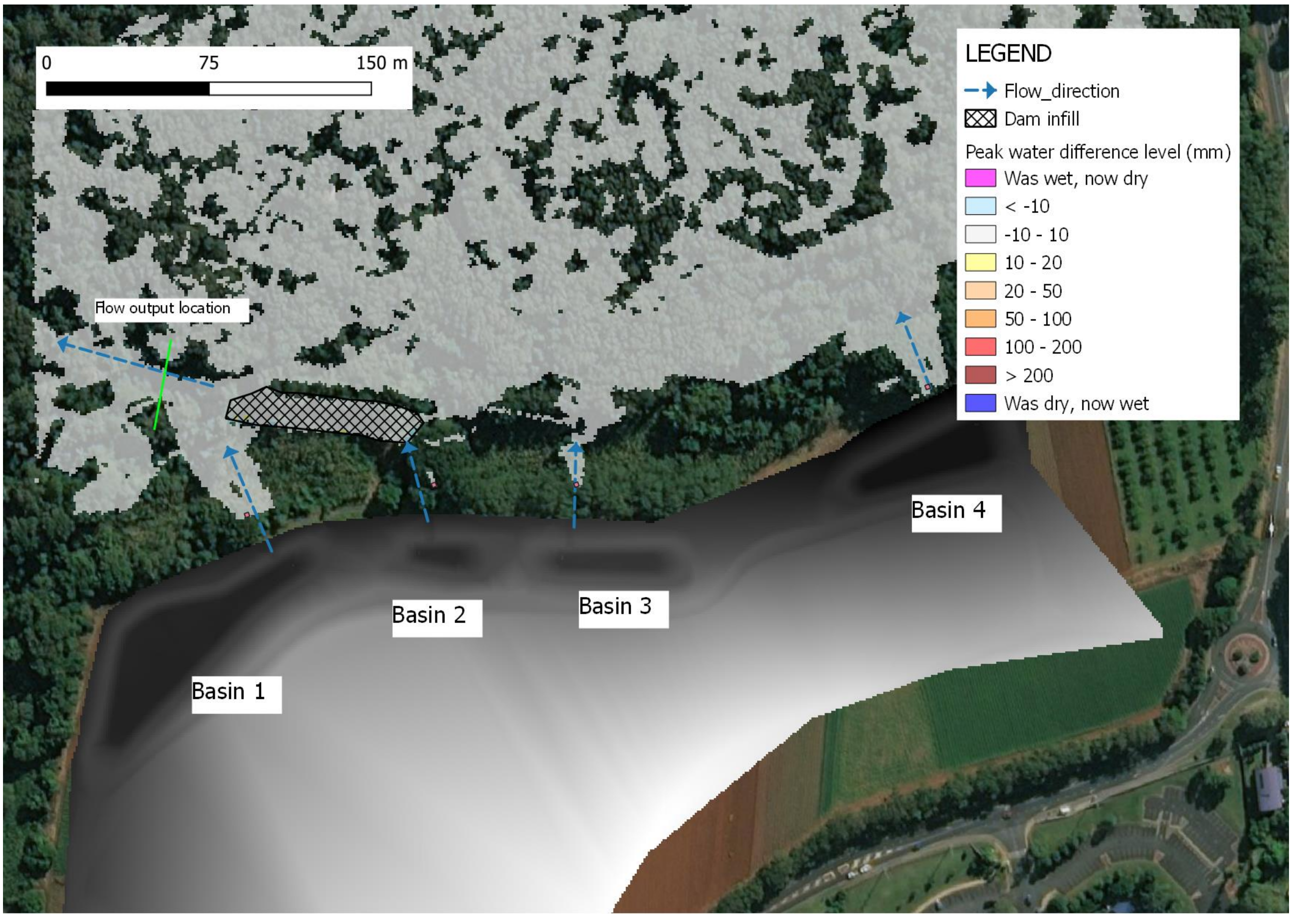

Figure 3: 1% AEP Peak flood level impact map

The impacts from in the infilling are larger for the 4EY event where the loss of storage is more significant relative to the storm volume. For the 4EY event the flood levels increase approximately 50 mm at the outlet of the dam. It is noted there is no increase in inundation extent from the dam infilling for any design event.

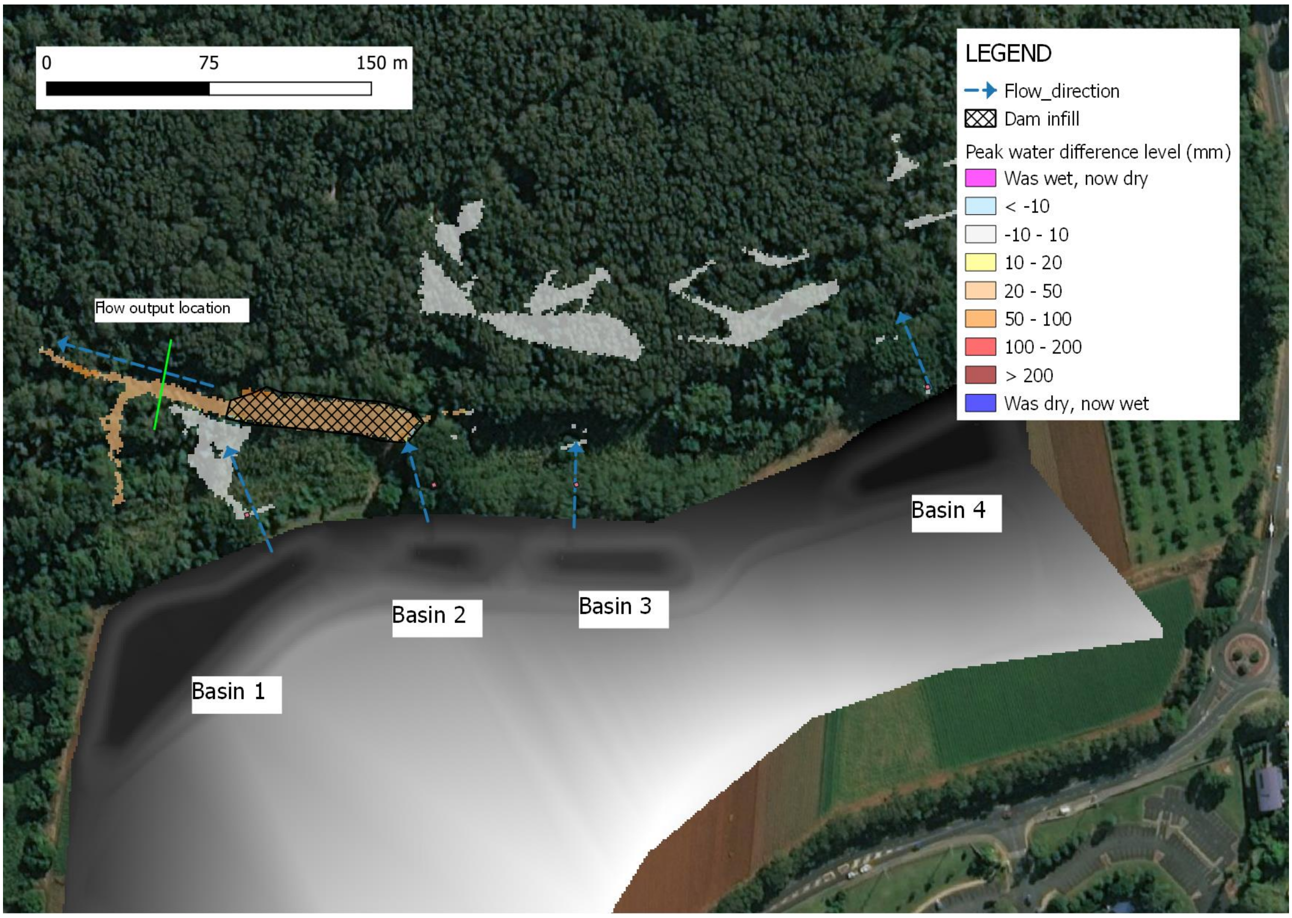

Figure 4: 4EY Peak flood level impact map

Figure-5 below shows the hydrograph plots for the outlet of the dam for the respective scenarios in the 1% AEP event. The loss of storage is seen early in the hydrograph although at the peak of the storm the loss of storage volume of the dam is negligible with peak discharges similar.

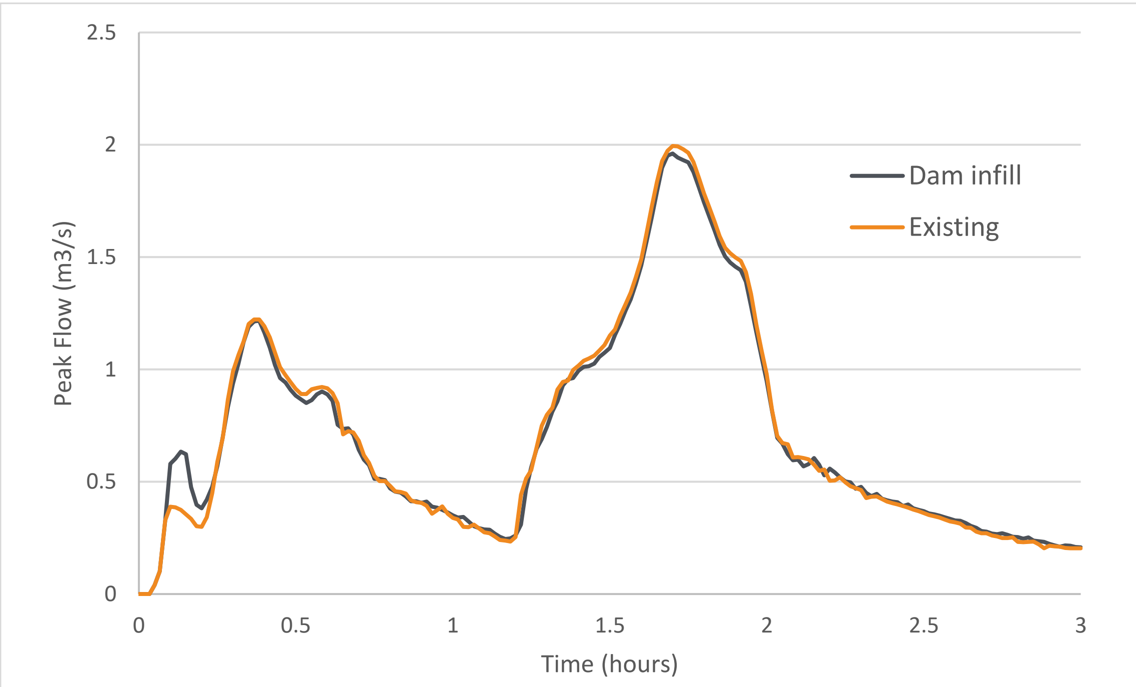

Figure 5: 1% AEP dam outflow hydrograph

Figure 6 below shows hydrograph plots for the outlet of the dam for the respective scenarios in the 4EY event. The peak flow is only 0.125 m3/s, and when compared to the volume of the wetland with an area of 30.7ha is almost negligible.

The change in flows and volume has not resulted in any increased inundation extent and from a flooding perspective is considered to have no impact on the 1% and 20% AEP flood levels, and no material impact from more frequent events from a hydrology perspective. Ecological impact should be assessed for the frequent events

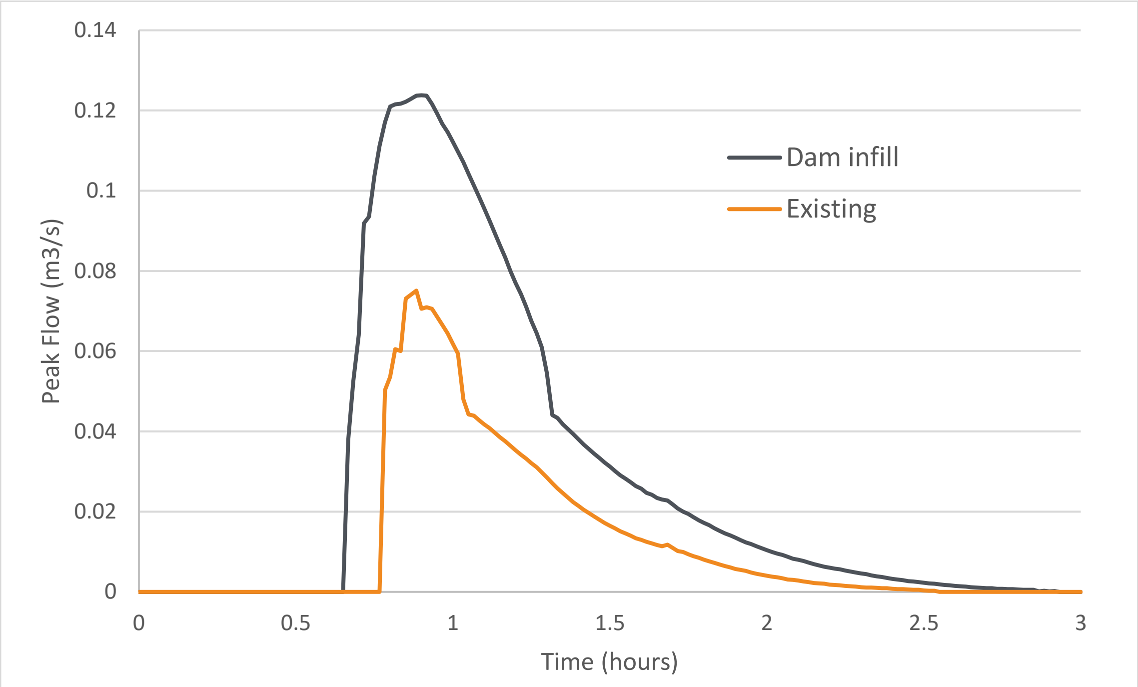

Figure 6: 4EY dam outflow hydrograph

4.3 Option 2: Impact of filling the dam with low flow channel

Although the dam filling has no impact from a flood perspective, it would be considered prudent to provide some form of low flow channel or path to allow low flows to drain, minimising isolated pools and soft spots that could affect maintenance access to the area for removal of Salvinia.

5 Ecological Values associated with the Coastal Wetland

Previous ecological assessment of the site (Greencap, 2019) identified a number of threatened species and ecological communities within and adjacent to the 36ha of mapped coastal wetland area.

These include:

- Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions EEC;
- Lowland rainforest on floodplain in the NSW North Coast Bioregion EEC;
- Mitchell's rainforest snail *Thersites mitchellae* specimens were detected during BDAR threatened species surveys, however, all of these were recorded outside the Project Site boundary in the northern portion of former Lot 102 DP 870722 (Greencap 2019); and
- Two pH dependent amphibians were identified by the BAM Calculator as candidate threatened species – Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis.* There are records for these species within the 1,500 m assessment area and within the receiving catchment (Greencap, 2019).

As noted earlier in the report current modelling predicts a mean total annual flow from site to increase by almost 50% from pre-development (90.6 ML/yr) to post development (140 ML/yr), although previous discussion considers mitigation of these flow volumes.

The potential impacts considering the current additional flows is assessed in the following sections by a suitably qualified professional (Jon Alexander, Ecologist, CV in Appendix B).

5.1 Impacts on vegetation communities

5.1.1 Swamp sclerophyll forest on coastal floodplains

The composition of this community is primarily determined by the frequency and duration of waterlogging and the texture, salinity nutrient and moisture content of the soil, and latitude. The composition and structure of the understorey is influenced by grazing and fire history, changes to hydrology and soil salinity and other disturbance, and may have a substantial component of exotic grasses, vines and forbs (NSW OEH, 2019).

The vegetation within the mapped extent of the coastal wetland has previously been identified as predominately being Broad-leaved Paperbark (*Melaleuca quinquenervia*) Closed Forest to Woodland (TSC LGA Mapping, 2012). While Broad leaved paperbark cannot survive permanent inundation, they do have adaptations such as fibrous or adventitious roots around their lower trunk that are thought to function as breathing roots, helping the tree to survive during long periods of submersion (McJannet, 2008). Similarly the composition and diversity of the mid and understorey will vary with latitude and the length of time the swamp contains water, but can typiclly include shrubs such as quinine berry *Petalostigma pubescens*, and *Banksia sp.* on the margins; sedges such as soft twigrush *Baumea rubiginosa*, *Lepironia articulata* and bogrush *Schoenos breviofolius*; saw-sedges such as *Gahnia sieberiana*; reeds such as the common reed *Phragmites australis*; other grasses such as *Ischaemum spp*., swamp rice grass *Leersia hexandra*, blady grass *Imperata cylindrica* and saltwater couch *Sporobolus virginicus (DERM, 2010).*

Given these factors the addition of approximately 10 to 20mm of additional inflow from the developed site during significant events for parts of the wetland, and 10-50mm within the dam, is unlikely to result in any significant structural change to the dominant floristics of this community.

It is noted that flooding from Tweed River (BMT, 2018) indicates inundation depths for the wetland of approximately 2m for the 5% AEP event and 3m for the 1% AEP event. This suggests that the existing, long established, coastal wetland area has proved resilient throughout numerous inundation event well in excess of anything likely to result from the inflows from the proposed development.

5.1.2 Lowland rainforest on floodplain

The occurrence of this community appears to be limited to the slightly elevated margins of the Broad-leafed paperbark community and is probably closely linked to the localised limits of the volcanically derived soils in the area. Given its occurrence in these slightly elevated locations it is considered unlikely to be materially impacted by the additional inflows expected and, given the seasonality of rainfall in the region, may in fact benefit from additional inflows during the drier winter period.

5.2 Impacts on Fauna Species

5.2.1 Mitchells Rainforest Snail *(Thersites mitchellae)*

Mitchell's Rainforest Snail is restricted to lowland subtropical rainforest and swamp sclerophyll forest with a rainforest understorey, typically on alluvial soils with a basaltic influence. It is apparently absent from other rainforest types in the area, such as littoral rainforest (Stanisic 1998). This type of correlation with particular rainforest communities is common in many land snail species in eastern Australia (Stanisic 1994). The limited research available suggests the species is dependent on high moisture levels, low fire frequency, and a well-developed leaf litter layer. With consideration of those habitat preferences it seems unlikely that a minor increase in inflow levels will negatively impact the development or maintenance of existing habitat.

There may be potential positive impacts for this species associated with the reduction in sediments coming from the hospital site as the landuse is transferred from agricultural/horticultural use with exposed soils, to the proposed end use where all pervious areas are vegetated, and stormwater treated.

5.2.2 Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis*

Records of these two species exist within the 1,500 m assessment area and within the receiving catchment (Greencap, 2019). Survey was not undertaken to detect these species for the BDAR, as the directly impacted windrow vegetation was considered too degraded and/or did not represent suitable habitat for these species (Greencap, 2019).

Both species of frogs are more commonly associated with coastal sandplain swamps than with the Broad-leaved paperbark which is predominate in the mapped extent of the coastal wetland area. Wallum froglet has been recorded in swamp sclerophyll forests but is more typically associated with sedgelands and wet heathlands (Anstis, 2013). This habitat preference is also true of the Olongburra frog which has a strong preference for inundated areas characterised by the presence of emergent sedges, with upright species such as *Baumea* spp. and *Schoenus* spp. preferred by adult frogs for perching (Shuker, J.D. and Hero, J. (2012) .

Given the uncertainty of the presence of these species in the mapped coastal wetland area and their preference for generally different habitat, including inundated areas with the presence of emergent sedge species, there is no obvious likelihood of a negative impact on these species as a consequence of changed inflows associated with the development.

If the species are present, the reduction in sediment load and residual agricultural chemicals, resulting from the changed landuse and improved stormwater management is likely to be beneficial to these species.

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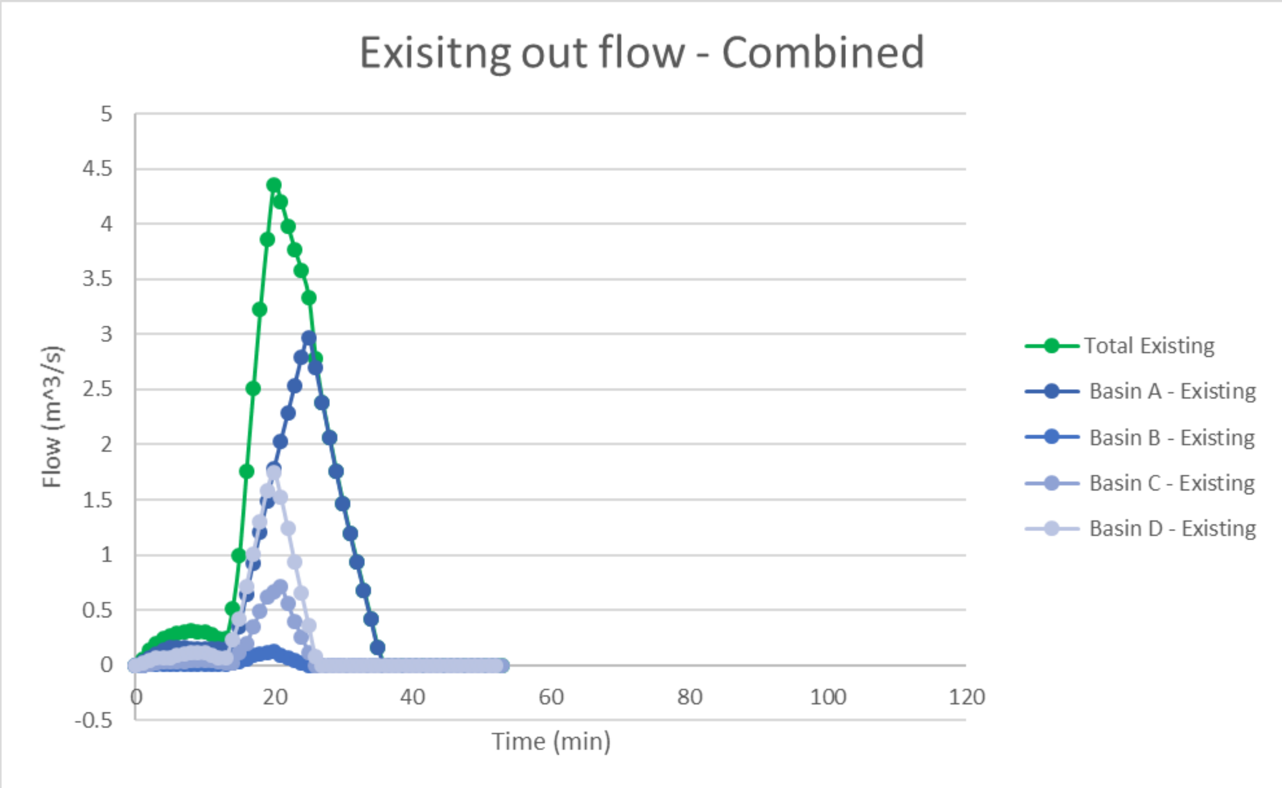
Appendix A DRAINS – Hydrograph outputs

1% AEP – Existing



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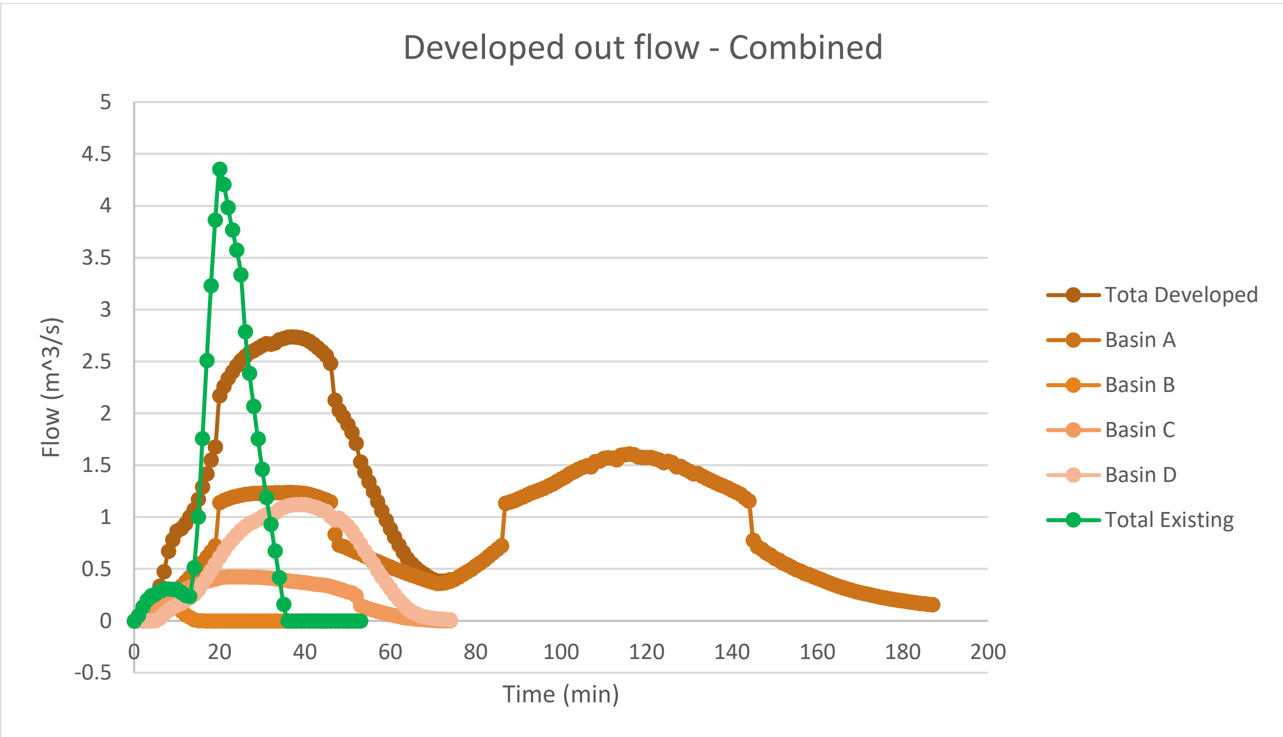

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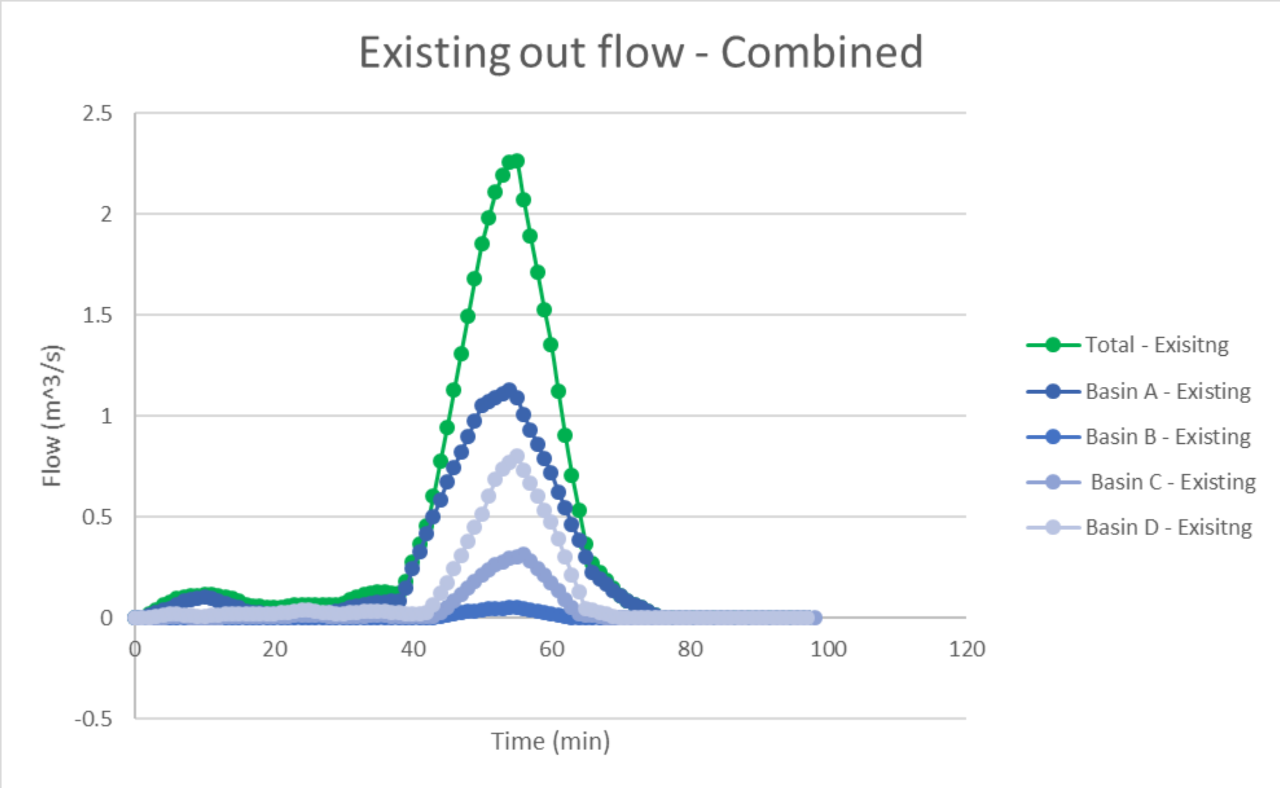

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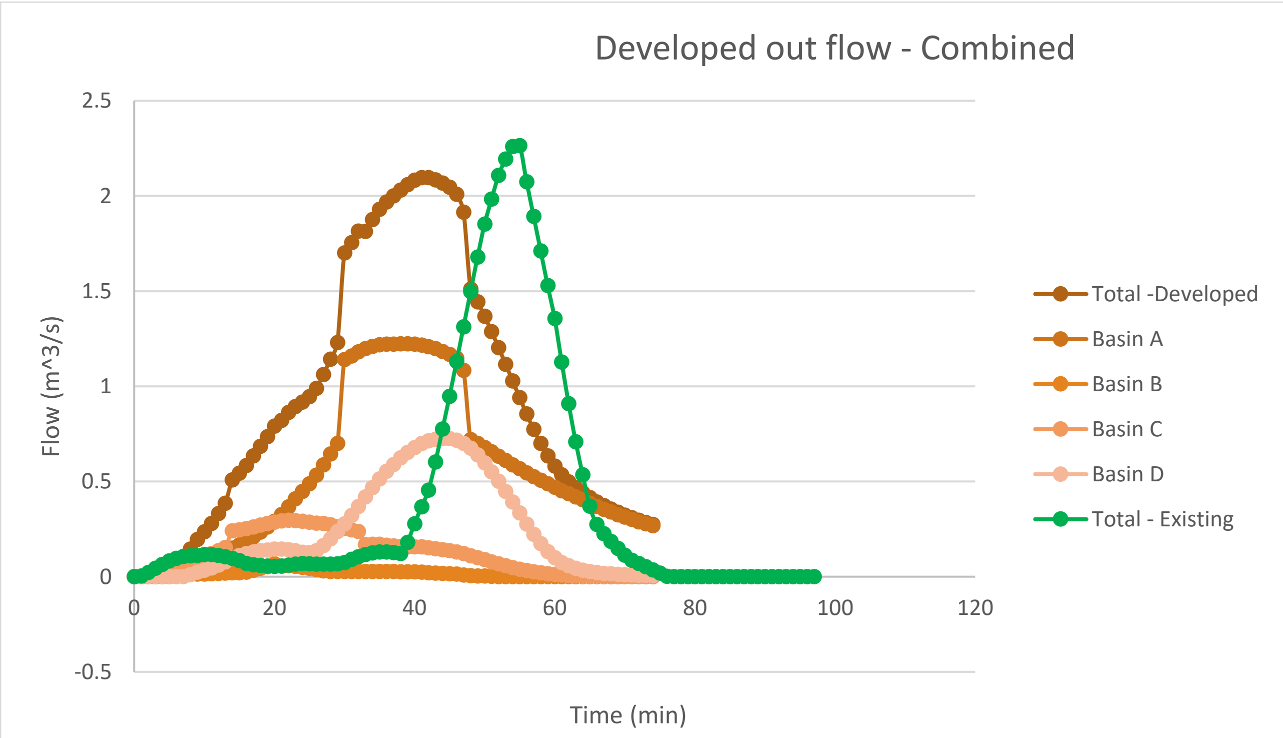

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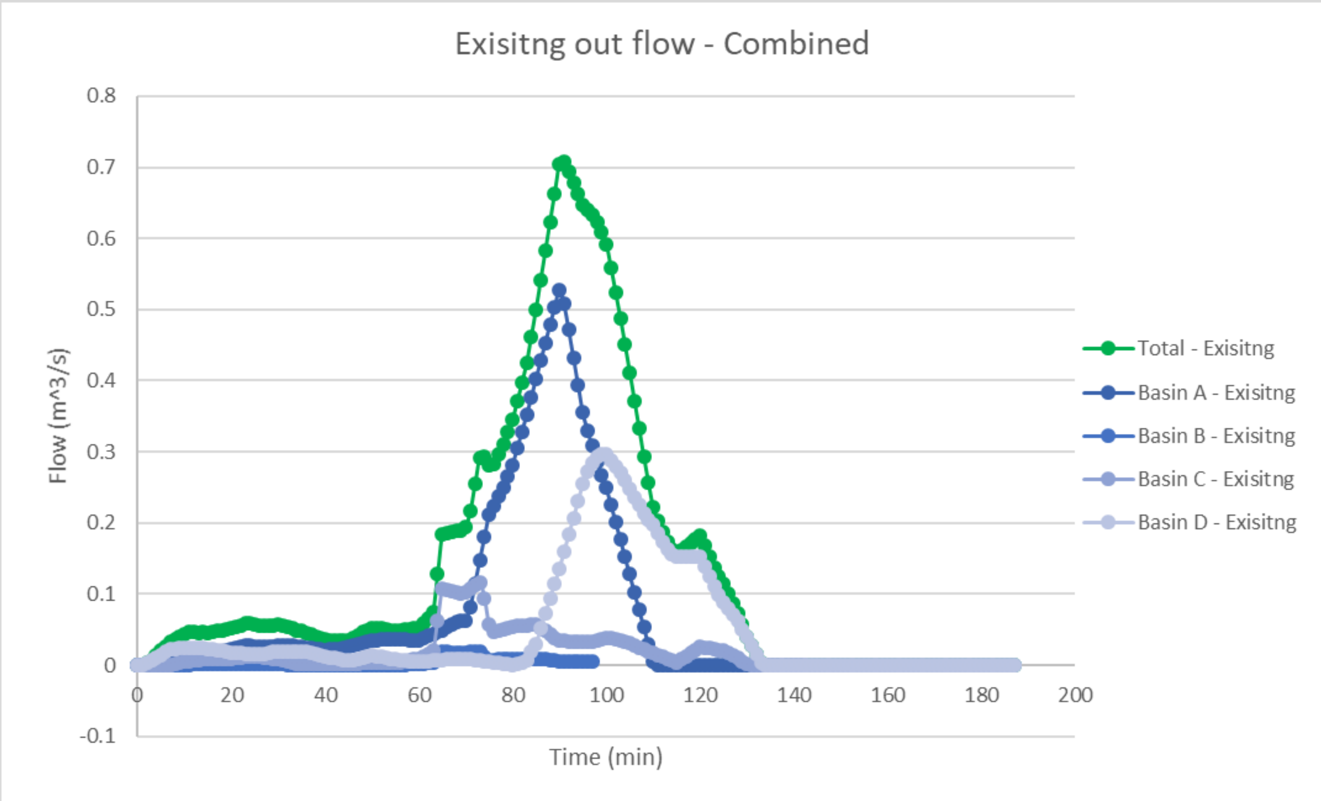

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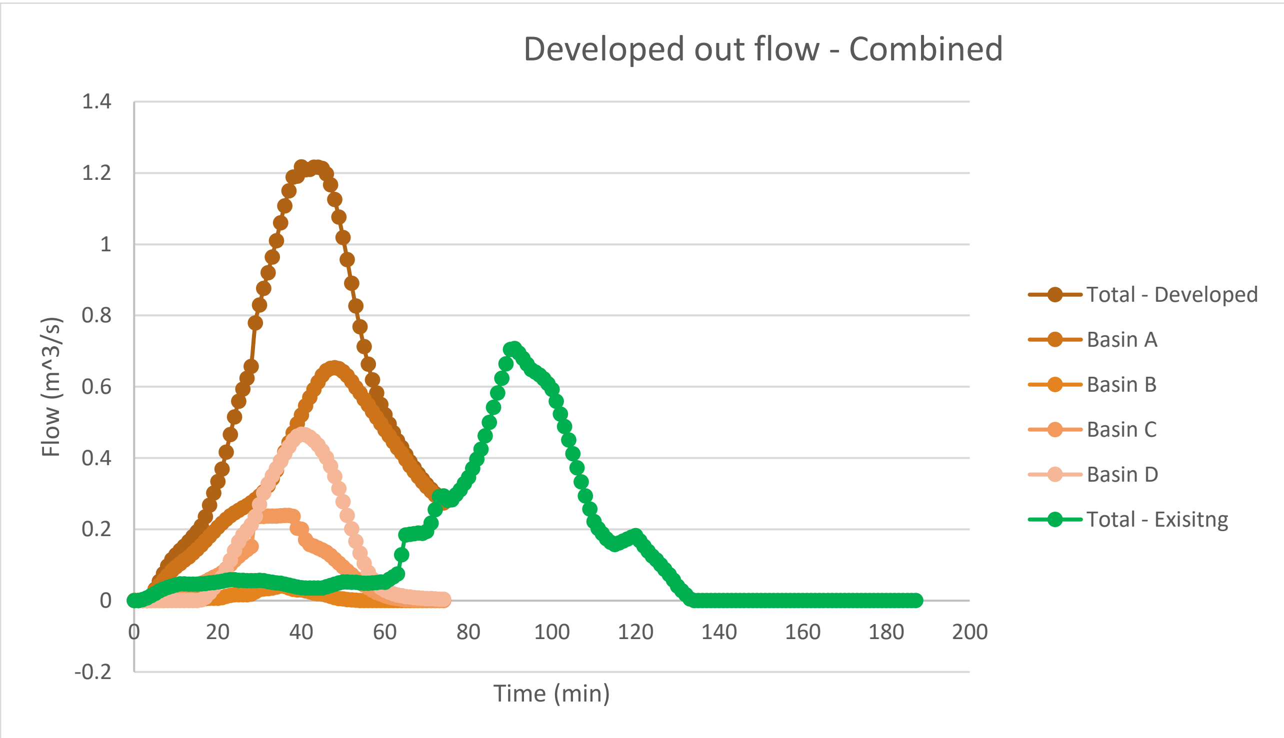

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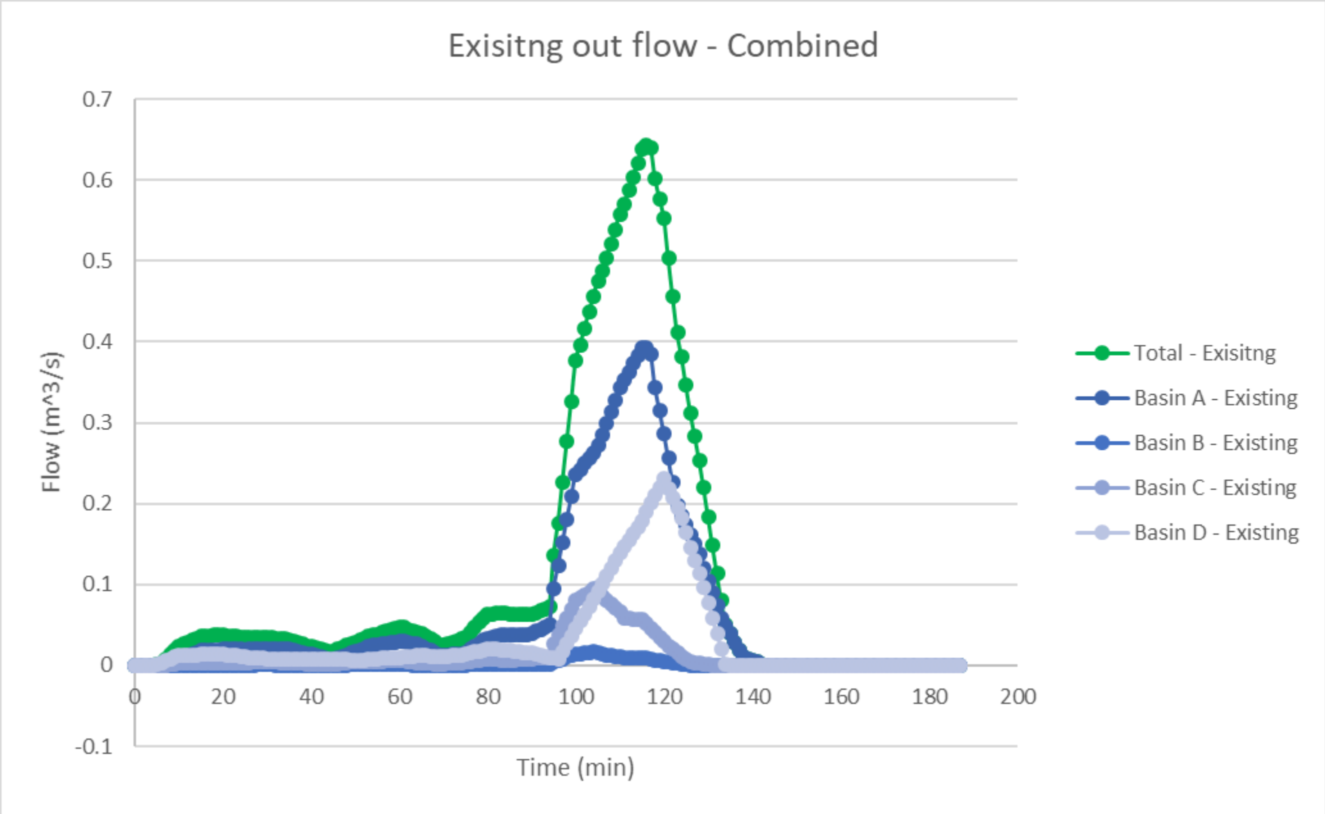

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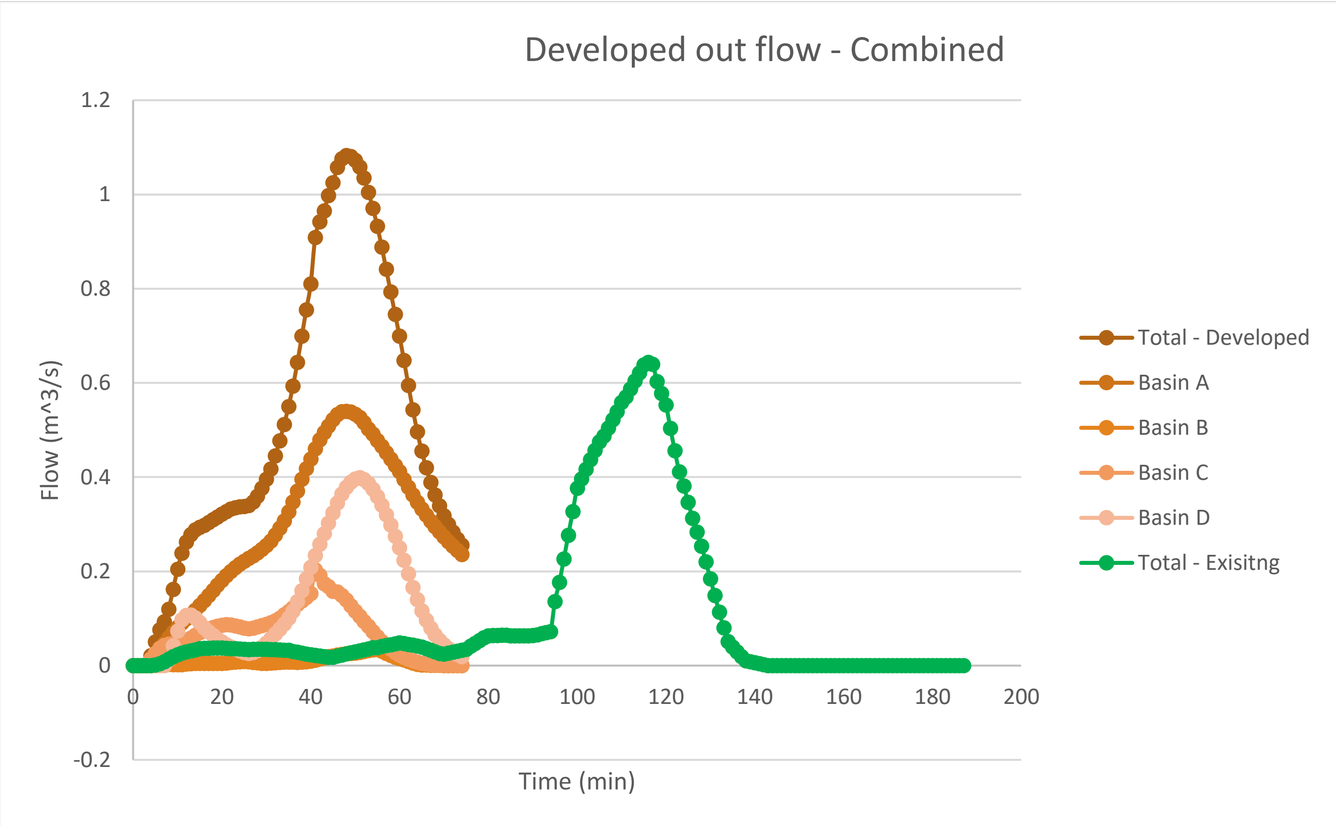

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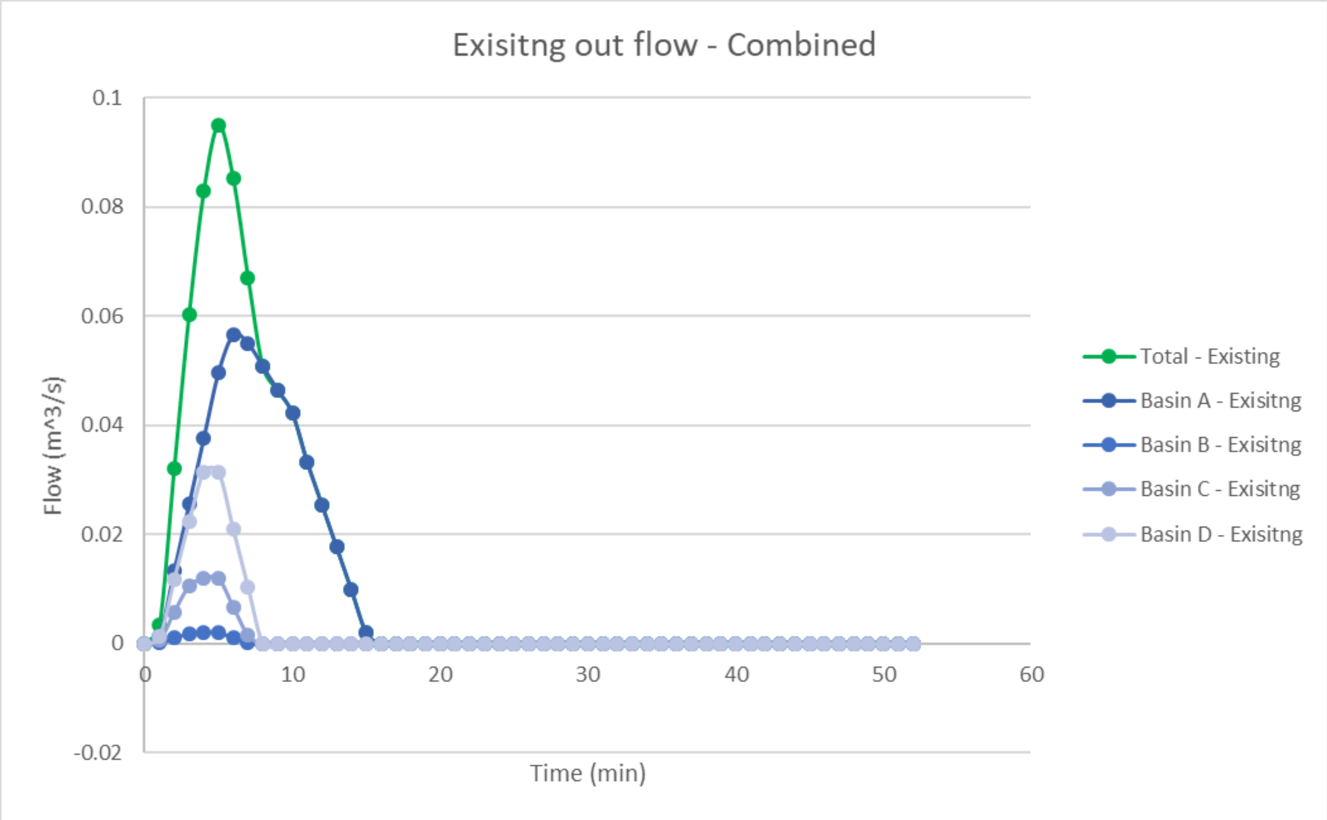

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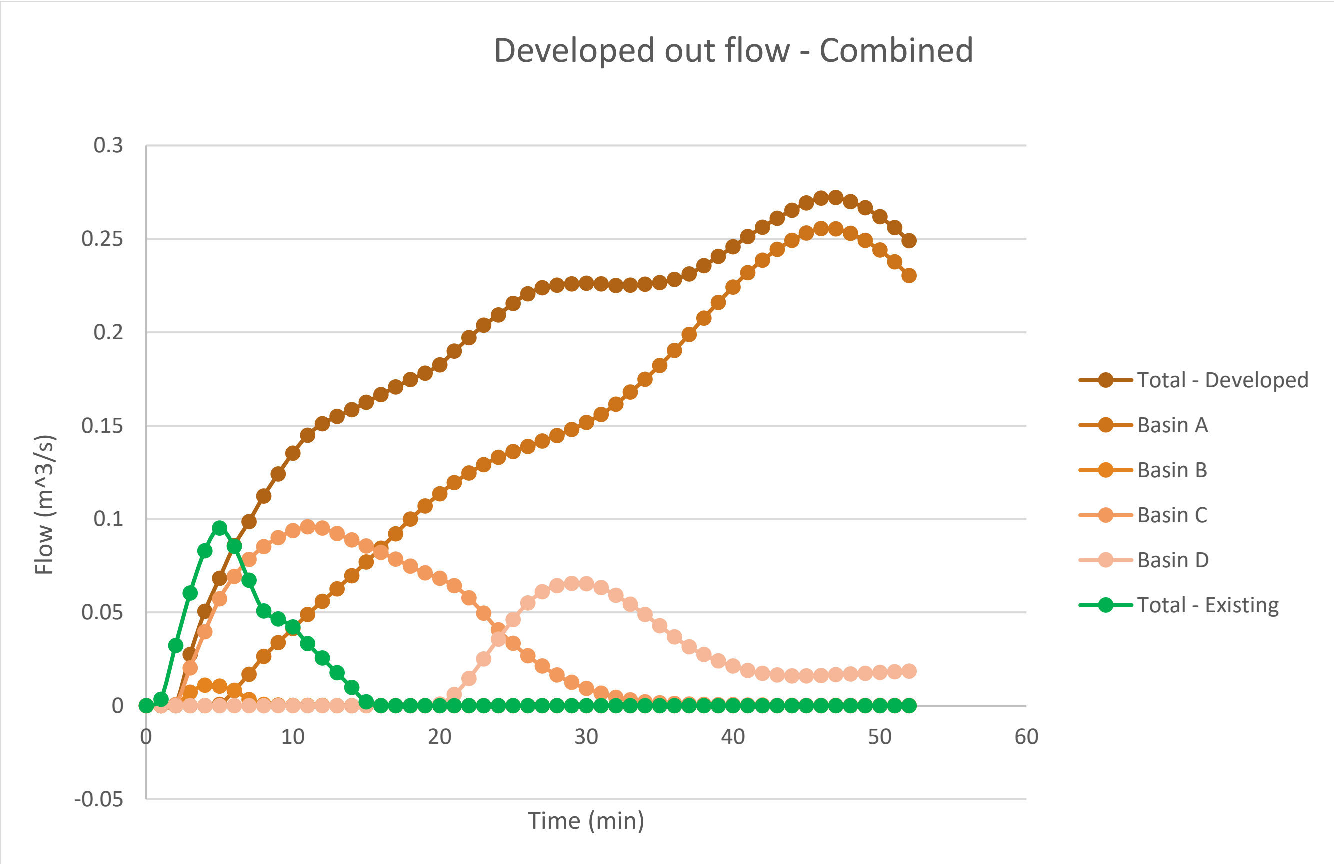

Appendix B CV: Jon ALEXANDER, Ecologist

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