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EXECUTIVE SUMMARY

This report has been undertaken for Lendlease to assess 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 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
- Stormwater management for the site incorporates rainwater tanks and re-use of rainwater for irrigation
- The annual flow volumes for the current design are higher post development than pre development but can be mitigated by removing the proposed bio-basin lining and providing additional infiltration downstream of the basins, noting that the location is directly adjacent to the wetland and infiltration to groundwater would quickly connect to the basin. The groundwater in the existing condition is connected to the wetland and therefore adding infiltration provides limited practical benefit.
- The impact of increased and more frequent flows on the wetland is assessed as minimal, however it is recommended that staging the basin outlets to reduce peak discharges during more frequent events than the 1% and 5% AEP design events be considered
- 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

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 (14ML/yr).

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 options, Section 4. The ecological impact of this has been assessed in Section 5.

2.3 Reducing post development flow volume

Using the recommended MUSIC model parameters indicates that reducing post development annual flow volume to pre-development levels required an increase in basin size of almost 15 fold, using lined basins, which is not feasible.

A detailed review of geotechnical data found results from permeability testing (W&G 2018) indicating that the infiltration rate on site is very high, being approximately 60mm/hr. Therefore removing the liner from the basins would assist in reducing total outflow.

The development site has high permeability rates in the lower levels where the basins are located, and it is likely that the existing infiltration makes its way to the wetland via groundwater. This is discussed in Section 3.4. with an infiltration trench used to model the groundwater infiltration showing that it is possible to reduce annual surface flow volumes.

Infiltration trenches are not recommended on the slope where the development is located without detailed stability analysis.

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 2 and

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

Table 2: 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 3: 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 DRAIN 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 4.

Table 4: 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 5 shows the individual outflow from each basin.

Table 5: 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 6 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 6: 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 7 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 7: 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. Although not a design requirement to reduce these higher frequency flows, further assessment could be carried out to refine the basin outflow design (such as staged outlets) to reduce outflows to existing peak flows for a greater range of events to minimise the impact on the coastal 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 8 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 8: 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 m³/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. It is expected options shall be addressed during the design by RBG.

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 9: 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 10 and indicate high permeability values. The testing shows that rainfall readily infiltrates into the ground in the lower elevations of the site.

Table 10: 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.

When the MUSIC model is run with the basins unlined, and water recycling used at 14ML/yr (email from RBG) this infiltration rate

Table 11: Flow Volumes after Infiltration to groundwater

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	90.6	140
Basins unlined and water re-use for irrigation (14ML/yr)	90.6	112
Basins unlined, water recycling (14ML/yr), and 1000 m ² infiltration trench downstream of the basins	90.6	88.7

The modelling shows that making the basins unlined and allowing the basin outflow to connect and travel over an infiltration channel of 1000m² (say 250m long x 4m wide), then the flow volume is reduced to pre-development levels. Given that the infiltration trench is only transferring surface flow to groundwater flow immediately adjacent to the wetland, to which the groundwater is connected, there is no advantage in constructing a custom infiltration trench.

3.4.1 Recommendation

To reduce outflow volume, it is recommended that the bioretention basins be unlined and that the outlet channels be extended along the contour with wide flow spreaders to connect to the wetland (1%AEP velocity < 1m/s). The risk to be considered with this option is if there is a concern that contaminant spills from upstream could infiltrate to the wetland through the infiltration rather than being contained in a lined basin.

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.

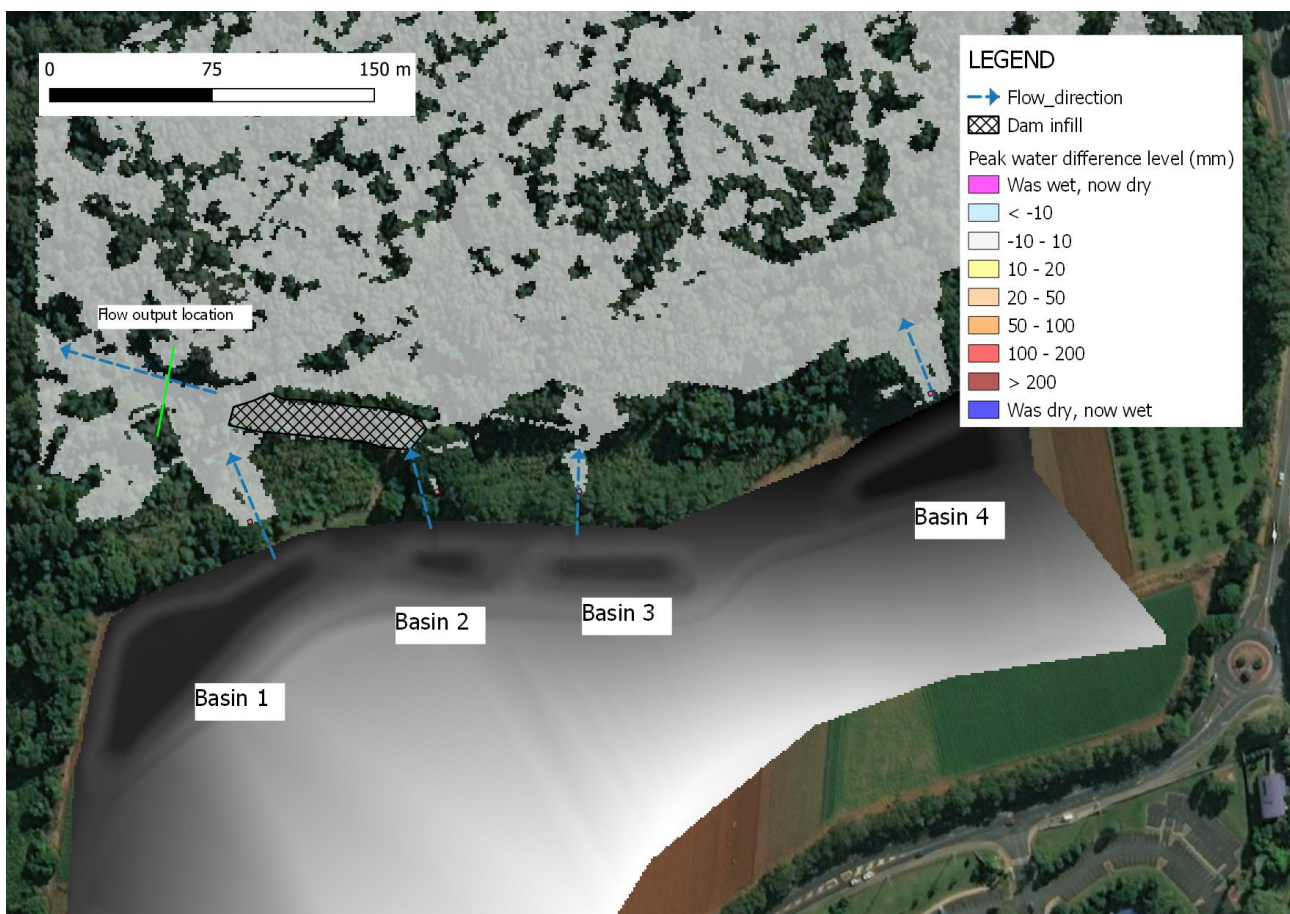


Figure 3: 1% AEP Peak flood level impact map

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.

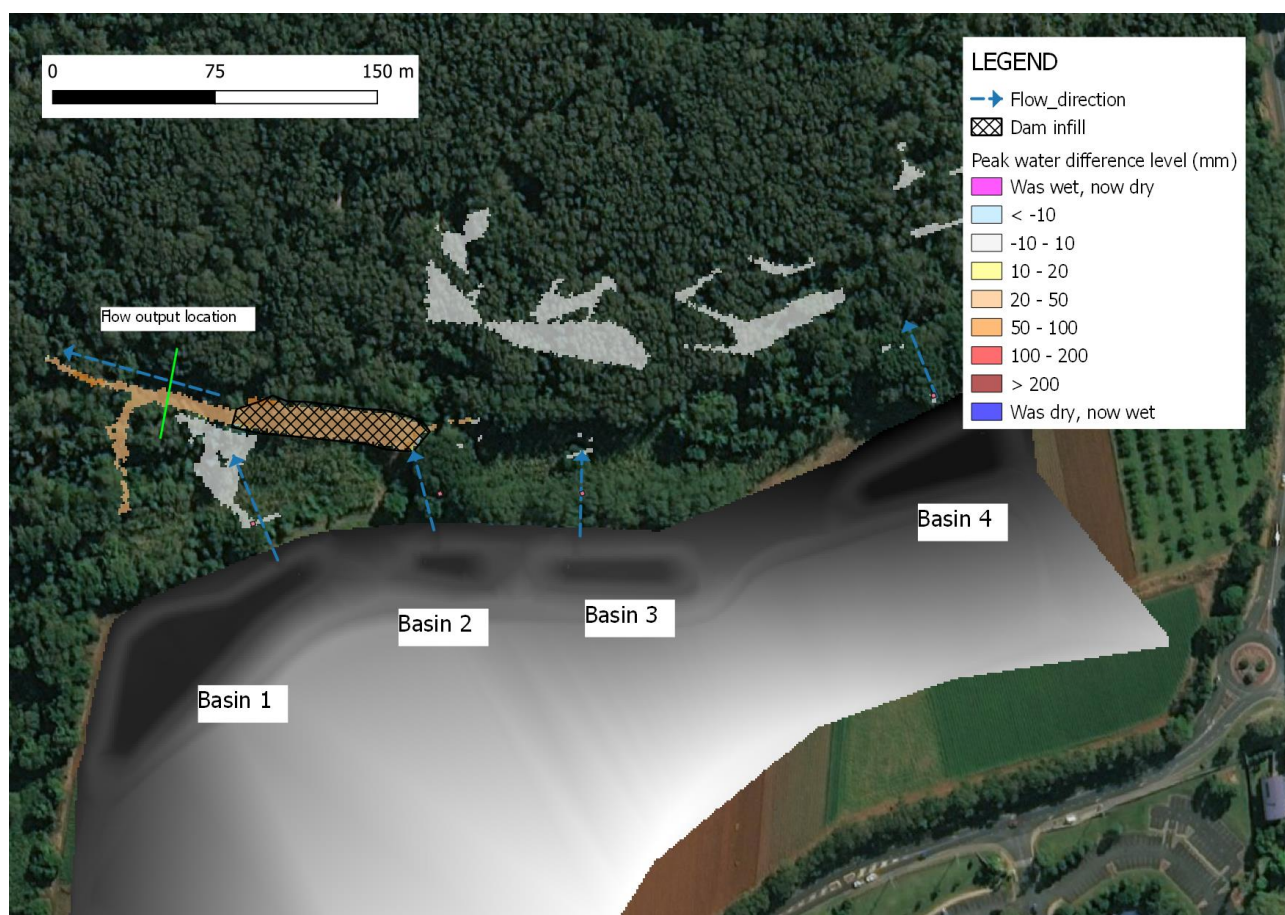


Figure 4: 4EY Peak flood level impact map

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.

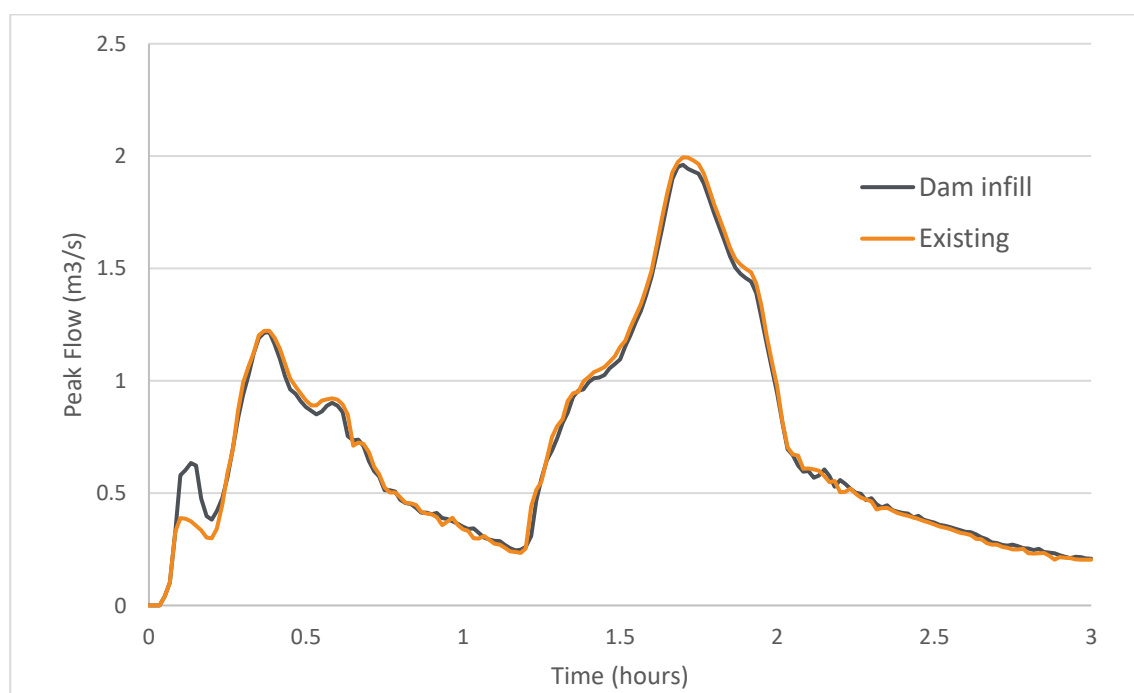


Figure 5: 1% AEP dam outflow hydrograph

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

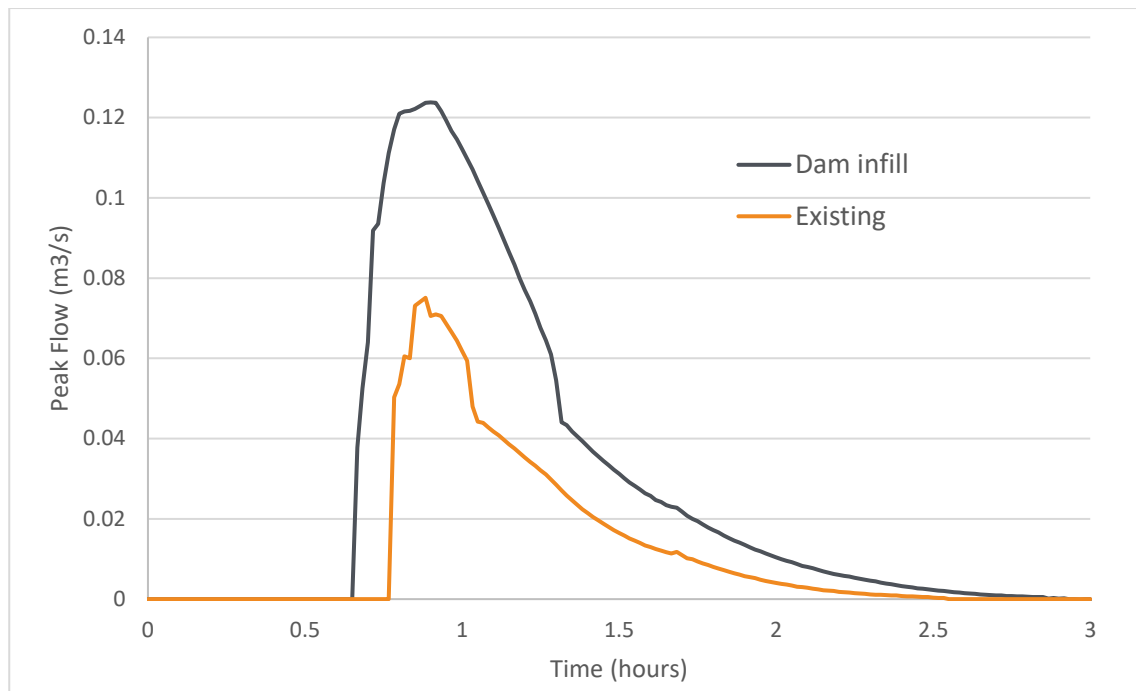


Figure 6: 4EY dam outflow hydrograph

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 typically 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 *Schoenus brevifolius*; 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-leaved 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 sedgeland 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.

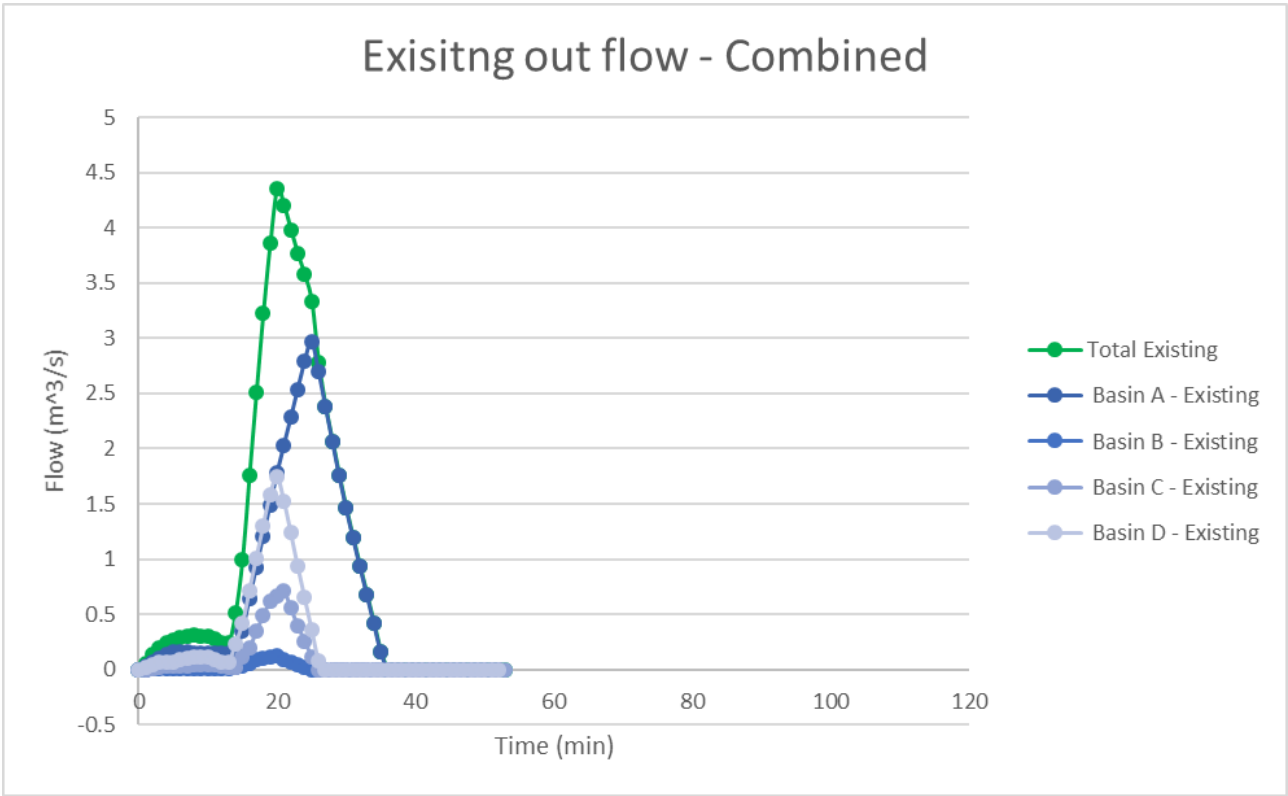
If the species are present, the reduction in sediment load and residual agricultural chemicals, resulting from the changed landuse and improved stormwater management is likely to be beneficial to these species.

6 References

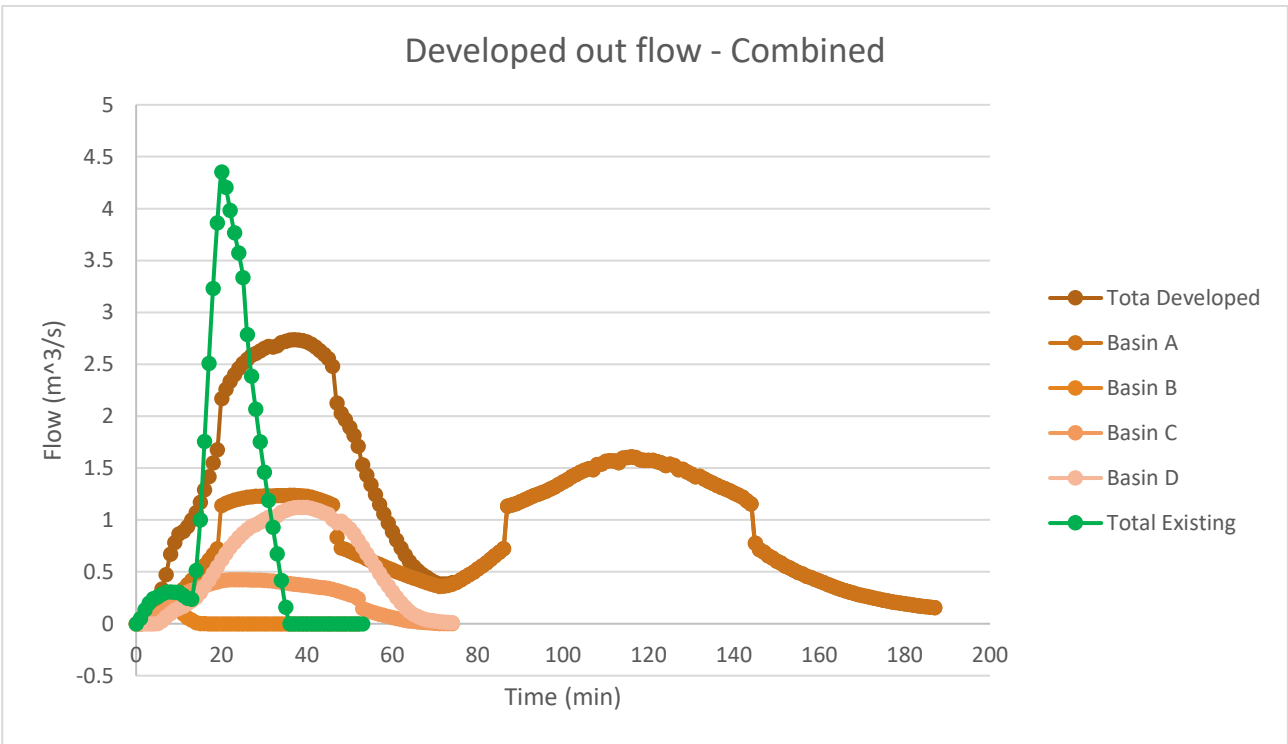
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- Stanisic, J. (1998). Survey for Land Snail *Thersites mitchellae* in Northern New South Wales. Unpublished report prepared for NSW National Parks and Wildlife Service.
- Shuker, J.D. and Hero, J. (2012) Perch substrate use by the threatened Wallum Sedge Frog (*Litoria olongburensis*) in wetland habitats of mainland eastern Australia. *Australian Journal of Zoology* 60: 219–224.
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- W&G (2018), Wood and Grieve Engineers Pty Ltd, Additional Geotechnical Investigation - proposed Tweed Valley Hospital, by Morrison Geotechnic.

Appendix A DRAINS – Hydrograph outputs

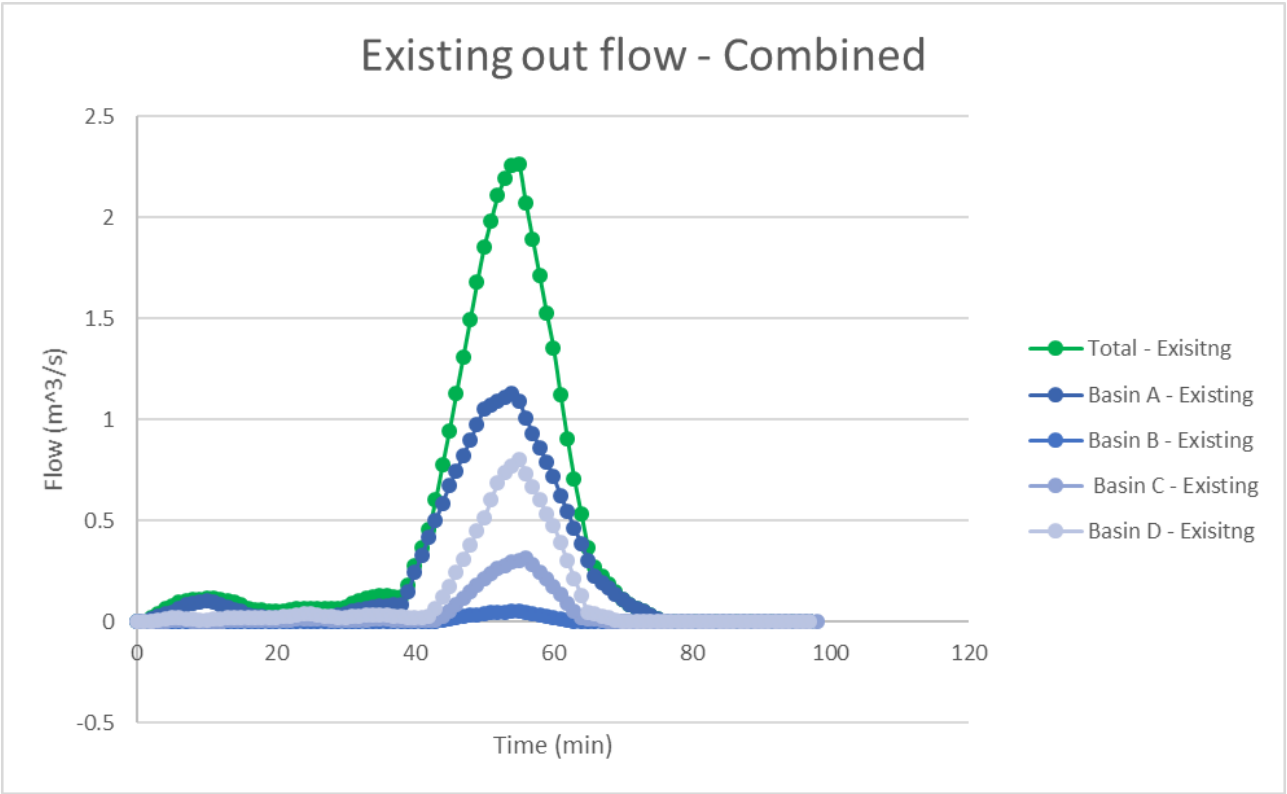
1% AEP – Existing



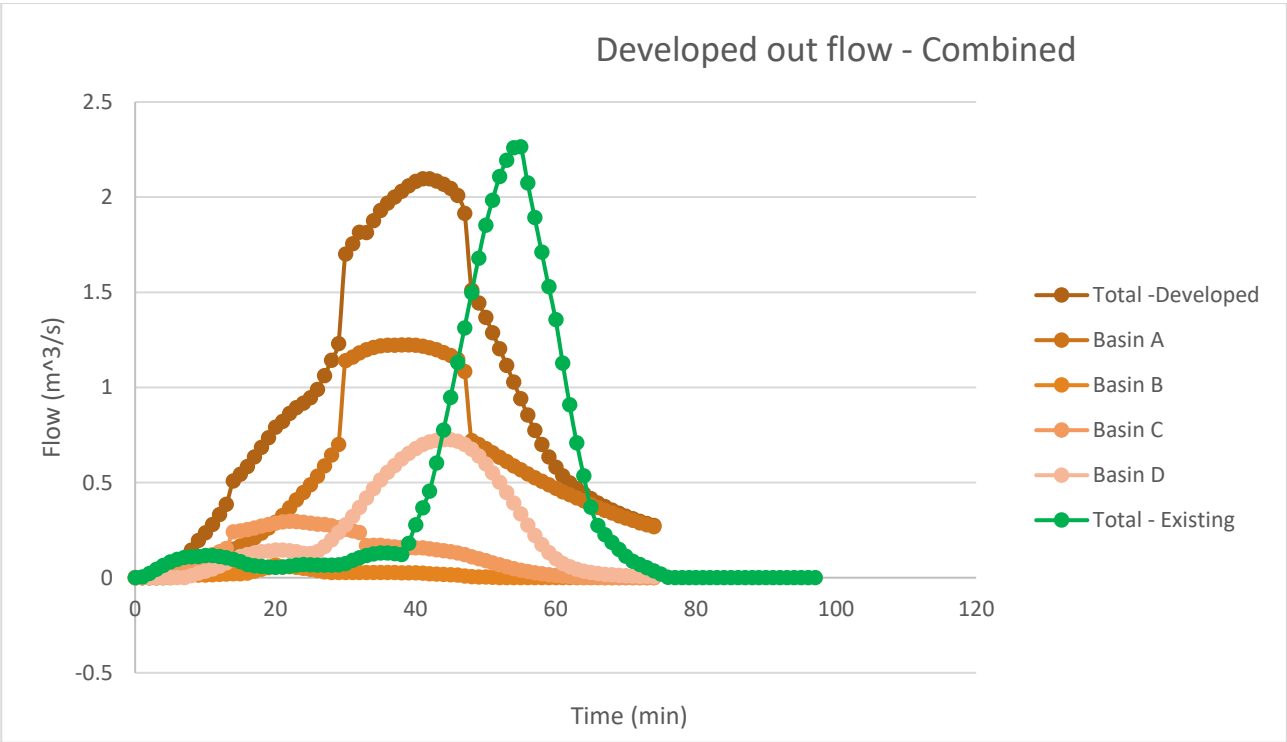
1% AEP – Developed



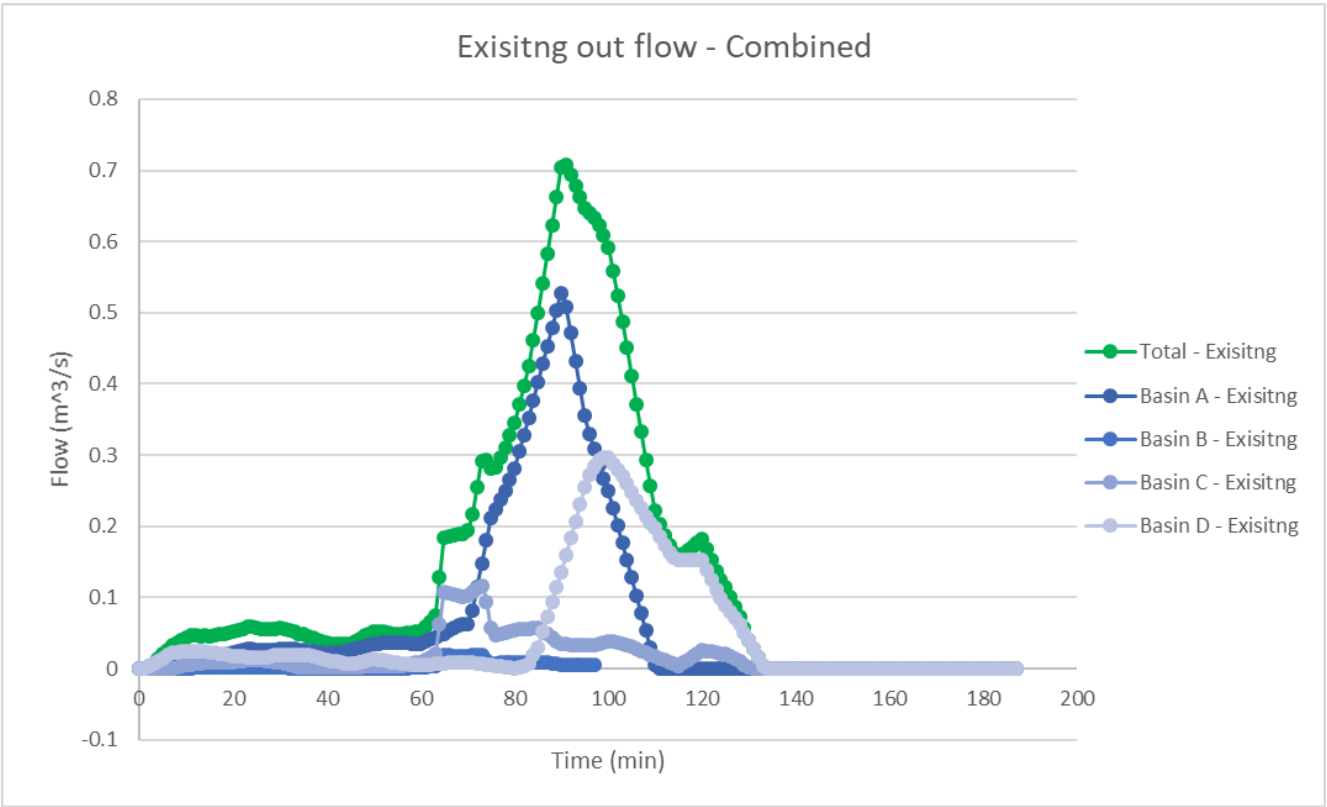
20% AEP – Existing



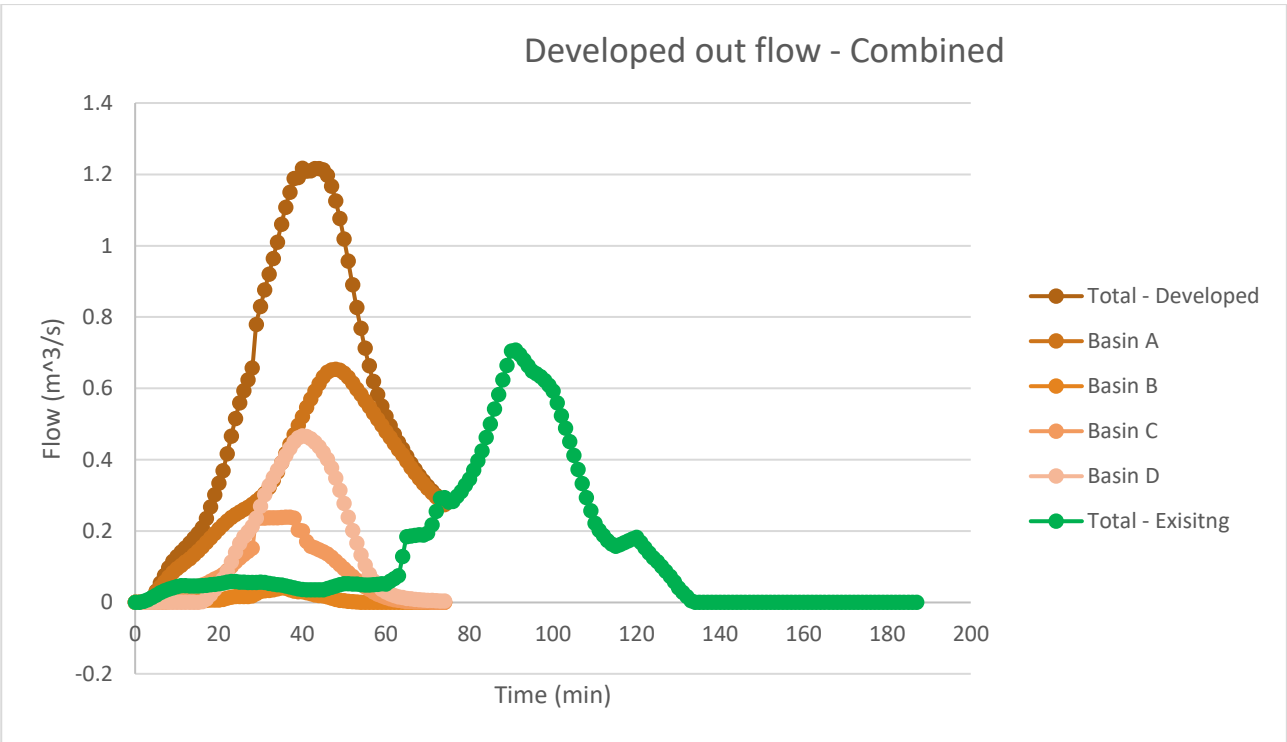
20% AEP – Developed



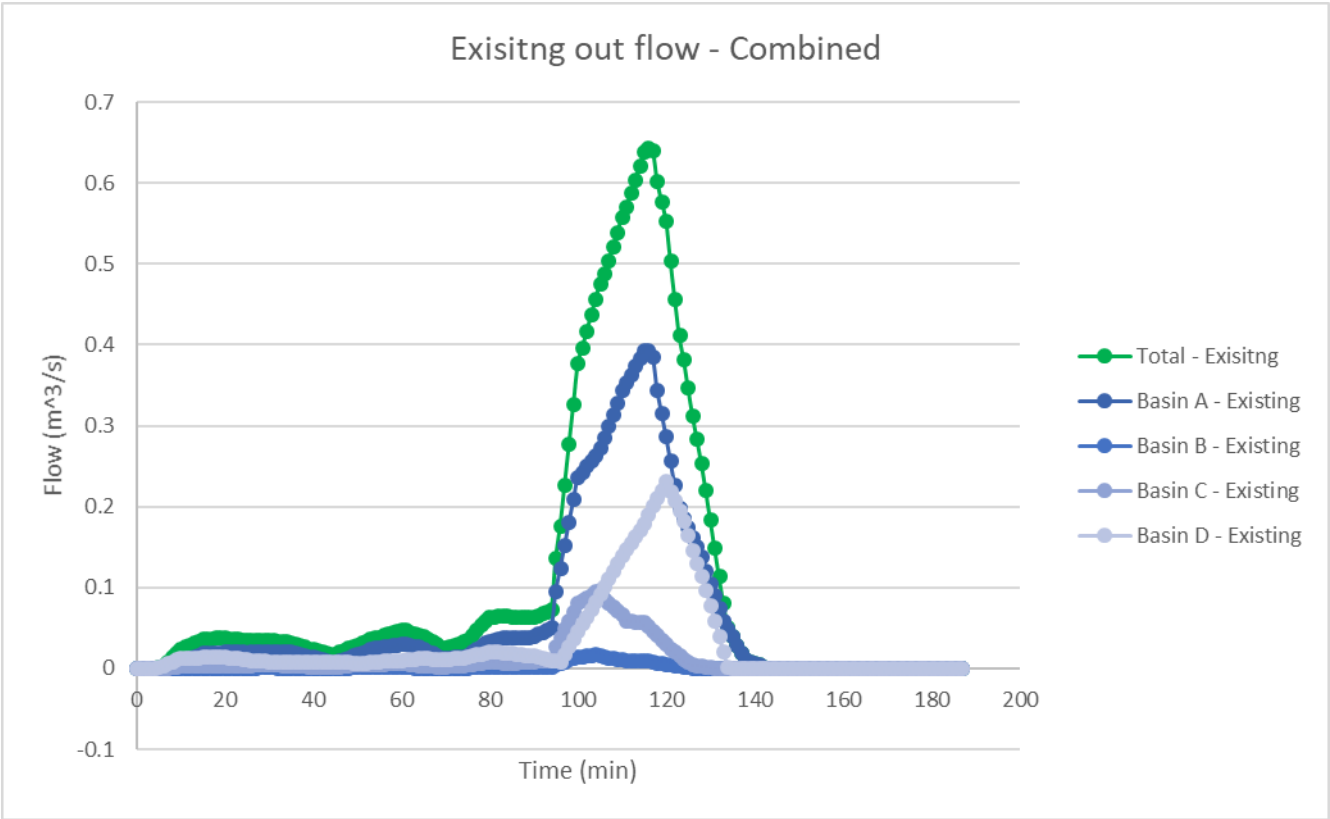
50% AEP – Existing



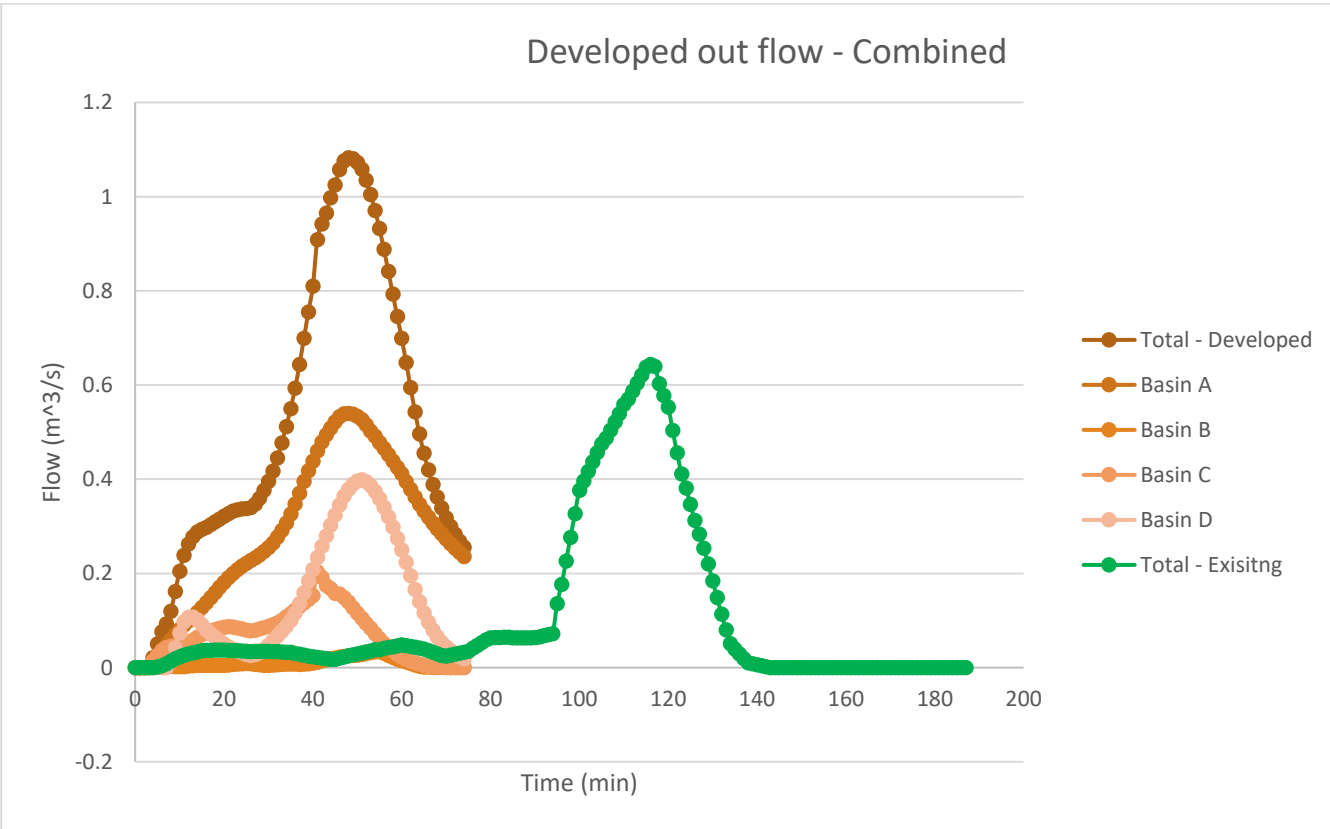
50% AEP – Developed



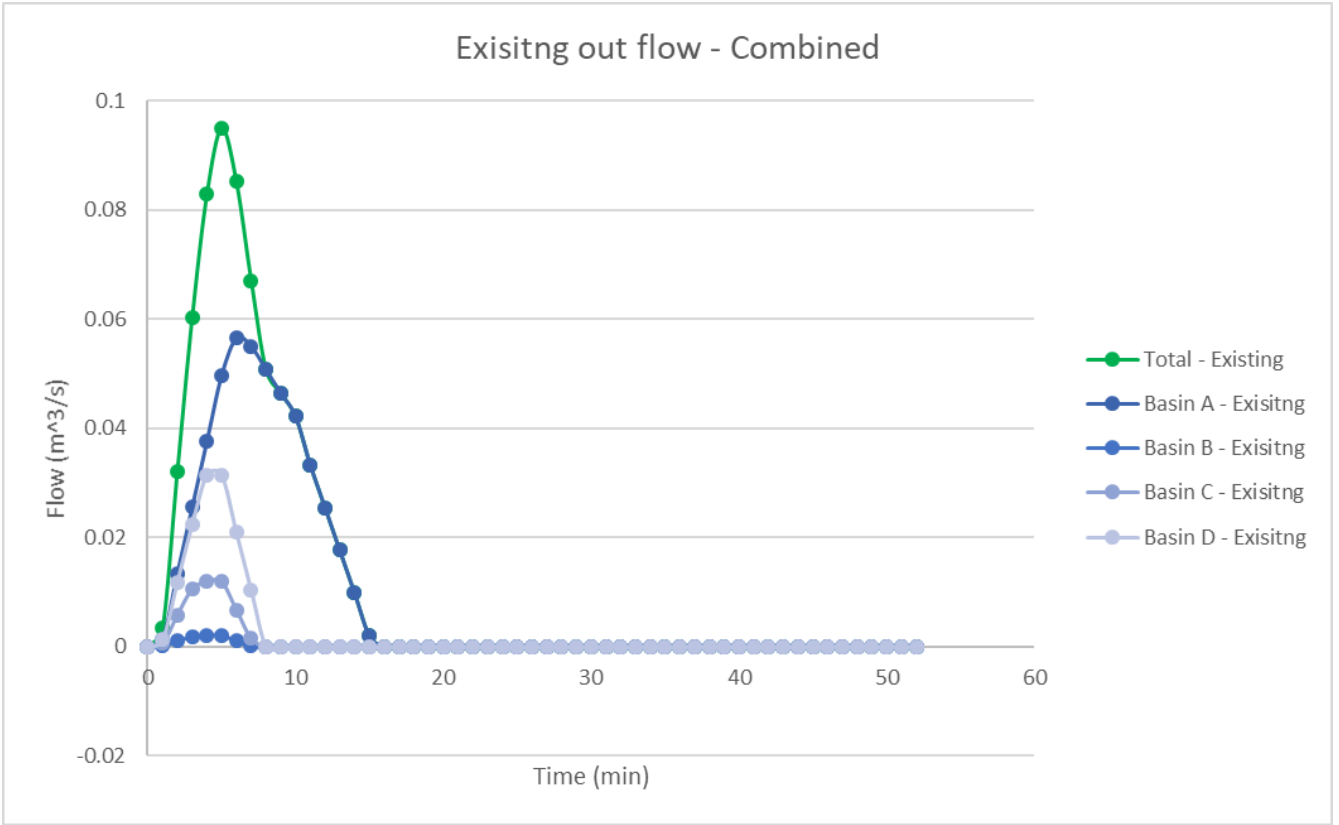
1EY – Existing



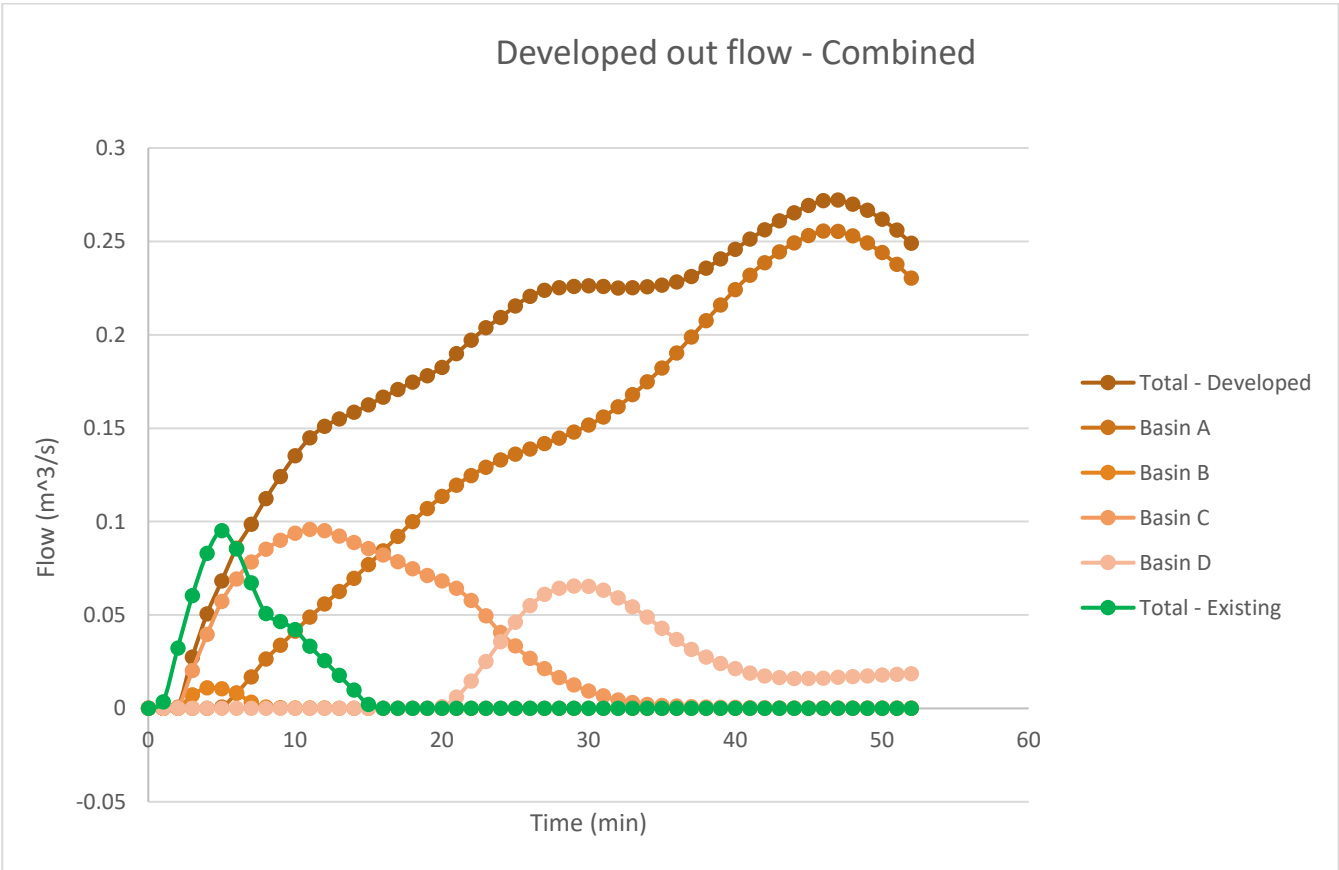
1EY – Developed



4EY – Existing



4EY – Developed



Appendix B CV: Jon ALEXANDER, Ecologist



Jon Alexander

Principal Ecologist

Professional Overview

Jon has over 25 years' experience in Ecological Assessment, Management and Planning with particular expertise in terrestrial vegetation ecology, Threatened species survey and conservation, vegetation rehabilitation and biodiversity related impact assessment.

Jon has been with SMEC for over 11 years and his areas of responsibility include assessment of environmental impacts on a diverse range of projects ranging from open cut mining and large scale linear infrastructure projects to ecotourism resorts and residential subdivisions.

Relevant Project Experience

Tugun Bypass Project Value (Construction) \$500 Million.

Client: QLD DTMR/NSW RMS

Environment Manager of the operational component of the Tugun Bypass project. Responsible for delivery of an extensive post construction environmental monitoring program including survey of ENVT flora species and monitoring of ENVT Flora Translocation sites and detailed reporting to multiple stakeholders.

Cobaki Estate – Saltmarsh Rehabilitation Plan

Client: LEDA Manorstead Role: Project Manager

Preparation of a rehabilitation management plan and conducting of a baseline monitoring plan for a 75 ha saltmarsh rehabilitation project. This includes detailed vegetation mapping and ongoing monitoring of the site once rehabilitation has been undertaken.

Groundtruthing of Vegetation Mapping (Tamworth region)

Client: NSW National Parks & Wildlife Service

As part of a State wide Vegetation mapping exercise acted as a consultant botanist conducting Floristic survey and groundtruthing of NPWS vegetation mapping of the Tamworth area, North NSW. Project required survey of 96 full floristic sites.

Targeted Threatened Species Survey (*Grevillea beadleana*)

Client: NSW NPWS Northern Directorate

Conducted a targeted 2 week survey for the nationally endangered species *Grevillea beadleana* on the NSW northern tablelands and northwest slopes and plains.

Targeted Threatened Species Survey (*Hakea pulvinifera*)

Client: NSW NPWS Northern Directorate

Conducted a targeted 2 week survey for the nationally endangered species *Hakea pulvinifera* on the NSW northwest slopes and plains.

Groundtruthing of Vegetation Mapping (Blackville, NSW)

Client: Department of Land and Water Conservation

Floristic survey and groundtruthing of DLWC vegetation mapping of the Blackville Area, Central Western NSW. 120 full floristic sites.

Years of Industry Experience

25+ years

Qualifications and Memberships

- Bachelor of Applied Science (Hons). (Environmental Planning Major) Southern Cross University, Lismore. N.S.W.
- Bachelor of Applied Science. (Natural Resources) Southern Cross University, Lismore. N.S.W.
- Associate Diploma of Horticulture, Hawkesbury Agricultural College, Richmond. N.S.W
- Member of the Ecological Society of Australia
- Member of the Environment Institute of Australia and New Zealand

Key Skills and Competencies

- Flora Survey & Vegetation Assessment
- Terrestrial Ecology
- Vegetation Rehabilitation
- Bushfire Management
- Environmental Monitoring, Survey and Design
- Environmental Impact Assessment

Dunngir National Park Pest Management Planning**Client: NSW National Parks & Wildlife Service**

Project involved survey and mapping of significant weed infestations throughout Dunngir National Park and preparation of a Weed and Vertebrate Pest management plan for the entire Park.

Lismore Mullumbimby 132kv Line Upgrade, NSW -**Client: Transgrid**

Principal Botanist for this project. Responsible for targeted flora survey along the 45 km corridor. Locate, identify and map the location of listed threatened species within the corridor. Identify measures for management of impacts associated with construction and operational phases of the project. Provide input to amelioration and rehabilitation plans.

Flora Survey Mt Kaputar National Park Central Section**Client : New South Wales National Parks & Wildlife Service, Narrabri District**

In collaboration with J.T.Hunter. Full floristic survey of Mt Kaputar National Park Central Section. Installation of 70 full floristic sites. Mapping of vegetation communities throughout the area and preparation of a detailed Report regarding the flora of the Park.

Flora Survey of Myall Lakes National Park**Client: New South Wales National Parks & Wildlife Service, Central Coast**

In collaboration with J.T.Hunter. Conducted a full Floristic survey of Myall Lakes National Park including installation of 100 full floristic sites. Prepared detailed mapping of vegetation communities throughout the area and prepared a detailed Report regarding the flora of the Park.

Flora Survey of sections of the Pilliga Nature Reserve**Client : New South Wales National Parks & Wildlife Service, Western Zone Dubbo**

In collaboration with J.T.Hunter. As part of a much larger exercise being run by the NSW NPWS conducted a floristic survey of parts of the Pilliga Nature Reserve. This included installation of 54 full floristic sites and preparation of raw data for incorporation into overarching reporting.

Flora Survey of additions to Guy Fawkes National Park.**Client : New South Wales National Parks & Wildlife Service, Glen Innes District**

100 sites full floristic survey of additions to Guy Fawkes National Park. Other works included air photo interpretation. vegetation community mapping, preparation of a detailed report on the flora of the park addition.

EIS Flora Survey, Woodburn - Ballina Highway Diversion, NSW**Client: NSW RMS**

Principal Botanist. This project was conducted as part of the route selection studies for the EIS of the Woodburn – Ballina Highway diversion and upgrade. The survey was conducted over the 5 proposed alternate routes and was used to help in the corridor selection process. Major tasks were field investigation and identification of significant flora and flora communities, detailed vegetation mapping, involvement in community consultation processes and provision of recommendations for corridor selection and supply of advice on rehabilitation of impacted areas

Clarence River (Kangaroo Creek Dam) Riparian and Instream Flora Survey, NSW**Client: NSW Public Works**

Principal Botanist. This survey was conducted as part of the location selection planning studies prepared for the proposed Kangaroo Creek Dam. Principal tasks involved full floristic survey, vegetation mapping, and preparation of GIS coverages and air photo interpretation of approximately 30 sites across the lower Clarence catchment.

Shannon Creek Dam Flora Survey**Client: NSW Public Works**

Principal Botanist. This survey was conducted as part of the planning studies prepared for the proposed Shannon Creek Dam. Major tasks involved a full floristic survey of the dam inundation area, vegetation mapping and air photo interpretation.

NCA Protected Plant Flora Trigger Surveys**Client: Various clients (Brisbane CC, GC Water, DTMR and Private Developers)**

Completed 30 surveys of this nature since the Flora trigger Protected Plant requirement was introduced. All Surveys have been conducted in accordance with the relevant guidelines and all reporting has been accepted with no requests for additional information from State agencies.

Moreton Bay Rail Link – Saltmarsh Rehabilitation Plan**Client – Qld TMR Role: Technical reviewer**

Technical review of a multi-site Saltmarsh Management and rehabilitation plan, as part of the offsetting requirements associated with the Moreton Bay Rail Link project.

Ipswich Motorway Upgrade (Dinmore to Goodna)**Client: Qld DTMR**

Principal Botanist. Conducted detailed surveys for EVR species and communities and provided reports to inform the road design/ statutory approvals process. Also conducted detailed investigations and provide mapping of declared and environmental weeds.

Ipswich Motorway Upgrade (Rocklea to Darra)**Client: Qld DTMR**

Principal Botanist. Conducted detailed surveys for EVR species and communities and provided reports to inform the road planning and preliminary design process. Also conducted detailed investigations and provide mapping of declared and environmental weeds.

Ecological (Flora and Fauna) Assessment**Client: Tiger International**

Yeeda Station (WA) as lead ecologist completed detailed flora and fauna surveys and associated feasibility analysis for the establishment of a large scale aquaculture facility (1000 ha).

Daru Island (PNG) – Deep Water Port – EIS**Client: PNG Sustainable Development**

Principal botanist/ team leader for flora assessment's required to support the preparation of the Environmental Impact Statement for the proposed deep water port at Daru Island, PNG.

Provision of Expert Witness Services**Client: Dept of Environment (Commonwealth)**

Provision of expert witness advice to assist the Dept of Environment in the prosecution of landholders, under the EPBC Act for the alleged deliberate destruction of an area of endangered plant community. This involved flora survey of remaining vegetation community, provision of a detailed assessment of floristic structure and provision of expert opinion regarding the likelihood of regeneration.

New Oakleigh and Akland Mines Rehabilitation Monitoring**Client: New Hope Coal**

Design and implementation of a mine vegetation rehabilitation monitoring program. This involved flora baseline survey, design of rehabilitation acceptance criteria in accordance with existing mine approvals and ongoing six monthly monitoring (Flora survey) of rehabilitation areas. Survey and rehabilitation planning advice for

Mangrove Health Monitoring**Client: Pacific Reef Fisheries (Bowen)**

Annual monitoring (flora survey and floristic structure assessment) of Mangrove communities in accordance with the GBRMPA approval conditions for Pacific Reef Fisheries Aquaculture facility

Mangrove Health Monitoring**Client: Australian Prawn Farms Pty Ltd (Sarina)**

Annual monitoring (flora survey and floristic structure assessment) of Mangrove communities in accordance with the GBRMPA approval conditions for Australian Prawn Farms Aquaculture facility.

Mangrove Health Monitoring

Client: Harbor Light Prawns Pty Ltd

Annual monitoring (flora survey and floristic structure assessment) of Mangrove communities in accordance with the GBRMPA approval conditions for Harbor Light Prawns Aquaculture facility.

North Curtis Island Ecotourism Facility

Client: Universal Partners

Survey, delineate and mapping of vegetation communities across the 2500ha North Curtis Island site to allow preparation of a Property Map of Assessable Vegetation (PMAV)

local people
global experience

SMEC is recognised for providing technical excellence and consultancy expertise in urban, infrastructure and management advisory. From concept to completion, our core service offering covers the life-cycle of a project and maximises value to our clients and communities. We align global expertise with local knowledge and state-of-the-art processes and systems to deliver innovative solutions to a range of industry sectors.