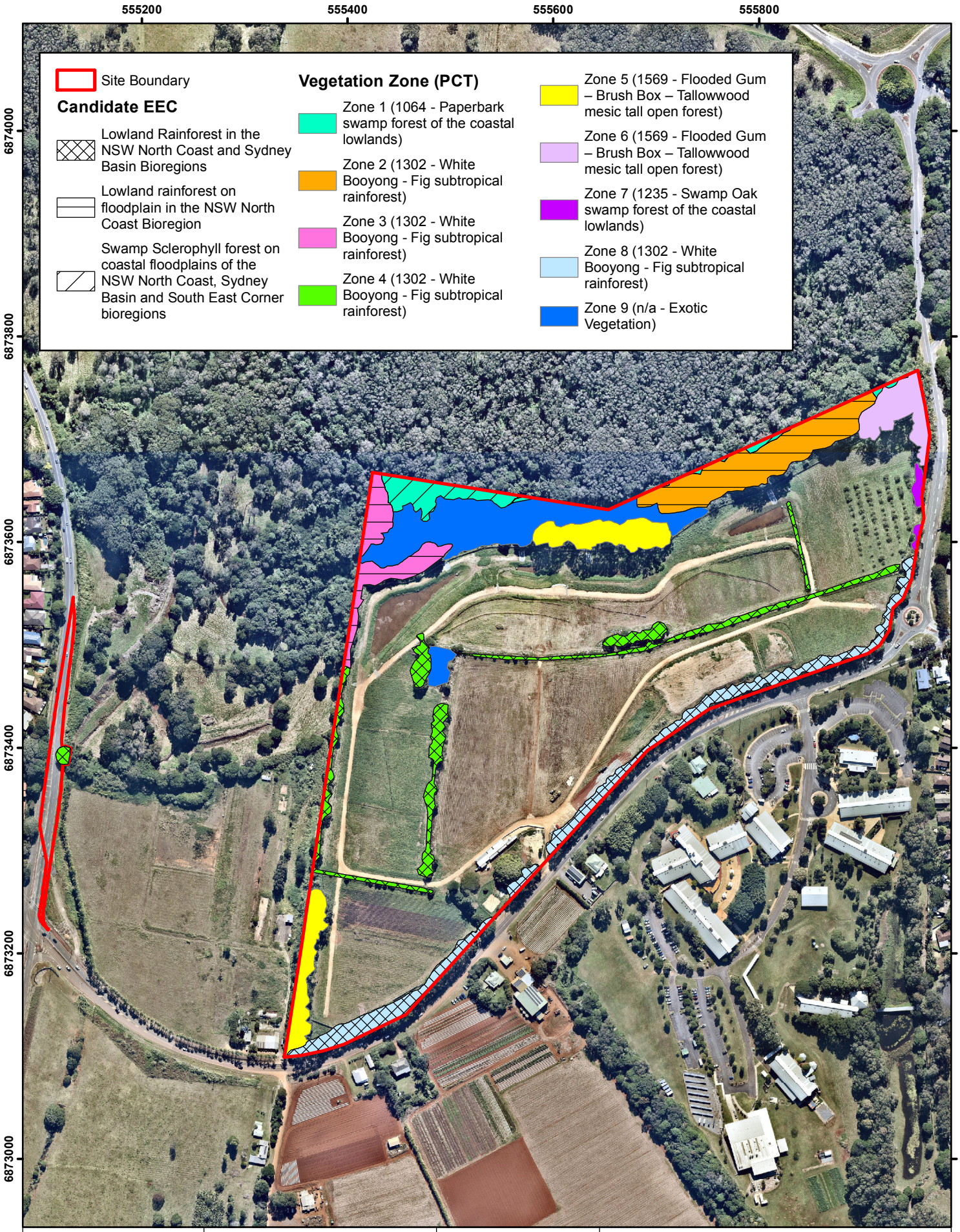

Client: C107778	N 0 50 100 m	Scale (@A4): 1:4,750	**Threatened Ecological Communities**
Job #: J156455-13			
Author: D. Correa	Coordinate System: GDA 1994 MGA Zone 56		
Checked: C. Maloney	*Imagery 15th July 2019 (7.5 cm) © Nearmap 2019*	Tweed Valley Hospital Condition B31c Report 771 Cudgen Road Cudgen NSW	**Figure 4**
Date: 19/08/2019	*Vegetation mapping: Greencap (2018)*		
GREENCAP			

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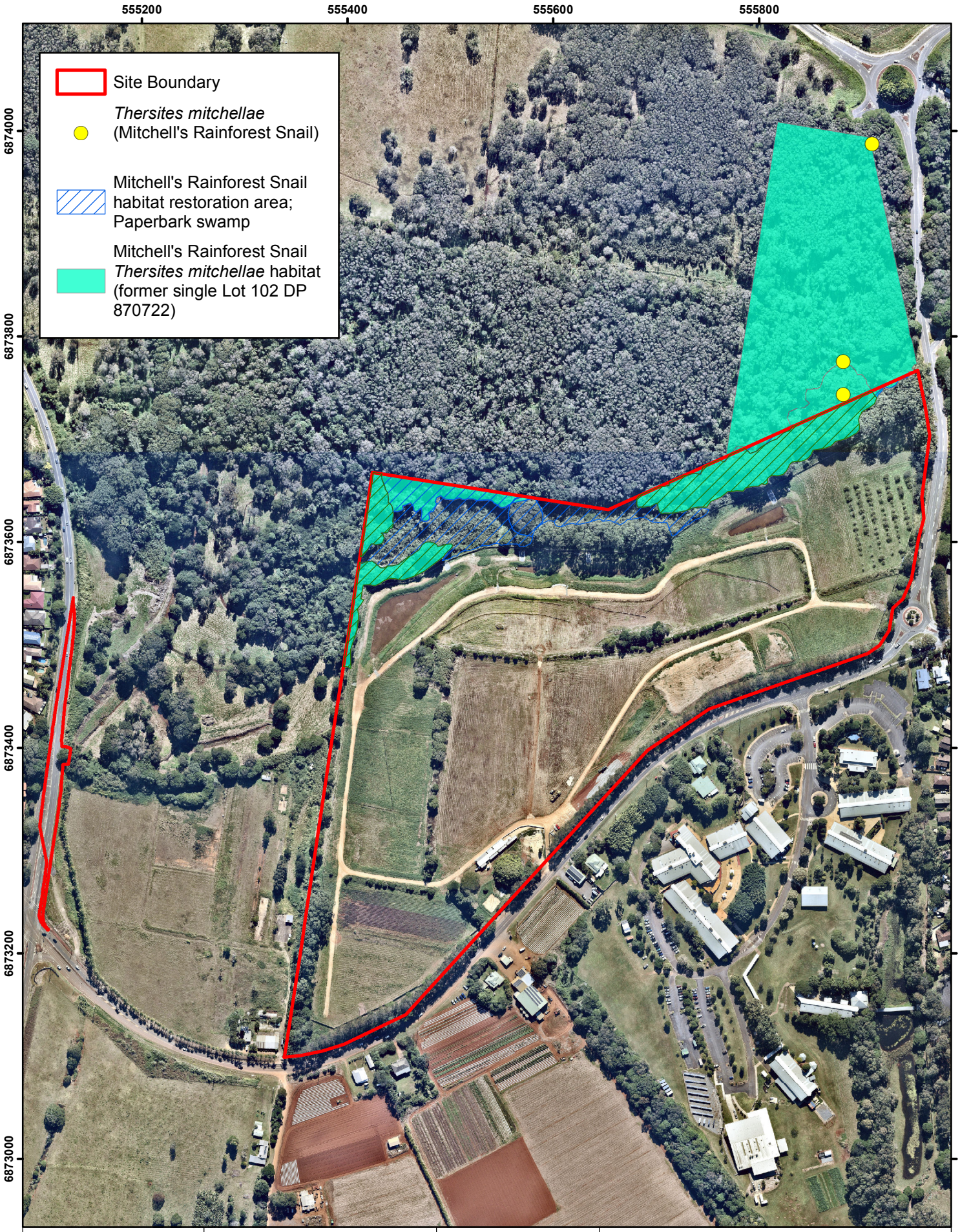
Doc Path: \\ser2bne1\Brisbane_Projects\C107778_Health Infrastructure\J156455_Tweed Valley Hospital\3. Job Folder\GIS\J156455_13_TVHs2\B31c Report\mxds\J156455_13_B31cReport_F04_TEC_site_190819.mxd



Client: C107778	N 0 50 100 m	Scale (@A4): 1:4,750	**Mitchells Rainforest Snail Habitat and Survey Results**
Job #: J156455-13			
Author: D. Correa	Coordinate System: GDA 1994 MGA Zone 56		
Checked: C. Maloney	*Imagery 15th July 2019 (7.5 m) Nearmap 2019*	Tweed Valley Hospital Condition B31c Report 771 Cudgen Road Cudgen NSW	**Figure 5**
Date: 19/08/2019	*Vegetation mapping: Greencap (2018)*		
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5 HYDROLOGY

5.1 Current (Pre-development) Hydrology

The site topography falls generally from south to north with an overall fall from approximately RL 27m AHD at the highest point near the southern boundary, to approximately RL 1m AHD at the lowest point on the northern boundary. The land to the north of the site is an existing low-lying wetland forest which is within the floodplain of Tweed River with flood levels of approximately RL 3 – 3.5m AHD in the 1% annual exceedance probability (AEP) flood (RBG 2019).

Apart from a bund that has been constructed along the western boundary of the Site which adjoins an open drain, under the previous land use there was no stormwater management system in place. In the western section of the Site the aspect of the land is roughly west to north-west and the bund currently directs untreated stormwater flows to three discharge points that have been bulldozed through the bund wall. The topography of the Site and ploughed furrows generally directs sediment-laden stormwater to run downhill and discharge directly via sheet flow across the land into the receiving catchment and wetland located to the north of the Site.

A flood assessment carried out for the Project determined that the northern part of the site within the Tweed River floodplain is subject to regular inundation (BMT, October 2018). The TECs located within the wetland area are species which are generally located in areas subject to periodic inundation (NSW Scientific Committee 1999).

An agricultural dam is situated in the north west corner of the site. The dam consists of an excavated area and an earth bund to retain water for presumably for irrigation. Currently, there is an infestation of *salvinia molesta* growing in the dam. In order to prevent further infestation, decrease on going control requirements, it has been recommended that the dam is backfilled and decommissioned so that this portion of the site returns to a more natural state of flow to the wetland to the north (Greencap 2019). The location of the existing dam is shown in Figure 1.3 of the SWMP (RBG 2019).

A constructed, east-flowing floodplain drain drains the catchment and strikes roughly north-east through the northernmost portion of the former Lot 102 DP 870722, which is situated north of the Project Site.

5.2 Post Development Hydrology

The storage volumes of the converted basins have been modelled to ensure that the combined post development discharge from the basins is no greater that the pre-development flow. The preliminary DRAINS model confirms that there is no increase in the total site discharge rate in the 5-year and 100-year ARI storm events (RBG 2019). However, the discharge from the bio-detention basins will be via four surface headwalls, which would therefore not produce an exact match to the existing flow regime. This may result in some amount of concentration of flow rather than the existing sheet flows (RBG 2019), however the rock scour protection will dissipate the water via sheet flow across the land to mitigate any direct impact on native vegetation directly within the discharge area.

An assessment of the potential ecological impact on the coastal wetlands to the north of the site as a result of any changes to hydrology (flow regimes) caused by the Project was undertaken by SMEC (2019). The assessment considered EECs, TECs, threatened species and the overall biophysical, hydrological and ecological integrity. Modelling results indicated that the Project will have minimal impact on the coastal wetland estimated water levels. For detailed results on the hydrology (flow regimes) modelling please refer to SMEC 2019. The modelling conducted as part of the assessments predicts a mean total annual flow from Site to increase by almost 50% from 90.6 ML/yr pre-development to 140 ML/yr post development. This volume increase is due to: a predicted greater frequency of minor runoff events into the wetland, more

frequent than the 20% AEP; approximately 10 to 20mm of additional inflow from the developed site during significant events for parts of the wetland and 10 to 50mm within the dam. Mitigation measures to reduce modelled higher frequency flows further are outlined in **Section 5.3** below.

The potential impacts of these additional flows on the EECs identified on the Site, MRS and two pH dependent threatened species (i.e. Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis*) were assessed by Jon Alexander, an ecologist and suitably qualified professional (SMEC 2019). In summary, the assessment found that the predicted minor increases in flow are unlikely to result in any apparent or significant impacts due to;

- The coastal wetlands to the north of the site are dominated by Broad-leaved Paperbark *Melaleuca quinquenervia*. Although this species cannot survive permanent inundation, it has adaptations such as fibrous roots around their lower trunk that are understood to allow the plant to respire during long periods of submersion. Furthermore, the mid- and understory species such as rushes, sedges, ferns and grasses are also adapted to periodic inundation.
- Predicted change in flood level from the Projects outflows is expected to be very small (<50mm). When compared to the existing flooding from the Tweed River (BMT 2018) which indicates inundation depths for the wetland of approximately 2m for the 5% AEP event and 3m for the 1% AEP event. Suggesting that the Paperbark swamp forest present are naturally resilient to large scale flood events in excess of the inflows likely to be a result of the Project;
- White Booyong – Fig subtropical rainforest community appears to be limited to the slightly elevated fringes of the Paperbark swamp forest and therefore is unlikely to be materially impacted by the additional inflows expected;
- The available information on MRS habitat suggests the species is dependent on high moisture levels, low fire frequency, and a well-developed leaf litter layer and are typically found on somewhat elevated ground around the edges of wetlands (DEE 2019; OEH 2019). It was assessed that the predicted change in inflow levels is unlikely to negatively impact or reduce the existing MRS habitat to the north of the site through permanent inundation;
- The Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis* prefer areas of generally different habitat such as inundated habitat with emergent sedge species. If present, there is no apparent likelihood that the additional inflows expected would negatively impact these species; and
- Additionally, if the above species are present, the expected improvement in water quality as a result of the Projects stormwater management system could potentially be of benefit. However, additional data from long term monitoring of these species would be required to assess any potential impacts as a result of the Project in greater detail.

Additionally, an analysis of the impact of any change in hydrological flows on the wetland as a result of infilling the dam was undertaken by SMEC (2019). The assessment identified that filling the dam back to natural ground level will have no impact on the 1% AEP (100 year ARI), the 20% AEP (5 year ARI) flood levels and no material impact from more frequent events post development (SMEC 2019). Mitigation measures to reduce any change in flow that could occur as a result of infilling the dam are outlined in **Section 5.3** below.

5.3 Post-development Hydrology Mitigation Measures

The impacts of any changes to hydrology (flow regimes) associated with the development on the EECs, TECs, threatened species located within the coastal wetlands to the north of the Site, and on the overall biophysical, hydrological and ecological integrity of the mapped wetlands within the Site and the adjoining lands is addressed below.

A flood assessment carried out for the project determined that the northern part of the site within the Tweed River floodplain and are subject to regular inundation (BMT 2018). The outlet pipes from the four proposed

bio-detention basins are above the existing 1% AEP flood level (approx. RL 3.5m AHD). All roads, buildings and other infrastructure will be constructed above the PMF flood level (approx. RL 8.0m AHD) (RBG 2019).

In respect of the TECs located within the wetland area, it is noted that these species are generally located in areas subject to periodic inundation (NSW Scientific Committee 2004). The storage volumes of the converted basins have been modelled to ensure that the combined post development discharge from the basins is no greater that the pre-development flow. The preliminary DRAINS model confirms that there is no increase in the total site discharge rate in the 5-year and 100-year ARI storm events (RBG 2019). Therefore, the sediment basins will function to limit the peak stormwater flow from the site to match the pre-development peak flows. However, the discharge from the bio-detention basins will be via four surface headwalls, which would therefore not produce an exact match to the existing flow regime which may result in some amount of concentration of flow rather than the existing sheet flows (RBG 2019).

An analysis of the impact of any change in hydrological flows on the wetland as a result of infilling the dam was undertaken by SMEC (2019) as described in **Section 5.2**. The report recommends that the detailed design of the dam infilling incorporate a minimal downhill grade, low flow channel or path to allow flows to travel from the upstream to the downstream side of the decommissioned dam and minimise the amount of ponding water that could become reinfested with *Salivina molesta* (SMEC 2019).

To reduce the modelled higher frequency flows (more frequent than the 20% AEP), mitigation measures recommended by SMEC (2019) will further minimise the impact on the coastal wetland. These include additional assessment to inform potential modification(s) in the basin outflow design, such as staging the basin outlets to reduce peak discharges and by removing the proposed bio-basin lining and providing additional infiltration downstream of the basins.

6 STORMWATER RUNOFF QUALITY

6.1 Pre-development Stormwater Runoff Quality

The pre-development land use was agricultural. Site observations during the biodiversity assessment associated with the development of the BDAR indicated that the cultivated fields were ploughed across the topographic contours (Greencap 2019a). Under this cultivation regime, sediment-laden stormwater was encouraged to run downhill through ploughed furrows. Observations also indicated frequent use of pesticides on the crops (Greencap 2019a). The aspect of the rest of the Site is roughly north and the ploughing regime directed sediment-laden stormwater to discharge directly into the receiving catchment and wetland located to the north of the Site. Furthermore, a Council owned drain carrying untreated stormwater flows from Turnock Street discharges directly into the receiving catchment. Surface water quality background data was collected in 2018, as described in **Section 6.3.3**.

6.2 Post-development Stormwater Runoff Quality

The proposed stormwater measures will collect stormwater from the new impervious areas of the site, including buildings, roads, car parks and other hard standings, and discharge treated water at a controlled rate to the existing wetland (ecological receptor) to the north of the site (RBG 2019).

As described in the SWMP (RBG 2019), the Projects stormwater design was prepared with consideration of the *Guidelines for Development Adjoining Land managed by the Office of Environment and Heritage* (OEH 2013). Also, the design was developed in accordance with the *Tweed Shire Council Development Design Specifications D5 – Stormwater Drainage Design* and *D7 –Stormwater Quality* (TSC 2016).

6.2.1 Stormwater Quality Model

Stormwater quality outcomes were modelled by RBG using MUSIC Version 6.2.1 software, the results of which are included in the SWMP (RBG 2019).

The Projects SWMP (RBG 2019) summarises the results of the MUSIC model that demonstrates compliance of the system with the water sensitive urban design (WSUD) objectives developed for the site, including:

- *Tweed Shire Council Development Design Specification D7 – Stormwater Quality – Tweed shire Council Water Quality Objectives* (TSC 2016); and
- No increase in the natural annual average load of nutrients and sediments in accordance with *Guidelines for Developing Adjoining Land managed by the Office of Environment and Heritage* (OEH 2013).

The MUSIC model assessed water quantity and water quality under the existing land use, across the following parameters:

- Flow;
- Total suspended solids;
- Total phosphorus;
- Total nitrogen; and
- Gross pollutants.

In summary, based on the SWMP (RBG 2019), predicted stormwater discharge water quality parameters will meet the water quality objectives in **Table 1**. These will be achieved by employing WSUD features that are described in more detail in **Section 6.3.**

Table 1 Water quality objectives

Pollutant	Minimum reductions in mean annual load from unmitigated development
Total Suspended Solids (TSS)	80% reduction
Total Phosphorous (TP)	60% reduction
Total Nitrogen	45% reduction
Gross pollutants .5mm (GP)	90% reduction

6.3 Stormwater Quality Mitigation Measures

The quality of stormwater entering the downstream wetland habitat of the EECs and threatened species listed in **Section 4.1** will be managed and monitored in accordance with the mitigation measures outlined below and in the Stage 1 BMP and Stage 2 BMP (Greencap 2019b; Greencap 2019c).

6.3.1 Pre-Construction and Construction Phase

Mitigation measures in place to manage stormwater discharge quality during the construction phase are in the form of Erosion and Sediment Control (ESC) and surface water management measures in accordance with *NSW Managing Urban Stormwater "Blue Book"* (Landcom 2004) and the *Tweed Shire Council Development Design Specifications D7 –Stormwater Quality* (TSC 2016); and in accordance with the Sites approved SWMP, ESCP, CEMP and associated CSWMSP which sets out the key items to manage stormwater runoff, as follows:

- Installation of four adequately sized sediment basins with a total capacity of 7,562 m^3 volume have been constructed to capture flows (Bonacci 2019);
- Regular inspections of basins;
- Retained capacity in detention basins;
- Test, treat and discharge collected stormwater off-site if it cannot be reused on site; and
- No discharge of non-compliant water or off-site pollution.

Sediment basins were constructed as part of preliminary works which will capture and treat stormwater on the Site during the pre-construction and construction phases of the project. Sediment basins will minimise the impact of any change in water quality and protect the TEC in the wetland area.

A series of bunds and swales will be installed to direct runoff from the majority of the earthworks areas to the four existing basins in the northern portion of the site. Any runoff from areas or earthworks which cannot be directed to the sediment basins will be treated by means of grass buffer strips and sediment fences (RBG 2019).

The sediment basins function by providing a large, standing body of water such that stormwater runoff entering the basins, which is laden with sediments, has a chance to settle to the base of the basin before it overflows via the weir into the receiving watercourse. The weir and headwalls have been constructed with rock scour protection which will dissipate the water via sheet flow across the land to mitigate any direct impact on native vegetation directly within the discharge area. The size of the sediment basins has been designed in accordance with the *NSW Managing Urban Stormwater "Blue Book"* (Landcom 2004). The basins have been designed for five-day rainfall, and adequate settling is required four days from the conclusion of each storm event (RBG 2019).

Sediment basins will be managed in accordance with the SWMP (RBG 2019), as described below:

- Each basin will be dosed with flocculent per rain event to settle sediment;
- Water quality will be confirmed by site specific testing prior to being pumped out within five days from the conclusion of a rainfall event;
- Each sediment basin is lined so water should only be able to escape by overtopping the weir, through evaporation or pumping, following testing of pH and TSS (Total Soluble Solids) levels; and
- In the event of an uncontrolled discharge, a monitoring event will be triggered to assess potential impacts resulting from surface water discharges on the receiving environment as described in **Section 6.3.3**.

The use of gypsum as a flocculent in the sediment basins to quickly settle sediment-laden stormwater runoff during construction may impact the threatened amphibian species Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis* upon discharge from basins to the downstream receiving wetland environment. To avoid any potential changes in pH and impacts on these threatened species, other commercially available flocculants (i.e. Turbiclear) that work as effectively as a gypsum replacement yet do not create the large changes in pH will be used to treat stormwater before discharge on the Site.

Greencap has reviewed information provided by the supplier of the proposed flocculent (Turbiclear), including the product's Safety Data Sheet (SDS), ecological reports and emails provided by the supplier verifying the product's history of use on other projects with similar ecological constraints. Based on the information that has been provided, when used in accordance with both the manufacturer's recommendations and in accordance with the proposed Erosion and Sediment Control Plan the use of Turbiclear as a flocculant in the onsite sediment basins during construction works is not expected to be detrimental to downstream ecological receptors in the wetlands. Ongoing water quality monitoring of the downstream receptors will be important to confirm that there is no impact as described in **Section 6.3.3**.

Additional controls such as hydro mulching of exposed areas of ground to provide ground cover, and the installation of sediment fencing on the down-gradient site boundaries have also been undertaken to minimise the potential for sediment to mobilise off site.

6.3.2 Post-Development/Operation Stormwater Discharge Quality Mitigation Measures

The WSUD measures proposed for the final development are designed to provide a reduction in nutrient levels of stormwater discharged from the Site which would potentially be beneficial to ecological receptors in the wetlands.

Once the site excavation works and roads have been completed and all surfaces have been stabilised with appropriate ground cover (i.e. landscaping has commenced), the four existing sediment basins will then be converted into bio-detention basins that in combination with proprietary pit filter baskets (Enviropods or similar) to be provided in all stormwater pits, will capture and treat stormwater on the Site for the operational life of the project.

Bioretention systems improve stormwater water quality via nutrient uptake and denitrification. The bioretention system will be made up of three sub-surface layers: filtration, transition and drainage layer. The stormwater pools on the surface which is densely planted with grasses, sedges and select shrub or tree species, and filters down through the soil filter media (RBG 2019).

The compactly vegetated surface of bioretention systems physically controls the flows across the filter media. Beneath this, the root zone of the plants is very biologically effective as sediments and nutrients in stormwater are caught or utilised by the plants, bacteria and fungi. As part of an integrated living system, the plant life cycle maintains the soil structure and hydraulic conductivity of the natural filter (RBG 2019).

Bioretention systems require regular routine maintenance, including inspections every three to six months or after heavy rain, cleaning and inspections and replacement of filter media every five to seven years. The proprietary pit filter baskets (i.e. enviropods) in the stormwater pits also require routine monitoring and cleaning. An indicative maintenance plan for the bioretention systems is provided in the SWMP (RBG 2019).

6.3.3 Water Quality Monitoring

Background data

In addition to the modelling undertaken by RBG (2019) as described above, Greencap conducted three surface water sampling events on 19 and 26 November and 19 December 2018 to record water quality conditions under the existing land use. The intention of this sampling was to create some indicative background data to enable detection of potential changes during construction and operation in receiving water quality resulting from the Project. The water quality monitoring program collected water quality data over two sampling events on existing stormwater which flows into the downstream forested wetland and the east-flowing floodplain drain receiving environment. Sample locations were selected to allow a best possible indication of stormwater runoff quality upstream and downstream of the Site and the receiving environment (wetland).

Given the objective for detection of changes to water quality in receiving water bodies during construction and operation of the Project, specific contaminants of concern were selected as listed above. Organochlorine Pesticides (OCP) and Organophosphorus Pesticides (OPP) as a result of the historic and current agricultural land-use. Physico-chemical parameters were also monitored for pH dependent threatened species such as the Wallum froglet *Crinia tinnula* and Olongburra frog *Litoria olongburensis*.

The results of the pre-construction water quality monitoring are summarised below:

- Slightly acidic water, low dissolved oxygen and generally low turbidity;
- No detections of organochlorine pesticides (OCP) or organophosphorus pesticides (OPP);
- No detections of hydrocarbons;
- Elevated concentrations of some nutrients at some locations, particularly oxides of nitrogen, ammonia, filterable reactive phosphorus, as well as total nitrogen at all locations; and
- Elevated concentrations of some metals, particularly aluminium, cobalt, copper, manganese and zinc in the dam.

Surface water quality monitoring

A surface water quality monitoring plan is being implemented to enable effective management of prescribed impacts on water. The surface water monitoring objectives for the Site are to detect changes during construction in receiving water quality resulting from the Project, with stormwater discharges potentially containing increased sediment loads, nutrients, total and dissolved metals, hydrocarbons or other contaminants such as pesticides.

The details of the water quality monitoring plan, including background data, sampling locations, sampling frequency, and parameters are provided in the Stage 2 BMP (Greencap 2019c).

As part of the adaptive management approach, the water quality monitoring program will be reviewed periodically. Reviews will be completed once sufficient data is available to ensure alignment with any changes in Site activities and/or potential impact pathways; and to determine whether any parameters should be excluded from further monitoring rounds. Based on the seasonality of rainfall in the region, it is anticipated that 12 months of monitoring data would be required to adequately assess all parameters. It is proposed that this review of data and trend is undertaken as part of the annual reporting process with recommendations for any change in parameters included in the report.

6.3.4 Threatened Species Monitoring

Under the Stage 1 BMP and Stage 2 BMP (Greencap 2019b; Greencap 2019c), Mitchell's rainforest snail *Thersites mitchellae* (MRS) habitat will be managed to protect this threatened species, including the management of water quality entering the MRS habitat as described in **Section 6.3** above. Additionally, in accordance with the Stage 2 BMP (Greencap 2019c) and MRS recovery plan (NPWS 2001), ongoing long-term monitoring and reporting of the MRS population should be undertaken to establish an estimated population size at the Site and to monitor any changes in population over time.

A pre-construction survey was undertaken by Dr Stephanie Clark in May 2019 to collect baseline data on population size, with further surveys to resume later in 2019 during warmer weather when snails are more active. The survey was undertaken at night within the MRS habitat within the Site boundary and no MRS were detected. However, three living MRS were found adjacent to the Site, outside the Project Site boundary (Clark 2019).

7 IMPACT ASSESSMENT

7.1 Stormwater Quality Impact Assessment

As a result of the implementation of mitigation measures for stormwater runoff quality control outlined in **Section 6.3**, it was identified that the residual risk of adverse impacts of any changes to stormwater runoff quality associated with the development on the EECs, TECs, threatened species located within the coastal wetlands to the north of the site and on the overall biophysical and ecological integrity of the mapped wetlands within the site and the adjoining lands was low.

Furthermore, as assessed under the BDAR, on the basis of the previous state of the Site as described in **Section 5.1** and the mitigation measures discussed above, it was considered that the adverse impact of the development on water quality that sustain threatened species and threatened ecological communities is, on balance, a positive impact (Greencap 2019a).

A detailed risk assessment including measures to mitigate the residual impacts of the Project is outlined in the BDAR [Appendix I and J] that was developed for Stage 1 of the SSD (Greencap 2019a).

7.2 Hydrology (flow regimes) Impact Assessment

The stormwater design for the site was based on ensuring that the post development discharge rate does not exceed the pre-development rate in the 100-year and 5-year ARI storms (RBG 2019).

An assessment of the potential ecological impact on the coastal wetlands to the north of the site as a result of any changes to hydrology (flow regimes) caused by the Project was undertaken by SMEC (2019). The assessment considered EECs, TECs, threatened species and the overall biophysical, hydrological and ecological integrity as outlined in **Section 5.2**.

In summary, the assessment found that the predicted minor increases in flow are unlikely to result in any apparent or significant impacts on the on the coastal wetlands to the north of the site, nor threatened species (Wallum froglet *Crinia tinnula*, Olongburra frog *Litoria olongburensis* and Mitchell's rainforest snail *Thersites mitchellae*). The assessment also included recommended modifications to further mitigate any potential impact as follows:

- Potential modification(s) in the basin outflow design, such as staging the basin outlets to reduce peak discharges during more frequent events than the 1% and 5% AEP design events; and
- Removing the proposed bio-basin lining thus providing additional infiltration downstream of the basins.

8 CONCLUSIONS

As a result of the application of stormwater runoff quality mitigation measures for outlined above and managed as part of the Stage 1 and Stage 2 BMP, it was identified that the residual risk of adverse impact of any changes to stormwater runoff quality associated with the development on biophysical and ecological integrity of the EECs and threatened species was very low. Furthermore, based on the modelling by RBG (2019), the WSUD measures proposed for the final development are designed to provide a reduction in nutrient and sediment levels of stormwater discharged from the Site which would seemingly be beneficial to ecological receptors in the wetlands.

An assessment of the potential ecological impact on the coastal wetlands to the north of the site as a result of any changes to hydrology (flow regimes) caused by the Project was undertaken by SMEC (2019). In summary, the assessment found that the predicted minor increases in flow are unlikely to result in any apparent or significant impacts on the coastal wetlands to the north of the site or threatened species (Wallum froglet *Crinia tinnula*, Olongburra frog *Litoria olongburensis* and Mitchell's rainforest snail *Thersites mitchellae*) and recommended modification(s) to further mitigate any potential impact. For detailed results on the hydrology (flow regimes) modelling please refer to SMEC (2019).

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