martens
consulting engineers since 1989

Posted	
Faxed	
Emailed	X
Courier	
By Hand	
Contact:	Andrew Norris
Our Ref:	P1203365JC57V03
Pages:	36
cc.	-

September 24, 2018

The Halloran Trust
c/o John Toon

By email

Dear John,

RE: PROPOSED WEST CULBURRA RESIDENTIAL DEVELOPMENT: RESPONSE TO UNSW WRL REVIEW – MATTERS OF MERIT.

This document provides a response to the *Independent Review on Water Quality Assessment for the West Culburra Concept Proposal (Major Project Application SSD 3846)* signed by Grantley Smith as manager of the UNSW Water Research Laboratory (WRL). Martens has been engaged by The Halloran Trust (THT) to respond to specific matters of merit raised by the review in the following sections with a separate response provided to address errors and misrepresentations within the review (P1203365JC58V01).

For ease of reference paragraphs have been numbered as shown in attached copy of review letter (Attachment A).

1. At paragraph 7 WRL make broad statements regarding the two wetlands (we read this reference as to be a reference to SEPP 14 wetlands 350 and 351) to the north of the development. WRL claims these wetlands are 'highly sensitive to changes in surface water flows, changes in groundwater table elevations, and are likely adversely impacted by changes to the wetting / drying cycle within their catchment area'. While WRL does not then make any assessment of the significance of these processes with respect to the proposed development by raising these issues in the review there is the clear inference that the development will alter these processes and thus have a detrimental impact on these wetlands.

   Attachment B provides a copy of the local bathymetry (levels are depth below the datum of 0.0 mAHD) of the estuary immediately north of the development. This bathymetry is provided by Department of Natural Resources and is the most current data for the area. It is the data, together with NSW LPI terrestrial LiDar data, used in the project hydrodynamic model for Tuflow AD estuary water quality modelling. This data shows that the area between the development and wetland 351 is inundated during most tidal cycles being below 0 mAHD (which equates to mean sea level).

   The results of the Tuflow model were presented to the IPC during the Applicant's presentation, these videos showed the continual inundation of the space between the development and wetland 351 and the periodic inundation of the area of wetland 350 south and east of Billy's Island.

Head Office
Suite 201, 20 George St
Hornsby NSW 2077, Australia
Ph 02 9476 9999 **Fax** 02 9476 8767

> mail@martens.com.au
www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

A plot of recorded water levels at various points in the estuary is presented in the Martens Estuarine Processes Modelling Report (P1203365JR04V02 as available on DPE MP web site), this field data further confirms that the water level in the Crookhaven estuary is, for the vast majority of the time above 0.0 mAHD.

This information demonstrates that development on the Halloran Trust lands is separated from wetland 351 by an area inundated by estuarine waters and that much of wetland 350 is frequently inundated or similarly separated from the development by inundated areas.

A portion of wetland 350 fringes the development along its northern boundary. The elevation of these lands is not clear in SEPP 14 mapping. However, given the description of the land as mangrove forest and saltmarsh in various flora assessment documents we understand that these areas are in the intertidal zone.

Site geotechnical investigations and limited groundwater assessment work identified limited groundwater beneath the site (4 of the 8 groundwater wells were dry), where water was observed it was in clay soils. As such the groundwater flow beneath the site and thence to the estuary (or fringing wetlands) would be minimal and its effects would be 'swamped' by the inundation of these areas by estuarine waters during the tidal cycle.

WRL identify development impacts on groundwater levels as the groundwater impact of potential significance. At low elevations adjacent to the estuary groundwater levels shall be 'supported' by the estuary's water levels and will not be controlled by the minimal flow of groundwater from the clay soils or underlying siltstone of the site. The development shall not alter the estuary hydrodynamics and therefore shall not alter the groundwater levels beneath the small portion of wetland 350 fringing the development site.

The dominant hydrological control on wetlands #350 and # 351 shall be their tidal inundation by Crookhaven estuary waters (whose water quality is shown not to be impacted by completed Tuflow AD modelling). Groundwater influences shall be negligible compared to this frequent inundation.

To claim potential impact of the development on the wetlands due to groundwater level impacts demonstrates a lack of understanding of the development's environmental context and the wetland's position within the estuary's intertidal zone. This claimed potential impact is repeated through the review and should be disregarded.

2. The third mechanism of potential impact identified by WRL in Paragraph 7 is surface water flows. The management of surface water flows to the wetlands has been extensively assessed through the peer reviewed assessment process. Pollutant loads to the SEPP 14 wetlands catchment has been assessed as a receiving environment in the completed modelling. Martens' modelling results confirm that the Neutral or Beneficial Effect Test (NorBET) is achieved at this location.

   Further analysis was completed in the WCMR (Paragraph 4h of WRL) to assess the effects of the proposed development on flow rates to the wetlands. This assessment (Section 6.3.3) of the WCMR further supported the conclusion that the proposed development would not impact adversely on the hydrology of the wetlands.

   Further to the terrestrial hydrology and water quality modelling complete the development of the estuary hydraulics and water quality model ('Tuflow AD'

model) assessed the possibility that there are temporal changes in water quality which are not identified in the annual pollutant loads as assessed by MUSIC. Tuflow AD modelling confirmed that there is no such impact.

It is acknowledged in the design and assessments of the site water quality solution that, as WRL noted, development adjacent to a wetland has the <u>potential</u> to detrimentally impact on the wetlands. This is the reason why design and analytical effort has been made to ensure a stormwater management solution which does not impact the wetlands. WRL does not seek to provide any contrary scientific / engineering information to discount the design assessment and relies simply on vague, unsupported claims.

3. At paragraph 8 WRL states '*A smaller portion of the proposed development (about 6 ha), consisting of medium density dwellings, an industrial precinct and a sport field, is proposed within the Lake Wollumboola catchment*.'

   This statement appears incorrect in that the proposal does not seek approval for 'medium density dwellings'. If this reference to 'medium density dwellings' is for the 'small lot housing' proposed for Stage 1 then the statement remains an incorrect characterisation of the development proposed. It is also incorrect because, as outlined in Martens letter report regarding Stage 1 (note at paragraph 4u of WRL) '*Only a relatively small portion of the Stage 1 area is not captured by the proposed drainage system discharging to the north. The area draining to the lake is for Asset Protection Zones (APZ) so will be 100% pervious in nature'*. That is, by design all 'residential' (roofs, roads, yards etc) elements of the Stage 1 development shall be drained to the north to the Crookhaven and not to Lake Wollumboola. To say this development is '*within the Lake Wollumboola catchment*' is misleading or shows a lack of understanding of the completed design (a similar concern as is detailed below for the industrial precinct) which redirects the runoff from roads and residential lots away from Lake Wollumboola. It is inconceivable that WRL is seeking to argue that runoff from the proposed Asset Protections Zones (i.e. managed grassland) poses a threat to the Lake's water quality.

   Paragraph 8's statement regarding the industrial precinct is further evidence of WRLs failure to review provided documentation. Review of the WCMR Section 4.3.5 clearly states that the industrial precinct will be drained to the Crookhaven River; this is further documented in the 'Post-Development MUSIC Model Layout' provided in Attachment A of the WCMR.

   This design diverts industrial precinct runoff north, this has been a feature of the application for many years and has not been raised as a matter of concern by DPE's peer reviewer. Such absence of comment is unremarkable as the drainage proposal is a simple drainage engineering solution. WRL either: (1) lacks the technical skills and practical development experience to understand this as a simple civil engineering requirement; or (2) failed to adequately review the provided documentation.

   Development components draining to the Lake (oval and a small road area) makes up approximately 0.1% of the Lake's catchment. The oval is of the order of 1.8 kilometres from the Lake and the road is an existing road section which will be reconfigured and have stormwater treated added and is more than 1.1 kilometres from the Lake.

   Runoff from the hardstand associated with the oval and the road shall be treated through biofiltration systems, all runoff from the oval precinct shall be treated by a

wetland with stormwater harvested for oval irrigation. These measures ensure that the very minor development elements within the Lake Wollumboola catchment achieve the NorBET as demonstrated by MUSIC modelling.

Given the minute contribution of the development to the Lake (0.1% of catchment), the great distance from the development to the Lake (1.8 kilometre for oval and 1.1 kilometre for the road) and the designed stormwater treatment system the proposed development shall not have a detrimental impact on the Lake.

4. Paragraphs 10 – 14 raises 'concern' regarding the evolution of the development's details through the assessment process and the lack of detail provided in the application. These comments highlight WRL's lack of practitioner experience in the field of water quality engineering for land development. The evolution of a development's design through the process of assessment is entirely normal and is a positive outcome of the assessment process. The development has been modified to respond to issues raised through the assessment which is entirely appropriate.

   The removal of detail from the proposal (i.e. individual lot boundaries and minor roads etc) is entirely consistent with the approval being sought, WRL's raising this as a concern again highlights their lack of experience in the assessment of development applications and their failure to understand the changes in the context of the application's assessment. DPE sought the removal of those details from the application so WRL's reliance on this as a reason for refusal is nonsensical.

   Modifications to an application through the assessment process in response to consent authority questions and requests is entirely normal. By raising these as 'concerns' WRL highlights their inexperience as a practitioner in the industry.

5. Paragraphs 15 – 17 raise WRL's concerns regarding the development's impacts on groundwater flows and therefore on wetlands and the Lake. These comments are, unsupported by local conditions. As discussed above they are irrelevant when considering the SEPP 14 wetlands (# 350 and #351) of concern to WRL. Given the tidal inundation of all areas separating wetland 351 from the development and tidal inundation of the mangroves and saltmarshes of wetland 350 WRL's commentary on groundwater is irrelevant and its inclusion misleads the reader to think an issue exists where, a well informed and experienced technical reviewer would realise there is no such issue. As detailed above the impact on the Lake caused by the minimal development in its catchment shall be insignificant.

6. Our review of the DPE Major Project register shows the last major residential development approved by DPE was in 2013, it was the 'Riverside' development at Tea Gardens (MP10_0136) for 855 dwellings. This development was supported by a Stormwater Quality design developed by Martens. Unlike WRL, Martens is a practitioner in the land development industry and has extensive experience in the development of water quality solutions for major residential and other development.

   This project, like all others in which Martens has been involved over the last 29 years, have not include the calibration of MUSIC input parameters. Furthermore, we have been involved in numerous peer reviews and Land & Environment Court proceedings and are unaware of any MUSIC models which have been calibrated using site data. WRL claims at paragraph 20 that '*It is important to note that MUSIC, like any other numerical model, requires calibration based on local flow data as well as treatment performance*'. This statement again highlights WRLs lack of understanding of industry best practice, their highly 'academic' approach to the

project review which has led them to make incorrect statements and to assume requirements that are not reasonable, industry best practice, or necessary.

Again WRL has raised concerns which are inconsistent with NSW industry best practice again confirming their lack of industry experience and understanding.

7. At paragraph 22 WRL states they are '*concerned that pre-development values of TSS, TN and TP for the SEPP 14 wetlands area and Lake Wollumboola catchment were respectively increased by 30%, 60% and 70% between the November 2016 main water quality report (Martens, 2016a) and the short addendum provided in June 2017 (Martens, 2017b) without any clear explanation*'. Here WRL again demonstrates their lack of understanding of the technical detail of the project. Martens (2017b) states '*To address the Peer Reviewer's concern, water quality modelling has been revised to achieve NorBe without the treatment of infiltrated water*'.

   To a technical expert reading this and understanding the proceeding technical works completed this is more than adequate explanation as to the changes pre development pollutant loads. The removal of the infiltration and vegetation update nodes from the MUSIC models is the reason for the assessed pre-development loads increase – this is not a complex link to draw for an experienced MUSIC modeller who understands the project and the modelling completed.

   WRL demonstrates their cursory understanding of the project by this comment and, by extension, misleads the IPC by suggesting an incorrect change to the pre-development conditions. DPE's reviewer and THT's reviewer have raised no such concerns as they, unlike WRL, understand the MUSIC modelling completed for the project.

8. At paragraph 23 WRL states '*it should be noted that the peer-reviewer appointed by the proponent also pointed out that the most recent modelling, which we can only suppose used these unjustified increased pre-development conditions, was actually not able to achieve NorBE within the SEPP 14 wetlands area*'. This conclusion by Cardno (THT's peer reviewer referenced by WRL at paragraph 4y) was based on their use of reduced treatment efficiencies for of the Enviropod / Stormfilter system. Cardno considers that the reported 44% in the "Water" (September 2011) article provided as Attachment C is too high, instead they have reassessed the system performance assuming only 20% TN removal. Using this assumption Cardno concludes load to the wetland catchment increases by 14 % which equates to 7 kg/year.

   We disagree with Cardno and consider their reduction of the treatment efficiency of the proposed solution to be overly conservative. But regardless, as Cardo states: '*It is expected that as part of future design development, NorBE could still be achieved for catchment 'O2' by making minor adjustments to the stormwater system*'. Rather than considering the comments of Cardno regarding this in their entirety WRL has reported part of the statement, out of context, and then used it to support their position. This disingenuous approach results in a misleading conclusion being presented to the IPC.

   WRL has selectively quoted Cardno's review resulting in a misrepresentation of Cardno's final conclusion regarding the development.

   WRL has failed to understand that the application is not for any works. The concept plan approval only seeks approval to progress to the staged detailed design of the

development. Each subsequent application shall require further modelling and assessment to confirm that NorBET is achieved. This is an entirely consistent approach for Concept Plan approvals issued by DPE over the last 10 years (see examples of conditions from past MP approvals in Attachment D. Again, WRL demonstrated their lack of understanding of the practical application of water quality modelling and their ignorance with regards to the approvals process for land development proposals in NSW.

WRL appears not to understand that the concept approval sought will be followed by staged subsequent approvals prior to any development works begin approved on the site.

9. Paragraph 25 raises faecal coliform risks to the oyster leases. This is a matter which was raised some years ago and had been addressed to the satisfaction of stakeholders through the estuary management and monitoring processes proposed (see reference at WRL paragraph 4i and 4j).

10. WRL paragraph 26 raises a concern regarding the '20 year period' of development in the 'Crookhaven Estuary and Lake Wollumboola' catchments. Lake Wollumboola catchment works include the oval and minor road works, it is unlikely these would take more than 12 months – to include the Lake in a discussion of '20 year development cycle' is misleading.

    Subdivision development works may take of the order of 20 years, but they will be staged with only a small portion of the overall site disturbed at any one time. NSW best practice is the Landcom developed 'Blue Book' for construction phase sediment and erosion control. This document informed the 'Sediment and Erosion Control Plan' in the WCMR, this plan would be further developed as part of each future stage of development.

    At paragraph 27 WRL notes they did '*not locate any comments by the peer-reviewers on this subject*', the subject being construction phase sediment impacts. This is most likely because the Department's and THT's peer-reviewers understand that construction phase impacts are able to be appropriately managed using measures based on Landcom and can be appropriately conditioned. The silence of the peer-reviewers on this is not confirmation of WRLs comments – rather it is a rebuttal of their incorrect position.

11. At paragraph 28 WRL raises the need for '*an Operation and Maintenance Plan for the site be developed in collaboration with Council for the proposed development*'. This would be appropriate as a condition of approval.

12. Paragraph 29 states 'the *proponent will rely on constructed wetlands to perform as bio-retention basins within the Lake Wollumboola catchment*' and that '*it should be noted that this proposed solution has the inherent risk of overflow and release of untreated, nutrient rich run-off into the neighbouring coastal wetlands and Lake Wollumboola*'.

    The first statement is incorrect, the proposed solution relies on a bioretention system for the hardstand areas associated with the oval (access road and carparking) followed by wetland treatment for basin overflow and oval runoff. These two treatment elements are distinct and WRL has misrepresented the design by their statement.

The second statement regarding 'overflows' is confusing. There is no assumption made or results reported by Martens that there will not be overflow from the wetlands as inferred by the reviewers' comment that the 'proposed solution has the inherent risk of overflow or release of untreated, nutrient rich run-off'. The model assesses the quality of inflow and outflow using the industry best practice algorithms in MUSIC. There will most certainly be overflows – otherwise the reduction in flow would be 100%. This is not a design or assessment limitation, it is an expected outcome. The result of the overflow is the important result. Overflow volumes and pollutant loads are assessed by the model and demonstrate that there is an acceptable nutrient discharge outcome.

13. At paragraph 32 WRL recommends deferral of the development in the Lake Wollumboola catchment until the '*finalization(sic) of the Gateway Determination for the Planning Proposal*'.

    The road works in the Lake's catchment cover 0.9 ha which is less than 0.02% of the Lake's catchment. They will replace an existing stretch of untreated road. To suggest that such works need to be deferred till the Planning Proposal is approved is completely without merit.

    The oval proposal covers approximately 0.1% of the Lake's catchment and is 1.8 kilometres from the Lake. The oval's water quality management system has been developed to achieve NorBET, no peer review has provided any technical reasons to refute this. Therefore, the oval's inclusion shall have no impact on Lake water quality.

14. Section 7 (paragraphs 33-37) relate to impacts on Lake Wollumboola which, for reasons detailed above are either irrelevant or overstated.

15. Paragraph 38 appears to have been copied from the WRL review of the Long Bow Point Golf Course for the IPC. It concludes that the West Culburra proposal should be refused on the basis of the impact on the Lake. That is, that the application should be refused because of 6.0 ha of development, 1.8 kilometres from the Lake, which has been demonstrated to have no water quality impacts on the Lake. This is clearly not a view supported by scientific or engineering analysis or reasonable assessment.

16. Paragraph 39 then adds that the proposal's consideration should be deferred until the Planning Proposal groundwater studies are completed. Again, for reasons detailed above groundwater impacts on wetlands #350 and #351 are negligible and the ongoing local groundwater studies have no scientific or engineering bearing on the IPC's ability to approve this application.

In summary the WRL review has presented no technical scientific or engineering grounds for the refusal of the application. As previously detailed and documented the proposed West Culburra development, with the extensive water quality control systems, shall not result in increased nutrient load to the Crookhaven River estuary or Lake Wollumboola and should be approved.

If you have any queries please contact the undersigned.

For and on behalf of

MARTENS & ASSOCIATES PTY LTD

ANDREW NORRIS
BSc(Hons), MEngSc, MAWA
Director

Attachment A – WRL review with paragraphs numbered

Attachment B – Bathymetry data by DNR (2008) – Sheet 10/28 of Plan 56228

Attachment C – 'WATER' Journal article

Attachment D – Water quality conditions from past Major Project Approvals

Attachment A – WRL review with paragraphs numbered

11 September 2018

WRL Ref: WRL 2018058 LR20180911

Alana Jelfs | Senior Planning Officer
Independent Planning Commission NSW
Level 3, 201 Elizabeth Street
Sydney NSW 2000

By email: alana.jelfs@ipcn.nsw.gov.au

Water Research Laboratory

Dear Alana,

Independent Review of the Water Quality Assessment for the West Culburra Concept Proposal (Major Project Application SSD 3846)

1. Introduction

1 This letter provides an independent review of the technical reports and reviews prepared in support of the West Culburra Concept Proposal State Significant Development (SSD 3846). Our review is targeted at the surface water, groundwater and water quality aspects of the application only.

2 The review was completed by Dr Francois Flocard, Principal Engineer at the Water Research Laboratory of UNSW Sydney (WRL) and Dr Will Glamore, Associate Professor at UNSW Sydney WRL. Both staff have undertaken multiple expert reviews on similar projects and their CVs are available on request. Over the past 15 years the reviewers have undertaken numerous on-ground projects to study, model, rehabilitate and create large estuarine wetlands across Australia. These projects are extensively documented and have been recognised via multiple awards representing best practice. Associate Professor Glamore also has extensive experience in the Shoalhaven area, having conducted his PhD in the region from 1999-2003 and subsequently completed numerous surface and groundwater studies including field based projects.

3 WRL staff have an on-going role of providing high-level expert advice to the Federal Department of the Environment and the Murray Darling Basin Authority concerning developments near Ramsar Wetlands. WRL's advice has largely been concerned with the hydrological impact to surface and groundwater of large developments near Ramsar Wetlands in nearly every state and territory in Australia. More information on our background expertise or previous review projects can be provided upon request.

2. Documents reviewed

4 This independent review was based on the information provided below:

- 4a BMT WBM (2014a), PROC-1000395 – West Culburra Water Cycle Management Review, 6 March 2014.
- 4b BMT WBM (2014b), West Culburra - Water Cycle Management Review – Peer Review, 23 October 2014.
- 4c BMT WBM (2014c), Re: Estuarine Management Study: Proposed Mixed Use Subdivision – West Culburra, NSW. Peer Review., 7 November 2014.

- Martens (2015a), Re: Vegetation Uptake Rates - West Culburra (MP 09_0088), 30 January 2015.
- BMT WBM (2015a), West Culburra - Further Review, 19 August 2015.
- Martens (2015b), Re: Estuary Hydrodynamic And Solute Transport Model Calibration – West Culburra Estuarine Management Study (MP 09_0088), 18 November 2015.
- BMT WBM (2015b), Re: Estuary Hydrodynamic And Solute Transport Model Calibration – West Culburra Estuarine Management Study (MP 09_0088). Peer Review, 18 November 2015.
- Martens (2016a), Water Cycle Management Report (WCMR) - Mixed Use Subdivision; West Culburra, NSW, P1203365JR01V07, November 2016.
- Martens (2016b), Estuary Management Study (EMS) - Mixed Use Subdivision; West Culburra, NSW, P1203365JR02V04, November 2016.
- Martens (2016c), Water Quality Monitoring Plan (WQMP) - Mixed Use Subdivision; West Culburra, NSW, P1203365JR03V04 November 2016.
- HGEO (2017), West Culburra groundwater assessment – Preliminary report (Stage 1). Prepared for the Shoalhaven City Council.
- Martens (2017a), Explanatory Note - West Culburra Concept Plan (SSD 3846); Water Quality Issue Land Side Stormwater Report, 31 January 2014 [*sic*].
- Alluvium (2017a), Review of Explanatory Note - West Culburra Concept Plan and associated documents, 24 February 2017.
- BMT WBM (2017a), Review of Estuarine Processes Modelling Report: Proposed Mixed Use Subdivision, West Culburra, 5 May 2017.
- BMT WBM (2017b), Review of Estuarine Processes Modelling Report: Proposed Mixed Use Subdivision, West Culburra, 8 May 2017.
- Martens (2017b), Water Cycle Management Report Addendum; Mixed Use Subdivision, West Culburra (SSD 3846), 8 June 2017.
- John Toons (2017a), West Culburra Mixed Use Concept Plan Major Project 09-0088, Now SSD 3846 Supplementary Response to Submissions, July 2017.
- Alluvium (2017b), Assessment of West Culburra Concept Plan, 19 July 2017.
- BMT WBM (2017c), Review of Water Cycle Management Report Addendum, 20 July 2017.
- Martens (2017c), Stormwater Quality Assessment – Stage 1; Culburra West Mixed Use Development, Culburra. November 2017.
- John Toons (2017b), West Culburra Mixed Use Concept Plan; Review of Sept. 2017 submissions. November 2017.
- Department of Planning and Environment (2018), State Significant Development Assessment: West Culburra Concept Proposal SSD 3846 (June, 2018), NSW Department of Planning and Environment.
- Martens (2018), Independent Planning Commission Water Quality Briefing – Culburra West Mixed Use Development (SSD3846) (30 July 2018).
- Cardno (2018), West Culburra Mixed Use Subdivision (SSD 3846) – Stormwater Quality Peer Review, 10 August 2018.

3. General Comments

3.1 Environmental Setting of Proposed Development

5 The site of the West Culburra Concept Proposal is located to the west of the Culburra Beach township on the south coast of NSW. Culburra Beach is surrounded by the Crookhaven River estuary to the north and Lake Wollumboola to the south.

6 WRL understands that the latest version of the concept proposal envisions the development of approximately 75 ha of the 100 ha site and will predominantly consist of low/medium density dwellings (around 45 ha). The majority of the development will be on the northern side of the ridge line and will therefore affect the surface hydrology within Crookhaven Estuary catchment. The Crookhaven Estuary can be considered a sensitive ecosystem as it supports a number of priority oyster leases and also provides habitat to migratory bird species. At this stage, the concept proposal is to include nearly 3 km of vegetated foreshore in the immediate proximity of two SEPP 14 Coastal Wetlands.

7 Wetland environments such as the two wetlands north of the development site are highly sensitive to changes in surface water flows, changes in groundwater table elevations, and are likely adversely impacted by changes to the wetting/drying cycle within their catchment area.

8 A smaller portion of the proposed development (about 6 ha), consisting of medium density dwellings, an industrial precinct and a sport field, is proposed within the Lake Wollumboola catchment. Lake Wollumboola is classified as a Sensitive Coastal Lake in the 2018 State Environmental Planning Policy (SEPP), is listed as a Wetland of National Importance and forms part of the Jervis Bay National Park. Any potential change to the surface water and groundwater dynamics, in terms of quantity or quality, is likely to have a direct impact to Lake Wollumboola, although the extent of impact is difficult to determine.

9 Lake Wollumboola can be classified as an Intermittently Closed or Open Lake or Lagoon (ICOLL). ICOLLs typically have long residence times as there can be extended periods when the lake entrance to the ocean is closed resulting in limited exchange of lake and ocean waters. As a result of the intermittent entrance opening, ICOLLs can have high flow retention rates resulting in nutrient and phytoplankton levels within the estuary closely associated with catchment development runoff volume and quality. Importantly, calculating the ICOLL water balance and its subsequent influence on water quality can be complex due to the circulation of fresh and saltwater caused by interactions of fresh water runoff, groundwater and coastal waters. The nature of these fresh and salt water exchanges influence lake water quality gradients and sedimentation, and thereby the health of ecological communities.

3.2 Uncertainty regarding the nature of the proposal

10 The nature of the concept proposal, as reported by DPE and the proponent, has evolved since it was first lodged in 2010 and needs to better framed. This lack of clarity and consistency can directly be observed in the way the proposal has been referred to in the proponent submission documents, such as “Mixed Use Concept Plan” or “Mixed Use Development”, while DPE’s recommendation referred to it as “Concept Proposal”.

11 According to the proponent, the major project application SSD 3846 only concerns “the basic concepts such as zone boundaries, location and type of facilities and infrastructure” (John Toons, 2017). The proponent states that the considered staged development of West Culburra over 20 years, if approved, will then be the subject of subsequent DAs submitted to the Shoalhaven City Council, which will provide additional information and plans with a higher level of details.

12 The consequence of the proponent’s approach is that a number of Response to Submissions by different agencies and peer-reviewers are not satisfied with the level of detail of the proposal and associated assessments on potential impact to surface water, water quality and nearby ecological sensitive areas.

13 At this stage, the concept proposal includes development in the immediate proximity of the coastal wetlands around Billy's Island in the Crookhaven River, previously classified as SEPP 14 coastal wetlands and now as SEPP 2018, as well as within the catchment of Lake Wollumboola. The potential disruption to the hydrology of these two sensitive ecosystems calls for a precautionary approach, which cannot be properly assessed without a clear and detailed understanding of what the proponent is considering within the concept proposal area.

14 As such, we believe that the proposed approach of a staged authorisation and development process is problematic since it does not provide sufficient information for the assessment as well as certainty regarding the effectiveness of storm water treatment solution of the completed development and is therefore not recommended. This major project application would be considered more suitable for assessment if it was submitted with a higher level of detail, this allowing all parties involved in its assessment a higher level of certainty regarding the potential impacts on the environment and more specifically the water quality (NorBE).

3.3 Groundwater

15 Groundwater is an integral component of the water balance for coastal wetlands and ICOLLs. The groundwater contribution can only be verified and quantified through field based data. Based on our review of the limited onsite groundwater data presented by the proponent for the West Culburra Concept Proposal (SSD 3846) and the Long Bow Point Golf Course (SSD 8406), we believe that groundwater discharges to Lake Wollumboola cannot be adequately assessed. Due to the potential importance of the groundwater regime to sensitive receivers, we consider that this is a critical data gap that warrants further consideration for any development within the Lake Wollumboola catchment.

16 We are aware that Shoalhaven Council has commissioned HGEO (2017) to undertake a comprehensive groundwater assessment for the area to the west of Culburra Beach, including the proposed golf course development on Long Bow Point. The HGEO field investigation is planned to have a total of 23 monitoring bores, with ongoing monitoring of groundwater levels and water quality parameters. The proposed field investigation and monitoring program, which we understand will be performed over two years, will provide valuable insight into the groundwater contribution to Lake Wollumboola and regimes within the West Culburra proposed development. We recommend its commission as it will offer critical information regarding predevelopment conditions at the site and allow baseline conditions to be measured as a benchmark for assessing any impact of the proposed developments on neighbouring coastal wetlands and Lake Wollumboola.

17 The 2010 field investigations at the proposed development site did not consist of long term monitoring of the groundwater and therefore do not enable the derivation of a robust understanding of the groundwater recharge cycle at the site. Perched groundwater aquifers were found in multiple locations across the site and would likely be impacted by the development. Based on the presently available investigations, the proponent is only able to conclude that the proposed development will likely alter groundwater flow to downslope sites, which includes the two SEPP coastal wetlands.

4. Review of the Water Quality Modelling

18 The proponent's water quality management assessment is based on numerical modelling using a combination of the MUSIC and TUFLOW software modelling packages.

19 A MUSIC model was developed to assess the suitability of the proposed water quality controls and treatment trains for stormwater discharges into the Crookhaven Estuary catchment and within the Lake Wollumboola catchment. The MUSIC software is widely used by industry and is generally suitable for modelling treatment trains of water quality control measures.

20 WRL's reviewers are familiar with the MUSIC software and have reviewed numerous Storm Water Management Plan models and installations based on modelling results. It is important to note that MUSIC, like any other numerical model, requires calibration based on local flow data as well as treatment performance. Based on our review, it appears that the presented MUSIC model was extensively peer-reviewed but has not been field calibrated for pre-development conditions which are key to to establish the appropriateness of the proposed treatment solution achieving NorBE.

21 Based on our review of the water quality related documents, the proponent appointed water quality consultant Martens and DPE's appointed reviewers, i.e. BMT WBM / Alluvium, appear to have been actively collaborating on the development of the modelling suite until August 2017. Our review of the provided correspondence between both parties shows that while the proponent did implement some of the requests raised by the reviewers, a number of significant concerns regarding the overall reliability of the proposed stormwater treatment solution and results of the modelling remain outstanding.

22 The modelling presented in the reviewed report indicates a decrease in the annual average pollutant loads (TSS, TN and TP) into the two neighbouring coastal wetlands and into Lake Wollumboola. This conclusion has been previously questioned both by OEH and DPE. In our opinion, this conclusion has not been sufficiently justified by the proponent. The proponent has stated on numerous occasions that the proposed stormwater treatment solution was able to achieve the required NorBE criteria by showing that post-development values were less than pre-development values. While we would expect the different modifications to the stormwater treatment solution to change post-development values of pollutants, we are concerned that pre-development values of TSS, TN and TP for the SEPP 14 wetlands area and Lake Wollumboola catchment were respectively increased by 30%, 60% and 70% between the November 2016 main water quality report (Martens, 2016a) and the short addendum provided in June 2017 (Martens, 2017b) without any clear explanation. This important modification to pre-development conditions in two highly sensitive ecosystems is concerning as it casts doubt on the exact performance of the proposed solution and if NorBE is effectively achieved.

23 Additionally, it should be noted that the peer-reviewer appointed by the proponent also pointed out that the most recent modelling, which we can only suppose used these unjustified increased pre-development conditions, was actually not able to achieve NorBE within the SEPP 14 wetlands area.

24 Overall, the manner in which the surface water quality modelling has been conducted and reported is concerning as the proponent has repeatedly refused to take into account valid recommendations of the DPE's appointed reviewers only to suddenly implement them with very limited explanations (i.e. vegetation uptakes). We disagree with the most recent statement (John Toons, 2018) by the proponent that "*there are no unresolved water quality assessment issues between MA and the peer reviewers*".

25 Based on our experience in the Shoalhaven area in relation to oyster leases, the risk of faecal coliform contamination will be increased with the development and this risk should be better addressed by the proponent both in the stormwater design and in the water quality monitoring plan.

5. Comments on the Water Quality Treatment Solution

26 Presently, we understand that the proposed staged approach of the development could result in works being staged over a 20 year period. Such an extended period of construction works is concerning due the risk of high-intensity rainfall events occurring during the development period with an associated high potential for the release of TSS within the Crookhaven Estuary and Lake Wollumboola.

27 Based on our review of the water quality modelling outputs (MUSIC modelling), the potential effectiveness of the proposed erosion/construction control solutions on TSS during the development phase is unclear. The November 2016 report (Martens, 2016a) does not provide any detailed modelling results and we could not locate any comments by the peer-reviewers on this subject.

28 The proposed stormwater treatment solution relies on a combination of bioretention basins connected to filter catch-basin type devices (Enviro Pod Storm Filter). We are familiar with these type of devices, having tested a number of them in our facilities for a range of manufacturers. We commend the proponent for representing these devices in MUSIC using field based test data provided by the manufacturer (Cardno, 2018). We are, however, concerned that the available data used to represent the effectiveness of this type of device may not be appropriate for the conditions experienced in the Shoalhaven area, due to the potential for dissolved iron to rapidly clog the filter media used in the catch-pit. This potential clogging has a high risk of rapidly decreasing the effectiveness of the proposed solution and will likely require additional monitoring and maintenance. As such, it is imperative that an Operation and Maintenance Plan for the site be developed in collaboration with Council for the proposed development.

29 It appears that the proponent will rely on constructed wetlands to perform as bio-retention basins within the Lake Wollumboola catchment. While we do not support any development within the Lake Wollumboola catchment, if development was to occur, it should be noted that this proposed solution has the inherent risk of overflow and release of untreated, nutrient rich run-off into the neighbouring coastal wetlands and Lake Wollumboola. Additional design detail for these ponds is required to fully assess their functionality and likely performance.

6. Gateway Determination for the Planning Proposal

30 In November 2015, the Deputy Secretary, Planning Services, as delegate of the Minister for Planning, issued a Gateway Determination recommending that land in the Lake Wollumboola catchment be zoned for environmental protection, dependent on the outcomes of a biodiversity offset strategy and water quality studies prepared to support the Planning Proposal.

31 The reviewers understand that The Gateway Determination for the Planning Proposal will be supported by detailed studies, including a two-year groundwater monitoring study presently underway that will assist in defining appropriate development boundaries around Lake Wollumboola and an investigation into alternative locations for a golf course in the locality, though outside of the lake catchment. It is our understanding that the Gateway Determination for the Planning Proposal will take 3 to 4 years to finalise and be available in 2019.

32 We support the recommendation that any development within the Lake Wollumboola be deferred until completion of the HGEO groundwater study and finalization of the Gateway Determination for the Planning Proposal.

7. Cumulative Impacts and Tipping Point for Lake Wollumboola

33 We understand that the area west of Culburra Beach within the Lake Wollumboola catchment is currently the subject of multiple development applications including:

33a
- a portion of the West Culburra Mixed Use Subdivision (SSD 3846), which could include housing, an industrial zone and a sport field;

33b
- the proposed golf course development on Long Bow Point (SSD 8406);

33c
- two separate Development Applications for individual houses in the Long Bow Point vicinity (DA 09/2675 and DA 10/1330).

34 These approved and proposed developments along the foreshore of Lake Wollumboola, as well as the existing pollutant loads from the Culburra Beach residential area, are likely to be associated with a cumulative increase in nutrients and pollutants into the neighbouring coastal wetlands and the lake.

35 The different versions of the concept proposal presented between 2013 and 2017, resulted in a number of changes to the location and size of the proposed developments within the Lake Wollumboola catchment. For instance, while the latest proposal in July 2017, retained the industrial estate, in its latest RtS (John Toons, November 2017), the proponent notes that it could accept "…delete it entirely from the concept plan if required by DPE". As previously mentioned, the inherent vagueness of the Concept Proposal and the numerous modifications to the proposal, which appear to be more reactive responses than planned and designed, is concerning.

36 At present, it is difficult to establish an acceptable level of nutrient or pollutant increase to a complex ecosystem such as Lake Wollumboola. Given the accepted highly sensitive ecological nature of Lake Wollumboola, any proposed development impact should be assessed in accordance with a precautionary approach. Several researchers have previously highlighted the importance of avoiding an algal dominated state with lake systems, as once lakes have turned towards an algal dominated state they are more likely to remain in that state. As such, it is highly recommended that unless detailed scientific processes are supported with field data, a precautionary approach should be adopted. Therefore at this stage, we recommend that all developments within the Lake Wollumboola catchment be removed from the Concept Proposal.

37 Review of the water quality and estuarine modelling indicates that the development will result in an overall reduction of surface water flows to this SEPP 2018 wetland post development during low intensity storm events. In the absence of an adequate understanding of the groundwater contribution, there is a risk that the hydrology cycle of this coastal wetland will be impacted. It should also be noted that we are concerned that clearing of the riparian vegetation immediately next to the SEPP wetland for creating view corridors and the establishment of a cycle path and walkway, will increase the risk of long term damage to this sensitive ecosystem.

8. Summary

38 In summary, based on the review of the technical surface water, estuarine modelling, groundwater and water quality reports prepared in support of West Culburra Concept Proposal State Significant Development (SSD 3846), as well as the warranted precautionary approach due to the sensitive ecological nature of Lake Wollumboola, the reviewers support DPE's recommendations to the Independent Planning Commission.

39 We recommend that the final decision on the project application awaits the final results of the Gateway Determination for the Planning Proposal associated groundwater investigation. This groundwater investigation will offer critically required information quantifying predevelopment conditions at the site and enable baseline conditions to be quantified and subsequently used to assess any impact of the proposed development on the neighbouring coastal wetlands and Lake Wollumboola. Further studies are also required to gain a better understanding of trigger points for the Lake Wollumboola ecosystem after which irreversible changes might occur.

40 Thank you for the opportunity to provide this independent review. Should you require further information please contact Dr Francois Flocard or Associate Professor Will Glamore in the first instance.

Yours sincerely,

Grantley Smith
Manager

Attachment B – Bathymetry data by DNR (2008) – Sheet 10/28 of Plan 56228

B 56228

ORIENT POINT

Goodnight Island

Crow Island

Billys Island

Curleys Bay

CULBURRA BEACH

TASMAN SEA

PACIFIC OCEAN

294000 E 294250 E 294500 E 294750 E 295000 E 295250 E 295500 E 295750 E 296000 E

6134500 N 6134250 N 6134000 N 6133750 N 6133500 N 6133250 N 6133000 N 6132750 N

SHEET LAYOUT DIAGRAM
NOT TO SCALE
1:2,500 PLAN SERIES

MK	DETAILS OF AMENDMENTS	APPROVED	DATE	

PLAN PREPARED BY
DEPARTMENT OF COMMERCE
SURVEYING & SPATIAL INFORMATION SERVICES
LEVEL 14 McKELL BUILDING
2-24 RAWSON PLACE SYDNEY
TEL: (02) 9372 7907 FAX: (02) 9372 7922

DATUM: AUSTRALIAN HEIGHT DATUM

CAUTION
THIS PLAN HAS BEEN PRODUCED AT THE SCALE/S SHOWN BELOW FOR THE PURPOSE OF ESTUARY MANAGEMENT AND SHOULD NOT BE USED FOR ANY OTHER PURPOSE.

0 25 50 100 150 200 250
REDUCTION RATIO 1:2,500 METRES
AT A0 SHEET SIZE

CO-ORDINATES	-	MGA ZONE 56
CONTOUR INTERVAL	-	0.5 METRE
SURVEYOR	-	S.HOLTZNAGEL
SURVEY DATE/S	-	SEPT 2005 - NOV 2006
PROJECT CONTROLLER	-	M.FITZHENRY
CADD OPERATOR	-	R.CASAGRANDE
PLAN EXAMINER	-	A.R.GORDON
JOB NUMBER	-	1925100

Department of Natural Resources

ESTUARY MANAGEMENT PROGRAM

SURVEYOR	-	S.HOLTZNAGEL 22/12/2008
PROJECT CONTROLLER	-	M.FITZHENRY 22/12/2008
PLAN EXAMINER	-	A.R.GORDON 22/12/2008

SHOALHAVEN RIVER HYDROGRAPHIC SURVEY SEPTEMBER 2005 - NOVEMBER 2006

BATHYMETRY

SHEET No 1 / 10
1:2,500 SERIES
No IN SET 10 / 28
PLAN ROOM CAT No 56228

B 56228

Attachment C – 'WATER' Journal article

NUTRIENTS AND SOLIDS REMOVAL BY AN ENGINEERED TREATMENT TRAIN

Field evaluation of a gully pit insert and cartridge media filter

M Wicks, N Vigar, M Hannah

Abstract

The performance claims for individual stormwater treatment devices is often open to debate, as much of the data available has not been subjected to robust scrutiny and/or the claims are unable to be replicated. The following article summarises the results from a field trial of two such devices: an EnviroPod® and a StormFilter®, arranged in series (or a 'treatment train') treating runoff from a small road catchment on Streets Creek, Kuranda, west of Cairns in Far North Queensland.

This field trial complements an earlier research project undertaken on the same system by James Cook University. Data was collected from six storm events, predominantly during the dry seasons of 2008 and 2009, and includes simultaneous sampling of both the flow rate and water quality on the inflows to, and outflows from, the treatment train for a suite of particulate and soluble stormwater pollutants. Influent concentrations for both Phosphorus and Nitrogen were found to be half to one-third of concentrations reported in the literature as typical for urban catchments in Australia.

One storm was also analysed for an expanded suite of nitrogen analytes, which determined that more than half the load was in soluble form. Furthermore, results from the field trial and research project indicated that this treatment train system has the potential to achieve meaningful load reductions of Suspended Solids (up to 99%), Phosphorus (up to 70%) and Nitrogen (up to 45%) through the use of conventional screening, filtration and ion-exchange removal technologies.

Introduction

Livingston and McCarron (1992) identified that pollution loads (gross pollutants, sediment and nutrients) in stormwater increase proportionally with the degree of urbanisation in the catchment. Most consent authorities in Australia have established pollution removal efficiencies to be achieved prior to discharge from the urban catchment (eg, NSW Department of Environment and Climate Change (DECC) 2007 recommends Suspended Solids (SS) 85%, Total Phosphorus (TP) 65%, and Total Nitrogen (TN) 45%) and/or Event Mean Concentrations (EMCs) in any stormwater discharged into natural ecosystems (e.g. ANZECC 2000 recommends turbidity 2-15 Nephelometric Turbidity Units (NTU), TP 0.01 mg/L and TN 0.15 mg/L for river systems in tropical Australia).

In general, each pollutant is removed from the water column using a specific physical, chemical or biological process. Arranging these processes in sequence provides a treatment train approach that addresses and treats the whole pollutant load. There is, however, a paucity of published peer-reviewed scientific information validating the removal efficiency of each element or device used within a treatment train – let alone the performance of the treatment train itself. The research referred to herein provides information to validate the performance claims of an EnviroPod® gully trap and a StormFilter ® cartridge arranged in series as a treatment train.

Photo: ©Google, ©GeoEye ©Wherels® Sensis Pty Ltd ©Digital Globe

Figure 1. Location of the Kuranda Test Site.

Background

This field trial follows a previous research project undertaken by the School of Earth and Environmental Sciences, James Cook University (JCU), as part of a wider investigation into the impacts of road runoff on the Kuranda Range Road watershed, near Cairns (Munksgaard and Lottermoser, 2008), which discharges into the sensitive environment of Streets Creek. JCU reported on the quality of the watershed's receiving waters, the chemical characterisation of the road runoff and the performance of the system over four runoff events.

JCU found that the system "had a high retention capacity for suspended sediment and by implication particulate metals". Conversely, they reported that the "treatment train" had only a "modest retention capability for dissolved (filtered) metals". In addition, JCU identified that the treatment train system was, in fact, responsible for a significant net export of zinc. On the basis of their data, nutrient levels in the road runoff were low, and do not constitute a water quality concern at Streets Creek. However, they also reported significant retention of both TN and TP. The JCU study, which, in their own words "do[es] not constitute a full evaluation of the EnviroPod/StormFilter treatment system", found the system

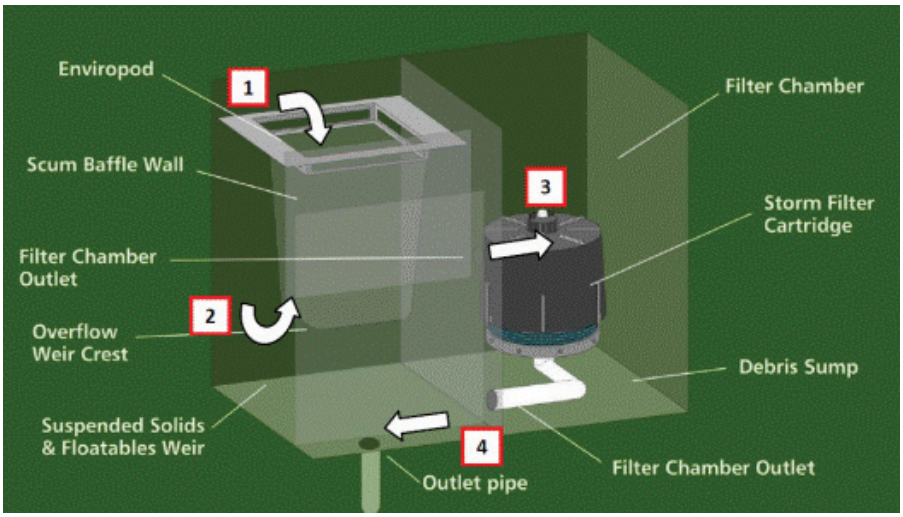

Figure 2. Schematic of the SYSTEM treatment train.

achieved substantial removal of Total Nitrogen (45%), Total Phosphorus (70%), Total Aluminium (71%), Total Nickel (73%), Total Lead (60%) and Total Copper (58%). On the other hand, it identified potential releases of Suspended Solids under 500 microns, as well as dissolved zinc and copper.

One explanation for the above-mentioned releases is that they could be related to the anaerobic conditions present in either the standing water within the wet-sump or, in the case of zinc, corrosion of the exposed galvanised protection on the steel components. Given the substantial removal of suspended solids, nutrients and total metals, it appears unlikely that the dissolved copper and zinc, observed in the outflows, was associated with a release of the under-500 micron sediment fraction.

It was largely to address these issues and better understand the sources of these copper and zinc releases that Stormwater360 undertook a further field evaluation of the treatment train system, which is the subject of this evaluation.

Table 1. Water quality analytical parameters.

Parameter	Abbreviation	Analytical Method*	Units	Limit of Reporting	Analysed by
Electrical Conductivity	EC	APHA 2510B	µS/cm	1	Cairns Water
pH	pH	APHA 4500-H+	-	0.1	Cairns Water
Suspended Solids above 500 microns	SS > 500 micron	500 micron sieve & APHA 2540B	mg/L	1	Cairns Water
Volatile Suspended Solids above 500 microns	SS Vol. > 500 micron	500 micron sieve & APHA 2540E	mg/L	0.1% Dry Solids	Cairns Water
Suspended Solids below 500 microns	SS < 500 micron	APHA 2540B; equiv. ASTM D-3977-97	mg/L	1	Cairns Water
Volatile Suspended Solids below 500 microns	SS Vol. < 500 micron	APHA 2540E	mg/L	0.1% Dry Solids	Cairns Water
Suspended Solids	SS	Calculated	mg/L	-	-
Volatile Suspended Solids	SS Vol.	Calculated	mg/L	-	-
Total Phosphorus	TP	APHA 4500-P	mg/L P	0.02	Cairns Water
Total Nitrogen	TN	APHA 4500-N	mg/L N	0.05	Cairns Water
Total Kjeldahl Nitrogen	TKN	Calculated	mg/L N	-	-
Ammonia Nitrogen (Ammonium Nitrogen)	NH3-N	APHA 4500-NH3	mg/L N	0.05	Cairns Water
Nitrate/Nitrite (Total Oxidised Nitrogen)	NO3-/NO2--N	APHA 4500-NO3	mg/L N	0.01	Cairns Water
Total Organic Carbon	TOC	APHA 5310-B	mg/L	1	ALS
Dissolved Organic Carbon	DOC	APHA 5310-B	mg/L	1	ALS
Particle Size Distribution (Laser Diffraction)	PSD	Malvern Mastersizer S	micron	0.05	QUT

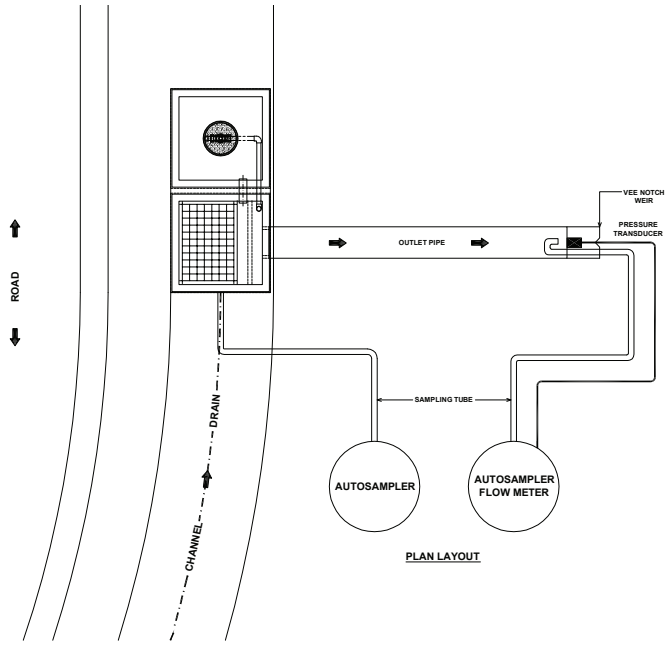

Figure 3. Schematic of the sampling location.

Sampling Procedure and Equipment

A graphical representation of the system is shown in Figure 2. The direction of flow through the gully pit insert (EnviroPod®) and into the cartridge media filter (StormFilter®) is shown in sequence from 1 to 4. The gully pit insert is intended to treat most flows and filter solids above 100 µm while containing contaminants in a dry state.

After treatment by the gully pit insert, water is filtered radially through the media cartridge (outside to inside). The media cartridge had a nominal flow rate of 0.95 L/s (at 46 cm head, when the cartridge is primed) and a peak flow rate of *ca.* 1.3 L/s (at maximum 0.88 m head prior to bypass). The ZPG™ media used was a proprietary blend containing perlite (50%), granular activated carbon (GAC, 10%) and zeolite (40%).

The system samples were collected using automated influent and effluent samplers (Figure 3), collecting continuous flow and precipitation data and water quality simultaneously. The influent sampler was programmed to send an SMS alert to Stormwater360, via the GSM cellular network, when the sampling program was triggered. A dial-up connection was then made to each sampler to download data for analysis.

To qualify as a representative sample, the following criteria were specified.

I. Collection of at least three simultaneous influent and effluent samples per storm;

II. Samples must have been collected while the treatment system operated within design flow rates (not in bypass);

III. The sampled portion of the storm event must represent at least 60% of the storm total flow volume;

IV. A minimum of six data sets must be collected for a full performance evaluation.

Antecedent dry period was not identified as a constraint, due to the impervious nature of the catchment and the absence of a base flow; however, at least a three-day antecedent dry period was preferred. If the storm was deemed to qualify, Stormwater360 would inform Cairns Water and Waste Laboratory Services (Cairns Water, NATA accreditation # 14204) that samples required collection and analysis. Analysis was performed by Cairns Water and Waste Laboratory Services, ALS Laboratory Group – Brisbane (ALS, NATA accreditation # 825). All water quality parameters for qualifying storms were sent to an independent peer reviewer at Queensland University of Technology (QUT), ensuring transparency of data. Test methods for water quality analysis used for this study are provided in Table 1.

Gross pollutants were not monitored as part of this study, although significant quantities were captured. Previous monitoring by White *et al*. (2001) demonstrated that the Enviropod® filter retained all (100%) litter up to an approach flow of 100L/sec.

Results and Discussion

The system was installed at the Streets Creek site in March 2006 and remained an active treatment and sampling site for four years until being decommissioned in March 2010. Stormwater360 monitored the system from April 2008 to December 2009. During this time, the unit was maintained annually, prior to the onset of each dry season. Complete maintenance involved removing all sediments and debris from the system, gully pit insert and replacing the cartridge media. The gully pit insert required additional manual maintenance approximately once per year.

Maintenance frequencies for the study were conducted in line with the systems standard operational lifecycle. Due to the nature of the catchment and size, there was an absence of a base flow or dry weather flows. Potential pollutant leaching of soluble contaminants was, however, still accounted for; organic debris left within the system was allowed to break down between maintenance periods and permitted to be sampled by the effluent sampler during storm events.

A summary of the principal analytes sampled is contained in Table 2.

Suspended Solids

ANZECC (2000), DECC (2007) and Fletcher *et al*. (2004) have identified suspended solids as a stressor of aquatic ecosystems. In addition, many of the other pollutants, such as metals, hydrocarbons etc, are transported attached to the suspended solids and sediment. The system achieved an SSC

Table 2. Summary of results.

Analyte	No. of events	Range of Influent EMCs (mg/L)	Median Influent EMC (mg/L)	Range of Effluent EMCs (mg/L)	Median Effluent EMC (mg/L)	Mean Removal Efficiency (Sum of Loads)
SSC	6	75 to 4384	1181	8 to 63	20	99%
SSC < 500 micron	6	48 to 180	105	8 to 62	20	78%
TP	6	0.08 to 0.19	0.123	0.02 to 0.15	0.055	47%
TN	6	0.6 to 1.5	1.045	0.2 to 0.9	0.615	44%
TKN	6	0.6 to 1.2	1.007	0.175 to 0.800	0.515	49%
NH3-N	6	0.05 to 0.15	0.050	0.05 to 0.07	0.050	31%
TOC	6	3 to 16	7	3 to 10	5	32%
DOC	6	3 to 12	7	3 to 11	6	21%

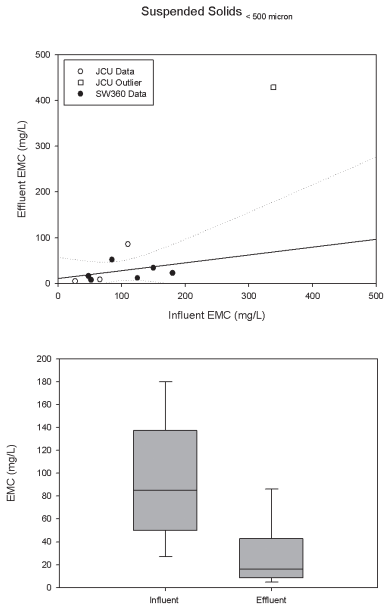

Figure 4. SS <500micron data (JCU + SW360).

aggregate load reduction of 99%. SSC (ie, SSC is defined as the sum of SS <500 micron and SS >500 micron) is 'suspended' in the sense that all these particles were sufficiently suspended to reach the system. However, SS <500 micron represents what is more commonly understood by the term 'suspended solids'. It excludes coarse settleable sediment, which, while being a management issue, does not represent such an acute threat to water quality.

Figure 4 shows influent and effluent data (Stormwater360) for SS <500 micron, together with the results published by JCU. In the scatter plot, the filled-in circles represent data from the trial reported herein, and open circles represent data from the previous JCU's research project. The exception is the JCU outlier represented as an open square, which has not been included in this evaluation. The line of best fit shown as a solid straight line was calculated by a least squares linear regression for all data points except the JCU outlier (intended to be informational only). Its relative slope provides an appreciation of the trend of the removal efficiency for the treatment train. The dotted curves represent the 95% confidence limits for these same data points. The true statistical significance of the regression lines is open to interpretation and requires further investigation, due to the limited number of data points available for this analysis.

Over the six storms analysed by Stormwater360, the influent EMC for SS <500 micron was in the range of 48 to 180 mg/L with a median influent EMC of 105 mg/L. Duncan (1999) literature review determined that the median concentration for most land uses (roofs excepted) lies between 71 mg/L (forested catchments) and 232 mg/L (urban roads). Fletcher *et al*. (2004) recommend using a value of *ca.* 120 mg/L for roads and *ca.* 100 mg/L for most other land uses. Both sources propose a median value of *ca.* 40 mg/L for forested catchments. The influent concentration of Suspended Solids at Streets Creek is within the typical range of average annual EMCs proposed within the literature; however, no data was collected during large wet-season storm events. Consequently, the median influent EMC reported herein should not be regarded as indicative of an annual median value.

Effluent EMCs recorded for SS <500 micron were in the range of 8 to 62 mg/L. The median effluent EMC was 20 mg/L. Mean removal efficiency for SS<500 micron, calculated by aggregate load reduction, was 78%. It is evident from Figure 4 that the Stormwater360 and JCU data sets are in relatively good agreement with each other, with the exception of the JCU outlier, which represents the first storm from JCU's research project. This storm was deemed an outlier for all water quality parameters due to possible sampling errors and has been removed from the analyses. The box plot in Figure 4 shows that the combined dataset is also clustered around an influent EMC of *ca.*100 mg/L and an effluent EMC of *ca.*20 mg/L. In practical terms, 10 mg/L approximates the system's irreducible EMC for under-500 micron suspended solids. The box plot in Figure 4 indicates that, over the course of two trials, the effluent EMCs from the system, were typically within the range of 10 to 40 mg/L.

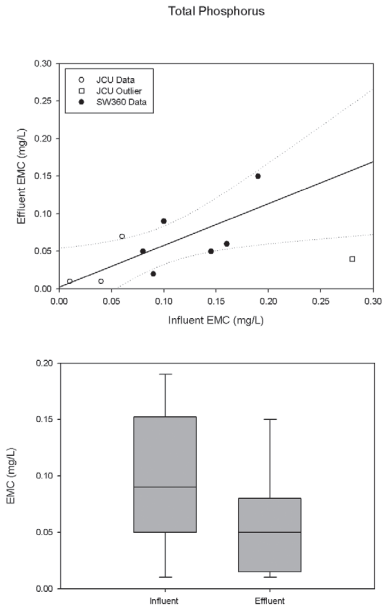

Figure 5. Total Phosphorus (SW360 and JCU combined).

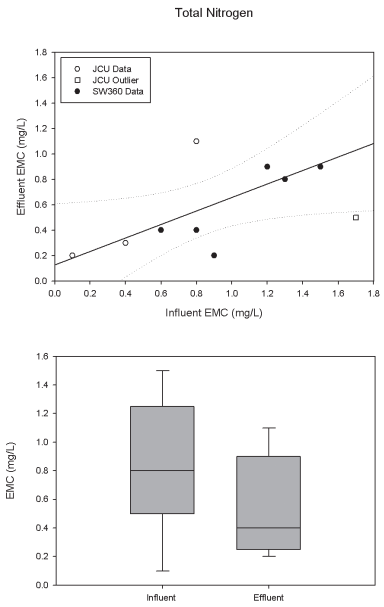

Figure 6. Total Nitrogen (SW360 and JCU combined).

Particle size distribution (PSD) by laser diffraction was performed for the SS <500 micron fraction for three storms during the Stormwater360 evaluation. Inspection of the three cases analysed consists of particles between *ca.* 10 microns and 200 microns in diameter. There is substantial variation between the three events.

- Storm 2 influent PSD centred at *ca.* 20 microns for a removal efficiency of approximately 65%;
- Storm 3 influent PSD centred at *ca.* 100 microns for a removal efficiency of approximately 85%;
- Storm 6 influent PSD centred at *ca.* 35 microns for a removal efficiency of approximately 75%.

Generally, the higher removal efficiency would be expected for the coarser samples, and this was the case for all three storms sampled.

Total Nutrients

The system achieved an aggregate load reduction for total phosphorus (TP) of 47% (note, JCU recorded a load reduction of 70%), the median influent and effluent EMCs for TP were 0.123 mg/L and 0.055 mg/L respectively (refer to Table 2). Duncan (1999) and Fletcher *et al.* (2004) recorded EMCs within a similar range and Fletcher (2004) recommends mean TP concentrations of between 0.25 and 0.50 mg/L for most land uses. Similarly, BMP Database (2010) suggests that a typical range for TP concentrations in stormwater is from 0.11 to 0.38 mg/L, across a range of land uses. In this context it is apparent that the influent TP concentration at the Kuranda site is towards the very low end of published data. Consequently, the 47%

Table 3. Nitrogen results from Storm 6.

Phase	Analyte	Influent EMC (mg/L)	Effluent EMC (mg/L)	Mean Removal Efficiency (Sum of Loads)
Total (dissolved and particulate)	TN	0.8	0.4	50%
	TKN	0.8	0.34	58%
	NH3-N	0.15	0.07	53%
	Org-N	0.65	0.27	58%
	NO3-/NO2--N	0.01	0.06	-500%
Dissolved	TN	0.4	0.3	25%
	TKN	0.39	0.23	41%
	NH3-N	0.16	0.073	54%
	Org-N	0.23	0.157	32%
	NO3-/NO2--N	0.01	0.07	-600%
Particulate (by calculation)	TN	0.4	0.1	75%
	TKN	0.41	0.11	73%
	NH3-N	0	0	N/A
	Org-N	0.41	0.11	73%
	NO3-/NO2--N	0	0	N/A

reduction recorded in the Stormwater360 trial could be related to the difficulty in removing TP at very low influent EMCs, and a much higher removal rate (similar to the 70% recorded by JCU) could be expected as the influent EMC increased.

The system achieved an aggregate load reduction for total nitrogen (TN) of 44%, while the median influent and effluent EMCs for TN were 1.045 mg/L and 0.615 mg/L respectively (Table 2). Again, this influent EMC is low with respect to most of the published data and, according to Duncan (1999), it correlates well with the median for data from forested catchments (0.95 mg/L), but is significantly lower than the median for roads (2.2 mg/L) or urban catchments (2.5 mg/L). Fletcher *et al*. (2004) recommends using a typical total nitrogen value of at least 2 mg/L for most land uses, with the exception of forested catchments.

The total nitrogen results from JCU and SW360 are presented in Figure 6. The spread of influent EMCs is broad, but removal efficiency appears relatively consistent and substantial. This is in spite of the low influent concentrations. TN is generally considered to be predominantly soluble, which is best removed by biological uptake or denitrification (in an anaerobic environment). Consequently, the consistent removal of TN exhibited by the system deserves further consideration. The majority (*ca.* 95%) of the total nitrogen load at Kuranda is TKN and a breakdown of TN species is contained in Table 3.

A small proportion of this TKN load (*ca.* 5%) is ammonia nitrogen, which implies that *ca.* 90% of the total nitrogen load is present as organic nitrogen, in either soluble or particulate forms. An expanded nitrogen suite analysis was conducted for Storm 6, and filtered (0.45 micron) and unfiltered samples were processed in order to establish whether the removal processes, for this event, involved particulate removal or removal of dissolved species. Essentially, the entire TN load was present as TKN and *ca.* 20% of this was ammonia-N (Table 3).

The entire ammonia-N load was soluble, and the treatment train system achieved 54% removal of this species. The remainder (*ca.* 80%) of the TN/TKN load was present as organic nitrogen, of which *ca.* 35% was dissolved. Overall, 73% removal of particulate organic nitrogen and 32% removal of dissolved organic nitrogen was achieved.

Given the removal efficiency for suspended solids, the high removal of particulate organic nitrogen is understandable. Removal mechanisms for dissolved organic nitrogen are less obvious. It is possible that there is some adsorption to the 'schmutzdecke' (bio-film) that develops on the cartridge; another possibility is removal under the anaerobic conditions within the standing water within the wet-zones, being the wet-sump and around the base of the cartridge.

When runoff first enters the StormFilter®, it initially displaces the standing water in the wet-zones. Any pollutants in the standing water are sampled by the effluent sampler (once they have passed through the StormFilter® cartridge), but they are not sampled by the influent sampler. Furthermore, the last of the runoff to enter the cartridge during a storm event does not necessarily pass through the filter cartridge during that event and may be retained within the wet-sump until the next storm event, whereupon it is displaced. When the (particulate or dissolved) organic nitrogen converts to ammonia in the anaerobic wet sump, it can be removed as ammonia-N by the zeolite.

Table 4. Grab samples from wet sump.

Date	Antecedent Dry Period (days)	Report #	Diss. Cu (mg/L)	Diss. Zn (mg/L)	DOC (mg/L)	Diss. N (mg/L)	Diss. NH3-N (mg/L)	Diss. NOx--N (mg/L)
07/07/2008	8	40627	0.011	0.053	17	-	-	-
20/02/2009	6	42998	0.001	0.016	-	2.4	2.39	<0.01
06/05/2009	19	43826	0.005	0.082	16	7.2	5.85	0.72
21/07/2009	79	44703	0.004	0.083	20	3.4	2.24	0.025

Periodic grab samples from the wet-sump indicate that most of the TN load in the standing water is present as ammonia-N at concentrations that are two orders of magnitude higher than typical influent ammonia-N concentrations. As such, ammonia-N is, possibly, generated in the wet-zones by anaerobic decomposition of organic nitrogen in the inter-storm event periods. This has two important implications: 1): the load of ammonia-N passed to the StormFilter® cartridge is significantly higher than is suggested by the influent EMC, which implies that the removal rates for ammonia-N removal may be an under-estimate; and 2): by converting organic nitrogen to ammonia-N in the wet-zones and then removing this ammonia, the system has the potential to remove soluble organic-N.

Discussion

The results for Storm 6 represent a snapshot of one storm, and should not be considered as comprehensive; they do suggest, however, that the main TN removal pathways for the treatment train is the efficient removal of particulate organic nitrogen, complemented by the sorptive removal of soluble ammonia-N and organic-N.

Very often TN removal is treated as a key performance benchmark for stormwater treatment practices. This is potentially problematic, given the apparent variation in the nature of the TN load. In a comprehensive study of nitrogen composition in Melbourne (Taylor *et al*., 2005), *ca.* 25% of the load was present as particulate organic nitrogen. The remainder was soluble and, of these species, oxidised nitrogen predominated over dissolved organic nitrogen and ammonia-N.

Taylor *et al*. (2005) inferred that either 'removing' the water by infiltration or denitrification (ie, in the anaerobic zone of bio-retention practices) would be necessary to achieve significant TN reduction. Fletcher *et al*. (2004) reported that the TN composition measured in wet weather samples for various land uses in the Sydney and Illawarra regions was extremely variable. For urban catchments, median oxidised nitrogen concentrations were in the range 0.09 to 0.42 mg/L, while the median TN concentration range was 0.65 to 2.32 mg/L.

The oxidised nitrogen represents a much smaller proportion of the TN load than was observed by Taylor *et al*. (2005) for Melbourne data. In a study of nutrient build-up on urban roads in the Gold Coast, Miguntanna *et al*. (2010) found that oxidised nitrogen comprised only *ca.* 10% of the TN load, across three different land uses, and most of the TN load was present as TKN and a significant proportion of this was particulate in nature. Consequently, the measured TN load from the Gold Coast catchments is similar to that measured at the Streets Creek, Kuranda site, providing applicability of Nitrogen removals to various urban land uses.

Conclusions

The results from this field trial generally correlate well with an earlier study at this site by JCU (Munksgaard and Lottermoser, 2008). The data collection from this study has been based on a rigorous and technically demanding monitoring program, which adds further credibility of the results (Goonetilleke, 2010). From an operational perspective, the system captured an appreciably large sediment load requiring annual cleaning to maintain its operational effectiveness.

The EnviroPod®/StormFilter® treatment train achieved 78% removal for suspended solids under 500 microns, which approximates the long-term environmental target recommended by NSW DECC (2007), QLD DERM (2010) for South East Queensland (SEQ) and consistent with the 80% reduction target of many consent authorities in the US.

The runoff at Streets Creek contained very low levels of phosphorus and nitrogen. Total Phosphorus removal was between 45% and 70% respectively in both the Stormwater360 field trial and the JCU research project, which approximates the NSW DECC (2007) and QLD DERM (2010) SEQ long-term environmental targets of 65% and 60% respectively, and is better than expected given the low influent EMCs. Total Nitrogen removal was consistent, substantial and in agreement with the NSW DECC (2007) and QLD DERM (2010) SEQ 45% long-term environmental target, despite the proximity of the influent EMC to the irreducible concentration of the treatment train. The removal of nitrogen was particularly noteworthy, given that the debris captured and stored within the treatment train was not included in the influent load into the system, but may have been sampled as a soluble leachate by the effluent sampler.

Acknowledgements

The authors would like to acknowledge the support of and contributions by Professor Ashantha Goonetilleke and Geoffrey Hunter.

The Authors



Michael Wicks (email: michaelw@stormwater360.com.au) is Technical Director of Stormwater360 Australia. **Nick Vigar** is Research Manager and **Mike Hannah** is Technical Director, both of Stormwater360 New Zealand.

References

ANZECC, 2000: *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1. The Guidelines.* Tables 3.3.4-3.3.5 Tropical Australia p.3.3-12 and Table 3.3.5 p.3.3-13. National Water Quality Management Strategy, October 2000.

BMP Database, 2010: *International Stormwater Best Management Practices (BMP) Database Pollutant Category Summary: Nutrients.* Prepared by Geosyntec Consultants Inc. and Wright Water Engineers Inc. (available from http://www.bmpdatabase.org).

Duncan HP, 1999: *Urban Stormwater Quality: A Statistical Overview*, Report 99/3, Cooperative Research Centre for Catchment Hydrology, Melbourne, Australia. ETV (2004).

Fletcher T, Duncan H, Poelsma P & Lloyd S, 2004: *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures – A Review and Gap Analysis.* Cooperative Research Centre for Catchment Hydrology, Technical Report 04/8.

Goonetilleke A, 2010: Letter to Author, 15 March, 2010.

Livingston EH & McCarron ME, 1992: *Stormwater Management: A guide for Floridians.* Florida DER (71 pages).

Miguntanna NP, Goonetilleke A & Egodowatta P, 2010: Understanding nutrient build-up on urban road surfaces. *Journal of Environmental Sciences*, Vol 22(6), pp 806–812.

Munksgaard NC & Lottermoser B, 2008: *Treatment of Road Runoff Waters, Kuranda Range Project.* Report for Queensland Department of Main Roads, School of Earth and Environmental Sciences, James Cook University, Cairns, Queensland, Australia.

NSW Department of Environment and Climate Change (DECC, 2007): *Managing Urban Stormwater: Environmental Targets.* Consultation Draft – October 2007, Department of Environment and Climate Change NSW, p 4.

QLD DERM, 2010: *Urban Stormwater Quality Planning Guidelines 2010* – December 2010, Department of Environment and Resource Management, Table 2.2 SEQ (2010).

Taylor GD, Fletcher TD, Wong THF, Breen PF & Duncan HP, 2005: Nitrogen Composition in Urban Runoff – Implications for Stormwater Management. *Water Research*, Vol 39, pp 1982–1989.

White M & Pezzaniti D, 2001: *Evaluation of Gully Pit Inlet Control Systems Project Number: 2368261,* Urban Water Resources Centre, University of South Australia (20 pages).

Attachment D – Water quality conditions from past Major Project Approvals

MP 10_0084 Approved June 12, 2012.

MP 10_0103 Approved July 25, 2013.

MP 10_0136 Approved June 27, 2013 – conditions reference Concept Water Cycle Management Strategy developed by Martens.

Concept Approval

Section 75O and 75P of the *Environmental Planning and Assessment Act 1979*

The Planning Assessment Commission of New South Wales (the Commission) under the *Environmental Planning and Assessment Act 1979* ("the Act") determines:

(a) pursuant to section 75O of the Act, to grant Concept Plan approval for the proposal referred to in Schedule 1, subject to the modifications set out in Schedule 2;

(b) pursuant to section 75P(1)(a) and 75P(2)(c) of the Act, the further environmental assessment requirements (as specified in Schedule 2, Part D) for subsequent development applications associated with the Concept Plan;

(c) pursuant to section 75P(1)(c) of the Act, that the subdivision of land that gives effect to the transfer of lands to a public authority or a Minister of the Crown requires no further environmental assessment and approve the development under section 75J of the Act (subject to the conditions set out in Schedule 3 of this approval); and

(d) pursuant to section 75P(1)(b) of the Act, that all development associated with the Concept Plan be subject to Part 4 (excluding exempt and complying development) or Part 5 of the Act, which ever is applicable.

Garry Payne AM	Richard Thorp	Jan Murrell
Commission Member	**Commission Member**	**Commission Member**

Sydney, 12 July 2012

SCHEDULE 1

Application No:	10_0084
Proponent:	Coal & Allied Operations Pty Ltd
Approval Authority:	Minister for Planning
Land:	Lot 2 DP 1043151 and Lot 57 DP 755266, Kanangra Drive, Gwandalan in Wyong Shire Local Government Area
Local Government Area:	Wyong
Concept Plan:	Concept plan for: • residential development of a 62.24ha development site into a maximum of 623 dwellings across two stages, referred to as Hamlet A and Hamlet B; • local open space and bushland reserves; • dedication of 205.75 hectares of Conservation Lands • conceptual road, pedestrian and cycleway network; • conceptual lot layout; and • associated infrastructure.

PART D - FURTHER ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Pursuant with Section 75P(2)(c) of the Act, the requirements listed below shall apply to all future development applications relating to this concept plan.

Urban Design

1.10 Each development application for subdivision shall:

a) demonstrate that the quantity of open space is consistent with the concept plan; and

b) include details on the following:

- strategy for retention of trees on the site;
- proposed public domain treatments; and
- proposed landscaping of all public domain areas including swales, detention basins, and roadside verges.

Any such details must be carried into landscaping plans and public domain plans to be completed in consultation with Council, prior to commencement of subdivision works on site.

Contributions and Open Space

1.11 A staging plan prepared in consultation with Council and to the satisfaction of the Director-General is to be submitted prior to the first application for subdivision that details the schedule for delivery (and dedication where relevant) of the following:

a) provision of roads, stormwater and other service infrastructure;

b) items identified for Gwandalan in the $5 million allocated to the Coal & Allied Southern Estates;

c) section 94 contributions;

d) State Infrastructure Contributions; and

e) Location and management regime for open space.

Note: In relation to section 94 contributions any works in kind or dedication of land in lieu of monetary contributions required under Council's Section 94 Plan must be negotiated with Council.

Water Quality

1.12 Detailed design of all stormwater management devices, is to be submitted with each development application for subdivision in accordance with Council requirements.

1.13 Each development application for subdivision must outline management arrangements for public stormwater facilities prior to dedication to Council, both during and after construction. These arrangements should be negotiated with Council.

1.14 A water quality and hydrological monitoring plan is to be provided as part of any development application for subdivision. The program shall include:

a) Monitoring of data against relevant water quality standards and the baseline data collected prior to commencement of works;

b) Monitoring of changes in hydrology caused by the development to ensure no detrimental impact on the water quality in Crangan Bay, seagrass communities in Crangan Bay, and Strangers Gully which adjoins the development area.

c) Details on mechanisms and responsibilities for the management and reporting of the results;

d) Identification of remedial actions to be implemented in the event of a discrepancy between the actual and predicted performance of the water quality controls and/or any adverse impacts on seagrass beds communities or Strangers Gully; and

e) A program to report monitoring results to Council and NSW Office of Water.

Concept Plan Approval

Section 75O of the *Environmental Planning and Assessment Act 1979*

As delegate of the Minister for Planning and Infrastructure under delegation executed on 27 February 2013, pursuant to Part 3A of the *Environmental Planning and Assessment Act 1979* (the Act) I determine:

(a) to approve the concept plan referred to in Schedule 1, subject to the terms of approval and modifications in Schedule 2, and the proponent's Statement of Commitments in Schedule 3;
(b) under section 75P(1)(b) of the Act, development the subject of the Concept Plan is subject to Part 4 or Part 5 or the Act whichever is applicable; and
(c) under section 75P(2)(c) of the Act, where development is subject to Part 4 or Part 5 of the Act (other than complying development), that development is subject to the further environmental assessment requirements specified in Part C of Schedule 2.

The modification and further assessment requirements are required to:

- encourage the orderly future development of the site;
- ensure adequate mitigation of environmental impacts of future development;
- ensure the protection of threatened species and their habitat; and
- set out future environmental management measures for the site.

Chris Wilson
Executive Director
Development Assessment Systems & Approvals

Sydney 25 July 2013

SCHEDULE 1

Application No.:	10_0103
Proponent:	Eric Norman Developments Pty Ltd Jaclesta Pty Ltd Machro Pty Ltd Shannon Pacific Pty Ltd
Approval Authority:	Minister for Planning and Infrastructure
Land:	Lots 31 and 223 DP 754396 and Lot 57 DP 1117398, Steve Eagleton Drive, South West Rocks – Kempsey local government area
Concept Plan:	Residential subdivision, comprising: • 137 residential lots; • On-site and off-site biodiversity offsetting (biobanking); • Active open space; • Road network continuation of Trevor Judd Avenue; • Road network connections to Steve Eagleton Drive and Keith Andrews Avenue; and • Internal road network.

C5 Traffic Generation

As part of any future development application(s) lodged, a detailed traffic assessment prepared by a suitably qualified traffic engineer and in consultation with RMS and council must be submitted. The traffic assessment is required to:

1) consider the impacts of traffic generated by the site on the intersection of Trevor Judd Avenue with Steve Eagleton Drive, including cumulative impacts on the functioning of the Steve Eagleton Drive, Gregory Street, and Belle O'Connor Street roundabout; and

2) be prepared in accordance with the RMS' Guide to Traffic Generating Developments.

In addition to the requirements of Terms C5(1) and C5(2), any development application that proposes to establish a road network connection to Keith Andrews Avenue is required to:

3) investigate the level of impact likely to occur at the intersection of Gregory Street with Frank Cooper Street having regard to the warrants provided under section 4.8 of Austroads Guide to Road Design Part 4A: Unsignalised and Signalised Intersections; and

4) provide analysis and consideration of the implications of Bruce Field Street potentially becoming a rat-run for future traffic accessing Gregory Street via Frank Cooper Street.

C6 Access Arrangements

For any future development application(s) involving the creation Lots 46 to 61 inclusive, the proponent is to demonstrate the following Restrictions as to Users under Section 88B of the *Conveyancing Act 1919* can be applied:

1) Restriction as to User burdening Lots 46 to 50 inclusive: prohibiting direct vehicle access to Gregory Street.

2) Restriction as to User burdening Lot 51: prohibiting direct vehicle access to Gregory Street and Keith Andrews Avenue.

3) Restriction as to User burdening Lots 52 to 61 inclusive: prohibiting direct vehicle access to Keith Andrews Avenue.

C7 Road Traffic Noise

The proponent is to investigate potential road traffic noise attenuation measures as part of any future development application(s) involving lots that directly adjoin Gregory Street.

1) Noise attenuation measures may be in the form of building restrictions placed on future dwellings (double glazing, insulation, etc) or via the erection of a suitable designed noise barrier constructed wholly within the site boundary, to be designed in consultation with council.

2) Any future dwellings proposed on Lots 46 to 54 inclusive are restricted to single-storey construction, to be encumbered to this effect with a Section 88B instrument under the *Conveyancing Act 1919*.

C8 Stormwater Management

All future development application(s) must include a detailed Stormwater Management Plan, prepared by a suitably qualified person and in consultation with council and the NSW Office of Water. The Plan is to be prepared having regard to Section 4.2 of the Civil Engineering Report prepared by Hopkins Consultants, dated August 2012 and submitted as Appendix D of the EA, and Council's DCP 36 – Guidelines for Engineering and Subdivision. The Plan is required to include the following:

1) proposed measures based on Water Sensitive Urban Design (WSUD) principles to address any foreseeable or potential impacts on the site and surrounding environment, including consideration of potential stormwater run-off discharing to Spencers Creek, Back Creek, and/or Saltwater Creek and Lagoon;
2) outline drainage and water quality control measures for the site;
3) outline erosion and sediment control measures during both construction and occupation stages;
4) a detailed design layout plan(s) for the preferred stormwater treatment train showing the location, size and key functional elements of each part of the system.
5) MUSIC modelling must be undertaken to demonstrate that appropriate water quality objectives can be achieved with the quality of post-development stormwater flows to not exceed the quality of pre-development flows. Details of the MUSIC modelling must be included as part of the Plan; and
6) any provisions for ongoing water quality monitoring and/or implementation of relevant management plans.

C9 Earthworks

On-site earthworks and vegetation clearing is limited to the staging of the subdivision, and may only occur in sequence with approval for the creation of residential lots.

C10 Vegetation Clearing and Fauna Protection Measures

Any future development application(s) must include a Vegetation Management and Fauna Protection Plan, prepared by a suitable qualified ecologist. The Plan is required to detail measures to manage vegetation clearing and protect of native fauna during construction of the development. The following measures are to be included as part of the Plan:

1) a suitably qualified ecological consultant must to be present on site during any vegetation clearing works who is required to monitor works in sensitive areas, offer advice during the clearance process, and be present to supervise recovery procedures in the event of accidental harm to wildlife;
2) trees should be retained within the development footprint wherever possible;
3) tree felling is to be supervised by a qualified fauna specialist appropriately licenced under the *NSW National Parks and Wildlife Act 1974* for the purpose of rescuing and relocating displaced native fauna species;
4) a search for the presence of native fauna species, carried out by a suitably qualified ecologist is required prior to the commencement of any tree felling or vegetation removal;
5) non-hollow bearing trees are to be felled first. At least 24 hours is required between clearing of non-hollow bearing trees and hollow-bearing trees to allow any fauna species present time to vacate and relocate; and
6) all tree hollows are to be salvaged and re-used by means of permanent attachment, at an appropriate height, to suitable trees within land that forms part of the on-site biodiversity offsetting area.

Concept Plan Approval

Section 75O and 75P of the *Environmental Planning & Assessment Act 1979*

As delegate of the Minister for Planning and Infrastructure under delegation executed on 27 February 2013, pursuant to Part 3A of the *Environmental Planning and Assessment Act 1979 (The Act)* I determine:

(a) to approve the concept plan referred to in Schedule 1, subject to the terms of approval and modifications in Schedule 2,
(b) pursuant to section 75P(1)(c) of the Act, that no further environmental assessment is required for the subdivision of the conservation lands,
(c) under section 75P(1)(b) of the Act, development the subject of the Concept Plan is subject to Part 4 or Part 5 or the Act whichever is applicable,
(d) under section 75P(2)(c) of the EP&A Act, where development is subject to Part 4 of the Act (other than complying development), that development is subject to the further environmental assessment requirements specified in Schedule 3 of this approval.

The modification and further assessment requirements are required to:

- Encourage the orderly future development of the site;
- Ensure adequate mitigation of environmental impacts of future development; and
- Ensure protection and restoration of threatened species and their habitat.

Executive Director
Development Assessment Systems & Approvals

Sydney 27 June **2013**

SCHEDULE 3

REQUIREMENTS FOR FUTURE APPLICATIONS

Pursuant to section 75P(2)(c) of the Act the following requirements apply, as relevant, with respect to future stages of the project to be assessed under Part 4 or 5, as relevant, of the Act:

C1 Subdivision Staging – Precinct Plans

Note: A 'Precinct' refers to the 14 development stages identified in the 'Staging Plan' prepared by Crighton Properties Pty Ltd, Drawing No. R.C -07, Revision O and dated November 2012.

A Precinct Plan must be submitted with each future development application for each stage of subdivision on the site. The Precinct Plan must, at a minimum, include the following information:

a) A detailed plan and accompanying assessment of all **Water Sensitive Urban Design (WSUD/IWM)** measures for the precinct and how they relate to other stages of subdivision (see C9) below;

b) Details of **community title arrangements**, including a list of all maintenance responsibilities resting with the Community Association;

c) **Housing density and typology arrangements** (see C2) below;

d) Consideration of **affordable housing** (see C3) below;

e) **Bushfire management:** Location and width of Asset Protection Zones; level of construction required for dwellings/buildings adjacent to Asset Protection Zones in accordance with Planning for Bushfire Protection 2006 and Australian Standard 3959 – 1999 – Construction of Building in Bushfire Prone Areas (see C11) below;

f) Fill and finished floor levels requirements on flood prone lots as identified in the Flood assessment (see C10 below);

g) All other matters specified for in the Draft *Great Lakes Council DCP 2012* except where varied by the terms of this approval.

C2 Housing Density and Typology

As part of the Precinct Plan requirements identified in Term C2 above, plans must be provided which:

a) Demonstrate adoption of the neighbourhood planning principles in the Mid North Coast Regional Strategy 2006 (or any subsequent version thereof);

b) Are not inconsistent with the provisions of the Tea Gardens/Hawks Nest Housing Strategy 2006 (or any subsequent version thereof);

c) Identify locations within the precinct not covered by the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008;

d) Detail the likely mix of housing densities in each precinct, and the objectives for and location of various housing densities;

e) Details the proposed number, size and type of dwellings expected in each precinct;

the site to ensure management strategies do not conflict and each plan can be implemented without negatively impacting on the objectives of another.

C5 Construction Environmental Management Plans (CEMPs)

All future development applications are to include an outline of a stage-specific **Construction Environmental Management Plans** (CEMPs) that detail measures to address the impacts of construction including, but not limited to: erosion and sediment control (in accordance with *Managing Urban Stormwater–Soils & Construction Version 4, Landcom 2004, or the latest version)*; protection of fauna; groundwater and acid sulfate soils; and protection of trees and vegetation to be retained.

C6 Groundwater Management

(1) In order to ensure the protection of groundwater quality, the water quality of the Myall River and maintain the health and integrity of Groundwater Dependent Ecosystems (GDEs), a detailed groundwater monitoring and review plan must be prepared by a suitably qualified person to be submitted with the stage 1 development application.

(2) All future applications where the use of groundwater or the interception of the groundwater table is proposed, the proponent, after consulting with the NSW Office of Water, is to submit detailed Site Water and Groundwater Management and Monitoring Plans, supported by baseline groundwater monitoring conducted for an appropriate period, for the approval of the Certifying Authority prior to the issue of the construction certificate for the 1st staqe development application.

C7 Acid Sulfate Soils Management Plan

(1) A detailed Acid Sulfate Soils Management Plan (ASSMP) must be submitted with each stage specific development application and prior to issue of any construction certificates for earthworks. The ASSMP must be produced generally in accordance with the *ASSMAC Guidelines (1988)* and certified by a suitably qualified person.

(2) The ASSMP must include actions for determining ASS conditions ahead of excavation, handling of groundwater levels and quality, detailed management procedures for surface waters and flood routing, interaction (short and long term) of the groundwater with surface water in order to prevent the formation of monosulfides, materials evaluation and handling, materials balance, stockpile treatment, validation testing, monitoring systems with trigger levels, contingency actions, protection for structural elements, and evaluation of off-site impacts etc.

C8 Stormwater Management and Water Quality Monitoring

(1) All future development applications for each development stage are to submit a detailed stormwater management plan prepared by a suitably qualified person. The Stormwater Management Plan must address and outline measures based on Water Sensitive Urban Design Principles which addresses impacts on the surrounding environment, drainage and water quality controls for the catchment, and erosion and sediment controls at construction and operational stages.

(2) Each plan is to include a detailed design layout plan for the preferred stormwater treatment train showing location, size and key functional elements of each part of the system must be submitted with each development application for subdivision. MUSIC modelling must be undertaken to demonstrate appropriate water quality objectives are being achieved.

(3) A detailed Water Sensitive Urban Design (WSUD) plan must be submitted with each Precinct Plan generally in accordance with the [the final updated Marten's report which is included as Annexure C of the PPR dated January 2013]. The Plan must be prepared in consultation with Council and NSW Office of Water and must address and outline measures, based on WSUD principles which address impacts on the surrounding environment, drainage and water quality controls for the catchment at construction, maintenance and operational stages.

(4) The applicant must ensure that any detailed design and urban stormwater quality modelling provides consistency with proposed mitigation measures as outlined in the Preferred Project Report Volume 1 Annexure C Concept Integrated Water Cycle Management Strategy, January 2013 prepared by Martens Consulting Engineers. This work must be certified as consistent by a recognised professional engineer.

(5) The applicant must ensure that works as constructed are consistent with the design works and the proposed mitigation measures as outlined in the Preferred Project Report Volume 1 Annexure C Concept Integrated Water Cycle Management Strategy, January 2013 prepared by Martens Consulting Engineers. The delivered assets must be certified as consistent by a recognised professional engineer.

(6) All future applications for each stage of the development are to demonstrate, through the provision of monitoring and adaptive management plans and commitments, that any proposed surface water/stormwater pollution reduction devices will be monitored to determine their pollutant removal efficiencies and the need for further treatment of drainage to ensure the preservation of water quality in the Myall River and associated wetlands.

C9 Flooding and Climate Change

(1) In order to ensure the protection of life and property during a flood event, an updated flood assessment of the site must be submitted with the first stage development application.

(2) The flood assessment in (1) must be consistent with the findings and recommendations within the Tattersall Landers Flood assessment included in Annexure C of the PPR dated January 2013. The flood assessment must be prepared in consultation with and to the satisfaction of the Director-General in consultation with OEH and include further information in relation to ground elevation data, model calibration and sensitivity analysis, refinement of the grid spacing, catchment boundary (Myall Rd), impact of the development on Myall River Flooding, impact of the development at northern boundary and Toonang Drive, the East West Deflector Embankment Levee, Blockage Modelling and Access and Evacuation routes.

(3) All future applications for each stage of development are to incorporate any re-calibrations of the relevant Council flood model.

(4) A preliminary development landform for the entire site is to be provided with the first development application for residential subdivision to allow comprehensive flood modelling to be carried out, but not in such a way as to preclude necessary modifications to land forms in subsequent stages of development.

(5) All future applications for residential subdivision shall provide an updated Design Flood Level Map showing peak flood levels for local and regional flood events at 0.1m contours and a detailed flood impact assessment for all flood liable land.

C10 Geotechnical Assessments

(1) In order to ensure the stability of development lots, a detailed geotechnical assessment prepared by a suitably qualified person must be submitted with each future