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Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development Final Report

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Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development

Final Report

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Title :	Review of Water Quality Management for the Proposed Riverside at Tea Gardens Development
Author :	Tony Weber
Synopsis :	This report provides a review of the water quality management approaches proposed for the Riverside at Tea Gardens development, including assessment of existing documentation, review of stakeholder comments and detailed analysis of water quality modelling.

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1 INTRODUCTION

The proposed development of a 230 hectare site at Tea Gardens on the Central Coast of NSW has been the subject of numerous studies, reviews and assessments. Originally proposed to be a mix of golf course and residential land uses, the current proposal, termed “Riverside at Tea Gardens”, includes residential, recreation and tourist related activities. The development site is immediately adjacent to the Myall River and surrounding wetlands and consequently the management of impacts associated with both the construction and operation of the Riverside development will be critical to protect those environmental assets.

This water quality review has focussed on reviewing the existing relevant documentation available from the Department of Planning and Infrastructure (DoPI), including original Integrated Water Management Reports, Appendices, stakeholder comments and reviews from the NSW Office of Water, the NSW Office of Environment and Heritage, Great Lakes Council and the Planning Assessment Commission and other supporting documentation where required. The associate model files that were run using the MUSIC (Model for Urban Stormwater Improvement Conceptualisation) were also assessed.

The key elements of this review were to:

a) Review the water quality impacts and associated measures put in place to address them

b) Review the MUSIC modelling undertaken by the developer’s consultant

c) Assess the compliance of the water quality measures with relevant targets

d) Provide recommendations to DoPI.

These elements are addressed in each section of the report.

2 REVIEW OF WATER QUALITY IMPACTS AND MEASURES

2.1 Overview

The proposed development at Tea Gardens would be considered as large scale development in accordance with the Great Lakes Council DCP 54 Water Sensitive Design. Such large scale developments are likely to have numerous environmental impacts if not well managed. These impacts include pollutants associated with both the construction phase (e.g. litter, paint spills, sediment) and the operational phase (e.g. litter, sediment, nutrients, heavy metals, petroleum hydrocarbons).

Early efforts in the water quality field in managing these impacts focussed around removing litter and other “aesthetic” pollutants, usually through proprietary devices such as gross pollutant traps, vortex filters and other physically based devices, using a screen or mesh to trap larger pollutants and store them for later removal. From there, water quality ponds and wetlands were the technique next considered, usually as large to very large “end of pipe” measures designed to capture finer sediments, nutrients and associated pollutants. The proposed water quality management measures for the Riverside development are consistent with this approach.

In the last 15 years or so, Water Sensitive Urban Design (WSUD) or Water Sensitive Design (WSD) has become widespread, which considers not only the physically based measures and elements such as ponds and wetlands, but a wider philosophy of attempting to manage pollutants at source and develop “treatment trains” of a combination of vegetative based systems to both disconnect drainage systems from directly discharging to receiving waters, and integrating treatment measures throughout the built environment. Apart from one existing swale and two conveyance swales in the proposed development, the water quality management measures at Riverside are not consistent with a WSUD approach. The focus on using large, end of pipe treatment systems is an approach that puts “all the eggs in one basket” and if the systems do not perform adequately, they will pose a significant failure risk to downstream environments as there would be no “back up” treatment available. A WSUD approach would see numerous smaller elements integrated throughout the development so that if any one measure fails, it is only a very small proportion of the total treatment system available. Such systems also tend to be more robust and require significantly less maintenance than the more “end of pipe” systems (BMT WBM 2011). The disadvantage of the WSUD approach is that more care needs to be taken in the design, construction and establishment of some measures, and that poor design and/or implementation has usually been the major cause failure of particular measures, especially constructed wetlands.

2.2 Potential Water Quality Impacts of the Riverside Development

The following tables outline the key pollutants of concern during both the construction and operational phases from a development such as Riverside at Tea Gardens.

2.2.1 Construction Phase

The pollutants listed in Table 2-1 are typically generated during the construction phase of a development such as the proposed project.

Table 2-1 Pollutants Typically Generated During the Construction Phase

Pollutant	Source	Likelihood of occurrence at Riverside
Litter	Paper, construction packaging, food packaging, cement bags, off-cuts	High
Sediment	Unprotected exposed soils and stockpiles during earthworks and building works	High
Hydrocarbons	Fuel and oil spills, leaks from construction equipment	Medium
Toxic materials	Cement slurry, asphalt prime, solvents, cleaning agents, wash waters (eg. from tile works)	Medium
Acid or Alkaline substances or producing substances	Acid sulfate soils, cement slurry and wash waters	High

(Adapted from GCCC 2007)

2.2.2 Operational Phase

The pollutants indicated in Table 2-2 are typically generated during the operational stage of a development such as the proposed project.

Table 2-2 Pollutants Typically Generated During the Operational Phase

Pollutant	Urban Residential	Tourist/Recreation Areas
Litter	Yes	Yes
Sediment	Yes	Yes
Oxygen Demanding Substances	Yes	Yes
Nutrients (N&P)	Yes	Yes
Pathogens	Potentially	Potentially
Hydrocarbons	Yes	Potentially
Heavy Metals	Yes	Potentially
Surfactants	Yes	Potentially
Organochlorines and organophosphates	Potentially	No
Thermal Pollution	No	No
pH altering substances	No	No

(Adapted from GCCC 2007)

If combined with the consideration of the particle sizes and relevant treatments necessary to target them, this gives an indication as to the likely treatments suitable in such a development. This is discussed further below.

2.3 Water Quality Management Measure Assessment

2.3.1 Overview

In managing stormwater quality and, to a lesser extent, quantity, WSUD practices are best utilised via a series of measures, each focussing on one or more objective(s) or target pollutant(s). This 'treatment train' approach is utilised to ensure that the measures selected operate most effectively in terms of their specific hydraulic and treatment capabilities.

It is therefore important to understand the locations where treatment measures may be utilised within a WSUD plan so that the quantities of pollutants and flow likely to be received at each location are appropriate.

A sequence of stormwater treatment measures should be formulated which aims to manage specific size ranges of pollutants at appropriate timescales, based on the areas available for siting treatment measures. For example, coarse sediment will settle out of stormwater in a matter of minutes once stilling of the flow occurs, whereas removal of nutrients can take hours to days. As such, a treatment measure that is effective at removing coarse sediment may not necessarily be suitable to remove nutrients. It may also mean that a stormwater treatment measure designed to remove nutrients may require more frequent maintenance if it also has to remove coarse sediment.

2.3.2 Treatment Processes

As discussed above, each stormwater treatment measure operates over particular hydraulic loading rates and pollutant size ranges, however the pollutants typically targeted for removal by the stormwater elements of a WSUD (e.g. sediment, nutrients, litter etc.) can have very large size ranges. This is shown in Table 2-3 below.

From Table 2-3, it can be seen that to treat a certain suite of pollutants, one treatment measure will not be suitable. For example, while a vegetated swale may be able to remove some nutrients, it will not be effective in removing colloidal and dissolved material, and a wetland or bioretention system may provide more efficient treatment. The swale may then become the pre-treatment measure for the wetland, and hence a 'treatment train' is created.

Table 2-3 Relationship of Particle Size and Hydraulic Loading

Size Range (µm)	Pollutant					Treatment Measure					Hydraulic Loading Rate Inflow/Surface Area (m/yr)
	Litter	Sediment	Nutrients	Organics	Metals	Gross Pollutant Traps	Sediment Basins	Swales and Buffer Strips	Constructed Wetlands	Biofilters	
>5000 (Gross solids)											1,000,000 - 100,000
5000 - 125 (Coarse)											50,000 - 5,000
125 - 10 (Fine)											2,500 - 1,000
10 - 0.45 (Colloidal)											500 - 50
<0.45 (Dissolved)											10

Adapted from CRCCH 2004

Table 2-3 also shows that to treat gross pollutants and coarse sediment in stormwater, the hydraulic loading rate (i.e. the quantity of water able to pass through a given surface area of a treatment measure) can be very high, whereas to treat nutrients or metals a much smaller hydraulic loading rate is required. This means that either less water can be treated, or the treatment measure needs to be much larger to treat an equivalent amount of water. The space requirements for a device are then inversely proportional to the hydraulic loading rate; the lower the loading rate, the larger the measure.

For this reason, treatment trains should be focussed on treating gross particulates (litter, larger organic matter etc.) first, then coarse particulates (sediment) and finally fine, colloidal and dissolved material.

One treatment measure cannot treat all of the particle size ranges and a combination of measures will be most effective. (NWC 2010).

2.3.3 Proposed Treatment Measures for the Riverside Development

From the report entitled “Riverside at Tea Gardens – Integrated Water Management – Main Report” by Cardno, dated December 2011, it would appear that the treatment system proposed consists of 4 wetlands, some small ponds, two very large freshwater lakes and the existing salt water lake. Two swales have also been incorporated into the development, though their purpose is not entirely clear.

Total areas of proposed treatment are:

Wetlands = 2.515 ha

Ponds = 0.3715 ha

Freshwater Lakes = 3.5 ha

Existing Salt Water Lake = 6 ha

The overall areas available for treatment measures is considerable, however the ponds and lakes as they are configured, without significant pretreatment in some cases, means that they should be considered as receiving environments rather than part of the stormwater treatment train. With no pretreatment, the ponds would likely fill with sediment relatively quickly and require frequent maintenance.

It would appear that the two large freshwater lake systems are there simply as “borrow pits” to provide fill for parts of the development so as to raise development platforms above the design flood level. They also provide a convenient discharge point within the development to ensure that hydraulic grade requirements can be met for the conventional stormwater drainage network, as given the large expanses of flat land, using pipe gradients of 1:200 or similar would mean that stormwater outlets would be submerged if they had to discharge directly to the Myall River. While the existing saltwater lake currently appears to have satisfactory water quality, this is likely to be largely due to a reasonable degree of tidal flushing rather than any specific water quality measures. As proposed, the loads to this lake would increase, and with two freshwater lake systems also included in the development also receiving considerable pollutant loads, the maintenance burdens of these systems would be considerable in order to maintain their aesthetic function. There are numerous examples across the eastern seaboard of Australia of such freshwater lakes causing considerable burdens on local governments, body corporates and other responsible agencies and there are only a handful of examples where such systems have been successful, and even then only after considerable (>$100k per annum) maintenance expenditure and with suitable treatment systems in place upstream (BMT WBM 2007 (2)).

The wetland systems do not appear to have been configured optimally, with only very short (6-8 hour) detention times, no high flow bypasses and no sediment forebays to remove coarse sediment. As such, it is expected that those systems will not perform sufficiently to protect the downstream lake systems and any material that they do collect would likely be scoured out directly into the downstream lakes in high flow events. This would then result in lakes that would present water quality issues in the short to medium term (2-5 years) and cause problems for both the residents of the proposed development and Great Lakes Council. These problems could include:

- Eutrophication (excessive plant growth) from the increased nutrient loads.
- Loss of aesthetic amenity due to either algae (phytoplankton) blooms or excessive submerged macrophyte (water plant) growth.
- Safety issues due to toxicity from cyanobacterial blooms and/or entanglement and drowning through contact with the excessive submerged macrophyte growth.
- Odour issues, where decaying plant matter may cause hydrogen sulfide and other odour causing gas generation
- Siltation and sedimentation, from poor wetland design and/or poor erosion and sediment control during construction, leading to both anoxic conditions in the lakes themselves (dependent on depth) and subsequent release of nutrients to the water column.
- Excessive nutrient discharge to downstream receiving waters, especially the Myall River as a result of the above issues.
- A considerable cost burden to the final asset owner, whether this be the residents (if the lake is held under a community title) or Great Lakes Council

Recommendation 1

It is recommended that the pond and lake systems be removed from the development proposal or at the very least, considered as receiving environments and not part of the water quality treatment system.

It is noted that some lake modelling has been conducted using the CRC for Freshwater Ecology's Pond Model, developed by Dr Ian Lawrence. This model, first developed in 1998 and revised in 2000 and 2001 was a simple spreadsheet model and is now considerably dated. It should also be noted that this model was developed for freshwater systems, not for saline systems such as that currently present in the existing salt water lake (CRCFE 2001). The modelling of the lakes would therefore not be considered best practice as far more sophisticated modelling techniques and assessment processes are now available, e.g. Melbourne Water's Shallow Lake Guidelines, Mackay Regional Council's Artificial Waterbody Design Guidelines. If the lake system is deemed a necessary part of the development (for non-water quality outcomes only), then more sophisticated assessment techniques should be considered.

Recommendation 2

If freshwater lake systems are deemed a necessary part of the development, suitable treatment measures should be put in place for their protection, and a more sophisticated assessment of their performance be undertaken. If lakes are deemed necessary, they should be assessed independently of the treatment train and considered only as receiving waters.

3 REVIEW OF MUSIC MODELLING

3.1 Outline

The assessment of water quality management measure performance is commonly conducted using some sort of modelling software. In Australia, the most common modelling platform is MUSIC (Model for Urban Stormwater Improvement Conceptualisation). The MUSIC software uses a conventionally node-link style of framework to develop a representation of the hydrology and pollutant export characteristics of a catchment. Originally developed by the CRC for Catchment Hydrology, further revisions and updating of the software has been undertaken by the eWater CRC, the successor Cooperative Research Centre to both the Catchment Hydrology and Freshwater Ecology CRCs. The current version of the model is Version 5.11, which has updated parameters for treatment measure performance, considerable GUI improvements and represents the best available science in Australia on the prediction of WSUD treatment measure efficacy.

This review was conducted on two models received from Dr Brett Phillips of Cardno via electronic submission on 3 May 2012.

MUSIC Model "Exist82-May04 Current Mar09.sqz" represented the existing situation of the proposed location, including previous urbanised areas.

MUSIC Model "FutDaily82-May04+Pond NoRWT T10 Dec11.sqz" represented the future development layout.

A third model "Exist82-May04 Theoretical Mar09.sqz" was also received, however this was not assessed in detail as it did not appear to represent the site as it currently existed and the exact reason for the development of this model was not apparent in the modelling reports.

In undertaking this review, the reviewer used the NSW MUSIC Modelling Guidelines (SMCMA 2010) as the primary reference, but also drew on experience in developing the MUSIC software with the eWater CRC and the numerous MUSIC models both reviewed and constructed by the reviewer.

3.2 Model Review

3.2.1 Approach

The approach taken by Cardno in developing the MUSIC model was to retain consistency with earlier modelling undertaken by another modelling package, AQUALM-XP, in 2004. The overall subcatchment breakdown is very much similar to that which would be undertaken using that software, but is not consistent with either a "surface type" or "lumped" approach as recommended in the NSW Guidelines, but rather appeared to be a mix of both types.

It is difficult to understand why the MUSIC model was developed to be consistent with the AQUALM model when that model does not represent the latest available science, nor was consistent with best modelling practice as outlined in the NSW guidelines. There is no justification in the report to qualify why this approach was taken, as it is envisaged that no calibration of the AQUALM model (other than rudimentary calculations) would have been undertaken in 2004, simply as there does not appear to be any relevant gauging stations nearby with which to calibrate the model hydrology. The overall modelling approach then appears to be flawed as it is simply attempting to replicate an existing uncalibrated model, and as such, has no quantitative basis with which to compare to the MUSIC model in this fashion. If the modellers had used the available guidance with which to construct their model, at least the modelling approach and parameters would have had a primary reference as their basis. The NSW guidelines contain parameters that have been selected based on regional hydrologic calibration approaches and available literature. The process outlined in them would therefore result in a model that while not calibrated, at least uses parameters that have some scientific basis and would be justifiable to review.

Recommendation 3

Revise the existing and developed case MUSIC models to be consistent with the NSW MUSIC Modelling Guidelines.

3.2.2 Model Parameters

It is not clear from the report how the parameters for both hydrology and pollutant export were derived, other than to be consistent with the previous AQUALM modelling. The parameters used are significantly different to that recommended in the NSW guidelines, especially for pollutant export. Given that only limited water quality monitoring has been undertaken on site, and that has not focussed on storm event monitoring, the parameters used are not considered appropriate for the site in either the existing or developed model cases and **both models would not be representative of the hydrology and pollutant export likely to originate from the site**.

Recommendation 4

Revise the existing and developed case MUSIC models to have parameters which are both justified and consistent with the NSW MUSIC modelling guidelines.

The modeller has used the “deep seepage” parameter in the MUSIC source nodes to represent losses to groundwater, however this parameter should only be used where it is expected that the groundwater table is relatively deep and the infiltrated water is not likely to reappear downstream. In the case of the Riverside at Tea Gardens site, the groundwater assessments detailed in the Cardno report show that the groundwater table is very shallow (~0.5m) in large areas of the site and given both the proximity of the SEPP 14 wetlands and the Myall River, the groundwater table is likely to interact considerably with those receiving environments and would therefore need to be assessed in terms of overall contributions of pollutants from the site. The groundwater itself should also be included as a receiving water, given the importance of both surface and groundwater hydrology and quality in maintaining the SEPP 14 wetland conditions. It is not apparent that this has been undertaken other than to state that no net increase of pollutants would occur.

Recommendation 5

The deep seepage parameter should not be used in any MUSIC models of the site.

Recommendation 6

The groundwater contributions of the site, using the outputs of the MUSIC model and other models, need to be better assessed to quantify the hydrologic and water quality impacts on the adjacent SEPP 14 wetlands.

In areas where direct rainfall is being accounted for onto the lake systems, the modeller has set the pollutant export values to numbers that are not representative of the suspended solids and nutrients likely to be present in rainfall.

Recommendation 7

Appropriate parameters to represent nutrients likely to be present in rainfall are to be used where direct rainfall onto lakes are being modelled.

3.2.3 Source Node Configuration

The models have been set up to represent the existing site using the agricultural node in MUSIC, but reparameterised so as to be consistent with the previous AQUALM model. It is understood that the existing site was once used as a pine plantation in some parts, and if properly configured, the agricultural node for these areas would be considered appropriate. However, there are also areas on site that appear to be in relatively good condition. Those areas should have been set up as a vegetated area of good condition, typically using parameters for a forested land use. Without a detailed assessment of the site, the reviewer was not able to identify the exact areas of the site that should be configured as “forested”, though with a site inspection and clear aerial photographs, this should be relatively straight forward. As currently configured, the model may be over predicting existing catchment loads and therefore making it less difficult to achieve a “Neutral or Beneficial Effect” from the developed case. It was also not clear whether the existing commercial areas had been adequately accounted for in the existing case model, as no different pollutant export values or hydrologic parameters could be seen for the impervious nodes in that area within the model.

Recommendation 8

Revise the existing case MUSIC model source nodes to better reflect both the “agricultural” and “forested” conditions of the existing site and to include specific nodes reflecting the commercial areas in the existing site.

For the future case model, several nodes labelled “WBD” were included but it was not apparent what they were representing, perhaps some direct rainfall onto a wet detention basin. No specific areas were labelled as being set up for commercial development to represent the existing commercial area, so it is unsure whether this land use was properly reflected in the model.

Recommendation 9

Clarify the WBD nodes and whether the existing commercial areas have been properly accounted for in the future case model.

3.2.4 Climate and Warmup Configuration

The model timestep used for both models was a daily timestep. There is no justification for this approach and with the inclusion of grassed swales in the developed case model, such timesteps are not appropriate and not consistent with the NSW guidelines. As vegetated swales only have a short period of time in which to treat pollutants (in the order of minutes), using a daily timestep model overestimates their performance considerably, as instead of having a few minutes with which to “treat” the water in the model, the swales would have a full 24 hours, and the overall hydraulic and pollutant load per unit time is much lower, therefore resulting in the over estimation. The models should be run at 6 or 12 minute timesteps to better assess performance of treatment measures, using the nearest pluviometer station (Williamtown RAAF base) to provide data. It should be noted that the Williamtown station has a lower mean annual rainfall than Hawks Nest, the station used by Cardno, so some adjustment of the pluviometer timeseries may be required.

Recommendation 10

Use a sub-daily timestep through both the existing and developed case models, either 6 or 12 minute.

The MUSIC software was set up with the “catchment warmup” turned off. This feature runs one year of climate data through the model prior to commencing a full run, to ensure that the model parameters have reached equilibrium prior to running. With hydrologic models such as that in MUSIC, some model elements start off empty, and so some proportion of the rainfall is lost when the catchment warmup is turned off, leading to an under-representation of the overall site runoff and pollutnant loads. If the model warmup is turned off, it is best practice then to discard the first year of results as these would not be considered valid. This was not done in the case of these Riverside models, nor was any justification provided as to why the warmup was switched off.

Recommendation 11

The model warmup should be turned on in any future models of the site, or the first year of results not included in the analysis of model outputs.

3.2.5 Treatment Node Configuration

The wetland treatment nodes in the developed case model have been set up with no sediment forebay so the vegetated zone (or macrophyte zone) of the wetlands are likely to become silted up with sediment if this was the case. When modelling and designing a wetland, a sediment forebay is considered essential in terms of assessing a robust treatment system. While the removal of fine sediments are expected in the vegetated zone, a sediment forebay would ensure that the vegetated zone would continue to remove fine sediment throughout the lifespan of the wetland.

The wetlands have also been configured without a dedicated high flow bypass from inlet of the wetlands. This would result in the wetlands being scoured out in very high flows and the previously collected material being deposited either in the downstream lakes or into the Myall River, thus rendering their treatment capacity as redundant.

There are two different extended detention depths proposed for each wetland (0.1 and 0.3m). It is not clear in the report why two different depths are used. The configuration of the wetlands is such that they have very short detention times. While this may increase the overall loads removed by the wetlands, it may impact upon both the nutrient concentrations and scour velocities present in them and result in them not functioning appropriately.

The wetlands are proposed to be lined to prevent contact with the groundwater table, however this would be required in constructing these assets anyway as the shallow groundwater table may result in structural weakness of any constructed bunds, weirs and other associated infrastructure. The proposed lining may prevent water from the wetlands contacting the groundwater, but may not be sufficient to prevent groundwater leaching into the wetlands themselves due to the high groundwater table and the proposed height of the wetland standing water level. It may be that if this difference is significant, then this may lead to localised lowering of the groundwater table, however this should be further considered in any assessment of the groundwater reports.

The overall issue of protection of groundwater quality through lining of the water quality assets has not been thoroughly investigated in the Cardno report. It is likely that the best way to manage the hydrology in the existing SEPP 14 wetlands is to allow for some infiltration into the existing groundwater table, however any such infiltrated should be treated prior to this so as to protect existing groundwater quality

Recommendation 12

Wetland nodes, where used, should be configured both within the model and in design drawings to contain a high flow bypass, and a sediment forebay to remove coarse sediment. Also the configuration of the wetlands should be revised so as to provide reasonable (24-48 hour) detention times and consistent extended detention depths.

Recommendation 13

Any measures included in the water quality management regime should be designed such that treatment occurs prior to any interaction with the groundwater.

Two vegetated swales are also included in the treatment train, however these were both configured unusually. One swale (labelled “Swale”) was set up with a low flow bypass of 100 m^3/s, which would mean that flows up to 100 m^3/s would bypass the system prior to it beginning treatment. This doesn’t seem to make sense and is likely to be a simple error.

The second swale (labelled “Swale CZ”) has had its overall length modified to represent losses via lateral flows as it would appear that this swale is to be used to “recharge” the SEPP 14 wetland areas that it adjoins. If so, the modeller should simply have included this as an exfiltration in the swale node, and accounted for the losses at the end of the treatment train, as shown in the NSW guidelines. The approach used, to shorten the length of the swale to represent lateral losses, is not consistent with modelling best practice.

Recommendation 14

Reconfigure the swale nodes to be consistent with the NSW guidelines.

4 ASSESSMENT OF THE COMPLIANCE OF THE WATER QUALITY MANAGEMENT MEASURES

4.1 Outline

The treatment system proposed has been discussed in the previous two sections. It can be surmised from that discussion that the approach adopted by Cardno in the Riverside at Tea Gardens is not considered best practice. In fact, wetlands within the Great Lakes Council region have not been largely successful, in some cases due to dated design approaches, but also the difficulty in ensuring systems are free draining in tidally influenced areas.

A prime example of this the Council constructed wetland at Goldens Road, Forster. This wetland has suffered from a constrained outlet design which resulted in elevated water levels in the vegetated areas as shown in the image below. These high water levels have resulted in the destruction of most of the wetland vegetation, and colonisation by Salvinia spp. causing both visual and odour problems as can be seen.

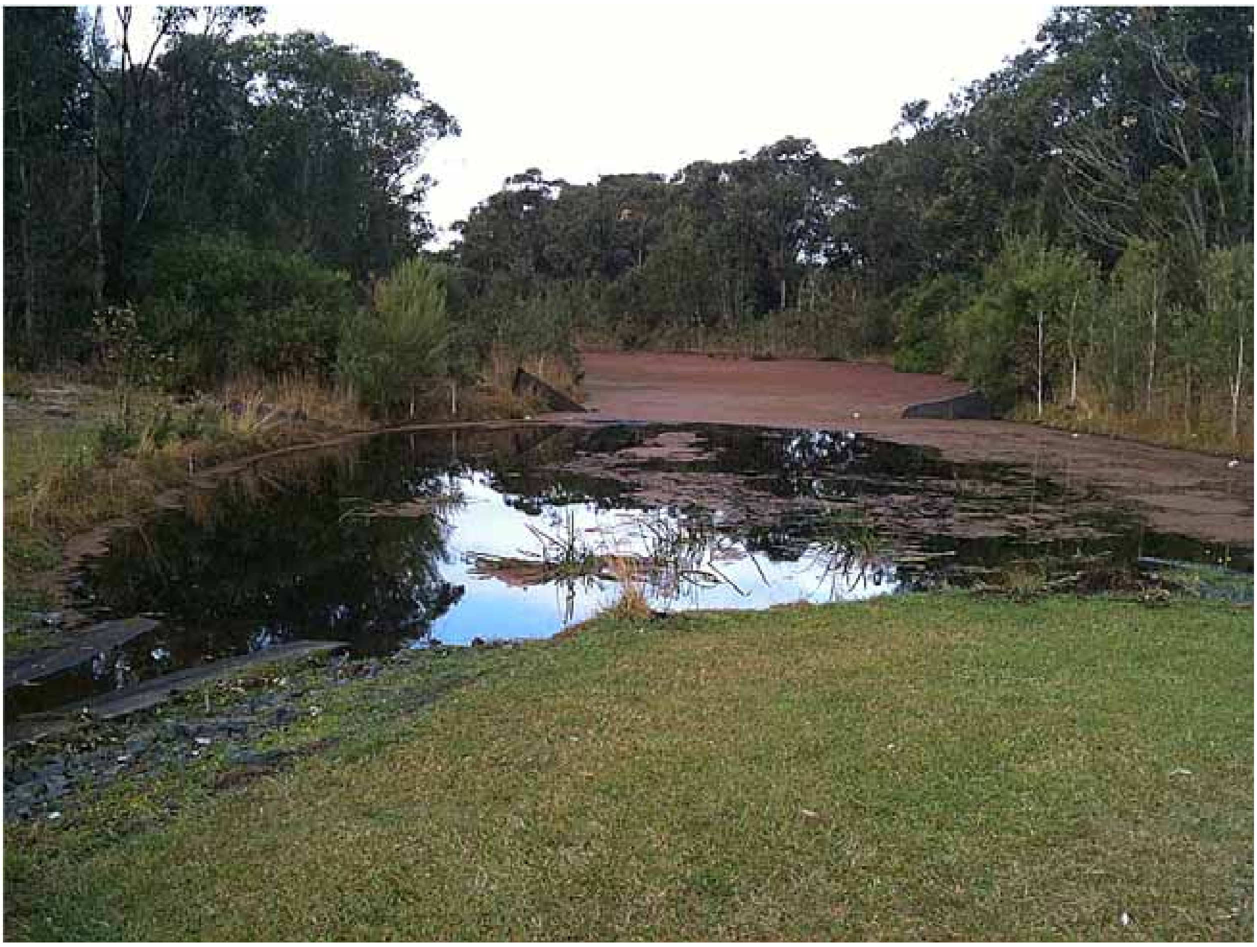

Figure 4-1 Goldens Road Wetland, Forster

The above image also highlights the inherent risk in large wetlands as part of the treatment train, in that large end of pipe systems, if they fail, result in no treatment of the upstream catchment, or worse, may result in increased pollutants due to rotting vegetation and anoxic zones. While MUSIC may indicate such systems can perform adequately, it is also worth considering the practical application of the treatment systems in the areas where they are to be adopted.

This review has examined the performance of the treatment train proposed with both the models "as is" and after modification to be consistent with the recommendations in this report.

4.2 Assessment of Compliance

The MUSIC models as submitted by Cardno were run in MUSIC Version 5.11 so as to compare them with results obtained from revised MUSIC models prepared by the reviewer. The results of these assessments are presented below. The model outputs were reviewed to ensure that the targets of Neutral or Beneficial Effect (NorBE) were satisfied consistent with the requirements of Great Lake Council DCP 54 Water Sensitive Design.

Table 4-1 Original Cardno Model Results

	Existing Case	Treated Developed Case (no tanks)	NorBE Achieved
Flow (ML/yr)	954	1540	
Total Suspended Solids (kg/yr)	126000	27000	yes
Total Phosphorus (kg/yr)	268	164	yes
Total Nitrogen (kg/yr)	2070	2020	yes
Gross Pollutants (kg/yr)	4630	0	yes

Of note from this assessment is the reductions achieved for Total Suspended Solids. This equates to over 100 tonnes of sediment being trapped within the proposed wetlands ponds and lakes which would require removal. While it is important that this material not enter the receiving environments, it also indicates the magnitude of sediment accumulation likely in the treatment measures.

The MUSIC models were then modified so as to be consistent with the recommendations of the report, including using 12 minute timestep climate data, revising the pollutant export and hydrologic parameters and modelling with and without the lakes in the treatment train. The results are presented in the following tables.

Table 4-2 Revised Model With Lakes Included

	Existing Case	Treated Developed Case (no tanks)	NorBE Achieved
Flow (ML/yr)	1360	1630	
Total Suspended Solids (kg/yr)	52200	28900	yes
Total Phosphorus (kg/yr)	194	177	yes
Total Nitrogen (kg/yr)	1850	2190	no
Gross Pollutants (kg/yr)	3750	0	yes

It should be noted from the above that with the lakes included, NorBE can be achieved for Suspended Solids and Phosphorus, but not for nitrogen. Note that climate data used for this assessment was the Williamtown RAAF gauge, but without adjustment to increase the mean annual rainfall to be consistent with Hawks Nest. As such, the results obtained likely represent an underestimation of the flows and loads likely from the site, but are still useful for comparative purposes.

If the lake systems are removed from the treatment train, the following results are obtained.

Table 4-3 Revised Model Without Lakes

	Existing Case	Treated Developed Case (no tanks)	NorBE Achieved
Flow (ML/yr)	1360	1650	
Total Suspended Solids (kg/yr)	52200	97600	no
Total Phosphorus (kg/yr)	194	294	no
Total Nitrogen (kg/yr)	1850	2740	no
Gross Pollutants (kg/yr)	3750	9760	no

It is apparent that the existing treatment train of wetlands and swales is not sufficient to be in compliance with the targets in the GLC DCP 54, as the lakes themselves provide a significant proportion of the treatment removals. If the lakes were removed from the development proposal, or treated as receiving environments, then the loads to receiving waters (freshwater lakes, saline lake and the Myall River) would result in NorBE not being achieved.

Recommendation 15

The treatment system should be revised (using revised MUSIC models) to achieve NorBE prior to any discharge to receiving waters including any proposed freshwater lakes and the existing saline lake.

4.3 Revised Treatment System

The proposed treatment train is not consistent with either the requirements of Great Lakes Council DCP 54, or WSUD practice in general. From the above, it is clear that further treatment would be necessary in order to achieve compliance without the lakes being part of the treatment train.

With the increased flows coming from the future development, another consideration which has not been fully assessed is the impact of increased surface flows to the SEPP 14 wetlands. Currently, significant amounts of water are infiltrated into the shallow groundwater table and this hydrologic cycle sustains the existing wetlands. As the site develops, the increased imperviousness will result in a significant decrease of infiltrated water, and a large increase in surface water, radically altering the hydrologic cycle. The Cardno report states that the lowering of the groundwater table due to the development will be compensated by increased sea levels due to climate change after (in their estimate) approximately 10 years, but in that time it is highly likely that the wetland will be significantly impacted if not fully destroyed. It also neglects the impact of significant surface flow increases.

Recommendation 16

It is recommended that an approach which treats and then infiltrates surface water, and reuses as much surface water as possible through rainwater and stormwater harvesting

would be a far better approach for the site. Such a system would use biofiltration systems designed to infiltrate to the shallow groundwater, distributed throughout the development, perhaps coupled to well-designed wetlands that had provision for stormwater harvesting. This approach would be far more consistent with a WSUD philosophy and also result in better outcomes for the SEPP 14 wetlands, but at a reduced capital and operational cost to the developer. This obviously has not been assessed as part of this review but suggested as a possible revised treatment system.

Recommendation 17

Assessment of both the surface and groundwater impacts to the SEPP 14 wetlands be considered in further revisions of the Integrated Water Management Plan with a view to minimising hydrologic changes consistent with the requirements of the SEPP 14 and the Great Lakes Council DCP 54 Water Sensitive Design.

5 CONCLUSIONS AND RECOMMENDATIONS

This review has been prepared through a desktop assessment of the information made available to the reviewer through the NSW Department of Planning and Infrastructure and Great Lakes Council. The documents and models were assessed as they were presented in order to determine whether the water quality modelling and management approach for the Riverside at Tea Gardens development was consistent with best practice techniques.

Overall, the approach taken by the developer's consultants in terms of water quality management of the impacts of urban development at the proposed development site is not consistent with a best practice approach and is not in accordance with a Water Sensitive Urban Design philosophy. The "end of pipe" approach proposed has not demonstrated compliance with the Great Lakes Council DCP 54 Water Sensitive Design in terms of the treatment regime adopted, and if the MUSIC modelling was conducted in accordance with the relevant guidelines, in terms of meeting the required targets of a Neutral or Beneficial Effect on water quality. There are significant concerns regarding the long-term viability of the proposed scheme, especially in the use of large scale waterbodies as part of the treatment regime.

The modelling undertaken has some significant flaws in terms of parameterisation and configuration and is not considered representative of the pollutant loads and flows coming from the existing site and proposed development.

In terms of specific recommendations, these have been noted in the relevant sections, but are reproduced below for clarity.

Recommendation 1

It is recommended that the pond and lake systems be removed from the development proposal or at the very least, considered as receiving environments and not part of the water quality treatment system.

Recommendation 2

If freshwater lake systems are deemed a necessary part of the development, suitable treatment measures should be put in place for their protection, and a more sophisticated assessment of their performance be undertaken. If lakes are deemed necessary, they should be assessed independently of the treatment train and considered only as receiving waters.

Recommendation 3

Revise the existing and developed case MUSIC models to be consistent with the NSW MUSIC Modelling Guidelines.

Recommendation 4

Revise the existing and developed case MUSIC models to have parameters which are both justified and consistent with the NSW MUSIC modelling guidelines.

Recommendation 5

The deep seepage parameter should not be used in any MUSIC models of the site.

Recommendation 6

The groundwater contributions of the site, using the outputs of the MUSIC model and other models, need to be better assessed to quantify the hydrologic and water quality impacts on the adjacent SEPP 14 wetlands.

Recommendation 7

Appropriate parameters to represent nutrients likely to be present in rainfall are to be used where direct rainfall onto lakes are being modelled.

Recommendation 8

Revise the existing case MUSIC model source nodes to better reflect both the "agricultural" and "forested" conditions of the existing site and to include specific nodes reflecting the commercial areas in the existing site.

Recommendation 9

Clarify the WBD nodes and whether the existing commercial areas have been properly accounted for in the future case model.

Recommendation 10

Use a sub-daily timestep through both the existing and developed case models, either 6 or 12 minute.

Recommendation 11

The model warmup should be turned on in any future models of the site, or the first year of results not included in the analysis of model outputs.

Recommendation 12

Wetland nodes, where used, should be configured both within the model and in design drawings to contain a high flow bypass, and a sediment forebay to remove coarse sediment. Also the configuration of the wetlands should be revised so as to provide reasonable (24-48 hour) detention times and consistent extended detention depths.

Recommendation 13

Any measures included in the water quality management regime should be designed such that treatment occurs prior to any interaction with the groundwater.

Recommendation 14

Reconfigure the swale nodes to be consistent with the NSW guidelines.

Recommendation 15

The treatment system should be revised (using revised MUSIC models) to achieve NorBE prior to any discharge to receiving waters including any proposed freshwater lakes and the existing saline lake.

Recommendation 16

It is recommended that an approach which treats and then infiltrates surface water, and reuses as much surface water as possible through rainwater and stormwater harvesting would be a far better approach for the site. Such a system would use biofiltration systems designed to infiltrate to the shallow groundwater, distributed throughout the development, perhaps coupled to well-designed wetlands that had provision for stormwater harvesting. This approach would be far more consistent with a WSUD philosophy and also result in better outcomes for the SEPP 14 wetlands, but at a reduced capital and operational cost to the developer. This obviously has not been assessed as part of this review but suggested as a possible revised treatment system.

Recommendation 17

Assessment of both the surface and groundwater impacts to the SEPP 14 wetlands be considered in further revisions of the Integrated Water Management Plan with a view to minimising hydrologic changes consistent with the requirements of the SEPP 14 and the Great Lakes Council DCP 54 Water Sensitive Design.

6 REFERENCES

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