WATER CYCLE MANAGEMENT STUDY

Proposed OneSchool Global Campus

DEVELOPMENT ADDRESS

Magpie Hollow Road
South Bowenfels, NSW 2790

LEGAL DESCRIPTION

LOT 1 DP527491

FOR

DEZIGN

ORIGINAL REPORT DATE
May 2024

AMENDMENT / DATE
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CONTENTS

1. INTRODUCTION

Developer	DEZIGN
Address	Magpie Hollow Road, South Bowenfels, NSW 2790
Local Authority	Lithgow City Council
Property Description	LOT 1 DP527491
Size of Development	Approx. 1.17ha
Type of Development	Proposed OneSchool Global Campus
Time to Undertake Works	12 – 18 Months
Existing Land Use & Zone	Vacant Lot Zone R2 – Low Density Residential.
Adjacent Land Use & Zone	Residential and Rural Pastures R2 – Low Density Residential
Engineering Consultant	Calare Civil
Report Written By	Harrison Oakley
Qualifications	B.E (Hons) Civil / B.E (Hons) Environmental
Experience	6+ years' experience across disciplines including civil design and project management, construction supervision, hydrologic and hydraulic investigation, modelling and design.
Report Checked By	Garth Dean Director
Qualifications	B.E. GDSTT FIEAust CPEng NER APEC Engineer IntPE (Aus) RBP (Vic/NT)
Experience	30+ Years Civil Engineering Experience
Purpose of Report	To assist WaterNSW with their assessment of the proposed development demonstrating how a neutral or beneficial effect on water quality is achieved. This report is to provide a hydraulic basis for the proposed stormwater management measures and an explanation of the corresponding MUSIC model. It will detail all key assumptions, parameters, treatment train configurations, management measures and effectiveness.

2. SITE DESCRIPTION – Topography & Drainage

The proposed development is located on the northern side of Magpie Hollow Road, approximately 100m west of the Great Western Highway, South Bowenfels. The site is an undeveloped lot situated on a crest between the catchments for Farmers Creek and Bowen Creek which both drain into the Coxs River and ultimately the Warragamba Dam. For reference, a general locality plan is provided in **Figure 2-1** below.

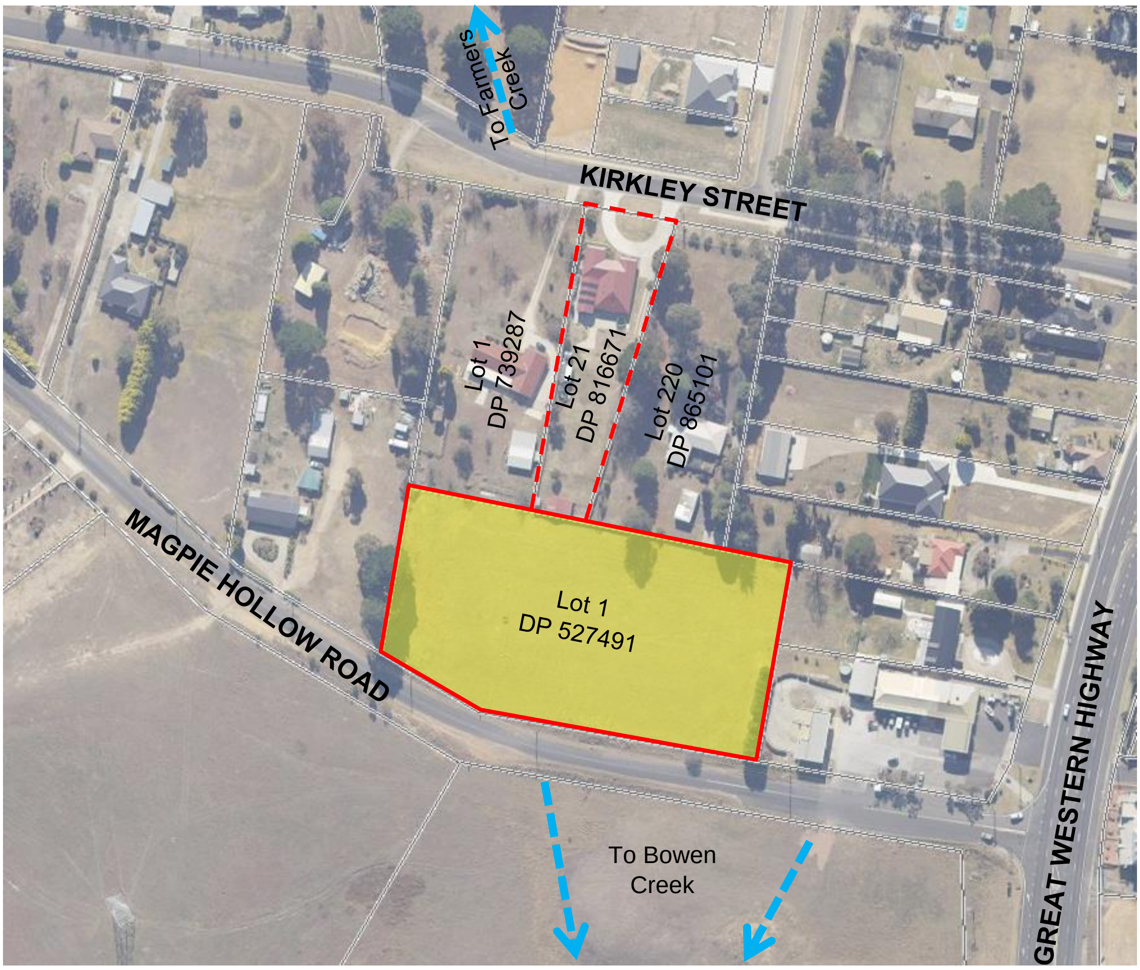

Figure 2-1: *Locality plan for the Proposed Development, relative to the adjacent water courses*

Currently, there are no formal stormwater management measures at the site with all runoff draining to the north towards Kirkley Steet via uncontrolled overland flows. It is proposed that as part of this development, a new pit and pipe network is to be constructed that captures all runoff from the roof and hardstand areas discharging into the existing network in Kirkley Street. As the site naturally grades to the north and towards the existing dwellings, this proposed pit and pipe network is to be sized such that it can capture and convey up to and including the 1% AEP event so to eliminate overland flows that would otherwise flow through these lots to the north. In order to achieve this, a new stormwater line and corresponding easement is proposed through Lot 21 DP 816671; for further details on the proposed stormwater management network please refer to the plan C01 provided in **Appendix A**.

Prior to discharge, all stormwater from the site is to be first treated via a series of propriety water quality improvement devices set up in a treatment train configuration. This treatment train is to include an Ecoceptor GPT, two Atlan Filter Vaults each containing 10 sand filter cartridges and two AtlanBasins which are modular bioretention basins. It is the design and performance of this treatment train that is the subject of this report noting in this report we will detail all key assumptions, parameters, the precise configuration and the overall pollutant reductions achieved.

3. DATA

3.1. Statutory Requirements

The site is within the Sydney Drinking Water Catchment and therefore regulated by the *State Environmental Planning Policy (Biodiversity & Conservation) 2021.* Under the SEPP it is a requirement that the development has a Neutral or Beneficial Effect (NorBE) on water quality, meaning the development must:

- Have no identifiable impact on water quality, or
- Contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on the site, or
- Transfer any water quality impact outside the site where it is treated and disposed of to standards approved by the consent authority.

Although the neutral position is the minimum requirement of this legislation, Water NSW prefer it if a beneficial impact can be achieved with a target pollutant load reduction of 10% for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorous (TP). For Gross Pollutants (GP), the post development load only needs to be equal to or less than the pre-development load. In addition, the treatment train must demonstrate load reductions of 85%, 65% and 45% for TSS, TP and TN respectively between the source and residual (post -treatment) nodes for the developed scenario.

Furthermore, another consideration of the SEPP is that pollutant concentrations for TP and TN for the post-development case must be equal to or better than the pre-development case between 50-90% of the time when runoff occurs over the five-year modelling period i.e. exclude periods where no runoff is generated. To demonstrate this, comparative cumulative frequency graphs, for both the pre and post development cases are to be provided. As meeting the pollutant percentile concentrations for TP generally also meets the requirements for TSS, cumulative frequency analysis is not required for TSS.

3.2. Stormwater Management Plans

The Water Cycle Management Study (WCMS) provided herein is in accordance with the following guidelines:

- Developments in the Sydney Drinking Water Catchment – Water Quality Information Requirements, Water NSW (February 2023).
- Using MUSIC in Sydney's Drinking Water Catchment, Water NSW (February 2023).
- Neutral or Beneficial Effect on Water Quality Assessment Guideline, Water NSW (October 2022).

3.3. Literature Review

Due to site constraints, the use of more traditional water quality improvement devices is not possible. For example, an open air bioretention basin would not be suitable as the proposed development is a school and water bodies pose an unacceptable risk to students. Furthermore, a traditional bioretention basin that is fenced would still occupy a significant portion of the available open space which again impedes on the functionality of the school by reducing playground areas. For these reasons alternate treatments measures were investigated and through liaison with *Atlan Stormwater* it was determined that with the application of the following devices connected in series, the water quality pollution reduction targets as required by Water NSW could be achieved.

The proposed treatment train includes the following devices:

1) Altan Ecoceptor – An inline Gross Pollutant Trap.
2) 20 x Atlan Cartridge Filters – up flow filter cartridges contained within pre-cast concrete vaults. For this project it was found that 20 filters are required, split between 2 concrete vaults (10 per vault) connected in series.
3) 2 x Atlan Modular Bioretention Basins – horizontal flow bioretention with multi-stage pretreatment protection for the filter media. For this project, 2 of the largest modular basins (MWS-L-4-21) were adopted, connected in series.

The brochures for each product noted above, as provided by *Atlan Stormwater,* have been included in **Appendix B** for review. However, in the MUSIC modelling discussed in **Section 5** it is noted that treatment performance for each device as presented in these documents, of which has been verified through *Stormwater Australia's* Stormwater Quality Improvement Device Evaluation Protocol (SQUIDEP), have been adjusted in accordance with Water NSW's approved performance criteria. These figures have been adjusted at Water NSW's request to account for a number of potential inconsistencies in performance such as lack of maintenance; however if these devices are installed, operated and maintained in accordance with the manufacturer's specification the full treatment performances can be achieved.

3.4. Water Quality/Stream Health

No study has been undertaken to determine the water quality of the recipient waterway and does not form a part of this document.

4. OPPORTUNITIES AND CONSTRAINTS

4.1. Opportunities

Through the construction of the proposed development, there is the opportunity to formalise the site drainage noting that currently all runoff generated is discharged from the site via uncontrolled overland flows. These uncontrolled overland flows have the potential to impact (flood) the lots downstream and so formalising the site drainage will aim to minimise any downstream flooding potential.

Through formalising the site drainage there is also the opportunity to ensure the water quality being discharged from the site.

4.2. Constraints

As the proposed development is for a school, the use of traditional water quality improvement devices such as bioretention basins or wetlands are not suitable as open water bodies pose an unacceptable drowning risk. In addition, the size of the site and the footprint of the proposed development inhibits the use of measures that require a large footprint thus prompting the use of small modular treatment measures that can be located below ground.

5. STORMWATER QUALITY

5.1. Existing Conditions

As noted previously the site is an undeveloped lot, typical of cleared rural pastures. There is significant grass coverage and a row of pines on the western boundary. There are no impervious areas and so through the development of this lot, the volume of runoff will be increased and water quality could be potentially reduced if mitigation measures are not implemented.

Currently, there are no formal stormwater quality improvement devices (SQIDs) or water sensitive urban design (WSUD) measures in place. As part of the proposed stormwater management network detailed on Plan C01 provided in **Appendix A**, a new water quality improvement treatment train is to be provided as a means of ensuring that discharge water quality is not affected by the proposed development.

5.2. Receiving Waters

The site currently discharges all stormwater runoff via a series of uncontrolled overland flow paths that drain to the north towards Kirkley Steet. From here, it enters the existing pit and pipe network and is discharged to one of the unnamed tributaries that flow down to Farmers Creek. The proposed development aims to formalise the site drainage and provide a connection to the existing pit and pie network in Kirkley Steet, thus eliminating the uncontrolled overland flows. This proposed connection is to subsequently capture and convey flows generated from the site during events up to and including the 1% AEP event.

From review of aerial imagery, it appears that the channel that the existing piped network discharges into is relatively undisturbed with only minor modification in its most upper reaches. This tributary then flows down to Farmers Creek joining it downstream of the township of Lithgow. It is noted that Farmers Creek is a highly modified environment with intermittent concrete lining of the channel. The reach in which this tributary joins Farmers Creek has a natural channel profile however it is noted that this portion of this creek is subject to a constant discharge from the Lithgow Sewerage Treatment Plant (STP) which results in a perennial flow regime. With the corresponding nutrient loading and perennial flow regime, Farmers Creek has a modified ecosystem where invasive and non-native species have been able to establish themselves within the riparian corridor.

Due to the nature of this development, the current site conditions, and the nature of the unnamed tributary and Farmers Creek, it is expected that there will be no detrimental impacts of these proposed works on the receiving environment. In addition, with the proposed water quality treatments, the development will have a neutral and or beneficial effect on water quality. This will therefore satisfy Water NSW's requirements for development in the Sydney Drinking Water Catchment of which is demonstrated below through the MUSIC modelling.

5.3. Objectives

To provide recommendations around the provision of suitable SQIDs or WSUD measures to be included as part of the proposed development so to satisfy the requirements of the SEPP, thus achieving a NorBE on water quality.

5.4. Methodology

Stormwater quality modelling was undertaken to estimate the load of common stormwater pollutants including Gross Pollutants (GP), Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) generated by the proposed development. MUSIC modelling was undertaken to estimate continuous hydrology and runoff water quality for the proposed development over a typical 5-year period.

MUSIC includes algorithms to evaluate the hydrology and concentrations / loads from urban catchments and estimate the performance of stormwater management measures (like those listed in **Section 5.5)** at capturing these pollutants. MUSIC was designed to continuously simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data. MUSIC is considered within the industry to be an appropriate conceptual design tool for the analysis of runoff water quality in the urban environment. The hydrologic algorithms in MUSIC represents the rainfall runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 day)
- Areal Potential Evapo-Transpiration (PET) rates
- Catchment parameters (area, % impervious and % pervious)
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters)
- Storm event and base flow stormwater (event mean) pollutant concentrations for differing land uses.

MUSIC can be applied for the comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios is expected to be appropriate for decision making.

An overview of the MUSIC model developed as part of this study is shown in **Figure 5-3**.

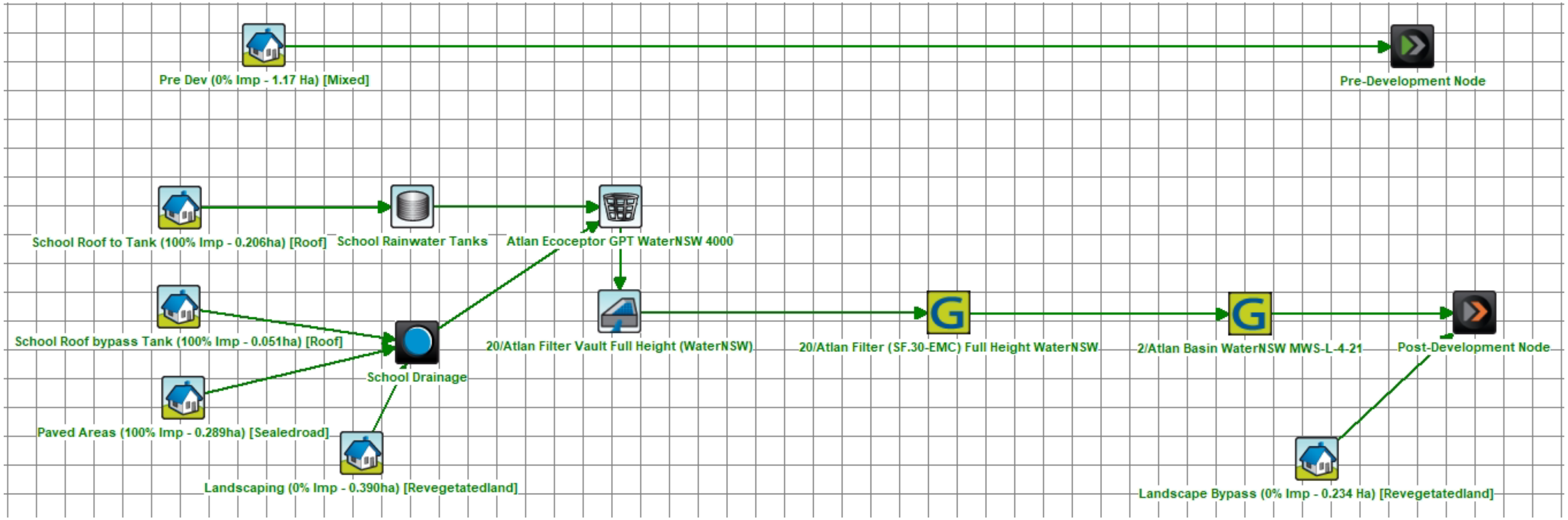

Figure 5-3: *MUSIC Model for the subject site (includes the pre and post development scenarios)*

Delineation of Surface Types, Areas and Parameters

The surface types, areas and proportion impervious for the catchment nodes in both the existing and developed scenario were estimated using a combination of aerial imagery and the concept design drawings prepared by Brett Moulds Design & Drafting (ref. BMD222389, rev N). A high-level summary of the catchment parameters is provided in the following table.

Table 5-1: *Catchment Area and Land Use Summary*

Catchment Name	Usage	MUSIC Land Use	Catchment Area (ha)	Fraction Impervious (%)
Existing				
Pre Dev	Rural Pasture	Mixed	1.17	0
Developed				
School Roof to Tank	Roof area that reports to the rainwater tanks	Roof	0.206	100
School Roof Bypass Tank	Roof area that bypasses the rainwater tanks	Roof	0.051	100
Paved Area	Carpark and Hardstand Areas	Sealed Road	0.289	100
Landscaping	Landscaped Areas	Revegetated Land	0.390	0
Lumped Catchment Bypass	Landscaped Areas	Revegetated Land	0.234	0

As a conservative means of estimating the pollutant loads, the following assumptions were made:

- That 20% of the total site area, of which would consist of the broader landscaped areas, is able to bypass all treatment nodes, this is represented by the Lumped Catchment Bypass Source Node. In reality, very little bypass would occur if the entire site is suitably graded towards pit locations.
- Only 80% of the roof area reports to the rainwater tanks, the remaining 20% reports directly to the stormwater management network.

No additional calculations to determine the effective impervious areas (EIA) were undertaken for this development as in both the existing and developed scenario the EIA equalled the total impervious area. This is because as all impervious areas are directly connected to the stormwater management network.

Rainfall and Evaporation

To simulate the performance of the proposed stormwater quality treatment measures, MUSIC requires the input of data from a representative continuously recorded rainfall station or a pluviograph. For the Sydney Drinking Water Catchment, Water NSW has developed climate templates for each zone within the catchment, for this model the Zone 4 template file was adopted which provided standard daily rainfall and evapotranspiration data for a five-year period, using six-minute time step between 01 January 1997 to 31 December 2001.

The 5-year input data period presented in **Figures 5-4** and **5-5,** was selected to include both periods of high and low rainfall which best represents a range of scenarios. It is from this data that the flows and stormwater runoff volumes could be analysed for the site.

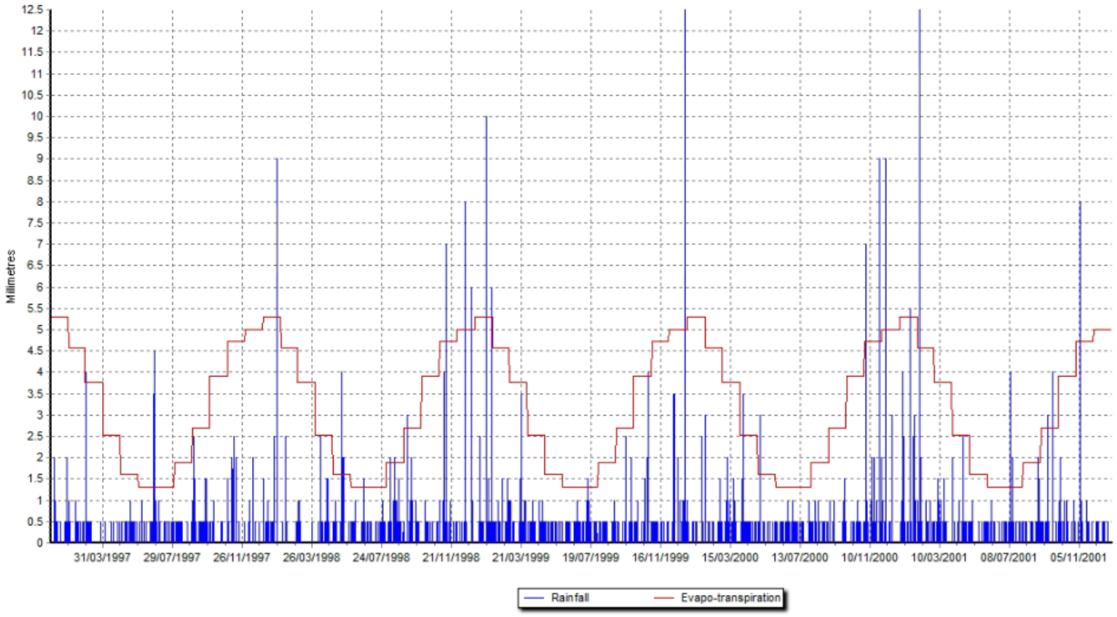

Figure 5-4: *MUSIC Hydrological Input Data*

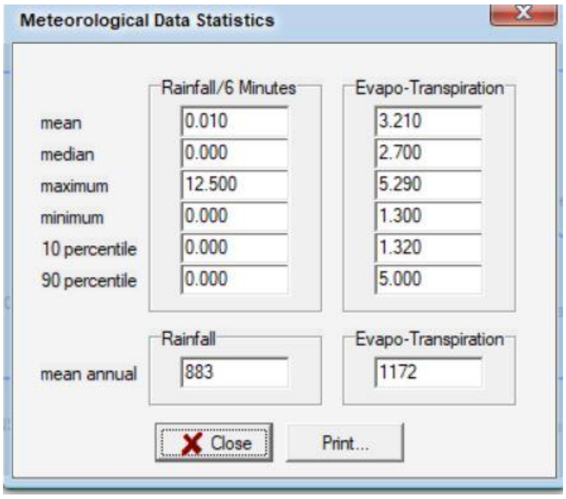

Figure 5-5: *MUSIC Meteorological Data Statistics*

Model Timestep

A 6-minute time-step was adopted to simulate rainfall-runoff processes, water quality and characterise pollutant loads across the site.

Rainfall Runoff Parameters

The soil parameters and stormwater constituent pollutant concentrations were adopted in accordance with the values provided in Tables 4.4 – 4.7 in Water NSW's guidelines, *Using MUSIC in Sydney's Drinking Water Catchment*.

In addition, the suggested soil parameters for clayey loams were adopted for the infiltration and groundwater properties. Clayey loams were assumed to be present at the site based on the site's locality and Calare Civil's general understanding of the soil profiles in the area.

5.5. Proposed Water Quality Management Strategies

The detailed design of the proposed development should consider the implementation of the following in order to improve the quality of any stormwater runoff. The following water quality controls are proposed to be connected in series, and this configuration has been modelled using the MUSIC software to assess their effectiveness in satisfying the objectives noted in **Sections 3.1** and **5.3.**

The proposed treatment train is as follows, for additional details please refer to the MUSIC model provided with this report:

1. **2 x 10,000L Rainwater Tanks –** For the first stage of the water quality treatment process it was assumed that 80% of the proposed roof area is to report to some form of rainwater storage with the remaining 20% reporting directly to the stormwater management network. Based on Water NSW's guidelines on rainwater reuse, specifically Tables 5.3 and 5.4 of *Using MUSIC in the Sydney Drinking Water Catchment*, it was assumed that the use of 2 x 10,000L rainwater tanks would be a conservative assumption for a development on this nature. This assumption is based on the fact that the total site area is 11,700m^2 and the total roof area is 2,572m^2. In addition, it is assumed that only 50% of the tanks volume is initially available i.e. at the start of a storm the tank is already half full.

   Regarding the re-use parameters, again we conservatively adopted the commercial re-use values of 0.1kL / day / 1,000m^2 of roof area for internal uses, and 20kL / year / 1,000m^2 of landscaped areas for external areas. Noting the roof area is 2,572m^2 and the landscaped area is 6,239m^2, this equated to reuse demands of 0.257 kL / day and 124.79 kL / year for internal and external areas respectively.

2. **Altan Ecoceptor –** An inline Gross Pollutant Trap (GPT). This GPT forms the second stage of the water treatment process separating and capturing gross pollutants, sediments, silts, suspended solids, and oil and grease. For this site we anticipate a 4000 series Ecoceptor is required which has a treatable flowrate of up to 1400 L/s; the sizing of this unit was estimated through an application of the rational method which enabled us to determine the likely discharge from the reporting catchment. The removal efficiencies of this unit are listed in the product brochure provided in **Appendix B**, however for the purpose of this assessment the following reduced removal efficiencies have been adopted as per Water NSW's requirements, refer Table 5.5 of *Using MUSIC in the Sydney Drinking Water Catchment*.
   - GP (particles > 5mm) 90%
   - TSS 65%
   - TP 15%
   - TN 14%
   - Hydrocarbons 90%

3. **20 x Atlan Cartridge Filters** – up flow filter cartridges contained within a pre-cast concrete vault. These filters form the third stage of the water treatment process targeting fine particulate matter and nutrients. For this project it was found that 20 filters are required, split between 2 concrete vaults (10 filters per vault). Each filter has a treatment flow rate of 3 L/s, yielding a combined treatment flow rate of 60 L/s. The filter vaults and (and subsequent filters) are connected in parallel with flows being evenly distributed between vaults via an upstream splitter pit. Each vault will then fill at the same rate and treat the incoming water simultaneously. It is only during high flow events i.e. events that exceed the treatment threshold, that bypass of the filters is possible.

   As shown in **Figures 5-1** and **5-2**, water enters the filter compartments and fills up around the filters. Through the developing hydrostatic pressure water is forced up through the filter media and into the outlet line which is situated centrally, see image below. A one-way air release valve at the top of the filter cartridge allows air to escape as the filter fills, developing siphonic flow which then sustains the flow through the filter membrane even when the hydrostatic pressure within the vault falls below the filters outlet level. The siphonic flow conditions are then maintained until the water level falls below the inlet level of the filter cartridge. Once the siphonic flow ceases, the filters backwash (i.e. any water remaining in the filter when siphonic flow ceases, flows down and out the inlet ports via gravity) and subsequently expels a large proportion of the filtered sediment which then accumulates on the floor of the filter vault.

The outlet pipes then transfer filtered water to the discharge compartment at the end of the concrete vault. At the end of the vault is also a high-level weir, set a minimum of 850mm above the invert of the vault; this weir allows a controlled volume of untreated water to spill over into the discharge compartment during high flow events.

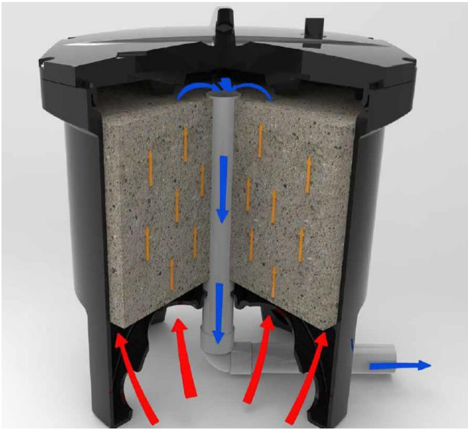

Figure 5-1: *Atlan Filter Cartridge typical detail*

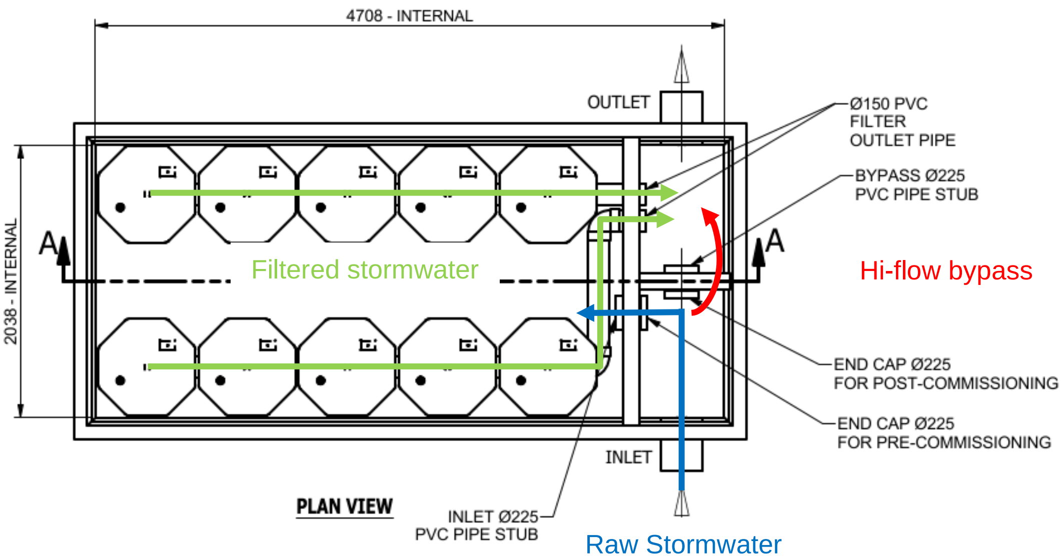

Figure 5-2: *Atlan Filter Vault Schematic*

The removal efficiencies of this these filters are listed in the product brochure provided in **Appendix B**, however for the purpose of this assessment the following reduced removal efficiencies have been adopted as per Water NSW's requirements:

- GP (particles > 5mm) 100%
- TSS 75%
- TP 40%
- TN 25%

4. **2 x Atlan Modular Bioretention Basins** – horizontal flow bioretention with multi-stage pretreatment protection for the filter media. For this project, 2 of the largest modular basins (MWS-L-4-21) with a combined treatable flowrate of 20 L/S were adopted as the fourth and final stage of the water treatment process. They have been adopted to chemically capture any remining TSS, metals, nutrients and bacteria. Similarly to the filter vaults, these are connected in series with a high flow weir located at the downstream end of each module. It is only during high flows that this weir will be overtopped and untreated water allowed to bypass the system.

   The removal efficiencies of these modular bioretention basins are listed in the product brochure provided in **Appendix B**, however for the purpose of this assessment the following reduced removal efficiencies have been adopted as per Water NSW's requirements:
   - GP (particles > 5mm) 100%
   - TSS 76%
   - TP 43%
   - TN 34%

5.6. Effectiveness of the Proposed Stormwater Quality Controls.

A conceptual WSUD strategy for the site was assessed using the MUSIC model provided which estimates the treatment effectiveness of water quality controls in addressing the stormwater quality targets as outlined in **Sections 3.1** and **5.35.3.** The mean annual pollutant loads reductions for the subject site are shown in **Tabel 5-2**. From these results it is clear that the NorBE requirements can be achieved through the proposed treatment train, however it should be noted that the performance of this system is likely underestimated as the removal efficiencies adopted in the model are significantly less than what has been found for each of these treatment measure through rigorous product testing. To obtain the full removal efficiencies, each treatment measure must be installed and maintained in accordance with the manufacturer's specification.

The performance of these measures is further emphasised through the analysis of the source and residual pollutant loads for the developed conditions. As demonstrated in **Table 5-3** the treatment train's effectiveness i.e. its ability to reduce pollutant loads, satisfies the requirements of the SEPP which state it must achieve reductions of 85%, 65% and 45% for TSS, TP and TN respectively between the source and residual (post-treatment) nodes for the developed scenario.

Table 5-2: *Mean Annual Pollutant Load Reductions*

Parameter	Mean Annual Load Reductions		
	Pre-Developed	Post-Developed	% Reduction
Flow (ML/yr)	2.09	5.19	n/a
Total Suspended Solids (kg/yr)	325	81.3	75.0%
Total Phosphorus (kg/yr)	0.757	0.608	19.7%
Total Nitrogen (kg/yr)	5.8	5.73	1.2%
Gross Pollutants (kg / yr)	0	0	100%

Table 5-3: *Treatment Train Effectiveness*

Parameter	Post Developed Conditions		
	Source	Residual	% Reduction
Flow (ML/yr)	5.4	5.19	3.9%
Total Suspended Solids (kg/yr)	941	81.3	91.4%
Total Phosphorus (kg/yr)	1.83	0.608	66.8%
Total Nitrogen (kg/yr)	12	5.73	52.3%
Gross Pollutants (kg / yr)	110	0	100.0%

Finally, for the developed scenario it needs to be confirmed that pollutant concentrations for TP and TN are either equal to or better than those yielded in the pre-developed scenario. This is a requirement for between the 50th and 98th percentiles over the five-year modelling period when runoff occurs. To demonstrate compliance with this, cumulative frequency graphs have been provided for TP and TN in **Figures 5-6** and **5-7** respectively, note the low flow thresholds for both the pre and post development nodes have been set to 0 m³/s. As can be seen, in each case the post developed TP and TN concentrations are less than those in the pre-developed scenario for the entire frequency range, as such this aspect of the NorBE requirements is also met.

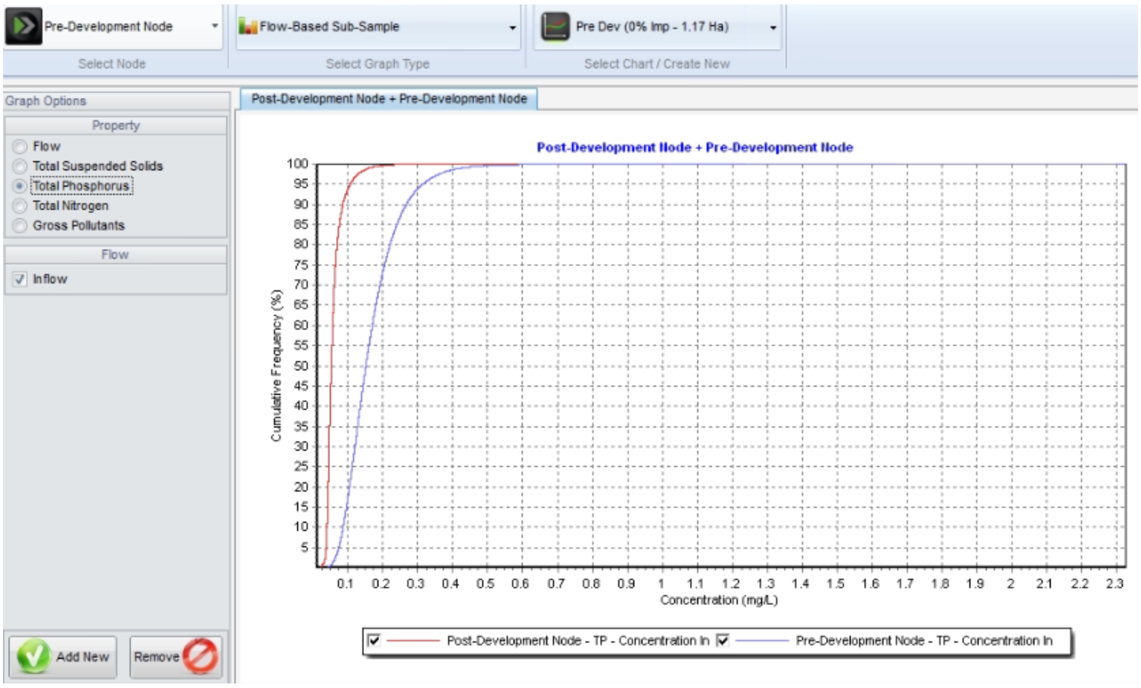

Figure 5-6: *Cumulative Frequency Graph – Total Phosphorous (TP)*

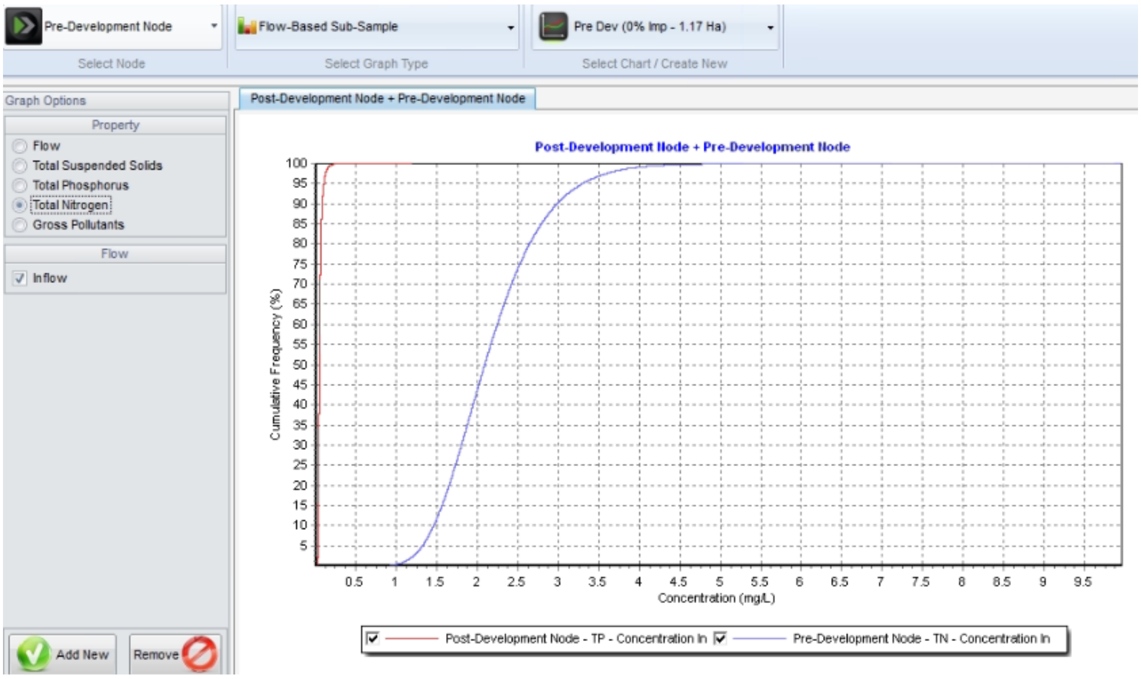

Figure 5-6: *Cumulative Frequency Graph – Total Nitrogen (TN)*

6. ASSET HANDOVER

There are no assets to hand over to Council, it will be the responsibility of the landholder to correctly maintain and operate the proposed water quality treatment devices.

7. CONCLUSION & RECOMMENDATIONS

Based on the analysis and modelling results presented in this Water Cycle Management Study, Calare Civil recommend that in order to suitably treat the increased runoff as a result of developing the site, such that NorBE on water quality are achieved, the following measures should be implemented.

- Provision of at least 2 x 10,000L rainwater tanks that capture up to 80% of the roof area. The rainwater captured is to be reused internally for toilets and washing, and externally for landscape irrigation.
- Construction of a pit and pipe network capable of capturing and conveying up to and including the 1% AEP storm event. This network is to discharge to the existing stormwater network on Kirkley Street.
- Provision of the following on-line stormwater treatment devices connected in series:
    - An Atlan 4000 Series Ecoceptor,
    - 20 x Atlan Filter Cartridges contained within 2 precast Filter Vaults
    - 2 x Atlan Modular Bioretention Basins

These measures have been recommended due to the site constraints as traditional bioretention is not feasible. Each can be practically implemented at the nominated locations however a refinement of the configuration may be required during detailed design.

The implementation of these proposed SQID & WSUD measures will improve the quality of any discharge and thus satisfy the NorBE requirements for development within the Sydney Drinking Water Catchment. It will be the detailed designer’s and construction contractor’s responsibility to ensure that the proposed measures are properly implemented, or an approved alternative provided.

APPENDIX A

Plans

APPENDIX B

Atlan Product Brochures and Technical Specifications