PDT Architects

Ballina Indoor Sports Centre

at

Cherry Street, Ballina

STORMWATER MANAGEMENT REPORT

REV: D

DATE: 20th March 2018

JOB No.: STP17-0890

CAIRNS	TOWNSVILLE	MACKAY	BRISBANE
SUITE 7 FIRST FLOOR	316 STURT STREET	LEVEL 2	LEVEL 1, 99 BRIDGE STREET
78 MULGRAVE ROAD	TOWNSVILLE	56 GORDON STREET	FORTITUDE VALLEY QLD 4006
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Rev D Amendments

Section 6 - Earthworks – amended
Appendix A – Stormwater Layout - amended

1 INTRODUCTION

STP Consultants has prepared the following Stormwater Management Report to investigate the effect of the proposed new building location on the existing stormwater flows through the site. This report also takes account of the proposed stormwater layout for the new High School buildings directly adjacent to the south of the site.

All stormwater quantity and quality control measures will be designed in accordance with the *Ballina Shire Council Stormwater Management Standards for Development*.

2 EXISTING SITE

The site is located at Cherry Street, Ballina on the existing high school property as shown below in Figure 1. The proposed development area occupies approximately 1.0ha of the total site area of 6.3ha. The site is extremely flat but generally falls from the centre to the boundaries at grades of less than 0.5%. Discharge from the site is to the external kerbs and drainage infrastructure.

Figure 1 – Site location relative to Ballina township. (Google Maps)

3 DEVELOPMENT PROPOSAL

The proposed development involves the construction of a new Indoor Sports Centre adjacent to the proposed new High School at the location shown in Figure 2 below.

Figure 2 – Proposed Sports Centre location within the High School grounds.

4 EXISTING HYDROLOGY

After construction of the new Ballina High School development, flows from the southern catchment will be directed through an open channel to discharge to the existing infrastructure in Cherry Street.

Ballina Shire Council Flood Mapping shows that the site is fully inundated during events with an AEP of 2% or less as illustrated in Figure 3. Flood levels for these events are given in Table 1 below.

Rainfall Event	Water Surface Level (AHD m)
2% AEP (ARI 50-yr)	2.0
1% AEP (ARI 100-yr)	2.1

Table 1 – Flood levels (BSC).

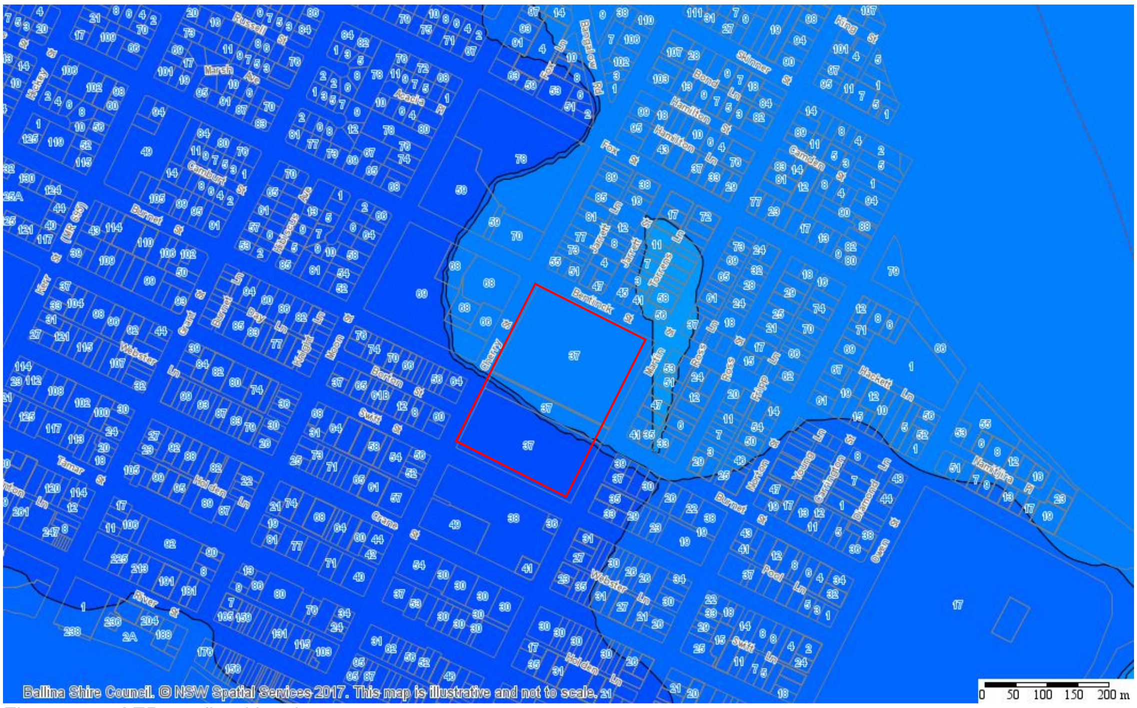


Figure 3a – AEP 2% flood levels.

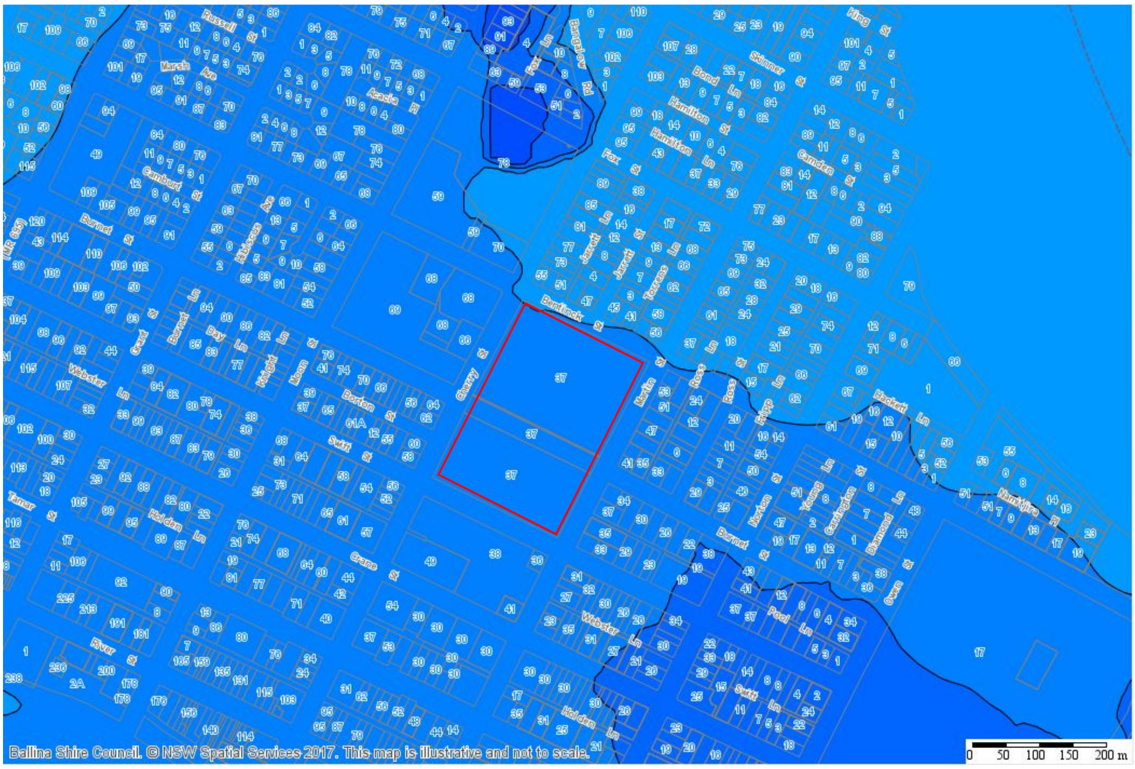


Figure 3b – AEP 1% flood levels.

Accordingly, minimum floor levels for both developments have been set at the AEP 1% level plus 500mm or RL2.6m AHD. Generally, finished ground and pavement levels will be above the AEP 1% level of RL 2.1m AHD.

Catchment and impervious areas for the pre-development state are shown below in Figure 4. The northern catchment consists entirely of pervious playing fields and is extremely flat with numerous areas of ponding. The majority of the runoff that doesn't infiltrate or evaporate, eventually finds its way to Bentinck Street. The southern catchment consists of the existing school buildings, landscaped areas and car parking with an impervious ratio of 55% discharging to the recently constructed box drain located below the existing car park.

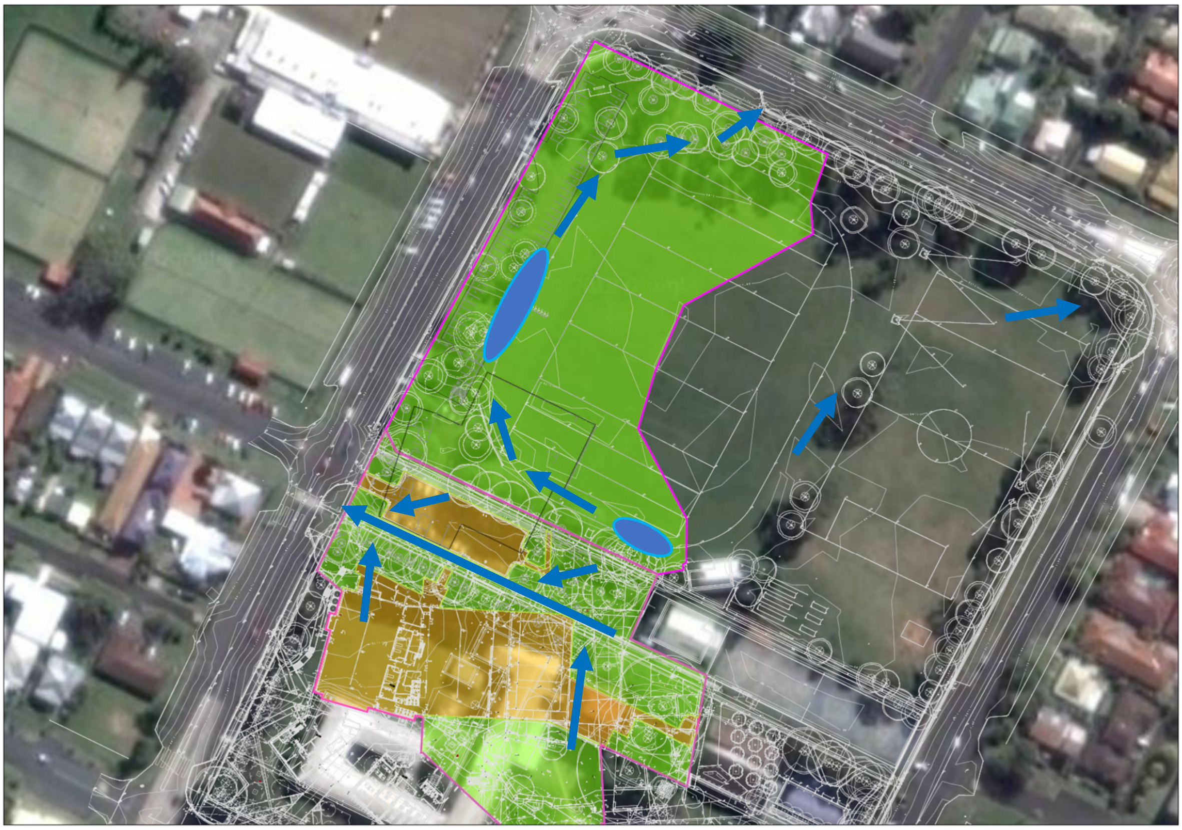


Figure 4 – Pre-development catchment areas.

5 POST-DEVELOPMENT HYDROLOGY

5.1 Catchment Areas

The location of the proposed building and car park slightly alter the boundary between the northern and southern catchments. Overall, the southern catchment has slightly reduced in area. Catchment and impervious areas are shown below in Figure 5.

Flows for the southern catchment for all AEPs have been calculated as shown in Table 2 below and show a subsequent reduction in flows across the board.

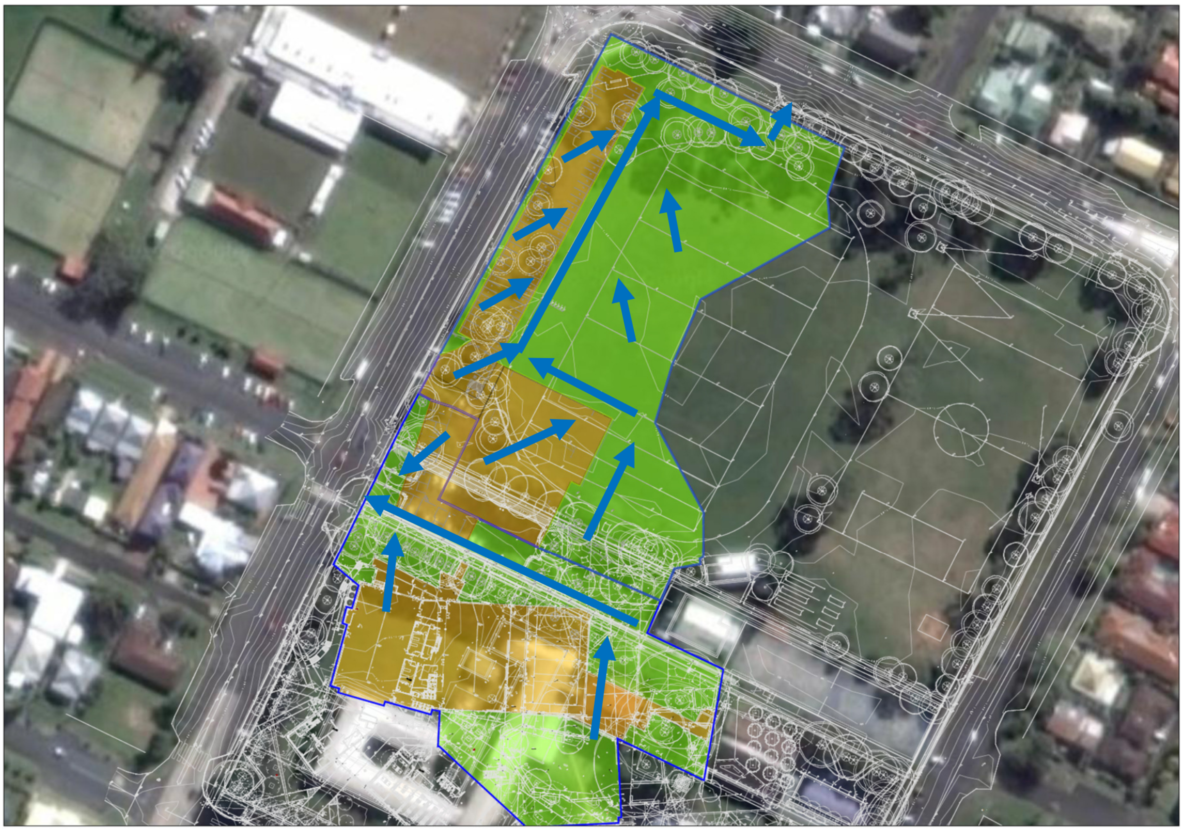


Figure 5 – Post-development catchment areas.

SCHOOL CATCHMENT PRE BISC							
Area (m^2)	(ha)	Impervious Area (%)		C_{10}	Time of Concentration (min)		
11030	1.10	55		0.765	10		
	C_1	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
	0.612	0.65025	0.72675	0.765	0.80325	0.87975	0.918
	I_1	I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
mm/hr	90.9	115	141	156	176	202	221
	Q_1	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}
m^3/s	0.170	0.229	0.314	0.366	0.433	0.544	0.622

SCHOOL CATCHMENT POST BISC							
Area (m^2)	(ha)	Impervious Area (%)		C_{10}	Time of Concentration (min)		
10320	1.03	55		0.765	10		
	C_1	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}
	0.612	0.65025	0.72675	0.765	0.80325	0.87975	0.918
	I_1	I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}
mm/hr	90.9	115	141	156	176	202	221
	Q_1	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}
m^3/s	0.159	0.214	0.294	0.342	0.405	0.509	0.582

Table 2 – Southern catchment runoff calculations.

5.2 High School Box Drain

Figure 6 below, shows the cross-section dimensions for the existing open channel.

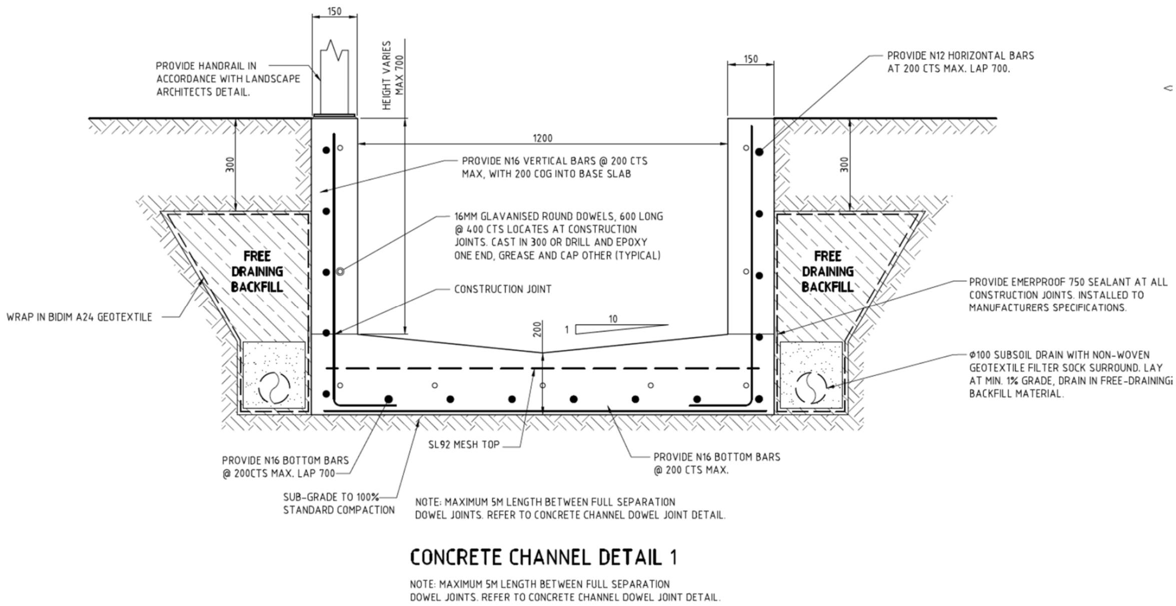


Figure 6 – Box channel section (Northrop Engineers).

From Manning's Equation, the capacity of the box drain at 900mm deep is 2.29m^3/s (at 0.25% grade). The maximum runoff from the southern catchment at AEP 1% is only 0.622m^3/s, or 27% of the capacity. Even with 50% blockage of the box drain, it is extremely unlikely that it would overtop. Flow from the channel out to the existing infrastructure in Cherry Street would be mitigated through the existing 375mm RCP to around 0.17m^3/s thereby providing detention storage of 75m^3 within the channel. A more detailed analysis of the southern catchment would be required to accurately determine the detention storage requirements and would have been calculated for the design of the box drain. This is beyond the scope of this report.

5.3 Sports Centre and Car Park Drainage and Overland Flow

As shown in Appendix A, drainage from the main roof and surface drainage from the car park and plaza areas will be conveyed via a series of overland flow paths, swale drains and infiltration trenches (refer Section 7.3) towards the existing stormwater gully in Bentinck Street.

PRE-DEVELOPMENT

Area (m^2)	(ha)	Impervious Area (%)	C_{10}	Time of Concentration (min)
13690	1.37	0	0.7	20

C_1	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}	
0.56	0.595	0.665	0.7	0.735	0.805	0.84	
I_1	I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}	
66.5	84.4	104	115	130	150	164	mm/hr
Q_1	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}	
0.142	0.191	0.263	0.306	0.363	0.459	0.524	m^3/s

POST-DEVELOPMENT

Area (m^2)	(ha)	Impervious Area (%)	C_{10}	Time of Concentration (min)
14400	1.44	70	0.81	10

C_1	C_2	C_5	C_{10}	C_{20}	C_{50}	C_{100}	
0.648	0.6885	0.7695	0.81	0.8505	0.9315	0.972	
I_1	I_2	I_5	I_{10}	I_{20}	I_{50}	I_{100}	
90.9	115	141	156	176	202	221	mm/hr
Q_1	Q_2	Q_5	Q_{10}	Q_{20}	Q_{50}	Q_{100}	
0.236	0.317	0.434	0.505	0.599	0.753	0.859	m^3/s

DIFFERENCES

0.094	0.126	0.171	0.199	0.235	0.293	0.335	m^3/s

Table 3 – Northern catchment runoff calculations for the pre- and post-development scenarios.

5.4 On Site Detention and Discharge Attenuation

As shown in Table 3 and Figure 7, runoff from the northern catchment will be detailed within the swale system and discharge via a new grated inlet pit connecting to the existing gully pit in Bentinck Street. The pit will discharge through a three-stage orifice plate that will mitigate flows to the pre-development levels for the 5-year, 20-year and 100-year events. The required storage volume of 139m³ will be contained the lower section of the playing field and the drainage swales.

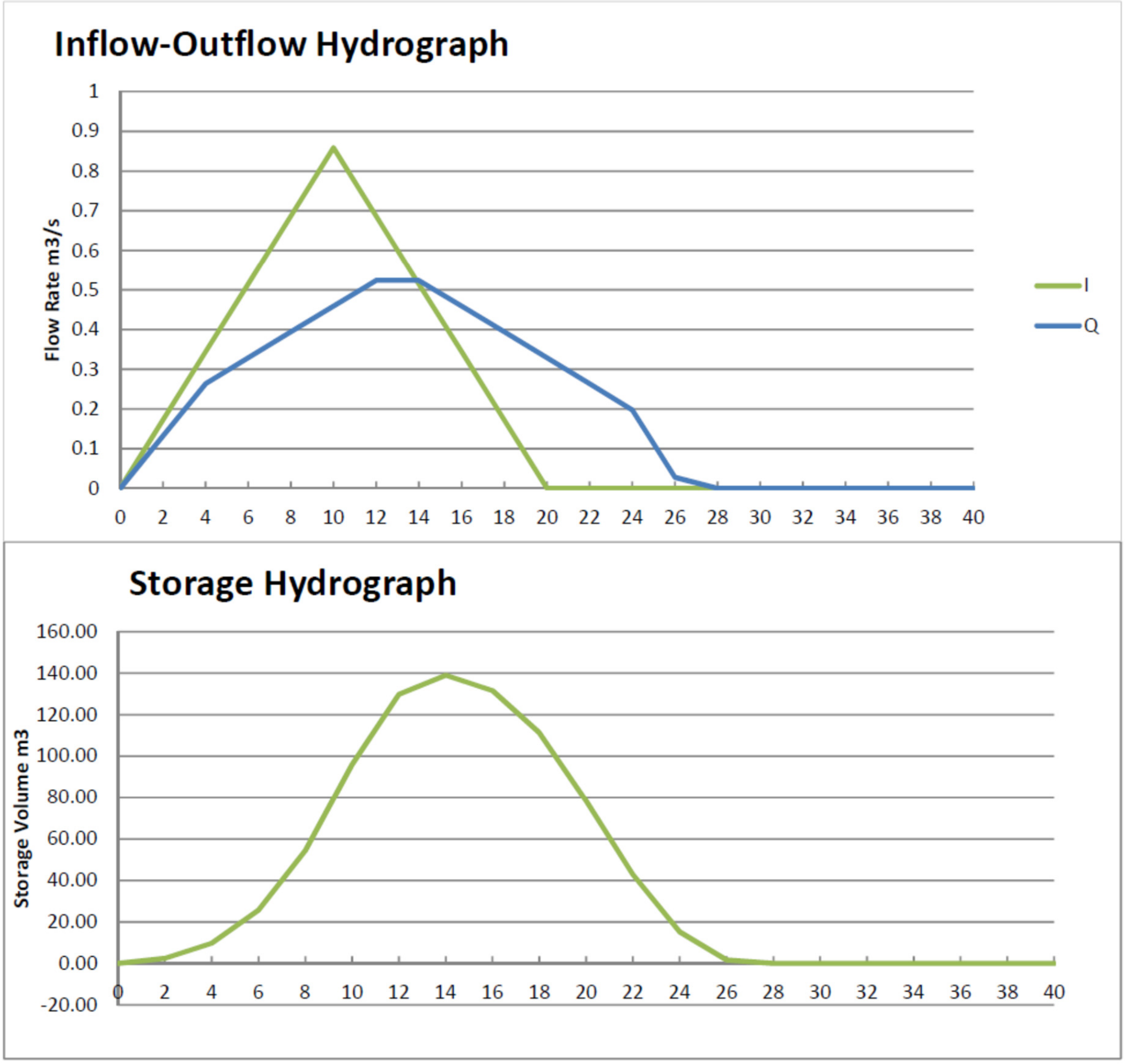


Figure 7 – Storage hydrograph for the northern catchment.

6 EARTHWORKS

The building footprint should be filled to the AEP 1% flood level of RL2.1m AHD as a minimum. In order to prevent ponding on the playing fields and to provide a definite flow path to the discharge point in Bentinck Street, the western half of the remaining part of the playing field should be filled and graded accordingly. The maximum additional fill height will be approximately 400mm at the southern end of the playing field grading at 1 in 100 to the northern end. The maximum depth of the swale drain will be 500mm at the northern (downstream) end.

7 STORMWATER QUALITY

7.1 Pollutants of Concern

The *Ballina Shire Council Stormwater Management Standards for Development* references *Water by Design (SEQ Healthy Waterways Partnership 2010)* in matters of stormwater quality management. The Water Quality Objectives for Ballina Shire are listed in Table 3. The pollutants most likely to be of concern for residential developments are identified in Table 2 below.

Table 1 Pollutants Likely to be of Most Concern

Pollutant	Development Phase	
	Construction	Operation
Litter	✓	✓
Sediment	✓	possibly
Hydrocarbons (including oil and grease)	✓	possibly
Toxic materials (e.g. cement slurry, asphalt primer, solvents)	✓	unlikely
pH altering substances (e.g. cement slurry and wash waters)	✓	unlikely
Oxygen demanding substances (organic and chemical matter)	possibly	unlikely
Nutrients (nitrogen and phosphorus)	✓	✓
Pathogens / Faecal coliforms (bacteria and viruses)	possibly	unlikely
Heavy metals (often associated with fine sediment	unlikely	unlikely
Surfactants (e.g. detergents from car washing)	unlikely	possibly
Thermal pollution (heat)	unlikely	unlikely

7.2 Design Objectives for Water Management

The Environmental Protection (Water) Policy 1997 provides a framework for identifying environmental values and associated water quality objectives; this framework is consistent with the efficient use of resources and best practice environmental management and involves the community through consultation and consideration of economic and social impact assessment. Environmental Values (EV) are a reflection of the qualities of a catchment that the community believes to be important. As such, environmental values are established through community consultation rather than through a scientific process. Once EV are established for a catchment, Water Quality Objectives (WQO) can be defined, which are meant to protect these values.

Table 2 Water Quality Objectives for Ballina Shire.

Parameter	Statistic	Load Based Reduction
Total Suspended Solids (TSS)	Mean Range	80%
Total Phosphorous (TP)	Mean Range	60%
Total Nitrogen (TN)	Mean Range	45%
PH	Mean Range	-
Dissolved Oxygen	Mean	-
Litter/debris	-	90%
Coarse sediment	-	-

While load based reduction targets focus on performance of a stormwater quality management system within the urban footprint, concentration based WQO's are concerned with median flow concentrations as they enter downstream receiving water.

7.3 Proposed Stormwater Treatment Train Analysis

The proposed development site has a large area available to dedicate to stormwater treatment measures. Impervious runoff from the majority of the site is to be channelled via overland flow and treated by grassed swales and infiltration trenches prior to discharge to Bentinck Street.

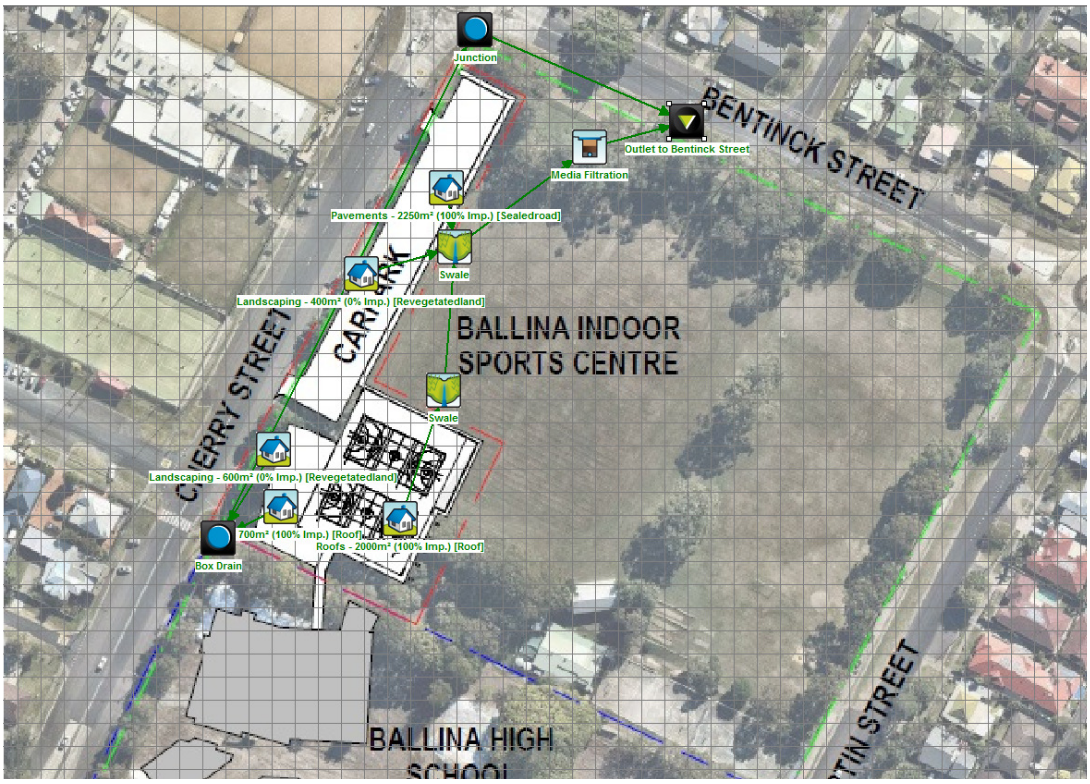


Figure 6 – Proposed stormwater treatment train (MUSIC)

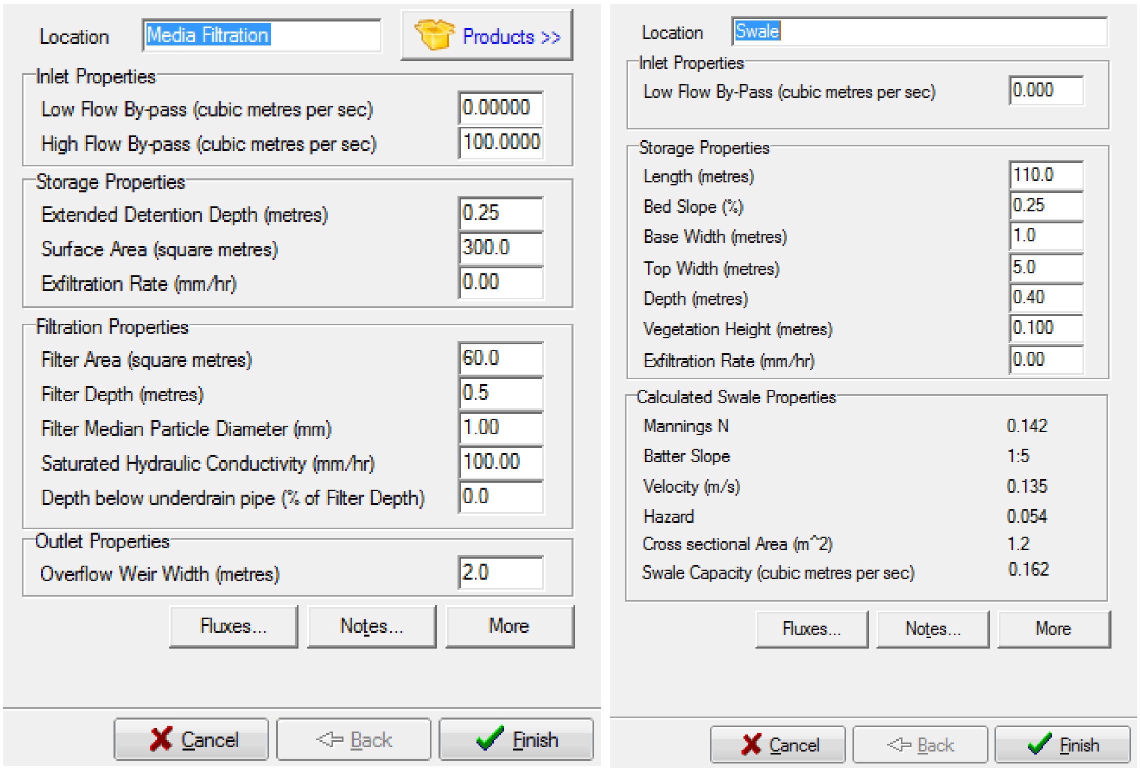


Figure 7 – Media filtration trench and grassed swale model parameters (MUSIC)

7.4 MUSIC Modelling

Model Parameters

Table 3 Basic MUSIC Model Rainfall Parameters

Input	Data Used
Rainfall Station	58131 – ALSTONVILLE
Rainfall Period	01/01/2000 – 31/12/2009
Mean Annual Rainfall (mm)	1543
Evapotranspiration (mm)	1517
Maximum Rainfall (6min)	17.84mm
Model Timestep	6 min
Rainfall Runoff Parameters	Urban Residential
Pollutant Parameters	Urban Residential

Rainfall & Runoff Parameters

Table 5 Adopted MUSIC Quantity Parameters

Parameter	Roof/ Road/Ground Level
Rainfall Threshold (mm/day)	1
Soil Storage Capacity (mm)	120
Soil Initial Storage (% of Capacity)	25
Field Capacity (mm)	80
Infiltration Capacity coefficient - a	200
Infiltration Capacity exponent - b	1.0
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	5.0
Daily Deep Seepage Rate (%)	0.0

7.4.1 Pollutant Generation

In MUSIC, stormwater quality is characterized by event mean concentrations (EMCs) for storm flows and base flows. In this study, the EMC are the default MUSIC model values.

The pollutants of concern that were assessed include total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN). The quality of stormwater runoff is characterised by inputting event mean concentrations (EMCs) for storm flow and base flow conditions as well as the standard deviation of each EMC.

Pollutant concentrations are based on Urban Residential land use parameters using the split catchment parameters.

Table 6 Adopted MUSIC Quality Parameters Urban Residential for Split Catchments

Flow Type	TSS ($\log_{10}$ values)		TP ($\log_{10}$ values)		TN ($\log_{10}$ values)	
	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Baseflow						
Roof	N/A	N/A	N/A	N/A	N/A	N/A
Roads	1.00	0.34	-0.97	0.31	0.20	0.20
Ground	1.00	0.34	-0.97	0.31	0.20	0.20
Stormflow						
Roof	1.30	0.39	-0.89	0.31	0.26	0.23
Roads	2.43	0.39	-0.30	0.31	0.26	0.23
Ground	2.18	0.39	-0.47	0.31	0.26	0.23

7.4.2 Results

The indicative layout of the MUSIC model is given in Figure 6.

The results in the table below show that the overall stormwater treatment train and reuse strategy for the site meets the current best practice design objectives for stormwater quality as identified in Section 7.4.

Table 7 **Treatment Train Effectiveness**

	Sources	Residual Load	% Reduction
Flow (ML/yr)	7.6	7.62	-0.2
Total Suspended Solids (kg/yr)	1270	83.7	93.4
Total Phosphorus (kg/yr)	2.59	0.594	77.1
Total Nitrogen (kg/yr)	17	9.38	45
Gross Pollutants (kg/yr)	160	22.7	85.9

8 STORMWATER QUALITY MANAGEMENT CONCEPT

8.1 Stormwater Quality Management

A review of the site's opportunities and constraints was conducted to determine the potential for the use of various stormwater quality management practices.

8.2 Civil Construction

Filter devices (sediment fences) will be installed at stormwater discharge locations from the site which will allow water velocities to be reduced, pollutants to be trapped and the prevention of sediments being transported off the site and into downstream waterways.

Once site earthworks are completed, permanent storm water quality control devices shall be installed to prevent water-borne pollutants from entering into the downstream stormwater system.

8.3 Post-Civil Construction

Once the civil construction is complete, the two (2) predominant causes of stormwater quality issues are 1) establishment of disturbed areas; and 2) construction of buildings. To assist in reducing the potential for these two (2) activities to cause stormwater quality problems, the following strategies will be undertaken by the Managing Contractor:

- Landscaping of exposed areas to reduce exposed soils.
- Controlled entry / exit to site including implementation of soil erosion and sediment controls onsite.
- Mandatory waste collection points for each building during construction.

8.4 Water Quality Assessment

8.4.1 Assessment of Water Quality Objectives

The following water quality objectives are defined for the site in accordance with stormwater quality control guidelines:

8.4.2 Key Indicators and Water Quality Objectives

Key Indicator	Water Quality Objective
Suspended Solids	50mg/L for combined wet and dry periods. 100mg/L for wet weather periods.
Litter	No anthropogenic (man-made) material greater than 5mm in any dimension.
Turbidity	100 NTU for combined wet and dry periods.

8.4.3 Determine Impact of Runoff from the Site to Receiving Waters

Due to the surrounding catchment being heavily urbanised, the current development should have little effect on the overall water quality. During the construction phase, sediment runoff is the major source of pollutants. It is envisaged that the constructed sediment basins will collect stormwater runoff. This will provide sufficient time for sediments to settle out or be treated prior to dewatering. No uncontrolled storm water or sediment will leave the site.

The SESC component of this plan identifies ways in which erosion will be prevented and sediment will be controlled during the life of this development.

8.4.4 Establish Controls Necessary to Ensure Guidelines are met

The pre-developed allotment currently directs stormwater runoff from the site to the existing drainage system. The proposed works on site ensures all stormwater runoff is captured on site and may be discharged to existing drainage infrastructure should dewatering meet Water Quality objectives detailed above.

8.4.5 Monitor the Quality of the Receiving Waters

Monitoring of the water quality discharging offsite will be carried out as part of the Soil Erosion and Sediment Control Plan monitoring requirements. The monitoring is the responsibility of the Managing contractor during construction and post construction operations.

A suggested minimum monitoring schedule is summarised in the following table:

8.4.6 Water Quality Monitoring Schedule

Location	Frequency	Type	Parameters Monitored
Site Boundary, Stormwater drain outlets.	Three Monthly or after rainfall event.	Sampled and analysed in laboratory	Suspended Solids (SS) Turbidity (NTU)

9 Water Quality Monitoring Program

During the construction phase, runoff exiting the site will be visually monitored during and after rainfall events that generate flow from the site.

Following construction, other water quality monitoring will be undertaken where required by Council, the Department of Natural Resources and Mines or in response to a complaint from the public.

10 Maintenance Plans

All stormwater quality controls require maintenance in order to function efficiently. A detailed maintenance schedule will be developed as part of the detailed design of the site.

Structural controls to manage urban hydrology for healthy waters aim to ‘disconnect’ impervious surfaces from hydraulically efficient drainage systems. This can be achieved bypassing stormwater run-off from impervious surfaces through structural treatments that significantly slow the rate of stormwater run-off and maximize infiltration where possible, reducing the overall volume of stormwater run-off flowing to the receiving waterway.

Treatments that target retention of soluble pollutants and pollutants attached to fine colloidal particulates require significant contact time between stormwater run-off and soil and vegetation elements. These types of treatments (such as constructed stormwater wetlands and bio-retention systems) will significantly slow the rate of stormwater run-off and can provide a quality of water suitable for a range of re-use options, thus also reducing the volume of stormwater run-off discharged to receiving waterways (Urban Stormwater Planning Guidelines).

A. General Maintenance

All retention system components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 25mm of rainfall.

Sediment removal should take place when the structures are thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass outside of the bio-retention system should be mowed at least once a month during the growing season. Grasses within the bio-retention system must be carefully maintained so as not to compact the soil

Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation. When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be re-established in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of the bio-retention system. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the ground surface in the system. This normal drain time should then be used to evaluate the system's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72-hour maximum is exceeded, the system's planting soil bed, underdrain system, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the system.

E. Maintenance Checklist

- Routine inspection of the facility profile to identify any areas of obvious increased sediment, scouring damage and rill erosion.
- Routine inspection of inlet points, surcharge pits and field inlet pits to identify any area of blockages.
- Regular watering/irrigation of vegetation until plants are established and actively growing.
- Mowing of turf slashing of vegetation (if required) to preserve the optimal design height for the vegetation.
- Removal and management of invasive weeds.
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.

- Pruning to remove dead or diseased vegetation material and to stimulate new growth.
- Litter and debris removal.
- Vegetation pest monitoring and control.

11 TEMPORARY SOIL EROSION AND SEDIMENT CONTROLS

During the construction phase of a development, erosion and sediment controls are required to be implemented to minimise any water quality impacts associated with construction activities. Erosion and sediment control measures for development site should be designed and installed in accordance with the "*Best Practice Erosion and Sediment Control.*" (IE Aust 2008).

11.1 Legal and other requirements

The Environmental Protection Act 1994 and subordinate legislation (particularly Environmental Protection Policy (Water) 1997) places responsibility on the developer to undertake all construction activities in a manner that does not cause unauthorized "environmental harm". This responsibility is reflected in the requirements of the Development Application. The development application requires the preparation of an ESCP in accordance with Charters Towers Regional Council Planning Scheme prior to Operational works being granted for the project to commence.

11.2 Definitions and Abbreviations

- Buffer Zone- an area of permanent vegetation around or adjacent to an identified sensitive resource.
- Check Dam-small dam constructed across a swale or drainage ditch.
- Cohesive Soil-soil particles that have intermolecular resistance to being pulled apart at their point of contact e.g. clay.
- Erosion- the wearing away of soil or other material by the action of flowing water, wind or other geological agents.
- Erosion Control-The application of temporary or permanent measures to control erosion of land surfaces.
- Sheet erosion- Erosion of thin layer of earth-surface material, more or less evenly, from extended areas of gently sloping land by broad continuous sheets of running water, without the formation of rills, gullies, or other channelized flow.
- Silt fence-specially designed synthetic fabric fasted on supporting posts, which are designed to efficiently control and trap sediment runoff from disturbed areas.
- Sediment trap- a temporary excavated pit provided to intercept the store sediment e.g. rock filter dam.
- Stockpile-topsoil or spoil stored and managed at a work site so that it is protected from erosion or loss by virtue of its placement in an area specifically selected for it.

11.3 Responsibility of Key Personnel

Table 9 Personnel Responsibility

POSITION	RESPONSIBILITIES
Project Superintendent	• Overall responsibility of ESC implementation; • Notify the Environmental Manager immediately of any non-compliance with ESCP; • Ensure the prompt implementation of measures to mitigate erosion and sediment generation;
Project Engineer	• Provide design information as required;

	• Inspect ESC installation and maintenance; • Inspect offsite impacts and management;
Site Supervisor/ Foremen	• Monitor daily rainfall; • Notify Environmental Advisor/Consultant when runoff generating rainfall occurs in the previous 24 hours; • Treat, test and dispose of captured runoff as per operating procedures; • Maintain current records of rainfall, storage volumes, water quality, treatment practices, discharge volumes;
Environmental Advisor/ Consultant	• Conduct in-situ monitoring; • Collect and submit samples to laboratory; • Collate results and prepare reports as required; • Sample basin water quality and authorise discharge; • Conduct site inspections and audits as required;
SESC Auditor/Advisor	• Conduct site inspections and audits as required; • Prepare audit reports; • Provide advice regarding ESC site improvement;
All Personnel	• Report any damage to ESC devices and any potential or actual environmental harm in line with Duty to notify under the requirements of the Environmental Protection Act 1994;

11.4 Drainage Control

Drainage control measures aim to prevent or reduce soil erosion caused by concentrated flows (including the management of rill and gully erosion), and to appropriate manage the movement of ‘clean’ and ‘dirty’ water through the site.

It is generally achieved by following these principles:

1. Temporary or permanent drainage channels need to be constructed and maintained with sufficient gradient and surface conditions to maintain their required hydraulic capacity.
2. Flow velocities need to be limited to the maximum allowable velocity for each individual drainage system.
3. Divert “clean” and “dirty” water around the soil disturbance areas and the “clean” water need to be diverted around sediment traps that maximizes the sediment trapping efficiency.
4. In regions containing dispersive soils, construction details of drainage systems and bank stabilization works need to be applied.
5. Stormwater outlets, discharge point, spillways and slope drains need to be placed adequate scour protection for dissipating flow energy and minimize the risk of soil erosion.

11.5 Erosion Control

Erosion occurs when the susceptible soil particles are subjected to eternal forces of sufficient magnitude to dislodge and carry the particles away. Erosion control measures aim to prevent or reduce soil erosion caused by raindrop impact and sheet flow.

The susceptibility of the soil erosion and degree of erosion is based on following parameters:

- Soil types and the associated soil cohesiveness;
- Ground vegetation condition
- Soil particle size
- Ground disturbance (e.g. grading, clearing, digging, trenching, stockpiles.)

- Area of disturbance
- The time the soil is exposed to erosion
- The erosion medium (e.g. water or wind)
    1) For water erosion, existing water drainage structures (e.g. entry points, capacity, choke points, settlement areas)
    2) For wind erosion, the detachment, transportation, and deposition of loose topsoil or sand by the action wind should be taken into account.
- Ground slope level
- The volume, flow rate and time duration of erosion medium should be considered.

The mitigation methodology is described below:

- Erosion control measures need to be appropriate for the slope of the land and the expected surface flow conditions.
- If tree clearing is required for earthworks, then tree clearing methods that will minimise potential soil erosion need to be employed to minimise the disturbance of the erodible subsoils in order to avoid tunnel erosion.
- Finished soil surfaces need to be left in an appropriate roughened state and quality to enhance natural germination of the revegetation where required.

Table 10 Erosion Control Measure

ESC Measure	Application
Mulching, top soiling & seeding	Applied to stripped areas as soon as practicable and used to stabilise decommissioned access tracks. Erosion and sediment controls such as contour drains and sediment fences should be maintained until rehabilitated areas are stabilised.
Geofabric/ Concrete lining	Used as underlining for rock pads and channels to avoid soil exposure.
2D Matting	Used to cover stripped areas that will remain un-vegetated or mulched for a period longer than two weeks. (Once landscaping has commenced matting may be rolled up and reused at other sites).
Level Spreader	Turn the concentrated flow into sheet flow then discharging to a grassed buffer zone before entering the sediment trap.
Deco blanket for subsoil protection	50-100mm of deco to be bladed over cut and compacted subsoil, where possible the deco should be wet up and rolled should rain be imminent or site to be left longer than 7 days.

Table 11 Application of Erosion Control Measures to soil slopes (IECA 2008)

Flat Land (<1 in 10)	Mild Slopes (1 in 10 – 1 in 4)	Steep Slopes (steeper than 1 in 4)
Erosion Control Blankets	Bonded Fibre matrix	Bonded Fibre Matrix
Gravelling	Compost Blankets	Cellular Confinement Systems
Mulching	Erosion Control Blankets, Mats and Mesh	Compost Blankets
Revegetation	Mulching well anchored	Erosion Control Blankets, Mesh, and Mats
Rock Mulching	Revegetation	Revegetation
Soil Binder	Rock Mulching	Rock Armouring
Turfing	Turfing	Turfing

11.6 Sediment Control

- Sediment control measures aim to trap and retain sediment displaced by up-slope erosion processes and to protect adjacent properties and downstream environments from the sediment-laden water displaced from the site. The mitigation considerations are listed below:
- Erosion control should be carried on before erosion control. Work site must not only rely on sediment control.
- Sediment control devices need to be appropriately designed for the given soil properties, expected weather conditions, required treatment standard.
- Adequate construction access needs to be provided to allow for the installation and maintenance of all sediment traps according to soil type and site conditions.
- The potential safety risk of a proposed sediment trap to site worker and public needs to be given suitable consideration and management, especially those devices located within the public road.
- Sediment fences must not be placed across concentrated flow.
- Sediment control measures employed during de-watering process need to be properly managed based on soil particle, potential environmental risk and scope of the works.
- Site managers and/or the nominated responsible ESC personnel need to maintain a good working knowledge of the correct installation and operational procedures of all ESC measures used on site.

Table 12 Design standard drainage

Structure	Conveyance/stability	Notes
Temporary Drainage Structures	2 year ARI + 150mm freeboard	Assumes <12 month design life
Emergency Spillway Basin	20 year ARI + 300mm freeboard	Assumes <12 month design life
Diversion of clean water around the site	2 year ARI + 150mm freeboard	Assumes <12 month design life
C_{10}	0.70	Low soil permeability assumed, ${}^{1}I_{10}$ = 59.9mm/hr

11.7 Dewatering

1. All sediment control measures implemented for the control of sediment-laden is charge from de-watering activities are designed to satisfy, as a minimum, the current best practice discharge standards.
2. Filter bag should be used and inspect regularly for de-watering operations.
3. Inspect the filter tubes for obvious leaks resulting from holes, tears or joint failure in the fabric. Replace any filter tube if sediment blockage of the fabric decreases the flow rate to an unacceptable level, or the filter tube contains excessive sediment.

11.8 Maintenance and Reporting

Maintenance of the SESCP shall be carried out regularly on all controls based on the following criteria being achieved:

- Structures are installed in accordance with engineering specification and drawings.
- Minimum sediment storage capacity of 50% of design capacity available.
- Regular removal of sediment and repairs to SESC.

To ensure SESC are being regularly maintained and inspected, the Managing Contractor (MC) will be required to conduct a weekly inspection to confirm that the above criteria is being achieved. These inspections will also assist to identify the performance of each SESC, identify rectification works and additional controls if required.

Weekly reports must be handed into the Superintendent for the Civil Works for review and audit of any non-conforming works before the next weekly inspection. It will be the Managing contractor's responsibility for ensuring that the site is maintained in accordance with the SESCP during construction.

- Status of Works including witness, hold and end points.
- Analysis of performance standards against actual results.
- Corrective actions, amendments to SESCP based on failure to achieve performance standards.
- Copies of weekly inspection reports.
- Copies of instructions given to amend, repair or change SESCP.
- Rainfall events and monitoring results including water sampling and photos.

12 Asset Handover

All stormwater controls will remain the assets of the owner of the proposed development.

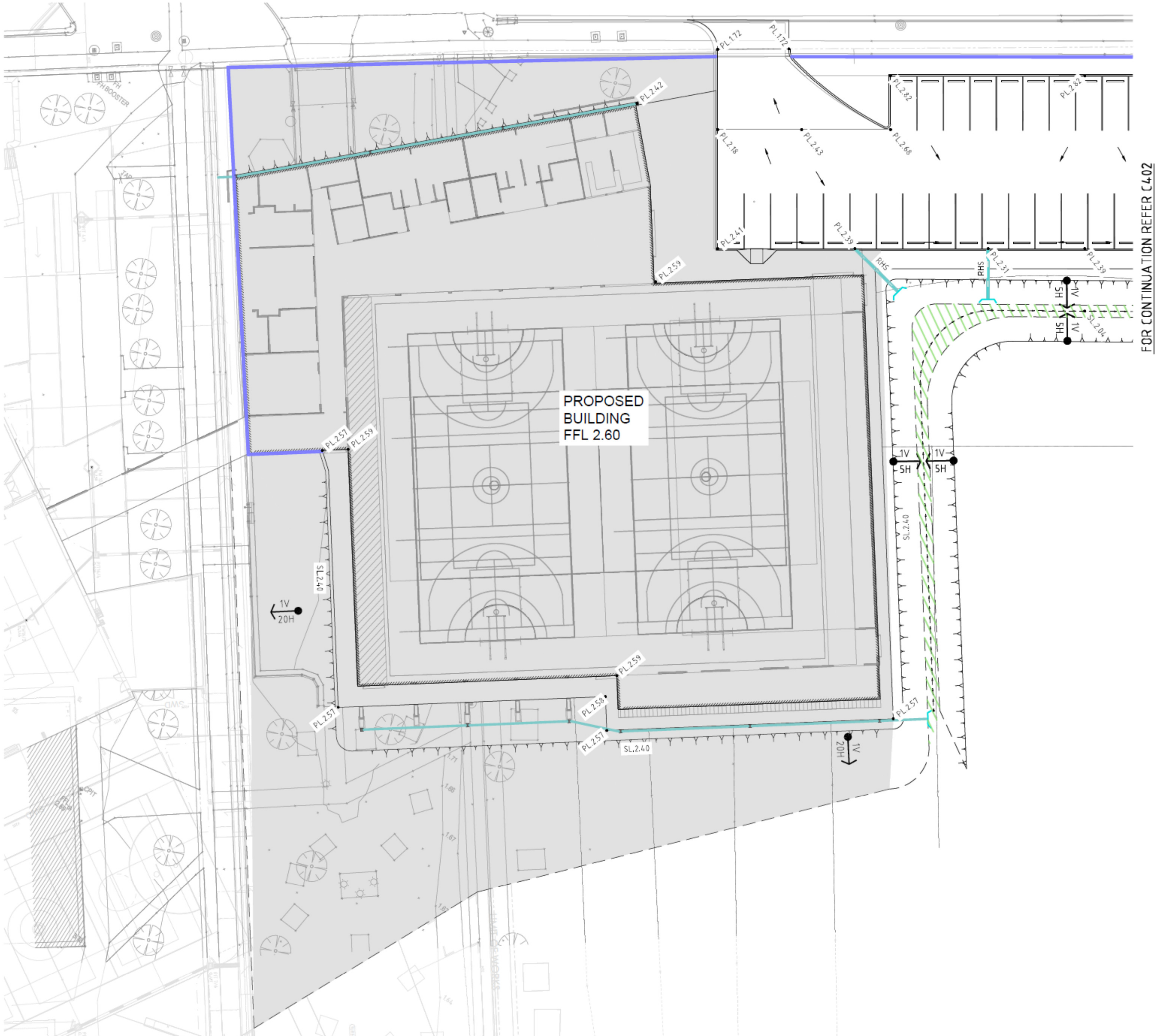
13 Conclusion

Best Practice Stormwater Management measures were applied to the proposed development, in which use of the existing stormwater drainage facilities was considered the best treatment option.

It should be noted that the stormwater treatment measures described in this report are conceptual in nature. Detailed design specifications and drawings for the stormwater quality management measures will need to be prepared and lodged by the Project Engineers prior to the commencement of operational works.

The stormwater management system proposed for the development is consistent with minimising water contamination during the construction and post construction phases of the development.

APPENDIX A – Proposed Stormwater Layout



STORMWATER DRAINAGE

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE HYDRAULICS DRAWINGS.
2. ROOF WATER DRAINAGE IS TO BE CONNECTED TO PITS OR PIPES AS SHOWN ON DRAWINGS IN ACCORDANCE WITH THE HYDRAULICS REQUIREMENTS.
3. ALL STORMWATER PIPES AND PITS ARE TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S REQUIREMENTS AND RELEVANT AUSTRALIAN AND LOCAL AUTHORITY STANDARDS.
4. STORMWATER PITS ARE TO BE CONSTRUCTED IN SITU IN ACCORDANCE WITH DRAWINGS OR VARIED AS NOTED ON THE DRAWINGS. PREFABRICATED STORMWATER PITS MAY BE USED SUBJECT TO WRITTEN APPROVAL FROM THE SUPERINTENDENT. CLASS D HEAVY DUTY GALVANIZED STEEL GRATES ARE TO BE FITTED IN TRAFFIC AREAS, CLASS B LIGHT DUTY GALVANIZED STEEL GRATES ARE TO BE FITTED IN LANDSCAPED OR PEDESTRIAN AREAS UNLESS NOTED OTHERWISE. ALL GRATES TO COMPLY WITH AS3996 FOR BICYCLE & WHEELCHAIRS AND TO BE NON SLIP.

LEGEND

- EXISTING EDGE OF BITUMEN
- EXISTING FENCE
- PROPOSED CHANGE OF GRADE
- PROPOSED TOP OF BATTER
- PROPOSED EDGE OF STRUCTURE, REFER ARCHITECTS DWG'S
- PROPOSED STORMWATER DRAINAGE LINE
- PROPOSED RETAINING WALL
- 100% SLOTTED SUB-SOIL DRAIN WITH CLEAN OUT POINTS
- PROPOSED GRATED INLET PIT

HATCHING LEGEND

- FILTER MEDIA AREA
- 20mm GRAVEL BACKFILL AREA

LEVEL DATUM

PM No. 37145
LEVEL DATUM RL 1.559 AHD DERIVED

SCALE 1:200 (A1) 1:400 (A3)
DO NOT SCALE USE ONLY THE DIMENSIONS PROVIDED.

Rev	Description	By	Appd	Date
A	FOR COORDINATION	MAF	KEM	09.03.18

IN ASSOCIATION WITH

Client: PDT ARCHITECTS
Project: BALLINA SPORTS CENTRE
Title: STORMWATER MANAGEMENT LAYOUT PLAN

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Design	KEM
Drawn	MAF
Date	SEPT 2014
Checked	KEM
Certified	TJS
RPEQ No.	03321

NOT FOR CONSTRUCTION

Job Number: STP17-0890
Drawing Number: C401
Certified
Rev: A

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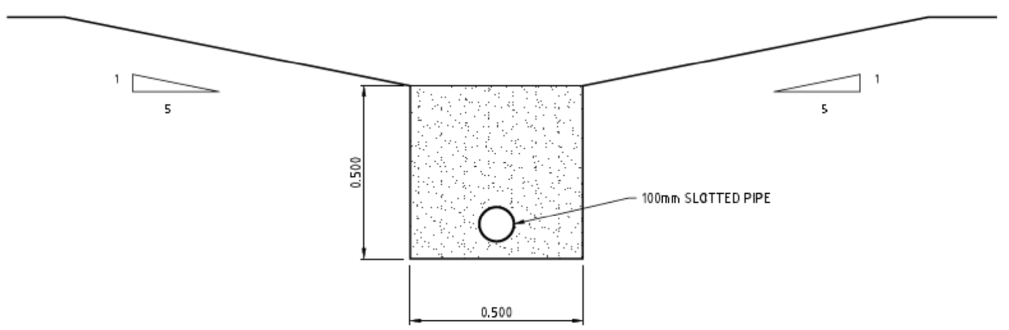
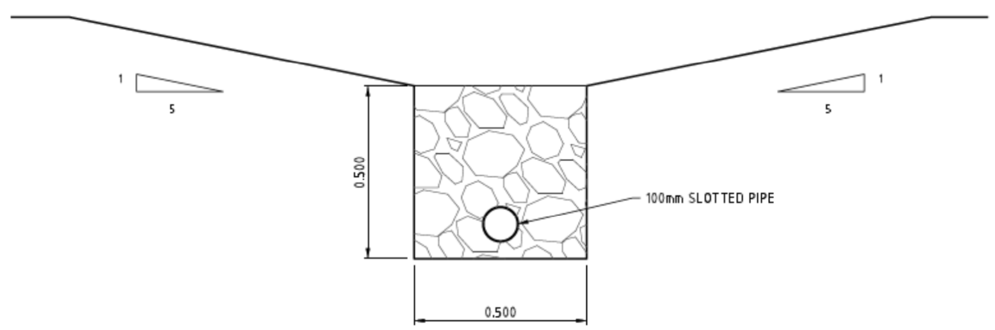


SECTION A
SCALE 1:10 @ A1 SIZE



SECTION B
SCALE 1:10 @ A1 SIZE

LEVEL DATUM

PM No. 37145
LEVEL DATUM RL 1.559 AHD DERIVED

SCALE 1:200 (A1) 1:400 (A3)

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