Appendix E

Stormwater Management Plan

4.4 Existing Site Peak Flow Estimate

4.4.1 Existing Site Catchment Plan

The existing site catchment plan is illustrated in Figure 4-3.

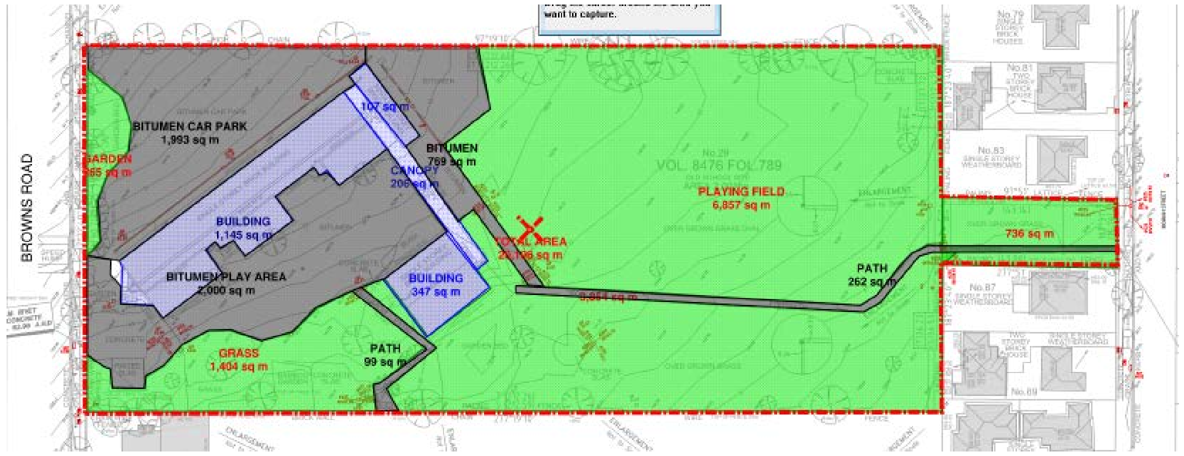


Figure 4-3 Pre-Development Catchment Plan

Area take-off for the pre-developed site is provided in Table 3-1.

Table 3.1 Pre-Development Site Catchment Areas

Catch	Total Area (m^2)	Hard Pavement			Roof			Grass Surface			Total	
		Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Eff. Imp Area (m^2)	C_v
1	20,106	5,067	90%	4,560	1,805	100%	1,805	13,166	15%	1,975	**8,340**	**41%**

The impervious fraction of the existing site for the use in hydrological calculations has been calculated to be 41%.

Calculation of 5 year ARI peak flows for the existing site catchment has been calculated from the XPSWMM model discussed above.

Multiple storm durations have been trialled to identify the peak value for catchment. The peak rate of discharge was found to result from the 30 minute storm duration with values 126 litres/sec.

Refer discharge hydrographs presented in Figures 4-4 below.

document control

project name Proposed Residential Development - 29 Browns Road, Clayton

project number 14ME0779

Revision	Date				
		File name 14ME0779-Rpt-SMP-pm1-R0.1.docx			
0	21/08/2015	Description Draft for Comment			
			Prepared	Checked	Approved
		Initial	PM1	LOT	PM1
		File name 14ME0779-Rpt-SMP-pm1-R1.docx			
1	15/09/2015	Description Final Report			
			Prepared	Checked	Approved
		Initial	PM1	LOT	PM1
		File name 14ME0779-Rpt-SMP-pm1-R2.docx			
2	07/10/2015	Description Final Report (Minor Revision)			
			Prepared	Checked	Approved
		Initial	PM1	LOT	PM1
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			
		File name			
		Description			
			Prepared	Checked	Approved
		Initial			

contents

Glossary of Terms

Average Return Interval (ARI) — The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. Eg. 100 year ARI flood is expected to be exceeded every 100 years. It is implicit in this definition that the periods between exceedances are generally random.

Australian Height Datum (AHD) — A common national surface level datum approximately corresponding to mean sea level.

Catchment — Area draining to a site. It always relates to a particular location and may include the catchment of tributaries as well as main stream.

Discharge — The rate of flow of water measured in terms of volume over time.

Geographical Information Systems (GIS) — A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.

Hydraulics — Is the topic in civil engineering with the mechanical properties water flow through such things as pipe drainage networks, dams rivers, stream and across land.

Hydrograph — A graph that shows the discharge to time relationship of a hydraulic flow at a particular location.

Hydrology — The term given to the study of the rainfall and runoff processes as it relates to the derivation of hydrographs for given floods.

Intensity Frequency Duration (IFD) Analysis — Statistical analysis, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.

Peak flow — The maximum discharge occurring during a flood event.

Legal Point of Discharge — The point which is specified by Council as the stormwater outlet point for an individual property,

Runoff — The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.

Topography — A surface that describes the ground profiles of a chosen land area.

XP-SWMM — The hydrological and hydraulic model used in this study to simulate the site catchments runoff and flow of water through the pipe drainage network.

1 Introduction

1.1 General

This Stormwater Management Plan (SMP) has been prepared for the proposed residential development at 29 Browns Road, Clayton (referred to herein as The Development). The SMP has been prepared in support of the town planning application to the City of Monash Council being completed by Mushan Architects.

The SMP will provide details of the stormwater drainage scheme proposed for The Development and will demonstrate compliance with the Council's drainage requirements for the site as well as other relevant Australian Standards and best practice Water Sensitive Urban Design (WSUD) principles.

More specifically key aims of the SMP are to define:

- the Legal Point of Discharge for The Development;
- the design criteria for the on-site drainage in accordance with requirements of AS 3500;
- the stormwater drainage scheme plan for The Development including notional drainage alignments, building connection points, location of detention systems and WSUD features;
- on-site detention requirements including calculation of volumes required to meet Council requirements;

and to:

- outline the proposed WSUD systems to achieve pollution reduction targets set for the development.

2 Existing Site Conditions

2.1 Locality

The Development site is a disused secondary school at 29 Browns Road Clayton. The site fronts onto Browns Road and connects to the rear with Moriah Street in Clayton. The overall area of the Development site is 1.92 hectares.

2.1 Site Topography and Features

The Development site and surrounding area has been surveyed by Bosco Johnson and a topographical plan showing existing conditions is presented in Figure 2-1 below.

Inspection of the site was conducted by Peter Munzel of Irwinconsult in August 2015 and brief discussion on the site features follows.

The site topography generally falls from north-west to south-east with levels ranging from RL65.2m AHD to 60.3m AHD. The average grade across the site is ~2.2%. Grading of the site is even with no appreciable depressions or low lying land.

The site is currently occupied by a derelict school with old school building and infrastructure remaining that includes asphalt car parking and play areas, stormwater drainage, sewer and grassed playing fields. This remaining infrastructure will need to be demolished to make way for The Development

The remainder of the site is grassed and there a number of small to medium size gum trees dotted around the sites perimeter.

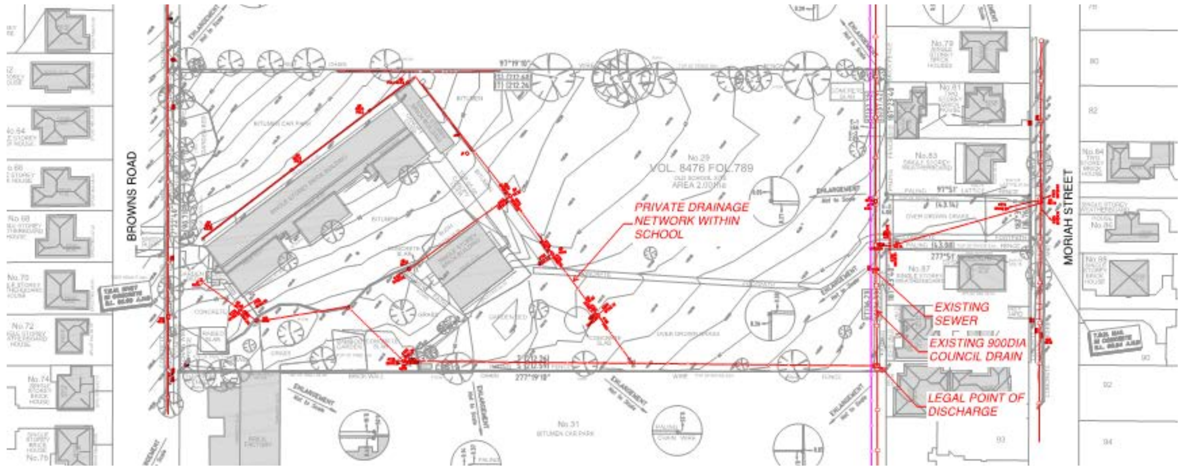


Figure 2-1 Existing Site Survey Plan

Through the visual inspection, the ground across the site was observed to be loamy clay in nature.

2.2 Existing Drainage

Asset records of existing Council drainage assets have been obtained from City of Monash and presented in Figure 2-2 below.

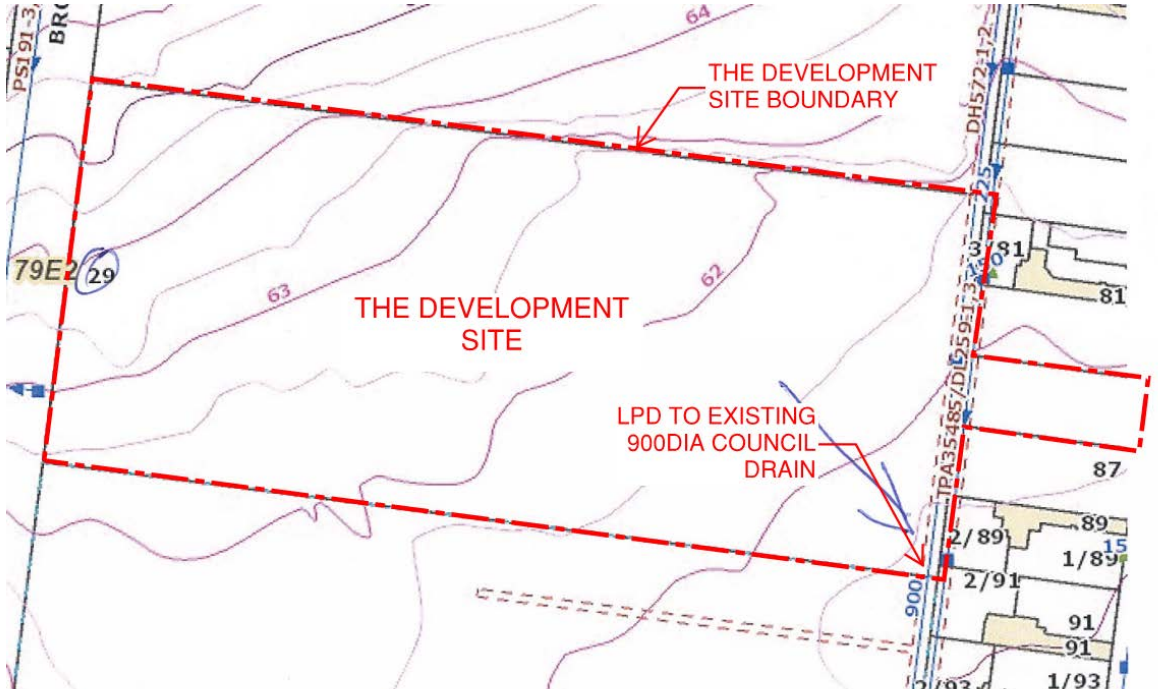


Figure 2-2 Existing Site Drainage Plan

There are a number of Council drainage assets around The Development site, including:

- a 375Ø drain in Browns Road
- a 525Ø drain in Moriah Street, and
- 900Ø drain that runs along the eastern side of the site in a sewer/drainage easement (Note there is a South East Water sewer in the easement also).

There is existing private drainage across the school site the ranges in size from 150Ø to 300Ø that connect to the 900Ø Council drain on the east side of the site. This private drainage is redundant infrastructure and will be removed when the school infrastructure is demolished.

3 The Development

The Development plan by Mushan Architects proposes the construction of residential apartments including:

- Two and three story townhouses
- Apartment blocks
- Below the apartment blocks there is a basement car park

The apartment block will be positioned central to the site with townhouses positioned on the east, west and north sides of the site.

Hard surfacing across the site will include vehicular driveways, car parking and pedestrian pathways. The remainder of the site will be soft landscaped with lawns and garden beds

A copy of The Development site plan proposed by Mushan Architects is provided in Figure 3-1 below.

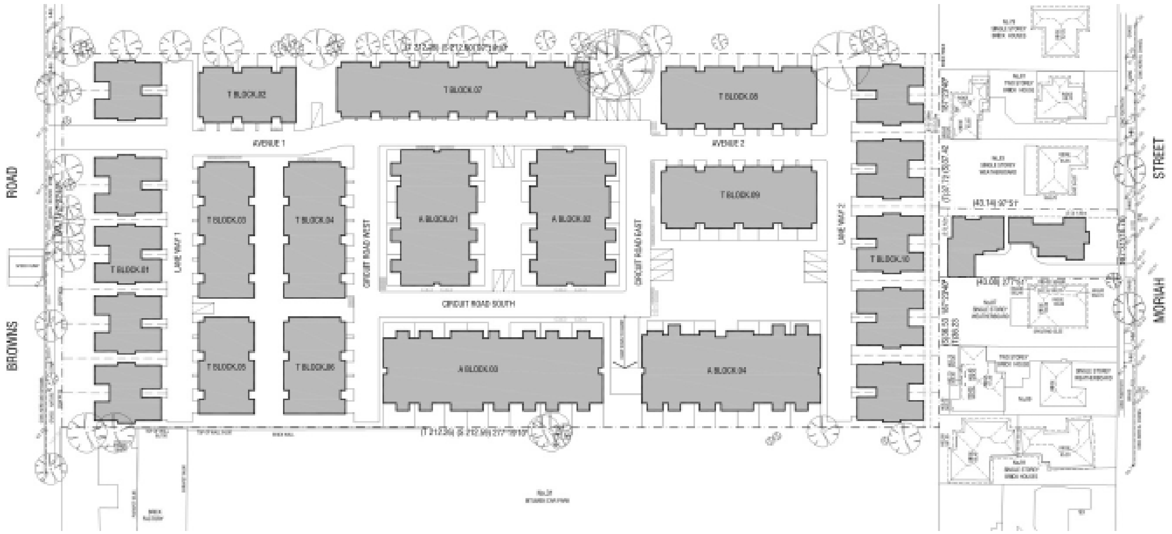


Figure 3-1 The Development Site plan

Proposed Residential Development
29 Browns Road, Clayton
Stormwater Management Plan

4 Drainage Strategy

4.1 Drainage Design Criteria

4.1.1 Legal Point of Discharge

The Legal Point of Discharge (LPD) for the development site has been provided by the City of Monash in their response dated 17/03/2015. The nominated point discharge is the 900mm Ø Council drain located in the sewerage easement along the eastern boundary of The Development site. Connection to the drain is to be made via a 900x600mm pit to be constructed to Council standards.

Copy of the approved LPD from Council is provided in Appendix A.

The LPD approval from the Council also stipulates that the development needs to also provide on-site detention. Council has confirmed that stormwater detention is required for The Development to balance the 10 year ARI post development peak flows with the existing 5 year ARI peak flow rate.

4.1.2 Australian Standards

The design criterion for below ground pipe drainage has been adopted from Table 5.1 of AS3500 Pt 3 as follows:

- Minor below ground drainage system inside the development 10 year ARI
- Major overland flow drainage 100 year ARI

4.2 Drainage Scheme Plan

4.2.1 Ground Level Drainage

The drainage scheme plan for the Development is presented in Figure 4-1 below and repeated in Appendix B for clarity.

Figure 4-1 Stormwater Drainage Scheme Plan

The stormwater drainage system for The Development will include both above ground and below ground systems. The drainage system is to be designed with minor below ground drainage systems for the 10 year Annual Return Interval (ARI) storm events, and overland flow paths provided around and away from buildings for the major 100 year events.

Below ground stormwater detention tanks are proposed to meet attenuation requirements by the Council. Refer to Section 4.3 for details of the proposed stormwater detention system.

Stormwater pollution reduction is proposed by the inclusion of rainwater harvesting and oil/bio-retention separation unit installed at the end of the system and prior to water discharging off site. Refer to Section 4.5 for discussion of proposed WSUD systems.

4.2.2 Basement Drainage

Basement drainage will be provided to take away groundwater from behind retaining walls and any water that may seep through walls into the building.

All groundwater collected from the basement will be to a small pump station and pumped out to the external building drainage system.

Any water that may seep through the basement walls will be collected in spoon drains that will run around the perimeter of the basement. Water collected in the spoon drains will discharge to basement perimeter drainage system via floor wastes fitted into the spoon drainage at discrete locations.

The basement subsoil pump station will be a two pump duty standby system with each pump rated to pump at 2 litres/sec. The pump will have high level and failure alarm system that will be connected to the core building control systems. A rising main from the pump station will connect to the stormwater drainage system external to the building at ground level.

4.3 Stormwater Detention Calculations

4.3.1 General

Hydrological and hydraulic modelling of the stormwater detention system has been undertaken using the computer software XPSWMM. The software is recommended in AR&R Volume 1 Book VIII Urban Stormwater for modelling of complex drainage systems and is considered suitable for this project.

This computer modelling has been completed to determine the existing discharge rate from the site as well as sizing the stormwater detention system.

4.3.2 Rainfall Intensity-Frequency-Duration

Rainfall Intensity Frequency Data (IFD) used in the hydrological model has been derived using procedures and data provided in AR&R Volumes 1 and 2. A copy of the IFD chart is Figure 4-2 below.

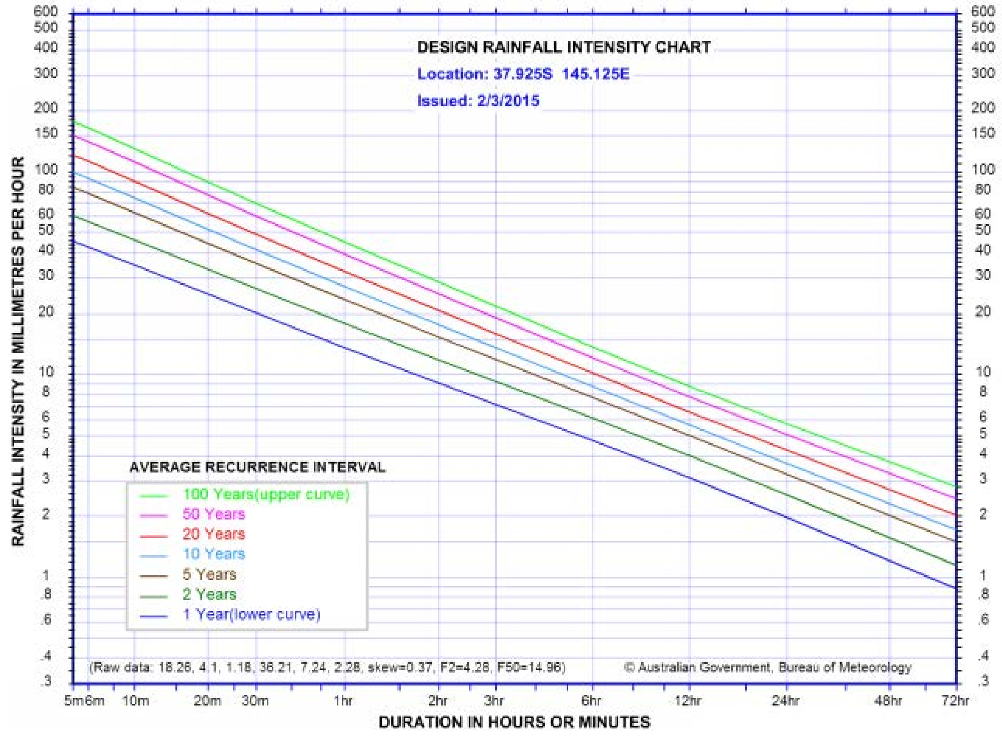


Figure 4-2 Rainfall IFD Data

4.3.3 Hydrological Model

The hydrological model used is the SWMM Non-linear Runoff Routing Method utilising the Horton Infiltration model. Parameters adopted are summarised below;

- Horton Infiltration Model (values estimated for dry loamy soils)
  - Max Infiltration Rate (Fo): 150mm/hr
  - Min (Asymptotic) Infiltration: 1.3mm/hr
  - Decay rate of infiltration: 1.18×10^{-3} 1/sec
  - Max Infiltration volume 0.0mm
- Pervious Area
  - Manning's n: 0.03
  - Depression storage: 2.5mm
- Impervious
  - Manning's n: 0.014
  - Depression storage 1mm
  - Zero Detention (%) 25

The maximum or initial infiltration capacity, mm/hr. This parameter depends primarily on soil type, initial moisture content and surface vegetation conditions. The values adopted are typical for loamy soils as recommended by Akan (1993) – Reference XPSWMM User Manual.

4.4 Existing Site Peak Flow Estimate

4.4.1 Existing Site Catchment Plan

The existing site catchment plan is illustrated in Figure 4-3.

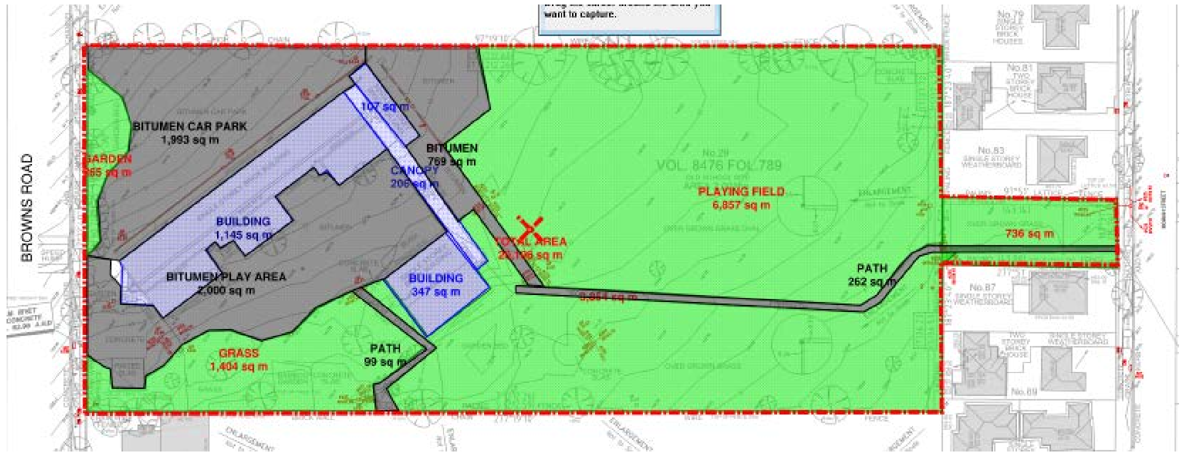


Figure 4-3 Pre-Development Catchment Plan

Area take-off for the pre-developed site is provided in Table 3-1.

Table 3.1 Pre-Development Site Catchment Areas

Catch	Total Area (m^2)	Hard Pavement			Roof			Grass Surface			Total	
		Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Eff. Imp Area (m^2)	C_v
1	20,106	5,067	90%	4,560	1,805	100%	1,805	13,166	15%	1,975	**8,340**	**41%**

The impervious fraction of the existing site for the use in hydrological calculations has been calculated to be 41%.

Calculation of 5 year ARI peak flows for the existing site catchment has been calculated from the XPSWMM model discussed above.

Multiple storm durations have been trialled to identify the peak value for catchment. The peak rate of discharge was found to result from the 30 minute storm duration with values 126 litres/sec.

Refer discharge hydrographs presented in Figures 4-4 below.

Proposed Residential Development
29 Browns Road, Clayton
Stormwater Management Plan

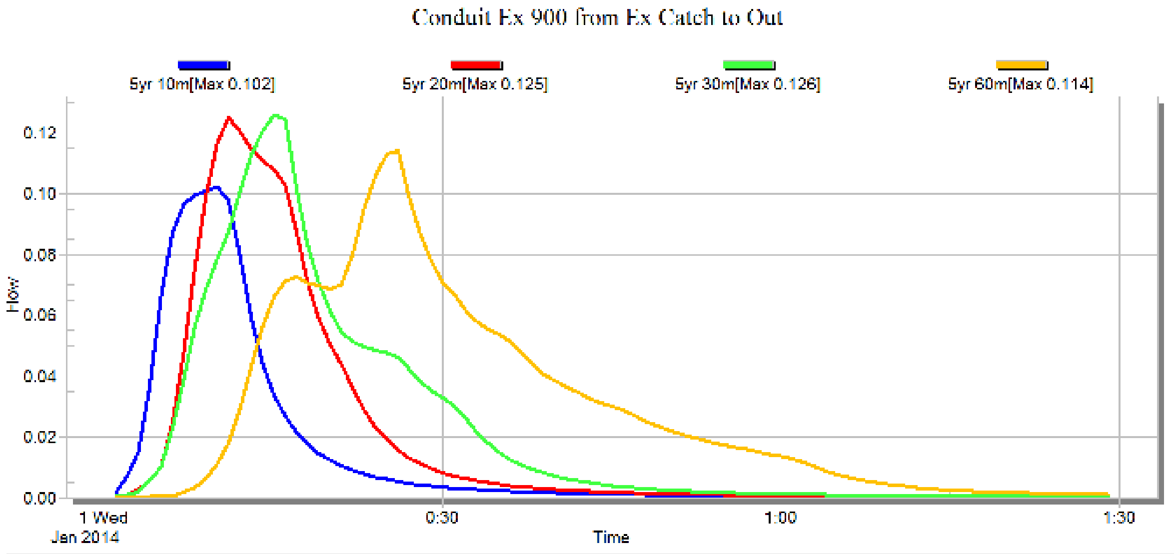


Figure 4-4 Existing Site 5 Year ARI Peak Flow Estimate

4.4.2 Development Catchment Plan

Catchment plan for the development is presented in Figure 4-5 below.

Figure 4-5 Post Development Catchment Plan

Area take-off for the post-developed site is provided in Table 4-2 below.

Table 4.1 Post-Development Site Catchment Areas

Catch	Total Area (m^2)	Hard Pavement			Roof			Grass Surface			Total	
		Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Sub-Total Area (m^2)	C_v	Eff. Imp Area (m^2)	Eff. Imp Area (m^2)	C_v
1	20,106	6,562	90%	5,906	8,261	100%	8,261	5,283	15%	792	**14,959**	**74%**

The site will be fully developed with roofs, access roads and hard standing covering the majority of the site. The impervious fraction of the site for the use in hydrological calculations has been calculated to be 74%.

4.4.3 Stormwater Detention

The strategy for stormwater detention is to balance peak flows from The Development for all events up to 10 year ARI with the existing site 5 year ARI peak flow values.

Existing site 5 year ARI peak flow estimates is 126 litres/sec (Ref. Section 4.4.1).

Stormwater detention is achieved by inclusion of two (2) no. 75m^3 below ground detention tanks providing a total storage volume of 150m^3. The tanks are proposed to be located on the west and east sides of the site as presented in Figure 4-1. Notional design parameters of the tank are as follows:

- Eastern Tank : Plan Area 50m^2, 1.5m depth
- Western Tank : Plan Area 50m^2, 1.5m depth

Peak discharge flow control from the detention tanks is to be achieved by fitting 160mm Ø orifice plates fitted to the junction pit directly downstream of each tank.

The detention tank system has been evaluated using the XPSWMM model for the 10 year ARI critical storm event. The detention system has been tested for all relevant storm durations with calculated peak flow rate leaving the site presented in Figure 4-6 below.

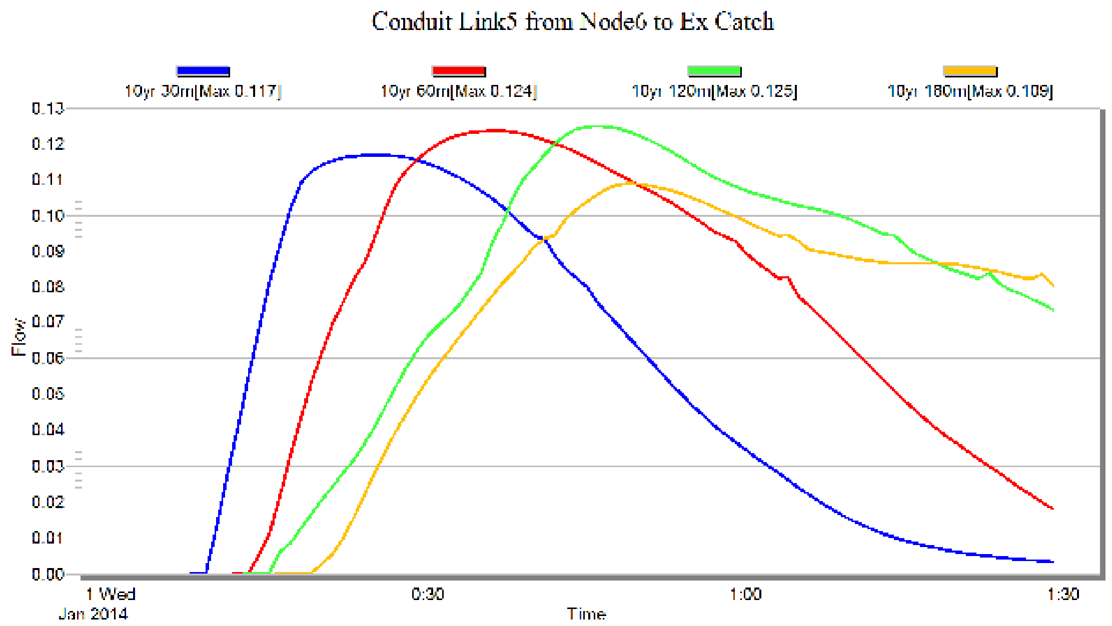


Figure 4-6 Developed Site Calculated 10 Year ARI Peak Discharge Rates

The peak discharge rate from the basin for the critical 10 year 120minute storm event has been calculated to be 125 litres/second. This value is just below the existing site calculated 5 year ARI peak (126 litres/sec) hence considered acceptable.

4.5 Water Sensitive Urban Design

The WSUD scheme has been developed with the aim to comply with the City of Monash's planning requirements, specifically Council's Stormwater Management Policy Clause 22.04 that set the objective to minimise the introduction of polluted stormwater to the drainage waterway system.

For The Development it is proposed to target typical best practice water quality performance objectives meeting reduction targets as follows:

- Suspended solids – 80% retention of typical urban annual load
- Total Nitrogen – 45% retention of typical urban annual load
- Total Phosphorous – 45% retention of typical urban annual load
- Litter - 70% retention of typical urban annual load.

To achieve the pollution reduction target WSUD initiatives have been recommended for The Development, including:

It is proposed to deal with gross pollutants both at source and through structural controls. Litter control measures proposed to be implemented at the source include:

- Provision of grated covers to all stormwater collection points to restrict large litter entering the drainage system.
- Drainage pits to be fitted with trash baskets

Total Suspended Solids (TSS), Total Petroleum Hydrocarbons and Free Oils

To meet this criterion, end of line structural controls are proposed in the form of the Jellyfish filter system by Humes (or approved equivalent). This unit provides treatment of the runoff from external road and carpark pavement areas.

Total Nitrogen (TN) and Phosphorus (TP)

The existence of phosphorus and nitrogen pollutants in stormwater typically comes from pet waste, detergents and garden and lawn fertilisers. Reduction of TP and TN load will be achieved by a series of the treatment systems along the stormwater drainage system that will include:

- Roof areas from the apartment building and Townhouse Lot 1 may be directed to rainwater harvesting tanks for re-use. This harvesting will in turn reduce the total volume of water leaving the development and will therefore reduce the overall pollutant load.
- Final polishing of stormwater will be achieved by the end of line treatment system Jellyfish filter system by Humes (or approved equivalent).

The water quality systems described above are considered to be in line with water quality management best practices and have been selected to achieve the required pollution reduction targets.

Details of the WSUD system are to be developed through the detail design phase pf the project with WSUD systems supported by MUSIC analysis.

5 Reference Documents

Relevant Australian Standards:

- AS3500.3 Stormwater Drainage

Other guidance documents:

- City of Monash Council, Policy Engineering Requirements for Infrastructure Construction
- Australian Rainfall and Runoff Volumes 1 & 2
- Victoria State Planning Policy Framework, Clause 19 Infrastructure
- CSIRO, Urban Stormwater: Best Practice Environmental Management Guidelines

Proposed Residential Development
29 Browns Road, Clayton
Stormwater Management Plan

Appendix A – Legal Point of Discharge

Appendix B – Stormwater Drainage Scheme Plan

Proposed Residential Development
29 Browns Road, Clayton
Stormwater Management Plan

Appendix C – WSUD Product Literature

Appendix A – Legal Point of Discharge

FILE NO: DRAIN52

ENGINEERING REPORT ON PROPERTY – POINT OF DISCHARGE

CITY OF MONASH

Send To: Gervaise Christie C/O Irwinconsult **Email:** gervaise.christie@irwinconsult,com.au

Property Address: 29 Browns Road CLAYTON

NOTE: THE COST FOR POINT OF DISCHARGE REPORTS IS $55.00

The location of the nominated point of discharge for a **unit development** on this site is the corner where all stormwater is to be collected and piped to **900mm Council drain located in the drainage and sewerage easement along the Eastern property boundary via a 900mm x 600mm junction pit to be constructed to Council Standards. ALL ON-SITE DRAINAGE SHOULD BE CONNECTED TO THIS POINT. THESE WORKS REQUIRE A ROAD OPENING PERMIT AND MAY REQUIRE A REFUNDABLE SECURITY DEPOSIT.**

*** NB The owner / developer must confirm the precise location of the point of discharge, prior to any work being carried out on site. If the point of discharge cannot be located, Council's Engineering Office should be notified immediately.**

Conditions relevant to the Point of Discharge

- ☐ Proposed additions to the dwelling should be connected to the existing stormwater system serving the property.
- ☑ Council records indicate that a **900mm** diameter stormwater drain (offset **Unknown**, depth **Unknown)** is contained within the **Eastern** Drainage and Sewerage easement.
  Sewer information should be obtained from **South-East Water.**
- ☐ Development plans indicate that fill has been used on this site and it is recommended that you obtain information from the land developer/Council records prior to the issue of a Building Permit.
- ☐ This property is located in an area which has been identified as requiring further drainage assessment by Council Engineers /Melbourne Water and Building plans should be forwarded to Council Engineers/Melbourne Water for comment prior to the issue of a Building Permit.

Other Council Requirements

- ☑ Any proposed removal and/or addition of a vehicle crossing/s requires a Vehicular Crossing Permit. The Vehicle Crossing Permit must be obtained from the Council's Engineering Department prior to any crossing works commencing. A copy of the approved Town Planning Plan **must** be presented when obtaining the Vehicle Crossing Permit.
- ☑ This property may be subject to Town Planning Overlays/Controls. Please contact Council's Town Planning Department for further information.
- ☑ For developments of this nature a on-site detention system may be required. A drainage levy may be accepted in lieu of the detention system. These developments require Town Planning approval prior to any Building Permit being issued. **During the Town Planning Permit approval process any Detention System Requirement and/or Drainage Contribution for this development will be determined. If a Town Planning Permit has already been approved please refer to it for further details.**
- ☑ Any new drainage connection into a Council easement drain requires the approval of the Council's Engineering Division prior to the works commencing. **Three copies of the plans (*A3-A1 size*) for the drainage works must be submitted to and approved by the Engineering Division prior to the commencement of works.** The plans are to show sufficient information to determine that the drainage works will meet all drainage conditions of the permit.

Please note, this information is provided from design plans/records held by Council.
The City of Monash does not guarantee the accuracy of this information and disclaims any liability resulting from its usage.

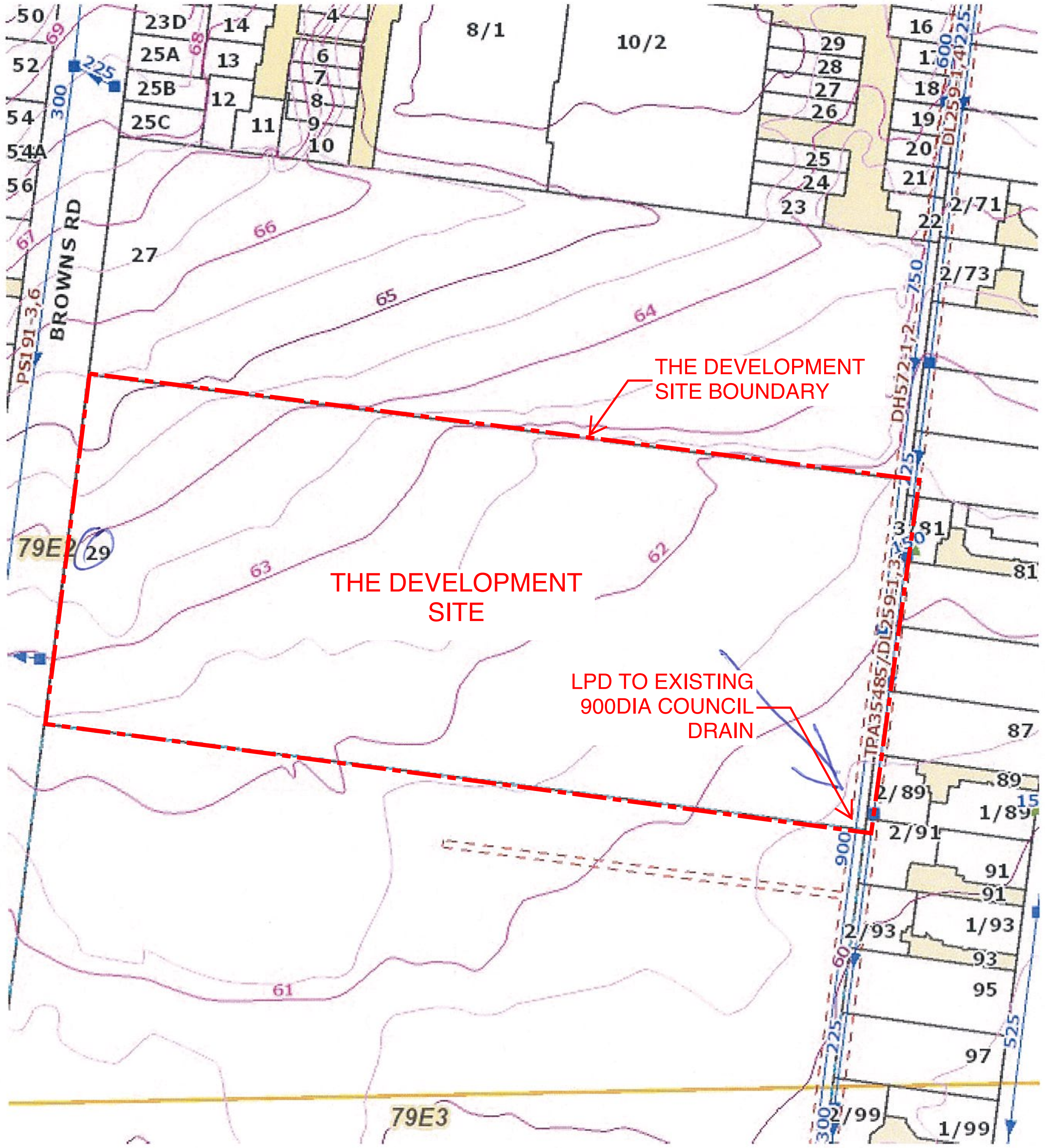
Existing Council and Service Authority assets (trees, pits, poles, shelters, hydrants, parking bays, etc, are not to be altered, removed or relocated without the approval of the Responsible Authority. The property **owner** is required to identify and take into account the location of any existing assets in the design of driveways and vehicle crossings and notify the Responsible Authority prior to the construction of any buildings where these assets may be affected. Approval for relocation or removal may not be given at a later date.

Responsible Officer .... 17.3.15 Date

Constituted as Monash City Council 293 Springvale Road (PO Box 1) Glen Waverley VIC 3150
Telephone **(03) 9518 3555** Facsimile (03) 9518 3444 Ausdoc DX15005 TTY (Hearing Impaired) (03) 9518 3655
Email mail@monash.vic.gov.au Website www.monash.vic.gov.au

Appendix B – Stormwater Drainage Scheme Plan

Legal Point of Discharge



Address:
29 Browns Rd Clayton

Legend
Drain Pits (Ownership): Council, Melbourne Water, Private, Unknown, VicRoads
Drains (Ownership): Council, Melbourne Water, Private, Unknown, VicRoads
Drain - Diameters: eg. 225; LSIO / SBO; Melway Grid (eg 70 E1)

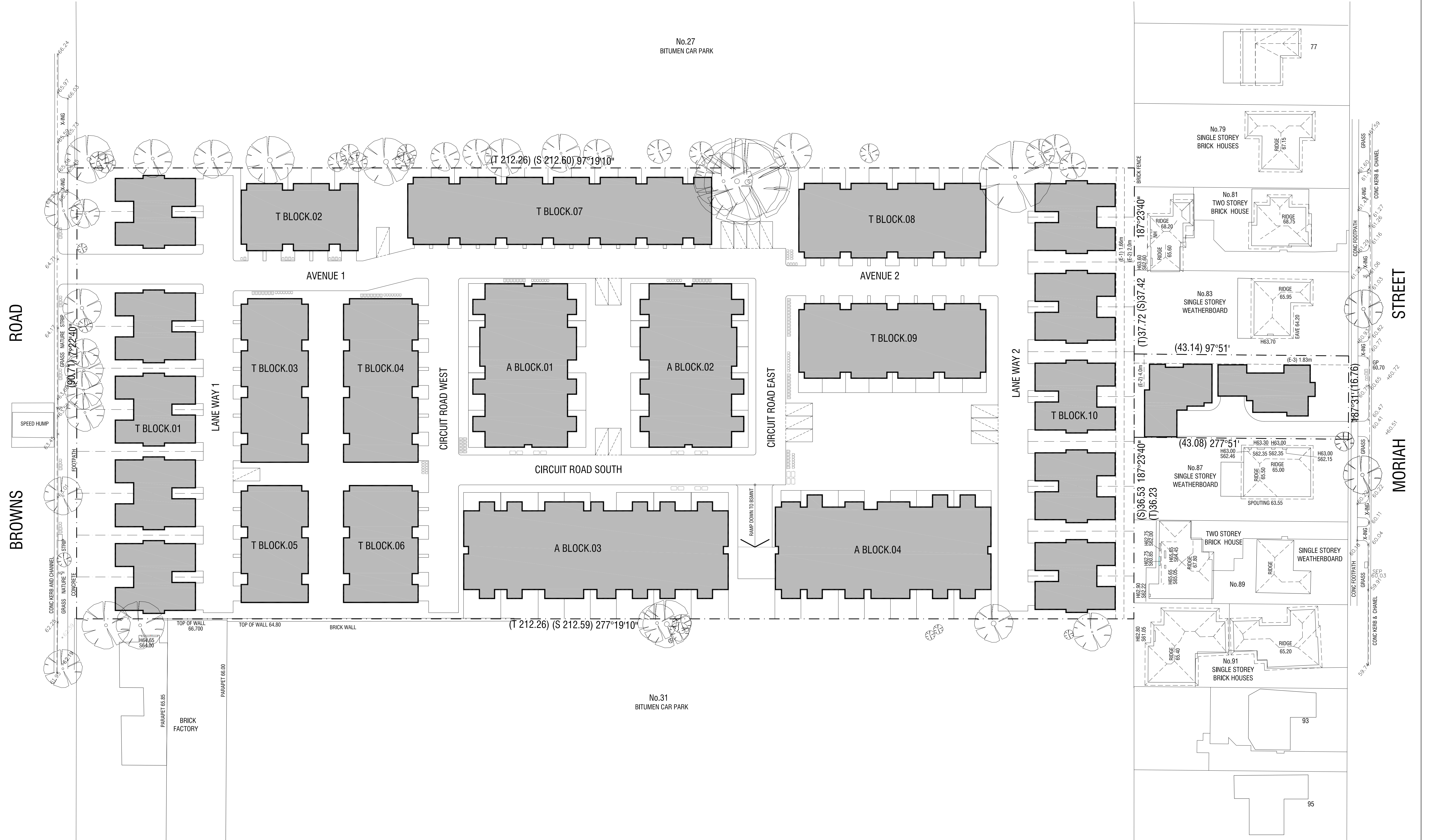
Engineers Referral (LPD)

N

1:1500

Map Produced: 16/03/2015 6:16 PM

Base data is supplied under Licence from Land Victoria. This map is for general use only and may not be used as proof of ownership, dimensions or any other status. The City of Monash endeavours to keep the information current, and welcomes notification of omissions or inaccuracies.



PRELIMINARY DRAWING
NOT TO BE USED FOR CONSTRUCTION PURPOSES

REV	DATE	AMENDMENT	INITIALS
-	09.09.15	ISSUED FOR CONSULTANT CO-ORDINATION	DZP/XX
A	30.09.15	ISSUED FOR CONSULTANT CO-ORDINATION	DZP/XX

木山集團 MUSHAN
MUSHAN DESIGN STUDIO PTY LTD
LEVEL 15, 333 COLLINS STREET
MELBOURNE VIC 3000
ABN: 44 162 772 714
PH: 03 8611 7605
EMAIL: INFO@MUSHAN.COM.AU
This design is dependent on approval by relevant authorities and comparison with client budget requirements. At time of design confirmation of these approvals has not been confirmed.

PROJECT
PROPOSED RESIDENTIAL DEVELOPMENT
29 BROWNS ROAD, CLAYTON
VIC 3168

TITLE
OUTLINE PLAN

Date	SEPTEMBER 3015
Scale	1:350 @ A1
Drawn by	DZP/XX
Checked	DZP
Job number	M023
Drawing number	A SK01

Appendix C – WSUD Product Literature

Humes

Strength. Performance. Passion.

JellyFish® filter Technical manual

Issue 5

Contents

enviro DEVELOPMENT™ PROFESSIONAL

JellyFish® filter

The JellyFish® filter is a tertiary stormwater treatment system featuring membrane filtration to provide exceptional pollutant removal at high treatment flow rates with minimal head loss and low maintenance costs.

The JellyFish® filter uses gravity, flow rotation, and up-flow membrane filtration to provide tertiary treatment to stormwater in an underground structure. Using unique filtration cartridges, each JellyFish® filter provides a large membrane surface area, resulting in high flow rates and pollutant removal capacity.

The JellyFish® filter efficiently captures a high level of stormwater pollutants, including:

- Total Suspended Solids (TSS), median removal efficiency of 89%, including particles down to two microns
- Total Nitrogen (TN), median removal efficiency of 55%
- Total Phosphorous (TP), median removal efficiency of 65%
- Total Copper (Cu), median removal efficiency of 61%
- Total Zinc (Zn), median removal efficiency of 91%.

Designed as a polishing device for constrained sites, the JellyFish® filter is available in a range of sizes to cater for both at-source and end-of-pipe solutions.

- **The system provides tertiary level performance with a small footprint**
  The proven performance of the JellyFish® filter and high flow rate membranes enables water quality objectives to be met with a smaller footprint system than typical bioretention systems.
- **It has been independently researched and proven**
  The JellyFish® filter has been independently researched under both laboratory and field conditions in the United States and Australia. In the United States, it has received verification under the stringent New Jersey Corporation for Advanced Technology (NJCAT) protocol.
- **It treats higher flow rates than most filters**
  Each filter cartridge has an effective filter area of 35.4 m^2 designed to treat 5 litres per second (L/s) during operation.
- **Above-ground land use is maintained**
  The system is assembled within a fully-trafficable, precast concrete structure for underground installations on constrained sites, allowing maximum use for above-ground activities.
- **Maintenance is easy**
  The filter backwashes after peak flows so it can self-clean several times in each storm event. Manual backwash is recommended annually. When cartridge replacement is required (usually every three to five years), it is a safe and simple process.
- **We provide world class treatment solutions**
  Humes has a team of water specialists dedicated to delivering sustainable solutions, creating maximum value for your project, accommodating your site conditions, design requirements and construction factors.

System components

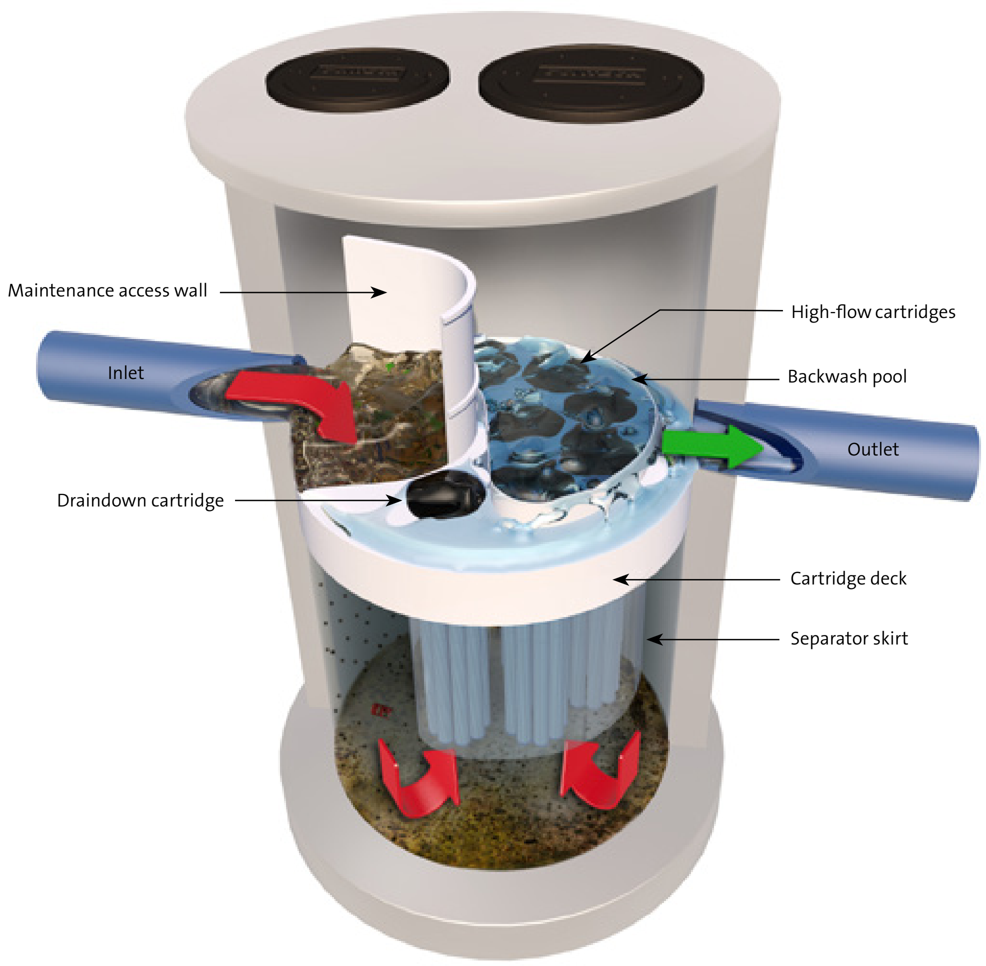
The JellyFish® filter is comprised of several structural and functional components:

- A cylindrical precast concrete structure which is available in a range of diameters and depths that serves as a vessel providing structural support for a 50 year design life and provides storage for accumulated filtered pollutants.
- A rigid high-strength fibreglass cartridge deck separates the vessel into a lower chamber and upper chamber. This houses the filter cartridges, provides a surface and flow path for treated water to the effluent pipe, and provides containment of oil and other hydrocarbons below the deck and also provides a platform for maintenance personnel to safely service the filter cartridges.
- The lower chamber provides storage for pollutant separation and membrane filtration.
- The upper chamber provides adequate clearance for inspection and maintenance.
- A rigid high-strength fibreglass Maintenance Access Wall (MAW) attenuates influent water velocity and directs flow into the lower chamber through a large opening in the cartridge deck. In addition, it provides storage for floatable pollutants. It also serves as an inspection and maintenance access point.
- JellyFish® membrane filtration cartridges are secured to the deck by the cartridge lids. Each filter cartridge consists of multiple membrane filter tentacles, which treat the stormwater by filtering out fine suspended particulates (TSS) and particulate-bound pollutants on the membrane of each tentacle. Filtered water passes through the membranes, up the centre tube of each tentacle and exits through the top.
- Filter cartridges are designated as either high-flow or draindown cartridges, depending on their location in the cartridge deck. High-flow cartridges placed within the backwash pool are automatically backwashed after each storm event.
- Draindown cartridges located outside the backwash pool facilitate the draindown of the backwash pool. The design flow rate (2.5 L/s) of a draindown cartridge is controlled by the lid orifice. The lower design flow rate of the draindown cartridge ensures the membranes last for longer periods between scheduled maintenance.
- Cartridge lids are fastened into the deck to securely anchor the filter cartridges. The lids are removable to allow manual rinsing and replacement of the filter cartridges when required. Cartridge lids contain a flow control orifice that is specifically sized for use with high-flow and draindown cartridges. Blank lids have no orifice and are used to cover unoccupied deck apertures in systems that do not use the full rated flow capacity of the system.
- A rigid fibreglass backwash pool weir extends 150 mm above the cartridge deck and encloses the high-flow cartridges. During inflow, filtered water leaving the high-flow cartridges forms a pool inside the weir. When the water level in the pool exceeds the weir height it overflows and spills to the cartridge deck where it then flows to the outlet pipe. As the inflow event subsides and pressure decreases, water in the backwash pool reverses flow direction and automatically backwashes the high-flow cartridges, cleaning the membrane surfaces. Water in the lower chamber (below deck) is displaced through the draindown cartridges.

  This self-cleaning mechanism may occur multiple times during a single storm event as rainfall/runoff intensities rise and fall, thereby significantly extending the service life of the cartridges and the maintenance interval.
- A separator skirt encloses the filtration cartridge and defines the filtration zone. The separator skirt extends the full length of the filtration tentacles and prevents contamination of the membranes with oil and floatable debris. The separator skirt also forces water to enter the filtration zone under low velocities. The separator skirt is attached to the underside of the cartridge deck.
- As an option, the inlet pipe can be located below the deck for drainage networks with deep invert levels. In these systems, a deflector plate is installed across the inlet pipe to induce tangential water flow through the channel between the chamber wall and separator skirt.
- Large diameter access lids are installed at the surface and are removed to allow access for maintenance of the system. The upper chamber is designed with tapered surrounds to match with finished surface grades.

The JellyFish® filter and components are depicted in Figure 1 below.

Figure 1 – JellyFish® filter components



Membrane filtration cartridge

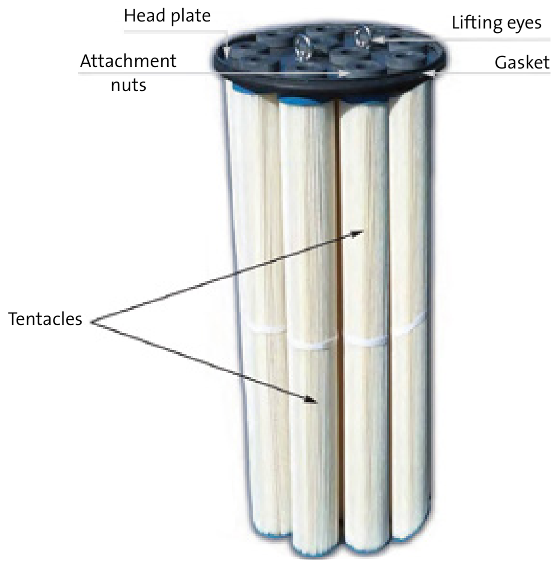
The JellyFish® filter utilises multiple lightweight membrane filtration cartridges. Each cartridge consists of multiple removable filter elements (“filtration tentacles”) attached to a cartridge head plate. Each filtration tentacle consists of a central perforated tube surrounded by a specialised membrane. A removable oil-resistant polymeric gasket provides a watertight seal between the cartridge and the deck. A JellyFish® membrane filtration cartridge is depicted in Figure 2.

The cartridge length is 1,372 mm. The dry weight of a new cartridge is less than 9 kg, and the wet weight of a used cartridge is less than 23 kg. No heavy lifting equipment is required during exchange.

The filtration tentacle membranes provide a large surface area, resulting in high flow and suspended sediment removal capacities. A typical JellyFish® cartridge with 11 filtration tentacles has 35.4 m^2 of membrane surface area. Hydraulic testing on clean filter cartridges demonstrated a flow rate of 11.3 L/s at 455 mm of driving head.

Extensive independent field testing, including testing at an urban site with high intensity rainfall and runoff, has demonstrated consistently high pollutant removal performance with a conservative design flow rate of 5 L/s for the high-flow cartridges and 2.5 L/s for the draindown cartridges.

Figure 2 – JellyFish® membrane filtration cartridge



These values translate to a conservative design membrane filtration flux rate (flow per unit surface area) of 0.14 L/s/m^2 for the high-flow cartridge and 0.07 L/s/m^2 for the draindown cartridge.

In addition, the filtration membrane has been treated to allow biofilm to grow but not clog the pores of the membrane. The flow rating of a particular JellyFish® filter cartridge is based on the membrane filtration surface area of the cartridge and data collected from both laboratory testing and field testing. The cartridge deck contains apertures for each filter cartridge.

System operation

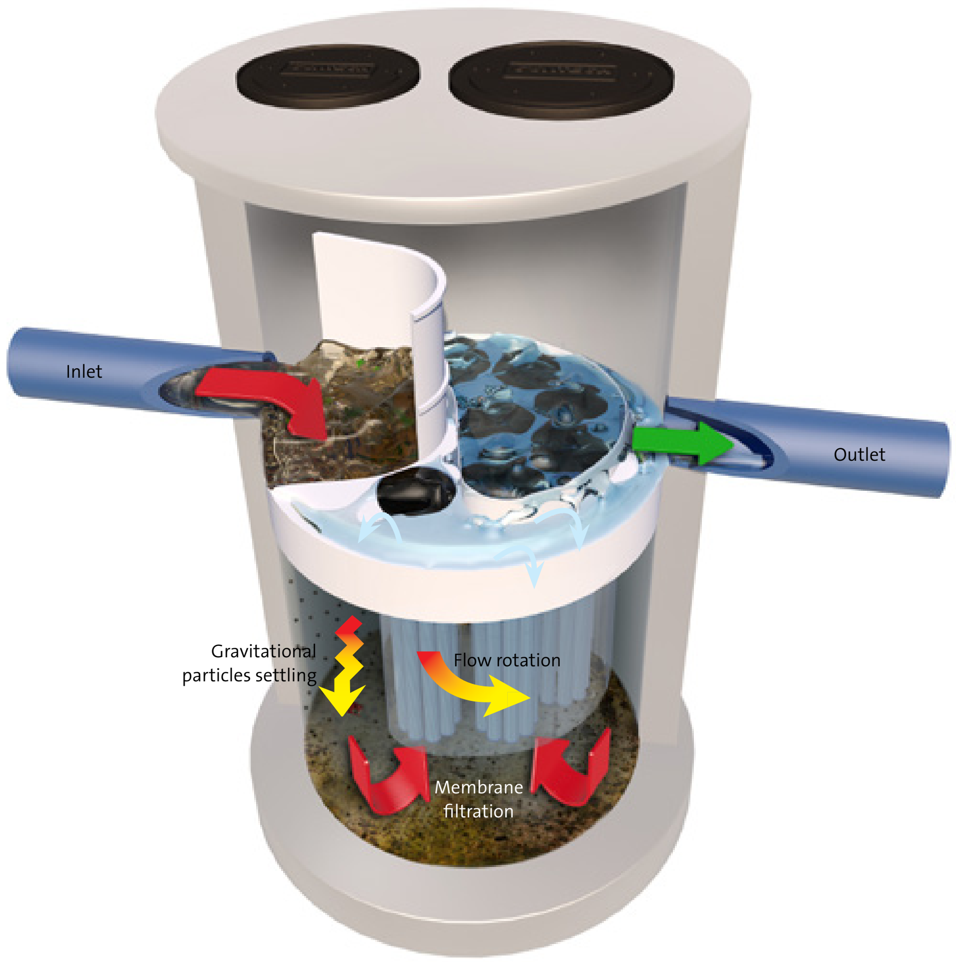
As a tertiary treatment system, the JellyFish® filter is designed to be an “offline” structure, as part of a treatment train. For effective operation, the system requires a difference in elevation between upstream and downstream water levels. Typically, a minimum 455 mm of driving head is designed into the system but may vary from 305 mm to 610 mm depending on specific site requirements.

The JellyFish® filter uses gravity, flow rotation and membrane filtration treatment to remove pollutants from stormwater runoff. These functions are depicted in Figure 3 below.

Gravitational forces remove coarse sediment (generally >50 microns), particulate-bound pollutants (nutrients, toxic metals, hydrocarbons), free oil and floatable trash and debris (that may bypass upstream primary treatment devices). Large, heavy particles fall to the sump (sedimentation) and low specific gravity pollutants rise to the surface (floatation) behind the MAW.

Treatment begins when flow enters the system through the inlet pipe (standard). Below-deck inlet pipes are offered as an option. Influent enters the MAW zone and passes through a large opening in the deck to the lower chamber. The large deck opening and change in flow direction attenuate the influent flow velocity. Buoyant pollutants remain on the surface in the MAW zone.

Figure 3 – JellyFish® filter functions



Flow into the lower chamber must then pass tangentially around the separator skirt protecting the cartridges and increasing the flowpath length. Coarse sediment settles out of the MAW zone into the sump. As water flows tangentially around the separator skirt in the lower chamber, the large opening in the bottom of the separator skirt and upward change in direction further reduces flow velocity and enhances particle separation. As a result, sediment settles in the sump.

Flows pass through the cartridge in the filtration zone. Each filter cartridge consists of multiple tentacles. Hydraulic pressure across the entire membrane surface area causes water to penetrate the filtration tentacles. Water enters the membrane pores radially and deposits fine particulates on the exterior membrane surface. Filtered water flows into the centre drain tube of each tentacle, the water then flows upward and out the top.

Water exiting the top of the tentacles combines under the lid, where the combined flow exits the cartridge through the orifice with a pulsating fountain effect into the backwash pool. When the water level in the backwash pool exceeds the weir height it overflows to the outlet pipe.

Outside the backwash pool, the draindown cartridge provides treatment at a reduced flow rate (2.5 L/s) and allows the treated water captured in the backwash pool to return through the cartridges and balance water pressure as the storm event ends.

As particles build up on the external membrane surface, the pores progressively become smaller. This process, referred to as "filter ripening", significantly improves the removal efficiency relative to a brand new or clean membrane. Filter ripening accounts for the ability of the JellyFish® filter to remove particles finer than the nominal pore size. An animation of the JellyFish® filter operation and maintenance is available at humes.com.au.

Self-cleaning functions

The JellyFish® filter utilises several self-cleaning processes to remove accumulated sediment from the external surfaces of the filtration membranes, including automatic backwash of the high-flow cartridges, vibrational pulses, and gravity. These processes have been confirmed by more than 12 months of full scale prototype testing. Combined, these processes significantly extend the cartridge life, maintenance interval and reduce life-cycle costs.

Automatic backwash occurs with the high-flow cartridges at the end of each runoff event. This can occur multiple times during a single storm event as intensity and driving head varies. As the inflow subsides and driving head decreases, water in the backwash pool reverses flow direction and automatically backwashes the high-flow cartridges, removing sediment from the membrane surfaces. Water in the lower chamber (below deck) is displaced through the draindown cartridges.

Vibrational pulses occur as a result of complex and variable pressure and flow direction conditions that arise in the deck during operation. During forward flow a stream of filtered water exits the top of each filtration cartridge and encounters resistance from the turbulent pool of water in the backwash pool. Water is forced through the cartridge lid orifice into the backwash pool with a pulsating fountain effect. The resulting pulses transmit vibrations through the deck to the membranes, thereby dislodging accumulated sediment. The effect is pronounced at higher flow rates, and influences all cartridges.

Accumulated sediment on the membranes will settle under gravity both during inflow events and inter-event dry periods. As fine particles form into larger masses on the membrane surface, adhesion to the membrane surface lessens, and sediment sheds away from the membrane. Chemical processes and biofilm effects also play a role.

System performance

The JellyFish® filter has been designed to provide tertiary level treatment and may be combined with a Gross Pollutant Trap (GPT) as part of a treatment train to optimise overall performance.

Treatment efficiency

Extensive research of the JellyFish® filter has proven its performance under Australian laboratory, US field conditions and Australian field conditions. Field testing in the United States has received independent verification under the stringent New Jersey Corporation for Advanced Technology (NJCAT) protocol. The results are summarised in Table 1 below.

Table 1 – JellyFish® filter performance summary

Pollutant	Median reduction
TSS	89%
TP	65%
TN	55%
Cu	61%
Zn	91%
Total oil and grease	62%

Reference: University of Florida (2011) and West Ipswich (2014).

Inlet and outlet pipes

An above-deck inlet pipe configuration is standard for the JellyFish® filter and an optional below-deck inlet configuration is available on request. Specific site constraints generally determine the configuration that is most favourable. In both configurations, the invert level of the outlet pipe is identical to the cartridge deck elevation.