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CONCEPTUAL STORMWATER MANAGEMENT PLAN

Proposed Industrial Development
437 Stafford Road, Stafford

Lot 1 on RP126855

For Sarris International Pty Ltd
15 June 2026
File No: LC26013-0002-CSMP

DOCUMENT CONTROL RECORD

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Synopsis:	This Conceptual Stormwater Management Plan describes the existing site characteristics, and corresponding stormwater quantity and quality management controls to be implemented during the operation phase of the development.

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1.0 INTRODUCTION

1.1 Background

Legend Consultants Pty Ltd has been appointed by Sarris International Pty Ltd to prepare a Conceptual Stormwater Management Plan (CSMP) in support of a Development Application to Brisbane City Council (BCC) for the proposed Industrial Development, located at 437 Stafford Road, Stafford.

This report is based on approved development layout and the maintaining the site's Lawful Point of Discharge (LPOD).

The development site is described as Lot 1 on RP126855 and has a total site area of 0.1765 ha.

1.2 Scope of Report

This CSMP describes the detail planning, layout and strategy of the stormwater management infrastructure for the construction and operational stages of the proposed development.
This CSMP endeavours to:

- Determine the necessary criteria assessing both the existing and proposed stormwater quantity and quality enhancement systems.
- Present a detail design of the stormwater infrastructure including stormwater quality enhancement devices and stormwater quantity management controls.
- Establish the modelled post-development stormwater quality flowing from the site does not negatively effect the water quality and ecological values of downstream watercourses and systems.
- Determine that stormwater runoff is transmitted through the site to a Lawful Point of Discharge (LPOD) in accordance with the Queensland Urban Drainage Manual (QUDM), and
- Provide reporting and monitoring procedures to ensure the execution of the proposed system can be evaluated to enable detection of corrective actions/modifications required to ensure the intended objectives are upheld.

This CSMP has been compiled in accordance with the IEAust *Australian Runoff Quality: Guide to Water Sensitive Urban Design, Queensland State Planning Policy 2017*, IPWEA *Queensland Urban Drainage Manual (QUDM) Fourth Edition (2017)* and *Brisbane City Council (BCC) Planning Scheme Policies.*

2.0 SITE DESCRIPTION

2.1 Site Location

The development site is situated at 437 Stafford Road, Stafford within a Low Density Residential zone. The site is front by Stafford Road to the south, Victor Street to the west and bounded by residential properties to the east and north. The site covers a total combined area of 0.1765 ha, with details as provided in Table 1 and per the locality given in Figure 1.

Table 1: Site Description

Client	Lot and Property Description	Street Address
Sarris International Pty Ltd	*Lot 1 on RP126855*	*437 Stafford Road, Stafford*

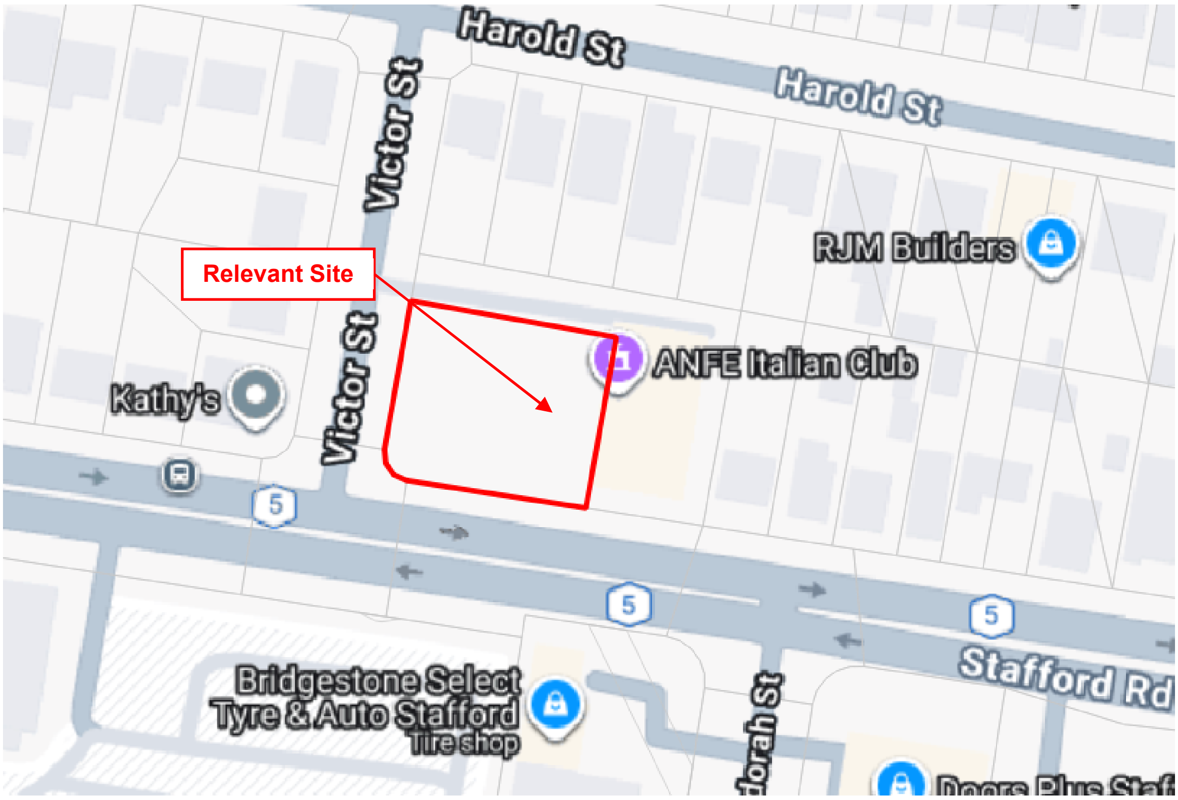


Figure 1: Locality Plan (Source: Google Maps)

2.2 Site Characteristics

The site's terrain is relatively flat, with an average slope of approximately 1%, falling from around RL.22.5 m AHD to approximately RL.22.2 m AHD at the south boundary.

Based on the provided survey and aerial information, any stormwater runoff from ground surfaces drains overland to the Legal Point of Discharge (LPOD) in the south of the site.

Further information of the site survey has been provided by J Surveyors Plan of Detail Survey (Ref: JS 383 - DET01 - REV.A) included as Appendix A.

2.3 Existing Vegetation and Use

The project site is predominantly a vacant lot with grass areas. An aerial photograph of 12 April 2026 of the development site is included in Figure 2.

Figure 2: Aerial Image of the Site (Source: MetroMap)

2.4 Proposed Development

The proposed development for the site is the shopping market Bob Jane T-Mart, driver way and carparking. The proposed development at time of writing this report has provided a detailed level of landscaping, anticipated to comply with the landscaping footprints as per Council's requirements.

Access to the site is to be gained directly off Stafford Road on the south side of the development.

Refer to Appendix B for preparation by *Sarris, Ground Floor Plan (Ref: AS88)* included in Appendix B.

2.5 Proposed Drainage Concept

It is proposed that all developed area stormwater flow will be collected by the internal drainage system and treated by the proposed Enviro treatment device then combined with runoff from the undeveloped area before being discharged to the detention tank. The captured flows within the tank are discharged to the southern site LPODs.

The proposed stormwater drainage for the site with discharge to the (LPOD) is detailed in the Legend Consultants Stormwater Management Plan (Ref: LC26013-SK400-A) provided in Appendix E

2.6 Rainfall Data

Rainfall intensity data has been acquired from the Australian Bureau of Meteorology's 2016 Design IFD Rainfall System. The data has been obtained for the nearest grid cell at Latitude -27.4093 (S) and Longitude 153.0107 (E). The IFD data and average rainfall intensities utilized in this report are in accordance with the techniques outlined in Geosciences Australia, Australian Rainfall and Runoff 2019.

3.0 STANDARDS AND DATA REFERENCES

The following provides the data references which have been utilised in order to prepare this report for the site:

- Detailed site survey provided by J Surveyors Plan of Detail Survey (Ref: JS 383 - DET01 - REV.A) included as Appendix A.
- Proposed site plan provided by Sarris, Ground Floor Plan (Ref: AS88).
- LIDAR data for the development site obtained from Australian Government Elevation and Depth Foundation Spatial Data (ELVIS), Date Source: 2019, DEM Data.
- Rainfall and Meteorological 2016 IFD Data by the Australian Bureau of Meteorology.
- Information Extracted from Brisbane City Council, Interactive Map.

4.0 SITE HYDROLOGY

4.1 Background

The subsequent segments of this report delineate the approach and parameters employed in the hydrological analysis of the site, aiming to create a simulation of the expected flow patterns and maximum discharge at the Lawful Point of Discharge (LPOD). Additionally, a Rational Method calculation is presented for comparative analysis.

The Rational Method, as outlined in Section 4.3 of the Queensland Urban Drainage Manual (QUDM 2017), proves to be a suitable estimation technique due to its flexibility in data requirements. It is capable of generating reliable estimates for peak site discharges with the following data inputs:

- specific intensity frequency duration (IFD) data.
- length/type of flow path.
- contributing catchment areas, and
- coefficient of discharge.

4.2 Pre-Development

4.2.1 Lawful Point of Discharge and Defined Catchments

The analysis of the pre-development site has been analysed as an internal catchment and has contributing area of 0.1765ha.

Any stormwater on ground surfaces is conveyed as sheet flow through the development site towards to the southern boundary discharged to the site LPOD.

The catchment area and LPOD for the development site are shown on Legend Consultants Pre-Development Catchment Plan (Ref: LC26013-SK100-A) included as Appendix C.

4.2.2 Coefficient of Discharge

The pre-development coefficient of runoff (C year) was calculated using the fraction impervious method outlined in QUDM. According to the survey data, the pre-development catchment features impervious surfaces covering 0ha resulting in fraction impervious (fi) of 0 %. With a one-hour, ten-year rainfall intensity (1I10) set at 70.50 mm/hr, the pre-development catchments adopt a C10 value of 0.70.

The pre-development coefficients of runoff, as presented in Table 2, have been selected in alignment with QUDM Table 4.5.2. These coefficients correspond to the frequency factors associated with standard Annual Exceedance Probability (AEP) design storms at 39%, 18%, 10%, 5%, 2%, and 1%. These percentages correspond to the 2, 5, 10, 20, 50, and 100-year Average Recurrence Interval (ARI) storms, respectively.

Table 2: Pre-Development Coefficient of Discharge

Catchment	C2	C5	C10	C20	C50	C100
Pre A	0.60	0.67	0.70	0.74	0.81	0.84

4.2.3 *Time of Concentration*

The Time of Concentration for the pre developed catchment have been calculated in accordance with QUDM section 4.6.6 – Overland Flow. Friend's Equation (t = (107n L 0.333)/S 0.2) has been used to calculate the initial travel time using sheet flow. Refer to Table 3 for the calculated Time of Concentration for the pre-development catchments.

Table 3: Pre-development Time of Concentration

Catchment	Catchment Area (ha)	Catchment Properties	Time of Concentration		
			Overland flow Friend's Equation	Concentrated Overland Flow	Total tc
Pre A	0.176	Average grassed surface	Horton's (n) = 0.045 L = 70 m Slope = 1% t = 19.82 mins	-	19.82 mins

4.2.4 *Design Discharge*

Pre-development peak flow rates for the selected storms have been calculated utilizing design rainfall intensities sourced from the Bureau of Meteorology IFD Data. The estimation of design peak flow rates for the pertinent site has been conducted using the Rational Method (Q = 2.78 x 10-3 CIA). The resulting pre-development peak flows for the development site are detailed in *Table 4*.

Table 4: Estimated Pre-Development Peak Discharges – Rational Method

Pre A							
Annual Exceedance Probability	**AEP**	39%	18%	10%	5%	2%	1%
Coefficient of Runoff	**C**	0.60	0.67	0.70	0.74	0.81	0.84
Area of Catchment (ha)	**A**	0.177	0.177	0.177	0.177	0.177	0.177
Average Rainfall Intensity (mm/h)	**I**	90.38	112.59	128.70	147.77	170.88	187.99
Peak Flow Rate (m^3/s)	**Q**	**0.026**	**0.037**	**0.044**	**0.053**	**0.068**	**0.078**

4.3 Post Development

4.3.1 *Catchment Definition and Lawful Point of Discharge*

The post-development scenario has been analysed as a internal catchment A and has contributing area of 0.177 ha.

Stormwater collected from the development area shall be conveyed via an internal drainage network sized to capture all events, and treated by the proposed Enviro treatment device, then discharged to the detention tank. The captured flow within the tank is connected to the site LPOD.

The post development catchment area and LPOD are detailed on Legend Consultants Post Development Catchment Plan (Ref: LC26013-SK200-A) and Music Catchment Plan (Ref: LC26013-SK300-A) included as Appendix D.

4.3.2 *Coefficient of Discharge*

The post-development coefficients of runoff (C year) were established through the application of the fraction impervious method, as stipulated in QUDM.

According to the provided architectural plans, the Post development feature impervious surfaces covering 0.141 ha resulting in fraction impervious (fi) of 80%. With a one-hour, ten-year rainfall intensity (1I10) set at 70.50 mm/hr, the post-development catchments adopt a C10 value of 0.86.

The post-development coefficients of runoff, as indicated in Table 5, have been selected in accordance with QUDM Table 4.5.2. These coefficients align with the frequency factors associated with standard Annual Exceedance Probability (AEP) design storms at 39%, 18%, 10%, 5%, 2%, and 1%. These percentages correspond to the 2, 5, 10, 20, 50, and 100-year Average Recurrence Interval (ARI) storms, respectively.

Table 5: Post Development Coefficient of Discharge

Catchment	C2	C5	C10	C20	C50	C100
Post A	0.73	0.82	0.86	0.90	0.99	1.00

4.3.3 *Time of Concentration*

The Time of Concentration for the post-development catchment has been computed following the guidelines outlined in QUDM Table 4.6.3 and QUDM section 4.6.6 – Overland Flow, specifically referring to the recommended roof drainage system travel times and calculate travel time using Friends Equation (t = (107n L 0.333)/S 0.2).

Refer to *Table 6* for the calculated Time of Concentration for the post-development catchments.

Table 6: Post-development Time of Concentration

Catchment	Time of Concentration		
	Standard Inlet Time	Pipe Flow Time	Total tc
Post A	8	1.33	9.33 mins

4.3.4 Design Discharge

Post-development peak flow rates have been computed for the selected storms by utilizing design rainfall intensities obtained from the Bureau of Meteorology 2016 IFD Data. The Rational Method (Q = 2.78 x 10-3 CIA) has been employed to estimate the necessary design peak flow rates for the respective site. The resulting post-development peak flows for the development site are outlined in Table 7.

Table 7: Estimated Post Development Peak Discharges – Rational Method

Post A							
Annual Exceedance Probability	**AEP**	39%	18%	10%	5%	2%	1%
Coefficient of Runoff	**C**	0.73	0.82	0.86	0.90	0.99	1.00
Area of Catchment (ha)	**A**	0.177	0.177	0.177	0.177	0.177	0.177
Average Rainfall Intensity (mm/h)	**I**	125.73	156.93	180.87	206.93	240.67	265.27
Peak Flow Rate (m^3/s)	**Q**	**0.045**	**0.063**	**0.076**	**0.092**	**0.117**	**0.130**

4.4 Change in Discharge

The variance in peak flow rates, computed for the entire pre and post-developed site, has been assessed using The Rational Method. The outcomes are given in Table 8.

Table 8: Estimated Change in Peak Discharges– Rational Method from the subject site

LPD A							
Annual Exceedance Probability	**AEP**	39%	18%	10%	5%	2%	1%
Pre-Developed Peak Flow Rate (m^3/s)	**Q**	0.026	0.037	0.044	0.053	0.068	0.078
Post-Developed Peak Flow Rate (m^3/s)	**Q**	0.045	0.063	0.076	0.092	0.117	0.130
Change in Peak Flow Rate (m^3/s)	**Q**	**+0.019**	**+0.026**	**+0.032**	**+0.038**	**+0.049**	**+0.053**

As demonstrated in Section 4.2 and Section 4.3 and Table 8, due to the increase of impervious area, discharged peak flow rate from post catchment is higher than the existing condition. On-site detention measures will be required for catchment development.

4.5 External Catchments

External contours and infrastructure surrounding the proposed development have been analysed to determine if any external catchments are anticipated to discharge stormwater into the proposed development.

Based on the contours sourced from ELVIS data, no external catchment is identified that they has potential to discharge through the proposed.

5.0 STORMWATER QUANTITY ASSESSMENT

5.1 Background

The land development is anticipated to augment peak flow rates originating from the development site, primarily attributed to the expansion of impervious areas and a decrease in the surface roughness of the site. Consequently, the forthcoming section of this report offers initial particulars about a proposed On-Site Detention (OSD) system.

The purpose is to illustrate that there will be no escalation in nuisance flows and adverse impacts, stemming from potential increased post-development runoff. This demonstration aims to address concerns related to neighbouring properties, downstream waterways, and the stormwater infrastructure of relevant authorities.

5.2 Objective

Aligned with the stipulations of Brisbane City Council and typical residential-standard practices, the subsequent objective has been established for the post-development stormwater discharge from the site:

- Ensure there is no net increase in peak flows originating from the development site for all events up to the 1% Annual Exceedance Probability (AEP) design storm event in the post-developed condition.

To verify this objective, a suitable hydrologic and hydraulic modelling package will be employed. This demonstration will involve the containment of site runoff from the development site within the proposed buried detention tank.

5.3 Hydraulic Model

A calculation of the necessary detention volume to counteract any rise in total site discharge rates has been conducted using the XP-SWMM software program, in adherence to the Australian Rainfall and Runoff 2019 (ARR 2019) Guideline.

At the preliminary planning stage, an XP-SWMM model has been employed to ensure a more confident estimation of the detention volume. Given that finished site levels are preliminary but grounded in topographic site survey data, this initial calculation serves as an estimate with sufficient accuracy to advance the design confidently.

The model was formulated by simulating the layouts of the pre-development, post-development, and mitigated catchments, comparing the peak flow rates generated from each scenario. The mitigated catchment encompasses the 1% Annual Exceedance Probability (AEP) runoff from the entire site, encompassing roofs, ground areas, and driveways. This configuration ensures ample mitigation to demonstrate that there is no increase in peak flow rates exiting the site compared to the pre-development scenario.

It is important to highlight that the design of roof gutters and the site drainage system aims to channel the significant 1% Annual Exceedance Probability (AEP) event into the detention tank.

A comprehensive analysis was conducted for a variety of storm events, extending up to the 1% AEP design storm event, covering standard durations ranging from 5 minutes to 360 minutes. The XP-SWMM model was utilized to calculate the combined peak discharge rates for the site in both scenarios. The results are presented below.

The pre and post-development catchment area and LPOD are detailed on Legend Consultants Pre-Development Catchment Plan (Ref: LC26013-SK100-A) and on Legend Consultants Post Development Catchment Plan (Ref: LC26013-SK200-A) and Music Catchment Plan (Ref: LC26013-SK300-A) included respectively as Appendices C and D.

The Q100 Rational Method calculation result of the subject site was used as sanity check with XP-SWMM output and shown in Table 9.

Table 9: Peak Discharge Rational Method vs XP-SWMM Model of the Subject Site (m³/s)

Catchment ID	Q100 Peak Flow Rate Discharge (m³/s)		
	Rational Method	XP-SWMM	Different (%)
Pre A	0.078	0.070	-10.9
Post A	0.130	0.115	-13.4

Table 10: Anticipated Peak Site Discharge Rate at LPoD – From XP-SWMM Model (m³/s)

LPD A						
Annual Exceedance Probability	39%	18%	10%	5%	2%	1%
Pre-Development Peak Flow Rate (m³/sec)	0.023	0.034	0.042	0.050	0.061	0.070
Unmitigated Peak Flow Rate (m³/sec)	0.052	0.065	0.079	0.090	0.103	0.115
Change in Peak Flow Rate (m³/s)	+0.029	+0.031	+0.037	+0.04	+0.042	+0.045

The XP-SWMM assessment for the proposed development indicates an anticipated increase in peak flow rates discharging from the site. Consequently, the implementation of On-Site Detention (OSDs) is considered necessary to mitigate flows and maintain conditions comparable to pre-development levels.

5.4 Detention Volume

It is proposed that detention tank will be installed at inground below the proposed access ramp, with the tank roof slab at ground level, to capture all runoff from the proposed development buildings and parking areas. The following detention storage parameters were adopted to achieve the target predevelopment flow rates, via mitigation of the post-development flow rates. The detention storage parameters of the low flow outlet and high flow outlet configurations are presented in Table 11.

Table 11: Adopted Detention Tank Parameters

Catchment A	
Detention Tank Surface Area:	50 m^2
Low Flow Outlet	0.1*0.1m Orifice @ 0.3m Base
High Flow Outlet	0.6x0.6m Riser, crest @ 0.85m above Base
Consolidated Outlet	Connect to 0.300m dia Outlet Pipes @ Base
Maximum Water Depth	0.914 m
Detention Volume:	46 m^3

The 1%AEP 25min-TP09 design storm was determined as the critical storm duration for determining the required volume within the detention tank for post-developed catchment

A comparison of the pre-development and mitigated flow rates at the LPOD based on the above arrangement is shown in Table 12.

Table 12: Comparison of Pre-Development & Mitigated Flow Rates – From XP-SWMM

Catchment A						
Annual Exceedance Probability	**39%**	**18%**	**10%**	**5%**	**2%**	**1%**
Pre-Development Peak Flow Rate (m^3/sec)	0.023	0.034	0.042	0.050	0.061	0.070
Mitigated Peak Flow Rate (m^3/sec)	0.023	0.027	0.03	0.048	0.061	0.070
Change in Peak Flow Rate (m3/s)	+0	-0.007	-0.012	-0.002	+0	+0

As evident from the outcomes presented in Table 12, the detention configuration is observed to proficiently alleviate the post-development flows during the critical design storm Annual Exceedance Probability (AEP) events that have been adopted.
The hydraulic analysis using the XP-SWMM model has determined that a minimum total of 46 m^3 of storage is required for runoff attenuation. The detention tank is to be fitted with an outlet configuration (low and high flow outlets) as detailed in Table 11Table 11.

to satisfy the mitigation requirements. Refer to the Legend Consultants Stormwater Management Plan (Ref: LC26013-SK400-A) provided in Appendix E for details of the tank's arrangement and indicative location.

The final location onsite and construction levels will be determined at the detailed design stage, and are to be aligned to negate clashing with the existing 1800mm dia piped stormwater system while providing connection to the stormwater system in Stafford Road.

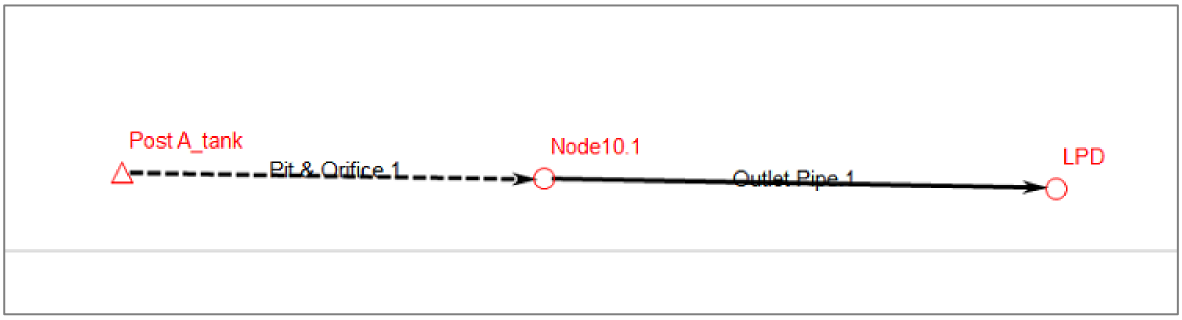


Figure 3: XP-SWMM Model

A copy of XP-SWMM model used in this report can be made available to council upon request.

6.0 STORMWATER QUALITY ASSESSMENT

6.1 Operational Phase

The following sections provide details of the Stormwater Quality Improvement Devices (SQID's) proposed for the operational phase of the development. Legend Consultants Stormwater Management Plan (Ref: LC26013-SK400-A) in Appendix E illustrates the size and location of the proposed SQID's.

6.1.1 Stormwater Quality Objectives

To protect the water quality of the downstream watercourses the following Water Quality Objectives (WQO's) have been applied to stormwater runoff from the site.

Best Management Practices (BMP) are required to be demonstrated for all Development Applications within the Brisbane City Council and are recommended to be implemented by the developer. Where practicable, methods such as first flush devices, and discharging stormwater to landscaped/grassed areas prior to discharge to the LPOD, are to be incorporated into the site's stormwater strategy, where the opportunity is available.

The following load reduction targets must be achieved when assessing the post-development treatment train (comparison of unmitigated developed case versus developed mitigated case).

- 80% reduction in Total Suspended Sediment (TSS)
- 60% reduction in Total Phosphorus (TP)
- 45% reduction in Total Nitrogen (TN)
- 90% reduction in litter (sized 5 mm or greater)

6.1.2 Post Development MUSIC Modelling

To assess the potential quantities of pollutants anticipated to be discharged from the site, the water quality modelling package 'Model for Urban Stormwater Improvement Conceptualisation' (MUSIC) V6.3 by eWATER has been applied. MUSIC Modelling Parameters and delineated data have been sourced from Water by Design, MUSIC Modelling Guidelines, and where possible, via online MUSIC Link data.

Rainfall data has been sourced from Rainfall Station 40223 Brisbane Aero using a date range from 1980 to 1989 and a 6 Minute Time Step, in accordance with TSC requirements.

Table 13: Rainfall Runoff Parameters

PARAMETER	SOURCE NODES
Land use	Commercial
Rainfall threshold (mm)	1
Soil storage capacity (mm)	18
Initial storage (% capacity)	10
Field capacity (mm)	80
Infiltration capacity coefficient a	243
Infiltration capacity coefficient b	0.6
Initial depth (mm)	50
Daily recharge rate (%)	0
Daily baseflow rate (%)	31
Daily deep seepage rate (%)	50

The pollution source node parameters were adopted as recommendation of MUSIC modelling Guideline.

Table 14: Pollutant Export Parameters

LAND USE	FLOW TYPE	TSS (LOG10 MG/L)		TP (LOG10 MG/L)		TN (LOG10 MG/L)	
		MEAN	ST. DEV.	MEAN	ST. DEV.	ST. DEV.	MEAN
Roof-Commercial	Baseflow	-	-	-	-	-	-
	Stormflow	1.3	0.38	-0.89	0.34	0.37	0.34
Road-Commercial	Baseflow	0.78	0.39	-0.6	0.5	0.32	0.3
	Stormflow	2.43	0.38	-0.3	0.34	0.37	0.34
Landscape-Commercial	Baseflow	0.78	0.39	-0.6	0.5	0.32	0.3
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34

6.1.3 Stormwater Quality Improvement Devices

An Enviro Stormwater Quality Improvement Device (SQID) will be utilised to treat stormwater runoff from the site as it is deemed more suitable for the proposed site use. One Enviro H30 Treatment Device has been adopted as the SQID modelled, to be incorporated into the operational phase development layout.

The proposed SQID has been provided for modelling purposes only and is subject to council approval. Accordingly, similar alternative devices may be adopted with council review and approval.

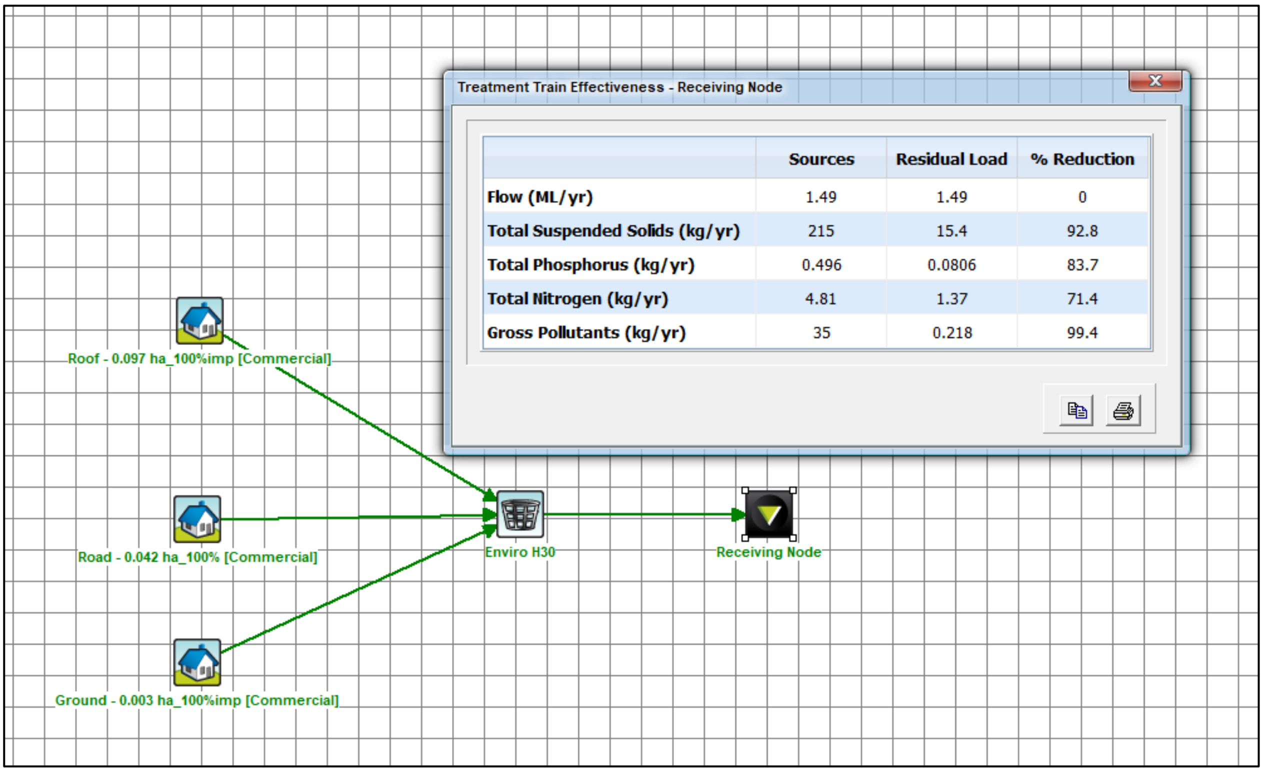
The adopted MUSIC catchment areas for the subject site are as follows;

Table 15: Adopted MUSIC Catchment Areas

Catchment	Area A (ha)	% Impervious
Roof- Commercial	0.097	100
Road- Commercial	0.042	100
Landscape- Commercial	0.003	100
Bypass	0.142	

Stormwater runoff captured from the developed area will be directly conveyed via downpipes to the proposed pit and pipe network by building hydraulics designer to the proposed Enviro H30 treatment device.

An illustration of the MUSIC model of the adopted operational treatment train for the post-development site has been provided in *Figure 4*.



Treatment Train Effectiveness - Receiving Node

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.49	1.49	0
Total Suspended Solids (kg/yr)	215	15.4	92.8
Total Phosphorus (kg/yr)	0.496	0.0806	83.7
Total Nitrogen (kg/yr)	4.81	1.37	71.4
Gross Pollutants (kg/yr)	35	0.218	99.4

Figure 4: Operational Phase Treatment Train

6.1.4 Design Parameters of the Stormwater Quality Improvement System

Detailed design of the stormwater treatment train shall be in accordance with the Water Sensitive Urban Design (WSUD), Technical Design Guidelines for South East Queensland – Version 1 (June 2006).

Enviro H Series

H Series is the optimal system for Commercial + Industrial applications due to the unique oil/water separator function which is certified to EN858-1 which has undergone extensive performance stress testing by independent authorities. These tests indicate the highest compliance with EPA Legislation and Guidelines which prohibit the discharge of pollutants into stormwater. The H Series system removes 99.95% of petroleum hydrocarbons, making it the safest and easiest system to install, maintain and support environmental and sustainability compliance.

6.1.5 Post Development Modelling Results - Mitigated

The modelled Stormwater Quality Improvement Devices (SQID) have demonstrated a reduction in the amount of sediments and nutrients discharging from the proposed residential development. *Table 16* illustrates the effectiveness of the SQID's in the treatment train for the development.

Table 16: Treatment Train Effectiveness at Receiving Node

Parameter	Post	Post Mitigated	Reduction	Water Quality Objectives
Flow (ML/yr)	1.49	1.49	**0**	-
TSS (kg/yr)	215	15.4	**92.8 %**	80 %
TP (kg/yr)	0.496	0.0806	**83.7 %**	60 %
TN (kg/yr)	4.81	1.37	**71.4 %**	45 %
Gross Pollutants (kg/yr)	35	0.218	**99.4 %**	90 %

The results demonstrate that the proposed SQID's meet the intended Water Quality Objectives for Gross Pollutants, Suspended Solids, Phosphorous and Nitrogen levels, in accordance with the TSC Requirements.

7.0 OPERATIONAL PHASE MAINTENANCE REQUIREMENTS

The proposed stormwater management devices will require maintenance and monitoring to ensure that they function as designed. The following section provides an outline of the necessary maintenance tasks for the proposed devices.

7.1 Enviro H Series Maintenance

The storage chamber located below the processing chamber is designed to be easily inspected and serviced. Based on the ARQ extrapolation of 1m3/ann/ha from typical urban catchment, the large storage volume provides for extended service intervals. In most installations, service intervals are nominally 1 year (12 months).

Service is by evacuation. The volume of water contained in the process chamber is minimised to reduce evacuation costs. This water can be pumped out as the first stage of service, avoiding evacuation and the cost of disposal. A dry sump option is available on request.

All surfaces inside the Enviro series are visible from the service covers, eliminating the need for personnel to enter the device and perform longer term wash downs while negating the need for confined space entry.

If required, screens can be removed manually, without entering the device. This facilitates inspection, cleaning or replacement, without additional labour or equipment.

During the construction phase, i.e. before hand over to the client, screens can be removed enabling the device to act as a sediment trap. This allows the constructor to clean out the device and handover to the client an unused unit, eliminating disputes over device condition.

8.0 CONCLUSIONS

Legend Consultants, on behalf of Sarris International Pty Ltd, has undertaken the preparation of a Conceptual Stormwater Management Plan (CSMP) to support a Development Application for a proposed Industrial Development at 437 Stafford Road, Stafford. This CSMP establishes an optimized stormwater management system that aligns seamlessly with the intended site use.

The plan outlines the planning, layout, and design of the stormwater management infrastructure for both the construction and operational phases of the development, ensuring compliance with Brisbane City Council Planning Scheme 2015.

Based on a hydrological analysis, it has been determined that the expected post-development peak flow rates from the site are increased compared to the pre-development rates. Consequently, on-site stormwater detention will be incorporated into the site design.

To mitigate the flows resulting from the increase of impervious area on site, and to mitigate impacts for properties downstream of the site, a detention tank is proposed to be constructed. The total peak storage capacity of the tank is 46 m^3. The design of the tank is consistent with the stormwater guidelines referred in Brisbane City Council Planning Scheme 2015.

Legend Consultants Pty Ltd has adopted a Water Sensitive Urban Design (WSUD) approach, in accordance with the State Planning Policy, to managing the stormwater runoff from the proposed development by treating stormwater runoff within an Enviro H30 Series. The SQID's utilised within the MUSIC model have been adopted to demonstrate a potential treatment system, pending council approval.

The CSMP includes a comprehensive monitoring and maintenance plan for the proposed infrastructure. Additionally, an erosion and sediment control plan has been outlined for the construction phase, with implementation responsibilities assigned to the contractor and developer.

APPENDIX

A

J Surveyors Plan of Detail Survey (Ref: JS 383 - DET01 - REV.A)


PHOTO 1


PHOTO 2

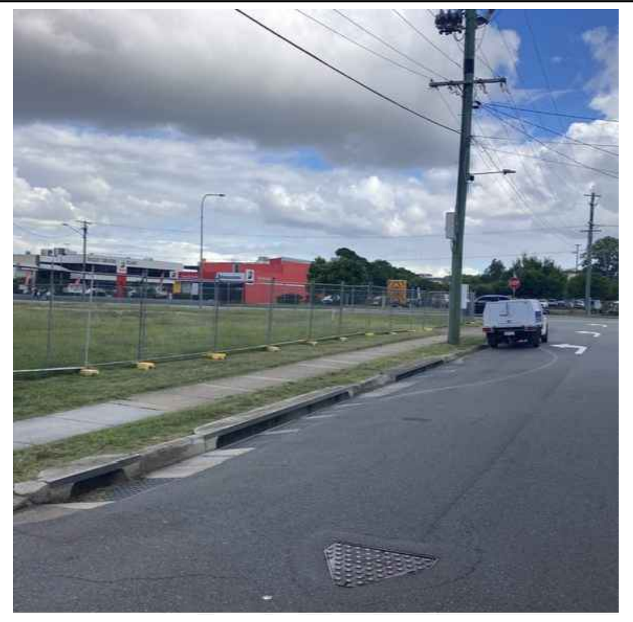
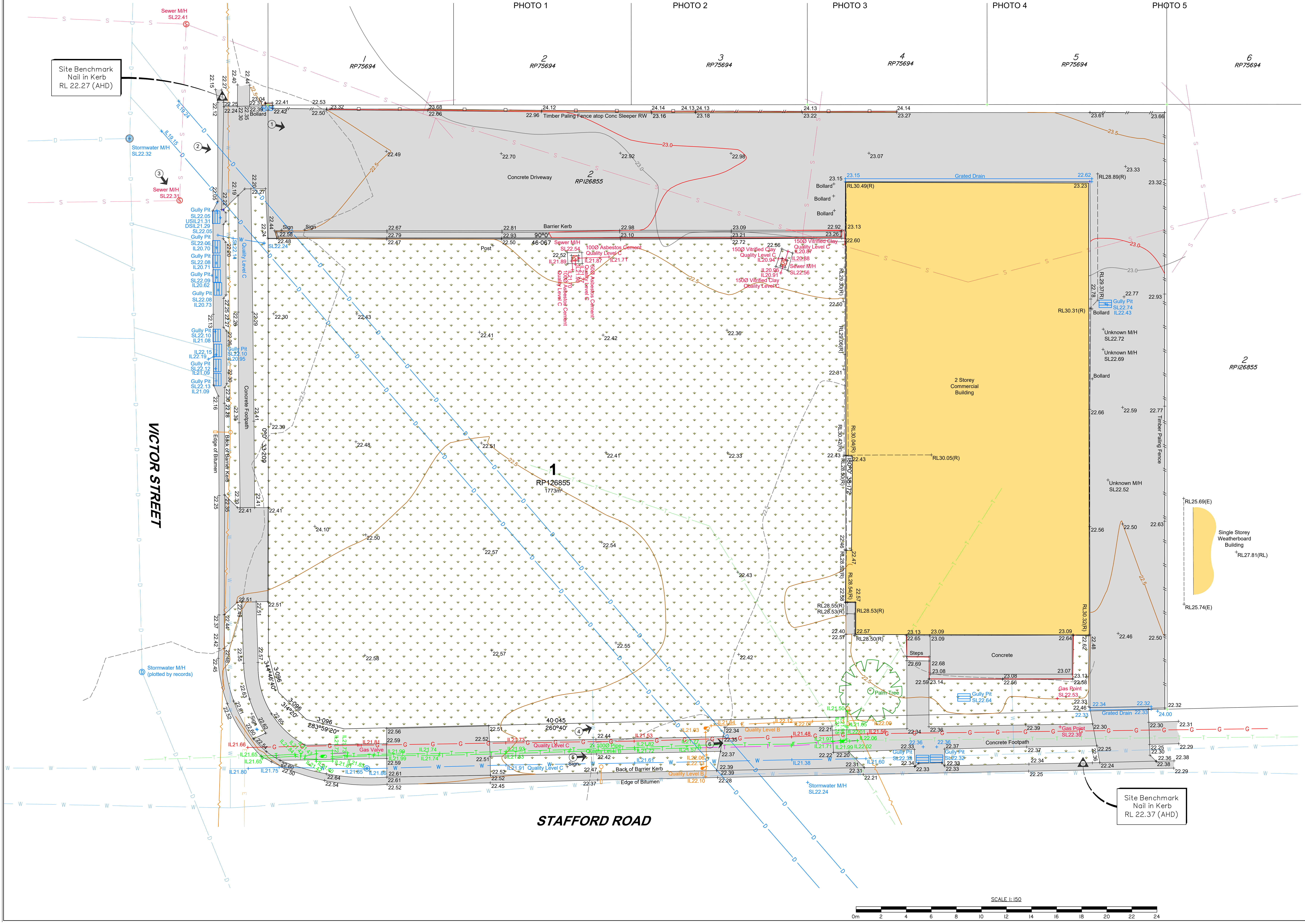


PHOTO 3


PHOTO 4


PHOTO 5


PHOTO 6



Unit 5/121 Newmarket Road, Windsor,4030
admin@jsurveyors.com.au
Ph (07) 3117 0730

NOTES

1. Drawn to scale on A1 at 1:150 (A1) or 1:300 (A3)
2. Property boundaries have not been defined by this survey. An Identification survey must be completed to confirm the exact location of the property boundaries prior to any operational works.
3. This plan has been prepared for the exclusive use and purposes of the client as stated on this plan and should not be used by any other person or corporation and for any other purpose.
4. Underground features have been plotted from records. Only those services as shown on this plan have been located by this survey. Prior to any construction, demolition or excavation on the site, the relevant authority should be contacted for the location of any further underground services and detailed location of all services.
5. For flood level information impacting the subject lot. Please refer to FloodWise Property Report attached to this documentation.
6. For underground service information impacting the subject lot. Please refer to Service Location Report attached to this documentation.
7. This plan may not be photocopied unless these notes are included.
8. JSURVEYORS accepts no responsibility for any loss or damages caused in contravention of the above.
9. All levels are in metres on Australian Height Datum and have been derived from OPM43289 RL24.396 (AHD) via GNSS.
8. Natural surface contours have been plotted by BCC eBimap records 2002.
9. Contour Interval . . . 0.5m

LEGEND

—— D ——	Underground Stormwater Line
—— W ——	Underground Water Line
—— S ——	Underground Sewer Line
—— G ——	Underground Gas Line
—— T ——	Underground Telstra Line
——^——	Underground Comms Line
—— E ——	Underground Power Line
——^——	Overhead Power Line
——□——	Retaining Wall
——//——	Fence Line
— —— —— —	Top of Bank
– – – – – – –	Bottom of Bank
————	Major Contour (Existing)
————	Minor Contour (Existing)
————	Major Contour (Natural)
– – – – – – –	Minor Contour (Natural)
....	Column/Concrete Wall below
Ⓓ	Stormwater Manhole
Ⓗ	Fire Hydrant
Ⓥ	Water Valve
Ⓜ	Water Meter
Ⓡ	Roof Water Outlet
Ⓢ	Sewer Manhole
ⓘ	Sewer Inspection Opening
Ⓥ	Gas Valve
Ⓜ	Gas Meter
●	Telstra Pit
●	Comms Pit
Ⓔ	Electrical Pillar
●	Electrical Pit
○—□	Electrical Light/Power Pole
RL25.69 (E)	Eave Line
RL30.05 (R)	Roof Line
RL27.81 (RL)	Ridge Line

A	ORIGINAL ISSUE	13.04.26	QT	BC
Issue	Description	Date	Drawn	Check

Client:
SARRIS INTERNATIONAL

Title:

Plan of Detail Survey
of
Lot 1 on RP126855

437 Stafford Road, Stafford, QLD

Drawing No: JS 383 - DET01 - REV.A

Sheet. No: 1 of 1

APPENDIX

B

Sarris, Ground Floor Plan (Ref: AS88)

PROPERTY DESCRIPTION

437 STAFFORD ROAD, STAFFORD
QLD 4053.

LOT 437 AREA:	1774.00m^2
PROPOSED SITE COVER:	834.20m^2 47.02%

GFA CALCULATIONS

SALES AREA:	108.20m^2
WORKSHOP AREA:	666.40m^2
MEZZANINE AREA:	515.40m^2
TOTAL GFA:	1,290.00m^2
GFA / SITE COVER:	72.71%

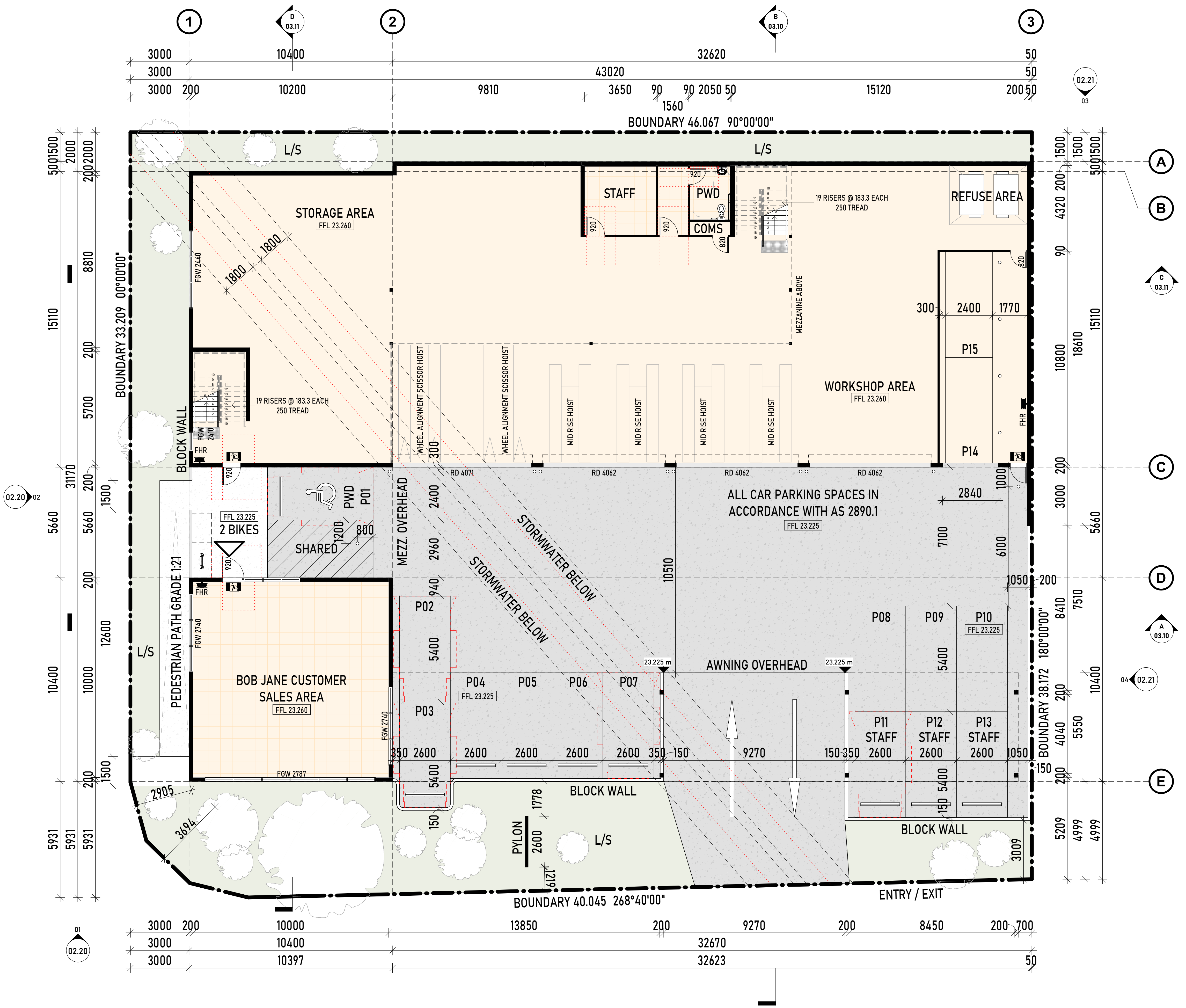
CAR PARKING CALCULATIONS

1 SPACE PER 100m^2 of GFA
+ 2 PER TENANCY

1,290.00m^2 / 100 =	12.9
12.9 + 2 =	14.9
REQUIRED:	15
PROVIDED:	15

BIKE PARKING CALCULATIONS

REQUIRED:	02
PROVIDED:	02



No.	AMENDMENT	DATE
C	REVISED ISSUE	23.03.2026
D	CAR PARKING AMENDMENTS	23.04.2026
E	REVISED ISSUE	21.05.2026
F	PYLON REVISION	28.05.2026
G	PODIUM HEIGHT REVISION	18.06.2026.

GENERAL NOTES

Architectural documents to be read in conjunction with relevant Structural, Fire Service, Mechanical, Hydraulic, Electrical, Civil and Landscaping documents. Technical drawings to be read in conjunction with appropriate sections of technical specification.
Contractor to verify all dimensions / condition on site prior to commencement of works. Contractor to seek clarification of all inconsistencies and resolve all discrepancies on plans and site conditions prior to commencement of any works on site. Commencement of works on site by the contractor is deemed to be acceptance of all conditions and plans and any variations will be the responsibility of the contractor expense.
Figured dimensions shall take precedence to scaled dimensions.

Notify SARRIS ARCHITECTURE of any changes. No changes to occur without SARRIS approval.

SARRIS

DP.AD. 2298

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M +61 433 263 928

SINGAPORE
A Level 26, PSA Building
460 Alexandra Road, Singapore 119963
T + 65 3138 6928
E allister@allistersarris.com
W www.linkedin.com/profile/view

project :	BOB JANE T MART
address :	437 STAFFORD ROAD, STAFFORD, QLD
description :	
drawing title :	Ground Floor

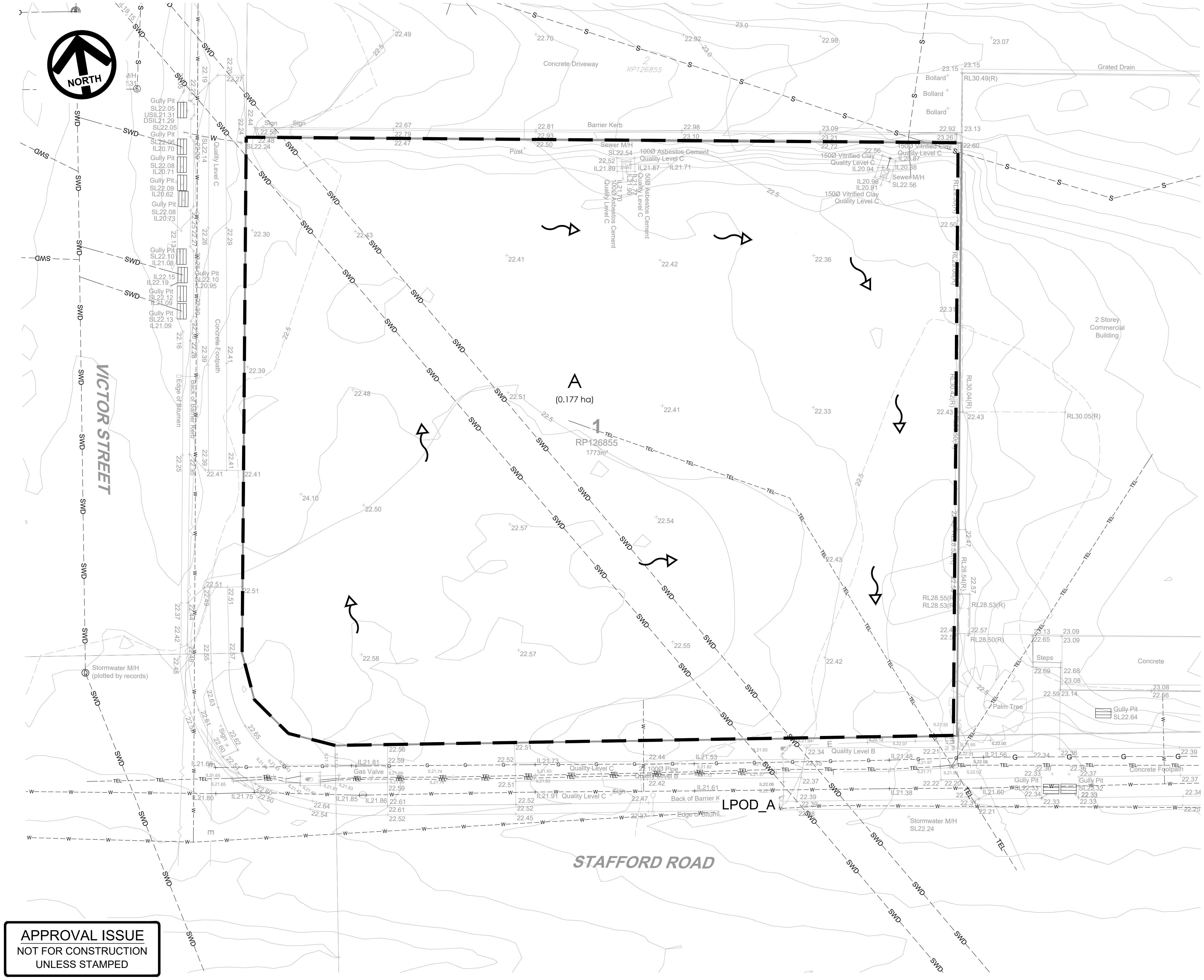
SARRIS
CORPORATE COMMERCIAL INTERIOR DESIGN

ISSUE PRELIMINARY		
Project No. AS88	Drawing No.	
Total Area -		
First Drawn April 2025	Option	Revision
Date Issued -	Paper Size A3	

APPENDIX

C

Legend Consultants Pre-Development Catchment Plan (Ref: LC26013-SK100-A)



LEGEND

- STORMWATER CATCHMENT BOUNDARY
- SITE BOUNDARY
- A1 STORMWATER CATCHMENT I.D.
- FLOW DIRECTION
- LPOD POINT OF DISCHARGE

EXISTING SERVICES LEGEND

- S EXISTING SEWER MAIN (FROM SURVEY)
- SRM EXISTING SEWER MAIN
- W EXISTING WATER MAIN (FROM SURVEY)
- E-O/H EXISTING ELECTRICAL (FROM SURVEY)
- TEL EXISTING TELSTRA CONDUIT (FROM SURVEY)
- SWD EXISTING STORMWATER PIPE (FROM SURVEY)
- C EXISTING COMMUNICATIONS CABLE
- G EXISTING GAS (FROM SURVEY)

APPROVAL ISSUE
NOT FOR CONSTRUCTION
UNLESS STAMPED

Legend Consultants
Efficiency · Innovation · Quality

A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
A	15.06.26	PRELIMINARY ISSUE	RM

RPEQ NO. 16695

PROJECT
PROPOSED DEVELOPMENT
437 STAFFORD ROAD, STAFFORD,
QUEENSLAND

DRAWN	LD
DESIGNED	LD
CHECKED	JW
APPROVED	RM
DATE	Jun 2026
GRID REF.	AHD

CLIENT
SARRIS INTERNATIONAL
PTY LTD

TITLE
PRE DEVELOPMENT
CATCHMENT PLAN

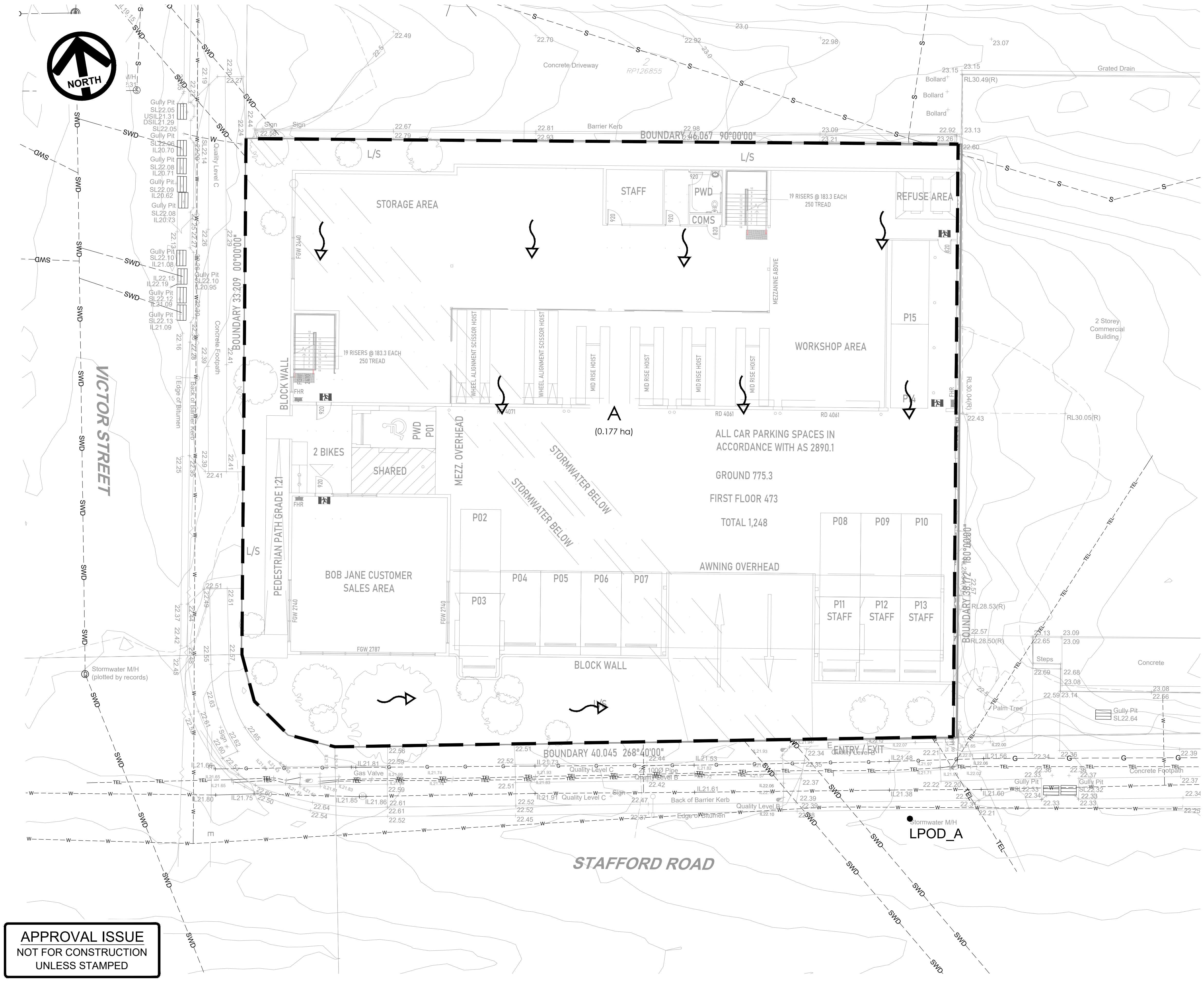
DRAWING NO. LC26013-SK100

REV. A

APPENDIX

D

Legend Consultants Post Development Catchment Plan (Ref: LC26013-SK200-A) and Music Catchment Plan (Ref: LC26013-SK300-A)



LEGEND

▬ ▬ ▬	STORMWATER CATCHMENT BOUNDARY
——	SITE BOUNDARY
A1	STORMWATER CATCHMENT I.D.
⤳	FLOW DIRECTION
LPOD	POINT OF DISCHARGE

EXISTING SERVICES LEGEND

— — S — —	EXISTING SEWER MAIN (FROM SURVEY)
— — SRM — —	EXISTING SEWER MAIN
— — W — —	EXISTING WATER MAIN (FROM SURVEY)
— — E - O/H — —	EXISTING ELECTRICAL (FROM SURVEY)
— — TEL — —	EXISTING TELSTRA CONDUIT (FROM SURVEY)
— — SWD — —	EXISTING STORMWATER PIPE (FROM SURVEY)
— — C — —	EXISTING COMMUNICATIONS CABLE
— — G — —	EXISTING GAS (FROM SURVEY)

APPROVAL ISSUE
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REV	DATE	REVISION DETAILS	APPROVED
A	15.06.26	PRELIMINARY ISSUE	RM

RPEQ NO. 16695

PROJECT
PROPOSED DEVELOPMENT
437 STAFFORD ROAD, STAFFORD,
QUEENSLAND

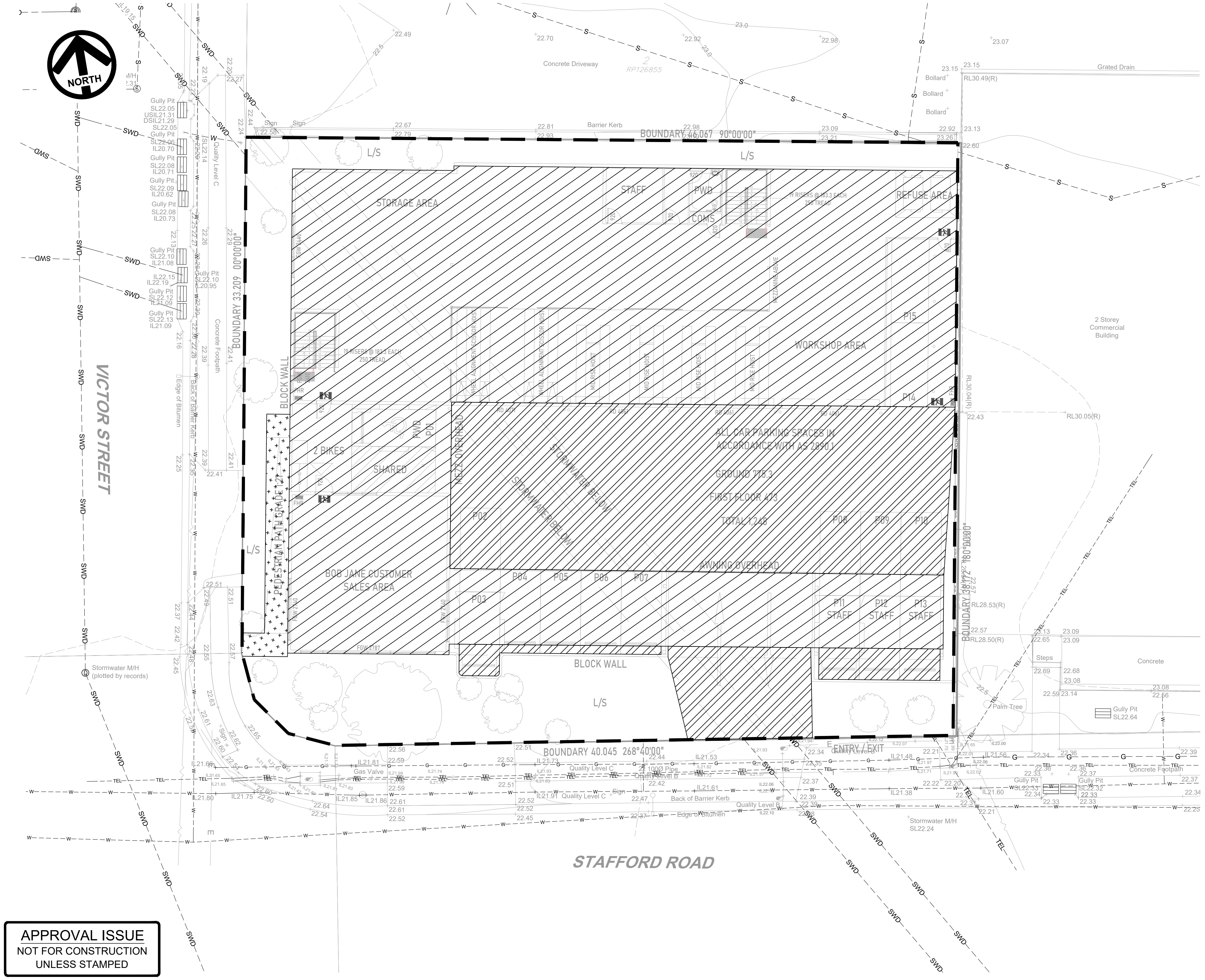
DRAWN	LD
DESIGNED	LD
CHECKED	JW
APPROVED	RM
DATE	Jun 2026
GRID REF.	AHD

CLIENT
SARRIS INTERNATIONAL
PTY LTD

TITLE
POST DEVELOPMENT
CATCHMENT PLAN

DRAWING NO. LC26013-SK200

REV. A



APPROVAL ISSUE
NOT FOR CONSTRUCTION
UNLESS STAMPED

LEGEND

- ▬ ▬ ▬ STORMWATER CATCHMENT BOUNDARY
- ── MUSIC CATCHMENT
- A1 STORMWATER CATCHMENT I.D.
- ▨ ROOF AREA
- ▨ ROAD AREA
- ⁺⁺⁺ GROUND AREA

MUSIC CATCHMENT TABLE

MUSIC I.D.	MUSIC A (ha)
ROOF (100% IMP)	0.097
ROAD (100% IMP)	0.042
GROUND (100% IMP)	0.003
TOTAL	0.142

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REV	DATE	REVISION DETAILS	APPROVED
A	15.06.26	PRELIMINARY ISSUE	RM

RPEQ NO. 16695

PROJECT
PROPOSED DEVELOPMENT
437 STAFFORD ROAD, STAFFORD,
QUEENSLAND

DRAWN	LD
DESIGNED	LD
CHECKED	JW
APPROVED	RM
DATE	Jun 2026
GRID REF.	AHD

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PTY LTD

TITLE
MUSIC CATCHMENT PLAN

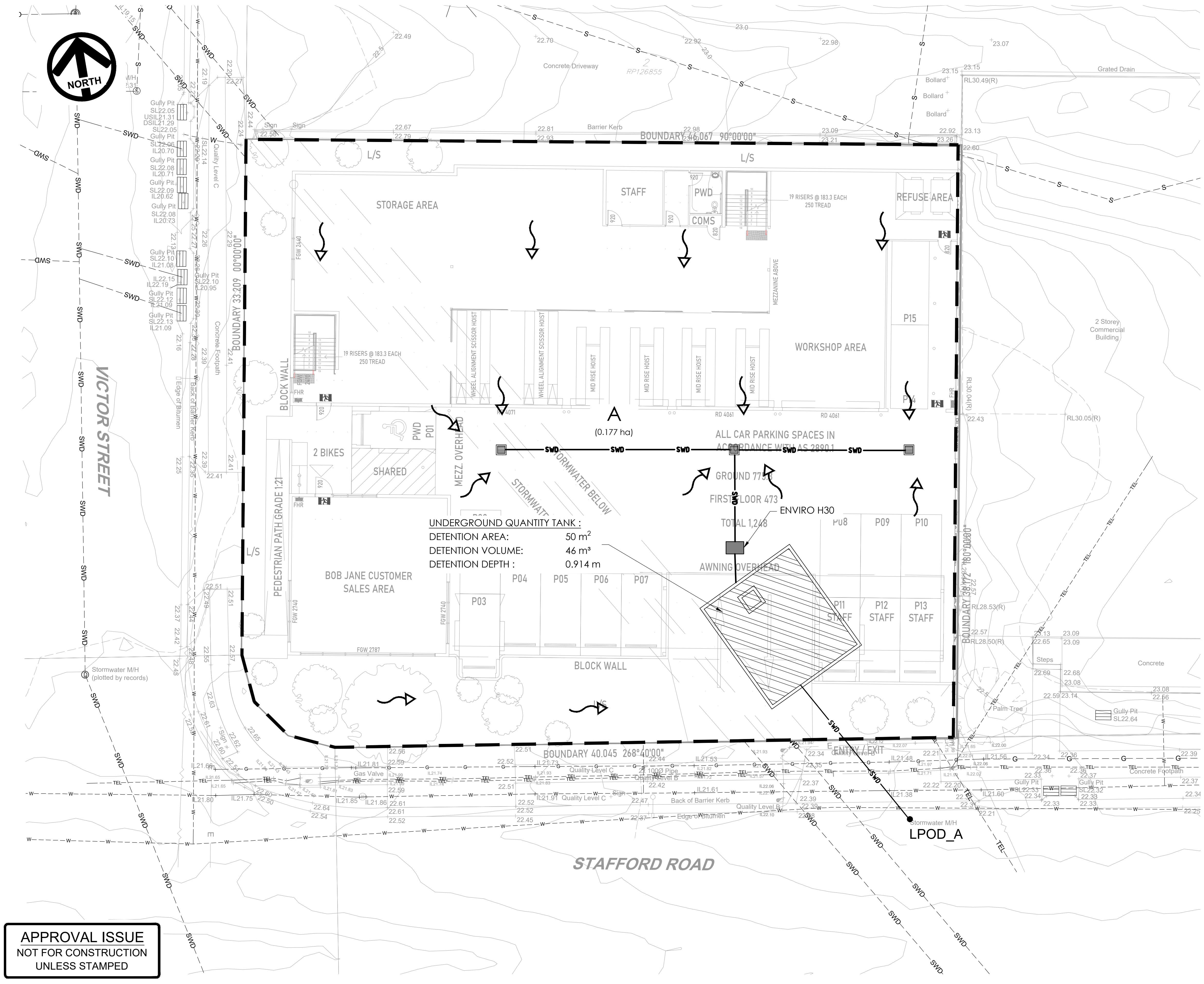
DRAWING NO. LC26013-SK300

REV. A

APPENDIX

E

Legend Consultants Stormwater Management Plan (Ref: LC26013-SK400-A)



UNDERGROUND QUANTITY TANK :
DETENTION AREA: 50 m^2
DETENTION VOLUME: 46 m^3
DETENTION DEPTH : 0.914 m

LEGEND

— — —	STORMWATER CATCHMENT BOUNDARY
——	SITE BOUNDARY
A1	STORMWATER CATCHMENT I.D.
↝	FLOW DIRECTION
LPOD	POINT OF DISCHARGE
▨	PROPOSED QUANTITY TANK

EXISTING SERVICES LEGEND

— — S — —	EXISTING SEWER MAIN (FROM SURVEY)
— — SRM — —	EXISTING SEWER MAIN
— — W — —	EXISTING WATER MAIN (FROM SURVEY)
— — E-O/H — —	EXISTING ELECTRICAL (FROM SURVEY)
— — TEL — —	EXISTING TELSTRA CONDUIT (FROM SURVEY)
— — SWD — —	EXISTING STORMWATER PIPE (FROM SURVEY)
— — C — —	EXISTING COMMUNICATIONS CABLE
— — G — —	EXISTING GAS (FROM SURVEY)

APPROVAL ISSUE
NOT FOR CONSTRUCTION
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A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
A	15.06.26	PRELIMINARY ISSUE	RM

RPEQ NO. 16695

PROJECT
PROPOSED DEVELOPMENT
437 STAFFORD ROAD, STAFFORD,
QUEENSLAND

DRAWN	LD
DESIGNED	LD
CHECKED	JW
APPROVED	RM
DATE	Jun 2026
GRID REF.	AHD

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TITLE
STORMWATER MANAGEMENT PLAN

DRAWING NO. LC26013-SK400
REV. A

APPENDIX

F

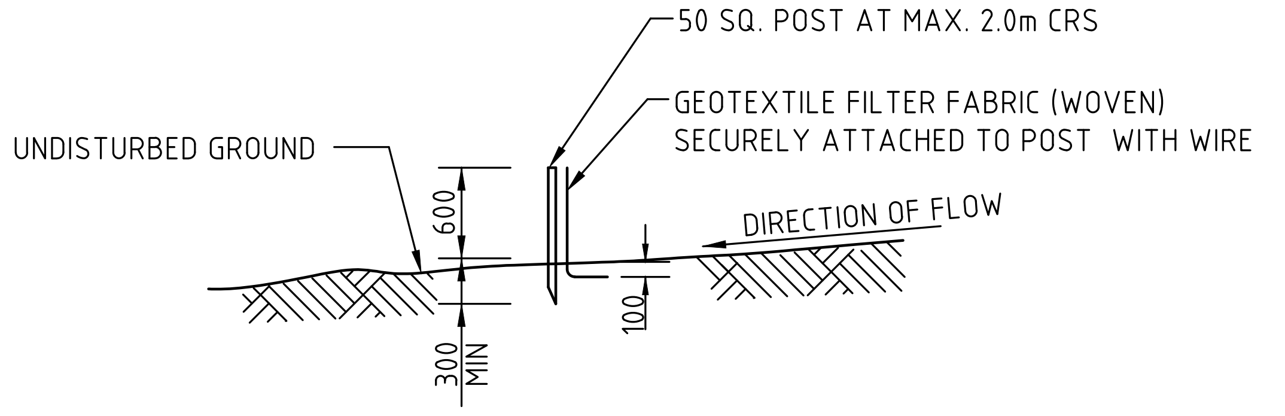
Legend Consultants Erosion & Sediment Control Plan & Details (Ref: LC26013-C250)

LEGEND:

—7.2—	FINISHED CONTOUR (0.1m INTERVAL)
— — — —	EXISTING BDY
— // — // —	EXISTING FENCE
— S — — —	EXISTING SEWER
— OE — — —	EXISTING OVERHEAD ELECTRICITY
— UE — — —	EXISTING UNDERGROUND ELECTRICITY
— SW — — —	EXISTING DRAINAGE PIPE
— W — — —	EXISTING WATER
— T — — —	EXISTING TELECOMMUNICATION
— G — — —	EXISTING GAS MAIN
═	EXISTING KERB
‴— ‴— ‴—	EXISTING EDGE OF BITUMEN
—	EXISTING FOOTPATH
- - - - - -	EXISTING EASEMENT
— — — — —	EXISTING DRIVEWAY
—///—///—	EXISTING BUILDING
⊗	EXISTING TREES
╤╤╤	PROPOSED BATTER
▬ ▬ ▬	PROPOSED RETAINING WALL
— // — // —	PROPOSED SEDIMENT FENCE
⌜ ⌝	DRAINAGE STRUCTURE PROTECTION

SEDIMENT AND EROSION CONTROL NOTES

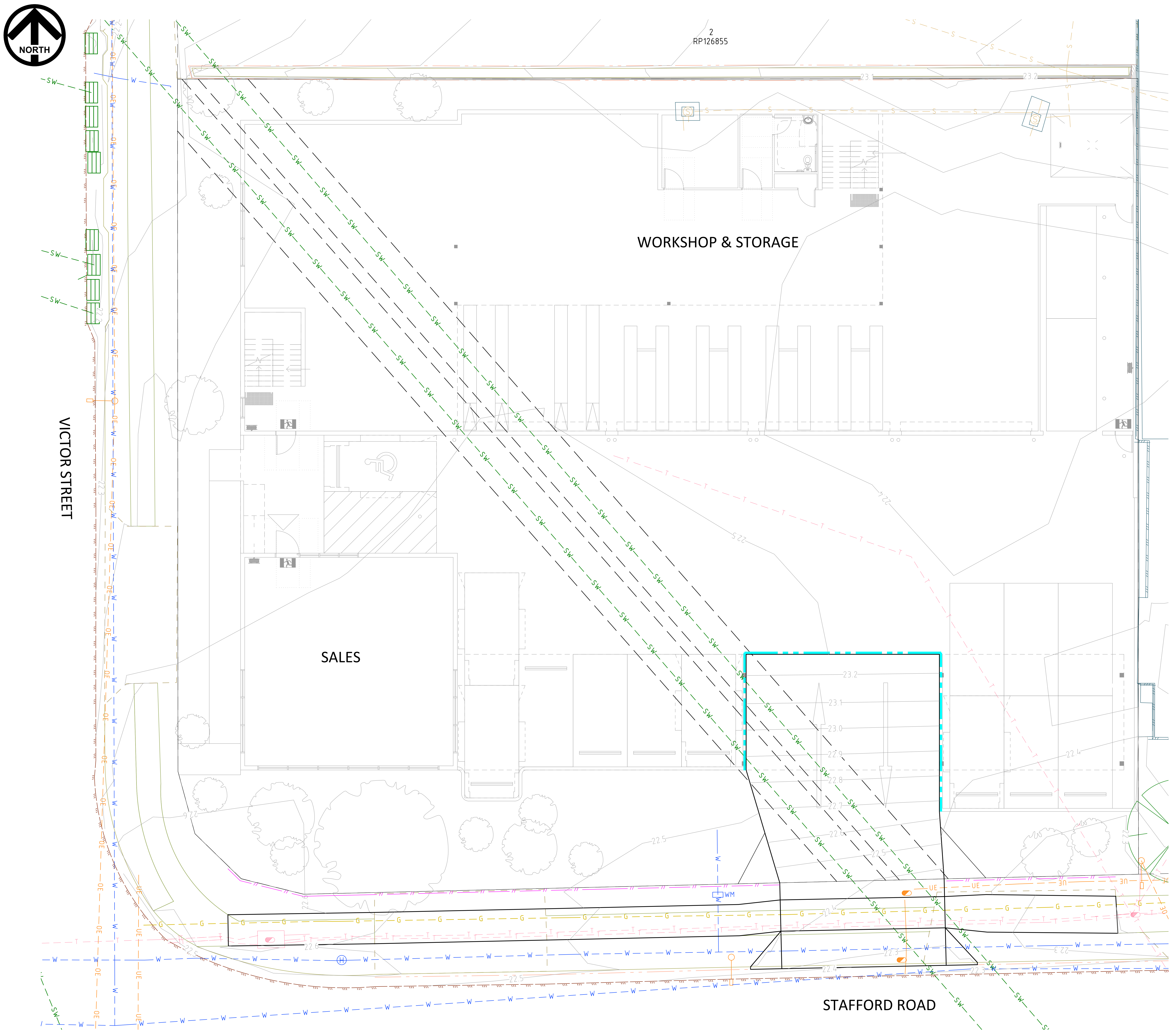
1. THE PROJECT SEDIMENT AND EROSION CONTROL DRAWINGS ARE TO BE READ IN CONJUNCTION WITH THE SITE'S APPROVED STORMWATER MANAGEMENT PLAN.
2. CONSTRUCTION IS TO BE PROGRAMMED TO PROVIDE INSTALLATION OF PERIMETER LANDSCAPING / SURFACE TREATMENTS AS EARLY AS PRACTICAL.
3. THE CONTRACTOR'S WORKS PROGRAM IS TO BE REVIEWED AT THE PRESTART MEETING. ALTERATIONS TO THE PROGRAM MAY BE REQUIRED TO ENSURE SATISFACTORY EROSION AND SEDIMENT CONTROL.
4. SAFETY ISSUES MUST BE CONSIDERED AND MONITORED FOR EACH DEVICE TO THE SATISFACTION OF THE SUPERINTENDENT.
5. SEDIMENT FENCE FILTER FABRIC IS TO BE APPROVED BY THE ENGINEER. FILTER CLOTH AND SHADE CLOTH ARE NOT TO BE USED.
6. SEDIMENTATION MANAGEMENT DEVICES SHALL BE INSTALLED PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES AND MAINTAINED AT A SUITABLE LEVEL/ CONDITION THROUGHOUT CONSTRUCTION.
7. SEDIMENT FENCES ARE TO BE CLEANED OUT WHEN CAPACITY IS REDUCED BY 30%.
8. DRAINAGE STRUCTURE PROTECTION IS TO BE CLEANED FOLLOWING EACH SIGNIFICANT RUNOFF PRODUCING STORM.
9. ACCESS TO THE SITE IS TO BE PROVIDED BY THE CONTRACTOR. APPROVAL IS TO BE OBTAINED FROM COUNCIL FOR THE LOCATION OF THE SITE ACCESS POINT AND WASH DOWN AREA WHICH IS TO BE MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD. ACCESS TO AND FROM THE SITE IS TO BE VIA THE SHAKEDOWN FACILITY ONLY. ALL VEHICLES ARE TO BE WASHED DOWN PRIOR TO LEAVING THE SITE.
10. THE CONTRACTOR SHALL PROVIDE TEMPORARY DRAINAGE CONTROLS TO DIVERT FLOW FROM UNDISTURBED AREAS AROUND DISTURBED AREAS AND DIRECT FLOW FROM DISTURBED AREAS TOWARD CONTROL DEVICES.
11. SEDIMENT TRAP WILL COLLECT SEDIMENT DURING RUN-OFF EVENTS . DEWATERING OF THIS SEDIMENT TRAP CAN ONLY OCCUR WHEN TSS IS <50MG/L AND PH IS BETWEEN 6.5 - 8.5 IN ACCORDANCE WITH IECA GUIDELINES.



SEDIMENT FENCE

N.T.S.

NOTE: SILT FENCE TO HAVE TURNOUTS AT 50m MAX INTERVALS.



EROSION AND SEDIMENT CONTROL LAYOUT PLAN

SCALE: 1:100

1:100 0 1 2 3 4 5m

FOR APPROVAL
NOT FOR CONSTRUCTION
UNLESS STAMPED

Legend Consultants
Efficiency • Innovation • Quality
75 BARDEN RIDGE ROAD, REEDY CREEK, QLD 4227

A1 THE SCALE SHOWN IS ORIGINAL DRAWING SCALE

REV	DATE	REVISION DETAILS	APPROVED
A	24.04.26	ORIGINAL ISSUED	JW

RPEQ NO.

PROJECT
437 STAFFORD ROAD, STAFFORD,
QUEENSLAND
PRELIMINARY DESIGN

DRAWN	VL
DESIGNED	VL
CHECKED	JW
APPROVED	JW
DATE	APR 26
GRID REF.	AHD

CLIENT
SARRIS INTERNATIONAL
PTY LTD

TITLE
EROSION AND SEDIMENT
LAYOUT PLAN

DRAWING NO.
LC26013.C250

REV.
A

APPENDIX

G

Enviro Australis H30 Filter Technical Specifications

FLOW RATES BASED AT 1% PIPE GRADIENT:-

TREATED FLOW....... 22 L/SEC
GROSS FLOW......... 123 L/SEC

MASS:

(BASED ON "D" CLASS COVERS)

TOTAL MASS (FOR MINIMUM INVERT) : 2.850 TONNE

Enviro H30

General Notes

The Enviro 'H' series is an Australia Designed and Manufactured Device for the removal of pollutants including oils from run-off water. The Enviro 'H' Series is normally installed in-line within new or existing drainage pipes and can be adapted to be installed in an open channel if required. The device does not require any power, utilising the energy in the water flow to separate and contain pollutants for periodical removal by evacuation equipment. Internal surface can be inspected and washed as required, whilst screens can be removed and also cleaned if and as required.

The Enviro 'H' Series are a unique oil/water Separator as well as a Stormwater Quality Improvement Devices (SQID's) which has undergone extensive performance stress testing by independent authorities. These tests indicate compliance with Environmental Protection Authority (EPA) Legislation and Guidelines which prohibit the discharge of pollutants into stormwater. The aim of the Enviro 'H' Series is to restore water quality to a safe and environmentally sustainable state, which pre-existed urbanisation. The application is aimed at any catchment, where an oil spill risk may exist.

Recommendations made in the Australian Run-Off Quality Guideline 2007 (ARQ) are adhered to. The 'H' models also comply with EN-858-1, Class 1 oil/water separators.

Specifications: -

1. Design service life 100 years for fixed parts and 25 years for replacement parts
2. Hydraulic Resistance k factor = 0.425
3. Inlet to outlet differential = 25mm
4. Concrete chamber, risers and cover slabs are designed and manufactured in accordance with AS3600-2009 and under Quality Assurance 9001.
5. Covers are designed and tested in accordance with AS3996 – 2006 Access Covers and Grates
6. Internal components are manufactured from high grade, stainless steel to comply with International Corrosion Standards. There is no welding used. This complies with advice from both the American and Australian Institute of Engineers warning that welded stainless steel exposed to bacterial charged water can result in early corrosion and failure.
7. 'H' Series performance testing verifies the following pollutant removal rates. The testing was performed across a range of concentrations and flow rates which replicated various run-off water conditions and confirmed: -

S.NO	Pollutants	Minimum Reduction Required	Test Reduction Achieved
7.1	Total Suspended Solids	80%	86%
7.2	Total phosphorus	60%	97%
7.3	Total Nitrogen	45%	85%
7.4	Gross Pollutants	90%	100%
7.5	Total Hydrocarbons	99.95%	99.95%

8. The lower storage chamber has the capacity to hold the annual load discharged from a catchment based on the ARQ Section 3.7 recommended allowance of 1m3/ha/ann.
9. Treated flow through the Enviro 'H' Series is in compliance with EPA definitions, which require the entire catchment run-of to pass through a SQID, until sufficient flows have occurred to mobilise at least 90% of the potential pollutant load.
10. Particle size capture is set to retain all particles greater than 500µ and to then retain a majority of particles to less than 100µ.
11. Hydrocarbon retention occurs in a separate chamber which operates as a best practice oil and grease arrestor
12. Re-suspension of hydrocarbons and all retained materials is prevented by including separate chambers for separation from flow and retention

REV.	DESCRIPTION	DATE	APPROVED
R3	Illustration changed	29-Dec-22	LC
R2	2 x 600 x 600 'D' Class covers changed to 1 x 600 x 900 'D' class cover	10-Jun-22	LC
R1	Chamber Wall & Base thickness changed from 150mm to 100mm	21-May-22	LC
0	Technical Specification Created	29-Nov-21	LC

REVISIONS

For further assistance: -
Technical Support Ph: ....+61 8 8564 2347
Email: info@enviroaustralis.com.au

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

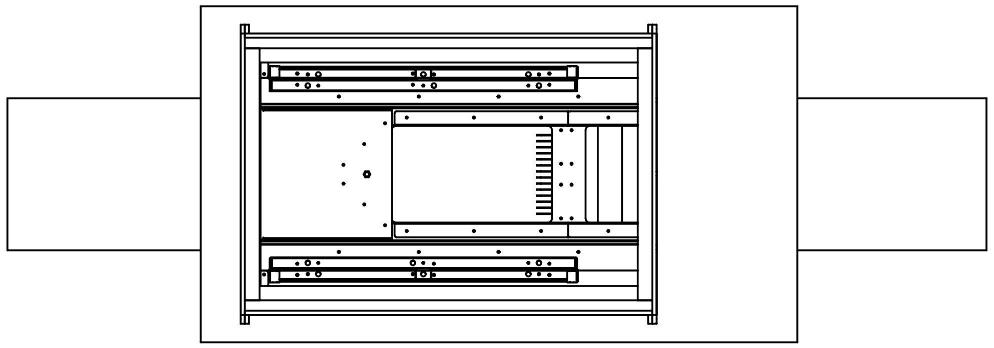
BENDING RADIUS	K - FACTOR

PREPARED BY: Logesh S
CHECKED BY: LR
APPROVED BY: LC
DATE: 29-Dec-22
MATERIAL: CONCRETE & S/STEEL
WEIGHT: Kg

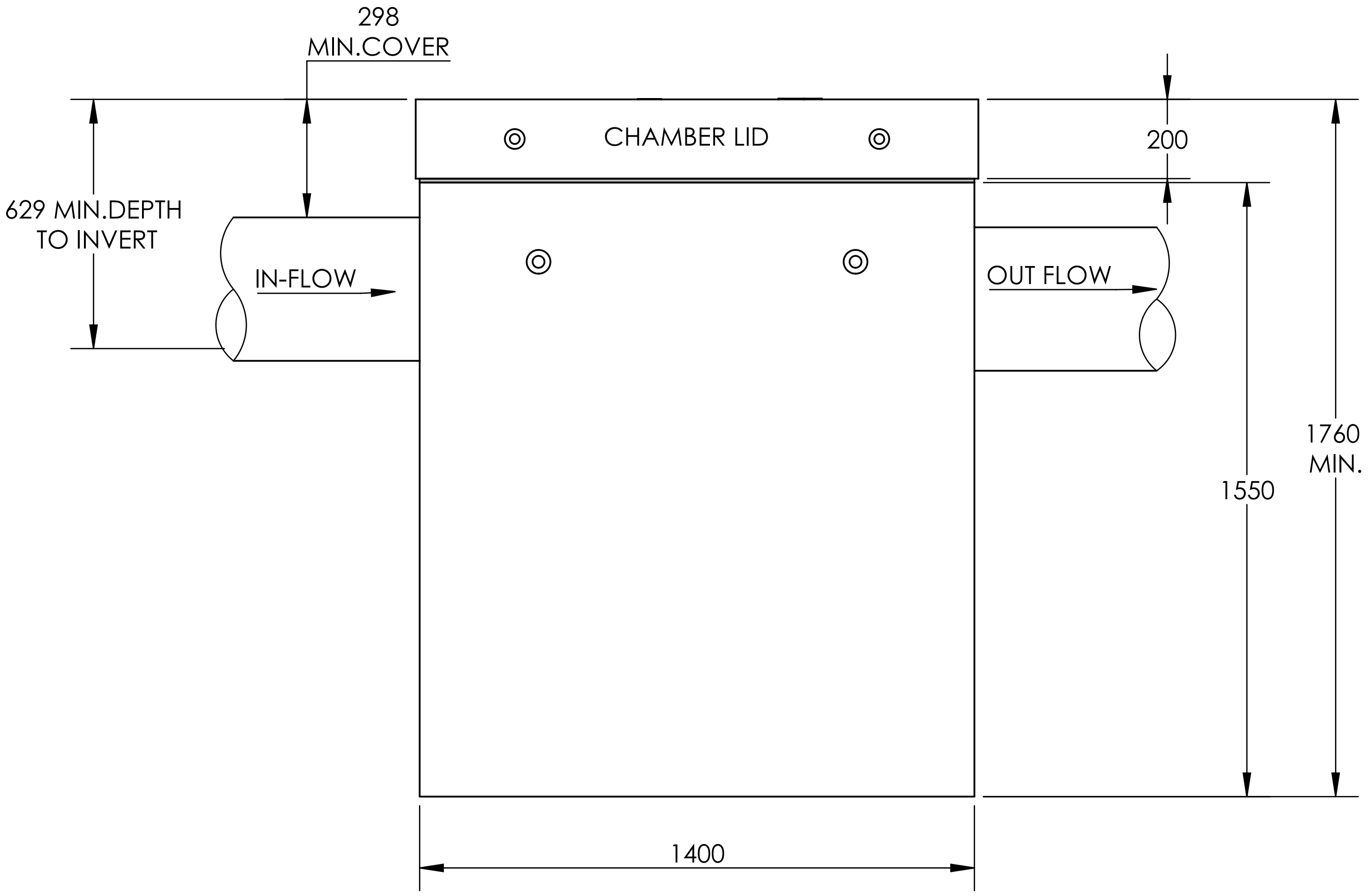
ENVIRO

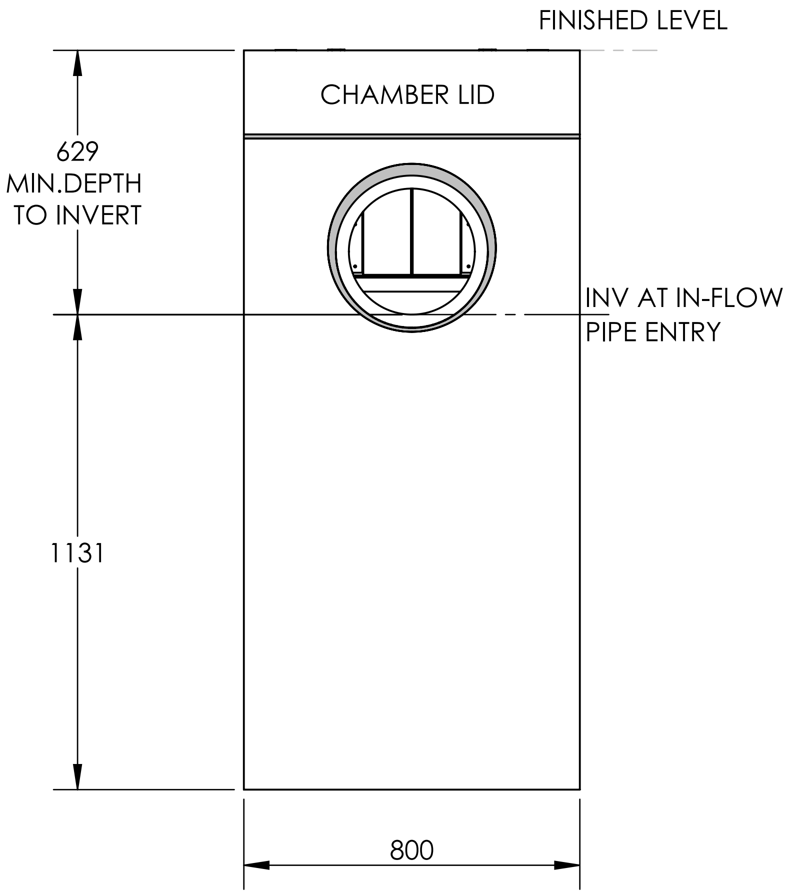
TITLE:
ENVIRO H30
SPECIFICATIONS & TECHNICAL DATA

DRAWING NO: ENV-TEC-H30-000-1
ASSEMBLY: H30
A3
REV: R3
SCALE: NTS
SHEET 1 OF 4



VIEW AS SEEN THROUGH COVERS OPENING
FOR SERVICE AND INSPECTION





CLASS	OVERALL HEIGHT (MIN.)	MIN. DEPTH TO INVERT
'D' CLASS	1760 mm	629 mm

The design and details shown in this drawing remain the property of Enviro Aus Pty Ltd ACN 616 059 806 and must not be copied, used, disclosed or communicated to any party unless with the express permission of Enviro Aus Pty Ltd with whom copyright resides.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22

MATERIAL:
CONCRETE & S/STEEL

WEIGHT: Kg

ENVIRO

TITLE:
ENVIRO H30
GENERAL ARRANGEMENT

DRAWING NO: ENV-TEC-H30-000-2

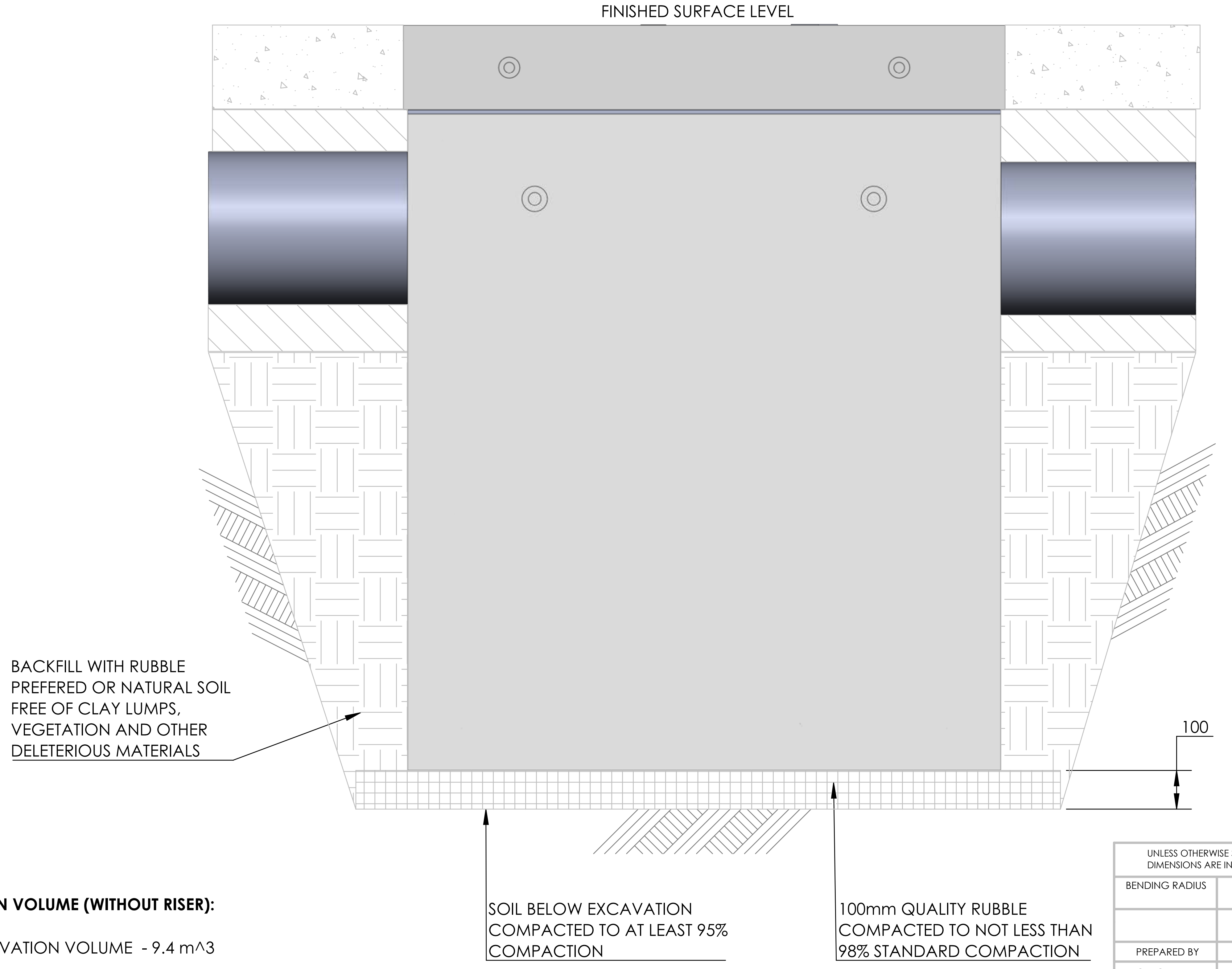
ASSEMBLY:
H30

A3

REV: R3

SCALE: NTS

SHEET 2 OF 4



EXCAVATION VOLUME (WITHOUT RISER):

TOTAL EXCAVATION VOLUME - 9.4 m^3

BACKFILL VOLUME FROM CHAMBER BOTTOM
TO PIPE INVERT = 3.11 m^3

BACKFILL VOLUME FROM PIPE INVERT
TO TOP = 4.34 m^3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22

MATERIAL:
CONCRETE & S/STEEL

WEIGHT: Kg

ENVIRO

TITLE:
ENVIRO H30
SITE INSTALLATION

DRAWING NO: ENV-TEC-H30-000-3

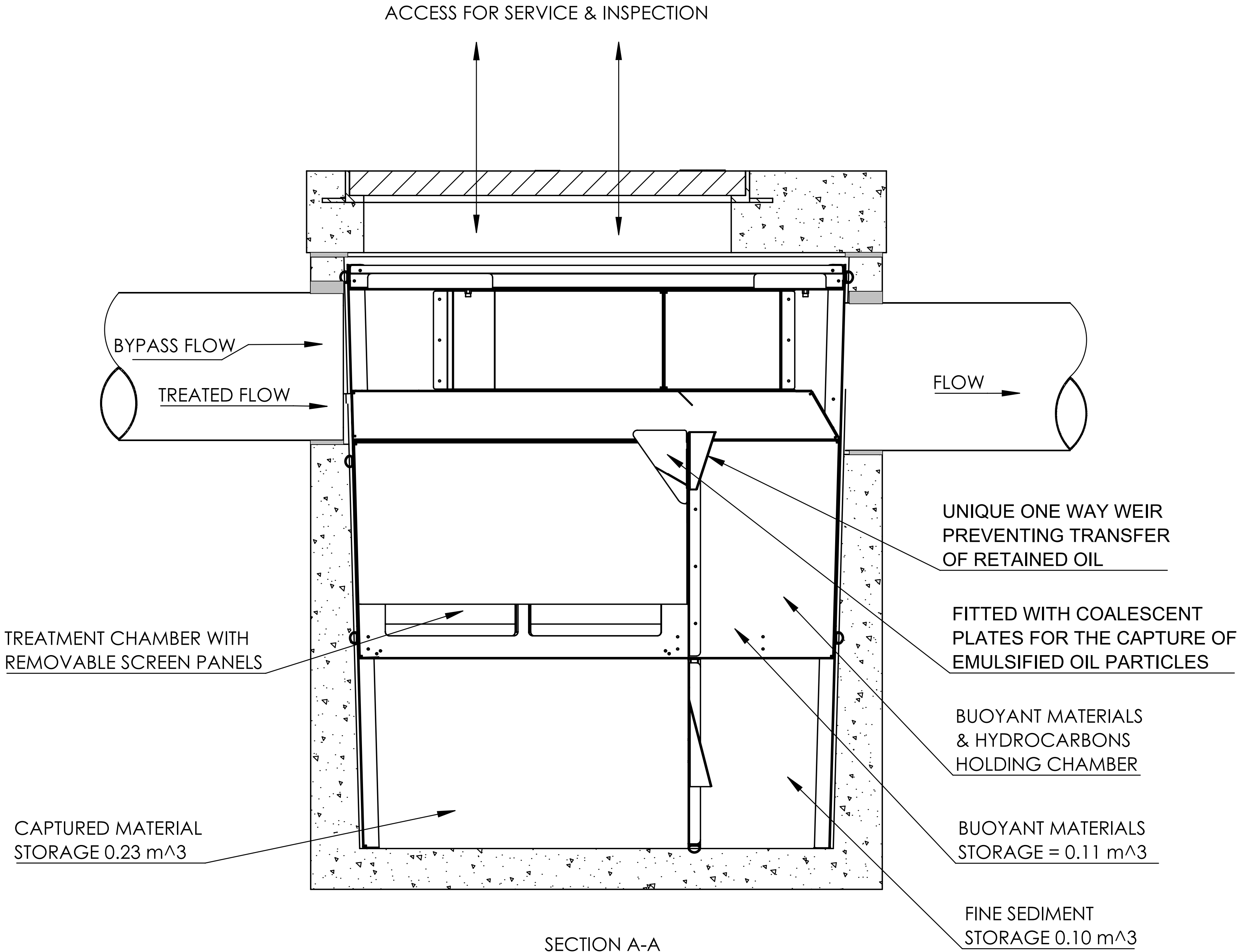
ASSEMBLY:
H30

A3

REV: R3

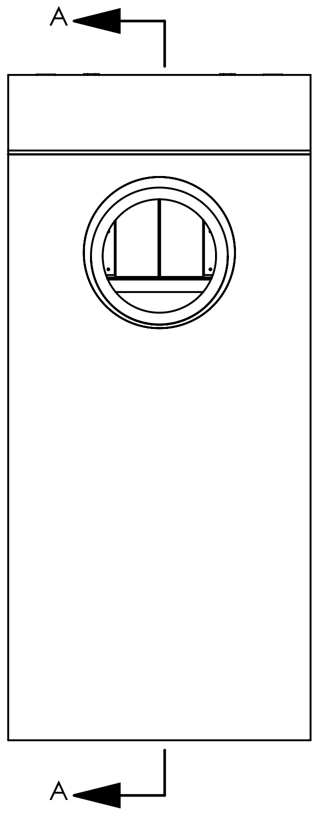
SCALE: NTS

SHEET 3 OF 4



SECTION A-A

TOTAL STORAGE CAPACITY = 0.44 m ^3



MANUFACTURING GENERAL SPECIFICATIONS
CONCRETE- 32 mpa (minimum)
REINFORCEMENT- SL81, CENTRAL
WALL THICKNESS- 100mm (minimum)

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS	
BENDING RADIUS	K - FACTOR
PREPARED BY	Logesh S
CHECKED BY	LR
APPROVED BY	LC
DATE	29-Dec-22

ENVIRO

TITLE:
ENVIRO H30
GENERAL OPERATION

DRAWING NO: ENV-TEC-H30-000-4

MATERIAL:
CONCRETE & S/STEEL

ASSEMBLY:
H30

A3

REV: R3

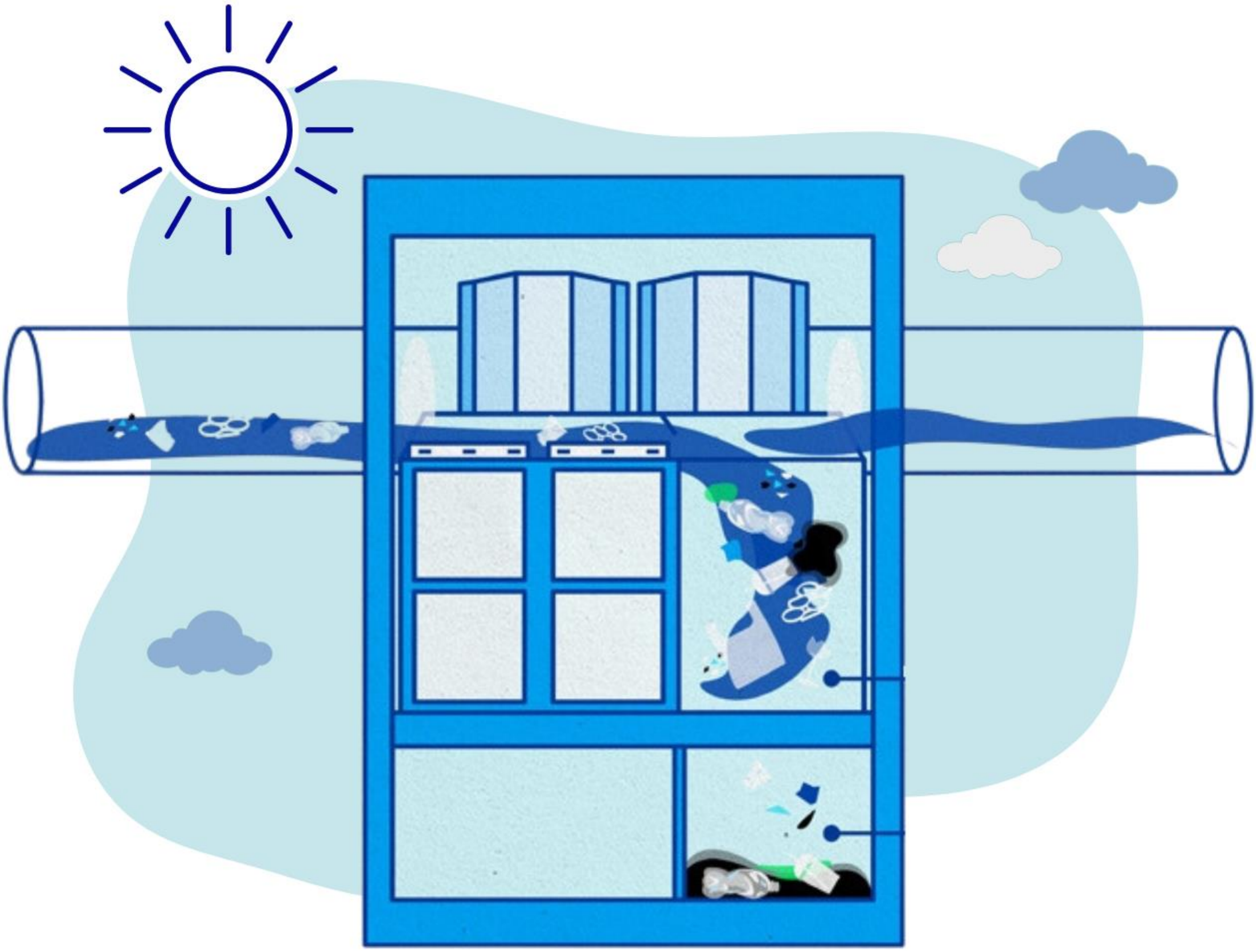
WEIGHT: Kg

SCALE: NTS

SHEET 4 OF 4

ENVIRO

STORMWATER TREATMENT SOLUTIONS



TECHNICAL MANUAL

VERSION 5

GOOD DESIGN AWARD®
WINNER

About Enviro Australis

Enviro Australis Pty Ltd (Enviro) is a South Australian owned and operated company. Many years of research and considerable financial investment have resulted in the development of revolutionary fully integrated stormwater pollution control systems which remove the broad spectrum of pollutants and include devices specifically designed for oil/water separation for catchments where a risk of oil spillage exists.

Enviro is a passionate specialist company supplying Environmental Protection Systems that are compliant with current Australian and International legislation. Enviro prides itself on providing systems that are low cost to install, service and maintain. Enviro EPS are unique world-first integrated devices that replace a treatment train. One Enviro device can remove gross pollutants (trash and litter), sediments (fine and course), nutrients and oils. All Enviro systems are **independently tested** and **approved.** For example; the oil/water separation process that Enviro developed was independently certified to comply with the strictest European Standard EN858-1.

Australia has adopted the term “Gross Pollutant Trap” or “GPT” to describe stormwater treatment, but Enviro has taken a different approach. Enviro devices capture the full range of contaminants and have adopted the term “Environmental Protection System” or “EPS”, to differentiate from gross pollutant traps that represent only 30% of the pollutant spectrum. This is driven by recognising that Australian Environmental Protection Legislation lists pollutants that are deemed unlawful to discharge into stormwater drains.

Enviro also has solutions for the reduction of biological oxygen demand (BOD) and enrichment of dissolved oxygen (DO) in wetlands to support the principles of Water Sensitive Urban Design (WSUD).

Introduction

Enviro’s intention is to provide stormwater pollution control that is in line with environmental protection policy and legislation, i.e. the total pollution load (as defined in legislation) discharged from urban development must be reduced in accordance with set reduction targets.

Enviro EPS are designed to suit the type and load transported by storm water from a catchment. This is the primary selection criterion to determine the series required. The model within each series is then sized to suit treated flow, WSUD and structural duty.

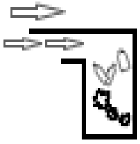
The aim of this Technical Manual is to provide one source of reference material that encapsulates the research, development and testing conducted over more than ten years.

The manual describes:
- The application of Enviro EPS
- Performance testing and validation; and
- Some of the processes evaluated during the development phase.

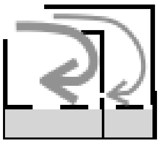
Supporting documents and references to substantiate the Enviro approach are included as appendices.

Major Benefits

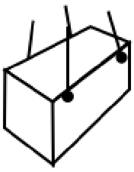
① Permanently retain all buoyant materials via a one-way trap, not relying on a barrier



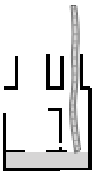
② Separate materials and prevent churning

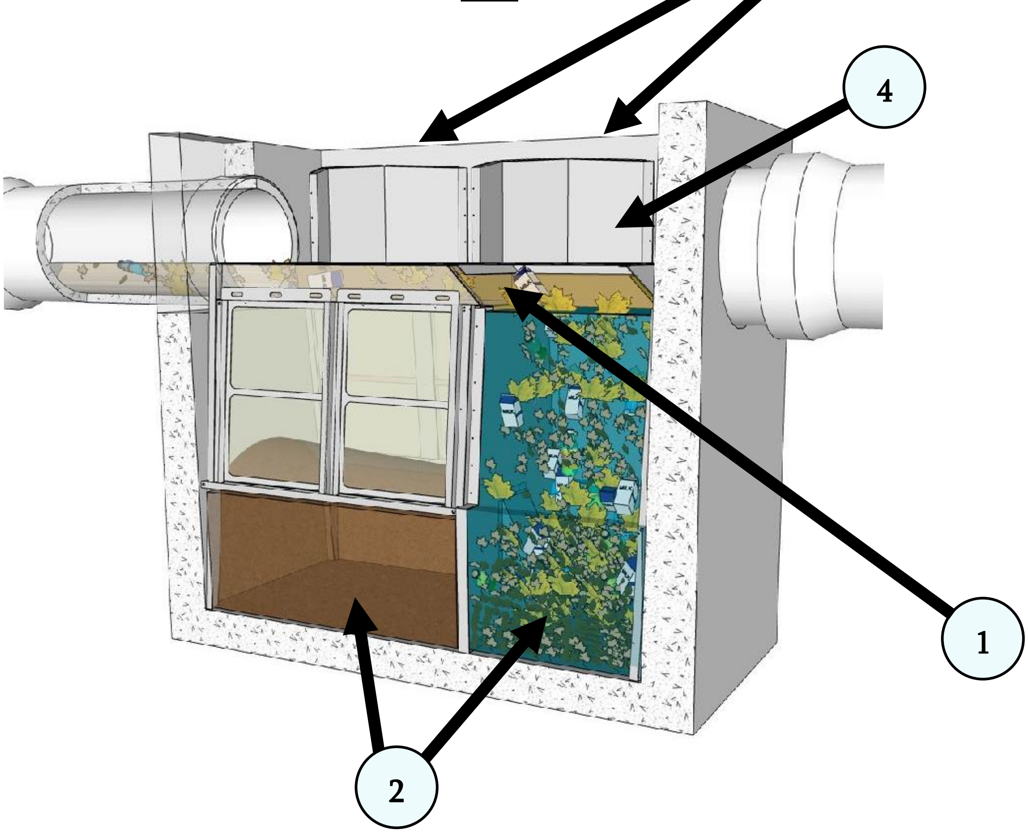


③ Ease of installation



④ Ease of service with one operator and vehicle





Environmental Protection Authorities (EPA) refer to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) and have in turn enacted legislation that prohibits discharge of pollutants into stormwater. Each state is responsible for administering the legislation; however, the principles are common, and a list of pollutants is readily available. In principle, the aim of the legislation is to remove anthropogenic impact by requiring large reductions in synthetic materials in stormwater, while allowing some nutrients to be discharged at similar concentrations to natural background levels.

Enviro continues to refine and develop processes aimed at meeting current legislation and is passionate about the environmental impact of stormwater pollutants.

TABLE OF CONTENTS

1 Technical Manual Summary

The Enviro EPS is a fully integrated in-line range of devices for removal of pollutants from stormwater.

Environmental protection, under legislation and as part of our social responsibility, demands that anthropogenically generated pollutants are **removed before** run-off water enters receiving waters.

In the development phase Enviro's approach was to:

1. Define pollutants
2. Understand the nature of pollutants
3. Research the source and associated characteristics
4. Develop and test processes for removal, storage and safe handling of pollutants
5. Consider all of the above with regard to ease of manufacture, installation, service and life expectancy

1.1 The Final Result

With more than a decade of combined development and field experience, Enviro's range of Environmental Protection Systems (EPS) represents world-leading technology, backed by performance. Designed and manufactured in Australia, these systems are available nationally.

Pollutant groups extend well beyond gross pollutants, which are typically related to gross pollutant traps (GPTs).

The resulting Enviro EPS design removes the broadest range of pollutants that compromise aquatic ecosystems. Where required, Enviro can also supply solutions to reduce Biological Oxygen Demand (BOD) and increase Dissolved Oxygen (DO).

1.2 Enviro EPS Range

The Enviro EPS range is divided into three levels, providing systems that are suitable for anticipated load, being mindful of installation and service costs. The EPS series has multiple functions to suit catchment load discharge varying from low impact to high impact where oils (hydrocarbons) may spill.

Performance is validated through rigorous stress testing conducted by independent experts. This methodology aligns with industry standards that necessitate long-term proof of performance. The stress testing simulated worst-case scenarios over repeated events, effectively replicating the equivalent to two years of service.

Pollutant groups and test results are in the following table:

Oil removal as per EN858-1	**99.95%**
Gross pollutants	**100%**
Suspended solids	**86%**
Total Nitrogen	**85%**
Total Phosphorous	**97%**

The breakdown of catchment activities and the suitable EPS series is summarised as follows:

	EPS Series		
CATCHMENT	**H**	**E**	**G**
Residential housing – low to medium density	✓	✓	✓
Traffic, passenger vehicle – low density	✓	✓	✓
Residential – high density	✓	✓	
Discharge to sensitive water body or wetlands	✓	✓	
Transport vehicles	✓	✓	
Commercial and retail	✓	✓	
Industrial activity	✓	✓	
Transport terminal	✓		
Fuel handling and chemical process	✓		

The EPS range is primarily an "at source" stormwater pollution control system. The "at source" term refers to discharge generated from a new development that does not include extensive hinterland activity which may extend time lag periods from internal wetlands. The latter are accommodated by "end of pipe" solutions that are custom designed to suit the specific requirements and characteristics of the catchment.

2 Enviro Performance

A critical part of development of the Enviro EPS was understanding the source and nature of pollutants transported by stormwater run-off to the treatment location.

Some of the above is detailed in the publication, *Balanced Urban Development: Options and Strategies for Liveable Cities.* Enviro's Director of Engineering, Leo Crasti was a contributing author to this publication. Refer extract Appendix 1

The following summarises the research which is also illustrated in Fig 2.1

- "Gross pollutants" is a term that generally describes trash and litter. Enviro has determined that this category includes items sized down to 0.5mm and should be limited to a large size of 150mm in the minor dimension as this is the nominal opening of kerbside drains. If larger items may be transported, some custom designing can be applied.
    - **Trash** is defined as anthropogenic, in that it was not part of a natural environment and includes a wide range of materials such as polystyrene, PVC, cardboard etc. Most of these exhibit buoyant properties and are subject to breakdown, particularly if exposed to constant churning. The Enviro process is to separate these materials into a holding chamber, to avoid churning and breakdown.
    - **Litter** is defined as materials that are organic in nature, such as grass clippings and similar. Although these are mostly not recognised as pollutants, the excessive raw state overdoses receiving waters and stresses DO levels. Litter and animal excrement are also major contributors to nutrient overload. These materials also exhibit buoyant properties and are separated in the EPS (E and H Series) in a separate chamber to avoid churning, bio-release and remobilisation.
    - Testing showed 100% retention of this category.

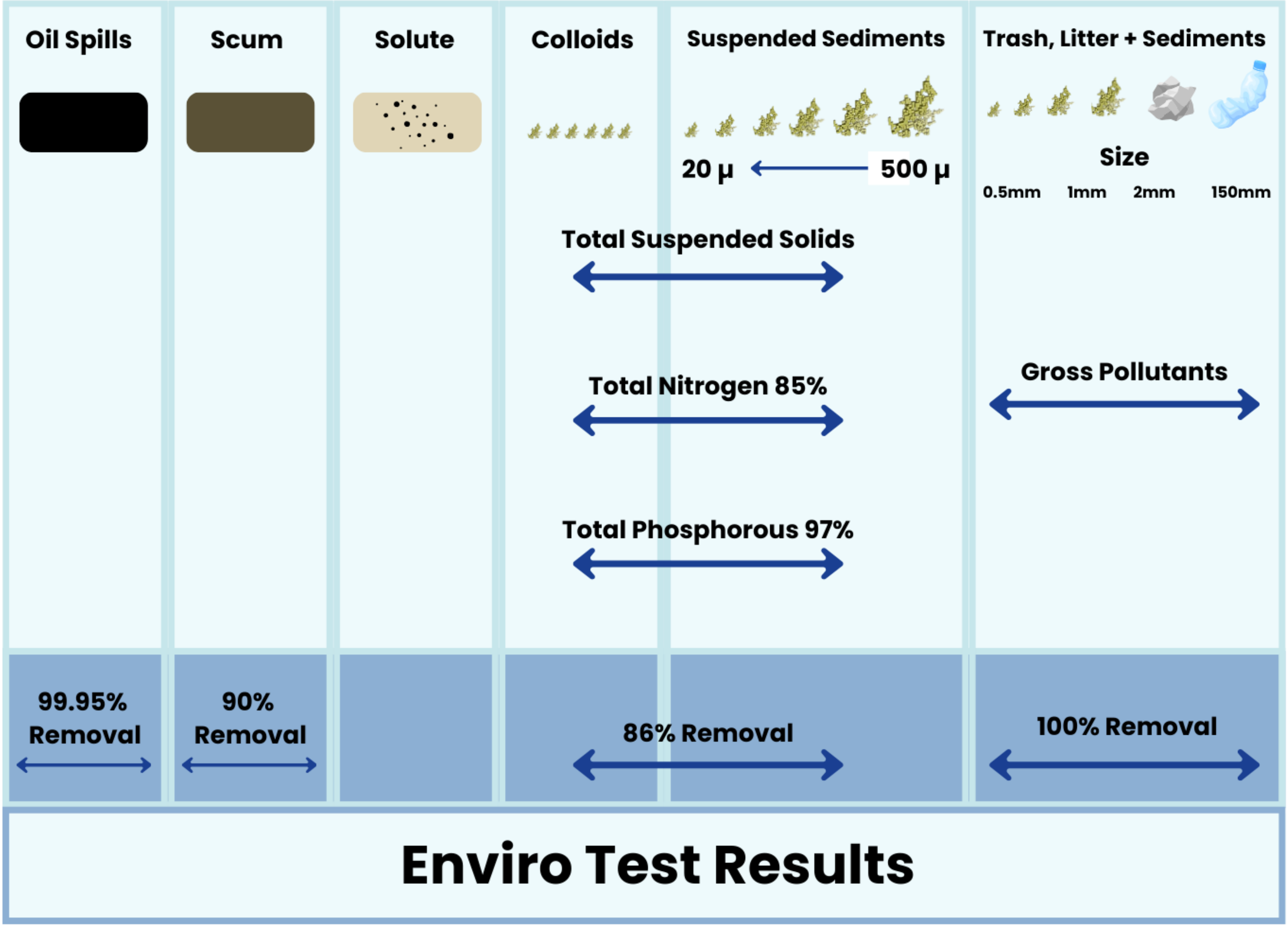
- **Sediment** covers a wide range of fine materials transported by stormwater. Although sediments in the natural environment produce rich alluvial soils, unfortunately sediment generated from an urban (built) environment are quite different. Rubber from tyres, dust from brake linings and particulates from industrial exhausts are some examples of the origin of sediment.

- Most of this particulate matter includes toxic chemicals and nutrients that need to be excluded from indigenous sediment beds created prior to urbanisation. Enviro has applied its best effort to reducing discharge of sediment and defined this particulate matter as less than 500 microns in size.
    - Removal of these fine sediments was tested at a size range where 90% was below 500 microns (Refer to Section 7).
    - Enviro's proprietary process utilises a combination of hydraulics and three-dimensional screening to separate fine particles from the flow and deposit these in a quiescent storage zone.
    - Very fine particles are transferred into a separate chamber where settlement may occur over an extended period of time.

- Nutrients of concern are **nitrogen (N)** and **phosphorous (P)**. In nature, P exists in very low concentrations while N is abundant as it is used to form most of the bio-mass on the planet. The source of P in run-off is of anthropogenic origin and is mostly discharged through the sewer system. The source of N is wide-spread – (Refer to Section 8)
    - Although solute forms of N are readily available, the source should be limited, and therefore substantially reduced in the catchment design. These solute forms of N are transitional in the N cycle and should not appear in significant concentrations at a treatment location. Solute forms may well be generated once water flows into permanent water bodies where release will occur.
    - EPS performance does not include removal of solute forms of nutrients. Adsorption by media was found to be ineffective due to blinding by fine sediment. Removal of fine sediment proved to be more reliable for most catchments. Alternatives are available for removal of dissolved forms of nutrients as required.

2.1 Enviro Test Results

The diagram below shows test results achieved by Enviro for separation of the different pollutant groups. *Refer Appendix 2*



3 EPS Series Explanation

3.1 G Series – Low-cost device intended for low impact catchments such as Residential areas

- The Enviro G Series is an in-line single chamber device designed to remove the broad spectrum of pollutants transported by stormwater run-off water in low impact catchments, typically residential developments.
- The G Series as a single device that replaces the conventional GPT which is part of a treatment train.
- Suitable for low impact catchments, typically residential developments.
- Other aspects are as detailed in the E Series with exception of incidental oil removal.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro G30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.25 m^3	1.2m x 0.9m	1.2m	2.6 tonnes	1.7 m^3
Enviro G45	450mm ID	66 litres/sec 0.52 m^3	1.5m x 1.2m	1.4m	4.6 tonnes	3.3 m^3
Enviro G60	600mm ID	142 litres/sec 0.87 m^3	2.2m x 1.2m	1.8m	7.5 tonnes	6.2 m^3
Enviro G75	750mm ID	258 litres/sec 3.2 m^3	2.85m x 1.95m	2.2m	13.3 tonnes	15.9 m^3
Enviro G90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity.	419 litres/sec 3.3 m^3	3.6m x 1.95m	2.0m	15.8 tonnes	18.3 m^3
Enviro G120	1200mm ID	902 litres/sec 3.0 m^3	3.6 m x 2.1m	1.8m	16.3 tonnes	10.3 m^3

Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500μ
Nominal particle size capture	100μ
Design service life	100 years
Fully removable internal screens	

The above table shows the percentage reductions based on test results.

Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of $1m^3$/ann based on ARQ section 3.7.

3.2 E Series – General-purpose device for Commercial and Industrial catchments

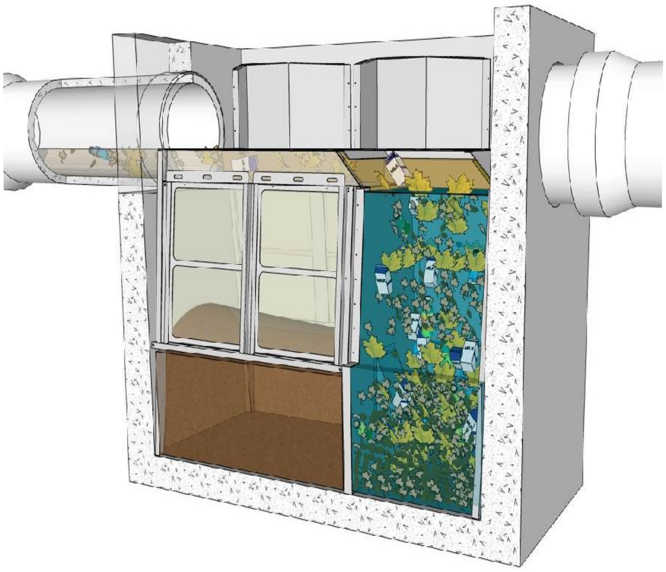
- The Enviro E series is an in-line multi-chamber device designed to remove the broad spectrum of pollutants transported by stormwater run-off water from high impact catchments, typically where commercial and industrial activities are carried out.
- Removes incidental oil/fuel spillage as well as gross pollutants, sediment and nutrients.
- Pollutant groups are separated and contained in separate zones for removal.
- Independently tested and accredited by University of South Australia, with supporting analysis and verification by University of Sydney.
- Compliant with all current required legislation.
- Arrives fully assembled, ready for easy installation.
- Minimal excavation and backfill required.
- No concrete slab or tie downs required.
- Multiple processes in one unit – replaces a conventional treatment train.
- Servicing and maintenance is required once per 12 months, with use of any local qualified contractor with vac truck.
- Removable screens for cleaning, and common to all systems.
- Separate waste storage location prevents scouring and remobilisation.
- Designed to store 12 months load in accordance with ARQ 3.7 for ease of maintenance and servicing.
- Hydraulic flow is managed to ensure particles do not become attached to the screens and settle into the lower chamber.
- Separate storage chamber below the processing section, in a quiet zone, prevents scouring and remobilisation.
- Personnel are not required to enter the device for cleaning, making Enviro a safer system. Entry into any device is defined as entering a confined space and requires specialist training and entry permits.
- Can be legally transported without special conditions.
- Internal components are not welded to avoid potential corrosion.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro E30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.23 m^3	1.5m x 0.9m	1.2m	3.2 tonnes	2.2 m^3
Enviro E45	450mm ID	66 litres/sec 0.45 m^3	2.2m x 1.2m	1.4m	6.1tonnes	4.9 m^3
Enviro E60	600mm ID	142 litres/sec 0.85 m^3	2.8m x 1.2m	1.8m	9.3 tonnes	7.9 m^3
Enviro E75	750mm ID	258 litres/sec 3.1 m^3	3.6m x 1.95m	2.2m	16.1 tonnes	20.1 m^3
Enviro E90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity	419 litres/sec 3.2 m^3	4.35m x 1.95m	2.0m	18.6 tonnes	22.1 m^3
Enviro E120	1200mm ID	902 litres/sec 5.2 m^3	4.35m x 2.1m	1.8m	19.2 tonnes	22.0 m^3

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro E130	1300 mm ID	1285 litres/sec 6.7 m^3	5.1m x 2.4m	1.7m	23.9 tonnes	25.0 m^3
Enviro E180	1800 mm ID	2570 litres/sec 13.4 m^3	9.5m x 5.1m	1.65m	87.3 tonnes	56.0 m^3

Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Hydrocarbon removal	90%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years
Fully removable internal screens	

The above table shows the percentage reductions based on test results.



Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of 1m^3/ann based on ARQ section 3.7.

3.3 H Series – High Impact catchment with risk of oil spillage and/or sensitive wetlands

- This is our optimal environmental protection system for **high impact catchments** where there is likelihood of oil spillage and/or downstream sensitive wetlands that need to be protected.
- The Enviro H series has been independently tested and certified in accordance with EN858 – 1 Class 1 by UniSA and process verification by Manly Hydraulics Laboratory.
  Refer test report Appendix 3
- This EPS is an in-line, multi-chamber and multi-zone system that includes oil/water separator functions.
- All other functions are as detailed in the E Series.

Model	Pipe Size	Treated Flow and Storage Capacity	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro H30	Nominally 300 ID. Can be used for 375mm ID subject to gradient and velocity	22 litres/sec 0.6 m^3	1.5m x 0.9m	1.2m	3.2 tonnes	3.2 m^3
Enviro H45	450mm ID	66 litres/sec 1.3 m^3	2.2m x 1.2m	1.4m	6.3 tonnes	6.1 m^3
Enviro H60	600mm ID	142 litres/sec 2.0 m^3	2.8m x 1.2m	1.8m	9.9 tonnes	9.3 m^3
Enviro H75	750mm ID	258 litres/sec 7.7 m^3	3.6m x 1.95m	2.2m	16.9 tonnes	16.1 m^3
Enviro H90	Nominally 900 ID. Can be used for 1,050mm pipe size subject to gradient and velocity	419 litres/sec 8.1 m^3	4.35m x 1.95	2.0m	19.2 tonnes	18.7 m^3

Oil removal as per EN858-1	99.95%
Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Other factors include:	
Treated flow of pipe diameter[1]	30%
Hydraulic resistance, k factor	0.425
Nominal service intervals [2 & 3]	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years

The above table shows the percentage reductions based on test results.

Note 1: Treatment continues after this level is exceeded enabling capture of higher density materials transported by increased energy in flow resulting from higher rainfall intensity.

Note 2: Additional storage of a further 1.4 m^3 is available before unit performance is compromised.

Note 3: Load volume allowance of 1m^3/ann based on ARQ section 3.7.

3.4 OE Series – High Risk catchment with risk of bulk oil spillage

- High risk catchments typically include the handling, storage and dispensing of total petroleum hydrocarbons (TPH). This may also extend to other chemicals.
- The bulk spill volume can be adjusted to suit the assessed risk volume which may vary from 0.5 to 20kL in one (1) device. Larger bulk spill volume can be provided (M Series).
- The Enviro OE series includes the H Series oil/water separator insert which has been accredited to EN858–1.
- Included is a reservoir which functions as a secondary oil scum removal. A 2m deep water trap provides a secondary polishing process, reducing the potential for TPH presence in the outflow.
- The reservoir also acts to contain bulk oil spills by causing the oil to displace water, relying on the natural differential in density.
- The OE Series are full retention separators for the oily water stream. The remainder of catchments may also be treated by applying a flow control chamber ahead of the nominated device.
- The insert retains its feature of being a multi-chamber and multi-zone with an intermediate coalescent plate separator to achieve EN858-1 compliance.
- All other functions are as detailed in the H Series.

Model	Pipe Size	Treated Flow & Sediment Storage	Bulk Spill Capacity (Litres)	Plan Dimensions (external length x width)	Depth Below Invert	Mass	Excavation Volume
Enviro OE30	Nominally 160mm HDPE	22 litres/sec 0.33 m^3	11,242L	2,870m dia	2.15m	8.6 tonnes	16.9 m^3
Enviro OE45	Nominally 225mm HDPE	66 litres/sec 0.76 m^3	11,064L	2,870m dia	2.11m	9.6 tonnes	16.9 m^3
Enviro OE60	Nominally 315mm HDPE	142 litres/sec 1.33 m^3	10,471L	2,870m dia	2.02m	10.2 tonnes	16.9 m^3

Oil removal as per EN858-1 [2]	99.95%
Gross pollutants	100%
Suspended solids	94%
Total Nitrogen	85%
Total Phosphorous	97%
Total Secondary Oil Removal [3]	99.99%
Bulk Spill Containment	10,000L
Treated flow of pipe diameter [1]	100%
Hydraulic resistance, k factor	0.425
Nominal service intervals	1year
Maximum particle size by-pass	500µ
Nominal particle size capture	100µ
Design service life	100 years

The above table shows the percentage reductions based on test results

Note 1: The OE Series is a full retention separator with no bypass.

Note 2: The internal processing cartridge complies with EN858-1which acts as the primary oil/water separation function.

Note 3: Water discharging from the insert exits as a laminar flow allowing any residual scum to be captured by a 2m deep water trap acting as a secondary oil removing function. Typically, this will remove all residual oils.

4 Enviro Series and Size Selection Guide

The Enviro EPS range is divided into three catchment load/risk categories with the final model selected based on pipe size, treated flow and enclosure load requirements. There are other selection criteria to suit other stormwater issues such as OSD and other site related factors.

The following guide will assist in determining a recommended EPS. For further technical support contact Enviro's team of Engineers – info@enviroaustralis.com.au or via our website www.enviroaustralis.com.au

Project Details

- Project name and details

Catchment Characteristics

- The pollutant type and load concentration from the catchment will determine which EPS level of pollution control is required
- A brief description should define whether activities in the catchment would be regarded as being of low, medium or high impact on the downstream receiving waters

Select EPS Series

Enviro EPS System	**H**	**E**	**G**
Residential Housing Low/Medium Density	✓	✓	✓
Traffic, Passenger Vehicles, Low Density	✓	✓	✓
Residential, High Density	✓	✓	
Discharge to Sensitive Water Body or Wetlands	✓	✓	
Transport Vehicles	✓	✓	
Commercial and Retail	✓	✓	
Industrial Activities	✓	✓	
Transport Terminal	✓		
Fuel Handling and Chemical Process	✓		

Review Treated Flow

- Treated flow has no fixed parameter. It is defined as the volume of water that flows across a catchment and transports at least 90% of the pollutants; and preferably 100% of gross pollutants (*refer ARQ 2.4.2*)
  Refer to Section 5.1

Pipe Diameter

- All EPS models are initially sized on the pipe diameter
- Treated flow is set at 30% of pipe depth
- If the treated flow of the initial model selection is insufficient, select the next larger size with increased treated flow

Flow Rate

- Flow rate refers to the gross flow for 'as designed' pipe diameter and gradient. This will vary subject to flood design conditions for that catchment

Flow Velocity

- Flow velocity is also a consideration. The velocity should, where possible, be limited to 3m/sec. If flow velocity cannot be managed with the drainage system, some custom design may be required

Confirm performance compliance MUSIC Node	• MUSIC modelling provides an assessment of treatment effectiveness and compliance. *Refer Appendix 4* • Enviro MUSIC Nodes have been independently developed to ensure transparency and avoid any conflict of interest that results from self-certification
Further application considerations	• The following are other design issues that may need to be considered prior to finalising the selection of an Enviro EPS
On-site Detention Integration (OSD)	• OSD's are generally applied as a flood mitigation measure, by which post-development flow is intended to be similar to pre-development flow • Where possible, an EPS should be positioned ahead of an OSD to avoid the OSD becoming part of a treatment train • Enclosed OSD's also become confined spaces and are subject to appropriate safety provisions before entry. *Refer Appendix 1 Section 6.4* for further information
In-line Installation	• All EPS devices are designed to be in-line installations. This avoids the cost and performance compromise associated with off-line installations. Diversion weirs are subject to the hydraulic jump phenomenon and introduce flow restriction issues
Submerged Potential	• EPS models can be configured to operate in submerged conditions such as may apply when pavements are contoured, to act as detention basins or where periodical flooding may occur
Tidal and Backwash Potential	• Backwash caused by water drainage design or tidal influence can also be accommodated and is subject to customised review

5 Treated Flow

5.1 The most important design parameter for determining size and type of SQID

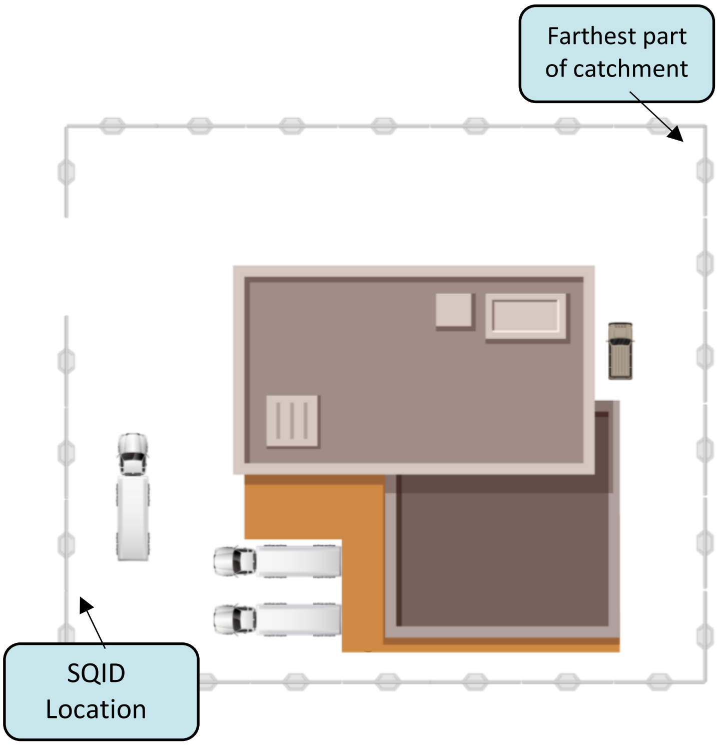
Treated flow is one, if not **the** most important design parameter in determining the size and type of a Stormwater Quality Improvement Device (SQID).

The following is a simple method of estimating treated flow:

1. Determine the longest drainage leg on a time basis
2. Calculate flow volume at the proposed SQID location factored by time lag
3. Apply that flow as the minimum flow that should be treated

The following diagrams illustrate the treated flow determination process. For further information *refer to Appendix 1 Section 6.2.2*

Fig 5.1.1 Illustrates a typical warehouse property with drainage lines servicing impervious yard and roof areas.



As rainfall begins, water level rises across the catchment and induces flow overland, gathering contaminants before flowing into drains.

Water volume collected at pit P1, P2 and P3 are approximately equal at this stage, subject to the area serviced by each pit. *Refer Fig 5.1.2.*

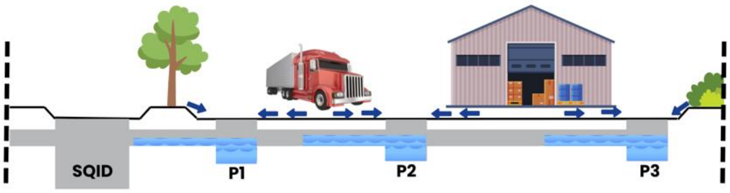


Fig 5.1.2

As rainfall continues, the volume of upstream water aggregates with P1 and P2 merging before water from P3 merges with P2 and ultimately to P1 and the SQID.

During the time lag for P3 water to reach the SQID, additional water volume has also been fed into the drainage system via P1 and P2. This defines the value of Treated Flow which needs to pass through the SQID to achieve the percentage reduction targets.

This latter flow rate needs to be the treated flow. *Refer Fig 5.1.3.*

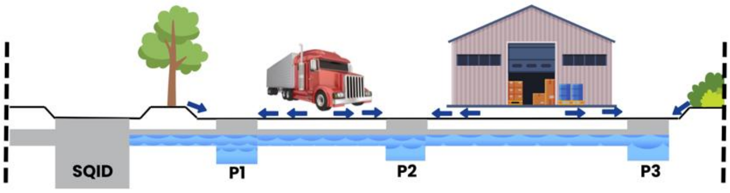


Fig 5.1.3

5.2 The Physics of Treated Flow

Fundamentally, treated flow occurs when there is sufficient energy in the water flow to transport the materials surrounded by that water.

If water falls on porous (pervious) surfaces, water is unlikely to surround those materials. The result would be wet stationary materials. This condition remains for as long as the rate of infiltration exceeds the rate of rainfall. Once the rate of rainfall exceeds infiltration, run-off begins.

The starting point for run-off will vary depending on the surface porosity (permeability), roughness and gradient.

The driving factor is to determine run-off energy. Energy is available in two forms.

Firstly, the explosive energy of rain drops striking the surface mobilises materials, in particular, smaller sized materials such as sediment.

The next available energy is wind, creating a horizontal force. The greater prevailing form of energy is gravitational energy, creating a force to cause water to flow, relative to gradient.

The final component of treated flow is duration (time) required for the flow to transport the material at source to the point of separation and retention.

Refer images 1,2 and 3 for flow stages example.

Treated flow determination is generally expressed in rainfall, as intensity and/or depth. Therefore, to determine treated flow, **both** factors need to be considered.

There is no fixed standard by which treated flow is determined. The range of variables are diverse, complex and unique to a catchment at the time of a rainfall event.

Engineers need to be mindful that they are ultimately responsible for compliance with Environmental Protection Legislation, that has provisions for prosecution. Though suppliers of Stormwater Quality Improvement Devices (SQID's) are responsible for performance claims, Engineers (designers/specifiers) are responsible for catchment related factors; and in particular treated flow.

Further information on treated flow and determination factors is available in Balanced Urban Development, Chapter 6, by Leo Crasti and the included references. *Refer Appendix 1.*

Image 1

Image 2

Image 3

5.3 Treated Flow and Enviro EPS Devices

Enviro G Series are single chamber, in-line devices for capture and retention of pollutants as defined by the ARQ Section 8.5.

Enviro E Series are multi-chamber devices with increased storage capacity and ability to capture fine sediments below 53 microns, along with incidental oils.

One objective of Environmental Protection Authorities (EPA's) worldwide is to have all anthropogenically generated contaminants removed from catchment run-off. That expressed in other terms, is that the load from 100% of catchment should be reduced or removed. The percentage reduction targets are based on the whole catchment.

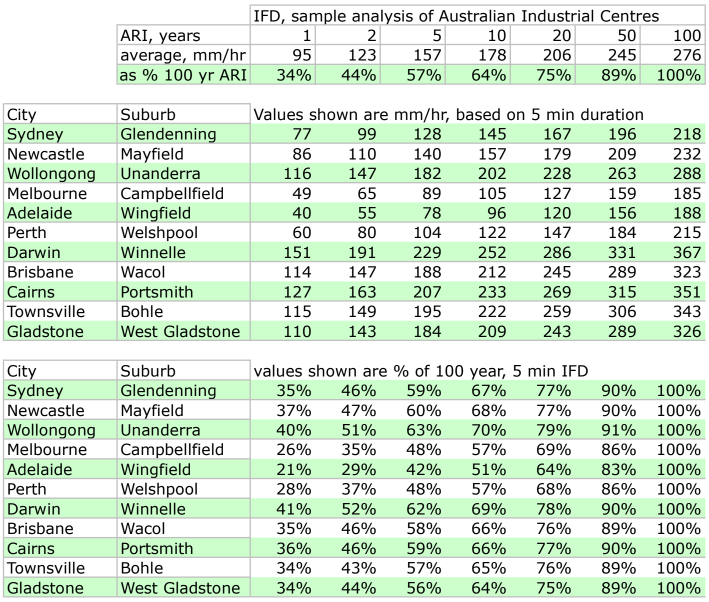
Treated flow is the portion of run-off that passes through a device and is therefore treated i.e. water quality is improved.

Stormwater quality improvement is defined as reduction of total load transported from a catchment on an annual basis, not just the reduction achieved through a device.

The Enviro EPS treated flow capacity is based on a 1 year, 5 min IFD, that also follows the recommendations made in the ARQ Section 2.4.2. The ARQ recognizes that a 1 year ARI is regarded as necessary to export up to 90% of the catchment load. This depth and rate based on the AR&R87 IFDs is charted as the 1EY, 5min event.

Note: The treatment of a lesser rainfall event is unlikely to reach 90% transport of pollutants, reducing effectiveness dramatically, and hence compliance of a device set at a lower ARI.

A 1-year ARI treated flow is typically required to compensate for the time lag in drainage pipe runs, enabling the farthest entry pit water to be treated **before** by-pass commences. This has been determined through a review of typical projects and analysis of national BOM data as *shown in Fig 5.3.1.*



	IFD, sample analysis of Australian Industrial Centres						
ARI, years	1	2	5	10	20	50	100
average, mm/hr	95	123	157	178	206	245	276
as % 100 yr ARI	34%	44%	57%	64%	75%	89%	100%

City	Suburb	Values shown are mm/hr, based on 5 min duration						
Sydney	Glendenning	77	99	128	145	167	196	218
Newcastle	Mayfield	86	110	140	157	179	209	232
Wollongong	Unanderra	116	147	182	202	228	263	288
Melbourne	Campbellfield	49	65	89	105	127	159	185
Adelaide	Wingfield	40	55	78	96	120	156	188
Perth	Welshpool	60	80	104	122	147	184	215
Darwin	Winnelle	151	191	229	252	286	331	367
Brisbane	Wacol	114	147	188	212	245	289	323
Cairns	Portsmith	127	163	207	233	269	315	351
Townsville	Bohle	115	149	195	222	259	306	343
Gladstone	West Gladstone	110	143	184	209	243	289	326

City	Suburb	values shown are % of 100 year, 5 min IFD						
Sydney	Glendenning	35%	46%	59%	67%	77%	90%	100%
Newcastle	Mayfield	37%	47%	60%	68%	77%	90%	100%
Wollongong	Unanderra	40%	51%	63%	70%	79%	91%	100%
Melbourne	Campbellfield	26%	35%	48%	57%	69%	86%	100%
Adelaide	Wingfield	21%	29%	42%	51%	64%	83%	100%
Perth	Welshpool	28%	37%	48%	57%	68%	86%	100%
Darwin	Winnelle	41%	52%	62%	69%	78%	90%	100%
Brisbane	Wacol	35%	46%	58%	66%	76%	89%	100%
Cairns	Portsmith	36%	46%	59%	66%	77%	90%	100%
Townsville	Bohle	34%	43%	57%	65%	76%	89%	100%
Gladstone	West Gladstone	34%	44%	56%	64%	75%	89%	100%

Data Supplied By: Australian Government, Bureau of Meteorology

Fig 5.3.1

Fig 5.3.1 is an analysis of rainfall IFD's published by BOM Australia across the major cities and suburbs that attract commercial development.

An assumption is that pipe sizes are set at 100-year 5min IFD. The conclusion drawn from this analysis is that on average, 1 year 5 min IFD is equivalent to 34% of a 100-year 5 min IFD.

Therefore, setting the diverter at a nominal 30% of pipe depth approximates the treatment volume (flow rate) necessary to capture 90% of the total catchment load.

5.4 Treated Flow and Bypass

The **Enviro G and E Series** have the same operating method for internal diversion of water into the treatment chamber. Both devices are in-line and are pre-set to treat approximately 30% of the pipe maximum flow capacity, before by-pass begins.

Fig 5.4.2 shows the flow entry exclusively passing into the process chamber. This is further illustrated in *Fig 5.4.2(a).* The lower portion of the pipe flow is diverted by a horizontal separator into the primary chamber. Materials are collected and deposited into the lower storage chamber where a quiescent state has been created.

Fig 5.4.3 shows how the treatment of flow continues after by-pass commences. The fixed horizontal separator continues to divert the lower portion of the pipe as flow rate and velocity increases. This feature increases the treatment capacity allowing for capture of higher density materials that are transported by the increased energy of higher flow rates and velocity.

Fig 5.4.3(a) further illustrates the ‘over’ nature of the by-pass. Water flows around a central turret installed for ease of access to inspect and service.

Fig 5.4.2(a)

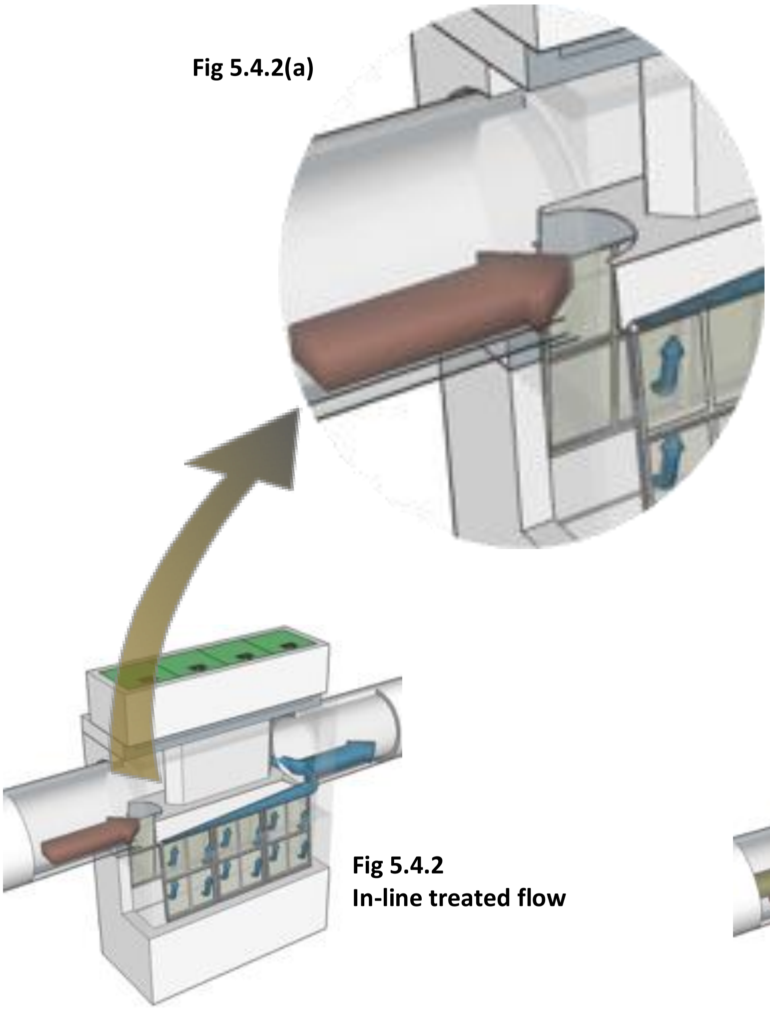


Fig 5.4.2
In-line treated flow

Fig 5.4.3(a)

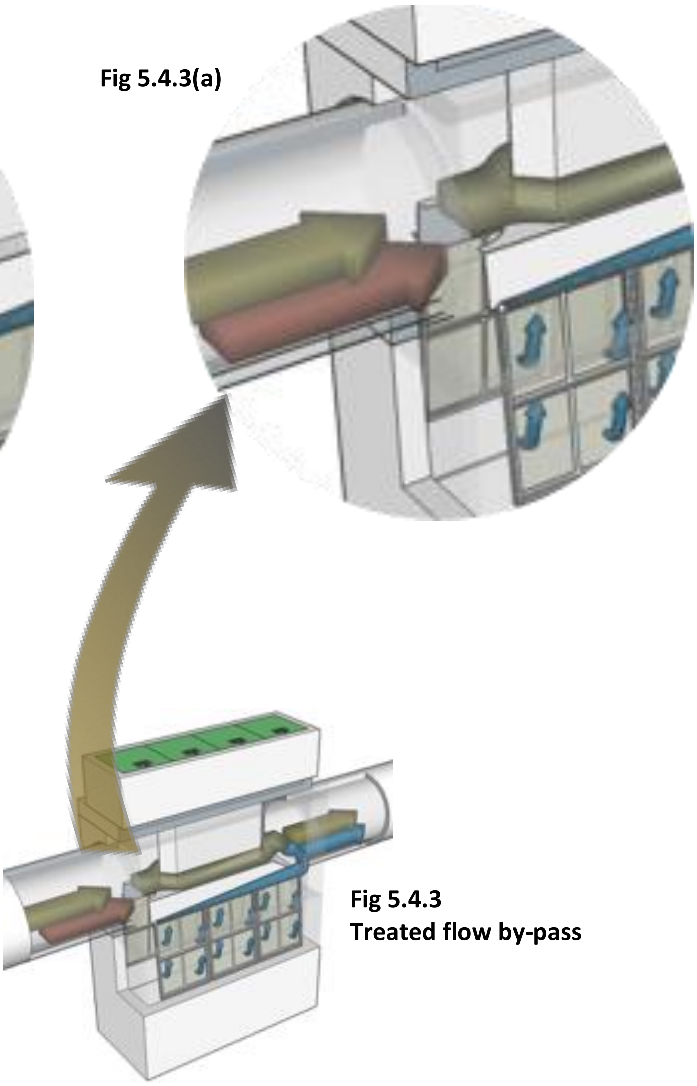


Fig 5.4.3
Treated flow by-pass

The area around the central turret is greater than the pipe area, eliminating hydraulic impedance. Even at trickle flows, re-suspension and remobilization does not occur due to the positive water flow. This feature was noted in the Manly Hydraulics Laboratory testing that reported 100% capture of gross pollutants and no re-suspension.

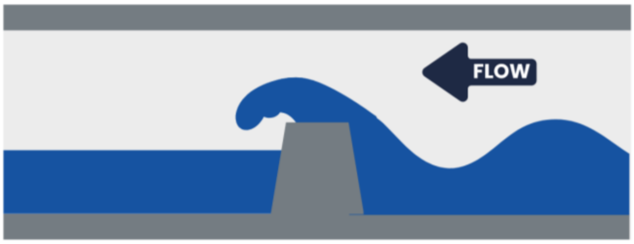
5.5 Off Line Diversion: Issues to be Considered

Though off-line diversion may be used in large custom designed installations, the Enviro EPS standard range are exclusively in-line installations.

Weirs used to divert water are well known to exhibit hydraulic jump properties and subsequent draw through. This is illustrated in *Fig 5.5.1 and 5.5.2*

Fig 5.5.1

Fig 5.5.2



Hydraulic resistance within off-line devices will also influence the critical flow at which hydraulic jump occurs. *Figs 5.5.3, 5.5.4 and 5.5.5* illustrate where elevated hydraulic impedance may occur, as the outflow from an off-line device is returned back to the downstream side of the weir.

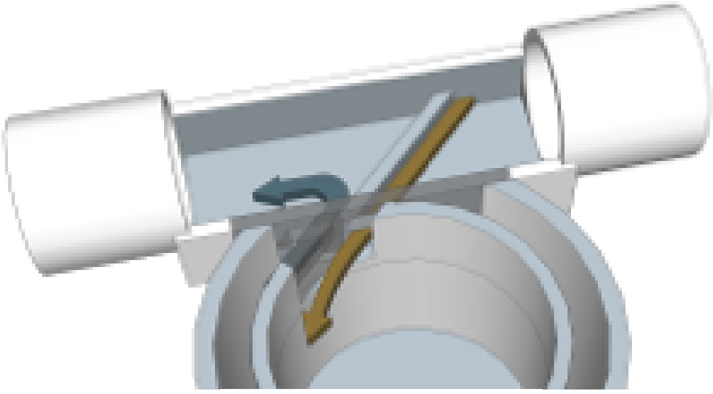


Fig 5.5.3
Off-line treated flow

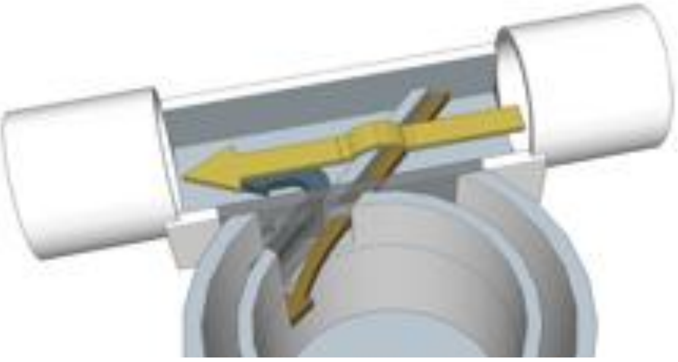


Fig 5.5.4
By-pass begins

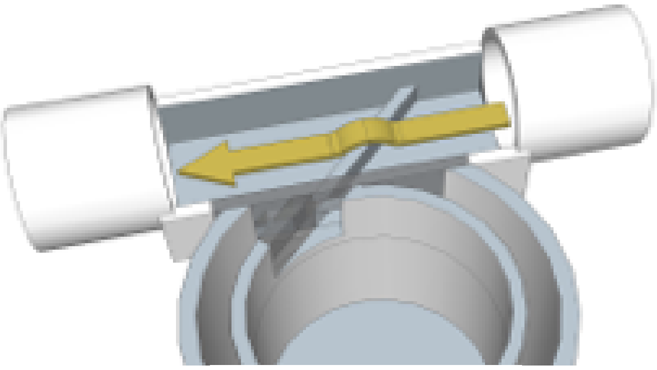


Fig 5.5.5
Total by-pass occurs

Figs 5.5.4 and 5.5.5 illustrate the flow path that is generated as flow increases. The initial stage diverts the flow, however hydraulic resistance of the greater flow path, plus the energy change at the weir causes the main flow height to rise immediately prior to the weir.

A factor often overlooked is that as the flow increases, the differential height across the weir reduces, creating competing factors.

When the hydraulic jump starts, some diversion continues. However, when critical flow is reached, often at 70% of the weir height, the diversion effectively stops, and all flow continues along the main conduit.

6 Gross Pollutants

6.1 A Minor Part of the Pollutant Load Consisting of Trash and Litter

In Australia, removal of gross pollutants has been the focus of stormwater quality improvement devices (SQIDs) for some time. This category of pollutants remains important to be removed, as it is the source of various pollution-related issues that compromise water quality; such as micro-plastics and increased biological oxygen demand (BOD) in receiving waters. Receiving waters need to include natural waterways and water bodies as well as constructed wetlands designed as part of water sensitive urban design (WSUD).

Enviro has divided gross pollutants into two constituents: trash and litter. The reason for this sub-division is to more clearly understand the impact of the two pollutant types.

Trash is not organic by definition. These materials are of anthropogenic origin, consisting mostly of package materials that do not breakdown in a sustainable manner. Plastics now pollute most ocean waters and have been found at depths of 11km. Micro-plastics have now become part of the wider food chain that includes birds and mammals. *Refer Appendix 5*

Litter on the other hand is organic and can be broken down by decomposition that relies on bacterial action. In nature this occurs in leaf litter, soil, ground water and finally in streams, rivers and estuaries before entering oceans.

The urban (built) environment displaces natural surfaces and processes with impervious surfaces causing an overdose of BOD in receiving waters, including oceans. The demand on dissolved oxygen (DO) is extreme, due to the difference between atmospheric availability at 20% and aquatic DO of 5ppm.

Gross pollutants are generally regarded as representing 30% of the gross load discharged from a catchment.

Enviro has classified gross pollutants as being larger than 1.0mm. The process employed to remove particles greater than 1.0mm by default, produced tested results of 100% of both trash and litter removal when the correct level of treated flow has been applied in accordance with the Enviro model selection process.

The photos included *(right)* were taken on 9 January 2019 in Adelaide, South Australia and show the presence of gross pollutants that have bypassed up-stream removal systems i.e. GPTs. Obviously, these have been ineffective.

In 2015, Enviro's Engineering Director, Leo Crasti met with Professor Emma Johnson at the Sydney Institute of Marine Science (SIMS) to express concern about micro-plastics and fibers. Reports on recent research found micro pollutants were accumulating inside the gut of fish removed from Sydney Harbour confirming the need for concern.

Other research also showed the presence of similar pollutants in the intestinal tract of sediment dwellers (benthic organisms) which form the base of the aquatic food pyramid.

In conclusion, the widespread acknowledgment of the need to remove trash and litter larger than 1mm from waterways has significantly influenced the development of the Enviro EPS system. Its innovative multi-chamber design effectively separates these materials from sediments, enhancing environmental cleanup efforts.

6.2 Microplastics Warning

National Geographic posted a warning that microplastics (pieces of plastic smaller than 5mm) are in the food chain and are now regularly detected in food for human consumption.

Microplastics are being studied by various institutions and environmental groups with findings such as:

- Micro plastics float (travel) in ocean currents and carry bacteria from region to region, altering the micro-organism population.
- They become micro-sponges attracting chemicals that accumulate in lower food chain organisms. Hence, it may not necessarily be plastic in the food chain that is harmful, it may be the chemicals around and within the particles.
- *Refer to Appendix 5* for further insight

Enviro has taken this into consideration and has applied the principle that if possible, all trash should be removed at source.

Enviro systems are designed to **remove all particles**, at minimum 0.5mm and greater. Smaller micro beads are present in waste water; generally present in cosmetics and household products. The risk of plastics entering oceans via storm water will be eliminated with an Enviro EPS applied at source.

Image: Micro plastics found on beaches

7 Sediment

7.1 The Major Transporter of Toxic Chemicals and Nutrients

Enviro has researched sediment and identified the importance of removing sediment generated from urban catchments.

Historically, in an undisturbed environment, sediment which has eroded from land surfaces, is transported to form deep beds of rich alluvial plains and fertile marine beds. This process is gradual and involves integrated processes of organic matter conversion by microorganisms and plants that produce low levels of nutrient content in the sediment.

However, in urban catchments (built environments) comprising of impervious surfaces, run-off water and the content of sediment has changed. Sediment includes raw un-processed organic material and chemicals, previously not present in these types of areas.

The photos opposite, were taken on 20 January 2019 in Adelaide, South Australia, showing the presence of gross pollutants mixed with substantial deposits of sediment. There are clear indications of nutrient release as water levels diminish and water temperature elevates. The presence of increased algal activity with raised water temperature and reduced depth is mostly misunderstood. The cause, or trigger is a combination of:

- Increased nutrient levels
- Reduced DO as a result of elevated water temperature due to natural reduced saturation as water temperature increases
- Stagnation, preventing DO replenishment

It is estimated that sediment accumulation in this catchment discharge stream exceeds 100 tonnes per annum.

Remediation, in the form of dredging will need to be carried out in the foreseeable future unless accumulation is mitigated.

Enviro's technology has been designed to remove sediment, reduce biological oxygen demand (BOD) and increase dissolved oxygen (DO) in catchments such as that shown in the photos to the *right*.

7.2 The Nature of Particles

Prior to undertaking full-scale testing, Enviro engineers worked closely with Sydney University to understand the particle bonding mechanism and the strength of these bonds measured in release-rate vs time.

Professor Federico Maggi has independently researched the nature of particles and constructed a method of filming microscopic particles. A 3D diagram of a 40-micron particle is illustrated in *Section 7.3*.

At the same time professor Maggi supervised a study of particulate matter gathered from the Sydney CBD. Analysis of that particulate matter showed high affinity to nutrients, heavy metals and other toxicants.

Visualisation of the particle and grouping of sub-micro particles *(Section 7.3)* provides evidence to demonstrate that the level of particle capacity to bond with various chemical compounds is potentially far higher than previously anticipated.

As illustration *7.3.2* and *7.3.3* show, the particle has three levels of bonding mechanism. *Refer Appendix 6*.

Electrostatic attraction is high as a result of the large surface area created by aggregation of micro particles.
Again, driven by the large surface area is the high potential for chemical attraction. Mechanical entrapment also occurs as sub-particles aggregate.

This created an understanding of why sediment beds have such high capacity to trap and retain nutrients and toxicants.

In parallel with particle imaging, Sydney University with assistance from the Australian Mathematical Sciences Institute (AMSI), created a working model of the particle separation process and analysed the mechanism at play. A complex mathematical model was also created using known hydraulic and pore theories and compared the actual performance with the mathematical prediction.

It was demonstrated that the particle separation process was supported by known mechanisms, with the model being used as the basis for future design and is currently embedded in the modelling process used to determine Enviro system size.

Studies were conducted to determine the relationship between nutrient release into solute form vs catchment transport time. The aim was to determine whether during the relatively short time that material is wetted and transported; that nutrient would transfer from bonded to solute form.

Two studies were conducted in parallel. One focused on **phosphorous** and the other focused on **nitrogen**.

The results of the nitrogen release study showed that nitrogen remained bonded to particulate matter and concluded that early removal of urban debris and associated particulate matter was a means of preventing nutrification of urban waterways.

The overall conclusion reached by both studies was that early capture and retention of fine particles was a reliable method of removing the majority of nutrient from storm water flows.

The final process of the Enviro system is the holding of particulate matter in a quiescent state. This process utilises entrapment as observed in nature, where sediment beds capture and hold nutrient and toxicants as mentioned earlier. During the MHL testing, various concentrations and flow rates were monitored while allowing captured materials to aggregate in the storage zone. This was used as a method of replicating actual, real world conditions.

Accumulation of materials during tests that replicated two years of rainfall events showed no evidence of scouring, resuspension and mobilisation of captured materials. All tests were conducted using a known influent mass of pollutants while monitoring discharge water quality. At the completion of testing the materials collected were recovered and assessed to ascertain the net balance of pollutant materials captured.

While developing the current Enviro multi-chamber multi-zone device, process reviews, analysis and prototype testing was conducted using various configurations and methods. Some of these are cited in *Section 11*.

7.3 The Importance of Particle Removal and "The Particle"

Our findings show that timely capture of fine particles is directly proportional to the retention of toxic chemicals and nutrients.

This conclusion was reached as a result of several studies in collaboration with University of Sydney students, mentored by Professor Federico Maggi. The studies included:

- Screening efficiency testing, modelling and computer analysis. *(Fig 7.3.1)*
- Particle column filming and creation of a 3-dimensional model. *Fig 7.3.2* is a photographic image of a 40-micron particle. *Fig 7.3.3* shows an animation of the particle. This research confirmed that particles are compacted micro structures and not solid. The 3D model in *Fig 7.3.3* reveals a complex structure with a large surface area to volume and a high capacity to bond chemicals via electrostatic attraction, chemical and mechanical bonding.
- Field and laboratory data gathering, measuring the release rates of nutrients to solute forms.
- Field studies of wetlands and existing installations.

The research conducted supported the hypothesis, that particles exhibit an ability to retain nutrients and unwanted chemicals to a greater level than expected. This was verified by student field studies that measured the time rate of release of nutrients from accumulated bio-mass in a typical suburban catchment. These field studies were carried out in Sydney's northern suburbs. *Refer Appendix 7*

Results confirmed that negligible release occurred for at least 30 minutes after wetting, confirming that early capture of particles, is a practical method of reducing nutrient and toxic chemical discharge in run-off water.

This research then led to a greater understanding of pollutant categories and characteristics and gave rise to development of the **Enviro E Series**.

Details of this research are available on request, together with an independent review by UniSA.

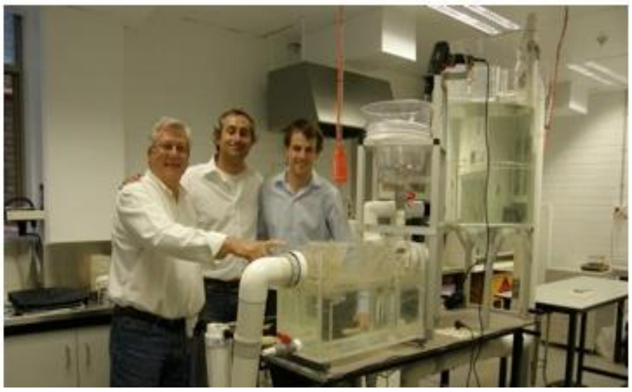


Fig 7.3.1 Laboratory modelling

AMSIIntern

An Innovative University and Industry Collaboration

The University of Sydney program supported by Leo Crasti and mentored by Dr Federico Maggi, created a laboratory simulation of rainfall and pollutant load. This resulted in creation of a world-first mathematics model that is now the basis of the Enviro operating process.

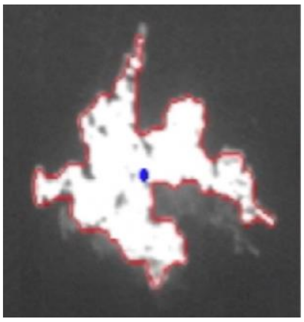
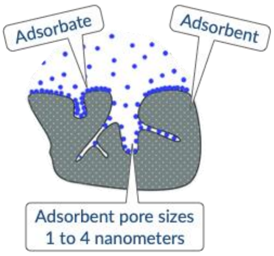


Fig 7.3.2
Photographic image of particle

Fig 7.3.3
40-micron particle model

8 Nutrients

The functionality of media is typically based on adsorption, which operates as illustrated *below*.



For that functionality to operate, influent water must be removed of particulate matter, which if present would cause the media to clog and for the adsorption process to be compromised. In stormwater conditions where the presence of solute chemicals is anticipated, Enviro can supply tertiary treatment modules comprising a suitable media for attracting the predicted solute chemicals from solution.

It is well-recognised that stormwater is the major transporter of anthropogenic pollutants into fresh and marine water environments.

Nutrients are depleting oxygen levels and spawning algal blooms resulting in over-nutrification in many locations.

Nutrients in relation to stormwater are noted as Phosphorous (P) and Nitrogen (N), both of which stimulate algal blooms in marine and freshwater aquatic environments. The major concern is N as this is a significant part of biomass. In an undisturbed environment the N cycle operates in balance, with most remineralization occurring in soil and therefore land-based biomass. The introduction of large impervious areas forces that process downstream into the aquatic environment where the availability of oxygen is greatly reduced.

The aim of pollution reduction targets is to reduce the total load of N, hence the reference to Total Nitrogen as TN. The definition of TN is Total Kjeldahl Nitrogen (TKN = Ammonia (NH_4/NH_3) + Organic Nitrogen) + Nitrite (NO_2) + Nitrate (NO_3). *Refer Appendix 8*

Nutrients in the form of N and P form part of the natural food chain. The ARQ, table 2.5 suggests guideline levels for Total Nitrogen (TN) at <0.5mg/L and for Total Phosphorous (TP) at a level of <0.05 mg/L.

The Phosphorous cycle is simple as it is regarded as the predominant trigger in marine species of algae. Environmental Phosphate is present in low concentrations in rocks, soil and sediment. The urban built environment introduces excess Phosphates in similar input paths as Nitrogen.

Phosphates are released via decomposition, or direct discharge from waste.

The Nitrogen cycle is more complex, where N moves from gas to bio-mass, then breaks down via decomposition to be released as gas or returned to bio-mass. *Fig 8.1* shows the Nitrogen Cycle.

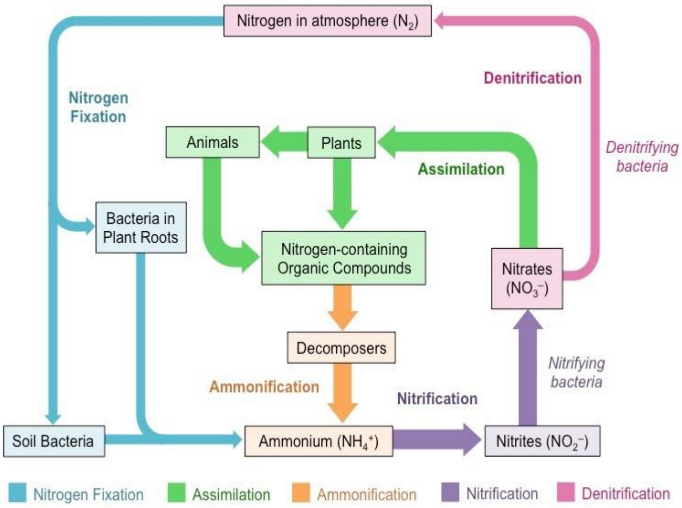


Fig 8.1

We live in an atmosphere that is 78% nitrogen (N_2). N_2 is an inert gas and is not taken up by water, otherwise rainfall would be charged with N_2.

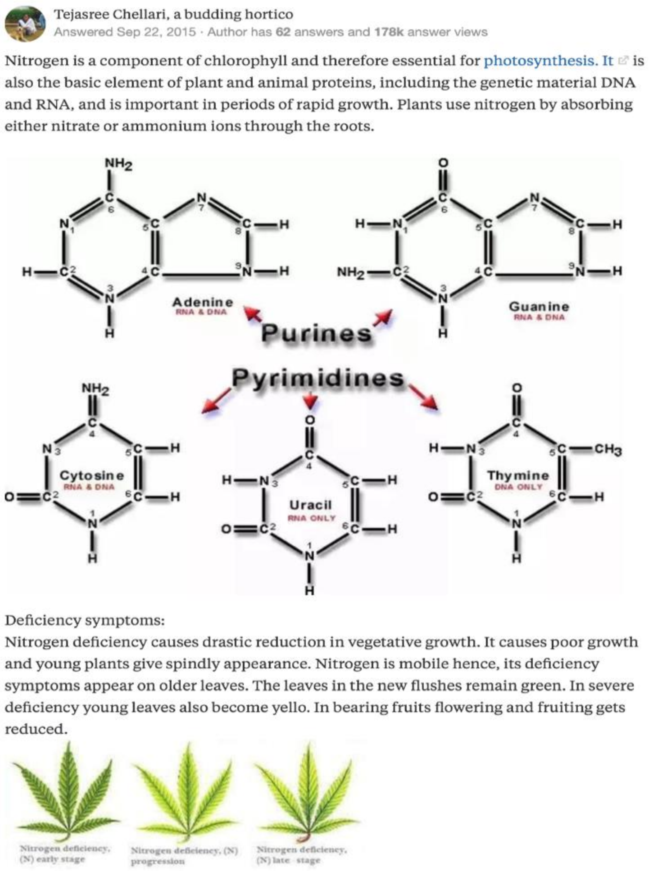
N_2 is converted by bacteria for assimilation by plants, and in turn animals. These are the fixation and assimilation phases.

Decomposition and assimilation have an internal cycle of unstable Nitrogen species converted by bacteria in a balanced process with some N_2 returned to the atmosphere.

Soil bacteria are the organisms responsible for the conversion process.

In atmospheric conditions decomposition is relatively fast due to the availability of Oxygen (O_2), which is approximately 20% of air. In aquatic environments the availability of O_2 is limited to a few parts per million (ppm) typically, 5pmm. Therefore, the rate of decomposition requiring Oxygen is very slow in an aquatic environment.

Though discharge of readily available, N and P stimulates immediate depletion of DO. The receiving of N and P that is part of other biological matter such as Chlorophyll and Protein, still has the same result over an extended period of time. *Refer Fig 8.2*



Tejasree Chellari, a budding hortico
Answered Sep 22, 2015 · Author has **62** answers and **178k** answer views

Nitrogen is a component of chlorophyll and therefore essential for photosynthesis. It is also the basic element of plant and animal proteins, including the genetic material DNA and RNA, and is important in periods of rapid growth. Plants use nitrogen by absorbing either nitrate or ammonium ions through the roots.

Deficiency symptoms:
Nitrogen deficiency causes drastic reduction in vegetative growth. It causes poor growth and young plants give spindly appearance. Nitrogen is mobile hence, its deficiency symptoms appear on older leaves. The leaves in the new flushes remain green. In severe deficiency young leaves also become yello. In bearing fruits flowering and fruiting gets reduced.

Fig 8.2

Enviro has adopted the principle of removing as much of the source N and P as possible within acceptable constraints determined by the physics and economics of stormwater treatment.

The principles relied upon are:

1. In the case of P that it is bonded to other particles and its origins are typically products that have P associated with its chemistry. P in nature is a rare mineral present in very low concentrations.

2. The presence of N is far more prolific, and the forms vary. All plant and animal matter rely upon N as a critical ingredient. N is not taken up by water except in certain circumstances, since the atmosphere is 78% N. Fortunately this does not occur, because if it did, water in storage tanks would be toxic. Acid rains have been caused by uptake of chemicals by rain in the atmosphere, however these chemicals are present in atmospheric suspension as fine particles.

Urban environments have disrupted the natural relationship between rainfall, organic matter, decomposition and conversion to biomass. In an undisturbed environment a small amount of N is utilised as nutrient for aquatic organisms. The urban environment creates large impervious surfaces and pollutant load is transported by stormwater down drains into the aquatic environment which receives an overdose. That overdose is now defined as pollutants. It is this overdosing that is to be reduced.

8.1 Pre-Urbanisation

In an undeveloped environment, leaf litter, plants and animals are broken down (decompose) due to the high availability of Oxygen from the atmosphere. Various organisms participate in the process. As matter decomposes, N in various forms is produced and converted by bacteria, typically in the presence of water in the soil where plants assimilate Nitrates; or it is returned to the atmosphere as N_2.

Farmers and gardeners are well aware that Nitrates are readily taken up by plants and stimulate growth. In a well-balanced natural environment, the Ammonia through Nitrite to Nitrate phases are relatively short. A walk in any natural bushland reveals layers of leaf litter, compost and sweet-smelling soil.

Fig 8.1.1 illustrates the pre-urbanisation passage of water that delivers low concentrations of refined nutrients to the aquatic ecosystem.

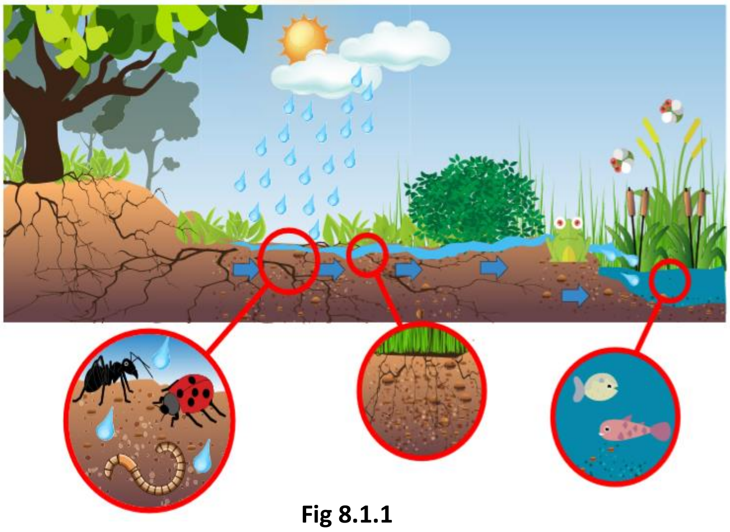


Fig 8.1.1

8.2 Post-Urbanisation

Urbanisation dramatically alters the Nitrogen cycle, removing the environment that enables decomposition to occur over time – weeks, months and years. Raw unprocessed biological material is transported within minutes directly to receiving waters.

This bypass of the natural decomposition phase also brings a compounding effect, due to availability or lack of Oxygen (O_2). Decomposition previously had access to air, which is approximately 20% O_2. In the aquatic environment O_2 is reduced to an average of 5 ppm.

Fig 8.2.1 illustrates water run-off in an urban area.

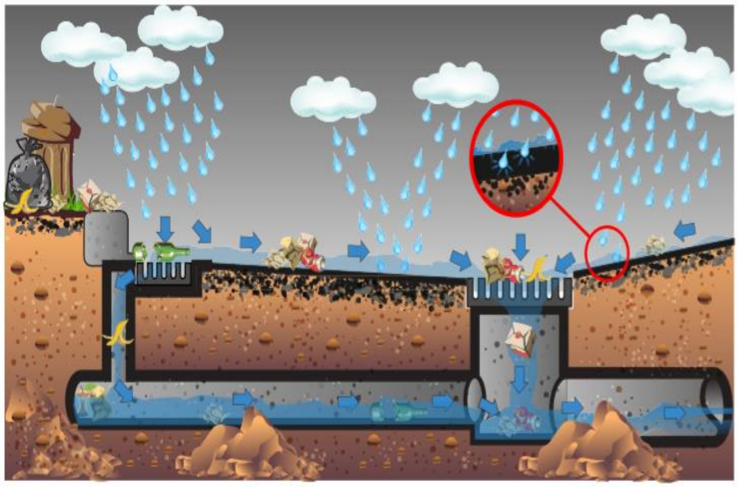


Fig 8.2.1

Most urban catchments have impervious areas representing approximately 50% of the total surface area. Rainfall on these surfaces has higher energy and greater capacity to mobilise load into stormwater drains. Most stormwater drains are round pipes, which are favoured as they convey water at very low gradients, a factor in fluid dynamics associated with flow, hydraulic gradient and velocity.

Flat gradients cause materials to accumulate during low flow conditions due to flow energy being insufficient to mobilise the material. As flow increases, materials are suddenly mobilised, creating short-term high concentrations. All of these conditions compromise sample methods described in *Section 10*.

The urban-built environment alters the cycle through many factors, mainly:

- Removal of soil habitats where plants grow, and bacteria exists.
- Increased load density of organic matter that will decompose.
- Introduction of pre-processed matter, such as sewage discharge and animal waste.
- Addition of other forms of Nitrogen via fertilisers, waste, and consumer products, etc.

Allowing these to enter water bodies drives eutrophication and depletion of Dissolved Oxygen, compromising aquatic bio-diversity.

8.3 Removal of Nutrients – Nitrogen and Phosphorous

Removal of TP and TN is fundamental to improving water quality in fresh and marine ecosystems.

Environmental Protection Authorities nominate reduction targets of:

- TN reduction - 45%
- TP reduction - 65%

Enviro systems are designed to comply with reduction targets by removing the major source of TN and TP; being fine particles, defined as suspended solids. It is an established principle that both TN and TP are primarily transported by these fine particles. Nutrient tests carried out by UniSA in February 2020 show that the EPS removes 85% of N and 97% of P.

References:

- Email from Baden Myers, Research Fellow UniSA. *Refer Appendix 9*
- UniSA report on Nutrient Reduction.
- *Refer Appendix 10*
- Suspended solids, various articles and studies

  https://www.sciencedirect.com/topics/earth-and-planetary-sciences/suspended-sediment

The urgency for reduction in nutrient discharge is emphasized in a science report published in January 2015 (*refer* https://science.sciencemag.org) that analysed the planet's sustainability factors and identified over-nutrification having reached critical levels adjacent to many high population areas.

The Enviro method of removing nutrients is based on the following principles:

1. Anthropogenic pollutants include litter and other organic matter including Nitrogen.

2. Sediments, which are more closely aligned to soil and detritus in the sub 1.0mm size range include banded forms of N and P.

3. The presence of solute forms of nutrient varies by catchment but is not a usual occurrence in catchments that are newly designed and constructed. This would require permanent water bodies to be included, and these are repositories for organic matter that induces high presence of BOD and low DO.

4. If solute forms of N are present, Enviro has measures available to compliment the natural process of conversion, release to gas or conversion to bio-mass.

Enviro Engineers in developing the EPS processes, referred to existing contemporary understanding and in-house research to establish a cost-effective method of removing nutrients from stormwater flows to meet nominated reduction targets.

These reduction targets are achieved by removing particulate matter to sizes defined as fine sediment within the Enviro multi chamber EPS. The processes included in the EPS are separation, settlement and consolidation awaiting recovery.

The following is an explanation of development, research and principles employed as well as some reference material. Further reference material is available upon request. Alternatively, more evidence can be found by conducting personal website research.

Current accepted science is that Phosphorous is mostly bonded to particles. There is little evidence that solute forms are present in stormwater discharge. Phosphorous is naturally an exotic mineral that is present in very low concentrations. Phosphorous is currently recognised as the major trigger for algal blooms and phytoplankton.

Nitrogen in its various forms, however, is readily available in the environment and there has been much concern that solute forms of Nitrogen need to be removed from storm water as a priority.

Studies conducted over recent years have concluded that particle bonded Nitrogen is the major form transported in storm water drains. Therefore, meeting the 45% reduction target is best achieved by removing fine particles, as test results confirm. *Refer Dissolved Organic Nitrogen:*

https://www.sciencedirect.com/science/article/pii/S0048969717331649
and
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/dissolved-organic-nitrogen

The eWater MUSIC model also assumes that N and P are transported by particulate matter.

Refer MUSIC Manual
https://wiki.ewater.org.au/display/MD6

8.4 Further Discussion

Solute forms of Nitrogen are difficult to remove as these are in the size realm of < 1 micron and more likely 0.2 microns. N.O.G. Jorgensen has written and defined properties of N in various forms as detailed in his article. *Refer Fig 8.4.1*

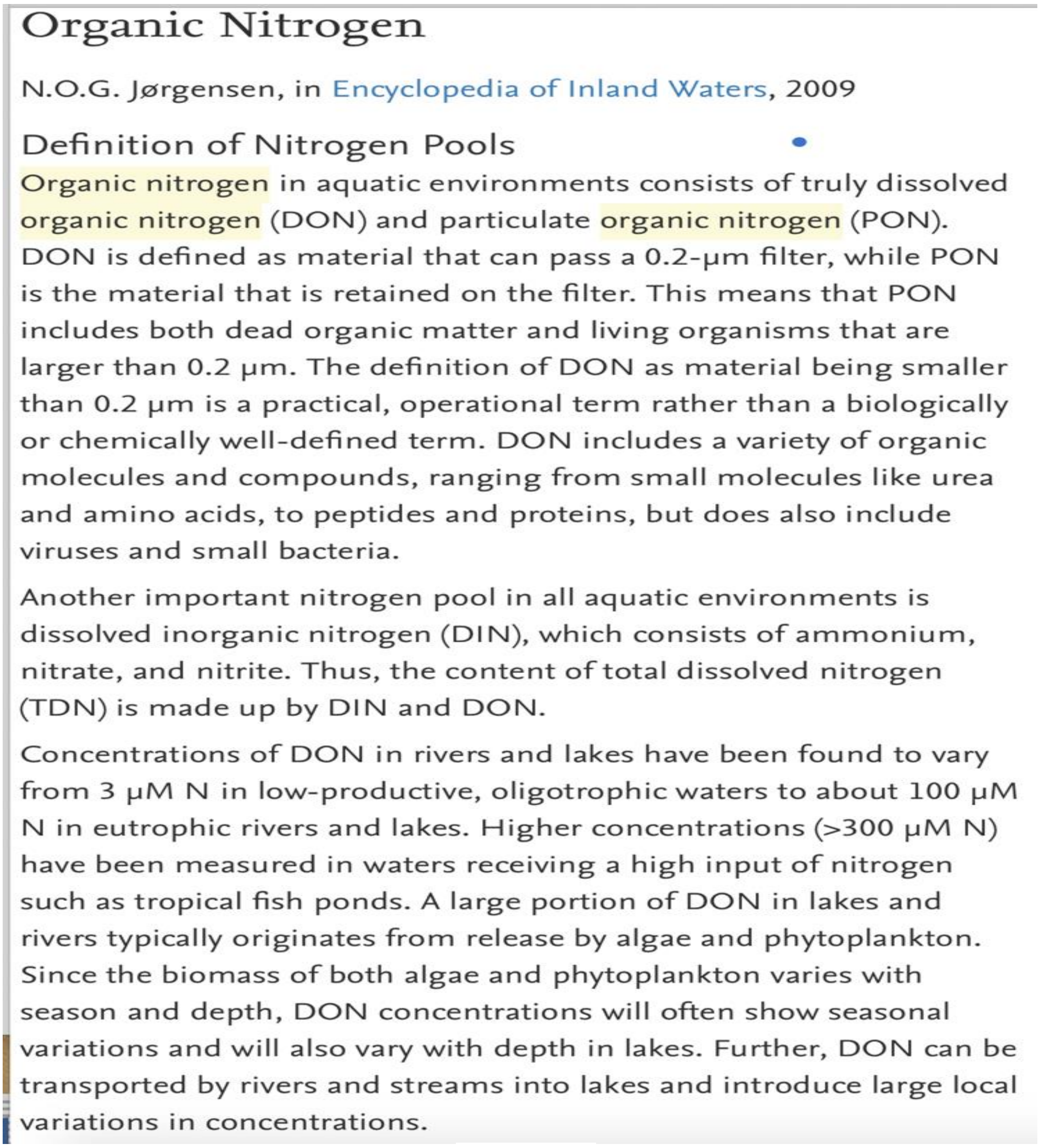
In nature, solute forms are readily taken up by vegetation and converted by bacteria that typically occurs in natural wetlands.

Although the application of adsorption media can reduce the level of solute forms, in practice, media performance quickly declines as a result of blinding caused by fine particles. Therefore, if adsorption media were to be used, removal of fine sediment is a precursor.

The ARQ defines fine sediment as particles of < 62 microns. Other studies have created a definition of suspended solids as being < 500 microns. *Refer sediment and bedload discussion papers at:*

https://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/

These studies point out that larger particles should be considered as bed-load and should not be taken into account as part of the totally suspended solids (TSS) reduction target which is typically 80%.



Organic Nitrogen

N.O.G. Jørgensen, in Encyclopedia of Inland Waters, 2009

Definition of Nitrogen Pools

Organic nitrogen in aquatic environments consists of truly dissolved organic nitrogen (DON) and particulate organic nitrogen (PON). DON is defined as material that can pass a 0.2-μm filter, while PON is the material that is retained on the filter. This means that PON includes both dead organic matter and living organisms that are larger than 0.2 μm. The definition of DON as material being smaller than 0.2 μm is a practical, operational term rather than a biologically or chemically well-defined term. DON includes a variety of organic molecules and compounds, ranging from small molecules like urea and amino acids, to peptides and proteins, but does also include viruses and small bacteria.

Another important nitrogen pool in all aquatic environments is dissolved inorganic nitrogen (DIN), which consists of ammonium, nitrate, and nitrite. Thus, the content of total dissolved nitrogen (TDN) is made up by DIN and DON.

Concentrations of DON in rivers and lakes have been found to vary from 3 μM N in low-productive, oligotrophic waters to about 100 μM N in eutrophic rivers and lakes. Higher concentrations (>300 μM N) have been measured in waters receiving a high input of nitrogen such as tropical fish ponds. A large portion of DON in lakes and rivers typically originates from release by algae and phytoplankton. Since the biomass of both algae and phytoplankton varies with season and depth, DON concentrations will often show seasonal variations and will also vary with depth in lakes. Further, DON can be transported by rivers and streams into lakes and introduce large local variations in concentrations.

Fig 8.4.1

8.5 Development of Enviro Systems

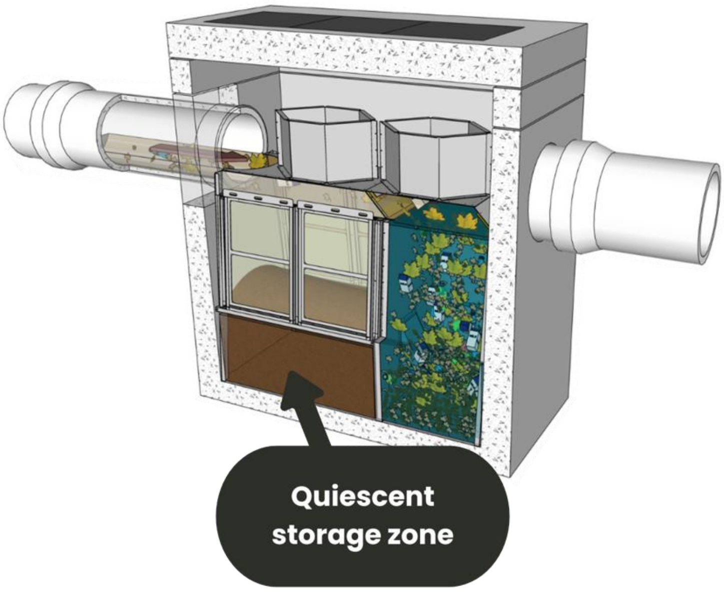


Fig 8.6.1

The Enviro systems have been developed based on a similar conclusion, i.e. particle removal is biased to < 500 microns. During full-scale testing at Manly Hydraulics Laboratory (MHL) the Enviro process was stress tested using sediment recovered from discharge of a sediment basin at the Blacktown International Sports Park.

The sediment profile was 90% below 500 microns and 35% below 53 microns. Removal rates exceeded 80%. *Refer to Process and Performance Testing at Section 3* of this manual. This particle size distribution profile follows very closely the profile of particles found to be the major transporter of TN.

8.6 The Enviro Final Design

The final design has taken two separation principles into account:

The first separation principle is that floatables need to be separated from sediments. Floatables are directed from gross influent materials into a secondary chamber via a one-way weir preventing further breakdown and remobilisation. This enables sediments to be removed from the flow and retained in a separate storage sump.

The second separation principle is the screening of fine particulate matter while eliminating the tendency for screen blinding. This has been achieved by Enviro after substantial hydraulic in-house testing and with University assistance. Design and construction of this remains part of intellectual property associated with EPS performance.

In summary, the process was tested and proven to reliably remove particulate matter < 20 microns without compromising screen performance. In addition to the unique design, particles are directed into a lower quiescent storage zone. *Refer Fig 8.6.1*

9 Testing

Enviro has adopted empirical testing methods where full-scale systems are exposed to in-field flow rates that can be dosed with known pollutants at pre-determined concentrations. *Refer 8.2 Post-Urbanisation.*

The outflow volume is completely captured and then filtered to determine the composition and quantity of by-pass. This provides an absolute measure of performance across variables of flow, pollutant mix and concentrations.

9.1. Enviro Testing and Proof of Performance

The following summarises results and conclusions derived from university research and independent testing which included Ecological Consultants Australia, SESL (NATA Certified Laboratories) and Manly Hydraulics Laboratory (MHL) in Sydney. *Fig 9.1.1* shows the testing facility at MHL.

Fig 9.1.1

A full-scale model equivalent to the Enviro E45 was tested. Over 1.0 megalitre of water was processed, simulating about 38 rainfall events with varying concentrations of pollutants.

The published test results are in summary:

1. Gross pollutant removal……………………………………100%
   Construction of the Enviro devices includes proprietary screening with apertures of 1mm or less. The entry is one-way - reverse flow is impossible - and the configuration does not allow re-suspension.

2. Sediment removal………………………………………………86%
   Testing utilised a PSD with a bias towards fine sediment where 90% were less than 500 microns and 35% of the particles were less than 53 microns. Removal rate achieved was 81% to 86% across a range of flow rates and concentrations.

3. Nutrient removal, potentially ……………..………………80%
   The fact that sediments are the major transporters of TN and TP is well established. This only varies for discharge from wetlands where release has occurred. Sydney University students researched the release rate of both N and P from catchment materials and concluded that wetted durations of greater than 10 minutes were required, to achieve significant release. These studies confirmed that early capture of particles represented a viable method of substantial nutrient export.

Enviro, in conjunction with Civilmart, established a world first testing facility, that can mimic rainfall events and provide proof of performance. *Refer 9.1.2 and 9.1.3*

In October 2018, the Enviro H model was tested in accordance with EN 858-1 to confirm oil/water separation in addition to the removal of stormwater pollutants and in February 2020 the EPS was tested for nutrient removal. These tests were conducted by UniSA.

The oil/water separation tests included continuous dosing of raw diesel oil into the influent for 20 minutes. After this duration of accumulated oil, discharge water samples were collected and tested.

The results proved that 99.95% of the oil was separated and collected. Only 4.1 ppm was detected in the out-flow samples.

Nutrient testing involved dosing the inflow with leaf litter, grass clippings, soil and potting mix

Fig 9.1.2

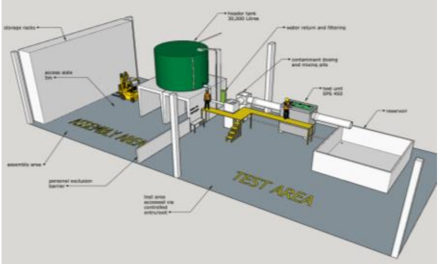


Fig 9.1.3

10 Field Validation

10.1 Sampling

Stormwater is difficult to sample in the field, predominantly because of flow infrequency and the constraints of retrieving samples.

Sampling methods proposed by industry associations are based on the use of automatic samplers retrieving small and infrequent samples for analysis. Analysis is then limited to dissolved fractions and some fine particulate matter that may be drawn into the sampling tube. These samples only provide an indicative measure and it is therefore not convincing for them to be used to substantiate broad spectrum pollution removal performance.

Enviro has investigated sampling methods associated with key suppliers such as Sigma and ISCO water samplers. *Refer 10.1.1*

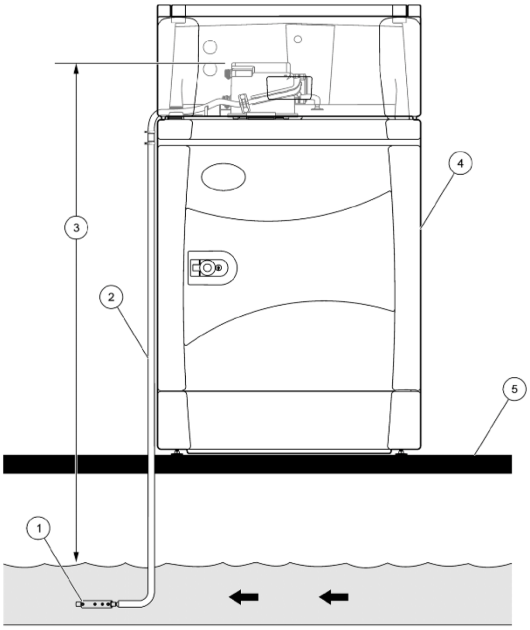


Figure 8 Mounting configuration

1	Strainer	4	All weather refrigerated sampler
2	Intake tubing	5	Mounting surface
3	Vertical lift		

Fig 10.1.1
Automatic water sampler

Samplers from these providers operate on similar principles i.e. the use of a pump to draw a set of samples from pipe water into sample bottles. Limitations of these devices are:

- A small diameter tube (6-10mm) is used to draw a sample.
- The tube nominally faces downstream.
- A strainer is attached to the tube to prevent particles from being drawn into the tube as the pump method operates on a peristaltic principle.
- Samples are relatively small, typically, 1-5L.

There are various factors that will alter validity of samples taken in this manner, such as:

- The position of suction points relative to a location within a pipe, noting that obstructions, changes of direction, pipe joints etc. alter flow patterns and potentially create accumulation of debris. *Fig 10.1.2*

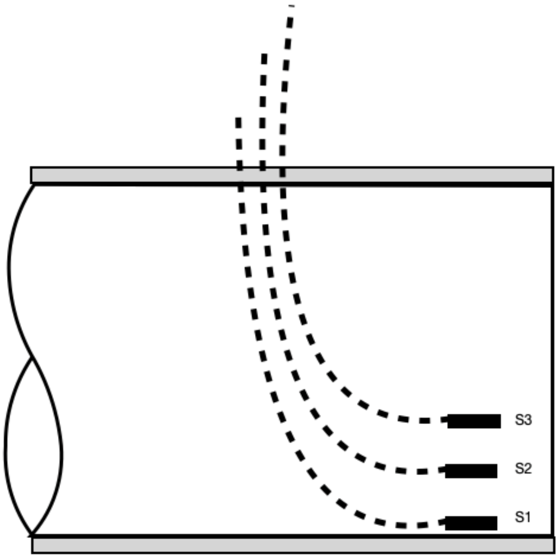


Fig 10.1.2

- Timing of samples is an issue e.g. if the first sample is taken at a trickle flow the sample may include air and compromise the sample itself as well as the sampling mechanism. *Refer 10.1.3*

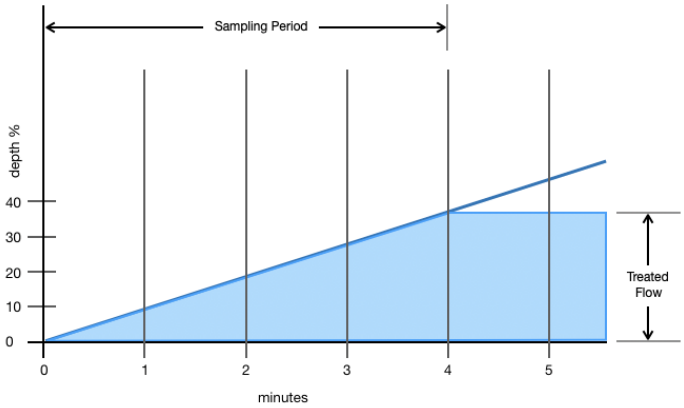


Fig 10.1.3

- The concentration of material may be heavily biased with depth, which causes concern as to where the sample be taken within the pipe diameter.
  Refer Fig 10.1.4

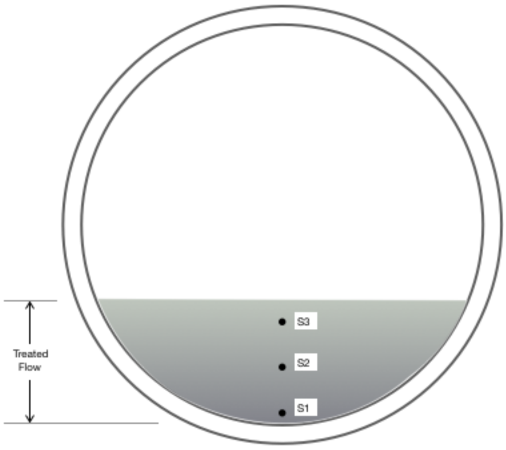


Fig 10.1.4

- The sample may not be as representative as what would occur in a water body that is reasonably homogenous. The constituents within a stormwater drain flow vary substantially by time and may never be replicated.

Suppliers of samplers refer to testing in water bodies such as streams and lakes. There does not appear to be reference to sampling conducted in stormwater drains with intermittent flow.

11 Methods Reviewed and Rejected by Enviro

11.1 Enviro Hydraulic Process Review

During the development of the current Enviro multi-chamber process, various hydraulic flow control methods were trialed.

The following details some of those methods. Enviro discarded most as unsuitable for broad spectrum separation and containment of pollutants.

11.2 Hydro-Cyclones

Hydro-cyclones are circular screens where cyclonic or vortex action is encouraged, with materials captured on the inside of a cylinder allowing water to escape outwards. *Refer Fig 11.2.1*

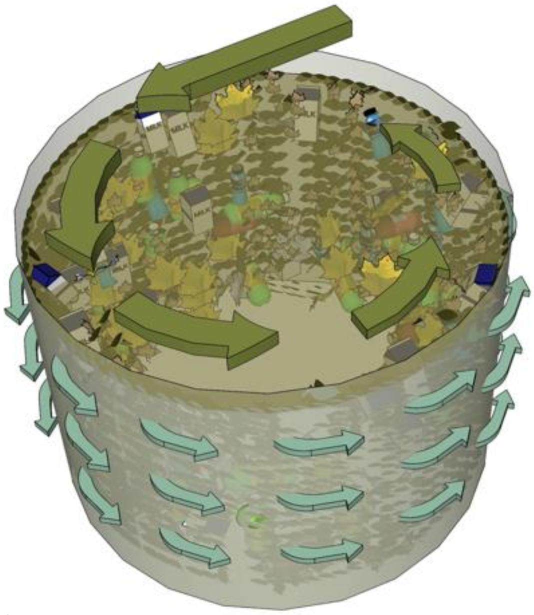


Fig 11.2.1

This process is contrary to normal centrifugal based cyclones where heavy matter is projected to the outside while clean fluid is drawn from the centre. Floatable materials contribute substantially to a grating effect which causes fine sediments to pass through the screen. Organic matter, particularly resident from previous rainfall events, breaks down and by-passes the screen. The observation was documented by Professor Gavin Birch. *Refer research article:*

http://dx.doi.org/10.1080/15730620902807056

Infiltration or media was also tested as a potential process in a treatment train after larger (gross pollutants) were removed. This method was discontinued as the life expectancy of media was limited and replacement caused high service costs.

Hydro-cyclones *(Fig 11.2.2)* are widely used to remove sediment in pipe lines. Efficiency is directly related to flow velocity generating a centrifugal force *(Fig 11.2.3)*, which causes materials to be thrown to the outside, while clean water flows from the centre of the vortex.

This same principle is used in dust extractors *(Fig 11.2.4)*. The main factors that caused Enviro to disqualify this method from serious consideration are the variable flow velocities in a drainage system, coupled with awkward configuration of pipe work.

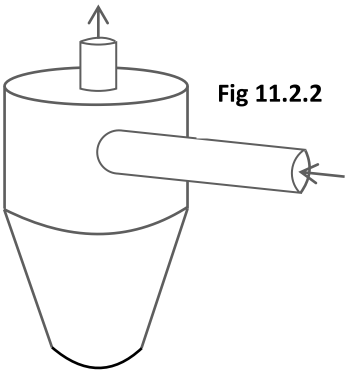


Fig 11.2.2

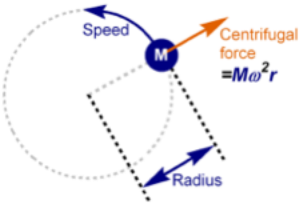


Fig 11.2.3

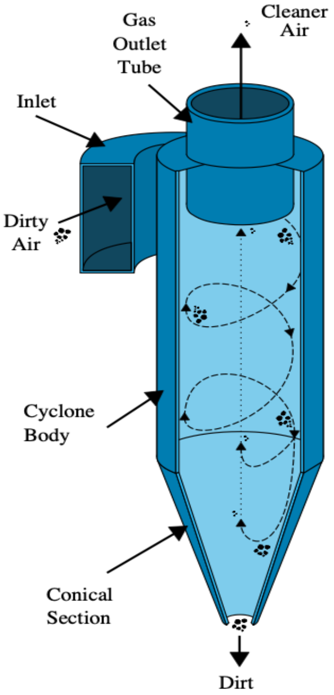


Fig 11.2.4

11.3 Screened Chamber

Enviro reviewed a simple attack screen where water passed directly through a screen causing the screen to act as a sieve. As expected, the sieve principle is limited by the area and size of pores. As pores fill, the aperture reduces and there is accelerated tendency for the sieve to further blind.

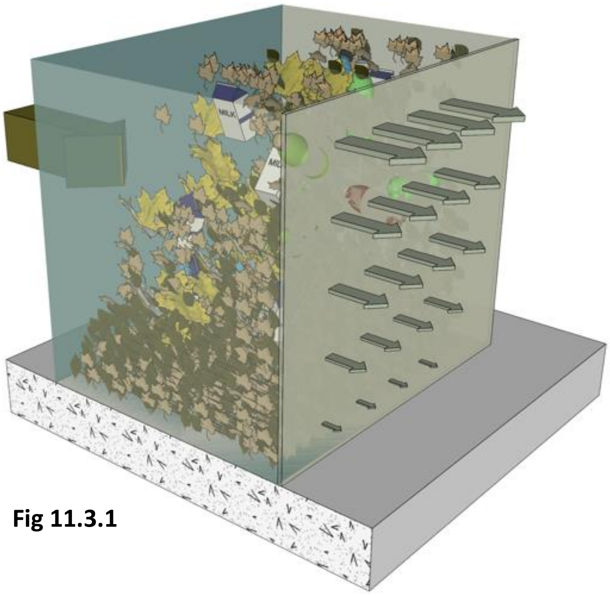


Fig 11.3.1

Fig 11.3.1 shows the principle sometimes employed with an attack screen. Though initially successful, short term blinding of the screen requires servicing immediately prior to a rainfall event. Constant churning during a rainfall event causes particulate matter to be drawn through the mesh and for organic matter to breakdown and be drawn through also.

Fig 11.3.2 shows a chamber where the flow is caused to divert vertically under a weir and pass through an attack screen. Though claims of some oil retention is possible, the main function of gross pollutant and sediment capture is limited because:

1. The weir could not cause buoyant materials to submerge. Floatables accumulated and were eventually drawn through as the volume allowed for floatables was relatively small.
2. Some heavy sediments were captured and settled; however lighter sediments were not captured, and some were retained by the screen openings. As the screen is in an attack orientation, a dramatic loss in screen-through volume compromised performance and caused pre-mature by-pass.
3. Scouring was also found to occur with subsequent flow, as materials in the sump broke down and became suspended by gaseous discharge.

Use of this principle required introduction of a primary floatable chamber or pit inserts, and an extended chamber size to create extended settlement periods.

A quiescent chamber *(Fig 11.3.3)* coupled with a skimming weir is the principle used in oil separators and grease arrestors. The principle was also tested for sediment and gross pollutant retention.

Conclusions:

- Suitable for low flow rates and velocities only. Excessive volume and velocity create turbulence and re-suspension.
- Sediment removal occurs via settlement, which is particle size and time related. Medium to fine particles may take 1 to 2 hours to settle. This is impractical in this type of device as it requires a large chamber to hold the entire catchment run-off volume to be stored for the settlement period.

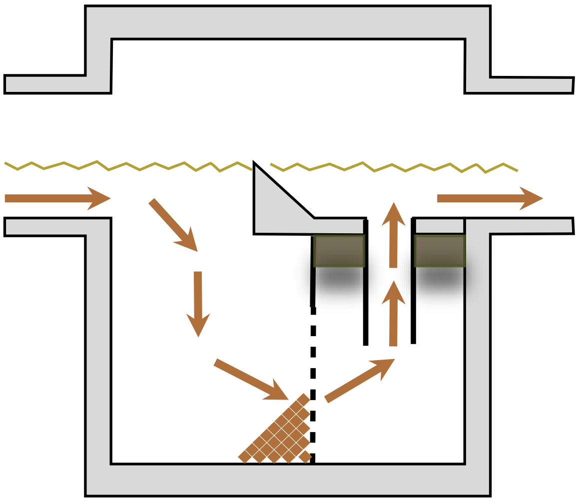


Fig 11.3.2 Diversion through attack screen

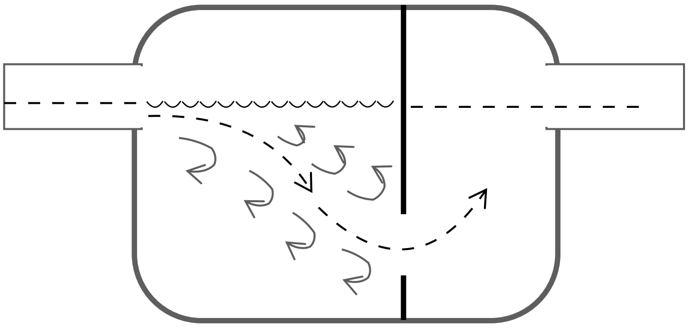


Fig 11.3.3 Quiescent Chamber

11.4 Inverse Vortex

Inverse vortex *(Fig 11.4.1)* is used by some manufacturers of stormwater devices. These systems are not true vortex/centrifuges in that retained material is mobilised towards a screen, compromising efficiency. Other factors that limit performance are:

- The process chamber needs to be off-line, requiring a diversion weir which is subject to the hydraulic jump phenomenon as water flow rates increase to 1m/sec.
- Hydraulic impedance is high, as water flow direction needs to be reversed to rejoin the main pipe conduit.
- Trickle and low flow tend to pass through the screen until sufficient flow velocity generates a vortex.

The illustration *(Fig 11.4.2)* shows the outcome of tests where the material tend to orbit the chamber, either impeding flow as velocity increases or fragmenting to smaller sizes and bypassing.

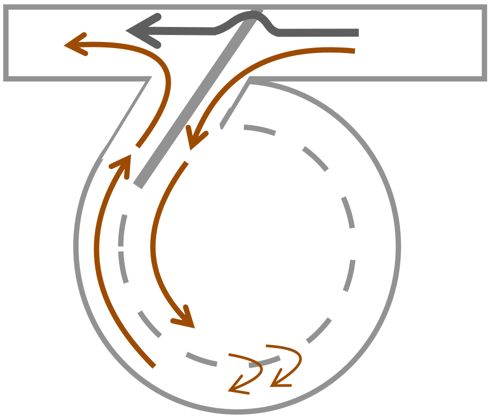


Fig 11.4.1 Inverse vortex

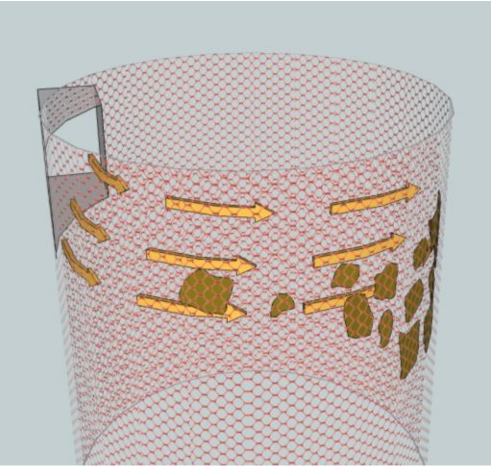


Fig 11.4.2

11.5 Solute Forms of Nutrients – Removal Process

Artificial or tertiary treatment methods that may be applied to remove Dissolved Nutrients, and in particular Dissolved Organic Nitrogen (DON), have physical limitations. DON is defined as being smaller than 0.2 microns *(Refer Fig 8.4.1)*. It therefore follows that removal of suspended sediment is a pre-curser to the implementation of DON removal media.

In simple terms, if fine media is required, that media will very quickly blind if exposed to suspended solids that are present in the influent.

The practical conclusion therefore is, that removal of the prime carrier, being suspended solids smaller than 500 microns, is critical to artificial and natural methods that occur in wetlands. Natural methods involve interaction between plants and bacteria where Dissolved Nitrogen is a ready source of nutrient and is converted to biological material.

The illustration below demonstrates the tendency for media beds similar to those used in bio filtration, to attract a layer of surface material inhibiting the infiltration process. *Fig 8.8.1*

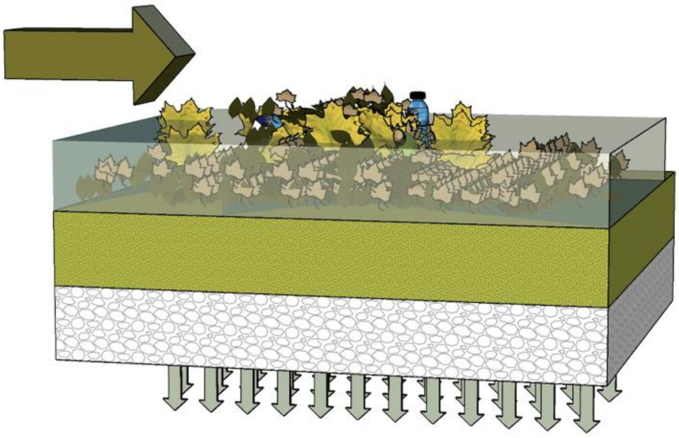


Fig 8.8.1

12 Design Service Life

12.1 Design Life Expectancy

Enviro systems are designed with a service life of 100 years for fixed components and 25 years for replaceable parts.

The main materials used are:

1. Precast reinforced concrete designed and manufactured in accordance with AS3600, exposure classification Table 4.3, 4(b)(i) permanently submerged in sea water.
2. Marine grade stainless steel, either 304L or 316, for the internal processing cartridge.
3. Polypropylene (PP) is used for screens, taking advantage of resistance to chemicals and fatigue. PP resists microbial attack and prevents fatigue failure from vibration and flexing under flow conditions.

12.2 Stainless Steel - Microbially Influenced Corrosion (MIC)

Stainless steel is vulnerable to MIC around heat affected zones, particularly welds.

Enviro utilises stainless steel, with no heat applied and no welding. Materials are processed by cold cutting (laser), mechanical punching and riveting. By avoiding welding and heating processes, the creation of an environment that would harbour and induce microbial attack is avoided.

Concerns with MIC date back over 30 years. In 2007, MIC was the topic of a two-day International Symposium in Perth (WA) when growing awareness of the nature and danger of MIC was brought to the attention of marine, mining and industrial applications of stainless steel. This conference followed a Nickel Institute 2005 paper that warned about MIC in all grades of stainless steel exposed to bacterially active water e.g. well water, surface water and raw water. *(NI reference book series No. 11 026, page 11).*

MIC is caused by bacteria harbouring within micro cracks, where their excreta builds up and creates a localised acidic environment.

Refer to a publication by Susan Borenstein, August 2002, "Susceptibility of Stainless-Steel Weldments to Microbiologically Influenced Corrosion"

https://www.researchgate.net/publication/231975642_Susceptibility_of_Stainless_Steel_Weldments_to_Microbiologically_Influenced_Corrosion

Susan Borenstein has over 30 years of metallurgical and corrosion engineering experience for the petrochemical, utility and chemical industries.

Professional Registrations

Registered Engineer, Texas - 87474
Registered Corrosion Engineer, California - CR 1059
Registered Mechanical Engineer, Rhode Island - 6953
Registered Professional Engineer, Delaware - 11654

Austral Wright Metals, one of the larger suppliers of stainless steel in Australia include the above mentioned warning in their technical data.

https://www.australwright.com.au/wp-content/uploads/2012/07/Types-Myths-of-SS1.pdf

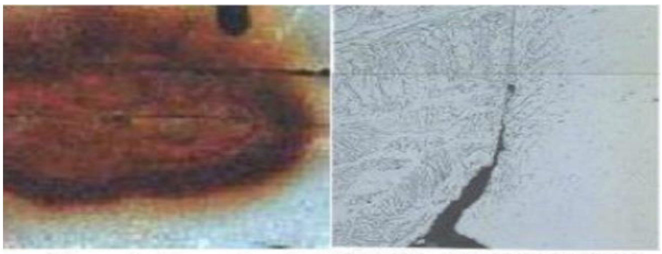
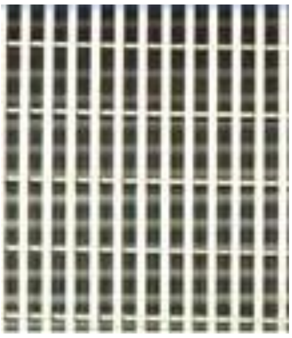


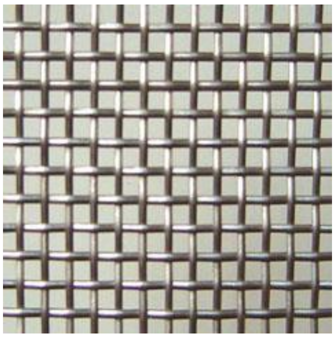
Figure 1—Overview of pit on corroded 304L stainless steel weld

Figure 2—Closeup showing deep crevice adjacent to weld bead/base metal interface

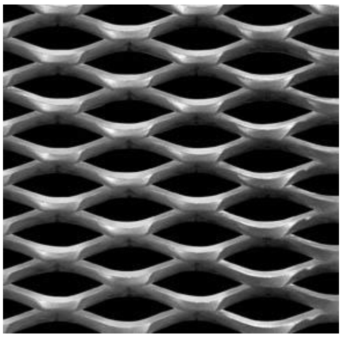
Extract image from research paper by Susan Borenstein

12.2 Screen Selection


1. Trapezoidal wire


2. Woven mesh


3. Punched sheeting


4. Expanded mesh

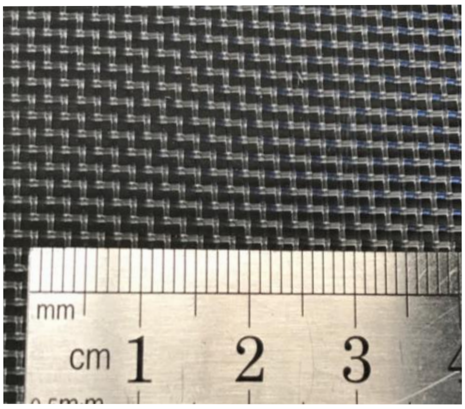
During development of Enviro systems, substantial research and testing of screening methods and materials were conducted. All of the above screen example materials were analysed and discarded as unsuitable or partially suitable. Each are shown at approximate full size.

The following are summary comments only, greater detail is available upon request.

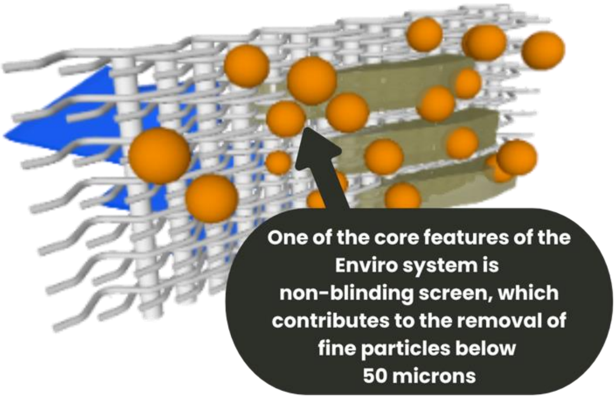
1. **Trapezoidal wire** often used in waste water screens is limited to aperture size.
2. **Woven mesh** can be used where larger apertures may be tolerated. The wire laps tend to gather fibrous materials.
3. **Punched sheeting** is bi-directional and is expensive. Flow rates are relatively slow requiring large screen surfaces.
4. **Expanded mesh** is limited to large apertures of 6 to 10mm. If smaller apertures are used, the burred and sharp edges together with the twisted nature of the expanding process accumulates fibrous materials.

The Enviro solution is a specially woven high strength fabric, mounted on stainless steel frames for ease of service and replacement as required. This follows common practices in many filtering applications.

The fibres are also pretreated to a smooth finish to prevent attraction of fibrous materials. High resistance to bio-filming occurs as a result of the smooth surfaces.



Typical Enviro Screen


One of the core features of the Enviro system is non-blinding screen, which contributes to the removal of fine particles below 50 microns

12.3 Enviro Systems can be Offered with a De-Watered Sump Feature

A de-watered sump can be environmentally important for the following reasons:

Photos 3 and 4 where taken inside two separate systems to demonstrate the actions of bio-digestion. The enlarged section of *Photo 3* shows bubbles rising to the surface generated by decomposition of organic material in retained water. The gas generated is similar to the anaerobic process used in waste water treatment. The output includes Carbon Dioxide, Methane and potentially, Hydrogen Sulphide. **Some of these gases are toxic and potentially life threatening.**

Of further concern is the bacterial conversion of bonded chemicals and nutrients such as Nitrogen and Phosphorus into solute forms. These toxic chemicals easily enter the food chain, while over-nutrification depletes available Dissolved Oxygen (DO).

Nutrients cause spontaneous generation of algal blooms, some of which are toxic. The greater issue is that algae takes up the available DO and starves all other aquatic flora and fauna.

Often it is difficult to appreciate the importance of DO to aquatic sustainability. On Earth we live in a Nitrogen atmosphere which has 20% Oxygen (O_2). This is also a ready source of O_2 for the decomposition process. Transfer this into an aquatic environment, and the availability of O_2 is vastly less. DO levels vary around 10 to 15 ppm depending on temperature and other factors, therefore the conversion and breakdown of organic matter takes a long time and many exchanges of DO when compared to atmospheric exposed conversion.

12.3.1 Service Costs are Greatly Reduced

By eliminating the free water, service evacuation does not have to include the cost of on-site treatment if this is possible or transfer to a waste plant for final processing.

Photo 3

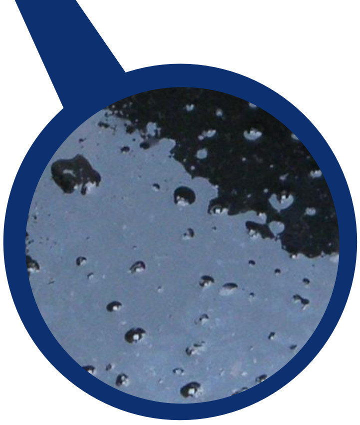


Photo 3 - Enlarged section

Photo 4

13 Service and Maintenance

Enviro G, E and H series are designed to minimise service and maintenance costs as a result of the following features:

1. The storage chamber located below the processing chamber is designed to be easily inspected and serviced. Based on the ARQ extrapolation of 1m^3/ann/ha from typical urban catchment, the large storage volume provides for extended service intervals. In most installations, service intervals are nominally 1 year (12 months).
2. Service is by evacuation. *(Refer Fig 1)*. The volume of water contained in the process chamber is minimised to reduce evacuation costs. This water can be pumped out as the first stage of service, avoiding evacuation and the cost of disposal. A dry sump option is available on request.
3. All surfaces inside the Enviro series are visible from the service covers, eliminating the need for personnel to enter the device and perform longer term wash downs. *(Refer Fig 2)*
4. If required, screens can be removed manually, without entering the device. This facilitates inspection, cleaning or replacement, without additional labour or equipment. *(Refer Fig 3)*
5. During the construction phase, i.e. before hand over to the client, screens can be removed enabling the device to act as a sediment trap. This allows the constructor to clean out the device and handover to the client an unused unit, eliminating disputes over device condition.

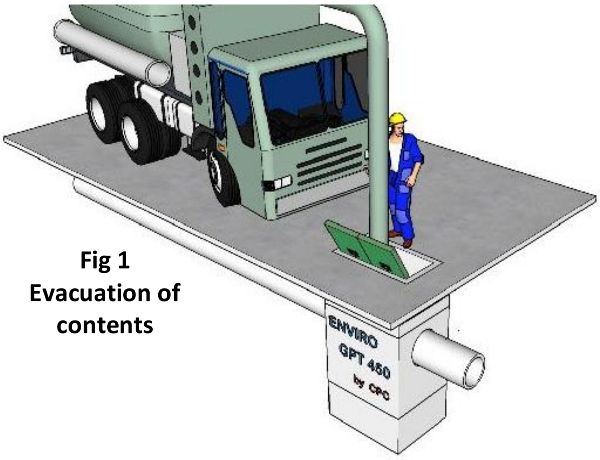


Fig 1
Evacuation of contents

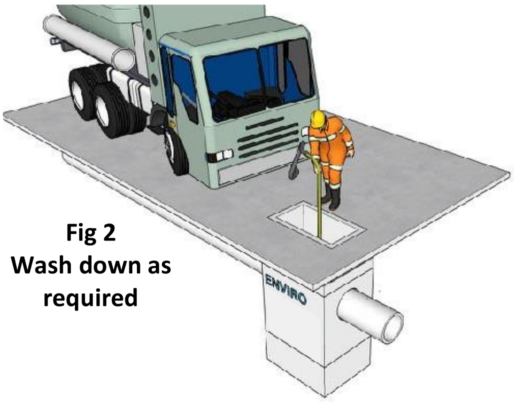


Fig 2
Wash down as required

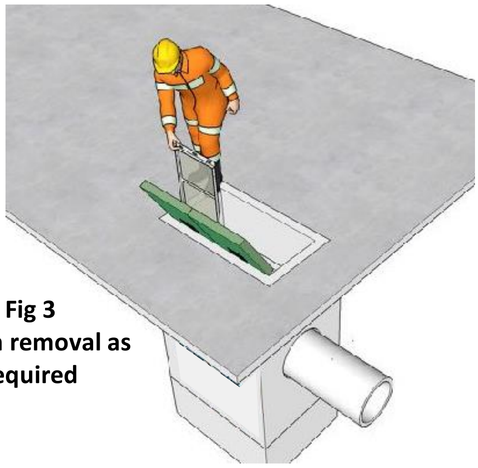


Fig 3
Screen removal as required

Appendices

(Appendices are prepared as a separate folder)

Number	Title	Author
1	Balanced Urban Development: Options and Strategies for Liveable Cities Chapter 6	Leo Crasti
2	Enviro Process Testing Summary	Leo Crasti
3	Performance Testing of Enviro Australis Oil/Water Separator	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
4	MUSIC Node	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
5	Deep Sea Pollution paper - Human footprint in the abyss: 30-year records of deep-sea plastic debris	Sanae Chiba, Hideaki Saito, Ruth Fletcher, Takayuki Yogi, Makino Kayo, Shin Miyagi, Moritaka Ogido, Katsunori Fujikura
6	Adsorption of Nutrients to Particles in Urban Stormwater Systems	Nicola Hayes supervised by Professor Federico Maggi University of Sydney
7	Particle Removal Efficiency from Stormwater	Scott Manning supervised by Professor Federico Maggi University of Sydney
8	Nutrient Discharge to Stormwater	Mason Bonacci peer reviewed by Simon Sharp EPA Victoria
9	Email: Relationship between Nutrients and Particles in Runoff	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers
10	Performance testing of the Enviro EPS – Nutrient removal	Australian Flow Management Group School of Natural and Built Environments University of South Australia Research Fellow: Dr Baden Myers

APPENDIX

H

Stormwater Code Response

9.4.9 Stormwater Code Response – 437 Stafford Road, Stafford

9.4.9.1 Application

1. This code applies to assessing a material change of use, reconfiguring a lot or operational work if:
    a. assessable development where this code is identified as a prescribed secondary code in the assessment benchmarks column of a table of assessment for a material change of use (section 5.5), reconfiguring a lot (section 5.6) operational work (section 5.8) or an overlay (section 5.10); or
    b. impact assessable development, to the extent relevant.
2. When using this code, reference should be made to section 1.5 and section 5.3.3.

Note—The following purpose, overall outcomes, performance outcomes and acceptable outcomes comprise the assessment benchmarks of this code.

Note—Where this code includes performance outcomes or acceptable outcomes that relate to infrastructure design and construction works, guidance is provided in the Infrastructure design planning scheme policy.

9.4.9.2 Purpose

1. The purpose of the Stormwater code is to assess the suitability of the stormwater aspects of development.
2. The purpose of the code will be achieved through the following overall outcomes:
    a. Development achieves acceptable levels of stormwater run-off quality and quantity by applying water sensitive urban design principles as part of an integrated stormwater management framework.
    b. Development protects public health and safety and protects against damage or nuisance caused by stormwater flows.
    c. Development has a stormwater management system which maintains, recreates or minimises impact to natural catchment hydrological processes.
    d. Development ensures that the environmental values of the city’s waterways are protected or enhanced.
    e. Development minimises run-off, including peak flows.
    f. Development maintains or enhances the efficiency and integrity of the stormwater infrastructure network.
    g. Development minimises the whole of life cycle cost of stormwater infrastructure.

9.4.9.3 Performance outcomes and acceptable outcomes

Table 9.4.9.3.A—Performance outcomes and acceptable outcomes

Performance outcomes	Acceptable outcomes	Comments
Section A—If for a material change of use, reconfiguring a lot, operational work or building work Note—Compliance with the performance outcomes and acceptable outcomes in this section should be demonstrated by the submission of a site-based stormwater management plan for high risk development only.		

PO1 Development provides a stormwater management system which achieves the integrated management of stormwater to: a. minimise flooding; b. protect environmental values of receiving waters; c. maximise the use of water sensitive urban design; d. minimise safety risk to all persons; e. maximise the use of natural waterway corridors and natural channel design principles. Editor's note—The stormwater management system to be developed to address PO1 is not intended to require management of stormwater quality.	**AO1** Development provides a stormwater management system designed in compliance with the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO2 Development ensures that the stormwater management system and site work does not adversely impact flooding or drainage characteristics of premises which are up slope, down slope or adjacent to the site.	**AO2.1** Development does not result in an increase in flood level or flood hazard on up slope, down slope or adjacent premises. **AO2.2** Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO3 Development ensures that the stormwater management system does not direct stormwater run-off through existing or proposed lots and property where it is likely to adversely affect the safety of, or cause nuisance to properties.	**AO3.1** Development ensures that the location of the stormwater drainage system is contained within a road reserve, drainage reserve, public pathway, park or waterway corridor. **AO3.2** Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
	AO3.3	

	Development obtains a lawful point of discharge in compliance with the standards in the Infrastructure design planning scheme policy.	
	AO3.4 Where on private land, all underground stormwater infrastructure is secured by a drainage easement.	
PO4 Development provides a stormwater management system which has sufficient capacity to safely convey run-off taking into account increased run-off from impervious surfaces and flooding in local catchments.	**AO4.1** Development provides a stormwater conveyance system which is designed to safely convey flows in compliance with the standards in the Infrastructure design planning scheme policy. **AO4.2** Development provides sufficient area to convey run-off which will comply with the standards in the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP and hydraulic impact assessment LC26013-0004-HIA
PO5 Development designs stormwater channels, creek modification works, bridges, culverts and major drains to protect and enhance the value of the waterway corridor or drainage path for fauna movement.	**AO5** Development ensures the design of stormwater channels, creek modifications or other infrastructure, permits terrestrial and aquatic fauna movement.	N/A
PO6 Development ensures that location and design of stormwater detention and water quality treatment: a. minimises risk to people and property; b. provides for safe access and maintenance; c. minimises ecological impacts to creeks and waterways.	**AO6.1** Development locates stormwater detention and water quality treatment: a. outside of a waterway corridor; b. offline to any catchment not contained within the development. **AO6.2** Development providing for stormwater detention and water quality treatment devices are designed in compliance with the standards in the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP. No confined space entry required.

PO7 Development is designed, including any car parking areas and channel works to: a. reduce property damage; b. provide safe access to the site during the defined flood event.	**AO7.1** Development (including any ancillary structures and car parking areas) is located above minimum flood immunity levels in Table 9.4.9.3.B, Table 9.4.9.3.C, Table 9.4.9.3.D, Table 9.4.9.3.E and Table 9.4.9.3.F. Note—Compliance with this acceptable outcome can be demonstrated by the submission of a hydraulic and hydrology report identifying flood levels and development design levels (as part of a site-based stormwater management plan). **AO7.2** Development including the road network provides a stormwater management system that provides safe pedestrian and vehicle access in accordance with the standards in the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO8 Development designs stormwater channels, creek modification works and the drainage network to protect and enhance the environmental values of the waterway corridor or drainage path.	**AO8.1** Development ensures natural waterway corridors and drainage paths are retained. **AO8.2** Development provides the required hydraulic conveyance of the drainage channel and floodway, while maximising its potential to maximise environmental benefits and minimise scour. Editor's note—Guidance on natural channel design principles can be found in the Council's publication Natural channel design guidelines.	N/A
	AO8.3 Development provides stormwater outlets into waterways, creeks, wetlands and overland flow paths with energy dissipation to minimise scour in compliance with the standards in the Infrastructure design planning scheme policy.	
	AO8.4 Development ensures that the design of modifications to the existing design of new stormwater channels, creeks	

	and major drains is in compliance with the standards in the Infrastructure design planning scheme policy.	
PO9 Development is designed to manage run-off and peak flows by minimising large areas of impervious material and maximising opportunities for capture and re-use.	**AO9** No acceptable outcome is prescribed.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO10 Development ensures that there is sufficient site area to accommodate an effective stormwater management system. Note—Compliance with the performance outcome should be demonstrated by the submission of a site-based stormwater management plan for high-risk development only.	**AO10** No acceptable outcome is prescribed.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO11 Development provides for the orderly development of stormwater infrastructure within a catchment, having regard to the: a. existing capacity of stormwater infrastructure within and external to the site, and any planned stormwater infrastructure upgrades; b. safe management of stormwater discharge from existing and future up-slope development; c. implication for adjacent and down-slope development.	**AO11.1** Development with up-slope external catchment areas provides a drainage connection sized for ultimate catchment conditions that is directed to a lawful point of discharge. **AO11.2** Development ensures that existing stormwater infrastructure that is undersized is upgraded in compliance with the Infrastructure design planning scheme policy.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO12 Development provides stormwater infrastructure which: a. remains fit for purpose for the life of the development and maintains full functionality in the design flood event; b. can be safely accessed and maintained cost effectively; c. ensures no structural damage to existing stormwater infrastructure.	**AO12.1** The stormwater management system is designed in compliance with the Infrastructure design planning scheme policy. **AO12.2** Development provides a clear area with a minimum of 2m radius from the centre of an existing manhole cover and with a minimum height clearance of 2.5m.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP

PO13 Development ensures that all reasonable and practicable measures are taken to manage the impacts of erosion, turbidity and sedimentation, both within and external to the development site from construction activities, including vegetation clearing, earthworks, civil construction, installation of services, rehabilitation, revegetation and landscaping to protect: a. the environmental values and water quality objectives of waters; b. waterway hydrology; c. the maintenance and serviceability of stormwater infrastructure. Note—The Infrastructure design planning scheme policy outlines the appropriate measures to be taken into account to achieve the performance outcome.	**AO13** No acceptable outcome is prescribed.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP and the erosion and sediment control plans. Earthworks are not proposed for the development and ESC controls are propsed for VXO and footpath works.
PO14 Development ensures that: a. unnecessary disturbance to soil, waterways or drainage channels is avoided; b. all soil surfaces remain effectively stabilised against erosion in the short and long term.	**AO14** No acceptable outcome is prescribed.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
PO15 Development does not increase: a. the concentration of total suspended solids or other contaminants in stormwater flows during site construction; b. run-off which causes erosion either on site or off site.	**AO15** No acceptable outcome is prescribed.	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP
Section B—Additional performance outcomes and acceptable outcomes which apply to high-risk development, being one or more of the following: a. a material change of use for an urban purpose which involves greater than 2,500m^2 of land that: i. will result in an impervious area greater than 25% of the net developable area; or ii. will result in 6 or more dwellings.		N/A

b. reconfiguring a lot for an urban purpose that involves greater than 2,500m^2 of land and will result in 6 or more lots; c. operational work for an urban purpose which involves disturbing greater than 2,500m^2 of land.		
PO16 Development ensures that the entry and transport of contaminants into stormwater is avoided or minimised to protect receiving water environmental values. Note—Prescribed water contaminants are defined in the *Environmental Protection Act 1994*. Note—Compliance with the performance outcome should be demonstrated by the submission of a site-based stormwater management plan for high-risk development only.	**AO16** Development provides a stormwater management system which is designed in compliance with the standards in the Infrastructure design planning scheme policy.	N/A
PO17 Development ensures that: a. the discharge of wastewater to a waterway or external to the site is avoided; or b. if the discharge cannot practicably be avoided, the development minimises wastewater discharge through re-use, recycling, recovery and treatment. Note—The preparation of a wastewater management plan can assist in demonstrating achievement of this performance outcome. Editor's note—This code does not deal with sewerage which is the subject of the Wastewater code.	**AO17** No acceptable outcome is prescribed.	N/A
Section C—Additional performance outcomes and acceptable outcomes for assessable development for a material change of use or reconfiguring a lot		
PO18 Development protects stormwater infrastructure to ensure the following are not compromised: a. the long term infrastructure for the stormwater network in the Long term infrastructure plans; b. the existing and planned infrastructure for the stormwater network in the Local government infrastructure plan; c. the provision of long term, existing and planned	**AO18** Development protects stormwater infrastructure in compliance with the following: a. for long term infrastructure for the stormwater network, the Long term infrastructure plans; b. for existing and planned infrastructure for the stormwater network, the Local government infrastructure plan; c. the standards for stormwater drainage in the	Complies – Please refer Legend Consultants stormwater management plan LC26013-0002-CSMP

infrastructure for the stormwater network which: i. is required to service the development or an existing and future urban development in the planning scheme area; or ii. is in the interests of rational development or the efficient and orderly planning of the general area in which the site is situated. Editor's note—A condition which requires a proposed development to keep permanent improvements and structures associated with the approved development clear of the area of long term infrastructure, may be imposed.	Infrastructure design planning scheme policy.	
PO19 Development provides for the payment of extra trunk infrastructure costs for the following: a. for development completely or partly outside the priority infrastructure area in the Local government infrastructure plan; b. for development completely inside the priority infrastructure area in the Local government infrastructure plan involving: i. trunk infrastructure that is to be provided earlier than planned in the Local government infrastructure plan; ii. long term infrastructure for the stormwater network which is made necessary by development that is not assumed future urban development; iii. other infrastructure for the stormwater network associated with development that is not assumed future urban development which is made necessary by the development. Editor's note—The payment of extra trunk infrastructure costs for development completely inside the priority infrastructure area in the Local government infrastructure plan is to be worked out in accordance with the Charges Resolution. Editor's note—See section 130 Imposing Development conditions (Conditions for extra trunk infrastructure costs) of the *Planning Act*	**AO19** No acceptable outcome is prescribed.	N/A

2016.		

Table 9.4.9.3.B—Categories of flood planning levels

Flooding type[(1)]	**Minimum design floor or pavement levels (m AHD)**[(2)] **(refer to Table 9.4.9.3.C for assignment of these categories)**				
	Category A	**Category B**	**Category C**	**Category D**	**Category E**
Waterway[(A)] or open channel	1% AEP flood level + 500mm	1% AEP flood level + 300mm	1% AEP flood level	1% AEP flood level	5% AEP flood level
Overland flow flooding[(B)]	2% AEP flood level +500mm	2% AEP flood level +300mm	2% AEP flood level	2% AEP flood level	5% AEP flood level

Notes—

(1) Where the site is subject to more than one type of flooding that is overland flow flooding, creek or waterway flooding or river flooding, the minimum flood immunity level is the highest level determined from these sources.

(2) Where flood levels are not available from Council’s Floodwise Property Report such as overland flow flooding, the applicant will need to engage a suitably qualified Registered Professional Engineer Queensland with expertise in undertaking flood studies to estimate the relevant flood level.

Note (A) A waterway, including any indicated on the planning scheme maps, is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks, typically with a catchment area greater than 30ha.

Note (B) Overland flow flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways, and in the older established areas, through private properties within existing low points and gullies. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30ha.

Note—A flood event with an AEP of 1% is the equivalent of a 100 year ARI flood event.

Note—A flood event with an AEP of 2% is the equivalent of a 50 year ARI flood event.

Note—A flood event with an AEP of 5% is the equivalent of a 20 year ARI flood event.

Note—The flood immunity level in some older inner-city areas is often controlled by local ponding.

Table 9.4.9.3.C—Flood planning level categories for development types

BCA building classification[(1)]	**Development types and design levels, assigned design floor or pavement levels**	**Category Refer to Table 8.2.11.3.L**
Class 1—4	Habitable room	Category A

	Non-habitable room including patio and courtyard	Category B
	Non-habitable part of a Class 2 or Class 3 building excluding the essential services(2) control room	Category B
	Parking located in the building undercroft of a multiple dwelling	Category C
	Carport(4), unroofed car park; vehicular manoeuvring area	Category D
	Essential electrical services(2) of a Class 2 or Class 3 building only	Category A(6)
	Basement parking entry(3)	Category C + 300mm
Class 5, Class 6, or Class 8	Building floor level	Category C
	Garage or car park located in the building undercroft(3)	Category C
	Carport(4) or unroofed car park	Category D
	Vehicular access and manoeuvring areas	Category D
	Basement parking entry(3)	Category C
	Essential electrical services(2)	Class 8 — Category C(6) Class 5 & 6 — Category A(6)
Class 7a	Refer to the relevant building class specified in this table	
Class 7b	Building floor level	Category C
	Vehicular access and manoeuvring area	Category D
	Essential electrical services(2)	Category C
Class 9	Building floor level	Category A

	Building floor level for habitable rooms in Class 9a or 9c where for a residential care facility	0.2% AEP flood
	Garage or car park located in the building undercroft(3)	Category C
	Carport(4) or unroofed car park	Category D
	Vehicular access and manoeuvring areas	Category D
	Essential electrical services(2)	Category A
Class 10a	Car parking facility	Refer to the relevant building class specified in this table
	Shed(5) or the like	Category D
Class 10b	Swimming pool	Category E
	Associated mechanical and electrical pool equipment	Category C
	Other structures	Flood immunity standard does not apply

Notes—

(1) Refer to the Building Code of Australia for definitions of building classifications.

(2) Essential services include any room used for fire control panel, telephone PABX, sensitive substation equipment including transformers, low voltage switch gear, high-voltage switch gear, battery chargers, protection control and communication equipment, low voltage cables, high-voltage cables and lift controls.

(3) Basement car parks must be suitably waterproofed and all air vents, air-conditioning ducts, pedestrian access and entry and exit ramps at the car park entrance have flood immunity in accordance with this table.

(4) A shelter for a motor vehicle, which has a roof and one or more open sides, and which can be built against the side of a building.

(5) A slight or rough structure built for shelter and storage; or a large strongly built structure, often open at the sides or end.

(6) Where essential services are proposed in a basement below the specified flood planning level, the flood immunity of all air vents, air-conditioning ducts, pedestrian access, lift shafts and entry/exit ramps at the basement entrance and any other openings into that basement must conform to Category A for Residential development, and the relevant basement entry level of all other uses. This will require a waterproof basement design to prevent floodwaters entering the basement to ensure flood immunity.

Note—A flood event with an AEP of 2% is the equivalent of a 50 year ARI flood event.

Note—A flood event with an AEP of 0.2% is the equivalent of a 500 year ARI flood event.

Note—Where a building has a combination of uses that includes a component of class 2, 3 or 9, the essential services for that building shall comply with the requirements of the building class with the greatest flood immunity requirement.

Note—Use classes for residential development also include basement storage.

Table 9.4.9.3.D—Flood planning levels for a new road

Flooding type(1)	Minimum design levels at the crown of the road (m AHD) (2)	
	Residential development	**Industrial or commercial development**
Waterway(A) or open channel	1% AEP flood level	2% AEP flood level
Overland flow flooding(B)	2% AEP flood level	2% AEP flood level

Notes—

(1) Where the site is subject to more than 1 type of flooding, the minimum flood planning level is the highest level determined from these sources. It should be noted that the flooding planning level in some older areas is often controlled by local ponding.

(2) Where flood levels are not available from Council's Floodwise Property Report, such as overland flow flooding, the applicant will need to engage a suitably qualified Registered Professional Engineer Queensland with expertise in undertaking flood studies to estimate the relevant flood level.

Note (A) A waterway including any indicated on the planning scheme maps is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks typically with a catchment area greater than 30ha.

Note (B) Overland flow flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways, and in the older established areas, through private properties within existing low points and gullies. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30ha.

Note—A flood event with an AEP of 1% is the equivalent of a 100 year ARI flood event.

Note—A flood event with an AEP of 2% is the equivalent of a 50 year ARI flood event.

Note—A flood event with an AEP of 5% is the equivalent of a 20 year ARI flood event.

Table 9.4.9.3.E—Flood planning levels for essential community infrastructure

Type of essential community infrastructure	Minimum design levels
Emergency services	0.2% AEP flood
Emergency services, where for an emergency shelter	0.5% AEP flood
Emergency services, where for police facilities	0.5% AEP flood
Hospital and health care service, where associated with a hospital	0.2% AEP flood

Community facility where involving storage of valuable records or items of historic or cultural significance (e.g. galleries and libraries)	0.5% AEP flood
State-controlled roads Major or minor electricity infrastructure not otherwise listed in this table Utility installation where for rail transport services Air service Telecommunications facility	No specific recommended level but development proponents should ensure that the infrastructure is optimally located and designed to achieve suitable levels of service, having regard to the processes and policies of the administering government agency.
Power stations (as defined in the *Electricity Act 1994*) or renewable energy facility.	0.2% AEP flood
Major electricity infrastructure where a major switch yard	0.2% AEP flood
Substations	0.5% AEP flood
Utility installation where for a sewage treatment plant	DFE
Utility installation where for a water treatment plant	0.5% AEP flood

Note—A flood event with an AEP of 0.2% is the equivalent of a 500 year ARI flood event.

Note—A flood event with an AEP of 0.5% is the equivalent of a 200 year ARI flood event.

Table 9.4.9.3.F—Flood planning levels for reconfiguring a lot

Flooding type$^{(1)}$	**Minimum lot levels (m AHD)**$^{(2)}$	
	Residential	**Other than residential**
Waterway$^{(A)}$ or open channel	1% AEP flood level + 300mm	1% AEP flood level
Overland flow flooding$^{(B)}$	1% AEP flood level + 300mm	2% AEP flood level

Notes—

(1) Where the site is subject to more than one type of flooding, the minimum flood immunity level is the highest level determined from these sources.

(2) Where flood levels are not available from Council's Floodwise Property Report such as overland flow flooding, the applicant will need to engage a suitably qualified Registered Professional Engineer Queensland with expertise in undertaking flood studies to estimate the relevant flood level.

Note (A) A waterway including any indicated on the planning scheme maps is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks typically with a catchment area greater than 30ha.

Note (B) Overland flow flooding usually occurs when the capacity of the underground piped drainage system is exceeded or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways, and in the older established areas, through private properties within existing low points and gullies. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30ha.

Note—A flood event with an AEP of 1% is the equivalent of a 100 year ARI flood event.

Note—A flood event with an AEP of 2% is the equivalent of a 50 year ARI flood event.