Jemalong Mundamia Pty Ltd
C/- Allen, Price & Associates

Stormwater Management Assessment – Lot 30 DP 1198692, Mundamia Urban Release Area, Mundamia, NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1304007JR01V03
May 2015

Copyright Statement

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to provide a stormwater management assessment in accordance with the scope of services set out in the contract / quotation between Martens & Associates Pty Ltd and Jemalong Mundamia Pty Ltd (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources which may include for example site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client *etc*. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

Head Office
Suite 201, 20 George St
Hornsby, NSW 2077, Australia
ACN 070 240 890 ABN 85 070 240 890
Phone: +61-2-9476-9999
Fax: +61-2-9476-8767
Email: mail@martens.com.au
Web: www.martens.com.au

Document and Distribution Status

Author(s)	Reviewer(s)	Project Manager	Signature
Grant Harlow	Andrew Norris	Andrew Norris	

Revision No.	Description	Status	Release Date	Document Location			
				File Copy	Allen, Price & Associates		
1	Draft Report	Draft	25.07.14	1E,1P,1H	1P		
1	Final for DA	Final	14.08.14	1E,1P,1H	1P		
2	DoPE amendments	Final	27.11.14	1E,1P,1H	1P		
3	DoPE amendments	Final	21.01.15	1E,1P,1H	1P		
4	DoPE amendments	Final	25.05.15	1E,1P,1H	1P		

Distribution Types: F = Fax, H = hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Overview

This stormwater assessment is prepared by Martens & Associates Pty Ltd (MA) on behalf of the Client to support an application to subdivide Lot 30 DP 1198692 (the 'site').

This report details an environmentally sustainable strategy for the management of stormwater generated from the site as well as detailing existing stormwater conditions at the site and likely impacts resulting from the proposed development.

Method

Assessment of water quality and quantity changes as a result of the proposed land release has been completed using the *DRAINS* and *MUSIC* hydrological and water quality models. Analysis included assessment of existing conditions and developed conditions.

An iterative approach was used to determine the requirements for site on-site detention as well as the need for, and preliminary dimensions / capacities of water quality structures to achieve adopted site objectives of 'no change' hydrological regime.

Results

Analysis concluded that a range of stormwater quality and quantity control solutions were required on the site. These systems were required to address requirements of the site hydrogeological assessment (that is to replace lost site groundwater recharge) and to achieve water quality treatment and flow detention following development.

The assessment concludes that the site requires the following stormwater structures to minimise the effects of the land's development on the local stormwater hydrology:

- Rainwater tanks and dedicated OSD storages on all residential lots.
- Roadside bioretention swales, doubling up as groundwater recharge areas.
- End –of-line OSD basins combined with Bioretention filters.

Implementation and Management

The implementation of the proposed water quality and quantity control measures would be through the development approval process. Design requirements for OSD and water quality control systems should be made conditions of development consent.

To allow for ongoing maintenance of water quality (roadside bioretention swales and basins) and quantity (OSD basins) systems, it is recommended that all such systems be located on Council allotments. This shall allow Council access and enforcement powers to ensure that these systems are maintained and operated in perpetuity.

End-of-line systems such as OSD basins would most likely be vested to Council for ongoing maintenance and operation.

Conclusions

The completed analysis indicates that, even with best practice water quality and quantity control solutions as developed in this assessment it is not feasible to achieve a post development surface water regime which mimics the pre-development condition exactly. However, the proposed development does not have an adverse impact on downslope areas (in terms of increased peak discharge rates and pollutant loads) based on detailed hydrological and water quality modelling completed.

Site OSD tanks and basins are designed to mitigate peak discharges for the range of storm durations for recurrence intervals from 1 in 3 month ARI to 1 in 100 year ARI.

Results indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, will be met by the proposed stormwater treatment train.

Preliminary sizing of site water quality components has been assessed. Roadside Bioretention swales fulfil minimum base area requirements of 125 m^2/ha to ensure that site recharge requirements (as per the hydrogeological assessment) are met.

Rainwater tanks (for non-potable reuse) and dedicated OSD storages are to be included on all lots in accordance with report water quality and OSD findings

Contents

Tables

1 Overview

1.1 Study Overview

This stormwater assessment is prepared by Martens & Associates Pty Ltd (MA) to support an application to subdivide Lot 30 DP 1198692 (the 'site'). The report addresses the requirements of Shoalhaven City Council's DCP 100 (2002), Engineering Design Specification (1999) and Council's Sustainable Stormwater Guidelines.

This report details an environmentally sustainable strategy for the management of stormwater generated from the site as well as detailing existing stormwater conditions at the site and likely impacts resulting from the proposed development. The solutions and conceptual designs presented in this report draw from field inspections, modelling, relevant planning and engineering controls, policy objectives and guiding principles and represent a model for best practice management techniques for stormwater management.

1.2 Project Scope

The report addresses the following issues:

- Review of hydrogeological assessment findings from previous Martens and Associates stormwater management reports:
  - *Hydrogeological Assessment, Proposed Sub-division, Mundamia Release Area, Mundamia NSW* (MA reference P1001761JR01V02, June 2011a)
  - *Surface Water Hydrology Assessment, Mundamia Urban Release Area* (MA reference P1103064JR01V02, August 2011b).
  - *Stormwater Management Assessment – Lot 1 DP 1021332 and Lot 458 DP 1063107, George Evans Road, Mundamia* (MA reference P1002863JR03V02, December 2012).
- Assessment of the existing and post-development peak stormwater discharges from the site for a range of average recurrence intervals.
- Assessment of likely changes to stormwater quality as a result of the proposed development to ensure a neutral or beneficial effect (NorBE) on post-development site stormwater discharge quality.

- Provide preliminary details of minimum requirements for stormwater management system components.

1.3 Proposed Development

We understand that the proposed works include:

- Proposed staged subdivision for 319 residential lots and public reserves.
- Internal road network with associated stormwater drainage infrastructure including stormwater quality and quantity control measures.
- Sewerage, water, power and gas infrastructure to service the development.

A site plan showing the proposed development is provided in Attachment A.

1.4 Policy and Objectives

A number of planning controls and principles have been considered and implemented in the development of site stormwater management solutions. The objectives of these are summarised below:

1.4.1 Shoalhaven City Council DCP 100 (2002)

This document addresses minimum requirements for stormwater runoff quantity and quality management. Specific objectives of Council's DCP (2002) considered pertinent to this study include:

- To provide a stormwater system which adequately protects the natural and built environment at the acceptable level of risk.
- To provide a major system which is economically maintainable, taking account of life-cycle costs.
- To control flooding and maintain road access in accordance with accepted levels of service.
- To minimise the risk of traffic accidents related to flooded roads in accordance with accepted level of risk.
- To consider damage by stormwater to property such as houses.
- To provide a minor system that takes in account of the whole life-cycle costs and minimises nuisance flooding.

- To reduce localised flooding to a level which adequately protects the community.
- To minimise the risk of traffic accidents by reducing the contributing factor of water on roads in a minor storm event.
- To ensure that downstream systems are not adversely affected and ensure no net increase in pollution levels discharging from the development.
- The interception and treatment of pollutants through the use of appropriate water quality control measures prior to discharge to receiving waters, including wetlands, lakes and ponds.
- The drainage system optimises control of any accumulation of silts and controls blockages by debris of inlet structures and pipes.
- The design and construction of water quality facilities will be undertaken to the requirements of Council and relevant authorities.

1.4.2 Shoalhaven City Council (1999) Engineering Design Specifications

This document summarises the objectives and technical specifications for developments to comply with Council's DCP 100 (2002). Specific objectives and specifications considered to be pertinent to this study include the following:

- To ensure that inundation of private and public buildings located in flood-prone areas occurs only on rare occasions and that, in such events, surface flow routes convey floodwaters below the prescribed velocity/depth limits.
- To provide conveyance and safety for pedestrians and traffic in frequent stormwater flows by controlling these flows within prescribed limits.
- Retain within each catchment as much incident rainfall and runoff as possible and appropriate for the planned use and the characteristics of the catchment.

1.4.3 Shoalhaven City Council Sustainable Stormwater Guideline.

This document provides specific performance objectives for stormwater quality and quantity control structures based on size of development and likely impacts on downslope properties.

1.4.4 Martens and Associates Surface Water Hydrology Assessment – Mundamia Urban Release Area (August, 2011)

This document provided a previous assessment of surface water hydrology and hydrogeology and recommendations made in this document are considered pertinent to this study. Notably the following recommendations with respect to maintenance of existing surface stormwater and groundwater regimes:

- Stormwater runoff from site roofs to be directed to rainwater tanks on individual lots for non-potable re-use purposes. Minimum volume of rainwater tanks to be 3 KL.
- Stormwater runoff from site lots and road reserves is to be directed to supplementary groundwater recharge systems with a minimum filter area of 125 m^2/ha to ensure groundwater recharge for downslope ecosystems.
- Stormwater system be designed to maintain existing stormwater flows and nutrient loads where possible to minimise possible adverse impacts on sensitive flora located downslope of the development site.
- OSD basins / tanks be utilised to ensure that peak post-development stormwater flows are reduced to existing peak discharges, particularly for more frequent storm events.
- Site stormwater outlets to be designed and constructed with appropriate level spreader / energy dissipater to replicate existing flow conditions.

1.5 Peer Review

This report has been prepared to address specific details of a project application peer review undertaken by Evans & Peck (EP) dated 22 July, 2013. The EP review addressed both the application for land covered in this report (MP08_0141) and adjacent Council lands (MP09_0056). At the time of the review the stormwater assessment for the subject land had been prepared by others while the report for MP 0056 was prepared by MA. The review identified extensive issues in the project application stormwater assessment relating to stormwater system design, OSD provisions and details of the water quality control solution, in contrast the MA report for MP09_0056 was found to be 'adequate as a concept design'.

Subsequent to the review and consultation with Department of Planning and EP, MA was commissioned to prepare this report to address the issues identified by EP in the original application report (by

others). The stormwater solution detailed in this report provides for on-site detention, water quality controls and stormwater infiltration to address site specific requirements for hydrogeological conditions in a manner generally consistent with that provided for adjacent MP09_0056 and in a manner addressing issues identified by the peer reviewer.

Remaining specific issues raised by EP regarding both applications relate to the potential impact of proposed site infrastructure (building foundations, roads, service trenches) and the like on the passage of shallow sub-soil water flows across the site. These matters were subsequently addressed in documentation as provided in Attachment C of this report.

2 Site Description

2.1 Location and Existing Landuse

The 41.39 ha site is located within the Mundamia Urban Release Area (MURA) and currently accessed by George Evans Road and Jonsson Road, Mundamia within the Shoalhaven Local Government Area (LGA). The site is surrounded by predominantly underdeveloped bushland, rural land and a previously mined quarry/gravel pit (Figure 1).

Figure 1: Site location

The site consists predominantly of cleared paddock areas with increased bushland scrub towards the eastern boundary.

2.2 Topography and Drainage

A south-north orientated ridge-line is located outside of the western boundary of the site. As such, the site slopes in a generally north-east to east direction towards Flatrock Creek located in the adjoining allotment, approximately 100m from the site's eastern boundary at its nearest point. Generally slopes are gentle (2-5%) across the majority of the site, becoming moderate (10%) within the south west and north east corners of the site. Site drainage is via unconcentrated overland sheet flow towards those corners in the direction of the Creek.

2.3 Groundwater

A hydrogeological assessment for MURA was completed by Martens and Associates in August, 2011 (Martens ref: P1002761JR01V02) and included the installation of two groundwater monitoring wells, GMB3 and GMB5, within the subject site and one, GMB4, adjacent to the site. The following is summarised from the 4 month well monitoring period:

- GMB3 and GMB5, both located within the forested steeper areas of site's east, were saturated above the soil/rock interface for approximately 50% and 35% of the monitoring period respectively.

- GMB4, located midway along the site's western boundary, remained dry above the soil/rock interface throughout the whole of the monitoring period. This was expected given the highly permeable layer of silty gravel above the rock interface in this borehole.

- Groundwater level response occurs once daily rain exceeds approximately 3mm. Analysis of long-term climate data for Nowra indicates that on average rain day of greater than 3 mm will occur 63 days per year.

The hydrogeological assessment concluded that the site has a shallow ephemeral (non-permanent) groundwater system within the soil mantle over shallow sandstone rock. This groundwater discharges as seepage at areas of rock outcropping and maintains water supply to potential Spring Tiny Greenhood Orchid habitat within Kunzea Shrubland and Nowra Heath Myrtle vegetation.

The assessment proposed the implementation of groundwater management measures to enable site development with a neutral impact on groundwater systems and associated ecological communities, including:

- A system of stormwater infiltration areas to supplement groundwater recharge. The recommended stormwater infiltration areas are to be located throughout the development area. Recharge systems are required at a rate of 125 m^2/ha.

- Design of road and other structures/infrastructure with the potential to intercept, disrupt or redirect groundwater flows is to be undertaken with due consideration to maintain the existing downslope groundwater regime.

Martens & Associates (November, 2013) in consultation with NSW Department of Planning and Infrastructure (DOPI) subsequently prepared documentation (MA Ref: P1304007JC01V01 131119) detailing engineering design measures to address potential interruption of shallow groundwater flows across the MURA. The documentation (Attachment C) outlines mitigation strategies for impacts on groundwater from dwelling foundations, road pavements and service trenches. These strategies are to be implemented within future site development design.

2.4 Geology and Soil Landscapes

Geological survey of NSW geology sheet (Wollongong 5609) maps the site being underlain by Nowra Sandstone, a subgroup of the Megalong Conglomerate Group geology. Geotechnical testing, undertaken as part of the hydrogeological assessment (Martens ref: P1002761JR01V02) and supplementary *Preliminary Acid Sulfate Soils Assessment* (Martens ref: P0802193JR05V01, April 2014), confirm this geology. Basic soil profile is described as sands overlying sandy clay and sandstone bedrock. Soil depth varies from 2 - 2.5 m in the site's west to < 0.2 m along the central eastern area of the proposed development footprint.

3 Stormwater Management

3.1 Stormwater Management and Performance Objectives

Stormwater management objectives are broadly defined as:

- Provide comment and recommendation for likely on-site stormwater detention (OSD) requirements.
- Provide recommendations for on-site stormwater quality measures to ensure compliance with identified performance objectives.
- Provide preliminary details of stormwater infrastructure to drain the site via water quality controls and OSD basins.

Performance objectives are specified to generally comply with Shoalhaven City Council's (1999) Engineering Design Specification and Sustainable Stormwater Guideline. The principles of Water Sensitive Urban Design (WSUD) and Ecologically Sustainable Development (ESD) are also applied in the concept design with respect to sensitive flora downslope of the site. Objectives are summarised as follows:

- Post-development discharge rates are not to exceed the rate of discharge for existing conditions for a range of storms up to and including the 1 in 100 year ARI.
- Site OSD is designed to limit the post-development peak discharges to existing peak discharges for frequent events (1 in 3 month to 1 in 1 year ARI storm events) which have the greatest effect on vegetation.
- Site stormwater conveyance systems designed under "major/minor" concept with minor systems (pit and pipe network) designed for 1 in 5 year and major systems for 1 in 100 year ARI peak storm events.
- Site stormwater management system to achieve minimum target groundwater recharge rates to ensure existing recharge rates are maintained. Previous hydrogeological studies showed that a minimum of 125 m^2/ha of site recharge area is required.
- Post-development water quality outcomes are to be maintained as near as possible to pre-development condition to minimise impacts on native vegetation, whilst also adhering to the objectives for pollution retention listed in Table 1.

Table 1: Summary of pollution retention targets.

Pollutant	Post-development average annual load retention (%)
Total Suspended Solids	85
Total Phosphorus	65
Total Nitrogen	45
Gross Pollutants	90

3.2 Conceptual Stormwater Management System

Components of the concept site stormwater management system are:

- Rainwater tanks located on each lot (including medium density residential lots) to capture roof runoff for non-potable uses such as toilet flushing and irrigation.
- Lot OSD provided either as separate tanks or dedicated volume within rainwater tanks to provide additional at-source detention of roof runoff assuming that rainwater tanks are full at time of storm event.
- Roadside bio-infiltration swales located on one side of single cross-fall roads designed to: treat stormwater flows from roads and lots; allow recharge to groundwater systems throughout development footprint; provide surface conveyance of flows to downslope treatment measures; and provide areas for landscape planting.
- Site pit and pipe network pits and pipes designed to adequately convey the design peak storm event to site stormwater management measures.
- OSD basins (with underlying bio-infiltration functionality for OSD Basins C2a) to capture and attenuate stormwater flows from the developed site to pre-development discharge rates, whilst providing further mechanism for groundwater recharge. Basins C1a and C1 not proposed to have underlying bio-infiltration due to potentially limited soil depth in proposed basin areas.

The above measures are sized through iterative hydrological, hydraulic and water quality modelling. Design takes account of requirements for groundwater recharge determined in the hydrogeological assessment (MA report P1103064JR01V02, August 2011).

3.3 Study Methodology and Assumptions

The study used the following computer models to assess OSD and water quality requirements:

- *DRAINS* (2014.07) hydrological modelling package to determine preliminary requirements for OSD sizing. Design rainfall intensity data used in the model were consistent with figures given in Shoalhaven City Council's (1999) Engineering Design Specification. *DRAINS* model layouts used are provided in Attachment B.

- *MUSIC* (6.0.4) water quality modelling package to determine requirements for water quality treatment measures for the site. The *MUSIC* model layouts used are provided in Attachment B.

Models used the design layout (Attachment A) provided by the Client. Key assumptions used in the modelling are outlined below.

In addition to hydrological and water quality modelling, fulfilment of the minimum prescriptive groundwater recharge rate for the development of 125 m^2/ha (as per MA, 2011) was assessed through checking against proposed roadside bio-infiltration swale base areas including allowance for driveway cross-overs.

3.3.1 *DRAINS* Model Assumptions

- Existing conditions modelling used the *RAFTS* component within *DRAINS* to calculate discharge.

- Post-development site levels shall undergo a degree of alteration through cut and fill to allow appropriate road and drainage construction drainage.

- Impervious and pervious areas are based on measured lot and road areas from the conceptual layout Allen Price and Associates (Attachment A).

- Initial and continuing losses for proposed conditions include an additional 2.9 mm of depression storage to be provided in groundwater recharge system in accordance with the hydrogeological assessment (MA report P1002761JR01V01, June 2011).

- Rainwater tanks on individual lots are assumed to be 100% full at the commencement of rainfall events thus, do not contribute to site OSD and are not included in hydrological model. However,

specific OSD provision on individual lots (through dedicated OSD tanks/volume) is included at a rate of 3KL per lot.

- Site run-on flows are not considered in modelling as these areas are minor and not anticipated to change from existing conditions.

3.3.2 *MUSIC* Model Assumptions

- *MUSIC* model used 6 minute pluviograph data from Nowra climate station available on the *MUSIC* website (www.toolkit.net.au/specials/). Data was for the period 1964 – 1982. Average monthly evapotranspiration rates for Nowra (BOM, 2001) were also used in the modelling.

- Sub-catchments used the stochastic pollutant generation method for determining pollutant loads as specified by SMCMA (2010) guidelines.

- Model used combined catchments based on sub-catchments calculated for the *DRAINS* hydrological model.

- Pollutant generation rates used in the model are from SMCMA (2010).

- All stormwater runoff was assumed to go to proposed stormwater treatment measures with no areas bypassing.

- Site road bioretention swales are assumed to be 2 m wide at the base, 3 m wide at the top and are modelled as a combined unit per catchment. Swales are assumed to have 3.5 m wide gaps at the front of each lot that they are adjacent to, to allow for a driveway crossing.

- Exfiltration rates for all roadside bioretention swales were set at 10 mm/hr for required site groundwater recharge.

- Proposed rainwater tanks (3KL/dwelling) are combined into one treatment node for each catchment. All roof areas are assumed to drain to rainwater tanks.

- Rainwater re-use rates are based on typical potable water demand for residential lots from Shoalhaven Water of 548 L/day (200 KL/year) which is defined as 1 Equivalent Tenement (ET). 44% of this rate is assumed to be non-potable demand (as per NSW Department of Water and Energy, 2008 '*NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential*

Premises') and shall be satisfied by rainwater tanks. This equates to 88KL/year /dwelling.

- The proposed medium density lot was estimated to be equivalent to 3 dwellings in terms of reuse and rainwater tank allowance.

3.4 Site Hydrological Assessment

3.4.1 *DRAINS* Model Set-up

DRAINS modelling set-up assumptions are outlined above in Section 3.3.1. Model catchments, initial and continuing losses and area type breakdowns are summarised in the following tables.

Hydrological model setup is consistent with the approach utilised in *Stormwater Management Assessment – Lot 1 DP 1021332 and Lot 458 DP 1063107* (MA reference P1002863JR03V02, December 2012). A RAFTS based model was utilised for the rural land type pre-development model with initial and continuing losses presented in Table 2. An Ilsax based model was utilised for the urbanised post-development model with paved, supplementary and grassed area depression storages allowances as nominated also in Table 2.

Table 2: Hydrological model setup used in *DRAINS* modelling.

Component	Mundamia Proposed[1] (ILSAX based)	Mundamia Existing (RAFTS based)
Paved area depression storage (mm)	3.9	-
Supplementary area depression storage (mm)	3.9	-
Pervious area depression storage (mm)	7.9	-
Impervious Initial Loss (mm)	-	1
Impervious Continuing Loss (mm/hr)	-	0
Pervious Initial Loss (mm)	-	15
Pervious Continuing Loss (mm/hr)	-	2

Note: [1] Soil Type = 3.

Catchments setups are summarised in Table 3 and Table 4 and are based on measured areas from the proposed site plan (Attachment A); a dwelling roof area estimate of 250m^2 per lot; pavement widths of 6m per 16m road reserve and 9m per 20m road reserve; driveway layback

areas of 10m^2 per lot and an additional 20% supplementary (paved areas running on to grassed areas) for all urban areas.

Table 3: Pre-development catchment DRAINS model setup.

Catchment	Area (ha)	Imp Area (%)	Slope (%)	Mannings (n)
Pre C1a Cleared	2.418	0	2	0.05
Pre C1a Forested	1.53	0	13.3	0.08
Pre C1 Cleared	2.457	0	1.8	0.05
Pre C1 Forested	3.789	0	8.1	0.08
Pre C2 Cleared	15.74	0	1.9	0.05
Pre C2 Forested	7.116	0	4.1	0.08
Pre Road Reserve	0.853	30	1.6	0.03
Total	**33.903**			

Table 4: Post-development catchment DRAINS model setup.

Catchment	AREA	(Roads Area)	PAVED					SUPPLEMENTARY					GRASSED				
	(ha)	(ha)	Area % (% of total)	Addit. Time (mins)	Length (m)	Slope (%)	Roughness (Coeff.)	Area % (% of total)	Addit. Time (mins)	Length (m)	Slope (%)	Roughness (Coeff.)	Area % (% of total)	Addit. Time (mins)	Length (m)	Slope (%)	Roughness (Coeff.)
C1a Other	2.459	0.488	20%	0	235	2.1	0.013	20%	0	30	2	0.013	60%	0	235	2.1	0.33
C1a Roof	0.8		100%	5				0%					0%				
C1 Other	4.797	0.854	18%	0	350	3.3	0.013	20%	0	30	2	0.013	62%	0	350	3.3	0.33
C1 Roof	1.825		100%	5				0%					0%				
C1&C1a/0	0.424	0	0%					0%					100%	0	21	19	0.15
C2a Other	5.398	0.862	16%	0	480	1.2	0.013	20%	0	30	2	0.013	64%	0	480	1.2	0.33
C2a Roof	2.05		100%	5				0%					0%				
C2/0 Other	0.872	0.1074	9%	0	135	5.9	0.013	20%	0	30	2	0.013	71%	0	135	5.9	0.33
C2/0 Roof	0.325		100%	5				0%					0%				
C2/1 Other	5.347	0.552	8%	0	350	3.1	0.013	20%	0	30	2	0.013	72%	0	350	3.1	0.33
C2/1 Roof	1.2		100%	5				0%					0%				
C2/2 Other	3.399	0.5412	11%	0	510	1.8	0.013	20%	0	30	2	0.013	69%	0	510	1.8	0.33
C2/2 Roof	1.35		100%	5				0%					0%				
C2/3 Other	2.757	0.45225	12%	0	400	1	0.013	20%	0	30	2	0.013	68%	0	400	1	0.33
C2/3 Roof	0.9		100%	5				0%					0%				
Total	**33.903**																

Table 5: DRAINS model results summary - Total simultaneous site discharge (m^3/s).

ARI	Scenario	Duration (Mins)										
		30	45	60	90	120	180	270	360	540	720	1080
1 in 3 mth	Existing	0.09	0.28	0.42	0.53	0.61	0.64	0.60	0.70	0.96	0.87	0.61
	Proposed	0.06	0.06	0.11	0.15	0.16	0.16	0.15	0.16	0.23	0.23	0.22
	Change	-0.03	-0.22	-0.30	-0.39	-0.45	-0.48	-0.45	-0.54	-0.73	-0.63	-0.39
1 in 1 yr	Existing	0.65	1.04	1.25	1.38	1.48	1.41	1.41	1.61	1.76	1.74	1.17
	Proposed	0.13	0.25	0.33	0.35	0.38	0.40	0.42	0.46	0.62	0.68	0.59
	Change	-0.52	-0.79	-0.92	-1.03	-1.10	-1.01	-0.99	-1.15	-1.14	-1.07	-0.58
1 in 10 yr	Existing	3.13	4.03	4.65	4.68	4.97	4.43	5.20	4.61	4.20	4.51	3.38
	Proposed	1.44	1.93	2.22	2.41	2.55	2.73	2.72	2.54	3.11	2.78	1.97
	Change	-1.69	-2.10	-2.43	-2.27	-2.42	-1.70	-2.48	-2.07	-1.09	-1.73	-1.41
1 in 100 yr	Existing	6.59	7.85	8.87	8.90	9.68	7.85	9.07	7.93	6.90	7.44	5.46
	Proposed	4.58	6.96	7.31	6.93	7.07	6.74	6.73	6.20	5.41	5.66	4.29
	Change	-2.01	-0.89	-1.56	-1.97	-2.61	-1.11	-2.34	-1.73	-1.49	-1.78	-1.17

3.4.2 *DRAINS* Model Results

End-of-line OSD Basins (Basin1a, Basin1, Basin2a and Basin2) were iteratively designed to ensure post-development flows were less than pre-development flows for all storm events (1in 3month to 1 in 100 year ARI) for all durations (10 minutes to 1080 minutes). Results are summarised in Table 5. General comments about the hydrological model are as follows:

- Results show that the proposed OSD end-of-line basins together with lot OSDs (3KL per lot) are effective at reducing total site simultaneous post-development peak discharges to existing condition (pre development) peak discharges for all modelled storms and durations.

- Table 6 summarises preliminary minimum OSD requirements for the proposed development. Note that *DRAINS* modelling was based on the volume vs elevation method and as such basin areas will be dependent on basin form (batters, shape etc.), and would typically be developed in the next stages of project design and involve consideration of a number of issues including amenity, environment and geotechnical considerations.

- Table 7 provides preliminary descriptions of OSD characteristics and is also subject to change during the detailed design phase.

Table 6: Summary of preliminary OSD basin requirements.

Catchment / Basin	OSD Volume (m^3)	OSD Area (m^2)[1]	Invert (mAHD)	Outlet Pipe Orifice (mm) and R.L. (mAHD)							
				Low-Flow		Mid-Level		High-Flow		Weir	
				Orifice	Level	Orifice	Level	Orifice	Level	Invert	Top
C1a	600	1000	54.0	100	54.0	225	54.25	3 x 200	54.4	54.7	54.9
C1	1,200	2000	52.0	100	52.0	225	52.25	3 x 250	52.3	52.7	52.9
C2a	2,500	2900	63.0	100	63.0	225	63.3	3 x 335	63.45	63.75	63.9
C2	5,400	7000	48.0	3 x100	48.0	3 x 225	48.2	4 x 320	48.3	48.7	48.9
Lot OSD	3/lot	Subject to detailed design (319 residential allotments)									

Note: [1] Preliminary area, approximate only and derived allowing for 1:3 batters along 1 edge of basin and vertical sides along others. Basin area and form to be defined during detailed design stage.

Table 7: Preliminary OSD basin descriptions.

Basin	Location	Form[1]	Groundcover[1]	Other
C1a	Public Reserve (Bushland)	Rear - 1in3 batter, front - blockwork retained.	Native low spreading sedges/ groundcovers	-
C1	Public Reserve (Bushland)	Rear - 1in3 batter, front - blockwork retained.	Native low spreading sedges/ groundcovers	-
C2a	Public Reserve (Park)	Rear - 1in3 batter, front - blockwork retained.	Maintained grass	Underlying bio-retention filter
C2	Public Reserve (Bushland)	Rear - 1in3 batter, front - blockwork retained.	Native low spreading sedges/ groundcovers	-

Note: [1] Basin area and form to be defined during detailed design stage. Additional volume allowance to be incorporated into design to allow for basin vegetation.

3.5 Site Stormwater Quality

3.5.1 *MUSIC* Model Set-up

MUSIC model was set-up with sub-catchments and treatment nodes as detailed in the following tables and assumptions outlined in Section 3.3.2. Sub-catchments were assigned event mean and baseflow pollutant generation rates based on the catchment usage and soil parameters based on the site sub-surface investigations. Details of pollutant generation rates used are given in Table 8, soil parameters in Table 10. Rates and parameters adopted are based on SMCMA (2010).

Table 8: Event mean and baseflow concentration of pollutants used in *MUSIC* modelling (SMCMA, 2010).

Land-use	Parameter	Base Flow (mg/L)		Storm Flow (mg/L)	
		Log (mean)	Log (stdev)	Log (mean)	Log (stdev)
Agricultural	Total suspended solids	1.300	0.130	2.150	0.310
	Total phosphorus	-1.050	0.130	-0.220	0.300
	Total nitrogen	0.040	0.130	0.480	0.260
Forest	Total suspended solids	0.780	0.130	1.600	0.200
	Total phosphorus	-1.520	0.130	-1.100	0.220
	Total nitrogen	-0.520	0.130	-0.050	0.240
Urban Residential	Total suspended solids	1.200	0.170	2.150	0.320
	Total phosphorus	-0.850	0.190	0.600	0.250
	Total nitrogen	0.110	0.120	0.300	0.190
Road	Total suspended solids	1.200	0.170	2.430	0.320
	Total phosphorus	-0.850	0.190	-0.300	0.250
	Total nitrogen	0.110	0.120	0.340	0.190
Roof	Total suspended solids	na	na	1.300	0.320
	Total phosphorus	na	na	-0.890	0.250
	Total nitrogen	na	na	0.300	0.190

Table 9: Catchments used in *MUSIC* modelling.

Scenario	Model Catchment	Catchment Area (ha)	Impervious (% of Total)	Pervious (% of Total)	Adopted Land-use
Pre Development	Pre C1a Cleared	2.418	0	100	Agricultural
	Pre C1a Forest	1.530	0	100	Forest
	Pre C1 Cleared	2.457	0	100	Agricultural
	Pre C1 Forest	3.789	0	100	Forest
	Pre C2 (& C2a) Cleared	15.111	0	100	Agricultural
	Pre C2 (& C2a) Forest	7.116	0	100	Forest
	Existing Forested Road Easement	0.629	0	100	Forest
	Existing Road Reserve	0.853	30	70	Road
	Total	**33.903**			
Pre Development	Roads C1a	0.488	100	0	Road
	Roofs C1a	0.800	100	0	Roof
	Urban C1a	2.067	5	95	Urban Residential
	Roads C1	0.854	100	0	Road
	Roofs C1	1.825	100	0	Roof
	Urban C1	4.271	5	95	Urban Residential
	Roads C2a	0.862	100	0	Road
	Roofs C2a	2.050	100	0	Roof
	Urban C2a	4.536	5	95	Urban Residential
	Roads C2	2.232	100	0	Road
	Roofs C2	3.775	100	0	Roof
	Urban C2	10.143	5	95	Urban Residential
	Total	**33.903**			

Table 10: Soil parameters used in *MUSIC* modelling.

Modelling Parameter	Value Adopted
Rainfall Threshold (mm/day)	1.5
Soil Storage Capacity (mm)	142
Initial Storage (% of Capacity)	25
Field Capacity (mm)	94
Infiltration Capacity Coefficient - a	180
Infiltration Capacity Coefficient - b	3.0
Initial Depth – Groundwater (mm)	10
Daily Recharge Rate – Groundwater (%)	25
Daily Baseflow Rate – Groundwater (%)	25
Daily Deep Seepage Rate – Groundwater (%)	0

Table 11: General parameters used in treatment nodes for post-development conditions.

Treatment Node	Parameters Adopted for *MUSIC* model
Rainwater tank (Individual tank properties)	Low flow by-pass – 0.0 m^3/s
	High flow by-pass – 0.005 m^3/s/dwelling
	Volume below overflow pipe – 3.0KL
	Depth above overflow – 0.2 m
	Surface area – 1.7m^2
	Initial volume - 3.0KL
Road bioretention swale	Low flow by-pass – 0 m^3/s
	High flow by-pass – 5.0 m^3/s
	Extended detention depth – 0.10 m
	Filter depth – 0.52 m
	Saturated hydraulic conductivity – 100 mm/hr
	TN content of filter material – 500 mg/kg
	Orthophosphate content of filter material – 50 mg/kg
	Exfiltration rate – 3.6mm/hr
	Base lined – No; Effective nutrient plants - Yes,
	Overflow weir width = 5m; Underdrain present – Yes; Submerged with carbon present - No.

Table 12: Treatment node parameters by catchment.

Treatment Node	Parameter	C1a	C1	C2a	C2
Rainwater tank	Volume (m^3)	96	219	246	453
	Demand[4] (KL/yr)	2,816	6,424	7,216	13,288
Roadside bioretention swale	Length (m)	354	1,004	1,013	2,226
	Swale area[1,2] (m^2)	443	1,255	1,266	2,783
	Filter area (m^2)	354	1,004	1,013	2,226
	Filter perimeter[3] (m)	732	2,074	2,192	4,554
Bioretention filter underlying OSD basin	Width & length (m)	Not provided	Not provided	40 x 70	Not provided
	Surface area[1,2] (m^2)			1,400	
	Filter area (m^2)			1,400	
	Filter perimeter[3] (m)			220	

Notes: [1.] Measured as area at half the depth of the swale. [2] 50% of measured areas (swale storage area and filter area) utilised in modelling to represent effect of catchment flows entering swale along length of swale rather than at top of swale. [3] Perimeter estimated as (2 x swale length) + (no. of driveway crossovers x 2). [4] Demand distribution – PET Rain mechanism.

3.5.2 *MUSIC* Model Results

Results of the *MUSIC* model are summarised in Table 13 and Table 14 and indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, are satisfied by the proposed stormwater treatment train.

Water quality modelling results are preliminary only and treatment train design should be further refined at detailed design stage of the development.

Table 13: Results of *MUSIC* modelling – mean annual loads.

Catchment	Conditions	Total Suspended Solids (kg/year)	Total Phosphorus (kg/year)	Total Nitrogen (kg/year)
C1a	Existing	1,010	3.98	22.5
	Proposed	417	2.04	18.7
	Change	-593	-1.94	-3.8
C1	Existing	1,220	4.5	28.2
	Proposed	625	3.8	33.9
	Change	-595	-0.7	5.7
C2 & C2a	Existing	7,460	26.6	148
	Proposed	1,910	12.0	105
	Change	-5,550	-14.6	-43
Total Site	Existing	9,690	35.0	199
	Proposed	2,950	17.9	158
	Change	-6,740	-17.1	-41

Table 14: Results of *MUSIC* modelling – pollution retention rates.

Catchment		Total Suspended Solids (kg/year)	Total Phosphorus (kg/year)	Total Nitrogen (kg/year)	Gross Pollutants
C1a	Generated	2,610	5.41	40.8	347
	Discharged	417	2.04	18.7	0
	Reduction (%)	84.0	62.4	54.2	100
C1	Generated	4,900	10.7	84.3	729
	Discharged	625	3.8	33.9	0
	Reduction (%)	87.2	64.5	59.8	100
C2 & C2a	Generated	17,300	36.9	284	2,420
	Discharged	1,910	12	105	0.115
	Reduction (%)	89.0	67.4	62.9	100
Total Site	Generated	24,800	53.0	409	3,500
	Discharged	2,950	17.9	158	0.115
	Reduction (%)	88.1	66.3	61.4	100
Target	**Reduction (%)**	**85**	**65**	**45**	**90**

3.6 Groundwater Recharge

Proposed roadside bioretention swales, with unlined bases, along all site roads will a provide a mechanism for groundwater recharge across the entire development site in order to best replicate pre-development recharge conditions. Total base area of proposed bioretention swales is 9,914 m^2. This equates to approximately 295 m^2/ha of recharge area and satisfies the prescribed 125 m^2/ha requirement (MA, 2011a)

4 Recommendations Summary

4.1 Stormwater System Design

The following recommendations regarding system design, implementation and management are provided to detail the scope of future requirements. They are to be reviewed, finalised and developed as the development progresses with final solutions developed prior to the release of construction certificate.

4.1.1 Design Recommendations

The following design recommendations are made with respect to stormwater management for the site. These recommendations address the findings of the hydrogeological assessment (MA report P1002761JR01V01, June 2011):

- Stormwater runoff from all site roofs is to be directed to rainwater tanks on individual lots for non-potable re-use purposes (e.g. irrigation, toilet flushing, laundry, *etc.*). Rainwater tanks are to have a minimum volume of 3 KL/lot for individual residential lots and 1.5 KL/dwelling for medium density and dual occupancy lots.

- A dedicated OSD (with appropriately designed orifice controlled outlet) of 3KL/lot is also to be provided as either a standalone OSD tank or as dedicated additional OSD volume within the rainwater tank.

- Stormwater runoff from lots and roads is to be directed to roadside bioretention swales. Swales are to have a minimum top width of 3.0 m and a minimum base width of 2.0 m. Swales are to be a minimum of 0.1 m deep with 1V:2.5H side slopes. Bioretention filters are to be a minimum depth of 0.52 m and are to be unlined to allow groundwater recharge. Swales are to have an underdrain and overflow system connected to an appropriately sized pit and pipe drainage system.

- A stormwater system including pits, pipes and associated infrastructure is to be constructed within road reserves to direct flows from bioretention swales to site OSD basins and discharge control structures. Detailed sizing and location of all pits and pipes is to be completed prior to the issue of a construction certificate.

- Runoff from site areas is to be directed to proposed OSD basins located as shown in Attachment A and primarily consistent with properties as outlined in Table 6. Basin C2a is to incorporate a bioretention filter with parameters as outlined in Table 12.

- Preliminary OSD basin design consists of a discharge pit with low-level, mid-level and high flow pipes that discharge to an outlet headwall. Pipe outlets are summarised in Table 6. Basin 2a pipe discharge is to be located east of the proposed development in the vicinity of the outlet for Basin C2.

- Detailed design of OSD basins is to be completed prior to the issue of a construction certificate.

- Site stormwater outlets will require appropriate level spreader(s) / energy dissipater(s) to replicate existing flow conditions. An appropriate setback should be established between site stormwater outlets and areas of sensitive vegetation.

4.1.2 System Implementation Recommendations

The proposed solution includes works both in future public lands (road side swales and end-of-line OSD basins within public reserves to be vested to Council) and on private lands (rainwater and OSD tanks). The following section provides initial comments on matters to be considered to ensure the solution is appropriately implemented on the site.

The construction of end of pipe and roadside structures would be undertaken as a condition of future sub-division consent and would occur as the development road system is constructed. On completion, these systems may be maintained for a period by the developer or be transferred to Council for their management. It is anticipated that the specifications for the system shall form a condition of future sub-division consent.

Future allotments shall be burdened with the need for stormwater management infrastructure to achieve the objectives of this study. The infrastructure required shall include a rainwater tank (as is generally required throughout NSW due to BASIX), and dedicated OSD storage, both with minimum volume as detailed in this report.

4.1.3 System Management Recommendations

To ensure that the proposed stormwater systems continue to perform as designed, the following management and maintenance measures are required:

- Road side bioretention swales and OSD basins should be inspected and cleaned routinely to ensure litter accumulation does not become excessive.

- Periodic removal of accumulated silts from bioretention swales, beds, and OSD basins may be required to ensure ongoing hydraulic performance. System monitoring is to be undertaken to ensure that adequate infiltration into filter media is maintained. Where infiltration deteriorates, the owner of the infrastructure shall be required to replace filter media.

- Vegetation management is required to ensure that systems do not become clogged with dead and decaying vegetation and to ensure that vegetation does not block water flow through the systems. Maintenance requirements for vegetation shall depend on the nature of the plants and is to be developed in detail as part of the final project landscape management plan.

5 Conclusions

The following recommendations and conclusions are made based on the hydrological and water quality assessments:

- The completed analysis indicates that, even with best practice water quality and quantity control solutions as developed in this assessment it is not feasible to achieve a post development surface water regime which exactly mimics the pre-development condition.

- However, the proposed development does not have an adverse impact on downslope areas (in terms of increased peak discharge rates and pollutant loads) based on detailed hydrological and water quality modelling completed.

- Site OSD basins are designed to mitigate peak discharges for the range of storm durations for recurrence intervals from the 1 in 3 month ARI to the 1 in 100 year ARI.

- Results indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, will be met by the proposed stormwater treatment train.

- Site roads are to be designed as single cross-fall pavements with bioretention swales located within the verge of the low side (Attachment B).

- Nominated road bioretention swale base areas achieve minimum prescribed groundwater recharge area requirements (125 m^2/ha) as per the hydrogeological assessment (MA, 2011a).

- Rainwater tanks (for non-potable reuse) and dedicated OSD storages are to be included on all lots in accordance with report water quality and OSD findings.

6 References

Bureau of Meteorology (2001), *Climatic Atlas of Australia – Evapotranspiration.*

Institute of Engineer's Australia (1987), *Australian Rainfall and Runoff.*

Martens & Associates (June, 2011a), *Hydrogeological Assessment, Proposed Sub-division, Mundamia Release Area, Mundamia NSW* (MA reference P1001761JR01V02).

Martens & Associates (August, 2011b), *Surface Water Hydrology Assessment, Mundamia Urban Release Area* (MA reference P1103064JR01V02).

Martens & Associates (December, 2012), *Stormwater Management Assessment – Lot 1 DP 1021332 and Lot 458 DP 1063107, George Evans Road, Mundamia* (MA reference P1002863JR03V02, December 2012).

NSW Department of Water and Energy (2008), *NSW Guidelines for Greywater Reuse in Sewered, Single Household Residential Premises.*

Shoalhaven City Council (2002), *Development Control Plan 100.*

Shoalhaven City Council (1999), *Engineering Design Specifications.*

Shoalhaven City Council *Sustainable Stormwater Guidelines.*

Sydney Metropolitan Catchment Management Authority (2010), *Draft MUSIC Modelling Guidelines.*

www.toolkit.net.au/specials/

7 Attachment A – Site Plan

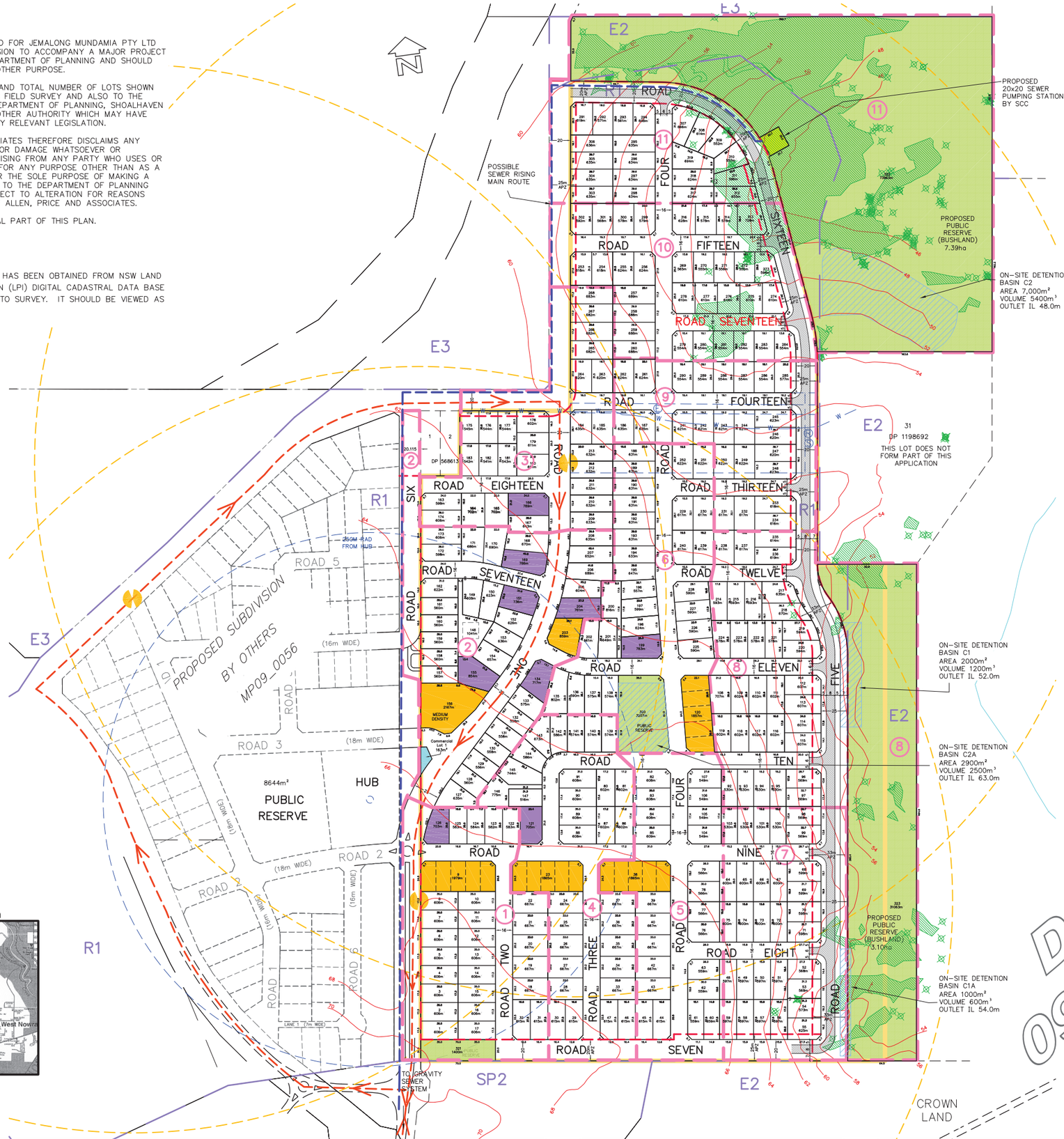
THIS PLAN WAS PREPARED FOR JEMALONG MUNDAMIA PTY LTD AS A PROPOSED SUBDIVISION TO ACCOMPANY A MAJOR PROJECT APPLICATION TO THE DEPARTMENT OF PLANNING AND SHOULD NOT BE USED FOR ANY OTHER PURPOSE.

THE DIMENSIONS, AREAS AND TOTAL NUMBER OF LOTS SHOWN HEREON ARE SUBJECT TO FIELD SURVEY AND ALSO TO THE REQUIREMENTS OF THE DEPARTMENT OF PLANNING, SHOALHAVEN CITY COUNCIL AND ANY OTHER AUTHORITY WHICH MAY HAVE REQUIREMENTS UNDER ANY RELEVANT LEGISLATION.

ALLEN, PRICE AND ASSOCIATES THEREFORE DISCLAIMS ANY LIABILITY FOR ANY LOSS OR DAMAGE WHATSOEVER OR HOWSOEVER INCURRED ARISING FROM ANY PARTY WHO USES OR RELIES UPON THIS PLAN FOR ANY PURPOSE OTHER THAN AS A DOCUMENT PREPARED FOR THE SOLE PURPOSE OF MAKING A SUBDIVISION APPLICATION TO THE DEPARTMENT OF PLANNING AND WHICH MAY BE SUBJECT TO ALTERATION FOR REASONS BEYOND THE CONTROL OF ALLEN, PRICE AND ASSOCIATES.

THIS NOTE IS AN INTEGRAL PART OF THIS PLAN.

NOTE:
CADASTRAL INFORMATION HAS BEEN OBTAINED FROM NSW LAND & PROPERTY INFORMATION (LPI) DIGITAL CADASTRAL DATA BASE (DCDB) AND IS SUBJECT TO SURVEY. IT SHOULD BE VIEWED AS APPROXIMATE ONLY.



COMMERCIAL

DUAL OCCUPANCY

MULTI DWELLING HOUSING

APZ LINE

PROPOSED BUS ROUTE SHOWING DIRECTION OF TRAVEL

PROPOSED BUS STOP

500m WALKING DISTANCE FROM PROPOSED BUS STOP

R1 ZONING LINE

DENOTES LOCATION OF NOWRA HEATH MYRTLE BY SLR– FIG. 8

DENOTES LOCATION OF NOWRA HEATH MYRTLE PATCHES BY SLR FIG. 8

PROPOSED SEWER RISING MAIN ROUTE BY SCC

11 STAGING

DEVELOPABLE AREA

DENOTES EASEMENTS OF DP 1198692 TO BE PROGRESSIVELY EXPUNGED AS WORKS PROGRESS

EASEMENTS CREATED IN DP 1198692

W DENOTES EASEMENT FOR WATER OVER EXISTING LINE OF PIPE (APPROX. POSITION) (DP 1198692)

(R) RIGHT OF WAY 75 WIDE (DP 1198692)

(S) EASEMENT FOR SUPPLY OF SERVICES 75 WIDE (DP 1198692)

(E) EASEMENT FOR OVERHEAD POWERLINES 9 WIDE (DP 1198692)

RESIDENTIAL STAGING

1	29 LOTS
2	35 LOTS
3	28 LOTS
4	32 LOTS
5	25 LOTS
6	30 LOTS
7	30 LOTS
8	33 LOTS
9	24 LOTS
10	32 LOTS
11	21 LOTS
TOTAL	319 LOTS

LOT YIELD

RESIDENTIAL LOTS	304	
DUAL OCCUPANCY	9	(18 DWELLINGS)
MULTI DWELLING LOTS	6	(29 DWELLINGS)
TOTAL	319	(351 DWELLINGS)
PUBLIC RESERVE	4	
COMMERCIAL LOT	1	

OVERALL SITE AREA	41.39 ha
OVERALL DEV. AREA	31.57 ha
JEMALONG PUBLIC RESERVE	4,607m²
SCC PUBLIC RESERVE	8,644m²
TOTAL	13,251m²

RESERVE AREA REQUIRED
JEMALONG
351 DWELLINGS x 2.5 People x 12m² = 10,530m²

SCC
103 LOTS x 2.5 People x 12m² = 3,090m²

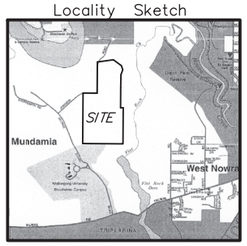
TOTAL 13,620m²

PUBLIC RESERVE (BUSHLAND)–NTH 7.39ha
PUBLIC RESERVE (BUSHLAND)–STH 3.10ha
TOTAL 10.49ha

JEMALONG DEVELOPMENT AREA PER HECTARE
31.57ha/351 dwellings = 11.11 dwellings per hectare

DRAFT 09.04.2015

Locality Sketch



0 25 50 75 100
scale: – 1:2000

Liability limited by a scheme approved under Professional Standards Legislation.
COVER OF EXCELLENCE

RATIO: 1:2000 AT A1
1:4000 AT A3

DATUM:
ORIGIN:
DATE OF PLAN: 25 FEB. 2014

SURVEY	
DESIGN	MJP
DRAWN	DS
CHECK'D	

	REVISION	BY	DATE
1	MINOR AMENDMENTS TO LOT LAYOUT. ALLOCATED DP No .ADDED.	DS	14.07.2014
2	MINOR AMENDMENTS TO LOT LAYOUT.	DS	15.07.2014
3	MINOR AMENDMENTS TO LOT LAYOUT, APZ AMENDED, NOTES RE ON SITE DETENTION ADDED.	DS	12.08.2014
4	APZ's, DETENTION BASINS & HEATH MYRTLE PATCHES AMENDED TO REFLECT CONSULTANTS STUDIES.	DS	15.08.2014
5	APZ's AMENDED TO ADD RADII. BUFFER REMOVED. NOTE ADDED TO NORTHERN CONSERVATION AREA.	DS	15.08.2014
6	MINOR AMENDMENTS TO STAGES, LOT YIELD, COMMERCIAL LOT ADDED	DS	27.10.2014
7	LOT LAYOUT AMENDED TO SUIT REVISED APZ ZONES	DS	23.03.2015
8	KERB DETAIL ADDED ROAD 5. DET.BASINS C1 & C1A SHIFTED.	DS	09.04.2015

allen, price & associates
land and development consultants
75 plunkett street, nowra, nsw. 2541
phone:(02) 4421 e544 fax:(02) 4422 1821
consultants@allenprice.com.au www.allenprice.com.au

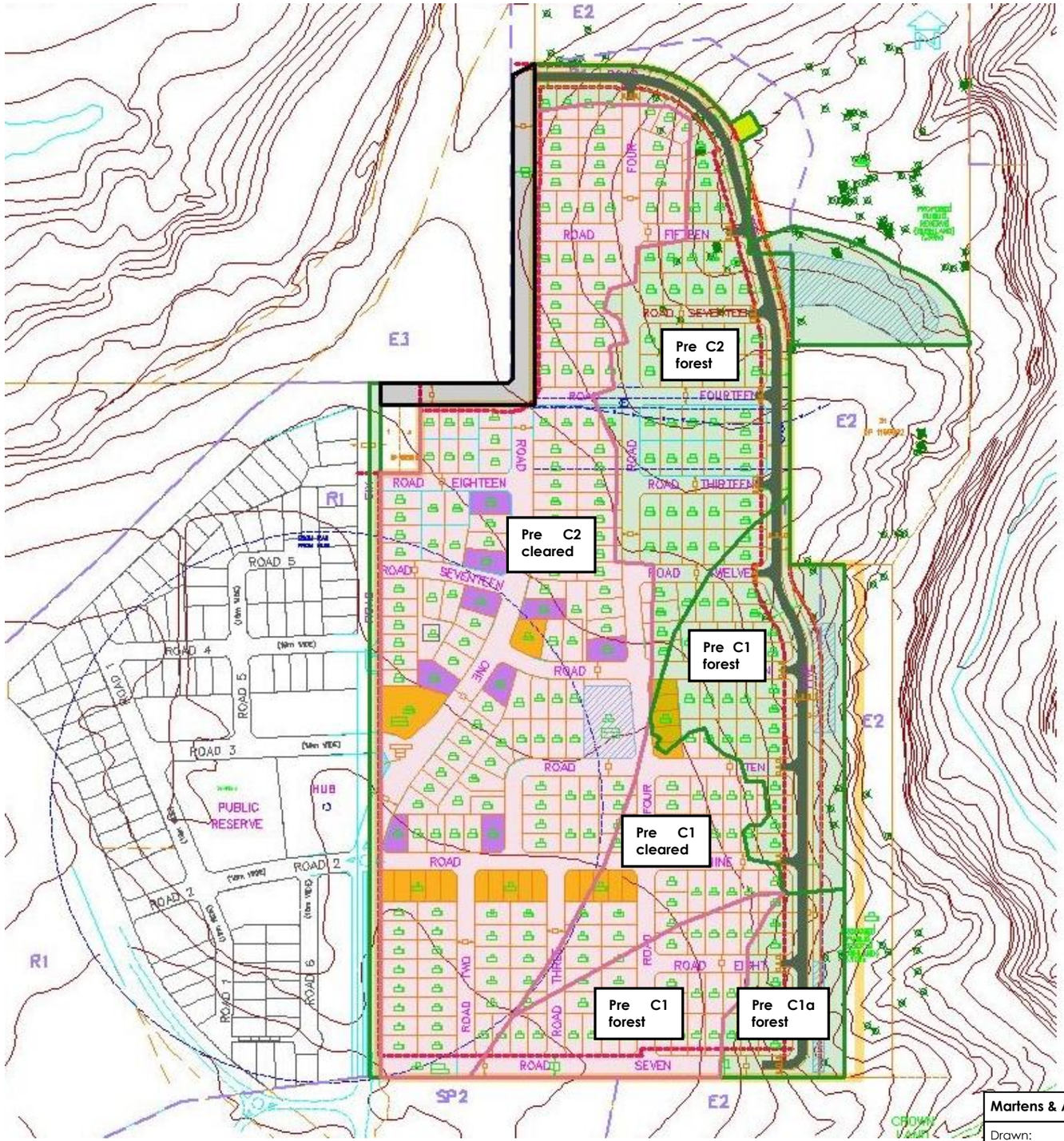
PLAN SHOWING PROPOSED SUBDIVISION OF LOT 30 DP 1198692 (PREVIOUSLY LOT 3 DP 568613 & LOT 384 DP 755952) AT MUNDAMIA GROWTH AREA FOR JEMALONG MUNDAMIA PTY LTD

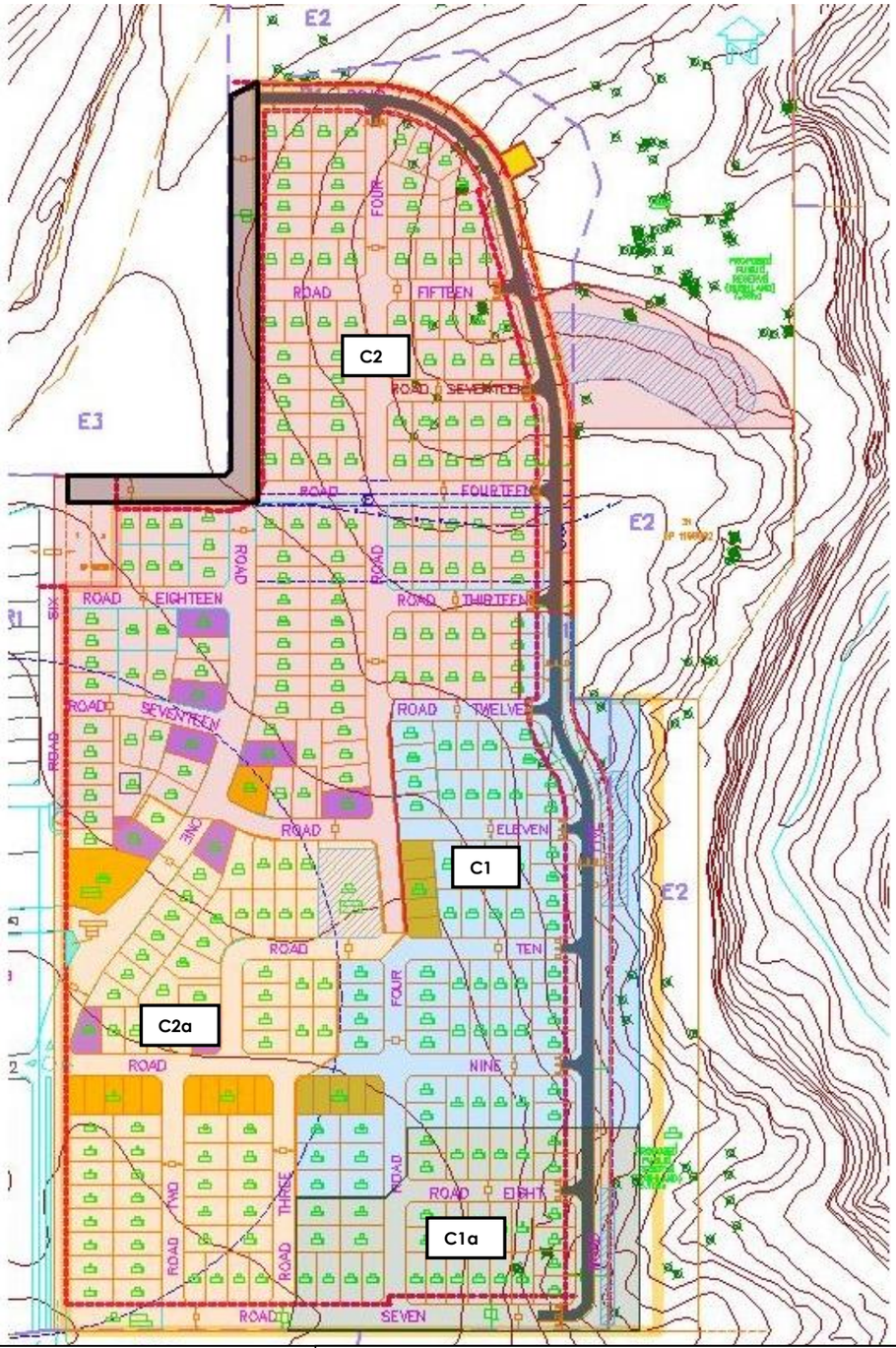
REF. No. 25489–11

SHEET 1 OF 1 SHEETS

REVISION 07

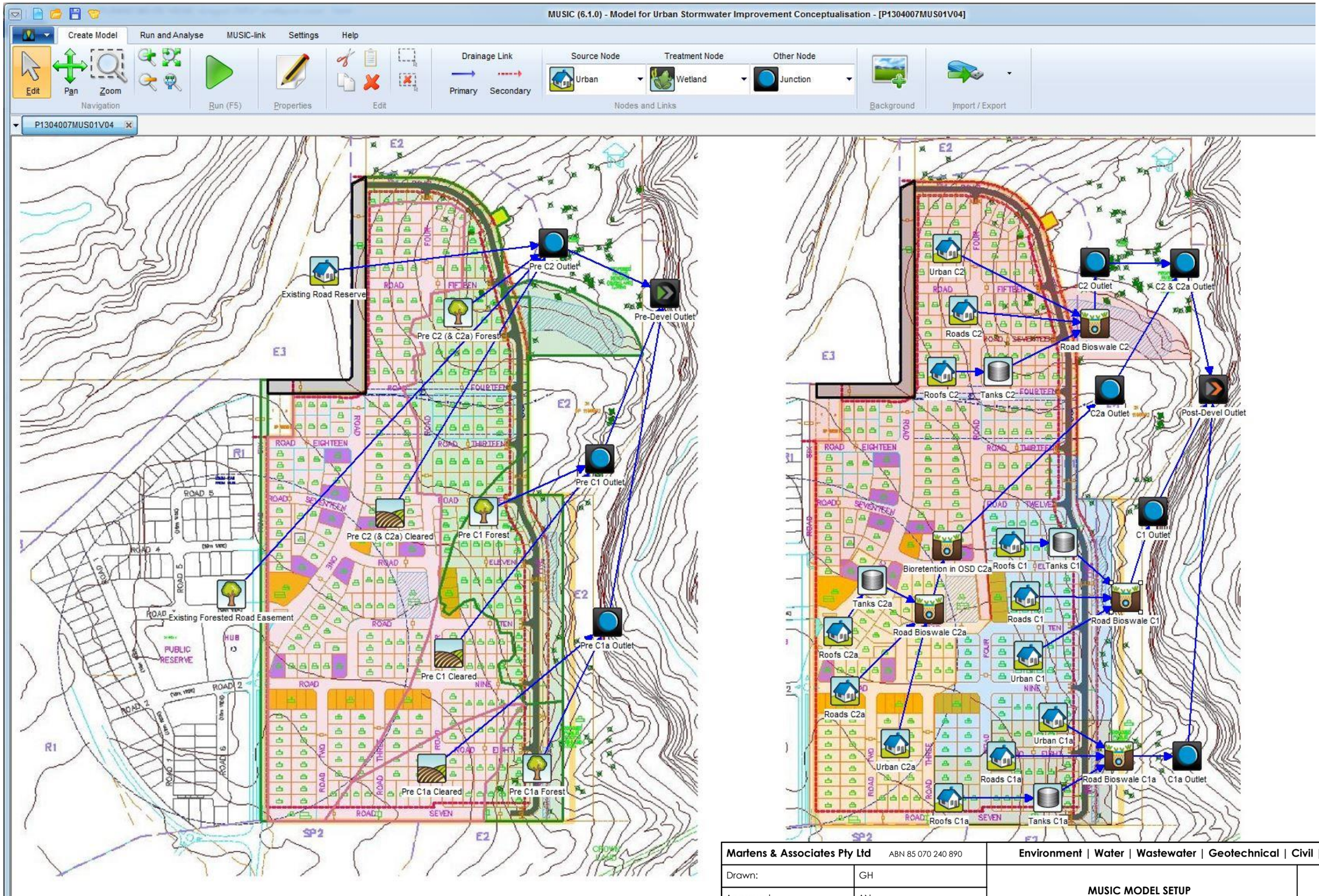
8 Attachment B – Model Sub-Catchment Plans and Set-ups



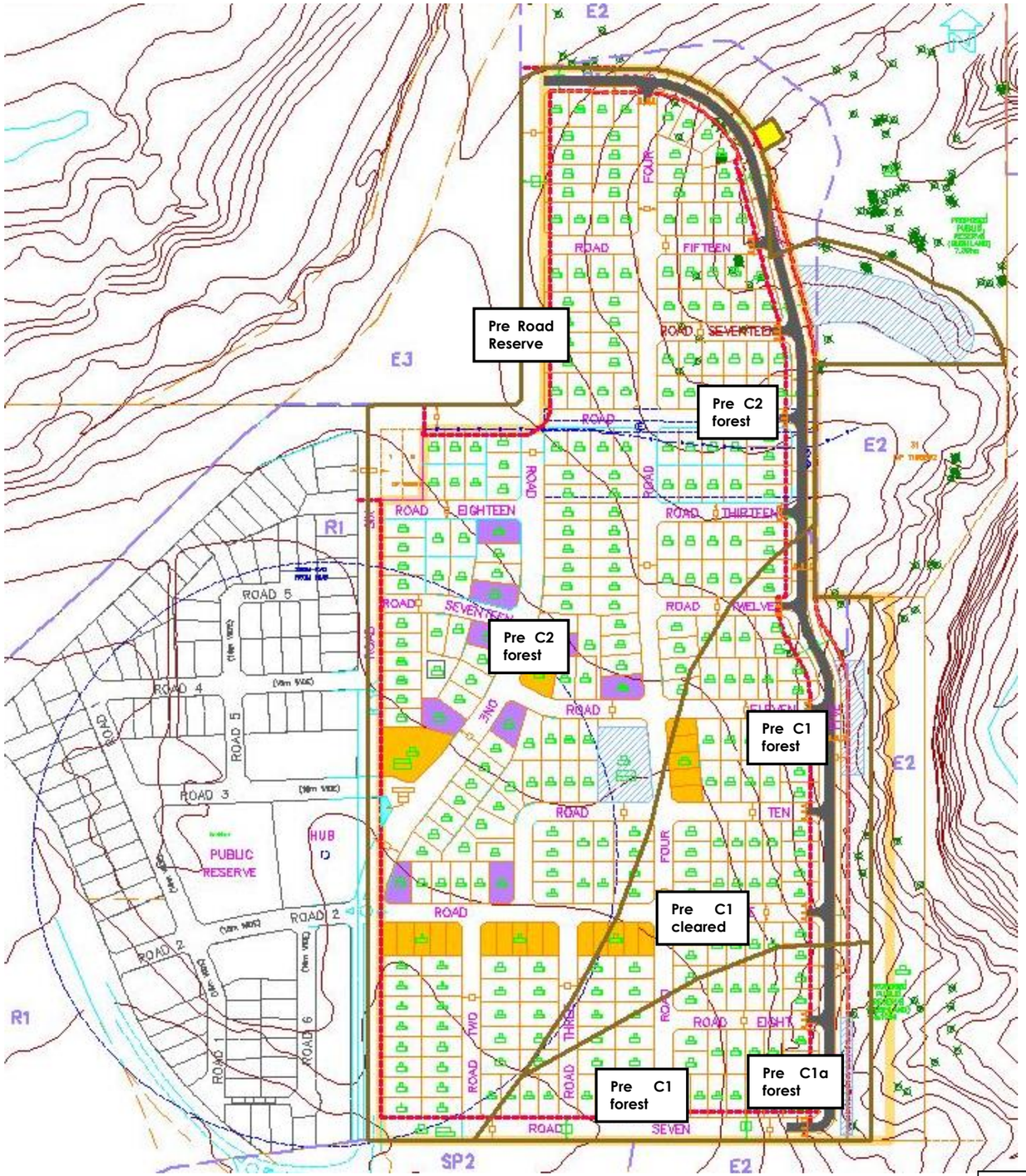


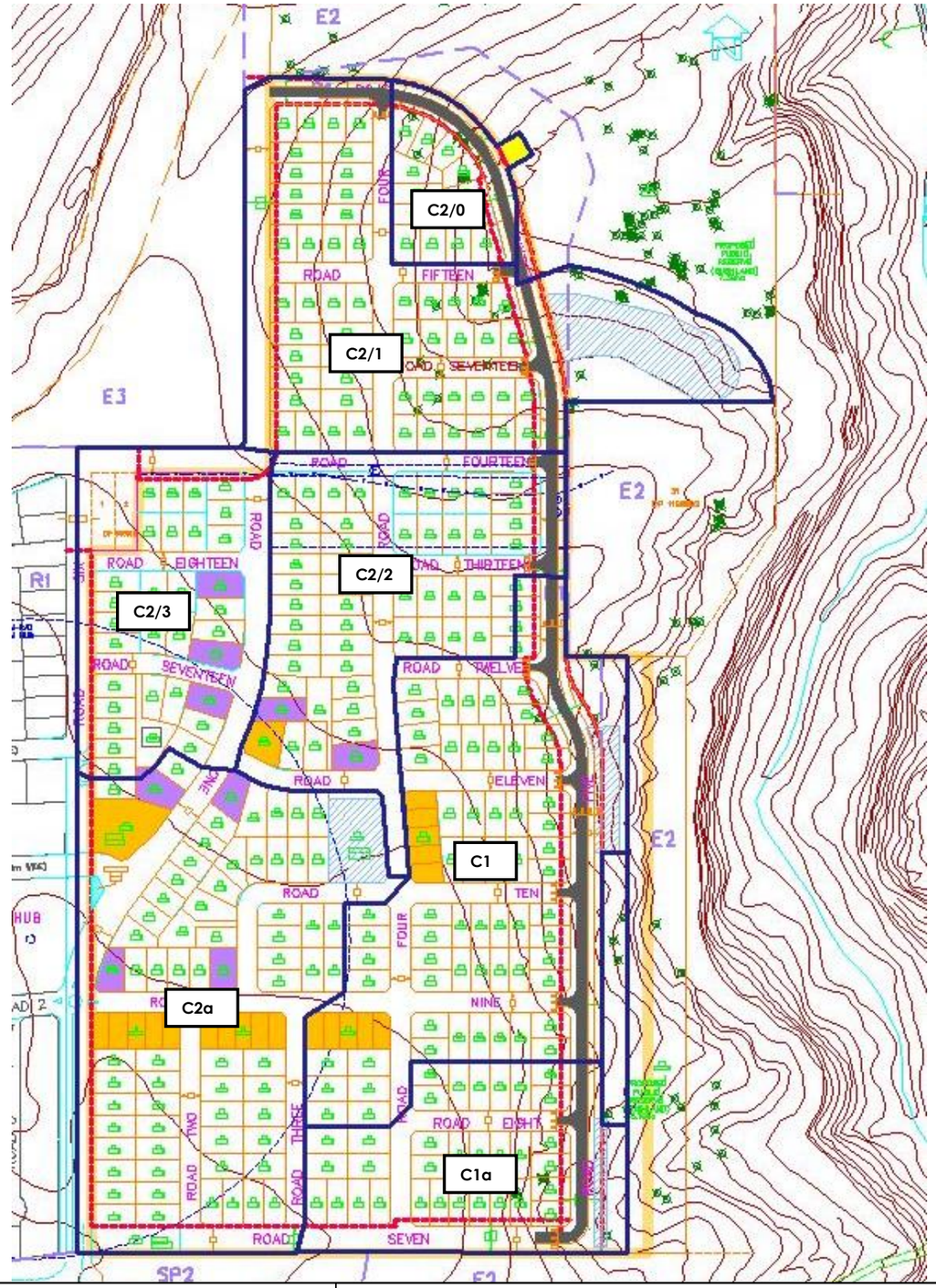
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**
Drawn:	GH	**MUSIC MODEL CATCHMENTS**
Approved:	AN	**FIGURE B1**
Date:	26.05.15	
Scale:	NA	Job No: P1204007

martens



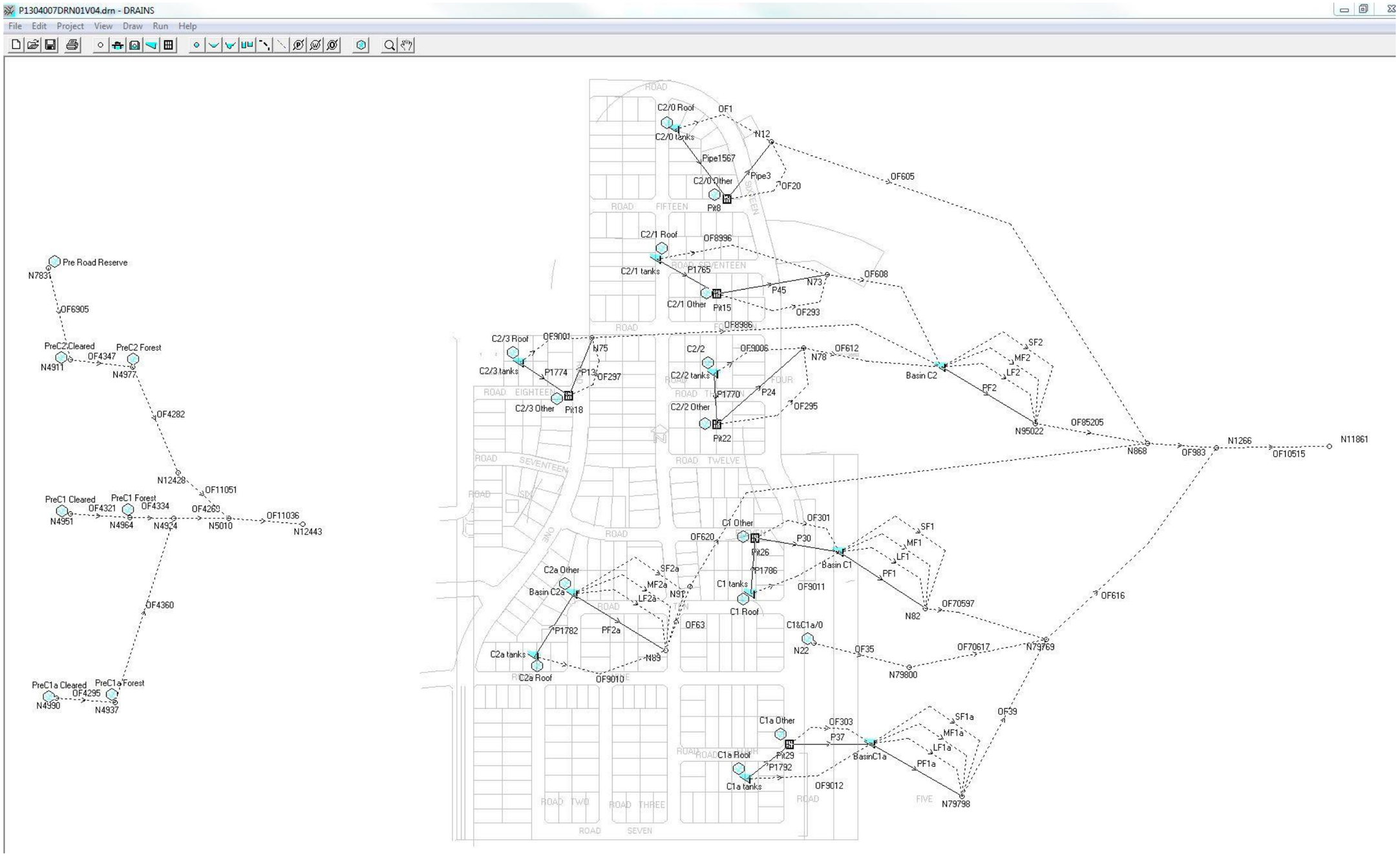
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GH	**MUSIC MODEL SETUP**	**FIGURE B2**
Approved:	AN		
Date:	26.05.15		Job No: P1304007
Scale:	NA		





Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GH	**DRAINS MODEL CATCHMENTS**	**FIGURE B3**
Approved:	AN		
Date:	26.05.15		Job No: P1304007
Scale:	NA		

martens



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GH	**DRAINS MODEL SETUP**	**FIGURE B4**
Approved:	AN		
Date:	26.05.15		
Scale:	NA		Job No: P1304007

martens

9 Attachment C – Hydrological Impact Engineering Measures and Typical Sections

martens
consulting engineers since 1989

Posted ☐
Faxed ☐
Emailed ☐
Courier ☐
By Hand ☐
Contact: Andrew Norris
Our Ref: P1304007JC01V01.doc
Pages: 2
cc. -

November 19, 2013

RE: MUNDAMIA URBAN RELEASE AREA (MURA) – HYDROLOGICAL IMPACT MANAGEMENT

Further to consultation with the NSW Department of Planning and Infrastructure (DOPI) and their engaged hydrology consultants additional information detailing measures to address potential interruption of shallow groundwater flows across the Mundamia Urban Release Area (MURA) has been requested and subsequently developed. Typical sections showing the development and measures to mitigate impacts on sub-surface flows are attached.

In summary possible structures and works which may impact flows and the design measures to mitigate these potential effects are summarised as follows:

Potential Impact	Mitigation
Dwelling foundations – identified as likely to require rock founding in project geotechnical reports. Should strip footings be taken to rock lateral water flow through the soil may be disrupted and locally redistributed.	Typical foundation solution for a dwelling on a site such as MURA would be: 1 - a raft slab not founding on rock and therefore not impeding groundwater flows. 2 – strip footings with piers to rock. Sub-soil flows of water shall pass between piers and continue unimpeded down slope. Importantly, controls within the MURA DCP shall be required to prevent future dwellings from being constructed with strip footings to rock.
Road pavements – Construction of road pavements may create a barrier to flows of sub-soil water. Also, in order to protect pavements sub-soil drainage systems may be constructed to collect and redirect water similarly disrupting natural flows across the site.	As is articulated in various Aus-Spec design and construction specifications (including for example the Warringah Council's Aus-Spec) the use of a drainage blanket beneath pavements is an acceptable and proven method of allowing sub-soil drainage to pass beneath a road without reducing the pavements serviceability. Warringah Aus Spec says '...drainage mats are intended to ensure continuity of sheet flow of water under fills...' Such mats are constructed using fines free aggregate materials which allow free passage of water beneath the pavement but prevent capillary rise of water into overlying pavement

Head Office
Unit 6 / 37 Leighton Place
Hornsby NSW 2077, Australia
Ph 02 9476 9999 **Fax** 02 9476 8767

> mail@martens.com.au
www.martens.com.au
MARTENS & ASSOCIATES P/L
ABN 85 070 240 890 ACN 070 240 890

Potential Impact	Mitigation
Service trenches – while not being designed to act as subsoil drains the use of granular backfill materials in service trenches results in their performance as a de facto sub-soil drainage system. The result is sub-surface flows are collected and discharged at designated outlets or low points.	To prevent the passage of water along service trenches sections of the trench are to be backfilled with impermeable material. The effect of this shall be to prevent the movement of water down the trench forcing it to continue its passage across the trench and down slope. The use of a material such as cement stabilised sand would be an appropriate impermeable material still meeting specification for service conduit backfil material. Stabilised sand (with sufficient cement) shall also allow for comparative ease for future maintenance excavation if and when required.

The development of the MURA DCP for the control of all aspects of the MURA's development shall be required to address the above identified design solutions as well as those matters detailed and document in supporting reports such as the supplementary groundwater recharge system.

Attached:

SK001 – Typical Development Section

SK002 – Typical Development Planview

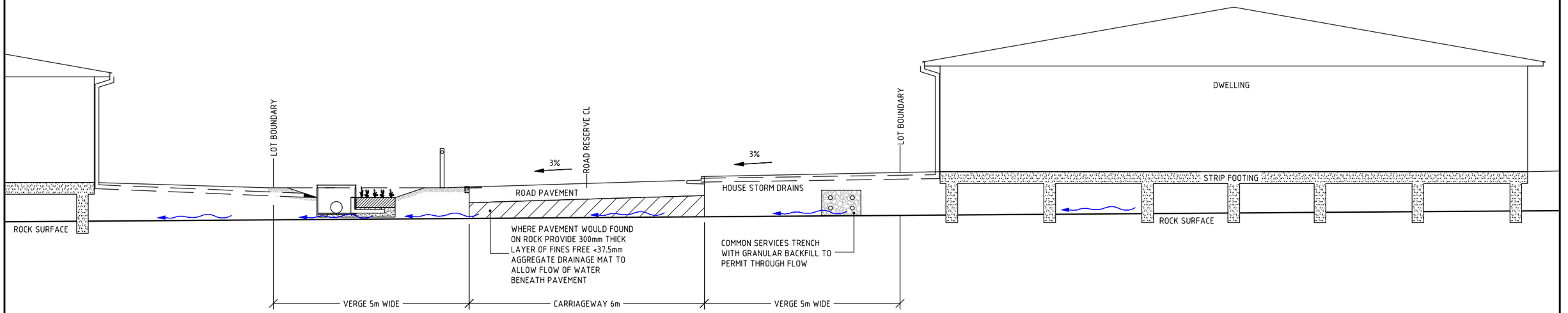


TABLE C230.4 - TYPE C FILTER MATERIAL

TEST METHOD	PROPERTY	REQUIREMENT
AS 1141.11	MAXIMUM PARTICLE SIZE	37.5mm
	MAXIMUM PASSING THE 9.5mm AS SIEVE	5% BY MASS
AS1141.22	MAXIMUM (D90:D10)	3
	MINIMUM WET STRENGTH	100kN
	MAXIMUM 10% FINES	
	WET/DRY VARIATION	30%

NOTE:
THE D90 VALUE SHALL BE DETERMINED BY SIEVING THE MATERIAL USING 75mm, 53mm, 37.5mm, 26.5mm, 19mm, 13.2mm AND 9.5mm AS SIEVES, AS APPROPRIATE, AND THEN PLOTTING THE RESULTS ON A GRAPH OF AS SIEVE SIZE V PERCENTAGE PASSING. THE PLOTTED POINTS SHALL BE JOINED BY STRAIGHT LINES AND THE D90 VALUE SHALL BE DETERMINED AS THE THEORETICAL SIEVE SIZE CORRESPONDING TO 90% PASSING.

D10 DENOTES THE THEORETICAL SIZE OF A SIEVE THROUGH WHICH 10% OF THE MATERIAL WOULD PASS AND SHALL BE DETERMINED FROM THE SAME GRAPH USED TO DETERMINE THE D90 VALUE.

PAVEMENT DRAINAGE BLANKET.

DRAINAGE BLANKETS TO PERMIT PASSAGE OF GROUNDWATER BENEATH ROAD PAVEMENT WITHOUT IMPACTING PAVEMENT MATERIALS.
SOLUTION AS DETAILED IN D4 OF WARRINGAH AUS-SPEC FOR TYPE A BLANKET.
AGGREGATE FILL FOR BLANKET TO COMPLY WITH TYPE C MATERIAL GRADING (SOURCED TABLE C230.4 OF AUS-SPEC 230-6 OF WARRINGAH COUNCIL).

KEY:

SUBSOIL DRAINAGE PATHS

NOTES: ROADSIDE SWALE SUBMERGED ZONE ACTS AS TEMPORARY STORE FOR STORMWATER TO ALLOW FOR INFILTRATION TO SATISFY GROUNDWATER RECHARGE REQUIREMENTS OF PROJECT.

0 1 2 3 4 5
UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890

Environment | Water | Wastewater | Geotechnical | Civil | Management

6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

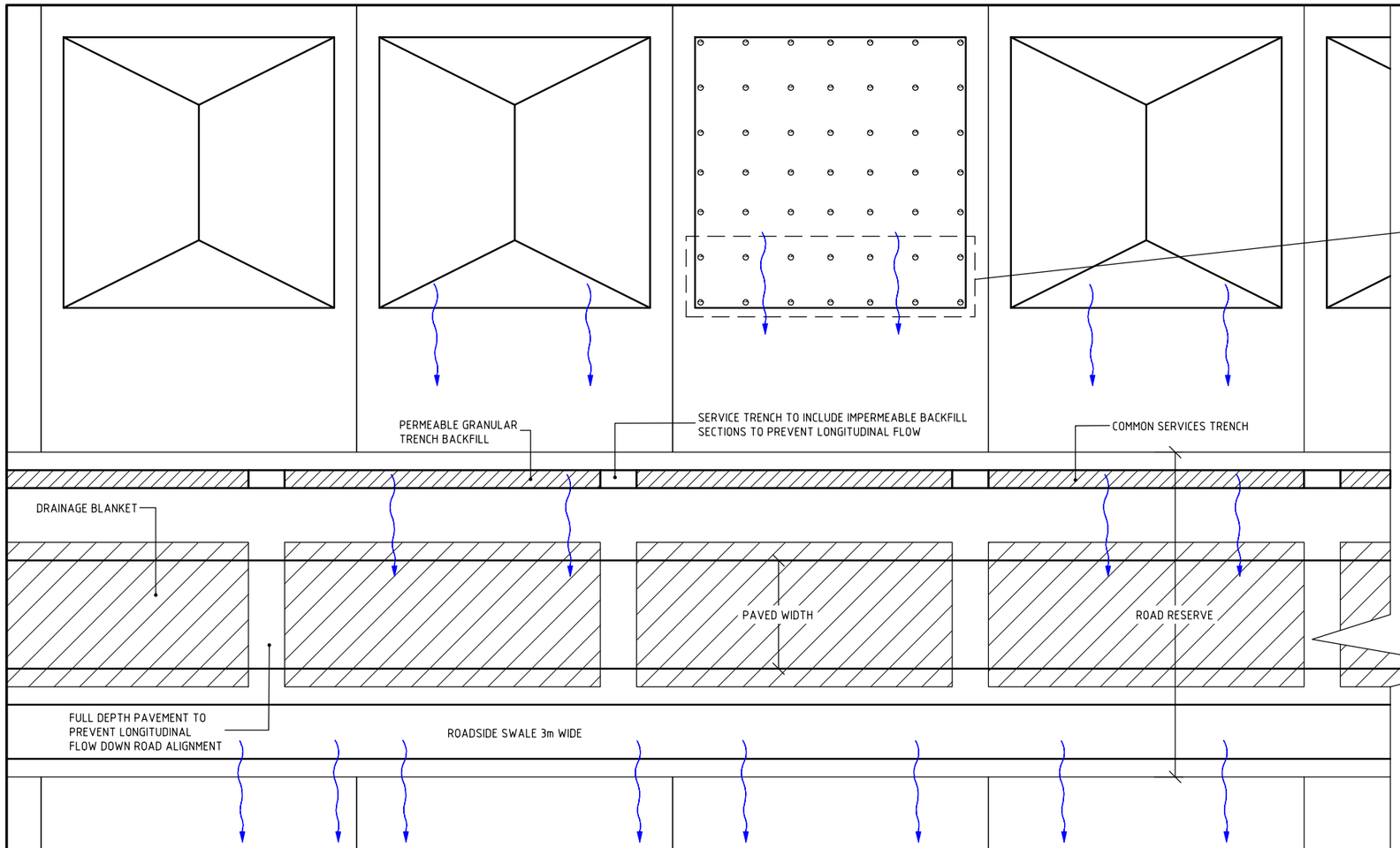
Drawn:	KT
Approved:	AN
Date:	12/11/13
Scale @A3:	1:100

TYPICAL SITE SECTION
MUNDAMIA, NSW
MIXED USE SUBDIVISION

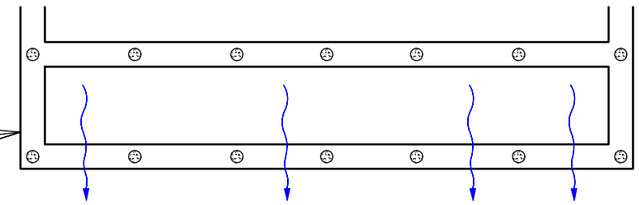
Drawing No./ID:
SK001

Project:	File:	Revision:
P1304007	JD01V01	A

martens



TYPICAL DWELLING PIERED FOOTINGS TO PERMIT GROUNDWATER FLOW



KEY:

SUBSOIL DRAINAGE PATHS

0 3 6 9 12 15

UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890	**Environment | Water | Wastewater | Geotechnical | Civil | Management**
Drawn: KT	**SUBSOIL DRAINAGE MANAGEMENT PLAN** **MUNDAMIA, NSW** **MIXED USE SUBDIVISION**
Approved: AN	Drawing No./ID: **SK002**
Date: 12/11/13	
Scale @A3: 1:300	

6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

Project:	File:	Revision:
P1304007	JD01V01	A

martens