Yates Beaggi Lawyers

Concept Stormwater Management Plan: Proposed Subdivision - 54 Luchetti Avenue, Hazelbrook, NSW.

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

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

Contents

1 Introduction

1.1 Overview

This report has been updated to reflect the agreed commitments arising from the Section 34 conciliation meeting held on the 11th of August to support a development application (DA) for the subdivision of 54 Luchetti Road, Hazelbrook, NSW.

It provides an assessment of the proposed development with respect to stormwater quality, quantity and flood management.

1.2 Proposed Development

Subdivision at the site will result in the creation of:

- 17 residential lots with a minimum lot size of 1,200 m^2.
- Internal road and stormwater network.
- Biofiltration basins and rainwater tanks for stormwater quality purposes.

A proposed lot layout and concept stormwater drainage plan produced by Williams Consulting Engineers Australia P/L is provided in Attachment A.

1.3 Scope

This report provides the following:

- Documentation of results of a water quality assessment using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC).
- Treatment train specification to achieve nominated water quality objectives.
- A hydrologic model (DRAINS) for the site to determine peak flows of the 2 year, 5 year, 100 year Average Recurrence Interval (ARI) and the Probable Maximum Flood (PMF) storm events.
- A hydraulic flood model (1D/2D SMS Tuflow) for the site under existing and proposed conditions.
- A hydraulic flood model for the proposed conditions.

- Relevant flood maps including flood extents, depths, VD product, water level and impact.

1.4 Relevant Planning Controls and Design Principles

The following planning and engineering controls and design principles have been considered:

- Blue Mountain City Council (WSC) (2015) Development Control Plan (DCP).
- BMCC (1991) Local Environmental Plan (LEP).
- BMCC (2015) Local Environmental Plan (LEP).
- Hazelbrook and Woodford Catchments Mainstream and Overland Flow Flood Study (2013) – Manly Hydraulics Laboratory.
- BMT WBM (August, 2015) NSW MUSIC Modelling Guidelines.
- NSW Department of Infrastructure, Planning and Natural Resources (2005) *Floodplain Development Manual, The Management of Flood Liable Land.*
- NSW Public Works (2013) – Hazelbrook and Woodford Catchments Mainstream and Overland Flow Flood Study.

2 Site Description

2.1 Location and Existing Land use

The site is located on Luchetti Avenue, Hazelbrook within the BMC Local Government Area (LGA). The site area included in the assessment is approximately 3.24 ha (Attachment A) and is bound by Caratel Avenue to the east, existing residential lots to the south and mostly undeveloped rural/forest lots to the west.

The site is currently vegetated with an existing house in the south east corner of the property.

2.2 Topography and Hydrology

The site drains generally South West to North East. A broad, shallow, discontinuous drainage depression located centrally on the site grades to the north east, discharging to a headwall. These flows are partly piped under the existing properties to the north of the site and connect to Luchetti Avenue storm water infrastructure.

There were no natural watercourses observed on the property.

2.3 Lithology and Soil Landscapes

The Katoomba 1:100,000 Geological Series Sheet 8930 (1966) describes the underlying geology of the site primarily as Gymea Formation, comprising shallow to moderately deep (30 – 100cm), moderately well-drained Yellow Earths and Earth Sands on crests and insides of benches.

Undulating to rolling rises and low hills on Hawkesbury Sandstone. Broad complex crests, moderately inclined side slopes with wide benches, localised rock outcrop on low broken scarps.

3 Stormwater Quality Assessment

3.1 Water Quality Objective

As per BMCC DCP (2015) Part 6 the development aims to achieve a neutral or beneficial effect (NorBE) on water quality. Additionally, agreed actions stemming from the Section 34 conciliation meeting are as follows:

- The MUSIC model to include relevant upslope and downslope areas, to assess overall impacts at the creek discharge point.
- Clarify land-use allocations and areas nominated on plans.
- Clarify the size, location and operation of water quality treatment devices.
- And seek to increase groundwater recharge and reduce stormflow volumes where possible.

3.2 Modelling Methodology

3.2.1 Overview

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*, Version 6.2) developed by the CRC for Catchment Hydrology was utilised to evaluate pre and post development pollutant loads from the site with and without treatment. The following modelling scenarios were considered

1. <u>Pre Development</u> – the existing site with relevant upslope and downslope areas was modelled to determine baseline pollutant generation rates for TSS, TN and TP.
2. <u>Post Development (untreated)</u> – the developed site with relevant upslope and downslope areas was modelled without water quality structures to determine baseline gross pollutant generation rates.
3. <u>Post Development (treated) no infiltration</u> – the developed site was modelled with water quality structures included to achieve adopted objectives for nutrients and gross pollutants.
4. <u>Post Development (treated) with infiltration</u> – the developed site was modelled with infiltration in water quality structures to achieve adopted objectives for nutrients, gross pollutants and a reduction in stormflow volumes.

Pre and post development (with treatment nodes) MUSIC model layouts are provided in Attachment C.

3.2.2 Approach

An iterative approach was used for post development modelling to determine appropriate types, sizes and locations of stormwater treatment devices for modelling scenarios to achieve adopted objectives.

Individual lots and the road reserve were assessed to determine an effective treatment option.

3.2.3 Climate Data

MUSIC was run using the Wentworth Falls Country Club pluviograph data obtained from *ewater*. The data was run on a 6 minute timestep from 30/06/1967 – 01/02/1972. It is understood there are no other records available from the Bureau of Meteorology.

3.2.4 Input Parameters

Input parameters for source and treatment nodes are consistent with BMT WBM (2015) and are provided in Attachment B.

3.2.5 Catchment Areas

Catchment areas were updated to include the relevant upslope/downslope areas. Upslope and downslope catchment areas were delineated from the surface provided by Cardno and are provided in Attachment C.

3.2.6 Model Parameters

MUSIC land use for all areas were based on the zoning/surface type outlined in BMT WBM (2015). Impervious areas outside of the site were nominated on typical values for similar sites. The stormwater pollutant parameters outlined in Table 1 were derived from BMT WBM (2015).

Table 1: Adopted pollutant parameters for source nodes.

		Base Flow (mg/L)		Storm Flow (mg/L)	
Node Type	Parameter	Log (mean)	Log (stdev)	Log (mean)	Log (stdev)
Sealed roads	TSS	1.200	0.170	2.430	0.320
	TP	-0.850	0.190	-0.300	0.250
	TN	0.110	0.120	0.340	0.190
Roof	TSS	na	na	1.300	0.320
	TP	na	na	-0.890	0.250
	TN	na	na	0.300	0.190
Residential	TSS	1.200	0.170	2.150	0.320
	TP	-0.850	0.190	-0.600	0.250
	TN	0.110	0.120	0.300	0.190
Rural	TSS	1.150	0.170	1.950	0.320
	TP	-1.220	0.190	-0.660	0.250
	TN	-0.050	0.120	0.300	0.190
Forest	TSS	0.780	0.130	1.600	0.200
	TP	-1.220	0.130	-1.100	0.220
	TN	-0.520	0.130	-0.050	0.240

Note:

[1] Adopted input parameters for source and treatment nodes are provided in Attachment C. Pollutant loads are stochastically generated.

3.3 Treatment Train Philosophy

The stormwater treatment strategy for the site utilises roof water capture and reuse in combination with at source controls to ensure treatment objectives are satisfied. Individual stormwater quality improvement devices (SQIDs) are outlined in the following sections.

3.3.1 Rainwater Tanks

Rainwater tanks will be included on each lot to capture roof water for reuse, including landscape irrigation, and at the future owner's discretion, laundry. The following was included in modelling:

- 5 kL rainwater tank for all lots with 80% of total volume capacity.
- An average internal daily reuse rate of 173 L/day/dwelling was applied in accordance with WBM BMT (2015).
- An annual external reuse rate of 151 L/d/dwelling was applied and scaled by potential evapotranspiration variations.

Input parameters are summarised in Attachment B.

3.3.2 Biofiltration Basin (On-Site Lots)

Overland flows from Lot 2 – Lot 16 will be directed to a biofiltration basin via controlled overland flow. The biofiltration basin provides treatment through filtration, evapotranspiration and detention. Preliminary specifications are as follows:

- Extended detention depth: 0.30 m.
- Minimum filter area: 5 m^2 (for Lot 10 – Lot 16) and 8m^2 (for Lot 2 – Lot 9).
- Filter depth: 0.40 m.
- Saturated Hydraulic Conductivity: 100 mm/hr (this being 50% of the initial 200mm/hr conductivity to allow for long term blockage).

Input parameters are summarised in Attachment B.

3.3.3 Biofiltration Basin (Roadside)

Stormwater runoff from the one-way cross fall road is captured and conveyed by kerb and gutter to biofiltration basins located in the verge area behind the kerb. Castellations are to be provided in the kerb to allow flows to enter the biofiltration basins for treatment. Any stormwater within the biofiltration basin above the extended detention depth will be captured via a raised surface inlet pit located within the biofiltration basin and conveyed to a nearby stormwater pit.

- Extended detention depth: 0.30 m
- Minimum filter area: Total area of 105 m^2 split between 1x20 m^2, 5x15 m^2, 1x10 m^2 basin shown in Attachment C.
- Filter depth: 0.40 m.
- Saturated Hydraulic Conductivity: 100 mm/hr (this being 50% of the initial 200mm/hr conductivity to allow for long term blockage).

Input parameters are summarised in Attachment B.

3.4 MUSIC Results

Results extracted from MUSIC are shown in Table 2 and Table 3. Table 2 presents a comparison of pre-development vs post-development with infiltration and without infiltration for the site/upslope/downslope areas. Table 3 presents a comparison of pre-development vs post-development with and without infiltration for the site only.

Table 2: MUSIC results: Pre-development and Post-development entire catchment.

Parameter	Pre Sources	Post Sources (Treated) with no Infiltration	% Change	Pre Sources	Post Sources (Treated) with Infiltration	% Change
Flow (ML/yr)	106	108	+1.8	106	108	+1.8
TSS (kg/year)	3830	3590	-6.2	3830	3650	-4.7
TP (kg/year)	11	11	0.0	11.2	11.1	-0.8
TN (kg/year)	120	119	-0.8	120	118	-1.7
Gross Pollutants (kg/year)	302	282	-6.6	302	282	-6.6

Table 3: MUSIC results: Pre-development and Post-development for site.

Parameter	Pre Sources	Post Sources (Treated) with no Infiltration	Achieved Reduction %	Pre Sources	Post Sources (Treated) with Infiltration	Achieved Reduction %
Flow (ML/yr)	14.1	16.4	+16.3	14.1	16.4	+16.3
TSS (kg/year)	371	161	-56.6	390	167	-57.2
TP (kg/year)	1.28	1.21	-5.4	1.28	1.22	-4.7
TN (kg/year)	13.1	11.9	-9.1	13	12	-7.7
Gross Pollutants (kg/year)	21.80	1.74	-92.0	21.80	1.74	-92.0

3.5 Flow Frequency Analysis

Flow frequency analysis was undertaken to assess pre-development and post-development flow rates to measure the differences in mean annual flow volumes for the entire catchment. The mean annual flow volume increase for the post development condition (with and without) infiltration was negligible. Refer to MUSIC results summary in Attachment C.

The Rational Estimation Method was used to calculate the 2 year ARI pre-development flow and then multiplied by the critical flow factor for sand outlined in WBM BMT (2016). The critical flow was calculated to be $0.043 m^3/s$ and is included on the graph in Attachment C along with a flow frequency chart comparison of pre-development vs post-development flow frequency. The chart shows changes in flows greater than the critical flow are minimal.

3.6 Conclusions

The results indicate that post development water quality objectives will be met by the proposal.

The proposed management system is consistent with the principles of Water Sensitive Urban Design (WSUD) as the proposed treatment strategy utilises 'at source' controls and a 'treatment train' rather than relying solely on large end of line structures. This approach is considered the most appropriate for the site and will provide the best outcome for receiving environments.

4 Proposed Drainage System Assessment

4.1 Overview

A concept stormwater management plan including pit and pipe layout was prepared by Williams Consulting Engineers Australia P/L (2016) (WCEA) and is provided in Attachment A. Key features of the drainage system include:

- Two 2.0 m x 2.8 m grated sump pits to capture offsite upstream flows.
- Trunk drainage network with variable pipe sizes (675mm – 1050mm) to convey upstream offsite and site flows.
- Swales above the trunk drainage system to convey drainage network bypass flows, allowing for pipe blockage.
- An extension and upgrade to the existing council network to connect to existing creek headwall.

The WCEA (2016) pit and pipe network was used a preliminary design and updated to reflect changes in water quality and flooding requirements stemming from Section 34 agreed works in Attachment F. A hydraulic drainage analysis was carried out on the updated pit and pipe network using 12d Civil modelling package to confirm hydraulic capacity of the concept design.

4.2 Objectives

Site stormwater management has been designed to comply with the objectives of Blue Mountains DCP (2015) as follows:

- Drainage system to be designed to carry peak flow during minor storm, being 5 year ARI storm event (as agreed by Council's expert witness), by way of a pit and pipe network.
- Drainage system to be designed to carry all flows during major storm events, being 100 year ARI event, by way of pit and pipe and overland flow.

The report has been updated to reflect agreed commitments stemming from the Section 34 conciliation meeting.

4.3 Modelling Methodology and Approach

Hydraulic analysis was undertaken using the 12d modelling package for the minor (5 year ARI) and major (100 year ARI) storm events varying between 10 minutes and 6 hours to confirm the concept stormwater plan complies with council objectives.

Modelling approach included:

- Intensity Frequency Duration (IFD) coefficients based on the Bureau of Meteorology (1987) tables. IFD data is provided in Attachment D.
- Sub-catchment delineation was developed using LIDAR, offsite survey and the proposed site grading.
- The catchment impervious area for each proposed lot was assumed to be 250 m^2 roof area (no including driveways) with impervious areas for roads included separately. It was observed that roof areas surrounding the site are in the range of 200 m^2-350 m^3 based on recent SIX Maps Aerials (2014).
- The catchment draining to the site includes residential lots, roads and open spaces with a total catchment area of 10.94 ha.
- Pit inlet capacities were limited to 50% for sag pits and 80% for on-grade pits.
- Time of concentration (t_c) values for sub-catchments were calculated by 12d based on flow paths.
- Bypass flows were modelled in 12d to model overland flows from pits.

4.4 Pit and Pipe Network

Modelling demonstrates the proposed drainage system has the capacity to convey the minor storm event (5 year ARI) and the major storm event (100 year ARI). Results are provided in Attachment C and are in accordance with Blue Mountains DCP (2015).

4.5 Rainwater Tanks

All lots shall have a 10 kl rainwater tank with 5kl (inclusive) dedicated to OSD to limit peak flow rates from the developed site,

4.6 On-Site Detention

An OSD with a capacity of 300 m^3 was modelled in TUFLOW to minimise flooding impact on downstream properties and creek from concentrating stormwater flows upslope of the creek. This OSD was remodelled in 12d to assess the hydraulic capacity of the pit and pipe network. Detailed design of the OSD outlet control structure may enable a smaller OSD volume to be provided.

4.7 Conclusion

The proposed drainage system has been designed to convey upstream and site runoff through the development via a series of swales and linear bio-filtration to achieve a degree of infiltration prior to reaching the pit and pipe network, OSD in the form of rainwater tanks on each lot and a buried tank under the proposed road is provided as determined by TUFLOW flood modelling. Hydraulic modelling confirms the concept drainage system is able to capture and convey stormwater in accordance with council requirements.

5 Flood Assessment

5.1 Overview

A flood assessment has been undertaken to determine existing flood characteristics at the site, mitigate proposed development impacts on adjoining properties and comply with Blue Mountains DCP (2015).

Flood modelling addresses the agreed matters as outlined in Dr Martens email of 11/08/2016 (in Attachment F) to council expert witness Dr Brett Phillips. The design approach was as follows:

- Upslope overland flow is captured by a series of swales which direct runoff into the proposed pit and pipe system.
- The proposed pit and pipe system has been designed to cater for all flows up to and including the 100 year ARI as detailed in Section 4.
- Site discharges are directed to an easement with a proposed 900mm pipe and overland flow path between 20 – 34 Luchetti Avenue which extends to the existing creek headwall.

5.2 Modelling Objectives

Modelling objectives are as follow:

- Ensure 2 year and 5 year ARI storm impacts on the creek are acceptable by limiting changes in water level up to 60mm and do not destabilise the watercourse.
- Ensure the 100 year ARI storm impacts on downstream properties are acceptable by limiting changes in water level up to 10mm adjacent to existing buildings.
- Ensure 2 year ARI, 5 year ARI, 100 year ARI flooding hazards do not make matters worse in downstream areas.
- Ensure that egress from site is available during the Probable maximum flood (PMF).

5.3 Modelling Scenarios

The following modelling scenarios were adopted for site hydrologic and hydraulic analysis.

- 2 year ARI, 5 year ARI, 100 year ARI and PMF for existing conditions.
- 2 year ARI, 5 year ARI, 100 year ARI and PMF for the proposed development.

5.4 Hydrology Modelling

5.4.1 Overview

The DRAINS software package (version 2015.06 – 6 May 2015) was used with the ILSAX hydrological engine to calibrate flows to Cardno (2016) flow rates and water levels from the truncated model based on MHL (2013).

5.4.2 Modelling Set-up

Modelling assumptions derive from the following sources:

- Intensity Frequency Duration (IFD) data were based on the Bureau of Meteorology based on Australian Rainfall and Runoff (1987). IFD data provided in Table 4.
- Probable Maximum Precipitation (PMP) intensities and temporal distributions were determined using the Bureau of Meteorology *Generalised Short-Duration Method* (1994). Probable Maximum Precipitation (PMP) data used in the model are consistent with NSW Public Works (2013) flood study.
- Sub-catchment delineation and flow paths were determined from LIDAR and in accordance with MHL (2013).
- ILSAX parameters have been derived from the suggested values in the DRAINS Content Menu (2013) for similar catchments. ILSAX setup parameters are outlined in Table 4.

Table 4: Rainfall data and ILSAX parameters used in DRAINS modelling.

Parameter	Element	Value
IFD data [1]	2year 1hour Rainfall Intensity (mm/h)	33.8
	2year 12hour Rainfall Intensity (mm/h)	8.94
	2year 72hour Rainfall Intensity (mm/h)	2.78
	50year 1hour Rainfall Intensity (mm/h)	64.7
	50year 12hour Rainfall Intensity (mm/h)	19.3
	50year 72hour Rainfall Intensity (mm/h)	6.98
	G	0.06
	F2	4.3
	F50	15.76
	Antecedent Moisture Condition [2]	3.0
ILSAX parameters [3]	Impervious area depression storage (mm)	1.0
	Supplementary area depression storage (mm)	1.0
	Grassed area depression storage (mm)	5.0
	Soil type	2.5

Notes

1. Obtained based on Bureau of Meteorology (BOM 2015) Rainfall IFD Data System.
2. Assumed based on typical values for similar catchments.
3. Obtained from the DRAINS Content Menu (2013) for similar catchments.

- Time of concentration was calculated as an estimate of flow path lengths, flow velocities, overland flow and channelised flow. Tc's calculated to be less than 5 minutes were rounded up to a minimum of 5 minutes. Surface velocities used in the DRAINS model have been outlined in Table 5. t_c's for each catchment have been provided in Table 6.

Table 5: Input parameters for calculating t_c.

Parameter	Element
Gutter flow velocity (m/s)	1.2
Overland flow velocity (m/s)	0.5
Additional time for roof t_c (min)	1
Minimum t_c (min)	5

- Sub-catchment impervious areas were determined based on recent SIX Maps Aerials (2014). Local catchment area draining to the site includes residential lots, roads and open spaces. See Attachment D for a detailed catchment plan, and modelling layout used in DRAINS. Catchment setup parameters are outlined in Table 6.

Table 6: DRAINS catchment setup parameters

Catchment	Area (ha)	Impervious (%)	Pervious (%)	t_C Impervious (min)	t_C Pervious (min)
CAT A SITE PRE	0.648	0%	100%	-	5.7
CAT B SITE PRE	1.114	0%	100%	-	6.7
CAT C SITE PRE	1.487	0%	100%	-	5.0
CAT A SITE POST	0.576	2%	98%	5.0	5.0
CAT A SITE ROOF	0.050	0%	100%	-	5.0
CAT A SITE ROAD	0.022	0%	100%	-	5.0
CAT B SITE POST	0.943	5%	95%	5.0	5.1
CAT B SITE ROOF	0.125	0%	100%	-	5.0
CAT B SITE ROAD	0.046	0%	100%	-	5.0
CAT C SITE POST	1.125	5%	95%	5.0	5.0
CAT C SITE ROOF	0.250	0%	100%	-	5.0
CAT C SITE ROAD	0.112	0%	100%	-	5.0
CAT A UPSTREAM	3.748	15%	85%	5.0	7.2
CAT B UPSTREAM	3.013	5%	95%	6.7	5.7
CAT C UPSTREAM	0.491	40%	60%	5.0	5.0
CAT D	10.687	25%	75%	11.2	14.8
CAT E	2.561	30%	70%	5.0	6.4
CAT F	3.703	30%	70%	5.0	6.7
CAT G	3.460	30%	70%	5.7	6.0
CAT H	3.045	30%	70%	5.5	7.3
TOTAL	23.456				

- On-site detention (OSD) has been provide for all lots, in the form of rainwater tanks (additional 5 kl/lot), and was included in the DRAINS model.
- A 300 m³ OSD tank was not included in the DRAINS model but modelled in TUFLOW.

5.4.3 Results

Results of peak flow rates for sub-catchments arriving at the site for critical duration 2 year ARI, 5 year AR, 100 year ARI and PMF storm events are summarised in Table 7. The critical storm duration was determined to be 2 hours for all storm events and is consistent with MHL (2013).

Table 7: Peak 2 year, 5 year, 100 year and PMF flow rates for critical duration storms estimated by DRAINS modelling for sub-catchments arriving at the site.

	Peak Catchment Flow Rates (m³/s)			
Storm Event	**2 year ARI**	**5 year ARI**	**100 year ARI**	**PMF**
Pre Total Cat A	0.638	1.097	2.090	3.760
Pre Total Cat B	0.607	1.054	2.019	3.510
Pre Total Cat C	0.316	0.553	1.040	1.710
Post Total Cat A	0.642	1.096	2.084	3.770
Post Total Cat B	0.631	1.084	2.051	3.530
Post Total Cat C	0.336	0.546	0.995	1.740
Cat D	1.152	1.961	3.949	9.020
Cat E	0.419	0.694	1.290	2.240
Cat F	0.597	0.989	1.839	3.230
Cat G	0.585	0.964	1.782	3.000
Cat H	0.480	0.795	1.478	2.650

Notes

Post-development flow rates exclude OSD within the road reserve which was modelled using TUFLOW.

5.5 Hydraulic Modelling

5.5.1 Overview

The SMS Tuflow 1D/2D hydraulic model (SMS 11.2.10 11May 2015) was used to determine existing and proposed development flood characteristics, including flood water levels, depth and VD product for each scenario in Section 5.2.

An extract of Council's model was provided by Cardno (2016) and was initially considered to be included in MA's flood model but was not included in this assessment due to time constraints and instabilities in the truncated model. Furthermore it was deemed appropriate to continue using the direct hydrograph method which was agreed to by Council's expert witness.

5.5.2 Terrain Data

3D surfaces of the site and local catchment were developed for use in the Tuflow model for the existing and proposed conditions.

a. Existing surface based on LIDAR, site survey data from S.Mark Bowler and Associates (2016) and the easement, Luchetti avenue and downstream creek from Matthew Freeburn (2016).

b. Proposed surface was an amalgamation of the existing surface and the proposed grading at the site – refer to drawing PS02-C100 in Attachment C for proposed grading.

5.5.3 Tuflow Modelling Set-up

5.5.3.1 Base (existing) Model:

Tuflow model construction consisted of:

1. Development of a 1.0m x 1.0m topographic grid based on the available survey and LIDAR data outlined in Section 5.5.2.a.

2. Establishment of model boundary extents generally along catchment ridgelines and/or connecting catchment high points surrounding the study area.

3. Establishment of model boundary extents to downstream of the culvert under Oaklands Road, with sufficient width to comprise the PMF floodplain in the vicinity of the site.

4. Inflow hydrographs:

    i. Offsite catchments hydrographs applied at the respective downstream catchment boundary.

    ii. Existing site catchments hydrographs were applied upstream of the site to conservatively model increased flow through the site.

5. Downstream boundary extent slope of 0.145.

6. Assigning elevations to existing buildings above the floodplain to model flow obstructions.

7. Assigning existing site Manning's roughness coefficients based on recent aerials (SIX maps) for hydraulic modelling as shown in Table 8.

8. Including relevant kerbs on Luchetti as z line modifications to ensure these features are incorporated in the existing model surface.

9. Flood model elements consistent with MHL (2013) including:

    i. Off-site Manning's roughness coefficients.

    ii. Pit and pipe network, including the culvert under Oaklands Road modelled as 1D elements with 0% blockage.

    iii. We note the z line modifications to surface levels in the creek upstream of the culvert under Oaklands Road were not included in the model, as surface levels in this area have been updated based on project survey data.

5.5.3.2 Proposed case model:

All base model elements described in the previous section were used in the proposed scenario, with the following additions and modifications:

1. Development of a 1.0m x 1.0m grid based on proposed surface and base case surface.

2. Replacing existing site catchment inflow hydrographs with proposed site catchment inflow hydrographs.

3. Assigning proposed site Manning's roughness coefficients based on the design layout (drawing PS02-E100) for hydraulic modelling as shown in Table 8.

4. Inclusion of Cardno (2016) 1d elements, terrain and roughness coefficients.

Table 8: Manning's roughness coefficients used in SMS Tuflow modelling.

Catchment Material	Manning's Roughness Applied[1]
Existing Building	10.000
Existing Pervious	0.025
Existing Forest	0.065
Existing Road	0.013
Proposed Building	10.000
Proposed Pervious	0.025
Proposed Road	0.013
Proposed Swale	0.060
Proposed Check Dam swale	0.100

Notes

1. Assumed based on typical values for similar catchments.

5. Assigning elevations to proposed buildings above the floodplain to model as flow obstructions.

6. Including relevant proposed site drainage features such as swales, bunds and kerbs as z line modifications to ensure these features are incorporated in the proposed model surface.

7. Inclusion of proposed site pit and pipe network:

    i. 1-D network pipe locations, sizes and invert levels are based on the proposed stormwater network (drawing PS02-E100 in Attachment C).

    ii. Pipe roughness coefficients were assumed to be 0.013 (concrete).

    iii. Pipes have been conservatively modelled with 50% blockages based on the assessment procedure in Australian Rainfall and Runoff (AR&R, 2013).

8. Inclusion of a proposed basin modelled as a z polygon with 300 m^3 capacity and dimension 5 m x 25 m x 2 m.

9. Upgrading Council pipe sizes on Luchetti as per drawing PS02-E100 in Attachment C.

5.6 Model Validation

The flood model for existing conditions was compared to Councils flood extents and water levels shown in NSW Public Works (2013) *Hazelbrook and Woodford Catchments Mainstream and Overland Flow Flood Study Stage 4 – Draft Flood Study report*. Generally, MA's flood model agrees with Council's findings.

The existing model construction was changed iteratively to achieve the best calibration to Cardno (2016) truncated flood model, 100 year water levels, extents and flow rates. The adopted model construction described in Section 5.5.3.1 gave the best overall calibration, with MA modelled flood levels and extents given in Attachment D.

MA and Cardno water levels were compared at Luchetti Avenue, Oaklands Road and at two locations in the creek, as well as flows through the Oaklands Road culvert. Validation locations are provided in Attachment D, and results comparison are summarised in Table 9 and Table 10.

Table 9: Calibration points and change in water level.

Location	Cardno Model HW_1pct_120min_Truncate (mAHD)	MA existing 160907b 100yr (mAHD)	Difference (m)	Difference (%)
Luchetti Avenue	640.206	640.206	0.000	0.00
Creek Upstream	631.871	631.843	-0.028	-0.01
Creek Downstream	622.424	622.365	-0.058	0.00
Oaklands Road culvert	619.692	619.695	0.003	0.00

Table 10: Calibration points and change in peak flow rate.

Location	Cardno Model HW_1pct_120min_Truncate (m^3/s)	MA existing 160907b 100yr (m^3/s)	Difference (m^3/s)	Difference (%)
Oaklands Road culvert	3.506	3.730	0.22	+6.40

We note:

1. Modelled 100 year flood extents closely match Cardno (2016) flood model results.

2. Modelled flood levels and flow rates are very similar to Cardno (2016) flood model results with a comparison provided in Table 9 and Table 10.

3. Water levels are considered well calibrated and have a maximum difference of 0.058 m.

4. Flow rates are also well calibrated with a maximum difference of 0.22 m^3/s.

5. Minor flood characteristic differences are attributed to:

   i. Different modelling approaches between Cardno and MA (direct rainfall vs inflow hydrographs). Despite the difference in model approach, hydraulic results are very similar, confirming the validity of both approaches.

   ii. Inclusion of recent creek survey which improves site flood study accuracy in this area.

We consider the differences are negligible, and conclude the model is adequate for the purposes of development impact assessment.

5.7 Results and Comments

Results for water level, depth, hazard and impact for the 2 year, 5 year, 100 year and PMF storm event are provided in Attachment D. The following observations are made:

1. Proposed flood conditions demonstrate that the proposed development footprint will have negligible impact on hazard with V x D product < 0.4 m^2/s on site for all modelled storm events. Therefore site egress for pedestrians and vehicles is maintained and available towards Caratel Avenue. Additionally, low hazard surface flows within lots for the site are acceptable as long as flows are directed away from building envelopes (bunds/swales) as shown in Attachment C.

2. Proposed flood conditions demonstrate:

   a. 11 properties downslope of the site benefit from development works through a decrease in flood level and hazard.

   b. That the development will have minor material impact (i.e. maximum flood water level increase of 10mm) on the downstream dwellings of Luchetti Avenue with the majority of water level increase limited to the creek.

   c. The proposed development does not reduce watercourse stability for minor flood events and limits erosion in creek by maintaining similar flow characteristics as modelled in existing conditions.

3. Modelling demonstrates that two areas (being 16 m^2 and 28 m^2) along Luchetti Avenue experience a water level increase up to 100 mm in the 100 year storm event. The increase is considered acceptable as these areas are located outside of private properties and V x D hazards do not increase within those areas.

4. Proposed condition flood extents retain the base condition characteristics with a reduction in water extents on site which are attributed to the channelising of upstream flows.

5. Provision of OSD within the site effectively ameliorates the effects of flow concentration that is typical of urban development.

6. For all flood affected areas on site, a minimum of 500mm freeboard should be provided for habitable floor levels and 150mm freeboard for non-habitable areas.

6 Conclusion

This report demonstrates that matters raised in the Section 34 conciliation meeting have been addressed satisfactorily and the proposed subdivision can safely convey standard flood flows through the site via the proposed stormwater system with significant benefits to a majority of currently flood affected properties.

Water Quality modelling indicates:

1. That post development water quality objectives will be met by the proposal, through the use of an appropriate stormwater treatment train including rainwater tanks and bio-filtration basins.

2. Changes in flow volumes are minimal for the site based on flow frequency analysis.

3. The proposed management system is consistent with the principles of Water Sensitive Urban Design (WSUD).

Flood modelling indicates:

1. Flows resulting from up to the 2 year, 5 year and 100 year storm event can be conveyed via a series of swales and pipes through the site and discharge to the downstream creek. This significantly reduces flooding within existing downslope properties.

2. No adverse impacts on flooding downslope of the site.

3. Low hydraulic hazard for flood flows within the site and improved impacts d/s of the site.

4. Freeboard considered achievable to all lots.

It is recommended that following detailed design of the sub-division, required freeboards are confirmed with an updated flood model.

Flood modelling should include the final engineering design elements comprising the final earthworks, road grading and stormwater elements, including final pipe sizing.

7 References

Australian Rainfall and Runoff, 11 Feb 2013, *Project 11*.

Bureau of Meteorology (1994), *Generalised Short-Duration Method.*

Bureau of Meteorology (2016), *Rainfall IFD Data System,* <www.bom.gov.au/water/designRainfalls/ifd>

Blue Mountain City Council (WSC) (2015) Development Control Plan (DCP).

BMCC (1991) Local Environmental Plan (LEP).

BMCC (2015) Local Environmental Plan (LEP).

BMT WBM (August, 2015) NSW MUSIC Modelling Guidelines.

Cardno (2016), truncated model results.

DRAINS (2016), *DRAINS content menu*

Institution of Engineers, Australia (2006) – *Australian Rainfall and Runoff*

Katoomba 1:100,000 Geological Series Sheet 8930 (1966). Landcom, 2004, *Managing Urban Stormwater – Soils and Construction.*

Land and Property Information NSW (2016) – *SIX Maps Viewer.*

Nearmaps (2016), *Nearmaps Viewer*

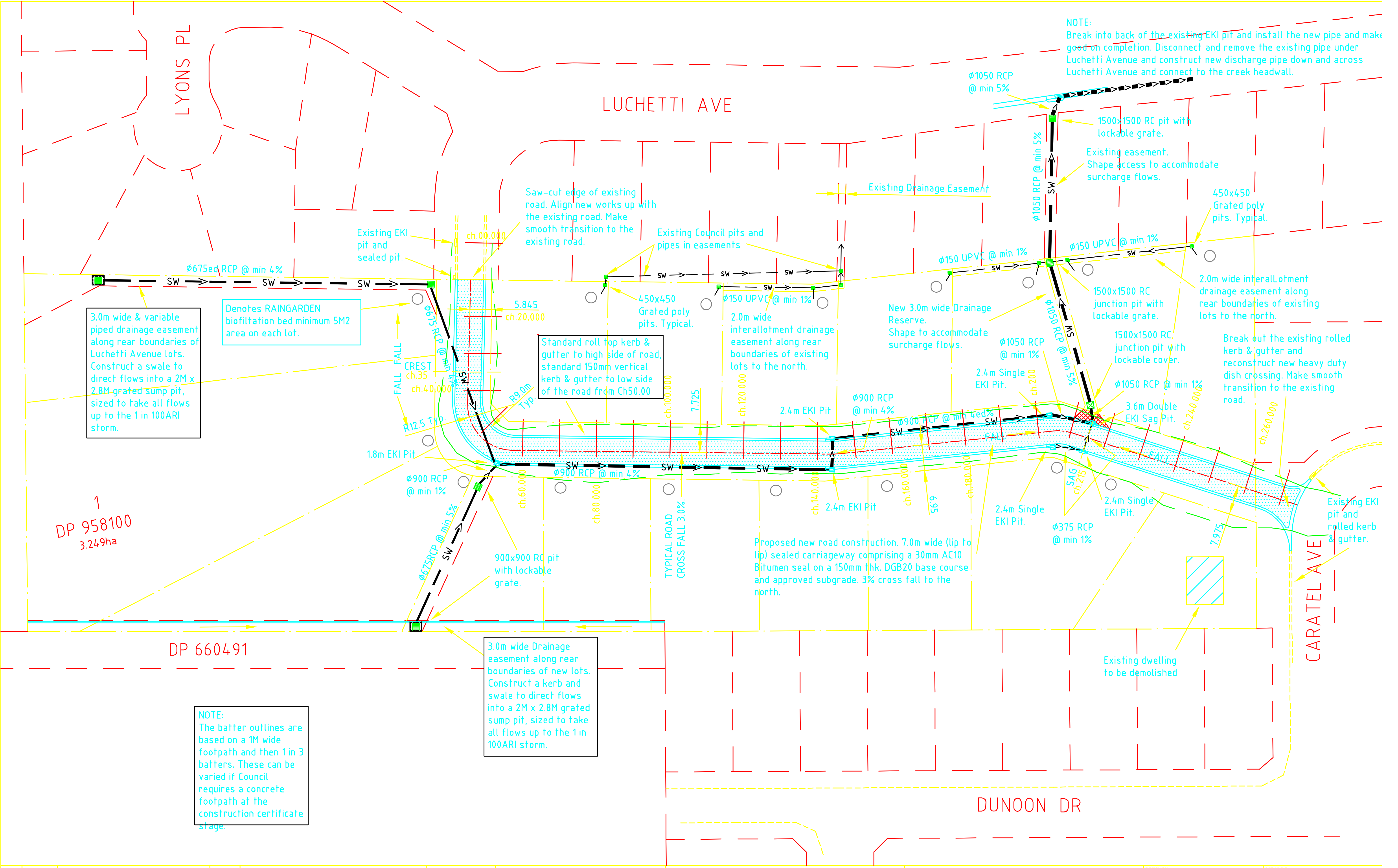
Public Works, Manly Hydraulic Laboratory (2013) – *Hazelbrook and Woodford Catchments Mainstream and Overland Flow Flood Study.*

8 Attachment A – Site Survey and Concept Stormwater Plans

Approximate proposed subdivision area

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	GL	**Site Aerial and Boundaries** Source: SixViewer	**FIGURE 1**
Approved:	TH		
Date:	14.03.2016		
Scale:	NA		Job No: P1605170

martens



Issue	Date	Amendment	Checked
A	10/2/2016	Amended to conform to site constarints.	RDW

AMENDMENTS

PRINTED 12/2/2016

Note:

The Contractor to verify all dimensions on site before commencing work.

All figured dimensions given are to be taken in preference to scaling.

PAPER SIZE A3 — PRINT SCALE A3x1

Layout: Concept edRoad Works and Drainage

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION PURPOSES UNLESS SIGNED BY THE ENGINEER.

DATE

DESIGN INFORMATION

Proposed ROAD & DRAINAGE WORKS at 17 LOTS SUBDIVISION, No. 54 LUCHETTI AVE, HAZELBROOK, NSW, 2779

DESIGN BY: R.D.W.
DETAILS BY: Franz
CHECKED: [signature]
DRAWING No.: 2014/129/DA2
SCALES: 1:1000
DATE: October 2015
ISSUE: A

WILLIAMS CONSULTING ENGINEERS AUSTRALIA P/L.
CONSULTING, CIVIL AND STRUCTURAL ENGINEERS.
Unit 3/31 Attunga Road, Blaxland, NSW. Post Office Box 79, Blaxland, NSW. 2774
5000 Channel Highway, Gordon, TAS. Post Office Box 79, Middleton, TAS. 7163
Email : ralph@wcea.com.au
Mobile Phone : 0425307531

9 Attachment B – MUSIC modelling input parameter and source

Element	Factor	Input	Source
Setup	Climate File	Wentworth Falls Golf Club Pluviogaph. 6 minute time step from 30/06/1967 – 01/02/1972	ewater
Source nodes	Node Type	Post development = Sealed road pavement, Roofs, Rural, Forest.	Assumption based on subdivision layout and Council land zoning maps.
	Rainfall Threshold	Based on land use type or surface type as specified in Table 3-6 of BMT WBB Music Guidelines (2015)	
	Pervious Area Parameters	Based on Katoomba 1:100,000 Geological Series Sheet 8930 (1966) and Table 5-5 of MBT WBM Music Guidelines (2015)	MBT WBM Music Guidelines (2015)
	EMC's	As per MBT WBM Music Guidelines (2015)	MBT WBM Music Guidelines (2015)
	Estimation Method	Stochastically generated	MBT WBM Music Guidelines (2015)
Biofiltration Basin	Low Flow Bypass	0 m³/s	MBT WBM Music Guidelines (2015)
	High Flow Bypass	0.2 m³/s	MBT WBM Music Guidelines (2015)
	Extended Detention depth	0.40 m	By Design
	Surface Area	Equivalent to filter area as a minimum requirement	MBT WBM Music Guidelines (2015)
	Filter Area	See Section 3.3.3	By design
	Unlined filter media	Varies	MBT WBM Music Guidelines (2015)
	Saturated Hydraulic Conductivity	100mm/hr	MBT WBM Music Guidelines (2015)
	Filter Depth	0.40	By design
Biofiltration	TN Content of filter	400 mg/kg	MBT WBM Music

Element	Factor	Input	Source
Basin Continued	media		Guidelines (2015)
	Orthophosphate content of filter media	40 mg/kg	MBT WBM Music Guidelines (2015)
	Exfiltration rate	0 mm/hr	By design
	Is Base Lined	Yes	Lined
	Vegetation Properties	With effective nutrient removal plants	Landscaping will include deep rooted vegetation
	Overflow Weir Width	10% of Surface Area depending on Biofiltration Basin.	By design
	Underdrain Present	Yes	By design
	Submerged zone with carbon present	No	By design
Rainwater Tank	Low Flow Bypass	0m³/s	WBM BMT (2015)
	High Flow Bypass	0.085	WBM BMT (2015) 0.005 m³/s per dwelling
	Volume below overflow	Assumed 5kL	WBM BMT (2015)
	Depth above overflow	0.20	Tank design
	Surface Area	34m^2	Cumulative surface area for tanks based on number of lots
	Overflow pipe diameter	90mm per tank	Tank design
	Reuse	0.36KL/day/dwelling for internal reuse in toilet flushing and laundry for 3 b/r house 112KL/yr/dwelling for external reuse for irrigation (scaled by PET)	Tank design

10 Attachment C – Civil and Drainage Works Plan

11 Attachment D – Flood Modelling Results

12 Attachment E – Response to Council Letter

	Council Correspondence (25/02/2016) Section F	Response
	Engineering	
a)	The proposed stormwater management concept to convey the flows from the upstream catchment upstream does not adequately address the environment impacts of piping the flows through the site (see also environmental comments below). The use of a piped system will result in increase to the peak flows discharging into the downstream drainage system. The capacity of the downstream system to cater for this, potential changes in flood affection of downstream properties and stream health and decrease in water quality have not been considered. A drainage system that does not increase the downstream flows and maintains water quality is required.	The flood assessment demonstrates a significant benefit to properties immediately downslope of the proposed sub-division with no downstream flooding impacts modelled. Refer to flood assessment plans.[2] Assessment of the 1% AEP flow immediately downstream of the site (i.e near creek at Luchetti Ave) demonstrates that the post development peak flow remains materially unchanged.
b)	Hard engineering works within private property to collect flows from upstream is not acceptable for dedication as a Council asset.	Hard engineering works have not been proposed see civil plans. [1]
c)	Where it is proposed to augment the downstream drainage system within the road reserve and drainage easement, a concept design of the proposed works based on survey is required.	Refer to civil plans.[1]
d)	The drainage system for the development site is to be kept separate from the flows entering the site from upstream as far as possible. A treatment regime to ensure that the water quality is not reduced by the development, supported by MUSIC modelling is to be provided. Water quality treatment is to be designed to provide a low maintenance solution as far as practical.	Offsite stormwater flows are captured and conveyed through the site via pipe and are separated from Lot and road reserve runoff. Refer to civil plans[1]. Water quality is addressed through MUSIC modelling. See results and stormwater treatment devices outlined in civil plans[1].
e)	Hydraulic Modelling is to be provided to assess any potential benefits of on-site stormwater detention (OSD) to reduce peak flows to the downstream drainage system. Where a benefit is found, an estimate of the volume is to be calculated, and provided in a suitable location on the site.	It is considered that OSD is <u>not</u> required based on the response at a) above.
f)	There is insufficient information to adequately assess the current stormwater management concept. Detailed calculations/ hydraulic modelling of any future design is to be provided for assessment. This is to include an analysis assuming pit blockage in accordance with the recommendations of AR&R to estimate overland flows, hydraulic grade line analysis of piped systems, an assessment of the inlet capacity of pits and the capacity of the proposed roads and channels (based on survey) to convey the required overflows, etc.	Results of Hydraulic analysis for the drainage system is provided in the civil plans[1]. Drainage long sections include hydraulic calculations for the 5% AEP and 1% AEP flows. Pit and pipe blockages in accordance with AR&R have been considered. Swales convey overland flows due to this blockage and are shown to convey flows up to the 1% AEP via Tuflow flood modelling. Refer to the flood assessment plans[2].

	Environmental	
g)	The proposed drainage works do not comprise best practice water management techniques to protect surface and groundwater regimes and water quality for the site, as required by LEP 1991 clause 10.5(a)(v).	Proposed drainage and water quality treatment works outlined in the civil plans[1] demonstrate compliance with LEP 1991 clause 10.5(a)(v).
h)	The drainage plan proposes the combined piping of all flows across the site from both natural areas and developed areas. The proposed piping is excessive and needs to be minimised and restricted to the development area.	The proposed drainage system is considered appropriate and sized to capture and safely convey: - The 1% AEP flows arriving from upstream of the site. - The 1% AEP flows generated from within the subdivision.
i)	The lot layout, road placement and stormwater design does not consider or maintain the flow paths of natural catchments and ephemeral watercourses. Existing natural flow paths and opportunities for infiltration and percolation need to be identified and retained.	Safe flow paths have been provided for both the upstream offsite flows and site generated runoff within stormwater easements. Stormwater infiltration has been provided via bio filtration basins for individual lots and the road reserve as outlined in the civil plans[1].
j)	Natural catchment (clean) flows are not kept separate from the developments stormwater treatment system. Clean and dirty flows need to be kept separate.	Clean flows (assumed to be upslope forested areas) are conveyed via a pit/pipe network through the site separate from lot and road drainage runoff. Lot and road runoff are conveyed through water quality structures prior to joining with offsite flows in the trunk drainage system. These combined flows are then conveyed to the downstream discharge location to minimise duplication of the drainage system. Refer to civil plans. [1]
k)	The proposed water quality treatment focusses on raingardens for future dwelling, not proposed to be constructed as part of this application. The drainage plan does not adequately treat the road runoff (being the main development impact at the subdivision stage). Adequate provisions must be provided to treat the quality of runoff from all impervious surfaces proposed by this development application.	Road reserve runoff is treated via roadside raingardens. Refer to civil plans. [1] MUSIC modelling results outlined in the civil plans[1] demonstrate compliance with Council's requirements.
l)	A stormwater quality model (such as MUSIC) has not been submitted to support the proposal and is required. The model needs to include appropriate stormwater quality devices, adequately sized, to ensure the quality of surface or ground water leaving the site is not reduced in the short or long term due to the development. The model needs to address all impervious areas proposed as part of the subdivision application.	MUSIC model has been undertaken with results outlined in the civil plans. [1]

Note:
[1] Civil plans refers to Martens plan ref P1605170PS01-R02.
[2] Flood Assessment plans refers to Martens plan ref P1605170PS02-R03.

13 Attachment F – Summary of Agreed Commitments

Darren Galia

From: Brett Phillips <Brett.Phillips@cardno.com.au>
Sent: Friday, 12 August 2016 8:01 AM
To: Daniel Martens; fnagel@bmcc.nsw.gov.au; Terry Harvey
Cc: Josh Coates; Trevor Cork
Subject: 59917018 Hazelbrook application [P1605170]

Daniel,

Many thanks for your summary of agreed actions. I have only one suggestion below in this colour.

No doubt the court will want to know the timeframe to undertake the agreed assessments. Can you advise? In relation to our inputs our aim would be to provide these within 3 working days subject to the immediate concurrence from Council regarding the provision of the identified information and subject to the hydraulic model run time (we will need to run the 2 yr ARI event with Council's overall model because this event has not been assessed previously).

It is also my understanding that Trevor Cork needs to provide a status report to the Court by lunchtime today(?). Because Josh and I are both participating in an all day Workshop (located away from the office) commencing at 8.00 am I have copied Trevor in on this email so that he is aware of the scope of the agreed actions.

Fiona,

Do you have any additional comments on the agreed actions below?

Cheers
Brett

Dr Brett C Phillips
DIRECTOR
CARDNO (NSW/ACT) Pty Ltd

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Shaping the Future

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Email brett.phillips@cardno.com.au Web www.cardno.com

From: Daniel Martens [mailto:DMartens@martens.com.au]
Sent: Thursday, 11 August 2016 5:54 PM
To: Brett Phillips <Brett.Phillips@cardno.com.au>; fnagel@bmcc.nsw.gov.au; Terry Harvey <THarvey@martens.com.au>
Subject: FW: Hazelbrook application [P1605170]

Dear All,

Here is my initial draft summary of agreed commitments arising out of today's s34 conciliation meeting between Cardno, Martens & Council:

1. Water quality modelling and management (Martens)
    a. Update the MUSIC model to include relevant upslope areas
    b. Clarify land-use allocations and areas nominated on plans
    c. Clarify the size, location and operation of water quality treatment devices
    d. Seek to increase groundwater recharge and reduce storm flow volumes where possible
    e. Provide MUSIC file to Cardno / Council once agreed changes are made.

2. Drainage system (Martens)
    a. Where possible convey upstream runoff and site runoff through the development via swales and/or linear biofiltration to achieve a degree of infiltration and to maintain the current soil moisture regime.
    b. Amend pit and pipe system as necessary to accommodate the water quality outcomes
    c. Include detention systems as required (if necessary) by flood modelling
    d. Nominate locations where 88B restrictions may be needed
3. Flooding
    a. Martens would:
        i. Extend the model extents to the culvert under Oaklands Road
        ii. Include 1D elements for trunk drainage pipe network
        iii. Obtain supplementary survey to assist in modelling the necessary easements
        iv. Model existing and developed conditions under 2yr, 5 yr and 100 yr ARIs + PMF
        v. Prepare impact maps for 2yr, 5yr and 100 yr ARI, including changes in flood level and flow velocity
        vi. Rely on the pre-2016 IFD data and storm temporal distributions
    b. Council would, through Cardno, supply:
        i. The terrain file used for the Council's flood model so that it can be used to extend the Martens flood model
        ii. Inflow hydrographs from Council's flood model in the region of Lyons Place and any other relevant area
        iii. Provide access to results of Council's flood model in order confirm validity of Martens 2D flood model
4. On-going discussions
    a. In the interests of resolving the technical matters, continue to discuss between the parties as necessary
5. Revised civil plans
    a. If the discussion result in modification to the drainage system, ultimately Martens will need to provide amended civil drawings

Kind regards,

Dr Daniel Martens
Managing Director | Principal Engineer
BSc(Hons1), MEngSc, PhD, MAWA, FIEAust, CPEng, NPER

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