STORMWATER MANAGEMENT PLAN
For
Marchese Partners Pty Ltd
At
124-128 Killeaton St St Ives

Ref: **14160-001-swmp-Rev B**
Date: **July 2015**

Report reviewed by:

Andrew Castle – Director

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1.0 INTRODUCTION

ABC consultants have prepared this report so as to be read in conjunction with the Development Application to Ku-ring-gai Council for the proposed residential development on 124 – 128 Killeaton St, St Ives

The scope of the report includes an assessment and strategy for the best practice of stormwater management with reference to Council requirements for the proposed development (DCP 47 (2005) – Type 5 – Location A) and those outlined within the Local Centres DCP.

Furthermore the concept of the proposed stormwater system in terms of operation and the various components of the drainage system are included within.

The proposed measures are subject to review and assessment by the Council as part of the Development Application process and as such some modification and revision may occur to the aforementioned proposed management system prior to the issue of a Construction Certificate.

The following documents were referenced during the compilation of this report:-

- Marchese Architects; Architectural Drawing Ref: 14071 Dated: June 2015 Revision B
- ABC Consultants; Civil Drawings Ref: 14160 Dated: 17/10/2014
- Ku-ring-gai Council; Development Control Plan (DCP 47 - 2005)
- Ku-ring-gai Council; Local Centres DCP Volume C Part 4B.5
- “Australian Runoff Quality – A guide to Water Sensitive Urban Design”, Engineers Australia (2006)

2.0 STORMWATER MANAGEMENT

2.1 General remarks

The key objective of stormwater management is to ensure that there are no adverse impacts to the water quality and stormwater flow paths and volumes downstream of the site, as a result of the proposed development.

Generally a new development alters the overall roughness of the catchment area as a result of a general increase in impervious areas, increasing the rate of storm water runoff. Furthermore alterations to the topography through excavation and fill can have the ability to redirect and generally concentrate flow paths.

As such, during a storm event, flooding of the downstream drainage systems may occur and in the longer term potentially erode overland flow paths result ing in degradation of the downstream assets.

The proposed stormwater management system must therefore ensure flows arising from the proposed development are safely directed and that the downstream drainage system is of sufficient capacity.

2.2 Items for consideration

The following items will be considered as part of the proposed stormwater drainage system:-

- **Runoff Volume** – An increase in impervious areas (Roof or hardstand) will in most instances result in an increase in stormwater runoff from the site during a storm event.
- **Runoff Rate –** The existing site is divided into three residential lots. Only one of which currently drains to the Mona Vale Rd Kerb Inlet Pit, The others drain to Killeaton St. The proposal involves discharging to the Monavale Rd Pit only, which essentially would triple the catchment area that currently drains to the pit. As such runoff is to be attenuated to mimic the existing runoff conditions from the single residential lot (Lot 1. No. 124 Killeaton St).
- **Runoff Quality –** A new development, whether that be residential or commercial will generally increase the contamination of the runoff due to the changed nature of the use of the site. Vehicles, landscaping and gardens, household litter and commercial pollutants etc. all have the potential to generally increase the pollutant, sediment and nutrient content of stormwater runoff.

2.3 Site Description

The site is situated on the Southern side of Killeaton St\ and is bounded by adjacent residential properties and a major arterial Road (Mona Vale Rd) to the West. The existing properties are residential, and have residential dwellings, and numerous trees towards the front of the property. The rear of the site have trees and out buildings. The site generally slopes towards the North West and would generally be discharging to the existing kerb and gutter or directly to the existing kerb inlet pits on Killeaton St and Mona Vale Rd. See mark up on aerial map below. The proposed development involves the excavation of a split level underground basement carpark and a split level 4 storey residential unit block. The aforementioned front and rear vegetation is to generally remain in its current state post development. Deep Soil zones and existing trees that are to remain are noted on the landscape and architectural plans.

Figure 1:- Site Location

2.4 Design Guidelines

The stormwater management and Planning Elements are to designed and constructed in accordance with the following:-

Runoff Volume: Ku-ring-gai Council DCP 47 and the Local Centres DCP Volume C Part 4B.5
The development is a multi-unit and is classified Type A under DCP 47. The site can discharge to the kerb and/or existing kerb inlet pits, and is thus classified as Location A under the DCP 47 guidelines.

The fact that the site lies relatively near the top of Ku-Ring-Gai Creek catchment that flows to middle harbour through numerous downstream urban drainage structures means there are direct effects (however delayed to its final destination) of runoff during storm events downstream of the site. It is thus an effective measure to ensure that some form of on-site detention (OSD) is provided.

Runoff rate and Discharge point: Subject to RMS approval

As discussed previously in section 2.2, the runoff rate has been restricted to that of the single lot (124 Killeaton St) that currently discharges to the MonaVale Rd Kerb Inlet Pit (KIP). The calculated values for this site (No. 124) are listed below:-

- Area = 1528.27 m2
- Impervious = 42.9% of Site
- Path Length = 55m
- Site Slope = 1.5%
- Time of Concentration = 13.12 min

The On-Site Detention (OSD) tank has been made much larger than what would otherwise ordinarily be the case, if only the Council guidelines were strictly adhered.

Following discussions with Council it was deemed appropriate to ensure that the discharge from the site post-development to the Roads and Maritime operated pit was no greater than what is currently being discharged pre-development.

STORM EVENT	Permitted Site Discharge (L/s)
ARI 100	70.2
ARI 50	60.9
ARI 20	47.8
ARI 10	39.7
ARI 5	33.7

Table 1.

Water quality: Ku Ring Gai DCP 47 (2005)
The primary objective for the site water quality is to reduce pollution directly downstream of the site, and thereby reducing the overall pollution at the end of the catchment and the largely adverse effect on the receiving environment.

The council guidelines (DCP 47 (2005) – Chapter 8.3.1) outline the goals and objectives for all types of development and are tabled below with criteria based on the annual load generated from the development site:-

PARAMETERS	CRITERIA (kg/ha/yr)
Gross Pollutants	70% Reduction in the average annual load
Suspended solids	80% Reduction in the average annual load
Total Phosphorous	45% Reduction in the mean annual load
Total Nitrogen	45% Reduction in the mean annual load

Table 2.

2.5 Objectives and Targets

With reference to the policy requirements the objectives and targets for stormwater management are table below:-

STORMWATER MANAGEMENT	OBJECTIVES	TARGET
Quantity	The existing runoff flow regimes for the full storm events should be maintained and provide safe conveyance system for the major storm events.	Maintain existing runoff flow regimes including:- - No increase in peak runoff. - No increase in the frequency of runoff. - Achieve 50% reduction in Mean Runoff via retention and Re-Use. - No adverse impact on the downstream properties.
Quality	The health of receiving waters should be maintained or improved Development should not result in increased pollutant load or concentrations	Runoff from the site to achieve natural dry and wet weather concentrations for the catchment.

Table 3.

2.6 Overall Concept and Strategy

The strategies in management of storm water runoff to achieve the above objectives have been divided into long term (operational) and short term (construction) strategies as per table below. The focus of this report is on the operational nature of the stormwater management system. Any further information other than that included below regarding the control of runoff during construction should be ascertained from the relevant sediment and erosion plan :-

STRATEGY	DESCRIPTION
Operational	The proposed development will have landscaped areas, in addition to hardstand areas with public and/or private access and vehicular crossings and associated facilities. All the above items generally increase the nutrient, and suspended solid concentrations in stormwater runoff and also the volume of litter and debris potentially flowing downstream.

	As such physical devices to reduce flow rates, including filters, swales and/or bio retention are to be implemented.
Construction	Excavation and earthworks during construction leads to exposed earth over a period of months. The potential erosion and runoff of earth in the form of suspended solids and pollutants from construction processes and machinery is much greater during construction. Thus physical barriers, such as sediment traps and other erosion control measures should be documented on a soil and stormwater management plan (SWMP) and/or sediment and erosion control plan. The erosion control plans should be installed and implemented if necessary prior to commencement of works.

Table 4.

3.0 STORMWATER QUANTITY CONTROL

3.1 General Remarks

Generally a development increases the impervious areas of the site through the alteration and/or addition to the existing impervious areas such as roofs and hardstand.

The time of concentration of runoff on the site is thus reduced and is likely to have the potential of interfering with the peak runoff capacity of the downstream drainage systems.

Ideally runoff from the site should be limited to the pre-development flow rates and volumes. Any additional volumes anticipated from the hydrology modelling of the post development site can thus be detained on site and discharged into the downstream drainage system generally over a period of hours. The longer period of discharge thereby limits the runoff load of the downstream drainage system to a more manageable level in terms of its peak design capacity.

3.2 Proposed Drainage System

The drainage system on the proposed development will be designed to collect the all of roof runoff, and other impervious areas such as balconies, and the majority of runoff from footpaths, driveways, and ancillary buildings.

In addition flows from pervious areas may have some method of collecting runoff particularly in areas that are to be part of developments landscaping.
The drainage system for the proposed development includes:-

- A network of gutters and pipes for roof runoff, pipes and surface inlet pits to suspended impervious areas and surface pits and buried pipes for any finished ground surface runoff.
- Overland flow paths for the safe carriage of major storm event runoff through the site.

- Pit insert baskets for the removal of litter and gross pollutants from collected runoff.
- Hydrodynamic separator to remove hydrocarbons and oils from stormwater runoff.
- Filtration and flow reduction systems to remove sediment and nutrients.

3.3 Stormwater Retention Requirements

The rainwater tanks are to collect 100% of roof runoff (1425 m2 or 31% of the site, refer to Appendix E). Runoff is to be directed to the tanks via a first flush device to remove contaminants. The rainwater tank for the Eastern Building (Building B) is to be installed within the garbage room within Basement 1, its size has been determined by a water balance model, to achieve 50% reduction in runoff, and is designed as 10,000L.

It is likely this tank will be a number of prefabricated poly-ethelene tanks hydraulically connected, and as such the structural slab of B1 should be designed to accommodate the additional loads the tank will induce in this area.

The rainwater tank for the Western Building (Building A) is to be installed within the proposed On Site detention (OSD) tank (also within Basement 1), its size has been determined by a BASIX report, and is designed as 8000L.

As such in total some 18,000 Litres of retention for the use in irrigation is proposed.

Overflow for the Building A tank is to be a pipe that is to be installed along the inside of the shoring wall that direct flow to the High Early Discharge chamber within the OSD tank.

The overflow of the second Building B tank will be via a weir at the top of the cast in-situ concrete walled tank, whose level is some 100mm above the top water level of the OSD tank. Overflow will be directed into the main chamber of the OSD tank, however should council deem it more appropriate, an overflow pipe could be installed to ensure flows are directly carried to the High early discharge chamber.

The collected water will be connected to the landscape irrigation hose lines, external taps, and furthermore used for laundry and toilet flushing.

The tank will also have the following features such as:-

- Duty and stand by pumps configured to operate at alternate intervals
- Mains water top-up
- Easily accessible Control Panels
- Float valves
- Access lid/hatches and step irons
- Reticulation treatment

With respect to Council requirements the tank volume is to be determined by the maximum required under BASIX or that which is determined by a water balance model to achieve 50% reduction in runoff days. A water balance model was created using rainfall data from:-

- Sydney Observatory Hill (Station 66062) from 1963 – 1993 (31 years)
- Building A roof area 722 m2 initial tank volumes of 800L
- Building B roof Area 789m2 initial tank volumes of 8000L

Estimated usage was based on the following assumptions, with reference to the KCC MUSIC modelling guidelines and the Sydney Water guide for average daily water use. The results are presented within the Appendix.

The inputs for usage are based on:-

- An average daily demand of 3.48 L/m2 of floor area, Sydney Water recommendations.
- The average demand is spilt between 25% Gardens and 75% Laundry and Toilet flushing.
- The average Building A unit size is 2427/37=65.6m2
- The average Building B unit size is 3028/37=81.8m2
- The number Units plumbed from Ground to Level 2 is a minimum of 23 Units.
- Total average daily demand per Unit in Building A is 170 L (Block A = 3.91 kL/day)
- Total average daily demand per Unit in Building B is 162L (Block B = 3.74 kL/day)
- Median Garden Usage is 4057 kL/Ha/yr as per North Kellyville Study by Agsol (Appendix E – Soil and Groundwater Studies)
- 25% of the units area subject to irrigation as per Sydeny Water recommendations.
- Ground Floor garden areas = 44.3% of the site (2026 m2 or 0.2026 Ha)

Within the MUSIC model, a daily demand for each unit bloc (Building A and B) was multiplied by the number of units from Ground to Level 2 (23 units) and factored by 75% to estimate the potable water use.

Similarly the irrigation use was factored by 25%, and converted to a total annual use which was fixed to the Evapo-Transpiration (PET) levels, as irrigation use can be regarded as seasonal.

Irrigation use for all the ground floor gardens was based on the median value obtained from the 10 year study completed by Agsol for the North Kellyville development.

It must be stressed that the report has factored typical garden usage for individual lots, in a suburban low density environment, and that a well maintained garden, as would be expected by a body corporate of a higher density development would generally have a higher water usage.

Furthermore factors such as site position, exposure to hours of sun/shade, seasonal rainfall (wet and dry periods) and planting density and plant species all factor the usage.

In consideration of all of the above, the median value recommended in the above Kellyville report is considered appropriate and somewhat conservative in terms of determining re-use.

The model was run over a period of 30 years (1963 – 1993) and the volumes of the tanks were initially set to those that were recommended by the BASIX report. A process of trial and error determined that the BASIX report volumes required to be increased to achieve the 50% reduction in runoff, a volume of some 10kL and 8kL is required for Building A and Building B respectively. Results from the model are included within the tables below:-

BLDG A (WEST) – 8kL	
	FLOW (ML/yr)
Flow In	0.80
Pipe Out	0.35
Weir Out	0.00
Reuse Supplied	0.39
Reuse Requested	2.31
% Reuse Demand Met	17.17%
% Load Reduction	**49.33%**

Table 5.

BLDG B (EAST) – 10kL	
	FLOW (ML/yr)
Flow In	0.88
Pipe Out	0.44
Weir Out	0.00
Reuse Supplied	0.43
Reuse Requested	2.24
% Reuse Demand Met	19.45%
% Load Reduction	49.57%

Table 6.

3.4 On-Site Stormwater Detention (OSD) Requirements

As stated previously, given the sites location within the catchment and the proposed increase in hardstand an on-site detention system is proposed.

There is also a requirement for deep soil zones, and the fact that there are two separated buildings, the tank is best suited to be located in two locations within the building footprint. As such, the tanks are shown to be under the proposed driveway ramp and garbage room to the front of the property, and within the North Western corner of lower basement 1.

Overflow and discharge will be directed to the boundary discharge pit and the nearby existing kerb inlet pit via gravity.

Permitted site discharges are restricted to values calculated from the existing single lot on No.124 Killeaton St. Discharge rates are discussed in Section 2.4 Design guidelines.

The DRAINS program was specifically developed for urban stormwater analysis. It uses the time-Area method to generate flow hydrographs. These time-Intensity based inputs are specified by the user and essentially calculate catchment flows in a similar way to that of the Rational method.

A DRAINS model was created with the site modelled as the proposed site, with roof, level 4 balcony and ground catchments, for both the Eastern and Western buildings, and some 250m2 bypassing the OSD and being discharged to the kerb on Killeaton St.

This is conservative given some 70m2 of the bypass area will in fact be directed to the basement pump out pit, which will in turn pump the water to the OSD tank. In addition for longer storm events of some 6 – 12 hours, the ongoing usage of water within the buildings will drain the rainwater tanks will become a significant factor in the final destination of the collected stormwater runoff. The act of storing and pumping the runoff from the pump out pit and rainwater tanks in effect slows the rate of discharge, hence the conservative nature of the assumption.

STORM EVENT	Required Storage (m3)	Calculated OSD Discharge (L/s)	Calculated Site Discharge (L/s)	Permitted Site Discharge (L/s)
ARI 100	220	36	52	70.2
ARI 50	160	36	48	60.9
ARI 20	140	34	42	47.8
ARI 10	110	30	32	39.7
ARI 5	85	27	31	33.7

Table 7.

Refer to DRAINS models for the various storm events in Appendix of this report. A Soft copy can be provided on request.

4.0 WATER QUALITY

4.1 General Remarks

The quality of runoff from a catchment is primarily dependent on land use and the effectiveness of any implemented land management practices.
The increasing density of our cities and suburbs and the green fields expansions at the cities limits require a change in the methods of management and generally upgrading the existing management facilities.

Changes of sanitation and waste disposal, roads and transport infrastructure, vegetation, water courses and topography in addition to increased population density all have the potential to detrimentally affect water quality with pollutants. Pollutants from runoff in urban areas include litter and gross pollutants, sediments, nutrients, hydrocarbons and heavy metals.

The upgrading of our urban environment involves a construction phase in which generally a stage of earthworks removes any existing vegetation and exposes underlying soil strata. During this construction period of earthworks the potential for erosion of the exposed sediment is greatest. The sediment runoff has the potentially to detrimentally impact the downstream water quality.

4.2 Proposed Water Quality Controls

The proposed controls discussed within this report relate to the expected operational water quality and control measures. Any control measures for runoff quality during the construction phase are included within the sediment and erosion control plan issued as part of the development application and do not form part of the scope of this report.

There are many methods for reducing pollutant loads from captured runoff, the choice of a particular or combination of control device is largely dependent on the desired targets of reduction, relative costs of maintenance and construction, site area and topography.

Refer to the table below for a summary of the relative performance characteristics of each method:-

CONTROL DEVICE	DESRIPTION
On-site Detention tank Stormfilters	- **Stormfilter** is a proprietary device containing multiple cartridge units in a single racked system thereby suitable for larger catchments - Cartridges can be fitted with a range of filtration media to achieve desired performance targets - The proposed system has 6x980mm units capable

	of treating 9.6 L/s. - Each cartridge consists of Perlite/Zeolite media capable of removing up to 80% of TSS, 30% of TN, 60% of TP, and 100% of gross pollutants. - Typically the filters require a maintenance frequency of once every 12 months during operation. A higher frequency is to be expected during the construction phase of the project.
Enviropods	**Enviropod** is a catch basin insert installed in the inlet pits. - It is effective in removing litter, debris and other pollutants form runoff. - It is effective as a pretreatment device in a treatment train and is often installed at source. - There are two types of **Enviropods**, a GPT bag model and a 200 micron filter model. - **Enviropod** in this project are the 200 micron filter type. The filters will be installed to surface inlet pit on the project picking up the general landscaping and common area runoff that bypasses the On-site detention tank. - Maintenance involving clean out and removal of litter and debris should occur once every 3 – 6 months. The bags and filters, along with a thorough inspection of the fixings and seals should occur once every 3 – 5 years. -Enviropods will not be required to be installed to any of the Level 1, 2, 3 or 4 Balconies. Pit baskets are assumed in the modelling to be inserted to all surface inlet pits elsewhere on this project.
Rainwater and On-Site Detention Tanks	- Rainwater tanks are effective in the removal of the pollutant loads at source. The pollutant removal process is by harvesting runoff for reuse, thereby limiting the nutrients discharging into the downstream watercourses. - The tanks also reduce stormwater runoff volumes and potential risk of flooding. - A minimum 20kL of rainwater tank storage will be provided for this development. As such 2 x 10kL tanks are specified adjacent to the OSD tanks on this development. The re-use purpose is assumed to be irrigation for all the landscaped areas proposed. - Maintenance of tanks whether they be rainwater or on-site detention require regular maintenance given the gross pollutant traps and first flush units generally will accumulate litter and debris after every storm

	event. A minimum of once every 3 – 6 month period of clean out and removal should be adopted.

Table 8.

Landscaping and vegetation will provide a buffer to the downstream watercourse, filtering and reducing the pollutant runoff concentrations. Whilst these are not considered in the modelling, their effect will be to further contribute to the meeting the water runoff quality targets. As such the assessment and modelling of the water quality can be regarded as conservative to some extent.

4.3 Effectiveness Study

A computer numerical modelling assessment of the proposed development runoff quality was compared to the council requirements. The effectiveness of the proposed strategy is documented below.

4.3.1 MUSIC Model

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) was adopted for this project. The numerical modelling program was developed as part of research team in the Cooperative Research Centre for Catchment Hydrology (CRCCH). MUSIC is an model for simulating the performance and arrangement (Treatment train) of various stormwater management measures whether they be connected in series or parallel.

The time step for the model was chosen as 6 minutes. This would be a reasonable measure given the MUSIC User Manual (CRCCH 2004) suggest s that the time step should not be greater than the time of concentration of the smallest sub-catchment.

The MUSIC model was set up with catchment characteristics and expected imperviousness ratios to replicate the catchment at the time of the completed development.

The model input was generated from the 6 minute rainfall and monthly evapotranspiration data.

The pollutant loads from the site were modelled in the output through the various treatment methods as a percentage reduction. The key pollutants modelled were:-

- Gross pollutants (GP)
- Total suspended solids (TSS)
- Total Phosphorous (TP)
- Total Nitrogen (TN)

4.3.2 Event Mean Concentration

MUSIC uses different event mean concentrations (EMC) for different land uses. The EMCs within MUSIC were based on research by Duncan (1999) through CRCCH and reproduced within the Australian Runoff Quality – a Guide to Sensitive Urban Design (ARQ).

The following EMC values as per the Sydney Metropolitan MUSIC modelling guidelines are summarized in the table below:-

	MEAN BASE FLOW CONCENTRATION PARAMETERS Log_{10} (mg/l)			MEAN STORM FLOW CONCENTRATION PARAMETERS Log_{10} (mg/L)		
LAND USE	**TSS**	**TP**	**TN**	**TSS**	**TP**	**TN**
Roof Areas	Not Applicable			1.3	-0.89	0.3
Driveways (Roadways)	1.2	-0.85	0.11	2.43	-0.3	0.34
Landscaping (ground)	1.2	-0.85	0.11	2.15	-0.6	0.3

Table 9.

4.3.3 Configuration and Layout

Below tabulates the catchment areas and respective imperviousness as modelled:-

	DEVELOPED CONDITIONS		
LAND USE	**BUILDING A WEST AREA (m^2)**	**BUILDING B EAST AREA (m^2)**	**IMPERVIOUSNESS (%)**
Roof Areas	722.4	789.7	100
Balconies to Suspended Levels	110.0	145.2	95
Driveways and Hardstand	467.2	405.8	95
Landscaping	915.5	615.5	10
Bypass Areas	250	200	10

Table 10.

The type and quantity of quality control devices:-

STORMWATER QUALITY DEVICE	QUANTITY
Enviropods	4
Rainwater Tank	BLDG A 10.0kL & BLDG B 8.0kL

Storm filters – Perlite/Zeolite filter cartridges	4.8 L/s (3 x 980mm Standard cartridge)

Table 11.

4.3.4 Results

The results were assessed against the water quality targets in Section 2.4 of the report.

The pollutant loads from the development are expressed in kilogram per year. The reduction percentage is the total modelled pollutant runoff with the proposed controls divided by the pollutant runoff without any controls. As such the effectiveness of the treatment can be compared to that of a development without any controls.

PARAMETER	POST DEVEL WITHOUT CONTROLS	POST DEVEL WITH CONTROLS	REDUCTION (kg/ha/yr)	CRITERIA (kg/ha/yr)	TARGET MET
GP (kg/yr)	87.2	0	100.0%	70%	YES
TSS (kg/yr)	405	51.1	83.0%	80%	YES
TP (kg/yr)	0.908	0.315	62.8%	45%	YES
TN (kg/yr)	9.67	5.31	49.9%	45%	YES

Table 12.

The results show that the proposed system of runoff control devices or “treatment train” will ensure that the required stormwater quality targets are met with respect to the proposed development and its effect on the downstream drainage systems and the environment that the catchment discharges to.

By implementing the above strategy of control measures no detrimental impacts on the downstream environment running off directly from the site.

5.0 FLOODING

Whilst the existing kerb inlet pit may be susceptible to upwelling in extreme storm events given the position of the site within the catchment and also the fact that the habitable levels are some 400mm above the highest point of the adjacent roadway kerb flooding is not expected to be an issue to this site.

6.0 CONCLUSIONS

This report has been prepared to supplement the proposed development Application to Ku Ring Gai Council for the proposed residential development.

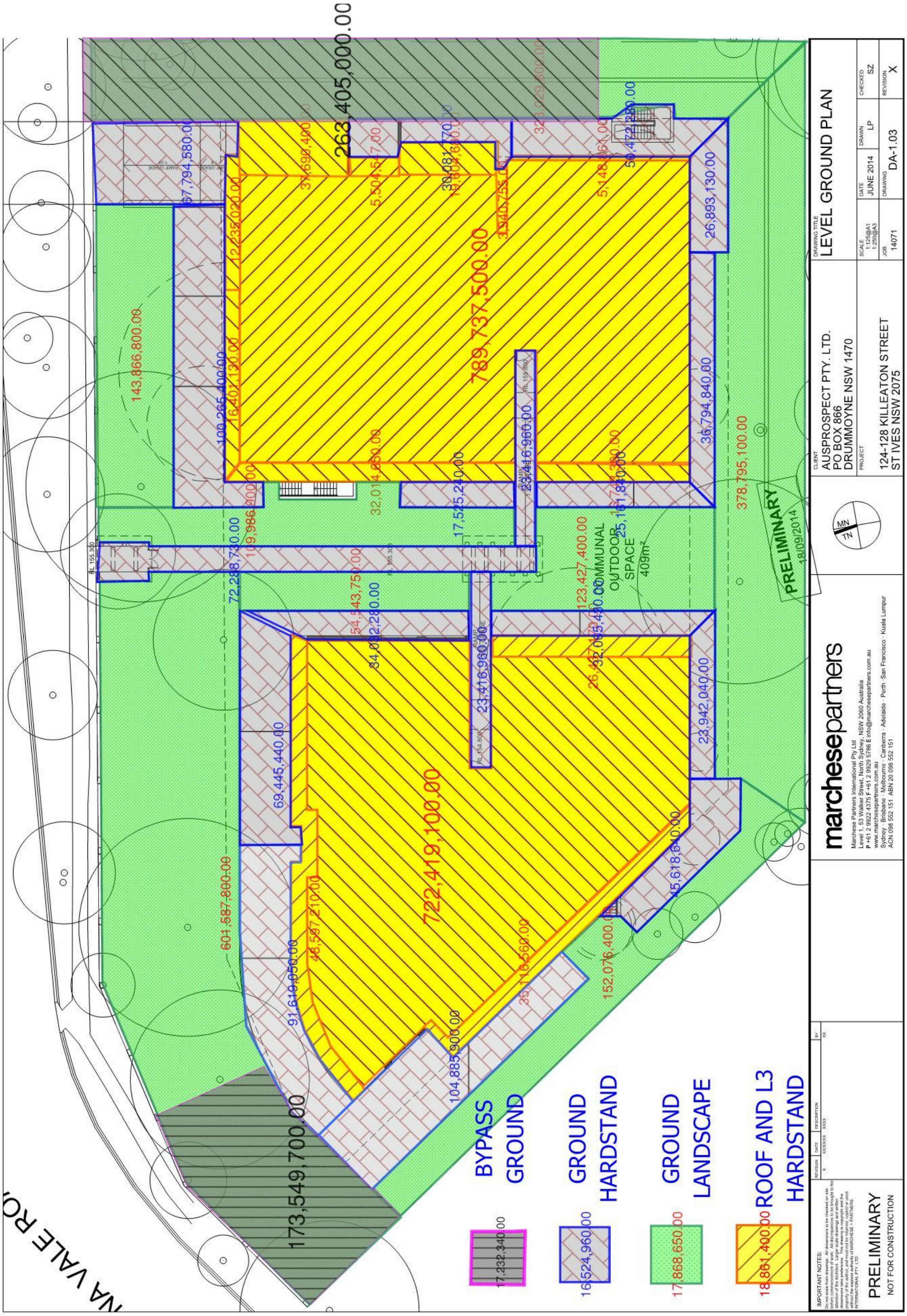
Without the implementation of stormwater management, the site would more than likely lead to adversely affecting the water quality and possibly affect the capacity of the downstream drainage system during peak storm events.

The key strategies that are to implemented as part of this development are:-

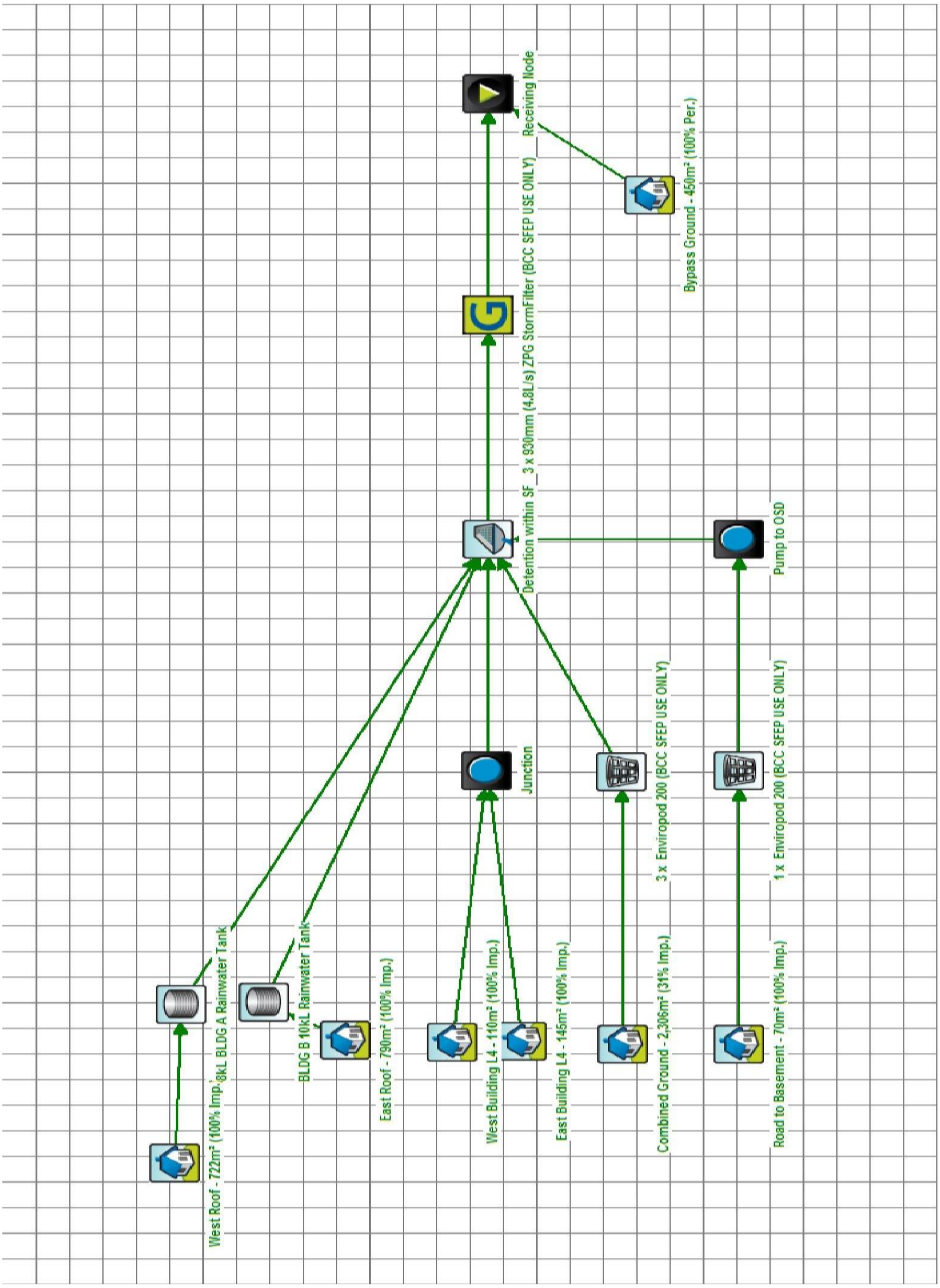
- Piped drainage and surface inlet pits to collect minor storm surface runoff and prevent localized ponding.
- **Enviropods** to be installed in all surface inlet pits to control gross pollutants prior to them entering the ancillary drainage system.
- Rainwater re-use tank, to store water on site for use over a period of weeks following a storm event, reducing site runoff.
- On-Site Detention tank with Gross Pollutant trap and **Stormfilters** to remove pollutants prior to them discharging into the downstream watercourses.
- Overland flow paths to direct runoff through the site during a major storm event without flooding or eroding the property.

We are satisfied that the modelling and investigation into the various strategies for this project have improved the quality and volume of runoff from the site. The strategy and management of the stormwater will result in a safer development and a more ecologically sustainable environment to watercourses downstream.

Appendix A - Proposed Development Catchment Plans



Appendix B – MUSIC Model



Appendix B – MUSIC Model

Receiving Node

Treatment Train Effectiveness

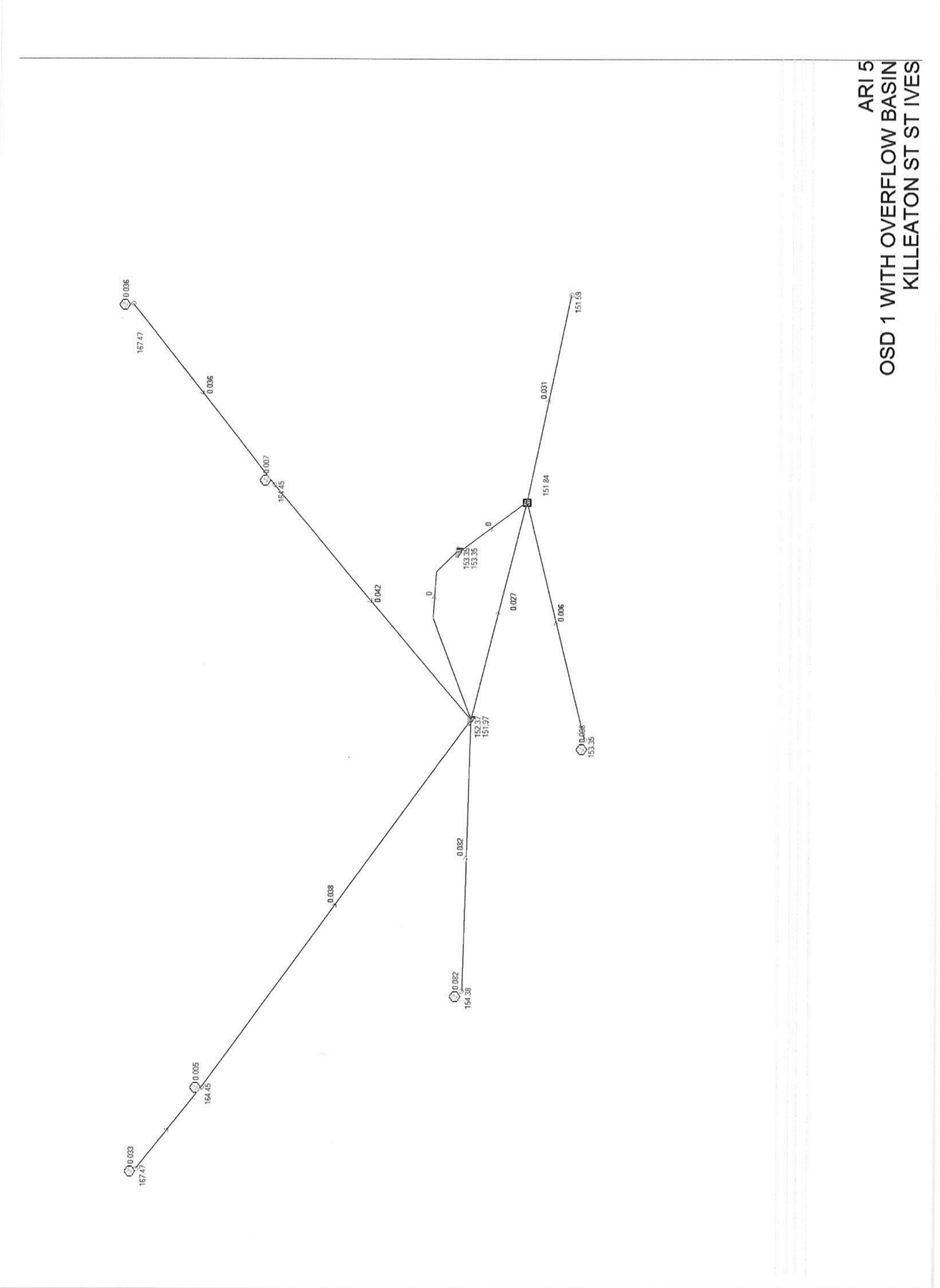
	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Sources	4.00	627	1.19	11.3	98.2
Residual Load	3.08	121	0.451	5.80	0.00
% Reduction	23.0	80.8	62.0	48.9	100.0

Appendix C – Permitted Site Discharge Results

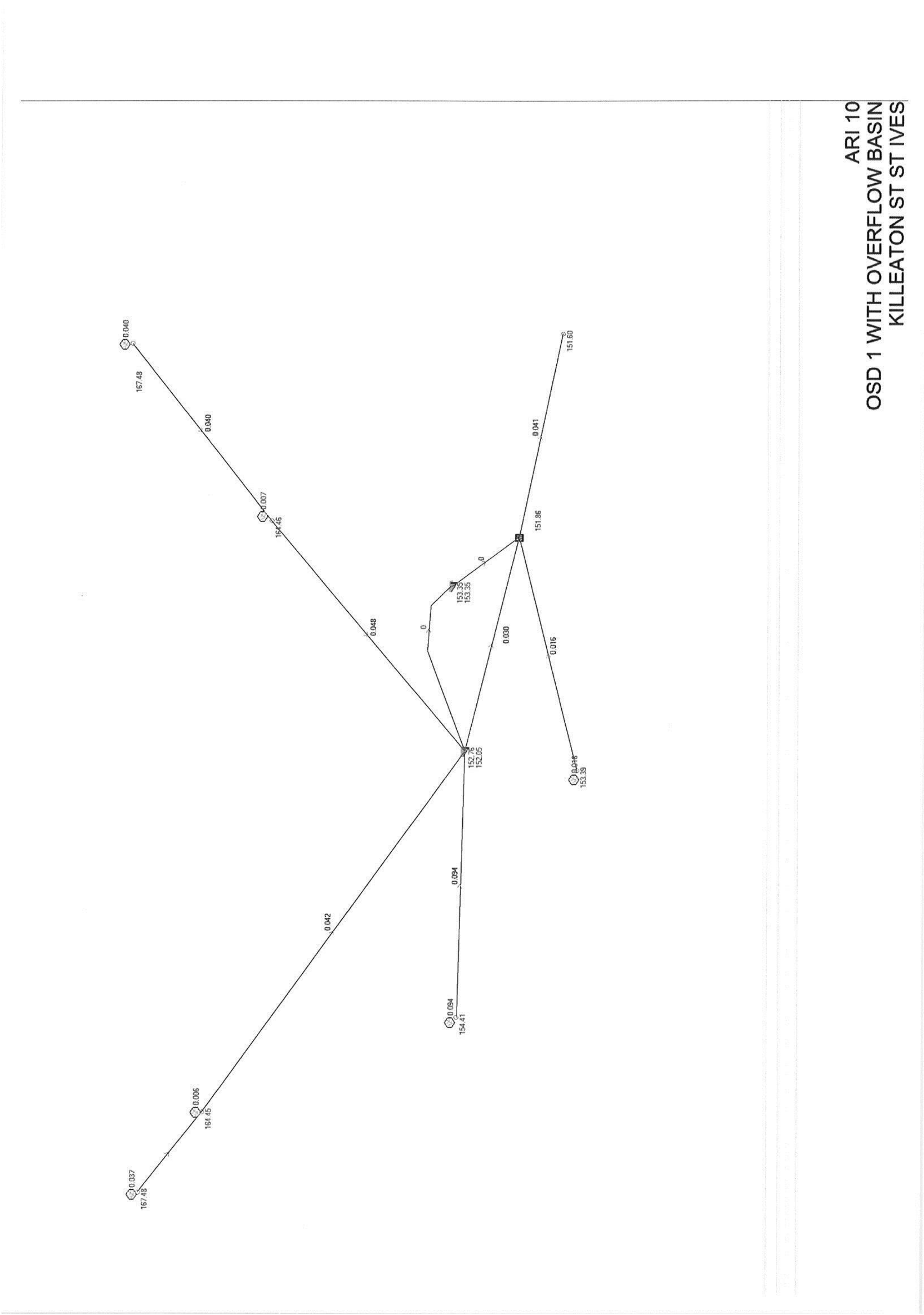
Ac =	tc	I_{100}	C	**Q100**	I_{50}	C	**Q50**
(ha)	(min)	(mm/hr)		(m^3/s)	(mm/hr)		(m^3/s)
0.1528	13.62	191.54	0.86	**70.24**	173.35	0.83	**60.92**

I_{20}	C	**Q20**	I_{10}	C	**Q10**	I_5	C	**Q5**	I_2	C	**Q2**
(mm/hr)		(m^3/s)	(mm/hr)		(m^3/s)	(mm/hr)		(m^3/s)	(mm/hr)		(m^3/s)
149.16	0.76	**47.86**	129.97	0.72	**39.72**	116.09	0.68	**33.70**	91.33	0.61	**23.73**

Appendix C – DRAINS MODEL



Appendix C – DRAINS MODEL



Appendix D – Development Data

DEVELOPMENT DATA

	UNIT MIX				AREA (m^2)			SEPP65	
LEVEL	ONE BED	TWO BED	THREE BED	SUB TOTAL	NSA	GFA	GBA	CROSS VENTILATION	SOLAR ACCESS
B2									
B1									
G	6	10	0	16	1109	1218	1784	11	10
1	4	11	1	16	1153	1260	1776	11	10
2	4	11	1	16	1162	1260	1776	11	10
3	4	11	1	16	1164	1270	1776	11	12
4	0	4	6	10	856	928	1759	10	10
TOTAL	18	47	9	74	5444	5936	8871	54	52
	24%	64%	12%					73%	70%

SITE AREA CALCULATIONS

TOTAL SITE AREA:	**4575m²**
FSR CONTROL	**1.3:1**
TOTAL ALLOWABLE GFA:	**5947.5m²**
FSR PROPOSED:	**1.297:1**
SITE COVERAGE:	**1425m² (31.1%)**
DEEP SOIL AREA:	**2291m² (50.0%)**
TOP FLOOR % OF LEVEL BELOW:	**73%**

CARPARKING (REQUIRED)

1B (1/UNIT)	18
2B (1/UNIT)	47
3B (1.5/UNIT)	13.5
VISITORS (1/4 UNITS)	18.5
TOTAL	**97**
BICYCLES	
RESIDENTS (1/5 UNITS)	15
VISITORS (1/10 UNITS)	8

CARPARKING (PROPOSED)

RESIDENTIAL	73
ADAPTABLE UNITS	8
VISITORS	18
TOTAL	**99**
BICYCLES	
RESIDENTS	28
VISITORS	10
MOTORCYCLES	6