



City of Canterbury

City of Cultural Diversity

Specification 9 A Guide for Stormwater Drainage Design

Stormwater Management Manual Specification 9

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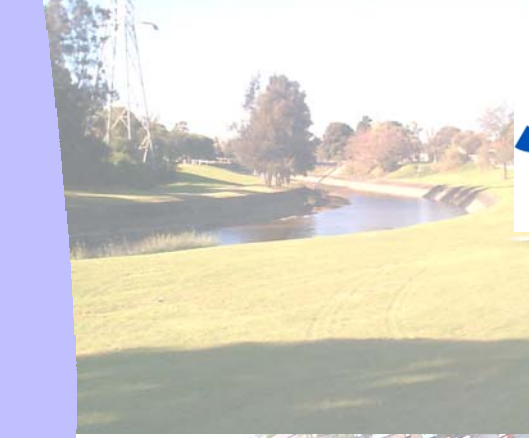


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1 OVERVIEW

1.1 INTRODUCTION

Council's Stormwater Drainage Design Manual is designed to help developers provide adequate and appropriate storm water drainage as part of their development, and to assist in compliance with conditions of Building and/or Development Consent. This Stormwater Drainage Design Manual - Specification 9 (SDDM) is not a stand-alone document, and should be read in conjunction with Council's Stormwater Management Manual - Specifications 1 to 8 and Flood Management Policy & Flood Proofing Code — Specification 10.

The purpose of this document is to provide a practical guide to aid in the preparation of designs to be submitted to Council. It is not intended that the SDDM cover all possible situations, and it does not absolve the designer of the necessity to plan for the specific requirements of the site being dealt with.

1.2 OBJECTIVES

In the urban environment, stormwater drainage systems are provided to convey runoff from developments in a safe, convenient, and environmentally conscious manner. Inherent in this philosophy is the analysis of rainfall events (storms) that result in both "minor" and "major" stormwater flows. Any stormwater drainage design is incomplete when only one of these stormwater flows is considered. Historically, a piped drainage system has been used to cater for "minor" storms, and "major" storms have been controlled by the provision of defined overland flow paths. The stormwater drainage provided on an individual development site should follow this same strategy. The majority of the SDDM deals with the requirements for a piped "minor" drainage system.

Where possible, site stormwater drainage should be directed to the street drainage system. This reduces the need for easements to drain the rear of properties. These easements and the pipelines within are difficult to access for maintenance purposes. In the case where a property slopes away from the street, roof drainage should still be directed into the street drainage system where possible. It is also preferable for drainage from properties to discharge into the gutter, rather than directly into drainage pipes in the street. This allows better maintenance, accessibility, and is generally less costly.

If it is not possible to drain the property directly into the street drainage system, "inter-allotment drainage" systems shall be provided by the developer. Inter-allotment drainage systems must be located within easements to ensure rights of access for maintenance.



2 FLOWRATES

2.1 RATIONAL METHOD

Use of the rational method for determining flow rates will be acceptable for relatively small catchments (< 7500 sq. meters).

The calculations should be based on the standard formula:

$$Q = C I A / 3600$$

where : **Q** = design flow rate (L/s)

C = runoff coefficient (see appendix 7.2)

I = design rainfall intensity (mm/hr , see appendix 7.1)

A = catchment area (sq. metres)

2.2 RUNOFF ROUTING METHODS

For larger catchments (> 7500 sq. metres), or where a more accurate estimation of flowrate is necessary, peak flowrates should be calculated using a recognised runoff routing model such as; **ILSAX, RAFTS, RO RB, and WBNM.**

3 PROPERTY DRAINAGE

3.1 PIPED STORMWATER DRAINAGE SYSTEM

The design submitted will have been carried out in accordance with principles detailed in the publication - "Australian Rainfall and Run-off" (1987 Edition).

This design will incorporate a piped drainage system and the provision of an On-Site Detention (OSD) in accordance with the following section. The provision of OSD will be a major component of the stormwater system design, and accordingly, the design of the OSD system and Council's requirements for that design are discussed separately in the manual.

The piped drainage system will be designed to cater for a 10% (1 in 10 year) ART event. Intensity-Frequency-Duration tables and polynomial coefficients are available for the Council area. These are attached at the end of this document.

In addition to the 10% ART event, consideration should be given to major flow paths for a 1% (1 in 100 year) ARI event. These should be indicated on the design plans.

In large commercial, industrial or residential developments a full Hydraulic Grade Line analysis of the piped drainage system is required. A large development for the purpose of this requirement is one with a total site area greater than 7500m².

For the purposes of design the time of concentration should be calculated using the kinematic wave method. The minimum acceptable time of concentration is 5 minutes.

All pipes are to have a minimum longitudinal grade of 1%. Pipes should be designed to be self cleansing without causing scour. The minimum pipe velocity should be 0.6 m/s during the design storm with a maximum velocity of 6 m/s.

Where Pipes are laid within the public roadway, or which drain public areas such as a road or public park, are to be a minimum diameter of 375 mm.

3.2 SURFACE INLET PITS

3.2.1 Dimensions

Minimum internal dimensions of a surface inlet pit are:

Depth (mm)	Minimum Pit Size (mm)
<300	300 * 300
300 - 600	450 * 450
600 - 1200	900 * 600
> 1200	900 * 900

Pits deeper than 1200mm require step irons.

The nominal size of any inlet pipe shall not exceed the nominal size of the outlet pipe.

3.2.2 Construction

The pits are to be constructed of either:

- reinforced concrete
- bricks cement rendered or
- precast concrete



All inlet and outlet pipes entering or exiting a pit shall be cut flush with the inside wall of the

3.2.3 Covers

Surface inlet pits shall be furnished with a removable cover. Covers shall be constructed of galvanised steel, cast iron or other approved material that is capable of withstanding any load likely to be imposed on the cover. The cover shall be either perforated with holes of not less than 15mm diameter and spaced at 40mm centers, or be of an open bar grill design, or of another approved design.

3.3 SILT ARRESTOR PITS

3.3.1 Silt Arrestor Requirement

An approved silt arrestor shall be installed where a stormwater service receives the discharge of surface water or washwater from vehicle parking areas or subsoil drainage.

In the case of car wash bays, the silt arrestor shall also be designed to retain oil.

The arrestor shall be located within the property served, and shall be installed upstream of the discharge point (i.e. connection to kerb & gutter or Council pipeline etc.)

Wherever practicable, the area adjacent to a silt arrestor shall be graded so as to drain to the silt arrestor.

A silt arrestor may receive the discharge from an upstream pit or sump which has been installed to receive surface water only, provided that the silt arrestor is of sufficient capacity to receive the additional discharge.

Such upstream pit or sump shall conform to the surface inlet pit requirements

3.3.2 Design of Silt Arrestor Pits

The capacity of the silt arrestor shall be determined from the estimated peak discharge to the arrestor.

Rectangular silt arrestors shall be designed and dimensioned in accordance with the following table.

Nominal Size of inlet pipe (diameter mm)	Minimum nominal size of outlet pipe (diameter mm)	Minimum internal dimensions		
		Width (mm)	Depth from invert of outlet pipe to base of pit (mm)	Length (mm)
	100	600	300	600
150	150	600	300	1000
225	225	700	300	1000
300	300	800	300	1000
450	450	1000	300	1200
600	600	1000	300	1500



Notes:

Capacity is to be determined from peak discharge.

See Appendix 7.4 for details

The arrestor is to be constructed of concrete or other approved materials.

The invert of any inlet pipe shall be located at least 50mm above the nominal water level in the arrestor under normal flow conditions.

Depending on the nominal size of the outlet pipe, the invert of the outlet pipe shall be at a height of not less than 300mm above the internal surface of the base.

Except where otherwise permitted, silt arrestors shall be furnished with a removable cover. Covers shall be constructed of galvanised steel, cast iron or other approved material and be capable of withstanding any load likely to be imposed on the cover. The cover shall be either perforated with holes of not less than 15mm diameter and spaced at 40mm centres, or be of an open bar grill design, or an approved design.

Weepholes are to be provided at the base of silt arrestor pit. Weepholes to be either 4 x 20mm diameter holes or 1 x 40mm diameter hole. Pits deeper than 1200mm require step irons.

All inlet and outlet pipes entering or exiting a pit shall be cut flush with the inside wall of the pit.

3.4 OVERLAND FLOW PATHS

- i) Generally the development site catchment should be graded to the detention basin. If this is not possible the pipe system should be designed to convey the full design storm to the detention area.

Note: Where the downstream overland flow path from the site is directly through private property and the Site overland flow path does not grade to the detention area, the pipe system shall be designed to convey the 100 year ARI storm event.

- ii) Where a major overland flow path from the surrounding local catchment is through the development site, the detention storage should be located clear of this overland flow path.

Council may also require that the designer determine the extent of the overland flow path through the site, and that any proposed development be located outside of, and with free board to the flow path.

3.5 FLOW OF RUNOFF ACROSS BOUNDARIES

Runoff currently entering the site from upstream properties should not be redirected so as to increase the quantity or concentration of surface runoff entering adjoining properties.

3.6 CONTROL OF SEEPAGE

Where increased seepage is anticipated or becomes evident as a result of site or building works, and that this seepage is likely to have an adverse impact on adjoining properties, adequate subsoil cutoff drains are to be provided and connected to the piped drainage system.



4 DISPOSAL OF STORM WATER FROM THE SITE

4.1 INTRODUCTION

The majority of developments within the City will require on-site detention as part of their Development Consent. Where on-site detention is required, Council requires a detailed hydraulic analysis of the entire stormwater drainage system prepared by a practicing Civil Engineer. The design shall incorporate provision for on-site detention of stormwater to the satisfaction of the Director of Technical Services. The stormwater shall be disposed of in accordance with the approved plans. Under no circumstances is work to begin on the site until the hydraulic plans have been approved by Council.

4.2 DISPOSAL OF STORMWATER

Stormwater runoff is to be disposed of to the satisfaction of Council's Director of City Works.

The stormwater runoff is to be discharged to either kerb & gutter, street drainage, a pipe in an easement, a pipe in an inter-allotment drainage system, Sydney Water channel or river.

The stormwater runoff is to be disposed of by an in ground gravity system. **Elevated pipelines are not favoured although, pipelines contained within buildings or low level garden beds may be considered. Charged pipelines are not favoured. Excessive filling of a property to allow an in ground pipeline to drain to the street rather than obtaining an easement for the disposal of stormwater is not acceptable.** See Appendix 7.3 for methods which are satisfactory to drain various types of developments.

4.3 CONNECTION TO THE KERB AND GUTTER

Stormwater runoff may be discharged directly into the kerb and gutter at a point no greater than 15 metres downstream from the development site. The maximum allowable single point discharge to Council's kerb and gutter shall be limited to 55 litres per second or the Permissible Site Discharge (for OSD), whichever is the lesser. If more than one outlet is required these should be separated by a minimum of 500 mm, however; the maximum discharge shall remain the lesser of the two values PSD or 55 l/s.

Stormwater conduits laid in the footpath area should be sewer grade PVC or galvanised steel. These conduits will not be greater than 100 mm in height. The pipe or conduit is to discharge into the kerb and gutter at an angle of 45 degrees to the flow in the gutter.

4.4 CONNECTION TO THE STREET PIPED DRAINAGE SYSTEM

Stormwater Runoff may be discharged into Council's street piped drainage system. The connection is to be made into the top third of Council's pipe and at an angle of 45 degrees to the flow in the pipe. No pipe protrusion is allowed into Council's pipeline. Council is required to inspect the connection prior to the sealing of the joint. All work is to be carried out to the satisfaction of Council's Director of City Works.

4.5 PUMP OUTS

Pump out systems are not permissible unless the development satisfies certain criteria as described in Appendix 7.3. The criteria being that the maximum area draining to the pump system is 50m². The pump wetwell is to have the capacity for a one hour storm (i.e. 50 m will require a pit with 3000 liters capacity).

4.6 ELEVATED PIPED SYSTEMS

Elevated piped drainage systems are not permitted.

4.7 DISPOSAL VIA. EASEMENTS

With the consent of the property owner stormwater runoff may be discharged via a pipeline in

a drainage easement through private property. The hydraulic details submitted will not be approved until Council has sighted documentation indicating that the easement documents have been lodged with the Lands Titles Office for registration.

Without an approved drainage plan the building work is not to commence.

Where there is an existing easement, the hydraulic details will not be approved until Council has sighted documentation that the applicant has rights to drain to the existing easement.

Stormwater runoff may be discharged via a pipeline in a Council drainage easement.

Council's consent is required and the connection is to be to the satisfaction of Council's Director of City Works.

Stormwater runoff may be discharged via a pipeline in a Sydney Water drainage easement. The applicant is to satisfy the requirements of Sydney Water. The hydraulic details will not be approved until Council has sighted documentation that Sydney Water approves of the proposed connection into their pipeline.

4.8 CONNECTION TO COUNCIL'S INTER-ALLOTMENT DRAINAGE SYSTEM

Stormwater Runoff may be discharged into Council's inter-allotment drainage system. The connection is to be made into the top third of Council's pipe and at an angle of 45 degrees to the flow in the pipe. No pipe protrusion is allowed into Council's pipeline. Council is required to inspect the connection prior to the sealing of the joint. All work is to be carried out to the satisfaction of Council's Director of City Works.

4.9 CONNECTION TO SYDNEY WATER DRAINAGE SYSTEMS

Stormwater Runoff may be discharged into Sydney Water channel. The applicant will need to satisfy the requirements of Sydney Water. The hydraulic details will not be approved until

Council has sighted documentation that Sydney Water approves of the proposed connection into the channel.

4.10 DISPOSAL TO A NATURAL WATERCOURSE

Stormwater Runoff may be discharged into a river. Rivers within the city are under the control of both the Public Works and Sydney Water. The applicant will have to identify the responsible authority and satisfy the requirements of the authority. The hydraulic details will not be approved until Council has sighted documentation that the relevant authority approves of the proposed connection into the river.

4.11 ON SITE DISPOSAL

Absorption pits

Absorption pits are permissible only where the development satisfies certain criteria as described in Appendix 7.3.

An absorption test is to be carried out on the site, and these results are to be used to confirm that the absorption system can discharge the design Storm.

5 ON-SITE DETENTION

5.1 DESIGN OBJECTIVES

Sufficient storage shall be provided to ensure that peak flowrates from the site are not increased to the downstream stormwater system in the design storm. To achieve this, a maximum permitted site discharge (PSD) is specified for all development within the Canterbury City Council area.

5.2 WHEN TO PROVIDE

On site stormwater detention is to be provided for all proposed developments with the exception of some residential development. See Appendix 7.3 for details.

5.3 PERMISSIBLE SITE DISCHARGE

The Permissible Site Discharge (PSD) shall be limited to 150 liters per second per hectare.

Calculations shall be submitted detailing the calculated site discharge with particular consideration being given to the pressure head effect on the outlet pipe.

5.4 SITE STORAGE REQUIREMENTS

A stage-storage model is the preferred method of calculating the required storage volume. Other methods of determining the volume may be used.

Methods which assume a constant discharge such as the Mass Curve Analysis require a factor to be applied to the constant discharge to determine the detention volume. The adjustment factor for above-ground storage is 0.75 and 0.6 for below-ground storages.

A minimum of 75% of the entire site area must drain through the storage area.. All roofed areas and as much of the paved areas as possible are to drain through the detention system.

The design shall incorporate provision for on-site storage resulting from a storm with an ARI of:

- 10 years where overland flow paths are not through private property. A weir shall be designed to direct the 100 year discharge to the street drainage system; and
- 100 years where overland paths are through private property and / or known flooding problems occur.

5.5 BASIN DESIGN CONSIDERATIONS

Storage area may be either above ground or below ground.

- The maximum ponding depths for above ground storage are:
- 150mm in car parking/driveway areas
- 300mm in landscape areas without a fence
- 1000mm in landscape areas with a pool type fence
- The minimum grade on storage areas are:
- 0.5% in car parks or paved areas
- 2% in landscape areas

The minimum free board required above the top of water level in the storage is:

- 300mm for a habitable room
- 100mm for a garage

An overland flow path is to be provided from the storage area for the 1 % storm.



5.6 RESTRICTION INSTRUMENT

In conjunction with the on-site detention system, Council requires an appropriate instrument being registered on the title of the property, concerning the presence and on-going operation of the on-site detention system. A document for the guidance of applicants or their advisers, setting out the terms required by Council in respect of the instrument to be registered is shown in Appendix 7.5.



6 SUBMISSION REQUIREMENTS

6.1 INTRODUCTION

The majority of developments within the City will require on-site detention as part of their Development Consent. Where on-site detention is required, Council requires a detailed hydraulic analysis of the entire stormwater drainage system to be prepared by a practising Civil Engineer. The design shall incorporate provision for on-site detention of stormwater to the satisfaction of the Director of City Works. Four copies of plans and calculations of the design shall be submitted and approved before the release of the Building Plans. The stormwater shall be disposed of in accordance with the approved plans. In no circumstances is work to begin on the site until the hydraulic plans have been approved by Council.

6.2 REQUIREMENTS FOR DEVELOPMENT APPLICATIONS

6.2.1 Objectives

In considering a Development Application, Council is seeking a demonstration that the issues relating to stormwater disposal have been addressed in the proposal. To satisfy this requirement a Drainage Concept Plan may be required to be submitted with the Development Application. Council's City Works Division should be contacted to determine whether a Drainage Concept Plan will be required.

6.2.2 Why a Drainage Concept Plan?

The requirement of a Drainage Concept Plan encourages the developer and architect to involve the drainage engineer in the site layout and initial design concepts. Experience has shown that trying to retro-fit Council's drainage requirements, especially the On-Site Detention requirements, on top of established site layout can lead to significant problems. This material is in the form of complicated and expensive drainage designs, sudden increases in project costs and delays in the approval process.

The processes involved in preparing a Drainage Concept Plan will address these problems. It will identify design conflicts at an early stage and through intelligent use of driveways; parking areas and landscaping can actually reduce project costs. This will enable the developer to more accurately determine the total cost of the project. Additionally, the detailed design process required at BA stage will be simplified and there will be less likelihood of delays in the release of Building Plans.

6.2.3 What is required in a Drainage Concept Plan?

The purpose of the Drainage Concept Plan is not to provide a detailed design but to demonstrate that the proposed drainage treatment is achievable. To show this the Drainage Concept Plan should include the following:

- A drainage concept plan to a scale of 1: 100 showing:
- Site layout, dimensions and proposed finished floor levels;
- Existing and proposed design contours at 0.1 m intervals;
- Any overland flow paths through the site;
- The discharge points into Councils (or other authorities) drainage system;
- The location and approximate finished levels of drainage pits;
- The configuration of the proposed pipe network;
- The location and extent of all on-site detention storage.
- A cross-section through each basin with approximate levels
- Sediment control details are to be in accordance with the SMM (Stormwater Management Manual) Specifications S1 through to S9;



Information accompanying the drainage concept plan:

- Approximate storage volume for the on-site detention system;
- Total site area (m²);
- Contributing pervious catchment areas (m²);
- Contributing impervious catchment areas (m²).
- A letter of intent to grant an easement from downstream property owners if inter-allotment easements are required through downstream properties.
- A letter granting permission to discharge stormwater runoff into another authority's drainage system. This would include SRA, RTA and Sydney Water channels and various rivers and creeks. The letter should detail any conditions of the approval.

6.3 CROWN DEVELOPMENTS

Where a development is proposed by the Crown (Department of Education, Department of Health, Department of Public Works, Department of Housing and so on) a Building Application is not required. Accordingly, more detail of the proposed drainage scheme is required at the time of the Development Application.

A detailed design of the stormwater drainage system is required. The design, calculations and other documentation shall encompass all the requirements of designs normally submitted with Development and Building Applications (as detailed in this manual). A condition of development consent will require the construction of the stormwater drainage system in accordance with approved drainage design plans (as amended).

Prior to occupation of the development the crown will submit evidence of the compliance of this condition of Development Consent and the registration of documents with the Land Titles Office protecting the On-Site Detention System.

6.4 REQUIREMENTS FOR BUILDING PPLICATIONS

6.4.1 Objective

Detailed design calculations and plans are required to be submitted with the Building Application. Three copies of all of the drainage plans and one copy of the design calculations and any relevant computer data files (on 3 1/2 inch floppy disk) are to be provided. The design is to be carried out by a suitably qualified and experienced Civil Engineer.

Council is seeking a drainage design that complies with the requirements and the intent of this document and the specific requirements of conditions of Development Consent. For this purpose the plans and design calculations submitted must:

- provide full and independent verification of the design proposed;
- be of sufficient quality to enable construction of the drainage system;
- be accompanied with certification by the Engineer.

The design should follow the Drainage Concept Plan approved in conjunction with the Development Application. Any site specific problems should have been addressed in the Drainage Concept Plan and accordingly the detailed design process required here should be greatly simplified. A satisfactory design will be stamped as approved (subject to any amendments required) and released with the building plans.

Warning: the Construction Certificate plans will not be released by Council until the drainage plans have been approved and stamped.



6.4.2 Crown Developments

Where a development is proposed by the Crown (Department of Education, Department of Health, Department of Public Works, Department of Housing and so on) a Building Application is not required. Accordingly, the requirements of this section should be addressed at the time of the Development Application.

6.4.3 Certification

The designing engineer shall certify that the design and supporting calculations comply with the requirements of this manual and any relevant conditions of Development Consent.

The certification will be on letterhead and include the Engineers full name, qualifications and registration number with the Institution of Engineers, Australia. Contact details including address, telephone and fax numbers will also be provided.

6.4.4 Variations

During the construction of the development there may be a need to amend an approved drainage design. If this is the case then contact should be made with Councils City Works Division before any changes are made. It is recommended that this contact be made by the developer's Civil Engineer. Based on the extent and implications of the amendment the Engineer will either be:

- advised on the spot as to the acceptance or refusal of the amendment; or
- requested to submit amended plans and calculations for approval.

6.5 STORMWATER DRAINAGE PLANS

The plans shall be neatly and accurately drawn and shall clearly indicate the proposed layout of the work including the position of any subsoil drains to be connected.

The plan shall include a block plan of the property drawn to a scale of 1: 100 showing the stormwater service. Reduced scale plots of plans (i.e. A1 size reduced to A3) maybe acceptable where the plans are produced by CAD and are legible at that scale.

The plans shall clearly indicate the following:

- Nominal size and grade of the stormwater service,
- Type of material to be used in work of stormwater drainage,
- Location of proposed inspection chambers, boundary traps and reflux valves or other pits or sumps, any polluted areas to be drained,
- Reduced levels or reference levels of any stormwater drains or stormwater channels and of the lowest silt arrestor to be drained. Australian Height Datum (AHD) should be the datum for these reduced levels,
- Details of any proposed subsoil drainage and associated pits or sumps.
- A detailed sketch of the proposed arrestor shall also be submitted.

6.6 WORKS AS EXECUTED PLANS & FINAL CERTIFICATION

The applicant shall provide Council with a Works as Executed plan detailing all the drainage and the on-site detention system. The plan shall be prepared by a registered surveyor or an engineer and include all relevant levels. A final certification shall be provided by the applicants engineer stating that the site drainage is satisfactory and was constructed in accordance with the approved drainage plans.



6.7 CREATION OF EASEMENTS

Where the creation of an inter-allotment drainage easement is required, a letter of agreement from the affected property owner(s) shall accompany the development application to demonstrate to Council that a suitable easement can be obtained. The subsequent Building Approval will not be released until the easement has been prepared by a registered surveyor and has been lodged with the Land Titles Office for registration. Finalisation of the Building Approval will not occur until evidence is received that the easement has been registered.



7 APPENDICES

APPENDIX 7.1	Intensity - Frequency - Duration Table
APPENDIX 7.2	Runoff Coefficients for Canterbury City Council
APPENDIX 7.3	Drainage Requirements Checklist for proposed development
APPENDIX 7.4	Standard Flow control Pit Detail
APPENDIX 7.5	Restriction Instrument
APPENDIX 7.6	Drainage Design Checklist
APPENDIX 7.7	Drainage Requirements for New Dual Occupancy
APPENDIX 7.8	Drainage Requirements for New Single Dwellings and Additions

APPENDIX 7.1

Rainfall Intensities

CANTERBURY CITY COUNCIL

Rainfall Intensity (mm/h) for Canterbury City Council

Duration (Minutes)	Average Storm Recurrence Interval (years)						
	1	2	5	10	20	50	100
5	94	120	155	173	199	233	258
6	88	113	146	163	188	219	243
7	83	107	138	155	178	208	231
8	79	101	131	147	169	198	220
9	75	97	125	141	162	190	211
10	72	93	120	135	156	183	203
11	69	89	116	130	150	175	196
12	67	86	112	126	145	170	189
13	64	83	108	121	140	165	183
14	62	80	104	118	136	160	178
15	60	78	101	114	132	155	173
16	58	75	98	111	128	151	168
17	57	73	96	108	125	147	164
18	55	71	93	105	122	143	160
20	52	68	89	100	116	137	152
25	46.9	61	80	90	105	123	138
30	42.7	55	73	83	96	113	127
35	39.3	51	67	76	89	105	117
40	36.6	47.5	61	71	83	98	110
45	34.3	44.5	59	67	78	92	104
50	32.3	42.0	56	63	74	88	98
55	30.6	39.8	53	60	70	83	94
60	29.1	37.9	50	57	67	80	89
45	36.6	47.5	61	71	83	98	78
90	22.7	29.5	39.2	44.7	52	62	69
2 hours	19.0	24.6	32.7	37.2	43.2	51	57
3 hours	14.7	19.0	25.2	28.6	33.2	39.3	44.0
4 hours	12.2	15.8	20.9	23.7	27.5	32.6	36.4
5 hours	10.6	13.7	18.1	20.5	23.8	28.2	31.5
6 hours	9.43	12.2	16.1	18.2	21.2	25.0	27.9



8 hours	7.88	10.2	13.4	15.1	17.6	20.7	23.1
10 hours	6.83	8.84	11.6	13.1	15.2	17.9	20.0
12 hours	6.08	7.87	10.3	11.7	13.5	15.9	17.7
14 hours	5.54	7.16	9.39	10.6	12.3	14.5	16.2
16 hours	5.1	6.60	8.65	9.78	11.3	13.3	14.9
18 hours	4.75	6.14	8.05	9.10	10.5	12.4	13.9
20 hours	4.45	5.75	7.54	9.53	9.87	11.6	13.0
22 hours	4.19	5.42	7.11	8.04	9.30	11.0	12.2
24 hours	3.97	5.14	6.74	7.61	8.81	10.4	11.6
36 hours	3.07	3.97	5.20	5.88	6.81	8.03	8.96
48 hours	2.53	3.27	4.29	4.86	5.62	6.63	7.40
60 hours	2.16	2.80	3.67	4.15	4.81	5.67	6.33
72 hours	1.89	2.45	3.21	3.63	4.21	4.96	5.54

Polynomial Coefficients for Canterbury City Council.

The following table has been obtained from the Bureau of Meteorology, reference FiV299O, dated 2nd May 1989 and refers to the following location **33.925 South, 151,100 East** (near Campsie).

List of Coefficients to equations of the form:

$$\ln(I) = a + b * (\ln(T)) + c*(\ln(T))^{**2} + d*(\ln(T))^{**3} + e*(\ln(T))^{**4} + f*(\ln(T))^{**5} + g*(\ln(T))^{**6}$$

I = Intensity in millimetres per hour

T = Time in hours

ARI (years)	a	b	c	d	e	f	g
1	3.3659	-0.5895	-0.0368	0.00768	0.001088	- 0.0002073	- 0.0000324
2	3.6278	-0.5874	-0.0393	0.00747	0.001347	- 0.0001911	- 0.0000417
5	3.9054	-0.5829	-0.0462	0.00787	0.001891	- 0.0002783	- 0.0000406
10	4.0403	-0.5802	-0.0504	0.0078	0.002316	- 0.0002836	- 0.0000526
20	4.1919	-0.5788	-0.0533	0.00821	0.002514	- 0.0003451	- -0.000047
50	4.3626	-0.5761	-0.0568	0.00802	0.002846	- 0.0003344	- 0.0000579
100	4.4766	-0.5749	-0.0592	0.00823	0.003037	- 0.0003675	- 0.0000579

* Please note; that the data provided is derived automatically by computer using the nearest grid point to the latitude and longitude of the location, not the location name. Therefore; because of possible mistake in specifying the latitude and longitude by the user or in transference to the Bureau computer, it is essential that you check that the location you require (to the nearest 0.025 degrees) corresponds to the latitude and longitude on the curves and tabulated data supplied. If there are any discrepancies, please contact the Bureau of Meteorology, Hydrology Branch, Melbourne.



Alternative Rainfall Site Data

The following nine parameters can be applied in the methods provided in Chapter 2 of Australian Rainfall and Runoff (1987).

2 year I 1 hr : 37.89 I 12 hr : 7.87 I 72 hr : 2.45

50 year I 1 hr : 79.68 I 12 hr : 15.90 I 72 hr : 4.96

Skewness Factor G : 0.00

Short Duration Factors: F2 : 4.29 F50 : 15.85



**APPENDIX 7.2
RUNOFF COEFFICIENTS FOR CANTERBURY CITY COUNCIL**

(from A.R.&R. Figure 14.13)

ARI (years)	Fraction Impervious										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
1	0.41	0.44	0.47	0.50	0.53	0.57	0.60	0.63	0.66	0.69	0.72
2	0.44	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77
5	0.49	0.52	0.56	0.60	0.61	0.67	0.71	0.74	0.78	0.82	0.86
10	0.51	0.55	0.59	0.63	0.67	0.71	0.75	0.78	0.82	0.86	0.90
20	0.54	0.58	0.62	0.66	0.70	0.74	0.78	0.82	0.86	0.90	0.95
50	0.59	0.63	0.68	0.72	0.77	0.81	0.86	0.90	0.95	0.99	1.04
100	0.62	0.66	0.71	0.76	0.80	0.85	0.89	0.94	0.99	1.03	1.08

Note: A minimum runoff coefficient of 0.7 should be adopted for design purposes.

APPENDIX 7.3

Drainage Requirement Checklist for proposed developments in Canterbury City

type of development	property falls to	OSD required	charged line	absorption pit	pump system	Comments
single dwelling	street	Yes ⁽¹⁾	NO	NO	NO	⁽¹⁾ OSD must be provided if the post-developed impervious area is greater than or equal to 70% of the site area
single dwelling	rear	Yes ⁽¹⁾	NO	NO	NO ⁽²⁾	⁽²⁾ drain site by a gravity pipe system using stormwater easement via downstream property, pump system may be considered where easement is rejected AND all supporting (documents *) are provided accordingly
single dwelling (add & alt)	street/rear	Yes ^{(1),(A)}	NO ⁽³⁾	NO ⁽³⁾	NO ⁽²⁾	⁽³⁾ small areas up to 25m ² may drain to an absorption pit or use charged line (i.e. garage & shed) ^(A) proposed development that does not increase existing impervious area shall be connected to existing drainage system to discharge into the receiving system via a silt arrestor pit, however ; OSD must be provided where the exiting impervious area is equal to 70% or more and the proposed is more than 5% of the site area
dual occupancy	street	Yes ⁽¹⁾	NO	NO	NO	⁽¹⁾ OSD must be provided if the post-developed impervious area is greater than or equal to 70% of the site area
dual occupancy	rear	Yes ⁽¹⁾	NO	NO	NO ⁽²⁾	⁽²⁾ drain site by a gravity pipe system using stormwater easement via downstream property, pump system may be considered where easement is rejected AND all supporting (documents *) are provided accordingly
townhouse/villa	street	Yes	NO	NO	NO	drain site to the street by a gravity pipe system
townhouse/villa	rear ^(B)	Yes	NO	NO	NO	^(B) gravity pipe system using a stormwater easement via downstream property is the only method accepted
RFB	street	Yes	NO	NO	NO ⁽⁴⁾	⁽⁴⁾ basement driveway with maximum area of 50m ² can drain into a pump system, pump wetwell to have a capacity for 1 hour storm (i.e. 50m ² will require a pit with 3000 litres capacity)
RFB	rear ^(B)	Yes	NO	NO	NO	⁽⁴⁾ basement driveway with maximum area of 50m ² can drain into a pump system, pump wetwell to have a capacity for 1 hour storm (i.e. 50m ² will require a pit with 3000 litres capacity) ^(B) gravity pipe system using a stormwater easement via downstream property is the only method accepted
commercial	street	Yes	NO	NO	NO	⁽⁴⁾ basement driveway with maximum area of 50m ² can drain into a pump system, pump wetwell to have a capacity for 1 hour storm (i.e. 50m ² will require a pit with 3000 litres capacity)
commercial	rear ^(B)	Yes	NO	NO	NO	⁽⁴⁾ basement driveway with maximum area of 50m ² can drain into a pump system, pump wetwell to have a capacity for 1 hour storm (i.e. 50m ² will require a pit with 3000 litres capacity) ^(B) gravity pipe system using a stormwater easement via downstream property is the only method accepted

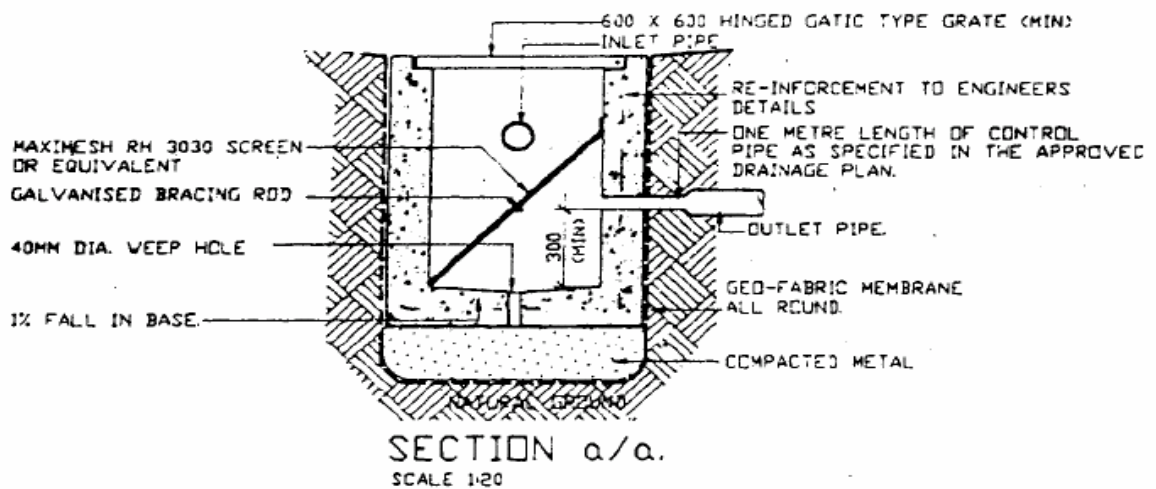
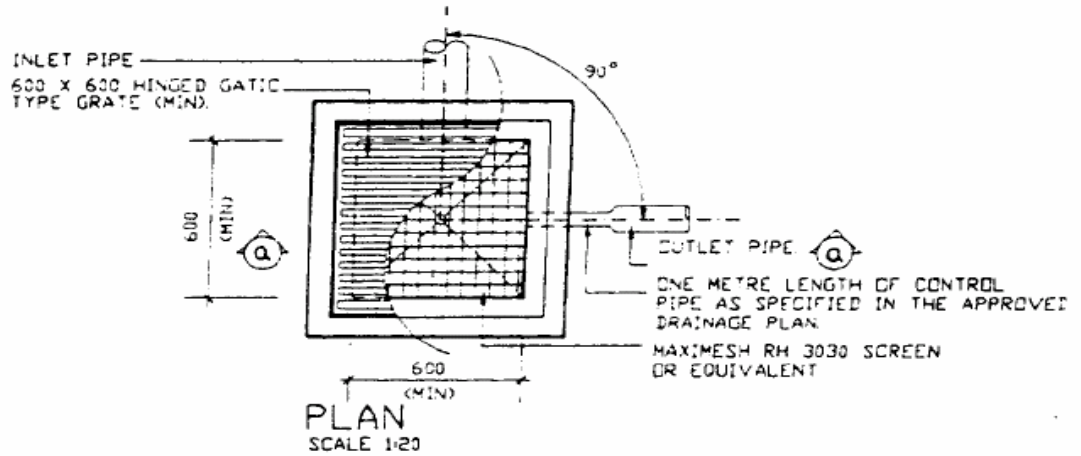
Table 1.1 – Note: impervious area includes all buildings and paved areas (roof, driveway, carparking space and swimming pool)

* Supporting documents include the following:

- A land valuation prepared by a registered land valuer to estimate the value of the easement only (excluding construction/installation cost)
- A signed letter of request from the applicant to all possible downstream properties requesting their permission to create a stormwater easement through their property, the amount estimated in the valuation report must be disclosed in the letter as an offer of compensation, and that all relevant expenses to construct and reinstate any disturbed areas is at the cost of the applicant
- A signed letter of correspondence from the downstream property owner(s)



APPENDIX 7.4



SILT ARRESTOR PIT DETAILS

NOTES:

GENERAL

1. PITS TO BE CONSTRUCTED IN THE FOLLOWING MANNER
 - 1.1 PRECAST
 - 1.2 BRICKS WITH CEMENT RENDER
2. OUTLET PIPES TO BE PLACED AT 90 DEGREES TO THE INLET PIPELINE (AS SHOWN IN THE PLAN)
3. INLET TO BE ABOVE THE SCREEN AND THE OUTLET TO BE BELOW THE SCREEN
4. ALL WORK TO BE TO THE SATISFACTION OF THE DIRECTOR OF TECHNICAL SERVICES
5. DRIFICE PLATES ARE NOT TO BE USED
6. FOR CONNECTION TO COUNCIL'S DRAINAGE SYSTEM
 - 6.1 CONNECTION TO BE MADE INTO TOP ONE THIRD OF COUNCIL'S PIPE AT 45 DEGREES TO FLOW
 - 6.2 ON PIPE PROTRUSION ALLOWED INTO COUNCIL'S PIPELINE
 - 6.3 INSPECTION TO BE MADE BY COUNCIL'S ENGINEER PRIOR TO THE SEALING OF THE JOINT

APPENDIX 7.5

INSTRUMENT SETTING OUT TERMS OF EASEMENTS AND RESTRICTIONS AS TO USER INTENDED TO BE CREATED PURSUANT TO SECTION 88B OF THE CONVEYANCING ACT 1919.

Lengths are in metres

(Sheet 1 of 3 sheets)

Plan:

Subdivision covered by Council Clerk's Certificate No.

Full name and address of proprietors of the land

Paul Citizen and Sharon Citizen
13 Cross Street City

PART 1

Identity of Restriction As To User, firstly referred to in the above mentioned plan.

Schedule of Lots Affected

Lot/s Burdened

Lot/s, name of Authority Benefited

Lot x

Canterbury City Council

Identity of Positive Covenant, Easement secondly referred to in the above mentioned plan.

Schedule of Lots Affected

Lot/s Burdened

Lot/s, name of Authority Benefited

Lot x

Canterbury City Council

PART 2

1. Terms of Restriction on Use firstly referred to in the above mentioned plan.

No (dwelling/future development/increase in hard paved area) shall be undertaken on the lots hereby burdened unless the proprietor has first constructed or has made provision for construction of an on-site stormwater detention system (which expression shall include all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily drain stormwater) (hereinafter called "**the system**"). The design, construction and/or provision of the system shall be to the requirements and satisfaction of Canterbury City Council.

2. Terms of Public Positive covenant (firstly/secondly/thirdly/fourthly) referred to in the above mentioned plan.

(i) The proprietors of the lots burdened will in respect to the systems described in the restriction on use referred to in this instrument:

(a) permit stormwater runoff to be temporarily detained by the system;

(b) keep the system clean and free from all silt, rubbish and debris;



- (c) maintain and repair the system so that it functions in a safe and efficient manner;
 - (d) replace, maintain, repair, alter, and renew the whole or parts of the system within the time and in the manner specified in a written notice issued by the Council;
 - (e) carry out the matters referred to in paragraphs (b), (c) and (d) above at the proprietor's expense;
 - (f) not make any alterations to the system or elements thereof without prior consent in writing of the Council;
 - (g) permit the Council or its authorised agents from time to time upon giving reasonable notice (but at any time and without notice in the case of an emergency) to enter and inspect the land for compliance with the requirements of the covenants set forth herein.
- (ii) In the event of the registered proprietor failing to comply with the terms of any written notice served in respect of the matters in clause (i) above, the Council or its authorised agents may enter with all necessary equipment and carry out any work required by such notice to ensure the safe and efficient operation of the system and recover from the registered proprietor the cost of carrying out such work, and if necessary, recover the amount due by legal proceedings (including legal costs and fees) and enter a covenant charge on the lot burdened under section 88F of the Conveyancing Act 1919. In carrying out any work under this clause, the Council shall take responsible precautions to ensure that the land is disturbed as little as possible.
 - (iii) Comply with the terms of any written notice issued by Council in respect to the requirements of the covenants set forth herein, within the time stated in the notice.

In these covenants "Council" means Canterbury City Council.

Name of person or authority whose consent is required to release, vary or modify the Restriction as to User and Positive Covenant referred to in the above mentioned plan.

The Council of the City of Canterbury

Signed in my presence by the said
Paul Smith

Signature of Witness

Signed in my presence by the said
Sharon Smith

Signature of Witness



APPENDIX 7.6 DRAINAGE DESIGN CHECKLIST

(An answer of “No” anywhere on this sheet indicates the design maybe unsatisfactory and is likely to be rejected)

GENERAL DRAFTING REQUIREMENTS	Yes	No
Is the plan drawn legibly	<input type="checkbox"/>	<input type="checkbox"/>
Is the north point given	<input type="checkbox"/>	<input type="checkbox"/>
Are street and site details accurate	<input type="checkbox"/>	<input type="checkbox"/>
Are site and road levels to AHD	<input type="checkbox"/>	<input type="checkbox"/>

DRAINAGE REQUIREMENTS

Are pipes shown, sized and grades specified	<input type="checkbox"/>	<input type="checkbox"/>
Are all pit sizes, surface and invert levels shown	<input type="checkbox"/>	<input type="checkbox"/>
Are overland flow paths shown / Provision of weir	<input type="checkbox"/>	<input type="checkbox"/>
Has the point of discharge been accurately shown	<input type="checkbox"/>	<input type="checkbox"/>
Is the point of discharge less than 15 meters from the property boundary	<input type="checkbox"/>	<input type="checkbox"/>
Is a detailed sketch of the silt arrestor and screen given.	<input type="checkbox"/>	<input type="checkbox"/>
Does the drainage prevent increased runoff to downstream properties	<input type="checkbox"/>	<input type="checkbox"/>
Are all stormwater pipes at a minimum grade of 1%	<input type="checkbox"/>	<input type="checkbox"/>
Are contours shown	<input type="checkbox"/>	<input type="checkbox"/>

ON SITE DETENTION REQUIREMENTS

Was OSD a condition of Development Approval (If OSD was not a Development Condition then the remainder of this section may be omitted)	<input type="checkbox"/>	<input type="checkbox"/>
Is there OSD designed on this plan	<input type="checkbox"/>	<input type="checkbox"/>
Are finished floor levels shown	<input type="checkbox"/>	<input type="checkbox"/>
Has the permitted site discharge been limited to 150 litres per second per hectare	<input type="checkbox"/>	<input type="checkbox"/>
Has consideration been given to variable discharge	<input type="checkbox"/>	<input type="checkbox"/>
Has detention been achieved using a one meter pipe	<input type="checkbox"/>	<input type="checkbox"/>
Are detention basins clearly defined	<input type="checkbox"/>	<input type="checkbox"/>
Are all pit surface levels outside the OSD higher than the top water level (ie no surcharge)	<input type="checkbox"/>	<input type="checkbox"/>
Do all impervious areas drain through the detention basin	<input type="checkbox"/>	<input type="checkbox"/>
Does a minimum of 75% of the site drain through the detention basin	<input type="checkbox"/>	<input type="checkbox"/>
Are minimum grades in OSD 2% for landscaped areas and 0.5% for paved areas.	<input type="checkbox"/>	<input type="checkbox"/>
Is there sufficient freeboard for garages and habitable rooms above the top water level.	<input type="checkbox"/>	<input type="checkbox"/>
Has provision been made to facilitate the cleaning of the detention basin	<input type="checkbox"/>	<input type="checkbox"/>
Have detention basin cross section been submitted	<input type="checkbox"/>	<input type="checkbox"/>

WHERE APPROPRIATE HAS THE FOLLOWING INFORMATION BEEN GIVEN

Proof that the easement documents have been lodged with Land Titles Office for registration	<input type="checkbox"/>	<input type="checkbox"/>
Absorption test results.	<input type="checkbox"/>	<input type="checkbox"/>
Approval from other authorities to connect into their drainage system	<input type="checkbox"/>	<input type="checkbox"/>
Overland drainage flow paths through the property identified	<input type="checkbox"/>	<input type="checkbox"/>



APPENDIX 7.7 Drainage requirements for New Dual Occupancy₂

- New Dual Occupancies that fall to the street, with an impervious area less than 70% of total site area.**
 Drain to the kerb & gutter or directly to the council stormwater system (such as a pit or pipe in the road). All stormwater runoff must be collected and discharged through a silt arrester pit prior to leaving the site.
- New Dual Occupancies that fall to the street, with an impervious area greater than or equal to 70% of total site area.**
 Drain to the kerb & gutter or directly to the council stormwater system (such as a pit or pipe in the road) through an on site detention system OSD in accordance with Section 5 in Specification 9 of Council's Stormwater Management Manual- " A Guide to Stormwater Drainage Design
- All Dual Occupancies that fall to rear.**
 The above 70% principle is applicable. OSD is required if post-development impervious area is greater than or equal to 70% of the site area.

Applicants are to make genuine attempts to negotiate an easement over all possible downstream properties to drain the site. In this regard, a 'genuine' attempt must include a monetary offer of compensation.

A letter signed by the downstream owners, which includes details of monetary offers of compensation being made, either accepting or rejecting the offer must be submitted with the application.

In the event that the applicant cannot obtain an easement, and all possible drainage solutions have been exhausted, Council at its discretion can approve a pump-out system, which includes the following requirements;

- Dual pumps being provided.
- Pump-out rate being limited to 150 L/s/ha.
- Storage being provided for the 1:100 year ARI rainfall event.
- The pit, immediately upstream of the pump system must be a silt arrester pit.
- It must be demonstrated through a consulting civil engineer, that in the event of a pump system failing, there is a 'safe' route for overland flow from the site to be conveyed around downstream properties. In the event that a 'safe' overland flow path cannot be established, a drainage easement will have to be negotiated over downstream properties to drain the site.

Table 1 indicates the storage volumes required for properties that fall into the category of requiring pump-out system/on site detention.

Site Area (m ²)	% impervious					
	100%	90%	80%	70%	60%	50%
500	22.0	20.0	18.5	16.5	15.0	13.5
600	26.0	24.0	22.0	20.0	18.0	16.0
700	31.0	28.0	26.0	23.0	21.0	19.0
800	35.0	32.0	29.5	26.5	23.5	21.5
900	40.0	36.0	33.0	30.0	27.0	24.3
1000	44.0	40.0	37.0	33.0	30.0	27.0

Table 1: Pump-out pit/On Site Detention volumes required (m²)



APPENDIX 7.8 Drainage requirements for New Single Dwellings (including additions).

- New Single Dwellings (including additions) that fall to the street, with an impervious area less than 70% of total site area.**
 Drain to the kerb & gutter or directly to the council stormwater system (such as a pit or pipe in the road). All stormwater runoff must be collected and discharged through a silt arrester pit prior to leaving the site.
- New Single Dwellings (including additions) that fall to the street, with an impervious area greater than or equal to 70% of total site area.**
 Drain to the kerb & gutter or directly to the council stormwater system (such as a pit or pipe in the road) through an on site detention system OSD in accordance with Section 5 of this Manual.
- All new Single Dwellings (including additions) that fall to rear.**
 The above 70% principle is applicable. OSD is required if post-development impervious area is greater than or equal to 70% of the site area.

Applicants are to make genuine attempts to negotiate an easement over all possible downstream properties to drain the site. In this regard, a 'genuine' attempt must include a monetary offer of compensation.

A letter signed by the downstream owners, which includes details of monetary offers of compensation being made, either accepting or rejecting the offer must be submitted with the application.

In the event that the applicant cannot obtain an easement, and all possible drainage solutions have been exhausted, Council at its discretion can approve a pump-out system, which includes the following requirements;

- Dual pumps being provided.
- Pump-out rate being limited to 150 L/s/ha.
- Storage being provided for the 1:100 year ARI rainfall event.
- The pit, immediately upstream of the pump system must be a silt arrester pit.
- It must be demonstrated through a consulting civil engineer, that in the event of a pump system failing, there is a 'safe' route for overland flow from the site to be conveyed around downstream properties. In the event that a 'safe' overland flow path cannot be established, a drainage easement will have to be negotiated over downstream properties to drain the site.

Table 1 indicates the storage volumes required for properties that fall into the category of requiring pump-out system/on site detention.

Site Area (m ²)	% impervious					
	100 %	90 %	80 %	70 %	60 %	50 %
500	22.0	20.0	18.5	16.5	15.0	13.5
600	26.0	24.0	22.0	20.0	18.0	16.0
700	31.0	28.0	26.0	23.0	21.0	19.0
800	35.0	32.0	29.5	26.5	23.5	21.5
900	40.0	36.0	33.0	30.0	27.0	24.3
1000	44.0	40.0	37.0	33.0	30.0	27.0

Table 1: Pump-out pit/On Site Detention volumes required (m³)

