

Site Ref

59-61 West St, Havant

Catchment

Hypothetical greenfield

Preliminary rainfall runoff management for developments-EA R&D W5-074/A/TR/1 rev E**Introduction**

The methodology in this document advises the requirements for setting stormwater discharge limits and initial sizing of storage elements for the control and treatment of stormwater runoff.

Basic key explanations and definitions are given below and reference should be made to the source documents for more detailed explanation.

It should be noted that setting discharge limits as required by this document (5mm interception, Q_1 & Q_{100} control rates) will not result in the runoff from a site replicating the undeveloped state.

An accurate assessment of greenfield runoff is therefore not fundamental to the flood protection of catchments.

It should also be noted that the calculation methodology is only to be applied for initial planning and design stages. Detailed computer models would normally be expected to be used for detailed design.

Runoff from greenfield sites differs in character to development runoff:

Volume	no runoff for small events, less runoff for large events
Runoff rate	slower later runoff for all events
Water quality	cleaner runoff (BOD, sediment, pathogens, metals, hydrocarbons)

The derived storage criteria address these three aspects and provide control to urban runoff that mimics, as practicably as possible, the greenfield behaviour of the site.

Interception Storage:

Around 50% of rainfall events are less than 5mm and generally cause no measurable runoff from greenfield areas to receiving waters. In contrast traditional development runoff takes place virtually every rainfall event and "flushes" polluted runoff into receiving waters. The concept of interception storage is to prevent runoff for rainfall depths up to 5mm. This is typically achieved by infiltration but certain SUDS features such as swales and pervious pavements can provide runoff characteristics that reflect this behaviour.

Long Term Storage:

In extreme rainfall events, the total volume of runoff from a developed site is typically 2-10 times the runoff volume from the same site in a greenfield condition. Without control, a large proportion of the runoff would tend to be released more quickly than greenfield runoff and secondly even if this volume was released at the peak rate of greenfield runoff, then flood depth and flood extents on the floodplain would be greater. In theory, therefore, the 100 year runoff from a site should be controlled to greenfield volume and rates. In practice this is virtually impossible to achieve. The calculation criterion used estimates the difference in runoff between greenfield and developed states for $M100_{6hr}$ runoff. In principle it would be preferable to control this volume by infiltrating this volume difference. Often this is not feasible because as many as 80% or more developments do not have the opportunity to use infiltration methods. If infiltration is not possible then a maximum discharge rate of 2 l/s/Ha shall be used AND the runoff from attenuation storage needs to be reduced to the same amount.

Attenuation Storage:

Whatever the event, development runoff through traditional pipe networks, if allowed unchecked, will discharge into receiving waters at orders of magnitude faster than the undeveloped site. For significant rainfall events this causes flashy flow in the river which is likely to cause scour

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and erosion that may seriously affect the morphology and ecology of the stream, and for extreme events this may exacerbate flooding downstream. Both of these aspects are therefore addressed by applying a limit of discharge from the developed site, thus requiring attenuation storage. The design principle is to limit runoff from events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from greenfield sites. In practice the rate for any given event will not exactly replicate the same rate of runoff, due to the difference in runoff characteristics. **To achieve an exact replication would be impossible and attempting to get a relatively good approximation would require advanced modelling and considerable effort. There is little justification for such an approach as the actual runoff from greenfield sites cannot be sufficiently accurately predicted.** The equivalence rule is therefore applied at both the 1 year event and the 100 year event using the critical duration storm to find the maximum attenuation storage volume.

In practice there are two conditions where the greenfield flow rate is not actually applied to define the limiting discharge rates:

- 1a) For permeable sites where Q_{BAR} is less than 1 l/s/Ha very large storage volumes would be generated which is unreasonable. For these sites Q_{BAR} is then set at 1 l/s/Ha.
- 2) Small sites would require impractically small controls where for levels below 5 l/s and therefore an absolute minimum of 5 l/s is used.

Non-compliance with providing volume control of runoff:

There are situations where providing the concept of LTS to a site and ensuring the drainage system operates to meet this criteria is difficult. In this situation an alternative peak rate of discharge is applied to the site for sizing the attenuation storage in the absence of separate LTS. Instead of using the rates for the 1 year and 100 year events, the discharge limits are set to the Q_1 and Q_{BAR} flow rates for sizing the storage. This results in a greater storage volume requirement.

- 1b) Similar to (1a) above for permeable catchments where Q_{BAR} is less than 2 l/s/Ha then a value of Q_{BAR} of 2 l/s/Ha is used to prevent unreasonable storage requirements.

Treatment of stormwater runoff:

Stormwater runoff for all events is contaminated to some degree. This is due to the flush of debris and sediment from paved surfaces being "washed off" in the first part of the event together with any sediment deposits in the pipe network. This is compounded by the fact that this highly concentrated initial flow enters the receiving water which is still flowing at base flow conditions, thus providing a minimum level of dilution. Although the interception criterion should address much of this pollution, there is a need to deal with the runoff from larger events (ie >5mm). The concept of Treatment Storage is to provide a 'body' of water in which dilution and partial treatment (by physical, chemical and biological means) of this runoff can take place. The amount of this storage normally provided is equivalent to the first 15mm of rainfall. This makes an initial assessment of the treatment volume. The actual volume is dependent upon the usage pollution risk factors and the components of the treatment train. Reference should be made to CIRIA C697 SUDS Manual for more detailed assessment. The storage volume is not a necessarily a static volume but can be provided in various forms which limit flow velocity through the infrastructure and allow pollutants to be intercepted or partially treated by filtration, biological uptake /breakdown etc.

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Interception Storage

Surfaced site area	2229	m ²
Rainfall depth	5	mm
Interception storage	11	m³

This may not require an explicit storage provision.

ASV1 Greenfield estimation of peak flow rate of runoff

Hydrological region	7 (SE)		Appendix A, Figure A1.1
Soil type (1-5)	3		WRAP map Appendix 1, Figure A5.1
Site size	0.38	Ha	Gross size (red line area)
Development area (A)	0.38	Ha	Gross size less public open space etc
Annual rainfall (SAAR)	700	mm	Appendix 1, Figure A4.1
Soil runoff (SPR)	0.37		
Development area less than 50Ha, scale factoring will be used			
scale factor	0.007542		
Q _{BAR50}	143.6	l/s	
Q _{BAR}	1.1	l/s	
Q _{BAR/A}	2.9	l/s/Ha	minimum value limit 1.0 l/s/Ha
Q _{BAR/A} modified	2.9	l/s/Ha	
Minimum discharge limit	5.0	l/s	Q _{throttle} (default 5.0 l/s)
1:100 year flow rate	13.3	l/s/Ha	Q _{throttle/A}
mean annual Q _{peak}	3.8	l/s/Ha	Q _{throttle} /3.5A
Q _{BAR/A} final	3.8	l/s/Ha	use Q _{throttle} /3.5A if > Q _{BAR/A} modified
Growth factor GC ₁	0.85		
Growth factor GC ₃₀	2.24		Appendix 1 Figure A1.2
Growth factor GC ₁₀₀	3.19		Appendix 1 Figure A1.2
Q ₁	3.2	l/s/Ha	
Q ₃₀	8.5	l/s/Ha	
Q ₁₀₀	12.1	l/s/Ha	

TV Initial sizing of Treatment Storage volume:

Development area (A)	0.38	Ha	Taken from form ASV1
PIMP estimate	59	%	Percentage of impermeable surface
SPR	0.37		Taken from form ASV1
M ₅₆₀ rainfall	20	mm	Appendix 1 Figure A2.1
M ₅₆₀ rainfall (r)	0.4		Appendix 1 Figure A2.1
Treatment volume	3	m³	(Tv)

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ASV2 Assessment of attenuation storage volume

Hydrological region	7 (SE)			Taken from ASV1
M ₅₆₀ rainfall	20	mm		Taken from TV
M ₅₆₀ rainfall (r)	0.4			Taken from TV
Development area (A)	0.38	Ha		Taken from ASV1
A impermeable drained	0.22	Ha		Exclude areas draining to infiltration
Proportion of A (α)	0.59			
Q _{BAR} /A final	3.8	l/s/Ha		Taken from ASV1
PIMP estimate	59	%		Taken from TV
If PIMP estimate < 50% adopt 50%				
PIMP adopted	59	%		
	<u>1 year</u>	<u>30 year</u>	<u>100 year</u>	
U _{vol} m ³ /Ha	80	180	250	App1 Figs A7.1-7.8
Basic Storage(BSV) m ³	18	40	56	
CC	1.2	1.2	1.2	
FF	1.0	1.0	0.9	Figs A11.1 & A6.1-6.3
SVR	1.20	1.20	1.33	
Adj Storage(ASV) m ³	21	48	74	
GC factors	1.00	1.05	1.17	Fig A1.3
HR	1.00	1.01	1.04	Fig A9.1
Atten. Storage(At.Vol)	21	49	77	m ³

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LTV Initial sizing of long term storage volume

Development area (A)	0.38	Ha	Taken from ASV1
PIMP estimate	59	%	Taken from TV
Impermeable area (AP)	0.22	Ha	
LTF	2.6	m ³ /Ha.mm	Fig A10.1/10.2
Rainfall depth (RD)	63	mm	Appendix 1 Fig A3.1
Long Term Vol (LTV)	36	m ³	

The practicalities of detailed design for this storage are not simple. Any element of reduction of runoff volume eg topographic management of indirect runoff, interception storage and rain water harvesting, even partial infiltration when ground conditions are poor will help to minimise this volume.

There are three basic approaches:

- 1) Provide for whole of LTV by infiltration. (*many sites do not have appropriate soil characteristics for this*)
- 2) System captures total flow (ie on line) then empties at a rate of less than 2 l/s/Ha using land drains or a throttle. (*The problems with this are that a significant area comes into operation in all events. This results in a much greater area than option (3). Due to the frequency of use it will tend to render the area unusable as a dual use public area and will restrict the type of planting that can be used in the storage area*)
- 3) LTV system only activates above a storm size threshold (ie off line) which captures the required volume & discharges it at the required rate. In practice this means the attenuation system has a direct discharge at greenfield discharge rates. (*The problems with this are that the design is complex. It is likely that the LTV storage may only operate of the order of once in 5 years. Whilst this may be acceptable for dual use as a football field etc if above ground storage in a parking area is mobilised depths would have to be limited. As use will be infrequent the drain down method must be robust. A simple throttle will rarely be effective as it would need to be impractically small for LTS on developments smaller than about 6Ha.*)

Further detail is contained in chapter 7.2 and reference should be made to Fig 7.4 and Fig 7.5 for schematic illustration of the basic principles.

SUMMARY

				Interception storage	11	m ³
Q ₁	greenfield	3.2	l/s/Ha	Attenuation storage ₁	21	m ³
Q ₃₀	greenfield	8.5	l/s/Ha	Attenuation storage ₃₀	49	m ³
Q ₁₀₀	greenfield	12.1	l/s/Ha	Attenuation storage ₁₀₀	77	m ³
				Treatment volume	3	m ³
				Long Term Volume	36	m ³

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Pre development

CIRIA C697 Initial stormwater drainage assessment**Rainfall Parameters**

SAAR	700	mm	CWI	116	
2DM5 rain	50	mm	DPRCWI	-2.2	%
M560 rain	18	mm	UCWI _{winter}	130	
r	36	%	Hydrometric area	7 (SE)	

Soil Parameters

Drainage class	commonly waterlogs within top 60 cm in the winter				
Slope class	<2 °				
Horizon depth class	40-80 cm				
Top soil drainage class	medium				
SOIL	0.40				
SPR	37	%			

Surface Parameters

Soft landscape	485	m ²	Roof Standard (impermeable)	1445	m ²
Permeable pavement	0	m ²	Pavement 1 (impermeable)	1841	m ²
Green roof ₍₁₎	0	m ²	Pavement 2 (50% permeable)	0	m ²
A_p	485	m ²	A_i	3286	m ²

(1) includes standard roof directed into permeable pavement

PIMP 100%

PR 82 %

 $t = 5 \text{ mins } (t_{\text{entry}}) + t_{\text{concentration}} = 5 \text{ mins}$ **Flows**

QBAR _{rural}	0.2	l/sec	TOTALS Q_i 94.3 Q₃₀ 232.3 Q₁₀₀ 301.3	Q _i urban	94.2	l/sec
Q ₁ rural	0.1	l/sec		Q ₃₀ urban	231.9	l/sec
Q ₃₀ rural	0.4	l/sec		Q ₁₀₀ urban	300.8	l/sec
Q ₁₀₀ rural	0.5	l/sec				

Volumes

V _{100 6hr} rural	21.7	m ³	TOTAL V_{100 6hr} 303.3	V _{100 6hr} urban	281.6	m ³
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Catchment

Post development

CIRIA C697 Initial stormwater drainage assessment**Rainfall Parameters**

SAAR	700	mm	CWI	116	
2DM5 rain	50	mm	DPRCWI	-2.2	%
M560 rain	18	mm	UCWI _{winter}	130	
r	36	%	Hydrometric area	7 (SE)	

Soil Parameters

Drainage class	commonly waterlogs within top 60 cm in the winter				
Slope class	<2 °				
Horizon depth class	40-80 cm				
Top soil drainage class	medium				
SOIL	0.40				
SPR	37	%			

Surface Parameters

Soft landscape	1542	m ²	Roof Standard (impermeable)	1086	m ²
Permeable pavement	0	m ²	Pavement 1 (impermeable)	1143	m ²
Green roof ₍₁₎	0	m ²	Pavement 2 (50% permeable)	0	m ²
A_p	1542	m ²	A	2229	m ²

(1) includes standard roof directed into permeable pavement A_i 2229 m²

PIMP 100%

PR 82 %

 $t = 5 \text{ mins } (t_{\text{entry}}) + t_{\text{concentration}} = 5 \text{ mins}$ **Flows**

QBAR _{rural}	0.5	l/sec	TOTALS Q₁ 64.3 Q₃₀ 158.5 Q₁₀₀ 205.7	Q ₁ urban	63.9	l/sec
Q ₁ rural	0.4	l/sec		Q ₃₀ urban	157.3	l/sec
Q ₃₀ rural	1.2	l/sec		Q ₁₀₀ urban	204.1	l/sec
Q ₁₀₀ rural	1.7	l/sec				

Volumes

V _{100 6hr} rural	69.0	m ³	TOTAL V_{100 6hr} 260.0	V _{100 6hr} urban	191.0	m ³
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Project Title: 59-61 West St, Havant

Site Location: Havant

$r = 0.36$ (range 0.12 to 0.45)

Drained Area = 2229 m²

Storage Length $L_x =$ 27 m

Storage Length $L_v =$ 4 m

Storage Depth = 1 m

TOTAL STORAGE AVAILABLE **108** **m³**

DISCHARGE RATE **5.0** l/sec

Climate change = 30 %

M5-60 Rainfall = 20 mm

[illegible]

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Catchment Element

Existing FW

Dry Weather Flows

Dry Weather Flows						DWF	
Category	per	m ³ /unit/day	min	max	No units	m ³ /day	
Residential (/person)	person	0.175	0.150	0.200	0	0.00	#DIV/0!
Day school	student	0.075	0.050	0.100	0	0.00	#DIV/0!
Boarding school	student	0.175	0.150	0.200	0	0.00	#DIV/0!
Nursing home	bed	0.350	0.300	0.400	0	0.00	#DIV/0!
Sports centre	visitor	0.020	0.010	0.030	0	0.00	#DIV/0!
Hospital	bed	0.625	0.500	0.750	0	0.00	#DIV/0!
Hotels/boarding houses	bed	0.023	0.150	0.300	0	0.00	#DIV/0!
Restaurants	customer	0.035	0.030	0.040	0	0.00	#DIV/0!
Pubs/clubs	customer	0.015	0.010	0.020	0	0.00	#DIV/0!
Cinema/theatre	seat	0.010	0.010	0.010	0	0.00	#DIV/0!
Shopping centre	m ²	0.004	0.004	0.004	0	0.00	#DIV/0!
Offices	m ²	0.008	0.008	0.008	0	0.00	#DIV/0!
Commercial premises	m ²	0.003	0.003	0.003	0	0.00	#DIV/0!
						0.00	
Light industrial	Ha	100.0	43.2	172.8	0.4	40.00	100.0%
Medium Industrial	Ha	150.0	129.6	345.6	0	0.00	0.0%
Heavy industrial	Ha	250.0	172.8	691.2	0	0.00	0.0%
						40.00	
						0.00	
Infiltration as % of non industrial flow		10	%				
						DWF = 40.00	m ³ /day

Peak Flows

Peak factor approach	factor	peak flow	
Gaines (1989) a	2.29	1.1	l/sec
Gaines (1989) b	5.42	2.5	l/sec
BS_EN 752-4	6.00	2.8	l/sec

In system flow attenuation up to point of interest

Low- small system, small diameters

In system diversification relating to point of interest

Low- few branches

Likely nature of peak factor

High

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Catchment Element

Developed FW

Dry Weather Flows

Category	per	m ³ /unit/day	min	max	No units	DWF m ³ /day	
Residential (/person)	person	0.175	0.150	0.200	120	21.00	100.0%
Day school	student	0.075	0.050	0.100	0	0.00	0.0%
Boarding school	student	0.175	0.150	0.200	0	0.00	0.0%
Nursing home	bed	0.350	0.300	0.400	0	0.00	0.0%
Sports centre	visitor	0.020	0.010	0.030	0	0.00	0.0%
Hospital	bed	0.625	0.500	0.750	0	0.00	0.0%
Hotels/boarding houses	bed	0.023	0.150	0.300	0	0.00	0.0%
Restaurants	customer	0.035	0.030	0.040	0	0.00	0.0%
Pubs/clubs	customer	0.015	0.010	0.020	0	0.00	0.0%
Cinema/theatre	seat	0.010	0.010	0.010	0	0.00	0.0%
Shopping centre	m ²	0.004	0.004	0.004	0	0.00	0.0%
Offices	m ²	0.008	0.008	0.008	0	0.00	0.0%
Commercial premises	m ²	0.003	0.003	0.003	0	0.00	0.0%
						21.00	
Light industrial	Ha	100.0	43.2	172.8	0	0.00	#DIV/0!
Medium Industrial	Ha	150.0	129.6	345.6	0	0.00	#DIV/0!
Heavy industrial	Ha	250.0	172.8	691.2	0	0.00	#DIV/0!
						0.00	
Infiltration as % of non industrial flow		10	%			2.10	
						DWF = 23.10	m³/day

Peak Flows

Peak factor approach	factor	peak flow	
Gaines (1989) a	2.37	0.6	l/sec
Gaines (1989) b	5.61	1.5	l/sec
BS_EN 752-4	6.00	1.6	l/sec

In system flow attenuation up to point of interest

Low- small system, small diameters

In system diversification relating to point of interest

Low- few branches

Likely nature of peak factor

High