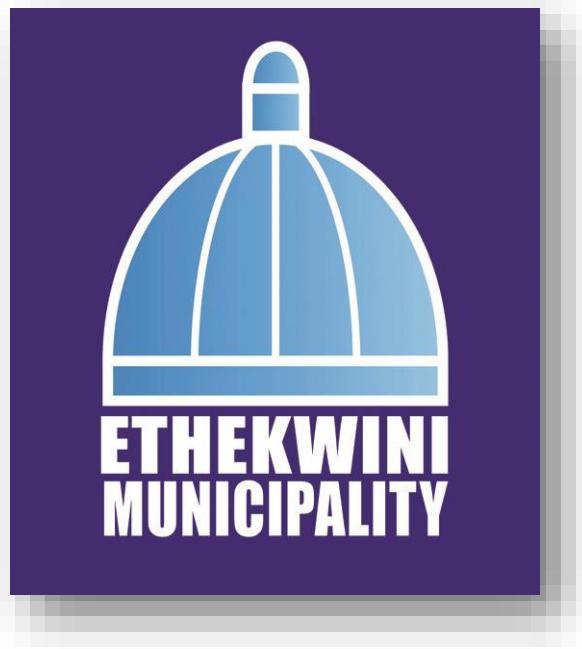


APPENDIX 6: STORMWATER MANAGEMENT PLAN



KLAARWATER STATION HOUSING

STORMWATER MANAGEMENT PLAN

DEVELOPMENT ENGINEERING DEPARTMENT
ENGINEERING UNIT
ETHEKWINI MUNICIPALITY

MAY 2018

PROPOSED KLAARWATER STATION
HOUSING DEVELOPMENT

STORMWATER MANAGEMENT PLAN

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PROPOSED LKAARWATER STATION HOUSING DEVELOPMENT

STORMWATER MANAGEMENT PLAN

1) Introduction

Development Engineering was appointed on behalf of Housing Projects to determine the Stormwater Management Plan (SWMP) for the Proposed Klaarwater Station Housing Development.

The SWMP must indicate how the proposed development proposes to manage the stormwater run-off and in particular how the increase in run-off from pre-development to post-development conditions is controlled.

2) Background

The proposed development consists of fifteen separate catchment areas spread out through the development. The fifteen development areas are referred to as areas A, B, C, D, F, G, H, I, J, K, L, M, N, O and P (Appendix 2) with the total catchment area being 27.17 ha.

The catchment does not require a formal assessment of floodlines due to the size of the catchment (less than 1km²) and there are no defined flow paths on the site. However, a SWMP for the development would be required which forms the basis of this report.

The major requirement from the Municipality is that the development should not cause any additional impacts on the downstream areas (including negative impacts during construction). This implies that the future peak flows must be attenuated back to pre-development peaks and that the post development flows must not be concentrated any more than would naturally have occurred.

The proposed development is therefore constrained in the range of options available to manage the run-off from site:

1. The development will result in an increase in peak flows and volumes for stormwater arising from the site;
2. The layout for the proposed development will result in some form of concentration in stormwater flows;
3. The post development 1:10 year and 1:50 year discharge from the site must be attenuated back to the 1:10 year and 1:50 year pre-development conditions.

3) Analysis

Storm water flows are calculated using the Rational Method.

Rainfall intensities for storms of varying return periods are taken from rainfall statistical data available on: www.durban.gov.za/eThekwini/Services/Engineering Unit /CSCM

A summary of the hydrological characteristics are listed below:

The relevant catchment characteristics were determined using G.I.S cadastral data. The results have been summarised in Table 1 below:

Table 1: Summary of Catchment Characteristics:

Catchment	Area (m ²)	Channel Slope (%)	Hydraulic Length (km)	Time of Concentration (h)	Land Use Distribution (Post Development %)	
					Rural	Urban
A	13 737	16.29	0.075	15	20	80
B	14 845	10.37	0.070	15	20	80
C	13 256	7.70	0.065	15	20	80
D	38 687	16.45	0.064	15	25	75
E	16 776	16.20	0.060	15	20	80
F	16 161	18.68	0.065	15	5	95
G	10 632	9.44	0.063	15	5	95
H	9 592	9.75	0.062	15	5	95
I	15 764	9.80	0.120	15	10	90
J	12 927	18.40	0.173	15	20	80
K	11 323	19.20	0.145	15	10	90
L	8 382	16.65	0.055	15	20	80
M	10 270	10.25	0.044	15	35	65
N	20 459	8.66	0.049	15	30	70
O	25 927	7.45	0.043	15	40	60
P	32 953	12.54	0.062	15	45	55

4) Adopted Flood Peaks and Volumes

The magnitude of the flood peaks is dependent on the catchment characteristics, rainfall and existing stormwater control measures. Taking into account the nature and the size of the catchments we found it appropriate to use the Rational Method.

Pre and Post Development Catchment peaks are summarised in Table 2 and Table 3.

Table 2: Summary of Estimated Peaks and Volumes for various Return Periods (Pre-Development)

Catchment	Area (m ²)	Estimated Peak Flow (m ³ /s)		Estimated Volume (m ³)	
		1:10 (yrs)	1:50 (yrs)	1:10 (yrs)	1:50 (yrs)
A	13 737	0.050	0.108	45	97.2
B	14 845	0.047	0.103	42.3	92.7
C	13 256	0.042	0.090	37.8	81
D	38 687	0.141	0.303	126.9	272.7
E	16 776	0.199	0.430	179.1	387
F	16 161	0.056	0.120	50.4	108
G	10 632	0.156	0.336	140.4	302.4
H	9 592	0.141	0.303	126.9	272.7
I	15 764	0.231	0.499	207.9	449.1

Catchment	Area (m ²)	Estimated Peak Flow (m ³ /s)		Estimated Volume (m ³)	
J	12 927	0.137	0.214	123.3	192.6
K	11 323	0.166	0.173	149.4	155.7
L	8 382	0.123	0.265	110.7	238.5
M	10 270	0.151	0.325	135.9	292.5
N	20 459	0.300	0.647	270	582.3
O	25 927	0.380	0.820	342	738
P	32 953	0.477	1.030	429.3	927

Table 3: Summary of Estimated Peaks and Volumes for various Return Periods (Post-Development)

Catchment	Area (m ²)	Estimated Peak Flow (m ³ /s)		Estimated Volume (m ³)	
		1:10 (yrs)	1:50 (yrs)	1:10 (yrs)	1:50 (yrs)
A	13 737	0.050	0.109	45	98.1
B	14 845	0.053	0.115	47.7	103.5
C	13 256	0.048	0.103	43.2	92.7
D	38 687	0.83	0.103	747	92.7
E	16 161	0.277	0.598	249.3	538.2
F	10 632	0.056	0.121	50.4	108.9
G	9 592	0.163	0.351	146.7	315.9
H	15 764	0.147	0.317	132.3	285.3
I	12 927	0.231	0.499	207.9	449.1
J	11 323	0.137	0.214	123.3	192.6
K	8 382	0.173	0.354	155.7	318.6
L	10 270	0.214	0.358	192.6	322.2
M	20 459	0.157	0.340	141.3	306
N	25 927	0.313	0.676	281.7	608.4
O	32 953	0.397	0.857	357.3	771.3
P	13 737	0.505	1.089	454.5	980.1

5) Impact Due to Development

Table 4 below summarises the percentage increase from pre to post development with regards to estimated peak flows and volumes.

Catchment	Percentage increase of peak flow %		Percentage increase of volume %	
	1:10 (yrs)	1:50 (yrs)	1:10 (yrs)	1:50 (yrs)
A	0.00%	0.92%	0.00%	0.92%
B	11.32%	10.43%	11.32%	10.43%
C	12.50%	12.62%	12.50%	12.62%
D	83.01%	194.17%	83.01%	194.17%
E	28.16%	28.09%	28.16%	28.09%
F	0.00%	0.83%	0.00%	0.83%
G	4.29%	4.27%	4.29%	4.27%

Catchment	Percentage increase of peak flow %	Percentage increase of volume %
H	4.08%	4.42%
I	0.00%	0.00%
J	0.00%	0.00%
K	4.05%	51.13%
L	42.52%	25.98%
M	3.82%	4.41%
N	4.15%	4.29%
O	4.28%	4.32%
P	5.54%	5.42%

6) Stormwater

All stormwater generated on site must be piped and fed into the municipal storm water system in a manner compliant with local storm water attenuation regulations. Additionally, all paved surfaces must be properly graded to allow storm water runoff and prevent ponding.

The eThekini Municipality has revised its Stormwater Design Manual in May 2008 and all designs and Management Plans will be in accordance with their guidelines.

7) Internal Stormwater

The roads within the developed areas will be designed to collect stormwater run-off and convey it to standard kerb inlets or open drains. Kerb inlets are to be positioned at 40m – 60m spacing along the roads.

Roads adjacent to open space will be designed to discharge stormwater run-off directly to grassed shoulders where appropriate.

The internal stormwater management system is based on the following principles:

The difference between the pre and post development runoff peaks will need to be controlled / attenuated in such a way that only an equivalent pre development outflow of stormwater runoff will be permitted. This will be achieved by either the construction of swales, large inlets/manholes for storage and slow release or attenuation ponds. Where areas have more than one outlet point Pre and Post flows and attenuation details will be designed for each outlet point. Details of these structures will be done at the Final design stage.

Stormwater will be directed along road surfaces to either discharge through energy dissipaters directly into watercourses, or collected by side inlets at strategic and critical points and directed into sub surface spigot and socket pipe systems.

These pipe systems will then discharge via. headwall outlets with erosion protection into swales running along natural contours and then into natural watercourses (Areas A; B; D; E; F; G; H; I; J; K; L; M; N; O & P) and where available directly into the existing stormwater network(Area C).

Surface runoff in roads will be contained by the road crossfall and the kerb. Road crossfalls, where practical will fall towards the cut side of the road in order to accommodate discharging of underground pipes onto the road surface through the kerb. Where it will not always be possible to slope the roads into the cut side of the road it may be necessary to allow for kerbing on both sides of the road to accommodate the drainage.

Servitudes will be provided to accommodate future midblock sub surface stormwater conduits as required.

Flow on roads exceeding the capacity of the kerb inlets and pipes will flow down the roads to low points. Overflow positions and drainage servitudes will be provided at these low points to convey the flood waters to the existing natural watercourses.

8) Services crossing Watercourses

Where services cross watercourses, care must be taken not to disrupt the natural intermittent flow system.

Underground services e.g. sewer pipes will be laid in trenches and backfilled utilising the excavated material to maintain natural groundwater movements, if required by environmental considerations, stone bedding or sand backfill will be used.

9) Erosion Control

The outlet structures and watercourse areas will be protected by Reno Mattresses and headwalls. All cut and fill banks will be grass sodded or hydro seeded to prevent soil erosion.

During construction, measures such as berms, hessian blankets and grassing is to be used to prevent erosion of stockpiles and construction areas.

10) Design Parameter Table

Table 5 below summarises the following design parameters which were used in accordance with the guidelines:

Design Parameters			
(a)	The Rational Method of design will be used with the following return periods:		
	General	- 3	Year storm
	Critical Points	- 10	Year storm
	Cross Drainage	- 5-20	Year storm
	Structures	- 50	Year storm
(b)	Minimum pipe size	- 450 mm - all grades	
(c)	Class of pipe		
	• Class 50D	- midblocks	
	• Class 100D	- Road crossings & Sidewalks	
(d)	Run-off factors		
	• Road areas	- 0,9	
	• Roof areas	- 0,9	
	• Other areas	- 0,6	
(e)	Side inlets, upstream gutter lengths	- According to HJC Forbes	
(f)	Minimum inlet length	- 2,44 m	
(g)	Maximum inlet length	- 3,66 m	
(h)	Inlets, manholes & headwall details	- eThekweni Municipal Standards	

11) RECOMMENDATIONS:

Based on our assessments to date, we recommend that the following be considered:

1. Erosion protection in the form of Reno Mattresses, Gabion baskets or stone pitching to be put in place at all stormwater discharge points as indicated on the drawing.
2. Temporary silt collection measures to be implemented prior to construction. This can be in the form of excavating low areas at pertinent points to collect silt. These areas would need to be re-vegetated on completion of the works. More critical areas can be in the form of hessian attached to rows of wooden stakes located at strategic points as directed by the Engineer on site.
3. Resident Engineer to confirm invert levels prior to installation.
4. At low points, increase pipe diameters, flatten grades and make inlets and manholes larger.
5. The Environmental and other Municipality and legal requirements need to be adhered to.

6. The Contractor is to comply with the Occupational Health and Safety (OHS) Act 85 of 1993 and the Construction Regulations 2014 issued on 07 February 2014 by the Department of Labour. If the contractor has any alternatives due to his/her construction methods, he/she must submit alternatives to the Engineer for approval.
7. The Resident Engineer to check that stormwater related work has been built according to Municipalities requirements.
8. Final approval and Requirements must be obtained from the Municipality.



D. Jooste
Snr. Man: Dev Eng (West)



M. Tootla
Man: CSCM(West)

APPENDIX 1

Stormwater Run-off Calculations (pre and Post)

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 51 45 long 30 51 20

Anal. by: TN Dlamini
Date: 02-May-18

Area A

Site Area (m²)	Tc pre (min)	Tc post (mins)
13737.00	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1	area2	area2 alt	area 3	inter y2'/y1'	inter y2''/y1'
		CT PRE d	CT POST d	15	30										
2	0.5	0.33	0.33	17.4	49.2	17.4	17.4	0.022	0	0	0	0	0	15	30
5	0.55	0.37	0.37	26	73.8	26.0	26.0	0.036	0.037	0	0	0	0	15	30
10	0.6	0.40	0.40	32.8	93	32.8	32.8	0.050	0.050	0	0	0	0	15	30
20	0.67	0.45	0.45	40.2	113.8	40.2	40.2	0.069	0.069	0	0	0	0	15	30
50	0.83	0.55	0.56	51.2	145.2	51.2	51.2	0.108	0.109	1	0	0	0	15	30
100	1	0.67	0.67	60.8	172.2	60.8	60.8	0.155	0.155	1	1	1	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
MAP	URBAN	MAP	URBAN
% > 900mm		Lawn sandy<2%	0 0.08
0 0.05		Lawn sandy>7%	0 0.18
7 0.11		Lawn heavy>2%	0 0.15
90 0.20		Lawn heavy>7%	0 0.30
3 0.30		Residential single	0 0.50
100 0.20		Flats/dense townships	80 0.60
%		Industry , light	0 0.65
0 0.05		Industry , heavy	0 0.70
0 0.10		Business local	0 0.60
100 0.20		Business CBD	0 0.85
0 0.30		Streets/roofs	20 0.95
100 0.20			100 0.67
Ct =	0.67	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(r/1000/S)^0.50487	
Dist (m)	r factor
75.00	smooth paving 0.02
Slope	clean soil 0.10
0.16	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.80
	choose r 0.40
T overland (mins)	NOTE: distance used
10.74	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (r)	150	Triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3g)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5 d^0.5 H^0.55	m/s	H/D>1.28	0<h/d<0.8
									H/D>0.8
				0.6	0.8	Q=0.43g^0.5 d^0.5 H^0.55	m/s	H/D<1.28	0.8<H/D<1.2
									H/D>1.2
									0.2557
									q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9
									q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5
									q=0.6p^0.5 d^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

Grate inlet operating as a orifice at low point-high flow depth 0.67*A*(2gd)^0.5			
Flow depth	Length	width	
0.4	1	0.4	

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
Descr: lat 29 51 43 long 30 51 23 **Area B**

Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m ²)	Tc pre (min)	Tc post (mins)
14845.00	15.00	15.00

RI (yrs)	RI Reduction factor It	RAIN DATA mm hr			lpre	lpost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1	area2	area2 alt	area 3	inter y2/y1	inter y2/y1'
		CT PRE	CT	POST d	15	30						area1	area2	area2 alt	area 3	inter y2/y1	inter y2/y1'
2	0.5	0.29	0.33		17.4	49.2	17.4	17.4	0.021	0.024	2	2	5	2	0	0	16
5	0.55	0.32	0.36		26	73.8	26.0	26.0	0.034	0.039	4	4	7	4	0	0	16
10	0.6	0.35	0.39		32.8	93	32.6	32.6	0.047	0.053	5	5	9	5	0	0	16
20	0.67	0.39	0.44		40.2	113.8	40.2	40.2	0.065	0.073	7	7	11	7	0	0	16
50	0.83	0.49	0.55		51.2	145.2	51.2	51.2	0.103	0.115	11	14	14	11	0	0	16
100	1	0.59	0.66		60.8	172.2	60.8	60.8	0.147	0.165	16	16	16	16	0	0	16

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
Catchment MAP	MAP	URBAN	%
Catchment Slope CS	% > 900mm	Lawn sandy<2%	0 0.0
< 3%	15 0.05	Lawn sandy>7%	0 0.1
3-10 %	75 0.11	Lawn heavy>2%	0 0.1
10 - 30 %	10 0.20	Lawn heavy>7%	0 0.3
> 30 %	0 0.30	Residential single	0 0.3
	100 0.11	Plats/dense townships	80 0.8
Soil Permeability Cp	%	Industry , light	0 0.6
Very perm (Dunes)	0 0.05	Industry , heavy	0 0.7
Perm (light soil)	0 0.10	Business local	0 0.6
Semi (most soils)	100 0.20	Business CBD	0 0.8
Imperm (rock, paving)	0 0.30	Streets/roofs	20 0.9
	100 0.20		100 0.8
Vegetal growth Cv	%	AREA WEIGHTING FACTORS	
Dense bush, forest	0 0.05	RURAL	15.00 0.6
Cult land, sparse bush	0 0.15	URBAN	85.00 0.8
Grassland	50 0.25	LAKES	0 0.0
Bare Surface	50 0.30	Cdesign	100 0.6
Rural Catchment coeff	Ct = 0.59		

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(D/1000/S) ^{0.5/0.487}	
Dist (m)	r factor
70.00	smooth paving 0.02
Slope	clean soil 0.10
0.10	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.60
	choose r 0.40
T overland (mins)	11.60 should not
Velocity (m/s)	0.10 exceed 20

sed

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv	INPUT	OUTPUT	n values
Manning n	0.011	SHAPE	Quinf=VA, Vel V, Tc mins
Slope (m/m)	0.025	Trapezoid	0.27, 2.74, 0.912, earth.018
Width (m)	1.000	rectangle	0.27, 2.74, 0.912, strameth.05
Depth (m) (not fit)	0.1	FullBoxCulv	0.18, 1.83, 1.366, Conc canal.0
path/distance (d)	150	Triangle	0.06, 0.02, 128.149, asph.016
slope slope 1:?	0.001	Gutter	0.00, 0.01, 203.424, grass.03
pipe dia (m)	0.45	FullPipeCulv	0.53, 3.35, 0.746, bushy.05
NB Pipe is assumed full			

SHORT STEEP BOX CULVERTS							INLET COEFF C	SHORT STEEP PIPE CULVERTS <= 250 mm dia					0.40
HEAD H (m)	span B	depth D	H/D	SQUARE	ROUND		HEAD H	DIA D (m)	H/D	slope		0.01	
5	0.8	0.80	6.25	0.9	1.0		1	0.35	2.857142857	0.01		sloped culverts	
Q=2*CBH/(2/3g)^(0.5) for H/D<1.2		m ³ /s		H/D>1.2	H/D>1.2		Q=0.35g ^{0.5} d ^{-0.001} H ^{0.55}	m ³ /s	H/D>1.28	H/D<1.28		0<h/d<0.8	
Q=CBD(2g/H-CD) ^{0.5} for H/D>1.2		m ³ /s		0.6	0.8		Q=0.43g ^{0.5} d ^{-0.001} H ^{0.51}	m ³ /s	0.230128008	H/D>1.28<4		H/D>0.8	
				3.616	4.735							0.8<H/D<1.2	
												0.8>H/D>1.2	
												h/d>>1.2	
												0.2557	
												0.6*p*d*4sqrt(2gh)	

Broad crested Weir Q=1.65LxD1.5	Length L	Depth of flow
	5	0.20
Q=	0.738	
Sharp crested Weir		
$Q=2.303(b+1) + 0.85(x-d)/d \times (2gx^0.5x(h-d))^{1.5}$		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
$\alpha-Q=M$	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth $Q = 1.6 \times (\text{Perimeter}) \times D^{1.5}$

	Flow depth	Length	width
For kerb inlet put width = 0	0.15	2	
$Q =$	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height

Grate inlet operating as a orifice at low point-high flow depth	Flow depth	Length	width
0.67*A*(2gd) ^{1/2}	0.4	1	1
Q=	depth	m3/s	
NB flow depth at least half width or length			

5.0285

MAN NING n FOR OPEN CHANNELS		$n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m$
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.006
	Minor	0.005
	Moderate	0.010 n1
Variation in ch	Severe	0.020 0.005
	Gradual	0.000
	Alternating Osc	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m
	Severe	1.300 1
		Manning n

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
Descr: lat 29 51 51 long 30 51 29 Area C

Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m ²)	Tc pre (min)	Tc post (mins)
13256.00	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm/hr		lpre	lpost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1	area2	area2 alt	area 3	inter y2'y1	inter y2'y1
		CT PRE d	CT POST d	15	30											
2	0.5	0.29	0.33	17.4	49.2	17.4	17.4	0.018	0.021	2	2	5	2	0	0	16
5	0.55	0.32	0.36	26	73.8	26.0	26.0	0.030	0.035	4	4	7	4	0	0	16
10	0.6	0.34	0.39	32.8	93	32.8	32.8	0.042	0.048	5	5	9	5	0	0	16
20	0.67	0.38	0.44	40.2	113.8	40.2	40.2	0.057	0.065	7	7	11	7	0	0	16
50	0.83	0.48	0.54	51.2	145.2	51.2	51.2	0.090	0.103	12	14	14	12	0	0	16
100	1	0.57	0.66	60.8	172.2	60.8	60.8	0.128	0.147	17	17	17	17	0	0	16

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
Catchment MAP	MAP	URBAN	%
Catchment Slope CS	% > 900mm	Lawn sandy<2%	0 0.0
< 3%	10 0.05	Lawn sandy>7%	0 0.1
3-10 %	85 0.11	Lawn heavy>2%	0 0.1
10 - 30 %	5 0.20	Lawn heavy>7%	0 0.3
> 30 %	0 0.30	Residential single	0 0.3
	100 0.11	Plats/dense townships	80 0.8
Soil Permeability Cp	%	Industry , light	0 0.6
Very perm (Dunes)	0 0.05	Industry , heavy	0 0.7
Perm (light soil)	0 0.10	Business local	0 0.6
Semi (most soils)	100 0.20	Business CBD	0 0.8
Imperm (rock, paving)	0 0.30	Streets/roofs	20 0.9
	100 0.20		100 0.8
Vegetal growth Cv		AREA WEIGHTING FACTORS	
Dense bush, forest	0 0.05	%	DWA
Cult land, sparse bush	0 0.15	RURAL	15.00 0.6
Grassland	70 0.25	URBAN	85.00 0.8
Bare Surface	30 0.30	LAKES	0 0.0
Rural Catchment coeff	Ct = 0.57	Cdesign	100 0.6

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000)^{0.5-0.47}	
Dist (m)	r factor
65.00	smooth paving 0.02
Slope	clean soil 0.10
0.07	sparse grass 0.30
	mod grass 0.40
	thick bush/grass choose r 0.80
	0.40 NOTE: distance u
T overland (mins)	12.18 should not
Velocity (m/s)	0.09 exceed 20

sed

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv					n values
INPUT	OUTPUT				
Manning n	0.011	SHAPE	Qunit=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid		0.27	2.74
Width (m)	1.00range			0.27	2.74
Depth (m) not full	0.1	FullBoxCulv		0.18	1.83
path/distance (m)	150	Triangle		0.00	0.02
side slope 1:?	0.001	Gutter		0.00	0.01
pipe dia (m)	0.45	PipeFullCulv		0.53	3.35
NB Pipe is assumed full					

SHORT STEEP BOX CULVERTS										INLET COEFF C				SHORT STEEP PIPE CULVERTS <= 250 mm dia						0.40	
HEAD H (m)										SQUARE	E	ROUND		HEAD H	DIA D (m)	H/D	slope	0.01	sloped culverts		
5	0.8	0.80	0.25	0.9	1.0					1				0.35	2.857142857		0.01				
Q=2*CBH/(2(3g) ^{0.5}) for H/D<1.2										m ³ /s	H/D>1.2	H/D>1.2		Q=0.35g ^{0.5} d ^{-0.5} H ^{0.55}	m ³ /s	H/D>1.28	H/D>1.28	0<H/D<0.8	H/D>0.8	q=d2*xqr(gD)*0.48(S/0.4)*0.05*(H/D)	
Q=CBH/(2g(H-CD)) ^{0.5} for H/D>1.2										m ³ /s	0.6	0.8		Q=0.43g ^{0.5} d ^{-0.5} H ^{0.55}	m ³ /s	H/D>1.28	H/D>1.28	0.8+H/D>1.28	0.8+H/D>1.28	q=d2*xqr(gD)*0.44(S/0.4)*0.05*(H/D)	
Q=CBH/(2g(H-CD)) ^{0.5} for H/D>1.2										m ³ /s	3.616	4.735				0.230128008	H/D>1.28<4	h/d>1.2	0.2557	q=0.6p*d2*4sqrt(2gh)	

Broad crested Weir Q=1.65LxD1.5	Length L	Depth of flow
Q=	5	0.20
	0.738	
Sharp crested Weir		
$q = 2.303(b+1) + 0.85(x-d)/d \cdot (2gx^0.5x(h-d)^{1.5})^{1/2}$	h	d
h=height water above datum	1	0.90
d=height of weir above datum		
$q = Q/M =$	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth $Q = 1.6 \times (\text{Perimeter}) \times D \times 1.5$

	Flow depth	Length	width
For kerb inlet put width = 0	0.15	2	
$Q =$	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet width

Grate inlet operating as a orifice at low point-high flow depth	
0.67*A*(2gd) ^{1/2}	Flow depth
Q=	Length
NB flow depth at least half width or length	width m3/s

5.0285

MAN NING n FOR OPEN CHANNELS		$n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m$
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.006
	Minor	0.005
	Moderate	0.010 n1
Variation in ch	Severe	0.020 0.005
	Gradual	0.000
	Alternating Osc	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m
	Severe	1.300 1
		Manning n

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
Descr: PRE and POST development
lat 29 51 39 long 30 51 34

Site Area (m ²)	Tc pre (min)	Tc post (mins)
38687.00	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm/hr		lpre	lpost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff						
		CT PRE d	CT POST d								area1	area2	area2 alt	area 3	inter y2/y1	inter y2/y1
2	0.5	0.32	0.33	17.4	49.2	17.4	17.4	0.059	0.062	3	3	3	0	0	0	15
5	0.55	0.35	0.37	26	73.8	26.0	26.0	0.057	0.102	4	4	4	0	0	0	15
10	0.6	0.38	0.40	32.8	93	32.8	32.8	0.134	0.141	6	6	6	0	0	0	15
20	0.67	0.42	0.45	40.2	113.8	40.2	40.2	0.183	0.192	8	8	8	0	0	0	15
50	0.83	0.52	0.55	51.2	145.2	51.2	51.2	0.269	0.303	20	16	16	0	0	7	15
100	1	0.63	0.66	60.8	172.2	60.8	60.8	0.413	0.434	19	19	19	0	0	0	15

DWA METHODEN

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient		
Catchment MAP	MAP	URBAN	%	
Catchment Slope CS	> 900mm	Lawn sandy<2%	0	
< 3%	10	0.05	Lawn sandy>7%	0
3-10 %	25	0.11	Lawn heavy<2%	0
10 - 30 %	60	0.20	Lawn heavy>7%	0
> 30 %	5	0.30	Residential single	0
	100	0.17	Flats/dense townships	80
Soil Permeability Cp	%	Industry , light	0	
Very perm (Dunes)	0	Industry , heavy	0	
Perm (light soil)	0	Business local	0	
Semi (most soils)	100	0.20	Business CBD	0
Imperm (rock, paving)	0	0.30	Streets/roofs	20
	100	0.20		100
Vegetal growth Cv	%	AREA WEIGHTING FACTORS		
Dense bush, forest	0	RURAL	15.00	
Cult land, sparse bush	0	URBAN	85.00	
Grassland	70	LAKES	0	
Bare Surface	30	Cdesign	100	
Rural Catchment coeff	Ct =	0.63	0.6	

Tc Rational METHOD "KERBY" FORMULA	
Overland flow t (mins) = 36(rD/1000/S) ^(1-0.48)	
Dist (m)	r factor
64.00	smooth paving
Slope	clean soil
0.16	sparse grass
	mod grass
	thick bush/grass
	choose r
T overland (mins)	NOTE: 0.40 distance unit
Velocity (m/s)	should note
	exceed 20 m/s

sed
:
0m

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv					n values
INPUT	OUTPUT				
Manning n	0.011	SHAPE	Qunit=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid		0.27	2.74
Width (m)	1.000	rectangle		0.27	2.74
Depth (m) not 0	0.1	FullBoxCulv		0.18	1.83
path/distance (m)	150	Triangle		0.00	0.02
side slope 1:?	0.001	Gutter		0.00	0.01
pipe dia (m)	0.45	FullPipeCulv		0.53	3.35
NB Pipe is assumed full					

SHORT STEEP BOX CULVERTS										INLET COEFF C				SHORT STEEP PIPE CULVERTS <= 250 mm dia					0.40	
HEAD H (m)	span B	depth D	H/D	SQUARE E		ROUND	HEAD H	DIA D (m)	H/D	slope					sloped culverts					
5	0.8	0.80	6.25	0.9	1.0		1	0.35	2.857142857	0.01					0.01					
Q=2xCBH/(2(3g) ^{0.5}) for H/D<1.2		m ³ /s		H/D>1.2	H/D>1.2		Q=0.35g ^{0.5} d ^{0.5} H ^{0.55}		m ³ /s	H/D>1.28	H/D<1.28					0<h/d<0.8	H/D>0.8	d=2xsrqt(g)d)0.48(S/0.4)0.05(H/D)		
Q=CBD(2g/CDH) ^{0.5} for H/D<1.2		m ³ /s					Q=0.43g ^{0.5} d ^{1.05} H ^{0.55}		m ³ /s	0.230128008	H/D>1.28<4					0.8xH/D>1.2	0.8xH/D>	d=2xsrqt(g)d)0.44(S/0.4)0.05(H/D)		
																h/d>>1.2	0.2557	g=0.6p ² d ⁴ srqt(2gh)		

Broad crested Weir Q=1.65LxD1.5	Length L	Depth of flow
Q=	5	0.20
	0.738	
Sharp crested Weir		
$q = 2.303(b+1) + 0.85(x-d)/d \cdot (2gx^0.5x(h-d)^{1.5})^{1/2}$	h	d
h=height water above datum	1	0.90
d=height of weir above datum		
$\alpha \cdot Q = m$	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)*D₁₅

	Flow depth	Length	width
For kerb inlet put width = 0	0.15	2	
Q=	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height

Grate inlet operating as a orifice at low point-high flow depth			
	Flow depth	Length	width
0.67*A*(2gd) ^{1/2}	0.4	1	0
Q=	depth	m ³ /s	

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS		$n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m$
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
	Coarse gravel	0.028 0.012
Irregularity	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Occ	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m
	Severe	1.300 1 Manning n

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 51 33 long 30 51 38
Anal. by: TN Dlamini
Date: 02-May-18

Area E

Site Area (m²)	Tc pre (min)	Tc post (mins)
16776.00	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'					
		CT PRE d	CT POST d	15	30						area1	area2	area2 alt	area 3	inter y2'/y1'	inter y2'/y1'
2	0.5	0.26	0.36	72.8	49.2	72.8	72.8	0.088	0.123	31	31	62	31	17	30	
5	0.55	0.29	0.40	108.8	73.8	108.8	108.8	0.145	0.201	51	51	93	51	17	30	
10	0.6	0.31	0.43	137.2	93	137.2	137.2	0.199	0.277	70	70	117	70	17	30	
20	0.67	0.35	0.48	168	113.8	168.0	168.0	0.272	0.379	96	96	143	96	17	30	
50	0.83	0.43	0.60	214	145.2	214.0	214.0	0.430	0.598	152	183	183	152	17	30	
100	1	0.52	0.72	254	172.2	254.0	254.0	0.614	0.855	217	217	217	217	17	30	

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
CATCHMENT MAP		MAP	URBAN
Catchment Slope CS	%	> 900mm	Lawn sandy<2%
< 3%	5	0.05	Lawn sandy>7%
3-10 %	90	0.11	Lawn heavy<2%
10 - 30 %	5	0.20	Lawn heavy>7%
> 30 %	0	0.30	Residential single
	100	0.11	Flats/dense townships
Soil Permeability Cp	%		
Very perm (Dunes)	0	0.05	Industry , light
Perm (light soil)	0	0.10	Industry , heavy
Semi (most soils)	100	0.20	Business local
Imperm (rock, paving)	0	0.30	Business CBD
Vegetal growth Cv	%		
Dense bush, forest	0	0.05	Streets/roofs
Cult land, sparse bush	55	0.15	
Grassland	20	0.25	RURAL
Bare Surface	25	0.30	URBAN
Rural Catchment coeff	100	0.21	LAKES
	Ct =	0.52	Cdesign
		100	0.72

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.567	
Dist (m)	r factor
60.00	smooth paving
Slope	clean soil
0.10	sparse grass
	mod grass
	thick bush/gras
	choose r
	0.40
	NOTE: distance used
T overland (mins)	10.80 should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (m)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3g)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5 d^0.5 H^0.55	m/s	H/D>1.28	
									0<h/d<0.8
									H/D>0.8
									0.8<H/D<1.2
									q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9
									0.8>H/D>1.2
									q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5
									h/d>>1.2
									0.2557 q=0.6p^2d^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	
Length L	Depth (of flow)
5	0.20
Q=	0.738
Sharp crested Weir	
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5	
h=height water above datum	h
d=height of weir above datum	d
q=Q/m=	1.00
	0.90
	0.058

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

Grate inlet operating as a orifice at low point-high flow depth			
Flow depth	Length	width	
0.67*A*(2gd)^0.5	0.4	1	0.4
Q=	depth	m3/s	
NB flow depth at least half width or length			

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m	
Material	Concreted 0.012
	earth 0.020
	rock cut 0.025
	Fine gravel 0.024 n0
Irregularity	Coarse gravel 0.028 0.012
	Smooth 0.000
	Minor 0.005
	Moderate 0.010 n1
	Severe 0.020 0.005
Variation in ch	Gradual 0.000
	Alternating Ord 0.005 n2
	Alternating Fre 0.01-0.015 0
Obstructions	Negligible 0.000
	Minor 0.01-0.015
	Appreciable 0.02-0.03 n3
	Severe 0.04-0.06 0
Vegetation	Low 0.005-0.01
	Medium 0.01-0.025
	High 0.025-0.05 n4
	Very high 0.05-0.1 0
Meandering	Minor 1.000
	Appreciable 1.150 m Manning n
	Severe 1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
Descr: lat 29 51 24 long 30 51 37 Area F

Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m ²)	Tc pre (min)	Tc post (mins)
16163.02	15.00	15.0

RI (yrs)	RAIN DATA mm hr				lpre	lpost	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1	area2	area2 alt	area 3	inter y2/y1	inter y2/y1'	
	RI Reduction factor ft	CT PRE d	CT POST d	15	30	15.0	Q PRE										
2	0.5	0.32	0.32	17.4	49.2	17.4	17.4	0.025	0.025	0	0	0	0	0	0	0	15
5	0.55	0.35	0.35	26	73.8	26.0	26.0	0.041	0.041	0	0	0	0	0	0	0	15
10	0.6	0.38	0.38	32.8	93	32.8	32.8	0.055	0.055	0	0	0	0	0	0	0	15
20	0.67	0.42	0.43	40.2	113.8	40.2	40.2	0.076	0.077	0	0	1	0	0	0	0	15
50	0.83	0.52	0.53	51.2	145.2	51.2	51.2	0.120	0.121	1	1	1	1	0	0	0	15
100	1	0.63	0.64	60.8	172.2	60.8	60.8	0.172	0.173	1	1	1	1	0	0	0	15

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
Catchment MAP	MAP	URBAN	%
Catchment Slope CS	% > 900mm	Lawn sandy<2%	0
< 3%	5	Lawn sandy-7%	0.1
3-10 %	15	Lawn heavy<2%	0.1
10 - 30 %	80	Lawn heavy-7%	0.3
> 30 %	0	Residential single	0.5
	100	Flats/dense townships	0.6
Soil Permeability Cp	%	Industry , light	0
Very perm (Dunes)	0	Industry , heavy	0.7
Perm (light soil)	0	Business local	0
Semi (most soils)	100	Business CBD	0.8
Imperm (rock, paving)	0	Streets/roofs	10
	100		100
Vegetal growth Cv	%	AREA WEIGHTING FACTORS	
Dense bush, forest	0	RURAL	0.00
Cult land, sparse bush	0	URBAN	100.00
Grassland	95	LAKES	0
Bare Surface	5	Cdesign	100
Rural Catchment coeff	Ct =		0.6

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = $36(rD/1000)^{0.5}$	
Dist (m)	r factor
65.00	smooth paving 0.02
Slope	clean soil 0.10
0.16	sparse grass 0.30
	mod grass 0.40
	thick bush/grass choose r 0.80
	0.40 NOTE: exceed 20
T overland (mins)	10.04 should not
Velocity (m/s)	0.11 exceed 20

13

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv					n values
INPUT	OUTPUT				
Manning n	0.011	SHAPE	Qunit=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid		0.27	2.74
Width (m)	1.00range			0.27	2.74
Depth (m) not full	0.1	FullBoxCulv		0.18	1.83
path/distance (m)	150	Triangle		0.00	0.02
side slope 1:?	0.001	Gutter		0.00	0.01
pipe dia (m)	0.45	PipeFullCulv		0.53	3.35
NB Pipe is assumed full					

Broad crested Weir Q=1.65LxD1.5	Length L	Depth of flow
	5	0.20
Q=	0.738	
Sharp crested Weir		
$Q=2.303(b+1) + 0.85(x-d)/d \times (2gx^0.5x(h-d)^{1.5})$		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
$\alpha-Q=M$	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth $Q = 1.6 \times (\text{Perimeter}) \times D_{1.5}$

	Flow depth	Length	width
For kerb inlet put width = 0	0.15	2	
Q =	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.

Grate inlet operating as a orifice at low point-high flow depth	
0.67*A*(2gd) ^{0.5}	Flow depth / Length
Q=	0.4 width m3/s
NB flow depth at least half width or length	

5.0285

MAN NING n FOR OPEN CHANNELS		$n = (n_0 + n_1 + n_2 + n_3 + n_4) \times m$
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
Variation in ch	Severe	0.020 0.005
	Gradual	0.000
	Alternating Occ	0.005 n2
Obstructions	Alternating Fre	0.01-0.015 0
	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
Vegetation	Severe	0.04-0.06 0
	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
Meandering	Very high	0.05-0.1 0
	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site:	Klaarwater Station Housing
PRE and POST development	
Descr:	lat 29 53 32 long 30 53 49
Anal. by:	TN Dlamini
Date:	02-May-18

Site Area (m ²)	Tc pre (min)	Tc post (mins)
10632.08	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2/y1 inter y2/y1'							
		CT PRE d	CT POST d	15	30						3	0	0	1	15	30		
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.069	0.072	4	3	6	3	0	0	15	30	
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.113	0.118	5	5	8	5	0	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.156	0.163	6	6	11	6	0	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.213	0.223	9	9	13	9	0	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.336	0.351	14	14	16	14	0	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.481	0.503	20	20	20	20	0	0	0	15	30

DWA METHOD
PRE/RURAL Runoff Coefficient
Catchment MAP
Catchment Slope CS

< 3%

3-10 %

10 - 30 %

> 30 %

Soil Permeability Cp

Very perm (Dunes)

Perm (light soil)

Semi (most soils)

Imperm (rock, paving)

Vegetal growth Cv

Dense bush, forest

Cult land, sparse bush

Grassland

Bare Surface

Rural Catchment coeff

POST/URBAN Runoff Coefficient
URBAN
%

> 900mm

Lawn sandy<2%

Lawn sandy>7%

Lawn heavy<2%

Lawn heavy>7%

Residential single

Flats/dense townships

Industry, light

Industry, heavy

Business local

Business CBD

Streets/roads

LAKES

Cdesign

100

0.30

0.19

0.65

0.70

0.60

0.85

0.95

0.67

0.64

0.67

Tc Rational METHOD "KERBY" FORMULA

$$\text{Overland flow T(mins)} = 36(r/1000)^{0.375} r^{0.625}$$

Dist (m)	r factor
63.00	smooth paving
Slope	clean soil
0.13	sparse grass
	mod grass
	thick bush/gras
	choose r
	NOTE: 0.40 distance used

INPUT		OUTPUT		n values
Manning n	0.011	SHAPE	Quinif-VA	Vel V
Slope (m/m)	0.025	Trapezoid	0.27	2.74 0.912
Width (m)	1.000	rectangle	0.27	earth.018 nat.stream.05
Depth (m) not f	0.1	FullBoxCulv	0.18	1.83 1.366
path/distancce (r)	150	Triangle	0.00	0.02 128.149 asph.016
side slope 1:?	0.001	Gutter	0.00	0.01 203.424 grass.03
pipe dia (m)	0.45	FullPipeCulv	0.53	0.35 0.746 bushy.05

NB Pipe is assumed full

SHORT STEEP BOX CULVERTS
INLET COEFF C
HEAD H (m)

5

span B

0.8

depth D

6.25

H/D > 1.2

Q=2/3CBH(2gH)^{0.5} for H/D<1.2m³/sQ=CBD(2g(H-CD))^{0.5} for H/D>1.2m³/s
SHORT STEEP PIPE CULVERTS <= 250 mm dia
HEAD H

1

DIA D (m)

0.35

slope

0.01

0 < H/D < 0.8

Q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9

0.8 < H/D < 1.2

Q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5

H/D > 1.2

Q=0.255698

q=0.6pi²d²/4sqrt(2gh)
sloped culverts
Broad crested Weir Q=1.65xLxD1.5
Length L

5

Depth (flow)

0.20

Q=

0.738

Sharp crested Weir
q=2/3x(h-0.08)(h-d)/d)x(2xg)0.5x(h-d)^{1/2}

h=height water above datum

h

d

1

0.90

q=Q/m

0.058

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)*D1.5
Flow depth

0.15

Length

2

width

0

Q=

0.186

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.

Grate inlet operating as an orifice at low point-high flow depth
Flow dept

0.4

Length

1

width

0.4

Q=

depth m³/s

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS		n=(n0+n1+n2+n3+n4) x m
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Oct	0.005 n2
	Alternating Fre	0.010-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m
	Severe	1.300 1 0.017

Manning n

0.017

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49
Anal. by: TN Dlamini
Date: 02-May-18

Area H

Site Area (m ²)	Tc pre (min)	Tc post (mins)
9592.21	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1 inter y2'/y1'					
		CT PRE de	CT POST de	15	30						3	5	3	0	0	15
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.062	0.065	3	3	3	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.102	0.107	4	4	4	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.141	0.147	6	6	6	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.192	0.201	8	8	8	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.303	0.317	12	12	12	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.434	0.453	18	18	18	0	0	15	30

DWA METHOD				Tc Rational METHOD "KERBY" FORMULA	
PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient		Overland flow T(mins) = 36(rD/1000/S ^{0.5}) ^{0.467}	
Catchment MAP		URBAN			
Catchment Slope CS		%	> 900mm	Dist (m)	r factor
< 3%	0	0.05	Lawn sandy<2%	62.00	smooth paving 0.02
3-10 %	10	0.11	Lawn sandy>7%	Slope clean soil 0.10	
10 - 30 %	90	0.20	Lawn heavy>2%	0.98 sparse grass 0.30	
> 30 %	0	0.30	Lawn heavy>7%	mod grass 0.40	
	100	0.19	Residential single	thick bush/grass 0.80	
Soil Permeability Cp		%	Flats/dense townships	choose r 0.40	
Very perm (Dunes)	0	0.05	Industry , light	NOTE: distance used	
Perm (light soil)	0	0.10	Industry , heavy	should not	
Semi (most soils)	100	0.20	Business local	exceed 200m	
Imperm (rock, paving)	0	0.30	Business CBD		
	100	0.20	Streets/roofs		
Vegetal growth Cv		%	100	6.44	
Dense bush, forest	0	0.05			
Cult land, sparse bush	0	0.15			
Grassland	100	0.25			
Bare Surface	0	0.30			
Rural Catchment coeff	Ct =	0.64			
	Cdesign	100	0.67		

Tc Rational METHOD "KERBY" FORMULA	
Overland flow T(mins) = 36(rD/1000/S ^{0.5}) ^{0.467}	
Dist (m)	r factor
62.00	smooth paving 0.02
Slope	clean soil 0.10
0.98	sparse grass 0.30
	mod grass 0.40
	thick bush/grass 0.80
	choose r 0.40
T overland (mins)	6.44
Velocity (m/s)	0.16

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv		
INPUT	OUTPUT	n values
Manning n	0.011	SHAPE
Slope (m/m)	0.025	Trapezoid 0.27 2.74 0.912
Width (m)	1.000	rectangle 0.27 2.74 0.912
Depth (m) not fo	0.1	FullBoxCulv 0.18 1.83 1.366
path/distance (m)	150	Triangle 0.00 0.02 128.149
side slope 1:?	0.001	Gutter 0.00 0.01 203.424
pipe dia (m)	0.45	FullPipeCulv 0.53 3.35 0.746
		bushy.05

SHORT STEEP BOX CULVERTS		INLET COEFF C	SHORT STEEP PIPE CULVERTS <= 250 mm dia		0.40
HEAD H (m)	span B	depth D	H/D		sloped culverts
5	0.8	0.80	6.25	0.9	
				1	
				0.35	
				2.857142857	
				0.01	
					0 < h/d < 0.8
					H/D > 0.8 q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9
					0.8 < H/D < 1.2 0.8 > H/D > 1 q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5
					h/d > 1.2 0.255698 q=0.6p*d/4sqrt(2gh)

Broad crested Weir Q=1.65xLxD1.5	
Length L (m)	Depth (of flow)
5	0.20
Q=	0.738
Sharp crested Weir	
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d) ^{1.5}	
h=height water above datum	h
d=height of weir above datum	d
q=Q/m=	0.058

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)*D1.5			
Flow depth	Length	width	
0.15	2	0	
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

Grate inlet operating as a orifice at low point-high flow depth			
0.67*A*(2gd) ^{0.5}	Flow depth	Length	width
Q=	0.4	1	0.4
NB flow depth at least half width or length			

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m	
Material	Concreted 0.012
	earth 0.020
	rock cut 0.025
	Fine gravel 0.024 n0
	Coarse gravel 0.028 0.012
Irregularity	Smooth 0.000
	Minor 0.005
	Moderate 0.010 n1
	Severe 0.020 0.005
Variation in ch	Gradual 0.000
	Alternating Occ 0.005 n2
	Alternating Freq 0.01-0.

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49 Area I
Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m²)	Tc pre (min)	Tc post (mins)
15764.34	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'						
		CT PRE d	CT POST d	15	30						8	4	7	12	9	16	9
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.102	0.107	4	4	4	0	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.168	0.176	7	7	7	0	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.231	0.242	9	9	9	0	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.316	0.330	13	13	13	0	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.499	0.521	20	24	20	0	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.713	0.745	29	29	29	0	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
MAP	URBAN	MAP	URBAN
% > 90mm		Lawn sandy<2%	0 0.08
0 0.05		Lawn sandy>7%	0 0.18
10 0.11		Lawn heavy<2%	0 0.15
90 0.20		Lawn heavy>7%	0 0.30
0 0.30		Residential single	0 0.50
100 0.19		Flats/dense townships	80 0.60
%		Industry , light	0 0.65
0 0.05		Industry , heavy	0 0.70
0 0.10		Business local	0 0.60
100 0.20		Business CBD	0 0.85
0 0.30		Streets/roofs	20 0.95
100 0.20			100 0.67
Ct =	0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.587	
Dist (m)	r factor
120.00	smooth paving 0.02
Slope	clean soil 0.10
0.13	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.80
	choose r 0.40
T overland (mins)	NOTE: distance used
14.04	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (d)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gh)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D<1.2	Q=0.35g^0.5 d^0.5 H^0.55	m/s	H/D>1.28	
						Q=0.43g^0.5 d^0.5 H^0.55	m/s	H/D<1.28	
							0.230128008	H/D>=1.28<4	
Q=CBD(2g(H-CD))^(0.5) for H/D>1.2	m/s								
									0.2557

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49 Area J
Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m²)	Tc pre (min)	Tc post (mins)
12927.48	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'					
		CT PRE d	CT POST d	15	30						area1	area2	area2 alt	area 3	inter y2'/y1'	inter y2'/y1'
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.084	0.088	5	3	7	3	15	30	
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.138	0.144	6	6	10	6	15	30	
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.169	0.198	8	8	13	8	15	30	
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.259	0.271	11	11	16	11	15	30	
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.409	0.427	17	20	20	17	15	30	
100	1	0.64	0.67	254	172.2	254.0	254.0	0.585	0.611	24	24	24	24	15	30	

DWA METHOD

PRE/RURAL Runoff Coefficient	MAP	POST/URBAN Runoff Coefficient	URBAN
Catchment MAP			
Catchment Slope CS	% > 900mm	Lawn sandy<2%	0 0.08
< 3%	0 0.05	Lawn sandy>7%	0 0.18
3-10 %	10 0.11	Lawn heavy<2%	0 0.15
10 - 30 %	90 0.20	Lawn heavy>7%	0 0.30
> 30 %	0 0.30	Residential single	0 0.50
Soil Permeability Cp	%	Filts/dense townships	80 0.60
Very perm (Dunes)	0 0.05	Industry , light	0 0.65
Perm (light soil)	0 0.10	Industry , heavy	0 0.70
Semi (most soils)	100 0.20	Business local	0 0.60
Imperm (rock, paving)	0 0.30	Business CBD	0 0.85
Vegetal growth Cv	%	Streets/roofs	20 0.95
Dense bush, forest	0 0.05		100 0.67
Cult land, sparse bush	0 0.15		
Grassland	100 0.25	RURAL	0.00 0.64
Bare Surface	0 0.30	URBAN	100.00 0.67
Rural Catchment coeff	100 0.25	LAKES	0 0.00
	Ct = 0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.50487	
Dist (m)	r factor
120.00	smooth paving
Slope	clean soil
0.13	sparse grass
	mod grass
	thick bush/gras
	choose r
T overland (mins)	NOTE: distance used
14.04	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (r)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gh)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5 d^0.5 H^0.55	m/s	H/D>1.28	0<h/d<0.8 H/D>0.8
									0.8<H/D<1.2 H/D>0.8
									h/d>>1.2 H/D>1.2 H/D>1.2
									0.2557 q=0.6ph^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

NB flow depth at least half width or length

Flow depth	Length	width
0.67*A*(2gd)^0.5	1	0.4

Q= depth m3/s

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49 Area K
Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m²)	Tc pre (min)	Tc post (mins)
11323.36	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'							
		CT PRE d	CT POST d	15	30						3	3	6	3	0	0	15	30
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.073	0.077	3	3	6	3	0	0	15	30	
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.121	0.126	7	5	9	5	0	0	2	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.166	0.173	10	7	11	7	0	0	3	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.227	0.237	9	9	14	9	0	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.358	0.374	15	18	18	15	0	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.512	0.535	21	21	21	21	0	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
MAP	URBAN	MAP	URBAN
% > 90mm		Lawn sandy<2%	0 0.08
0 0.05		Lawn sandy>7%	0 0.18
10 0.11		Lawn heavy<2%	0 0.15
90 0.20		Lawn heavy>7%	0 0.30
0 0.30		Residential single	0 0.50
100 0.19		Flats/dense townships	80 0.60
%		Industry , light	0 0.65
0 0.05		Industry , heavy	0 0.70
0 0.10		Business local	0 0.60
100 0.20		Business CBD	0 0.85
0 0.30		Streets/roofs	20 0.95
100 0.20			100 0.67
Ct =	0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.50487	
Dist (m)	r factor
173.00	smooth paving 0.02
Slope	clean soil 0.10
	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.80
	choose r 0.40
T overland (mins)	NOTE: distance used
17.96	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (m)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gh)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5*d^0.55 H^0.55	m/s	H/D>1.28	
						Q=0.43g^0.5*d^0.55 H^0.55	m/s	H/D<1.28	
							0.230128008	H/D>=1.28<4	
Q=CBD(2g(H-CD))^(0.5) for H/D>1.2	m/s								
									0.2557

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5	Flow depth	Length	width
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

Grate inlet operating as a orifice at low point-high flow depth	Flow depth	Length	width
0.67*A*(2gd)^0.5	0.4	1	0.4
Q=	depth m3/s		

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49 Areal L
Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m²)	Tc pre (min)	Tc post (mins)
8382.33	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'						
		CT PRE d	CT POST d	15	30						2	2	4	2	0	0	15
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.054	0.057	2	2	4	2	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.089	0.093	4	4	7	4	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.123	0.128	5	5	8	5	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.168	0.176	7	7	10	7	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.265	0.277	11	13	13	11	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.379	0.396	15	15	15	15	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
MAP	URBAN	MAP	URBAN
% > 900mm	Lawn sandy<2%	0	0.08
< 0.05	Lawn sandy>7%	0	0.18
10	Lawn heavy<2%	0	0.15
90	Lawn heavy>7%	0	0.30
0	Residential single	0	0.50
100	Flats/dense townships	80	0.60
%	Industry , light	0	0.65
0	Industry , heavy	0	0.70
0.10	Business local	0	0.60
100	Business CBD	0	0.85
0	Streets/roofs	20	0.95
100		100	0.67
Ct =	0.64	Cdesign	100
			0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.587	
Dist (m)	r factor
55.00	smooth paving
Slope	clean soil
0.16	sparse grass
	mod grass
	thick bush/gras
	choose r
T overland (mins)	NOTE: distance used
9.29	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (m)	150	Triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3g)^0.5 for H/D<1.2	m/s			H/D>1.2	H/D>1.2	Q=0.35g^0.5 H^0.55	m/s	H/D>1.28	0<h/d<0.8 H/D>0.8
Q=CBD(2g(H-CD))^(0.5) for H/D>1.2	m/s			0.6	0.8	0.6	m/s	H/D<1.28	0.8<H/D<1.2 H/D>1.2
				3.616	4.735			H/D>1.28	h/d>>1.2 0.2557

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m	
Material	Concreted 0.012
	earth 0.020
	rock cut 0.025
	Fine gravel 0.024 n0
Irregularity	Coarse gravel 0.028 0.012
	Smooth 0.000
	Minor 0.005
	Moderate 0.010 n1
	Severe 0.020 0.005
Variation in ch	Gradual 0.000
	Alternating Ord 0.005 n2
	Alternating Fre 0.01-0.015 0
Obstructions	Negligible 0.000
	Minor 0.01-0.015
	Appreciable 0.02-0.03 n3
	Severe 0.04-0.06 0
Vegetation	Low 0.005-0.01
	Medium 0.01-0.025
	High 0.025-0.05 n4
	Very high 0.05-0.1 0
Meandering	Minor 1.000
	Appreciable 1.150 m Manning n
	Severe 1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49 Area M
Anal. by: TN Dlamini
Date: 02-May-18

Site Area (m²)	Tc pre (min)	Tc post (mins)
10270.52	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'						
		CT PRE d	CT POST d	15	30						3	3	5	3	0	0	15
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.067	0.070	3	3	5	3	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.109	0.114	4	4	8	4	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.151	0.157	6	6	10	6	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.206	0.215	8	8	13	8	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.325	0.340	13	13	16	13	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	0.464	0.466	19	19	19	19	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
MAP	URBAN	MAP	URBAN
% > 900mm		Lawn sandy<2%	0 0.08
0 0.05		Lawn sandy>7%	0 0.18
10 0.11		Lawn heavy<2%	0 0.15
90 0.20		Lawn heavy>7%	0 0.30
0 0.30		Residential single	0 0.50
100 0.19		Flats/dense townships	80 0.60
%		Industry , light	0 0.65
0 0.05		Industry , heavy	0 0.70
0 0.10		Business local	0 0.60
100 0.20		Business CBD	0 0.85
0 0.30		Streets/roofs	20 0.95
100 0.20			100 0.67
Ct =	0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.5087	
Dist (m)	r factor
44.00	smooth paving 0.02
Slope	clean soil 0.10
0.10	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.80
	choose r 0.40
T overland (mins)	NOTE: distance used
9.30	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (d)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gh)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5*d^0.55 H^0.55	m/s	H/D>1.28	
									0.8<H/D<1.28
									H/D>1.28
									h/d>1.2
									0.2557
									q=0.6ph^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	Length L	Depth (of flow)
	5	0.20
Q=	0.738	
Sharp crested Weir		
q=2/3x(h-d)/d)x(2xg)0.5x(h-d)^0.5		
h=height water above datum	h	d
d=height of weir above datum	1	0.90
q=Q/m=	0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		

NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.

Grate inlet operating as a orifice at low point-high flow depth			
Flow depth	Length	width	
0.67*A*(2gd)^0.5	0.4	1	0.4

Q= depth m3/s

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49
Anal. by: TN Dlamini
Date: 02-May-18

Area N

Site Area (m²)	Tc pre (min)	Tc post (mins)
20459.18	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'						
		CT PRE d	CT POST d	15	30					5	5	11	5	0	0	15
2	0.5	0.32	0.34	72.8	49.2	72.8	0.133	0.139	5	5	11	5	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	0.218	0.228	9	9	16	9	0	0	15	30
10	0.6	0.38	0.40	137.2	93	137.2	0.300	0.313	12	12	20	12	0	0	15	30
20	0.67	0.43	0.45	168	113.8	168.0	0.410	0.429	17	17	25	17	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	0.647	0.676	26	32	32	26	0	0	15	30
100	1	0.64	0.67	254	172.2	254.0	0.925	0.967	38	38	38	38	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient	MAP	POST/URBAN Runoff Coefficient	URBAN
Catchment MAP			
Catchment Slope CS	% > 90mm	Lawn sandy<2%	0 0.08
< 3%	0 0.05	Lawn sandy>7%	0 0.18
3-10 %	10 0.11	Lawn heavy<2%	0 0.15
10 - 30 %	90 0.20	Lawn heavy>7%	0 0.30
> 30 %	0 0.30	Residential single	0 0.50
Soil Permeability Cp	%	Flats/dense townships	80 0.60
Very perm (Dunes)	0 0.05	Industry , light	0 0.65
Perm (light soil)	0 0.10	Industry , heavy	0 0.70
Semi (most soils)	100 0.20	Business local	0 0.60
Imperm (rock, paving)	0 0.30	Business CBD	0 0.85
Vegetal growth Cv	%	Streets/roofs	20 0.95
Dense bush, forest	0 0.05		100 0.67
Cult land, sparse bush	0 0.15		
Grassland	100 0.25	RURAL	0.00 0.64
Bare Surface	0 0.30	URBAN	100.00 0.67
Rural Catchment coeff	100 0.25	LAKES	0 0.00
	Ct = 0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.587	
Dist (m)	r factor
100.00	smooth paving 0.02
Slope	clean soil 0.10
0.13	sparse grass 0.30
	mod grass 0.40
	thick bush/gras 0.80
	choose r 0.40
T overland (mins)	NOTE: distance used
12.89	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (m)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gH)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5d^0.5H^0.55	m/s	H/D>1.28	
									0<h/d<0.8
									0.8>H/D<1.2
									0.8>H/D>1.2
									h/d>>1.2
									0.2557
									q=0.6ph^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	
Length L	Depth (m)
5	0.20
Q= 0.738	
Sharp crested Weir	
q=2/3x(h-d)/d)x(2xg)0.5x(h-d)^0.5	
h=height water above datum	h
d=height of weir above datum	d
q=Q/m= 0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q= 0.186			
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m	
Material	Concreted 0.012
	earth 0.020
	rock cut 0.025
	Fine gravel 0.024 n0
Irregularity	Coarse gravel 0.028 0.012
	Smooth 0.000
	Minor 0.005
	Moderate 0.010 n1
	Severe 0.020 0.005
Variation in ch	Gradual 0.000
	Alternating Ord 0.005 n2
	Alternating Fre 0.01-0.015 0
Obstructions	Negligible 0.000
	Minor 0.01-0.015
	Appreciable 0.02-0.03 n3
	Severe 0.04-0.06 0
Vegetation	Low 0.005-0.01
	Medium 0.01-0.025
	High 0.025-0.05 n4
	Very high 0.05-0.1 0
Meandering	Minor 1.000
	Appreciable 1.150 m Manning n
	Severe 1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49

Anal. by: TN Dlamini

Date: 02-May-18

Area O

Site Area (m²)	Tc pre (min)	Tc post (mins)
25927.10	15.00	15.00

RI (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'								
		CT PRE d	CT POST d	15	30					7	7	14	7	0	0	15	30	
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.168	0.176	7	7	14	7	0	0	15	30	
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.276	0.289	11	11	20	11	0	0	15	30	
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.360	0.397	23	15	26	15	0	0	8	15	30
20	0.67	0.43	0.45	168	113.8	168.0	168.0	0.520	0.543	21	21	32	21	0	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	0.820	0.857	50	40	40	33	0	0	17	15	30
100	1	0.64	0.67	254	172.2	254.0	254.0	1.173	1.226	48	48	48	48	0	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient		POST/URBAN Runoff Coefficient	
CATCHMENT MAP		MAP	URBAN
Catchment Slope CS	% > 90mm	Lawn sandy<2%	0 0.08
< 3%	0 0.05	Lawn sandy>7%	0 0.18
3-10 %	10 0.11	Lawn heavy<2%	0 0.15
10 - 30 %	90 0.20	Lawn heavy>7%	0 0.30
> 30 %	0 0.30	Residential single	0 0.50
Soil Permeability Cp	%	Flats/dense townships	80 0.60
Very perm (Dunes)	0 0.05	Industry , light	0 0.65
Perm (light soil)	0 0.10	Industry , heavy	0 0.70
Semi (most soils)	100 0.20	Business local	0 0.60
Imperm (rock, paving)	0 0.30	Business CBD	0 0.85
Vegetal growth Cv	%	Streets/roofs	20 0.95
Dense bush, forest	0 0.05		100 0.67
Cult land, sparse bush	0 0.15		
Grassland	100 0.25	RURAL	0.00 0.64
Bare Surface	0 0.30	URBAN	100.00 0.67
Rural Catchment coeff	100 0.25	LAKES	0 0.00
	Ct = 0.64	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.58	
Dist (m)	r factor
43.00	smooth paving
Slope	clean soil
0.07	sparse grass
	mod grass
	thick bush/gras
	choose r
T overland (mins)	NOTE: distance used
10.05	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (r)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3g)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5 d^0.5 H^0.55	m/s	H/D>1.28	0<h/d<0.8
									0.8-H/D<1.2
									h/d>>1.2
									Q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9
									Q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5
									Q=0.6pl^2d^2/4sqrt(2gh)
									0.2557

Broad crested Weir Q=1.65LxD1.5	
Length L	Depth (of flow)
5	0.20
Q= 0.738	
Sharp crested Weir	
q=2/3x(0.611+0.08x(h-d)/d)x(2xg)0.5x(h-d)^0.5	
h=height water above datum	h
d=height of weir above datum	d
q=Q/m= 0.058	

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q= 0.186			
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			

NB flow depth at least half width or length

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m	
Material	Concreted 0.012
	earth 0.020
	rock cut 0.025
	Fine gravel 0.024 n0
Irregularity	Coarse gravel 0.028 0.012
	Smooth 0.000
	Minor 0.005
	Moderate 0.010 n1
	Severe 0.020 0.005
Variation in ch	Gradual 0.000
	Alternating Ord 0.005 n2
	Alternating Fre 0.01-0.015 0
Obstructions	Negligible 0.000
	Minor 0.01-0.015
	Appreciable 0.02-0.03 n3
	Severe 0.04-0.06 0
Vegetation	Low 0.005-0.01
	Medium 0.01-0.025
	High 0.025-0.05 n4
	Very high 0.05-0.1 0
Meandering	Minor 1.000
	Appreciable 1.150 m Manning n
	Severe 1.300 1 0.017

5.02857

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Nov 06

Site: Klaarwater Station Housing
PRE and POST development
lat 29 53 32 long 30 53 49
Anal. by: TN Dlamini
Date: 02-May-18

Area P

Site Area (m²)	Tc pre (min)	Tc post (mins)
32953.80	15.00	15.00

Ri (yrs)	RI Reduction factor ft	RAIN DATA mm hr		Ipre	Ipost	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1 area2 area2 alt area 3 inter y2'/y1' inter y2'/y1'							
		CT PRE d	CT POST d	15	30						11	11	22	11	0	0	0	15
2	0.5	0.32	0.34	72.8	49.2	72.8	72.8	0.211	0.223	11	11	22	11	0	0	0	15	30
5	0.55	0.35	0.37	108.8	73.8	108.8	108.8	0.347	0.367	27	18	33	18	0	0	9	15	30
10	0.6	0.38	0.40	137.2	93	137.2	137.2	0.477	0.505	25	25	41	25	0	0	0	15	30
20	0.67	0.42	0.45	168	113.8	168.0	168.0	0.653	0.690	34	34	51	34	0	0	0	15	30
50	0.83	0.53	0.56	214	145.2	214.0	214.0	1.030	1.089	53	53	64	53	0	0	0	15	30
100	1	0.63	0.67	254	172.2	254.0	254.0	1.473	1.558	76	76	76	76	0	0	0	15	30

DWA METHOD

PRE/RURAL Runoff Coefficient	MAP	POST/URBAN Runoff Coefficient	URBAN
Catchment MAP			
Catchment Slope CS	% > 900mm	Lawn sandy<2%	0 0.08
< 3%	5 0.05	Lawn sandy>7%	0 0.18
3-10 %	10 0.11	Lawn heavy<2%	0 0.15
10 - 30 %	85 0.20	Lawn heavy>7%	0 0.30
> 30 %	0 0.30	Residential single	0 0.50
Soil Permeability Cp	%	Filts/dense townships	80 0.60
Very perm (Dunes)	0 0.05	Industry , light	0 0.65
Perm (light soil)	0 0.10	Industry , heavy	0 0.70
Semi (most soils)	100 0.20	Business local	0 0.60
Imperm (rock, paving)	0 0.30	Business CBD	0 0.85
Vegetal growth Cv	%	Streets/roofs	20 0.95
Dense bush, forest	0 0.05		100 0.67
Cult land, sparse bush	15 0.15		
Grassland	55 0.25	RURAL	0.00 0.63
Bare Surface	30 0.30	URBAN	100.00 0.67
Rural Catchment coeff	100 0.25	LAKES	0 0.00
	Ct = 0.63	Cdesign	100 0.67

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = 36(rD/1000S)^0.50487	
Dist (m)	r factor
45.00	smooth paving
Slope	clean soil
0.07	sparse grass
	mod grass
	thick bush/gras
	choose r
T overland (mins)	NOTE: distance used
10.26	should not exceed 200m
Velocity (m/s)	

Q, Vel, Time of concentration - defined watercourse/open channel/pipeline/box culv					
INPUT	OUTPUT	n values			
Manning n	0.011	SHAPE	Quinf=VA	Vel V	Tc mins
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912
Width (m)	1.000	rectangle	0.27	2.74	0.912
Depth (m) not 1	0.1	FullBoxCulv	0.18	1.83	1.366
path/distance (d)	150	triangle	0.00	0.02	128.149
side slope 1:?	0.001	Gutter	0.00	0.01	203.424
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746
					NB Pipe is assumed full

SHORT STEEP BOX CULVERTS		INLET COEFF C		SHORT STEEP PIPE CULVERTS <= 250 mm dia				sloped culverts	
HEAD H (m)	span B	depth D	H/D	SQUARE E	ROUND	HEAD H	DIA D (m)	H/D	slope
5	0.8	0.80	6.25	0.9	1.0	1	0.35	2.857142857	0.01
Q=2/3CBH(2/3gH)^0.5 for H/D<1.2	m/s								
				H/D>1.2	H/D>1.2	Q=0.35g^0.5*d^0.5*H^0.55	m/s	H/D>1.28	0<h/d<0.8
									H/D>0.8
									0.8<H/D<1.2
									0.8>H/D>1.2
									h/d>>1.2
									0.2557
									q=0.6p^0.5*d^2/4sqrt(2gh)

Broad crested Weir Q=1.65LxD1.5	
Length L	Depth (of flow)
5	0.20
Q=	0.738
Sharp crested Weir	
q=2/3x(h-d)/d)x(2xg)0.5x(h-d)^0.5	
h=height water above datum	h
d=height of weir above datum	d
q=Q/m=	1 0.90
	0.058

Grate inlet (or kerb inlet) operating as a weir at a low point-with low flow depth Q=1.6*(Perimeter)^D1.5			
Flow depth	Length	width	
For kerb inlet put width = 0	0.15	2	0
Q=	0.186		
NB flow depth assumed max of 0.5 width/length and less than kerb inlet height/opening.			


Grate inlet operating as a orifice at low point-high flow depth			
Flow depth	Length	width	
0.67*A*(2gd)^0.5	1	0.4	0.4


5.02857

MAN NING n FOR OPEN CHANNELS n=(n0+n1+n2+n3+n4) x m		
Material	Concreted	0.012
	earth	0.020
	rock cut	0.025
	Fine gravel	0.024 n0
Irregularity	Coarse gravel	0.028 0.012
	Smooth	0.000
	Minor	0.005
	Moderate	0.010 n1
	Severe	0.020 0.005
Variation in ch	Gradual	0.000
	Alternating Ord	0.005 n2
	Alternating Fre	0.01-0.015 0
Obstructions	Negligible	0.000
	Minor	0.01-0.015
	Appreciable	0.02-0.03 n3
	Severe	0.04-0.06 0
Vegetation	Low	0.005-0.01
	Medium	0.01-0.025
	High	0.025-0.05 n4
	Very high	0.05-0.1 0
Meandering	Minor	1.000
	Appreciable	1.150 m Manning n
	Severe	1.300 1 0.017

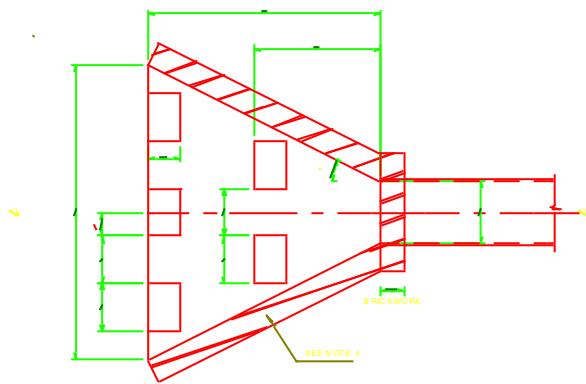
APPENDIX 2

Layout Plan Showing Catchment Areas

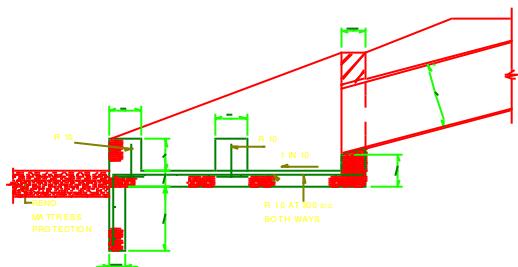




HEADWALL DETAILS



PLAN OF TYPES 'A' AND 'B' HEADWALLS



TYPE 'B' HEADWALL WHERE PIPE GRADE IS GREATER THAN 20% (1:5)