Appendix D

Overland Flowpath Assessment

OVERLAND FLOWPATH ASSESSMENT

FOR

BENTLEY STUDIOS LTD.

96 BEACH HAVEN ROAD/13 CRESTA AVENUE

BEACH HAVEN

Job Number: 200626-01 **Issue Date:** 16 June 2022

Document Control Record

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Quality Assurance Statement		
		Signature
Prepared by:	Natalie Naidoo	

Revision Schedule				
Rev. No	Date	Description	Prepared by	Approved by
0	6.09.2021	Draft Issue	NNN	MW
1	27.09.2021	Resource Consent Issue	NNN	MW
2	16.06.2022	Resource Consent Issue – RC RFI	NNN	MW

Contents

1. INTRODUCTION

Airey Consultants Ltd have been engaged to undertake an overland Flowpath assessment in support of a Resource Consent for the proposed development at 96 Beach Haven Road and 13 Cresta Avenue, Beach Haven. The client wishes to construct 81 new units under a unit title subdivision.

2. AUCKLAND GIS DATA

2.1 Location

The subject site comprises of the following two parcels of land totalling 7,147.00m².

Existing site elements	
Site address	• 96 Beach Haven Road and 13 Cresta Avenue
Legal description	• Lot 1 and Lot 2 DP 157383
Current Land Use	• Residential – Single Housing Zone
Current building coverage	• 338.00m² (4.73%)
Historical Land Use	• Residential

Figure 1. Aerial view of Subject Site – Council Geomaps

2.2 Topography

The subject site slopes in a Northerly direction towards 29 Cresta Avenue, with gradients ranging from 4% in the central portion of the site, to approximately 6% towards the Northern section of the site.

A 100-year overland Flowpath is present within the site currently flowing along a depression on the Western side of the site and thereafter exiting into the property at 15 Cresta Avenue.

3. DISCUSSIONS

Council GIS Indicates that there is an overland flow path traversing the site, along the western boundary of 96 Beach Haven Road. Following a site visit and a desktop Flood Assessment, it is apparent the overland flow path is a local feature originating in 92 Beach Haven Road, immediately upstream of the subject site. It is concluded that the overland flow path can easily be accommodated down the western boundary within the proposed development.

3.1 1 Percent AEP event

The proposal will lead to a small increase in peak runoff flow rates during the 1% AEP storm. Our calculations show that the 1% storm event can easily be catered for within the proposed development. Currently, overland flow from the 1% AEP storm event exits the site at the lowest point in the north west corner, and follows the topography in a Northward Direction through 15 Cresta Avenue. From there the overland flow continues in a Northerly direction on through a number of properties on Cresta Avenue before discharging into the Waitemata Harbour.

3.2 Overland Flowpath Management

An overland Flowpath has been identified on Auckland Council GIS entering the site at the Southern Boundary, traversing along the Western Boundary and exiting the site at the North West Boundary.

Following a site visit and a review of the topography of the area, it has been established that the overland Flowpath does behave in the manner as presented on GIS. The following table is a summary of the pre-development and post development flows:

Cross Section	Q100 Pre-development m3/s	Q100 Post Development m3/s	Flood Depth Pre-Development (mm)	Flood Depth Post Development (mm)	Velocity Pre-Development (m/s)	Velocity Post-Development (m/s)
A-A	0.444	0.457	130	150	2.166	1.738
B-B	0.444	0.457	130	150	2.257	1.785
C-C	*0.444*	*0.457*	*130*	*100*	*2.201*	*3.027*
No. 15 Cresta Avenue	0.525	0.532	180	190	0.738	0.783
No. 17 Cresta Avenue	0.619	0.650	280	290	0.844	0.859

We have assessed the catchment from the Auckland Council GIS records. We note as per our attached catchment plan, there is a small area of the site that currently discharges to the North East that has not been included in our calculations. This is a very minor catchment and will have very little effect on the calculations completed to date.

Several cross sections of the overland flowpath were developed along the western boundary of the proposed development and within the properties of No.15 and No. 17 Cresta Avenue, per enclosed Section Plan. This was to determine the flood levels in the post development scenario.

The overland flow path is through generally well-maintained grassed areas through the site and traverses through the properties of No. 15 and No. 17 Cresta Avenue. The design has been based on a Manning's co-efficient of 0.03 for the well-maintained grass areas, and a co-efficient of 0.1 for the downstream properties based on the Auckland Council Stormwater Code of Practice.

Based on the 100yr Overland Flow, all cross sections indicate a minimal increase in the water levels along the overland flow path in the post development scenario. The maximum flood depth increase is circa 20mm. These changes in the overland flow behaviour will not cause any adverse effect to downstream properties of No. 15 and No. 17 Cresta Avenue. These changes in the overland flow behaviour will be minor and not cause any adverse flood effects to downstream properties as the flow in the post development scenario will be contained with thein the current pathway as reflected on Auckland Council Geomaps. It is anticipated that there will be insignificant risk increase to the downstream properties.

A grassed conveyance channel is proposed within the site of the proposed development to accommodate for the 100yr Overland Flow. Due to the low flows, this will be more of a localised small depression in the grass surface. The channel will discharge into a scruffy dome manhole

located at the low point of the site. The scruffy dome will outlet into the existing public network. This is primarily to remove the overland flow from discharging over the proposed retaining wall at the intersection of 15 Cresta Avenue. There is sufficient capacity in the 750mm diameter stormwater line at this location. The 750mm SW line decreases to a 400mm diameter line at the boundary of 17 Cresta Avenue and a cesspit is located there which will allow the flood flows to bubble up to the surface again should the pipe capacity be exceeded. This is considered to be the same philosophy adopted previously given the current configuration of the change in SW lines through the development, so it matched with what is currently happening in the area.

4. CONCLUSION

We have assessed the proposed development against the activity table (Table E36.4.1) of the Auckland Unitary Plan (E36). The overland flowpath with maximum flood depth of 150mm will be rerouted with the same entry and exit points around the buildings for provision of future platform construction. Having assessed the table, we confirm the proposed development with the activity rules under Activities in the 1% AEP floodplain and Activities in overland flowpaths.

For development in proximity to flood areas, finished floor levels for habitable space (or vulnerable activities) and inhabitable space (or less vulnerable activities) must be at least 500mm and 300mm, respectively, above the 1 in 100-year flood level in accordance with Auckland Council Code of Practice for Land Development and Subdivision or 150mm if the flood depth is less than or equal to 100mm according to the New Zealand Building Code E1 – Surface Water.

For the proposed development at 96 Beach Haven Road and 13 Cresta Avenue, we propose the following minimum finished floor levels (MFFL) which provides ample protection above the flood water:

Unit	Minimum Freeboard (m) Habitable Space	MFFL (RL)
Block A	0.500	20.55 (20.05+0.500)
Block B	0.500	22.05 (21.55+0.500)
Block C	0.500	22.05 (21.55+0.500)
Block D	0.500	24.05 (23.55+0.500)

The overland flow path area shall be protected by registered easements in favour of Auckland Council in areas (as shown on Drawing No. 200626/01 – RC105) where the peak flow through the site is in excess of 100 l/s for the 1 in 100-year storm event. This complies with the Auckland Council Code of Practice for Land Development and Subdivision.

We request Auckland Council review the enclosed documentation and approve the proposal. Please find our assessment calculations enclosed in the Appendix.

Report prepared by	Reviewed and approved by
	
Natalie Naidoo	**Michael Williams**
Senior Civil Engineer	**Director**
MEngNZ	**CPEng (NZ), CMEngNZ, BE (Civil, Structural)**

Appendix A

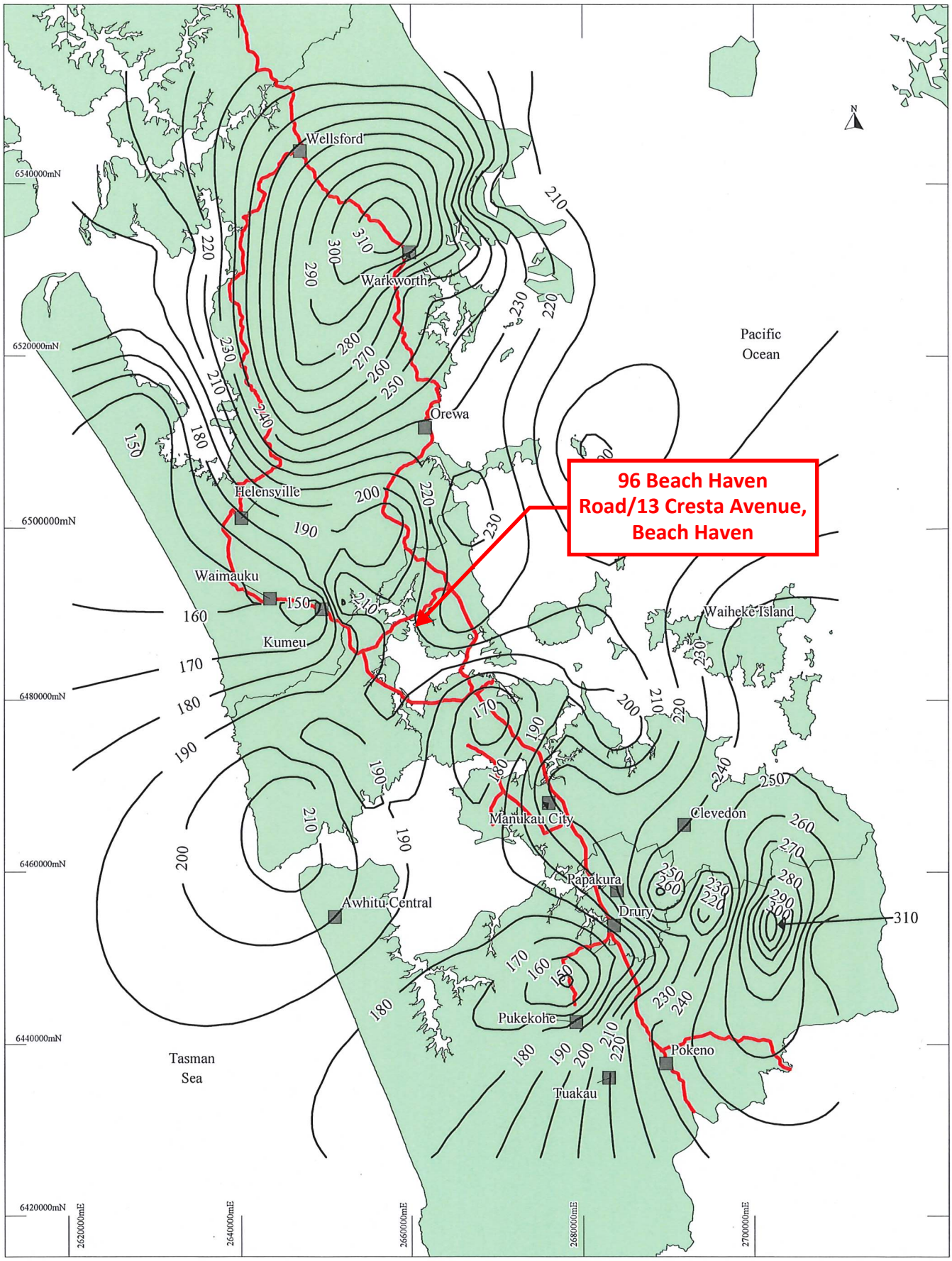
Overland Flow Path Design Calculations

OVERLAND FLOWPATH ASSESSMENT

Job: 200626/01

Location: 96 Beach Haven Road/13 Cresta Avenue, Beach Haven

Client	**Bentley Studios Ltd.**
Job No	200626/01
Date	27/09/2021
Design Engineer	Natalie Naidoo
Contact Phone	(09) 534 6523
Email	natalien@aireys.co.nz



A

Auckland *Regional* Council

Legend: — 90 — Rainfall Contour (mm)

State Highways

Figure A.6
100 Year ARI
Daily Rainfall Depth

Scale: 1:600,000 (at A4)
(Revised 25/08/1999)

Workspace: N:(civil)\25\2507757\gis\mapinfo\work\100yrari.wor Date: 25/08/1999

AIREY CONSULTANTS LTD.

TP108 Rainfall - Overland Flowpath

Job location: 96 Beach Haven Road/13 Cresta Avenue, Beach Haven

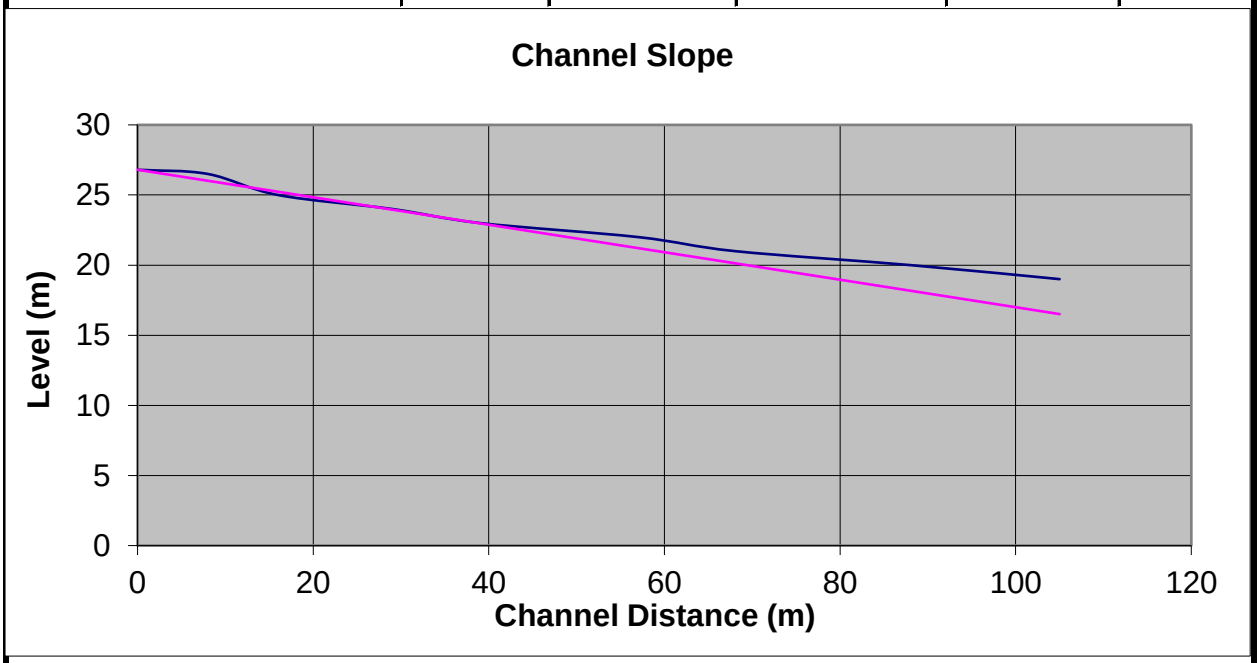
Rainfall Depth	210	mm
ARI	100	years

Duration hr	**Duration** mins	**Depth** mm	**Intensity** mm/hr (Q_{10})
0.166	10.0	28.26	170.22
0.333	20.0	43.45	130.49
0.5	30	53.59	107.19
1	60	75.55	75.55
2	120	102.04	51.02
6	360	156.00	26.00
12	720	200.15	16.68
24	1440	**245.28**	10.30
48	2880	494.48	10.30
72	4320	741.73	10.30

Job	96 Beach Haven Road/13 Cresta Avenue, Beach Haven
Job No	200626-01
Designer	Natalie Naidoo
Date	6/08/2021

SLOPE CALCULATIONS - EQUAL AREA METHOD - TP10

Description	Level (m)	Incremental distance (m)	Running distance (m)	"Area" from TP108	Average Slope Level
Inlet point	26.8	0	0		27
	26.5	8	8	213.2	26
	25	8	16	206	25
	24	13	29	318.5	24
	23	10	39	235	23
	22	18	57	405	21
	21	11	68	236.5	20
	20	16	88	328	18
	19	17	105	331.5	17
			105	0	17
			105	0	17
			105	0	17
			105	0	17
			105	0	17
Channel length (m)			**105**	2273.7	
Average Channel Slope	**-0.09801**				



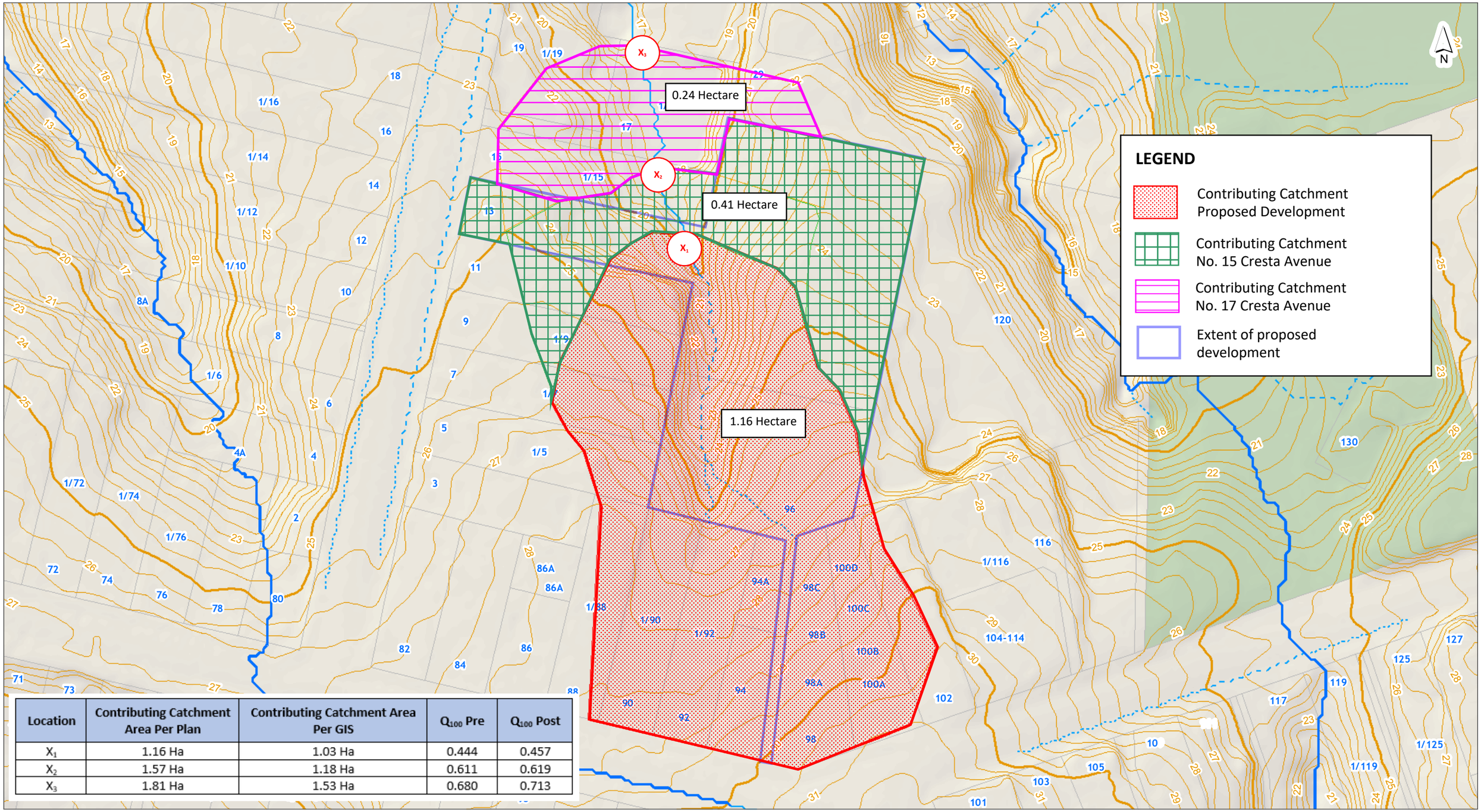
Overland Flowpath Cross Sections

0 10 20 30
Meters

Scale @ A3
= 1:1,000

Date Printed:
16/07/2021

Auckland Council
Te Kaunihera o Tāmaki Makaurau



Location	Contributing Catchment Area Per Plan	Contributing Catchment Area Per GIS	Q_{100} Pre	Q_{100} Post
X_1	1.16 Ha	1.03 Ha	0.444	0.457
X_2	1.57 Ha	1.18 Ha	0.611	0.619
X_3	1.81 Ha	1.53 Ha	0.680	0.713

Overland Flowpath Catchment Plan

0 10 20 30
Meters

Scale @ A3
= 1:1,000

Date Printed:
4/08/2021

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Hydrographs- SCS Method - Predevelopment flow from Proposed Development

Project Description

96 Beach Haven Road/13 Cresta Avenue
Beach Haven

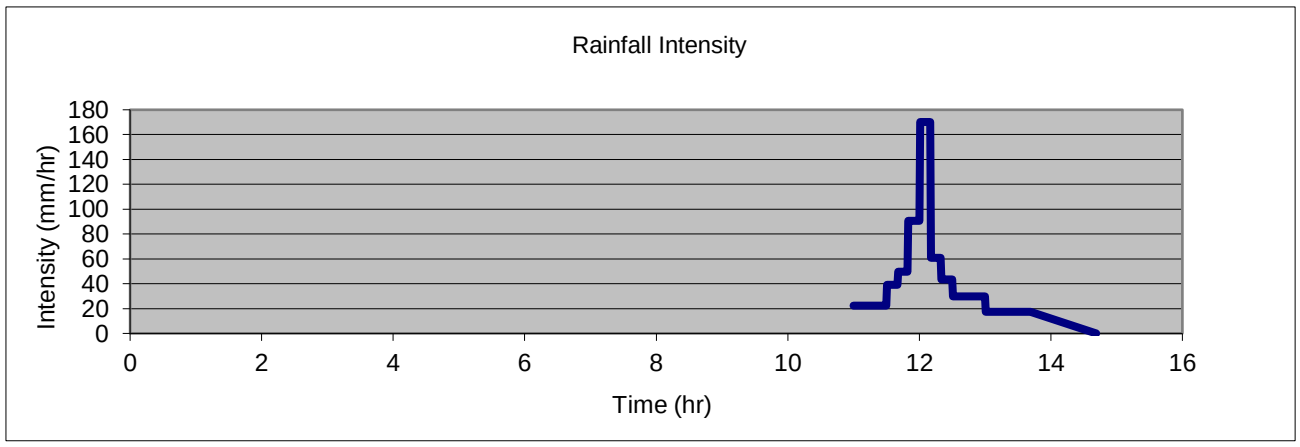
Rainfall Depth (mm) 245.28 100 YEAR ARI

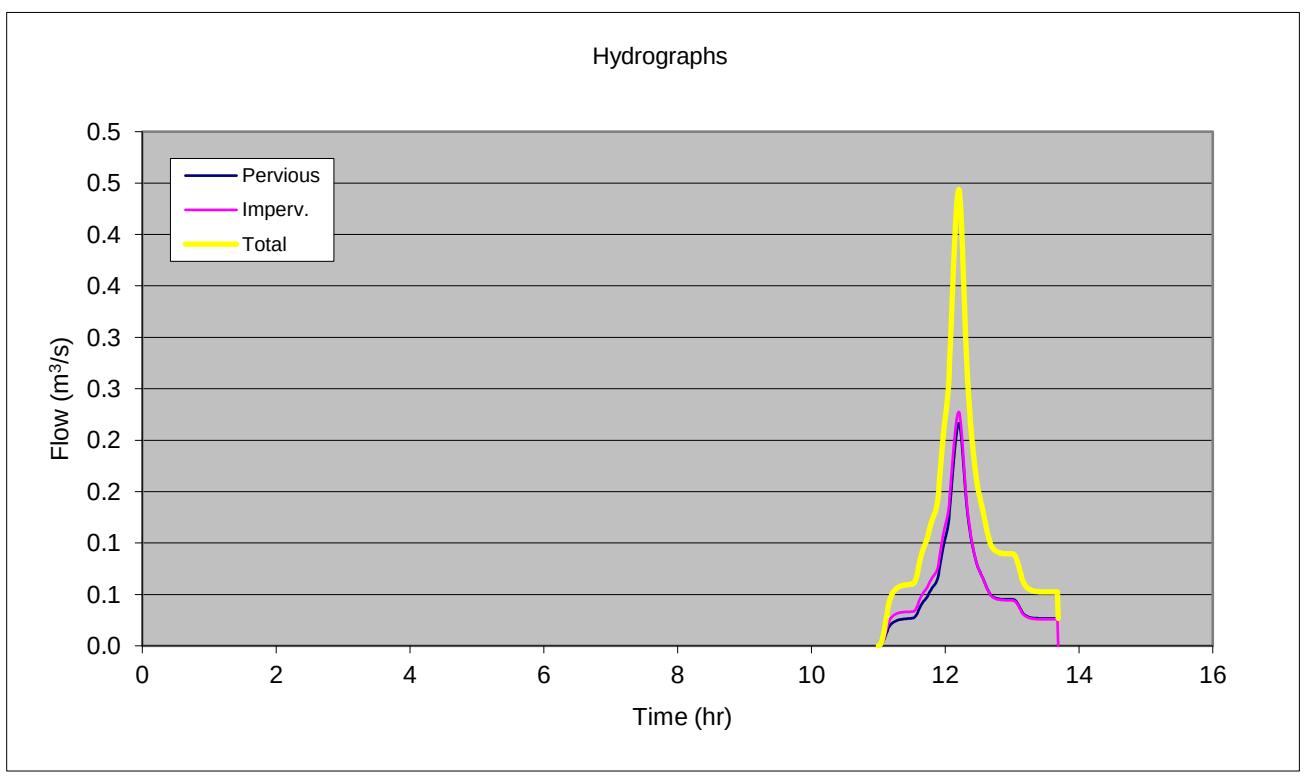
Notes:

1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.6264	0.5336
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	101	101
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	205.1
Peak Flow (m^3/s)	0.216	0.228	0.444
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.83
Runoff Coefficient - Volume	0.71	0.98	0.84





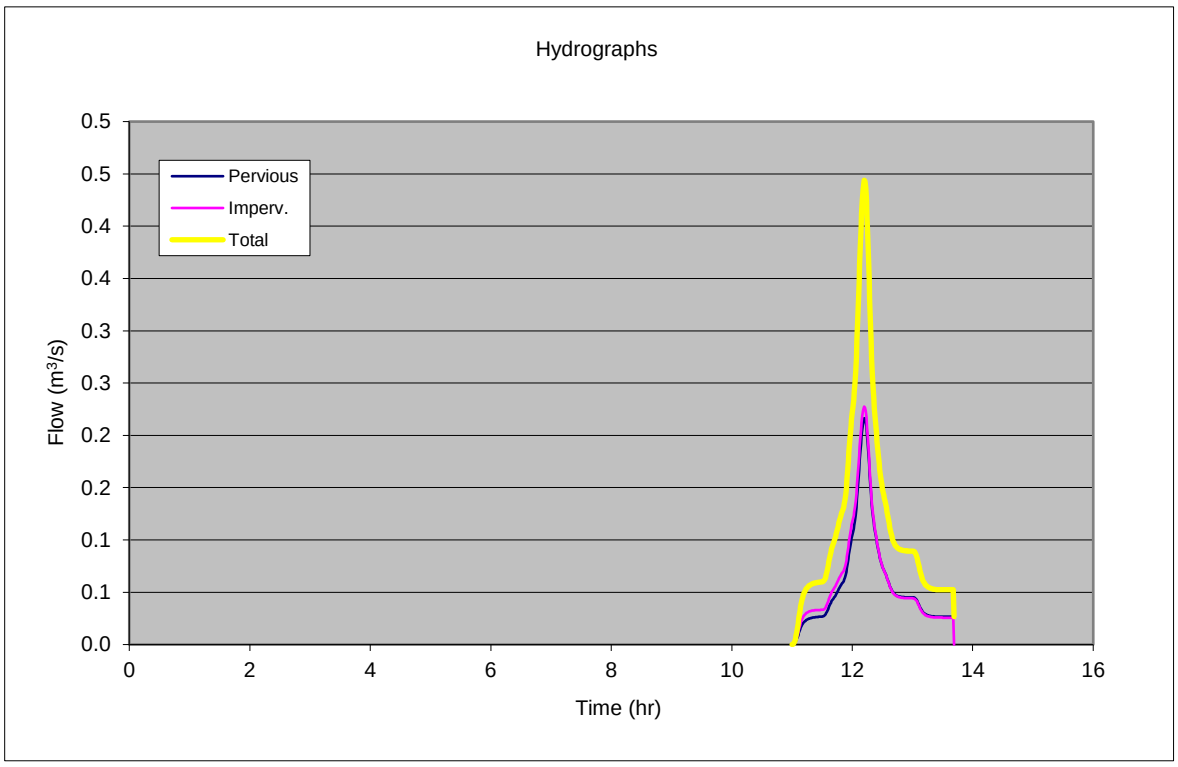
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue
Beach Haven

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.70%



Time (hr)	Flow (m^3/s)
11.001	0.000
11.347	0.058
11.491	0.060
11.601	0.076
11.694	0.098
11.776	0.115
11.850	0.130
11.918	0.161
11.981	0.210
12.040	0.246
12.096	0.320
12.150	0.403
12.201	0.444
12.230	0.430
12.259	0.387
12.290	0.330
12.320	0.278
12.352	0.240
12.384	0.214
12.417	0.191
12.451	0.170
12.486	0.154
12.522	0.143
12.559	0.133
12.597	0.121
12.637	0.108
12.678	0.099
12.721	0.094
12.767	0.092
12.814	0.090
12.864	0.090
12.917	0.089
12.975	0.089
13.037	0.088
13.106	0.075
13.184	0.060
13.277	0.054
13.398	0.053
13.690	0.027
-1.000	0.000

Hydrographs- SCS Method - Post Development Flow from the Proposed Development

Project Description

96 Beach Haven Road/13 Cresta Avenue
Proposed Development

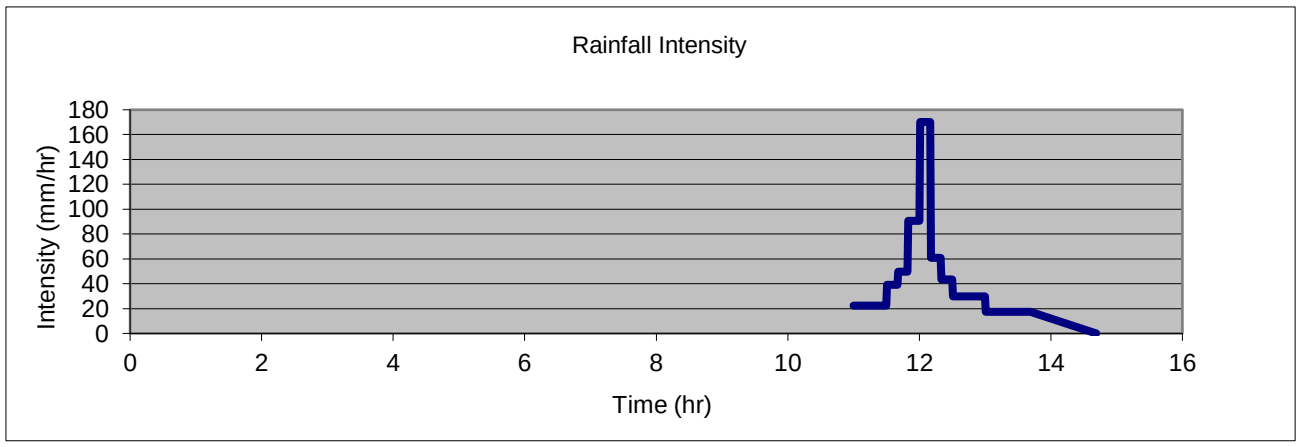
Rainfall Depth (mm) 245.28 100 YEAR ARI

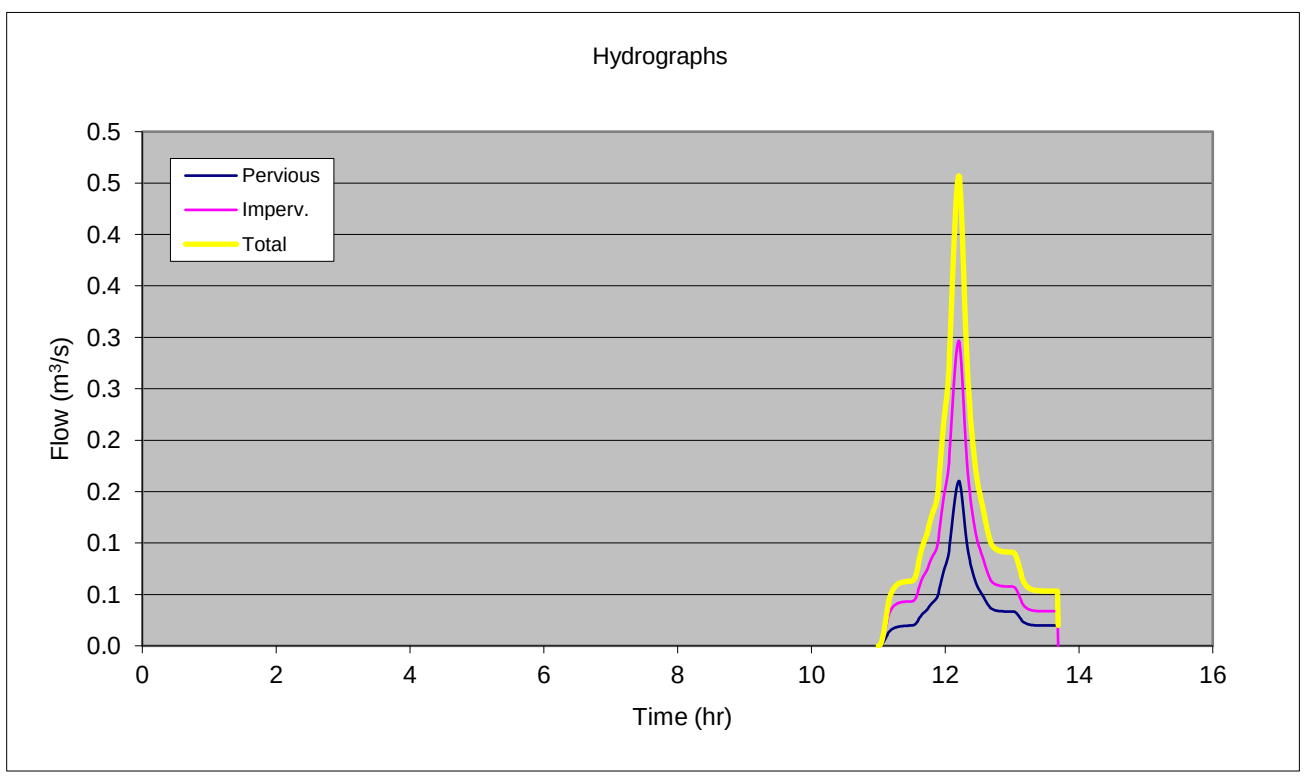
Notes:

1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.464	0.696
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	101	101
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m^3/s)	0.160	0.297	0.457
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
Runoff Coefficient - Volume	0.71	0.98	0.87





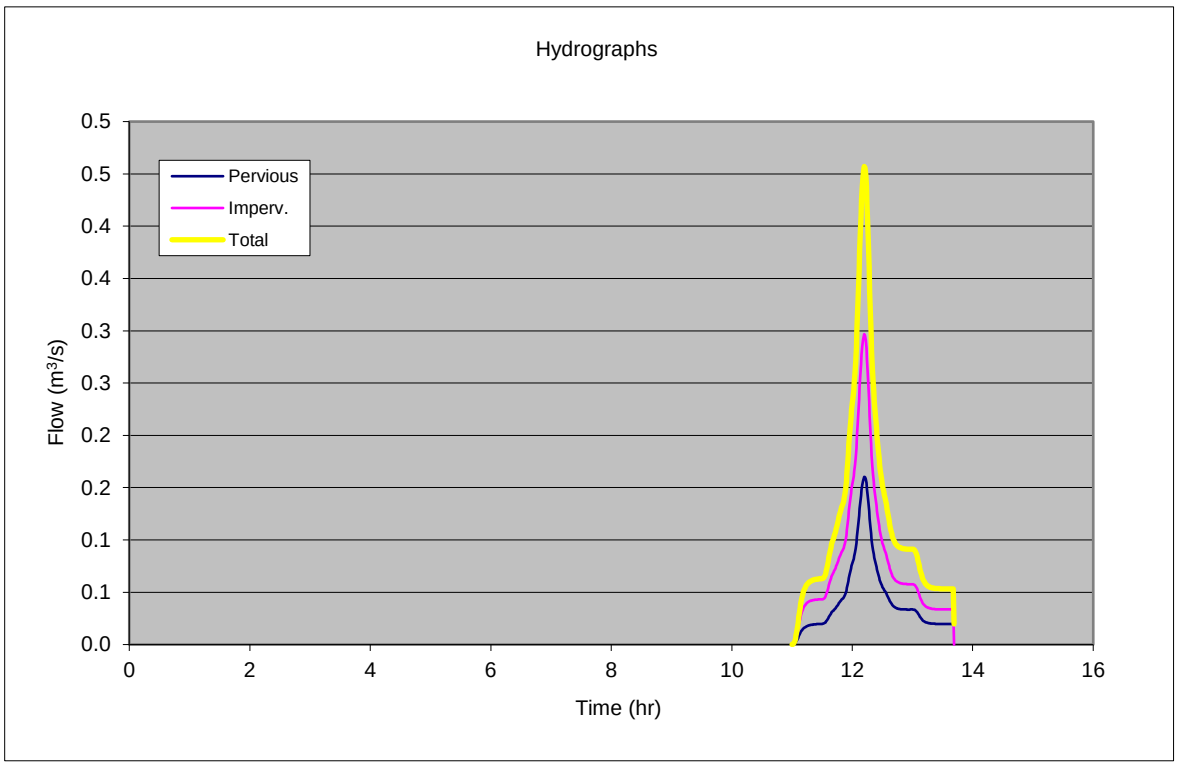
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue
Proposed Development

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr)
11.001
11.347
11.491
11.601
11.694
11.776
11.850
11.918
11.981
12.040
12.096
12.150
12.201
12.230
12.259
12.290
12.320
12.352
12.384
12.417
12.451
12.486
12.522
12.559
12.597
12.637
12.678
12.721
12.767
12.814
12.864
12.917
12.975
13.037
13.106
13.184
13.277
13.398
13.690
-1.000

CHANNEL CAPACITY SECTION PRE-DEVELOPMENT A-A

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	6.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.444
Case B	
Slope (S_o)	10%
Water level (m)	23.53
MFFL	23.68

0.13

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	23.7	0.03		Short Grass
0.5	23.5	0.03		Short Grass
1	23.4	0.03		Short Grass
2	23.4	0.03		Short Grass
2.5	23.50	0.03		Short Grass
3	23.7	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

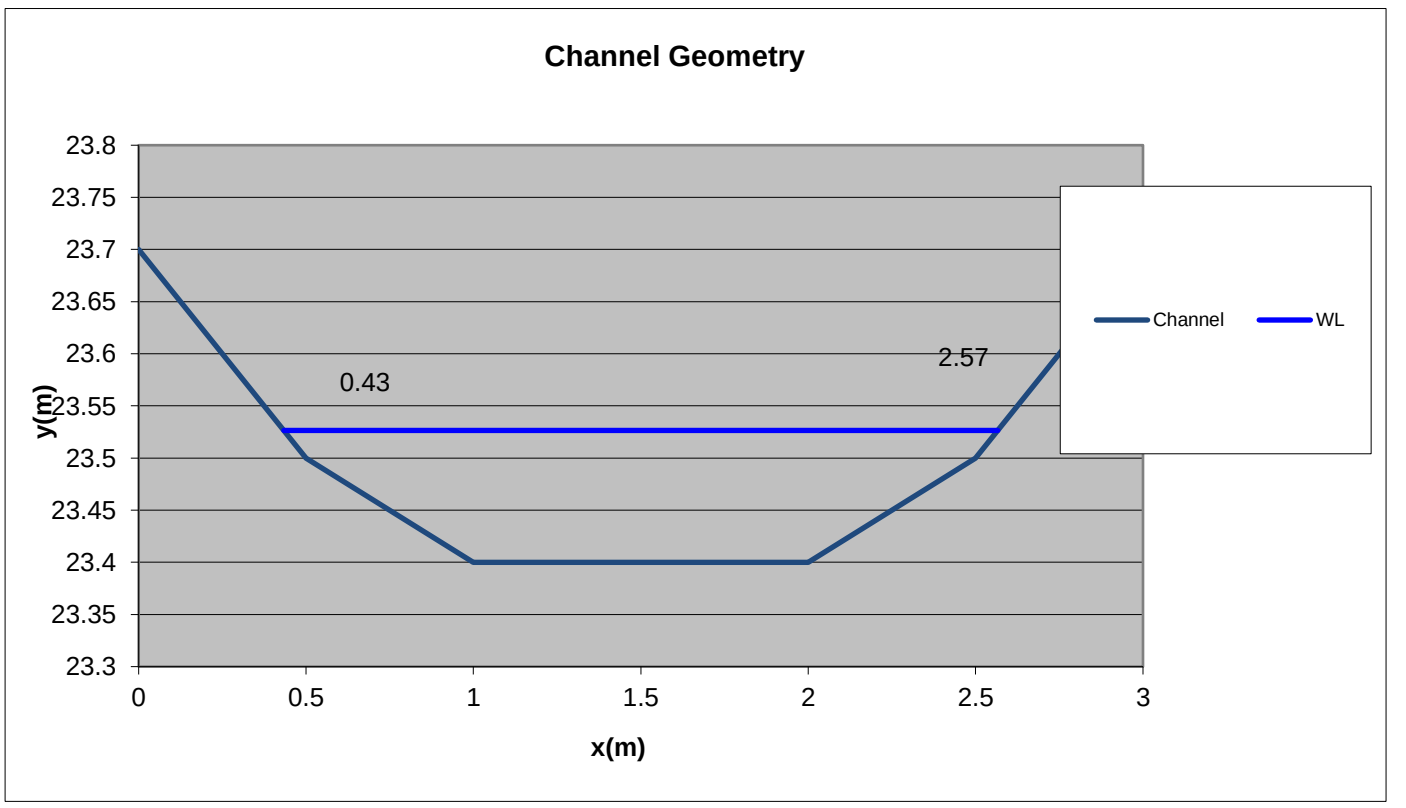
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.445** OK
Velocity (m/s)	2.173
S_o or S_f	0.1000
Energy (m)	23.767
Froude No	2.239
Bed Stress (Pa)	92.885
Equivalent "n"	0.030
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	23.527
Area (A-m^2)	0.205
Width (B-m)	2.132
Perimeter (P-m)	2.163

Critical Flow Conditions	
Flow (m^3/s)	**0.199** INCREASE CHA
Velocity (m/s)	0.971
Energy (m)	23.575

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



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CHANNEL CAPACITY SECTION POST DEVELOPMENT A-A

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	5.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.457
Case B	
Slope (S_o)	5%
Water level (m)	23.55
MFFL	23.70

0.15

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	23.7	0.03		Short Grass
0.5	23.5	0.03		Short Grass
1	23.4	0.03		Short Grass
2	23.4	0.03		Short Grass
2.5	23.49	0.03		Short Grass
3	23.7	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

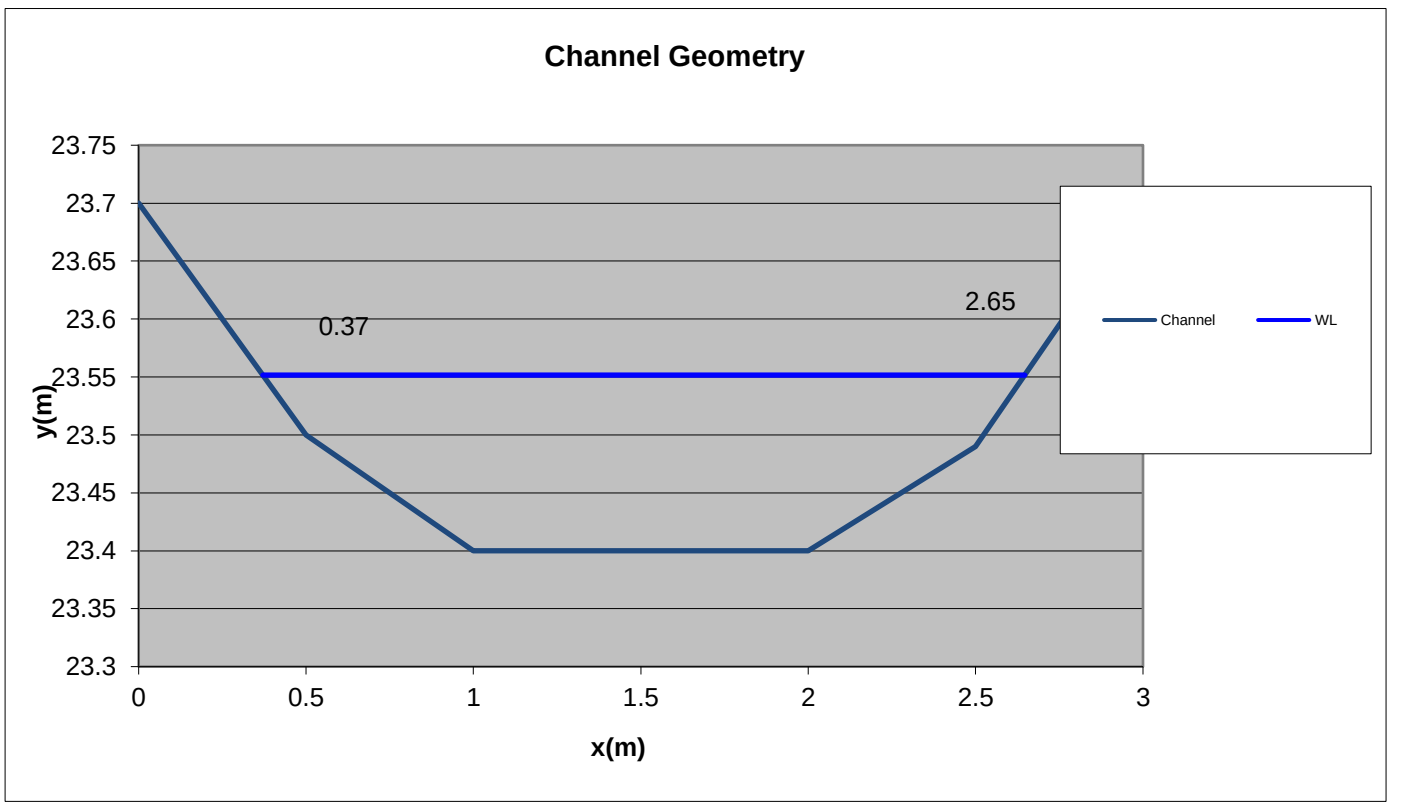
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.458** OK
Velocity (m/s)	1.738
S_o or S_f	0.0500
Energy (m)	23.705
Froude No	1.630
Bed Stress (Pa)	55.817
Equivalent "n"	0.030
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	23.552
Area (A-m^2)	0.264
Width (B-m)	2.276
Perimeter (P-m)	2.316

Critical Flow Conditions	
Flow (m^3/s)	**0.281** INCREASE CHA
Velocity (m/s)	1.066
Energy (m)	23.610

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



AIREY CONSULTANTS LTD.

CHANNEL CAPACITY SECTION PRE-DEVELOPMENT B-B

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	6.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B): B

Case A

Flow (m^3/s): 0.444

Case B

Slope (S_o): 10%

Water level (m): 21.53 | 0.13

MFFL: 21.68

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	22	0.03		Short Grass
0.5	21.5	0.03		Short Grass
1	21.4	0.03		Short Grass
2	21.4	0.03		Short Grass
2.5	21.50	0.03		Short Grass
3	22	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

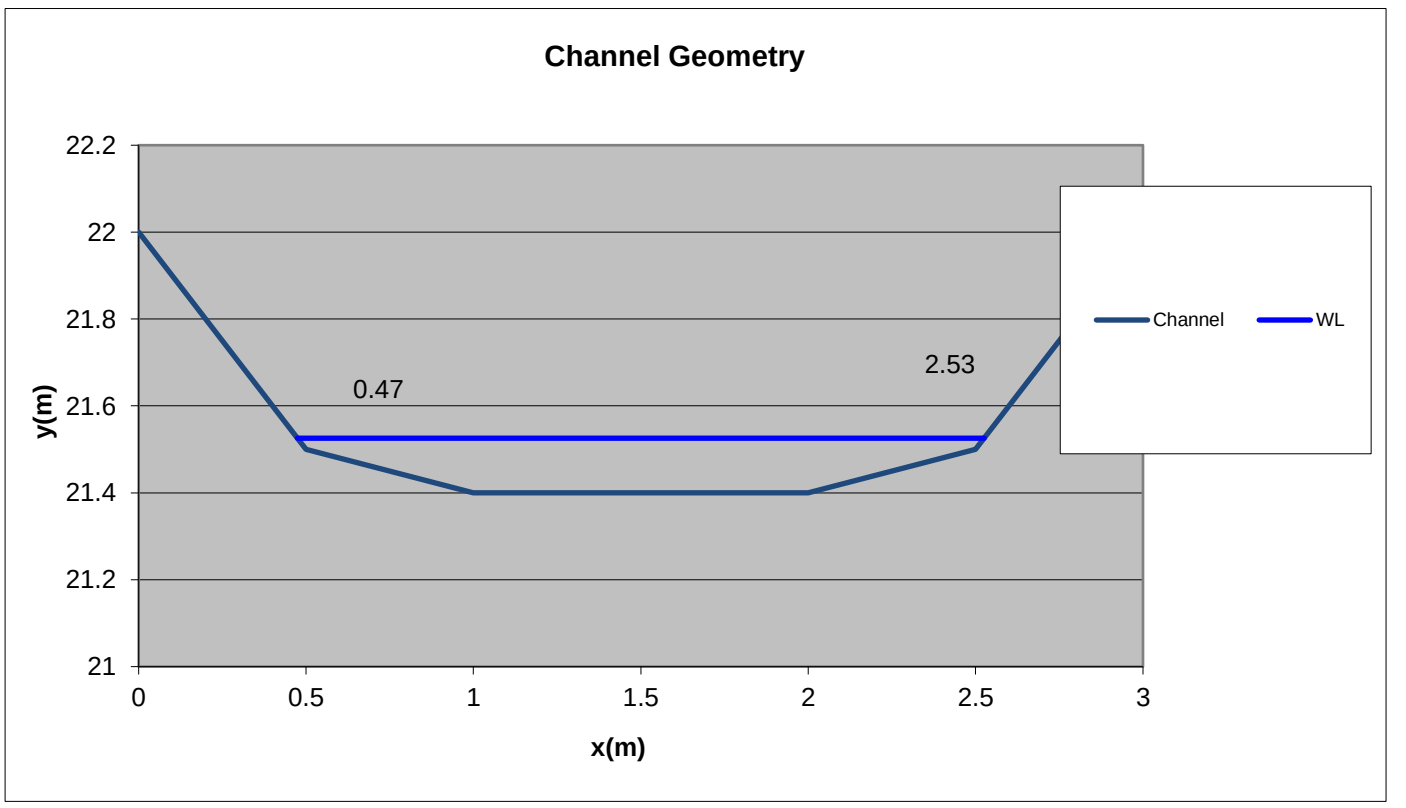
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.445** OK
Velocity (m/s)	2.201
S_o or S_f	0.1000
Energy (m)	21.773
Froude No	2.240
Bed Stress (Pa)	94.730
Equivalent "n"	0.030
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	21.526
Area (A-m^2)	0.202
Width (B-m)	2.051
Perimeter (P-m)	2.092

Critical Flow Conditions	
Flow (m^3/s)	**0.199** INCREASE CHA
Velocity (m/s)	0.983
Energy (m)	21.575

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



CHANNEL CAPACITY SECTION POST DEVELOPMENT B-B

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	5.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.457
Case B	
Slope (S_o)	5%
Water level (m)	21.55
MFFL	21.70

0.15

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	22	0.03		Short Grass
0.5	21.5	0.03		Short Grass
1	21.4	0.03		Short Grass
2	21.4	0.03		Short Grass
2.5	21.50	0.03		Short Grass
3	22	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

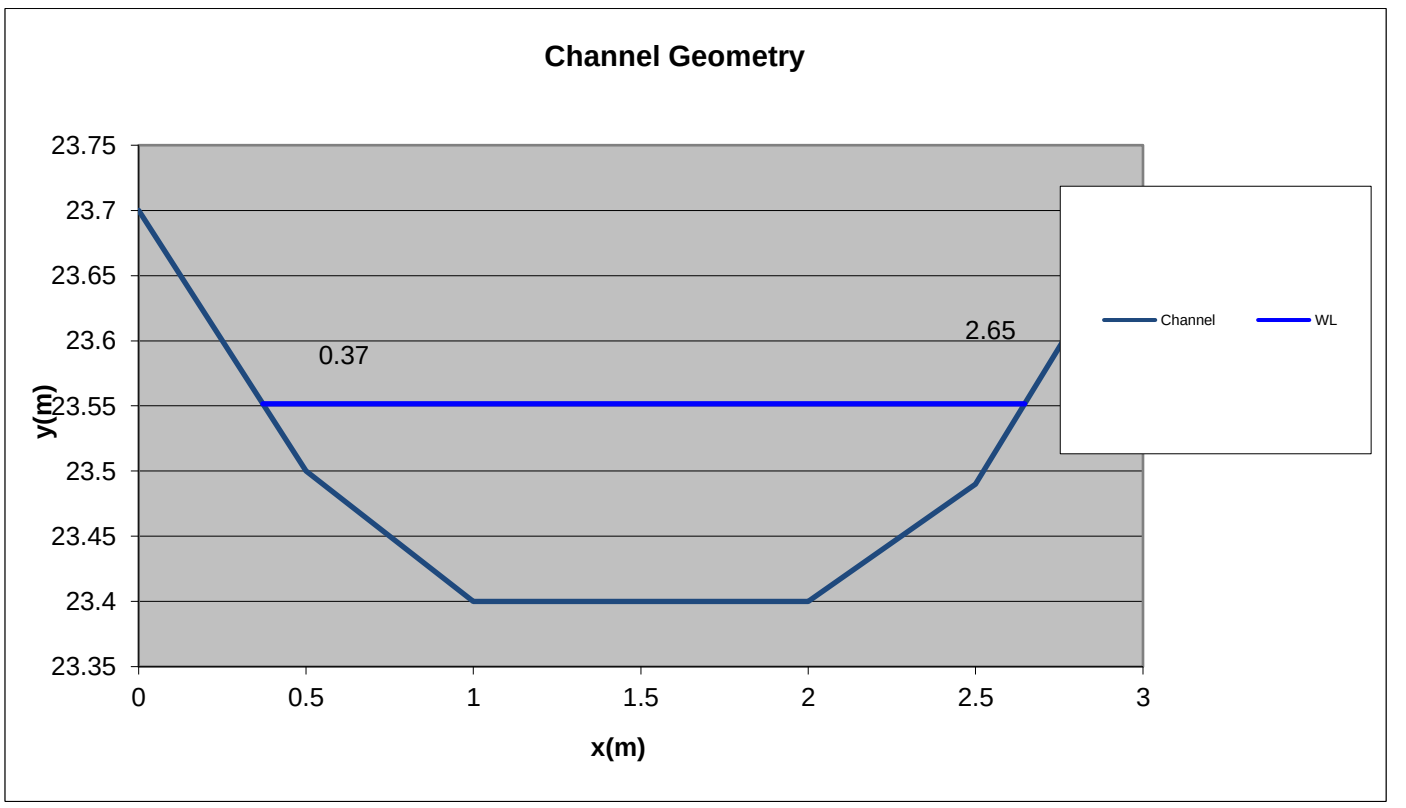
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.458** OK
Velocity (m/s)	1.785
S_o or S_f	0.0500
Energy (m)	21.714
Froude No	1.632
Bed Stress (Pa)	58.108
Equivalent "n"	0.030
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	21.552
Area (A-m^2)	0.257
Width (B-m)	2.104
Perimeter (P-m)	2.167

Critical Flow Conditions	
Flow (m^3/s)	**0.281** INCREASE CHA
Velocity (m/s)	1.094
Energy (m)	21.613

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



CHANNEL CAPACITY SECTION PRE-DEVELOPMENT C-C

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	6.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.444
Case B	
Slope (S_o)	10%
Water level (m)	20.03
MFFL	20.18

0.13

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	20.5	0.03		Property/Parcels
0.5	20.00	0.03		Property/Parcels
1	19.9	0.03		Property/Parcels
2	19.9	0.03		Property/Parcels
2.5	20.00	0.03		Property/Parcels
3	20.5	0.03		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

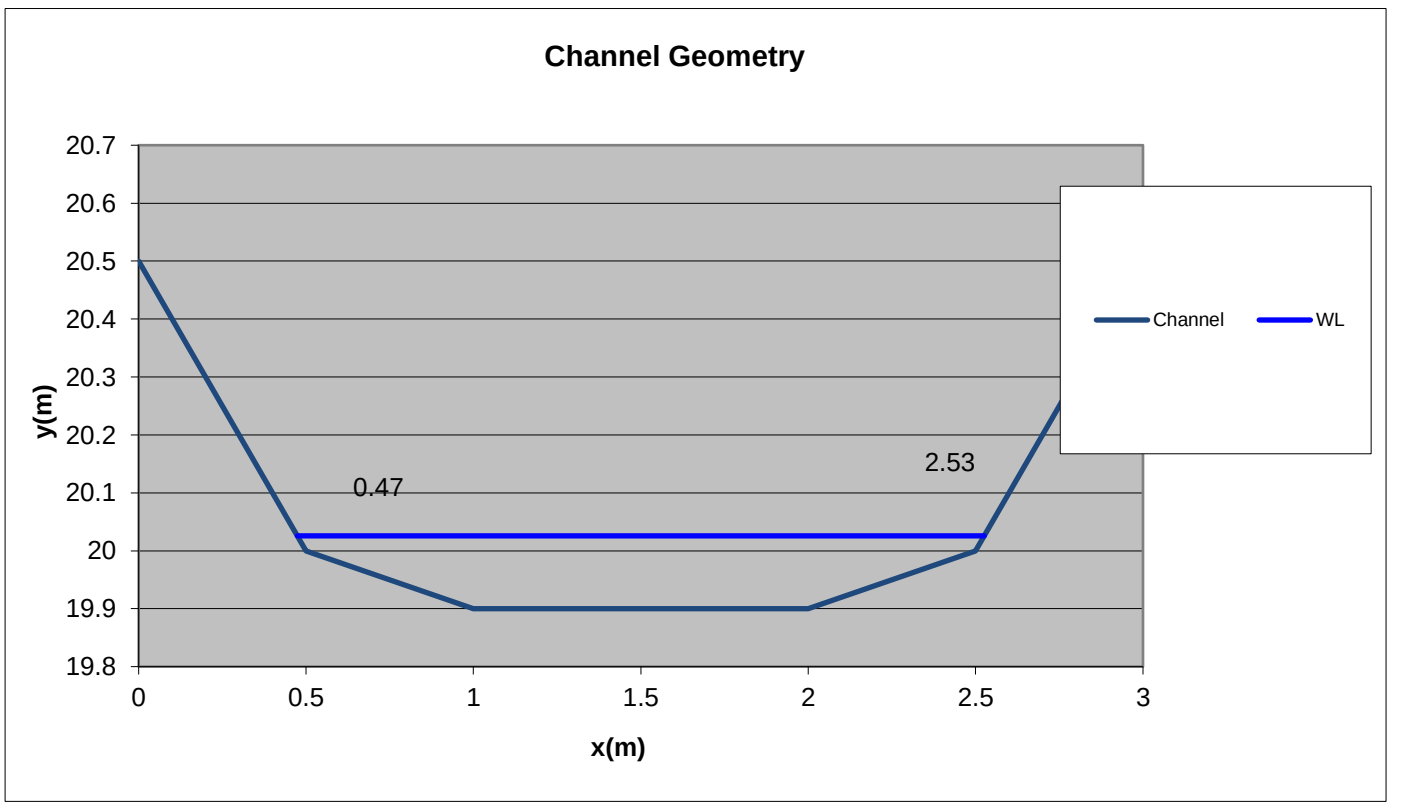
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.445** OK
Velocity (m/s)	2.201
S_o or S_f	0.1000
Energy (m)	20.273
Froude No	2.240
Bed Stress (Pa)	94.730
Equivalent "n"	0.030
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	20.026
Area (A-m^2)	0.202
Width (B-m)	2.051
Perimeter (P-m)	2.092

Critical Flow Conditions	
Flow (m^3/s)	**0.199** INCREASE CHA
Velocity (m/s)	0.983
Energy (m)	20.075

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



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CHANNEL CAPACITY SECTION POST DEVELOPMENT C-C - REVISION 1

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	16.06.2022
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.457
Case B	
Slope (S_o)	5%
Water level (m)	20.00
MFFL	20.15

0.10

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	20.5	0.013		COAL
0.5	20.00	0.013		COAL
1	19.9	0.013		COAL
2	19.9	0.013		COAL
2.5	20.00	0.013		COAL
3	20.5	0.013		COAL
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

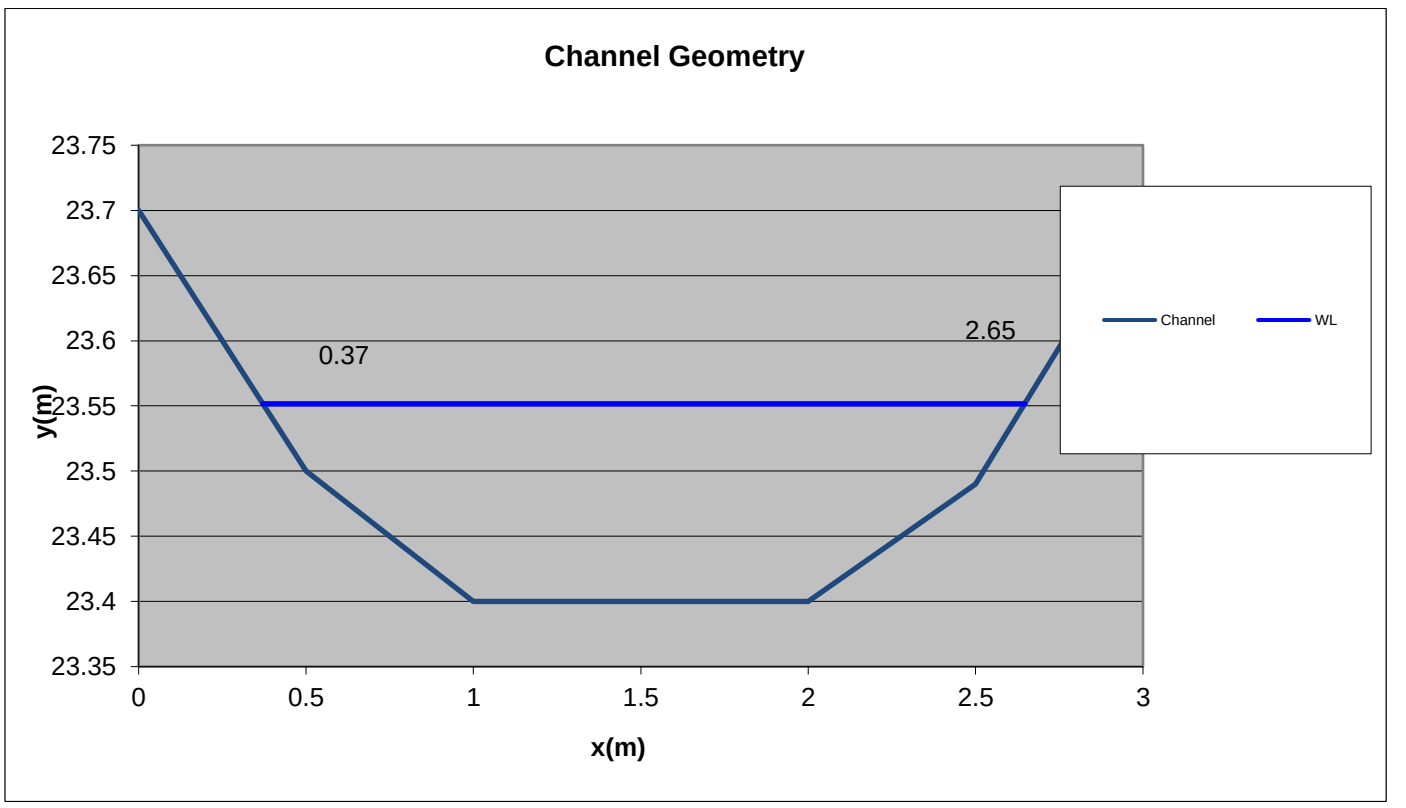
OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.458** OK
Velocity (m/s)	3.027
S_o or S_f	0.0500
Energy (m)	20.468
Froude No	3.516
Bed Stress (Pa)	36.687
Equivalent "n"	0.013
Equivalent k_s(mm)	1.75

Geometry for wetted conditions	
Depth (d-m)	20.001
Area (A-m^2)	0.151
Width (B-m)	2.001
Perimeter (P-m)	2.022

Critical Flow Conditions	
Flow (m^3/s)	**0.130** INCREASE CHA
Velocity (m/s)	0.861
Energy (m)	20.038

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



Hydrographs- SCS Method - Predevelopment Flow from No. 15 Cresta Avenue

Project Description

96 Beach Haven Road/13 Cresta Avenue
No. 15 Cresta Avenue

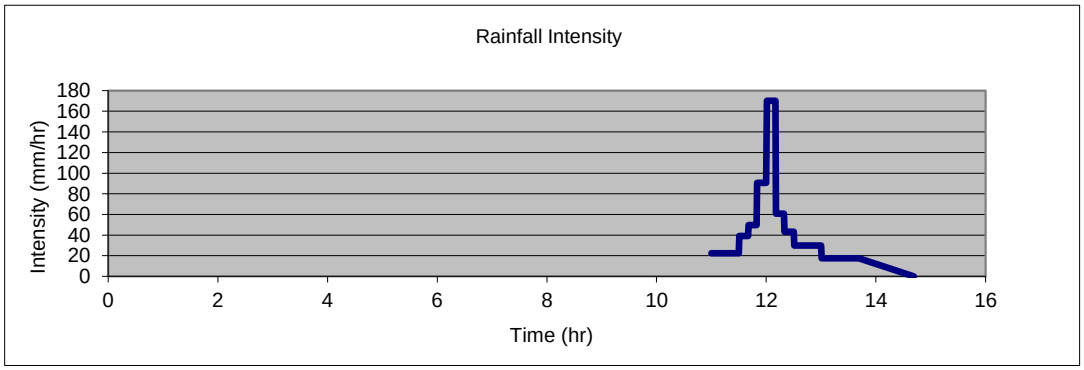
Rainfall Depth (mm) 245.28 100 YEAR ARI

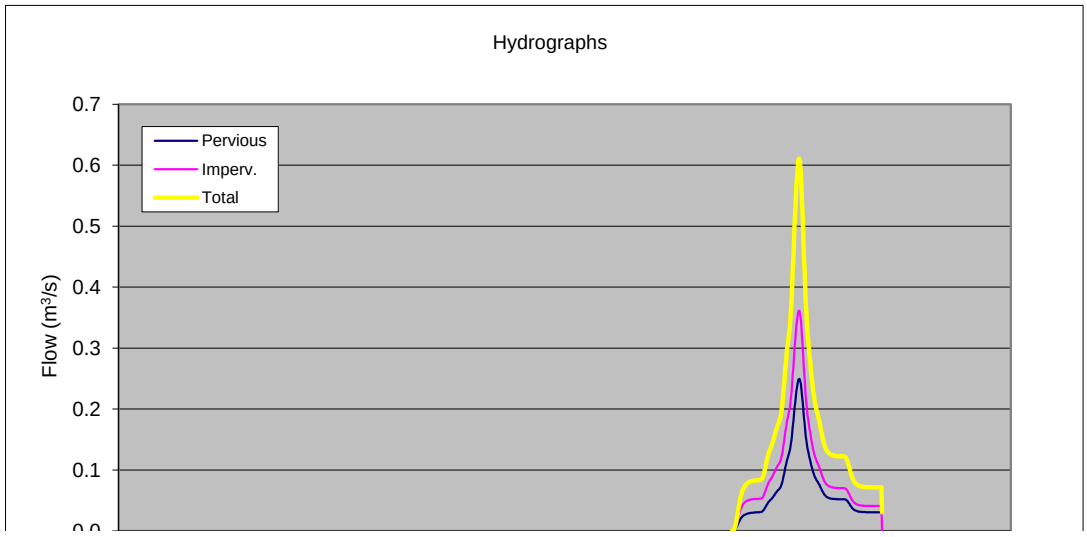
Notes:

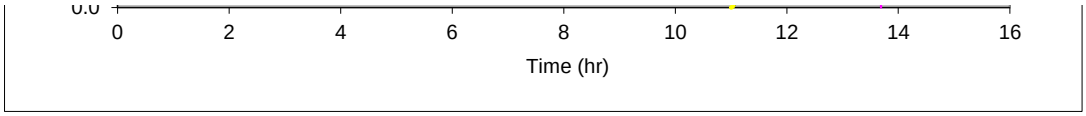
1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.7222	0.8478
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	120	120
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	210.3
Peak Flow (m^3/s)	0.250	0.362	0.611
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.85
Runoff Coefficient - Volume	0.71	0.98	0.86







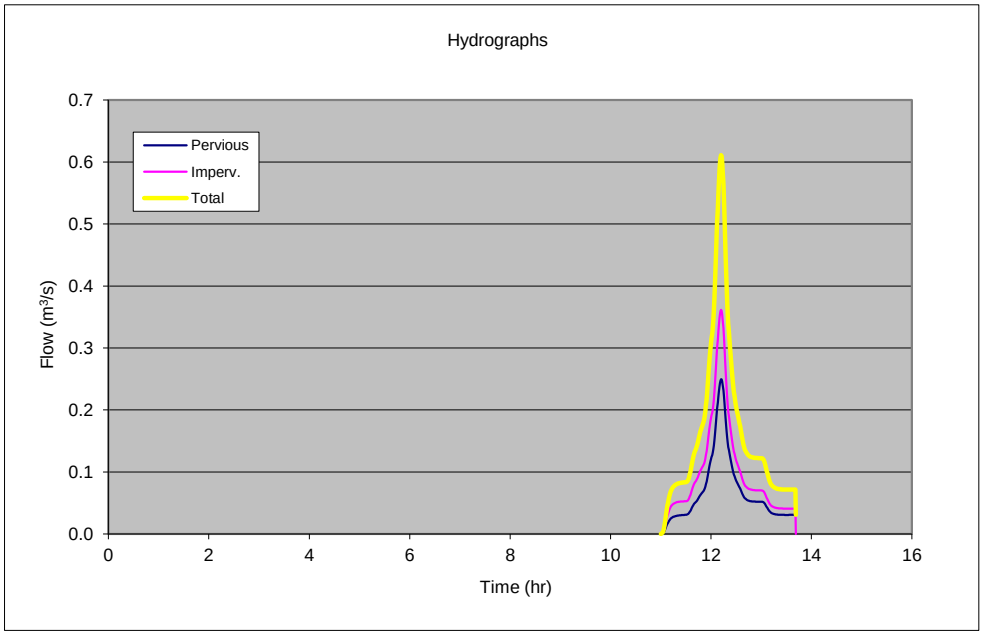
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue
No. 15 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.88%



Time (hr)	Flow (m^3/s)
11.001	0.000
11.347	0.081
11.491	0.083
11.601	0.105
11.694	0.136
11.776	0.160
11.850	0.180
11.918	0.224
11.981	0.291
12.040	0.340
12.096	0.441
12.150	0.556
12.201	0.611
12.230	0.592
12.259	0.532
12.290	0.454
12.320	0.382
12.352	0.330
12.384	0.294
12.417	0.262
12.451	0.234
12.486	0.212
12.522	0.196
12.559	0.183
12.597	0.165
12.637	0.148
12.678	0.136
12.721	0.129
12.767	0.126
12.814	0.124
12.864	0.123
12.917	0.122
12.975	0.122
13.037	0.121
13.106	0.103
13.184	0.082
13.277	0.074
13.398	0.072
13.690	0.031
-1.000	0.000

Hydrographs- SCS Method - Post Development Flow from No. 15 Cresta Avenue

Project Description 96 Beach Haven Road/13 Cresta Avenue
No. 15 Cresta

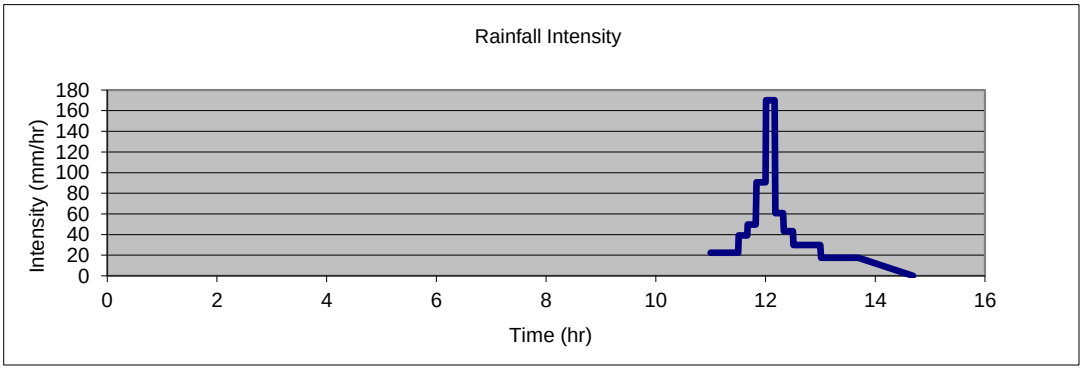
Rainfall Depth (mm) 245.28 100 YEAR ARI

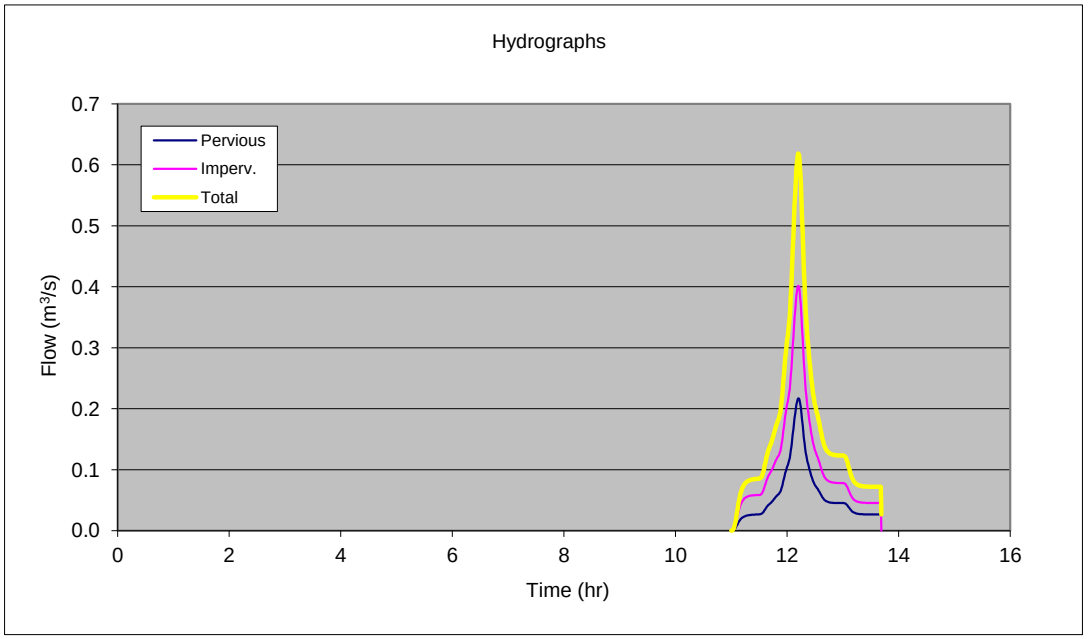
Notes:

1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.628	0.942
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	120	120
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m^3/s)	0.217	0.402	0.619
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
Runoff Coefficient - Volume	0.71	0.98	0.87



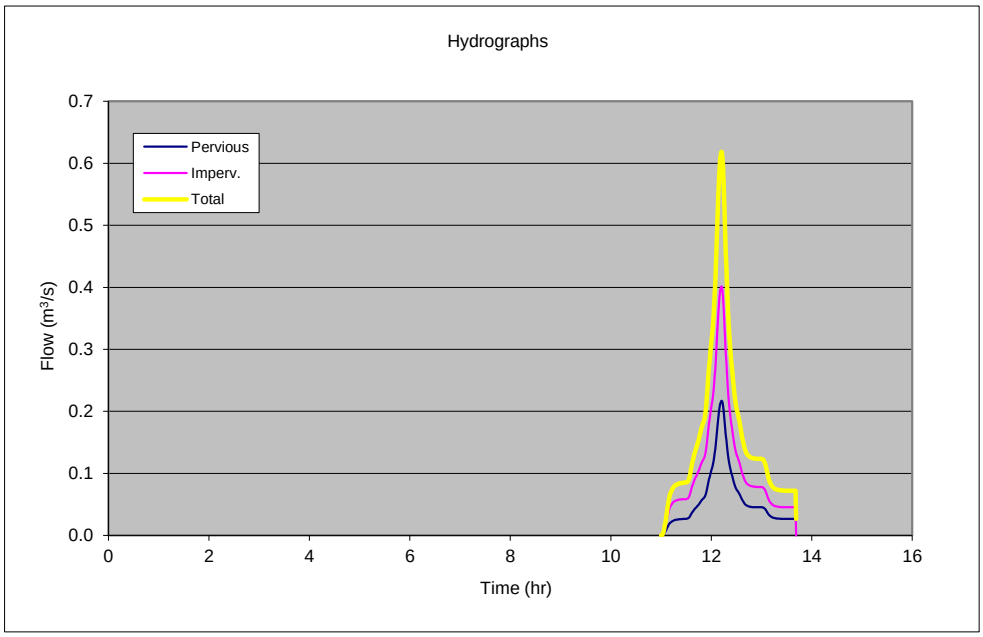


Hydrographs- SCS Method:

Project Description 96 Beach Haven Road/13 Cresta Avenue
No. 15 Cresta

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr)	Flow (m^3/s)
11.001	0.000
11.347	0.083
11.491	0.085
11.601	0.108
11.694	0.139
11.776	0.163
11.850	0.184
11.918	0.228
11.981	0.296
12.040	0.345
12.096	0.448
12.150	0.563
12.201	0.619
12.230	0.599
12.259	0.538
12.290	0.459
12.320	0.386
12.352	0.334
12.384	0.297
12.417	0.265
12.451	0.236
12.486	0.214
12.522	0.198
12.559	0.184
12.597	0.167
12.637	0.150
12.678	0.137
12.721	0.130
12.767	0.127
12.814	0.125
12.864	0.124
12.917	0.124
12.975	0.123
13.037	0.122
13.106	0.104
13.184	0.083
13.277	0.075
13.398	0.072
13.690	0.027
-1.000	0.000

CHANNEL CAPACITY SECTION PRE-DEVELOPMENT NO. 15 CRESTA AVE.

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	24.09.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.611
Case B	
Slope (S_o)	7%
Water level (m)	18.09
MFFL	18.24

0.19

Channel Geometry x (m)	Channel Geometry y (m)	Mannings "n" value	Sinuosity	
0	18	0.1		Property/Parcels
0.75	17.9	0.1		Property/Parcels
1.5	17.9	0.1		Property/Parcels
2.25	17.9	0.1		Property/Parcels
3.4	17.90	0.1		Property/Parcels
4.7	18	0.1		Property/Parcels
5	18.15	0.1		Property/Parcels
6	18.3	0.1		Property/Parcels
6.8	18.5	0.1		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

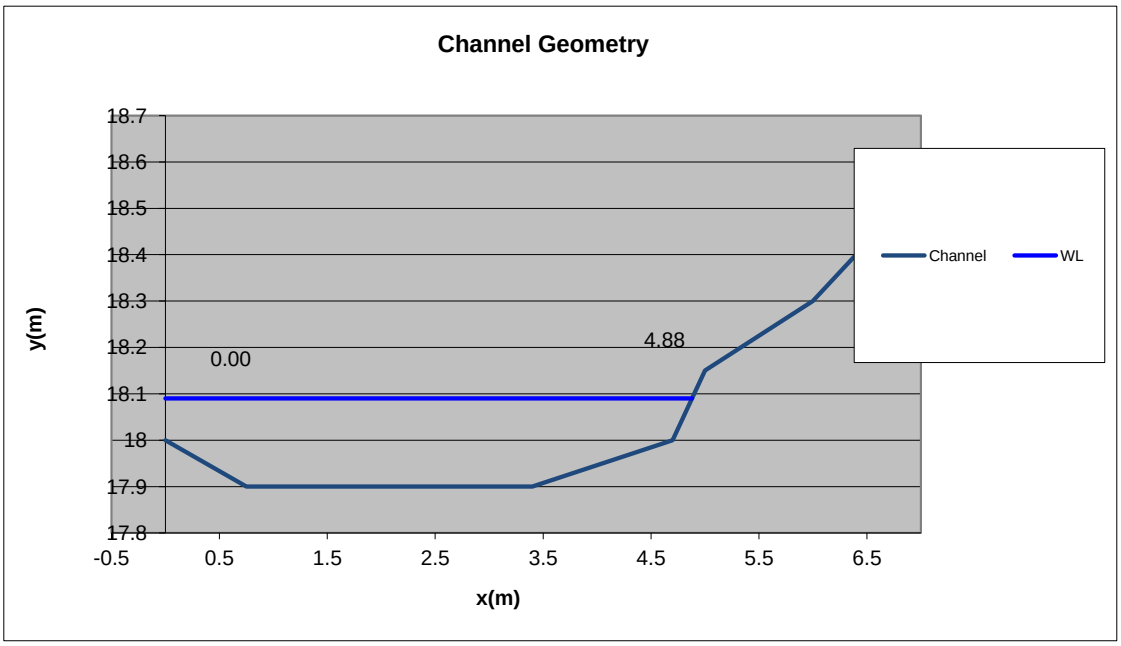
OUTPUTS

Normal Flow Conditions		
Flow (m^3/s)	**0.626**	OK
Velocity (m/s)	0.783	
S_o or S_f	0.0700	
Energy (m)	18.121	
Froude No	0.618	
Bed Stress (Pa)	111.651	
Equivalent "n"	0.100	
Equivalent k_s(mm)	N/A	

Geometry for wetted conditions	
Depth (d-m)	18.090
Area (A-m^2)	0.799
Width (B-m)	4.880
Perimeter (P-m)	4.912

Critical Flow Conditions		
Flow (m^3/s)	**1.012**	OK
Velocity (m/s)	1.267	
Energy (m)	18.172	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



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CHANNEL CAPACITY SECTION POST DEVELOPMENT NO. 15 CRESTA AVE.

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	5.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B): B

Case A

Flow (m^3/s): 0.619

Case B

Slope (S_o): 7%

Water level (m): 18.10

MFFL: 18.25

0.20

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	18	0.1		Property/Parcel
0.75	17.9	0.1		Property/Parcel
1.5	17.9	0.1		Property/Parcel
2.25	17.9	0.1		Property/Parcel
3.4	17.90	0.1		Property/Parcel
4.7	18	0.1		Property/Parcel
5	18.15	0.1		Property/Parcel
6	18.3	0.1		Property/Parcel
6.8	18.5	0.1		Property/Parcel
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

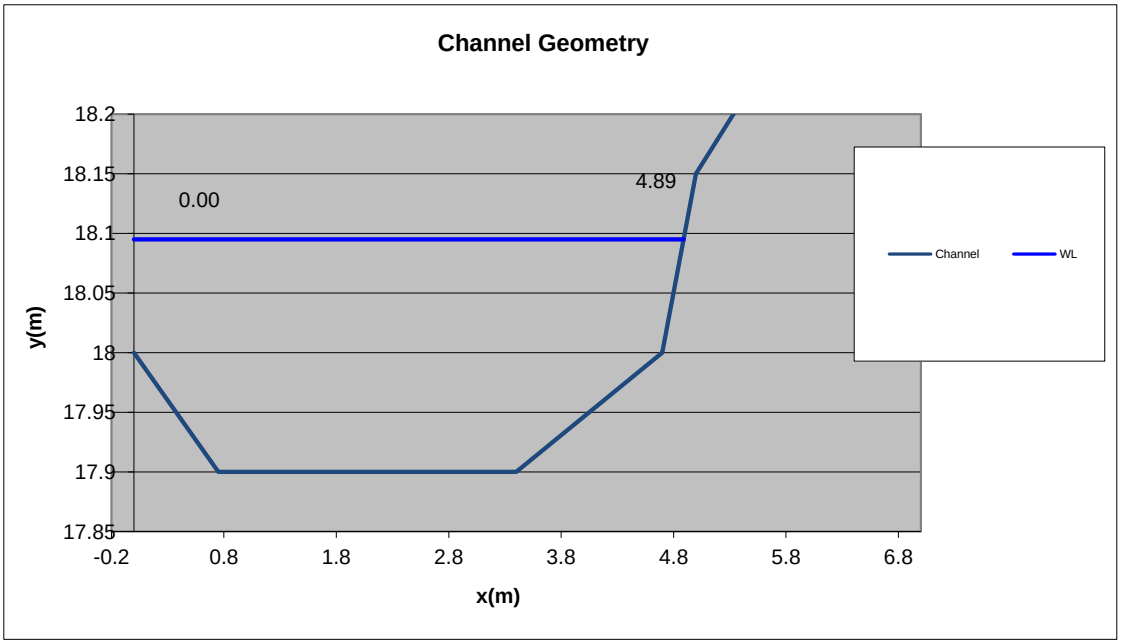
OUTPUTS

Normal Flow Conditions		
Flow (m^3/s)	0.657	OK
Velocity (m/s)	0.798	
S_o or S_f	0.0700	
Energy (m)	18.127	
Froude No	0.621	
Bed Stress (Pa)	114.804	
Equivalent "n"	0.100	
Equivalent k_s(mm)	N/A	

Geometry for wetted conditions	
Depth (d-m)	18.095
Area (A-m^2)	0.823
Width (B-m)	4.890
Perimeter (P-m)	4.923

Critical Flow Conditions		
Flow (m^3/s)	1.058	OK
Velocity (m/s)	1.285	
Energy (m)	18.179	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



Hydrographs- SCS Method - Predevelopment Flow from No. 17 Cresta Avenue

Project Description 96 Beach Haven Road/13 Cresta Avenue
No. 17 Cresta Avenue

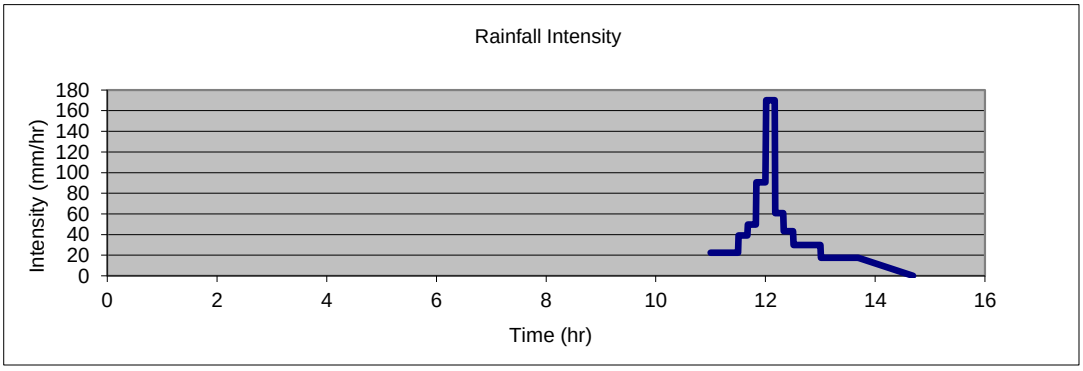
Rainfall Depth (mm) 245.28 100 YEAR ARI

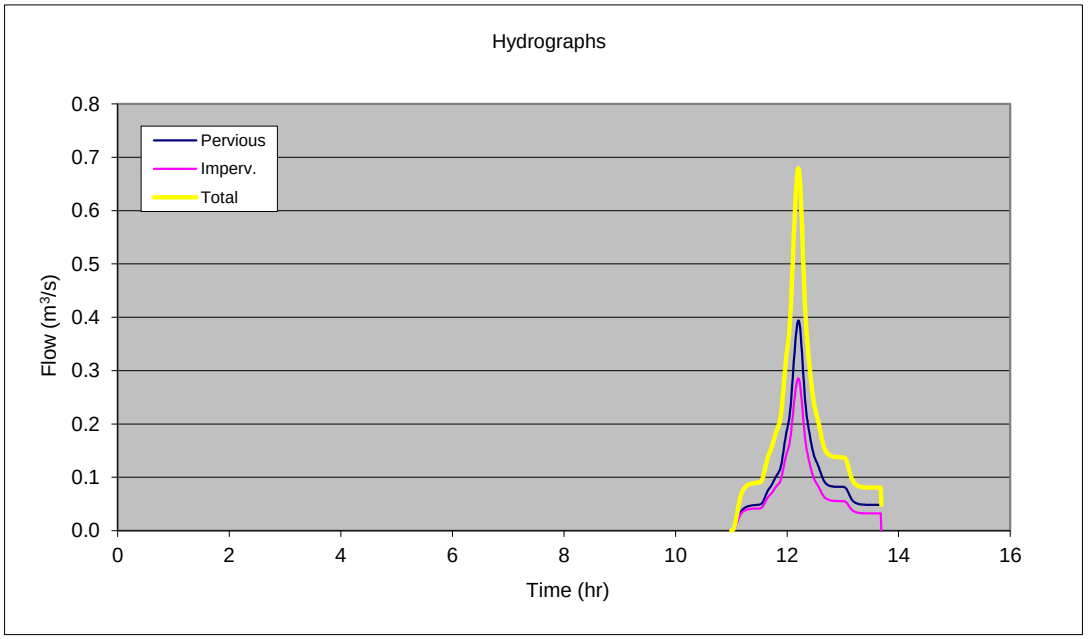
Notes:

1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	1.1403	0.6697
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	157	157
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	199.3
Peak Flow (m^3/s)	0.394	0.286	0.680
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.82
Runoff Coefficient - Volume	0.71	0.98	0.81





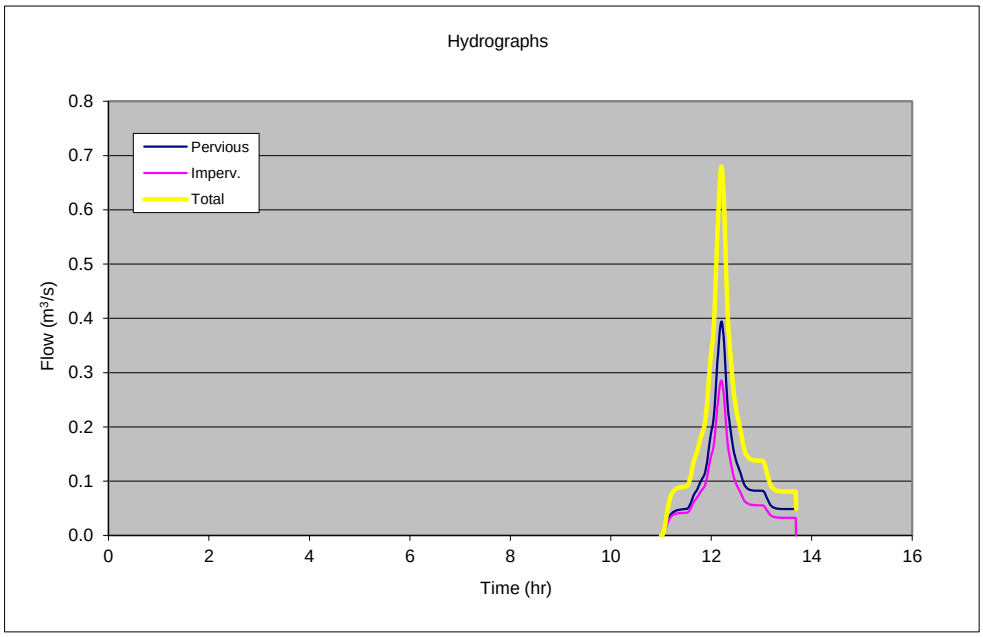
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue
No. 17 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.48%



Time (hr)	Flow (m^3/s)
11.001	0.000
11.347	0.088
11.491	0.090
11.601	0.114
11.694	0.148
11.776	0.175
11.850	0.197
11.918	0.245
11.981	0.319
12.040	0.374
12.096	0.488
12.150	0.617
12.201	0.680
12.230	0.659
12.259	0.593
12.290	0.506
12.320	0.426
12.352	0.369
12.384	0.329
12.417	0.294
12.451	0.262
12.486	0.237
12.522	0.220
12.559	0.205
12.597	0.186
12.637	0.166
12.678	0.152
12.721	0.145
12.767	0.141
12.814	0.139
12.864	0.138
12.917	0.138
12.975	0.138
13.037	0.136
13.106	0.116
13.184	0.093
13.277	0.084
13.398	0.081
13.690	0.049
-1.000	0.000

Hydrographs- SCS Method - Post Development Flow from No. 17 Cresta Avenue

Project Description

96 Beach Haven Road/13 Cresta Avenue
No. 17 Cresta Avenue

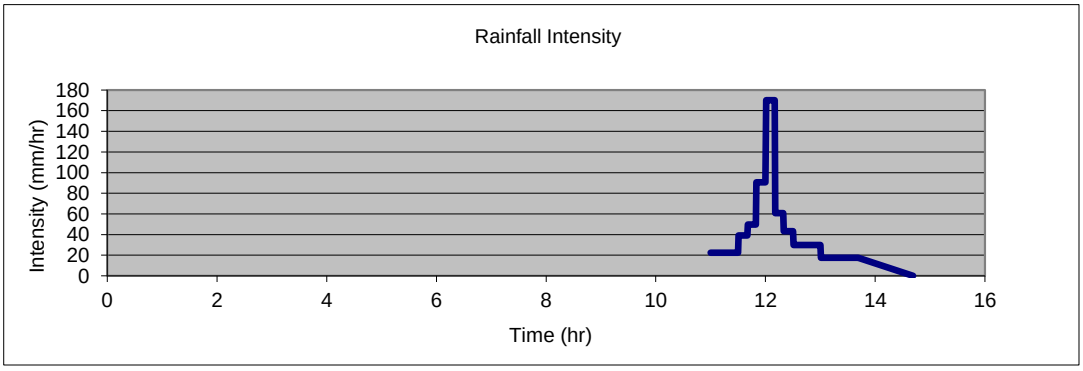
Rainfall Depth (mm) 245.28 100 YEAR ARI

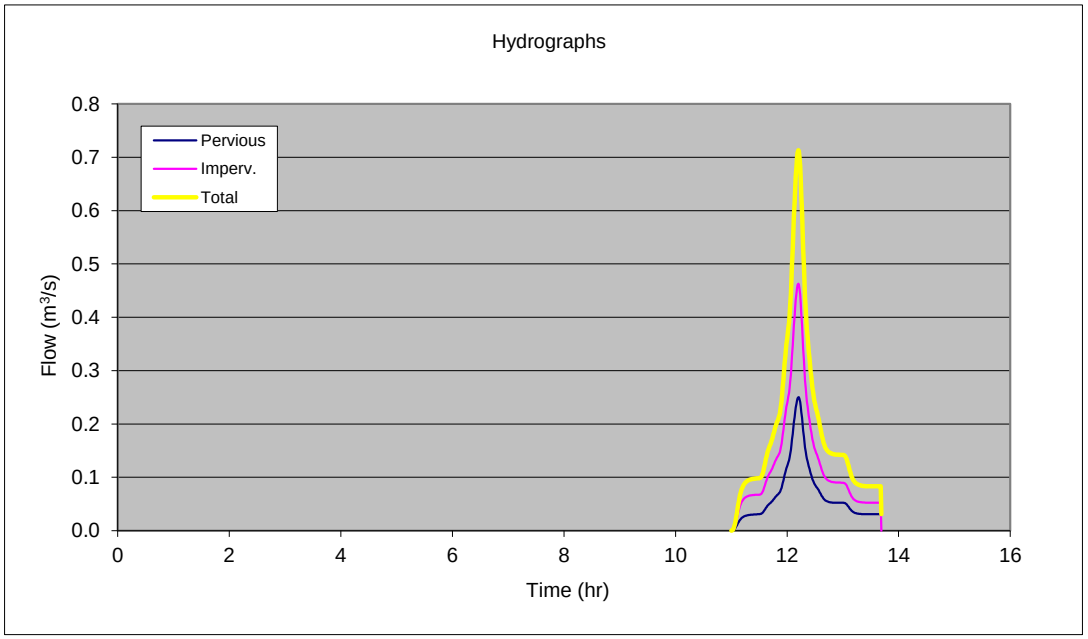
Notes:

1. Inputs
2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.724	1.086
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	157	157
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs			Total
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m^3/s)	0.250	0.463	0.713
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
Runoff Coefficient - Volume	0.71	0.98	0.87





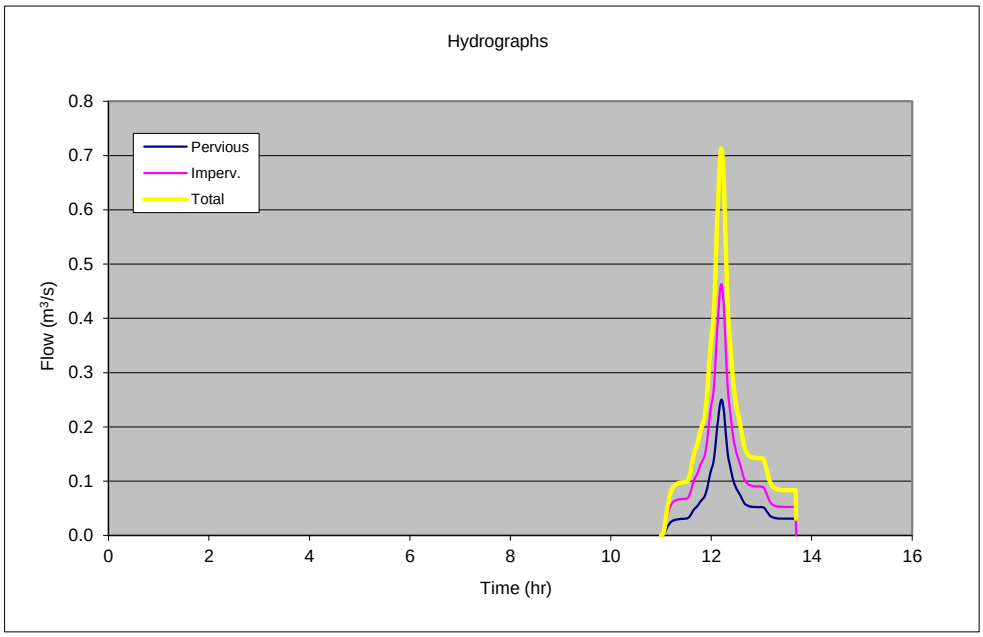
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue
No. 17 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr)	Flow (m^3/s)
11.001	0.000
11.347	0.096
11.491	0.098
11.601	0.124
11.694	0.160
11.776	0.188
11.850	0.212
11.918	0.262
11.981	0.341
12.040	0.398
12.096	0.516
12.150	0.650
12.201	0.713
12.230	0.691
12.259	0.621
12.290	0.529
12.320	0.445
12.352	0.385
12.384	0.343
12.417	0.306
12.451	0.272
12.486	0.246
12.522	0.228
12.559	0.213
12.597	0.192
12.637	0.172
12.678	0.158
12.721	0.150
12.767	0.146
12.814	0.144
12.864	0.143
12.917	0.142
12.975	0.142
13.037	0.140
13.106	0.120
13.184	0.095
13.277	0.086
13.398	0.084
13.690	0.031
-1.000	0.000

CHANNEL CAPACITY SECTION PRE-DEVELOPMENT NO. 17 CRESTA AVE.

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	24.09.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.68
Case B	
Slope (S_o)	6%
Water level (m)	16.75
MFFL	16.90

0.30

Channel Geometry		Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	16.5	0.1		Property/Parcels
1	16.45	0.1		Property/Parcels
2	16.5	0.1		Property/Parcels
3	16.6	0.1		Property/Parcels
4	16.85	0.1		Property/Parcels
6	17.5	0.1		Property/Parcels
8	17.75	0.1		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

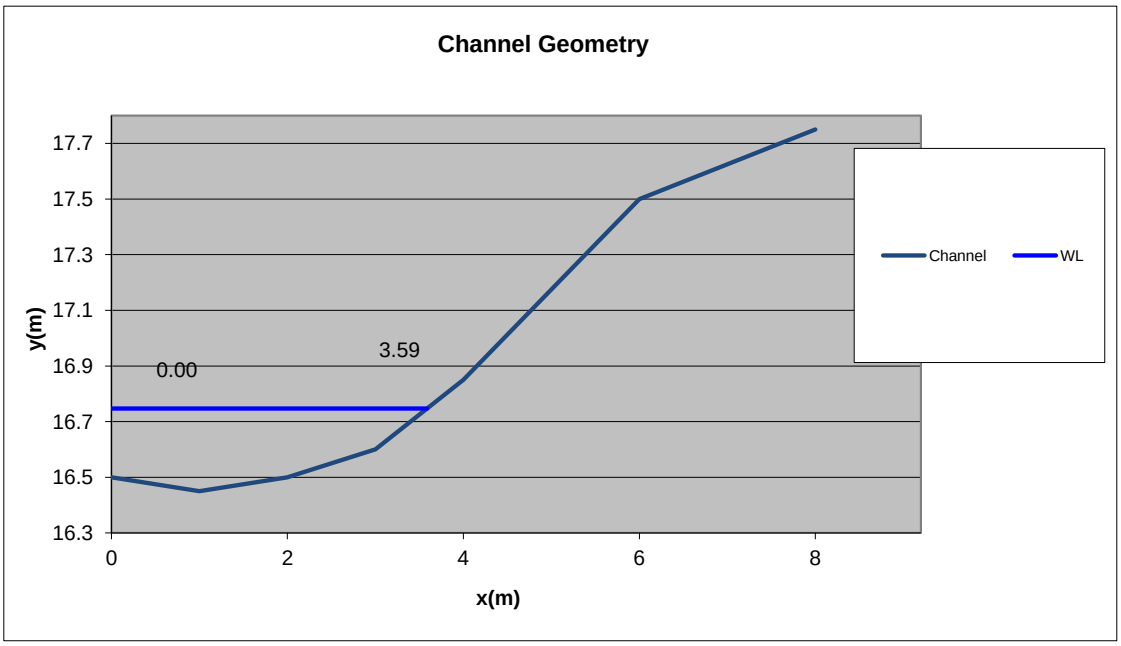
OUTPUTS

Normal Flow Conditions		
Flow (m^3/s)	**0.684**	OK
Velocity (m/s)	0.873	
S_o or S_f	0.0590	
Energy (m)	16.786	
Froude No	0.596	
Bed Stress (Pa)	125.609	
Equivalent "n"	0.100	
Equivalent k_s(mm)	N/A	

Geometry for wetted conditions	
Depth (d-m)	16.747
Area (A-m^2)	0.784
Width (B-m)	3.588
Perimeter (P-m)	3.614

Critical Flow Conditions		
Flow (m^3/s)	**1.148**	OK
Velocity (m/s)	1.464	
Energy (m)	16.856	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



CHANNEL CAPACITY SECTION POST DEVELOPMENT NO. 17 CRESTA AVE.

PROJECT NO:	200626-01
PROJECT NAME:	96 Beach Haven Road/ 13 Cresta Avenue
DATE:	5.08.2021
BY:	Natalie Naidoo
REF:	Overland Flowpath Cross Sections

INPUTS

Case (A or B)	B
Case A	
Flow (m^3/s)	0.713
Case B	
Slope (S_o)	6%
Water level (m)	16.76
MFFL	16.91

0.31

Channel Geometry x (m)	y (m)	Mannings "n" value	Sinuosity	
0	16.5	0.1		Property/Parcel
1	16.45	0.1		Property/Parcel
2	16.5	0.1		Property/Parcel
3	16.6	0.1		Property/Parcel
4	16.85	0.1		Property/Parcel
6	17.5	0.1		Property/Parcel
8	17.75	0.1		Property/Parcel
-1				

The table can input 10 (x,y) co-ordinates.
The (x,y) pairs should be in order
Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e.
$n=(\sum(P_1 n_1^{1.5}+....)/P)^{0.67}$

Sinuosity is the relative length of that flow channel element compared to other elements and input S_o.
Default value is 1.0.

OUTPUTS

Normal Flow Conditions	
Flow (m^3/s)	**0.747** OK
Velocity (m/s)	0.899
S_o or S_f	0.0590
Energy (m)	16.801
Froude No	0.600
Bed Stress (Pa)	131.188
Equivalent "n"	0.100
Equivalent k_s(mm)	N/A

Geometry for wetted conditions	
Depth (d-m)	16.760
Area (A-m^2)	0.831
Width (B-m)	3.640
Perimeter (P-m)	3.667

Critical Flow Conditions	
Flow (m^3/s)	**1.244** OK
Velocity (m/s)	1.497
Energy (m)	16.874

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5