REPORT

Tonkin+Taylor

Stormwater Management Plan - Appendices B, C and D

Private Plan Change 28

Prepared for
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Prepared by
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Date
June 2022
Job Number
1012397.1000.v2

Exceptional thinking together
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Appendix B: Stormwater Calculations

STORMWATER ASSESSMENT - CATCHMENTS

Project: Kaka Hill Development **By:** CHGR **Date:** 17/05/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 17/05/2022

Calculation Description

Categorise catchment into Pre and Post Development Areas with land cover and soil class

Pre-Development

Land Cover	SCS Cover Type	Soil Class	Soil Condi	C	Area (ha)	Product
Deciduous Hardwoods	Woods	C	Fair	73	1.47	107.26
Exotic Forest	Woods-grass combination	C	Fair	76	5.66	430.28
Forest - Harvested	Industrial	C	Fair	91	1.82	165.93
Gorse and/or Broom	Brush-weed-grass mixture with brush	C	Fair	70	66.58	4660.85
High Producing Exotic Grassland	Pasture , grassland or range-continuous forage for grazing	C	Fair	79	10.41	822.00
Low Producing Grassland	Pasture , grassland or range-	C	Poor	86	5.20	447.52
Urban Parkland/Open Space	Open Space (Lawns, Parks, golf courses, cemeteries, etc)	C	Fair	79	10.18	804.24
Built-up Area (settlement)	1/4 Acre	C	Fair	83	32.61	2706.46
		Total			**133.93**	**10144.54**

Weighted CN 75.74

Post-Development

Land Cover	SCS Cover Type	Soil Class	Soil Condi	Runoff Co	Area (ha)	Product
Deciduous Hardwoods	Woods	C	Fair	73	1.47	107.26
Exotic Forest	Woods-grass combination	C	Fair	76	5.17	393.20
Forest - Harvested	Industrial	C	Fair	91	1.32	120.05
Gorse and/or Broom	Brush-weed-grass mixture with brush	C	Fair	70	29.12	2038.56
High Producing Exotic Grassland	Pasture , grassland or range-	C	Fair	79	9.54	753.35
Low Producing Grassland	Pasture , grassland or range-	C	Fair	86	0.03	2.78
Urban Parkland/Open Space	Open Space (Lawns, Parks, golf	C	Fair	79	9.98	788.57
Built-up Area (settlement)	1/4 Acre	C	Fair	83	32.61	2706.46
Open Space Recreation	Open Space (Lawns, Parks, golf	C	Fair	79	2.68	211.72
Residential	1/8 acre or less (town houses)	C	Fair	90	12.44	1119.26
Residential Lower Density	1/4 Acre	C	Fair	83	29.58	2454.78
		Total			**133.93**	**10696.01**

Weighted CN 79.86

STORMWATER ASSESSMENT - PRE-DEVELOPMENT SCENARIO

Project: Kaka Hill Development **By:** **Date:**

Location: Walters Bluff Brooklands Catchment **Checked:** **Date:**

Calculation Description

Brooklands Catchment 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

			SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	*Woods - grass combo - fair*	76	1.711	130	0.35	0.60
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*Brush-weed-grass mix - fair*	70	16.915	1,184	0.35	5.92
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	6.341	501	0.40	2.54
Class C soils	Low Producing Grassland	*Pasture - poor*	86	2.597	223	0.40	1.04
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	1.643	130	0.40	0.66
	Subtotal for pervious Areas			29.206	2,168		10.75
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	5.469	503	0.55	3.01
					0		0.00
	Subtotal for Impervious Areas			5.469	503.151		3.01
			Totals	34.675	2671.274		13.76
				0.346755	km²		

CN (weighted) : total product / total area = 2,671 / 34.675 = 77.04 0.3968

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference%20Manual_(CPD

Time of Concentration t_c = 0.33 hrs 19.68 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.20 hrs 11.81071 min

3. S = ((1000/CN)-10)*25.4

Total = 75.7 mm
Pervious = 88.2 mm
Impervious = 22.1 mm

4. Initial Abstraction

Ia = 0.2S = 15.14282

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results	Peak Discharge (m3/s)		
hr	Q10	Q15	Q100
1	2.143	2.557	5.388
6	2.648	2.899	4.416
12	1.545	1.728	2.847

Rational Method

20 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	3.15	3.41	4.99	m³/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

			SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	*oods - grass combo - f*	76	3.811	290	0.35	1.33
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*ush-weed-grass mix - f*	70	9.676	677	0.35	3.39
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	0.000	0	0.40	0.00
Class C soils	Low Producing Grassland	*Pasture - poor*	86	2.240	193	0.40	0.90
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	8.537	674	0.40	3.41
	Subtotal for pervious Areas			24.265	1,834		9.03
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	14.815	1,363	0.55	8.15
					0		0.00
	Subtotal for Impervious Areas			14.815	1362.999		8.15
			Totals	39.080	3197.065		17.18
				0.390798	km²		

CN (weighted) : total product / total area = 3,197 / 39.080 = 81.81 — 0.4396

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refe

Time of Concentration	t_c =			0.31	hrs	18.71 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c	=	0.19	hrs	11.22796 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	56.5	mm
Pervious	=	82.0	mm
Impervious	=	22.1	mm

4. Initial Abstraction

Ia = 0.2S = 11.29612

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	3.442	4	7.64
6	3.309	3.598	5.33
12	1.962	2.173	3.448

Rational Method

19 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	3.93	4.26	6.23	m³/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	1.469	107	0.35	0.51
Class C soils	Exotic Forest	*oods - grass combo - f*	76	0.121	9	0.35	0.04
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*ush-weed-grass mix - f*	70	17.861	1,250	0.35	6.25
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	3.104	245	0.40	1.24
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.003	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			22.558	1,612		8.05
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	6.470	595	0.55	3.56
					0		0.00
	Subtotal for Impervious Areas			6.470	595.207		3.56
			Totals	29.028	2207.402		11.61

0.2902781 km²

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2,207}{29.028} = 76.04$ 0.3999

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refere

Time of Concentration	t_c =		0.30	hrs	17.81 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c =	0.18	hrs	10.68869 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	80.0	mm
Pervious	=	101.4	mm
Impervious	=	22.1	mm

4. Initial Abstraction

Ia = 0.2S = 16.0031

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.719	2.064	4.438
6	2.169	2.377	3.644
12	1.26	1.412	2.346

Rational Method

18 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	2.66	2.88	4.21	m³/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	*oods - grass combo - f*	76	0.000	0	0.35	0.00
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	1.823	166	0.70	1.28
Class C soils	Gorse and/or Broom	*ush-weed-grass mix - f*	70	12.717	890	0.35	4.45
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	0.128	10	0.40	0.05
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.000	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			14.668	1,066		5.78
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	0.000	0	0.55	0.00
					0		0.00
	Subtotal for Impervious Areas			0.000	0.000		0.00
			Totals	14.668	1066.222		5.78

0.146683 km²

CN (weighted) : total product / total area = 1,066 / 14.668 = 72.69 — 0.3939

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refe

Time of Concentration	t_c =			0.34	hrs	20.19 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c	=	0.20	hrs	12.11678 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	95.4	mm
Pervious	=	95.4	mm
Impervious	=	#DIV/0!	mm

4. Initial Abstraction

Ia = 0.2S = 19.08679

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.626	0.773	1.814
6	1.005	1.107	1.736
12	0.578	0.652	1.115

Rational Method

20 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	1.32	1.43	2.09	m³/s

TOC rounded to 20min

Calculation Description

Walters Bluff

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

			SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	*oods - grass combo - f*	76	0.019	1	0.35	0.01
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*ush-weed-grass mix - f*	70	9.415	659	0.35	3.30
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	0.832	66	0.40	0.33
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.363	31	0.40	0.15
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			10.629	757		3.78
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	5.854	539	0.55	3.22
					0		0.00
	Subtotal for Impervious Areas			5.854	538.575		3.22
			Totals	16.484	1296.048		7.00

0.164835 km²

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{1,296}{16.484} = 78.63$ 0.4247

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refer

Time of Concentration t_c = 0.32 hrs 19.18 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.51022 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 69.0 mm
Pervious = 102.4 mm
Impervious = 22.1 mm

4. Initial Abstraction

Ia = 0.2S = 13.8089

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results	Peak Discharge (m3/s)		
hr	Q10	Q15	Q100
1	1.157	1.368	2.781
6	1.305	1.425	2.151
12	0.766	0.854	1.388

Rational Method

19 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	1.60	1.74	2.54	m³/s

TOC rounded to 20min

STORMWATER ASSESSMENT - Post-DEVELOPMENT SCENARIO

Project: Kaka Hill Development **By:** **Date:**

Location: Walters Bluff Brooklands Catchment **Checked:** **Date:**

Calculation Description

Brooklands Catchment 1

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

			SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	*Woods - grass combo - fair*	76	1.711	130	0.35	0.60
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*Brush-weed-grass mix - fair*	70	2.272	159	0.35	0.80
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	6.169	487	0.40	2.47
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.000	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	1.484	117	0.40	0.59
Class C soils	Planning Zone - Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			11.64	894		4.45
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	5.469	503	0.55	3.01
Class C soils	Planning Zone - Residential_Hatch	*Residential district 1/4 acre size*	90	8.428	758	0.65	5.48
Class C soils	Planning Zone - Residential Lower Density_Hatch	*Residential district 1/4 acre size*	83	9.144	759	0.55	5.03
	Subtotal for Impervious Areas			23.040	2020.555		13.51
			Totals	34.675	2914.161		17.97

CN (weighted) : total product / total area = 2,914 / 34.675 = 84.04 0.5182

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\, t_c \qquad (38)$$

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference%20Manual_(CPD-74

t_c = 0.33 hrs 19.68 min

SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.20 hrs 11.81071 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 48.2 mm
Pervious = 76.7 mm
Impervious = 35.6 mm

4. Initial Abstraction

Ia = 0.2S = 9.646697

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Post-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	3.46	3.975	7.3
6	3.06	3.32	4.855
12	1.83	2.02	3.15

Rational Method

20 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	4.11	4.46	6.51	m^3/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	oods - grass combo - f	76	3.333	253	0.35	1.17
Class C soils	Forest - Harvested	Newly graded area (pervious areas only, no vegetation)	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	ush-weed-grass mix - f	70	0.663	46	0.35	0.23
Class C soils	High Producing Exotic Grassland	pasture - fair	79	0.000	0	0.40	0.00
Class C soils	Low Producing Grassland	Pasture - poor	86	0.032	3	0.40	0.01
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	8.498	671	0.40	3.40
Class C soils	Planning Zone - Open Space	Open Space - fair	79	0.002	0	0.40	0.00
	Subtotal for pervious Areas			12.53	974		4.81
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	Residential district 1/4 acre size	92	14.815	1,363	0.55	8.15
Class C soils	Planning Zone - Residential_Hatch	Residential district 1/4 acre size	90	2.947	265	0.65	1.92
Class C soils	Planning Zone - Residential Lower Density_Hatch	Residential district 1/4 acre size	83	8.790	730	0.55	4.83
					0		0.00
	Subtotal for Impervious Areas			26.552	2357.795		14.90
			Totals	39.080	3331.741		19.71

CN (weighted) : total product / total area = 3,332 / 39.080 = 85.25 — 0.5043

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refe

Time of Concentration t_c = 0.31 hrs 18.71 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.22796 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 43.9 mm
Pervious = 72.7 mm
Impervious = 32.0 mm

4. Initial Abstraction

Ia = 0.2S = 8.786073

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Post-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	4.27	4.884	8.77
6	3.526	3.818	5.551
12	2.115	2.327	3.6

Rational Method

19 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	4.51	4.89	7.15	m^3/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

			SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	*Woods - fair*	73	1.469	107	0.35	0.51
Class C soils	Exotic Forest	*oods - grass combo - f*	76	0.111	8	0.35	0.04
Class C soils	Forest - Harvested	*Newly graded area (pervious areas only, no vegetation)*	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	*ush-weed-grass mix - f*	70	13.295	931	0.35	4.65
Class C soils	High Producing Exotic Grassland	*pasture - fair*	79	3.104	245	0.40	1.24
Class C soils	Low Producing Grassland	*Pasture - poor*	86	0.000	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
Class C soils	Planning Zone - Open Space	*Open Space - fair*	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			17.98	1,292		6.45
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	*Residential district 1/4 acre size*	92	6.470	595	0.55	3.56
Class C soils	Planning Zone - Residential_Hatch	*Residential district 1/4 acre size*	90	0.002	0	0.65	0.00
Class C soils	Planning Zone - Residential Lower Density_Hatch	*Residential district 1/4 acre size*	83	4.576	380	0.55	2.52
					0		0.00
	Subtotal for Impervious Areas			11.048	975.225		6.08
			Totals	29.028	2266.823		12.52

0.2902781

CN (weighted) : total product / total area = 2,267 / 29.028 = 78.09 — 0.4315

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refere

Time of Concentration	t_c =		0.30	hrs	17.81 min
SCS Lag for HEC-HMS :	t_p =	$0.6\, t_c$ =	0.18	hrs	10.68869 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	71.3	mm
Pervious	=	99.6	mm
Impervious	=	33.7	mm

4. Initial Abstraction

Ia = 0.2S = 14.25196

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Post-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.004	2.378	4.888
6	2.274	2.485	3.762
12	1.33	1.485	2.425

Rational Method

18 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	2.87	3.11	4.54	m^3/s

TOC rounded to 20min

Calculation Description

Brooklands Catchment 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	oods - grass combo - f	76	0.000	0	0.35	0.00
Class C soils	Forest - Harvested	Newly graded area (pervious areas only, no vegetation)	91	1.319	120	0.70	0.92
Class C soils	Gorse and/or Broom	ush-weed-grass mix - f	70	10.042	703	0.35	3.51
Class C soils	High Producing Exotic Grassland	pasture - fair	79	0.128	10	0.40	0.05
Class C soils	Low Producing Grassland	Pasture - poor	86	0.000	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.000	0	0.40	0.00
Class C soils	Planning Zone - Open Space	Open Space - fair	79	0.000	0	0.40	0.00
	Subtotal for pervious Areas			11.49	833		4.49
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	Residential district 1/4 acre size	92	0.000	0	0.55	0.00
Class C soils	Planning Zone - Residential_Hatch	Residential district 1/4 acre size	90	0.302	27	0.65	0.20
Class C soils	Planning Zone - Residential Lower Density_Hatch	Residential district 1/4 acre size	83	2.877	239	0.55	1.58
					0		0.00
	Subtotal for Impervious Areas			3.179	265.976		1.78
			Totals	14.668	1099.076		6.27

CN (weighted) : total product / total area = 1,099 / 14.668 = 74.93 — 0.4273

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$ (38)

2. Time of Concentration

https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refe

Time of Concentration	t_c =		0.34	hrs	20.19 min
SCS Lag for HEC-HMS :	t_p =	$0.6\,t_c$ =	0.20	hrs	12.11678 min

3. Soil Storage Parameter :

S = ((1000/CN)-10)*25.4

Total	=	85.0	mm
Pervious	=	96.3	mm
Impervious	=	49.6	mm

4. Initial Abstraction

Ia = 0.2S = 16.9977

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Post-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.76	0.92	2.038
6	1.064	1.169	1.805
12	0.617	0.693	1.162

Rational Method

20 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	1.44	1.55	2.27	m^3/s

TOC rounded to 20min

Calculation Description

Walters Bluff

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)		SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	LCDB	CN classification					
Class C soils	Deciduous Hardwoods	Woods - fair	73	0.000	0	0.35	0.00
Class C soils	Exotic Forest	oods - grass combo - f	76	0.019	1	0.35	0.01
Class C soils	Forest - Harvested	Newly graded area (pervious areas only, no vegetation)	91	0.000	0	0.70	0.00
Class C soils	Gorse and/or Broom	ush-weed-grass mix - f	70	2.851	200	0.35	1.00
Class C soils	High Producing Exotic Grassland	pasture - fair	79	0.135	11	0.40	0.05
Class C soils	Low Producing Grassland	Pasture - poor	86	0.000	0	0.40	0.00
Class C soils	Urban Parkland/Open Space	Open Space - fair	79	0.000	0	0.40	0.00
Class C soils	Planning Zone - Open Space	Open Space - fair	79	2.678	212	0.40	1.07
	Subtotal for pervious Areas			5.68	423		2.13
	Impervious Areas (List)						
	LCDB	CN classification					
Class C soils	Built-up Area (settlement)	Residential district 1/4 acre size	92	5.854	539	0.55	3.22
Class C soils	Planning Zone - Residential_Hatch	Residential district 1/4 acre size	90	0.758	68	0.65	0.49
Class C soils	Planning Zone - Residential Lower Density_Hatch	Residential district 1/4 acre size	83	4.188	348	0.55	2.30
					0		0.00
	Subtotal for Impervious Areas			10.800	954.425		6.02
			Totals	16.484	1377.681		8.15

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{1,378}{16.484} = 83.58$ 0.4942

For ungaged watersheds, the SCS suggests that the time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\, t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refer

Time of Concentration t_c = 0.32 hrs 19.18 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.51022 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 49.9 mm
Pervious = 87.1 mm
Impervious = 33.4 mm

4. Initial Abstraction

Ia = 0.2S = 9.980694

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Post-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.612	1.857	3.436
6	1.443	1.565	2.296
12	0.861	0.95	1.488

Rational Method

19 min

	Q10	Q15	Q100	
Rainfall intensity	82.4	89.2	130.4	
Peak Flow Rate, Q :	1.86	2.02	2.95	m^3/s

TOC rounded to 20min

STORMWATER ASSESSMENT - CATCHMENTS

Project: Kaka Hill Development **By:** CHGR **Date:** 17/05/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 17/05/2022

Calculation Description

Categorise catchment into Pre and Post Development Areas with land cover and soil class

Pre-Development

Land Cover	SCS Cover Type	Soil Class	Soil Condi	C	Area (ha)	Product
Pasture	Pasture , grassland or range-continuous forage for grazing	B	Fair	69	9.52	656.95
		D	Fair	84	29.66	2491.27
Shrubland	Brush-weed-grass mixture with brush the major element	C	Fair	70	6.38	446.81
		D	Fair	77	197.11	15177.32
Forest	Woods	D	Fair	79	10.54	832.42
		Total			**253.21**	**19604.77**

Weighted CN 77.43

Post-Development

Land Cover	SCS Cover Type	Soil Class	Soil Condi	Runoff Co	Area (ha)	Product
Pasture	Pasture , grassland or range-continuous forage for grazing	B	Fair	69	0.98	67.50
		D	Fair	84	1.84	154.24
Shrubland	Brush-weed-grass mixture with brush	D	Fair	77	40.22	3097.11
Forest	Woods	D	Fair	79	10.54	832.46
Open Space Recreation	Brush-weed-grass mixture with brush	B	Good	48	3.78	181.32
Open Space Recreation	Brush-weed-grass mixture with brush	C	Good	65	0.91	58.96
Open Space Recreation	Brush-weed-grass mixture with brush	D	Good	73	18.55	1354.31
Rural	Brush-weed-grass mixture with brush	C	Fair	70	0.69	48.17
Rural	Brush-weed-grass mixture with brush	D	Fair	77	109.31	8416.66
Commercial	Commericial and business	B	Fair	92	0.25	22.56
Commercial	Commericial and business	D	Fair	95	0.13	12.29
Residential/Residential Higher Density	1/4 Acre	C	Fair	83	4.79	397.36
Residential/Residential Higher Density	1/4 Acre	D	Fair	87	33.84	2943.77
Residential Lower Density	1/8 acre or less (town houses)	B	Fair	85	4.52	384.15
Residential Lower Density	1/8 acre or less (town houses)	D	Fair	92	22.87	2104.32
		Total			**253.20**	**20075.18**

Weighted CN 79.29

1 Rural zoning is represented as Brush-weed-grass mixture assuming that there will be little to no change to land cover of this area during development

2 Open Space is represented as "Good" Condition Brush-weed-grass mixture to represent the proposed riparian zone around the stream

STORMWATER ASSESSMENT - PRE-DEVELOPMENT SCENARIO

Project: Kaka Hill Development **By:** CHGR **Date:** 17/05/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 17/05/2022

Calculation Description

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

Catchment 1

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class D soils	*Pasture (Fair Condition)*	84	0.365	31	0.30	0.11
Class C soils	*Shrubland (Fair Condition)*	70	5.023	352	0.35	1.76
Class D soils	*Shrubland (Fair Condition)*	77	129.691	9,986	0.45	58.36
Class C soils	*Forest (Fair Conditon)*	79	10.537	832	0.35	3.69
	Subtotal for Pervious Areas		145.616	11,201		63.92
	Impervious Areas (List)					
Class C soils	*Residential district 1/4 acre size*					
	Subtotal for Impervious Areas					
* from Table 3.3	Totals		145.616	11,201		63.92

CN (weighted) : total product / total area = 11,201 / 145.616 = 76.92 0.4389

For ungaged watersheds, the SCS suggests that th time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$t_{lag} = 0.6\,t_c$ (38)

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refere

Time of Concentration t_c = 0.59 hrs 35.60 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.36 hrs 21.3582 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 76.2 mm
Pervious = 76.2 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 15.24195

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	6.6	7.9	17.0
6	10.9	11.9	18.2
12	6.4	7.2	11.8

Rational Method

36 min

	Q10	Q15	Q100
Rainfall intensity	61.7	71.9	97.5
Peak Flow Rate, Q :	10.97	12.78	17.32

Calculation Description

Catchment 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class D soils	*Pasture (Fair Condition)*	84	5.260	442	0.30	1.58
Class C soils	*Shrubland (Fair Condition)*	70	1.360	95	0.35	0.48
Class D soils	*Shrubland (Fair Condition)*	77	26.572	2,046	0.45	11.96
	Subtotal for Pervious Areas		33.192	2,583		14.01
	Impervious Areas (List)					
Class C soils	*Residential district 1/4 acre size*					
	Subtotal for Impervious Areas					
* from Table 3.3	Totals		33.192	2,583		14.01

CN (weighted) : total product / total area = 2,583 / 33.192 = 77.82 — 0.4221

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\, t_c \qquad (38)$$

2. Time of Concentration https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Refe

Time of Concentration t_c = 0.32 hrs — 18.99 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs — 11.39346 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 72.4 mm
Pervious = 72.4 mm
Impervious = mm

4. Initial Abstraction

Ia = 0.2S = 14.47676

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.2	2.6	5.4
6	2.6	2.8	4.3
12	1.5	1.7	2.8

Rational Method

19 min

	Q10	Q15	Q100
Rainfall intensity	81.7	95.3	129.5
Peak Flow Rate, Q :	3.18	3.71	5.04

Calculation Description

Catchment 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class D soils	Pasture (Fair Condition)	84	1.060	89	0.30	0.32
Class D soils	Shrubland (Fair Condition)	77	21.637	1,666	0.45	9.74
	Subtotal for Pervious Areas		22.697	1,755		10.05
	Impervious Areas (List)					
Class C soils	Residential district 1/4 acre size					
	Subtotal for Impervious Areas					
* from Table 3.3		Totals	22.697	1,755		10.05

CN (weighted) : total product / total area = 1,755 / 22.697 = 77.33 — 0.4430

2. Time of Concentration

Time of Concentration	t_c =		0.30	hrs	17.81 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c =	0.18	hrs	10.68797 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	74.5	mm
Pervious	=	74.5	mm
Impervious	=		mm

4. Initial Abstraction

Ia = 0.2S = 14.89511

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.5	1.8	3.7
6	1.7	1.9	2.9
12	1.0	1.1	1.9

Rational Method

18 min

	Q10	Q15	Q100
Rainfall intensity	84.1	98.1	133.3
Peak Flow Rate, Q :	2.35	2.74	3.72

Calculation Description

Catchment 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class D soils	Pasture (Fair Condition)	84	14.075	1,182	0.30	4.22
Class B soils	Pasture (Fair Condition)	69	2.115	146	0.20	0.42
Class D soils	Shrubland (Fair Condition)	77	18.621	1,434	0.45	8.38
	Subtotal for Pervious Areas		34.811	2,762		13.02
	Impervious Areas (List)					
Class C soils	Residential district 1/4 acre size					
	Subtotal for Impervious Areas					
* from Table 3.3		Totals	34.811	2,762		13.02

CN (weighted) : total product / total area = 2,762 / 34.811 = 79.34 — 0.3742

2. Time of Concentration

Time of Concentration	t_c =		0.32	hrs	19.06 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c =	0.19	hrs	11.43574 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total	=	66.1	mm
Pervious	=	66.1	mm
Impervious	=		mm

4. Initial Abstraction

Ia = 0.2S = 13.22482

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	2.6	3.0	6.1
6	2.8	3.1	4.6
12	1.6	1.8	3.0

Rational Method

19 min

	Q10	Q15	Q100
Rainfall intensity	81.6	95.2	129.3
Peak Flow Rate, Q :	2.95	3.45	4.68

Calculation Description

Catchment 5

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class D soils	*Pasture (Fair Condition)*	84	8.898	747	0.30	2.67
Class B soils	*Pasture (Fair Condition)*	69	7.406	511	0.20	1.48
Class D soils	*Shrubland (Fair Condition)*	77	0.587	45	0.45	0.26
	Subtotal for Pervious Areas		16.891	1,304		4.41
	Impervious Areas (List)					
Class C soils	*Residential district 1/4 acre size*					
	Subtotal for Impervious Areas					
* from Table 3.3		Totals	16.891	1,304		4.41

CN (weighted) : total product / total area = 1,304 / 16.891 = 77.18 → 0.2614

2. Time of Concentration

Time of Concentration	t_c =			hrs	31.36 min
SCS Lag for HEC-HMS :	t_p =	0.6 t_c	= 0.31	hrs	18.81386 min

3. Soil Storage Parameter :

S = ((1000/CN)-10)*25.4

Total	= 75.1	mm
Pervious	= 75.1	mm
Impervious	=	mm

4. Initial Abstraction

Ia = 0.2S = 15.02028

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development

Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	0.8	1.0	2.1
6	1.3	1.4	2.1
12	0.8	0.8	1.4

Rational Method

31 min

	Q10	Q15	Q100
Rainfall intensity	65.3	76.1	103.2
Peak Flow Rate, Q :	0.80	0.93	1.27

STORMWATER ASSESSMENT - POST-DEVELOPMENT SCENARIO

Project: Kaka Hill Development **By:** CHGR **Date:** 17/05/2022

Location: Kaka Hill **Checked:** BYMU **Date:** 17/05/2022

Calculation Description

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

Catchment 1

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

		SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	Pervious Areas (List)					
Class D soils	*Shrubland (Fair Condition)*	77	39.402	3,034	0.35	13.79
Class D soils	*Forest (Fair Conditon)*	79	10.538	832	0.45	4.74
Class C soils	*Open Space (Good Conditon)*	65	0.674	44		0.00
Class D soils	*Open Space (Good Conditon)*	73	11.348	828		0.00
Class C soils	*Rural*	70	0.688	48		0.00
Class D soils	*Rural*	77	67.999	5,236		0.00
	Subtotal for Pervious Areas		130.648	10,023		18.53
	Impervious Areas (List)					
Class C soils	*Residential district 1/4 acre size*	83	3.660	304		0.00
Class D soils	*Residential district 1/4 acre size*	87	9.802	853		0.00
Class D soils	*Residential district 1/8 acre size*	92	1.496	138		0.00
	Subtotal for Impervious Areas		14.958	1,294		0.00
* from Table 3.3		Totals	145.606	11,317		18.53

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{11,317}{145.606} = 77.72$ 0.1273

Weighted CN Pervious = 76.72
Weighted CN Impervious = 86.52

2. Time of Concentration

Time of Concentration t_c = 0.59 hrs 35.60 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.36 hrs 21.3582 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 72.8 mm
Pervious = 77.1 mm
Impervious = 39.6 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 15.42
Initial abstraction - impervious Ia = 0.2S = 7.91

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	7.1	8.5	17.8
6	11.1	12.1	18.4
12	6.5	7.3	11.9

Rational Method

36 min

		Q10	Q15	Q100
Rainfall intensity		61.7	71.9	97.5
Peak Flow Rate, Q :		3.18	3.71	5.02

Calculation Description

Catchment 2

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

		SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	Pervious Areas (List)					
Class C soils	*Open Space (Good Conditon)*	65	0.233	15		0.00
Class D soils	*Open Space (Good Conditon)*	73	3.756	274		0.00
Class D soils	*Rural*	77	2.852	220		0.00
	Subtotal for Pervious Areas	74.39553	6.840	509		0.00
	Impervious Areas (List)					
Class C soils	*Residential district 1/4 acre size*	83	1.127	94		0.00
Class D soils	*Residential district 1/4 acre size*	87	21.549	1,875		0.00
Class D soils	*Residential district 1/8 acre size*	92	3.676	338		0.00
	Subtotal for Impervious Areas		26.353	2,307		0.00
* from Table 3.3		Totals	33.193	2,815		0.00

CN (weighted) : total product / total area = 2,815 / 33.193 = 84.82 0.0000

Weighted CN Pervious = 74.40
Weighted CN Impervious = 87.53

2. Time of Concentration

Time of Concentration t_c = 0.32 hrs 18.99 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.39346 min

3. Soil Storage Parameter :

S = ((1000/CN)-10)*25.4

Total = 45.5 mm
Pervious = 87.4 mm
Impervious = 36.2 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 17.48
Initial abstraction - impervious Ia = 0.2S = 7.24

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	3.6	4.1	7.3
6	3.0	3.2	4.7
12	1.8	1.9	3.0

Rational Method

19 min

		Q10	Q15	Q100
Rainfall intensity		81.7	95.3	129.5
Peak Flow Rate, Q :		0.00	0.00	0.00

Calculation Description

Catchment 3

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

		SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	Pervious Areas (List)					
Class D soils	*Open Space (Good Conditon)*	65	1.210	79		0.00
Class D soils	*Rural*	77	20.631	1,589		0.00
	Subtotal for Pervious Areas		21.842	1,667		0.00
	Impervious Areas (List)					
Class D soils	*Residential district 1/8 acre size*	92	0.855	79		0.00
	Subtotal for Impervious Areas		0.855	79		0.00
* from Table 3.3		Totals	22.697	1,746		0.00

CN (weighted) : total product / total area = 1,746 / 22.697 = 76.93 0.0000

Weighted CN Pervious = 76.33
Weighted CN Impervious = 92.00

2. Time of Concentration

Time of Concentration t_c = 0.30 hrs 17.81 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.18 hrs 10.68797 min

3. Soil Storage Parameter :

S = ((1000/CN)-10)*25.4

Total = 76.2 mm
Pervious = 78.7 mm
Impervious = 22.1 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 15.75 0-
Initial abstraction - impervious Ia = 0.2S = 4.42

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.5	1.7	3.6
6	1.7	1.9	2.9
12	1.0	1.1	1.9

Rational Method

18 min

		Q10	Q15	Q100
Rainfall intensity		84.1	98.1	133.3
Peak Flow Rate, Q :		0.00	0.00	0.00

Calculation Description

Catchment 4

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

		SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	Pervious Areas (List)					
Class B soils	*Pasture (Fair Condition)*	69	0.776	54	0.00	0.00
Class D soils	*Pasture (Fair Condition)*	84	1.029	86	0.00	0.00
Class D soils	*Shrubland (Fair Condition)*	77	0.821	63	0.00	0.00
Class B soils	*Open Space (Good Conditon)*	48	0.263	13		0.00
Class D soils	*Open Space (Good Conditon)*	73	0.404	30		0.00
Class D soils	*Rural*	77	17.825	1,373		0.00
	Subtotal for Pervious Areas		21.118	1,618		0.00
	Impervious Areas (List)					
Class B soils	*Commercial*	92	0.002	0		0.00
Class D soils	*Commercial*	95	0.048	5		0.00
Class B soils	*Residential district 1/8 acre size*	85	1.075	91		0.00
Class D soils	*Residential district 1/8 acre size*	92	12.569	1,156		0.00
	Subtotal for Impervious Areas		13.694	1,252		0.00
* from Table 3.3		Totals	34.811	2,870		0.00

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{2,870}{34.811} = 82.45$ 0.0000

Weighted CN Pervious = 76.61
Weighted CN Impervious = 91.46

2. Time of Concentration

Time of Concentration t_c = 0.32 hrs 19.06 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.19 hrs 11.43574 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 54.1 mm
Pervious = 77.5 mm
Impervious = 23.7 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 15.51
Initial abstraction - impervious Ia = 0.2S = 4.74

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	3.3	3.8	7.0
6	2.9	3.2	4.7
12	1.7	1.9	3.1

Rational Method

19 min

		Q10	Q15	Q100
Rainfall intensity		81.6	95.2	129.3
Peak Flow Rate, Q :		0.00	0.00	0.00

Calculation Description

Catchment 5a

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

		SCS Method			Rational Method	
Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area	C	Product
	Pervious Areas (List)					
Class B soils	*Pasture (Fair Condition)*	69	0.005	0	0.00	0.00
Class D soils	*Pasture (Fair Condition)*	84	0.800	67	0.00	0.00
Class B soils	*Open Space (Good Conditon)*	48	0.877	42		0.00
Class D soils	*Open Space (Good Conditon)*	73	1.834	134		0.00
	Subtotal for Pervious Areas		3.516	244		0.00
	Impervious Areas (List)					
Class B soils	*Commercial*	92	0.244	22		0.00
Class D soils	*Commercial*	95	0.081	8		0.00
Class D soils	*Residential district 1/4 acre size*	87	2.485	216		0.00
Class B soils	*Residential district 1/8 acre size*	85	0.333	28		0.00
Class D soils	*Residential district 1/8 acre size*	92	3.972	365		0.00
	Subtotal for Impervious Areas		7.115	640		0.00
* from Table 3.3		Totals	10.630	884		0.00

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{884}{10.630} = 83.11$ 0.0000

Weighted CN Pervious = 69.26
Weighted CN Impervious = 89.96

2. Time of Concentration

Time of Concentration t_c = 0.52 hrs 31.36 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.31 hrs 18.81386 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 51.6 mm
Pervious = 112.7 mm
Impervious = 28.3 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 22.546
Initial abstraction - impervious Ia = 0.2S = 5.669

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

Rational Method

31 min

		Q10	Q15	Q100
Rainfall intensity		65.3	76.1	103.2
Peak Flow Rate, Q :		0.00	0.00	0.00

Calculation Description

Catchment 5b

Determine peak flow rate with variety of methods
Determine runoff volume for pond sizing calculations

SCS Method

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	SCS Method: Curve Number CN*	SCS Method: Area (hectares)	SCS Method: Product of CN x Area	Rational Method: C	Rational Method: Product
	Pervious Areas (List)					
Class B soils	*Pasture (Fair Condition)*	69	0.197	14	0.00	0.00
Class D soils	*Pasture (Fair Condition)*	84	0.008	1	0.00	0.00
Class B soils	*Open Space (Good Conditon)*	48	2.638	127		0.00
	Subtotal for Pervious Areas		2.843	141		0.00
	Impervious Areas (List)					
Class B soils	*Residential district 1/8 acre size*	85	3.112	265		0.00
Class D soils	*Residential district 1/8 acre size*	92	0.305	28		0.00
	Subtotal for Impervious Areas		3.417	293		0.00
* from Table 3.3		Totals	6.260	433		0.00

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{433}{6.260} = 69.24$ 0.0000

Weighted CN Pervious = 49.55
Weighted CN Impervious = 85.62

2. Time of Concentration

Time of Concentration t_c = 0.00 hrs 0.00 min
SCS Lag for HEC-HMS : t_p = 0.6 t_c = 0.00 hrs 0 min

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 112.8 mm
Pervious = 258.6 mm
Impervious = 42.6 mm

4. Initial Abstraction

Initial abstraction - Pervious Ia = 0.2S = 51.718
Initial abstraction - impervious Ia = 0.2S = 8.529

above parameters used in SCS method analysis in HEC HMS

5. Rainfall data

Using Region-specific temporal patterns produced in HIRDS v4 by NIWA for 1 hour, 6 hour and 12 hour storm durations
RCP8.5

5. Results (Full Catchment 5)

Pre-Development
Results Peak Discharge (m3/s)

hr	Q10	Q15	Q100
1	1.2	1.4	2.5
6	1.3	1.4	2.1
12	0.8	0.8	1.3

Rational Method

0 min

		Q10	Q15	Q100
Rainfall intensity		0.0	0.0	0.0
Peak Flow Rate, Q :		0.00	0.00	0.00

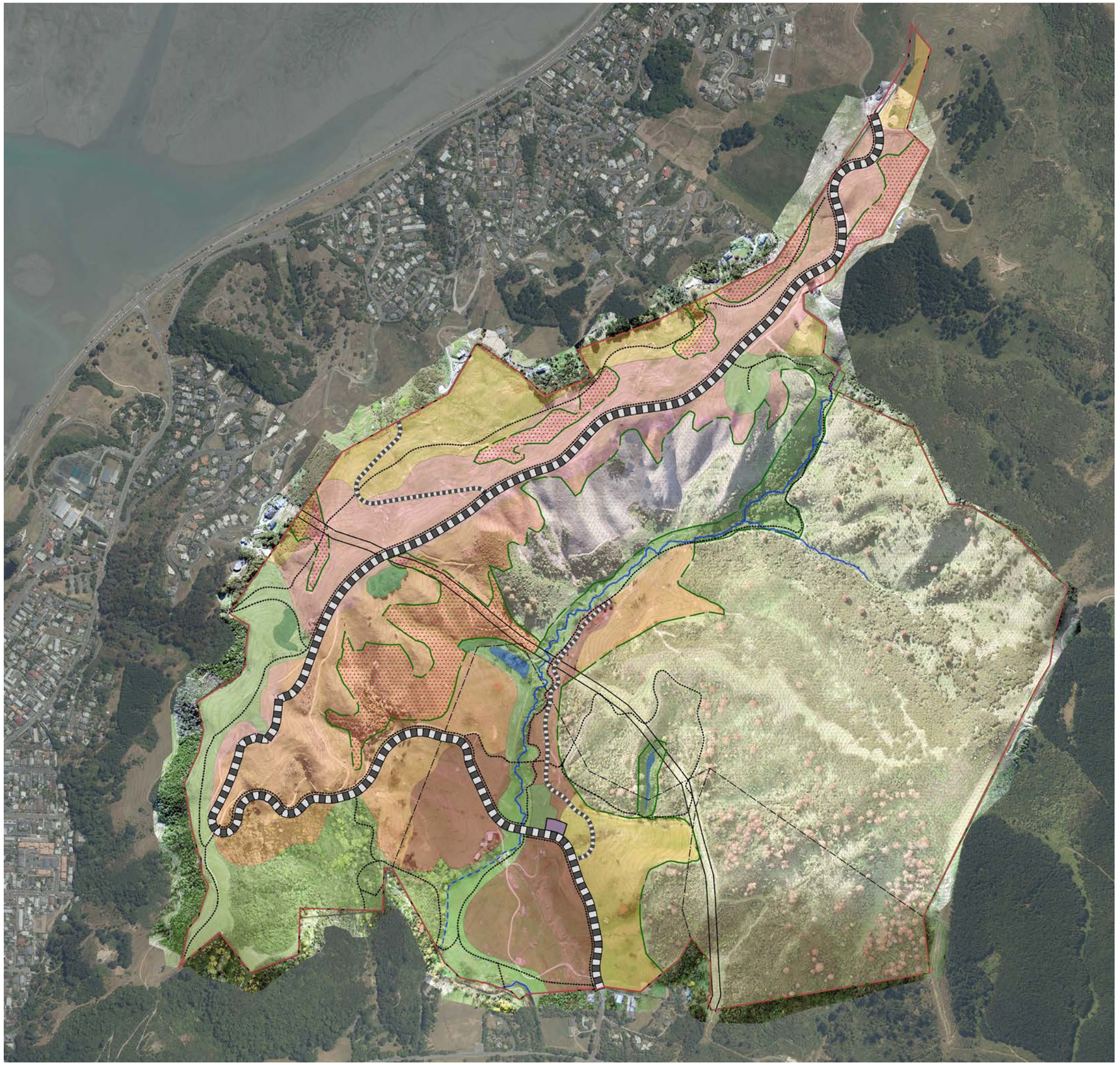
Appendix C: Structure Plan

Proposed Structure Plan (Over Aerial)

Legend

- Residential Zone
- Residential Zone Higher Density Area
- Residential Zone Lower Density Area
- Residential Zone Lower Density Backdrop Area
- Open Space Recreation Zone
- Suburban Commercial Zone
- Rural Zone
- Higher Density Small Holdings Area
- Neighborhood Reserve
- Indicative Road
- Indicative Walkway/ Cycleway Link
- Indicative Lookout Locations
- Wetland
- Existing Stream
- Proposed Stream
- Site Boundary
- Internal Cadastral Boundaries
- Secondary Roads
- Network Tasman Limited Corridor - No Earthworks
- Residential Green Overlay
- Revegetation Overlay In Rural Zone
- Kanuka Vegetation and Kahikatea Tree to be Protected

Scale 1:10000@A3



Appendix D: Morphum memo

MORPHUM environmental

Memorandum

Date:	[Publish Date]
To:	Neil Donaldson (CCKV Maitai Dev Co LP and Bayview Nelson Ltd)
From:	Stu Farrant
CC:	Maurice Mills (Tonkin & Taylor)
Project Number:	Project Number
Reviewed by:	Mark Lowe
Released by:	Caleb Clarke

Subject: Preliminary water management summary for SMP

This memorandum has been prepared by Morphum Environmental Ltd (Morphum) to support the development of the high level Stormwater Master Plan (SMP) being developed for the proposed Maitahi residential development. This SMP was requested by appointed technical experts representing submitters to the PPC28 application and Nelson City Council. Specifically, the SMP was requested during pre-hearing expert conferencing which was undertaken on ..... This conferencing identified that whilst the intent for the development to provide a high level of protection of the Kaka Stream and Maitai River ecosystem was documented through the application there was limited supporting evidence to demonstrate how this might be achieved on the ground. This is important to provide an appropriate level of confidence in the ability for the development to meet the stated stormwater management principles presented in the PPC28 application as X9.

Morphum were previously engaged to undertake a *Preliminary Structure Plan Environmental Review* (report dated 13/04/2021). This included 18 recommended principles which were adapted to form the basis of X9 principles and recommendations around how development related stormwater could be managed in a manner which protects the receiving environments from adverse impacts related to water quality and quantity. This supporting report should be referred to for further context.

At this stage of the development planning, no formal development typologies, urban design layouts or stormwater network design has been undertaken which would support more refined sub catchment analysis to inform the SMP. Therefore, a number of assumptions and committed development approaches are instead provided to define how the development will be progressed in a manner which protects the existing ecosystem function and enables restoration activities to enhance values. These approaches and assumptions are outlined in this memorandum with resulting spatial footprints which will need to be incorporated into design development in an integrated manner when it commences. All catchment delineation and estimates of imperviousness are based on catchment analysis undertaken by Tonkin & Taylor to inform their flood flow estimation. It is noted that these assumptions are considered conservative (given the topographical constraints that will limit developable land) with an expectation that spatial footprints for consolidated stormwater treatment devices will be reduced in later stages based on comprehensive water/contaminant balance modelling. Calculated footprints were increased by a factor of 30%.

Maitahi Development approach

The following points summarise the approach to land development which will have a direct influence on site wide stormwater planning.

1. All dwellings to include rainwater capture with reuse to service internal and external non potable demands to intercept an initial volume of runoff as a surrogate for naturally occurring evapotranspiration losses. This will include internally plumbed tanks which augment reticulated mains supply for fit for purpose non potable demands including toilet flushing, cold water laundry and external uses as a minimum. Modelling shall be undertaken to develop relationship between roof area and tank size to support an average of 80% reliability of supply and a reduction of roof runoff of at least 60% mean annual volume. This equates to an initial retention depth of between 5 – 10 mm which will be realised across the majority of daily timesteps and in particular will be met during summer conditions when stream flows are reduced and vulnerable to flashy inflows of contaminated stormwater. Development specific design guidelines will define required tank sizes for a range of connected roof areas.
2. All dwellings on suitable ground will include infiltration via porous manholes positioned to receive runoff from driveways and overflow from rainwater tanks. These will be sized based on relationship with roof area (and rainwater harvest) to provide a combined initial retention depth of approximately 10 mm. It is noted that this will only be suitable for dwelling on lower parts of the development due to the risk of ground instability and uncontrolled seepages to downslope properties from higher lots.
3. Stormwater sub catchments to be managed with 'traditional' pipe networks to collect excess flows from lots and runoff from roads. Sub catchment stormwater to be managed via consolidated treatment devices to mitigate impacts prior to discharge to any natural waterway or pipe networks which flow beyond the development boundary. Treatment devices will include;
    a. Consolidated raingardens designed with internal storage and infiltration to shallow groundwater. These can be integrated within the proposed Kaka Stream esplanade (where suitable) or in dispersed parklets which support community connection with water management and support amenity, urban ecology and education. These will be designed with careful consideration of lifecycle maintenance. Raingardens will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
    b. Consolidated constructed wetland designed to be integrated into green spaces and provide a high level of water quality treatment. These will be integrated within the proposed Kaka Stream esplanade, in particular on the lower terrace alongside the re-aligned channel reach. High quality constructed wetlands will support community connection with water management and support amenity, urban ecology and education. Consideration will be given to options to harvest treated water from wetlands to augment irrigation of high amenity planted gardens, community gardens or irrigation of parks. These will be designed with careful consideration of lifecycle maintenance. Raingardens will all be offline to full pipe flow with appropriately design bypass although flood attenuation can be accommodated above the operational water level as required.
    c. Passive irrigation of integrated green infrastructure such as street trees, verge planting and restoration planting. Careful design of any passive irrigation will need to ensure that peak flows are appropriately managed to prevent uncontrolled overland flow whilst enabling frequent small rainfall events to support healthy urban greenery with benefits in biodiversity, evapotranspiration and micro climate.

It is noted that modelling has provided recommendations for the required land area for both raingardens and wetlands (i.e. treatment requirements duplicated). In reality the final development design will include either one of the two devices or a combination in response to site conditions.

Maitahi Development assumptions

The following assumptions have been used to inform the nominated preliminary size of required devices in the SMP (refer Tonkin & Taylor).

1. Sub catchment delineated based on existing hydrologic catchments. These were delineated by T&T and are consistent with their reporting.
2. Residential development types (as proposed in structure plan) used to infer imperviousness which was then agglomerated across the sub catchment to give an estimated impervious area for developable land within each sub catchment. Non development land (rural, open space etc) excluded for the purposes of water quality.
3. Residential roofs (connected to rainwater tanks) assumed to comprise 50% of impervious cover
4. Residential hardstand (driveways) assumed to be 20% of impervious cover
5. Roads assumed to be 30% of impervious cover (15% of total development catchment). Roads assumed to be 80% impervious within corridor
6. Roof runoff effectively mitigated for quantity and quality via appropriately sized rainwater reuse tanks
7. Hardstand runoff effectively managed for quantity and quality for 50% of lots
8. Raingardens sized at 2% of connected impervious catchments (increased by 30% to allow for batters etc). Raingardens to be modelled to demonstrate ability to pass 80-85% of mean annual volume through filter media with underlying saturated zone and infiltration to be refined to meet overall groundwater recharge aspirations,
9. Wetlands sized at 4.5% of connected impervious catchments (increased by 30% to allow for batters etc). Wetlands to be modelled to demonstrate ability to pass 80-85% of mean annual volume through wetland with extended detention included. Further detention of flows may be achievable via harvest of a portion of treated stormwater.

Table 1 shows the summary of catchment landuse breakdowns and the resulting required footprint to manage site generated stormwater. It is noted that the reported footprints for raingardens/wetlands are for either of these options (i.e. will not need combined total) and the distribution of these is expected to be split into more than one device per sub catchment. The final selection of optimal treatment devices, layout and distribution will be developed in close co-ordination with urban designers, landscape architects, civil designers and Geotech.

Stu Farrant
Water Sensitive Design Lead
Morphum Environmental Ltd
Phone: 021 578904
stu.farrant@morphum.com

Table 1 Estimated development areas, impervious land covers and calculated stormwater management device sizes

Sub-catchment	Combined Developed Area (m²)	Impervious %	Sum of Impervious Area (m²)	Assumed roof area (m²)	Managed Hardstand (m²)	Un-managed hardstand (m²)	Road impervious (m²)	Raingarden Area (m²)	Wetland Area (m²)
1	834,081	19%	158,475	79,238	15,848	15,848	25,356	1,071	2,410
2	297,879	42%	125,109	62,555	12,511	12,511	20,017	846	1,903
3	216,558	30%	64,967	32,484	6,497	6,497	10,395	439	988
4	318,538	39%	124,230	62,115	12,423	12,423	19,877	840	1,890
5A	72,291	57%	41,206	20,603	4,121	4,121	6,593	279	627
5B	34,302	65%	22,296	11,148	2,230	2,230	3,567	151	339
Grand Total	**1,773,649**		**536,284**	**268,142**	**53,628**	**53,628**	**85,805**	**3,625**	**8,157**

NOTE THIS TABLE HAD BEEN SUPERSEDED BY TABLE 5.3 IN THE MAIN BODY OF THE STORMWATER MANAGEMENT PLAN

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