ADDENDUM A –

At-A-Site Evaluation of Appropriate CN Numbers

To be appended to -

Report: Pinehaven Stream

ARI 100 Hydrological Assessment

Various Development Scenarios

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Summary

We consider our CN numbers are representative of the hydrological characteristics of Pinehaven sub-catchment B. Previous studies for Greater Wellington Regional Council indicate a difference between pre- and post-development runoff volumes of between 0.5% and 1%. Our original analysis indicates these differences to be in the order of 600% to 700%, or, when we use the Cardno (2019) CN map, a difference in the order of about 200% increase in runoff volume. We think that the difference between our original runs and our later runs using the Cardno (2019) CN map can, in part, be explained by Cardno's high CN numbers applied to the ridgeline which we do not think are supported by field tests or by Landcare Research soil drainage and permeability data layer information. We therefore have misgivings about the validity and applicability of the CN numbers in the Cardno (2019) CN map for this part of the catchment.

At-A-Site Evaluation of CN Numbers

This is an exercise in assessing hydraulic neutrality in terms of the impact of some future development scenarios (DS1, DS2 and DS2A) on Pinehaven sub-catchment B in response to an ARI 100-year rain storm. Assessments of this kind need to consider both the effects of runoff during the storm and how modification of that runoff by development can effect subsequent stream flows in the longer term.

This exercise needs to make realistic assessment of both the pre- and post-development runoff volumes having regard to the actual infiltration characteristic of the catchment being studied. An under-estimation of infiltration capacity for the pre-development situation has implications for the design of mitigation measures such as under-estimating the size of detention storage required.

Part of the portion of the rainfall that enters into the ground as infiltration will ultimately re-emerge as stream flow at a later time. A high infiltration rate during a storm doesn't necessarily result in any significant increase in peak runoff because it would need to re-emerge reasonably quickly and re-enter the overland flow. Any effect of this kind would be largely confined to the riparian areas immediately adjacent to the stream. The time delay for any rainfall infiltrating into the ground that re-charges the stream as a release from groundwater will have the effect of supporting the latter part of the recession curve of the hydrograph rather than the peak.

Urban development of the kind contemplated in these future scenarios has the effect of denying the stream of some of this re-charge because it converts it to surface runoff during the storm. This will have an inevitable consequential effect on stream and riparian ecology.

Our original assessment employed the SCS method to determine rainfall runoff volumes and peak discharges for both the pre- and post-development situations. This methodology employs a runoff number (CN 'Curve Number') which reflects antecedent moisture condition, soil type and hydrological condition, land use and land cover. The infiltration rate of the soil is a key component for establishing the CN number. In order to assist that process we undertook infiltration tests at a number of points in forested parts of the catchment, and obtained values in the order of 500mm to 900mm per hour.

This high infiltration rate is attributed to the major disturbances to the soils which are known to have occurred since European settlement, and the presence of well-drained subsoil comprising regolith and heavily fractured argillite and greywacke basement rock within the Wellington fault crush zone. This strata is readily visible in cuttings on the Blue Mountains Road. It is worth noting that Pinehaven Stream follows a splinter fault of the Wellington fault, as does also the Mangaroa River. This situation has assisted both these waterways to incise into an old peneplain. Interestingly, both these waterways flow north in the opposite direction to the Hutt River because they follow weaknesses in the ground created by the splinter faults.

As noted in our report, we relied on the US National Engineering Handbook descriptions for soil groups determined on the basis of infiltration rates. We have used that approach plus the generic classifications in the Cardno (2019) report to obtain what we consider is a representative CN number.

Webb and Wilson (1995) provide the three classes of soil permeability used in the Landcare Research 'Soil Permeability Layer', namely 'Slow' (<4mm/hr), 'Moderate' (4mm to 72mm / hr), and 'Rapid' (>72mm/hr). Webb and Wilson note that these permeability classes are based on methodology by Griffiths (1985) using double-ring infiltrometer tests as the preferred method. Griffiths (1985) notes that *"in the absence of precise measurements, permeability may be assessed by examining the morphology and physical characteristics of the soil"*. In effect, we have used a combination of both double-ring infiltrometer tests and examination of the actual physical characteristics of the soil, in conjunction with the US National Engineering Handbook and the Cardno (2019) generic descriptions. We consider our CN numbers are representative of the hydrological characteristics of sub-catchment B.

An alternative approach is to use the CN numbers shown in map form in Appendix B of Cardno (2019). Cardno describe the method they used to develop the CN map as follows:

"The soil drainage component was derived from the Land Environments of New Zealand (LENZ) drainage layer and Fundamental Soils data layer (FSL) permeability layer and refined based on local knowledge of the Wellington soils. The land cover component was derived from the Land Cover Database (LCDB v4.1)." (Cardno, 2019, p7)

Notwithstanding that we have concerns about the numbers that are represented on the Cardno CN map (concerns which we will explain later), we have repeated the SCS method using the Cardno mapped CN numbers. The results of this further analysis repeat the pattern that we see in the original modelling run, albeit to a lesser extent. (See Figures A10 – A15, and results in Tables 1.1, 2.1, 3.1 and 4.1 below, and input parameters in Figure A9 below.)

What is noticeable in both these assessments is the marked difference in both the peak runoff and runoff volumes in pre- and post-development scenarios. It is interesting to note that the scale of these differences are not inconsistent with the comments made in Auckland Council's "Water Sensitive Design Guide for Stormwater" (GD04/2015 p32) which says:

"Based on international literature, a catchment containing 10-20% impervious surface will generally experience a two-fold increase in stormwater runoff volumes during a storm event; a 35-50% increase in impervious area will experience a three-fold increase in stormwater runoff; and a 75%$^{+}$ area, a five-fold increase (Paul and Meyer, 2001)."

The field infiltration test results shown along the ridge top of sub-catchment B in Figure A4 are reflective of the well-drained soils in the same area shown in Figure A19 (Landcare Research – Soil Drainage Map). However, when we look at Cardno (2019) CN map shown in Figure A20 in the same area we find CN values ranging from about CN68 to CN87, and averaging about CN77. CN numbers at this level would not normally be considered "well-drained" as shown in Figure A19 (Landcare Research – Soil Drainage Map). For this reason we have misgivings about the validity and applicability of the CN numbers in the Cardno (2019) CN map for this part of the catchment. We are of the view that the higher CN numbers we have used from the Cardno (2019) CN map contain anomalies which we think account, in part, for the difference between our results for these runs and our original runs.

The results of both the original assessment and the assessment using the Cardno map CN values are clearly very different to the results previously published for the various future development scenarios in this catchment by MWH, SKM, Beca and Jacobs for the Greater Wellington Regional Council. It is counter-intuitive that the differences indicated in the previous studies between pre- and post-development runoff volumes should be so small and at such variance with the opinion expressed in Auckland Council's Water Sensitive Design Guide for Stormwater (GD04/2015 p32). We therefore re-affirm our view that no reliance should be placed on the results of those earlier studies either for hydraulic neutrality assessment purposes or for floodplain mapping.

Cardno (2019): CN table and CN maps for the Wellington region.

Cardno

Reference Guide for Design Storm Hydrology
Standardised Parameters for Hydrological Modelling

Appendix B: Curve Number Tables and Map

Table B.1 Curve number values used to formulate the SCS curve number map

	SOIL GROUP			
LAND COVER	A Sand, loamy sand, or sandy loam (low runoff potential)	B Silt loam or loam	C Sandy clay loam	D Clay loam, silty clay loam, sandy clay, silty clay, or clay (high runoff potential)
Alpine tussock/grass	66	77	84	87
Bare	66	77	84	87
Forest	28	46	63	71
Impervious	98	98	98	98
Pasture-Crop	37	59	72	78
Scrub/Flax	33	54	68	75
Urban Open Space	37	59	72	78

Figure A1 - CARDNO (2019) - Appendix B - Curve Number Table
From Cardno "Reference Guide for Design Storm Hydrology - Standardised Parameters for Hydrological Modelling" 9 April 2019 (for Wellington Water Ltd)

Single Ring and Double-Ring Infiltrometer tests for ground infiltration capacity have been carried out in forested parts of the Pinehaven catchment (see separate report by Alex Ross). From these infiltration tests, it is deduced that the existing CN for sub-catchment B is likely to be in the range of CN28 to CN46, i.e. Cardno - Appendix B - Curve Number table: Forest (in Good condition) on Soil Group A (CN28) or Soil Group B (CN46), possibly generally CN37 (halfway between CN28 and CN46).

The Cardno (2019) CN map, however, shows higher CN values in the Pinehaven catchment.

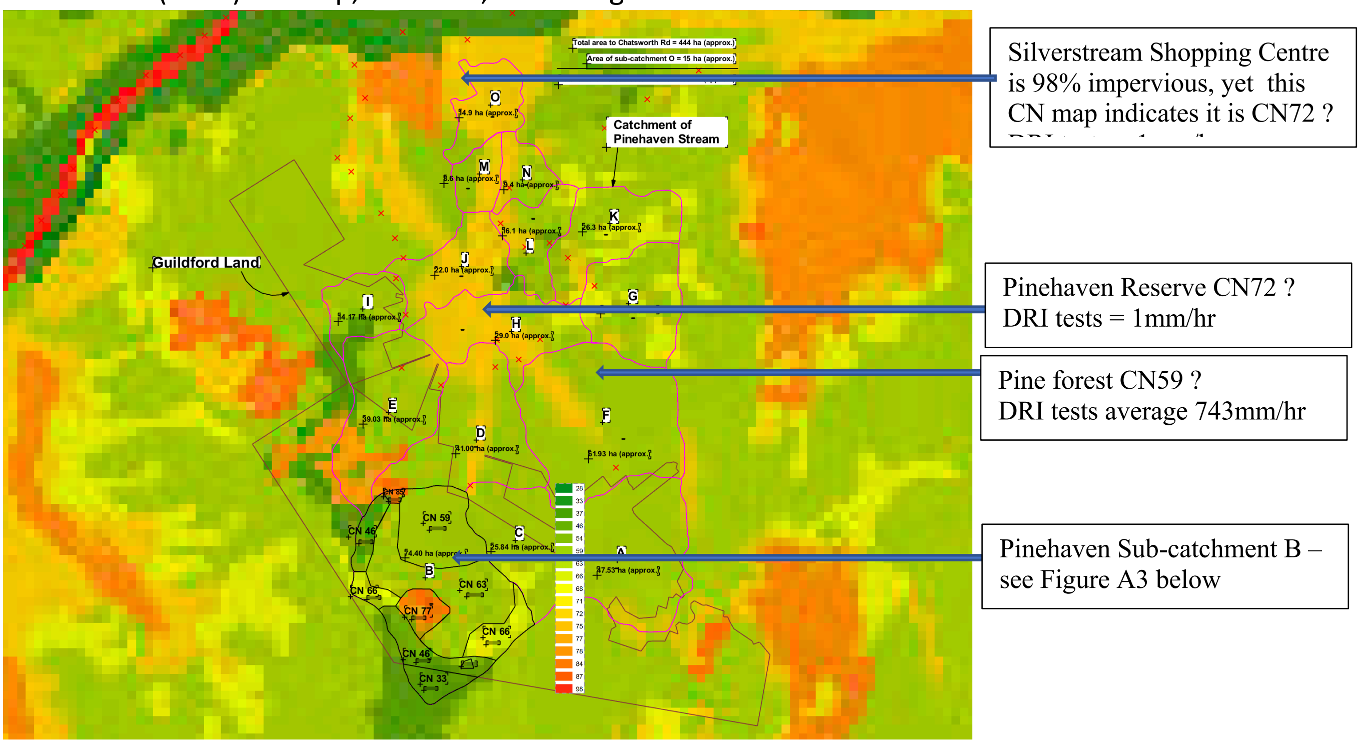

Figure A2 - Pinehaven Stream catchment overlaid on part-Cardno CN map (Cardno 2019 – Appendix B – CN Curve Number Map)

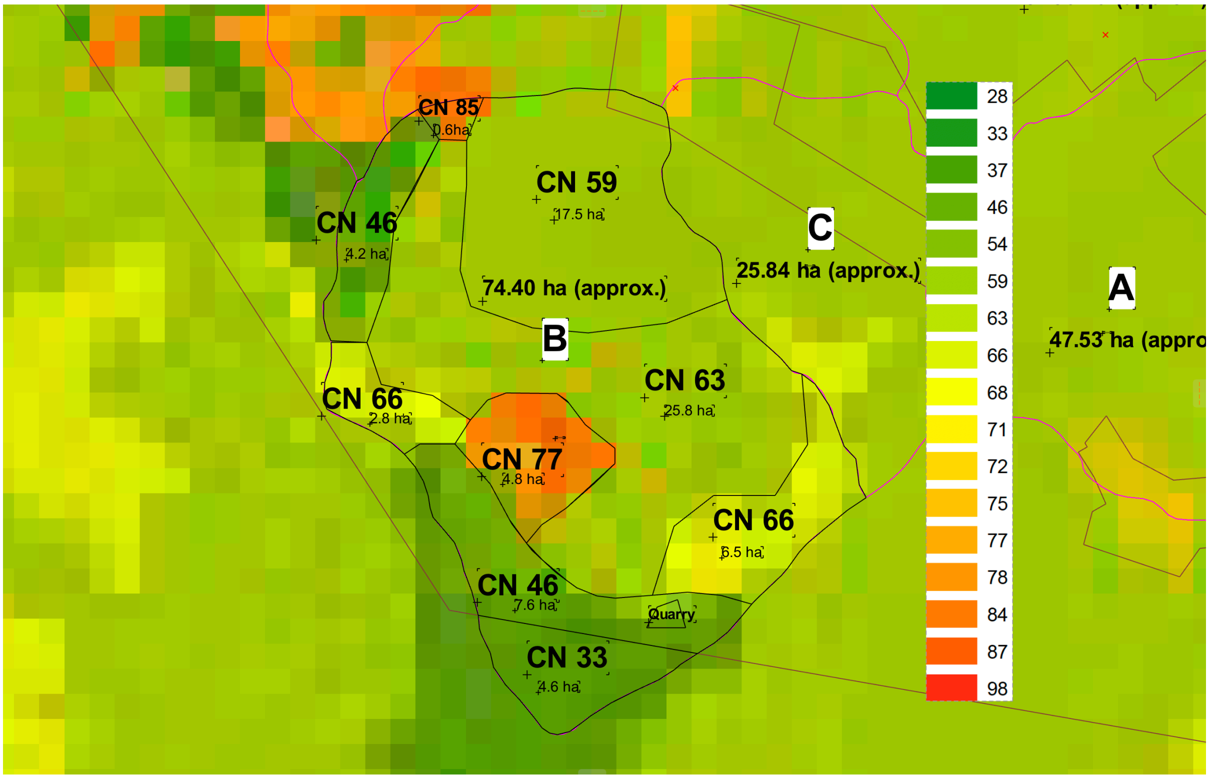

Figure A3 - Pinehaven Stream Sub-catchment B overlaid on part-Cardno CN map (Cardno 2019 – Appendix B – CN Curve Number Map)

CN numbers for sub-catchment B derived from the Cardno CN map (Figure A3 above) for the three development scenarios DS1, DS2 and DS2A are:

Sub-catchment B - Development Scenario OS1 / DS1
According to the above CN map: OS1 = CN 59 =
((85*0.6)+(59*17.5)+(63*25.8)+(66*6.5)+(33*4.6)+(46*7.6)+(77*4.8)+(66*2.8)+(46*4.2))/74.4

Sub-catchment B - Development Scenario OS2 / DS2
According to the above CN map: OS2 = CN 57 =
((85*0.61)+(66*5.76)+[46*(2.64+4.30)]+(77*2.70)+[66*(1.42+0.89)]+(46*5.33))/23.7

Sub-catchment B - Development Scenario OS2A / DS2A
According to the above CN map: OS2A = CN 61 =
((85*1.12)+(63*3.65)+(66*6.9)+[46*1.63+4.47)]+(77*6.59)+[66*2.34+1.06)]+(46*7.31))/35.1

Therefore a pre-development condition of CN63 (Cardno: Forest - Soil Group C) is assumed for all three scenarios in a re-run of the pre- and post-development modelling.

NOTES:

1. Existing CN values on Cardno's CN map (Fig. A3) appear to be raised where Guildford intend to build along the ridges - see DS2 (Fig. A7) and DS2A (Fig. A8);
2. Given the size of the orange area (CN77) on sub-catchment B (Fig. A3), DS2 footprint (Fig. A7) seems too small, and the larger footprint of DS2A (Fig. A8) seems justified;
3. Given the colour of the orange area (CN77) on sub-catchment B (Fig. A3), the assumption of medium density in the DS2A development (Fig. A8) seems justified.

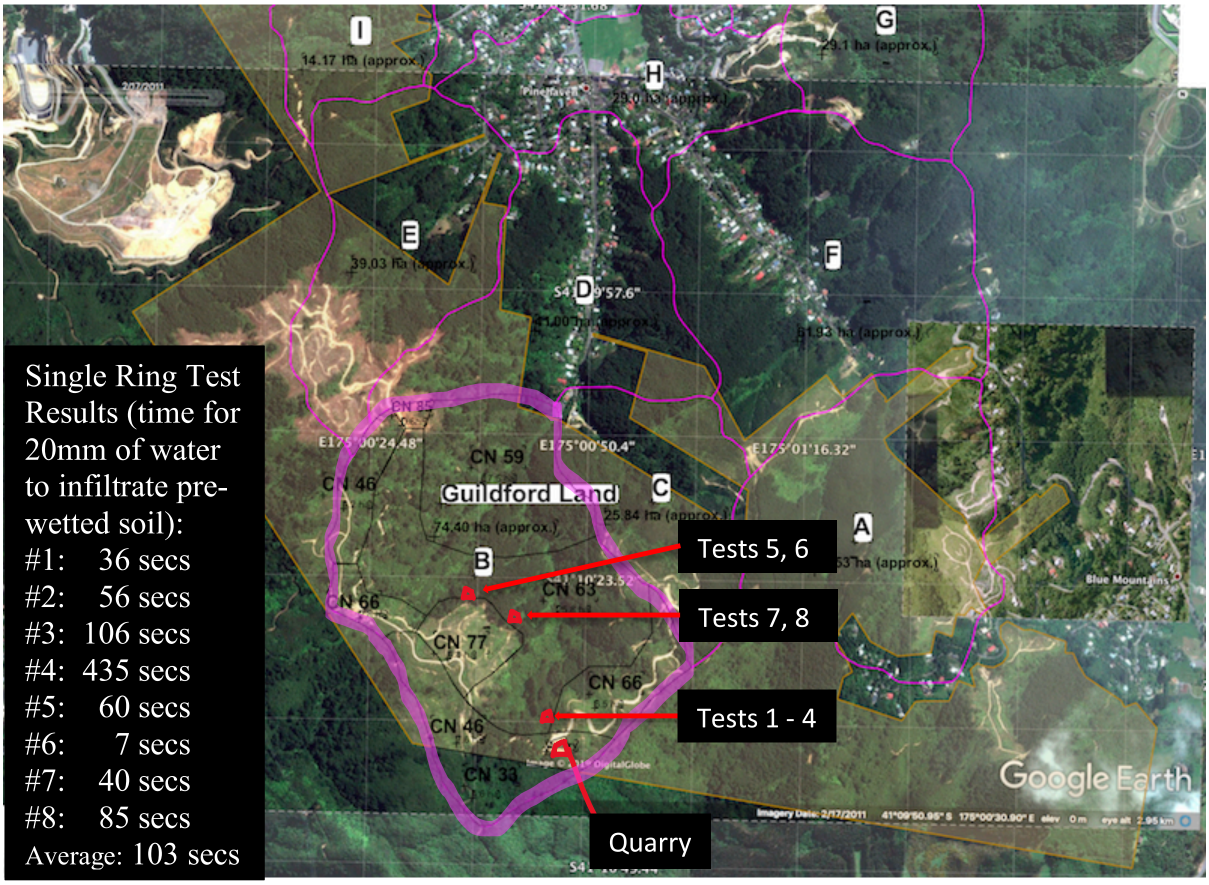

Figure A4 - Cardno CN numbers overlaid on Google Earth map (2011) of sub-catchment B. Locations of the single ring infiltration tests 1 – 8 on sub-catchment B are shown.
(For infiltration tests, see separate report by Alex Ross. Mr Ross notes that, setting aside the outlier Test #6 at 7 seconds, the average time is 119 seconds giving an infiltration rate of 603mm/hr, which is reasonably consistent with the double-ring infiltration tests in the pine forest above Elmslie Road, Pinehaven, of 516mm/hr, 800mm/hr and 912mm/hr, i.e. average 743 mm/hr.)

Figure A5 - Quarry on sub-catchment B.

Figure A6 - Quarry on sub-catchment B

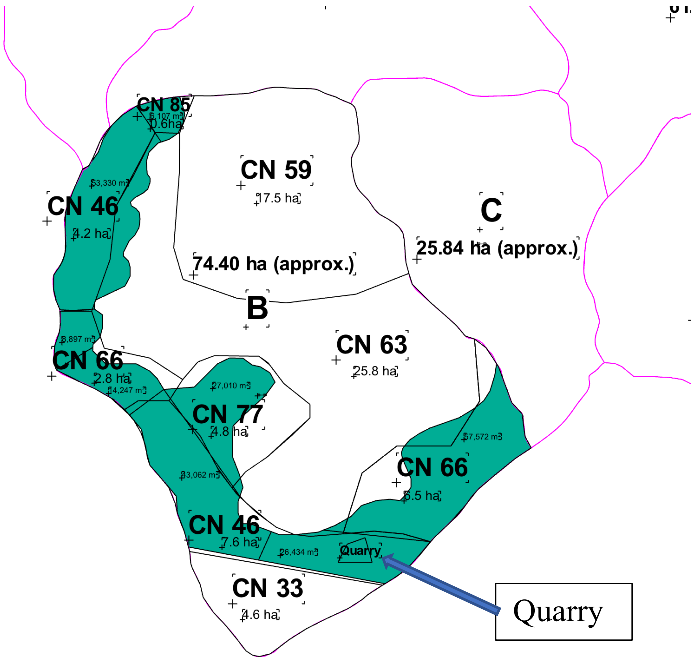

Figure A7 - Development Scenario DS2 footprint

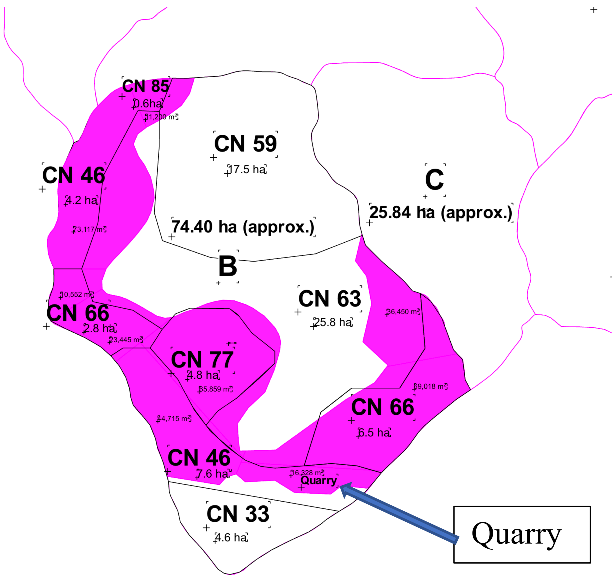

Figure A8 - Development Scenario DS2A footprint

As mentioned above, the Cardno CN map indicates the following CN values for the pre-development condition (OS) of the 3 development scenarios DS1, DS2 and DS2A:

- OS1 = CN59
- OS2 = CN57
- OS2A = CN61

Therefore a pre-development condition of CN63 (Cardno: Forest - Soil Group C) is assumed.

The following results are for a pre-development condition of CN63 (Forest on Soil Group C).

Pinehaven Stream, Upper Hutt
Future Development Scenarios - Summary of Results
Based on Cardno Curve Number Map (using CN63 for the pre-development condition)

Pre-Development without Climate Change

Table 1.1 - Results Sub-catchment B - 100yr ARI Peak Runoff - Based on Cardno Curve Number Map

	Peak Runoff (m3/s)								
	DS1 - Extensive Low Density			DS2 - Low Density Along Ridge			DS2A - Medium density Along Ridge		
Sub-catchment	OS1*	DS1†	DS1 Gain	OS2*	DS2†	DS2 Gain	OS2A*	DS2A†	DS2A Gain
B	7.7	17.2	222%	3.0	6.4	215%	4.1	9.9	240%

* existing situation - no climate change
† 16% added to rainfall for climate change (ARI 100yr)

Table 2.1 - Results Sub-catchment B - 100yr ARI Runoff Volume - Based on Cardno Curve Number Map

	Runoff Volume (m3)								
	DS1 - Extensive Low Density			DS2 - Low Density Along Ridge			DS2A - Medium density Along Ridge		
Sub-catchment	OS1*	DS1†	DS1 Gain	OS2*	DS2†	DS2 Gain	OS2A*	DS2A†	DS2A Gain
B	47,262	106,089	224%	15,196	33,980	224%	22,438	55,338	247%

* existing situation - no climate change
† 16% added to rainfall for climate change (ARI 100yr)

Pre-Development with Climate Change

Table 3.1 - Results Sub-catchment B - 100yr ARI Peak Runoff - Based on Cardno Curve Number Map

	Peak Runoff (m3/s)								
	DS1 - Extensive Low Density			DS2 - Low Density Along Ridge			DS2A - Medium density Along Ridge		
Sub-catchment	OS1†	DS1†	DS1 Gain	OS2†	DS2†	DS2 Gain	OS2A†	DS2A†	DS2A Gain
B	9.8	17.2	175%	3.8	6.4	169%	5.2	9.9	189%

† 16% added to rainfall for climate change (ARI 100yr)

Table 4.1 - Results Sub-catchment B - 100yr ARI Runoff Volume - Based on Cardno Curve Number Map

	Runoff Volume (m3)								
	DS1 - Extensive Low Density			DS2 - Low Density Along Ridge			DS2A - Medium density Along Ridge		
Sub-catchment	OS1†	DS1†	DS1 Gain	OS2†	DS2†	DS2 Gain	OS2A†	DS2A†	DS2A Gain
B	60,614	106,089	175%	19,482	33,980	174%	28,769	55,338	192%

† 16% added to rainfall for climate change (ARI 100yr)

Tables 1.1, 2.1, 3.1, 4.1 – Pre-Development and Post-Development Peak Flows and Volumes (based on Cardno CN map pre-development condition for sub-catchment B of CN63)

See Figures A10 – A12 for HEC-HMS modelling results where the pre-development condition does <u>not</u> include an allowance for climate change.

See Figures A13 – A15 for HEC-HMS modelling results where the pre-development condition <u>does</u> include an allowance for climate change.

Parameters	
Rainfall:	
HIRDSv4 - Location on road near top of Sub-catchment B	
Historical (no Climate Change)	
ARI 100yr (1% AEP)	
Nested Storm 12hr in 5minute intervals with peak intensity 67%	
US SCS Method	
Loss Method: SCS Curve Number	
Transformation Method: SCS Unit Hydrograph	
Existing Footprint OS1	**Development Scenario DS1**
Sub-catchment B - Area = 0.744 km2 (74.4 ha)	Sub-catchment B - Area = 0.744 km2. (74.4 ha)
OS1 (Pre-Development) CN 63	DS1 (Post-Development) CN 88 (composite)
Existing (Forest/bush) on Soil Group C	Urban Open Space (on Soil Group D) = CN78
Ia = 14.9mm	Ia = 2.4mm
Tc = 24 minutes	Tc = 18 minutes
Lag = 2/3 x Tc = 16 minutes	Lag = 2/3 x Tc = 12 minutes
Existing Footprint OS2	**Development Scenario DS2**
On ridge of Sub-catchment B - Area = 0.237 km2 (23.7 ha)	On ridge of Sub-catchment B - Area = 0.237 km2 (23.7 ha)
OS2 (Pre-Development) CN 63	DS2 (Post-Development) CN 88 (composite)
Existing (Forest/bush) on Soil Group C	Urban Open Space (on Soil Group D) = CN78
Ia = 14.9mm	Ia = 2.4mm
Tc = 15 minutes	Tc = 10 minutes
Lag = 2/3 x Tc = 10 minutes	Lag = 2/3 x Tc = 6.7 minutes
Existing Footprint OS2A	**Development Scenario DS2A**
On ridge of Sub-catchment B - Area = 0.351 km2 (35.1 ha)	On ridge of Sub-catchment B - Area = 0.351 km2 (35.1 ha)
OS2A (Pre-Development) CN 63	DS2A (Post-Development) CN 93 (composite)
Existing (Forest/bush) on Soil Group C	Urban Open Space (on Soil Group D) = CN78
Ia = 14.9mm	Ia = 2.4mm
Tc = 18 minutes	Tc = 12 minutes
Lag = 2/3 x Tc = 12 minutes	Lag = 2/3 x Tc = 8 minutes

Figure A9 – Parameters: Tables 1.1, 2.1, 3.1, 4.1 - HEC-HMS Hydrological Modelling Inputs

See Figures A10 – A12 for HEC-HMS modelling where the pre-development condition does not include an allowance for climate change.

See Figures A13 – A15 for HEC-HMS modelling where the pre-development condition does include an allowance for climate change.

HEC-HMS Modelling using Cardno Curve Number (CN63) for Pre-Development Situation

Pre-Development without climate change:

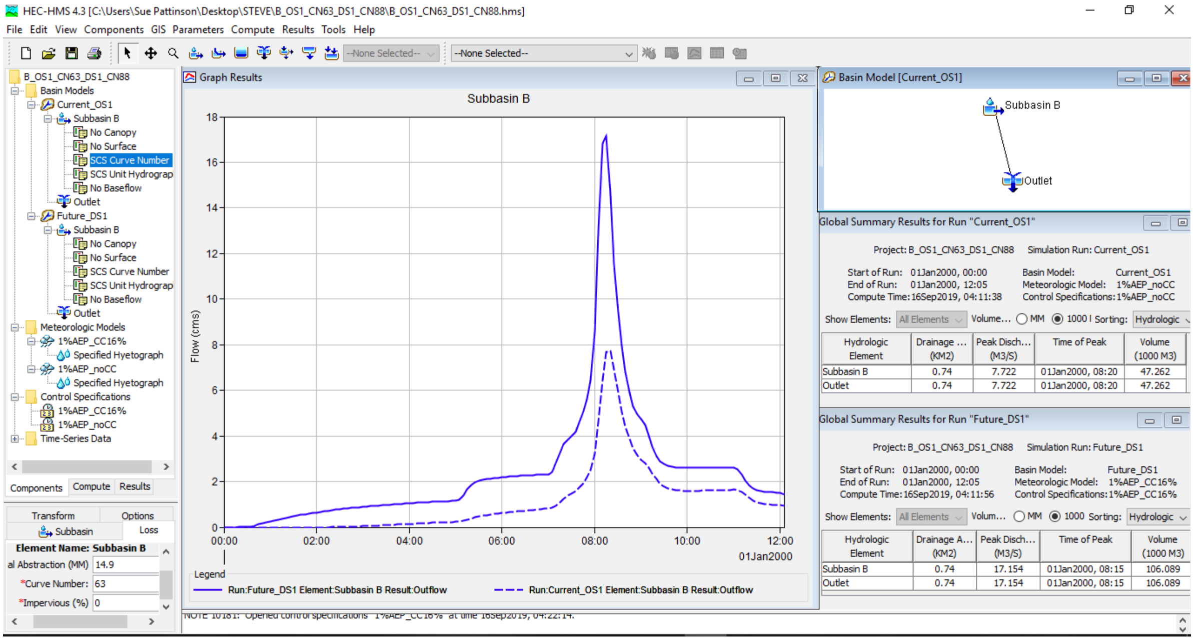

Figure A10 – Development Scenario DS1 – Low density over whole of sub-catchment B.
Pre-development (OS1) without allowance for climate change, and modelled using CN63.
Post-development (DS1) with climate change, and modelled using composite CN88.
See Figure A9 for input parameters, and Tables 1.1 (peak flows) and 2.1 (runoff volumes).

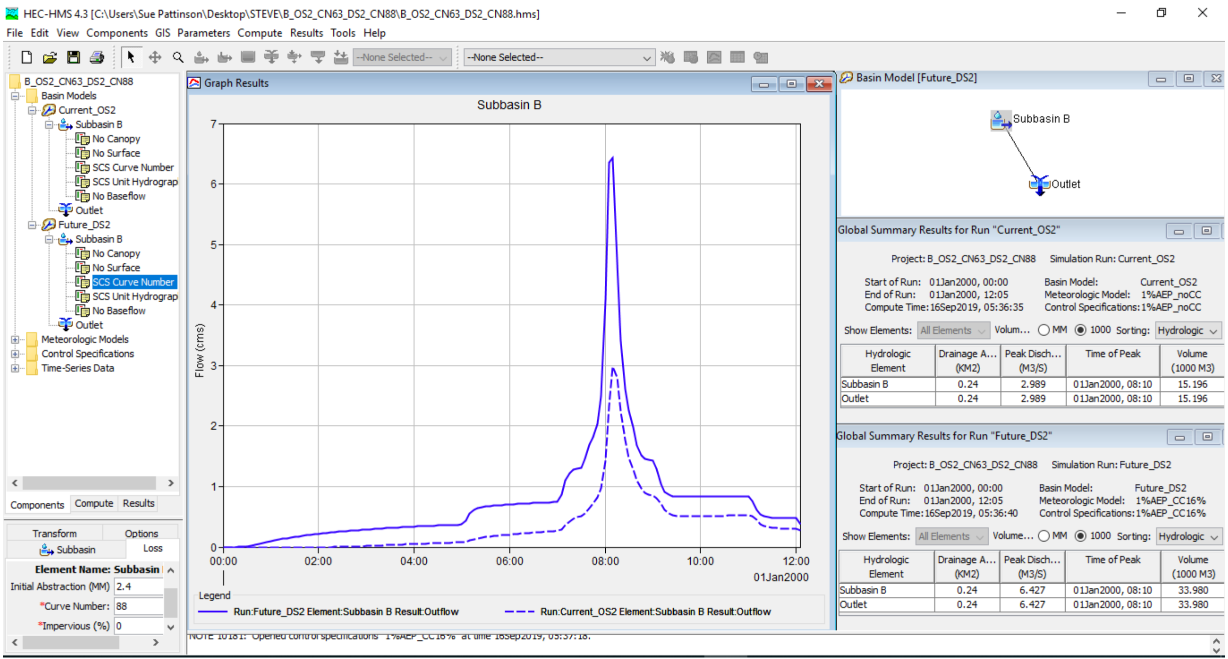

Figure A11 – Development Scenario DS2 (see Figure A7) – Low density along ridgeline of sub-catchment B.
Pre-development (OS2) without allowance for climate change, and modelled using CN63.
Post-development (DS2) with climate change, and modelled using composite CN88.
See Figure A9 for input parameters, and Tables 1.1 (peak flows) and 2.1 (runoff volumes).

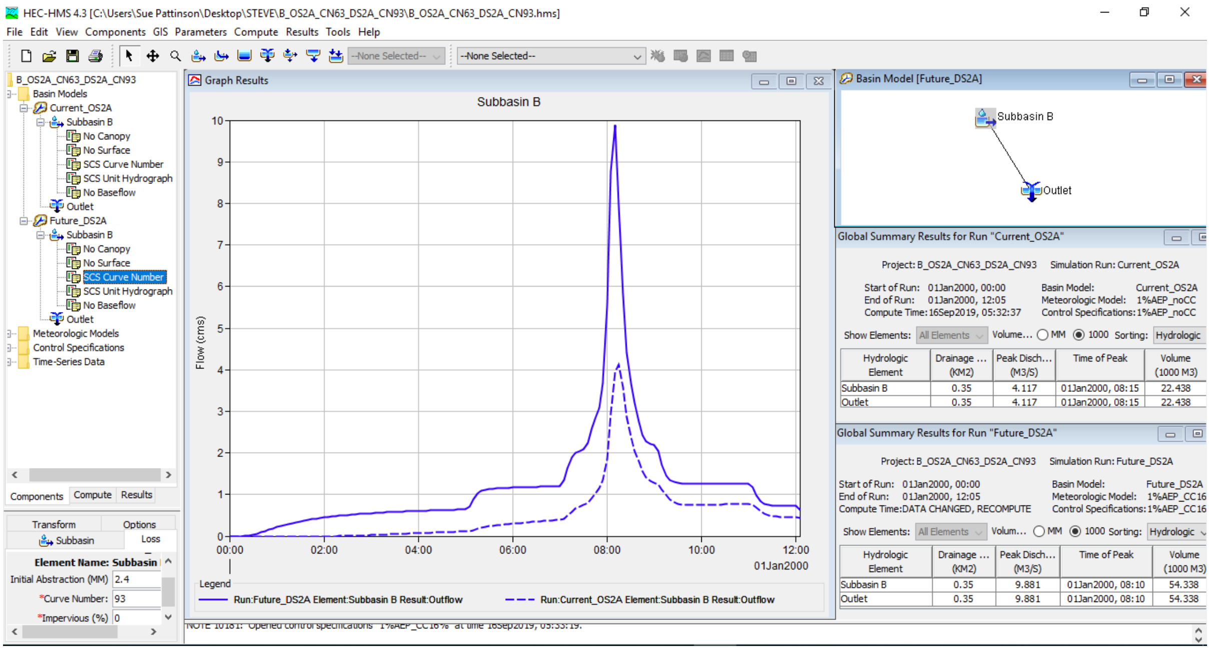

Figure A12 – Development Scenario DS2A (see Figure A8) – Medium density along the ridgeline of sub-catchment B.
Pre-development (OS2A) without allowance for climate change, and modelled using CN63.
Post-development (DS2) with climate change, and modelled using composite CN93.
See Figure A9 for input parameters, and Tables 1.1 (peak flows) and 2.1 (runoff volumes).

Pre-Development with climate change:

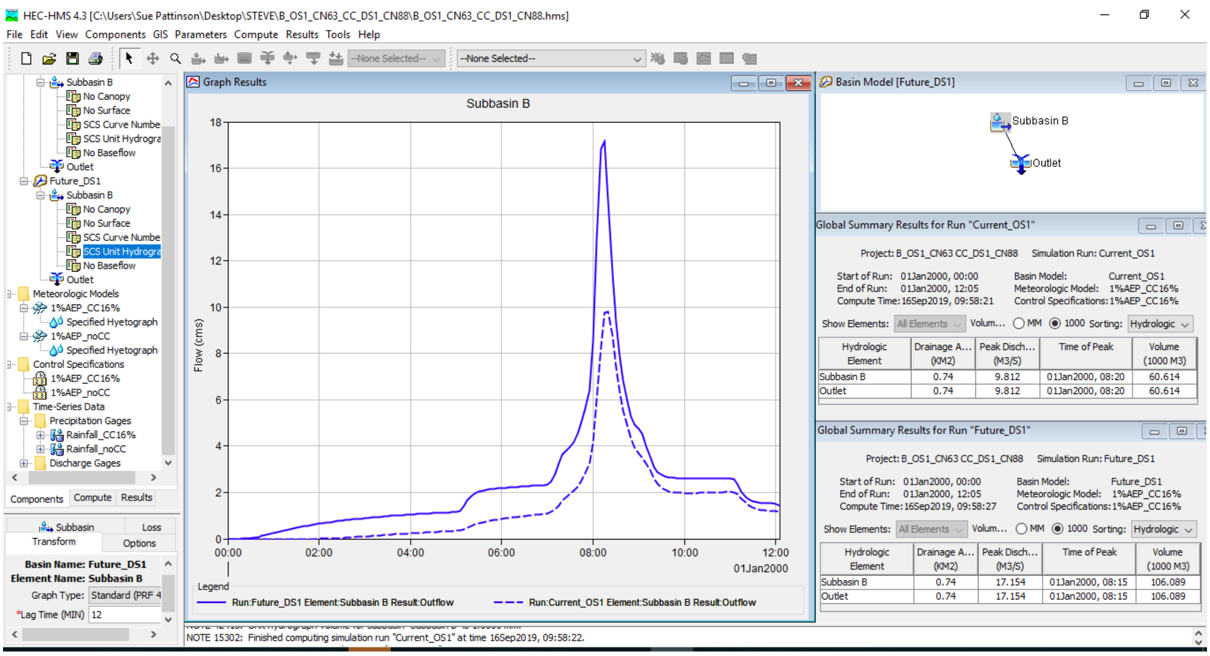

Figure A13 – Development Scenario DS1 – Low density over whole of sub-catchment B.
Pre-development (OS1) <u>with</u> allowance for climate change, and modelled using CN63.
Post-development (DS1) with climate change, and modelled using composite CN88.
See Figure A9 for input parameters, and Tables 3.1 (peak flows) and 4.1 (runoff volumes).

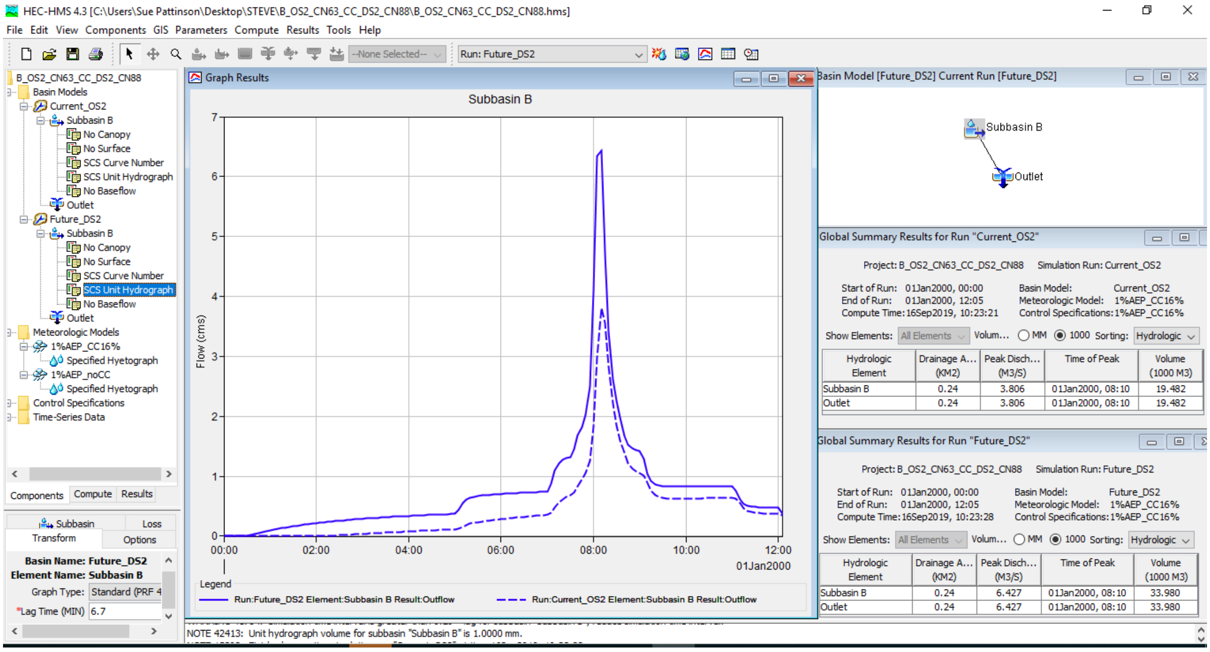

Figure A14 – Development Scenario DS2 (see Figure A7) – Low density along ridgeline of sub-catchment B.
Pre-development (OS2) with allowance for climate change, and modelled using CN63.
Post-development (DS2) with climate change, and modelled using composite CN88.
See Figure A9 for input parameters, and Tables 3.1 (peak flows) and 4.1 (runoff volumes).

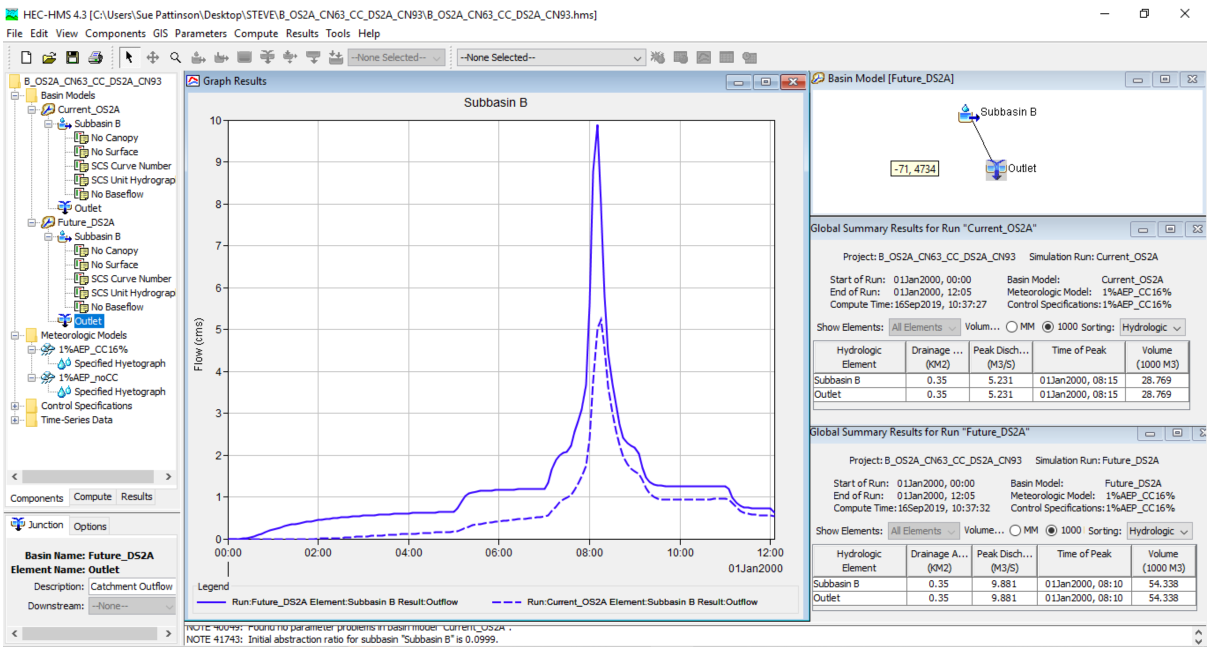

Figure A15 – Development Scenario DS2A (see Figure A8) – Medium density along the ridgeline of sub-catchment B.
Pre-development (OS2A) with allowance for climate change, and modelled using CN63.
Post-development (DS2A) with climate change, and modelled using composite CN93.
See Figure A9 for input parameters, and Tables 3.1 (peak flows) and 4.1 (runoff volumes).

Table 7–1 Criteria for assignment of hydrologic soil group (HSG)

* 40µm/s = 40 x 10^3 m/s = (40 x 3600)/1000 = 144mm/hr

** 5.67 in/hr = (5.67 x 25.4) in/hr = 144mm/hr

Depth to water impermeable layer 1/	Depth to high water table 2/	K_{sat} of least transmissive layer in depth range	K_{sat} depth range	HSG 3/	
<50 cm [<20 in]	—	—	—	D	
50 to 100 cm [20 to 40 in]	<60 cm [<24 in]	>40.0 µm/s * (>5.67 in/h) **	0 to 60 cm [0 to 24 in]	A/D	
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 60 cm [0 to 24 in]	B/D	
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 60 cm [0 to 24 in]	C/D	
		≤1.0 µm/s (≤0.14 in/h)	0 to 60 cm [0 to 24 in]	D	
	≥60 cm [≥24 in]	>40.0 µm/s 1 (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A	1 > 144mm/hr
		>10.0 to ≤40.0 µm/s 2 (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B	2 > 36mm/hr to < 144mm/hr
		>1.0 to ≤10.0 µm/s 3 (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C	3 > 4mm/hr to < 36mm/hr
		≤1.0 µm/s 4 (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D	4 < 4mm/hr
>100 cm [>40 in]	<60 cm [<24 in]	>10.0 µm/s (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A/D	
		>4.0 to ≤10.0 µm/s (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B/D	
		>0.40 to ≤4.0 µm/s (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C/D	
		≤0.40 µm/s (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D	
	60 to 100 cm [24 to 40 in]	>40.0 µm/s (>5.67 in/h)	0 to 50 cm [0 to 20 in]	A	
		>10.0 to ≤40.0 µm/s (>1.42 to ≤5.67 in/h)	0 to 50 cm [0 to 20 in]	B	
		>1.0 to ≤10.0 µm/s (>0.14 to ≤1.42 in/h)	0 to 50 cm [0 to 20 in]	C	
		≤1.0 µm/s (≤0.14 in/h)	0 to 50 cm [0 to 20 in]	D	
	>100 cm [>40 in]	>10.0 µm/s 5 (>1.42 in/h)	0 to 100 cm [0 to 40 in]	A	5 > 36mm/hr
		>4.0 to ≤ 10.0 µm/s 6 (>0.57 to ≤1.42 in/h)	0 to 100 cm [0 to 40 in]	B	6 > 15mm/hr to < 36mm/hr
		>0.40 to ≤4.0 µm/s 7 (>0.06 to ≤0.57 in/h)	0 to 100 cm [0 to 40 in]	C	7 > 2mm/hr to < 15mm/hr
		≤0.40 µm/s 8 (≤0.06 in/h)	0 to 100 cm [0 to 40 in]	D	8 < 2mm/hr

1/ An impermeable layer has a K_{sat} less than 0.01 µm/s [0.0014 in/h] or a component restriction of fragipan; duripan; petrocalcic; orstein; petrogypsic; cemented horizon; densic material; placic; bedrock, paralithic; bedrock, lithic; bedrock, densic; or permafrost.

2/ High water table during any month during the year.

3/ Dual HSG classes are applied only for wet soils (water table less than 60 cm [24 in]). If these soils can be drained, a less restrictive HSG can be assigned, depending on the K_{sat}.

Figure A16 – US NRCS National Engineering Handbook (2009), Chapter 7 – Hydrological Soil Groups, Table 7-1 “Criteria for Assignment of Hydrological Soil Group (HSG)”

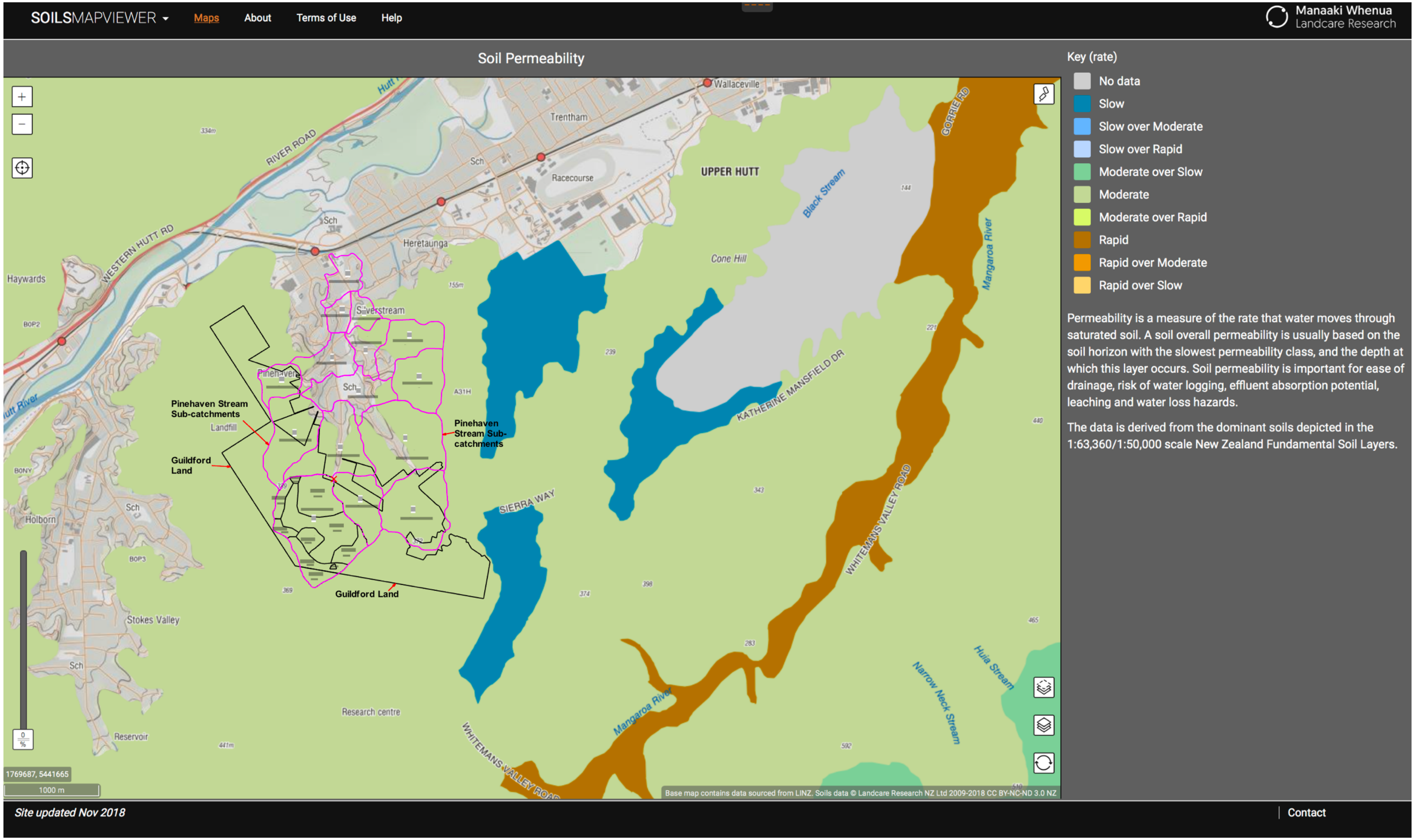

Figure A17 – Landcare Research – Soil Permeability Map shows Moderate for Pinehaven. (Pinehaven Stream sub-catchments and Guildford land are shown overlaid on this map.)

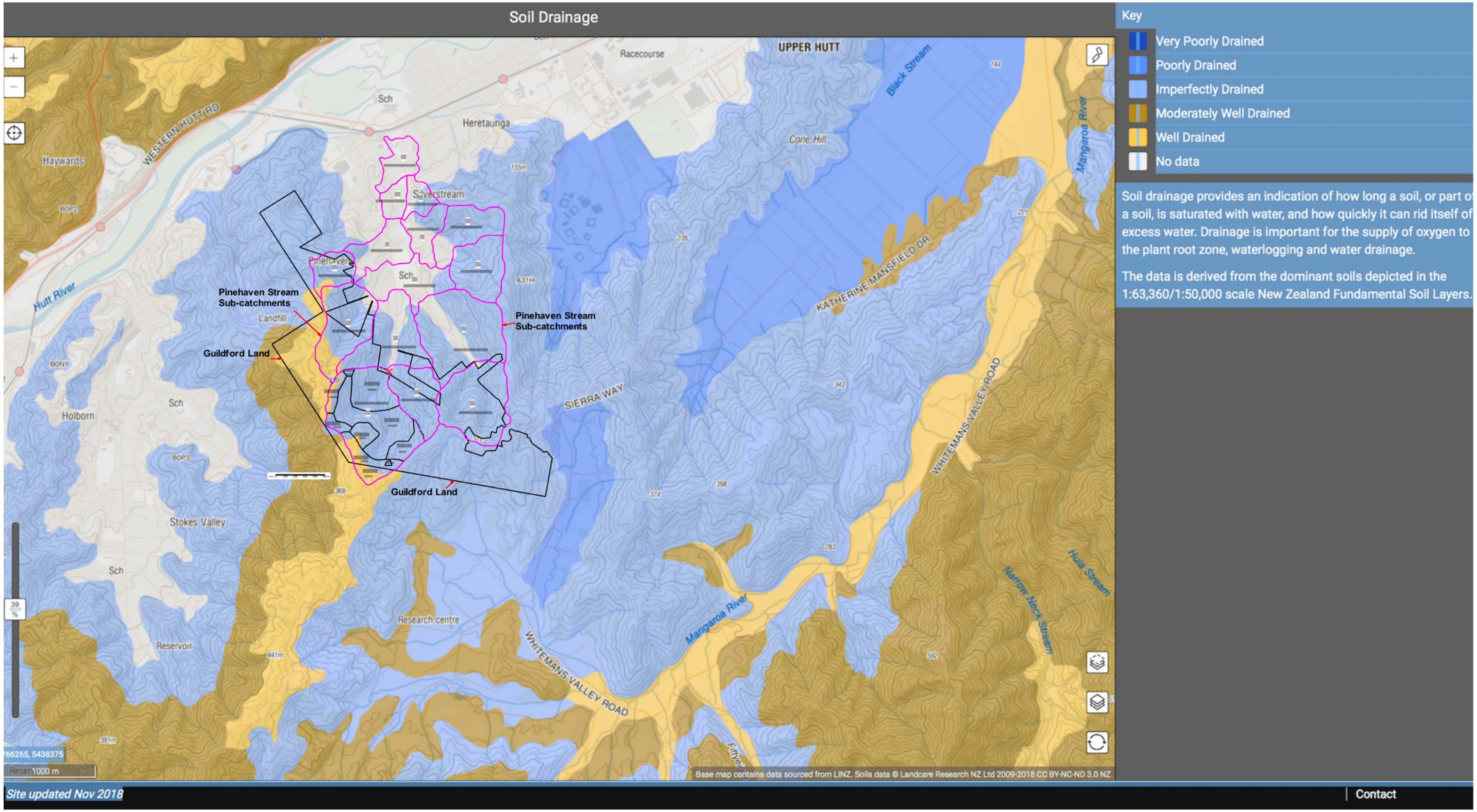

Figure A18 – Landcare Research – Soil Drainage Map generally shows Imperfectly Drained for Pinehaven, and Well Drained on Guildford ridgeline at sub-catchments B, E and I. (Pinehaven Stream sub-catchments and Guildford land are shown overlaid on this map.)

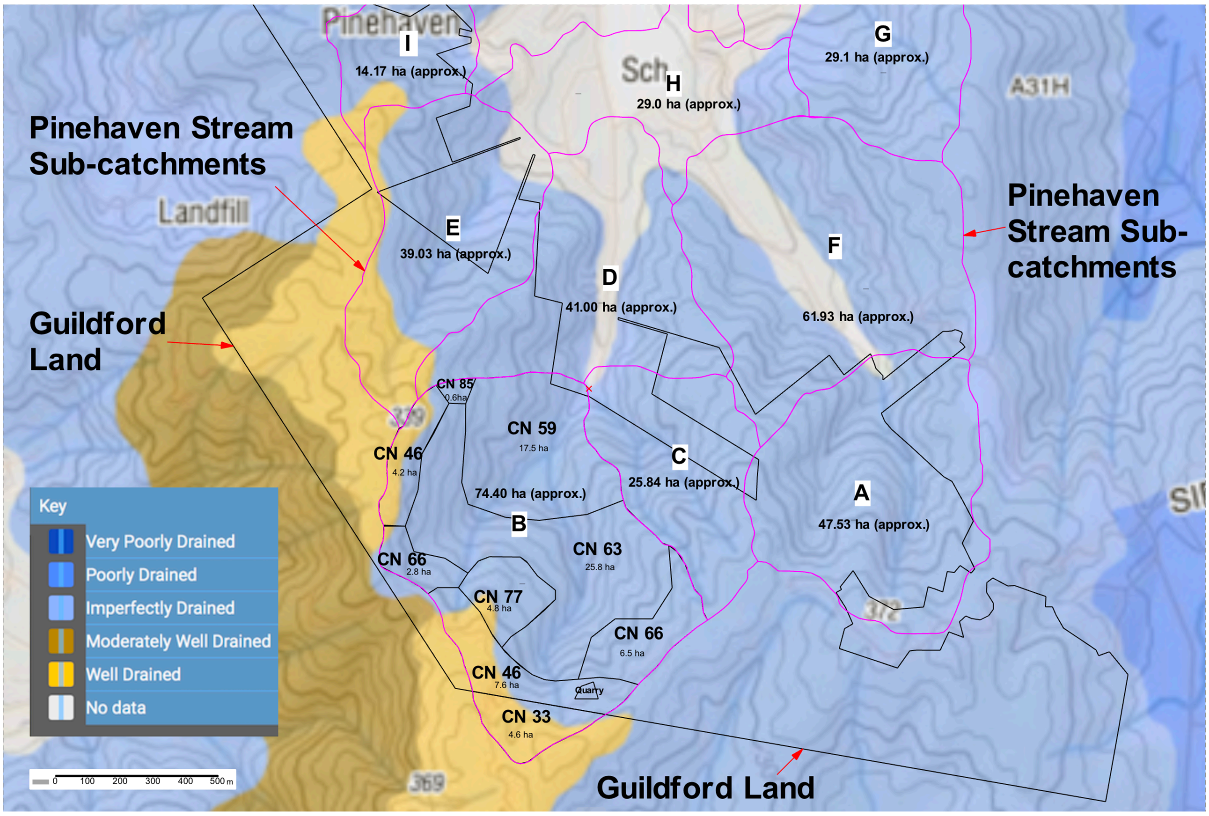

Figure A19 – Landcare Research – Soil Drainage Map – Upper Pinehaven Catchment: shows "Well Drained" on Guildford ridgeline at sub-catchments B, E and I.
(Pinehaven Stream sub-catchments and Guildford land are shown overlaid on this map.)

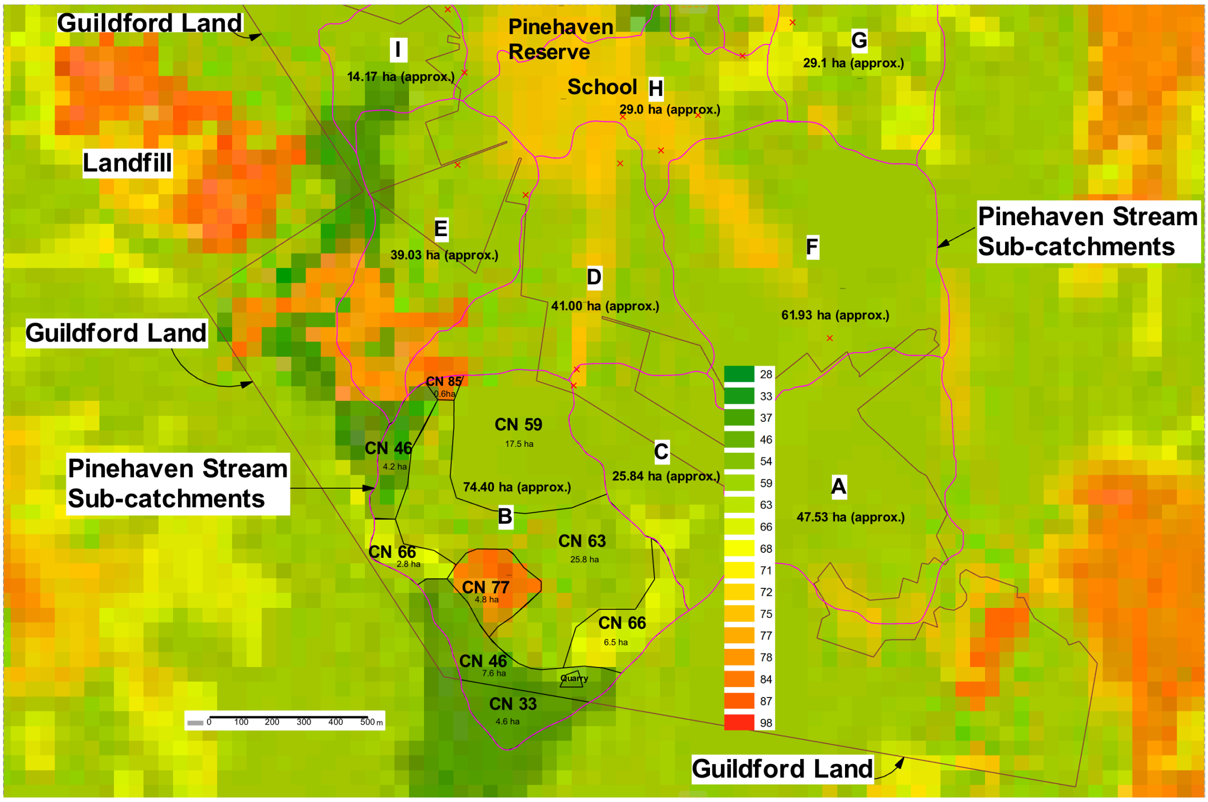

Figure A20 – Cardno (2019) CN Map Upper Pinehaven Catchment: why are CN numbers high (orange/red) on Guildford ridgeline at sub-catchments B and E where soil is "well-drained"?

Soil Tests – Antecedent Conditions (Rainfall prior to tests)

Test Date 2019	Test Nos.	Test Type	Test Location
26/27 June	A1 – A4 C1 – C4 D1 – D4	Single ring	Pine forest, 27 Elmslie Road
28 June	1 - 8	Single ring	Sub-catchment B
4 July	DRI-1	Double ring	Pine forest, 27 Elmslie Road
8 July	DRI-2,3	Double ring	Pine forest, 27 Elmslie Road
10 July	DRI-4,5,6	Double ring	Lawns, 27 Elmslie Road
10 July	DRI-7,8	Double ring	Pinehaven Reserve

Table 5 – Dates when soil infiltration tests were carried out

Rain Gauge Data   25 Elmslie Rd, Pinehaven, Upper Hutt   Year: 2019

2019	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	0.0	5.0	0.0	21.0	0.3	58.0	0.0	1.0					
2	0.0	0.0	0.0	9.5	0.0	8.5	0.0	2.8					
3	0.0	0.0	0.0	1.3	0.0	0.5	26.5	0.3					
4	0.0	0.0	0.0	0.3	0.0	3.5	10.0	0.0					
5	0.0	0.0	0.0	7.0	0.0	16.5	25.5	0.0					
6	1.0	0.0	0.0	17.0	0.0	2.5	7.5	0.0					
7	1.5	0.0	6.5	12.5	0.0	3.0	0.3	0.0					
8	0.0	0.0	50.0	1.0	0.0	0.0	0.0	6.0					
9	0.0	0.0	1.0	1.0	9.0	0.0	0.0	0.0					
10	0.5	0.0	0.0	1.5	1.0	0.0	2.8	18.0					
11	0.0	0.0	0.0	30.0	1.5	2.0	1.5	23.0					
12	0.0	0.3	7.3	9.5	12.5	3.0	3.0	20.5					
13	13.5	0.0	4.0	1.0	7.0	11.5	3.8	0.8					
14	0.0	1.8	0.0	0.0	1.0	1.3	19.5	0.0					
15	0.0	0.0	0.0	0.3	0.0	6.0	21.5	0.0					
16	0.0	0.0	0.0	1.0	3.5	0.5	11.5	0.0					
17	0.0	0.0	0.0	0.0	0.8	1.5	2.5	18.0					
18	0.0	0.0	0.0	0.0	0.0	3.3	1.0	2.3					
19	0.0	0.0	0.0	0.0	0.0	0.8	3.8	0.3					
20	0.0	0.0	0.0	13.5	0.0	3.3	15.5	1.5					
21	0.0	2.5	0.0	10.3	0.0	0.0	11.0	3.8					
22	0.0	13.0	0.0	0.5	0.0	0.5	0.3	9.8					
23	0.0	6.5	0.0	2.5	3.0	6.5	3.5	5.5					
24	11.0	23.5	0.0	0.0	0.0	2.5	0.8	1.0					
25	0.0	0.0	0.0	0.0	0.0	1.3	0.3	2.0					
26	0.3	0.0	2.5	0.0	0.0	0.3	0.0	7.0					
27	0.5	0.0	14.5	1.5	0.0	0.5	0.0	0.0					
28	0.0	0.0	0.0	13.0	11.5	0.3	0.0	0.0					
29	0.0		0.0	19.0	2.0	0.0	0.0	0.0					
30	0.0		0.0	2.0	37.5	0.0	3.0	0.0					
31	0.0		1.0		9.0		19.0	0.0					
TOTALS	28.3	52.5	86.8	176.0	99.5	137.3	193.8	123.3	0.0	0.0	0.0	0.0	897.3

Readings taken @ 9.00am and recorded for the previous day (rounded to the nearest 0.25mm)
Rain gauge situated at 25 Elmslie Road, Pinehaven, recorded by D J Longstaffe
gauge frozen

Table 6 – Rain Gauge data, 25 Elmslie Road, Pinehaven

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