LANDFILL DESIGN

RAINGARDEN PRELIMINARY DESIGN CALCULATIONS

RAINGARDEN SUMMARY

Tonkin+Taylor		Computed:	AFRE	15/10/2018	Office:	Auckland
		Checked:	JAAH	30/11/2018		
Project:	**Polaris Landfill Design**	Revised:	RVDM	23/05/2019	Job No:	1005069
		Checked:				
Description:	Water quality requirements only	Revised (DD):				
File Path:	T:\Auckland\Projects\1005069\Secure2019\1005069.1140\Working Material\Civil design\Landfill design\Rain garden	Checked:				
		Reviewed by:				

Reference: **Auckland Council Guideline Document 2017/001 Version 1**
"Stormwater Management Devices in the Auckland Region"

$A_{catchment}$	Total catchment area	**2.22**	ha
A_{imperv}	Total impervious area	**2.22**	ha
A_{perv}	Total pervious area	**0.000**	ha
Purpose	X	Sizing for water quality treatment and stream pro	

$A_{raingarden}$	Minimum rain garden area treatment	**450.0**	m^2
$A_{raingarden}$	Minimum rain garden area stream protection	**1110.0**	m^2

$A_{raingarden1}$	Minimum rain garden area treatment	**202.5**	m^2
$A_{raingarden1}$	Minimum rain garden area stream protection	**499.5**	m^2

$A_{raingarden2}$	Minimum rain garden area treatment	**247.5**	m^2
$A_{raingarden2}$	Minimum rain garden area stream protection	**610.5**	m^2

$A_{raingarden\ 1}$	Area of Raingarden 1	**500.0**	m^2	Ok exceeds minimum
$A_{raingarden\ 2}$	Area of Raingarden 2	**610.0**	m^2	Ok exceeds minimum
Total area		**1110.00**	m^2	Ok exceeds minimum

0

RAIN GARDEN AREA (to fit water quality criteria only)

Tonkin+Taylor		Project:	Polaris Landfill Design Project	Computed:	AFRE	29/06/2018	Office:	Auckland
				Checked:	JAAH	30/11/2018		
Details:	Water quality requirements			Revised:	AFRE	17/05/2019	Job No:	1005069
				Checked:				

Description:

Polaris requires design of water quality only. The following information outlines the design steps undertaken to size the raingardens within the bin exchange area of the site.

	Inputs
	Standard
	Calculated

Runoff coefficient

Description of area	Coefficient*	Area (ha)	C x A
Fully roofed and or sealed developments	0.90	2.220	1.998
Bush and scrub cover	0.35	0.000	0.000
		2.220	1.998

**Coefficients based on the run-off coefficients outlined in Table 1 of the Building Code, Section E1*

$A_{catchment}$	Area of the catchment	22200	m²	*Conservatively assuming entire area is impervious*
	Intensity	10	mm/hr	*Rainfall intensity for calculation of WQF using the rational method (GD01)*
	Coefficient	0.90		
WQF	Water Quality Flow	**199.8**	m³/hr	*Using Equation 1 GD01*
	Safety factor (allowance for clogging)	0.5	-	*(GD01 pg. 148)*
$K_{(media)}$	Infiltration rate for bioretention media	1	m/hr	*Maximum allowed value 1m/hr (C3.2.3.2 GD01)*
$A_{raingarden}$	Set area of rain garden	**450.0**	m²	
$A_{min,WQF}$	Minimum area of rain garden (WQF)	399.6	m²	>= *GD01, Eqn 13*
$A_{min,catch}$	2% of catchment area	444.0	m²	>=

Therefore rain garden needs to be 450 m^2 with standard minimum media depth of 500 mm for water quality

Bioretention device shall require a structural form of pre-treatment as the area exceeds 50 m2, in accordance with GD01. Paved surface to fall towards the raingarden so stormwater can be captured and treated. Media and geotextiles shall be included in accordance with GD01 and will be specified at Detailed Design stage.

RAIN GARDEN AREA (to meet water quality criteria)

Tonkin+Taylor	**Project: Polaris Landfill Design Consent Stage**	Computed:	AFRE	16/10/2018	Office:	Auckland
		Checked:	JAAH	30/11/2018		
Description:	Water quality requirements	Revised:	AFRE	17/05/2019	Job No:	1005069
		Checked:				

Inputs
Standard
Calculated

Catchment runoff (TP108)

Water quality required (mm/24hr) 30 *90% percentile 24-hour rainfall (from GD01, Section B, Table 11)*

TP108

	Cover description	Curve Number CN	Area (hectares)	Product CN x Area	Parameter S (mm)	Depth Q_{24} (mm)	Volume V_{24} (m^3)
Pre-Development	Plantation forestry (Group C)	72	2.2200	159.8	98.8	5.0	**112.1**
				0.0			
	Subtotal for Pervious Areas		2.2200	159.8			
				0.0	5.2	25.6	**0.0**
		98	0.0000	0.0			
	Subtotal for Impervious Areas		0.0000	0.0			
	Totals		**2.2200**				**112.1**
Post-Development	Bush	70	0.0000	0.0	108.9	4.7	**0.0**
				0.0			
	Subtotal for Pervious Areas		0.0000	0.0			
	Paved	98	2.2200	217.6	5.2	25.6	**567.9**
				0.0			
	Subtotal for Impervious Areas		2.2200	217.6			
	Totals		**2.2200**				**567.9**

Post-pre development runoff volume 455.8 m^3

RAIN GARDEN AREA (to meet water quality criteria)

Tonkin+Taylor	Project: Polaris Landfill Design Consent Stage	Computed:	AFRE	16/10/2018	Office:	Auckland
		Checked:	JAAH	30/11/2018		
Description:	Water quality requirements	Revised:	AFRE	17/05/2019	Job No:	1005069

Dimensioning of bioretention device

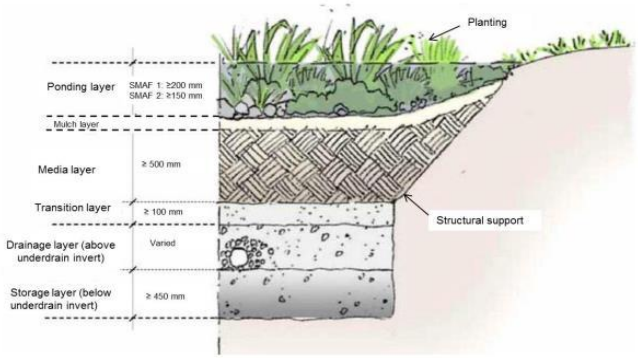


Figure 15: Schematic of rain garden cross-section

(Adapted from North Shore City Council "Bioretention Guidelines", 2008)

Infiltration rate of media 1000 mm/hr *> maximum allowabe infiltration rate (GD01, Section C3, Table 48)*

	Minimum requirements		Set dimensions					
	Minimum area (m^2)	Minimum depth (mm)	Length (m)	Width (top) (m)	Depth (m)	Slope (H:V = X:1)	Area (m^2)	Volume (m^3)
	(GD01, Section C3, Table 48)							
Ponding Requirements	1110	100						
Ponding Raingarden 1			90.0	8.0	0.1	2.00	720	69.3
Ponding Raingarden 2			23.0	22.0	0.1	2.00	506.0	49.9
Mulch	-	-	-	-	0.05	-	-	-
Media requirements	*Media + transition layer*	500 + 100						
Media Raingarden 1			90.0	8.0	0.5	2.00	720	292.5
Media Raingarden 2			23.0	22.0	0.5	2.00	506.0	235.8
Transition	-	100	-	-	0.1	-	-	
Transition	-	100	-	-	0.1	-	-	
Drainage layer		200 - 300						

RAIN GARDEN AREA (to meet water quality criteria)

Tonkin+Taylor	**Project: Polaris Landfill Design Consent Stage**	Computed:	AFRE	16/10/2018	Office:	Auckland
		Checked:	JAAH	30/11/2018		
Description:	Water quality requirements	Revised:	AFRE	17/05/2019	Job No:	1005069

Raingarden dimensions:

Based on the calculations above, 2 raingardens are required within the bin exchange area. The approximate dimensions of these rain gardens are as follows:

Raingarden 1

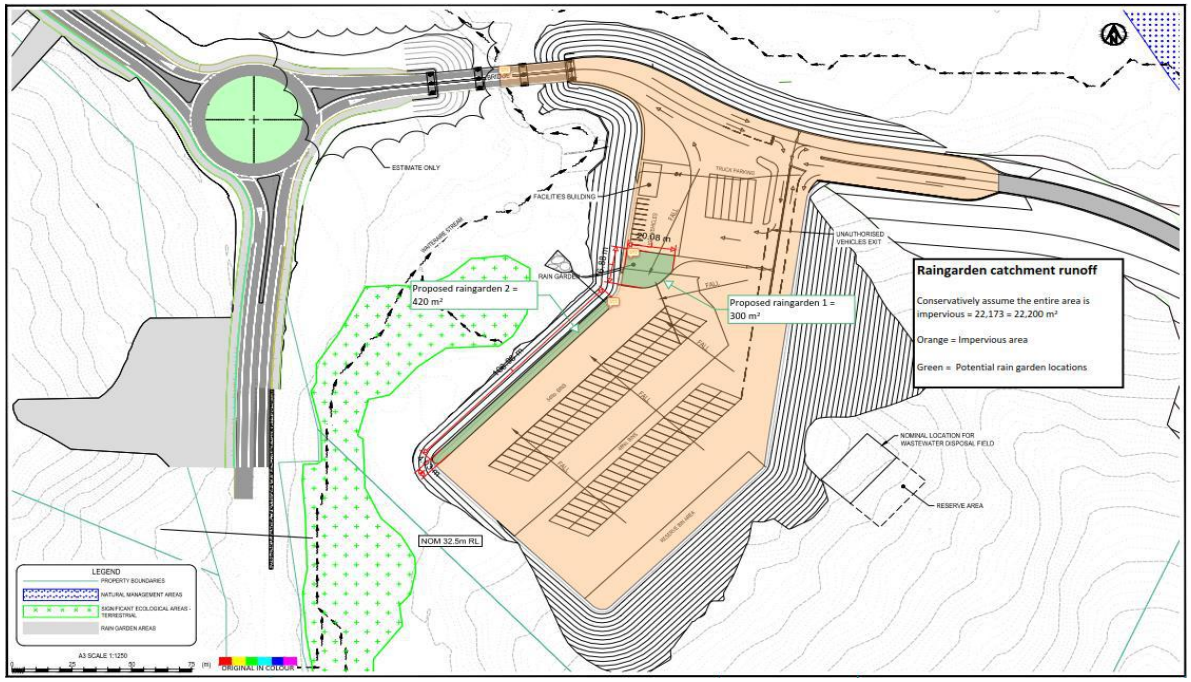
Width =	**23.0 m**
Length =	**22.0 m**
Area =	**500 m^2**

Raingarden 2

Width =	**6.8 m**
Length =	**90.0 m**
Area =	**610 m^2**

Plan showing location of proposed raingardens

Link to PDF: Polaris-GM-ENG-31-31.pdf



LANDFILL DESIGN

FILTER STRIP PRELIMINARY DESIGN CALCULATIONS

STORMWATER ASSESSMENT

Project:	Polaris landfill design	Computed:	rvdm
		Date:	23/05/2019
Job No:	1005069.114	Checked:	
		Date:	

INTRODUCTION

The following assessment is undertaken to calcultate the 95th Percentile Volume for Stream Protection for the Access Road for each 200m length (based on proposed filter strip catchment).

Runoff analysis peak discharge

Catchment summary:

Item	Pre-Development (Ha)	Post-Development (Ha)
Bush area	0.2	0
Impervious	0	0.2
Contributing catchment area	0.2	0.2

The rainfall data used in this analysis was obtained from Auckland Council GD01 Figure 6.

The following table summarises the rainfall data used in this analysis:

Average recurrence interval ARI	Rainfall depth (mm)
95th Percentile	42.0

The following table summarises the peak flow rates generated for pre and post development:

ARI	24 hour volume (m3)		
	Pre-development	Post-development	Difference
95th Percentile	19	84	65

Confirm sufficient capacity in drain

Collection drain length	200.000	m	
Collection drain width	2.000	m	
Average depth	0.25	m	assume channel 0.5m max depth
Total volume	100	m3	> 65 so sufficient capacity

PROJECT – Polaris

Design task statement

Tonkin+Taylor

Task	Filter Strip Design	Task No.		Filter Strips
Typical design of filter strip along the landfill road RS03			Initials	Date
		Design	AFRE	18/10/2018
		Checked	CJC	14/11/2018

Calculations Summary

		Max Req	Design	Unit
1	Discharge, Q (Water quality) [$Q = 0.00278CI_{wq}A$]	N/A	0.02	m3/s
2	Discharge, Q (10 yr) [$Q = 0.00278CI_{10yr}A$]	N/A	0.03	m3/s
3	Area, A = paved road area	N/A	0.20	Ha
4	Determine R assuming R=D and W = 40 m $D = \left(\frac{Q*N}{W*S^{0.5}}\right)^{0.6}$	0.05	0.010	m
5	Determine the area of the filter strip, A [A=WD]		0.42	m2
6	Velocity, V [Q=VA]	0.40	0.04	m/s
7	Length of filter strip, L (L = Vt)		22	m
8	Check velocity of flow for Q=10 yr (worst case)	1.5		
9	Determine R assuming R=D and W = 40 m $D = \left(\frac{Q*N}{W*S^{0.5}}\right)^{0.6}$	0.05	0.014	m
	Flow depth is still less than the max grass height therefore same mannings n has been adopted			
10	Velocity, V [V=Q/wd]		0.05	m/s
	V10 yr storm = 0.05 m/s which is well under the erosive velocity of 1.5 m/s therefore okay			

Project constraints / interfaces

1	Slope and width of filter strips are dependant on site topography and conditions.	
2	Length of vegetation between filter strip and stream can be up to 23 m.	

Assumptions

		Design	Unit	Comments
1	Design based on the guidelines provided in NZTA Stormwater treatment standard for state highway infrastructure May 2010	NZTA	-	-
2	CN number, C (impervious surfaces)	0.98	-	-
3	Intensity, I = 2-year, 1 hour rainfall depth taken from NIWA HIRDS V4 including 9% increase for climate change	31.0	mm/hr	-
4	Intensity, I = 10-year, 1 hour rainfall depth taken from NIWA HIRDS V4 including 13.2% increase for climate change	49.0	mm/hr	-
	Link to NIWA HIRDS information:	*..\NIWA\NIWA V4.xlsx*		
5	Total road width comprises of 4 m wide lanes plus 2 m wide corridor	10	m	-
6	Assume filter strip is required approx every 200 m length of road	200	m	-
7a	Slope, S = slope of existing ground (m/m)	0.09	m/m	(Dependant on site conditions)
7b	Is level spreaders required? Max lateral slope is 2%, level spreaders required if slope is greater than 2%	0.09>0.02		Y
8	Mannings n	0.35		
9	Width of filter strip, W (m)	40	m	(Dependant on site conditions)
10	Time, t (minimum resistance time = 9 min)	540	seconds	

Procedure

1	Calculate Q for the area draining to the filter strip using the rational method
2	Design the filter strip following NZTA guidelines
3	Check the velocities of flow do not exceed 1.5 m/s for the most critical event [10 yr AEP]

Equal area method

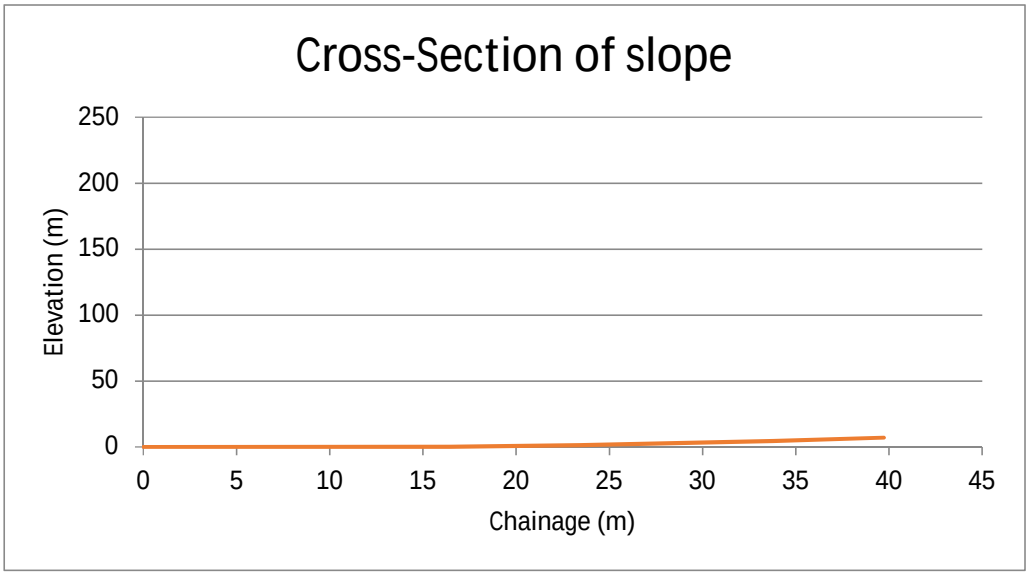
Project:	Polaris Concept design	Created by:	AFRE	27/07/2018
Location:	Southern channel drain	Reviewed by:	CJC	14/11/2018
Global mapper model:	..\WAYBY AFRE.gmw			

Equal Area Method

elevation (m)	h (m)	x (m)	Δ x (m)	$\overline{h}$ (m)	$\Delta A(=\overline{h}.\Delta x)$ (m^2)
33.1	0	0			
33.2	0.1	16.445	16.445	0.0525	0.8633625
34.4	1	23.433	6.988	0.683	4.772804
37.6	5	33.783	10.35	2.891	29.92185
40.2	7	39.723	5.94	5.781	34.33914
			39.723		69.8971565

Length 39.723 m

Slope, Sc = $2A/L^2$ 0.0886



LANDFILL DESIGN STOCKPILE
PRELIMINARY DESIGN CALCULATIONS

STOCKPILE POND SUMMARY						
Tonkin+Taylor		Computed:	AFRE	10/12/2018	Office:	Auckland
		Checked:	JAAH	12/12/2018		
Project:	Polaris Landfill Design	Revised:			Job No:	1005069
		Checked:				
Description:	Determine the volume required for sediment ponds	Revised (detailed design)				
File Path:	T:\Auckland\Projects\1005069\Secure2019\1005069.1140\WorkingMaterial\Civil design\Landfill design\Sediment ponds	Checked:				
		Reviewed by:				

Reference: Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region June 2016, Guideline Document 2016/005

Assumptions:

Stockpile pond sizing has been based on 3% of the contributing catchment

Clay borrow stockpile, Pond 6 contributing catchment

$A_{catchment}$	Total catchment area		4.25	ha
A_{imperv}	Total impervious area		0	ha
A_{perv}	Total pervious area		4.25	ha
Purpose		X	Sizing of stockpile pond	

$A_{stockpile\ pond\ 1}$	3% of catchment			1275.0	m^3	

Stockpile 1, Pond 7 contributing catchment

$A_{catchment}$	Total catchment area		13.720	ha
A_{imperv}	Total impervious area		0.16	ha
A_{perv}	Total pervious area		13.560	ha
Purpose		X	Sizing of stockpile pond	

$A_{stockpile\ pond\ 2}$	3% of catchment			4116.0	m^3	

Stockpile 2, Pond 8 contributing catchment

$A_{catchment}$	Total catchment area		11.160	ha
A_{imperv}	Total impervious area		0.46	ha
A_{perv}	Total pervious area		10.700	ha
Purpose		X	Sizing of stockpile pond	

$A_{stockpile\ pond\ 1}$	3% of catchment			3348.0	m^3	

Topsoil stockpile, Pond 9 contributing catchment

$A_{catchment}$	Total catchment area		1.220	ha
A_{imperv}	Total impervious area		0	ha
A_{perv}	Total pervious area		1.220	ha
Purpose		X	Sizing of stockpile pond	

$A_{stockpile\ pond\ 1}$	3% of catchment			366.0	m^3	

Catchment plan:

Stockpile catchment areas.pdf

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LEGEND

- EXISTING HOUSES
- EXISTING LOGGING TRACKS
- EXISTING MAIN ROADS
- LANDFILL ROAD
- PROPERTY BOUNDARIES
- PROPOSED LANDFILL ROADS
- STOCKPILE EXTENT
- LANDFILL EXTENT
- SIGNIFICANT ECOLOGICAL AREAS - TERRESTRIAL
- NATURAL MANAGEMENT AREAS
- EXISTING FORESTRY
- PROPOSED FORESTRY

POND 6
CLAY BORROW & STOCKPILE
POND 7
STOCKPILE 1
STOCKPILE RIDGE
POND 1 /WETLAND
POND 2
POND 3
GREEN ENERGY CENTRE
FUTURE FILL VALLEY 2
WILSON ROAD
WORKSHOP
OFFICE
POND 9
TOPSOIL STOCKPILE
WATER SUPPLY TANKS
FARM RIDGE
SITE EXTENT
ACCESS ROAD
BIN EXCHANGE AREA
SUNNY BROOK RIDGE
STATE HIGHWAY 1
RUSSELL ROAD
WAITERAIRE STREAM
POND 8

Linetype scale	1.000
Plot style	ByColor
Lineweight	ByLayer
Transparency	ByLayer
Hyperlink	
Thickness	0.000
3D Visualization	
Material	ByLayer
Geometry	
Current Vertex	1
Vertex X	1741321.430
Vertex Y	5977764.569
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Global width	0.000
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Length	435.213
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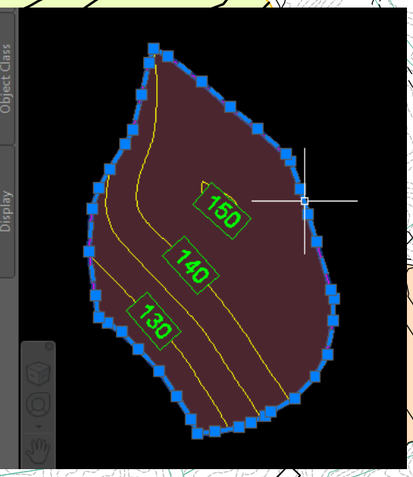
Closed	Yes
Linetype generation	Disabled



A3 SCALE 1:10000
0 0.1 0.2 0.3 0.4 0.5 (km)
ORIGINAL IN COLOUR

Tonkin+Taylor
Exceptional thinking together www.tonkintaylor.co.nz

PROJECT No.	1005069	
DESIGNED	AGBB	Jun.18
DRAWN	TORY	Aug.18
CHECKED		
APPROVED	DATE	

CLIENT WASTE MANAGEMENT NZ LTD
PROJECT AUCKLAND REGIONAL LANDFILL
TITLE SITE
SITE PLAN
SCALE (A3) 1:10000 FIG No. ENG-01 REV 1

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LEGEND

- EXISTING FORESTRY TRACKS
- PROPERTY BOUNDARIES
- MAIN ROADS
- 100 LINER CONTOUR (10m)
- PROPOSED LANDFILL ROADS

Total area of Stockpile 1 Pond :

Stockpile area = 111,600 m^2

Existing plantation forestry = 24,000 m^2

Access road = 1600 m^2

Catchment length = 600 m
Slope = (160-60)/540
= 0.19 m/m

CLAY BORROW & STOCKPILE
POND 6

POND 7

30 m

85.13 m

STOCKPILE 1

WETLAND 1

POND 1

POND 2

FLARES / EVAPORATORS

GENERATORS

GREEN ENERGY CENTRE

WORKSHOP AND FACILITIES

LEACHATE TANKS

INITIAL FLARE

WHEEL WASH
SEDIMENTATION POND

TOPSOIL STOCKPILE

WATER SUPPLY TANKS

A3 SCALE
0 50 100

Information - Default

General	
Point snap	
Type	Super
Model	DATA SP1B NULL
Name	DATA-SP1B-NULL
Colour	acad 002
Linestyle	1
Point/line	line
Closed	Yes
# pts	963
Length 3d	1418.730
Area	111605.441
Locks	Read (-1) Write (1)
X	1740889.640
Y	5978044.953
Z	94.125
Prof ch	951.304
Prof z	94.125
Bearing	267°28'19.29"

Lineweight	ByLayer
Transparency	ByLayer
Hyperlink	
Thickness	0.000
3D Visualization	
Material	ByLayer
Geometry	
Current Vertex	1
Vertex X	1740480.021
Vertex Y	5978616.563
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End segment width	0.000
Global width	0.000
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Closed	Yes
Linetype generation	Enabled

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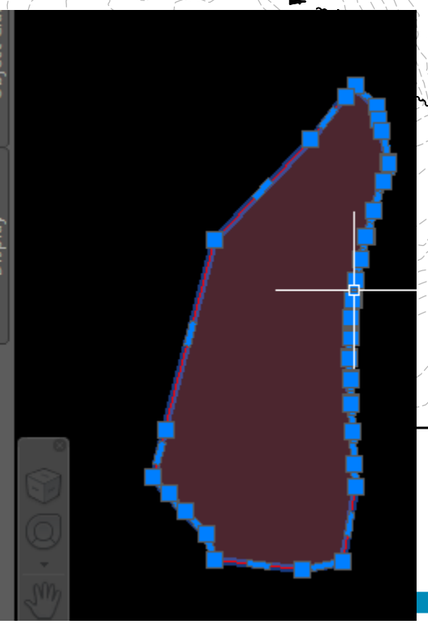
Display



Exceptional thinking

PROJECT No.	1005069	
DESIGNED	AGBB	Jun.18
DRAWN	TORY	Aug.18
CHECKED		
APPROVED	DATE	

CLIENT **WASTE MANAGEMENT NZ LTD**

PROJECT **POLARIS**

TITLE SITE
LANDFILL LAYOUT PLAN - WEST

SCALE (A3) 1:5000 FIG No. ENG-02 REV 1

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LEGEND

- PROPERTY BOUNDARIES
- MAIN ROADS
- LINER CONTOUR (10m)
- LINER CONTOUR (5m)
- EXISTING FORESTRY TRACKS
- PROPOSED LANDFILL ROADS

ENERGY CENTRE

Information - Default

General	
Point snap	
Type	Super
Model	bdytin STOCKPILE 2
Name	boundary strings 1
Colour	cyan
Linestyle	1
Point/line	line
Closed	Yes
# pts	481
Length 3d	1251.818
Area	72371.951
Locks	Read (-1) Write (1)
X	1743089.499
Y	5977432.206
Z	218.771
Prof ch	468.665
Prof z	218.771
Bearing	11°20'04.98"

Total area of Stockpile 2 Pond :

Stockpile area = 72,500 m^2

Existing plantation forestry = 34,500 m^2

Access road = 4,600 m^2

Catchment length = 480 m
Slope = (230-115)/480
= 0.24 m/m

STOCKPILE ACCESS

STOCKPILE 2

STOCKPILE POND 5

TOP

A3 SCALE 1:5000

0 50 100 150 200 250 (m)

ORIGINAL IN COLOUR

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PROJECT No.	1005069		
DESIGNED	AGBB	Jun.18	
DRAWN	TORY	Aug.18	
CHECKED			
APPROVED	DATE		

CLIENT **WASTE MANAGEMENT NZ LTD**

PROJECT

TITLE SITE
LANDFILL LAYOUT PLAN - EAST

SCALE (A3) 1:5000 FIG No. ENG-03 REV 1

LANDFILL DESIGN USLE

PRELIMINARY DESIGN CALCULATIONS

POLARIS LANDFILL DESIGN

TP108 PRELIMINARY DESIGN CALCULATIONS

STORMWATER ASSESSMENT

Project:	Polaris landfill design	Computed:	AFRE
		Date:	30/01/2019
Job No:	1005069.1140	Checked:	BEPE
		Date:	1/02/2019

INTRODUCTION

The following capacity assessment is undertaken to assess the pre and post development flows for the Polaris site

Pre dev areas: Pre-dev catchment areas.pdf

Post dev CAD catchment areas: ..\GM to CAD\1005069-CATCHMENTS_POST DEV_FINAL.dwg

Runoff analysis peak discharge

Catchment summary:

	Pre-Development (Ha)			Post-Development (Ha)		
Catchment area	Springhill farm	Access road	Stockpile 2	Springhill farm	Access road	Stockpile 2
Plantation forestry	23.5	0.0	79.2	99.5	4.1	71.7
Bush area	41.8	78.8	63.8	41.8	67.8	63.8
Grassed area	232.7	6.6	0.0	155.0	9.5	7.2
Impervious surface	4.0	0.0	0.0	5.7	4.0	0.3
Total area	302.0	85.4	143.0	302.0	85.4	143.0

The rainfall data used in this analysis was obtained from NIWA HIRDS V4. The climate change factors are in accordance with Auckland Councils Code of Practice For Land Development and Subdivision, Chapter 4-Stormwater.

The following table summarises the rainfall data used in this analysis:

Average recurrence interval ARI	Rainfall depth (mm)	Climate change factor *	Design rainfall depth (mm)
1/3 2year	32.9	9.0%	36
2 year	98.8	9.0%	108
10 year	152	13.2%	172
100 year	233	16.8%	272

*Is the percentage increase of the 24 hour design rainfall depth due to future climate change (based on a 2.1 degree increase in temp) obtained from the AC Code of Practice.

The following table summarises the peak flow rates generated for pre and post development:

ARI	Volume (m^3)					
	Pre-development			Post-development		
	Springhill farm	Access Rd	Stockpile 2	Springhill farm	Access Rd	Stockpile 2
1/3 2year	24,295	5,901	10,180	24,233	6,934	10,291
2	165,033	42,895	73,242	163,836	45,255	73,574
10	326,995	86,887	147,675	324,974	89,900	148,138
100	601,856	162,782	275,560	598,980	166,389	276,153

STORMWATER ASSESSMENT

Project:	Polaris landfill design	Computed:	AFRE
		Date:	30/01/2019
Job No:	1005069.1140	Checked:	BEPE
		Date:	1/02/2019

Pre-post development comparison:

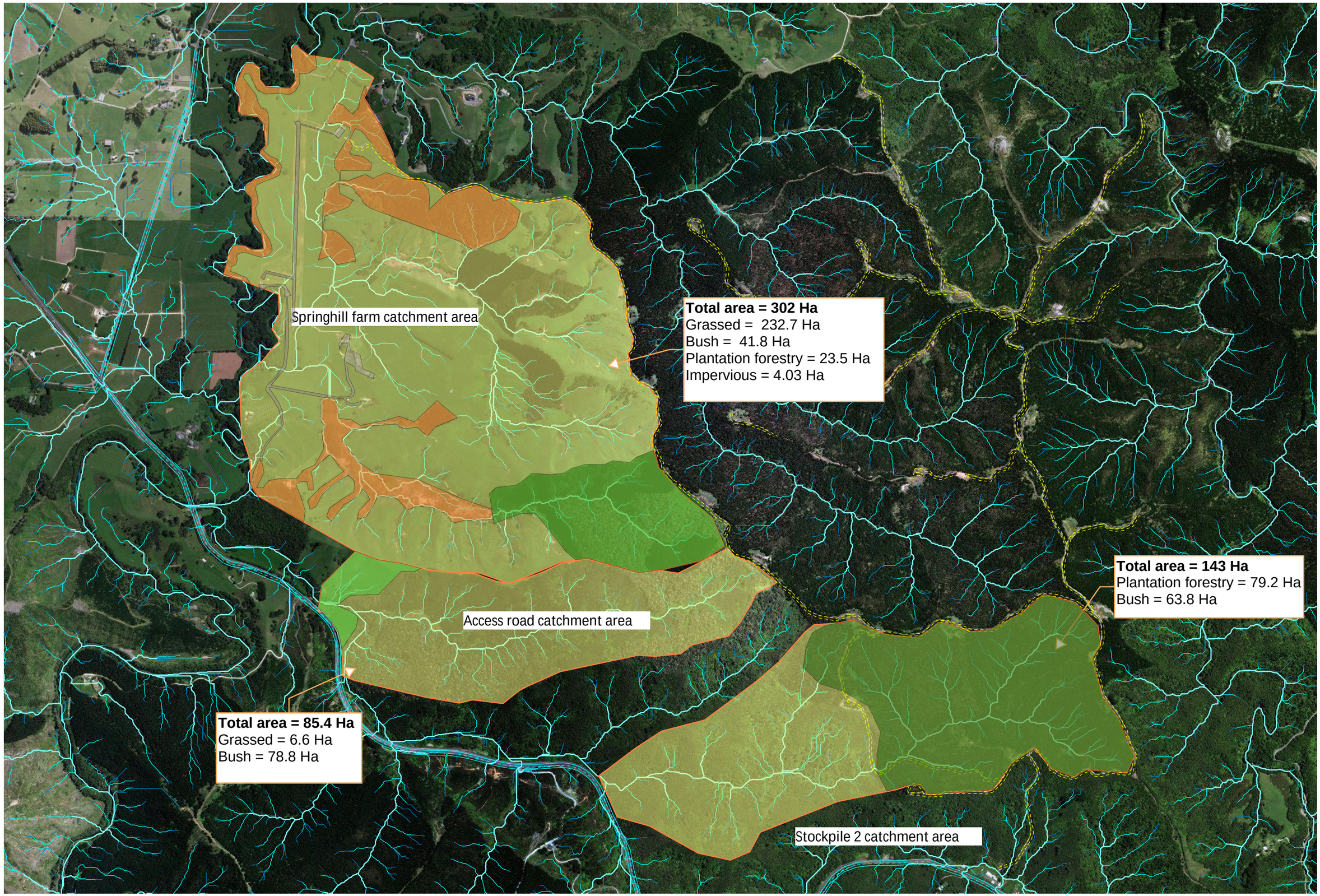
ARI	Springhill farm			Access road			Stockpile 2		
	Pre-development (m^3)	Post-development (m^3)	% change	Pre-development (m^3)	Post-development (m^3)	% change	Pre-development (m^3)	Post-development (m^3)	% change
2	165,033	163,836	-0.7%	42,895	45,255	5.5%	73,242	73,574	0.5%
10	326,995	324,974	-0.6%	86,887	89,900	3.5%	147,675	148,138	0.3%
100	601,856	598,980	-0.5%	162,782	166,389	2.2%	275,560	276,153	0.2%

ASSUMPTIONS

Assumed all roads are impervious CN 98

Assumed that proposed plantation forestry and impervious areas will remain in the Post development scenario

Assumed all newly graded areas have been capped and covered in grass CN = 74

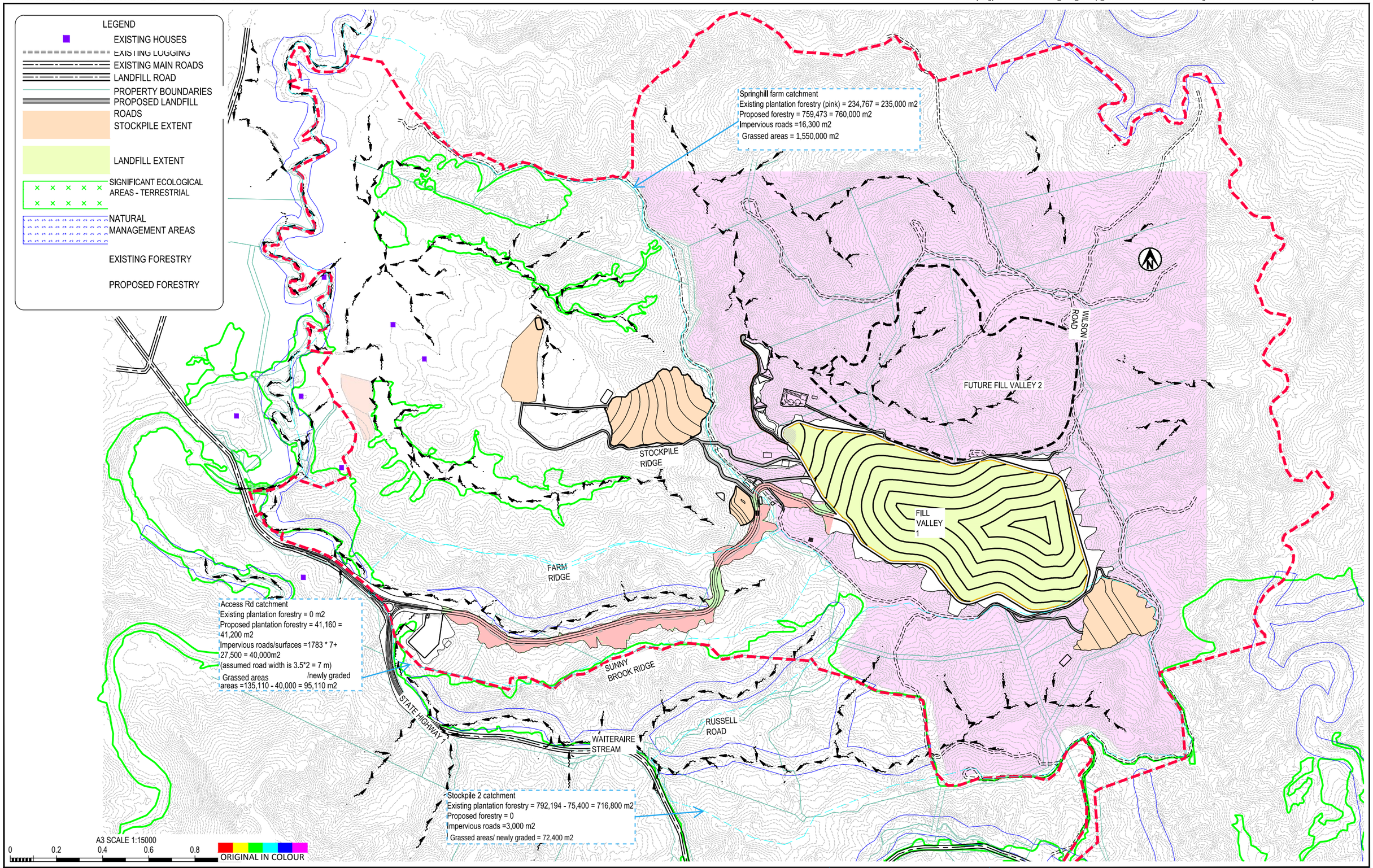


0 m 250 m 500 m 1000 m 1500 m

Scale 1:15,000

Polaris Pre-development Catchment Areas

C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\CAD\FIG\Polaris-GM-ENG-01.dwg 2019-Feb-04 11:24:22 a.m. Plotted By: ASHLEIGH FREW



Assumptions:

Assumed all roads are impervious CN 98

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Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

PROJECT No.	1005069	
DESIGNED	AGBB	Jun.18
DRAWN	TORY	Aug.18
CHECKED		
APPROVED		DATE

CLIENT **WASTE MANAGEMENT NZ LTD**

PROJECT **AUCKLAND REGIONAL LANDFILL**

TITLE SITE
PROPOSED POST-DEVELOPMENT SITE PLAN

SCALE (A3) 1:15000 FIG No. ENG-01 REV 1

Pre-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design By: AFRE Date: 30/01/19

Location: Springhill farm Checked: BEPE Date: 1/02/2019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	41.80	2,926
	Plantation Forestry	72	23.50	1,692
	Grassed	74	232.67	17,218
	Subtotal for Pervious Areas		297.97	21,836
	Impervious	98	4.028	395
	Subtotal for Impervious Areas		4.028	395
		Totals	302.000	22,230

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{22,230}{302} = 74$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 297.972}{302} = 4.93$ mm

2. Time of Concentration

Channelisation Factor :	C	=	1.0	
Catchment Length :	L	=	2.602	km (along drainage path)
Catchment Slope :	Sc	=	0.021	m/m
Runoff Factor R :	$\frac{CN}{200 - CN}$	=	0.58	C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 1.13 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.76 hrs

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

Total	=	91.1 mm
Pervious	=	92.6 mm
Impervious	=	5.2 mm

		Storm #1	Storm #2	Storm #4	Storm #5
4. **Average Recurrence Interval, ARI (yr) :**		1/3 2 year	2yr	10yr	100yr
5. **24 hour Rainfall Depth, P_{24} (mm),** (from Appendix A)		**36**	**108**	**172**	**272**
6. **Runoff Index, c* :** $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.13	0.35	0.47	0.59
7. **Specific Peak Flow Rate, q*,** (from Figure 5.1)		0.017	0.042	0.053	0.063
8. **Peak Flow Rate, q_p :** $= q^* A P_{24}$ (m^3/s)		1.846	13.801	27.524	51.461
9. **Runoff Depth, Q_{24} :** $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm)	Pervious	7.7	54.0	107.5	198.4
	Impervious	31.4	102.7	167.0	267.1
10. **Runoff Volume, V_{24} :** $= 1000 \times Q_{24} A$ (m^3)	Pervious	23,032	160,895	320,267	591,099
	Impervious	1,263	4,139	6,728	10,757
	Total	24,295	165,033	326,995	601,856

LANDFILL PRE DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Springhill farm drainage path
Details:	Pre dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	30/01/2019
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics	
Catchment (km^2)	3.02
CN	74
Channel Factor	1

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	23.181	0	0	0.00		
27.977	25.172	27.977	27.977	1.99	1.00	28
76.3	23.599	76.3	48.323	0.42	1.20	58
116.99	26.654	116.99	40.69	3.47	1.95	79
152.6	24.959	152.6	35.61	1.78	2.63	93
183.12	26.539	183.12	30.52	3.36	2.57	78
198.38	24.941	198.38	15.26	1.76	2.56	39
244.16	26.041	244.16	45.78	2.86	2.31	106
389.13	25.402	389.13	144.97	2.22	2.54	368
447.63	27.347	447.63	58.5	4.17	3.19	187
564.62	28.693	564.62	116.99	5.51	4.84	566
635.83	27.865	635.83	71.21	4.68	5.10	363
699.42	29.926	699.42	63.59	6.75	5.71	363
801.15	30.425	801.15	101.73	7.24	6.99	712
907.97	33.255	907.97	106.82	10.07	8.66	925
1032.6	34.654	1032.6	124.63	11.47	10.77	1343
1243.7	38.427	1243.7	211.1	15.25	13.36	2820
1309.8	40.828	1309.8	66.1	17.65	16.45	1087
1548.9	44.354	1548.9	239.1	21.17	19.41	4641
1658.3	45.155	1658.3	109.4	21.97	21.57	2360
1724.4	48.357	1724.4	66.1	25.18	23.58	1558
1749.8	54.401	1749.8	25.4	31.22	28.20	716
1762.5	49.21	1762.5	12.7	26.03	28.62	364
1859.2	50.693	1859.2	96.7	27.51	26.77	2589
1879.5	53.27	1879.5	20.3	30.09	28.80	585
1894	51.356	1894	14.5	28.18	29.13	422
1945.6	55.414	1945.6	51.6	32.23	30.20	1559
1966	53.407	1966	20.4	30.23	31.23	637
1983.8	57.439	1983.8	17.8	34.26	32.24	574
2007.5	56.09	2007.5	23.7	32.91	33.58	796
2044.8	57.04	2044.8	37.3	33.86	33.38	1245
2062.6	60.328	2062.6	17.8	37.15	35.50	632
2088.1	59.73	2088.1	25.5	36.55	36.85	940
2138.9	61.883	2138.9	50.8	38.70	37.63	1911
2187.3	72.021	2187.3	48.4	48.84	43.77	2119
2200	71.197	2200	12.7	48.02	48.43	615
2220.3	77	2220.3	20.3	53.82	50.92	1034
2233	84.907	2233	12.7	61.73	57.77	734
2261	80.484	2261	28	57.30	59.51	1666
2278.8	84.299	2278.8	17.8	61.12	59.21	1054
2306.8	85.932	2306.8	28	62.75	61.93	1734
2334.8	94.568	2334.8	28	71.39	67.07	1878
2380.6	98.741	2380.6	45.8	75.56	73.47	3365
2418.7	117.831	2418.7	38.1	94.65	85.11	3243
2436.5	121.709	2436.5	17.8	98.53	96.59	1719
2484.8	138.569	2484.8	48.3	115.39	106.96	5166
2502.6	149.344	2502.6	17.8	126.16	120.78	2150
2535.7	145.987	2535.7	33.1	122.81	124.48	4120
2576.4	159.56	2576.4	40.7	136.38	129.59	5274
2601.8	170.048	2601.8	25.4	146.87	141.62	3597
TOTAL	146.87	2601.8	2601.8			70212.738

Derived Characteristics

Max Elevation (mRL)	170.05
Min Elevation (mRL)	23.18
Δ Elevation (m)	146.87
Main Channel Slope	0.021
	2.1%

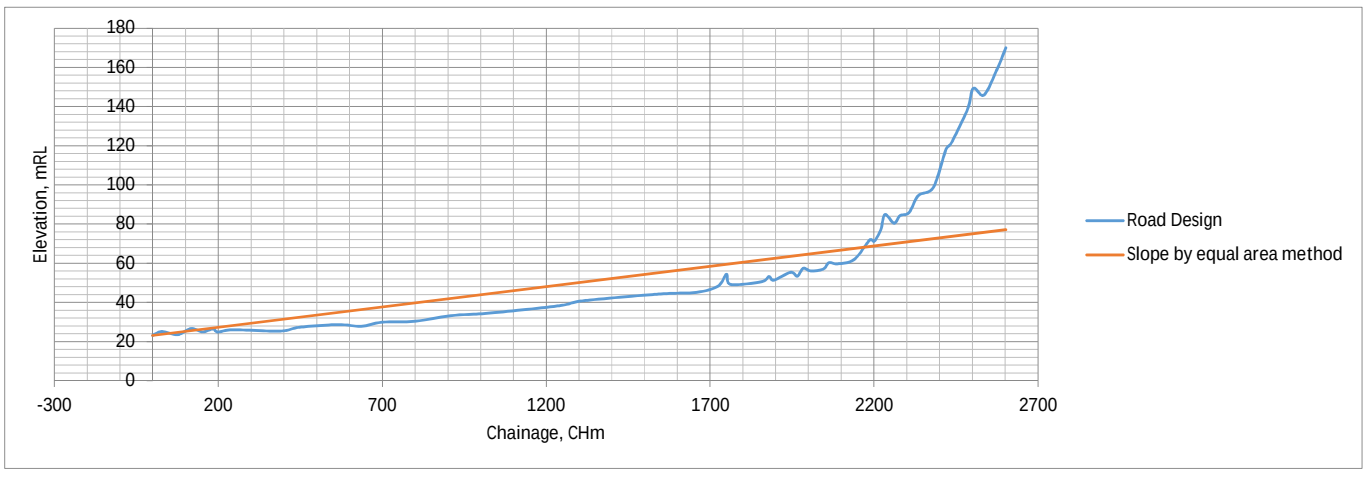
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.62	37.0	1.2
Bransby-Williams	0.99	59.5	0.7
ARC TP108	1.13	68.0	0.6
US Soil Conservation	0.42	25.1	1.7

Selected Time of concentration 68.0 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Pre-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design By: AFRE Date: 30/01/19

Location: Access Road Checked: BEPE Date: 1/02/2019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	78.8	5,516
	Plantation Forestry	72	0.000	0
	Grassed	74	6.600	488
	Subtotal for Pervious Areas		85.400	6,004
	Impervious	98	0.000	0
	Subtotal for Impervious Areas		0.000	0
* from Table 3.3		Totals	85.400	6,004

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{6,004}{85.4} = 70$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 85.4}{85.4} = 5.00$ mm

2. Time of Concentration

Channelisation Factor : C = 1.0

Catchment Length : L = 1.959 km (along drainage path)

Catchment Slope : Sc = 0.032 m/m

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.54 C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.86 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.57 hrs

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

Total = 107.3 mm

Pervious = 107.3 mm

Impervious = 0.0 mm

		Storm #1	Storm #2	Storm #4	Storm #5
4.	**Average Recurrence Interval, ARI (yr) :**	1/3 2 year	2yr	10yr	100yr
5.	**24 hour Rainfall Depth, P_{24} (mm),** (from Appendix A)	**36**	**108**	**172**	**272**
6.	**Runoff Index, c* :** $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$	0.11	0.31	0.43	0.55
7.	**Specific Peak Flow Rate, q*,** (from Figure 5.1)	0.017	0.045	0.058	0.069
8.	**Peak Flow Rate, q_p :** $= q^* A P_{24}$ (m^3/s)	0.528	4.164	8.565	16.137
9.	**Runoff Depth, Q_{24} :** $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm) Pervious	6.9	50.2	101.7	190.6
	Impervious	35.9	107.7	172.1	272.1
10.	**Runoff Volume, V_{24} :** $= 1000 \times Q_{24} A$ (m^3) Pervious	5,901	42,895	86,887	162,782
	Impervious	-	-	-	-
	Total	5,901	42,895	86,887	162,782

LANDFILL PRE DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Access Road drainage path
Details:	Pre dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	26/10/2018
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics	
Catchment (km^2)	0.85
CN	70
Channel Factor	1

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	24.614	0	0	0.00		
124.49	24.619	124.49	124.49	0.00	0.00	0
139.82	27.147	139.82	15.33	2.53	1.27	19
174.29	24.223	174.29	34.47	-0.39	1.07	37
191.53	26.786	191.53	17.24	2.17	0.89	15
220.26	26.415	220.26	28.73	1.80	1.99	57
375.4	28.248	375.4	155.14	3.63	2.72	422
476.91	31.814	476.91	101.51	7.20	5.42	550
541.86	31.923	541.86	64.95	7.31	7.25	471
630.13	34.525	630.13	88.27	9.91	8.61	760
641.62	39.068	641.62	11.49	14.45	12.18	140
676.29	42.98	676.29	34.67	18.37	16.41	569
735.47	44.726	735.47	59.18	20.11	19.24	1139
741.22	46.41	741.22	5.75	21.80	20.95	120
775.69	41.979	775.69	34.47	17.37	19.58	675
802.51	42.112	802.51	26.82	17.50	17.43	468
814	45.402	814	11.49	20.79	19.14	220
829.32	43.664	829.32	15.32	19.05	19.92	305
879.12	44.081	879.12	49.8	19.47	19.26	959
967.22	46.775	967.22	88.1	22.16	20.81	1834
1013.2	46.801	1013.2	45.98	22.19	22.17	1020
1061.1	56.085	1061.1	47.9	31.47	26.83	1285
1082.1	55.176	1082.1	21	30.56	31.02	651
1101.3	58.137	1101.3	19.2	33.52	32.04	615
1128.1	57.829	1128.1	26.8	33.22	33.37	894
1149.2	54.565	1149.2	21.1	29.95	31.58	666
1176	60.011	1176	26.8	35.40	32.67	876
1181.7	57.609	1181.7	5.7	33.00	34.20	195
1214.3	56.704	1214.3	32.6	32.09	32.54	1061
1260.3	58.024	1260.3	46	33.41	32.75	1507
1281.3	64.054	1281.3	21	39.44	36.43	765
1352.2	63.402	1352.2	70.9	38.79	39.11	2773
1369.4	60.228	1369.4	17.2	35.61	37.20	640
1386.7	68.442	1386.7	17.3	43.83	39.72	687
1415.4	67.185	1415.4	28.7	42.57	43.20	1240
1423.4	69.317	1423.4	8	44.70	43.64	349
1448	65.897	1448	24.6	41.28	42.99	1058
1467.1	70.048	1467.1	19.1	45.43	43.36	828
1497.8	67.815	1497.8	30.7	43.20	44.32	1361
1516.9	73.452	1516.9	19.1	48.84	46.02	879
1561	74.233	1561	44.1	49.62	49.23	2171
1601.2	82.454	1601.2	40.2	57.84	53.73	2160
1631.8	93.16	1631.8	30.6	68.55	63.19	1934
1654.8	93.144	1654.8	23	68.53	68.54	1576
1681.6	96.851	1681.6	26.8	72.24	70.38	1886
1714.2	96.239	1714.2	32.6	71.63	71.93	2345
1739.1	101.201	1739.1	24.9	76.59	74.11	1845
1806.1	103.764	1806.1	67	79.15	77.87	5217
1873.2	111.647	1873.2	67.1	87.03	83.09	5575
1959.3	125.388	1959.3	86.1	100.77	93.90	8085
TOTAL	101.17	1959.3	1959.3			60904.49

Derived Characteristics

Max Elevation (mRL)	125.39
Min Elevation (mRL)	24.22
Δ Elevation (m)	101.17
Main Channel Slope	0.032
	3.2%

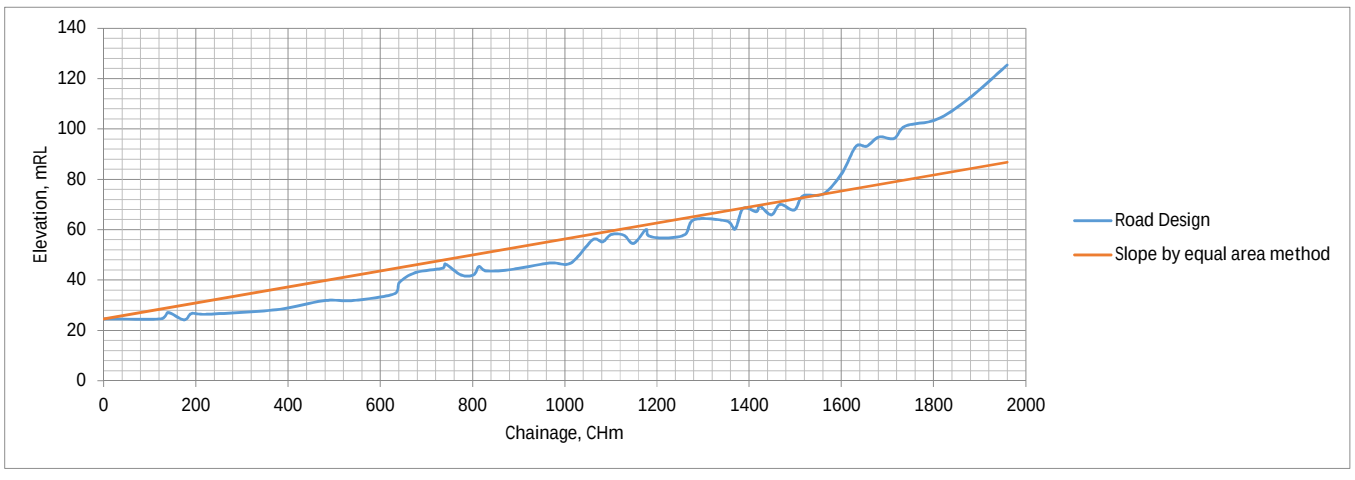
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.42	25.2	1.3
Bransby-Williams	0.86	51.7	0.6
ARC TP108	0.86	51.6	0.6
US Soil Conservation	0.35	20.9	1.6

Selected Time of concentration 51.6 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{-0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Pre-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design By: AFRE Date: 30/01/19

Location: Stockpile 2 Checked: BEPE Date: 1/02/2019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	63.8	4,466
	Plantation Forestry	72	79.200	5,702
	Grassed	74	0.000	0
	Subtotal for Pervious Areas		143.000	10,168
	Impervious	98	0.000	0
	Subtotal for Impervious Areas		0.000	0
* from Table 3.3		Totals	143.000	10,168

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{10,168}{143} =$ 71

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 143}{143} =$ 5.00 mm

2. Time of Concentration

Channelisation Factor : C = 1.0

Catchment Length : L = 2.530 km (along drainage path)

Catchment Slope : Sc = 0.040 m/m

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.55 C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.94 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.63 hrs

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

Total = 103.2 mm

Pervious = 103.2 mm

Impervious = 0.0 mm

		Storm #1	Storm #2	Storm #4	Storm #5
4.	**Average Recurrence Interval, ARI (yr) :**	1/3 2 year	2yr	10yr	100yr
5.	**24 hour Rainfall Depth, P_{24} (mm),** (from Appendix A)	**36**	**108**	**172**	**272**
6.	**Runoff Index, c* :** $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$	0.11	0.32	0.44	0.56
7.	**Specific Peak Flow Rate, q*,** (from Figure 5.1)	0.017	0.044	0.056	0.067
8.	**Peak Flow Rate, q_p :** $= q^* A P_{24}$ (m^3/s)	0.867	6.794	13.848	26.085
9.	**Runoff Depth, Q_{24} :** $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm) Pervious	7.1	51.2	103.3	192.7
	Impervious	35.90	107.69	172.06	272.14
10.	**Runoff Volume, V_{24} :** $= 1000 \times Q_{24} A$ (m^3) Pervious	10,180	73,242	147,675	275,560
	Impervious	-	-	-	-
	Total	10,180	73,242	147,675	275,560

LANDFILL PRE DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Stockpile 2 drainage path
Details:	Pre dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	26/10/2018
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics	
Catchment (km^2)	1.43
CN	71
Channel Factor	1

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	29.949	0	0	0.00		
44.507	29.988	44.507	44.507	0.04	0.02	1
175.55	38.077	175.55	131.043	8.13	4.08	535
222.53	35.394	222.53	46.98	5.45	6.79	319
249.73	38.611	249.73	27.2	8.66	7.05	192
264.57	34.959	264.57	14.84	5.01	6.84	101
292.11	40.032	292.11	27.54	10.08	7.55	208
388.2	42.133	388.2	96.09	12.18	11.13	1070
417.87	40.343	417.87	29.67	10.39	11.29	335
450.01	48.971	450.01	32.14	19.02	14.71	473
511.83	54.181	511.83	61.82	24.23	21.63	1337
563.75	50.437	563.75	51.92	20.49	22.36	1161
586.01	55.106	586.01	22.26	25.16	22.82	508
654.59	53.509	654.59	68.58	23.56	24.36	1671
687.38	57.983	687.38	32.79	28.03	25.80	846
702.22	53.151	702.22	14.84	23.20	25.62	380
749.2	56.008	749.2	46.98	26.06	24.63	1157
823.37	56.77	823.37	74.17	26.82	26.44	1961
848.1	52.911	848.1	24.73	22.96	24.89	616
877.77	58.163	877.77	29.67	28.21	25.59	759
909.92	54.235	909.92	32.15	24.29	26.25	844
998.93	59.115	998.93	89.01	29.17	26.73	2379
1036	55.748	1036	37.07	25.80	27.48	1019
1112.7	62.348	1112.7	76.7	32.40	29.10	2232
1144.8	61.38	1144.8	32.1	31.43	31.92	1024
1167.1	72.923	1167.1	22.3	42.97	37.20	830
1223.9	83.843	1223.9	56.8	53.89	48.43	2751
1253.6	76.116	1253.6	29.7	46.17	50.03	1486
1288.2	82.527	1288.2	34.6	52.58	49.37	1708
1362.4	91.23	1362.4	74.2	61.28	56.93	4224
1389.6	87.385	1389.6	27.2	57.44	59.36	1615
1545.4	88.644	1545.4	155.8	58.70	58.07	9047
1604.7	90.089	1604.7	59.3	60.14	59.42	3523
1681.4	93.428	1681.4	76.7	63.48	61.81	4741
1720.9	91.836	1720.9	39.5	61.89	62.68	2476
1809.9	93.223	1809.9	89	63.27	62.58	5570
1839.6	98.786	1839.6	29.7	68.84	66.06	1962
1903.8	97.24	1903.8	64.2	67.29	68.06	4370
1972.4	102.16	1972.4	68.6	72.21	69.75	4785
2012.7	108.576	2012.7	40.3	78.63	75.42	3039
2074.5	112.322	2074.5	61.8	82.37	80.50	4975
2086.2	109.938	2086.2	11.7	79.99	81.18	950
2163.5	117.906	2163.5	77.3	87.96	83.97	6491
2180.8	117.502	2180.8	17.3	87.55	87.76	1518
2222.9	125.272	2222.9	42.1	95.32	91.44	3850
2334.8	134.22	2334.8	111.9	104.27	99.80	11167
2358.2	140.023	2358.2	23.4	110.07	107.17	2508
2407.6	144.172	2407.6	49.4	114.22	112.15	5540
2450.3	170.35	2450.3	42.7	140.40	127.31	5436
2529.5	199.995	2529.5	79.2	170.05	155.22	12294
TOTAL	170.05	2529.5	2529.5			127981.49

Derived Characteristics

Max Elevation (mRL)	200.00
Min Elevation (mRL)	29.95
Δ Elevation (m)	170.05
Main Channel Slope	0.040
	4.0%

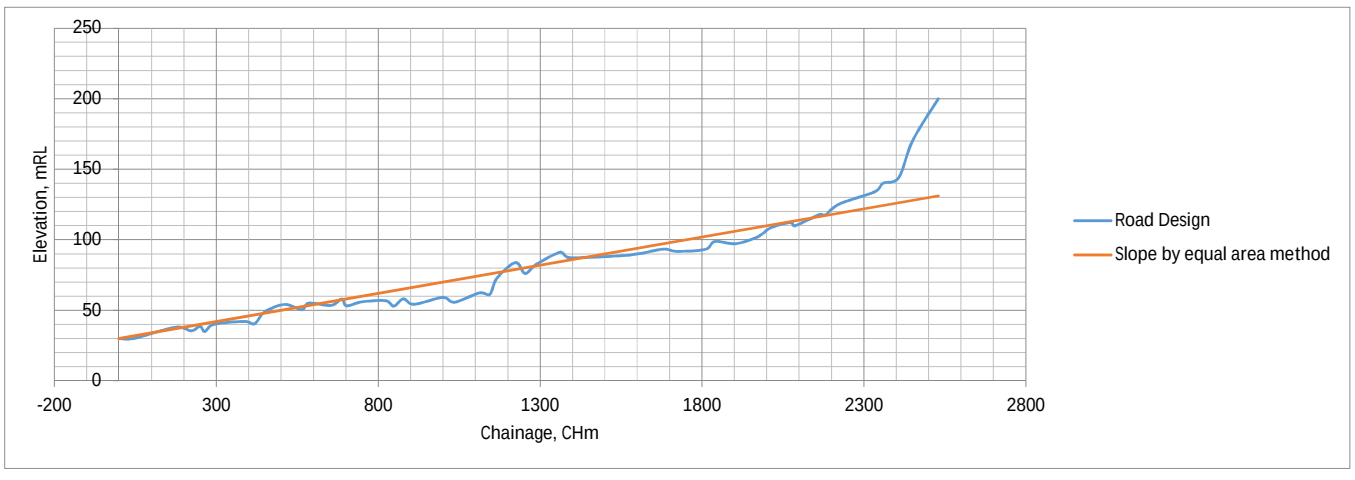
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.47	28.1	1.5
Bransby-Williams	1.00	60.2	0.7
ARC TP108	0.94	56.5	0.7
US Soil Conservation	0.38	23.0	1.8

Selected Time of concentration 56.5 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{-0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Post-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design By: AFRE Date: 30/01/19

Location: Springhill farm Checked: BEPE Date: 1/02/2019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	41.80	2,926
	Plantation Forestry	72	99.50	7,164
	Grassed	74	155.04	11,473
	Subtotal for Pervious Areas		296.34	21,563
	Impervious			
	Sealed roads/ roofs	98	5.66	554
	Subtotal for Impervious Areas		5.66	554
* from Table 3.3		Totals	302.000	22,118

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{22{,}118}{302} =$ 73

Ia (weighted) : $\frac{\text{5 x pervious area}}{\text{total area}} = \frac{5 \times 296.342}{302} =$ 4.91 mm

2. Time of Concentration

Channelisation Factor :	C	=	1.0	
Catchment Length :	L	=	2.602	km (along drainage path)
Catchment Slope :	Sc	=	0.021	m/m
Runoff Factor R :	$\frac{CN}{200 - CN}$	=	0.58	C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 1.14 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.76 hrs

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

Total = 92.8 mm
Pervious = 95.1 mm
Impervious = 5.2 mm

			Storm #1	Storm #2	Storm #4	Storm #5
4. Average Recurrence Interval, ARI (yr) :			1/3 2 year	2yr	10yr	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)			**36**	**108**	**172**	**272**
6. Runoff Index, c* :	$\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.12	0.35	0.47	0.59
7. Specific Peak Flow Rate, q*, (from Figure 5.1)			0.017	0.042	0.053	0.062
8. Peak Flow Rate, q_p :	$q^* A P_{24}$	(m^3/s)	1.820	13.673	27.325	51.157
9. Runoff Depth, Q_{24} :	$\frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$	(mm) Pervious	7.6	53.3	106.5	197.0
		Impervious	31.4	102.7	167.0	267.1
10. Runoff Volume, V_{24} :	$1000 \times Q_{24} A$	(m^3) Pervious	22,458	158,022	315,523	583,870
		Impervious	1,775	5,813	9,451	15,110
		Total	24,233	163,836	324,974	598,980

LANDFILL POST DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Springhill farm drainage path
Details:	Post dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	30/01/2019
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics		
Catchment (km^2)	3.02	
CN	73	
Channel Factor	1	(Natural channel)

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	23.181	0	0	0.00		
27.977	25.172	27.977	27.977	1.99	1.00	28
76.3	23.599	76.3	48.323	0.42	1.20	58
116.99	26.654	116.99	40.69	3.47	1.95	79
152.6	24.959	152.6	35.61	1.78	2.63	93
183.12	26.539	183.12	30.52	3.36	2.57	78
198.38	24.941	198.38	15.26	1.76	2.56	39
244.16	26.041	244.16	45.78	2.86	2.31	106
389.13	25.402	389.13	144.97	2.22	2.54	368
447.63	27.347	447.63	58.5	4.17	3.19	187
564.62	28.693	564.62	116.99	5.51	4.84	566
635.83	27.865	635.83	71.21	4.68	5.10	363
699.42	29.926	699.42	63.59	6.75	5.71	363
801.15	30.425	801.15	101.73	7.24	6.99	712
907.97	33.255	907.97	106.82	10.07	8.66	925
1032.6	34.654	1032.6	124.63	11.47	10.77	1343
1243.7	38.427	1243.7	211.1	15.25	13.36	2820
1309.8	40.828	1309.8	66.1	17.65	16.45	1087
1548.9	44.354	1548.9	239.1	21.17	19.41	4641
1658.3	45.155	1658.3	109.4	21.97	21.57	2360
1724.4	48.357	1724.4	66.1	25.18	23.58	1558
1749.8	54.401	1749.8	25.4	31.22	28.20	716
1762.5	49.21	1762.5	12.7	26.03	28.62	364
1859.2	50.693	1859.2	96.7	27.51	26.77	2589
1879.5	53.27	1879.5	20.3	30.09	28.80	585
1894	51.356	1894	14.5	28.18	29.13	422
1945.6	55.414	1945.6	51.6	32.23	30.20	1559
1966	53.407	1966	20.4	30.23	31.23	637
1983.8	57.439	1983.8	17.8	34.26	32.24	574
2007.5	56.09	2007.5	23.7	32.91	33.58	796
2044.8	57.04	2044.8	37.3	33.86	33.38	1245
2062.6	60.328	2062.6	17.8	37.15	35.50	632
2088.1	59.73	2088.1	25.5	36.55	36.85	940
2138.9	61.883	2138.9	50.8	38.70	37.63	1911
2187.3	72.021	2187.3	48.4	48.84	43.77	2119
2200	71.197	2200	12.7	48.02	48.43	615
2220.3	77	2220.3	20.3	53.82	50.92	1034
2233	84.907	2233	12.7	61.73	57.77	734
2261	80.484	2261	28	57.30	59.51	1666
2278.8	84.299	2278.8	17.8	61.12	59.21	1054
2306.8	85.932	2306.8	28	62.75	61.93	1734
2334.8	94.568	2334.8	28	71.39	67.07	1878
2380.6	98.741	2380.6	45.8	75.56	73.47	3365
2418.7	117.831	2418.7	38.1	94.65	85.11	3243
2436.5	121.709	2436.5	17.8	98.53	96.59	1719
2484.8	138.569	2484.8	48.3	115.39	106.96	5166
2502.6	149.344	2502.6	17.8	126.16	120.78	2150
2535.7	145.987	2535.7	33.1	122.81	124.48	4120
2576.4	159.56	2576.4	40.7	136.38	129.59	5274
2601.8	170.048	2601.8	25.4	146.87	141.62	3597
TOTAL	146.87	2601.8	2601.8			70212.738

Derived Characteristics

Max Elevation (mRL)	170.05
Min Elevation (mRL)	23.18
Δ Elevation (m)	146.87
Main Channel Slope	0.021
	2.1%

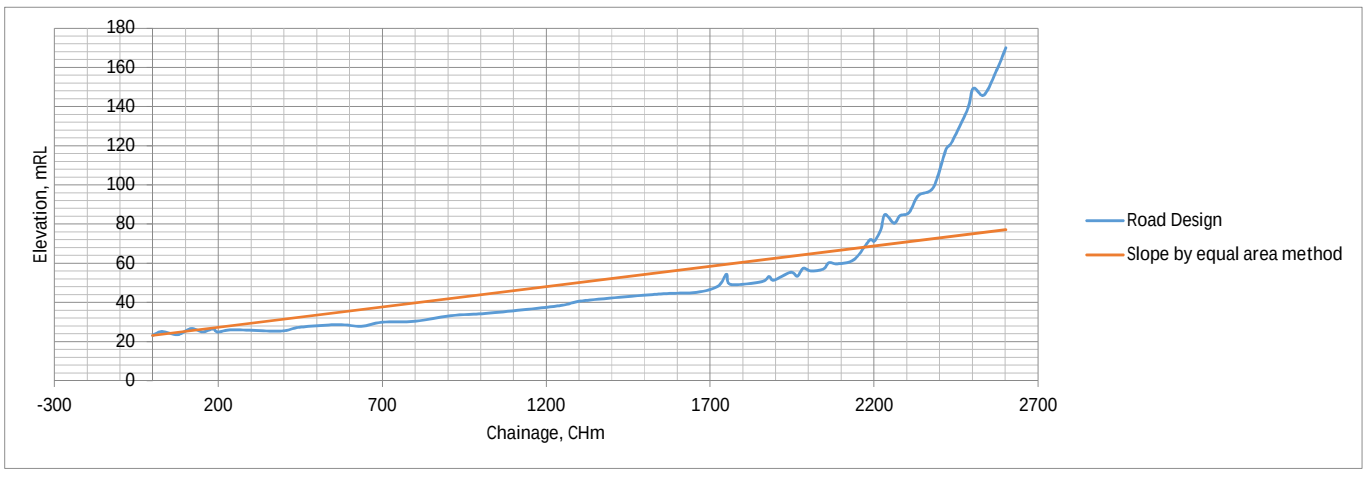
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.62	37.0	1.2
Bransby-Williams	0.99	59.5	0.7
ARC TP108	1.14	68.3	0.6
US Soil Conservation	0.42	25.1	1.7

Selected Time of concentration 68.3 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Post-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design | By: AFRE | Date: 30/01/19

Location: Access Road | Checked: BEPE | Date: 1/02/019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	67.80	4,746
	Plantation Forestry	72	4.12	297
	Grassed	74	9.48	702
	Subtotal for Pervious Areas		81.40	5,744
	Impervious			
	Sealed roads/ roofs	98	4.00	392
	Subtotal for Impervious Areas		4.00	392
* from Table 3.3		Totals	85.40	6,136

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{6,136}{85.4} =$ 72

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 81.4}{85.4} =$ 4.77 mm

2. Time of Concentration

Channelisation Factor : C = 1.0

Catchment Length : L = 1.959 km (along drainage path)

Catchment Slope : Sc = 0.032 m/m

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.56 C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.84 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.56 hrs

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

Total = 99.5 mm

Pervious = 105.9 mm

Impervious = 5.2 mm

		Storm #1	Storm #2	Storm #4	Storm #5
4.	**Average Recurrence Interval, ARI (yr) :**	1/3 2 year	2yr	10yr	100yr
5.	**24 hour Rainfall Depth, P_{24} (mm),** (from Appendix A)	**36**	**108**	**172**	**272**
6.	**Runoff Index, c* :** $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$	0.12	0.33	0.45	0.57
7.	**Specific Peak Flow Rate, q*,** (from Figure 5.1)	0.019	0.048	0.061	0.072
8.	**Peak Flow Rate, q_p :** $= q^* A P_{24}$ (m^3/s)	0.576	4.406	8.950	16.745
9.	**Runoff Depth, Q_{24} :** $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm) Pervious	7.0	50.5	102.2	191.3
	Impervious	31.4	102.7	167.0	267.1
10.	**Runoff Volume, V_{24} :** $= 1000 \times Q_{24} A$ (m^3) Pervious	5,679	41,145	83,218	155,707
	Impervious	1,255	4,110	6,681	10,682
	Total	6,934	45,255	89,900	166,389

LANDFILL POST DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Access Road drainage path
Details:	Post dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	26/10/2018
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics		
Catchment (km^2)	0.85	
CN	72	
Channel Factor	1	(Natural channel)

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	24.614	0	0	0.00		
124.49	24.619	124.49	124.49	0.00	0.00	0
139.82	27.147	139.82	15.33	2.53	1.27	19
174.29	24.223	174.29	34.47	-0.39	1.07	37
191.53	26.786	191.53	17.24	2.17	0.89	15
220.26	26.415	220.26	28.73	1.80	1.99	57
375.4	28.248	375.4	155.14	3.63	2.72	422
476.91	31.814	476.91	101.51	7.20	5.42	550
541.86	31.923	541.86	64.95	7.31	7.25	471
630.13	34.525	630.13	88.27	9.91	8.61	760
641.62	39.068	641.62	11.49	14.45	12.18	140
676.29	42.98	676.29	34.67	18.37	16.41	569
735.47	44.726	735.47	59.18	20.11	19.24	1139
741.22	46.41	741.22	5.75	21.80	20.95	120
775.69	41.979	775.69	34.47	17.37	19.58	675
802.51	42.112	802.51	26.82	17.50	17.43	468
814	45.402	814	11.49	20.79	19.14	220
829.32	43.664	829.32	15.32	19.05	19.92	305
879.12	44.081	879.12	49.8	19.47	19.26	959
967.22	46.775	967.22	88.1	22.16	20.81	1834
1013.2	46.801	1013.2	45.98	22.19	22.17	1020
1061.1	56.085	1061.1	47.9	31.47	26.83	1285
1082.1	55.176	1082.1	21	30.56	31.02	651
1101.3	58.137	1101.3	19.2	33.52	32.04	615
1128.1	57.829	1128.1	26.8	33.22	33.37	894
1149.2	54.565	1149.2	21.1	29.95	31.58	666
1176	60.011	1176	26.8	35.40	32.67	876
1181.7	57.609	1181.7	5.7	33.00	34.20	195
1214.3	56.704	1214.3	32.6	32.09	32.54	1061
1260.3	58.024	1260.3	46	33.41	32.75	1507
1281.3	64.054	1281.3	21	39.44	36.43	765
1352.2	63.402	1352.2	70.9	38.79	39.11	2773
1369.4	60.228	1369.4	17.2	35.61	37.20	640
1386.7	68.442	1386.7	17.3	43.83	39.72	687
1415.4	67.185	1415.4	28.7	42.57	43.20	1240
1423.4	69.317	1423.4	8	44.70	43.64	349
1448	65.897	1448	24.6	41.28	42.99	1058
1467.1	70.048	1467.1	19.1	45.43	43.36	828
1497.8	67.815	1497.8	30.7	43.20	44.32	1361
1516.9	73.452	1516.9	19.1	48.84	46.02	879
1561	74.233	1561	44.1	49.62	49.23	2171
1601.2	82.454	1601.2	40.2	57.84	53.73	2160
1631.8	93.16	1631.8	30.6	68.55	63.19	1934
1654.8	93.144	1654.8	23	68.53	68.54	1576
1681.6	96.851	1681.6	26.8	72.24	70.38	1886
1714.2	96.239	1714.2	32.6	71.63	71.93	2345
1739.1	101.201	1739.1	24.9	76.59	74.11	1845
1806.1	103.764	1806.1	67	79.15	77.87	5217
1873.2	111.647	1873.2	67.1	87.03	83.09	5575
1959.3	125.388	1959.3	86.1	100.77	93.90	8085
TOTAL	101.17	1959.3	1959.3			60904.49

Derived Characteristics

Max Elevation (mRL)	125.39
Min Elevation (mRL)	24.22
Δ Elevation (m)	101.17
Main Channel Slope	0.032
	3.2%

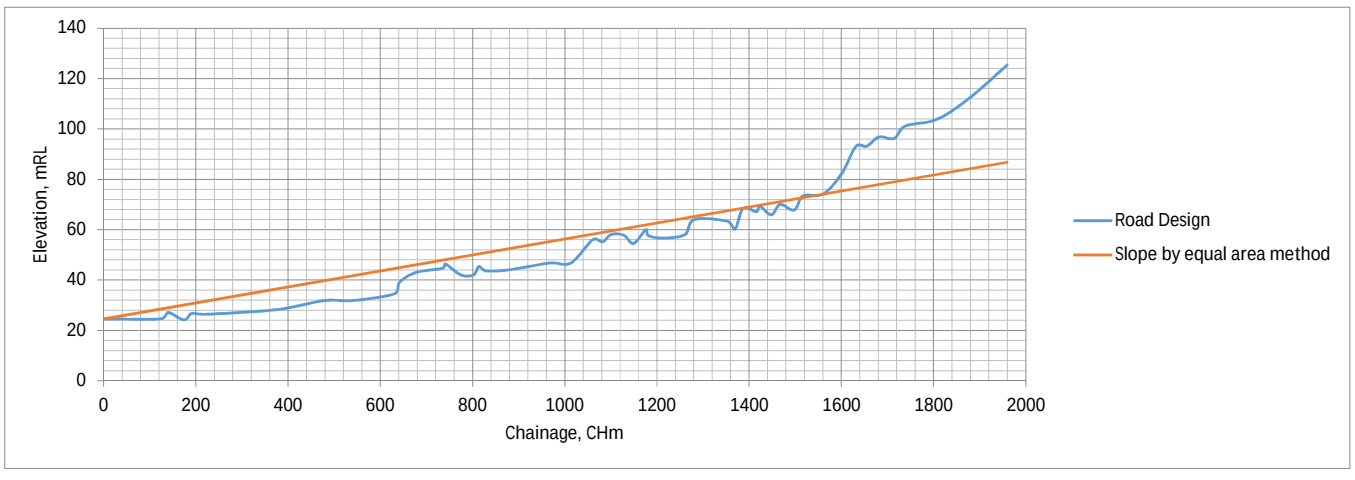
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.42	25.2	1.3
Bransby-Williams	0.86	51.7	0.6
ARC TP108	0.84	50.7	0.6
US Soil Conservation	0.35	20.9	1.6

Selected Time of concentration 50.7 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{-0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Post-development: TP108 - Runoff Analysis - Peak Discharge

Project: Polaris landfill design By: AFRE Date: 30/01/19

Location: Stockpile 2 Checked: BEPE Date: 1/02/2019

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

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
Soil Group C - Mudstone/sandstone	*Landscaped*			
	Bush	70	63.78	4,465
	Plantation Forestry	72	71.72	5,164
	Grassed	74	7.20	533
	Subtotal for Pervious Areas		142.70	10,161
	Impervious			
	Sealed roads/ roofs	98	0.300	29
	Subtotal for Impervious Areas		0.300	29
* from Table 3.3		Totals	143.000	10,191

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{10,191}{143} = 71$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 142.7}{143} = 4.99$ mm

2. Time of Concentration

Channelisation Factor :	C	=	1.0	
Catchment Length :	L	=	2.530	km (along drainage path)
Catchment Slope :	Sc	=	0.040	m/m
Runoff Factor R :	$\frac{CN}{200 - CN}$	=	0.55	C

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.94 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.63 hrs

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

Total = 102.4 mm
Pervious = 102.7 mm
Impervious = 5.2 mm

			Storm #1	Storm #2	Storm #4	Storm #5
4. Average Recurrence Interval, ARI (yr) :			1/3 2 year	2yr	10yr	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)			**36**	**108**	**172**	**272**
6. Runoff Index, c* :	$= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.11	0.32	0.44	0.56
7. Specific Peak Flow Rate, q*, (from Figure 5.1)			0.017	0.045	0.057	0.068
8. Peak Flow Rate, q_p :	$= q^* A P_{24}$	(m^3/s)	0.878	6.862	13.976	26.302
9. Runoff Depth, Q_{24} :	$= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$	(mm) Pervious	7.1	51.3	103.5	193.0
		Impervious	31.4	102.7	167.0	267.1
10. Runoff Volume, V_{24} :	$= 1000 \times Q_{24} A$	(m^3) Pervious	10,196	73,266	147,637	275,352
		Impervious	94.10	308.24	501.10	801.17
		Total	10,291	73,574	148,138	276,153

LANDFILL POST DEVELOPMENT EQUAL AREA SLOPE			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
			Stockpile 2 drainage path
Details:	Post dev longest slope	Job No:	1005069.1140
Computed:	AFRE	Date:	26/10/2018
Checked:	BEPE	Date:	1/02/2019

Notes:
Information extracted from lidar information on Global mapper- WAYBE file.

Catchment Characteristics		
Catchment (km^2)	1.43	
CN	71	
Channel Factor	1.0	(Natural channel)

Slope Characteristics

Chainage	Elevation (mRL)	X (m)	dX (m)	h (m)	Avg. h (m)	Δ A (m^2)
0	29.949	0	0	0.00		
44.507	29.988	44.507	44.507	0.04	0.02	1
175.55	38.077	175.55	131.043	8.13	4.08	535
222.53	35.394	222.53	46.98	5.45	6.79	319
249.73	38.611	249.73	27.2	8.66	7.05	192
264.57	34.959	264.57	14.84	5.01	6.84	101
292.11	40.032	292.11	27.54	10.08	7.55	208
388.2	42.133	388.2	96.09	12.18	11.13	1070
417.87	40.343	417.87	29.67	10.39	11.29	335
450.01	48.971	450.01	32.14	19.02	14.71	473
511.83	54.181	511.83	61.82	24.23	21.63	1337
563.75	50.437	563.75	51.92	20.49	22.36	1161
586.01	55.106	586.01	22.26	25.16	22.82	508
654.59	53.509	654.59	68.58	23.56	24.36	1671
687.38	57.983	687.38	32.79	28.03	25.80	846
702.22	53.151	702.22	14.84	23.20	25.62	380
749.2	56.008	749.2	46.98	26.06	24.63	1157
823.37	56.77	823.37	74.17	26.82	26.44	1961
848.1	52.911	848.1	24.73	22.96	24.89	616
877.77	58.163	877.77	29.67	28.21	25.59	759
909.92	54.235	909.92	32.15	24.29	26.25	844
998.93	59.115	998.93	89.01	29.17	26.73	2379
1036	55.748	1036	37.07	25.80	27.48	1019
1112.7	62.348	1112.7	76.7	32.40	29.10	2232
1144.8	61.38	1144.8	32.1	31.43	31.92	1024
1167.1	72.923	1167.1	22.3	42.97	37.20	830
1223.9	83.843	1223.9	56.8	53.89	48.43	2751
1253.6	76.116	1253.6	29.7	46.17	50.03	1486
1288.2	82.527	1288.2	34.6	52.58	49.37	1708
1362.4	91.23	1362.4	74.2	61.28	56.93	4224
1389.6	87.385	1389.6	27.2	57.44	59.36	1615
1545.4	88.644	1545.4	155.8	58.70	58.07	9047
1604.7	90.089	1604.7	59.3	60.14	59.42	3523
1681.4	93.428	1681.4	76.7	63.48	61.81	4741
1720.9	91.836	1720.9	39.5	61.89	62.68	2476
1809.9	93.223	1809.9	89	63.27	62.58	5570
1839.6	98.786	1839.6	29.7	68.84	66.06	1962
1903.8	97.24	1903.8	64.2	67.29	68.06	4370
1972.4	102.16	1972.4	68.6	72.21	69.75	4785
2012.7	108.576	2012.7	40.3	78.63	75.42	3039
2074.5	112.322	2074.5	61.8	82.37	80.50	4975
2086.2	109.938	2086.2	11.7	79.99	81.18	950
2163.5	117.906	2163.5	77.3	87.96	83.97	6491
2180.8	117.502	2180.8	17.3	87.55	87.76	1518
2222.9	125.272	2222.9	42.1	95.32	91.44	3850
2334.8	134.22	2334.8	111.9	104.27	99.80	11167
2358.2	140.023	2358.2	23.4	110.07	107.17	2508
2407.6	144.172	2407.6	49.4	114.22	112.15	5540
2450.3	170.35	2450.3	42.7	140.40	127.31	5436
2529.5	199.995	2529.5	79.2	170.05	155.22	12294
TOTAL	170.05	2529.5	2529.5			127981.49

Derived Characteristics

Max Elevation (mRL)	200.00
Min Elevation (mRL)	29.95
Δ Elevation (m)	170.05
Main Channel Slope	0.040
	4.0%

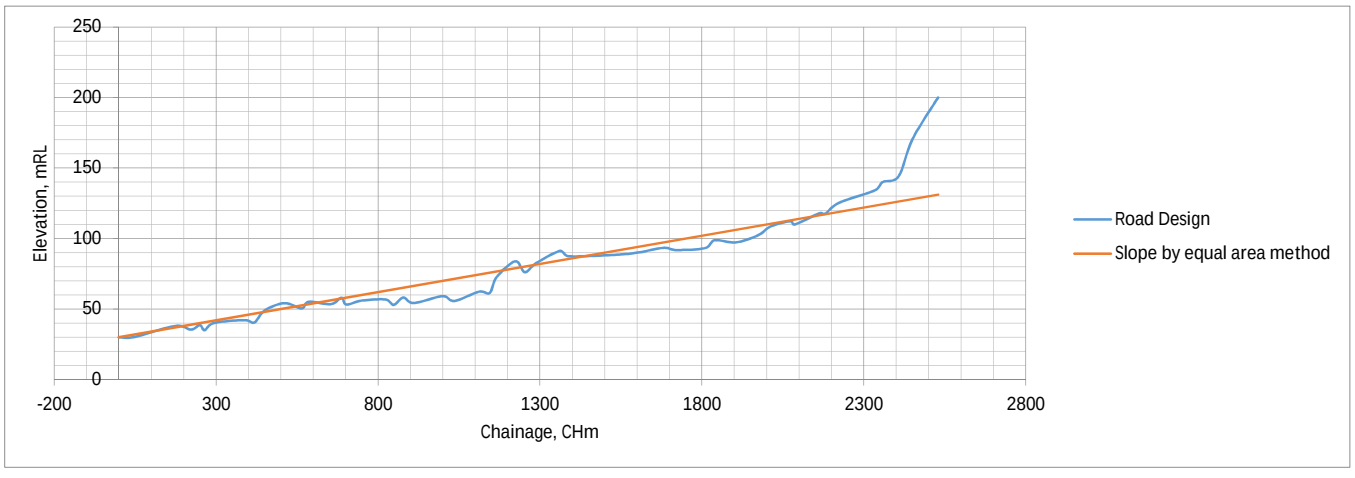
$$Slope = S_c = \frac{2A}{(\sum Dx)^2}$$

Time of Concentration

Method	Time (Hours)	Time (Minutes)	Avg. V (m/s)
Ramser-Kirpich	0.47	28.1	1.5
Bransby-Williams	1.00	60.2	0.7
ARC TP108	0.94	56.4	0.7
US Soil Conservation	0.38	23.0	1.8

Selected Time of concentration 56.4 minutes

Method	Formula	Parameter definitions
Ramser-Kirpich	$T_c = 0.0195\ L^{0.77} S_a^{-0.385}$	S_a = average channel slope (m/m) L = maximum flow length (m)
Bransby - Williams	$T_c = (0.953\ L^{1.2}) / (A^{0.1} H^{0.2})$	A = catchment area (km^2) L = maximum flow length (m) H = the difference in elevation between the highest and lowest points in the study area (m)
Auckland Regional Council TP108	$T_c = 0.14CL^{0.66}\{CN/(200-CN)\}^{-0.55} S_c^{-0.30}$	C = channelisation factor L = maximum flow length (km) CN = SCS Curve Number S_c = catchment slope (equal area method) (m/m)
U.S. Soil Conservation Service	$T_c = (0.87\ L^3 / H)^{0.385}$	L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m)



Appendix C: USLE calculations

UNIVERSAL SOIL LOSS CALCULATIONS (USLR)			
Tonkin+Taylor		Project:	Polaris Landfill Design Project
Details:	USLR during construction	Job No:	1005069.1140
Computed:	AFRE	Date:	30/11/2018
Checked:		Date:	

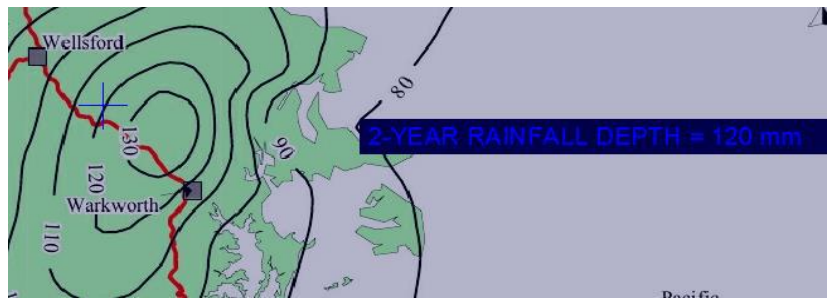
Calculating Sediment Yield using the USLE Method

Assumptions:
Longest cut length is 100 m
Maximum slope of the landfill cut is 1V:2H (50%)
Maximum area Stage 1 and 2: 34000

Sediment Generated, A = R.K.LS.C.P

Rainfall Erosion Index, R

R = $0.00828 \times p^{2.2} \times 1.7$
i= **110** mm from TP108 figure A1
p = 69.08 daily rainfall x 0.628
R = 156.6947
R = 160 J/hectare



Soil Erodibility Factor, K
Composition of soil (assumed to be uniform across site)

	Sand%	Silt%	Clay %	K	K_2	K_3
Stage 1						
Exposed ground	50	30	20	**0.28**	**0.38**	**0.50**

Silts/clays identified by bore logs info provided by Alex

K_2 - correction for organic content
K2 assumption: no organic matter 0% K1+0.1
K_3 - conversion from imperical to metric K2x1.32

Slope Length and Steepness Factor

	Length (m)	Grade (%)	LS Factor
Area 1	**100**	**50%**	**30.58**

Refer to attached plan

Ground Cover and Roughness Factors
Assume bare soil (combination of the first three in Table 2)

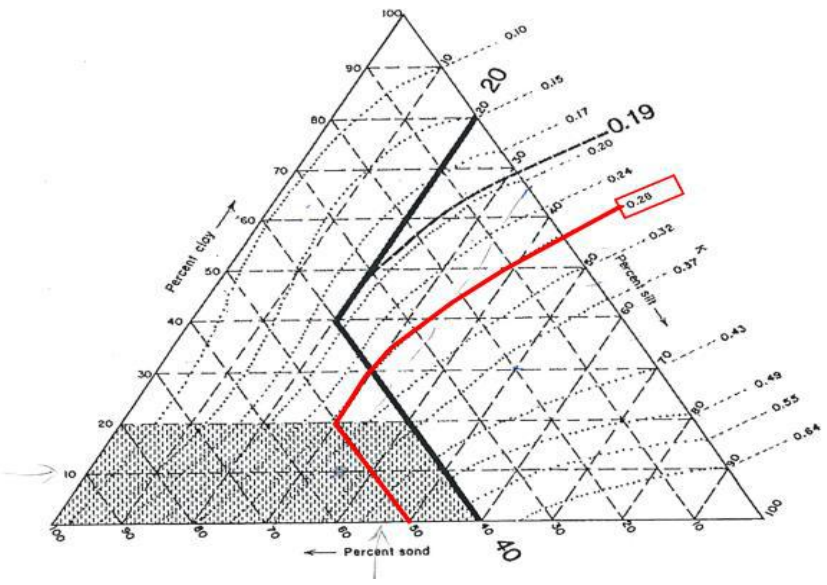
C = 1	P = 1

USLE Sediment Generation Rates

Construction Area	LS Factor	R j/ha	K t/unitR	C	P	Sed. Gen^n t/ha/yr	Area m^2	Time (yrs)	Est. of Sed. Gen^d (t)	Sed. Deliv. Ratio	Sed. Control Eff (%)	Sed. Yield (tonnes)	Type of control
Landfill	30.58	160	0.50	1	1	2454.23	34,000	0.5	4172.188	**0.5**	0%	2086.094	
											Total	**2086.094**	

Calculating K value:

Figure 1: Triangular Nomograph for Estimating K Values



Goldman et al. 1986

2. Correct for organic content using Table 1 (the nomograph assumes 2% organic matter).

Table 1

	Correction factor when percent organic matter is				
K Value	0% (clay)	1%	2%	3%	4% (topsoil)
Greater than 0.40	+ 0.14	+ 0.07	0	- 0.07	- 0.14
0.20 – 0.40	+ 0.10	+ 0.05	0	- 0.05	- 0.10
Less than 0.20	+ 0.06	+ 0.03	0	- 0.03	- 0.06

Site treatment varies, we have assumed P factor of 1 and C of 1

Table 2 (Modified from Goldman et al 1986)

Treatment	C factor	P factor
Bare Soil - compacted and smooth - track walked on contour - rough irregular surface - disked to 250 mm depth	1.0 1.0 1.0 1.0	1.32 1.2 0.9 0.8
Native vegetation (undisturbed)	0.01	1.0
Pasture (undisturbed)	0.02	1.0
Establishing grass	0.1	1.0
Mulch – on subsoil[2]	0.15 (3 month period only)	1.0
Mulch – on topsoil[3]	0.05 (3 month period only)	1.0

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