


Appendix B: Stormwater calculations

LANDFILL DESIGN POND
PRELIMINARY DESIGN CALCULATIONS

| PONDS SUMMARY | | | |
|---|------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Landfill Ponds summary | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 13/11/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Assumed that the ponds take 3% of the contributing catchment

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

Total areas of roads is assumed to be as shown below:

| Gravel Road | Length of road (m) | Width of road (m) | Area (ha) |
|-----------------------------|--------------------|-------------------|-----------|
| 1 | 430 | 8 | 0.34 |
| 2 | 620 | 8 | 0.50 |
| 3 | 120 | 8 | 0.10 |
| 4.1 | 400 | 8 | 0.32 |
| 4.2 | 220 | 8 | 0.18 |
| 5 | 430 | 8 | 0.34 |
| 6 | 350 | 8 | 0.28 |
| 7 | 720 | 8 | 0.58 |
| 8 | 570 | 6 | 0.34 |
| Perimeter road | 3500 | 8 | 2.80 |
| Paved roads | | | |
| Landfill road | 380 | 8 | 0.30 |
| Total gravel roads Phase 1= | | | 5.598 |
| Total gravel roads Phase 2= | | | 5.110 |
| Total paved roads = | | | 0.30 |

Total catchment areas for each Stage

| Pre-development contributing catchment | | | |
|--|---------------|--------|---------------|
| Catchment type | Upstream Pond | Pond 4 | Ponds 2 and 3 |
| <i>Pervious</i> | | | |
| Plantation forestry | 42.3 | 44 | 18.1 |

| Post-development Stage 1 Contributing catchment during earthworks (Ha) | | | |
|--|-----------------|--------|---------------|
| Catchment type | Upstream Pond 5 | Pond 4 | Ponds 2 and 3 |
| <i>Impervious</i> | | | |
| Gravel | - | 1.4 | 1.3 |
| Impervious hardstand | - | - | 0.3 |
| Paved | - | 0.3 | - |
| Open earthworks | - | 4.7 | - |
| <i>Pervious</i> | | | |
| Plantation forestry | 42.3 | - | - |
| Bush | - | 25.3 | 16.5 |
| Grassed | - | 12.3 | - |

Assumed 30% of the perimeter road is constructed
Hardstand = workshop platform

Assumed 1/3 of Phase 2 catchment (142,000 m²) is open excavation

Assumed bush will be planted outside of landfill extent
Assumed 1/3 of largest Phase area will be open excavation.
The rest of the landfill will be grass

| Post-development Stage 2 Contributing catchment during earthworks (Ha) | | |
|--|--------|---------------|
| Catchment type | Pond 4 | Ponds 2 and 3 |
| <i>Total catchment</i> | | |
| | 86.3 | 18.1 |
| <i>Impervious</i> | | |
| Gravel | 3.9 | 1.6 |
| Impervious hardstand | - | 1.0 |
| Paved | 0.3 | - |
| Open earthworks | 8.3 | - |
| <i>Pervious</i> | | |
| Plantation forestry | - | - |
| Bush | 32.9 | 15.5 |
| Grassed | 40.9 | - |

Assumed the entire perimeter road is constructed
Assume energy centre footprint included

Assumed 1/3 of the largest Phase catchment (Phase 6 catchment 248,000) is open excavation

Entire Stage 2 landfill extent -open excavation =grassed

PONDS SUMMARY



| | |
|----------|---------------------------------|
| Project: | Polaris Landfill Design Project |
| Job No: | 1005069.1140 |
| Date: | 13/11/2018 |
| Date: | 29/11/2018 |

| | |
|-----------|------------------------|
| Details: | Landfill Ponds summary |
| Computed: | AFRE |
| Checked: | JAAH |

| Post-development Stage 3 Contributing catchment during earthworks (Ha) | |
|--|---------------|
| Catchment type | Ponds 2 and 3 |
| <i>Total catchment</i> | <i>104.4</i> |
| Impervious | |
| Gravel | 5.45 |
| Impervious hardstand | 1.0 |
| Paved | 0.30 |
| Open earthworks | 3.1 |
| Pervious | |
| Plantation forestry | - |
| Bush | 39.18 |
| Grassed | 55.4 |

Assumed the entire perimeter road is constructed

Assume 1/3 of Phase 7 (93,000) is open EW = 3.1 Ha
Assume the remainder of the landfill is grassed

Total landfill area = 58.5 - Open excavation area

| Critical Pond Storage Volumes (m3) | |
|------------------------------------|--------|
| Pond 5 | 12,690 |
| Pond 4 | 25,890 |
| Combined Pond 2 and Pond 3 St 1 | 5,430 |
| Combined Pond 2 and Pond 3 St 3 | 31,320 |

| Pond 2 | Pond 3 |
|--------|--------|
| 1,170 | 4,260 |
| 12,528 | 18,792 |

Total catchment areas for each stage

Notes:


- Assumed that the ponds total storage is equivalent to 3% of the contributing catchment
- Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative
- Assumed that the landfill extent in each stage is finished and capped, CN = grass

| FINAL STAGE 1 | |
|-----------------------------|------------|
| <i>Total catchment (Ha)</i> | <i>104</i> |
| Impervious | |
| Gravel | 2.78 |
| Impervious hardstand | 0.3 |
| Paved | 0.30 |
| Open earthworks | N/A |
| Pervious | |
| Plantation forestry | 42.3 |
| Bush | 41.75 |
| Grassed | 17.0 |

Assume landfill extent is grassed, all other cut areas have been reinstated with bush

| FINAL STAGE 2 | |
|-----------------------------|------------|
| <i>Total catchment (Ha)</i> | <i>104</i> |
| Impervious | |
| Gravel | 5.45 |
| Impervious hardstand | 1.0 |
| Paved | 0.30 |
| Open earthworks | N/A |
| Pervious | |
| Plantation forestry | - |
| Bush | 48.48 |
| Grassed | 49.2 |

Assume landfill extent is grassed, all other cut areas have been reinstated with bush

| PONDS SUMMARY | | | |
|---|----------|---------|---------------------------------|
|  | Project: | | Polaris Landfill Design Project |
| | Details: | | Landfill Ponds summary |
| Computed: | AFRE | Job No: | 1005069.1140 |
| Checked: | JAAH | Date: | 13/11/2018 |
| | | Date: | 29/11/2018 |

| FINAL STAGE 3 | |
|----------------------|-------|
| Total catchment (Ha) | 104 |
| Impervious | |
| Gravel | 5.45 |
| Impervious hardstand | 1.0 |
| Paved | 0.30 |
| Open earthworks | N/A |
| Pervious | |
| Plantation forestry | 0 |
| Bush | 39.18 |
| Grassed | 58.5 |

Assume landfill extent is grassed, all other cut areas have been reinstated with bush

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 |


The following table summarises the peak flow rates generated for pre and post development. Stages 1-3 refer to the end of the stage where the landfill has been finished and capped.

| ARI | Peak flow rate (m ³ /s) | | | | | | |
|-----|------------------------------------|------------|------------|------------|---------------|---------------|---------------|
| | Pre-development | EW Stage 1 | EW Stage 2 | EW Stage 3 | Final Stage 1 | Final Stage 2 | Final Stage 3 |
| 2 | 5.79 | 10.32 | 8.43 | 6.83 | 9.45 | 8.08 | 6.73 |
| 10 | 11.73 | 20.47 | 16.67 | 13.59 | 19.03 | 16.20 | 13.45 |
| 100 | 21.86 | 37.51 | 30.25 | 25.15 | 35.08 | 29.71 | 24.95 |

| ARI | Volume (m ³) | | | | | | |
|-----|--------------------------|------------|------------|------------|---------------|---------------|---------------|
| | Pre-development | EW Stage 1 | EW Stage 2 | EW Stage 3 | Final Stage 1 | Final Stage 2 | Final Stage 3 |
| 2 | 54,891 | 56,941 | 59,908 | 58,706 | 55,402 | 57,222 | 57,699 |
| 10 | 109,551 | 112,023 | 115,976 | 114,564 | 110,068 | 112,563 | 113,284 |
| 100 | 203,472 | 206,262 | 211,133 | 209,578 | 203,949 | 207,092 | 208,063 |

| ARI | Difference between Pre development and Post development Volume (m ³) | | |
|-----|--|--------------|------------|
| | Pre-development | Max post-dev | Difference |
| 2 | 5.79 | 9.45 | 3.66 |
| 10 | 11.73 | 19.03 | 7.30 |
| 100 | 21.86 | 35.08 | 13.22 |

| ARI | development Volume (m ³) | | |
|-----|--------------------------------------|--------------|------------|
| | Pre-development | Max post-dev | Difference |
| 2 | 54,891 | 57,699 | 2,808 |
| 10 | 109,551 | 113,284 | 3,734 |
| 100 | 203,472 | 208,063 | 4,590 |

| LANDFILL PRE DEVELOPMENT EQUAL AREA SLOPE | | | |
|---|------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Pre dev landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

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

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|--------------------|
| Catchment (km ²) | 1.04 |
| CN | 72 |
| Channel Factor | 1 (Natural ground) |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|--------|------------|-----------------------|
| 0 | 81 | 0 | 0 | 0.00 | | |
| 41.328 | 81 | 41.328 | 41.328 | 0.00 | 0.00 | 0 |
| 52.043 | 82 | 52.043 | 10.715 | 1.00 | 0.50 | 5 |
| 114.8 | 82.013 | 114.8 | 62.757 | 1.01 | 1.01 | 63 |
| 122.45 | 83 | 122.45 | 7.65 | 2.00 | 1.51 | 12 |
| 165.31 | 83 | 165.31 | 42.86 | 2.00 | 2.00 | 86 |
| 180.62 | 84 | 180.62 | 15.31 | 3.00 | 2.50 | 38 |
| 280.11 | 84 | 280.11 | 99.49 | 3.00 | 3.00 | 298 |
| 322.97 | 86 | 322.97 | 42.86 | 5.00 | 4.00 | 171 |
| 402.57 | 86.018 | 402.57 | 79.6 | 5.02 | 5.01 | 399 |
| 436.24 | 88 | 436.24 | 33.67 | 7.00 | 6.01 | 202 |
| 521.96 | 88 | 521.96 | 85.72 | 7.00 | 7.00 | 600 |
| 529.61 | 89 | 529.61 | 7.65 | 8.00 | 7.50 | 57 |
| 564.82 | 89 | 564.82 | 35.21 | 8.00 | 8.00 | 282 |
| 578.59 | 90 | 578.59 | 13.77 | 9.00 | 8.50 | 117 |
| 670.43 | 90 | 670.43 | 91.84 | 9.00 | 9.00 | 827 |
| 697.99 | 93 | 697.99 | 27.56 | 12.00 | 10.50 | 289 |
| 705.64 | 92 | 705.64 | 7.65 | 11.00 | 11.50 | 88 |
| 736.25 | 92.152 | 736.25 | 30.61 | 11.15 | 11.08 | 339 |
| 769.93 | 93 | 769.93 | 33.68 | 12.00 | 11.58 | 390 |
| 788.3 | 94.065 | 788.3 | 18.37 | 13.07 | 12.53 | 230 |
| 806.66 | 98 | 806.66 | 18.36 | 17.00 | 15.03 | 276 |
| 854.12 | 100.003 | 854.12 | 47.46 | 19.00 | 18.00 | 854 |
| 862.7 | 102.504 | 862.7 | 8.58 | 21.50 | 20.25 | 174 |
| 896.97 | 107.14 | 896.97 | 34.27 | 26.14 | 23.82 | 816 |
| 945.96 | 107 | 945.96 | 48.99 | 26.00 | 26.07 | 1277 |
| 952.08 | 108 | 952.08 | 6.12 | 27.00 | 26.50 | 162 |
| 996.47 | 108 | 996.47 | 44.39 | 27.00 | 27.00 | 1199 |
| 1036.3 | 110 | 1036.3 | 39.83 | 29.00 | 28.00 | 1115 |
| 1066.9 | 110 | 1066.9 | 30.6 | 29.00 | 29.00 | 887 |
| 1079.1 | 111 | 1079.1 | 12.2 | 30.00 | 29.50 | 360 |
| 1109.7 | 111.009 | 1109.7 | 30.6 | 30.01 | 30.00 | 918 |
| 1115.9 | 112 | 1115.9 | 6.2 | 31.00 | 30.50 | 189 |
| 1167.9 | 112 | 1167.9 | 52 | 31.00 | 31.00 | 1612 |
| 1177.1 | 112.997 | 1177.1 | 9.2 | 32.00 | 31.50 | 290 |
| 1210.8 | 113.028 | 1210.8 | 33.7 | 32.03 | 32.01 | 1079 |
| 1215.4 | 114 | 1215.4 | 4.6 | 33.00 | 32.51 | 150 |
| 1252.1 | 114 | 1252.1 | 36.7 | 33.00 | 33.00 | 1211 |
| 1259.7 | 115 | 1259.7 | 7.6 | 34.00 | 33.50 | 255 |
| 1287.3 | 115 | 1287.3 | 27.6 | 34.00 | 34.00 | 938 |
| 1324 | 118 | 1324 | 36.7 | 37.00 | 35.50 | 1303 |
| 1359.2 | 119.074 | 1359.2 | 35.2 | 38.07 | 37.54 | 1321 |
| 1377.6 | 124.098 | 1377.6 | 18.4 | 43.10 | 40.59 | 747 |
| 1402.1 | 129.132 | 1402.1 | 24.5 | 48.13 | 45.62 | 1118 |
| 1438.8 | 151.275 | 1438.8 | 36.7 | 70.28 | 59.20 | 2173 |
| 1455.7 | 156.514 | 1455.7 | 16.9 | 75.51 | 72.89 | 1232 |
| 1472.5 | 158 | 1472.5 | 16.8 | 77.00 | 76.26 | 1281 |
| 1507.7 | 166.15 | 1507.7 | 35.2 | 85.15 | 81.08 | 2854 |
| 1539.9 | 187.072 | 1539.9 | 32.2 | 106.07 | 95.61 | 3079 |
| 1565.9 | 190.423 | 1565.9 | 26 | 109.42 | 107.75 | 2801 |
| TOTAL | 109.42 | 1565.9 | 1565.9 | | | 36164.899 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 190.42 |
| Min Elevation (mRL) | 81.00 |
| Δ Elevation (m) | 109.42 |
| Main Channel Slope | 0.029 |
| | 2.9% |

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

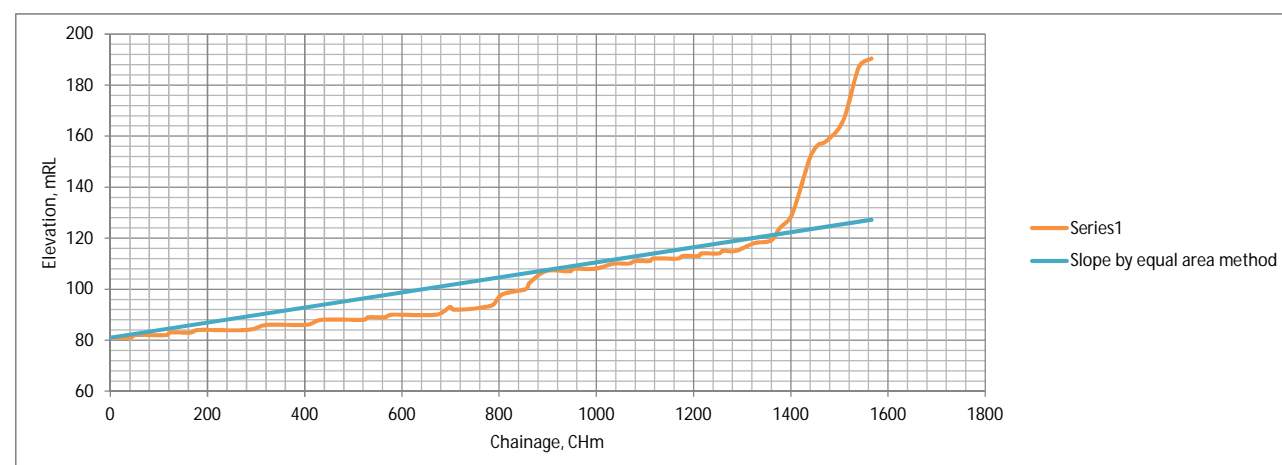
Time of Concentration


| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.36 | 21.8 | 1.2 |
| Bransby-Williams | 0.64 | 38.1 | 0.7 |
| ARC TP108 | 0.74 | 44.6 | 0.6 |
| US Soil Conservation | 0.26 | 15.7 | 1.7 |

Selected Time of concentration

44.6 minutes

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^{1.2}) / (A^{0.1} H^{0.7})$ | 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 | $T_c = 0.14 CL^{0.16} (CN/(200-CN))^{0.55} S_c^{-0.50}$ | 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) |



| LANDFILL DURING EW STAGE 1 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 3 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Information extracted from Tin CAP03 on Global mapper- WAYBE file.

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|------|
| Catchment (km ²) | 1.04 |
| CN | 73 |
| Channel Factor | 0.70 |

(Grassed channel) $c = 0.6 * 42.3 + 0.8 * 44 / (44+42.3)$
 $C = 0.7019699$

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|-------|------------|-----------------------|
| 0 | 89.344 | 0 | 0 | 0.00 | | |
| 49.802 | 101.296 | 49.802 | 49.802 | 11.95 | 5.98 | 298 |
| 53.719 | 102.237 | 53.719 | 3.917 | 12.89 | 12.42 | 49 |
| 66.589 | 105.325 | 66.589 | 12.87 | 15.98 | 14.44 | 186 |
| 74.423 | 107.206 | 74.423 | 7.834 | 17.86 | 16.92 | 133 |
| 81.697 | 108.934 | 81.697 | 7.274 | 19.59 | 18.73 | 136 |
| 83.936 | 109.232 | 83.936 | 2.239 | 19.89 | 19.74 | 44 |
| 85.055 | 109.406 | 85.055 | 1.119 | 20.06 | 19.98 | 22 |
| 86.174 | 109.6 | 86.174 | 1.119 | 20.26 | 20.16 | 23 |
| 87.293 | 109.813 | 87.293 | 1.119 | 20.47 | 20.36 | 23 |
| 88.412 | 110.045 | 88.412 | 1.119 | 20.70 | 20.59 | 23 |
| 89.531 | 110.298 | 89.531 | 1.119 | 20.95 | 20.83 | 23 |
| 90.091 | 110.378 | 90.091 | 0.56 | 21.03 | 20.99 | 12 |
| 92.329 | 110.372 | 92.329 | 2.238 | 21.03 | 21.03 | 47 |
| 104.64 | 110.329 | 104.64 | 12.311 | 20.99 | 21.01 | 259 |
| 107.44 | 110.321 | 107.44 | 2.8 | 20.98 | 20.98 | 59 |
| 121.99 | 110.272 | 121.99 | 14.55 | 20.93 | 20.95 | 305 |
| 123.67 | 110.282 | 123.67 | 1.68 | 20.94 | 20.93 | 35 |
| 127.02 | 110.315 | 127.02 | 3.35 | 20.97 | 20.95 | 70 |
| 130.38 | 110.36 | 130.38 | 3.36 | 21.02 | 20.99 | 71 |
| 144.93 | 110.653 | 144.93 | 14.55 | 21.31 | 21.16 | 308 |
| 149.41 | 110.745 | 149.41 | 4.48 | 21.40 | 21.36 | 96 |
| 165.63 | 111.082 | 165.63 | 16.22 | 21.74 | 21.57 | 350 |
| 175.71 | 111.29 | 175.71 | 10.08 | 21.95 | 21.84 | 220 |
| 190.81 | 111.604 | 190.81 | 15.1 | 22.26 | 22.10 | 334 |
| 213.2 | 112.068 | 213.2 | 22.39 | 22.72 | 22.49 | 504 |
| 214.88 | 112.102 | 214.88 | 1.68 | 22.76 | 22.74 | 38 |
| 231.1 | 112.439 | 231.1 | 16.22 | 23.10 | 22.93 | 372 |
| 241.18 | 112.647 | 241.18 | 10.08 | 23.30 | 23.20 | 234 |
| 267.48 | 113.195 | 267.48 | 26.3 | 23.85 | 23.58 | 620 |
| 294.89 | 113.769 | 294.89 | 27.41 | 24.43 | 24.14 | 662 |
| 317.28 | 114.236 | 317.28 | 22.39 | 24.89 | 24.66 | 552 |
| 333.5 | 114.576 | 333.5 | 16.22 | 25.23 | 25.06 | 407 |
| 344.14 | 114.797 | 344.14 | 10.64 | 25.45 | 25.34 | 270 |
| 348.05 | 114.88 | 348.05 | 3.91 | 25.54 | 25.49 | 100 |
| 358.13 | 115.089 | 358.13 | 10.08 | 25.75 | 25.64 | 258 |
| 371.56 | 115.37 | 371.56 | 13.43 | 26.03 | 25.89 | 348 |
| 386.1 | 115.672 | 386.1 | 14.54 | 26.33 | 26.18 | 381 |
| 395.62 | 115.871 | 395.62 | 9.52 | 26.53 | 26.43 | 252 |
| 408.49 | 116.138 | 408.49 | 12.87 | 26.79 | 26.66 | 343 |
| 422.48 | 116.43 | 422.48 | 13.99 | 27.09 | 26.94 | 377 |
| 430.87 | 116.601 | 430.87 | 8.39 | 27.26 | 27.17 | 228 |
| 452.13 | 117.07 | 452.13 | 21.26 | 27.73 | 27.49 | 584 |
| 464.24 | 117.335 | 464.24 | 12.11 | 27.99 | 27.86 | 337 |
| 470.04 | 116.188 | 470.04 | 5.8 | 26.84 | 27.42 | 159 |
| 471.16 | 116.02 | 471.16 | 1.12 | 26.68 | 26.76 | 30 |
| 472.28 | 115.914 | 472.28 | 1.12 | 26.57 | 26.62 | 30 |
| 472.84 | 115.769 | 472.84 | 0.56 | 26.43 | 26.50 | 15 |
| 473.96 | 115.644 | 473.96 | 1.12 | 26.30 | 26.36 | 30 |
| 572.44 | 115.644 | 572.44 | 98.48 | 26.30 | 26.30 | 2590 |
| TOTAL | 27.99 | 572.44 | 572.44 | | | 12841.862 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 117.34 |
| Min Elevation (mRL) | 89.34 |
| Δ Elevation (m) | 27.99 |
| Main Channel Slope | 0.078 |
| | 7.8% |

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

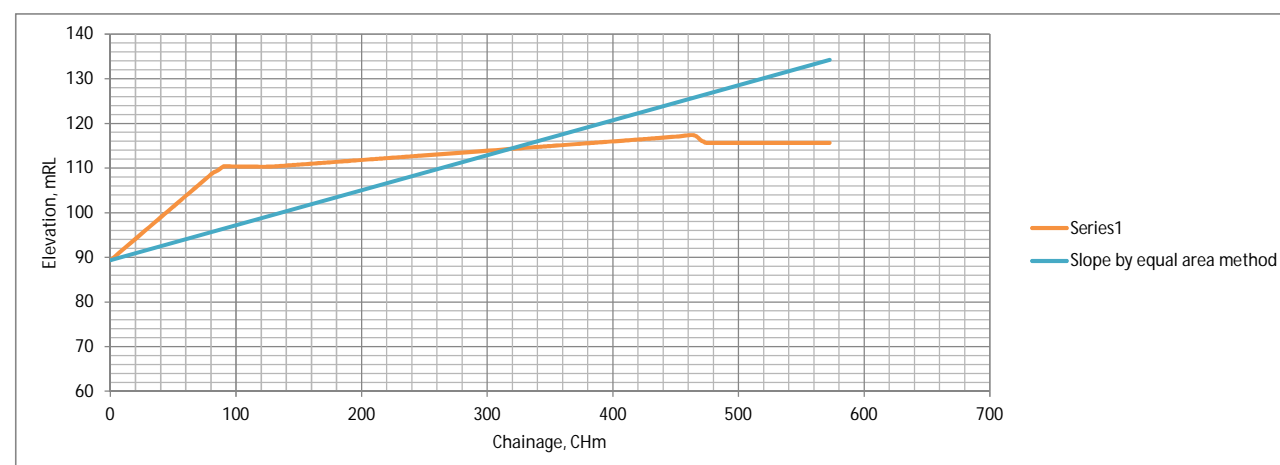
Time of Concentration

| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.12 | 6.9 | 1.4 |
| Bransby-Williams | 0.25 | 15.0 | 0.6 |
| ARC TP108 | 0.20 | 11.9 | 0.8 |
| US Soil Conservation | 0.14 | 8.3 | 1.2 |

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^{1.2}) / (A^{0.2} H^{0.5})$ | 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 | $T_c = 0.14 CL^{0.16} (CN/(200-CN))^{0.55} S_c^{-0.50}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |

Selected Time of concentration

11.9 minutes



| LANDFILL POST DEVELOPMENT STAGE 2 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 2 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

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

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|------------------------|
| Catchment (km ²) | 1.04 |
| CN | 75 |
| Channel Factor | 0.80 (Grassed channel) |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|--------|------------|-----------------------|
| 0 | 90.358 | 0 | 0 | 0.00 | | |
| 2.822 | 91.005 | 2.822 | 2.822 | 0.65 | 0.32 | 1 |
| 35.281 | 100.97 | 35.281 | 32.459 | 10.61 | 5.63 | 183 |
| 40.926 | 102.003 | 40.926 | 5.645 | 11.65 | 11.13 | 63 |
| 53.627 | 102.272 | 53.627 | 12.701 | 11.91 | 11.78 | 150 |
| 73.385 | 104.227 | 73.385 | 19.758 | 13.87 | 12.89 | 255 |
| 80.441 | 105.353 | 80.441 | 7.056 | 15.00 | 14.43 | 102 |
| 114.31 | 109.024 | 114.31 | 33.869 | 18.67 | 16.83 | 570 |
| 131.25 | 111.361 | 131.25 | 16.94 | 21.00 | 19.83 | 336 |
| 142.54 | 112.443 | 142.54 | 11.29 | 22.09 | 21.54 | 243 |
| 166.53 | 115.653 | 166.53 | 23.99 | 25.30 | 23.69 | 568 |
| 179.23 | 116.898 | 179.23 | 12.7 | 26.54 | 25.92 | 329 |
| 203.22 | 120.127 | 203.22 | 23.99 | 29.77 | 28.15 | 675 |
| 225.8 | 122.55 | 225.8 | 22.58 | 32.19 | 30.98 | 700 |
| 239.91 | 124.573 | 239.91 | 14.11 | 34.22 | 33.20 | 469 |
| 254.02 | 125.917 | 254.02 | 14.11 | 35.56 | 34.89 | 492 |
| 268.14 | 126.322 | 268.14 | 14.12 | 35.96 | 35.76 | 505 |
| 286.48 | 127.853 | 286.48 | 18.34 | 37.50 | 36.73 | 674 |
| 311.88 | 131.155 | 311.88 | 25.4 | 40.80 | 39.15 | 994 |
| 324.59 | 132.341 | 324.59 | 12.71 | 41.98 | 41.39 | 526 |
| 334.46 | 133.841 | 334.46 | 9.87 | 43.48 | 42.73 | 422 |
| 354.22 | 136.162 | 354.22 | 19.76 | 45.80 | 44.64 | 882 |
| 372.57 | 137.614 | 372.57 | 18.35 | 47.26 | 46.53 | 854 |
| 395.15 | 137.856 | 395.15 | 22.58 | 47.50 | 47.38 | 1070 |
| 406.44 | 138.256 | 406.44 | 11.29 | 47.90 | 47.70 | 539 |
| 424.78 | 139.469 | 424.78 | 18.34 | 49.11 | 48.50 | 890 |
| 524.98 | 144.389 | 524.98 | 100.2 | 54.03 | 51.57 | 5167 |
| 543.33 | 145.155 | 543.33 | 18.35 | 54.80 | 54.41 | 998 |
| 571.55 | 146.64 | 571.55 | 28.22 | 56.28 | 55.54 | 1567 |
| 635.06 | 149.531 | 635.06 | 63.51 | 59.17 | 57.73 | 3666 |
| 664.7 | 151.142 | 664.7 | 29.64 | 60.78 | 59.98 | 1778 |
| 692.92 | 152.328 | 692.92 | 28.22 | 61.97 | 61.38 | 1732 |
| 759.25 | 155.449 | 759.25 | 66.33 | 65.09 | 63.53 | 4214 |
| 781.83 | 156.964 | 781.83 | 22.58 | 66.61 | 65.85 | 1487 |
| 838.28 | 161.707 | 838.28 | 56.45 | 71.35 | 68.98 | 3894 |
| 848.16 | 162.321 | 848.16 | 9.88 | 71.96 | 71.66 | 708 |
| 884.85 | 165.688 | 884.85 | 36.69 | 75.33 | 73.65 | 2702 |
| 906.02 | 167.248 | 906.02 | 21.17 | 76.89 | 76.11 | 1611 |
| 1026.7 | 177.226 | 1026.7 | 120.68 | 86.87 | 81.88 | 9881 |
| 1050 | 178.93 | 1050 | 23.3 | 88.57 | 87.72 | 2044 |
| 1078.2 | 181.27 | 1078.2 | 28.2 | 90.91 | 89.74 | 2531 |
| 1145.9 | 186.69 | 1145.9 | 67.7 | 96.33 | 93.62 | 6338 |
| 1174.9 | 189.267 | 1174.9 | 29 | 98.91 | 97.62 | 2831 |
| 1188.1 | 190.113 | 1188.1 | 13.2 | 99.76 | 99.33 | 1311 |
| 1206 | 190.626 | 1206 | 17.9 | 100.27 | 100.01 | 1790 |
| 1237.7 | 190.471 | 1237.7 | 31.7 | 100.11 | 100.19 | 3176 |
| 1296.9 | 195.116 | 1296.9 | 59.2 | 104.76 | 102.44 | 6064 |
| 1371.7 | 199.911 | 1371.7 | 74.8 | 109.55 | 107.16 | 8015 |
| 1377.4 | 200 | 1377.4 | 5.7 | 109.64 | 109.60 | 625 |
| 1443.7 | 200 | 1443.7 | 66.3 | 109.64 | 109.64 | 7269 |
| TOTAL | 109.64 | 1443.7 | 1443.7 | | | 93890.653 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 200.00 |
| Min Elevation (mRL) | 90.36 |
| Δ Elevation (m) | 109.64 |
| Main Channel Slope | 0.090 |
| | 9.0% |

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

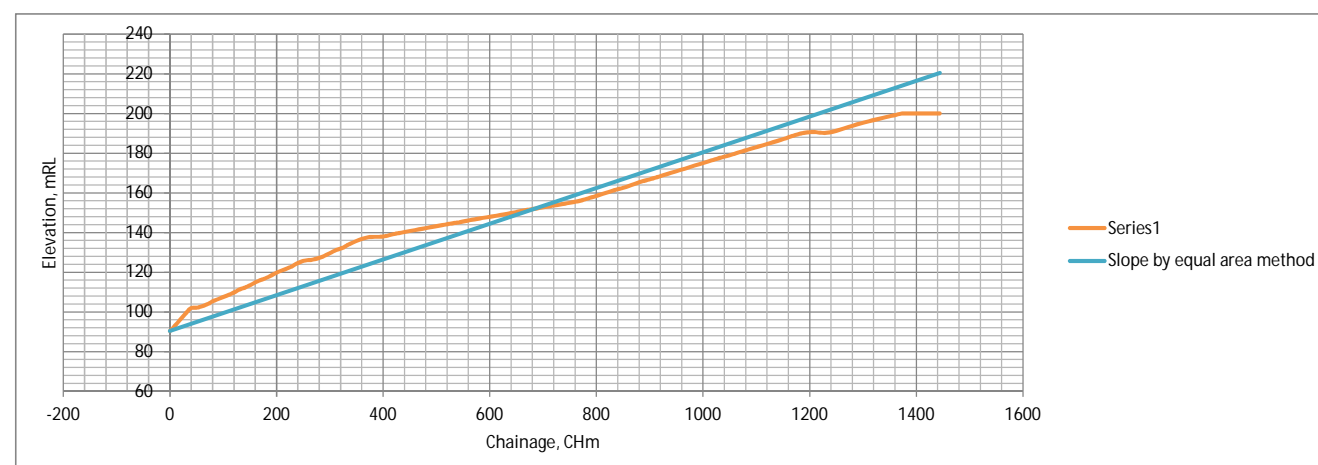
Time of Concentration


| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.22 | 13.3 | 1.8 |
| Bransby-Williams | 0.58 | 34.6 | 0.7 |
| ARC TP108 | 0.39 | 23.5 | 1.0 |
| US Soil Conservation | 0.24 | 14.2 | 1.7 |

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^2) / (A^{0.1} H^{0.2})$ | 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 | $T_c = 0.14 C L^{0.77} (CN / (200 - CN))^{0.55} S_c^{-0.385}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |

Selected Time of concentration

23.5 minutes



| LANDFILL POST DEVELOPMENT STAGE 3 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 3 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Information extracted from Tin CAP03 on Global mapper- WAYBE file.

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|-------------------------------|
| Catchment (km ²) | 1.04 |
| CN | 74 |
| Channel Factor | 0.80 <i>(Grassed channel)</i> |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|----------|----------|-------|------------|-----------------------|
| 0 | 92.36234 | 0 | 0 | 0.00 | | |
| 51.05898 | 92.36089 | 51.05898 | 51.05898 | 0.00 | 0.00 | 0 |
| 56.63955 | 92.4398 | 56.63955 | 5.58057 | 0.08 | 0.04 | 0 |
| 66.63955 | 92.97591 | 66.63955 | 10 | 0.61 | 0.35 | 3 |
| 76.05278 | 93.94356 | 76.05278 | 9.41323 | 1.58 | 1.10 | 10 |
| 103.2224 | 97.38443 | 103.2224 | 27.16962 | 5.02 | 3.30 | 90 |
| 112.6891 | 98.75503 | 112.6891 | 9.4667 | 6.39 | 5.71 | 54 |
| 135.2839 | 101.6163 | 135.2839 | 22.5948 | 9.25 | 7.82 | 177 |
| 145.0553 | 102.3688 | 145.0553 | 9.7714 | 10.01 | 9.63 | 94 |
| 160.2839 | 102.9365 | 160.2839 | 15.2286 | 10.57 | 10.29 | 157 |
| 166.4977 | 103.8194 | 166.4977 | 6.2138 | 11.46 | 11.02 | 68 |
| 267.592 | 123.3083 | 267.592 | 101.0943 | 30.95 | 21.20 | 2143 |
| 273.6172 | 124.159 | 273.6172 | 6.0252 | 31.80 | 31.37 | 189 |
| 277.592 | 124.3798 | 277.592 | 3.9748 | 32.02 | 31.91 | 127 |
| 303.9219 | 124.9463 | 303.9219 | 26.3299 | 32.58 | 32.30 | 850 |
| 310.2839 | 125.4035 | 310.2839 | 6.362 | 33.04 | 32.81 | 209 |
| 330.8905 | 128.7717 | 330.8905 | 20.6066 | 36.41 | 34.73 | 716 |
| 425.1547 | 145.7212 | 425.1547 | 94.2642 | 53.36 | 44.88 | 4231 |
| 434.9096 | 146.7109 | 434.9096 | 9.7549 | 54.35 | 53.85 | 525 |
| 457.5351 | 147.0605 | 457.5351 | 22.6255 | 54.70 | 54.52 | 1234 |
| 504.8958 | 147.9894 | 504.8958 | 47.3607 | 55.63 | 55.16 | 2613 |
| 576.1135 | 149.3005 | 576.1135 | 71.2177 | 56.94 | 56.28 | 4008 |
| 600.8004 | 149.7081 | 600.8004 | 24.6869 | 57.35 | 57.14 | 1411 |
| 725.7635 | 152.0087 | 725.7635 | 124.9631 | 59.65 | 58.50 | 7310 |
| 758.733 | 152.5531 | 758.733 | 32.9695 | 60.19 | 59.92 | 1975 |
| 861.0267 | 154.4363 | 861.0267 | 102.2937 | 62.07 | 61.13 | 6253 |
| 951.613 | 156.213 | 951.613 | 90.5863 | 63.85 | 62.96 | 5704 |
| 1088.346 | 158.7135 | 1088.346 | 136.733 | 66.35 | 65.10 | 8901 |
| 1180.772 | 160.2811 | 1180.772 | 92.426 | 67.92 | 67.13 | 6205 |
| 1242.661 | 161.4201 | 1242.661 | 61.889 | 69.06 | 68.49 | 4239 |
| 1281.787 | 162.0258 | 1281.787 | 39.126 | 69.66 | 69.36 | 2714 |
| 1314.27 | 162.4388 | 1314.27 | 32.483 | 70.08 | 69.87 | 2270 |
| 1426.075 | 163.6678 | 1426.075 | 111.805 | 71.31 | 70.69 | 7904 |
| 1472.398 | 164.1369 | 1472.398 | 46.323 | 71.77 | 71.54 | 3314 |
| 1541.916 | 164.8898 | 1541.916 | 69.518 | 72.53 | 72.15 | 5016 |
| 1561.916 | 165.3751 | 1561.916 | 20 | 73.01 | 72.77 | 1455 |
| 1581.916 | 166.3231 | 1581.916 | 20 | 73.96 | 73.49 | 1470 |
| 1606.478 | 167.9717 | 1606.478 | 24.562 | 75.61 | 74.79 | 1837 |
| 1629.25 | 169.3776 | 1629.25 | 22.772 | 77.02 | 76.31 | 1738 |
| 1692.432 | 173.7266 | 1692.432 | 63.182 | 81.36 | 79.19 | 5003 |
| 1731.929 | 176.1549 | 1731.929 | 39.497 | 83.79 | 82.58 | 3262 |
| 1786.287 | 179.8966 | 1786.287 | 54.358 | 87.53 | 85.66 | 4656 |
| 1816.633 | 181.77 | 1816.633 | 30.346 | 89.41 | 88.47 | 2685 |
| 1877.937 | 185.9898 | 1877.937 | 61.304 | 93.63 | 91.52 | 5610 |
| 1891.612 | 186.8211 | 1891.612 | 13.675 | 94.46 | 94.04 | 1286 |
| 1901.612 | 187.2898 | 1901.612 | 10 | 94.93 | 94.69 | 947 |
| 1921.612 | 187.8742 | 1921.612 | 20 | 95.51 | 95.22 | 1904 |
| 1932.537 | 188.0085 | 1932.537 | 10.925 | 95.65 | 95.58 | 1044 |
| 2191.95 | 190.6084 | 2191.95 | 259.413 | 98.25 | 96.95 | 25149 |
| 2197.441 | 190.6359 | 2197.441 | 5.491 | 98.27 | 98.26 | 540 |
| TOTAL | 98.28 | 2197.441 | 2197.441 | | | 139299.89 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 190.64 |
| Min Elevation (mRL) | 92.36 |
| Δ Elevation (m) | 98.28 |
| Main Channel Slope | 0.058 |
| | 5.8% |

$$Slope = S_c = \frac{2A}{(a D_x)^2}$$

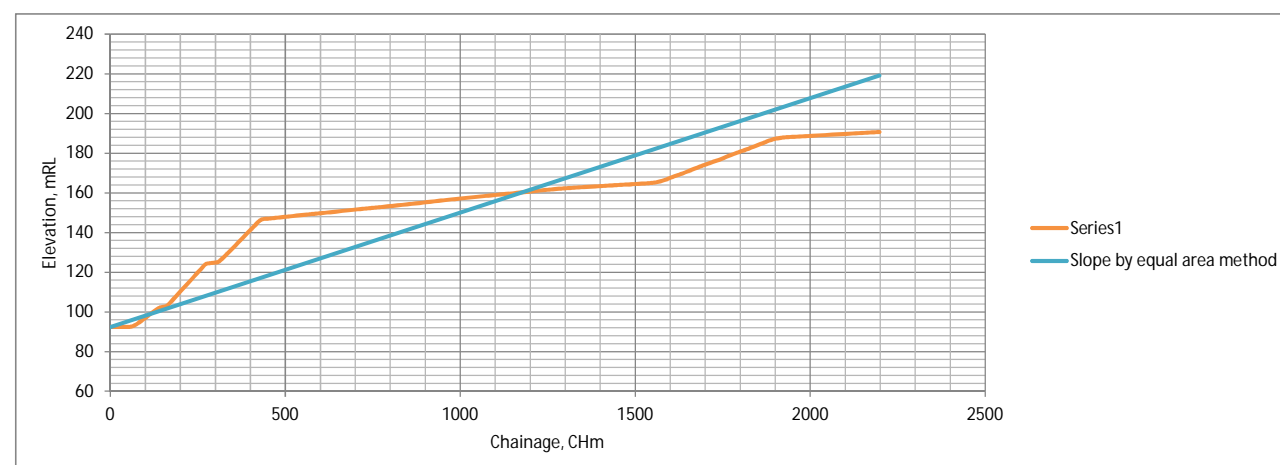
Time of Concentration


| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.36 | 21.9 | 1.7 |
| Bransby-Williams | 0.98 | 58.5 | 0.6 |
| ARC TP108 | 0.59 | 35.6 | 1.0 |
| US Soil Conservation | 0.40 | 24.1 | 1.5 |

Selected Time of concentration

35.6 minutes

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^2) / (A^{0.2} H^{0.5})$ | 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 | $T_c = 0.14 CL^{0.16} (CN/(200-CN))^{0.55} S_c^{-0.50}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |



| LANDFILL POST DEVELOPMENT STAGE 1 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 3 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Information extracted from Tin CAP03 on Global mapper- WAYBE file.

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|------|
| Catchment (km ²) | 1.04 |
| CN | 72 |
| Channel Factor | 0.70 |

(Piped plus grass channel)

$$c = 0.6 * 42.3 + 0.8 * 44 / (44+42.3)$$

$$C = 0.7019699$$

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|-------|------------|-----------------------|
| 0 | 89.344 | 0 | 0 | 0.00 | | |
| 74.902 | 107.32 | 74.902 | 74.902 | 17.98 | 8.99 | 673 |
| 82.074 | 108.991 | 82.074 | 7.172 | 19.65 | 18.81 | 135 |
| 90.042 | 109.993 | 90.042 | 7.968 | 20.65 | 20.15 | 161 |
| 121.92 | 109.916 | 121.92 | 31.878 | 20.57 | 20.61 | 657 |
| 129.88 | 109.992 | 129.88 | 7.96 | 20.65 | 20.61 | 164 |
| 250.21 | 112.586 | 250.21 | 120.33 | 23.24 | 21.95 | 2641 |
| 340.4 | 114.553 | 340.4 | 90.19 | 25.21 | 24.23 | 2185 |
| 423.12 | 116.422 | 423.12 | 82.72 | 27.08 | 26.14 | 2163 |
| 470.13 | 117.461 | 470.13 | 47.01 | 28.12 | 27.60 | 1297 |
| 478.1 | 117.947 | 478.1 | 7.97 | 28.60 | 28.36 | 226 |
| 488.46 | 119.481 | 488.46 | 10.36 | 30.14 | 29.37 | 304 |
| 498.82 | 120.914 | 498.82 | 10.36 | 31.57 | 30.85 | 320 |
| 504.4 | 121.243 | 504.4 | 5.58 | 31.90 | 31.73 | 177 |
| 508.38 | 122.153 | 508.38 | 3.98 | 32.81 | 32.35 | 129 |
| 513.96 | 122.476 | 513.96 | 5.58 | 33.13 | 32.97 | 184 |
| 517.94 | 123.271 | 517.94 | 3.98 | 33.93 | 33.53 | 133 |
| 523.52 | 123.71 | 523.52 | 5.58 | 34.37 | 34.15 | 191 |
| 532.29 | 125.142 | 532.29 | 8.77 | 35.80 | 35.08 | 308 |
| 536.27 | 126.128 | 536.27 | 3.98 | 36.78 | 36.29 | 144 |
| 539.46 | 126.438 | 539.46 | 3.19 | 37.09 | 36.94 | 118 |
| 547.43 | 127.83 | 547.43 | 7.97 | 38.49 | 37.79 | 301 |
| 556.99 | 129.542 | 556.99 | 9.56 | 40.20 | 39.34 | 376 |
| 560.97 | 130.396 | 560.97 | 3.98 | 41.05 | 40.63 | 162 |
| 564.96 | 130.987 | 564.96 | 3.99 | 41.64 | 41.35 | 165 |
| 568.94 | 131.94 | 568.94 | 3.98 | 42.60 | 42.12 | 168 |
| 572.13 | 132.272 | 572.13 | 3.19 | 42.93 | 42.76 | 136 |
| 589.66 | 135.386 | 589.66 | 17.53 | 46.04 | 44.49 | 780 |
| 593.64 | 136.264 | 593.64 | 3.98 | 46.92 | 46.48 | 185 |
| 597.63 | 136.829 | 597.63 | 3.99 | 47.49 | 47.20 | 188 |
| 601.61 | 137.747 | 601.61 | 3.98 | 48.40 | 47.94 | 191 |
| 604.8 | 138.105 | 604.8 | 3.19 | 48.76 | 48.58 | 155 |
| 622.33 | 141.228 | 622.33 | 17.53 | 51.88 | 50.32 | 882 |
| 626.31 | 142.134 | 626.31 | 3.98 | 52.79 | 52.34 | 208 |
| 629.5 | 142.53 | 629.5 | 3.19 | 53.19 | 52.99 | 169 |
| 633.48 | 143.403 | 633.48 | 3.98 | 54.06 | 53.62 | 213 |
| 637.47 | 143.926 | 637.47 | 3.99 | 54.58 | 54.32 | 217 |
| 642.25 | 144.859 | 642.25 | 4.78 | 55.52 | 55.05 | 263 |
| 655 | 147.054 | 655 | 12.75 | 57.71 | 56.61 | 722 |
| 658.98 | 147.978 | 658.98 | 3.98 | 58.63 | 58.17 | 232 |
| 662.97 | 148.481 | 662.97 | 3.99 | 59.14 | 58.89 | 235 |
| 666.15 | 149.195 | 666.15 | 3.18 | 59.85 | 59.49 | 189 |
| 669.34 | 149.609 | 669.34 | 3.19 | 60.27 | 60.06 | 192 |
| 674.92 | 150.662 | 674.92 | 5.58 | 61.32 | 60.79 | 339 |
| 687.67 | 152.87 | 687.67 | 12.75 | 63.53 | 62.42 | 796 |
| 691.65 | 153.821 | 691.65 | 3.98 | 64.48 | 64.00 | 255 |
| 701.21 | 155 | 701.21 | 9.56 | 65.66 | 65.07 | 622 |
| 707.59 | 154.83 | 707.59 | 6.38 | 65.49 | 65.57 | 418 |
| 715.56 | 155 | 715.56 | 7.97 | 65.66 | 65.57 | 523 |
| 815.16 | 155 | 815.16 | 99.6 | 65.66 | 65.66 | 6539 |
| TOTAL | 65.66 | 815.16 | 815.16 | | | 28129.867 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 155.00 |
| Min Elevation (mRL) | 89.34 |
| Δ Elevation (m) | 65.66 |
| Main Channel Slope | 0.085 |
| | 8.5% |

$$Slope = S_c = \frac{2A}{(a D_x)^2}$$

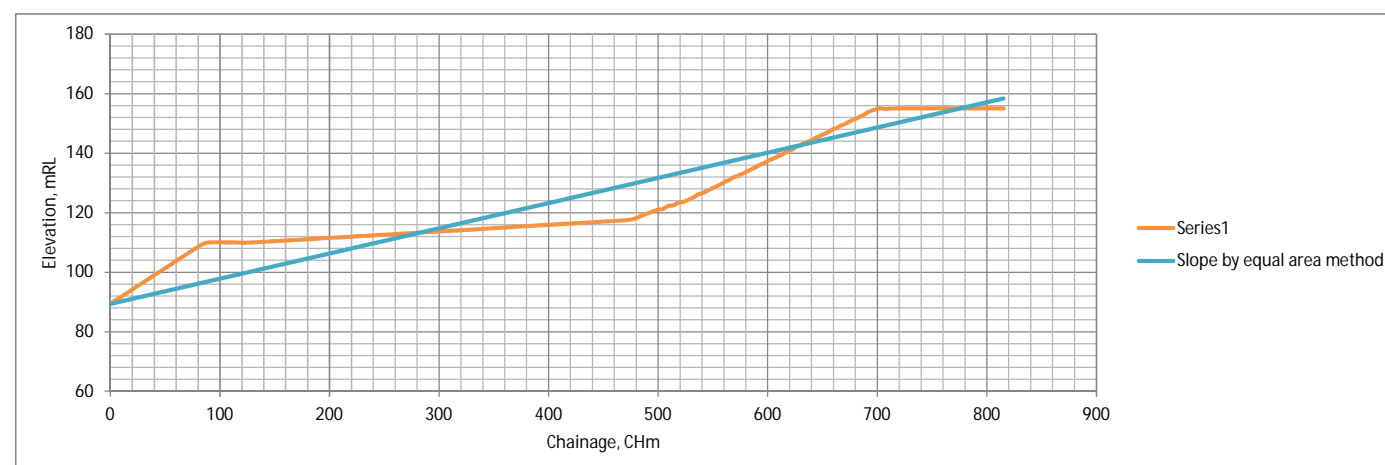
Time of Concentration


| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.15 | 8.8 | 1.5 |
| Bransby-Williams | 0.32 | 19.3 | 0.7 |
| ARC TP108 | 0.25 | 14.8 | 0.9 |
| US Soil Conservation | 0.15 | 9.0 | 1.5 |

Selected Time of concentration

14.8 minutes

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^{1.2}) / (A^{0.1} H^{0.7})$ | 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 | $T_c = 0.14 CL^{0.28} (CN / (200 - CN))^{0.55} S_c^{-0.30}$ | 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 | $T_c = (0.87 L^1 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |



| LANDFILL POST DEVELOPMENT STAGE 2 - EQUAL AREA SLOPE | | | |
|---|----------|---------------------------------|----------------------|
|  | Project: | Polaris Landfill Design Project | |
| | Details: | Post dev stage 2 landfill slope | Job No: 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

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

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|-----------------------|
| Catchment (km ²) | 1.04 |
| CN | 73 |
| Channel Factor | 0.8 (Grassed channel) |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|--------|------------|-----------------------|
| 0 | 90.358 | 0 | 0 | 0.00 | | |
| 2.822 | 91.005 | 2.822 | 2.822 | 0.65 | 0.32 | 1 |
| 35.281 | 100.97 | 35.281 | 32.459 | 10.61 | 5.63 | 183 |
| 40.926 | 102.003 | 40.926 | 5.645 | 11.65 | 11.13 | 63 |
| 53.627 | 102.272 | 53.627 | 12.701 | 11.91 | 11.78 | 150 |
| 73.385 | 104.227 | 73.385 | 19.758 | 13.87 | 12.89 | 255 |
| 80.441 | 105.353 | 80.441 | 7.056 | 15.00 | 14.43 | 102 |
| 114.31 | 109.024 | 114.31 | 33.869 | 18.67 | 16.83 | 570 |
| 131.25 | 111.361 | 131.25 | 16.94 | 21.00 | 19.83 | 336 |
| 142.54 | 112.443 | 142.54 | 11.29 | 22.09 | 21.54 | 243 |
| 166.53 | 115.653 | 166.53 | 23.99 | 25.30 | 23.69 | 568 |
| 179.23 | 116.898 | 179.23 | 12.7 | 26.54 | 25.92 | 329 |
| 203.22 | 120.127 | 203.22 | 23.99 | 29.77 | 28.15 | 675 |
| 225.8 | 122.55 | 225.8 | 22.58 | 32.19 | 30.98 | 700 |
| 239.91 | 124.573 | 239.91 | 14.11 | 34.22 | 33.20 | 469 |
| 254.02 | 125.917 | 254.02 | 14.11 | 35.56 | 34.89 | 492 |
| 268.14 | 126.322 | 268.14 | 14.12 | 35.96 | 35.76 | 505 |
| 286.48 | 127.853 | 286.48 | 18.34 | 37.50 | 36.73 | 674 |
| 311.88 | 131.155 | 311.88 | 25.4 | 40.80 | 39.15 | 994 |
| 324.59 | 132.341 | 324.59 | 12.71 | 41.98 | 41.39 | 526 |
| 334.46 | 133.841 | 334.46 | 9.87 | 43.48 | 42.73 | 422 |
| 354.22 | 136.162 | 354.22 | 19.76 | 45.80 | 44.64 | 882 |
| 372.57 | 137.614 | 372.57 | 18.35 | 47.26 | 46.53 | 854 |
| 395.15 | 137.856 | 395.15 | 22.58 | 47.50 | 47.38 | 1070 |
| 406.44 | 138.256 | 406.44 | 11.29 | 47.90 | 47.70 | 539 |
| 424.78 | 139.469 | 424.78 | 18.34 | 49.11 | 48.50 | 890 |
| 524.98 | 144.389 | 524.98 | 100.2 | 54.03 | 51.57 | 5167 |
| 543.33 | 145.155 | 543.33 | 18.35 | 54.80 | 54.41 | 998 |
| 571.55 | 146.64 | 571.55 | 28.22 | 56.28 | 55.54 | 1567 |
| 635.06 | 149.531 | 635.06 | 63.51 | 59.17 | 57.73 | 3666 |
| 664.7 | 151.142 | 664.7 | 29.64 | 60.78 | 59.98 | 1778 |
| 692.92 | 152.328 | 692.92 | 28.22 | 61.97 | 61.38 | 1732 |
| 759.25 | 155.449 | 759.25 | 66.33 | 65.09 | 63.53 | 4214 |
| 781.83 | 156.964 | 781.83 | 22.58 | 66.61 | 65.85 | 1487 |
| 838.28 | 161.707 | 838.28 | 56.45 | 71.35 | 68.98 | 3894 |
| 848.16 | 162.321 | 848.16 | 9.88 | 71.96 | 71.66 | 708 |
| 884.85 | 165.688 | 884.85 | 36.69 | 75.33 | 73.65 | 2702 |
| 906.02 | 167.248 | 906.02 | 21.17 | 76.89 | 76.11 | 1611 |
| 1026.7 | 177.226 | 1026.7 | 120.68 | 86.87 | 81.88 | 9881 |
| 1050 | 178.93 | 1050 | 23.3 | 88.57 | 87.72 | 2044 |
| 1078.2 | 181.27 | 1078.2 | 28.2 | 90.91 | 89.74 | 2531 |
| 1145.9 | 186.69 | 1145.9 | 67.7 | 96.33 | 93.62 | 6338 |
| 1174.9 | 189.267 | 1174.9 | 29 | 98.91 | 97.62 | 2831 |
| 1188.1 | 190.113 | 1188.1 | 13.2 | 99.76 | 99.33 | 1311 |
| 1206 | 190.626 | 1206 | 17.9 | 100.27 | 100.01 | 1790 |
| 1237.7 | 190.471 | 1237.7 | 31.7 | 100.11 | 100.19 | 3176 |
| 1296.9 | 195.116 | 1296.9 | 59.2 | 104.76 | 102.44 | 6064 |
| 1371.7 | 199.911 | 1371.7 | 74.8 | 109.55 | 107.16 | 8015 |
| 1377.4 | 200 | 1377.4 | 5.7 | 109.64 | 109.60 | 625 |
| 1443.7 | 200 | 1443.7 | 66.3 | 109.64 | 109.64 | 7269 |
| TOTAL | 109.64 | 1443.7 | 1443.7 | | | 93890.653 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 200.00 |
| Min Elevation (mRL) | 90.36 |
| Δ Elevation (m) | 109.64 |
| Main Channel Slope | 0.090 |
| | 9.0% |

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

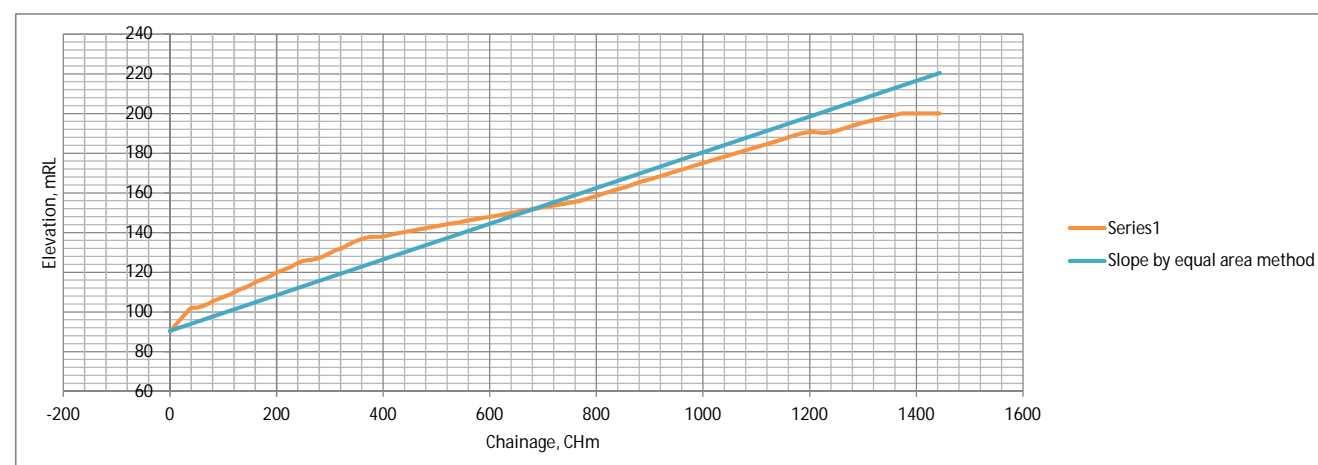
Time of Concentration


| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.22 | 13.3 | 1.8 |
| Bransby-Williams | 0.58 | 34.6 | 0.7 |
| ARC TP108 | 0.40 | 23.8 | 1.0 |
| US Soil Conservation | 0.24 | 14.2 | 1.7 |

Selected Time of concentration

23.8 minutes

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^2) / (A^{0.1} H^{0.2})$ | 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 | $T_c = 0.14 Cl^{0.08} (CN / (200 - CN))^{0.55} S_c^{-0.30}$ | 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 | $T_c = (0.87 L^1 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |



| LANDFILL POST DEVELOPMENT STAGE 3 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 3 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Information extracted from Tin CAP03 on Global mapper- WAYBE file.

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|------------------------------|
| Catchment (km ²) | 1.04 |
| CN | 74 |
| Channel Factor | 0.8 <i>(Grassed channel)</i> |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|----------|----------|-------|------------|-----------------------|
| 0 | 92.36234 | 0 | 0 | 0.00 | | |
| 51.05898 | 92.36089 | 51.05898 | 51.05898 | 0.00 | 0.00 | 0 |
| 56.63955 | 92.4398 | 56.63955 | 5.58057 | 0.08 | 0.04 | 0 |
| 66.63955 | 92.97591 | 66.63955 | 10 | 0.61 | 0.35 | 3 |
| 76.05278 | 93.94356 | 76.05278 | 9.41323 | 1.58 | 1.10 | 10 |
| 103.2224 | 97.38443 | 103.2224 | 27.16962 | 5.02 | 3.30 | 90 |
| 112.6891 | 98.75503 | 112.6891 | 9.4667 | 6.39 | 5.71 | 54 |
| 135.2839 | 101.6163 | 135.2839 | 22.5948 | 9.25 | 7.82 | 177 |
| 145.0553 | 102.3688 | 145.0553 | 9.7714 | 10.01 | 9.63 | 94 |
| 160.2839 | 102.9365 | 160.2839 | 15.2286 | 10.57 | 10.29 | 157 |
| 166.4977 | 103.8194 | 166.4977 | 6.2138 | 11.46 | 11.02 | 68 |
| 267.592 | 123.3083 | 267.592 | 101.0943 | 30.95 | 21.20 | 2143 |
| 273.6172 | 124.159 | 273.6172 | 6.0252 | 31.80 | 31.37 | 189 |
| 277.592 | 124.3798 | 277.592 | 3.9748 | 32.02 | 31.91 | 127 |
| 303.9219 | 124.9463 | 303.9219 | 26.3299 | 32.58 | 32.30 | 850 |
| 310.2839 | 125.4035 | 310.2839 | 6.362 | 33.04 | 32.81 | 209 |
| 330.8905 | 128.7717 | 330.8905 | 20.6066 | 36.41 | 34.73 | 716 |
| 425.1547 | 145.7212 | 425.1547 | 94.2642 | 53.36 | 44.88 | 4231 |
| 434.9096 | 146.7109 | 434.9096 | 9.7549 | 54.35 | 53.85 | 525 |
| 457.5351 | 147.0605 | 457.5351 | 22.6255 | 54.70 | 54.52 | 1234 |
| 504.8958 | 147.9894 | 504.8958 | 47.3607 | 55.63 | 55.16 | 2613 |
| 576.1135 | 149.3005 | 576.1135 | 71.2177 | 56.94 | 56.28 | 4008 |
| 600.8004 | 149.7081 | 600.8004 | 24.6869 | 57.35 | 57.14 | 1411 |
| 725.7635 | 152.0087 | 725.7635 | 124.9631 | 59.65 | 58.50 | 7310 |
| 758.733 | 152.5531 | 758.733 | 32.9695 | 60.19 | 59.92 | 1975 |
| 861.0267 | 154.4363 | 861.0267 | 102.2937 | 62.07 | 61.13 | 6253 |
| 951.613 | 156.213 | 951.613 | 90.5863 | 63.85 | 62.96 | 5704 |
| 1088.346 | 158.7135 | 1088.346 | 136.733 | 66.35 | 65.10 | 8901 |
| 1180.772 | 160.2811 | 1180.772 | 92.426 | 67.92 | 67.13 | 6205 |
| 1242.661 | 161.4201 | 1242.661 | 61.889 | 69.06 | 68.49 | 4239 |
| 1281.787 | 162.0258 | 1281.787 | 39.126 | 69.66 | 69.36 | 2714 |
| 1314.27 | 162.4388 | 1314.27 | 32.483 | 70.08 | 69.87 | 2270 |
| 1426.075 | 163.6678 | 1426.075 | 111.805 | 71.31 | 70.69 | 7904 |
| 1472.398 | 164.1369 | 1472.398 | 46.323 | 71.77 | 71.54 | 3314 |
| 1541.916 | 164.8898 | 1541.916 | 69.518 | 72.53 | 72.15 | 5016 |
| 1561.916 | 165.3751 | 1561.916 | 20 | 73.01 | 72.77 | 1455 |
| 1581.916 | 166.3231 | 1581.916 | 20 | 73.96 | 73.49 | 1470 |
| 1606.478 | 167.9717 | 1606.478 | 24.562 | 75.61 | 74.79 | 1837 |
| 1629.25 | 169.3776 | 1629.25 | 22.772 | 77.02 | 76.31 | 1738 |
| 1692.432 | 173.7266 | 1692.432 | 63.182 | 81.36 | 79.19 | 5003 |
| 1731.929 | 176.1549 | 1731.929 | 39.497 | 83.79 | 82.58 | 3262 |
| 1786.287 | 179.8966 | 1786.287 | 54.358 | 87.53 | 85.66 | 4656 |
| 1816.633 | 181.77 | 1816.633 | 30.346 | 89.41 | 88.47 | 2685 |
| 1877.937 | 185.9898 | 1877.937 | 61.304 | 93.63 | 91.52 | 5610 |
| 1891.612 | 186.8211 | 1891.612 | 13.675 | 94.46 | 94.04 | 1286 |
| 1901.612 | 187.2898 | 1901.612 | 10 | 94.93 | 94.69 | 947 |
| 1921.612 | 187.8742 | 1921.612 | 20 | 95.51 | 95.22 | 1904 |
| 1932.537 | 188.0085 | 1932.537 | 10.925 | 95.65 | 95.58 | 1044 |
| 2191.95 | 190.6084 | 2191.95 | 259.413 | 98.25 | 96.95 | 25149 |
| 2197.441 | 190.6359 | 2197.441 | 5.491 | 98.27 | 98.26 | 540 |
| TOTAL | 98.28 | 2197.441 | 2197.441 | | | 139299.89 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 190.64 |
| Min Elevation (mRL) | 92.36 |
| Δ Elevation (m) | 98.28 |
| Main Channel Slope | 0.058 |
| | 5.8% |

$$Slope = S_c = \frac{2A}{(a D_x)^2}$$

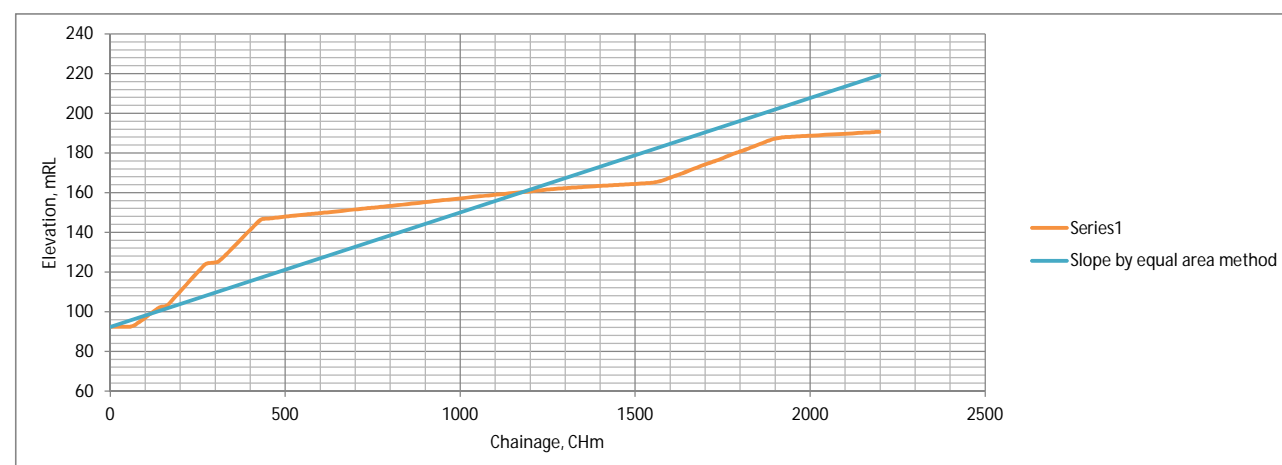
Time of Concentration

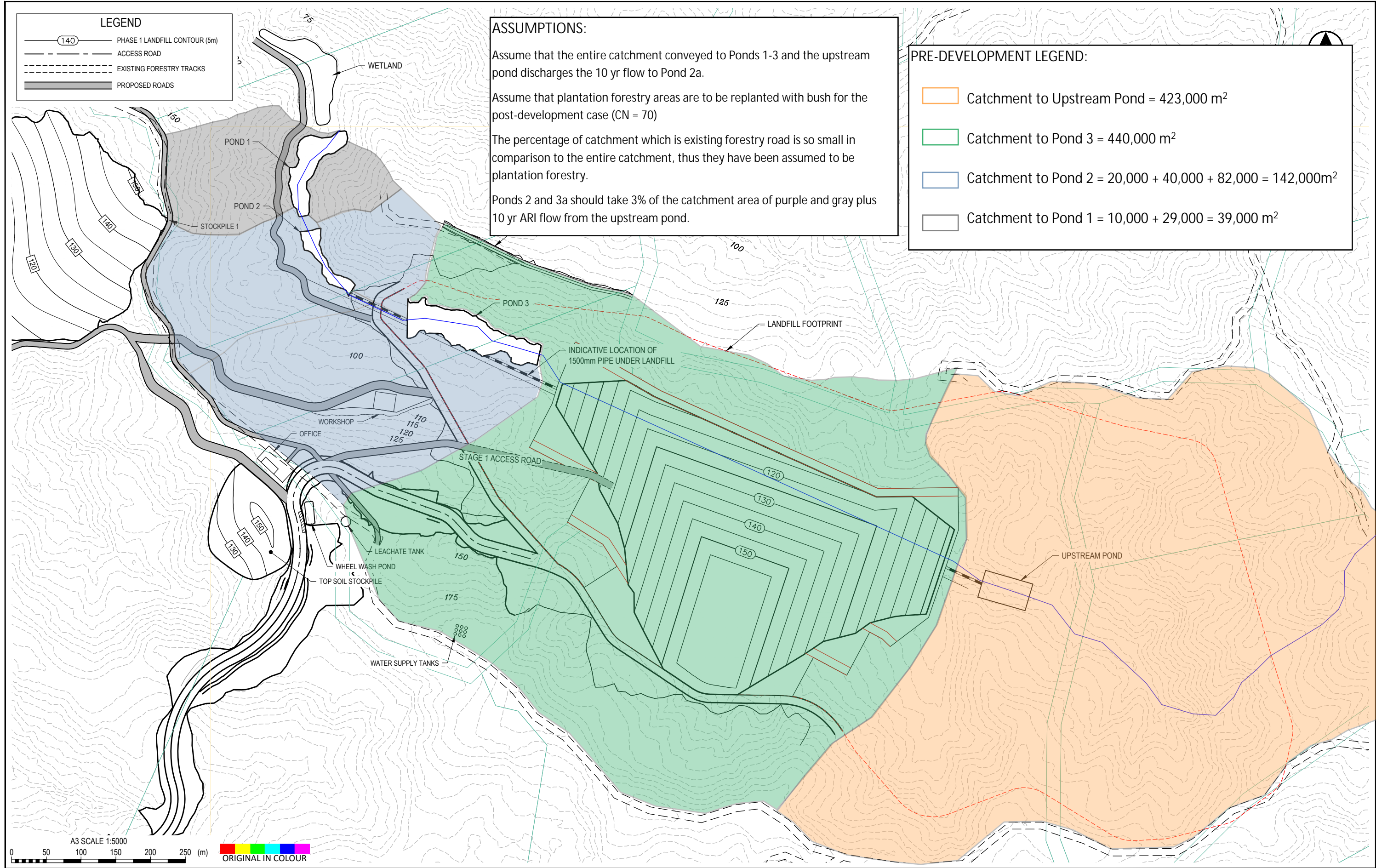
| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.36 | 21.9 | 1.7 |
| Bransby-Williams | 0.98 | 58.5 | 0.6 |
| ARC TP108 | 0.60 | 35.8 | 1.0 |
| US Soil Conservation | 0.40 | 24.1 | 1.5 |

Selected Time of concentration

35.8 minutes

| Method | Formula | Parameter definitions |
|---------------------------------|---|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S_c = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^{1.2}) / (A^{0.2} H^{0.5})$ | 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 | $T_c = 0.14 CL^{0.16} (CN/(200-CN))^{0.55} S_c^{-0.50}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |





LEGEND

| | |
|--|-------------------------------|
| | PHASE 1 LANDFILL CONTOUR (5m) |
| | ACCESS ROAD |
| | EXISTING FORESTRY TRACKS |
| | PROPOSED ROADS |

ASSUMPTIONS:

Assume that the entire catchment conveyed to Ponds 1-3 and the upstream pond discharges the 10 yr flow to Pond 2a.

Assume that plantation forestry areas are to be replanted with bush for the post-development case (CN = 70)

The percentage of catchment which is existing forestry road is so small in comparison to the entire catchment, thus they have been assumed to be plantation forestry.

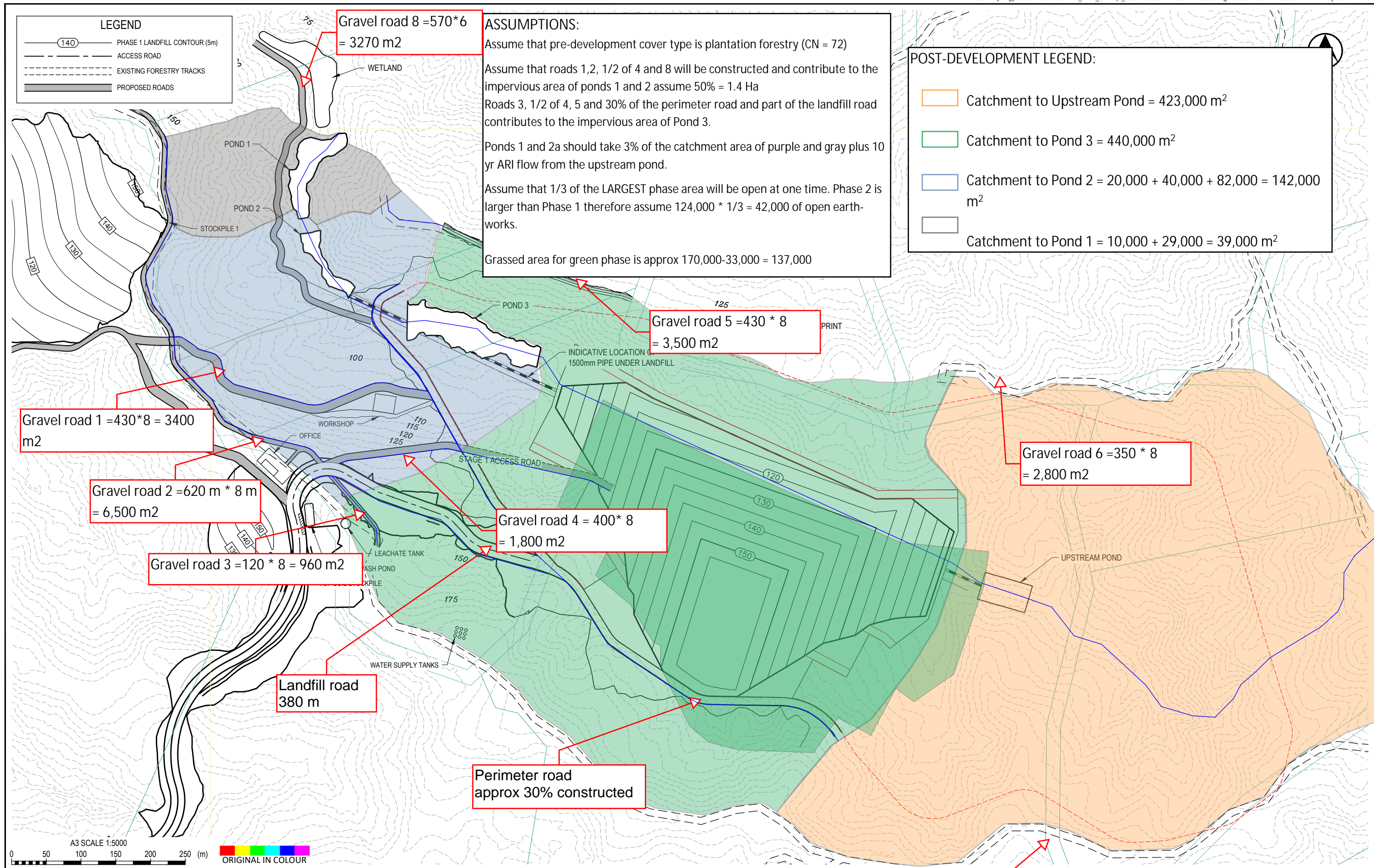
Ponds 2 and 3a should take 3% of the catchment area of purple and gray plus 10 yr ARI flow from the upstream pond.

PRE-DEVELOPMENT LEGEND:

| | |
|--|--|
| | Catchment to Upstream Pond = 423,000 m ² |
| | Catchment to Pond 3 = 440,000 m ² |
| | Catchment to Pond 2 = 20,000 + 40,000 + 82,000 = 142,000m ² |
| | Catchment to Pond 1 = 10,000 + 29,000 = 39,000 m ² |



| | | | | |
|--|---|--------------------------|---|--|
| <p>Tonkin+Taylor Exceptional thinking together www.tonkintaylor.co.nz</p> | <p>PRE-DEVELOPMENT POND AND WETLAND CATCHMENT AREAS</p> | | <p>PROJECT No. 1005069</p> | <p>CLIENT WASTE MANAGEMENT NZ LTD</p> |
| | <p>DESIGNED AGBB Jun.18</p> <p>DRAWN TORY Aug.18</p> <p>CHECKED</p> | <p>PROJECT</p> | <p>TITLE STORMWATER PHASE 2 - PLAN</p> | |
| | <p>APPROVED _____ DATE _____</p> | <p>SCALE (A3) 1:5000</p> | <p>FIG No. ENG-40</p> | |



POST-DEVELOPMENT STAGE 1 POND AND WETLAND CATCHMENT AREAS

PROJECT No. 1005069

CLIENT WASTE MANAGEMENT NZ LTD

DESIGNED
DRAWN
CHECKED

Gravel road 7 = 720*8
= 5,800 m²

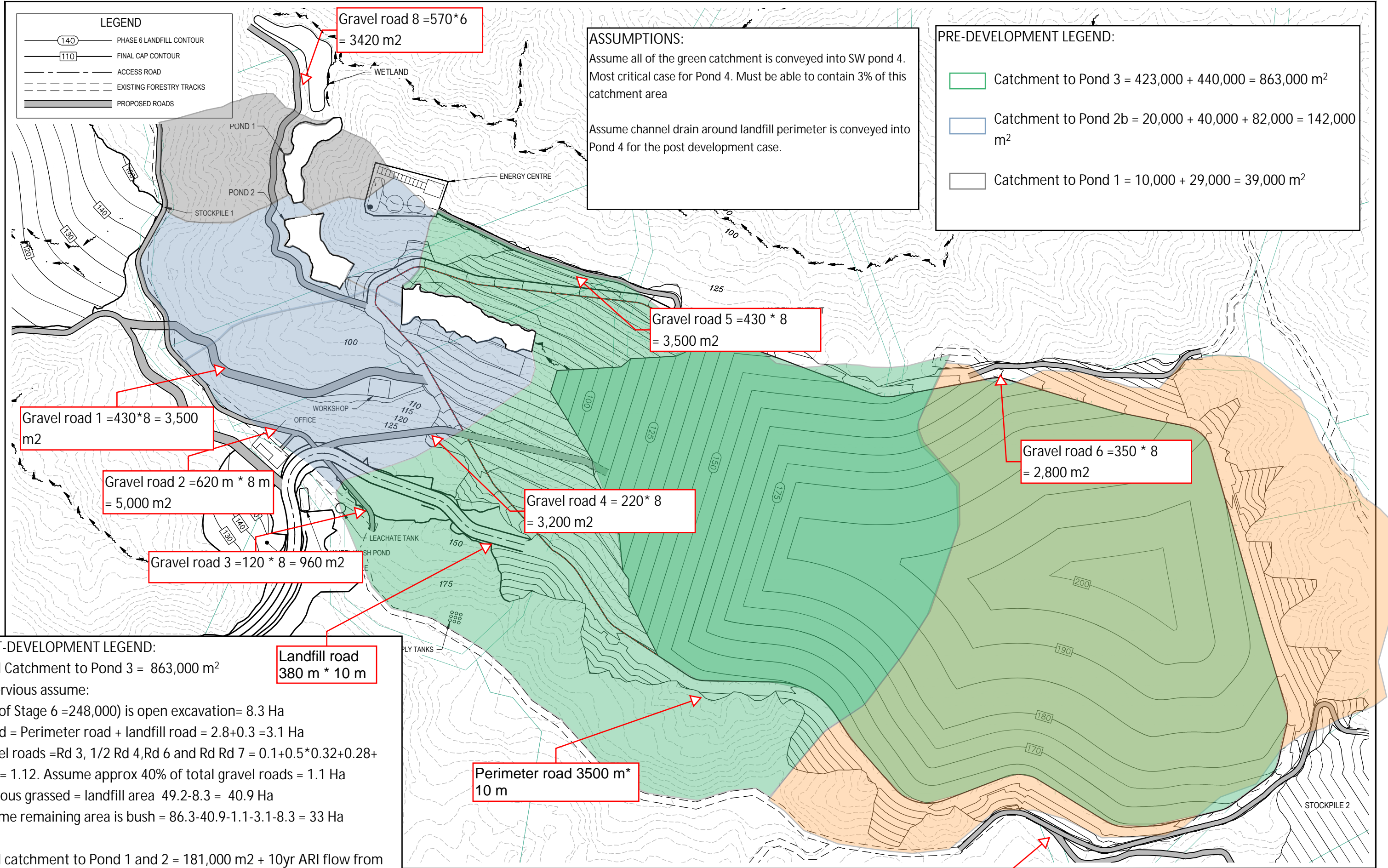
MWATER
PHASE 2 - PLAN

APPROVED DATE

SCALE (A3) 1:5000

FIG No. ENG-40

REV 1



POST-DEVELOPMENT LEGEND:

Total Catchment to Pond 3 = 863,000 m²

Impervious assume:
 (1/3 of Stage 6 = 248,000) is open excavation = 8.3 Ha
 Paved = Perimeter road + landfill road = 2.8 + 0.3 = 3.1 Ha
 Gravel roads = Rd 3, 1/2 Rd 4, Rd 6 and Rd Rd 7 = 0.1 + 0.5 * 0.32 + 0.28 + 0.58 = 1.12. Assume approx 40% of total gravel roads = 1.1 Ha
 Pervious grassed = landfill area 49.2 - 8.3 = 40.9 Ha
 Assume remaining area is bush = 86.3 - 40.9 - 1.1 - 3.1 - 8.3 = 33 Ha

Total catchment to Pond 1 and 2 = 181,000 m² + 10yr ARI flow from Pond 3 catchment

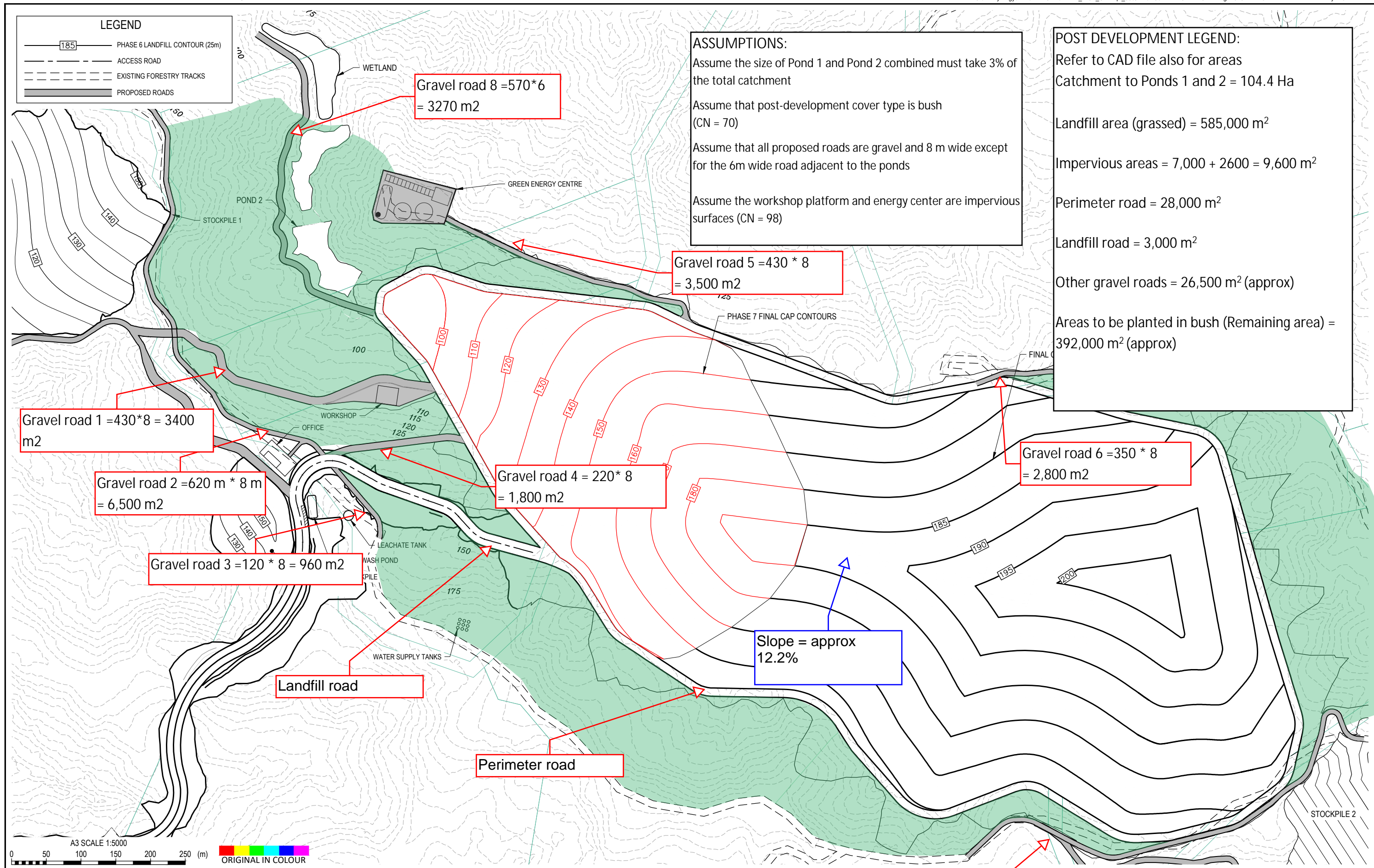
Gravel roads = Rd 1, 2, 0.5 * 4, 5, 8 = Assume 60% of total gravel road area = 1.7 Ha

Impervious hardstand areas = 0.96 Ha

Bush = 18.1 - 1.7 - 0.96 = 15.5 Ha

POST-DEVELOPED STAGE 2 AND WETLAND CATCHMENT AREAS

| | | | |
|-------------|---------|--|-------------------------|
| PROJECT No. | 1005069 | CLIENT | WASTE MANAGEMENT NZ LTD |
| DESIGNED | | Gravel road 7 = 720 * 8 = 5,800 m ² | |
| DRAWN | | | |
| CHECKED | | | |
| APPROVED | DATE | SCALE (A3) | 1:5000 |
| | | FIG No. | ENG-41 |
| | | | REV 1 |



POST-DEVELOPED STAGE 3 POND AND WETLAND CATCHMENT AREAS

TP108 - PRE-DEVELOPMENT

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Pre development landfill catchment area Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 104.40 | 7,517 |
| | Bush | 70 | 0.00 | 0 |
| | Grass | 74 | 0.00 | 0 |
| | Subtotal for Pervious Areas | | 104.40 | 7,517 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 0.00 | 0 |
| | Paved | 98 | 0.00 | 0 |
| | Subtotal for Impervious Areas | | 0.00 | 0 |
| | Totals | | 104.40 | 7,517 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,517}{104.40} = 72$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 104.4}{104.40} = 5.00 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 1 (from Table 4.2)
 Catchment Length : L = 1.566 km (along drainage path)
 Catchment Slope : Sc = 0.029 m/m
 Runoff Factor R : $\frac{CN}{200 - CN} = 0.56$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.74 \text{ hrs} = 44.60 \text{ mins}$
 SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.50 \text{ hrs} = 29.7 \text{ mins}$

3. Soil Storage Parameter : $S = ((1000/CN)-10) \times 25.4$
 Total = 98.8 mm
 Pervious = 98.8 mm
 Impervious = 0 mm

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3\text{/s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3\text{)}$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 |
|--|----------|----------|----------|----------|----------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 |
| Runoff Index, c* | 0.33 | 0.45 | 0.57 | 0.09 | 0.14 |
| Specific Peak Flow Rate, q* | 0.051 | 0.065 | 0.077 | 0.016 | 0.024 |
| Peak Flow Rate, q _p (m ³ /s) | 5.79 | 11.73 | 21.86 | 0.50 | 1.04 |
| Runoff Depth, Q ₂₄ (mm) | 52.6 | 104.9 | 194.9 | 5.0 | 10.1 |
| | 108.0 | 172.0 | 272.0 | 30.0 | 42.0 |
| Runoff Volume, V ₂₄ (m ³) | 54,891 | 109,551 | 203,472 | 5,272 | 10,526 |
| | 000 | 000 | 000 | 000 | 000 |
| Total | 54,891 | 109,551 | 203,472 | 5,272 | 10,526 |

11. Link to catchment area: <..\Phase catchments\Phase catchment plans.pdf>

TP108 - POST-DEVELOPMENT

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Stage 1 during earthworks Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 42.30 | 3,046 |
| | Bush | 70 | 41.75 | 2,923 |
| | Grass | 74 | 12.27 | 908 |
| | Subtotal for Pervious Areas | | 96.32 | 6,876 |
| | <i>Impervious Area</i> | | | |
| | Open earthworks | 91 | 4.73 | 431 |
| | Gravel | 89 | 2.78 | 248 |
| | Paved | 98 | 0.56 | 55 |
| | Subtotal for Impervious Areas | | 8.08 | 734 |
| | Totals | | 104.40 | 7,610 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,610}{104.40} = 73$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{3,206.666666}{104.40} = 4.61 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.70 (Weighted C value)

Catchment Length : L = 0.572 km (along drainage path)

Catchment Slope : Sc = 0.078 m/m

Runoff Factor R : $\frac{CN}{200 - CN} = 0.57$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.20 \text{ hrs} = 11.89 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.13 \text{ hrs} = 7.9 \text{ mins}$

3. Soil Storage Parameter :

$S = ((1000/CN)-10) \times 25.4$

| | | | |
|------------|---|-------|----|
| Total | = | 94.5 | mm |
| Pervious | = | 101.8 | mm |
| Impervious | = | 26 | mm |

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3\text{/s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3\text{)}$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 | |
|--|------------|----------|----------|----------|----------|--------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% | |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 | |
| Runoff Index, c* | 0.34 | 0.46 | 0.58 | 0.10 | 0.15 | |
| Specific Peak Flow Rate, q* | 0.092 | 0.114 | 0.132 | 0.031 | 0.044 | |
| Peak Flow Rate, q _p (m ³ /s) | 10.32 | 20.47 | 37.51 | 0.96 | 1.91 | |
| Runoff Depth, Q ₂₄ (mm) | | | | | | |
| | Pervious | 51.8 | 103.8 | 193.3 | 4.9 | 9.9 |
| | Impervious | 87.2 | 149.6 | 248.5 | 16.1 | 26.0 |
| Runoff Volume, V ₂₄ (m ³) | | | | | | |
| | Pervious | 49,895 | 99,935 | 186,186 | 4,748 | 9,500 |
| | Impervious | 7,047 | 12,088 | 20,076 | 1,305 | 2,104 |
| | Total | 56,941 | 112,023 | 206,262 | 6,052 | 11,604 |

11. Link to catchment area: [..\Phase catchments\Phase catchment plans.pdf](#)

TP108 - POST-DEVELOPMENT

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Stage 2 during earthworks Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 0.00 | 0 |
| | Bush | 70 | 48.48 | 3,394 |
| | Grass | 74 | 40.93 | 3,029 |
| | Subtotal for Pervious Areas | | 89.42 | 6,423 |
| | <i>Impervious Area</i> | | | |
| | Open earthworks | 91 | 8.27 | 752 |
| | Gravel | 89 | 5.45 | 485 |
| | Paved | 98 | 1.26 | 124 |
| | Subtotal for Impervious Areas | | 14.98 | 1,362 |
| | Totals | | 104.40 | 7,784 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,784}{104.40} = 75$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{1,415.333333}{104.40} = 4.28 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.80 (From Table 4.2)

Catchment Length : L = 1.444 km (along drainage path) *Assumed stage 2 post-development drainage path*

Catchment Slope : Sc = 0.090 m/m

Runoff Factor R : $\frac{\text{CN}}{200 - \text{CN}} = 0.59$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.39 \text{ hrs} = 23.47 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.26 \text{ hrs} = 15.6 \text{ mins}$

3. Soil Storage Parameter :

$S = ((1000/\text{CN}) - 10) * 25.4$

Total = 86.7 mm
 Pervious = 99.6 mm
 Impervious = 26 mm

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3/\text{s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3)$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 |
|------------------------------------|----------|----------|----------|----------|----------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 |
| c* | 0.36 | 0.49 | 0.60 | 0.11 | 0.16 |
| q* | 0.075 | 0.093 | 0.107 | 0.026 | 0.037 |
| q _p (m ³ /s) | 8.43 | 16.67 | 30.25 | 0.81 | 1.62 |
| Q ₂₄ (mm) | | | | | |
| Pervious | 52.4 | 104.6 | 194.5 | 5.0 | 10.0 |
| Impervious | 87.3 | 149.8 | 248.6 | 16.2 | 26.1 |
| V ₂₄ (m ³) | | | | | |
| Pervious | 46,820 | 93,535 | 173,874 | 4,485 | 8,961 |
| Impervious | 13,088 | 22,441 | 37,259 | 2,428 | 3,913 |
| Total | 59,908 | 115,976 | 211,133 | 6,913 | 12,874 |

11. Link to catchment area: [..\Phase catchments\Phase catchment plans.pdf](#)

TP108 - POST-DEVELOPMENT

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Stage 3 during earthworks Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 0.00 | 0 |
| | Bush | 70 | 39.18 | 2,743 |
| | Grass | 74 | 55.40 | 4,100 |
| | Subtotal for Pervious Areas | | 94.58 | 6,842 |
| | <i>Impervious Area</i> | | | |
| | Open earthworks | 91 | 3.10 | 282 |
| | Gravel | 89 | 5.45 | 485 |
| | Paved | 98 | 1.26 | 124 |
| | Subtotal for Impervious Areas | | 9.82 | 891 |
| | | Totals | 104.40 | 7,734 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,734}{104.40} = 74$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 94.582}{104.40} = 4.53 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.80 (From Table 4.2)
 Catchment Length : L = 2.197 km (along drainage path)
 Catchment Slope : Sc = 0.058 m/m
 Runoff Factor R : $\frac{\text{CN}}{200 - \text{CN}} = 0.59$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.59 \text{ hrs} = 35.60 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.40 \text{ hrs} = 23.7 \text{ mins}$

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

| | | | |
|------------|---|------|----|
| Total | = | 88.9 | mm |
| Pervious | = | 97.1 | mm |
| Impervious | = | 26 | mm |

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3/\text{s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3)$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 | |
|--|------------|----------|----------|----------|----------|--------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% | |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 | |
| Runoff Index, c* | 0.36 | 0.48 | 0.60 | 0.11 | 0.16 | |
| Specific Peak Flow Rate, q* | 0.061 | 0.076 | 0.089 | 0.020 | 0.029 | |
| Peak Flow Rate, q _p (m ³ /s) | 6.83 | 13.59 | 25.15 | 0.63 | 1.29 | |
| Runoff Depth, Q ₂₄ (mm) | | | | | | |
| | Pervious | 53.0 | 105.6 | 195.8 | 5.1 | 10.2 |
| | Impervious | 87.2 | 149.6 | 248.5 | 16.1 | 26.0 |
| Runoff Volume, V ₂₄ (m ³) | | | | | | |
| | Pervious | 50,145 | 99,877 | 185,184 | 4,841 | 9,655 |
| | Impervious | 8,561 | 14,687 | 24,394 | 1,585 | 2,556 |
| | Total | 58,706 | 114,564 | 209,578 | 6,426 | 12,211 |

11. Link to catchment area: <..\Phase catchments\Phase catchment plans.pdf>

TP108 - POST-DEVELOPMENT STAGE 1

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Finished Stage 1 Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 42.30 | 3,046 |
| | Bush | 70 | 41.75 | 2,923 |
| | Grass | 74 | 17.00 | 1,258 |
| | Subtotal for Pervious Areas | | 101.05 | 7,226 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 2.78 | 248 |
| | Paved | 98 | 0.56 | 55 |
| | Subtotal for Impervious Areas | | 3.35 | 303 |
| | Totals | | | 104.40 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,529}{104.40} = 72$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 101.054}{104.40} = 4.84 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.70 (Weighted C value) *Piped plus g*
 Catchment Length : L = 0.815 km (along drainage path) *c = 0.6 * 42.:*
 Catchment Slope : Sc = 0.085 m/m *C =*
 Runoff Factor R : $\frac{CN}{200 - CN} = 0.56$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.25 \text{ hrs} = 14.81 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.16 \text{ hrs} = 9.9 \text{ mins}$

3. Soil Storage Parameter : $S = ((1000/CN)-10) * 25.4$
 Total = 98.2 mm
 Pervious = 101.2 mm
 Impervious = 27 mm

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3\text{/s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3\text{)}$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 |
|------------|----------|----------|----------|----------|----------|
| | 2 | 10 | 100 | 90% | 95% |
| | 108 | 172 | 272 | 30 | 42 |
| | 0.33 | 0.45 | 0.57 | 0.09 | 0.14 |
| | 0.084 | 0.106 | 0.124 | 0.027 | 0.039 |
| | 9.45 | 19.03 | 35.08 | 0.85 | 1.72 |
| Pervious | 52.0 | 104.0 | 193.6 | 5.0 | 9.9 |
| Impervious | 86.7 | 149.0 | 247.8 | 15.9 | 25.7 |
| Pervious | 52,503 | 105,084 | 195,658 | 5,005 | 10,011 |
| Impervious | 2,899 | 4,984 | 8,290 | 532 | 860 |
| Total | 55,402 | 110,068 | 203,949 | 5,537 | 10,871 |

11. Link to catchment area: [..\Phase catchments\Phase catchment plans.pdf](#)

TP108 - POST-DEVELOPMENT STAGE 2

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Finished Stage 2 Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 0.00 | 0 |
| | Bush | 70 | 48.48 | 3,394 |
| | Grass | 74 | 49.20 | 3,641 |
| | Subtotal for Pervious Areas | | 97.68 | 7,035 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 5.45 | 485 |
| | Paved | 98 | 1.26 | 124 |
| | Subtotal for Impervious Areas | | 6.72 | 609 |
| | | Totals | | 104.40 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,644}{104.40} = 73$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 97.682}{104.40} = 4.68 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 1.444 km (along drainage path)

Catchment Slope : Sc = 0.090 m/m

Runoff Factor R : $\frac{\text{CN}}{200 - \text{CN}} = 0.58$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.40 \text{ hrs} = 23.84 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.26 \text{ hrs} = 15.9 \text{ mins}$

3. Soil Storage Parameter : $S = ((1000/\text{CN}) - 10) \times 25.4$

| | | | |
|------------|---|------|----|
| Total | = | 92.9 | mm |
| Pervious | = | 98.7 | mm |
| Impervious | = | 26 | mm |

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3/\text{s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3)$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 | |
|--|------------|----------|----------|----------|----------|--------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% | |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 | |
| Runoff Index, c* | 0.35 | 0.47 | 0.59 | 0.10 | 0.15 | |
| Specific Peak Flow Rate, q* | 0.072 | 0.090 | 0.105 | 0.024 | 0.034 | |
| Peak Flow Rate, q _p (m ³ /s) | 8.08 | 16.20 | 29.71 | 0.74 | 1.51 | |
| Runoff Depth, Q ₂₄ (mm) | | | | | | |
| | Pervious | 52.6 | 105.0 | 194.9 | 5.1 | 10.1 |
| | Impervious | 87.0 | 149.4 | 248.2 | 16.1 | 25.9 |
| Runoff Volume, V ₂₄ (m ³) | | | | | | |
| | Pervious | 51,377 | 102,529 | 190,417 | 4,935 | 9,854 |
| | Impervious | 5,845 | 10,034 | 16,675 | 1,078 | 1,741 |
| | Total | 57,222 | 112,563 | 207,092 | 6,014 | 11,595 |

11. Link to catchment area: <..\Phase catchments\Phase catchment plans.pdf>

TP108 - POST-DEVELOPMENT STAGE 3

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Finished Stage 3 Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 0.00 | 0 |
| | Bush | 70 | 39.18 | 2,743 |
| | Grass | 74 | 58.50 | 4,329 |
| | Subtotal for Pervious Areas | | 97.68 | 7,072 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 5.45 | 485 |
| | Paved | 98 | 1.26 | 124 |
| | Subtotal for Impervious Areas | | 6.72 | 609 |
| | | | Totals | 104.40 |

* from Table 3.3

$$\text{CN (weighted)} : \frac{\text{total product}}{\text{total area}} = \frac{7,681}{104.40} = 74$$

$$\text{Ia (weighted)} : \frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 97.682}{104.40} = 4.68 \text{ mm}$$

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 2.197 km (along drainage path)

Catchment Slope : Sc = 0.058 m/m

Runoff Factor R : $\frac{\text{CN}}{200 - \text{CN}} = 0.58$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{-0.55} S_c^{-0.30} = 0.60 \text{ hrs} = 35.81 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.40 \text{ hrs} = 23.9 \text{ mins}$

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

| | | | |
|------------|---|------|----|
| Total | = | 91.2 | mm |
| Pervious | = | 96.9 | mm |
| Impervious | = | 26 | mm |

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3/\text{s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3\text{)}$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 | |
|--|------------|----------|----------|----------|----------|--------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% | |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 | |
| Runoff Index, c* | 0.35 | 0.47 | 0.59 | 0.10 | 0.15 | |
| Specific Peak Flow Rate, q* | 0.060 | 0.075 | 0.088 | 0.020 | 0.029 | |
| Peak Flow Rate, q _p (m ³ /s) | 6.73 | 13.45 | 24.95 | 0.61 | 1.25 | |
| Runoff Depth, Q ₂₄ (mm) | Pervious | 53.1 | 105.7 | 195.9 | 5.1 | 10.2 |
| | Impervious | 87.0 | 149.4 | 248.2 | 16.1 | 25.9 |
| Runoff Volume, V ₂₄ (m ³) | Pervious | 51,854 | 103,250 | 191,388 | 5,010 | 9,991 |
| | Impervious | 5,845 | 10,034 | 16,675 | 1,078 | 1,741 |
| | Total | 57,699 | 113,284 | 208,063 | 6,089 | 11,732 |

11. Link to catchment area: <..\Phase catchments\Phase catchment plans.pdf>

Project: PONDS WETLAND
 Directory: C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\12D\DESIGN\PONDS WETLAND.12dmodel
 User: BKD
 Created: 2018-12-03T12:14:46

Storage Volumes Pond 2

Tin ST EG P1 mRL
 Minimum height 67.5 mRL
 Maximum height 79 m
 Height increment 0.2
 Fence name RL77
 Fence model DES P1 AREA

| Height | Delta height | Volume to height | Volume (1000 m3) | Delta volume | Plan area | Delta plan | Slope area | Delta slope |
|--------|--------------|------------------|------------------|--------------|-----------|------------|------------|-------------|
| 67.5 | | 0 | 0 | | 0 | | 0 | |
| 67.6 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67.8 | 0.2 | 0.003 | 0.000003 | 0.003 | 0.135 | 0.135 | 0.15 | 0.15 |
| 68 | 0.2 | 0.163 | 0.000163 | 0.16 | 1.709 | 1.574 | 1.912 | 1.763 |
| 68.2 | 0.2 | 0.772 | 0.000772 | 0.609 | 4.581 | 2.872 | 5.163 | 3.25 |
| 68.4 | 0.2 | 2.076 | 0.002076 | 1.303 | 8.653 | 4.072 | 9.798 | 4.635 |
| 68.6 | 0.2 | 4.314 | 0.004314 | 2.239 | 13.935 | 5.281 | 15.827 | 6.029 |
| 68.8 | 0.2 | 7.729 | 0.007729 | 3.415 | 20.411 | 6.477 | 23.233 | 7.406 |
| 69 | 0.2 | 12.556 | 0.012556 | 4.826 | 28.042 | 7.631 | 31.965 | 8.731 |
| 69.2 | 0.2 | 19.034 | 0.019034 | 6.478 | 37.281 | 9.239 | 42.545 | 10.58 |
| 69.4 | 0.2 | 27.867 | 0.027867 | 8.833 | 51.547 | 14.266 | 58.925 | 16.379 |
| 69.6 | 0.2 | 40.061 | 0.040061 | 12.194 | 72.432 | 20.885 | 82.824 | 23.899 |
| 69.8 | 0.2 | 57.365 | 0.057365 | 17.304 | 101.614 | 29.182 | 116.091 | 33.267 |
| 70 | 0.2 | 81.194 | 0.081194 | 23.828 | 137.978 | 36.364 | 157.411 | 41.32 |
| 70.2 | 0.2 | 113.084 | 0.113084 | 31.89 | 182.272 | 44.294 | 207.591 | 50.179 |
| 70.4 | 0.2 | 154.656 | 0.154656 | 41.572 | 234.855 | 52.583 | 266.964 | 59.374 |
| 70.6 | 0.2 | 207.475 | 0.207475 | 52.819 | 294.189 | 59.335 | 333.849 | 66.884 |
| 70.8 | 0.2 | 272.67 | 0.27267 | 65.196 | 358.586 | 64.397 | 406.401 | 72.553 |
| 71 | 0.2 | 351.187 | 0.351187 | 78.517 | 427.118 | 68.531 | 483.604 | 77.203 |
| 71.2 | 0.2 | 443.726 | 0.443726 | 92.539 | 498.801 | 71.684 | 564.31 | 80.706 |
| 71.4 | 0.2 | 550.884 | 0.550884 | 107.158 | 573.048 | 74.246 | 647.88 | 83.569 |
| 71.6 | 0.2 | 673.01 | 0.67301 | 122.126 | 648.252 | 75.204 | 732.608 | 84.728 |
| 71.8 | 0.2 | 810.198 | 0.810198 | 137.188 | 723.661 | 75.41 | 817.695 | 85.087 |
| 72 | 0.2 | 962.502 | 0.962502 | 152.304 | 799.528 | 75.867 | 903.38 | 85.685 |
| 72.2 | 0.2 | 1130.075 | 1.130075 | 167.573 | 876.374 | 76.846 | 990.134 | 86.754 |
| 72.4 | 0.2 | 1313.123 | 1.313123 | 183.047 | 954.28 | 77.906 | 1078.025 | 87.891 |
| 72.6 | 0.2 | 1511.857 | 1.511857 | 198.734 | 1033.158 | 78.878 | 1166.975 | 88.95 |
| 72.8 | 0.2 | 1726.416 | 1.726416 | 214.559 | 1112.734 | 79.576 | 1256.908 | 89.933 |
| 73 | 0.2 | 1957.136 | 1.957136 | 230.72 | 1194.65 | 81.916 | 1349.532 | 92.624 |
| 73.2 | 0.2 | 2204.297 | 2.204297 | 247.161 | 1276.985 | 82.335 | 1442.891 | 93.359 |
| 73.4 | 0.2 | 2467.957 | 2.467957 | 263.661 | 1359.676 | 82.691 | 1536.887 | 93.996 |
| 73.6 | 0.2 | 2748.193 | 2.748193 | 280.236 | 1442.764 | 83.089 | 1631.57 | 94.684 |
| 73.8 | 0.2 | 3045.087 | 3.045087 | 296.894 | 1526.24 | 83.475 | 1726.951 | 95.381 |
| 74 | 0.2 | 3358.738 | 3.358738 | 313.65 | 1610.499 | 84.259 | 1823.415 | 96.464 |
| 74.2 | 0.2 | 3689.396 | 3.689396 | 330.659 | 1696.366 | 85.867 | 1921.729 | 98.315 |
| 74.4 | 0.2 | 4037.396 | 4.037396 | 347.999 | 1783.908 | 87.542 | 2021.956 | 100.226 |
| 74.6 | 0.2 | 4403.005 | 4.403005 | 365.609 | 1871.636 | 87.729 | 2122.738 | 100.783 |
| 74.8 | 0.2 | 4786.052 | 4.786052 | 383.046 | 1959.098 | 87.462 | 2223.673 | 100.935 |
| 75 | 0.2 | 5186.759 | 5.186759 | 400.707 | 2048.34 | 89.242 | 2326.681 | 103.008 |
| 75.2 | 0.2 | 5605.651 | 5.605651 | 418.892 | 2141.446 | 93.106 | 2434.039 | 107.358 |
| 75.4 | 0.2 | 6043.689 | 6.043689 | 438.038 | 2239.541 | 98.095 | 2547.074 | 113.035 |
| 75.6 | 0.2 | 6501.671 | 6.501671 | 457.982 | 2340.786 | 101.245 | 2663.466 | 116.393 |
| 75.8 | 0.2 | 6980.201 | 6.980201 | 478.53 | 2445.024 | 104.238 | 2782.974 | 119.508 |
| 76 | 0.2 | 7479.886 | 7.479886 | 499.685 | 2552.319 | 107.295 | 2905.661 | 122.686 |
| 76.2 | 0.2 | 8001.302 | 8.001302 | 521.416 | 2662.173 | 109.855 | 3031.084 | 125.423 |
| 76.4 | 0.2 | 8544.865 | 8.544865 | 543.563 | 2773.718 | 111.545 | 3158.394 | 127.31 |
| 76.6 | 0.2 | 9110.897 | 9.110897 | 566.032 | 2886.87 | 113.153 | 3287.538 | 129.143 |
| 76.8 | 0.2 | 9699.74 | 9.69974 | 588.843 | 3001.984 | 115.114 | 3418.819 | 131.281 |
| 77 | 0.2 | 10311.791 | 10.311791 | 612.051 | 3118.761 | 116.777 | 3551.957 | 133.138 |
| 77.2 | 0.2 | 10947.393 | 10.947393 | 635.602 | 3237.689 | 118.929 | 3687.433 | 135.476 |
| 77.4 | 0.2 | 11607.015 | 11.607015 | 659.622 | 3358.858 | 121.168 | 3825.286 | 137.854 |
| 77.6 | 0.2 | 12291.077 | 12.291077 | 684.062 | 3482.057 | 123.2 | 3965.32 | 140.034 |
| 77.8 | 0.2 | 12999.953 | 12.999953 | 708.876 | 3607.001 | 124.944 | 4107.256 | 141.936 |
| 78 | 0.2 | 13733.869 | 13.733869 | 733.916 | 3732.226 | 125.225 | 4249.682 | 142.426 |
| 78.2 | 0.2 | 14492.935 | 14.492935 | 759.066 | 3858.663 | 126.437 | 4393.488 | 143.806 |
| 78.4 | 0.2 | 15277.39 | 15.27739 | 784.455 | 3985.935 | 127.272 | 4538.321 | 144.834 |
| 78.6 | 0.2 | 16087.375 | 16.087375 | 809.985 | 4114.244 | 128.309 | 4684.388 | 146.067 |
| 78.8 | 0.2 | 16923.258 | 16.923258 | 835.883 | 4245.419 | 131.174 | 4833.481 | 149.093 |
| 79 | 0.2 | 17786.313 | 17.786313 | 863.055 | 4386.878 | 141.459 | 4993.266 | 159.785 |

Summary

Polygon plan area: 13476.614 m²

| | | |
|---|--------|----------------|
| Assumed Pond base | 67.5 | m |
| Maximum allowable pond water level | 78.5 | m |
| Required total pond storage volume (base of pond to top of primary spillway) | 11,089 | m ³ |
| Assumed pond PWL level | 77.24 | m ² |
| 100 yr ARI detention volume (Post -Pre) | 4,590 | m ³ |
| Maximum estimated height of PWL plus 100 yr ARI extended detention volume (assuming all other outlets are blocked)* | 78.50 | m ³ |
| Available total pond storage volume | 15,679 | m ³ |
| Is the available pond storage greater than the required pond storage? | | YES |
| Assumed embankment crest level | 79.00 | m |
| Freeboard (PWL to top of embankment) | 0.50 | m ³ |

ASSUMPTIONS

*Height of PWL plus 100 yr ARI extended detention volume has been based on assuming all other outlets are blocked (overconservative) in reality the 95th percentile flow and 2yr and 10 yr ARI outlets will also be operating so the water level will in fact be lower.

-Design of Pond 2 is based on the assumption that the difference between post-pre development 2,10 and 100 yr ARI volumes is stored within Pond 2. This may change during the detailed design

Required Pond storage level has been designed based on the following assumptions:

-Top WL 0.5 m lower than the embankment level

-Top water level = Post -Pre development 100 yr ARI attenuation volume

-Permanent water level = Top WL - pre-post 100 yr ARI attenuation volume.

Project: PONDS WETLAND
 Directory: C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\12D\DESIGN\PONDS WETLAND.12dmodel
 User: BKD
 Created: 2018-12-03T12:15:40

Storage Volumes Pond 3 Phase 1

Tin ST EG P1
 Minimum height 78.2 mRL
 Maximum height 81 mRL
 Height increment 0.2 m
 Fence name RL86
 Fence model DES P2 AREA

| Height | Delta height | Volume to height | Volume (1000 m3) | Delta volume | Plan area | Delta plan | Slope area | Delta slope |
|--------|--------------|------------------|------------------|--------------|-----------|------------|------------|-------------|
| 78.1 | | 0 | 0 | 0 | 0 | | 0 | |
| 78.2 | 29.2 | 353.026 | 0.353026 | 353.026 | 837.263 | 837.263 | 855.294 | 855.294 |
| 78.4 | 0.2 | 541.765 | 0.541765 | 188.739 | 1054.051 | 216.788 | 1080.082 | 224.788 |
| 78.6 | 0.2 | 775.824 | 0.775824 | 234.059 | 1293.991 | 239.939 | 1328.402 | 248.32 |
| 78.8 | 0.2 | 1061.143 | 1.061143 | 285.32 | 1556.978 | 262.987 | 1600.81 | 272.408 |
| 79 | 0.2 | 1390.792 | 1.390792 | 329.649 | 1717.19 | 160.212 | 1771.594 | 170.784 |
| 79.2 | 0.2 | 1743.528 | 1.743528 | 352.736 | 1809.914 | 92.724 | 1875.443 | 103.849 |
| 79.4 | 0.2 | 2114.924 | 2.114924 | 371.396 | 1904.898 | 94.985 | 1981.983 | 106.54 |
| 79.6 | 0.2 | 2505.743 | 2.505743 | 390.819 | 2003.568 | 98.669 | 2092.737 | 110.755 |
| 79.8 | 0.2 | 2916.369 | 2.916369 | 410.626 | 2102.643 | 99.075 | 2204.159 | 111.422 |
| 80 | 0.2 | 3346.786 | 3.346786 | 430.417 | 2201.51 | 98.866 | 2315.555 | 111.396 |
| 80.2 | 0.2 | 3797.042 | 3.797042 | 450.256 | 2301.739 | 100.229 | 2428.401 | 112.846 |
| 80.4 | 0.2 | 4267.781 | 4.267781 | 470.739 | 2406.176 | 104.437 | 2545.506 | 117.105 |
| 80.6 | 0.2 | 4759.664 | 4.759664 | 491.884 | 2513.409 | 107.233 | 2665.526 | 120.02 |
| 80.8 | 0.2 | 5273.702 | 5.273702 | 514.038 | 2628.034 | 114.625 | 2793.112 | 127.586 |
| 81 | 0.2 | 5811.074 | 5.811074 | 537.371 | 2745.82 | 117.786 | 2924.002 | 130.89 |

Summary

Polygon plan area: 13049.245 m2

| | | |
|--|-------|----------------|
| Assumed Pond base | 78.2 | m |
| Assumed pond water level | 80.41 | m |
| Required total pond storage volume (base of pond to top of primary spillway) | 4300 | m ³ |
| Available total pond storage volume | 4511 | m ³ |
| Is the available pond storage greater than the required pond storage? | | Y |
| Assumed embankment crest level | 81.00 | m |
| Freeboard (Pond water level to top of embankment) | 0.59 | m ³ |

ASSUMPTIONS

*Required Pond total storage (based on 3% of the contributing catchment). Pond 2 is estimated to hold 11,000 m3, however during Stage 1 the required storage in Pond 2 and 3 combined is approximately 5,500 m3. Therefore this

Project: PONDS WETLAND
 Directory: C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\12D\DESIGN\PONDS WETLAND.12dmodel
 User: BKD
 Created: 2018-12-03T12:15:40

Storage Volumes Pond 3 Phase 3

Tin ST EG P1
 Minimum height 78.2 mRL
 Maximum height 86 mRL
 Height increment 0.2 m
 Fence name RL86
 Fence model DES P2 AREA

| Height | Delta height | Volume to height | Volume (1000 m3) | Delta volume | Plan area | Delta plan | Slope area | Delta slope |
|--------|--------------|------------------|------------------|--------------|-----------|------------|------------|-------------|
| 78.1 | | 0 | 0 | 0 | 0 | | 0 | |
| 78.2 | 29.2 | 353.026 | 0.353026 | 353.026 | 837.263 | 837.263 | 855.294 | 855.294 |
| 78.4 | 0.2 | 541.765 | 0.541765 | 188.739 | 1054.051 | 216.788 | 1080.082 | 224.788 |
| 78.6 | 0.2 | 775.824 | 0.775824 | 234.059 | 1293.991 | 239.939 | 1328.402 | 248.32 |
| 78.8 | 0.2 | 1061.143 | 1.061143 | 285.32 | 1556.978 | 262.987 | 1600.81 | 272.408 |
| 79 | 0.2 | 1390.792 | 1.390792 | 329.649 | 1717.19 | 160.212 | 1771.594 | 170.784 |
| 79.2 | 0.2 | 1743.528 | 1.743528 | 352.736 | 1809.914 | 92.724 | 1875.443 | 103.849 |
| 79.4 | 0.2 | 2114.924 | 2.114924 | 371.396 | 1904.898 | 94.985 | 1981.983 | 106.54 |
| 79.6 | 0.2 | 2505.743 | 2.505743 | 390.819 | 2003.568 | 98.669 | 2092.737 | 110.755 |
| 79.8 | 0.2 | 2916.369 | 2.916369 | 410.626 | 2102.643 | 99.075 | 2204.159 | 111.422 |
| 80 | 0.2 | 3346.786 | 3.346786 | 430.417 | 2201.51 | 98.866 | 2315.555 | 111.396 |
| 80.2 | 0.2 | 3797.042 | 3.797042 | 450.256 | 2301.739 | 100.229 | 2428.401 | 112.846 |
| 80.4 | 0.2 | 4267.781 | 4.267781 | 470.739 | 2406.176 | 104.437 | 2545.506 | 117.105 |
| 80.6 | 0.2 | 4759.664 | 4.759664 | 491.884 | 2513.409 | 107.233 | 2665.526 | 120.02 |
| 80.8 | 0.2 | 5273.702 | 5.273702 | 514.038 | 2628.034 | 114.625 | 2793.112 | 127.586 |
| 81 | 0.2 | 5811.074 | 5.811074 | 537.371 | 2745.82 | 117.786 | 2924.002 | 130.89 |
| 81.2 | 0.2 | 6372.064 | 6.372064 | 560.991 | 2864.221 | 118.401 | 3055.634 | 131.632 |
| 81.4 | 0.2 | 6956.884 | 6.956884 | 584.82 | 2983.714 | 119.494 | 3188.372 | 132.737 |
| 81.6 | 0.2 | 7565.222 | 7.565222 | 608.338 | 3098.964 | 115.25 | 3317.237 | 128.866 |
| 81.8 | 0.2 | 8196.4 | 8.1964 | 631.179 | 3212.845 | 113.881 | 3444.991 | 127.754 |
| 82 | 0.2 | 8850.417 | 8.850417 | 654.016 | 3327.516 | 114.671 | 3573.797 | 128.806 |
| 82.2 | 0.2 | 9527.488 | 9.527488 | 677.072 | 3443.368 | 115.852 | 3704.085 | 130.287 |
| 82.4 | 0.2 | 10227.795 | 10.227795 | 700.306 | 3559.662 | 116.294 | 3835.153 | 131.069 |
| 82.6 | 0.2 | 10951.444 | 10.951444 | 723.649 | 3677.141 | 117.479 | 3967.674 | 132.52 |
| 82.8 | 0.2 | 11698.77 | 11.69877 | 747.326 | 3796.423 | 119.282 | 4102.181 | 134.507 |
| 83 | 0.2 | 12470.142 | 12.470142 | 771.371 | 3917.617 | 121.194 | 4238.792 | 136.611 |
| 83.2 | 0.2 | 13265.946 | 13.265946 | 795.804 | 4040.729 | 123.112 | 4377.519 | 138.727 |
| 83.4 | 0.2 | 14086.577 | 14.086577 | 820.631 | 4166.039 | 125.31 | 4518.641 | 141.122 |
| 83.6 | 0.2 | 14932.549 | 14.932549 | 845.972 | 4294.189 | 128.15 | 4662.781 | 144.14 |
| 83.8 | 0.2 | 15804.48 | 15.80448 | 871.93 | 4425.77 | 131.581 | 4810.519 | 147.738 |
| 84 | 0.2 | 16703.151 | 16.703151 | 898.672 | 4561.841 | 136.071 | 4962.913 | 152.394 |
| 84.2 | 0.2 | 17629.593 | 17.629593 | 926.442 | 4703.545 | 141.705 | 5121.218 | 158.305 |
| 84.4 | 0.2 | 18584.972 | 18.584972 | 955.378 | 4851.491 | 147.946 | 5286.019 | 164.801 |
| 84.6 | 0.2 | 19570.542 | 19.570542 | 985.57 | 5004.946 | 153.455 | 5456.528 | 170.509 |
| 84.8 | 0.2 | 20587.279 | 20.587279 | 1016.737 | 5163.173 | 158.227 | 5631.857 | 175.329 |
| 85 | 0.2 | 21636.641 | 21.636641 | 1049.362 | 5333.442 | 170.268 | 5819.09 | 187.233 |
| 85.2 | 0.2 | 22721.011 | 22.721011 | 1084.37 | 5510.856 | 177.414 | 6013.503 | 194.414 |
| 85.4 | 0.2 | 23840.982 | 23.840982 | 1119.971 | 5688.489 | 177.634 | 6208.401 | 194.898 |
| 85.6 | 0.2 | 24996.185 | 24.996185 | 1155.203 | 5863.126 | 174.637 | 6400.67 | 192.269 |
| 85.8 | 0.2 | 26186.498 | 26.186498 | 1190.312 | 6042.106 | 178.98 | 6597.553 | 196.882 |
| 86 | 0.2 | 27415.174 | 27.415174 | 1228.676 | 6251.028 | 208.921 | 6825.331 | 227.778 |

Summary

Polygon plan area: 13049.245 m²

| | | |
|---|--------|----------------|
| Assumed Pond base | 78.2 | m |
| Required total pond storage volume (base of pond to top of primary spillway)* | 19,911 | m ³ |
| Assumed pond PWL level | 84.67 | m |
| Available total pond storage volume | 24,414 | m ³ |
| Is the available pond storage greater than the required pond storage? | | YES |
| Assumed embankment crest level (set at PWL)** | 84.67 | m |
| Freeboard (PWL to top of embankment) | 0 | m |

ASSUMPTIONS

*Required Pond total storage (based on 3% of the contributing catchment) is 31,000 m³. Pond 2 is estimated to hold 11,000 m³, therefore Pond 3 must detain approximately 20,000 m³

**Assume embankment crest level is set at PWL as we don't need to attenuate flows to pre development conditions as we plan to do this within Pond 2.

Project: PONDS WETLAND
 Directory: C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\12D\DESIGN\PONDS WETLAND.12dmodel
 User: BKD
 Created: 2018-12-03T12:14:06

Storage Volumes Pond 4

Tin ST EG P1
 Minimum height 80 mRL
 Maximum height 86 mRL
 Height increment 0.2 m
 Fence name DES
 Fence model DES P3 CAPACITY

| Height | Delta height | Volume to height | Volume (1000m3) | Delta volume | Plan area | Delta plan | Slope area | Delta slope |
|--------|--------------|------------------|-----------------|--------------|-----------|------------|------------|-------------|
| 80 | | 0 | 0 | | 0 | | 0 | 0 |
| 80.2 | 0.2 | 919.625 | 0.919625 | 919.625 | 4711.338 | 4711.338 | 4722.672 | 4722.672 |
| 80.4 | 0.2 | 1884.772 | 1.884772 | 965.147 | 4940.724 | 229.386 | 4963.538 | 240.867 |
| 80.6 | 0.2 | 2896.152 | 2.896152 | 1011.38 | 5173.665 | 232.94 | 5208.107 | 244.568 |
| 80.8 | 0.2 | 3954.475 | 3.954475 | 1058.323 | 5410.16 | 236.495 | 5456.377 | 248.27 |
| 81 | 0.2 | 5060.453 | 5.060453 | 1105.978 | 5650.209 | 240.049 | 5708.349 | 251.972 |
| 81.2 | 0.2 | 6214.796 | 6.214796 | 1154.343 | 5893.813 | 243.604 | 5964.022 | 255.674 |
| 81.4 | 0.2 | 7418.215 | 7.418215 | 1203.419 | 6140.971 | 247.158 | 6223.398 | 259.375 |
| 81.6 | 0.2 | 8671.421 | 8.671421 | 1253.206 | 6391.683 | 250.712 | 6486.475 | 263.077 |
| 81.8 | 0.2 | 9975.125 | 9.975125 | 1303.704 | 6645.95 | 254.267 | 6753.254 | 266.779 |
| 82 | 0.2 | 11330.038 | 11.33004 | 1354.913 | 6903.771 | 257.821 | 7023.735 | 270.481 |
| 82.2 | 0.2 | 12736.87 | 12.73687 | 1406.833 | 7165.147 | 261.376 | 7297.917 | 274.183 |
| 82.4 | 0.2 | 14196.334 | 14.19633 | 1459.463 | 7430.076 | 264.93 | 7575.802 | 277.884 |
| 82.6 | 0.2 | 15709.138 | 15.70914 | 1512.804 | 7698.561 | 268.484 | 7857.388 | 281.586 |
| 82.8 | 0.2 | 17275.995 | 17.276 | 1566.857 | 7970.6 | 272.039 | 8142.675 | 285.288 |
| 83 | 0.2 | 18897.615 | 18.89762 | 1621.62 | 8246.193 | 275.593 | 8431.665 | 288.99 |
| 83.2 | 0.2 | 20574.709 | 20.57471 | 1677.094 | 8525.34 | 279.147 | 8724.356 | 292.691 |
| 83.4 | 0.2 | 22307.988 | 22.30799 | 1733.279 | 8808.042 | 282.702 | 9020.75 | 296.393 |
| 83.6 | 0.2 | 24098.163 | 24.09816 | 1790.175 | 9094.298 | 286.256 | 9320.844 | 300.095 |
| 83.8 | 0.2 | 25945.944 | 25.94594 | 1847.781 | 9384.109 | 289.811 | 9624.641 | 303.797 |
| 84 | 0.2 | 27852.043 | 27.85204 | 1906.099 | 9677.474 | 293.365 | 9932.139 | 307.498 |
| 84.2 | 0.2 | 29817.171 | 29.81717 | 1965.127 | 9974.393 | 296.919 | 10243.34 | 311.2 |
| 84.4 | 0.2 | 31842.037 | 31.84204 | 2024.867 | 10274.867 | 300.474 | 10558.242 | 314.902 |
| 84.6 | 0.2 | 33927.354 | 33.92735 | 2085.317 | 10578.895 | 304.028 | 10876.845 | 318.604 |
| 84.8 | 0.2 | 36073.832 | 36.07383 | 2146.478 | 10886.478 | 307.583 | 11199.151 | 322.305 |
| 85 | 0.2 | 38282.182 | 38.28218 | 2208.35 | 11197.615 | 311.137 | 11525.158 | 326.007 |
| 85.2 | 0.2 | 40553.115 | 40.55312 | 2270.933 | 11512.306 | 314.691 | 11854.867 | 329.709 |
| 85.4 | 0.2 | 42887.342 | 42.88734 | 2334.227 | 11830.552 | 318.246 | 12188.278 | 333.411 |
| 85.6 | 0.2 | 45277.513 | 45.27751 | 2390.171 | 11991.008 | 160.456 | 12356.371 | 168.094 |
| 85.8 | 0.2 | 47675.715 | 47.67572 | 2398.202 | 11991.008 | 0 | 12356.371 | 0 |
| 86 | 0.2 | 50073.916 | 50.07392 | 2398.202 | 11991.008 | 0 | 12356.371 | 0 |

Summary

Polygon plan area: 11991.008 m²

| | | |
|--|--------|----------------|
| Assumed Pond base | 78.2 | m |
| Required total pond storage volume (base of pond to top of primary spillway) | 25,900 | m ³ |
| Available total pond storage volume | 44,078 | m ³ |
| Is the available pond storage greater than the required pond storage? | YES | |
| Assumed embankment crest level | 86.00 | m |
| Freeboard (Pond water level to top of embankment) | 85.50 | m ³ |

ASSUMPTIONS

*Required Pond total storage (based on 3% of the contributing catchment) is approximately 25,900 m³. Pond 2 is estimated to hold 11,000 m³, therefore Pond 3 must detain approximately 20,000 m³

**Assume pond level is set 0.5 m below the embankment crest level, this is likely to change at detailed design.

Project: PONDS WETLAND
 Directory: C:\12dSynergy\data\ALBTCAD\Polaris_WOL_Concept_55\12D\DESIGN\PONDS WETLAND.12dmodel
 User: BKD
 Created: 2018-11-30T16:40:18

Storage Volumes Pond 5

Tin ST EG P1
 Minimum height 108
 Maximum height 114.2
 Height increment 0.2
 Fence name Cont minor
 Fence model CONT PONDS 114p2

| Height | Delta height | Volume to height | Volume (1000m3) | Delta volume | Plan area | Delta plan | Slope area | Delta slope |
|--------|--------------|------------------|-----------------|--------------|-----------|------------|------------|-------------|
| 108.00 | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | |
| 108.10 | 59.00 | 0.42 | 0.00 | 0.42 | 3.12 | 3.12 | 3.46 | 3.46 |
| 108.20 | 0.20 | 1.40 | 0.00 | 0.99 | 7.01 | 3.89 | 7.77 | 4.31 |
| 108.40 | 0.20 | 3.42 | 0.00 | 2.02 | 14.29 | 7.28 | 15.74 | 7.97 |
| 108.60 | 0.20 | 7.62 | 0.01 | 4.21 | 29.24 | 14.95 | 31.88 | 16.14 |
| 108.80 | 0.20 | 15.81 | 0.02 | 8.19 | 53.90 | 24.66 | 58.26 | 26.37 |
| 109.00 | 0.20 | 29.86 | 0.03 | 14.05 | 89.51 | 35.61 | 96.16 | 37.90 |
| 109.20 | 0.20 | 53.73 | 0.05 | 23.87 | 155.17 | 65.66 | 165.21 | 69.05 |
| 109.40 | 0.20 | 94.40 | 0.09 | 40.67 | 256.47 | 101.30 | 271.08 | 105.87 |
| 109.60 | 0.20 | 156.72 | 0.16 | 62.32 | 362.76 | 106.29 | 382.42 | 111.34 |
| 109.80 | 0.20 | 238.67 | 0.24 | 81.95 | 456.40 | 93.64 | 480.99 | 98.57 |
| 110.00 | 0.20 | 339.53 | 0.34 | 100.86 | 554.47 | 98.07 | 584.39 | 103.40 |
| 110.20 | 0.20 | 460.90 | 0.46 | 121.37 | 659.63 | 105.17 | 695.53 | 111.13 |
| 110.40 | 0.20 | 603.75 | 0.60 | 142.85 | 770.03 | 110.39 | 812.46 | 116.94 |
| 110.60 | 0.20 | 770.05 | 0.77 | 166.30 | 897.27 | 127.24 | 946.80 | 134.33 |
| 110.80 | 0.20 | 962.90 | 0.96 | 192.85 | 1033.89 | 136.63 | 1091.36 | 144.56 |
| 111.00 | 0.20 | 1188.24 | 1.19 | 225.33 | 1235.55 | 201.66 | 1302.33 | 210.97 |
| 111.20 | 0.20 | 1455.86 | 1.46 | 267.63 | 1432.76 | 197.21 | 1509.94 | 207.61 |
| 111.40 | 0.20 | 1760.21 | 1.76 | 304.35 | 1616.39 | 183.63 | 1704.60 | 194.67 |
| 111.60 | 0.20 | 2102.77 | 2.10 | 342.56 | 1812.95 | 196.56 | 1912.81 | 208.21 |
| 111.80 | 0.20 | 2494.38 | 2.49 | 391.61 | 2105.35 | 292.40 | 2218.17 | 305.36 |
| 112.00 | 0.20 | 2943.11 | 2.94 | 448.73 | 2371.74 | 266.38 | 2498.39 | 280.22 |
| 112.20 | 0.20 | 3438.11 | 3.44 | 495.01 | 2577.22 | 205.49 | 2719.01 | 220.62 |
| 112.40 | 0.20 | 3975.78 | 3.98 | 537.67 | 2810.03 | 232.81 | 2967.60 | 248.59 |
| 112.60 | 0.20 | 4566.33 | 4.57 | 590.55 | 3087.14 | 277.11 | 3261.34 | 293.73 |
| 112.80 | 0.20 | 5207.00 | 5.21 | 640.67 | 3316.12 | 228.98 | 3508.27 | 246.94 |
| 113.00 | 0.20 | 5892.55 | 5.89 | 685.55 | 3544.80 | 228.68 | 3755.79 | 247.51 |
| 113.20 | 0.20 | 6628.89 | 6.63 | 736.34 | 3831.50 | 286.70 | 4062.26 | 306.48 |
| 113.40 | 0.20 | 7430.78 | 7.43 | 801.89 | 4183.02 | 351.52 | 4434.97 | 372.71 |
| 113.60 | 0.20 | 8298.48 | 8.30 | 867.69 | 4492.77 | 309.75 | 4767.07 | 332.10 |
| 113.80 | 0.20 | 9226.75 | 9.23 | 928.28 | 4793.39 | 300.62 | 5090.95 | 323.88 |
| 114.00 | 0.20 | 10219.81 | 10.22 | 993.06 | 5141.41 | 348.02 | 5463.38 | 372.43 |
| 114.20 | 0.20 | 11282.99 | 11.28 | 1063.17 | 5487.11 | 345.70 | 5834.69 | 371.31 |

Summary

Polygon plan area: 5499.212

| | | |
|---|--------|----------------|
| Assumed Pond base | 78.2 | m |
| Assumed pond water level (based on HEC-HMS results) | 113.48 | m |
| Required total pond storage volume (HEC-HMS results) | 7779 | m ³ |
| Available total pond storage volume | 8755.2 | m ³ |
| Is the available pond storage greater than the required pond storage? | YES | |
| Assumed embankment crest level | 114.20 | m |
| Freeboard (Pond water level to top of embankment) | 0.72 | m ³ |

ASSUMPTIONS

*Required Pond total storage (based on 3% of the contributing catchment) is approximately 12,700 m³. Pond 5 has been designed based on the assumption that a 1.35 m diameter culvert conveys flows from Pond 5 to Pond 3. Based on the HEC-HMS results, peak pond elevation is 113.48 mRL corresponding to a required Pond storage volume of approximately 7780 m³

Summary Results for Reservoir "UPSTREAM POND"

Project: Polaris Simulation Run: 100 yr ARI run
 Reservoir: UPSTREAM POND

Start of Run: 01Jan2000, 00:00 Basin Model: Basin 1
 End of Run: 02Jan2000, 00:00 Meteorologic Model: 100 YR ARI
 Compute Time: 03Dec2018, 11:58:21 Control Specifications: Control 1


Volume Units: MM 1000 M3

Computed Results

| | |
|--------------------------------|---|
| Peak Inflow: 14.9417 (M3/S) | Date/Time of Peak Inflow: 01Jan2000, 12:05 |
| Peak Discharge: 8.2098 (M3/S) | Date/Time of Peak Discharge: 01Jan2000, 12:17 |
| Inflow Volume: 199.536 (MM) | Peak Storage: 7.7855 (1000 M3) |
| Discharge Volume: 199.481 (MM) | Peak Elevation: 113.482 (M) |

LANDFILL DESIGN WETLAND
PRELIMINARY DESIGN CALCULATIONS

WETLAND DESIGN (Based on GD01)

| | | | | |
|---|----------|-------------------------|-----------|-----------------|
|  | Project: | Polaris Landfill Design | Computed: | AFRE 25/10/2018 |
| | Details: | Wetland hydrology | Job No: | 1005069.1140 |
| | | | Checked: | |
| | | | Revised: | |

Catchments

Pre-development

Assumptions

- Assume that the entire catchment conveyed to Ponds 1-3 and the upstream pond discharges to the wetland.
- Assume that pre-development cover type is plantation forestry (CN = 72)
- The percentage of catchment which is existing forestry road is so small in comparison to the entire catchment, thus they have been assumed to be plantation forestry.

Catchment areas: [Wetland catchment area plan.pdf](#)

| Wetland | Subcatchment | Total catchment area |
|-------------------------|--------------------------------|----------------------|
| | | Ha |
| Wetland catchment areas | Impervious (hardstand areas) | 0.00 |
| | Roads | 0.00 |
| | Pervious (plantation forestry) | 104.40 |
| Catchment totals | | 104.40 |

Post-development

Assumptions

- Assume that post-development cover type is bush (CN = 70). Green areas shown in the catchment plan that were previously plantation forestry will be replanted with bush
- Assume that all proposed roads are gravel and 8 m wide
- Assume the workshop platform and energy center are impervious surfaces (CN = 98)

| Wetland | Subcatchment | Post Catchment P2 | Post Catchment P3 | Total catchment area |
|-------------------------|------------------------------|-------------------|-------------------|----------------------|
| | | | | Ha |
| Wetland catchment areas | Impervious (hardstand areas) | | 0.96 | 0.96 |
| | Gravel Roads | 0.3 | 5.154 | 5.45 |
| | Paved Roads | | 0.30 | 0.30 |
| | Pervious (bush) | 3.5 | 35.68 | 39.18 |
| | Pervious (grassed) | | 58.50 | 58.50 |
| Catchment totals | | 3.80 | 100.60 | 104.40 |

| Gravel Road | Length of road (m) | Width of road (m)** | Area (Ha) |
|----------------|--------------------|---------------------|-----------|
| 1 | 430 | 8 | 0.34 |
| 2 | 620 | 8 | 0.50 |
| 3 | 120 | 8 | 0.10 |
| 4 | 220 | 8 | 0.18 |
| 5 | 430 | 8 | 0.34 |
| 6 | 350 | 8 | 0.28 |
| 7 | 720 | 8 | 0.58 |
| 8 | 570 | 6 | 0.34 |
| Perimeter road | 3500 | 8 | 2.80 |
| Paved road | | | |
| Landfill road | 380 | 8 | 0.30 |

Total gravel roads = 5.454
Total paved roads = 0.30

** Measured from CAD


Hydrology

| Event | Pre-development excl Climate Change | Post-development incl Climate Change |
|-----------------------------------|-------------------------------------|--------------------------------------|
| 2 year 24hr | 98.8 mm | 108 mm |
| 10 year 24hr | 152 mm | 172 mm |
| 100 year 24hr | 233 mm | 272 mm |
| 90th percentile 24hr ¹ | 30 mm | 30 mm |
| 95th percentile 24hr ² | 42 mm | 42 mm |

1. Source: Auckland Council Guideline Document GD2017/001, *Figure 5: Map of 90th percentile 24-hour rainfall event*
2. Source: Auckland Council Guideline Document GD2017/001, *Figure 6: Map of 90th percentile 24-hour rainfall event*
3. HIRDS V4 Depth-Duration-Frequency Results

Volumes

| Storm event | Pre development | Post-development Phase 3 | Difference |
|-------------|-----------------|-----------------------------|------------|
| | Volume (m3) | | |
| 2 | 54,891 | 57,699 | 2,808 |
| 10 | 109,551 | 113,284 | 3,734 |
| 100 | 203,472 | 208,063 | 4,590 |
| 90th %ile | 5,272 | 6,089 | 817 |
| 95th %ile | 10,526 | 11,732 | 1,206 |

| LANDFILL PRE DEVELOPMENT EQUAL AREA SLOPE | | | |
|---|------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Pre dev landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

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

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|--------------------|
| Catchment (km ²) | 1.04 |
| CN | 72 |
| Channel Factor | 1 (Natural ground) |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|--------|--------|--------|------------|-----------------------|
| 0 | 81 | 0 | 0 | 0.00 | 0.00 | 0 |
| 41.328 | 81 | 41.328 | 41.328 | 0.00 | 0.00 | 0 |
| 52.043 | 82 | 52.043 | 10.715 | 1.00 | 0.50 | 5 |
| 114.8 | 82.013 | 114.8 | 62.757 | 1.01 | 1.01 | 63 |
| 122.45 | 83 | 122.45 | 7.65 | 2.00 | 1.51 | 12 |
| 165.31 | 83 | 165.31 | 42.86 | 2.00 | 2.00 | 86 |
| 180.62 | 84 | 180.62 | 15.31 | 3.00 | 2.50 | 38 |
| 280.11 | 84 | 280.11 | 99.49 | 3.00 | 3.00 | 298 |
| 322.97 | 86 | 322.97 | 42.86 | 5.00 | 4.00 | 171 |
| 402.57 | 86.018 | 402.57 | 79.6 | 5.02 | 5.01 | 399 |
| 436.24 | 88 | 436.24 | 33.67 | 7.00 | 6.01 | 202 |
| 521.96 | 88 | 521.96 | 85.72 | 7.00 | 7.00 | 600 |
| 529.61 | 89 | 529.61 | 7.65 | 8.00 | 7.50 | 57 |
| 564.82 | 89 | 564.82 | 35.21 | 8.00 | 8.00 | 282 |
| 578.59 | 90 | 578.59 | 13.77 | 9.00 | 8.50 | 117 |
| 670.43 | 90 | 670.43 | 91.84 | 9.00 | 9.00 | 827 |
| 697.99 | 93 | 697.99 | 27.56 | 12.00 | 10.50 | 289 |
| 705.64 | 92 | 705.64 | 7.65 | 11.00 | 11.50 | 88 |
| 736.25 | 92.152 | 736.25 | 30.61 | 11.15 | 11.08 | 339 |
| 769.93 | 93 | 769.93 | 33.68 | 12.00 | 11.58 | 390 |
| 788.3 | 94.065 | 788.3 | 18.37 | 13.07 | 12.53 | 230 |
| 806.66 | 98 | 806.66 | 18.36 | 17.00 | 15.03 | 276 |
| 854.12 | 100.003 | 854.12 | 47.46 | 19.00 | 18.00 | 854 |
| 862.7 | 102.504 | 862.7 | 8.58 | 21.50 | 20.25 | 174 |
| 896.97 | 107.14 | 896.97 | 34.27 | 26.14 | 23.82 | 816 |
| 945.96 | 107 | 945.96 | 48.99 | 26.00 | 26.07 | 1277 |
| 952.08 | 108 | 952.08 | 6.12 | 27.00 | 26.50 | 162 |
| 996.47 | 108 | 996.47 | 44.39 | 27.00 | 27.00 | 1199 |
| 1036.3 | 110 | 1036.3 | 39.83 | 29.00 | 28.00 | 1115 |
| 1066.9 | 110 | 1066.9 | 30.6 | 29.00 | 29.00 | 887 |
| 1079.1 | 111 | 1079.1 | 12.2 | 30.00 | 29.50 | 360 |
| 1109.7 | 111.009 | 1109.7 | 30.6 | 30.01 | 30.00 | 918 |
| 1115.9 | 112 | 1115.9 | 6.2 | 31.00 | 30.50 | 189 |
| 1167.9 | 112 | 1167.9 | 52 | 31.00 | 31.00 | 1612 |
| 1177.1 | 112.997 | 1177.1 | 9.2 | 32.00 | 31.50 | 290 |
| 1210.8 | 113.028 | 1210.8 | 33.7 | 32.03 | 32.01 | 1079 |
| 1215.4 | 114 | 1215.4 | 4.6 | 33.00 | 32.51 | 150 |
| 1252.1 | 114 | 1252.1 | 36.7 | 33.00 | 33.00 | 1211 |
| 1259.7 | 115 | 1259.7 | 7.6 | 34.00 | 33.50 | 255 |
| 1287.3 | 115 | 1287.3 | 27.6 | 34.00 | 34.00 | 938 |
| 1324 | 118 | 1324 | 36.7 | 37.00 | 35.50 | 1303 |
| 1359.2 | 119.074 | 1359.2 | 35.2 | 38.07 | 37.54 | 1321 |
| 1377.6 | 124.098 | 1377.6 | 18.4 | 43.10 | 40.59 | 747 |
| 1402.1 | 129.132 | 1402.1 | 24.5 | 48.13 | 45.62 | 1118 |
| 1438.8 | 151.275 | 1438.8 | 36.7 | 70.28 | 59.20 | 2173 |
| 1455.7 | 156.514 | 1455.7 | 16.9 | 75.51 | 72.89 | 1232 |
| 1472.5 | 158 | 1472.5 | 16.8 | 77.00 | 76.26 | 1281 |
| 1507.7 | 166.15 | 1507.7 | 35.2 | 85.15 | 81.08 | 2854 |
| 1539.9 | 187.072 | 1539.9 | 32.2 | 106.07 | 95.61 | 3079 |
| 1565.9 | 190.423 | 1565.9 | 26 | 109.42 | 107.75 | 2801 |
| TOTAL | 109.42 | 1565.9 | 1565.9 | | | 36164.899 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 190.42 |
| Min Elevation (mRL) | 81.00 |
| Δ Elevation (m) | 109.42 |
| Main Channel Slope | 0.029 |
| | 2.9% |

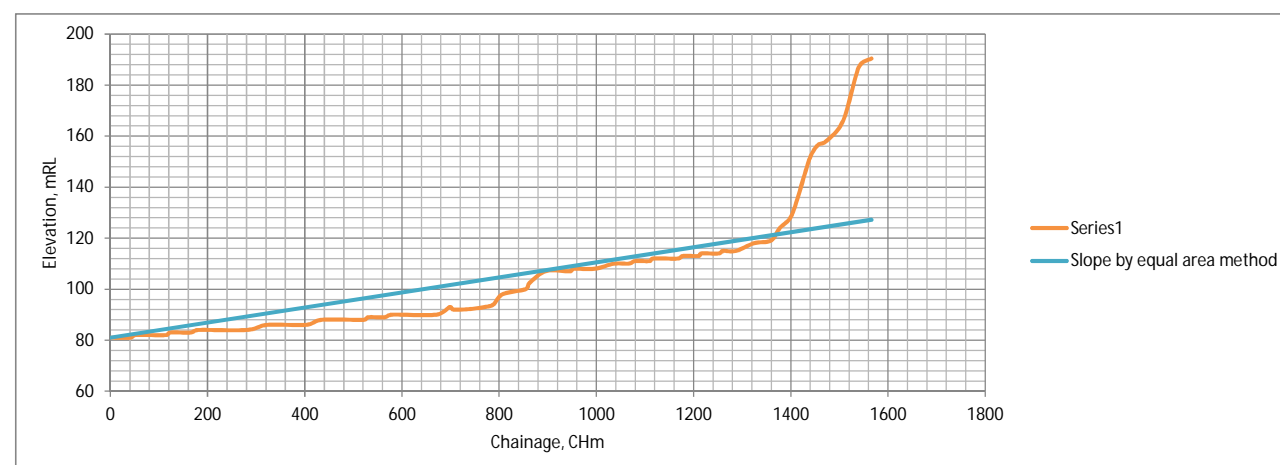
$$Slope = S_c = \frac{2A}{(a \cdot Dx)^2}$$

Time of Concentration

| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.36 | 21.8 | 1.2 |
| Bransby-Williams | 0.64 | 38.1 | 0.7 |
| ARC TP108 | 0.74 | 44.6 | 0.6 |
| US Soil Conservation | 0.26 | 15.7 | 1.7 |

Selected Time of concentration **44.6** minutes

| Method | Formula | Parameter definitions |
|---------------------------------|--|---|
| Ramser-Kirpich | $T_c = 0.0195 L^{0.77} S_c^{-0.385}$ | S _a = average channel slope (m/m) L = maximum flow length (m) |
| Bransby - Williams | $T_c = (0.953 L^{1.2}) / (A^{0.2} H^{0.2})$ | 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 | $T_c = 0.14CL^{0.86} (CN/(200-CN))^{0.35} S_c^{-0.33}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |



TP108 - PRE-DEVELOPMENT

Project: Polaris Landfill Design By: AFRE Date: 12/11/18
 Location: Pre development landfill catchment area Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 104.40 | 7,517 |
| | Bush | 70 | 0.00 | 0 |
| | Grass | 74 | 0.00 | 0 |
| | Subtotal for Pervious Areas | | 104.40 | 7,517 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 0.00 | 0 |
| | Paved | 98 | 0.00 | 0 |
| | Subtotal for Impervious Areas | | 0.00 | 0 |
| | Totals | | 104.40 | 7,517 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,517}{104.40} = 72$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 104.4}{104.40} = 5.00 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 1 (from Table 4.2)
 Catchment Length : L = 1.566 km (along drainage path)
 Catchment Slope : Sc = 0.029 m/m
 Runoff Factor R : $\frac{CN}{200 - CN} = 0.56$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{0.55} S_c^{-0.30} = 0.74 \text{ hrs} = 44.60 \text{ mins}$
 SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.50 \text{ hrs} = 29.7 \text{ mins}$

3. Soil Storage Parameter : $S = ((1000/CN)-10) \times 25.4$
 Total = 98.8 mm
 Pervious = 98.8 mm
 Impervious = #DIV/0! mm

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)


8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3\text{/s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3\text{)}$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 |
|--|------------|----------|----------|----------|----------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 |
| Runoff Index, c* | 0.33 | 0.45 | 0.57 | 0.09 | 0.14 |
| Specific Peak Flow Rate, q* | 0.051 | 0.065 | 0.077 | 0.016 | 0.024 |
| Peak Flow Rate, q _p (m ³ /s) | 5.79 | 11.73 | 21.86 | 0.50 | 1.04 |
| Runoff Depth, Q ₂₄ (mm) | 52.6 | 104.9 | 194.9 | 5.0 | 10.1 |
| | Impervious | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Runoff Volume, V ₂₄ (m ³) | 54,891 | 109,551 | 203,472 | 5,272 | 10,526 |
| | Impervious | 000 | 000 | 000 | 000 |
| Total | 54,891 | 109,551 | 203,472 | 5,272 | 10,526 |

11. Link to catchment area: [Wetland catchment area plan.pdf](#)

| LANDFILL POST DEVELOPMENT STAGE 3 - EQUAL AREA SLOPE | | | |
|---|---------------------------------|----------|---------------------------------|
|  | | Project: | Polaris Landfill Design Project |
| | | | |
| Details: | Post dev stage 3 landfill slope | Job No: | 1005069.1140 |
| Computed: | AFRE | Date: | 26/10/2018 |
| Checked: | JAAH | Date: | 29/11/2018 |

Notes:

Information extracted from Tin CAP03 on Global mapper- WAYBE file.

Catchment slope taken from within the landfill extent for pre- and post development scenarios to be conservative

| Catchment Characteristics | |
|------------------------------|------------------------------|
| Catchment (km ²) | 1.04 |
| CN | 74 |
| Channel Factor | 0.8 <i>(Grassed channel)</i> |

Slope Characteristics

| Chainage | Elevation (mRL) | X (m) | dX (m) | h (m) | Avg. h (m) | Δ A (m ²) |
|----------|-----------------|----------|----------|-------|------------|-----------------------|
| 0 | 92.36234 | 0 | 0 | 0.00 | | |
| 51.05898 | 92.36089 | 51.05898 | 51.05898 | 0.00 | 0.00 | 0 |
| 56.63955 | 92.4398 | 56.63955 | 5.58057 | 0.08 | 0.04 | 0 |
| 66.63955 | 92.97591 | 66.63955 | 10 | 0.61 | 0.35 | 3 |
| 76.05278 | 93.94356 | 76.05278 | 9.41323 | 1.58 | 1.10 | 10 |
| 103.2224 | 97.38443 | 103.2224 | 27.16962 | 5.02 | 3.30 | 90 |
| 112.6891 | 98.75503 | 112.6891 | 9.4667 | 6.39 | 5.71 | 54 |
| 135.2839 | 101.6163 | 135.2839 | 22.5948 | 9.25 | 7.82 | 177 |
| 145.0553 | 102.3688 | 145.0553 | 9.7714 | 10.01 | 9.63 | 94 |
| 160.2839 | 102.9365 | 160.2839 | 15.2286 | 10.57 | 10.29 | 157 |
| 166.4977 | 103.8194 | 166.4977 | 6.2138 | 11.46 | 11.02 | 68 |
| 267.592 | 123.3083 | 267.592 | 101.0943 | 30.95 | 21.20 | 2143 |
| 273.6172 | 124.159 | 273.6172 | 6.0252 | 31.80 | 31.37 | 189 |
| 277.592 | 124.3798 | 277.592 | 3.9748 | 32.02 | 31.91 | 127 |
| 303.9219 | 124.9463 | 303.9219 | 26.3299 | 32.58 | 32.30 | 850 |
| 310.2839 | 125.4035 | 310.2839 | 6.362 | 33.04 | 32.81 | 209 |
| 330.8905 | 128.7717 | 330.8905 | 20.6066 | 36.41 | 34.73 | 716 |
| 425.1547 | 145.7212 | 425.1547 | 94.2642 | 53.36 | 44.88 | 4231 |
| 434.9096 | 146.7109 | 434.9096 | 9.7549 | 54.35 | 53.85 | 525 |
| 457.5351 | 147.0605 | 457.5351 | 22.6255 | 54.70 | 54.52 | 1234 |
| 504.8958 | 147.9894 | 504.8958 | 47.3607 | 55.63 | 55.16 | 2613 |
| 576.1135 | 149.3005 | 576.1135 | 71.2177 | 56.94 | 56.28 | 4008 |
| 600.8004 | 149.7081 | 600.8004 | 24.6869 | 57.35 | 57.14 | 1411 |
| 725.7635 | 152.0087 | 725.7635 | 124.9631 | 59.65 | 58.50 | 7310 |
| 758.733 | 152.5531 | 758.733 | 32.9695 | 60.19 | 59.92 | 1975 |
| 861.0267 | 154.4363 | 861.0267 | 102.2937 | 62.07 | 61.13 | 6253 |
| 951.613 | 156.213 | 951.613 | 90.5863 | 63.85 | 62.96 | 5704 |
| 1088.346 | 158.7135 | 1088.346 | 136.733 | 66.35 | 65.10 | 8901 |
| 1180.772 | 160.2811 | 1180.772 | 92.426 | 67.92 | 67.13 | 6205 |
| 1242.661 | 161.4201 | 1242.661 | 61.889 | 69.06 | 68.49 | 4239 |
| 1281.787 | 162.0258 | 1281.787 | 39.126 | 69.66 | 69.36 | 2714 |
| 1314.27 | 162.4388 | 1314.27 | 32.483 | 70.08 | 69.87 | 2270 |
| 1426.075 | 163.6678 | 1426.075 | 111.805 | 71.31 | 70.69 | 7904 |
| 1472.398 | 164.1369 | 1472.398 | 46.323 | 71.77 | 71.54 | 3314 |
| 1541.916 | 164.8898 | 1541.916 | 69.518 | 72.53 | 72.15 | 5016 |
| 1561.916 | 165.3751 | 1561.916 | 20 | 73.01 | 72.77 | 1455 |
| 1581.916 | 166.3231 | 1581.916 | 20 | 73.96 | 73.49 | 1470 |
| 1606.478 | 167.9717 | 1606.478 | 24.562 | 75.61 | 74.79 | 1837 |
| 1629.25 | 169.3776 | 1629.25 | 22.772 | 77.02 | 76.31 | 1738 |
| 1692.432 | 173.7266 | 1692.432 | 63.182 | 81.36 | 79.19 | 5003 |
| 1731.929 | 176.1549 | 1731.929 | 39.497 | 83.79 | 82.58 | 3262 |
| 1786.287 | 179.8966 | 1786.287 | 54.358 | 87.53 | 85.66 | 4656 |
| 1816.633 | 181.77 | 1816.633 | 30.346 | 89.41 | 88.47 | 2685 |
| 1877.937 | 185.9898 | 1877.937 | 61.304 | 93.63 | 91.52 | 5610 |
| 1891.612 | 186.8211 | 1891.612 | 13.675 | 94.46 | 94.04 | 1286 |
| 1901.612 | 187.2898 | 1901.612 | 10 | 94.93 | 94.69 | 947 |
| 1921.612 | 187.8742 | 1921.612 | 20 | 95.51 | 95.22 | 1904 |
| 1932.537 | 188.0085 | 1932.537 | 10.925 | 95.65 | 95.58 | 1044 |
| 2191.95 | 190.6084 | 2191.95 | 259.413 | 98.25 | 96.95 | 25149 |
| 2197.441 | 190.6359 | 2197.441 | 5.491 | 98.27 | 98.26 | 540 |
| TOTAL | 98.28 | 2197.441 | 2197.441 | | | 139299.89 |

Derived Characteristics

| | |
|---------------------|--------|
| Max Elevation (mRL) | 190.64 |
| Min Elevation (mRL) | 92.36 |
| Δ Elevation (m) | 98.28 |
| Main Channel Slope | 0.058 |
| | 5.8% |

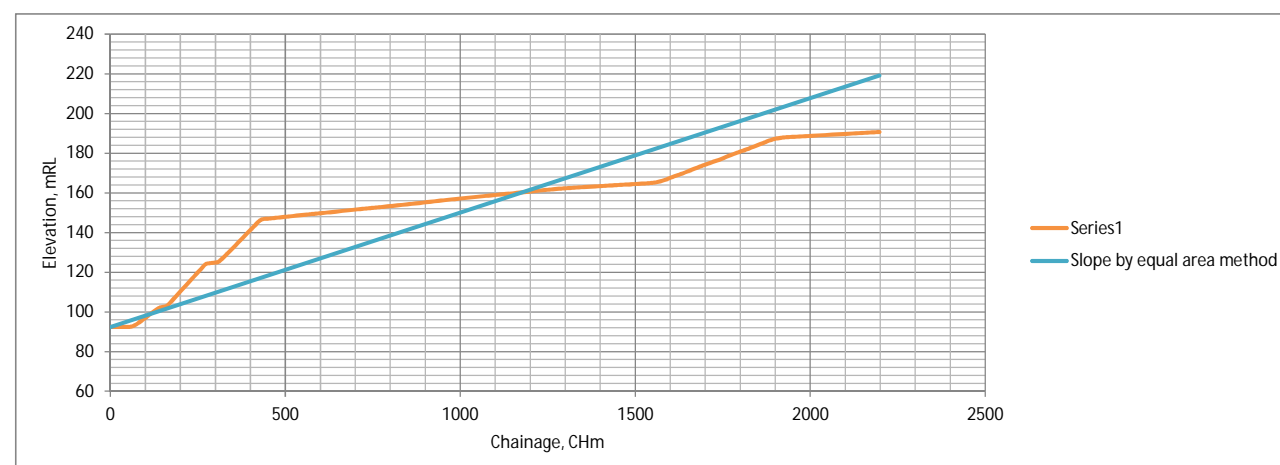
$$Slope = S_c = \frac{2A}{(a \cdot Dx)^2}$$

Time of Concentration

| Method | Time (Hours) | Time (Minutes) | Avg. V (m/s) |
|----------------------|--------------|----------------|--------------|
| Ramser-Kirpich | 0.36 | 21.9 | 1.7 |
| Bransby-Williams | 0.98 | 58.5 | 0.6 |
| ARC TP108 | 0.60 | 35.8 | 1.0 |
| US Soil Conservation | 0.40 | 24.1 | 1.5 |

Selected Time of concentration **35.8** 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 | $T_c = (0.953 L^{1.2}) / (A^{0.2} H^{0.2})$ | 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 | $T_c = 0.14CL^{0.86} (CN/(200-CN))^{0.35} S_c^{-0.33}$ | 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 | $T_c = (0.87 L^2 / H)^{0.385}$ | L = maximum flow length (km) H = the difference in elevation between the highest and lowest points in the study area (m) |



TP108 - POST-DEVELOPMENT STAGE 3

Project: Polaris Landfill Design By: AFRE Date: 12/11/18

Location: Finished Stage 3 Checked: JAAH Date: 29/11/18

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 |
|------------------------------|---|------------------|-----------------|----------------------|
| Group C | <i>Pervious area</i> | | | |
| | Plantation forestry | 72 | 0.00 | 0 |
| | Bush | 70 | 39.18 | 2,743 |
| | Grass | 74 | 58.50 | 4,329 |
| | Subtotal for Pervious Areas | | 97.68 | 7,072 |
| | <i>Impervious Area</i> | | | |
| | Gravel | 89 | 5.45 | 485 |
| | Paved | 98 | 1.26 | 124 |
| | Subtotal for Impervious Areas | | 6.72 | 609 |
| | | Totals | 104.40 | 7,681 |

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{7,681}{104.40} = 74$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 97.682}{104.40} = 4.68 \text{ mm}$

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 2.197 km (along drainage path)

Catchment Slope : Sc = 0.058 m/m

Runoff Factor R : $\frac{\text{CN}}{200 - \text{CN}} = 0.58$

Time of Concentration : $t_c = 0.14 C L^{0.66} R^{-0.55} S_c^{-0.30} = 0.60 \text{ hrs} = 35.81 \text{ mins}$

SCS Lag for HEC-HMS : $t_p = 2/3 t_c = 0.40 \text{ hrs} = 23.9 \text{ mins}$

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

| | | | |
|------------|---|------|----|
| Total | = | 91.2 | mm |
| Pervious | = | 96.9 | mm |
| Impervious | = | 26 | mm |

4. Average Recurrence Interval, ARI (yr) :

5. 24 hour Rainfall Depth, P₂₄ (mm), (from Appendix A)

6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$

7. Specific Peak Flow Rate, q*, (from Figure 5.1)

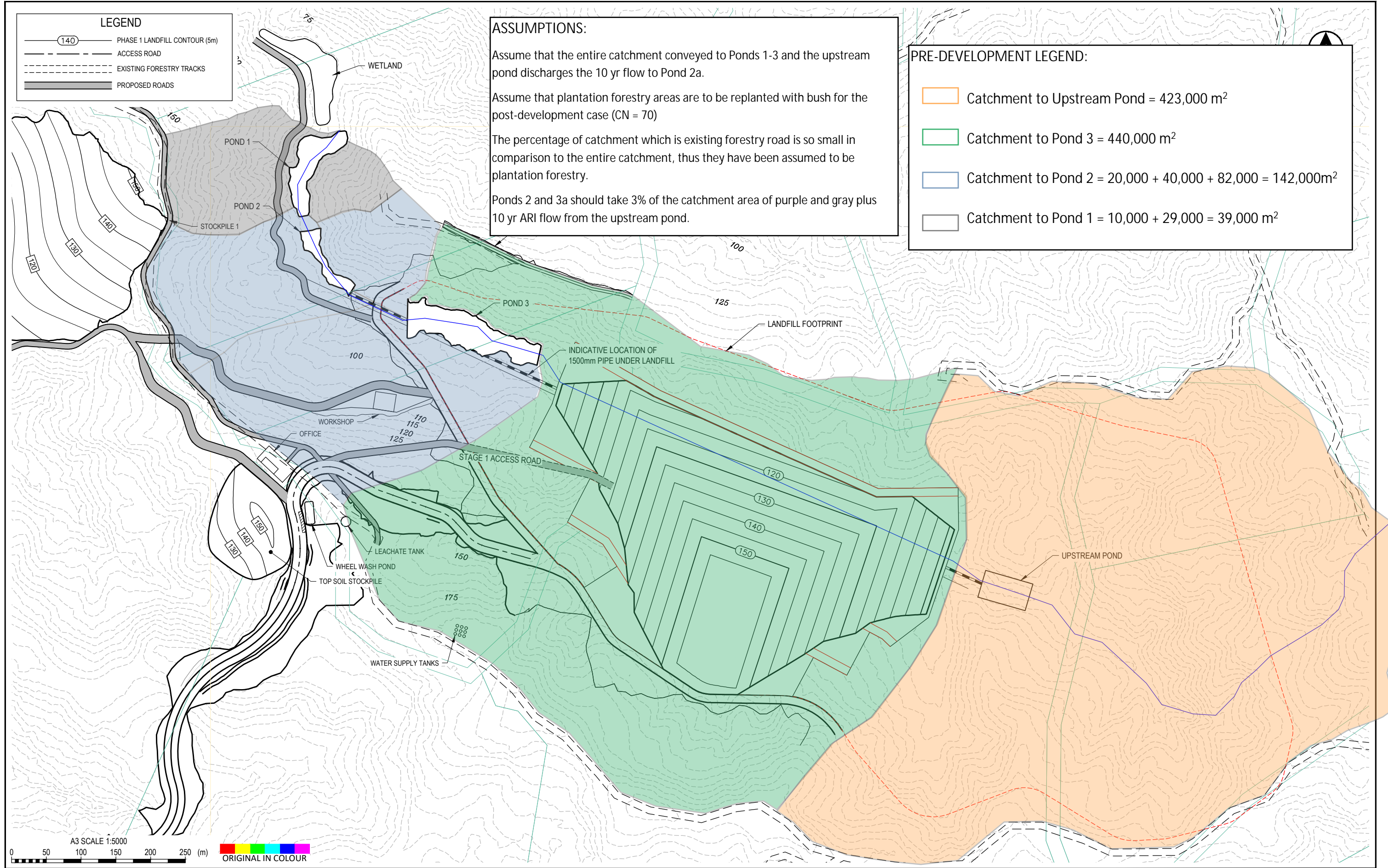
8. Peak Flow Rate, q_p : $= q^* A P_{24} \text{ (m}^3/\text{s)}$

9. Runoff Depth, Q₂₄ : $= \frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S} \text{ (mm)}$

10. Runoff Volume, V₂₄ : $= 1000 \times Q_{24} A \text{ (m}^3)$

| | Storm #1 | Storm #2 | Storm #3 | Storm #4 | Storm #5 |
|--|----------|----------|----------|----------|----------|
| ARI (yr) | 2 | 10 | 100 | 90% | 95% |
| P ₂₄ (mm) | 108 | 172 | 272 | 30 | 42 |
| Runoff Index, c* | 0.35 | 0.47 | 0.59 | 0.10 | 0.15 |
| Specific Peak Flow Rate, q* | 0.060 | 0.075 | 0.088 | 0.020 | 0.029 |
| Peak Flow Rate, q _p (m ³ /s) | 6.73 | 13.45 | 24.95 | 0.61 | 1.25 |
| Runoff Depth, Q ₂₄ (mm) | | | | | |
| Pervious | 53.1 | 105.7 | 195.9 | 5.1 | 10.2 |
| Impervious | 87.0 | 149.4 | 248.2 | 16.1 | 25.9 |
| Runoff Volume, V ₂₄ (m ³) | | | | | |
| Pervious | 51,854 | 103,250 | 191,388 | 5,010 | 9,991 |
| Impervious | 5,845 | 10,034 | 16,675 | 1,078 | 1,741 |
| Total | 57,699 | 113,284 | 208,063 | 6,089 | 11,732 |

11. Link to catchment area: [Wetland catchment area plan.pdf](#)



LEGEND

- 140 PHASE 1 LANDFILL CONTOUR (5m)
- ACCESS ROAD
- - - - EXISTING FORESTRY TRACKS
- ▬ PROPOSED ROADS

ASSUMPTIONS:

Assume that the entire catchment conveyed to Ponds 1-3 and the upstream pond discharges the 10 yr flow to Pond 2a.

Assume that plantation forestry areas are to be replanted with bush for the post-development case (CN = 70)

The percentage of catchment which is existing forestry road is so small in comparison to the entire catchment, thus they have been assumed to be plantation forestry.

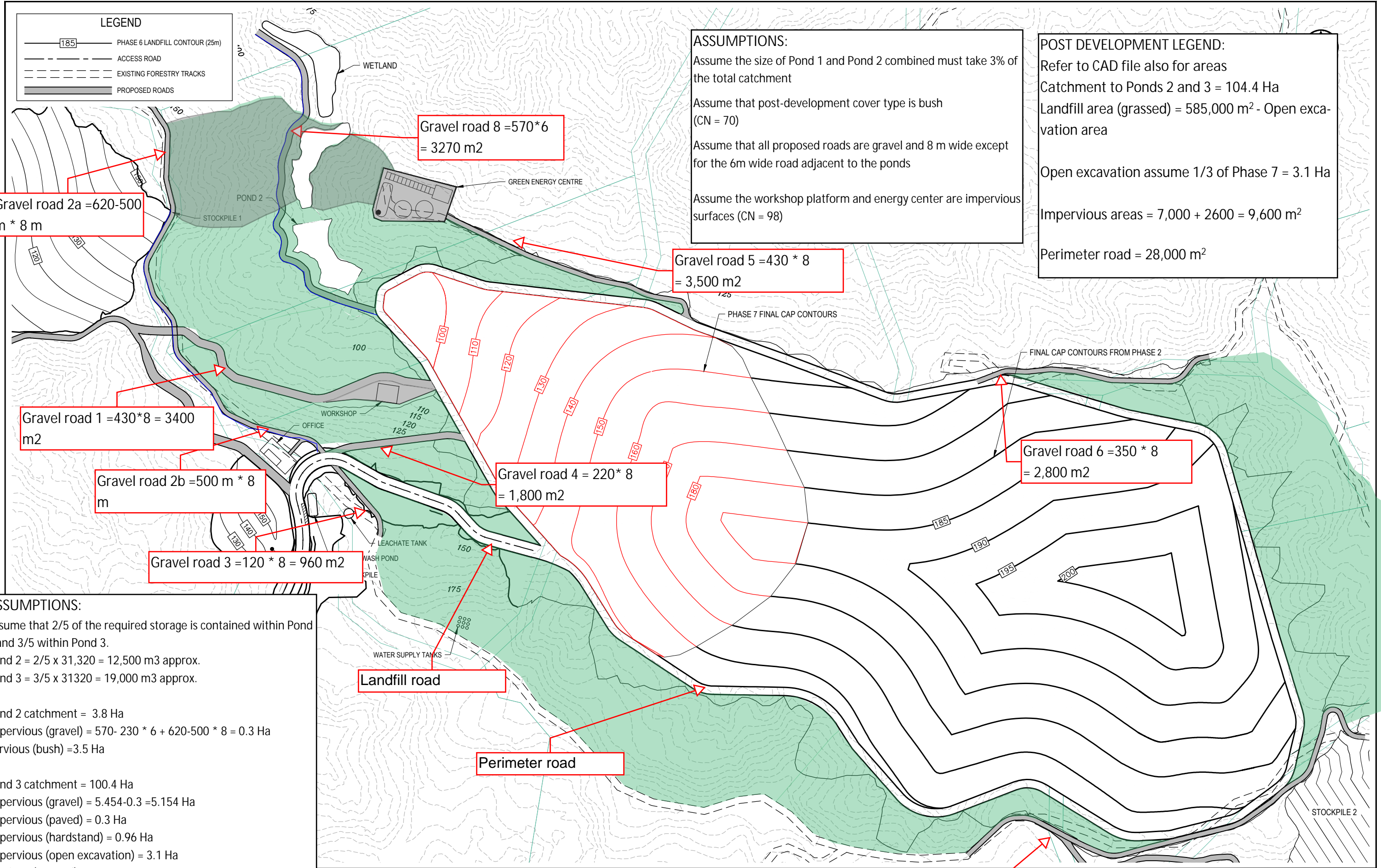
Ponds 2 and 3a should take 3% of the catchment area of purple and gray plus 10 yr ARI flow from the upstream pond.

PRE-DEVELOPMENT LEGEND:

- Catchment to Upstream Pond = 423,000 m²
- Catchment to Pond 3 = 440,000 m²
- Catchment to Pond 2 = 20,000 + 40,000 + 82,000 = 142,000m²
- Catchment to Pond 1 = 10,000 + 29,000 = 39,000 m²



| | | | |
|--|--|---|--|
| <p>Exceptional thinking together www.tonkintaylor.co.nz</p> | <h2 style="margin: 0;">PRE-DEVELOPMENT POND AND WETLAND CATCHMENT AREAS</h2> | <p>PROJECT No. 1005069</p> | <p>CLIENT WASTE MANAGEMENT NZ LTD</p> |
| | <p>DESIGNED AGBB Jun.18</p> <p>DRAWN TORY Aug.18</p> <p>CHECKED</p> | <p>PROJECT</p> | |
| | <p>APPROVED _____ DATE _____</p> | <p>TITLE STORMWATER PHASE 2 - PLAN</p> | |
| | | <p>SCALE (A3) 1:5000</p> | <p>FIG No. ENG-40</p> |
| | | <p>REV 1</p> | |



ASSUMPTIONS:
 Assume the size of Pond 1 and Pond 2 combined must take 3% of the total catchment
 Assume that post-development cover type is bush (CN = 70)
 Assume that all proposed roads are gravel and 8 m wide except for the 6m wide road adjacent to the ponds
 Assume the workshop platform and energy center are impervious surfaces (CN = 98)

POST DEVELOPMENT LEGEND:
 Refer to CAD file also for areas
 Catchment to Ponds 2 and 3 = 104.4 Ha
 Landfill area (grassed) = 585,000 m² - Open excavation area
 Open excavation assume 1/3 of Phase 7 = 3.1 Ha
 Impervious areas = 7,000 + 2600 = 9,600 m²
 Perimeter road = 28,000 m²

ASSUMPTIONS:
 Assume that 2/5 of the required storage is contained within Pond 2 and 3/5 within Pond 3.
 Pond 2 = 2/5 x 31,320 = 12,500 m³ approx.
 Pond 3 = 3/5 x 31320 = 19,000 m³ approx.

Pond 2 catchment = 3.8 Ha
 Impervious (gravel) = 570- 230 * 6 + 620-500 * 8 = 0.3 Ha
 Pervious (bush) = 3.5 Ha

Pond 3 catchment = 100.4 Ha
 Impervious (gravel) = 5.454-0.3 = 5.154 Ha
 Impervious (paved) = 0.3 Ha
 Impervious (hardstand) = 0.96 Ha
 Impervious (open excavation) = 3.1 Ha
 Pervious (grassed) = 55.4-3.1 = 51.5 Ha
 Pervious (bush) = 43.39 Ha

CATCHMENT SLOPE ASSUMED TO BE THE SAME AS POST DEV PHASE 3

POST-DEVELOPED STAGE 3 POND 2 AND 3 CATCHMENT AREAS

| | | | |
|-------------|---------|------------------------|-------------------------|
| PROJECT No. | 1005069 | CLIENT | WASTE MANAGEMENT NZ LTD |
| DESIGNED | | Gravel road 7 = 720*8 | |
| DRAWN | | = 5,800 m ² | |
| CHECKED | | | |
| APPROVED | DATE | SCALE (A3) | 1:5000 |
| | | FIG No. | ENG-42 |
| | | REV | 1 |

| | | | | |
|----------------------------|------------------|----------|-----------|------------|
| Task | Wetland 1 Design | Task No. | Wetland 1 | |
| Wetland and outfall design | | | Initials | |
| | | | Date | |
| | | Design | AFRE | 23/10/2018 |
| | | Checked | RVDM | 21/12/2018 |

| Calculations | | Output | |
|--------------|---|--|--|
| | | Min Req | |
| 1 | Water Quality Volume [m ³] | 6089 | |
| 2 | Depth Co-efficient (between 0.5 and 1.5) | 1.00 | |
| 3 | Is stream protection required? | Y | |
| 4 | Permanent Water Quality Volume (PWV) [m ³] | 3044 | |
| 5 | Permanent water level area [m ²] | 3044 | |
| 6 | Discharging to SMAF? | SMAF1 | |
| 7 | Extended Detention Volume for stream protection (EDV) [m ³] | 1206 | |
| 8 | PWV + EDV | 4250 | |
| 9 | Forebay volume [m ³] (15% PWV) | 913 | |
| 10 | Forebay depth (m) (minimum 1.5 m) | 1.5 | |
| | Forebay area [m ²] | 609 | |
| | Forebay length [m] | 35 | |
| | Forebay width [m] | 17 | |
| 11 | Sediment drying volume [m ³] (10% PWV) | 609 | |
| 12 | Orifice discharge rate (m ³) | 0.025 (maximum) | |
| 10 | Auxiliary spillway width (m) | 7.0 | |
| 11 | Wetland body side slopes | 3:1 (H:V) Above PWL 3:1 (H:V) Below PWL | |
| 12 | Elevation of 3m safety bench (slope break) | Not required | |
| 13 | Elevation of excavator and drying area platforms | 71 mRL | |

| Project constraints / interfaces | |
|----------------------------------|--|
| 1 | The location of the wetland is tightly constrained in all directions by the existing stream to the east and steep slopes to the right. The wetland size has been maximised, however 1V:3H side slopes will need to be adopted below the PWL to achieve the required volumes. |
| 2 | No flood modelling has been used at this stage. Flow rate has been estimated based on the stream catchment using TP108 and a cross section to work out the approximate stream levels. |

| Assumptions | |
|-------------|---|
| 1 | The wetland is designed to convey the PWQV and EDV. All storm events greater than this will discharge directly into the adjacent stream via the bypass channel. |
| 2 | Mannings stream roughness of 0.05 (Type 1.f) has been adopted for the existing stream based on Chow (1959). |
| 3 | Assume the longest contributing catchment length is applicable for the entire catchment |

| Procedure | |
|-----------|--|
| 1 | Use data from TP108 analysis of catchment to determine key parameters for design such as PWQV and EDV. |
| 2 | Design the wetland in accordance with GD01 guidelines. |

| Design Engineer remarks | |
|-------------------------|--|
| 1 | 3:1 slopes have been adopted for the internal side slopes of the forebays. In the body of the wetland 3:1 internal side slopes have been adopted above the PWL and below the PWL as the soil conditions are sufficient to enable a 1V:3H slope based on geotechnical advise. |
| 2 | A 6 m wide access road runs along the upstream side of the wetland |
| 3 | Manhole riser will need to be embedded in the wetland embankment to prevent floating. Extra concrete may need to be added in the base. |
| 4 | As the wetland is situated in private land, there will be no access to the public. Therefore, a 3 m safety bench around the wetland has not been provided |

| Checking Engineer remarks | |
|---------------------------|--|
| 1 | |
| 2 | |
| 3 | |

GD01- Wetland 1

Project: *Polaris landfill design* By: AFRE Date: 05/12/18
 Location: *Dome valley* Checked: RVDM Date: 21/12/18

1. Pond Volumes :

| Level | Depth | Area (m2) | | | Vol (m3) | | |
|-------|-------|-----------|---------|-----------|--------------|----------------------------|-----------|
| | | mRL | m | Forebay 1 | Main Wetland | Wetland + Forebay Combined | Forebay 1 |
| 68.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 68.10 | 0.10 | 404.49 | 0.00 | 404.49 | 38.97 | 0.00 | 38.97 |
| 68.20 | 0.20 | 434.58 | 0.00 | 434.58 | 80.92 | 0.00 | 80.92 |
| 68.30 | 0.30 | 465.36 | 0.00 | 465.36 | 125.91 | 0.00 | 125.91 |
| 68.40 | 0.40 | 496.82 | 0.00 | 496.82 | 174.02 | 0.00 | 174.02 |
| 68.50 | 0.50 | 528.98 | 0.00 | 528.98 | 225.30 | 0.00 | 225.30 |
| 68.60 | 0.60 | 561.84 | 249.22 | 811.06 | 279.84 | 249.22 | 529.05 |
| 68.70 | 0.70 | 595.37 | 506.85 | 1102.23 | 337.69 | 506.85 | 844.54 |
| 68.80 | 0.80 | 629.60 | 772.97 | 1402.57 | 398.93 | 772.97 | 1171.90 |
| 68.90 | 0.90 | 664.53 | 1047.62 | 1712.14 | 463.63 | 1047.62 | 1511.25 |
| 69.00 | 1.00 | 700.14 | 1330.87 | 2031.01 | 531.86 | 1330.87 | 1862.73 |
| 69.10 | 1.10 | 736.45 | 1622.78 | 2359.24 | 603.69 | 1622.78 | 2226.47 |
| 69.20 | 1.20 | 773.46 | 1923.42 | 2696.88 | 679.18 | 1923.42 | 2602.60 |
| 69.30 | 1.30 | 811.26 | 2232.85 | 3044.11 | 758.40 | 2232.85 | 2991.25 |
| 69.40 | 1.40 | 849.83 | 2551.15 | 3400.98 | 841.45 | 2551.15 | 3392.60 |
| 69.50 | 1.50 | 894.48 | 2879.33 | 3773.80 | 929.36 | 2879.33 | 3808.69 |
| 69.60 | 1.60 | 925.43 | 3215.60 | 4141.03 | 1020.36 | 3215.60 | 4235.96 |
| 69.70 | 1.70 | 956.67 | 3560.01 | 4516.68 | 1114.46 | 3560.01 | 4674.46 |
| 69.80 | 1.80 | 988.19 | 3912.56 | 4900.75 | 1211.70 | 3912.56 | 5124.26 |
| 69.90 | 1.90 | 1020.00 | 4273.30 | 5293.29 | 1312.11 | 4273.30 | 5585.40 |
| 70.00 | 2.00 | 1052.09 | 4642.24 | 5694.33 | 1415.71 | 4642.24 | 6057.95 |

note: wetland dimensions from 12D 5/12/18

2. Water Quality Treatment Design :

| | | | Minimum Req. | |
|---|----------------------|---|--------------|----------------|
| Assumed Depth of Permanent Water Quality Volume : | d | = | na | m |
| Top Elevation of Permanent Water Quality Volume : | H | = | 69.31 | mRL |
| Water Quality Volume (from Post-Dev. TP108) : | V _d | = | 6,089 | m ³ |
| Permanent Water Quality Volume (PWQV=WQV/2) : | V _{d(perm)} | = | 3,044 | m ³ |
| Total Forebay Volume Requirement (15%PWQV): | V _{forebay} | = | 913 | m ³ |
| Permanent Water level area : | A | = | 3,052 | m ² |
| Forebay area : | A _{forebay} | = | 610 | m ² |

3a.

Extended Detention Outlet Design :

| | | | | |
|---|----------------------|---|--------|---------------------|
| Extended Detention Volume (from Post-Dev. TP108) : | EDV | = | 1,206 | m ³ |
| Average Discharge (Q _{avg} =EDV/24hr): | Q _{avg} | = | 0.0140 | m ³ /sec |
| Top Elevation of EDV (level at PWQV+EDV) : | MH | = | 69.60 | m |
| Height of Extended Detention Volume : | MH | = | 0.29 | m |
| Maximum Discharge (Q _{max} =2*Q _{avg}) : | Q _{max} | = | 0.0279 | m ³ /sec |
| Selected Orifice Diameter : | d _{orifice} | = | 0.16 | m |
| Orifice Discharge Rate (Orifice equation) : | Q _i | = | 0.0253 | m ³ /sec |

OK

3b. Calculate the max wetland discharge assuming the max discharge = Average discharge over 24 hrs x 2

| | | | |
|---|---|--------|---------------------|
| PWQV +EDV | = | 7294.3 | m ³ |
| Average Discharge (Q _{avg} =EDV/24hr): | = | 0.08 | m ³ /sec |
| Maximum Discharge (Q _{max} =2*Q _{avg}) : | = | 0.17 | m ³ /sec |

4 Spillway - Check if the pipe is 100% blocked the spillway can take the PWQV + EDV

| | | | | |
|-------------------------------------|---------------------|---|------|---------------------|
| Max wetland inflow*: | Q _{pw +ed} | = | 1.86 | m ³ /sec |
| Depth over weir: | h | = | 0.30 | m |
| Width of Emergency Spillway | w | = | 6.30 | m |
| Adopted width of Emergency Spillway | w | = | 7.00 | m |
| Velocity | v | = | 0.99 | m/sec |

* The wetland has been designed to hold the PWQV + EDV, in larger storm events it is predicted that the water will bypass the wetland and be conveyed directly into the neighbouring stream