

WATER

26 Attachment 3

Township of Londonderry

Appendix C

Stormwater Management Design Criteria

Table C-1 - Rational Method Runoff Coefficients

Hydrologic Soil Group and Slope Range

| Land Use             | A                 |         |      | B       |         |      | C       |         |      | D       |         |      |
|----------------------|-------------------|---------|------|---------|---------|------|---------|---------|------|---------|---------|------|
|                      | 0 to 2%           | 2 to 6% | 6+%  | 0 to 2% | 2 to 6% | 6+%  | 0 to 2% | 2 to 6% | 6+%  | 0 to 2% | 2 to 6% | 6+%  |
| Cultivated Land      | 0.08 <sup>a</sup> | 0.13    | 0.16 | 0.11    | 0.15    | 0.21 | 0.14    | 0.19    | 0.26 | 0.18    | 0.23    | 0.31 |
|                      | 0.14 <sup>b</sup> | 0.18    | 0.22 | 0.16    | 0.21    | 0.28 | 0.20    | 0.25    | 0.34 | 0.24    | 0.29    | 0.41 |
| Pasture              | 0.12              | 0.20    | 0.30 | 0.18    | 0.28    | 0.37 | 0.24    | 0.34    | 0.44 | 0.30    | 0.40    | 0.50 |
|                      | 0.15              | 0.25    | 0.37 | 0.23    | 0.34    | 0.45 | 0.30    | 0.42    | 0.52 | 0.37    | 0.50    | 0.62 |
| Meadow               | 0.10              | 0.16    | 0.25 | 0.14    | 0.22    | 0.30 | 0.20    | 0.28    | 0.36 | 0.24    | 0.30    | 0.40 |
|                      | 0.14              | 0.22    | 0.30 | 0.20    | 0.28    | 0.37 | 0.26    | 0.35    | 0.44 | 0.30    | 0.40    | 0.50 |
| Forest               | 0.05              | 0.08    | 0.11 | 0.08    | 0.11    | 0.14 | 0.10    | 0.13    | 0.16 | 0.12    | 0.16    | 0.20 |
|                      | 0.08              | 0.11    | 0.14 | 0.10    | 0.14    | 0.18 | 0.12    | 0.16    | 0.20 | 0.15    | 0.20    | 0.25 |
| Residential 1/8 acre | 0.25              | 0.28    | 0.31 | 0.27    | 0.30    | 0.35 | 0.30    | 0.33    | 0.38 | 0.33    | 0.36    | 0.42 |
|                      | 0.33              | 0.37    | 0.40 | 0.35    | 0.39    | 0.44 | 0.38    | 0.42    | 0.49 | 0.41    | 0.45    | 0.54 |
| Residential 1/4 acre | 0.22              | 0.26    | 0.29 | 0.24    | 0.29    | 0.33 | 0.27    | 0.31    | 0.36 | 0.30    | 0.34    | 0.40 |
|                      | 0.30              | 0.34    | 0.37 | 0.33    | 0.37    | 0.42 | 0.36    | 0.40    | 0.47 | 0.38    | 0.42    | 0.52 |
| Residential 1/3 acre | 0.19              | 0.23    | 0.26 | 0.22    | 0.26    | 0.30 | 0.25    | 0.29    | 0.34 | 0.28    | 0.32    | 0.39 |
|                      | 0.28              | 0.32    | 0.35 | 0.30    | 0.35    | 0.39 | 0.33    | 0.38    | 0.45 | 0.36    | 0.40    | 0.50 |
| Residential 1/2 acre | 0.16              | 0.20    | 0.24 | 0.19    | 0.23    | 0.28 | 0.22    | 0.27    | 0.32 | 0.26    | 0.30    | 0.37 |
|                      | 0.25              | 0.29    | 0.32 | 0.28    | 0.32    | 0.36 | 0.31    | 0.35    | 0.42 | 0.34    | 0.38    | 0.48 |
| Residential 1 acre   | 0.14              | 0.19    | 0.22 | 0.17    | 0.21    | 0.26 | 0.20    | 0.25    | 0.31 | 0.24    | 0.29    | 0.35 |
|                      | 0.22              | 0.26    | 0.29 | 0.24    | 0.28    | 0.34 | 0.28    | 0.32    | 0.40 | 0.31    | 0.35    | 0.46 |
| Industrial           | 0.67              | 0.68    | 0.68 | 0.68    | 0.68    | 0.69 | 0.68    | 0.69    | 0.69 | 0.69    | 0.69    | 0.70 |
|                      | 0.85              | 0.85    | 0.86 | 0.85    | 0.86    | 0.86 | 0.86    | 0.86    | 0.87 | 0.86    | 0.86    | 0.88 |
| Commercial           | 0.71              | 0.71    | 0.72 | 0.71    | 0.72    | 0.72 | 0.72    | 0.72    | 0.72 | 0.72    | 0.72    | 0.72 |
|                      | 0.88              | 0.88    | 0.89 | 0.89    | 0.89    | 0.89 | 0.89    | 0.89    | 0.90 | 0.89    | 0.89    | 0.90 |
| Streets              | 0.70              | 0.71    | 0.72 | 0.71    | 0.72    | 0.74 | 0.72    | 0.73    | 0.76 | 0.73    | 0.75    | 0.78 |
|                      | 0.76              | 0.77    | 0.79 | 0.80    | 0.82    | 0.84 | 0.84    | 0.85    | 0.89 | 0.89    | 0.91    | 0.95 |
| Open Space           | 0.05              | 0.10    | 0.14 | 0.08    | 0.13    | 0.19 | 0.12    | 0.17    | 0.24 | 0.16    | 0.21    | 0.28 |
|                      | 0.11              | 0.16    | 0.20 | 0.14    | 0.19    | 0.26 | 0.18    | 0.23    | 0.32 | 0.22    | 0.27    | 0.39 |
| Parking              | 0.85              | 0.86    | 0.87 | 0.85    | 0.86    | 0.87 | 0.85    | 0.86    | 0.87 | 0.85    | 0.86    | 0.87 |
|                      | 0.95              | 0.96    | 0.97 | 0.95    | 0.96    | 0.97 | 0.95    | 0.96    | 0.97 | 0.95    | 0.96    | 0.97 |

NOTES:

<sup>a</sup> Runoff coefficients for storm recurrence intervals less than 25 years.

<sup>b</sup> Runoff coefficients for storm recurrence intervals of 25 years or more.

Source: Rawls, W.J., S.L. Long, and R.H. McCuen, 1981. Comparison of Urban Flood Frequency Procedures. Preliminary Draft Report prepared for the Soil Conservation Service, Beltsville, Maryland.

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**Table C-2 - Runoff Curve Numbers (from NRCS (SCS) TR-55)**

**Runoff Curve Numbers for Urban Areas**

| Cover Description                                    |  | Curve Numbers for Hydrologic Soil Groups |    |    |    |
|--|--|--|----|----|----|
|  |  | A  | B  | C  | D  |
| <b>Cover Type and Hydrologic Condition</b>           | <b>Average Percent Impervious Area</b> |  |    |    |    |
| Fully Developed Urban Areas (Vegetation Established) |  |  |    |    |    |
| Open Space (lawns, parks, golf courses, etc):        |  |  |    |    |    |
| Poor Condition (grass cover < 50%)                   |  | 68                                       | 79 | 86 | 89 |
| Fair Condition (grass cover 50% to 75%)              |  | 49                                       | 69 | 79 | 84 |
| Good Condition (grass cover > 75%)                   |  | 39                                       | 61 | 74 | 80 |
| Impervious Areas:                                    |  |  |    |    |    |
| Paved Parking Lots, Roofs, Driveways, etc.           |  | 98                                       | 98 | 98 | 98 |
| Streets and Roads:                                   |  |  |    |    |    |
| Paved: Curbed and Storm Sewers                       |  | 98                                       | 98 | 98 | 98 |
| Paved: Open Ditches                                  |  | 83                                       | 89 | 92 | 93 |
| Gravel   |  | 76                                       | 85 | 89 | 91 |
| Dirt   |  | 72                                       | 82 | 87 | 89 |
| Urban Districts:                                     |  |  |    |    |    |
| Commercial and Business                              | 85%                                    | 89                                       | 92 | 94 | 95 |
| Industrial   | 72%                                    | 81                                       | 88 | 91 | 93 |
| Residential Districts by Average Lot Size:           |  |  |    |    |    |
| 1/8 Acres or less                                    | 65%                                    | 77                                       | 85 | 90 | 92 |
| 1/4 Acre   | 38%                                    | 61                                       | 75 | 83 | 87 |
| 1/3 Acre   | 30%                                    | 57                                       | 72 | 81 | 86 |
| 1/2 Acre   | 25%                                    | 54                                       | 70 | 80 | 85 |
| 1 Acre   | 20%                                    | 51                                       | 68 | 79 | 84 |
| 2 Acres  | 12%                                    | 46                                       | 65 | 77 | 82 |

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## Runoff Curve Numbers for Cultivated Agricultural Lands

| Cover Description                                    |                                  |                      | Curve Numbers for Hydrologic Soil Groups |    |    |    |
|--|----------------------------------|----------------------|--|----|----|----|
| Cover Type   | Treatment                        | Hydrologic Condition | A  | B  | C  | D  |
| Fallow   | Bare Soil                        | --                   | 77                                       | 86 | 91 | 94 |
|  | Crop Residue Cover (CR)          | Poor                 | 76                                       | 85 | 90 | 93 |
|  |                                  | Good                 | 74                                       | 83 | 88 | 90 |
| Row Crops  | Straight Row (SR)                | Poor                 | 72                                       | 81 | 88 | 91 |
|  |                                  | Good                 | 67                                       | 78 | 85 | 89 |
|  | SR + CR                          | Poor                 | 71                                       | 80 | 87 | 90 |
|  |                                  | Good                 | 64                                       | 75 | 82 | 85 |
|  | Contoured (C)                    | Poor                 | 70                                       | 79 | 84 | 88 |
|  |                                  | Good                 | 65                                       | 75 | 82 | 86 |
|  | C + CR                           | Poor                 | 69                                       | 78 | 83 | 87 |
|  |                                  | Good                 | 64                                       | 74 | 81 | 85 |
|  | Contoured and Terraced (C and T) | Poor                 | 66                                       | 74 | 80 | 82 |
|  |                                  | Good                 | 62                                       | 71 | 78 | 81 |
| Small Grain  | C and T + CR                     | Poor                 | 65                                       | 73 | 79 | 81 |
|  |                                  | Good                 | 61                                       | 70 | 77 | 80 |
|  | SR                               | Poor                 | 65                                       | 76 | 84 | 88 |
|  |                                  | Good                 | 63                                       | 75 | 83 | 87 |
|  | SR + CR                          | Poor                 | 64                                       | 75 | 83 | 86 |
|  |                                  | Good                 | 60                                       | 72 | 80 | 84 |
|  | C                                | Poor                 | 63                                       | 74 | 82 | 85 |
|  |                                  | Good                 | 61                                       | 73 | 81 | 84 |
|  | C + CR                           | Poor                 | 62                                       | 73 | 81 | 84 |
|  |                                  | Good                 | 60                                       | 72 | 80 | 83 |
| Close Seeded or Broadcast Legumes or Rotation Meadow | C and T                          | Poor                 | 61                                       | 72 | 79 | 82 |
|  |                                  | Good                 | 59                                       | 70 | 78 | 81 |
|  | C and T + CR                     | Poor                 | 60                                       | 71 | 78 | 81 |
|  |                                  | Good                 | 58                                       | 69 | 77 | 80 |
|  | SR                               | Poor                 | 66                                       | 77 | 85 | 89 |
|  |                                  | Good                 | 58                                       | 72 | 81 | 85 |
|  | C                                | Poor                 | 64                                       | 75 | 83 | 85 |
|  |                                  | Good                 | 55                                       | 69 | 78 | 83 |
|  | C and T                          | Poor                 | 63                                       | 73 | 80 | 83 |
|  |                                  | Good                 | 51                                       | 67 | 76 | 80 |

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Runoff Curve Numbers for Other Agricultural Lands

| Cover Description   | Hydrologic Condition | Curve Numbers for Hydrologic Soil Groups |    |    |    |
|---|----------------------|--|----|----|----|
|   |                      | A  | B  | C  | D  |
| <b>Cover Type</b>   |                      |  |    |    |    |
| Pasture, Grassland, or Range – Continuous Forage for Grazing                  | Poor                 | 68                                       | 79 | 86 | 89 |
|   | Fair                 | 49                                       | 69 | 79 | 84 |
|   | Good                 | 39                                       | 61 | 74 | 80 |
|   |                      |  |    |    |    |
| Meadow – Continuous Grass, Protected from Grazing and Generally Mowed for Hay | --                   | 30                                       | 58 | 71 | 78 |
|   |                      |  |    |    |    |
| Brush – Brush, Weed, Grass Mixture with brush the major element               | Poor                 | 48                                       | 67 | 77 | 83 |
|   | Fair                 | 35                                       | 56 | 70 | 77 |
|   | Good                 | 30                                       | 48 | 65 | 73 |
|   |                      |  |    |    |    |
| Woods – Grass Combination (orchard or tree farm)                              | Poor                 | 57                                       | 73 | 82 | 86 |
|   | Fair                 | 43                                       | 65 | 76 | 82 |
|   | Good                 | 32                                       | 58 | 72 | 79 |
|   |                      |  |    |    |    |
| Woods   | Poor                 | 45                                       | 66 | 77 | 83 |
|   | Fair                 | 36                                       | 60 | 73 | 79 |
|   | Good                 | 30                                       | 55 | 70 | 77 |
|   |                      |  |    |    |    |
| Farmsteads – Buildings, Lanes, Driveways and Surrounding Lots.                | --                   | 59                                       | 74 | 82 | 86 |

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**Table C-3 - Manning's Equation "n" Roughness Coefficients**

| Description   | Manning's "n" |
|---|---------------|
| Smooth-Wall Plastic Pipe  | 0.011         |
| Concrete Pipe   | 0.012         |
| Smooth-Lined Corrugated Metal Pipe  | 0.012         |
| Corrugated Plastic Pipe   | 0.024         |
| Annular Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)  |               |
| 68 mm × 13 mm (2 2/3 in × 1/2 in) Corrugations  | 0.024         |
| 75 mm × 25 mm (3 in × 1 in) Corrugations  | 0.027         |
| 125 mm × 25 mm (5 in × 1 in) Corrugations   | 0.025         |
| 150 mm × 50 mm (6 in × 2 in) Corrugations   | 0.033         |
| Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)  |               |
| 75 mm × 25 mm (3 in × 1 in), 125 mm × 25 mm (5 in × 1 in), or 150 mm × 50 mm (6 in × 2 in) Corrugations                           | 0.024         |
| Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or Polymer Coated)  |               |
| 68 mm × 13 mm (2 2/3 in × 1/2 in) Corrugations  |               |
| a. Lower Coefficients*  |               |
| 450 mm (18 in) Diameter   | 0.014         |
| 600 mm (24 in) Diameter   | 0.016         |
| 900 mm (36 in) Diameter   | 0.019         |
| 1200 mm (48 in) Diameter  | 0.020         |
| 1500 mm (60 in) Diameter or larger  | 0.021         |
| b. Higher Coefficients**  | 0.024         |
| Annular or Helically Corrugated Steel or Aluminum Alloy Pipe Arches or Other Non-Circular Metal Conduit (Plain or Polymer Coated) | 0.024         |
| Vitrified Clay Pipe   | 0.012         |
| Ductile Iron Pipe   | 0.013         |
| Asphalt Pavement  | 0.015         |
| Concrete Pavement   | 0.014         |
| Grass Medians   | 0.050         |
| Grass – Residential   | 0.030         |
| Earth   | 0.020         |
| Gravel  | 0.030         |
| Rock  | 0.035         |
| Cultivated Areas  | 0.030 - 0.050 |
| Dense Brush   | 0.070 - 0.140 |
| Heavy Timber (Little undergrowth)   | 0.100 - 0.150 |
| Heavy Timber (with underbrush)  | 0.40          |
| Streams:  |               |
| Some Grass And Weeds (Little or no brush)   | 0.030 - 0.035 |
| Dense Growth of Weeds   | 0.035 - 0.050 |
| Some Weeds (Heavy brush on banks)   | 0.050 - 0.070 |

**NOTES:**

- \* Use the lower coefficient if any one of the following conditions apply:
  - a. A storm pipe longer than 20 diameters, which directly or indirectly connects to an inlet or manhole, located in swales adjacent to shoulders in cut areas, shoulders in cut areas or depressed medians.
  - b. A storm pipe which is specially designed to perform under pressure.
- \*\* Use the higher coefficient if any one of the following conditions apply:
  - a. A storm pipe which directly or indirectly connects to an inlet or manhole located in highway pavement sections or adjacent to curb or concrete median barrier.
  - b. A storm pipe which is shorter than 20 diameters long.
  - c. A storm pipe which is partly lined helically corrugated metal pipe.

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**Table C-4 - Manning’s Equation “n” Roughness Coefficients  
For TR-55 Time of Concentration Calculations (Sheet Flow)**

| Surface Description                                       | Manning's “n” <sup>1</sup> |
|---|----------------------------|
| Smooth Surfaces (Concrete, Asphalt, Gravel, or Bare Soil) | 0.011                      |
| Fallow (No Residue)                                       | 0.050                      |
| Cultivated Soils:   |                            |
| Residue Cover (less than or equal to 20%)                 | 0.060                      |
| Residue Cover (greater than 20%)                          | 0.170                      |
| Grass:  |                            |
| Short Grass Prairie                                       | 0.150                      |
| Dense Grasses <sup>2</sup>                                | 0.240                      |
| Bermudagrass  | 0.410                      |
| Range (Natural)   | 0.130                      |
| Woods: <sup>3</sup>                                       |                            |
| Light Underbrush  | 0.400                      |
| Dense Underbrush  | 0.800                      |

**NOTES:**

- <sup>1</sup> The “n” values are a composite of information compiled by Engman (1986).
- <sup>2</sup> Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
- <sup>3</sup> When selecting “n”, consider cover to a height of about 0.1 foot. This is the only part of the plant cover that will obstruct sheet flow.