APPENDIX C
SIMPLIFIED DESIGN APPROACH

This Appendix provides additional information concerning the derivation and application of the Simplified Design Approach outlined in Section 3.4.3 of the main report. The first sub-section deals with the derivation while the remaining sub-sections elaborate on the three major components of the Simplified Design Approach. These components are:

a) a synoptic level geomorphic survey of the stream channel to collect measurements of channel form and assess channel stability;
b) assessment of the applicability of the Simplified Design Approach for the proposed development; and
c) determination of the volume of source control and storage within an end-of-pipe facility (pond).

This Appendix focuses on the Rapid Geomorphic Assessment and storage volume determination elements.

C.1 Derivation of the Simplified Design Approach

Curves showing pond active storage volume as a function of total amount of directly connected imperviousness area (FRIMP) are provided in Figures C.1(a) and (b) for Soil Conservation Service (SCS) Hydrologic Soils Groups A to B and C to D, respectively. These curves provide a simplified method for the estimation of the active storage volume for small developments (that satisfy the criteria established in Table 3.4), knowing FRIMP, the SCS Hydrologic Soils Group and the amount of Source Control (in this context, source control includes lot level and conveyance controls). The derivation of the approach as outlined below is based on geomorphologic assessments carried out on over 40 streams in Ontario, British Columbia, Texas and Vermont as well as calibration of these curves as presented in Figures C.1(a) and (b) based on a continuous modelling of the flows and erosion potential in two streams in southern Ontario. The two case studies were:

(a) the west branch of the Humber River through the City of Brampton; and
(b) Morningside Tributary through the Town of Markham.

The model used in the analysis was QUALHYMO, a continuous hydrologic simulation model with pond routing algorithms and a routine for the assessment of in-stream erosion potential. The latter is expressed as indices based on a two-dimensional representation of excess boundary shear stress about an arbitrary channel perimeter. The hydrologic component of the model was set up and calibrated to flow gauge data collected by Environment Canada. The erosion index component of the model was set up based on diagnostic geomorphic surveys of the stream channel. The model was calibrated to observed geomorphic activity rates and verified using empirical relations developed for urban streams throughout North America.

Following the setup of the model a corroborative approach was adopted using hydrologic methods (flow exceedance analysis), critical shear stress concepts, and empirical relations and observations of geomorphic activity rates to provide independent but parallel methods of assessment. Different land use conditions were then assessed including:

(i) the pre-development scenario;
(ii) the existing land use condition; and
(iii) the future land use scenario.

The model for the latter two land use conditions was set up to assess the following SWM options:

(a) no SWM measures (baseline condition);
(b) centralized (end-of-pipe) control with no Source Control assuming:
    (i) 2-year control;
    (ii) 25 mm-24 hour control; and
    (iii) Distributed Runoff Control.
(c) centralized control with various levels of Source Control.

In each case the erosion indices were determined and compared to the in-stream erosion criteria adopted for the assessment. The volume of the pond and the pond outlet control structure were adjusted to maximize the reduction of in-stream erosion potential to the maximum amount allowed by the design technique employed. Results from the analysis are presented in MacRae (1996). MacRae (1996) found that the conclusions were consistent among the various methods of assessment. Further, the two case studies are representative of a wide range of stream conditions and hydrographic characteristics found in southern Ontario.

C.2 Synoptic Level Geomorphic Survey

A synoptic geomorphic survey involves:

a) the assessment of channel stability and mode of adjustment; and
b) an engineering-geomorphic survey of the following channel parameters:
    - bankfull channel depth;
    - bankfull channel width;
    - the width of the flood prone area at an elevation corresponding to twice bankfull depth;
    - the composition of the boundary materials composing the:
        i) lower third of the bank (on both banks); and
        ii) the intact bed materials or armor layer.
    - the Soil Conservation Service (SCS) Hydrologic Soil Group within the development.

These parameters will be used in the assessment of the suitability of the Simplified Design Approach for the design of SWM measures for the proposed development, and in the design of the volume of source control and pond storage.

C.3 Rapid Geomorphic Assessment

One approach to the assessment of channel stability and sensitivity to an alteration in the sediment-flow regime is to undertake a Rapid Geomorphic Assessment (RGA) of the channel system. An RGA form, developed for this purpose, is presented as one possible tool (Table C.1).

The RGA form consists of four factors that may be used to suggest evidence of adjustment in channel form or characterize processes indicating mode of adjustment. These factors are:

(a) Evidence of Aggradation (AI);
(b) Evidence of Degradation (DI);
(c) Evidence of Channel Widening (WI); and
(d) Evidence of Planimetric Form Adjustment (PI).

Each of the four factors is represented by a number of indices (see Column (3) in Table C.1). The indices are observed to be present or absent (Columns (4) and (5) in Table C.1). If “present“ the index is registered in the “Yes” column and the total number of “Yes” responses is indicated in the cell labelled “Sum of Indices.” For example, for the Factor “Evidence of Aggradation,” the indices numbered 2, 3, 4 and 5 (Column (2) in Table C.1) were present over a specified length of stream so the “Sum of Indices” would be “4.”

The “Factor Value” represents the number of “Yes” responses divided by the total number of responses. Consequently, in the above example, the “Factor Value” would be AI = 4/7 = 0.57 (assuming a response of “No” was recorded for all other indices). This process is repeated for each of the Factors listed in Column (1) of Table C.1. The “Factor Values” are then summed and divided by the number of Factors (m = 4) to arrive at the Stability Index (SI) value. Experience with approximately 40 streams indicates that the SI value may be interpreted in accordance with criteria outlined in Table C.2.

C.4 Simplified Design Approach: Volume Control

Once it has been established that the Simplified Design Approach is applicable then the volume of source control and the active storage component of the pond may be determined as a function of the SCS Hydrologic Soils Group and total basin imperviousness.

In-Stream Erosion Control Criterion
The change in in-stream erosion potential cannot exceed that change which is equivalent to a 10% paving of the basin without implementation of Stormwater Management measures for the control of erosion potential.

Table C.1: Summary of Rapid Geomorphic Assessment (RGA) Classification

FORM/ PROCESS (1)	GEOMORPHIC INDICATOR		PRESENT		FACTOR
	NO (2)	DESCRIPTION (3)	NO (4)	YES (5)	VALUE (6)
Evidence of Aggradation (AI)	1	Lobate bar			
	2	Coarse material in riffles embedded			
	3	Siltation in pools			
	4	Medial bars			
	5	Accretion on point bars			
	6	Poor longitudinal sorting of bed materials			
	7	Deposition in the overbank zone			
		SUM OF INDICES			
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			
	2	Exposed sanitary/storm sewer/pipeline/etc.			
	3	Elevated stormsewer outfall(s)			
	4	Undermined gabion baskets/concrete aprons/etc.			
	5	Scour pools d/s of culverts/stormsewer outlets			
	6	Cut face on bar forms			
	7	Head cutting due to knick point migration			
	8	Terrace cut through older bar material			
	9	Suspended armor layer visible in bank			
	10	Channel worn into undisturbed overburden/bedrock			
		SUM OF INDICES			
Evidence of Widening (WI)	1	Fallen/leaning trees/fence posts/etc.			
	2	Occurrence of large organic debris			
	3	Exposed tree roots			
	4	Basal scour on inside meander bends			
	5	Basal scour on both sides of channel through riffle			
	6	Gabion baskets/concrete walls/etc. out flanked			
	7	Length of basal scour > 50% through subject reach			
	8	Exposed length of previously buried pipe/cable/etc.			
	9	Fracture lines along top of bank			
	10	Exposed building foundation			
		SUM OF INDICES			
Evidence of Planimetric Form Adjustment (PI)	1	Formation of cute(s)			
	2	Single thread channel to multiple channel			
	3	Evolution of pool-riffle form to low bed relief form			
	4	Cutoff channel(s)			
	5	Formation of island(s)			
	6	Thalweg alignment out of phase meander form			
	7	Bar forms poorly formed/reworked/removed			
		SUM OF INDICES			
STABILITY INDEX (SI) = (AI + DI + WI + PI) / m					

Table C.2: Interpretation of RGA Form Stability Index Value

Stability Index (SI) Value	Classification	Interpretation
SI ≤ 0.2	In Regime	The channel morphology is within a range of variance for streams of similar hydrographic characteristics – evidence of instability is isolated or associated with normal river meander propagation processes
0.21 ≤ SI ≤ 0.4	Transitionally or Stressed	Channel morphology is within the range of variance for streams of similar hydrographic characteristics but the evidence of instability is frequent
SI > 0.4	In Adjustment	Channel morphology is not within the range of variance and evidence of instability is wide spread

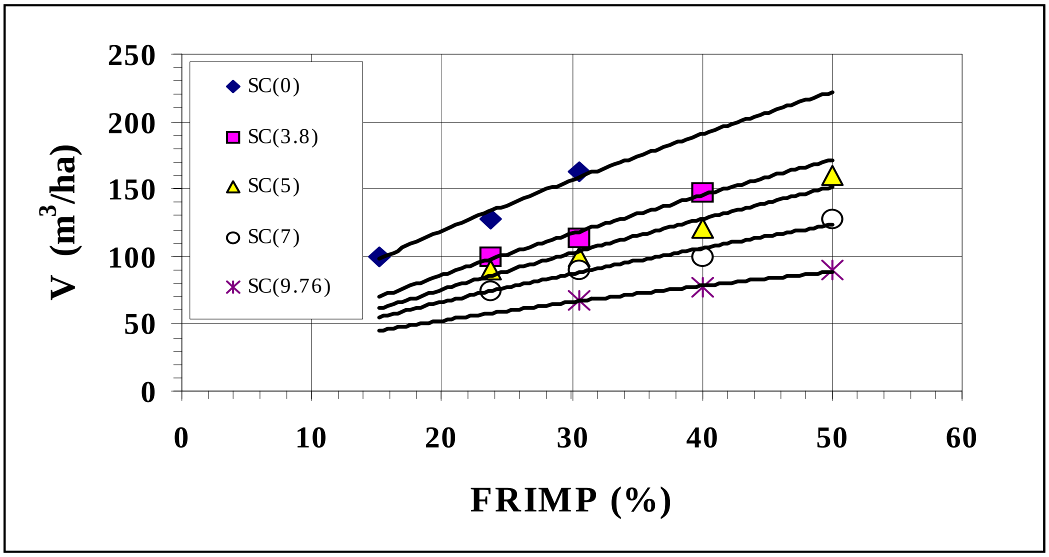
A diminishing return is associated with increasing pond storage for the control of in-stream erosion potential. This appears to be due to:

(a) the loss of effective storage associated with longer flow retention periods as pond size increases and the tendency for precipitation events to occur as multiple events;
(b) the alteration of the hydrologic response of the basin from riverine to lacustrine due to the non-uniform effect of pond attenuation on the distribution of shear stress about the channel boundary (a greater decrease in erosive forces occurs at the bank toe than the channel bed resulting in the tendency to aggrade);
(c) the containment of flows associated with rare flood flow events within the active channel due to peak flow attenuation resulting in the extended duration of high flow rates; and
(d) the impact on the sediment regime increases with larger pond volumes and retention times.

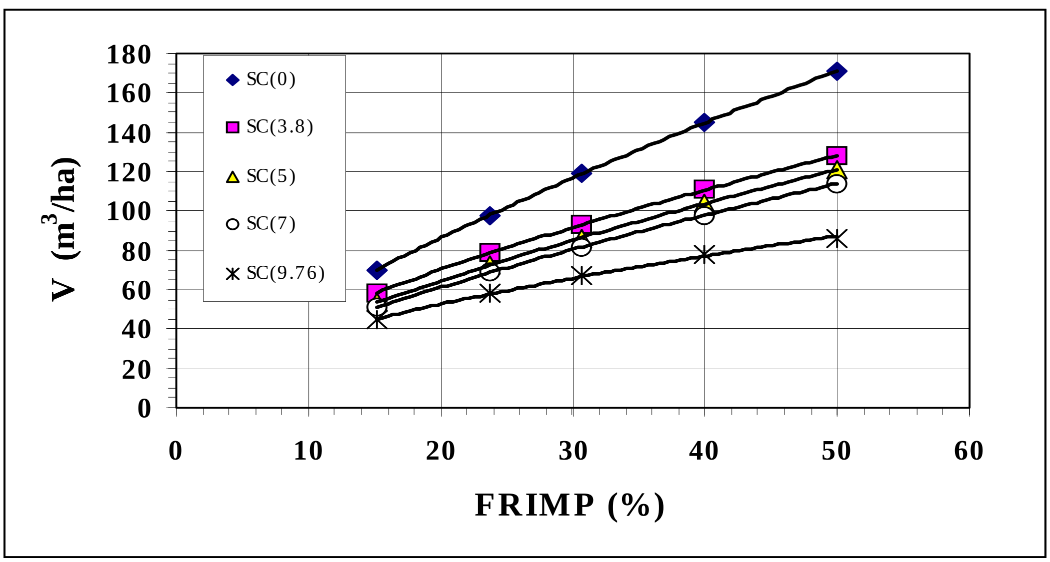
Figure C.1(a) and C.1(b) provide the storage volumes for a given total directly connected basin impervious area (FRIMP) and a range of Source Control (SC) values. As can be seen in Figure C.1(a), an application of 3 watershed-mm of source control will result in a reduction in pond storage volume of approximately 17% for a basin with SCS hydrologic Soil Group ‘D’ soils and a FRIMP of 40%. It was also observed that the rate of reduction in pond volume with Source Control declines with additional Source Control. Using the previous example, an additional 3 watershed-mm of Source Control would result in an additional decrease in pond storage volume of approximately 10 percent. A further increase in Source Control to a total of 9 watershed-mm would result in an incremental pond storage volume reduction of 5.5 percent, and a total volume reduction of 32%.

Figure C.1: Pond Active Storage Volume for Control of In-Stream Erosion Potential as a Function of Total Directly Connected Impervious Area (FRIMP) and Source Control (including lot level and conveyance control, in watershed-mm)

(a) SCS Soil Groups A and B



(b) SCS Soils Groups C and D



The following steps summarize the approach:

Step 1: Determine the total directly connected impervious area (FRIMP) for the development area.

Step 2: Establish the predominant SCS Hydrologic Soil Group for the development area.

Step 3: Determine the amount of source control practical and feasible for the development area.

Step 4: Based on the FRIMP value, the predominant SCS Hydrologic Soil Group and level of source control select the appropriate curve in Figure C.1 and determine the pond active storage volume for the development area.

Having established the volume requirements for the end-of-pipe and source control measures required to control in-stream erosion potential, the next phase involves determination of the hydraulic performance of the end-of-pipe outlet structure (see Appendix D).