Stormwater Management & Design Manual
Key Changes in 2011 Edition

Bert van Duin, M.Sc., P.Eng.,
Senior Development Engineer
City of Calgary, Water Resources
Infrastructure Planning, Development Approvals

Industry and Staff Briefing Session
October 17, 2011

Intended Audience of the Manual

- Consulting Industry
  - Land development professionals for
    - New subdivisions, or
    - Redevelopment areas
  - Municipal engineers, etc. for City of Calgary projects
- Water Resources / Water Services staff
- Other City of Calgary Business Units

How did we get here?

- First version issued in December 2000
- Discussion pertaining to updates started back in 2002
- Hiatus 2005-2007
- Started up again in 2008 with updated chapters and appendices forwarded to UDI for commenting
- Bi-weekly meetings with UDI representatives from early 2010 through spring 2011
- Close to 1,000 comments from UDI representatives reviewed and discussed

Acknowledgements

City of Calgary

- Kim Jaska
- Ryan Kidd
- Dwayne Giesbrecht
- Graham Tait
- Zhong Xiang
- Brad Larson
- Olga Abramovich
- Yin Deong
- and many, many others

UDI

- Rick Carnduff, Stantec
- Luis Narvaez, LGN
- Paul Jacobs, Stormwater Solutions
- Asif Aslam, AECOM
- Liliana Bozic, Urban Systems
- Maureen Beaudrault & Beverly Jarvis
- and many, many others

Implementation Schedule

- To be used for all new submissions
  - Master Drainage Plans
  - Staged Master Drainage Plans
  - Pond Reports
  - Stormwater Management Reports
  - DSSPs
  - Construction Drawings

as of November 1, 2011

Where can you find it?

- City of Calgary, Urban Development, Publications:

  http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Publications.aspx

- In addition, there are various templates, checklists and spreadsheets on the Water Resources, Development Approvals webpage:

  http://www.calgary.ca/UEP/Water/Pages/Specifications/Submission-for-approval-/Development-Approvals-Submissions.aspx

- THIS PRESENTATION WILL BE POSTED ON THE DEVELOPMENT APPROVALS WEBPAGE!

What about future updates?

- In addition to internal discussions, there will be monthly ongoing meetings with UDI's Water Management Committee
- "Urgent" revisions will be posted in memoranda at Urban Development's Bulletin Board, see
  - http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Urban-Development.aspx
- The manual will be updated on an annual to bi-annual basis, similar to the specifications
  - changes will be clearly identified at that time

Format of the document

- Navigational aids:
  - Clicking on a ***black hyper-linked reference*** takes you to the specified section within the manual
  - (ALT + "left arrow" to return)
  - Clicking on a *blue hyper-linked reference* takes you to the specified document on the internet
  - Clicking on the City of Calgary logo (bottom left of each page) takes you back to the Tables of Contents

2.3 Provincial

2.3.1 Environmental Protection and Enhancement Act

On September 1, 1993, Alberta's *Environmental Protection and Enhancement Act (EPEA)* and its associated regulations came into force, replacing nine former acts. The purpose of *EPEA* is to support and promote the protection, enhancement, and wise use of the environment, and is administered by Alberta Environment (AENV). In general, the Act specifies what is to be regulated, as well as the regulatory processes and applications. Refer to the following documents for more information:

- *EPEA Activities Designation Regulation, Alta Reg 276/2003*.
- Alberta Environment's *Stormwater Management Guidelines for the Province of Alberta*.
- Alberta Environment's *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems*.
- Alberta Environment's *Municipal Policies and Procedures Manual*.

2.3.2 Wastewater and Storm Drainage Regulation (119/93) and Activities Designation Regulation

2.3.2.1 Storm Drainage Systems

Pursuant to the *EPEA*, the *Wastewater and Storm Drainage Regulation*, and the *Activities Designation Regulation*, a written authorization is required from Alberta Environment for the construction, operation, or reclamation of a storm drainage system for subdivisions approved by The City of Calgary.

An Application for Registration must be submitted to obtain the authorization from Alberta Environment.The City of Calgary (Urban Development) will apply for authorization and submit engineering drawings provided by the owner or developer (or their designated consultant) to Alberta Environment as required. ***Figure 2-1*** and ***APPENDIX A: Alberta Environment Registration Process*** of this document outlines the typical application and approval process.

2.3.2.2 Stormwater Ponds

Pursuant to the *EPEA* and *Wastewater and Storm Drainage Regulation (119/93)*, a written authorization from Alberta Environment is required for the construction or modification of storm drainage treatment facilities, including stormwater ponds. An Application for Registration must be submitted to obtain the authorization. A Pond Report (approved by The City, Water Resources) is required prior to Water Resources submitting the application for registration to Alberta Environment.

The owner or developer (or designated consultant) is responsible for preparing and submitting the required information outlined in the *Wastewater and Storm Drainage Regulation (119/93)* to Water Resources, including Alberta Environment's

Items left for future editions

- Glossary
- Climate database
- Update of IDF curve
- Guidance on frequency analysis
- Procedures for design of drop manholes + manhole losses
- Review of minimum and maximum velocities in storm sewer design
- Aeration and ventilation
- Culvert and permanent erosion protection design
- Specifics on design of Source Control Practices
- Evolution of pond design
- City-wide performance targets

Both Chapters 8 (Best Management Practices) and 9 (Erosion and Sediment Control) were largely re-written! They are not discussed today.

Guidelines vs. Standards

- Objective:
  - Effective, reliable and economically affordable systems
- Not meant to:
  - Stifle technological innovation and evolution, nor
  - Eliminate design approaches appropriate for local conditions
- Preferences ≠ Requirements
- Flexibility is important for site-specific conditions

Guidelines vs. Standards

- Relaxations can be granted when,
  - to the satisfaction of the City,
  - all other options are exhausted, and
  - safe and satisfactory operation is still ensured
- AT ALL TIMES:

  The designer remains responsible for detailed design and satisfactory operation and performance

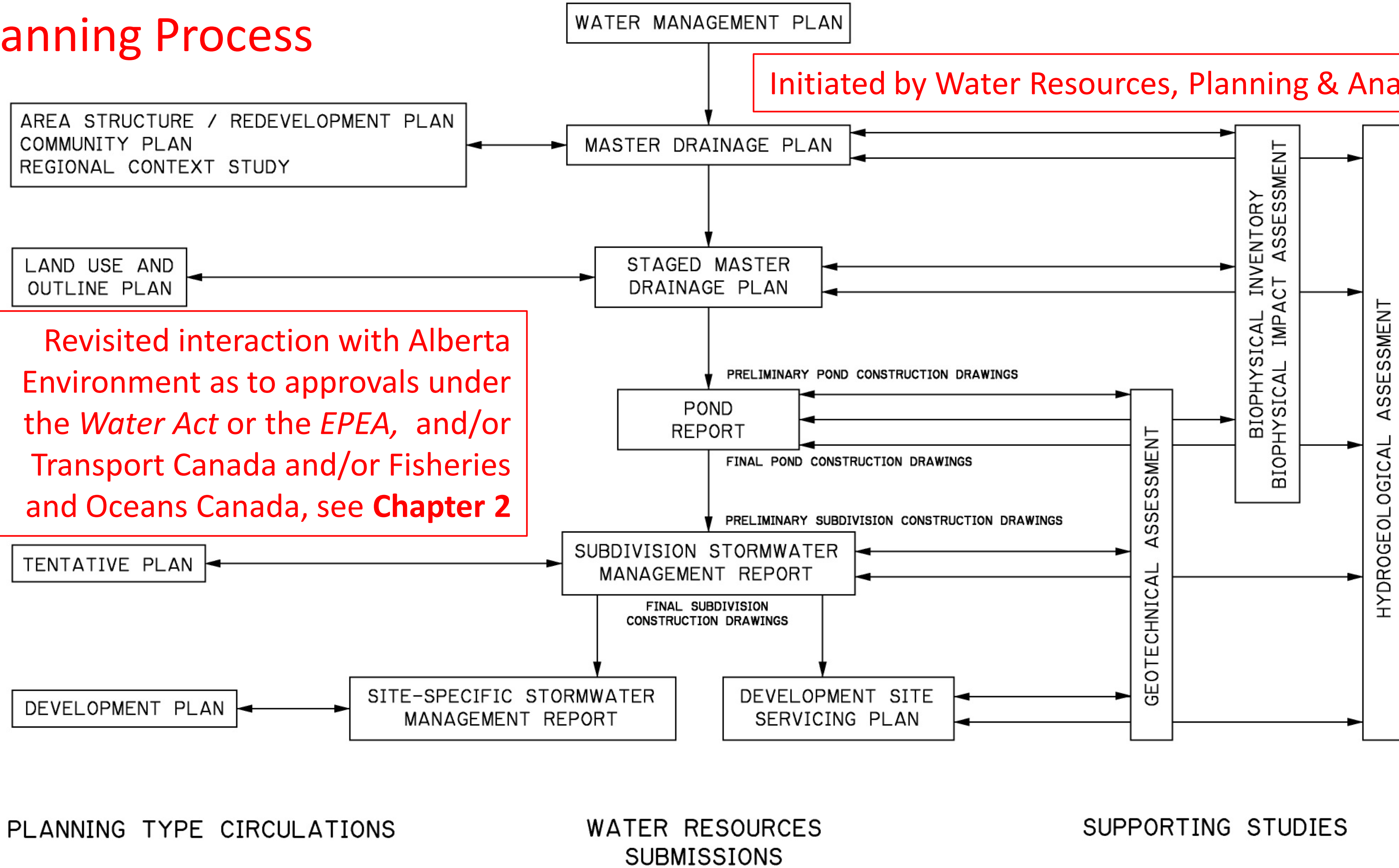
Evolution of Targets and Criteria

- Throughout the document, references have been updated or provided related to federal, provincial and municipal targets and criteria as they evolved since 2000. Examples include:
  - Total Loading Management Plan
  - Stormwater Strategy
  - Water Management Plans
  - Open Space and Wetland Conservation Plans
  - Codes of Practice

Updated Figure 1-4 on the Stormwater Management Planning Process

E.g. Nose Creek, Pine Creek, Bow Basin, see **Section 1.4.4**

Initiated by Water Resources, Planning & Analysis



Revisited interaction with Alberta Environment as to approvals under the *Water Act* or the *EPEA*, and/or Transport Canada and/or Fisheries and Oceans Canada, see **Chapter 2**

Doesn't cover retrofit type initiatives, see e.g. **Section 1.4.7 Community Drainage Plans**

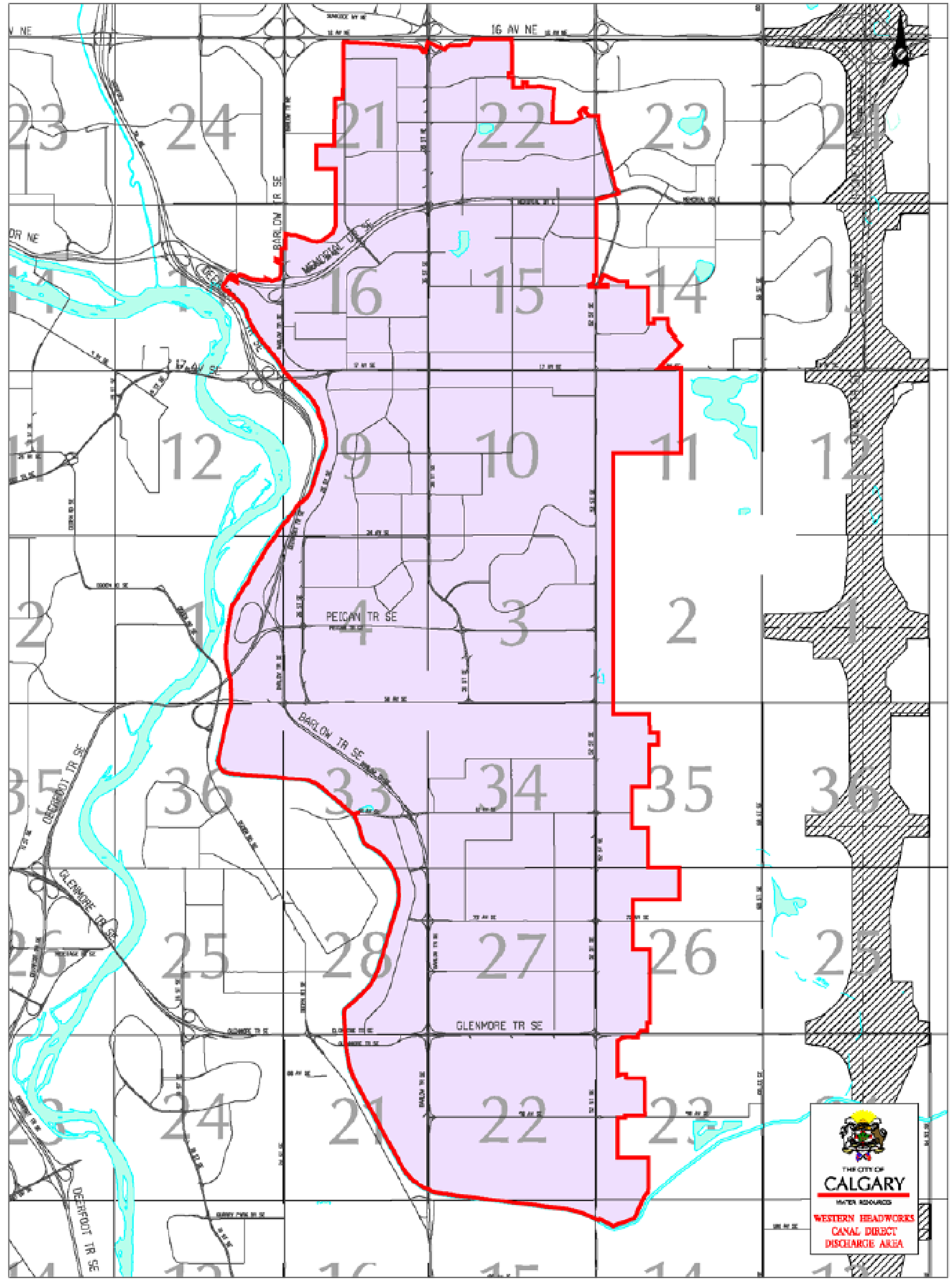
Section 4.7.3:

Servicing in Western Headworks Canal Catchment

- Any development or redevelopment is required to implement BMPs to yield, at a minimum, a net-zero increase in runoff rate, runoff volume, and pollutant loadings
- The assessment must address both the 1:5 year and 1:100 year conditions, volume, TSS, phosphorus and nitrogen

Protecting what's precious.
Land. Air. Water.

Figure 4-2: Servicing in Western Headworks Canal Catchment



Section 3.3.2.10:
City-Funded Storm Conveyance Infrastructure

The City of Calgary typically finances and pays for storm conveyance infrastructure consisting of storm sewer trunks that meet all of the following three conditions:

i. They are 900 mm in diameter and greater.
ii. They are downstream of a storm pond.
iii. They serve the lands owned by more than one landowner/developer.

In the event that a developer is permitted to build infrastructure that would normally be built and financed by The City of Calgary, a Construction and Financing Agreement (CFA) must be executed prior to construction. If construction of this infrastructure is commenced prior to the execution of the CFA, the developer will not be able to recover the costs of this infrastructure from The City of Calgary, nor will this infrastructure be eligible for cost recovery from the Oversize Fund.

Sections 3.1.4 and 4.4: Runoff Volume

With the increasing awareness that increased stormwater runoff can cause erosion, increase pollutant loadings, degrade receiving water body quality, and adversely impact aquatic habitat, **the need to control both runoff rate and volume** has been identified. Overall targets have been set for the Nose Creek, West Nose Creek and Pine Creek watersheds.

While the Water Management Plans (WMPs) for these watersheds provide the overall weighted targets for a large area, the designer must use the actual site-specific targets for the proposed land uses, subdivisions, and/or private sites from preceding MDPs, SMDPs, and/or Stormwater Management Reports (SWMRs). Contact Water Resources to verify that the runoff volume targets are applicable.

See Section 6.4.1: Constructed Stormwater Wetlands vs. Engineered Natural Stormwater Wetlands

- Constructed Stormwater Wetlands
  - those wetlands that have been designed and constructed specifically for stormwater management purposes, and, if properly designed, provide some ecological value and amenity
- Engineered Natural Stormwater Wetlands
  - are natural wetlands that have been deemed appropriate for stormwater management purposes and have been modified with forebays, control structures or other engineered components to increase stormwater storage and treatment capability.

Concerns expressed when dealing with Engineered Natural Stormwater Wetlands

- These wetlands inevitably forego some natural ecological and amenity value in lieu of providing stormwater management benefits.
- Where a natural wetland is incorporated, protection of the wetland must be considered.
- Design and management objectives for these wetlands need to address a balance between ecological function and habitat, amenity value and stormwater management requirements.
- Where significant impacts from development cannot be avoided, compensation may be required under these circumstances.
- The degree of pre-treatment in the storm pond may affect the amount of compensation required.

See Section 11.1.4.1 (iii):

For Engineered Natural Stormwater Wetlands, issues that might affect the footprint of the proposed facility

- Number and location of inlets
- Type and location of forebays or equivalents
- Level of pre-treatment required of stormwater allowed to enter engineered natural stormwater wetland, with specific attention to
  - TSS size removed, and
  - removal of nutrients and heavy metals
- Winter by-pass minimizing impact of chloride-laden winter runoff on sensitive areas

See Section 11.1.4.1 (iii) continued:

For Engineered Natural Stormwater Wetlands, issues that might affect the footprint of the proposed facility

- Magnitude and volume of runoff allowed to enter engineered natural stormwater wetland,
  - minimizing scour and erosion potential at the inlets, and
  - resulting in acceptable change in water level fluctuations
- Measures proposed
  - to prevent use of substrates that are "contaminated" or
  - contain invasive or non-desirable species
- ESC provisions to minimize entry of sediment-laden runoff from upstream catchment area
- Sediment deposition allowed prior to FAC

What about wetland approvals?

- New **<u>Section 2.3.3.3</u>** pertaining to approvals under the *Water Act* in case naturally occurring wetlands are impacted.
- Also, additional verbiage in **<u>Section 2.4.2.2</u>** as to the Calgary Wetland Conservation Plan and the policies in place at the City of Calgary Parks
- Note: In cases of disturbance to wetlands, the City of Calgary requires compensation for Stewart and Kantrud Class 3 or higher wetlands, whereas Alberta Environment also requires compensation for Class 1 and 2 wetlands!
- New **<u>Section 2.4.2.3</u>** Principles for Stormwater Wetlands Management

Additional information on Dam Safety:

- **Section 2.3.3.2**
- If a stormwater facility has an embankment that can be classified as a dam,
  - Ponds with a storage capacity ≥ 30,000 m^3
  - Embankment height ≥ 2.5 m

  a dam safety assessment must be submitted to Water Resources.
- Ponds with storage capacity ≥ 10,000 m^3 and embankment height ≥ 1.0 m will be assessed on a case-by-case basis. See **Section 6.1.7** on the assessment needs

We have introduced this to deal with situations like this:

Section 6.1.7: Geotechnical

- See the Canadian Dam Association's Dam Safety Guidelines
- The assessment might include:
  - Analysis of embankment stability in case of rapid drawdown of the pond.
  - Estimation of breach width and peak outflow rate.
  - Identification of probable downstream flow routes, peak flow rates and travel/peak-arrival times.
  - Inundation studies, with and without embankment failure.
  - Assessment of the erodibility of downstream flow routes.
  - Identification of potential transportation and egress route disruptions.
  - Listing of infrastructure, populations and addresses at risk, including institutional and utility features.
  - Listing of downstream safety issues including potentially damaged utilities, road wash-outs, etc.

Major Overhaul of **<u>Chapter 11</u>** Technical Requirements

- Describing submissions requirements for
  - Master Drainage Plans
  - Staged Master Drainage Plans
  - Community Drainage Studies
  - Pond Reports
  - Subdivision Stormwater Management Reports
  - Development Site Servicing Plans
  - Engineering Drawings
- See the Development Approvals web page for templates, checklists and other tools!

Section 11.1.3: Master Drainage Plans

- Interprets recommendations established in WMP
- Provides more detailed guidance for the area covered by the MDP
- Site inspections of existing drainage features such as
  - wetlands;
  - perennial and intermittent streams including ravines;

  and, man-made drainage infrastructure such as
  - impoundments,
  - ponds and
  - culverts
- Capacity of existing drainage infrastructure

Section 11.1.3.2: Streams and Ravines in MDPs

- Evaluate the stability thresholds and conveyance characteristics of existing streams and ravines.
- Identify the extent of ravines to be maintained in a natural-like state.
- If stormwater discharges into existing streams or ravines are proposed, post-development flow-duration curve should mimic pre-development flow-duration curves, to ensure long term morphologic stability, aesthetic and habitat function comparable to pre-development conditions

Section 11.1.3.2: Hydrogeological Assessment

- Conduct a planning-level hydrogeological assessment addressing
  - Groundwater impacts relevant to the preservation of existing streams or ravines in a natural-like state; and
  - Hydrogeological aspects related to the implementation of source control practices
    - soil texture
    - permeability
    - groundwater levels, etc.

- This will be revisited as part of the current Source Control Practices Guidelines & Standards project

Sections 3.4.6, 4.9.4., 6.1.7, 8.6.1.1

Conditions for Infiltration / Percolation into the subsoils

- Where infiltration/percolation into the subsoils is proposed to meet runoff volume targets, the proponent shall:
  1. Assess the impact on the groundwater table;
  2. Demonstrate that the assumed percolation rates are sustainable in the long run on a local and a regional level;
  3. Demonstrate that the percolating runoff will have no detrimental impact on adjacent roadways or any downstream structures; and
  4. Demonstrate that the percolating runoff will not contribute to an increase in inflow and infiltration into the sanitary system.
- Infiltration and / or percolation into the subsoils are not permitted if the runoff is contaminated with highly mobile constituents as assessed by an environmental specialist with Environmental Safety Management (The City of Calgary)

- This will be revisited as part of the current Source Control Practices Guidelines & Standards project

What about Low Impact Development?

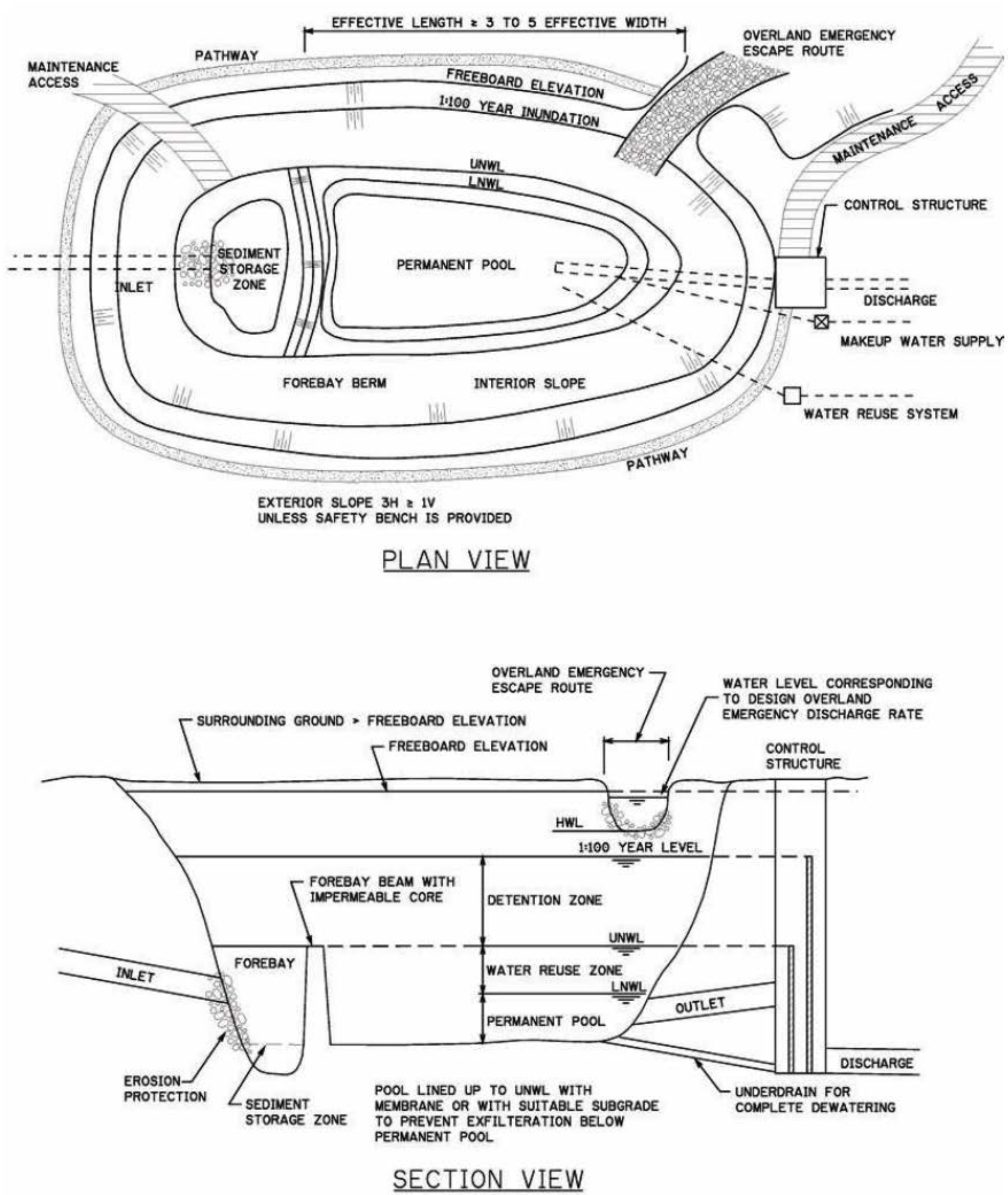
- For submissions that include Low Impact Development (LID) and provisions, refer to the "*Source Control Practices Handbook*"
- Use preliminary checklists to guide the implementation of Source Control Practices. These will be updated as part of the Source Control Practices project
- Contact Bert van Duin at (403) 268-6449 or Bert.vanDuin@calgary.ca for more information
- Attend future courses organized by City of Calgary and/or the Alberta Low Impact Development Partnership

Section 6.3.2 : (Wet Pond) Design

- Wet Ponds now include option for water re-use

- This will be revisited as part of the current Source Control Practices Guidelines & Standards project

Figure 6-8: Wet Pond



Sections 11.1.4 and 11.1.6: Staged Master Drainage Plan / Pond Report Templates

- Pond Report Template will be released soon. SMDP Template to be released later, but will be similar to Pond Report Template
- Some LID references included – more information in future versions
- Not all tables and information are relevant
- Digital version (in WORD) available
- For the latest version of the Templates, see the ***Development Approvals Submissions Page*** on the City of Calgary website

Section 11.1.4.2.2: SMDP Report Submission Requirements

- **Statement of Agreement** with affected stakeholders if the proposed pond and/or associated downstream tie-ins or outfalls are off-site
- This statement must be co-signed by the affected stakeholders

6.1.11.1: Staged Construction

- Will only be considered on a case-by-case basis, depending on the size of the drainage area, and risk of or impact from erosion from unstabilized recently excavated areas in the pond, as well as where future expansion consists of independent cells that can be isolated.
- Staging information must be submitted as part of the SMDP and/or Pond Report.
- FAC will not be issued until the required maintenance period has elapsed after the last phase of staged construction.
- The conditions pertaining to staged construction, including CCC and FAC, will be site-specific and must be outlined in the Development Agreement.
- The developer responsible for subsequent stages will be required to remediate any damage and/or remove excess sediment from the earlier constructed cells of the pond.

6.1.12: Temporary Ponds

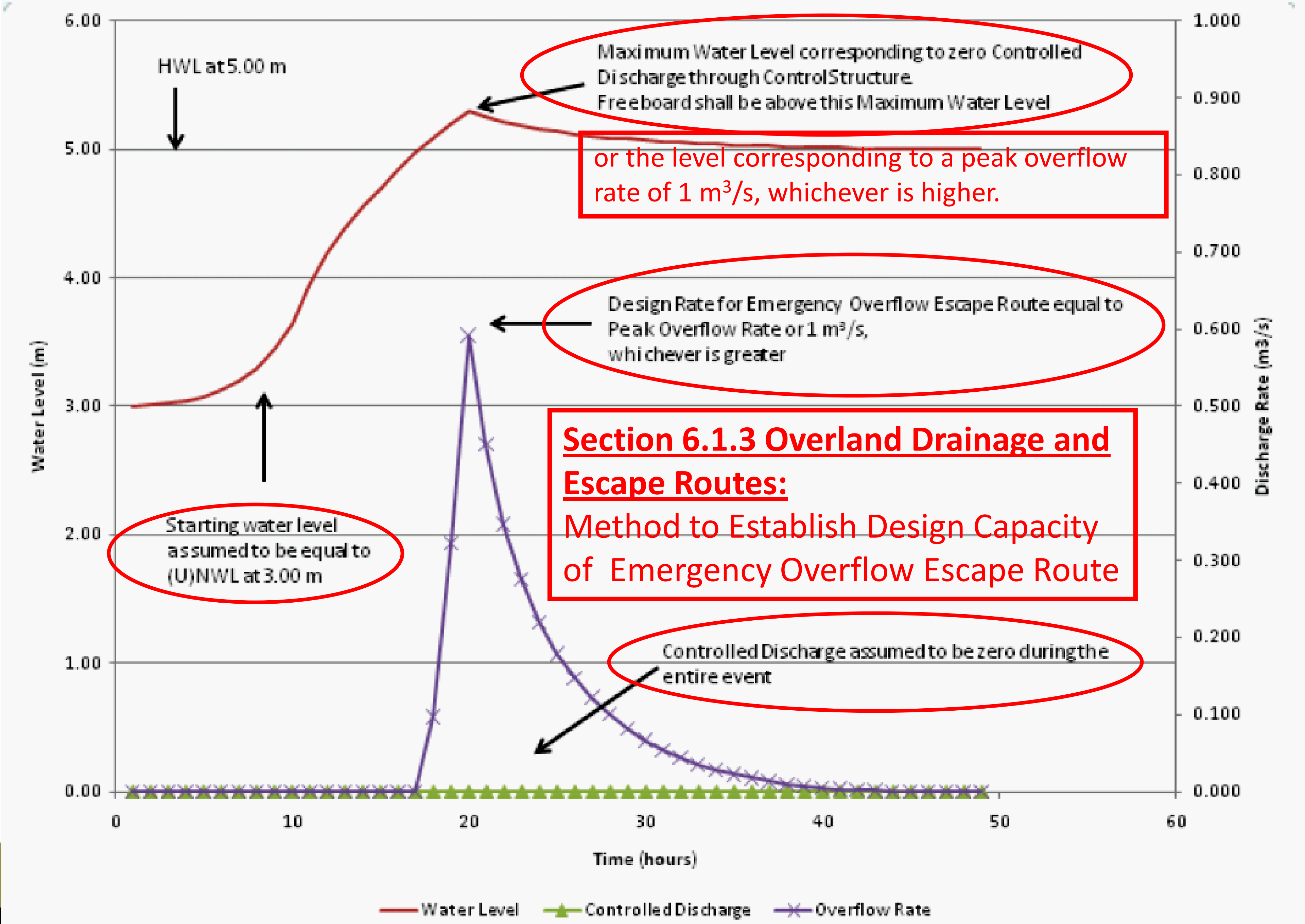
- Typically, Water Resources does not favour the construction of temporary ponds. If temporary ponds are implemented, the final pond must be constructed within a time frame to be agreed upon beforehand with Water Resources.
- Water Resources will not take over temporary ponds.
- The conditions pertaining to temporary ponds, including CCC and FAC, will be site-specific and must be outlined in the Development Agreement for the development in question.

Section 11.1.4.2.4: SMDP - Site Description

- Identify
  - type and size of individual development cells (residential, industrial, commercial, etc.)
  - interim undeveloped or future external development areas
  - total site area, including external areas
  - overland drainage direction, downstream storm ponds and outfalls;
  - all stormwater quality treatment facilities or Source Control Practices

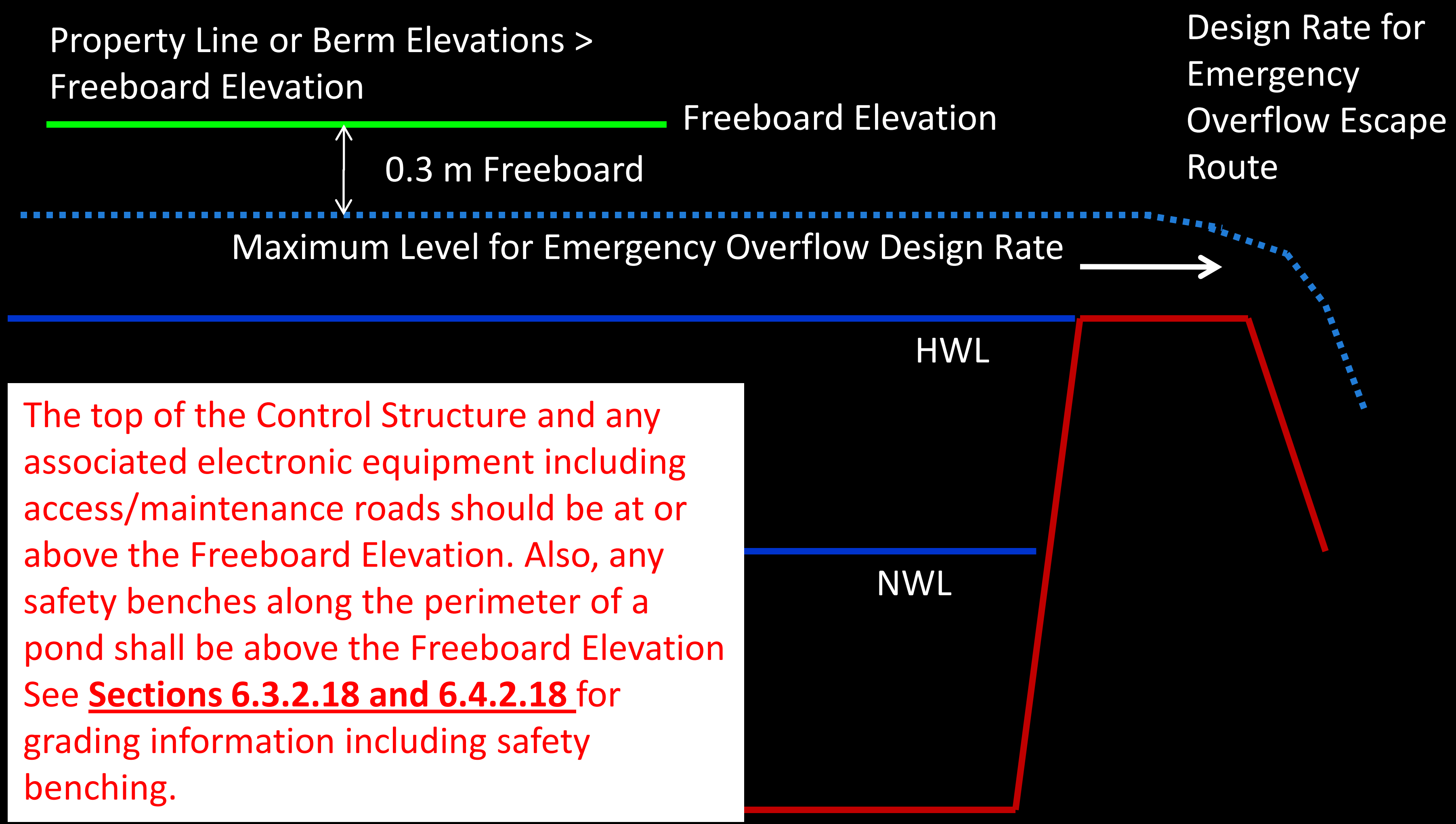
Section 6.1.3: Overland Drainage and Escape Routes

- Provide a designated continuous emergency overland escape route from all ponds.
- Demonstrate that the configuration and capacity of the emergency escape route is adequate to convey the design capacity without creating unsafe conditions or negatively impacting downstream property
- Assessment of the overland emergency escape route shall extend to the location where the spilling flow will enter a downstream pond or drainage course that has a capacity exceeding that of the overland emergency escape route



Maximum Water Level corresponding to zero Controlled Discharge through Control Structure.
Freeboard shall be above this Maximum Water Level
or the level corresponding to a peak overflow rate of 1 m³/s, whichever is higher.
HWL at 5.00 m
Design Rate for Emergency Overflow Escape Route equal to Peak Overflow Rate or 1 m³/s, whichever is greater
Section 6.1.3 Overland Drainage and Escape Routes:
Method to Establish Design Capacity of Emergency Overflow Escape Route
Starting water level assumed to be equal to (U)NWL at 3.00 m
Controlled Discharge assumed to be zero during the entire event
Water Level (m)
Discharge Rate (m3/s)
Time (hours)
Water Level
Controlled Discharge
Overflow Rate

Section 6.1.3: Overland Drainage and Escape Routes - Freeboard Derivation



The top of the Control Structure and any associated electronic equipment including access/maintenance roads should be at or above the Freeboard Elevation. Also, any safety benches along the perimeter of a pond shall be above the Freeboard Elevation See **Sections 6.3.2.18 and 6.4.2.18** for grading information including safety benching.

What to do if there is no escape route from a pond?

- In the demonstrated absence of a practical overland emergency escape route, and subject to **prior** approval by Water Resources, the following options may be considered in declining order of desirability:
  i. Provision of a pipe emergency escape route (i.e., culvert that daylights downstream) with a diameter equal to or greater than 600 mm, and capacity greater than 1 m^3/s. The freeboard elevation shall be 0.50 m above the water level that corresponds to the design overland emergency discharge rate, or 0.50 m above the obvert of the culvert, whichever is higher;
  ii. Increase the design flow rate of the downstream storm sewer system by a minimum of 1 m^3/s. The freeboard elevation shall be 0.50 m above the water level that corresponds to the design overland emergency discharge rate; or
  iii. The freeboard elevation shall be 0.50 m above the 1:500 year elevation.

See Section 3.2.4.2.2, Table 3-7 and Appendix K

Section 11.1.4.2.5: SMDP - Design Objectives

- Reference relevant WMP or MDP/SMDP reports
- State specific design objectives:
  - Allowable unit area and total discharge rates (in L/s/ha and L/s, respectively) and runoff volume target (in mm), if applicable, to downstream areas or into ravines. Changes from existing or pre-development conditions need to be rationalized
  - Storm discharge and runoff (expressed in L/s/ha, L/s and mm, respectively) allowed from upstream catchment areas, including temporary undeveloped catchments

Section 11.1.4.2.5: SMDP Design Objectives

- State specific design objectives:
  - Design basis for storm sewer system (L/s/ha)
  - Water re-use strategies including seasonal usage patterns, if applicable. In case of water re-use strategies, the report shall also address a fall-back scenario in which the re-use strategies are not operational
  - Information about stormwater quality treatment facilities or Source Control Practices upstream of any ponds, or water re-use strategies is of particular importance where the design of these facilities directly affects downstream ponds

Sections 11.1.4.2.9 and 11.1.6.2.9:

Storm Sewers (On-Site / Off-Site)

- Identify
  - preliminary design flow rates
  - (approximate) trunk sizes, alignment, and elevations
  - Hydraulic Grade Line(s) to the extreme extent of the storm sewer system to ensure that the upstream drainage system can operate properly, without undue surcharge conditions, with the proposed elevations of the pond.
  - identify typical trap low storage capacity (m^3/ha)

Section 3.1.2.3: Sizing of minor system

- Where possible, the minor system is to be designed using the Unit Area Release Rate Method or the Modified Unit Area Release Rate Method.
- For all new areas, the minor system must be designed using the Unit Area Release Rate Method (L/s/ha). In general, the recommended minimum unit area release rate is 70 L/s/ha. In steeper terrain, where on-street storage is minimal, or for higher imperviousness ratios, the design rate may need to be higher.

Section 3.1.2.3: Sizing of minor system

- Lower release rates will only be considered:
  - in flat areas,
  - for areas adjacent to stormwater ponds where flows in excess of the storm sewer system capacity can be readily conveyed to the pond as overland flow, or
  - for areas that utilize source control practices that significantly reduce the amount of runoff volume.

$$70 \text{ L/s/ha (UARR conventional)} \times \frac{\text{Runoff Volume}_{\text{(LID 1:5 year condition)}}}{\text{Runoff Volume}_{\text{(Conventional 1:5 year condition)}}}$$

- The minimum rate allowed is 45 L/s/ha

Sections 11.1.4.2.12 (ii) and 11.1.6.2.12 (ii):
Off-Site Discharge

- Summarize permissible and actual 1:100 year discharge to receiving water bodies or downstream drainage system(s), expressed in L/s/ha and L/s
- Provide derivation of emergency escape design flow rate and assess the configuration and capacity of the emergency escape route
- Also summarize annual runoff volume discharged (in mm) from the ponds or wetlands, if applicable
- For wet ponds subject to water re-use, quantify volumes of water available for re-use

Section 11.1.6.2.12 (v): Pond Report Water Re-Use Facility Characteristics

Parameter	Value
Bottom Elevation	m
Lower Normal Water Level (LNWL)	m
Upper Normal Water Level (UNWL)	m
High Water Level (HWL)	m
Invert Elevation of control structure	m
Pond Depth below LNWL	m
Water Re-Use Depth (LNWL to UNWL)	m
Active Pond Depth (UNWL to HWL)	m
Area at LNWL	ha
Area at UNWL	ha
Area at HWL	ha
Emergency overflow design rate	m^3/s
Emergency overflow design rate Elevation	m
Freeboard Elevation	m
Discharge at HWL	m^3/s
Storage Volume at LNWL	m^3
Storage Volume at UNWL	m^3
Storage Volume at HWL	m^3
Live Storage Volume at HWL	m^3
1:100 Live Storage Volume	m^3
1:100 Water Level	m
1:100 Discharge	m^3/s

NEW

NEW

NEW

Section 7.5.3.2:

Particle Sizes and Settling Velocities

Replacement of what used to be Table 7.2

Table 7-3: Particle Size and Settling Velocities for Sediment Removal

Updated Parameters for City of Calgary				
Size Range (µm)	Density (kg/m^3)	Fraction (%)	Cumulative Total (%)	Settling Velocity (m/s)
<10	1500	23	23	0.00000592
10 - 20	2000	9	32	0.00004730
20 - 50	2500	13	45	0.00028300
50 - 150	2650	23	68	0.00195000
>150	2650	32	100	0.01240000

Notes: **a)** Densities are estimated.
b) Settling velocities are based on 15 degree Celsius temperature.
c) Settling velocities are based on the lower end of the size range.
d) A size of 5 µm is used for the <10 µm size range.

Parameters for Forebay				
Particle Size (µm)	Density (kg/m^3)	Size Range (µm)	Fraction (%)	Settling Velocity (m/s)
50	2650	>50	55	0.00195
75	2650	>75	46	0.00438
150	2650	>150	32	0.01240

Notes: **a)** The particle size distribution follows the New Jersey Department of Environmental Protection curve. This curve, which reflects the presence of more fine particles than originally assumed, falls within the wide range of particle size data acquired.

b) The settling velocities are largely based on Stokes Equation or Newton's Law of settling for larger particles. This reflects the findings by Sansalone and others. These velocities are significantly greater than what was assumed in the 2000 manual, which, at the time, reflected the 1994 Ontario MOE stormwater guidelines. The latter data was removed in the 2003 Ontario MOE stormwater guidelines as it was no longer felt to be appropriate.

c) Refer to ***6.3.2.8.2 Sizing*** for more information.

Section 11.1.6.2.12 (vii): Pond Report Water Quality Enhancement

Summarize

- Total Suspended Solids (TSS) removal in the pond in tabular format
- Detention Time ~ Emptying Time (> 24 hrs)

$$t = \frac{2\,A_p}{CA_o(2g)^{0.5}}\left(h_1^{0.5} - h_2^{0.5}\right)$$

See Sections 6.1.2. (v)

- Length to width ratios in the pond (> 3:1)
- Please see **Section 6.1.2 (iv)** for a revised permanent wet pool requirement in wet ponds.

Sections 11.1.4.2.12 (iii) and 11.1.6.2.12 (iii) and (viii): Storage Requirements and Frequency of Inundation

Summarize storage based on single-event and/or continuous simulation:

- Provide results of statistical analysis for each frequency analysis analyzed

Provide elevation exceedance curves

- for wetlands; compare to pre-development conditions, if applicable; and
- for wet ponds subject to water re-use

Section 11.1.6.2.8 (ii) and (iii): Pond Report – Forebay Characteristics

- Describe and tabulate key characteristics

Parameter	Unit	Value
Bottom Elevation	m	
Normal Water Level (NWL)	m	
High Water Level (HWL)	m	
Invert Elevation of incoming pipe	m	
Pond Depth below NWL	m	
Forebay Length		
Forebay Width		
25-Year Sediment Storage Capacity	m^3	

See Sections 6.3.2.8.3 and 6.3.2.8.4, forebay settling length and dispersion length

CFD Analysis is acceptable to demonstrate this but come talk to us ahead of time!

- Summarize length to width ratios
- Describe how short-circuiting is avoided
- Express wet pool storage volume of wet ponds (m^3/ha)

Section 6.3.2.8.2: (Forebay) Sizing

Equation 6-2:Theoretical Sediment Accumulation

$$SSCR = 25 \times RV \times \{TSS\text{-}conc / 1000\} \times BF \times PSDF$$

where:

SSCR = sediment storage capacity required (kg).

25 = multiplication factor for 25 years of sediment storage.

RV = computed average annual runoff volume (m^3).

TSS-conc = TSS concentration from ***Table 7-2*** (mg/L).

BF = bedload multiplication factor = 2

PSDF = particle size distribution factor from ***Table 7-3***.

- An example is provided in Section 6.3.2.8.2

Section 11.1.6.2.10: Pond Report - Geotechnical

- Identify Geotechnical Report summarizing requirements for
  - pond lining,
  - toe drains,
  - french drains,
  - forebay berm including core
  - stable slopes
- Identify if any embankments may be classified as a dam under the *Water Act*.
- Identify whether any infiltration or percolation into the subsoils is proposed to meet runoff volume targets

Section 6.3.2.9: Wet Ponds: Forebay Berm Requirements

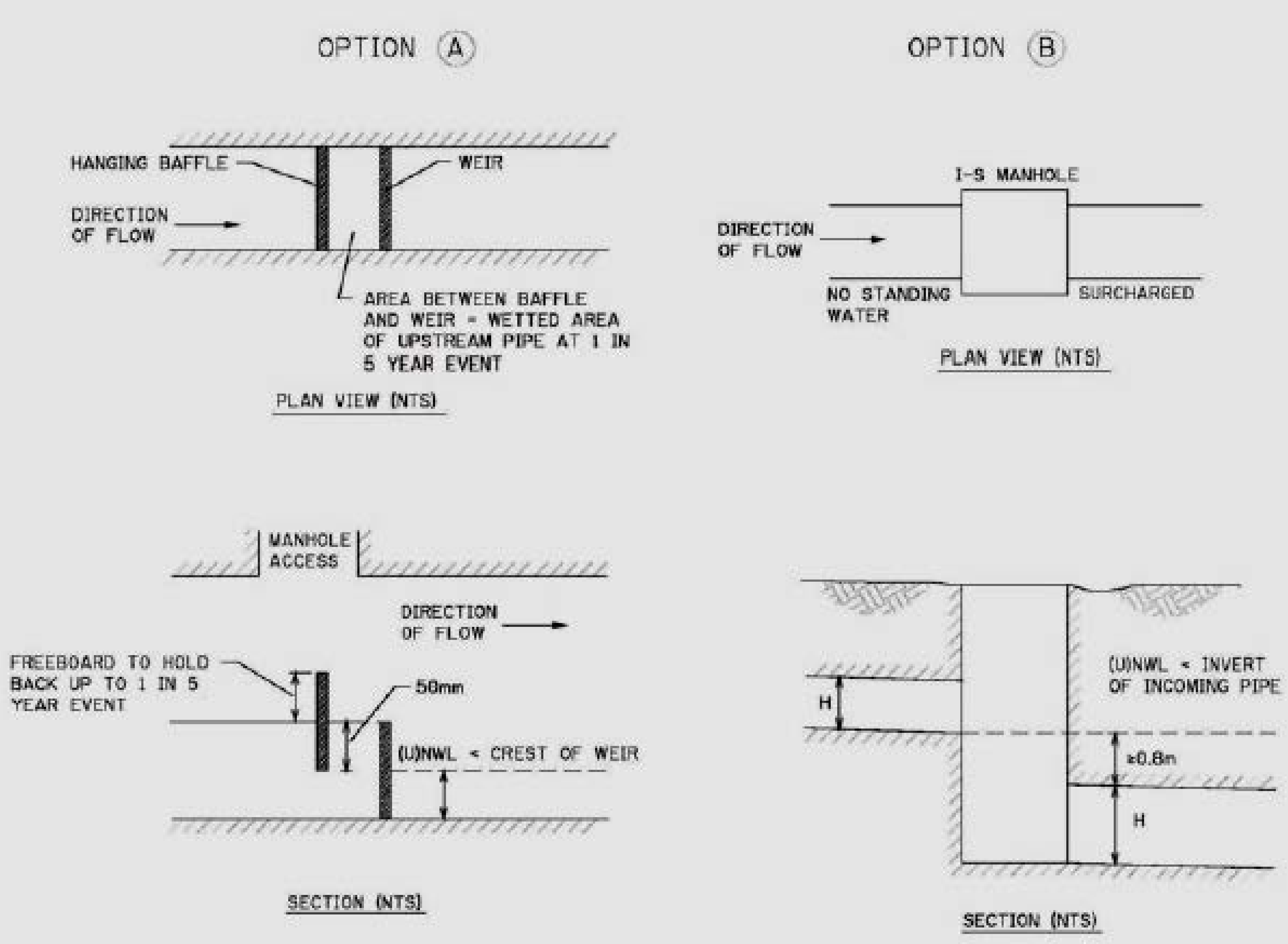
- The core of the berm shall be impermeable
- The berm shall be geotechnically stable under submerged conditions
- Sloughing of the berm shall be ≤ 150 mm at the time of FAC

Sections 6.3.2.22 and 6.4.2.22: Maintenance Vehicle Access

- Maintenance vehicle access (using 23 tonne tandem trucks) must be provided to:
  - The outlet control structure
  - The inlet structure
  - The skimming weir(s) or skimming manhole(s)
  - The forebay
- Operations staff using 1 tonne trucks must be able to access all areas of the pond
- The subgrade must conform to a “Lane” standard
- Re the outlet control structure, the entire maintenance vehicle access road (including the top of the control structure and any associated electronic equipment) must be at or above the freeboard elevation.

Sections 6.3.2.20 and 6.4.2.20: Inlets Sk

Figure 6-14: Skimming Manhole



Sections 11.1.4.2.12 (v) and 11.1.6.2.12 (ix):
Habitat

- In the case of engineered natural stormwater wetlands and constructed stormwater wetlands that provide compensatory value, demonstrate how the design objectives for the operation of the "habitat" components of the wetlands, as agreed with Water Resources and Parks, have been met

Section 11.1.4.2.12 (vi): SMDP On-Site Servicing

- Tabulate the preliminary
  - on-site permissible unit area discharge rates,
  - storage requirements and
  - runoff volume targets

  for each of the individual development cells within the study area
- This information shall be displayed on the Storm Area Drainage figure as well

Section 11.1.4.2.12 (vii): SMDP SCPs

- Outline in detail which types of SCPs will be implemented, and the corresponding performance requirements for each land use area / development cell
- Demonstrate collectively how each land use / development cell contributes to meeting the overall runoff rate and volume and water quality criteria set out for the development

Section 11.1.4.2.12 (vi): Distribution of Runoff Volumes over Catchment

Catchment – say 100 ha
Runoff Volume Target – say 50 mm – 50,000 m^3

Catchment – say 30 ha commercial
Runoff Volume Target – say 150 mm – 45,000 m^3

The remaining 50,000 – 45,000 = 5,000 m^3 would have to be balanced over the remainder of the catchment of 100 – 30 = 70 ha
Runoff Volume Target – 5,000 m^3 or 7.1 mm

Catchment – say 60 ha
Runoff Volume Target – say 40 mm – 24,000 m^3

Irrigation of Green Space – identify size and how much is re-used!

Wet Pond with water re-use system

Catchment – say 100 ha
Runoff Volume Target – say 50 mm – 50,000 m^3

Sections 4.7.2.2 and 4.8.4: Zero-Discharge Facilities replacing old Sections 4.6.2 and 4.8.6 Evaporation Ponds

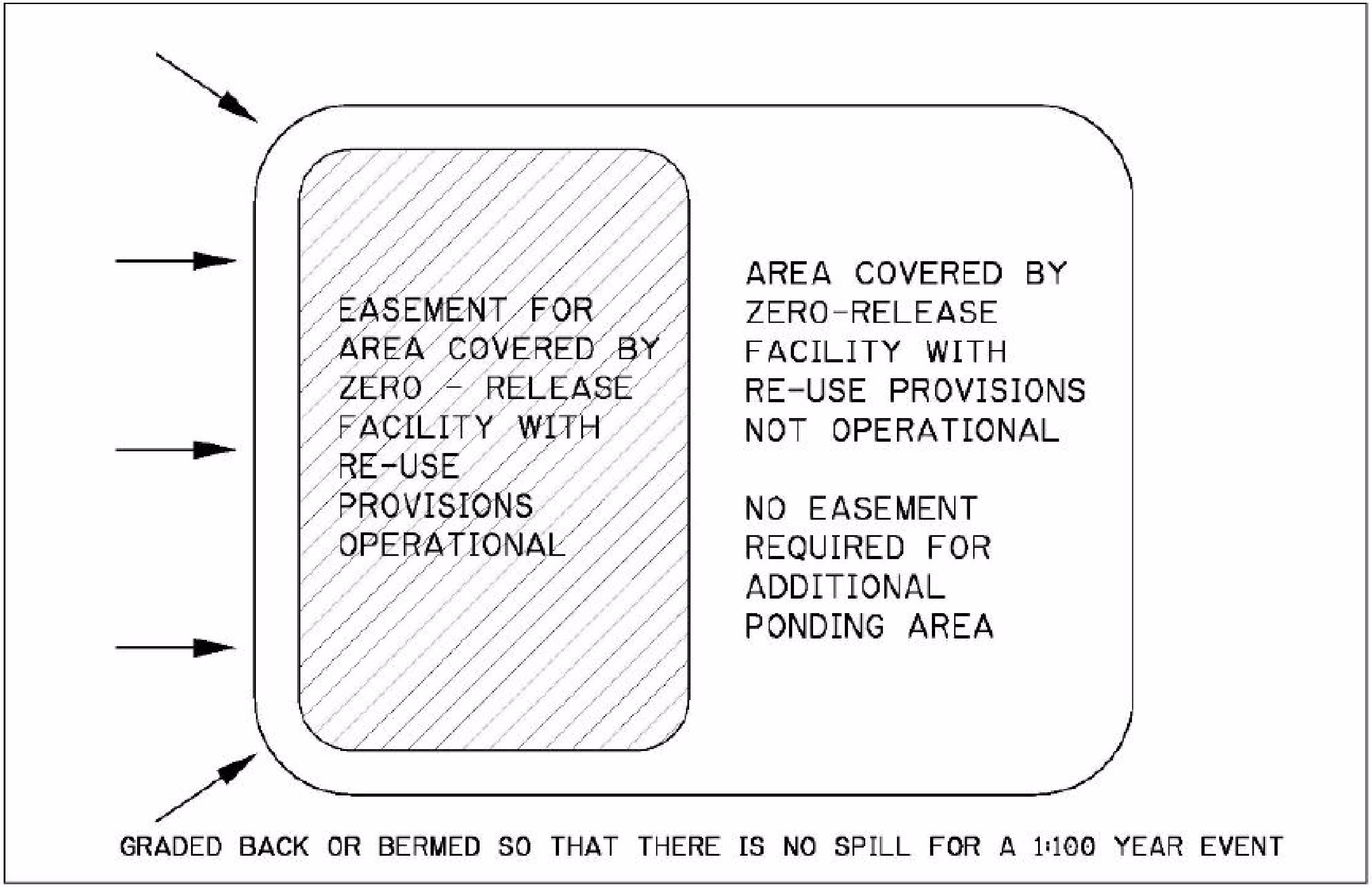
Section 4.7.2.2: Zero-Discharge Ponds

1. The long-term viability of water re-use and/or runoff reduction techniques needs to be demonstrated to the satisfaction of Water Resources;
2. A scenario in which only evaporation is used shall also be assessed; there must be no spillover into adjacent lands or onto public right-of-ways under this scenario; and
3. Computer modelling shall be completed for small sites when these volume reducing techniques are proposed.

In addition, provide:

1. an easement for the area covered (assuming water re-use provisions are operational); and
2. an appropriate emergency overland escape route

Section 4.7.2.2: Zero-Discharge Ponds



Sections 4.8.4 and 11.1.6.2.12 (iv):

Zero-Discharge Facilities

- Describe area subject to inundation for 1:100 year event
- Demonstrate balance between runoff and evaporation losses and/or water re-use for average annual year
- Identify area subject to inundation and water level for 1:100 year event in case water re-use system is not operational (if applicable)
- For zero-discharge facilities that do not empty from year to year:
  - the starting water level or pond volume for the simulation shall be established iteratively, and
  - correspond to the average water level or pond volumes over the period of record

Section 4.8.4:
Zero-Discharge Facilities

In addition to models such as QUALHYMO, QHM and SWMM, the "Water Balance Spreadsheet for the City of Calgary" will also be accepted by Water Resources. The analysis tools shall account for seasonal variations in water re-use. The climate database must include both rainfall and snowfall, covering the entire year, to account for the proper runoff volume. The analysis techniques shall also account for frozen soil conditions during the winter months.

For updated evaporation data, see Table 4-1: Shallow Lake Evaporation

The use of the different statistical distributions listed in Section 3.2.6 is only appropriate if the annual maximum volumes are independent. In the case of evaporation facilities this will often not be the case and therefore an auto-regression type statistical analysis should be carried out.

Section 4.8.4:
Zero-Discharge Facilities

Water Resources plans to undertake some work to establish the most appropriate statistical analysis and sizing method. Until this is determined, the storage requirements and associated surface area are to be based on:

(a) the maximum water level established as part of the continuous simulation calculations, or

(b) the 1:100 year water level from the statistical analysis of the annual maxima, whichever is higher.

A minimum 0.50 m freeboard must be provided above this elevation. Some flexibility may be exercised in the freeboard allowance on a case-by-case basis, if it can be demonstrated that risks associated with a reduced freeboard are addressed to the satisfaction of Water Resources.

Section 4.8.3: Batch Operation Scenario

- Applies to some ponds such as at landfills or certain industrial facilities, where all runoff is to be collected, tested, and possibly treated:
  - Need to identify what parameters need to be tested
  - Storage requirements must be increased to accommodate all runoff from a 7-day event

    (see Appendix K, Calgary Design Storm Tables for the 1 day – 30 day precipitation depths)
  - When using a SWMHYMO computation, assume that the soil is fully saturated after the first day unless absorbent landscaping is provided.

Section 11.6.3: Stormwater Ponds Construction Tolerances

- The construction of all ponds must meet the following tolerances:
  - Spillover Elevation must be
    - within +/- 50 mm for the overland emergency escape route; or
    - within +/- 25 mm for the weir wall in the outlet control structure
  - Freeboard Elevation shall not be more than 50 mm below the design elevation;
  - Width of the crest of the overland emergency escape route must be within +/- 100 mm;
  - Live storage capacity must be no less than 99% of the required 1:100 year storage capacity

Section 11.6.3: Stormwater Ponds Construction Tolerances

- The construction of all ponds must meet the following tolerances:
  - Discharge at 1:100 year elevation must be within +/- 1.0%
  - (U)NWL of wet ponds must be within +/- 50 mm
  - The crest elevation of the forebay must be within +/- 150 mm
- Construction tolerances for engineered natural stormwater wetlands shall be identified and agreed with Water Resources and Parks as part of the Pond Report

Section 11.6.3: Stormwater Ponds

CCC / FAC Requirements

- The sediment accumulation in **wet ponds** shall be such that, at FAC:
  - The sediment storage capacity in the forebay(s) shall be greater than or equal to the design 25-year sediment accumulation;
  - The top of the sediment accumulation in the forebay(s) is at least 300 mm below the lowest invert of the incoming pipe(s);
  - The wet pool capacity is greater than the design capacity; and
  - The sediment accumulation in the main cell(s) of the wet pond relative to CCC is less than 150 mm.

Section 11.6.3: Stormwater Ponds

CCC / FAC Requirements

- The sediment accumulation in **constructed stormwater wetlands** shall be such that, at FAC:
  - The sediment storage capacity in the forebay(s) shall be greater than or equal to the design 25-year sediment accumulation;
  - The top of the sediment accumulation in the forebay(s) is at least 300 mm below the lowest invert of the incoming pipe(s); and
  - The sediment accumulation in the main cell(s) of the wetland relative to CCC is less than 25 mm.
- In case of engineered natural stormwater wetlands, the tolerances shall be as agreed with Water Resources and Parks as part of the Pond Report

BREAK

Section 11.1.8: DSSPs
When is a Stormwater Management Report required?

- This report in support of a DSSP must be submitted:
  - For sites over 2 hectares.
  - For sites smaller than or equal to 2.0 hectares and
    - without servicing; or
    - where Best Management Practices and source control practices are proposed to reduce on-site storage requirements, control run-off volume and/or enhance water quality.
  - For the re-development of parcels of sites where the parcels are smaller than or equal to 2.0 hectares, but are part of a larger private site.

4.13: Best Management Practices (BMPs)

- Use of BMPs is recommended for all sites. However, BMPs are required for the following sites:
  - Sites subject to runoff volume targets.
  - Large sites (greater than 2 ha).
  - Gas stations, lube and oil change facilities, vehicle maintenance and mechanical shops (including adjacent parking lots), and sites with on-site storage of fuel.
  - Heavy industrial and manufacturing sites.
- Pre-treatment of runoff for sediment removal using oil/grit separators (or approved equivalent) is required for industrial/commercial sites that drain into vegetated swales or ditches. The pre-treatment system must remove a minimum of 85% TSS for particle sizes greater than or equal to 50 µm.

4.13: Best Management Practices (BMPs)

- An Operation & Maintenance manual and sample maintenance log must be provided to the owner of the BMPs.
- All BMPs must be inspected and maintained on a regular basis as per Drainage Bylaw 37M2005; records should be kept to demonstrate this.

Section 8.3.4: Oil/Grit Separators (OGSs)

- Checklist #5 Water Quality BMP (Oil-Grit Separator) must be submitted for each oil/grit or oil/water separator submission.
- Key design considerations:
  - Units should treat a minimum of 90% of the total runoff volume over the period of record.
  - A minimum annual TSS removal of 85% for particle sizes 50 μm and greater is required for each and every year.
  - The unit must have a minimum of one year of adequate sediment storage capacity without scouring.
  - The hydraulic loading rate (excluding the bypass) must be restricted to a maximum rate of 27 L/s/m^2.

Sections 3.1.2.1 and 4.2.1, both (ii) and (iii)

Clarification of Surcharge Conditions

- Where surcharge cannot be avoided, the maximum 1:100 year Hydraulic Grade Line shall be at least 1.2 m below surface to avoid compromising catchbasin interception. Also, proper aeration and venting shall be considered.
- On private sites, surcharge due to back-up from the flow control from the private site to the public system is acceptable. However, the designer shall ensure that the maximum 1:100 year water level is at least 0.30 m below slab elevations. This will also ensure that low-lying areas such as parkades are not negatively impacted by the backwater conditions.

Section 5.1.3: Hydraulic and Energy Grade Lines

Two types of flow conditions can be distinguished for free flow conditions: subcritical conditions and supercritical flow conditions. Subcritical conditions are typically characterized by a mild slope, with high flow depth and low velocity, resulting in a Froude number smaller than one. Supercritical conditions are typically characterized by a steep slope, with low flow depth and high velocity, resulting in a Froude number greater than one. The Froude number is defined as:

$$Fr = \frac{\overline{u}}{(gD)^{0.5}}$$

where: $\bar{u}$ = average velocity (m/s)

g = gravity acceleration (9.81 m^2/s)

D = hydraulic depth (m)

Section 5.1.3: Hydraulic and Energy Grade Lines

Caution must be exercised when a system is designed to operate under supercritical flow conditions, since tail water conditions, bends, or obstructions in the pipe or channel (which can be simple mis-aligned joints) might cause a hydraulic jump.

This hydraulic jump, in turn, could cause the flow to “jump” out of the channel or seal off the pipe, resulting in undesirable hydraulic transients and improper ventilation. In these situations, the conduit or channel must be designed to fully contain the hydraulic jump under atmospheric conditions.

Section 3.3.2.3:

Flow Velocities and Minimum Slope

ii. Storm sewers must be designed so that the actual velocity corresponding to the design flow is greater than 0.90 m/s.

iii. Where design velocities in excess of 3.0 m/s are propo… …inst displa… move… …ess provi… …tural stabil… …rs are re… …than, or equal to, 33%, or as requested by Water Resources.

This has not yet been changed from the 2000 version of the manual; however, we are paying more attention to this issue. Contact us if your design calls for steep pipes or “deep” drop manholes (see also Section 3.3.3.5).

Section 3.3.6: Weeping Tiles Drains

See Sections 3.3.6.2.1 (ii): required if **LTF ≤ 2.50 m** above the seasonally adjusted water table

All weeping tile is required to tie to the storm sewer by gravity. Connection to the sanitary sewer is not permitted.

There are some circumstances where (*a standard gravity*) connection to the storm sewer is not possible or recommended:

- Infill housing where storm sewer is available, but footing elevations must be set low to conform to grades of adjacent developments, therefore making gravity drainage impossible
- Infill housing where storm sewer is unavailable
- Existing lots that experience storm sewer backup,
- Lots where the hydraulic grade line (HGL) is sufficiently high to cause potential storm sewer backup. This includes lots or areas in a floodplain.

Section 3.3.6: Weeping Tiles Drains

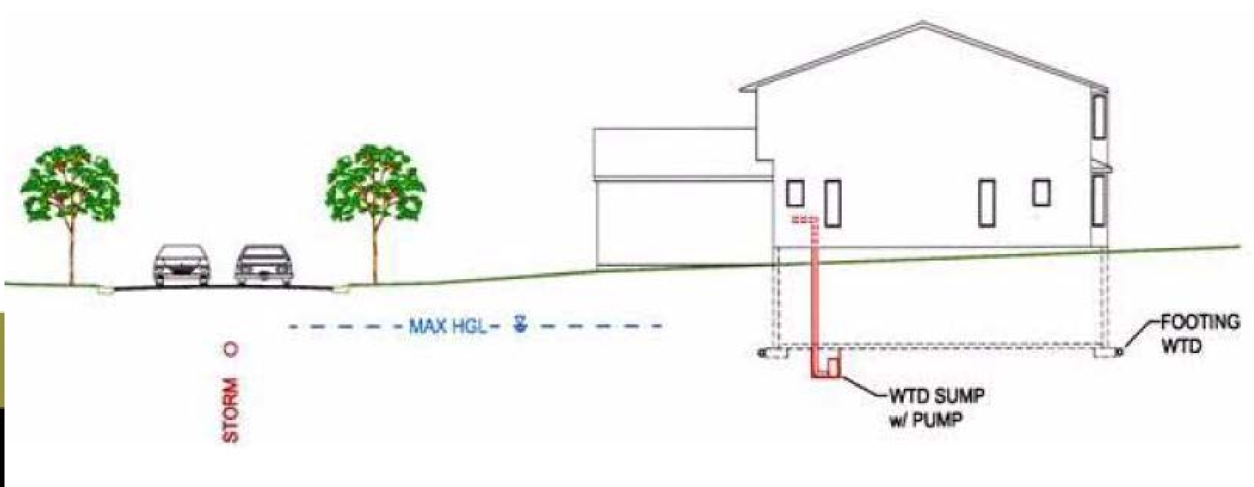
In these situations, pumping water from a sump (i.e., sump pump) is allowed. If a public storm sewer system is available, a connection to the storm sewer system is required.

The top of the goose neck in the discharge pipe of the sump pump must be above ground or above of the spillover elevation of adjacent trap lows, whichever is higher.

Discharge to ground is only permitted if there is no public storm sewer system. If discharging to ground, to prevent icing, the discharge should be into absorbent landscaping or bioretention areas, away from paved or impervious surfaces.

Sump pumps are typically installed on a case-by–case basis and require pre-approval from Water Resources.

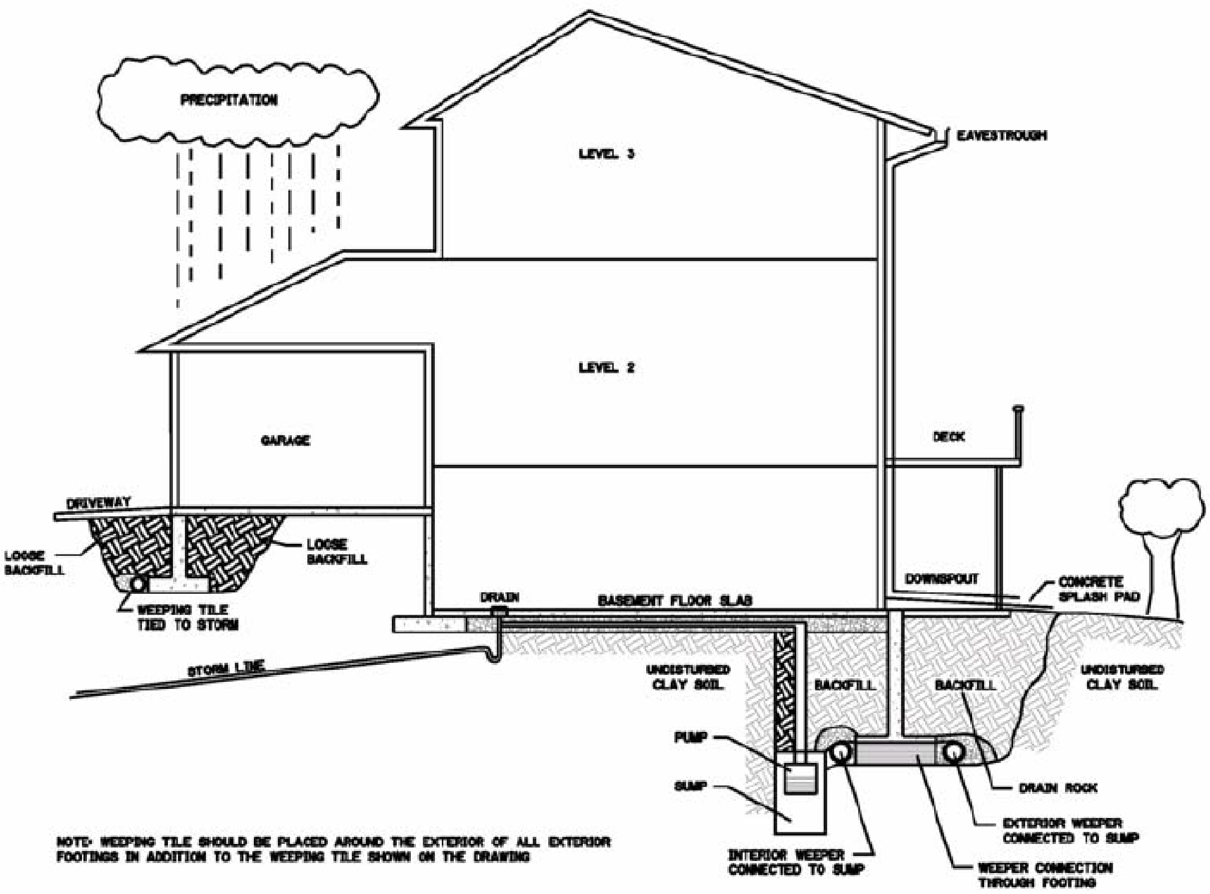
Figure 3-17: WTD Sump Pump to Surface



Section 3.3.6: Weeping Tiles Drains

In some cases, the weeping tile drain for a walkout basement cannot readily drain into the storm sewer by gravity. In that case, a sump pump that directs water from the walkout section of the weeping tile drainage system into the weeping tile drainage system servicing the balance of the building is permitted.

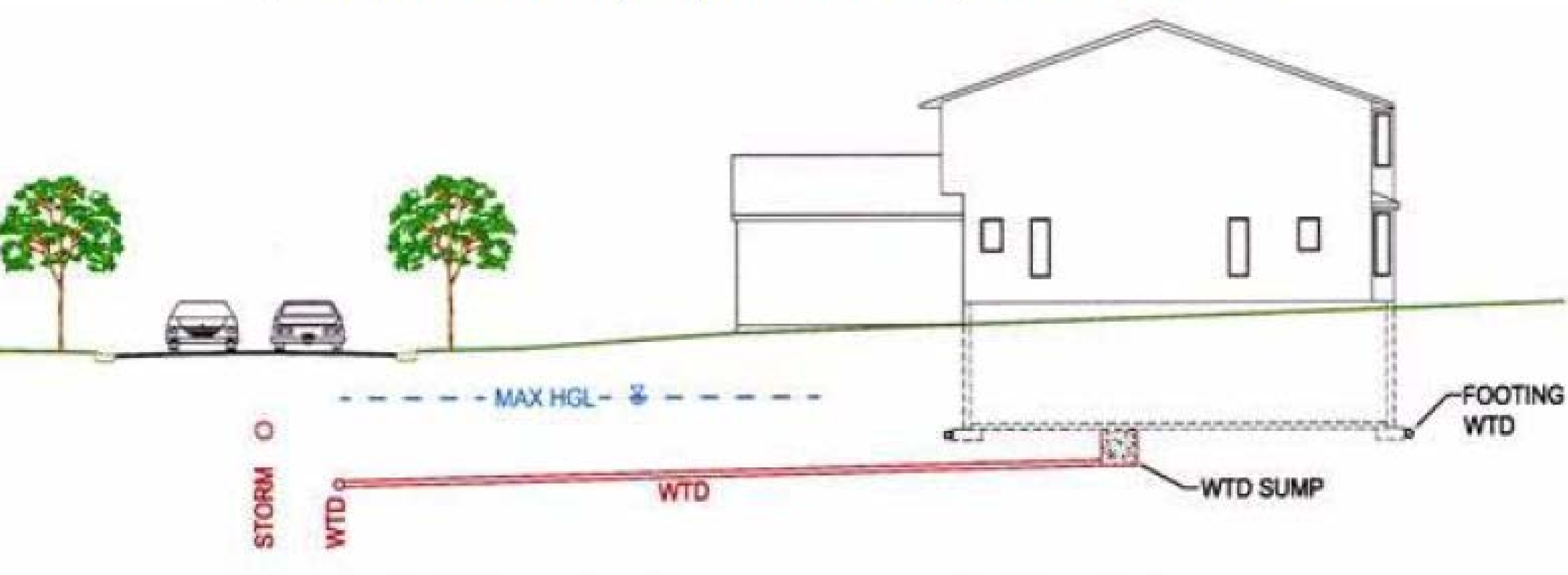
Figure 3-15: Weeping Tile Drain Arrangement for Walkout Basements



Section 3.3.6: Weeping Tiles Drains

When the HGL is sufficiently high and **the impact affects a significant area**, then a separate pipe system (third pipe) that carries only foundation drainage should be considered. Water Resources should be contacted. Although this is not necessarily the recommended solution, the three pipe system provides good and virtually fool-proof drainage to basements and allows the storm sewer to surcharge with virtually no consequences.

Figure 3-18: Three Pipe System with Separate WTD Main



Section 3.2.2: Computer Models

- OTTHYMO/INTERHYMO and OTTSWMM have been eliminated as acceptable models
- PCSWMM is now acceptable!
- A new version of QUALHYMO is under development. Contact Water Resources prior to using this version, since both the operational commands and units of input parameters are understood to have changed.

Section 3.2.2.9: Runoff Volume Analysis Tools

- Single-event models are not appropriate!
- The entire hydrologic cycle needs to be represented.
- An interim spreadsheet tool can be downloaded from the Development Approvals Submissions web page.

Section 3.2.2.9: Runoff Volume Analysis Tools

- Where typical modelling tools such as QHM, EPA SWMM, PCSWMM and/or XP-SWMM, are used, the modeller must explain how the following conditions have been met:
- Provision of thicker topsoil layers in case of absorbent landscaping.
- Re-direction of flows from hard surfaces into permeable landscaping, absorbent landscaping or bioretention / bioswale media.
- Seasonal variation of water re-use from rainwater harvesting or stormwater re-use facilities.
- Replenishment of soil moisture due to irrigation.
- Reduced infiltration during the winter months.
- Reduced infiltration due to clogging over time.

Section 3.2.2.10: Other Models

Other models must have clear benefits over the currently used tools and fit within Water Resources' long-term analysis objectives. Any tools to be considered must be

- commercially available and/or
- be made available to Water Resources at no cost for evaluation and future use.

Typically, application would only be on a one-time trial basis and would not denote future acceptance. The proponent would have to allow for one or multiple workshops to Water Resources.

Section 3.2.5.3.3: Green-Ampt Method

- Green-Ampt is now acceptable to represent infiltration

Table 3-12: Green-Ampt Values[12]

Soil Texture Class	Saturated Hydraulic Conductivity (K) mm/hr	Suction Head (ψ) mm	Porosity, Fraction (Φ)	Field Capacity, Fraction (FC)	Wilting Point, Fraction (WP)
Sand	120.396	49	0.437	0.062	0.024
Loamy Sand	29.972	61	0.437	0.105	0.047
Sandy Loam	10.922	110	3.450	0.190	0.085
Loam	3.302	88.9	0.463	0.232	0.116
Silt Loam	6.604	170	0.501	0.284	0.135
Sandy Clay Loam	1.524	220	0.398	0.244	0.136
Clay Loam	1.016	210	0.464	0.310	0.187
Silty Clay Loam	1.016	270	0.471	0.342	0.210
Sandy Clay	0.508	240	0.430	0.321	0.221
Silty Clay	0.508	290	0.479	0.371	0.251
Clay	0.254	320	0.475	0.378	0.265

Section 3.2.4.5 (v): Storm Duration and Time Interval

For the analysis of **runoff volumes for stormwater source controls practices and BMPs**, the following is recommended:

- A combination of single-event and continuous simulation techniques can be used for the sizing of BMPs and LID provisions.
- A single-event analysis for a 1:100 year design event will be needed at all times to verify that the drainage system meets the performance criteria of Section 3.3 Minor System Component Design and Section 3.4 Major System Component Design.
- Continuous simulation is required for
  - runoff volume analysis purposes,
  - BMPs and SCPs that utilize long-term storage, such as absorbent landscaping and rainwater harvesting, and stormwater capture and re-use systems, storm ponds and wetlands, and
  - water quality analysis purposes for sites where BMPs in series are implemented.

Section 3.2.4.5 (v): Storm Duration and Time Interval

For the design of trap low storage in subdivisions or small areas, the following minimum is recommended:

- 1 hour duration for areas designed with a Unit Area Release Rate for the minor system greater than 45 L/s/ha resulting in an emptying time of 30 minutes or less.
- 4 hour duration for retro-fit areas, or as directed by Water Resources.
- 24 hour duration if the minor system is subjected to backwater conditions from stormwater ponds.

Section 3.2.4.5 (v): Storm Duration and Time Interval

- The hyetograph time interval shall be 5 minutes for the single-event analysis of trap lows and peak flow rates.
- A longer duration interval may be considered for the single-event analysis of stormwater ponds.
- An hourly time interval is typically used for continuous simulation.

- See Section 3.2.4.2.2 and for rainfall depths and IDF parameters for extreme events, and see Appendix K tabulated hyetographs for all types of events!

Section 3.2.4.5 (v): Water Quality Design Event

When designing treatment-type SCPs or BMPs such as bioretention areas, bioswales and permeable pavement, a water quality design unit does not necessarily need to control and treat extreme events (such as a 1:100 year event) to achieve the desired water quality enhancement of the runoff. By controlling and treating all runoff generated by the more frequent events, the desired objectives should be achievable.

For Calgary, the Water Quality Design Event has a rainfall depth of 15 mm. See Appendix K for the tabulated hyetograph!

Section 3.2.4.5 (v): Water Quality Design Event

In the case of small sites (smaller than 2 ha), single event analysis is permitted for the sizing of single treatment type BMPs and source control practices that have negligible long-term storage, such as bioretention, bioswales and permeable pavement. These BMPs and source control practices are assumed to have adequate removal of sediments provided that:

a) all runoff for the Water Quality Design Event is directed through the treatment unit, without spillover;

b) the emptying time is less than 6 hours; and

c) the treatment unit has been designed according to Chapter 8.0 Stormwater Best Management Practices.

Section 11.1.7.2.5: Design Objectives

- Allowable minor system discharges from upstream areas into previous, now downstream phases

Table 11-6: Minor System Boundary Conditions - Permissible Inflows from Upstream Areas into Previous Phases

Location	Manhole Number	Area Size (ha)	Flow Rate		Runoff Volume		HGL	Design Storm	Source of Information
			(L/a)	(L/s/ha)	(m^3)	(mm)	(m)		

Section 11.1.7.2.5: Design Objectives

- Allowable overland spill from upstream areas into previous, now downstream phases

Table 11-7: Major System Boundary Conditions - Permissible Overland Inflows from Upstream Areas into Previous Phases

Location	Area Size (ha)	Flow Rate		Runoff Volume		Design Storm (type and duration)	Source of Information
		(L/a)	(L/s/ha)	(m^3)	(mm)		

Section 11.1.7.2.8 (vi): Boundary Conditions

- Summarize minor system flows exiting

Table 11-17: Minor System Boundary Conditions - Outflows

Location	Manhole Number	Area Size (ha)	Flow Rate (L/s)	Flow Rate (L/s/ha)	Runoff Volume (m^3)	Runoff Volume (mm)

Section 11.1.7.2.8 (vi): Boundary Conditions

- Summarize major system flows exiting

Table 11-16: Major System Boundary Conditions - Outflows

Location	Area Size (ha)	Flow Rate (L/s)	Flow Rate (L/s/ha)	Runoff Volume (m^3)	Runoff Volume (mm)

Section 11.1.7.2.8 (ii): Surcharge Analysis

- Summarize findings of surcharge analysis:

Table 11-10: Summary of Surcharge Conditions

Manhole Number	Location	Elevations			LTF	HGL	Surcharge	Freeboard relative to	
		Invert (m)	Obvert (m)	Ground (m)	(m)	(m)	(m)	Ground (m)	LTF (m)

Section 11.1.7.2.8 (iv): Private Sites

- Summarize permissible discharge rates and on-site storage requirements for private sites:

Table 11-12: Permissible Discharge Rates and Preliminary On-Site Storage Requirements for Private Sales

Location	Manhole Number	Invert	Obvert or Top	HGL	Area	Discharge Rate		Runoff Volume		Storage Volume	
		(m)	(m)	(m)	(ha)	(L/s/ha)	(L/s)	(m^3)	(mm)	(m^3/ha)	(m^3)

Section 11.1.7.2.8 (v): Overland Flow

- Tabulate key overland flow routes:

Table 11-13: Overland Flow Assessment

Street Segment Number	Peak Discharge (L/s)	Maximum Depth (mm)	Maximum Velocity (m/s)	Specific Energy (mm)	Gutter Type and Depth
S#1	52	51	0.79		
Traplow #1 - Spill	0	0	0.00		
S#2	112	64	1.08		
Traplow #2 - Spill	0	0	0.00		

Note: Specific Energy and Gutter Type and Depth only need to be provided for concrete drainage gutters/ swales in back of or between lots.

  - Must meet Alberta Environment's depth-velocity guidelines
  - All drainage gutters/swales must fully contain the flow (in the concrete section of the gutter) without overtopping!

Section 3.4.7: Swales

- Velocities and depths of flow for vegetated swales, concrete swales and bioswales should not exceed the values in Table 3-20 and Figure 3-23.
- This criterion does not apply to natural or naturalized drainage systems or larger conveyance systems such as the Shepard Ditch. Regardless, appropriate precautions such as the provision of signage or fencing should be considered at any locations where the public might access drainage courses and hence public safety might be impacted.

Section 3.4.7: Swales

- Special design consideration is required when swales discharge onto sidewalks and streets. In certain situations the potential exists for ice to build up in areas that are north–facing, in shade, or where the street has a low slope.

- The provision of a catchbasin at the downstream end of a swale, prior to it crossing the sidewalk, will eliminate a lot of these problems.

Section 3.4.7.1: Vegetated Swales

- Longitudinal slopes must ensure proper drainage and conveyance of flows. A minimum slope of 2% is recommended where possible. Grass swales in parks (MRs, ERs) require approval from both Water Resources and Parks.
- Longitudinal slopes flatter than 2% may be considered on a case-by-case basis if the grassed swale is equipped with a subdrain. Refer to Parks' "Landscape Guidelines and Specifications" for more information on swales in parks.
- All flows, up to and including the 1:100 year flow, must be contained in the swale
- For bioswales, refer to Chapter 8

Section 3.4.7.2: Concrete Swales

- Standard concrete swales are to be used when possible. Overland flows, up to and including the 100 year event, should be contained in the gutter. For gutters on a supercritical slope, the full energy head must be contained in the gutter to prevent the flow from jumping out of the gutter at bends or misaligned joints.
- Use of the drainage easement to convey overland flows should be avoided; approval from Water Resources is required if drainage easements are proposed. Overtopping of the concrete swale is not permitted.
- It is recommended that the operation of concrete drainage gutters be evaluated as early as possible during the layout phase of a subdivision (i.e., at the time of the preparation of the Outline Plan and SMDP), if even only in a preliminary fashion.

Section 3.4.7.2: Concrete Swales

- Rear yard and side yard concrete swales should not be used as overland escape routes. Where a side or rear yard overland escape route has been approved by Water Resources, the appropriate type of swale must be used (Overland Escape Route Swale, Highback or Standard).
- Highback concrete swales are required at points where the swale changes direction. The highback should extend far enough downstream to ensure that the flow does not jump out of the swale as the flow bounces from side to side. Where possible, turns should be radiused to facilitate flow conveyance.
- Swale hydraulics should be considered along with the effect of turns on critical and supercritical flows and keeping the flow within the swale. Highback and special design swales may be required to overcome these problems.

Section 3.3.4.1: Catchbasin Locations

- For roadway intersections with a continuous grade around a corner, catchbasins might have to be located at the end of curve (EC) or beginning of curve (BC) of the curb radii on the uphill side of the curb return. Special attention is required to ensure the grade is sufficient around the corner to convey the drainage. This also applies to cul-de-sacs.
- A catchbasin shall be installed at the curb upstream of locations where concentrated flows will cross any roadway. For example, from one super-elevated curve crossing to another super-elevated curve.

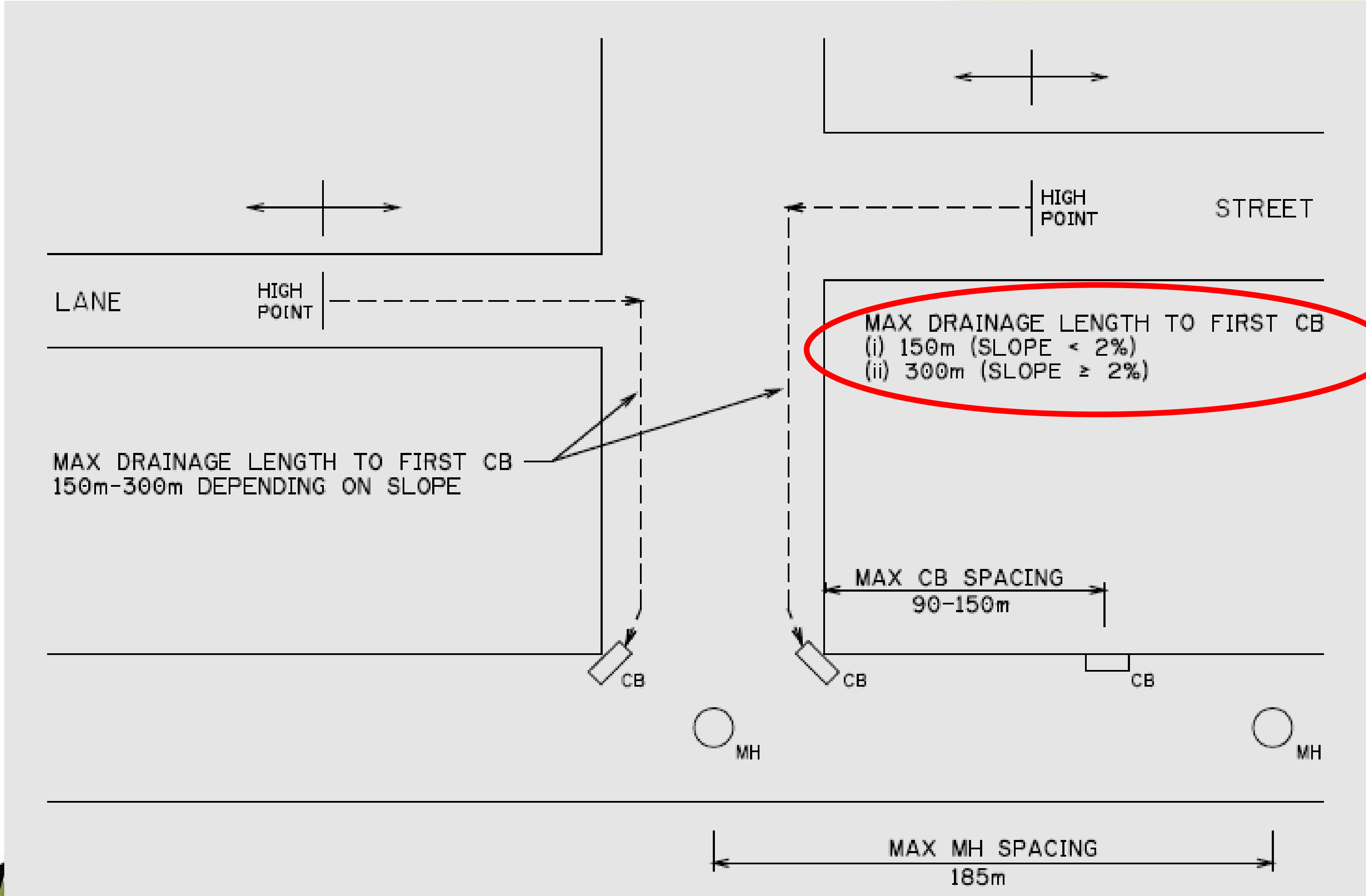
Section 3.3.4.2: Types

- There must be a minimum of one Type C CB in a trap low; K2 CBs will be accepted for the other CB(s). The Type C CB should intercept flows from the largest sub-catchment draining to the trap low.
- Where conflicts with driveways occur, the Type C CB can be changed to a K2 provided an additional Type C CB is installed on the curb just upstream of the driveway. The two CBs shall interconnected.
- The interception by the catchbasin shall reflect the greater driving head on the catchbasin lead when double barrels are used.

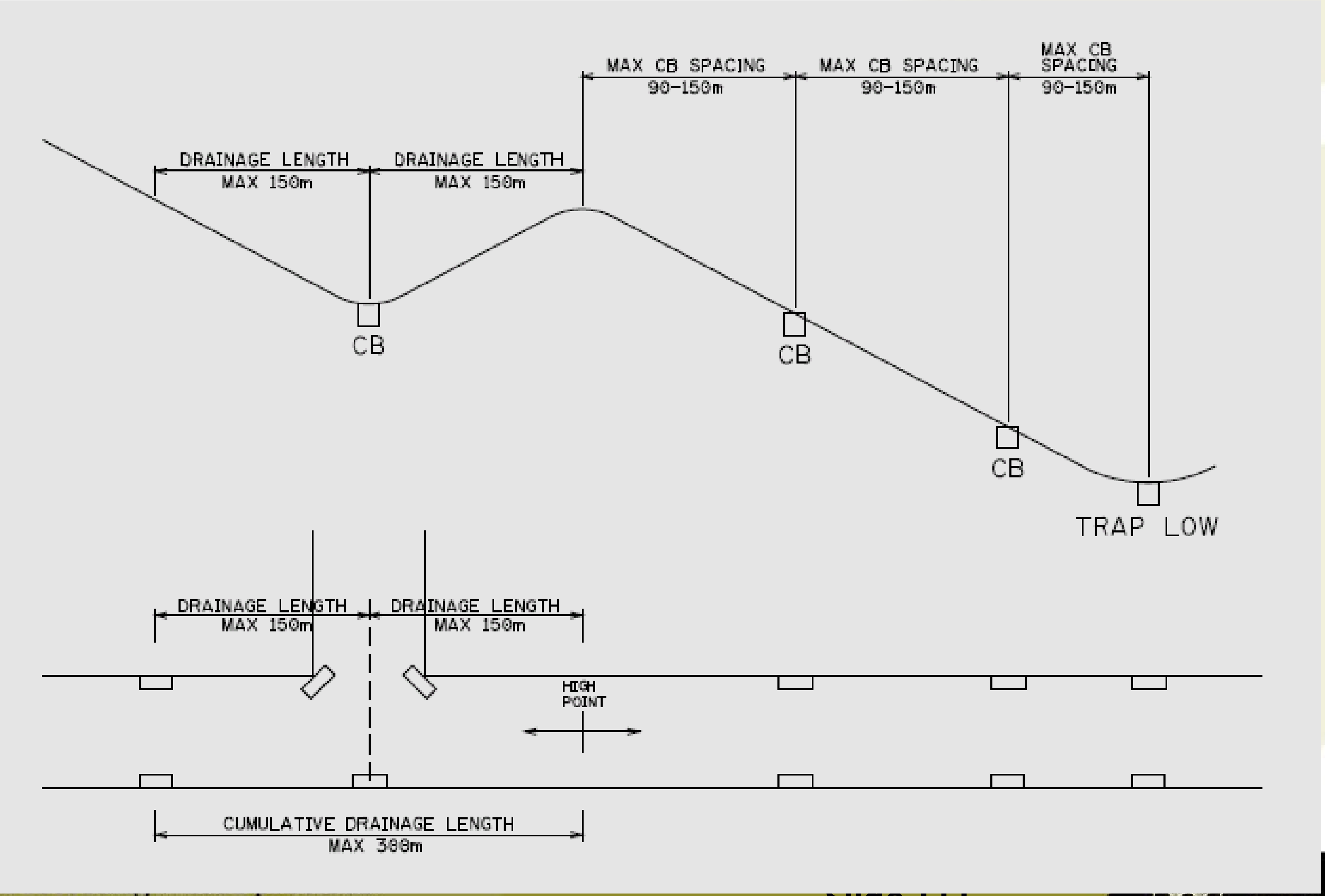
Sections 3.3.4.4.1, 3.3.4.4.2 and 3.3.5.2:
Catchbasin and ICD Capture Curves

- Capture curves have been updated for:
  - flow-by conditions for Type K2
  - ponding conditions for all types, and a grated top manhole has been added
  - all types of ICDs
    - Please note that the interception should be zero for a ponding depth equal to zero!
    - Please also note that vortex type devices are absent from the manual! We continue investigating these types of devices in view of operational challenges.

Section 3.3.2.7: Drainage Length



Section 3.3.2.7: Catchbasin Spacing



Sections 3.3.7 and 3.3.7.1: Outfalls

- Section 3.3.7 has been completely overhauled!
- Details should include design and analysis as detailed in Alberta Environment's "Code of Practice for Outfall Structures on Water Bodies".
- A Development Permit may be required for structures in the floodway. The design of the outfall should minimize incremental floodway obstruction.
- River flood backflow prevention valves should be incorporated for any outfall servicing catchment areas with ground or basement elevations below the local designated river flood level (1:100 year design event).

Section 3.3.7.1: Outfalls

- Outfalls must be constructed with adequate erosion protection. The outfall apron should also drain properly. The design of the outfall structure should account for potential long-term scour of the receiving water body's bed and banks to the satisfaction of Water Resources.
- For receiving water bodies that are braided or contain abandoned channel scrolls, locate the outfall as far from the main channel as practical to prevent failure and scour of the sewer and outfall under flood conditions.
- The structural design for outfall structures should account for groundwater rise and fall associated with flood conditions on receiving water bodies, including seepage, subsurface drainage and structure foundation considerations.

Section 3.3.7.1: Outfalls

- Local bank protection incorporating riprap, cobble or another earthworks-based erosion protection features should yield slopes preferably flatter than 3H:1V and always flatter than 2.5H:1V. Protection must be appropriate to local site conditions, including bank stability and habitat considerations.
- Erosion protection design should account for the local ice regime and potential bank scour by ice.

Section 3.3.7.2: Outfall Hydraulics

- In order to minimize erosion, outfalls are to extend to the bottom of drainage courses or to the edge of streams. This includes back-yard drainage into ravines. **Concentrated discharge onto steep slopes, without appropriate erosion protection, will not be accepted.**
- On smaller creeks and rivers, where the bankfull width of the receiving stream is less than six times the outfall diameter, an outfall discharge at 90 degrees (or perpendicular) to the opposite bank should be avoided or mitigated to the satisfaction of Water Resources. Alignment angled towards the downstream flow in the receiving water body is preferred; the configuration and angle will be subject to the approval of Water Resources..
- Where appropriate, bioengineering treatments should be incorporated into stream or receiving water body shoreline protection.

Section 3.3.7.2: Outfall Hydraulics

- Hydraulic analyses of the outfall and receiving water body should include consideration of outfall performance at a range of receiving water levels including open water season low quartile level, mean open water season level, as well as 1:2, 1:5, 1:20, and 1:100 year flood levels. Erosion protection should be incorporated for the most conservative scenario.
- Outfalls and storm sewers should be configured to avoid hydraulic jumps within the pipes or conduits directly upstream of the outfall. Appropriate energy dissipation structures with proper venting and aeration should be included where supercritical flows may develop.

Section 3.3.7.2: Outfall Hydraulics

Outfalls should typically have invert elevations above the 1:5 year level of the receiving stream. For receiving water bodies susceptible to winter ice build up, ice affected receiving water elevations should be considered.

Section 3.3.7.2: Outfall Maintenance

- Access to the top of the outfall or adjacent bank must be provided for maintenance purposes. Walking access to outfalls in environmentally sensitive areas may be considered, however all other outfalls must be accessible by vehicle for inspection and maintenance.
- Particular care in design of the roadway surface is required; it should be integrated with the adjacent landscape. A 4.0 m wide drivable surface (capable of handling a 23 tonne vacuum truck) is preferred; narrower widths are subject to approval by Water Resources.
- A turnaround might need to be provided at the outfall if it is situated more than 30.0 m from the adjacent roadway. The slope of the access route to the outfall should preferably be less than 5%, with a maximum slope of 8%.
- The subgrade must conform to a “Lane” road standard.

Section 3.3.7.2: Outfall Maintenance

- Inclusion of valves should be considered at all outfalls to allow for isolation of potential spills from reaching the receiving water body. Alternately, anchor points for sorbent booms should be incorporated into the structure.
- Valve actuation points should have appropriate signage or markings so that they are readily accessible, even under 1 meter of snow cover.
- Operation and maintenance procedures, including winter closure considerations must be provided as part of outfall designs. For large flood or isolation gates, provisions for automated or mechanically assisted actuation should be considered as per the direction of Water Resources.

Section 3.3.7.2: Outfall Maintenance

- A skimming MH, or approved equivalent, must be provided upstream of the outfall to remove oil and chemical spills. The skimming MH must be easily accessible for tandem axle maintenance vehicles. A skimming MH will not be required if the discharge to an outfall is directly from a stormwater wet pond, wetland, or approved oil/grit separator.
- Designs will be favoured which include provisions that accommodate future monitoring or sampling.
- An operating and maintenance manual must be provided for all outfalls that are equipped with backflow protection valves or have water quality appurtenances.
- Outfalls should be clearly signed. Water Resources/Water Services is responsible for providing and installing the signs.

Section 3.3.8: Culverts

This section has been completely overhauled.

- **Major culverts**, discussed in Section 3.3.8.1, concern culverts with diameter greater than 900 mm, typically located in named water courses or ravines, in MR or ER.
- **Minor culverts**, discussed in Section 3.3.8.2, concern culverts with diameter smaller than or equal to 900 mm, and that typically convey runoff from swales and ditches and are located in road right-of-ways or in parks.
- The minimum diameter shall be 450 mm.

- See **Section 5.3 Special Structures** for new references about culvert design!

Section 3.3.8.1: Major Culverts

- The capacity of the culvert is dictated by the level of service required for the roadway, as established by the City of Calgary. Typically, the culvert should have adequate capacity to convey the 1:100 year peak discharge with 300 mm freeboard from the obvert at the inlet.
- Culvert design and regulatory submissions must meet Alberta Environment's "Code of Practice for Watercourse Crossings" as well as Transport Canada (*Navigable Waters*), Environment Canada, and Fisheries and Oceans regulatory requirements where applicable.
- Hydraulic design calculations must be submitted and identify design flow conditions and inlet and outlet head conditions.
- Where possible, both the culvert inlet and outlet should be depressed at least 150 mm below the upstream channel invert.
- Culvert design should consider winter ice conditions and potential for ice accumulation.

Section 3.3.8.1: Major Culverts

- Energy dissipation and erosion control measures should be considered in the design. The design should preclude damage up to the 1:100 year peak discharge rate with a minimum factor of safety of 1.2 on shear stresses incorporated in the erosion protection design. In general, downstream energy dissipation should be placed for a distance of at least 3 to 6 times the design water width downstream of the outlet.
- The alignment of the culvert should be parallel to the stream channel, avoiding skewed crossings. Avoid locating culverts within 6 water widths of bends of the stream channel alignment.
- The design should be configured to prevent supercritical flow in the culvert.

Section 3.3.8.1: Major Culverts

Designs incorporating bevelled CSP (corrugated steel pipe) conduits projecting from fill should be avoided. Collars or headwall designs may be required to prevent uplift associated with differential head.

Where culverts cross fish-bearing streams, design must yield hydraulic conditions which meet or exceed provincial fish passage requirements. In general, natural bed or baffled designs are be preferred.

Perched/elevated culvert outlets with free drop onto splash pads should be avoided.

Where seepage considerations warrant, clay plugs or other geotechnical measures may be required.

Minimum cover as recommended by the structural engineer.

Section 3.3.8.2: Minor Culverts

- The minimum capacity of the culvert is dictated by the level of service required for the roadway. Typically, the culvert shall have adequate capacity to convey the 1:100 year peak discharge without overtopping of the road or driveway.
- Hydraulic design calculations of the culverts and upstream and downstream swales and/or ditches must be submitted. Design flow conditions and inlet and outlet head conditions shall be identified.
- In case the roadway or driveway is overtopped, appropriate erosion protection must be provided to prevent wash-out.
- Culvert design should consider winter ice conditions and potential for ice accumulation.
- Culverts in park areas (ER and MR) are to conform to Parks' Standards Specifications and will be reviewed and approved by Water Resources and Parks.

Section 3.3.8.2: Minor Culverts

- Erosion control measures should be considered in the design. The design should preclude damage up to the 1:100 year peak discharge rate with a minimum factor of safety of 1.2 on shear stresses incorporated in the erosion protection design. Erosion protection other than rip rap is preferred.
- Where possible, the design should be configured to prevent supercritical flow in the culvert.
- Culverts should have flared ends on both ends of the pipe to integrate with roadway or driveway embankment side slopes. Designs incorporating bevelled CSP conduits projecting from fill should be avoided.
- Minimum cover should be equal to the diameter or height of the culvert or as recommended by the structural engineer.

Section 3.3.9: Pumping and Lift Stations

Where a storm lift station has been approved, designs must be submitted to Water Resources for review and approval. Submission should include, but is not limited to:

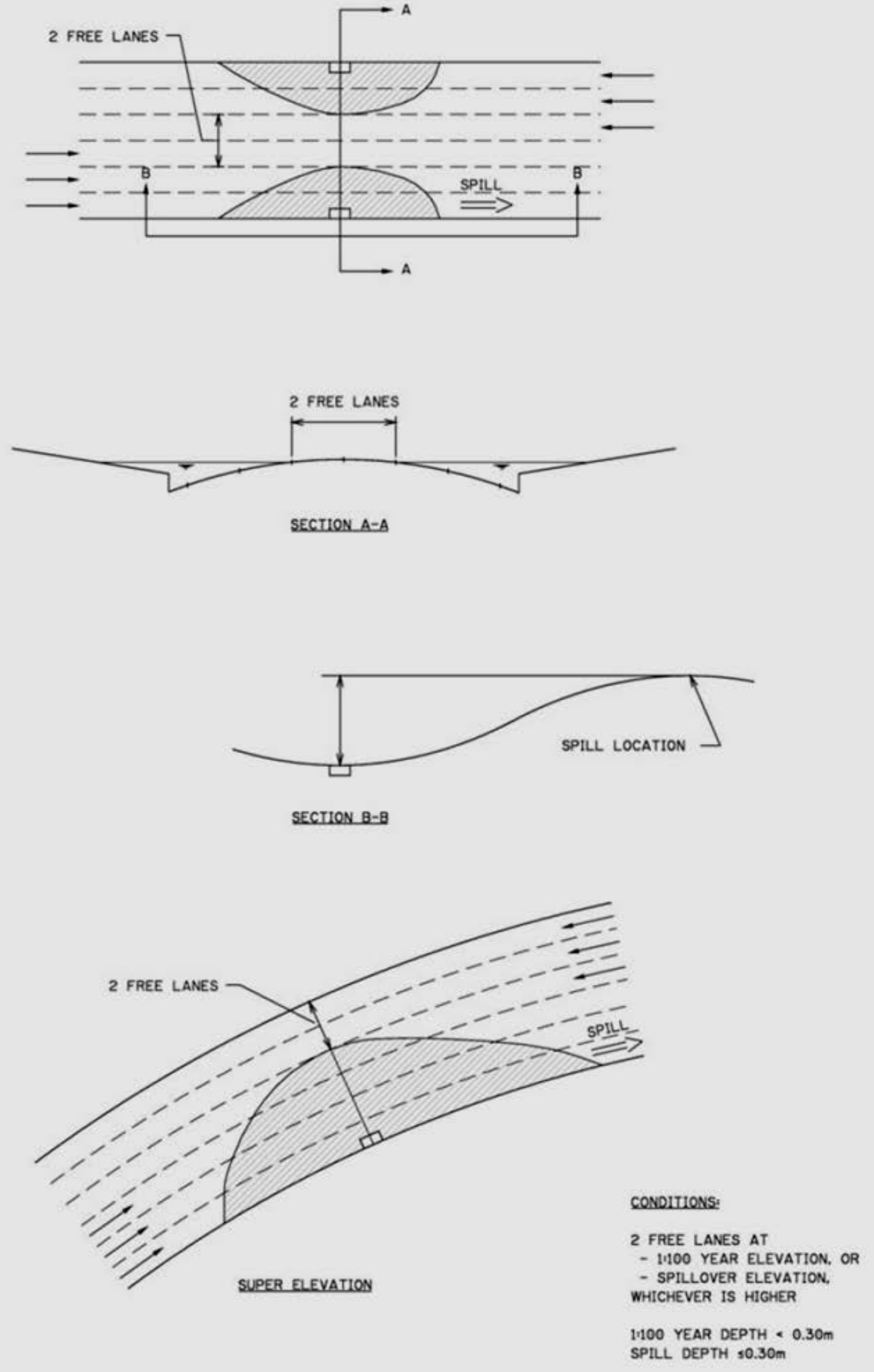
- Sizing information including dynamic system curve;
- Control philosophy including operating procedures;
- Pump and force main failure scenario and backup;
- SCADA set-up sensors and alarms including monitoring equipment for metering of flows, pressures and levels; and
- Maintenance procedures for wet wells and force mains.

An operating and maintenance manual must be included.

Section 3.4.3: Roads

- Clarification of inundation requirements for trap lows along arterial and major roads.

Figure 3-22: Inundation Requirements for Trap Lows along Arterial and Major Roads



Protecting what's precious.
Land. Air. Water.

Section 3.4.4.1: Traplows

- Where trap lows on major and collector roads can only be drained by pumping (i.e., underpasses), the area tributary to the trap low shall be minimized.
- In cases where back-up power supply and back-up pumps are not feasible, adequate (underground) storage capacity must be provided to completely store the entire runoff from a 24 hr, 1:100 year event without the ponding exceeding 0.30 m depth in the trap low.

Section 3.4.4.1: Traplows

- Where pumping is provided to drain a trap low or on-site storage unit on private sites, the storage capacity must accommodate the entire runoff volume from a 24 hour, 1:100 year event. In addition, a freeboard of 0.5 m must be provided above the elevation corresponding to the entire runoff volume from the 24 hour, 1:100 year event to minimize the potential of damage to property or spillage into adjacent properties.

Section 11.6.2: Tolerances for Trap Lows

- The actual as-built capacity of the trap low (corresponding to spillover conditions) shall not be more than 5% below the design capacity (corresponding to spillover conditions) unless the trap low still has spare capacity.
- In that case, the actual as-built capacity (corresponding to spillover conditions) shall be greater than the design 1:100 year trap low volume.
- If the actual as-built capacity is less than 95% of the design capacity (corresponding to spillover conditions) and the trap low now spills or spills more, impacts on adjacent and/or downstream development must be quantified and mitigated or the grading of the trap low remedied.

Section 3.4.6: Underground Storage

- When surface storage is not sufficient to provide all of the storage requirements, alternative storage methods such as underground storage will be considered. All underground storage designs are at the discretion of Water Resources. As part of the Stormwater Management Report and/or DSSP submissions to Water Resources Development Approvals, underground storage designs, and structures must be included for approval.
- Typically, the design loading for the underground storage chambers should be H20. For installations under pavement or other hard surfaces designated as fire vehicle access, H25 design loading must be used.

Section 3.4.6: Underground Storage

The submission should also include, but is not limited to:

- sizing information;
- overflow conditions;
- operating and maintenance procedures;
- need for pre-treatment and post-treatment;
- sediment build-up and storage capacity;
- inspection and maintenance access;
- and anticipated life span.

An operating and maintenance manual is also required.

Section 3.4.8: Escape Routes

In the absence of a demonstrated practical overland emergency escape route (i.e., infill development, redevelopment in existing communities, or elevated adjacent phases), and subject to prior approval by Water Resources, the following options may be considered in declining order of desirability:

i. Provision of a piped emergency escape route (i.e., culvert that daylights downstream) with a diameter equal to or greater than 450 mm. The invert of this pipe shall be at 0.500 m or lower above the catchbasin rim. The catchbasin shall be a combination of a grated top manhole and a storm back. Minimum building opening elevations MGs shall be 1.0 m above the catchbasin rim, or 0.50 m above the 1:100 year elevation ($Elev_{100}$), whichever is higher.

Section 3.4.8: Escape Routes

ii. Increase the interception capacity of the catchbasin to 150 L/s/ha (providing capacity is available) with a catchbasin lead greater than or equal to 450 mm in diameter and no ICDs. The catchbasin shall be a combination of a grated top manhole and a storm back. Minimum building opening elevation MGs shall be 1.0 m above the catchbasin rim, or 0.50 m above the 1:100 year elevation($Elev_{100}$), whichever is greater.

iii. For infill or retrofit situations where no changes can be made to existing grades or the storm sewer system, the minimum building opening elevation MGs shall be 1.0 m above the catchbasin rim, or 0.30 m above the 1:500 year elevation ($Elev_{500}$), whichever is greater. In addition, a second Type C catchbasin shall be provided at a higher elevation to provide relief in case the grate is clogged.

Section 4.5.1.2: Servicing

Typically, only one single stormwater service connection is allowed per site. However, more than one service connection may be allowed when multiple lots with existing stormwater service connections are consolidated.

Future Training Opportunities

- Annual week of courses on ESC, Stormwater Management and LID
- Slated for week of March 12-16, 2012
- Highlights:
  - Full slate of ESC courses including CPESC exam
  - ESC for LID installations
  - Stormwater Basics and Stormwater Design Course
  - Source Control Practices update
  - LID Design Example
  - Permeable Pavement or Silva Cell installations
  - PCSWMM for water quality and LID design

Comments and Questions?

- Please send any
  - suggestions about future content,
  - inquiries, and/or
  - comments about typos, discrepancies, etc., to

Bert van Duin, M.Sc., P.Eng.
Senior Development Engineer
City of Calgary Water Resources
Infrastructure Planning, Development Approvals
bert.vanduin@calgary.ca or (403) 268-6449