SECTION 3: STORMWATER MANAGEMENT

3.0 INTRODUCTION

This section covers the design of Stormwater Management facilities including, but not limited to, conveyance systems, storage systems, and treatment.

3.1 GENERAL

The overall design principles described in the introduction to these standards are the basis on which all construction is undertaken in the City of Prince Albert. Often a combination of principles will come into play when designing a particular component of the system.

The purpose of stormwater management is to handle precipitation so it does not become an inconvenience or present a hazard to the community while also reducing impacts on the environment. Current practice is to use a system of underground pipes, overland flow routes as well as wet and dry stormwater detention facilities.

Prince Albert would like to take a proactive role in promoting measures to reduce the impacts on the environment due to development. In this respect these guidelines may be more restrictive than the requirements of Saskatchewan Ministry of Environment.

The system must be designed to provide access to components for maintenance. Overland conveyance routes should be designed to limit the potential for erosion. Outfalls and other structures must be as low maintenance as possible.

Stormwater facilities should be designed to be neat and tidy with a minimal amount of maintenance. Wherever possible, stormwater facilities such as wet or dry ponds or major system conveyance should be integrated into a multi-use facility. In combined open space/stormwater facilities the area’s primary purpose will be as community green space with the stormwater purpose as a secondary role. The pond’s shape, slopes, inlets and outlets must be designed with safety and aesthetics in mind.

New systems must be designed without exceeding peak flow capacities of the older systems to which they connect; this applies to both overland flow routes and well as underground components of the system.

The designer must take into consideration safety concerns in the design of storm management facilities because rain and runoff events can be sudden and unexpected.

The following safety factors should be considered in the design of stormwater management facilities:

i. Depth, speed and extent of overland flow and ponding
ii. Preventing access to the piped portion of the system
iii. Ability to escape from ditches and ponds
iv. Preventing the formation of slipping hazards
v. Access for emergency service vehicles
vi. Prevention of flooding and erosion damage

3.1.1 Level of Service Objectives

Level of service for Stormwater Management Systems has traditionally been defined using the return period of the design storms used to size the system. This is described in terms of the Major and Minor systems. The Minor system handles small frequent runoff events and currently consists mainly of underground pipes. The Major system handles any runoff which cannot be taken by the Minor system and usually consists of overland flow from large infrequent events.

i. The Minor (underground) portion of the system shall be designed with capacity for a one in five (1 in 5) year storm. The piped system shall convey flows from 1 in 5 year storm. Ponding in trapped lows shall not occur for storms up to and including the 1 in 5 year event. Ponding and overland flow must be confined to public property and right of ways. Section 3.2 provides minor system design guidelines.

ii. The Major system, storm ponds and overland flow within new developments shall safely handle a one in one hundred (1 in 100) year event without causing flooding of private property or erosion damage. Ponding and overland flow shall be confined to public property and right of ways and be limited to no more than 300 mm deep as measured at the gutter of the streets for the 1 in 100 year event. Once collected, stormwater shall remain on public property. Section 3.3 provides Major system design guidelines.

iii. Peak post development flow rates shall not exceed pre-development flows resulting from the 1 in 5 year event. Where downstream constraints exist, post development flow rates may be restricted to less than the 1 in 5 year pre-development flow. The allowable release rate shall be maintained for all design storms up to and including the 1 in 100 year event.

iv. New developments must include measures to improve stormwater quality. Erosion and sediment control must be in place as permanent features of development. These include grassed swales and runways to trap silt and ponds designed with dimensions and detention times promoting settling. Higher priority will be placed on environmental considerations along the river banks and adjacent to environmental reserves. The City has already taken steps to improve stormwater quality by implementing a street cleaning program, placing limitations on pesticide use, instituting a doggie bag program and requiring catch basin sumps.

3.1.2 Regulations

The following list is the regulations which have provisions that pertain to stormwater management applicable within the City of Prince Albert:

i. Storm Sewer Bylaw;

ii. Connections Bylaw;

iii. Standard Construction Specifications and Drawings, Roadways, Water, and Sewer, City of Prince Albert;

iv. Stormwater Guidelines, Water Security Agency;

v. The Occupational Health and Safety Act, Province of Saskatchewan;

vi. The Plumbing and Drainage Regulations, Province of Saskatchewan;

vii. National Building Code;

viii. PVC Pipe: Design and Installation, (M23), American Water Works Association (AWWA); and

ix. PE Pipe: Design and Installation, (M55), AWWA.

Designers are encouraged to contact the Provincial and Federal governments with regard to regulations which may apply but are not listed here.

3.1.3 Stormwater Planning Requirements

See Section 2.4 for Infrastructure Planning Requirements.

3.1.4 Environmental Considerations and Best Management Practice

See Section 2.5 for Environmental Considerations.

3.1.5 Erosion Control and Sedimentation

i. Erosion protection shall be adequately provided on all permanent surfaces and channels in the development area to resist the 1 in 100 year event.

ii. Concentrated flows over the top of the riverbank, down unprotected slopes or into unprotected ditches and swales will not be permitted. Sheet flow must occur along the entire top of bank and adequate erosion controls must be implemented to prevent rill erosion and gully formation. In conjunction with erosion protection, slope drains may be used to collect flows and safely convey them to the bottom of the slope.

iii. Catch basins shall be provided with a sump to improve sedimentation.

3.1.6 Reducing Hazardous Chemicals, Petroleum Products, Pesticides and Herbicides

i. Stormwater containment and treatment will be required for developments proposing to use hazardous materials on site. It is recommended that developers contact the Director of Public Works at the concept stage when considering these types of facilities.

ii. Stormceptors or other oil and grit separators should be considered for any development with large parking areas or where there is a risk of a petroleum product spill.

iii. Stormceptors or an approved alternate oil and grit separator will be required at all sites containing gas stations. The device shall be installed inside the car washers, repair shops, etc.

iv. Please refer to Community Services Parks and Open Space Standard with regards to planting designs and methods that are naturally pest and weed resistant.

3.1.7 Stormwater Quality Best Management Practices

The City of Prince Albert strongly recommends the use of any measures taken in the design which improve stormwater quality, reduce peak flows and reduce runoff volumes. The following items are suggested for consideration in new developments:

i. Grass swales and runways should be incorporated into pond inlets and green strip conveyance paths. Flow spreaders to encourage sheet flows across grassed areas are highly desirable. Flows across vegetation have been shown to be effective in improving stormwater quality and in reducing volumes.

ii. Appropriately sized trash racks and properly designed transitions from paved to grass areas, which will limit the transport of materials off the street into the piped portion of the system.

iii. Constructed wetlands which mimic natural processes for treating stormwater should be considered a viable alternative to either dry ponds or wet pond features. Constructed wetlands and similar features would be especially appropriate for use in developments adjacent to the river valley provided that safe set back requirements are followed.

iv. Wet and dry ponds with larger length to width ratios are preferred because of their increased sedimentation efficiencies. Target length to width ratios are greater than 5 to 1. Increased flow path lengths can be achieved through the use of interior berms and baffles. Minimum accepted ratio is 3 to 1.

v. Where possible detention times of 24 to 48 hours should be used for ponds to allow greater time for sedimentation.

vi. Sediment fore bays are encouraged at pond entrances. Fore bay designs should include consideration of access for maintenance and sediment removal.

3.2 ESTIMATION OF PEAK FLOWS, RUNOFF VOLUMES AND HYDROGRAPHS

3.2.1 General Rules of Thumb

In order to provide a quick design and review of stormwater management systems the City has created the following rules of thumb:

i. Major overland flow – 200L/sec/Ha

ii. Minor system flow – 90L/sec/Ha

iii. Wet Pond Storage – 1000m^3/Ha for 0 release rate situations

iv. Pond size is to be a minimum of 1Ha of normal water level area but larger is preferred

The City will not require any computer model simulation unless these values are unattainable.

3.2.2 Computer Model Simulation

Computer simulation will be required to assess the impacts of added development on the stormwater system and to assist in designing detention facilities for optimal release rates and timing. The City establishes allowable release rates based on previously submitted stormwater management reports. Where designers can show that capacity is available in the downstream system larger release rates may be allowed. Digital format to be compactable with the City hydraulic model.

3.2.2.1 Design Storms

The following storms shall be used to evaluate the stormwater management system behavior:

i. One in two year 1 hour duration storm

ii. One in five year 1 hour duration storm

iii. One in one hundred year 12 hour duration storm

Additional storm of varying duration and return periods should be used to adequately design stormwater management systems. Though not a requirement it is suggested that historic long-term precipitation data and data from historical storms be used to evaluate the performance of stormwater management designs.

3.2.2.2 Natural Conditions

Natural conditions refer to the state of the land in the development area prior to its alteration by people. The impacts of the proposed development on peak flows and volumes shall be evaluated based on the following baseline conditions. The following table describes the general parameters to be used for the estimation of runoff characteristic resulting from natural conditions. These values represent typical conditions for Prince Albert and are provided as guidelines. Where a designer has more accurate information or actual values, they should be used.

3.2.2.3 Rational Method

The imperviousness for the existing neighbourhoods was measured using aerial photographs. For catchments composed of only single-family residential lots, typical impervious values were determined and applied throughout the study area, as shown in Table 3.2.2.3(a). For catchments that contained a mixture of land uses (e.g. multi-family residential, commercial, schools, parks), the imperviousness was calculated manually. Standard impervious values were used for the future development areas, as shown in Table 3.2.2.3(b).

Table 3.2.2.3(a): Imperviousness Values Single Family Residential Lots

Land-Use	*Percent Impervious*	*Runoff Coefficient*
Grassed	0%	0.10
Full Lot	30%	0.34
Front Half of Lot	40%	0.42
Back Half of Lot	20%	0.26
Streets	100%	0.90

Table 3.2.2.3(b): Land-Use Runoff Coefficents	
Land-Use	*Runoff Coefficent*
Residential	0.60
Multi-Residential	0.80
Commercial	0.80
Park	0.30
Farmland	0.20
Wet pond	1.00
School	0.30
Light Industrial	0.65
Heavy Industrial	0.75

3.2.2.4 Rainfall Intensity – Frequency - Duration

The effective Runoff Coefficient (*Ceff*) used in the Rational Method is related to the percent impervious value (*%Imp*). It may be calculated as a weighted average using the Runoff Coefficients for an impervious area (e.g. pavement) and a pervious area (e.g. grassed):

$$Ceff = \frac{\%Imp\,(Cimp) + (100 - \%Imp)(Cperv)}{100}$$

- *Cimp* is the Runoff Coefficient for an impervious area (0.90)
- *Cperv* is the Runoff Coefficient for a pervious area (0.10)

Subcatchment width was calculated based on the area and shape of the catchment. Subcatchment slope was set as the slope of the dominant flow path (2% for residential lots).

Design storms were derived from Intensity-Duration-Frequency (IDF) data collected by Environment Canada at the Prince Albert Airport (Glass Field) for the period of 1960 to 2001. Equations to fit the IDF curves were developed and were of the form:

$$i = \frac{a}{(t + b)^c}$$

- i is the average intensity (mm/h)
- t is time (minutes)
- a, b, c are coefficients to fit the equation to the IDF data

The coefficients for the 2, 5, 25, 50, and 100 year design storms are shown below in Table 3.2.2.4. From the IDF equations, rainfall hyetographs were generated for the following design storms: 2 year 1 hour, 100 year 1 hour (Chicago distribution) and 100 year 12 hour and 100 year 24 hour (Huff II distribution). The rainfall data was imported into XPSWMM as a tipping bucket gauge with the interval of the bucket tip set to the time step of the design storm.

Table 3.2.2.4: IDF Coefficients

	a	*b*	*c*
2 year	416.79	3.2	0.766
5 year	577.06	2.7	0.769
25 year	785.39	2.1	0.762
50 year	881.85	2.0	0.763
100 year	986.97	2.0	0.766

The hydraulic system was modelled in XPSWMM as a node and link system where the nodes represent manholes or ponds and the links represent pipes (or the drainage channel).

For further information on rainfall intensity duration frequency data for the City of Prince Albert visit the Environment Canada website.

3.3 MINOR SYSTEM

The Minor system shall be designed to accommodate the 1 in 5 year event. The Rational Method shall be used to determine design flows. Computer modelling shall be used to confirm design. The Minor system shall be evaluated to confirm that runoff during design events will be conveyed to adequate receiving waters without surcharging the pipe system. The release rate from a new neighbourhood shall not exceed the capacity of the downstream system, or as set by the Public Works Department.

3.3.1 Gravity Flow

Gravity storm mains shall be sized for full flow during the total design peak flow. The Manning Equation shall be used for the design and modelling of gravity sewers.

$Q =$ $(A*R^{2/3}*S^{1/2})/n$ Where: Q = Flow (m^3/s)

$A =$ Cross-sectional area of pipe (m^2)

$R =$ Hydraulic radius (area/wetted perimeter) (m)

$S =$ Slope of hydraulic grade line (m/m)

$n =$ Manning coefficient = 0.013 for all approved materials in straight alignment (s/m 1/3)

3.3.2 Velocity

Guidelines for Storm Works Design, a mean velocity of 0.61 m/s shall be maintained during average flow conditions to provide self-cleansing flow. The maximum velocity shall be 3.0 m/s to reduce the risk of undue turbulence and scour.

3.3.3 Size

The minimum size of gravity storm main pipe shall be 250 mm diameter.

3.3.4 Slope

Storm mains shall be laid in a straight alignment between manholes at the following minimum grades:

Sewer Size (mm)	Minimum Slope (%)
250	0.40
300	0.28
375	0.22
450	0.15
525	0.12
600 and greater	0.10
675 and larger	0.0812

3.3.5 Trapped Lows (Minor System Storage)

i. New developments shall be designed to limit the number of trapped lows required. The additional storage provided by trapped lows is marginal and the additional maintenance required by the use of Inlet Control Devices makes trapped lows undesirable.

ii. Trapped lows shall be designed so no significant ponding occurs for events up to the 1 in 5 year event. The maximum depth of ponding in trapped lows shall be 300 mm as measured from the gutter for the 1 in 100 year event. Detailed design drawings shall show the extent of flooded area at trapped lows during a 1 in 100 year rainfall event.

iii. Ponding in trapped lows shall be contained within the road right-of-way or public property.

iv. Overland flow routes out of trapped lows must conform to the requirements of Section 3.3.1.

v. Trapped lows shall not be located so they inundate sanitary manholes. Where sanitary manholes must be located within trapped lows, special provisions to limit stormwater inflow to the sanitary sewer must be taken and approved by the Public Works Department.

vi. Trapped lows shall be surveyed and the actual extents, spill elevations and catch basin elevations confirmed on the as-built drawings.

3.3.6 Piped System and Gutters

i. The minimum grade on gutters or paved surfaces shall be 0.6%. Greater grades are preferred on curved gutters and curb returns.

ii. Minimum grade of lanes shall be 1.5% for a minimum distance of 5 m from the back of concrete along the lane. The minimum grade of lanes shall be 0.6% at other locations.

iii. The surface of the asphalt in the lane shall be at least 12 mm higher than the concrete where the asphalt meets the back of concrete.

iv. Maximum depth of flow in gutters for the 1 in 5 year event shall be the lesser of 150 mm or the height of the sidewalk top above the gutter.

v. In the design of pipes a roughness coefficient equivalent to The Manning Equation of 0.013 shall be used to account for the degradation of the pipe over time.

vi. The piped system shall be designed so that no surcharging occurs during the 1 in 5 year event.

vii. The minimum size of storm drainage piping shall be 250 mm diameter.

viii. Minimum depth of pipe cover shall be 1.9 m.

ix. Frontage piping shall be of adequate depth to receive connections from adjacent properties.

x. Maximum distance between catch basins shall be 150 m.

xi. Maximum distance between manholes shall be 150 m.

xii. For back of lot easement grading is Standard Detail Drawing 00-06-01.

xiii. For minimum lot grading is Standard Detail Drawing 00-06-02.

xiv. For lot grading of split drainage back to front or walk out basements is Standard Detail Drawing 00-06-03.

3.3.7 Catch Basins

i. Catch basins which discharge directly to the piped system without passing through a downstream detention facility are required to accommodate peak runoff for the 1 in 5 year event.

ii. For combined manhole and catch basins see Standard Detail Drawing 00-01-06.

iii. For standard catch basins see Standard Detail Drawing 00-01-07.

iv. Catch basins shall not be located in the expected wheel path of vehicles.

v. Catch basins shall not be located in front of driveways, wheelchair ramps or in entryways.

vi. Catch basins shall be built with a 450 mm deep sedimentation sump.

vii. Catch basins in lanes are discouraged where possible lanes shall drain to a street. Where required, catch basins located in lanes shall be constructed with 10 m of weeping tile installed below the granular base course down the centerline of the lane each direction from the catch basin.

viii. Catch basin leads to be installed with a minimum 2.00% grade.

3.3.8 Connections to Existing Piped Systems

i. The designer is required to show that the system downstream from the development has adequate capacity to accommodate changes in peak flows and volumes resulting from the development. The City will provide conservative estimates of downstream system capacities upon request.

ii. In areas where the stormwater system capacity is less than required for the 1 in 5 year return period, peak flows off the development/redevelopment must not be increased above predevelopment levels. Flows from the development must be retained on site and released so that the length and severity of surcharging in the downstream system is not increased.

iii. All individual lot developments greater than 2500 m² shall provide a stormwater management plan for review and approval, and shall require a private underground storm sewer service connection.

iv.

Table 3.3.8(a): Surface Run Off Coefficients

Asphalt	0.95
Building	0.95
Concrete	0.95
Gravel	0.85
Grass	0.15

Table 3.3.8(b): Service Connection Manhole Requirement Chart

Storm Service-Service Connection Size (mm)

Main Size (mm)	200	250	300	375
200	Yes	N/A	N/A	See Below
250	Yes	Yes	N/A	See Below
300	No	Yes	Yes	See Below
375	Yes	Yes	Yes	See Below
450	See Below			

Each service larger than 375 mm will require review and approval by the Director of Public Works.

3.3.9 Manholes

Manholes shall be located at the upstream end of each line, at changes in size or alignment, at all junctions, and at all catch basin connections.

The minimum manhole diameter shall be 1.2 m. For pipes at depths greater than 5.5 m special manholes are required with safety platforms at intermediate levels. The lowest platform should typically be above the incoming flow. For standard manhole see Standard Detail Drawings 00-01-03, 00-01-04 and 00-01-05.

3.4 MAJOR SYSTEM

The Major system shall be designed to accommodate the 1 in 100 year 24 hour design event. Computer modelling shall be used to confirm that any flooding during design events shall be restricted to public areas. The grading of streets and the layout of the Major drainage system shall be assessed relative to the following guidelines during the design event. The maximum depth of ponding on the road shall be 0.30 m for all roadways. A depth of 0.45 m shall be considered if adequate justifications can be provided. In this case, the approval of the Public Works Department must be obtained. Continuity of the overland flow routes between adjacent developments shall be maintained.

3.4.1 Overland Flow

i. New developments shall have a continuous route for overland flow from the point of precipitation to a suitable outlet. Continuity of overland flow routes between adjacent developments shall be maintained. The overland flow route will handle runoff from storms that exceed the 1 in 5 year event.

ii. The route must be adequate to contain the 1 in 100 year event without causing flooding of private property or erosion damage to existing facilities. Flow and ponding shall be contained within public property and right-of-ways.

iii. Where private property is used to convey runoff from multiple lots:

  a. The means of conveyance shall be designed appropriately.

  b. The full width of flow under the design 1 in 100 year rainfall event shall be protected by an easement.

iv. Overland flow routes once they have reached public property must remain on public property. Providing an escape route for a trapped low via an easement between private residences will not be allowed. Overland flow routes of this type are only allowed along roadways, walkways, and other public properties such as Municipal Reserves.

v. The combined conveyance capacity of public right-of-ways downstream of a trapped low shall be equal to or great than the combined conveyance capacity of public right-of-ways upstream.

vi. Overland flow routes depth and velocity relationships will be determined for critical locations. Critical locations are those points where maximum flow rates are encountered, where high velocity flow is expected, where overland flow may present a danger to the public and locations where there is particular risk of significant erosion or flooding damage.

vii. Depth and velocity will be calculated using The Manning Equation for open channel flow or an approved alternative method.

viii. The following table provides safe flow velocity – depth relationships. Overland flows shall not exceed these limits for storms up to the 1 in 100 year event. In locations where these limits cannot be met measures must be taken to ensure public safety by limiting access and posting appropriate warning signs. Exceptions to these defined limits will be evaluated on a case-by-case basis. Note that Table 3.4.1 provides safety limits only and does not address erosion resistance requirements.

Table 3.4.1: Maximum Combination of Gutter Flow Depth and Velocity

Water velocity (m/s)	Maximum Permissible Depth (m)
0.50	0.80
1.00	0.32
2.00	0.21
3.00	0.09

3.4.2 Use of Roadways as Overland Conveyance

i. Local roadways may be used as part of the Major system conveyance route, provided that the requirements of Section 3.3.1 are adhered to for the 1 in 100 year event.

ii. Maximum depth of flow or ponding on local roads shall be 300 mm at the gutter of the road in a 1 in 100 year event.

iii. Collector roadways may be used as part of the Major system conveyance route, provided that the requirements of Section 3.3.1 are adhered to for the 1 in 100 year event.

iv. Depth of crossing flow or of ponding in trapped lows in Collector roads shall not exceed the lesser of 300 mm at the gutter of the road or 100 mm at the crown of the road in a 1 in 100 year event.

v. Collector roadways should have at least one lane which is not inundated parallel with the direction of flow.

vi. The travel lanes of Arterial roadways shall not be used as part of the Major system. The Public Works Department, on a case-by-case basis, will consider exceptions where it is especially difficult or expensive to prevent flows from entering the Arterial road right of way. In cases where Arterial roads must be used, the designer shall show that flow or ponding along the roadway will not adversely impact the operation of the Arterial road.

vii. Special permission must be obtained in order to use easements as part of the major overland flow route system.

3.4.3 Dry Ponds

i. Estimation of required storage volumes, peak flows and drainage times shall be done using an approved computer model.

ii. The pond shall provide sufficient storage so that operation of the emergency overflow does not occur during 1 in 100 year events.

iii. The dry pond shall be graded to properly drain all areas after its operation. The pond bottom shall have a minimum slope of 2.0% (Please refer to Community Services Parks and Open Space Standards for details).

iv. Ponds should be designed with organic shapes and undulating edges to provide visual relief. Rectangular ponds or dugout like ponds should be avoided.

v. The maximum 1 in 100 year high water level shall be 0.45 m below the floor elevation of the building on properties having a common property line with the pond.

vi. An emergency overflow shall be provided on all ponds. The path from the pond overflow to an approved outlet must be identified. Safe depth/velocity relationships cannot be exceeded and adequate erosion protection shall be provided for the emergency overflow and the overland flow routes within the development when operating with peak flows estimated for the 1 in 100 year event.

vii. All inlet and outlet structures associated with dry ponds shall have grates provided over their openings to restrict access and prevent entry into sewers by children or other persons. A maximum clear bar spacing of 100 mm shall be used for gratings.

viii. Grated outlet structures are to be designed with a hydraulic capacity of at least twice the required capacity to allow for possible plugging.

ix. Velocity of flow through gratings on inlets to pipes shall not exceed 1.0 m/s for maximum expected flows during the 1 in 100 year event.

x. Appropriate means of limiting access to outlets and reducing the danger of falls from headwalls and wing walls shall be taken.

xi. Where possible, dry ponds should be incorporated into parks and open space.

xii. In the design of combined park/dry pond facilities the park usage of the area shall take precedence over dry pond requirements.

xiii. Dry ponds located in parks shall include special needs access and egress points having slopes of less than 1 vertical to 12 horizontal.

3.4.4 Wet Ponds – Physical Characteristics

i. Estimation of required storage volumes, peak flows and drainage times shall be made using an approved computer model.

ii. The pond shall provide sufficient active storage so that operation of the emergency overflow does not occur during 1 in 100 year events.

iii. A minimum horizontal distance of 5 m shall be maintained from any property line to the high water level. 10 m will be required if a pathway is to be installed between HWL and the property line.

iv. A silt trap or forebay shall be provided at the inlet of each pond.

v. Access to the pond shall be provided to accommodate expected maintenance traffic including a boat ramp to facilitate maintenance for floating or submerged facilities.

vi. The lake bottom and side slopes shall be composed of an impervious material up to the 1 in 100 year level.

vii. The maximum 1 in 100 year water level shall be 0.45 m below the floor elevation of buildings on properties having a common property line with the pond.

viii. The lowest adjacent manhole invert shall be at or above the normal water level elevation.

ix. The pipe crown at the lowest manhole upstream of the pond shall be above the high water level during a 1 in 5 year storm event to limit back water effects.

3.4.5 Wet Ponds – Water Quality

3.4.5.1 Performance Objectives

Aesthetics: Maintain water clarity, colour and prevent odor and keep the pond looking and smelling clean.

3.4.5.2 Nutrient Control: (remove nutrients, litter/debris)

i. Suspended solids – 85% reduction of 75 micron particles and larger by weight.

ii. Total phosphorus and nitrogen – the pond shall incorporate proven strategies showing removals of these nutrients.

iii. Litter – the pond shall incorporate strategies that facilitate the trapping and subsequent collection of litter.

3.4.5.3 Design Considerations

i. Ponds shall be designed with sufficient area, dimensions, and flow characteristics to minimize aquatic weeds and maintain acceptable water quality. Inlets, outlets, pond shape, internal baffles and aquatic benching will be arranged to prevent stagnant areas and promote circulation. No dead bay areas shall be permitted. A wedge-shaped pond with the Major inflows on the narrow end can prevent short-circuiting and stagnation.

ii. Wet ponds should be designed with a length to width ratio of at least 3:1 to promote sedimentation. If the length to width ratio is lower the flow path through the pond should be maximized.

iii. Extents of Aquatic Benches: All ponds will include aquatic benches either:

a. As a continuous ring 2- 4 m in width around the perimeter of the permanent pool; or

b. Arranged in bands across the flow path covering a minimum of 20% of the open water area as measured at the normal water level. This type of aquatic benching will be arranged as wetland zones at the inlet and outlets from the pond; or

c. RIP RAP: Where a vegetated aquatic bench is not provided for shoreline protection rip rap must be used. Rip rap is to be a minimum of 200 mm diameter stones to minimize loss as a result of rip rap being thrown into the lake.

3.4.5.4 Aquatic Bench Configuration:

i. The aquatic benches will have a maximum depth of 450 mm below the normal water line.

ii. Organic soils at least 150 mm in depth will be used as a planting bed on aquatic benches. Organic soils can serve as a sink for pollutants and generally have high water holding capacities.

iii. Vegetation will be seeded or planted to initiate the growth of aquatic plants. Robust, non-invasive, perennial plants that establish quickly are ideal. The designer should select species that are tolerant of a range of depths, inundation periods, etc. Monoculture planting should be avoided due to the risk from pests and disease.

3.4.5.5 Circulation / Turn Over

i. A source of water is to be provided to all ponds as a make-up water supply and to allow flushing / refreshing of the pond permanent pool during low precipitation and high temperature periods.

ii. A pond aeration and circulation system is to be provided for all ponds.

3.4.5.6 Landscaping

i. Park-like facilities adjacent to wet pond facilities shall comply with Community Services Parks and Open Space Standards.

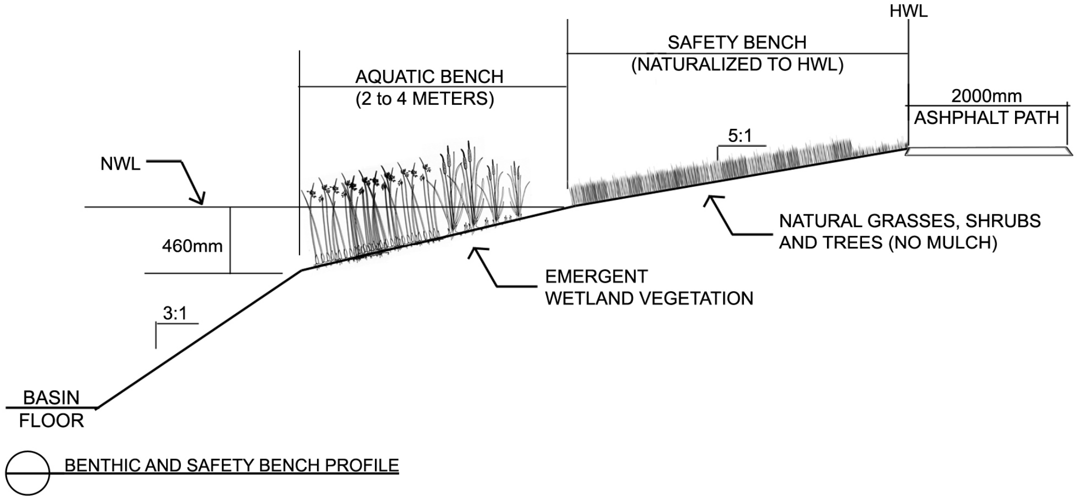
ii. Ponds should be designed with organic shapes and undulating edges to provide visual relief and integrate them into the park and open space. Rectangular ponds or dugout-like ponds should be avoided.

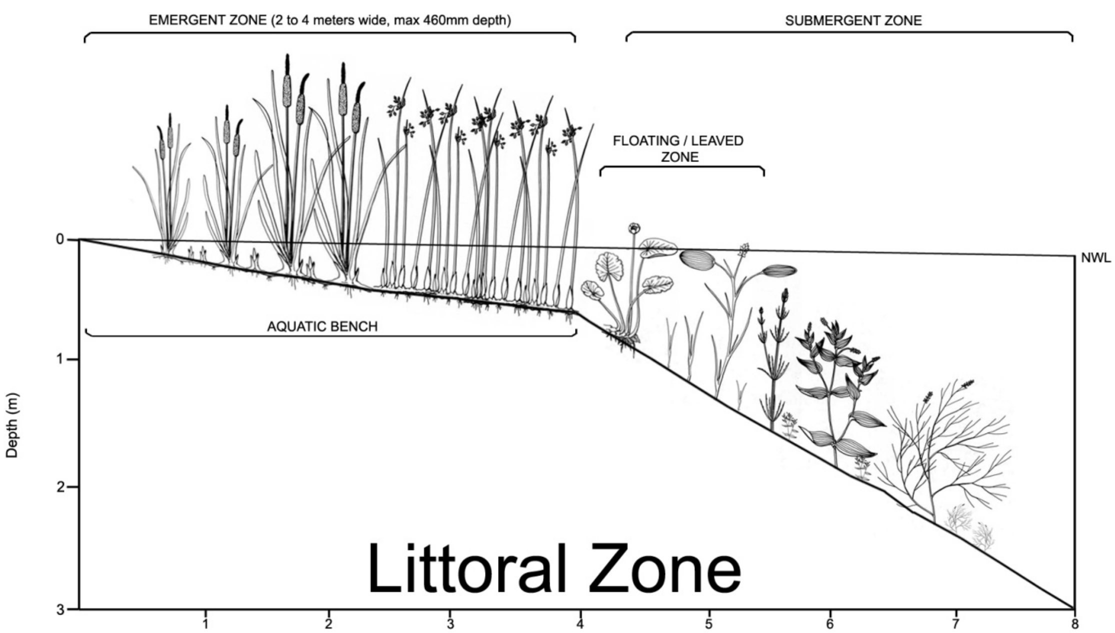
iii. Irrigation systems will not be installed below the High Water Level. Naturalized (native) vegetation is acceptable plant material between the HWL and NWL. All plant material below the HWL will require minimal maintenance.

iv. A physical division will be installed between the unmanicured vegetation below the High Water Level and manicured vegetation above it. This division can take the form of an asphalt pathway or moving strip.

v. When the irrigated areas in the vicinity of a wet pond exceed 2.5 ha the pond may become the park water supply and will require an irrigation pump house.

vi. If the lake is to be considered as a source for irrigation water then water quality must be modeled to ensure public safety.





Littoral Zone - The distribution of different types of macrophytes is largely determined by physical factors such as depth, light, wave action and sediment texture.

3.4.5.7 Storm Pumping Stations

See 5.4.6 Sewage Pumping Stations for details.

3.5 SERVICE CONNECTIONS

Effluent from sanitary sewers or surface drainage from industrial, agricultural or commercial operations that may be contaminated shall not be discharged to the storm sewer.

Connections from roof leaders shall not be made to the storm sewer system. Roof drainage from residential housing units, apartments, commercial and industrial buildings shall discharge to grassed or pervious areas except where building density makes this impractical (Central Business District).

Weeping tile connections to the storm sewer system through surface drainage shall be provided for in all new construction through sump pumps. Water from discharge pipes must end at least 2 m away from any sidewalk, road, park, alley, lane or surface drainage facility. The 2 m buffer zone allows some of the runoff to absorb into the ground before it enters the storm system. It also helps prevent icing on sidewalks and lanes in winter.

3.5.1 Site Drainage and Storm Sewer Service Restrictions

All developments are required to provide a detailed site grading drawing identifying storm drainage patterns, on site detention, storm sewers, manholes and catch basins.

Where a storm sewer exists adjacent to a property and the site is larger than 2500 m^2 in size, the installation of on-site catch basins and connection to the City's storm sewer system are generally required.

If the site is between 2500 m^2 and 5000 m^2 and more than 50% of the site is landscaped, on site catch basins and storm sewer connection requirements may not be required at the discretion of the Public Works Department.

Calculations for storm sewer and detention sizing must be provided for sites larger than 5000 m^2.

Under no condition shall a private property direct its drainage to another property unless it is a designated drainage route.

3.5.2 Storm Service Design Criteria

The storm service size is to be determined based on the following, depending on the capacity of the downstream storm sewer system.

3.5.3 Redevelopment Areas

Where a new service is being connected to an existing main, the allowable capacity for the development will be based on the following formula:

$$\text{Allowable Capacity} = \frac{\text{Development area X Capacity of Main}}{\text{Upstream Catchments Area}}$$

The calculated capacity of the service will likely be less than a 1 in 5 year storm discharge, but the allowable discharge shall not be greater than the 1 in 5 year discharges calculated for new development areas.

3.5.4 New Development Area

Where the new service is being connected to an existing main in a recently developed area of the City service, the allowable capacity of the development will be determined using the 1 in 5 year rainfall IDF curve and the appropriate run off coefficient.

All new building foundations shall drain to a sump discharging to the storm sewer system through surface drainage.

Foundation drains shall not be connected to the sanitary sewer system.

Storm service connections shall comply with the National Plumbing Code.

Properties zoned for non-residential land uses and for multi-family residential (excluding lots less than 2500 m²) must retain runoff volumes of the 1 in 5 year return period on site. The excess runoff control may take the form of a parking lot, rooftop, or underground storage, as well as wet or dry ponds. The Public Works Department shall approve runoff control designs.

Sump pump outlets and roof leaders shall discharge flows no closer than 1.0 m from property line, any sidewalk, road, park, alley, lane or surface drainage facility. Where possible, drainage across property lines shall be spread to encourage sheet flow and reduce concentrated erosive flows.

3.5.4.1 Length of Run

Surface water should not be permitted to run a distance greater than 150 m in streets or 200 m in lanes and swales without interception by a catch basin.

3.5.4.2 Back of Lot Drainage

The following will apply to back of lot drainage in lane less subdivisions:

For back to back lots and lots backing onto a park, a concrete swale is to be constructed along the rear property lines within a City easement to direct the drainage to a street. Concrete swales are to be constructed with continuous grade lines with a minimum 0.5% slope to convey rear lot drainage to a catch basin located in a street or utility right of way.

The swale shall be on the opposite side of the property line from the Crown Utilities easements.