DISTRICT OF LAKE COUNTRY

BYLAW 1241

TO AMEND SUBDIVISION AND DEVELOPMENT SERVICING BYLAW 1121, 2020

The Council of the District of Lake Country, in open meeting assembled, enacts as follows:

1. Subdivision and Development Servicing Bylaw 1121, 2020 is hereby amended by:

1.1. Deleting Schedule M Design and Construction of Stormwater Management Systems, in its entirety and replacing it with the revised Schedule M Design and Construction of Stormwater Management Systems, attached to and forming part of this Bylaw as Schedule A.

2. This bylaw shall be cited as "Subdivision and Development Servicing Amendment (Schedule M) Bylaw 1241, 2024".

READ A FIRST TIME this 20th day of August, 2024.
READ A SECOND TIME this 20th day of August, 2024.
READ A THIRD TIME this 20th day of August, 2024.

ADOPTED this x day of________, 2024.

______________________	______________________
Mayor	Corporate Officer

Schedule A to Bylaw 1241, 2024

SCHEDULE M
DESIGN AND CONSTRUCTION OF STORMWATER MANAGEMENT SYSTEMS

M.1. GENERAL

M.1.1. Overview

The purpose of Schedule M is to standardize the procedures for designing common drainage facilities in the District. All drainage works will be designed with considerations for public safety, regulatory requirements, and the natural environment. The Owner’s Engineer will consult with the District Engineer to determine what existing information may be of assistance to them.

The determination of the primary method for the management and disposal of stormwater will be at the discretion of the District Engineer. To aid in this determination, the Owner may be required to commission a study by a Qualified Professional to determine the viability of ground disposal for storm water.

The presence of an existing municipal drainage system does not mean, or imply, that the system has adequate capacity to receive the proposed design flows, nor does it indicate that the existing system pattern is acceptable to the District of Lake Country. Existing facilities that are undersized or inadequate to accept additional drainage must be upgraded at the Owner's expense to accommodate the appropriate flows. Alternative drainage proposals may be considered.

Stormwater management designs must conform to local government bylaws, regulations, and policies plus federal and provincial statutes and guidelines. These include, but are not limited to, the following:

- District of Lake Country Stormwater Management Design Guidelines
- Existing Master Drainage Plans, Watershed Plans, or Integrated Stormwater Management Plans
- Local Government Act
- Fisheries Act
- Water Sustainability Act
- Canadian Navigable Waters Act
- Canada Wildlife Act
- Migratory Birds Convention Act
- Dike Maintenance Act
- Land Development Guidelines for the Protection of Aquatic Habitat (Canada/B.C.)
- National Guide to Sustainable Municipal Infrastructure (Canada)
- Best Practices for Protection of Groundwater Resources in British Columbia (BC)
- Standards and Best Practices for Instream Works (Canada/BC)
- Riparian Areas Protection Regulation (BC)
- Canadian Dam Association Dam Safety Guidelines
- Applicable Professional Practice Guidelines provided by Engineers and Geoscientist British Columbia
- MMCD Green Design Guideline Manual

Where there is a discrepancy between this Schedule and any of the above-referenced documents, the more stringent requirements or guideline shall govern. Also note that the design standards in this Schedule set minimum acceptable standards.

M.1.2. Storm Drainage System Triggers

If a storm drainage system is required pursuant to this Bylaw, the Owner of the parcel being subdivided or developed must provide the proposed subdivision or the parcel being developed with a storm drainage system constructed and installed in accordance with the provisions of this Bylaw, as amended from time to time.

In addition to the requirements of Schedule C Servicing Requirements, a storm drainage system is required where the subdivision or development is located in an area where drainage studies adopted by Council indicate that drainage work should be constructed.

In addition to the requirements of Schedule C Servicing Requirements, a storm drainage system is required where the development includes or is solely for the alteration of land.

M.1.3. Georeferenced Data

It is the Owner's Engineer's responsibility to ensure they obtain true and accurate elevations for the development of the site and to confirm the accuracy of any mapping or information that may be provided by the District.

M.2. DESIGN OVERVIEW

M.2.1. General Requirements

a) The Owner's Engineer must design the storm drainage system so that all downstream drainage facilities are capable of handling the determined, controlled post development flows.

b) All stormwater runoff that is discharged to a receiving water, whether directly or indirectly, must be treated using approved methods and to an approved standard.

c) A Stormwater Management Plan must be prepared by the Owner's Engineer for District review for all phases of the proposed development to ensure required drainage routes and facilities are adequately identified, protected, and sized for ultimate development conditions. The level of detail required is contingent on the size and type of development proposed.

M.2.2. Dual Drainage System

Each storm drainage system must consist of a minor and a major drainage system as defined below:

M.2.2.1. Minor Drainage System

The minor drainage system is comprised of storm sewers, swales, channels, culverts and flow control facilities designed to prevent flooding and property damage and to minimize public inconvenience caused by frequent storm events. Runoff from the minor storm is referred to as the Minor Flow.

M.2.2.2. Major Drainage System

The major drainage system comprises surface flood paths, drainage outlets (i.e., designated storm sewers that convey the major flow), ditches, roadways, watercourses and flow control facilities designed to accommodate the runoff from rare and intense storms. A major drainage system shall be designed to protect the public and prevent significant property damage due to flooding caused by these rare and significant storm events. Runoff from these storm events is referred to as the Major Flow.

M.2.3. Service Levels

The service level for each of the drainage systems is defined by the capacity required to convey or control runoff from design storm events with return periods specified in Table M-1.

Table M-1: System Service Level Return Periods

Drainage System	Design Return Period
Minor	10 years
Major	100 years
Culverts & Bridges on Streams	200 years

M.2.4. Control Criteria

Stormwater discharge generated by the subdivision or development shall be controlled to reduce downstream impacts and to mimic the pre-development conditions as much as possible. The following level of runoff control shall be provided:

Table M-2: Control Criteria

Control Objective	Criteria
Water Quality Control	Treat 70% of the 2-year/24-hour post-development runoff volume or 90% of the average annual post-development runoff volume, depending on whether the design is based on single-event analysis or continuous simulation. See Section M.3.7
Runoff Rate Reduction	Store runoff from the critical minor-system design rainfall event and release it at a rate that approximates the natural pre-development Minor Flow. See Section M.3.3.
Peak Flow Conveyance	Ensure that the Major Drainage system is able to convey post-development runoff from extreme storm events (up to and including the Major Flow) in accordance with good engineering practice as determined by the District Engineer. If the District Engineer determines that this is not feasible, then Control Criteria for discharge to the Major System shall be provided as specified by the District Engineer.

Offsite discharge rates not based on the above criteria may be allowed at the discretion of the District Engineer based on downstream system capacity and/or ability to convey flows without causing erosion, negative impacts to the Receiving Water, flooding, damage to flood protection works or degraded water quality.

M.3. RUNOFF ANALYSIS

M.3.1. General

This section describes the rationale, methodology, and parameters for determining the design runoff rates and volumes corresponding to the proposed Development or Subdivision. This includes runoff generated within catchments both tributary to and within the Development or Subdivision. Where analysis of downstream conveyance systems by the Owner is required, runoff rates and volumes from catchments tributary to these works shall also be determined.

M.3.2. Upstream Catchments

The Design shall be sized to safely convey runoff from upstream catchments tributary to the Development or Sub-Division. Design runoff values from upstream catchments shall be determined in consultation with the District Engineer to reflect anticipated future land uses within these drainage catchments.

M.3.3. Pre-Development Runoff

In general, and for the purposes of this Schedule, “pre-development” refers to natural land cover prior to any disturbances or alterations by humans – including roads, clearings, agriculture, and buildings. The pre-development flow shall be calculated using Equation M-1.

Equation M-1: $Q_T = A \times URR_T$

Where: Q_T = pre-development runoff rate for a specified return period “T” [m^3/s]

A = drainage area [ha]

URR_T = Unit Runoff Rate for the return period “T” [Lps/ha], as found in the District’s *Stormwater Management Design Guidelines*

Alternatively, pre-development runoff may be determined using the Hydrograph Method. In this case, the model must reasonably reflect field hydrology conditions based on flow measurements and/or reliable anecdotal evidence. Modelling results are subject to approval by the District Engineer.

M.3.4. Climate Change

To account for a changing climate, the rainfall IDF values presented in the District’s Stormwater Management Design Guidelines have been adjusted to reflect projected rainfall intensities to the year 2100. This accommodation is adequate for single-event design storms. However, should continuous modelling be required, appropriate continuous climate values projected to 2100 must be used. These continuous data sets shall be obtained from the District.

M.3.5. Acceptable Methods

Storm drainage design shall be carried out using one or both of the following methods.

M.3.5.1. Rational Method

The Rational Method is applicable for preliminary design, for detailed design of minor drainage systems in urban areas and for the purposes of computing peak flow rates where no retention or detention features are included. Use of the Rational Method shall be limited to hydrologically simple and uniform catchments with a combined area less than 10 hectares. Its application shall also be limited to sizing conveyance systems only. It shall not be used to establish pre-development hydrology.

M.3.5.2. Hydrograph Method

Computer models that generate hydrographs shall be used for hydrologic and hydraulic analysis for all instances where the combined drainage catchment area is larger than 10 hectares, where drainage catchments are hydrologically complex and/or where stormwater management systems require more than basic conveyance (systems include green infrastructure, detention or retention storage, infiltration systems, and/or pump stations for example). This method is also acceptable for developing pre-development runoff rates provided that the model adequately reflects anecdotal or recorded flows using historical rainfall events.

M.3.5.3. Continuous Simulation

A continuous simulation model shall be used to design infrastructure where system capacity is based on runoff volumes that must be stored and/or released over extended time periods. Climate data time series may have a duration as short as several days (multi-day storms) or as long as several years or decades – the duration required shall be determined by the District Engineer. The maximum time interval for the rainfall time series shall be 1 hour. Digital files of hourly rainfall and temperature data can be obtained from the District.

M.3.6. Rational Method

M.3.6.1. Formula

The Rational Formula is expressed as: **Equation M-02:** $Q = CIA/360$

Where: Q_T = peak runoff for a specified return period “T”, m^3/s

C = runoff coefficient

A = drainage area, hectares

I_T = rainfall intensity for the return period “T” and storm duration equal to the Time-of-Concentration (T_C), mm/hr

M.3.6.2. Runoff Coefficients

Runoff Coefficient (C) values shall be established based on the proposed land uses, proposed **developments,** soils, catchment slopes, and hydrogeological information. Runoff calculations and rationale for the C values selected shall be included in the stormwater management section of the Detailed Design Brief that is part of the Detailed Design Submission.

“Default” C values, as shown on Table M-3 may also be used.

Table M-3: Rational Method Design Runoff Coefficients

Land Use	Minor Storm	Major Storm
Commercial	0.85	0.90
Industrial	0.75	0.80
Institutional	[1]	[1]
Residential - Single-Family areas	0.40	0.50
Residential - Multi-units, detached	0.50	0.60
Residential - Multi-units, attached	0.60	0.70
Apartments	0.75	0.80
Parks / Cemeteries	0.20	0.25
Streets – Asphaltic	0.85	0.95
Streets – Concrete	0.85	0.95
Drives and Walks	0.80	0.90
Roofs	0.80	0.90
Green Space (Lawn)	0.15	0.20
Landscaped (Trees / Shrubs)	0.10	0.15
Orchards / Vineyards (Mature)	0.12	0.18
Natural Areas [2]		
Slope < 2%	0.04	0.09
3% < Slope < 6%	0.09	0.14
Slope > 6%	0.13	0.18

[1] Calculate weighted average value based on site land use composition as per Equation M-03.

[2] Adjust to reflect amount, type, and density of vegetation - subject to approval by District Engineer.

Note: The above table assumes conventional site drainage of directing all surface drainage overland into streets and catch basins. The runoff coefficients account for “wet” antecedent conditions.

In a case of applying the Rational Method to a mixed land use in a drainage area, a weighted average C value shall be used and can be calculated from the following equation:

Equation M-03: $C_{avg} = \sum \frac{A_i C_i}{A}$

Where: C_{avg} = the average runoff coefficient for the catchment
A_i = the area of land within the catchment correlated to runoff coefficient C_i, and
A = the total catchment area

M.3.6.3. Time-of-Concentration

The value of the design rainfall intensity (I_T) for the Rational Method is selected from the appropriate Intensity Duration Frequency (IDF) curve, with a duration chosen to coincide with the Time-of-Concentration (T_C). T_C is the time required for run-off to become established and reach the catchment outlet from the furthest point within the contributing drainage catchment. T_C is the sum of two components, the “inlet time” and the “travel time”.

M.3.6.4. Inlet Time

The inlet time is the time it takes for overland flow to enter the conveyance system. It varies with size of the catchment area and surface imperviousness. In developed urban areas where paved surfaces drain directly to catch basins, the inlet times provided in Table M-4 shall be used. The minimum inlet times reflect roof leaders and parking lot drainage (hard surface) being discharged directly into a piped storm system. Longer inlet times may be appropriate to reflect roof leaders and parking lot drainage being discharged onto ground (grass, gravel, swales) and to account for travel distances and other variables. When Inlet Times other than those presented in Table M-4 are proposed, it is the Owner’s Engineer’s responsibility to verify that the selected values are appropriate and provide recommendations to the District Engineer for approval.

Table M–4: Inlet Times for T_C Calculations

Lot Type	Minimum Inlet time	
	10-Year	**100-Year**
Single Family Residential	15	10
Multi Family Residential	10	5
Commercial/Industrial/Institutional	10	5

For inlet times in rural areas, the overland flow time must be calculated using one of the following methodologies.

M.3.6.5. Travel Time

The travel time is the length of time required for flow to travel within the conveyance system from the point of inflow to the location being analyzed – typically the catchment or system outfall. When the channel or pipe characteristics and geometry are known, the preferred method of estimating channel flow time is to divide the travel length by the average travel velocity obtained by using the Manning equation. This may require one or two iterations since the flow rate used to calculate the velocity must first be estimated, then calculated using the results based on the initial assumption. Default roughness coefficients for different types of open channel linings and pipe materials are found in Sections M.5.2.1 and M.6.3.2.

M.3.6.5.1. Developed Areas – Use FAA Airport Equation

Common time of concentration calculations include the FAA, Kirpich, and Kerby equations. The FAA (U.S. Federal Aviation Administration) equation is the most commonly used of the three because it uses the widely recognized Rational Coefficient to describe watershed ground cover.

Equation M-05: $T_c = 3.26\ (1.1 - C)\ L^{0.5} / (S)^{1/3}$

Where: T_c = Time of concentration (minutes)C = Rational method runoff coefficient
L = Longest watercourse length in the watershed (m)
S = Average slope of the watercourse (m/m)

M.3.6.5.2. Rural / Undeveloped Areas – Use BC Water Management Method

This method was developed by the BC Ministry of Environment, Water Management Division, Hydrology Section. It is limited to drainage areas up to 1000 ha and is dependent on the catchment's characteristics. Equation M-06 and corresponding coefficients in Table M-6 reflects curves fitted to the graphical method presented in the BC Supplement to TAC Geometric Design Guide.

Equation M-06: $T_C = aA + bA^{0.5} + c$

Where: T_c = Time of concentration (hours)
A = Catchment area (ha)

Table M-5: Water Management Method Coefficients

Catchment Slope	Coefficients		
	a	b	c
Flat (slope ≈ 0%)	-0.0416	4.5609	0.4984
Rolling (slope ≈ 1%)	0.0488	3.0973	0.3041
Moderate (slope ≈ 2.5% slope)	-0.0113	2.2271	0.0642
Steep (slope > 10%)	0.0233	0.9075	0.0832

Note that for agricultural and rural basins, the curves labeled Flat or Rolling should be used. For forested watersheds, the curves labeled Rolling, Moderate, or Steep should be used.

M.3.6.6. Rainfall Intensity

Rainfall intensities shall be determined from the IDF data presented in the most recent version of the District's Stormwater Management Design Guidelines. Values obtained from the Guidelines shall be included in the Owner's Engineer's Design Brief accompanying the Stormwater Management Plan (SWMP) .

M.3.7. Hydrograph Method

M.3.7.1. General

Analysis using the Hydrograph Method requires computer software capable of modelling the hydrologic characteristics of the watershed and generating runoff hydrographs from rainfall hyetographs. The hydrographs are typically routed through a network of open channels, conduits, storage facilities, and other stormwater management infrastructure or components. Hydrographs my be generated from single-event storms as well as from continuous time series covering multiple rainfall events or even years-worth of historical rainfall and climate data. The Hydrograph Method shall be used to analyze non-homogeneous drainage catchments, complex combinations of infrastructure and runoff controls, and/or the effects of timing due to flow routing through the system. Analyses and reporting shall be completed as per the District's Stormwater Management Design Guidelines.

M.4. SITE DESIGN

M.4.1. Site and Lot Grading

A comprehensive lot grading plan shall be prepared by the Owner's Engineer. The plan shall retain as many natural surface drainage features as possible while meeting the grading requirements of all the proposed lots within the Development area. The grading plan shall also mitigate or at least minimize impacts on existing adjacent Development areas.

Grading shall comply with the B.C. Building Code and be prepared as per the District's Stormwater Management Design Guidelines.

M.4.2. Driveway Rough-In

Driveways for lots fronting a road serviced by a rural road section (ditches and culverts) shall be roughed-in at the direction of the District Engineer. This shall include a driveway culvert, sized and installed as per Section M.5.8 of this Schedule.

M.4.3. Minimum Building Elevation (MBE)

The MBE applies to the elevation of the lowest floor slab in a building or the underside of the floor joists where the lowest floor is constructed over a crawl space. Crawl space is defined as the space between a floor and the underlying ground having a maximum height of 1.2 m to the underside of the joists and is not used for the storage of goods or equipment damageable by flood waters.

The MBE shall be at least 0.60 m above the storm sewer service connection invert and 0.30 m above the Major Drainage System hydraulic grade line (HGL), whichever requires the greater MBE. Establishment of the MBE shall also consider the influence of the groundwater table at its annual peak.

For sites near a watercourse for which a floodplain elevation has been established, the MBE shall be a minimum of 0.30 m above the instantaneous 200-year return period flood elevation or 0.60 m above the maximum daily 200-year return period flood elevation. Where a flood elevation has not been established, setbacks should be as per current Provincial guidelines. Where more than one setback is applicable, the greater distance shall be applied.

M.5. MINOR SYSTEM

M.5.1. Service Level

The Minor System is considered as a “convenience” system. It is intended to capture and convey runoff from frequent rainfall and typical snowmelt events. For roads with an urban cross section, the minor system may include curbs, gutters, catch-basin inlets, catch-basins, catch-basin leads, maintenance holes, storm sewers, flow-control structures, detention storage, infiltration systems, stormwater quality treatment, and outfalls. For roads with rural cross sections, the Minor System may include ditches, culverts, and vegetated swales. The Minor System may also include green infrastructure and Low Impact Development (LID) Best Management Practices (BMPs).

M.5.2. Storm Mains

M.5.2.1. Sizing

Storm sewers shall be designed to provide the required capacity in free flow (not surcharged) conditions using Manning's formula. The following Manning’s roughness coefficients shall be used:

- 0.011 for smooth-walled PVC or HDPE pipes
- 0.013 for smooth-walled concrete pipes
- 0.024 for corrugated metal pipes

The minimum storm sewer diameter shall be:

- 250 mm for mains within all residential/single family zones
- 300mm for mains within all industrial/commercial/multi-family zones

Downstream pipe sizes shall not to be reduced unless the downstream pipe is 600 mm diameter or larger and increased grade provides adequate hydraulic capacity without exceeding velocity limits. Detailed hydraulic analysis and the District Engineer’s approval is required. The maximum reduction is two pipe sizes.

Storm sewers may be sized according to the required capacity taking 50% of the capacity of any upstream infiltration facilities into consideration. The infiltration capacity must be calculated and justified by a Qualified Professional experienced in this field. In no case shall main diameters be less than the specified minimums.

M.5.2.2. Surcharged Storm Sewers

Surcharged sewers to convey the design flows are permitted only as exceptions and with completion of a report by the Owner’s Engineer and approval of the District Engineer. In all such cases, it must be clearly demonstrated that the projected highest hydraulic grade line has no impact on downstream properties.

M.5.2.3. Grades and Velocities

Minimum grades of storm mains, flowing full or half-full, are required to obtain the minimum velocity of 0.6 m/s. Where velocity exceeds 4.5 m/s, or when super-critical flow occurs on steeper slopes, flow throttling or energy dissipation measures to prevent scour or to accommodate the transition back to subcritical flow may be required. Where the slope of the storm sewer main exceeds 10%, but is less than 20%, anchorage shall be considered by the Owner's Engineer. Justification for not including anchorage in the design under these slope conditions shall be included in the Design Brief.

Where slope is 20% or greater, anchorage must be incorporated into the design. Anchorage must be constructed in accordance with Standard Drawings. At the discretion of the District Engineer, the Owner's Engineer shall also determine if special provisions are required to protect against displacement of sewers by erosion or shock. These provisions shall be incorporated into the design and adequately detailed in the design drawings and specifications.

M.5.2.4. Discharge to Natural Watercourses

Runoff from developments near Okanagan Lake, Ellison Lake, Kalamalka Lake, and Wood Lake may be discharged directly to the lake provided that the required minor and major systems exist, stormwater quality is addressed, and approval from the appropriate provincial authority is obtained. Developments within the remaining areas of the District are required to attenuate offsite discharge to the appropriate pre-development runoff rate via on-site controls.

Where drainage discharge enters a natural watercourse, maximum discharge velocities shall be less than 1.0 m/s. All proposals for works affecting natural watercourses must be forwarded by the Owner to the appropriate provincial and/or federal authorities for review and approval.

Should siltation or erosion controls be required by the above agencies, details of the proposed works must be included in the engineering drawings and must be installed as part of the works.

M.5.2.5. Location

M.5.2.5.1. Public ROWs

Storm sewers shall be located as shown on the Standard Drawings within a Subdivision Road right-of-way (ROW) or open lane. Where this is technically impractical, and it is proposed to place storm sewers within private property, the Owner's Engineer shall provide rationale and analysis for consideration by the District Engineer. Works to be owned by the District, and which are on private property, shall be located within a Statutory Right of Way (SROW).

M.5.2.5.2. Statutory ROW Through Private Land

The District Engineer may require a statutory right-of-way over a drainage course that crosses private land to allow for future maintenance by the District and to prevent structures in a location where they could be damaged by stormwater. When a storm main is located within a statutory right-of-way (SROW) across private land, and appurtenances which require maintenance are located within the right-of-way, the Property Owner must ensure that maintenance access is available. For large structures or structures requiring an enhanced maintenance level such as oil/sediment chambers, control structures and pond inlet/outlet chambers, an access route adequate to support the maintenance vehicles shall be provided. The surface of the route may be gravel, concrete pavers, or asphalt depending on the location and the context of the site at the discretion of the District Engineer.

SROW requirements are further defined in Schedule B.7 of this bylaw.

M.5.2.6. Depth and Cover

Storm sewers should be of sufficient depth to:

- Permit gravity service to all tributary areas, including both sides of the roadway if feasible,
- Prevent freezing,
- Clear other underground utilities, and
- Prevent damage from surface loading.

Storm sewers shall be designed with cover ranging from a minimum of 1.2 m to a maximum of 4.5 m above the crown of the pipe, subject to approval by the District Engineer.

M.5.2.7. Alignment

Except as indicated for Curved Sewers, horizontal and vertical alignments shall be straight lines between maintenance holes unless approved by the District Engineer.

M.5.2.8. Curved Storm Sewers

Where permitted by the District Engineer, horizontal and vertical curves may be formed using pipe joint deflections as follows:

- Minimum radius shall be 300 times the outside diameter of the pipe barrel (300 x D) or 1.5 times the manufacturer’s recommended minimum radius of curvature – whichever is greater.
- Constant radius throughout curve.
- Joint deflection not to exceed 50% of maximum recommended by pipe manufacturer.
- Minimum design velocity = 0.9 m/s.
- Minimum grade = 1.0% (0.01 m/m).

The curve midpoint and two quarter-points shall be located by survey and shown on the as-constructed drawings with corresponding invert elevations and offsets.

Subject to approval by the District Engineer, sewers larger than 600 mm diameter may include deflections formed by mitred bends to a maximum mitre of 45 degrees.

M.5.2.9. Ditch Inlets

The minimum pipe diameter for ditch inlets to the storm sewer system shall be 400 mm. All ditch inlets shall be connected to a maintenance hole. All ditch inlets to storm sewers shall be equipped with a headwall, and for large pipes (>600 mm diameter), debris screens. If directed by the District Engineer, the ditch inlet shall include a sedimentation basin or trap.

M.5.2.10. Temporary Cleanouts

Temporary clean-outs may be provided at terminal sections of a main provided that:

a) Future extension of the main is proposed or anticipated,
b) The length of storm drain to the downstream maintenance hole does not exceed 45.0 m, and
c) The depth of the pipe does not exceed 2.0 m at the terminal point.

M.5.2.11. Pipe Joints

Watertight joints are preferred, but open joints may be used subject to approval by the District Engineer to support groundwater recharge. However, since open joints can increase the risk of erosion within pipe bedding, their use shall be limited to grades less than 5%. Where the use of open joints is approved, clear 19mm crush gravel rather than sand bedding shall be used.

M.5.3. Maintenance Holes

M.5.3.1. Where Required

Maintenance holes are required at the following locations:

- Every change of pipe size.
- Every change in grade, except as indicated for curved sewers.
- Every change in direction, except as indicated for curved sewers.
- Upstream end of every sewer line.
- Downstream end of curved sewers.
- Every pipe intersection except for service connections as per FIGURE M-1
- Every catch basin connection.
- Outfalls to the major system (i.e., creeks, channels, lake) in order to isolate the upstream main to facilitate cleaning. The maintenance hole shall be located as close as possible to the point of discharge.

M.5.3.2. Spacing

The maximum distance between maintenance holes shall be:

- 150 m for pipes with diameters less than 900 mm, or
- 250 m for pipes with diameters 900 mm and larger.

M.5.3.3. Hydraulic Considerations

The crown of the downstream pipe must not be higher than the crown elevation(s) of the upstream pipe(s).

Minimum drop in invert elevations across maintenance holes:

- Straight runs: 5 mm drop
- Deflection up to 45 degrees: 20 mm drop
- Deflection 45 to 90 degrees: 50 mm drop

M.5.3.4. Hydraulic Losses

Hydraulic losses shall be calculated for maintenance holes with significant change of grade or alignment. For high velocity flows, particularly for pipes with diameters 600 mm or larger, detailed analysis using the Froude number, or utilizing appropriate computer models is required. The Manning's equation should not be relied on for pipe slopes above 10%. For low to moderate velocities and smaller pipes, use following equation:

Equation M-08: $H_L = k\, V^2 / 2g$

Where: H_L = head loss (m)
V = flow velocity entering junction (m/s)
g = gravitational acceleration (9.81 m/s2)
k = head loss coefficient (1.0 for channelled 90 degree bends and tees to 1.5 without channelized benching)

Where benching is used, the minimum drops listed in Section M.5.3.3 are applicable for velocities below 1 m/s. Where flows exceed 1 m/s, H_L should be specifically computed - the greater of the two values shall be used as the drop across the junction.

M.5.3.5. Drop Maintenance Holes

Drop maintenance holes and outside ramp structures should be avoided where possible by steepening inlet sewers. Where necessary, drop maintenance holes or outside ramps shall be installed as per Table M-6:

Table M-6: Drop Maintenance Holes and Ramps Criteria

Invert Difference	Structure
Up to 0.25 m	Inside Ramp
0.25 to 0.90 m	Outside Ramp
Greater than 0.90 m	Outside Drop*

* Inside ramps may be permitted, but only where the proposed alignment conflicts with existing utilities or where an inside ramp is required to match upstream and downstream pipe slopes. Inside ramps must not exceed 450 mm and must be approved by the District Engineer.

M.5.3.6. Lid Markings

All maintenance hole lids shall be clearly labelled Lake Country Storm Sewer.

M.5.4. Catch Basins

M.5.4.1. General

a) Catch basins are required at regular intervals along roadways, at intersections, and at low points.

b) Side-inlet catch basins are required for all curbed roads. Lawn basins are required on boulevards and private properties where necessary to prevent ponding or flooding of sidewalks, boulevards, driveways, buildings, and yards.

c) Catch basin grates shall be installed as specified in the District's Standard Detail Drawings. Alternate grates may be allowed providing that corresponding rating curves are submitted to and approved by the District Engineer.

d) All catch basins shall discharge to a storm sewer system or approved infiltration system. Direct discharge from catch basins to natural streams or receiving waters shall not be allowed.

M.5.4.2. Spacing

Catch basin spacing shall provide sufficient inlet capacity to collect the entire minor flow, or major flow if required as per Section M.6.1 of this Schedule, into the pipe system. To ensure that the capture or inlet capacity matches the storm main capacity, the spacing of catch basins on streets shall, at the minimum, meet the following criteria:

a) Road grades less than or equal to 3% shall have a maximum spacing of 150 m or 675 m2 of paved area, whichever is more stringent.

b) Road grades greater than 3% shall have a maximum spacing of 100 m or 450 m2 of total area.

c) Catch basis will be spaced to ensure no overflows to driveways, boulevards, sidewalks, or private property.

d) Catch basis will be spaced at intersections so as not to interfere with crosswalks.

The Owner's Engineer shall provide confirmation that the above-listed maximums have not been exceeded by the design.

M.5.4.3. At Low Point

Double, side-inlet catch basins are required at all low points on a road, including cul-de-sacs. Double catch basins are required on both sides of the road if it is crowned, and only on the lower side of the road if it is cross-falled or super-elevated.

M.5.4.4. Sediment Trap

All catch basins shall be equipped with a minimum 0.5 m sump to capture and hold sediment.

M.5.4.5. CB Leads

M.5.4.5.1. Minimum Diameters

All catch basin leads shall be sized to convey the design inlet capacity, subject to the following minimum diameters:

a) from single, top-inlet catch basin – 200 mm

b) from double top-inlet or side-inlet catch basins – 250 mm

M.5.4.5.2. Minimum Slope

The minimum slope of the lead shall be 2.0% unless otherwise specified by the District Engineer.

M.5.4.5.3. Connections

All catch basin leads shall discharge into a maintenance hole.

M.5.4.5.4. Cover

Catch basin leads shall have a minimum cover of 0.9 m. If this is not feasible, the design shall include traffic load and frost protection. Design calculations must be provided.

M.5.5. Service Connections

M.5.5.1. General

Every legal lot shall be provided with a separate service connection where disposal to ground of discharge from foundation perimeter drains and/or roof drains is not recommended by a Qualified Professional or at the discretion of the District Engineer. Connections shall drain away from building foundations by gravity, but pumped connections may be permitted if requested prior to design, approved by the District Engineer, and appropriate covenants are provided.

M.5.5.2. Foundation Drains

Foundation perimeter drains for buildings are required as per the British Columbia Building Code. Where a hydrogeological study justifies their use, and subject to approval by the District Engineer, dry wells or ground infiltration systems may be used as the storm water disposal method for connection of perimeter drains. These systems shall be designed and supervised by a Qualified Professional.

Foundation perimeter drains are not permitted to be directed to any infiltration device or soak away pit that impacts an engineered retaining wall or reinforced earth structure.

Where infiltration systems are not recommended in the hydrogeological study, foundation perimeter drains may be connected by gravity via a storm service to the storm main provided that:

a) the elevation of the basement/crawlspace floor is at least 600 mm above the elevation of the storm main obvert, or

b) 600 mm above the anticipated or known high ground water table, or

c) 600 mm above the 100 year hydraulic grade line within the main at that point, whichever is higher.

M.5.5.3. Roof Leaders

Roof drainage leaders shall be connected to the storm service connection unless geotechnical conditions support use of splash pads for dispersal to the ground. The evaluation of this requirement shall be included in the scope of the study referenced in Section M.1.1. Use of ground disposal for roof leader discharge is subject to approval by the District Engineer.

Roof leaders shall not be directed onto driveways which drain directly onto District right-of-way, including roads, or to areas draining directly onto neighboring properties.

M.5.5.4. Size

Service connections shall be sized to accommodate peak design flow, subject to the following minimum pipe diameters:

- from Single Family or Low Density Multi-Family lots – 100 mm
- from Medium or High Density Multi-Family lots – 150 mm
- from Commercial, Industrial, or Institutional lots – 150 mm

M.5.5.5. Location and Depth

As a general rule service connections shall be located at the lowest corner of the property and installed at an offset of 4.0 m from the property pin.

Minimum depth will depend on the frost depth, but should be at least 0.9 m where subsurface building floor space is not required. Where basements are proposed, the depths of the storm sewers and services shall be increased to suit.

M.5.5.6. Grade

Service connections shall have the following minimum grades:

- 100 mm diameter pipe: 2%
- 150 mm diameter pipe: 1.00%
- Larger sizes: Grade based on minimum velocity of 0.75 m/s.

M.5.5.7. Connections to Mains

a) For connections to new mains, use standard wye fittings.

b) For connections to existing mains, use wye saddles or, if approved, insertable tees.

c) Service connections may be permitted into maintenance holes if

- the connection is not oriented against the flow in the main and
- maintenance hole hydraulic requirements are met.

d) Storm services to properties shall not be permitted from storm drains located in rights-of-way unless a clean-out is provided and the nature of the development will permit access to the right-of way for inspection, maintenance, and repair.

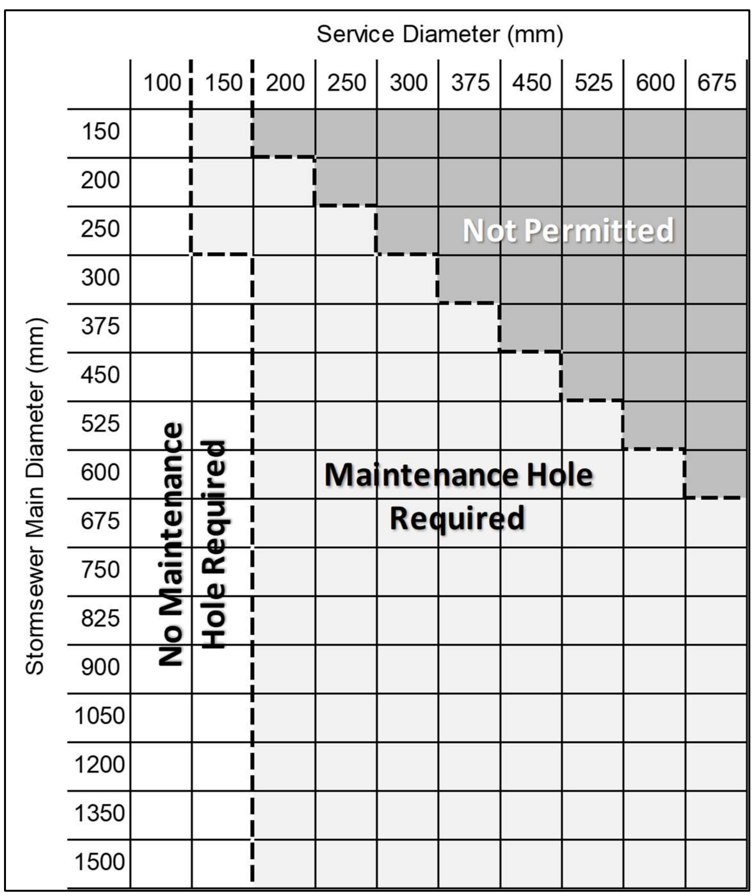
e) Must Include an inspection chamber unless service is less than 2.5 m long and connects to a maintenance hole.

f) Service connections shall be designed as mains if they exceed 30 m in length.

M.5.5.8. Maintenance Access

Maintenance holes are required for services relative to the size of the main as shown in **FIGURE M-1**

FIGURE M-1



M.5.6. Sub-Surface Disposal / Infiltration Facilities

M.5.6.1. General

Infiltration facilities are intended to reduce offsite-discharge volumes and rates, and to promote groundwater recharge. They are suitable for high permeability soils with low groundwater elevation, but must be supported by an appropriate study prepared by a Qualified Professional for confirmation and design guidance.

Design details should be in accordance with current technologies as outlined in Infiltration Systems guidelines in Land Development Guidelines for the Protection of Aquatic Habitat (Canada/B.C.), and related documents such as the MMCD Green Design Guideline Manual.

The Owner's Engineer shall submit all sizing assumptions and calculations for review and approval by the District Engineer.

Under no circumstances shall these systems or controls be used in the following conditions:

- Areas within 30 m of a slope that is steeper than 3.0 (horizontal) to 1.0 (vertical) and higher than 6.0 m, or a slope that has been assessed to be unstable or potentially unstable by a Qualified Professional.
- Areas where the post-development wet season groundwater table is less than 0.6 m below the base of proposed infiltration system or infiltrating surface.
- Areas where existing dwellings do not have foundation drains.
- Bedrock or other impermeable layer is located within 1.2 meters of the infiltrating surface.
- The infiltrating surface is located on top of fill material.
- The adjacent or underlying soils have a fully saturated percolation rate of less than 10 mm/hr.
- Site is sensitive to potential groundwater contamination.

M.5.6.2. Infiltration Rate Correction Factor

A correction factor, or factor of safety, is commonly applied to measured infiltration rates for design purposes. These correction factors are intended to mitigate the following:

- Long-term silting or "blinding" of the facility.
- Potential variability in the subsurface conditions.
- Type and size of infiltration facility.
- Whether it is public or private.

The correction factor is applied as follows:

Equation M-01: $K_{Design} = K_{Field} / SF$

Where: K_{Design} = the design infiltration rate (mm/hr)
K_{Field} = the infiltration rate as determined by field tests (mm/hr)
SF = the Safety Factor

The Safety Factor shall be recommended by the Qualified Professional, but shall not be less than 2.0.

M.5.6.3. Drywells

Where drywalls are deemed suitable by the District Engineer as part of an on-site storm water management plan for the minor system, the minimum number of dry wells must be determined by considering the flow generated from the site in relation to the infiltration capacity of the site soil. Sufficient temporary storage (within the drywell, surrounding drain rock, and potentially on the surface) shall be constructed with sufficient volume to temporarily store generated flows until such time as they infiltrate into the subsurface. Design shall be in accordance with Standard Detail Drawings.

M.5.6.4. Perforated Pipes

Perforated pipes within infiltration trenches are only suitable for undisturbed ground where water can move horizontally out of the trench and where drainage water is free from silts. The system must be designed to function under surcharged conditions, and is therefore more suitable to locations with flatter slopes. Where necessary, this type of infiltration system shall include internal overflows within each maintenance hole. Design shall be subject to approval by the District Engineer.

M.5.6.5. Infiltration Basins / Manufactured Systems

Surface infiltration basins shall be designed in accordance with the criteria specified in Section M.5.6. Pre-manufactured modular infiltration chambers shall be designed as per manufacturer's recommendations. Shop drawings for such systems shall be provided, and shall reflect site conditions, including invert elevations and layout dimensions. Details regarding inspection and maintenance access shall also be provided.

The design shall include provision for system failure and overflow under Major Storm conditions.

The design shall include an operations and maintenance manual, along with an estimate of annual O&M costs.

M.5.6.6. Pre-Treatment

Particularly in multi-family, commercial, institutional, and industrial developments, all infiltration systems shall include pre-treatment measures to remove sediments, suspended solids, and oils and greases prior to entering the infiltration zone. This is especially a concern in areas with new development until landscape vegetation has matured. Pre-treatment design shall be in accordance with Section M.9 of this Schedule.

M.5.7. Outfalls

Outfalls of a storm sewer system into watercourses shall be designed recognizing aesthetics and erosion control. All new all storm water outfalls to natural watercourses or water bodies must be approved by the appropriate provincial and federal authorities. In cases where the receiving water is classified as a navigable water way, approval may also be required from the Canadian Coast Guard.

Outfalls into lakes shall be submerged, extended from shore, and constructed according to the following:

- soft bottom, 0.6 metres minimum bury to allow for seasonal sand erosion and deposition
- rock bottom, criteria to be confirmed by Canadian Coast Guard
- exposed pipes must be a minimum of 2.4 metres deep during lake “low water” level

Where a storm sewer discharges into a natural watercourse or open channel, riprap bank protection will be provided and, if necessary, energy dissipation facilities. Discharge perpendicular to stream flow will be avoided.

M.5.8. Culverts

M.5.8.1. General

Culvert design shall be in accordance with the procedures outlined in the most current edition of a generally accepted design manual including, but not limited to:

- American Concrete Pipe Association – Concrete Pipe Design Manual
- Corrugated Steel Pipe Institute – Handbook of Steel Drainage and Highway Construction Products
- BC Supplement to TAC Geometric Design Guide.

Where the design guideline referenced above in section M.5.8.1 contradicts the requirements of this Schedule, the more conservative requirement shall govern.

M.5.8.2. Minimum Diameters

The minimum diameter for culverts will be:

- crossing residential driveways – 400 mm
- crossing commercial, industrial, or institutional driveways – 450 mm
- crossing public roads – 600 mm
- on a stream, regardless of road or driveway classification – 600 mm

M.5.8.3. Hydraulic Design

Culverts shall be sized to convey the design flow with a maximum headwater depth to culvert diameter ratio (Hw/D) of 1.0 measured from the culvert invert at the inlet. Analysis shall consider both inlet and outlet control and the design shall be based on the condition requiring the larger diameter.

- The following Manning’s roughness coefficients shall be used for circular culverts:
    - 0.011 for smooth-walled PVC or HDPE
    - 0.013 for smooth-walled concrete
    - 0.023 for corrugated HDPE
    - 0.024 for corrugated metal
- Manufacturer’s recommended roughness coefficients shall be used for non-circular culverts.

- Driveway culverts that form part of the Minor system shall be designed to convey runoff from the Minor Storm with a maximum headwater to diameter ratio (Hw/D) of 0.5 – measured from the culvert invert at the inlet.
- Culverts crossing roads shall be sized to convey the design flow with a maximum headwater to diameter ratio (Hw/D) of 1.0 measured from the culvert invert at the inlet.
- The design shall consider both inlet and outlet control and shall be based on the condition requiring the larger diameter.
- All culverts shall be constructed with inlet and outlet structures approved by the District Engineer. Exceptions may be granted at the discretion of the District Engineer.
- When culverts or storm pipes are greater than 600 mm, the outfall pipe or structure shall be protected against entry by a free swinging, lockable, weighted grating which will allow passage of materials on discharge.
- Energy dissipation and erosion control at culvert outfalls shall be considered in the design.

M.5.8.4. Depth and Cover

- The minimum depth of cover over culverts is 0.3 metres, subject to the manufacturer’s loading criteria.
- Culvert invert elevations shall be no lower than the corresponding design elevation of the ditch bottom. Where there is insufficient depth to maintain minimum cover, two or more culvert barrels may be installed to convey the design flow.

M.6. MAJOR SYSTEM

M.6.1. General

Storm runoff generated by less frequent, higher intensity rainstorms may exceed the capacity of the Minor System. Runoff from these events will pond in depressions and follow whatever overflow route is available. This network of ponding and overland flows is called the “Major System.” It may be comprised of some, or all, of the components found in the Minor System but sized to convey or otherwise accommodate the Major Flow. The Major System may also include road surfaces, overland drainage routes, and surface ponding. If the Major System is properly planned, it can minimize or even eliminate the potential inconvenience and property damage caused by large rainfall events or when inlets to the minor system become blocked by debris.

Even though storm sewers can function as part of the Major System, this is not encouraged. Using pipes to convey Major Flows may be implemented in special circumstances, but only with the approval of the District Engineer.

M.6.2. Surface Flow Routing

Roadways with curbs and gutters may be designed as wide channels to convey major surface flow. In this case, the Owner’s Engineer will consider the impact of surface routing on the major flow hydraulic grade line (HGL) of adjacent lateral roads. Existing lateral roads designed with the major HGL below surface may preclude using surface flow routing on the road being designed. Use of barrier curbs for major surface flows on roads is preferred, but rollover curbs may be used with approval of the District Engineer.

The design of the intersections will ensure that the surface flow can continue along the designated path crossing over lateral roads. Similar considerations are required if a change of surface flow direction is required at an intersection.

Calculations to verify that the surface flow is maintained within the road right-of-way and that the water elevation at maximum ponding/flow is at least 0.30 metres below the lowest Minimum Building Elevation (MBE) of adjacent buildings shall be provided with the design.

The following criteria for routing major design flows on road surfaces with an urban cross section shall be met:

- For all classes of roads, the flow/ponding depth shall not exceed 0.150 m above gutter line nor overtop the curb, whichever governs.
- Flow velocities greater than 2.5 m/s must be approved by the District Engineer.
- On local roads, the flow may spread to the crown.
- On collector roads, the flow spread must leave one lane or a road surface equivalent free of water to ensure access for emergency vehicles (fire, ambulance).
- On arterial roads, the flow spread must leave one lane in each direction free of water.
- Flooding is not permitted on private property except in flow channels within dedicated rights-of-way.

M.6.3. Ditches

M.6.3.1. General

Roads with rural cross-sections shall be constructed with ditches that ensure adequate road subgrade drainage (in compliance with standard road design). Ditch design shall conform to the criteria specified below. Variations may be implemented with appropriate justification by the Owner's Engineer and approval of the District Engineer.

- Minimum slope: 0.5% (0.005 m/m)
- Minimum depth: 0.3 m below road sub-grade
- Minimum freeboard: 0.3 m
- Maximum flow depth: 0.6 m
- Minimum bottom width: 1 m
- Maximum side slopes: 2:1 (H:V)

M.6.3.2. Sizing

Table M-7 provides acceptable Manning's "n" values for road surfaces, ditches, and swales, which shall be used with the Manning Formula for design and assessment of these structures.

Table M-7: Open Channel Roughness Coefficients

Condition	Manning's "n"	
	Minimum	Maximum
Concrete curb and gutter	0.012	0.016
Asphalt roadway	0.013	0.018
Grassed boulevards and swales	0.035	0.050
Ditches – gravel / small cobbles	0.025	0.030
Ditches – vegetated	0.030	0.035
Ditches - Rip-Rap (Class 10 kg / D_{50} 200mm)	0.068	0.072
Ditches - Rip-Rap (Class 25 kg / D_{50} 300mm)	0.071	0.076
Ditches - Rip-Rap (Class 50 kg / D_{50} 350mm)	0.073	0.078
Ditches - Rip-Rap (Class 100 kg / D_{50} 450mm)	0.075	0.080

Roughness coefficients for conditions not listed in Table M-9 shall be determined by the Owner's Engineer and submitted for approval by the District Engineer.

M.6.4. Swales

Swales shall be lined with turf on a minimum of 100mm of topsoil or lined with an erosion protection system approved by the District Engineer. All such swales serving two or more parcels of property shall be sized to accommodate the Major Design flow, and shall meet the following criteria:

- Minimum slope: 1.0% (0.01 m/m)
- Minimum freeboard: 0.15 m
- Maximum flow depth: 0.3 m
- Maximum side slopes: 4:1 (H:V)

All swales that are to be owned and operated by the District shall be located within a Statutory Right of Way (SROW).

M.6.5. Culverts

M.6.5.1. General

In addition to the design requirements presented in Section M.5.8, Major System culverts shall also be designed according to the following:

- All culverts shall be installed with inlet and outlet structures.
- Trash racks and/or debris barriers may be required upstream of culvert installations, as directed by the District Engineer.

M.6.5.2. On Streams

In addition to the design requirements presented in Section M.5.8, culverts on streams shall also be designed according to the following:

- All culverts shall be designed to convey the instantaneous 200-year return period flow or greater.
- Inlet and outlet structures are required for all culverts on streams, unless otherwise directed by the District Engineer.
- Culverts on fish-bearing streams shall meet conditions as specified by municipal, provincial, and federal authorities. Such culverts will be required to allow safe fish passage, and habitat restoration works will generally be required. The Owner's Engineer shall confirm and implement these requirements with the appropriate agencies.

M.6.6. Piped Systems

In special circumstances, or to accommodate lower building elevations, Minor System storm sewers may be enlarged or supplemented to accommodate major flows. System details shall be indicated in the Storm Water Management Plan and approved by the District Engineer. Design shall include:

- Provision of adequate inlets to accommodate major flows – including flows carrying suspended sediment and debris
- Surface overflow routes at potential surface ponding locations
- Compliance with minor drainage system guidelines.

M.6.7. Overflow Flow Routes

Sags or low points in roads and cul-de-sacs must be designed with a safe overflow route to an approved receiving water or to adequately sized drainage infrastructure. These overflow routes may be ditches or swales and shall be designed as per Sections M.6.3 and M.6.4 respectively. The overflow route shall also be located within a right-of-way in favour of the District, with a minimum width of 4.5 m.

Where a ditch crosses private property, the ditch shall be offset in the right-of-way to permit a 3.0-metre-wide access for maintenance vehicles. Additional right-of-way may be required to facilitate the ditch construction and access. The top of the ditch adjacent to the property line shall be a minimum 0.5 metres away from that property line, and the design HGL shall be at least 0.6 m below the MBE of adjacent buildings. Ditches shall be designed to maximize infiltration where infiltration is appropriate as per Section M.5.6.

M.6.8. Discharge to Natural Watercourses

Storm discharge rates and volumes to natural watercourses shall be controlled to prevent damage to the natural channel and harm to the ecological system. Consideration must be given to fish bearing streams and to streams presently at capacity.

Designs must conform to all applicable federal, provincial, and municipal laws and regulations. The Owner shall submit the designs to, and obtain comments and approvals from, the appropriate provincial and/or federal agencies.

M.6.9. Subsurface Disposal / Infiltration Systems

If the study referenced in Section M.1.1 indicates that soil conditions are suitable to support infiltration-based disposal of Major System flows, then the system shall be designed in accordance with Section M.5.6.

M.7. DETENTION FACILITIES

M.7.1. General

It is usual to provide detention storage facilities in conjunction with flow control. Such facilities temporarily store the volume of runoff corresponding to the condition where the inflow rate exceeds the controlled discharge rate.

Storage facilities may be surface or underground and may be “online” or “offline”. Storage facility selection shall be subject to approval by the District Engineer and shall include consideration of ownership and operation & maintenance requirements. The number of storage facilities shall be minimized.

Design details, other than discharge rates, should be in accordance with current technologies as outlined in Land Development Guidelines for Protection of Aquatic Habitat (Canada/B.C.), and related documents. Design for specific types of detention storage shall also reflect the following requirements.

M.7.1.1. Parking Lot Storage

a) Requires detailed lot grading design to ensure proper drainage, pedestrian safety and convenience, and major flow paths.
b) Maximum ponding depth: 300 mm outside vehicle stalls, 150 mm within vehicle stalls, however, also with consideration to frequency of ponding and impact to users of the parking lot.

M.7.1.2. Underground Storage

a) Facilities include tanks and oversized pipes, with outlet controls.
b) Cross sections and inlet and outlet locations shall be designed to minimize maintenance requirements.
c) Structural design to accommodate traffic loads and groundwater pressure.
d) Maintenance access provisions required.

M.7.1.3. Dry Detention Ponds

a) An off-line pond is preferred, but an on-line facility may be considered at the discretion of the District Engineer.
b) Fencing and graded slopes required as per referenced design guidelines.
c) May accommodate active recreational uses.
d) Overflow elevations to be coordinated with MBEs.
e) Provide warning signage indicating facility is a stormwater detention structure subject to flooding or rapid water level changes. Signs to be posted at all public access points or road frontages.

M.7.1.4. Wet Detention Ponds

a) Intention is to provide on-line detention storage and maintain a permanent minimum water levels.

b) Catchment area must be large enough to provide sufficient base flow to ensure wet storage and is sustained without becoming stagnant (based on local hydrologic characteristics).

c) Fencing and graded slopes required as per referenced design guidelines.

d) Can provide a public amenity within a passive park.

e) Overflow elevations to be coordinated with MBEs.

f) Provide warning signage indicating facility is a stormwater detention structure subject to flooding or rapid water level changes. Signs to be posted at all public access points or road frontages.

M.7.2. Flow Controls

Control structures shall be used to provide consistent flow control as specified in Section M.2.4. These structures shall be designed to include multi-stage controls. For example, two or more orifices located vertically on a control structure can be designed to provide increasing discharge rates as the water level rises. Safe overflow must be provided for conditions that exceed the maximum design flows.

Flow controls may be designed using the standard orifice and weir equations:

Equation M-09: Orifice Equation: $Q = CA(2gh)^{0.5}$

Where: Q = release rate (m^3/s)
C = orifice coefficient (0.62 for sharp or square edge)
A = area of orifice (m^2)
g = gravitational acceleration (9.81 m/s^2)
h = net head on orifice (m)

Equation M-10: Weir Equation: $Q = CLH^{1.5}$

Where: Q = release rate (m^3/s)
C = weir coefficient (to be determined by the Owner's Engineer, subject to approval)
L = effective length of weir crest (m)
H = net head on weir crest (m)

Release rates which do not reflect the criteria specified in Section M.2.4 may be allowed or required by the District Engineer, depending on downstream conveyance system capacity, stream protection, flood protection, and/or water quality issues.

M.7.3. Sizing

The design volume for detention facilities shall be determined using the Hydrograph Method and shall be the largest peak storage volume required to control flows as per the criteria specified in Section M.2.4. The District Engineer may require a 10% volumetric safety factor be applied to the calculated maximum volume. Rooftop or parking lot storage may be included in storage sizing calculations with the approval of the District Engineer. All sizing assumptions and results shall be provided as part of the design submission.

M.7.4. Inlet / Outlet Considerations

Design of inlet and outlet structures shall include consideration of energy dissipation and erosion control. Safety grates are required over all inlet and outlet openings larger than 500 mm diameter. Locks for access hatches are required.

M.7.5. Geotechnical Considerations

Geotechnical investigations by a Qualified Professional to address issues related to the design of all stormwater detention facilities shall be completed as part of the planning and design studies, and are a prerequisite to the final design of such facilities.

Wherever possible, the stormwater storage facility shall be excavated in natural, stable ground. Should topography dictate that a berm be constructed along one or more sides of a surface facility (dry or wet pond), the berm shall be designed by a Qualified Professional.

M.7.6. Ownership

For storage not under private ownership, all accesses to inlets/outlets, any structures and maintenance access routes to the facility shall be dedicated to the District. Land that is adjacent to a storage facility which is subject to flooding as per the design standard established, but which is part of the privately-owned parcel being developed, will be required to dedicate rights-of-way, to allow for encroachment of water onto the affected land. The right-of-way documents shall be prepared by the Owner, naming the District as grantee.

A restrictive covenant shall be placed on lots abutting the facility to control lot development so as not to compromise design requirements at the high-water level for major runoff events. This is to ensure an adequate freeboard is maintained.

The Owner shall confirm the need for an operational license for any wetland style storage or treatment facility with the appropriate municipal, provincial, or federal agency, and shall apply for and secure such license.

M.7.7. Operations & Maintenance

An Operations & Maintenance Manual for each type of detention storage facility shall be provided to the District. This shall include details of the system components and inspection and maintenance requirements in terms of tasks and frequencies.

For detention facilities that will be owned and operated by the District, suitable maintenance vehicle access from a public road to the detention facility shall be provided and protected by a right-of-way in favour of the District.

- For surface facilities (dry ponds), access shall include provisions for maintenance vehicles to access the pond.
- For buried facilities, access shall include adequate provisions to inspect and maintain the facility as per the required Operations & Maintenance Manual.

M.7.8. Emergency Overflow Provisions

If overflow is not provided as part of the flow control structure, then an adequate emergency overflow must be provided as part of the detention facility design. An adequate surface flow route from the overflow structure to the designated Major Drainage route must be provided and must be located within a public or District-owned right-of-way.

M.7.9. Rapid Drawdown

The ability to discharge from storage facilities at the maximum flowrate that the downstream system can accommodate after storm runoff peak flows have passed, and the flows from other contributing areas have decreased or ended, shall be provided. The discharge rate for drawdown purposes shall be sufficient to restore available storage capacity in the facility to sufficiently control runoff from subsequent storm events within a reasonable time frame as per TABLE M-1.

TABLE M-1: Drawdown Provisions

Time After Commencing Drawdown From Full Level	Available Volume Required Below Design Full Level
24 hours	Volume equivalent of 1 in 10-year, 24-hour run-off
72 hours	100% of total storage volume

M.7.10. Temporary Conditions

Where land developments occur in advance of permanent detention facilities, the District may consider temporary storage facilities on an individual basis. Maintenance charges and responsibility for temporary storage facilities will be borne by the developer.

M.8. EROSION CONTROL

M.8.1. General

Erosion and sediment control shall be incorporated into the design of all open channel conveyance routes and at all outfall / discharge locations. Typical erosion control methods include, but are not limited to vegetation, root-reinforced vegetation, manufactured materials and systems, rip rap, and velocity control.

M.8.2. Open Channels

Earthen open channels such as ditches and swales shall be designed to prevent incising, erosion, and movement of sediment. Such design is dependent on soil characteristics, channel lining, channel slope, flow depth, and flow velocity. Generally, open channels shall be designed to meet the maximum velocities specified in Table M-8.

Table M-8: Permissible Open Channel Velocities (Fully Vegetated / Grass-Lined)

Earth – Soil Type	Permissible Velocity (m/sec)		
Longitudinal Channel Slope	<0.5%	5-10%	>10%
Erosion Resistant Soils	1.2	0.9	0.7
Highly Erodible Soils	0.9	0.7	0.5

- Highly erodible soils include Fine Sand (non-colloidal), Sandy Loam (non-colloidal), Silt Loam (non-colloidal), and Ordinary Firm Loam.
- Erosion resistant soils include Fine Gravel, Stiff Clay (very Colloidal), Graded Loam to Cobbles (non-colloidal), Graded, Silt to Cobbles (colloidal), Alluvial Silts (non-colloidal), Alluvial Sites (colloidal), Coarse Gravel (non-colloidal), Cobbles, and Shales and Hard Pans.

At the discretion of the District Engineer, a more rigorous analysis using shear stress and soil characteristics supported by a study by a Qualified Professional, based on field investigation, may be required to establish the safe discharge rate for an open channel.

Bare-earth open channels will not be permitted, and must be vegetated or otherwise protected from erosion using rip-rap lined bottoms and sides, erosion control structures, geo-fabrics, or other methods approved by the District Engineer.

Erosion control calculations shall be submitted with the design. Rip rap design shall be conducted using methods presented in the most current edition of the BC Supplement to TAC Geometric Design Guide.

M.8.3. Sediment and Erosion Control

Given that disturbed soils are highly vulnerable to erosion and subsequent sediment transport during rainfall events, sediment and erosion control (SEC) measures as specified in Schedule N of this bylaw shall be implemented to protect stormwater management facilities and receiving waters. This applies, but is not limited to, areas that are cleared and grubbed, slope cuts, fills, and stockpiled materials such as sand, gravel, native soils, and topsoil.

M.9. STORMWATER QUALITY

M.9.1. General

Several potential organic and inorganic substances can be found in rainwater runoff and are referred to as “non-point source” (NPS) pollution because the sources tend to be highly dispersed across the landscape. The ones of greatest relevance and which are targeted for treatment are:

- Total suspended solids (TSS)
- Oil and grease (O&G)
- Trace metals, typically represented by copper and zinc

Focusing on the removal of these constituents is expected to yield adequate removal of other associated constituents.

M.9.2. Sizing

All developments shall incorporate water quality treatment provisions into the design to meet the performance targets provided in this section. The targets are expected to be met for every new development and redevelopment site by implementing Best Management Practices (BMPs). Facilities shall be sized to adequately treat the following:

- 70% of the 2-year/24-hour post-development runoff volume when using a single-event design approach, or
- 90% of the average annual post-development runoff volume when using continuous simulation for design.

M.9.3. Performance Targets

The performance targets are classified as “Basic Control”, which address suspended solids, and “Hydrocarbon Control”, which addresses oils and grease. These targets shall apply to all stormwater discharges from the subdivision or development, including offsite discharges and discharges to a receiving water.

M.9.3.1. Basic Control

Basic treatment focuses on removal of TSS along with associated pollutants attached to those sediments, including low levels of petroleum hydrocarbons (oil and grease). Basic control is applicable to all non-agricultural lands within the District and must provide treatment for:

- 80% removal of TSS.

Discharge from the treatment system must meet the BC Recreational Water Quality Guidelines for turbidity.

M.9.3.2. Hydrocarbon Control

Hydrocarbon (oil and grease) removal is specifically required for sites where there is significant likelihood that higher concentrations of petroleum hydrocarbons will be released; in general, this includes sites with significant presence or use of vehicles. The performance target is:

- No on-going or recurring visible sheen in receiving watercourse(s), and
- 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/L with a maximum discrete (grab sample) concentration no greater than 15 mg/L.

The catchment area to the treatment system may be restricted to drives, roads, and parking areas.

M.9.4. Best Management Practices

Table M-9 shows how the performance targets are to be applied to various land uses. Best Management Practices (BMPs) presumed to achieve the performance targets if properly designed, installed, and maintained are presented as follows:

M.9.4.1. Basic Control

- Rain Gardens / Vegetated Bioswales
- Porous Asphalt Drives, Sidewalks, Parking Areas
- Sand Filters / Filter Strips
- Stormwater Treatment Wet Ponds / Wetlands
- Manufactured TSS Removal Systems[1]

M.9.4.2. Hydrocarbon Control – Level 1

- Oil/water separator (API or coalescing plate type)[2]

M.9.4.3. Hydrocarbon Control – Level 2

- Stormwater Treatment Wetlands / Wet Ponds
- Subsurface Infiltration (requires pre-treatment)
- Sand Filters / Amended Sand Filters

Rainwater source controls and landscape-based, surface-oriented BMPs are encouraged over below-ground, manufactured (or engineered) devices. This list is not exhaustive, and alternative BMPs may be used subject to approval by the District Engineer.

Proposed use of manufactured devices must be accompanied by documentation of performance from a reputable testing or certification program[3]. Performance testing and/or monitoring may be required during the Maintenance Period at the discretion of the District Engineer.

1 Including media filter and membrane filter systems as well as manufactured biofiltration systems, at the District's discretion.

2 Requirement for an oil/water separator at multi-family residential sites may be waived at the discretion of the District Engineer if a development or redevelopment proponent can show that the site design has minimized impermeable surfaces and arranged buildings, roads, and parking elements in a manner similar to single-family residential areas. Typically, this will mean that total impermeable surfaces constitute less than 50% of the site and, more specifically, that large open parking lot areas must not be present. For purposes of rainwater management, impermeable surfaces includes all buildings, patios, decks, driveways, sidewalks, and parking areas on a single property; note that this is different than "parcel coverage" as defined in the District's Zoning Bylaw.

3 These programs include, in order of preference, (1) Canadian Environmental Technology (ETV) Program; (2) State of Washington (USA) Technology Assessment Protocol – Ecology (TAPE) program; and (3) Technology Acceptance and Reciprocity Partnership (TARP) Protocol for Stormwater Best Management Practice Demonstrations. Other testing or certification programs administered by third parties, such a universities or independent testing labs, may also be acceptable, at the discretion of the District Engineer.

Table M-9: Performance Targets by Land Use Classification

LAND USE CLASSIFICATION	TARGETS	Notes
Residential - Single Family	Basic	
Residential - Multi-Family	Basic + Hydrocarbon Control	Level 1 Hydrocarbon Control BMPs
Commercial – offices with primarily employee daily parking	Basic	
Commercial – retail use with significant daily traffic (>100 ADT per 100 m^2 of building) - Includes service station(s)	Basic + Hydrocarbon Control	Level 1 Hydrocarbon Control BMPs
Industrial – medium intensity use, with truck traffic and employee daily parking	Basic + Hydrocarbon Control	Level 1 Hydrocarbon Control BMPs
Industrial – high intensity use • Industrial machinery & equipment, and railroad equipment maintenance • Log storage and sorting yards • Railroad yards • Fueling stations • Vehicle maintenance and repair • Construction businesses	Basic + Hydrocarbon Control	Level 1 and Level 2 Hydrocarbon Control BMPs
Institutional (Schools; government; hospitals; cultural buildings)	Basic + Hydrocarbon Control	Level 1 Hydrocarbon Control BMPs
Parks and Open Space (Buildings, parking lots and other hard surfaces)	Basic	
Roads & Streets – low intensity use (<15,000 ADT) • Local roads • Lanes	Basic	
Roads & Streets – high intensity use (>15,000 ADT) • Arterials / Highways • Collectors • High use intersections (>15,000 ADT on main road; >10,000 ADT on intersecting road)	Basic + Hydrocarbon Control	Level 1 and Level 2 Hydrocarbon Control BMPs
Agricultural		Follow Applicable Provincial Rules and Guidelines for Agricultural Lands

M.9.5. Additional Requirements

All stormwater quality installations shall:

a) Provide a high flow bypass that regulates the flow rate into the treatment unit and conveys high flows directly to the outlet such that scour and re-suspension of material previously collected does not occur.

b) Provide maintenance access both to the structure and within the structure so that accumulated debris, oils, and sediments can be readily removed with a vacuum truck.

c) Meet H-20 loading criteria when located where vehicles can pass over the structure.

d) Joints and fittings shall be oil resistant and watertight.

M.10. PUMPING SYSTEMS

M.10.1. Lift Stations

Where possible, drainage pump stations are not to be used within the District and gravity systems utilized instead. Where drainage pumping is required, however, the Owner’s Engineer must review the proposed concept and design criteria with the District Engineer, submit a pre-design report, and obtain approval from the District Engineer before proceeding with design. At a minimum, the pre-design report should include the following:

a) Delineated catchment area map

b) Estimated flows and operating head / HGL

c) Pump station location

d) Connection point to existing infrastructure.

Stormwater lift stations shall be designed as per the requirements for sanitary lift stations (except where not applicable to stormwater) as presented in Schedule K of this bylaw.

M.10.2. Sump Pumps

In general, design that allows for the potential of ongoing ground water issues should be avoided. In special cases, where groundwater seepage is seasonal, the District Engineer may allow a sump pump system inside the building which will discharge to the storm main via a storm service. A backwater or check valve and a siphon break must be installed in the sump pump discharge line to prevent backflow into the building. Discharge may be to the surface or a soak away pit, if geotechnical conditions, reviewed by a Qualified Professional, permit.

Note that permanent groundwater pumping is not permitted to District storm sewers.