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Technical Memorandum

DATE: January 18, 2021

TO: Jenn Moller, P.Eng., District of West Vancouver

FROM: Laurel Morgan, P.Eng.
Chris Johnston, P.Eng.

RE: **Single-Family Residential Lot Stormwater Management Guidelines**
Our File 409.091-300

1. Introduction

1.1 Purpose of the Guideline

The purpose of this memorandum is to provide the District of West Vancouver (District) with:

- methodology in assessing the impacts from redevelopment of a single-family residential lot;
- design criteria for redevelopment of a single-family residential lot; and
- design guidance for permit application.

This information is intended to be used as a guide to facilitate the submission and evaluation of stormwater management plans for development and redevelopment of single-family residential lots. A professional engineer specializing in stormwater management will be required to seal all calculations and drawings for each lot.

1.2 Application Limitations

This guide is intended for single-family residential development and redevelopment for lots less 2500 m^2. For other land uses, development impacts and stormwater management design are required to be assessed by a Professional Engineer specializing in stormwater or stormwater management using a similar methodology or a different process approved by the District. The *Stormwater Management Criteria for Non-Single-Family Development* can be referenced for other development types.

This guide applies to a majority of the existing single-family lots in West Vancouver where primarily redevelopment is expected to occur. However, in areas of geotechnical concern, a professional geotechnical engineer should be engaged by the applicant to review the feasibility of the proposed infiltration approach for disposal of runoff. Areas of geotechnical concern may include:

- lots close or adjacent to ravines;
- lots with geotechnically significant slopes or where the surface grade will be modified or controlled by retaining walls that require design by a professional geotechnical engineer;
- lots with surficial or near-surface bedrock; and
- lots with defined or potential geohazards such as unstable fills or slopes.

Even in areas of geotechnical concern and where a geotechnical engineer determines that infiltration is not advisable, detention tanks should be used to provide the required level of flow control.

In areas where an Integrated Stormwater Management Plan (ISMP) has been completed, the ISMP will govern over this document in defining the on-lot stormwater management criteria if the ISMP criteria is more stringent than this guideline. This guideline will be a minimum standard for the District.

2. Stormwater Management Requirements

The basic requirements of these guidelines are listed as follows:

1. Prior to carrying out any development and/or redevelopment, [the permit applicant] must submit a stormwater management plan for the site and must obtain the District's written approval of the plan.
2. For any development and/or redevelopment, the stormwater management system must be installed according to the plan and may be inspected by the District prior to the approval of permit.
3. The site stormwater management plan should include:
   - A site plan showing the following:
     - overall site showing property boundaries, lot dimensions and area;
     - location of the District's storm sewer connection;
     - **existing** development including all buildings, patios, walkways, decks, driveways, and other impervious surfaces as well as gardens, lawn areas, and undisturbed forest areas. Areas must be labeled and their footprint area must be calculated in square metres. Existing surfaces should be shown by dashed lines;
     - **proposed** development including all buildings, patios, walkways, decks, driveways, and other impervious surfaces as well as gardens, lawn areas, and undisturbed forest areas. Areas must be labeled and their footprint area must be calculated and noted in square metres;
     - Storage volume required as described in Section 4 complete with dimensions and calculation for storage volume and orifice;
     - proposed drainage facilities including locations of roof leaders, splash pads, storage tanks, rock pits, overflow locations, lawn basins, etc.
     - upslope interception ditches (if applicable) to protect property from surface runoff potentially draining onto site from upslope (Note: interceptor ditches can't be used to intercept groundwater or interflow);
   - Area calculation (square metres) showing the proposed change in connected impervious area.
   - Calculation of volume (cubic metres) and rate of runoff (cubic metres / second) from the **existing** site (excluding natural forested areas).
   - Calculation of volume and rate of runoff from the **proposed** development on the site (excluding natural forested areas).
   - Calculation of storage volume required as shown in Section 4 complete with orifice dimensions and calculation.
   - Description, drawing, and sizing of the stormwater source controls to be used including any tanks, infiltration systems, rain gardens, and permeable pavements.

- If an infiltration facility is proposed for the site, supporting documentation must be submitted including:
  - Infiltration testing in the vicinity of the proposed facility and at the bottom depth of the proposed facility to determine the design infiltration rate used to size the infiltration facility.
  - Confirmation by a qualified geotechnical engineer that the proposed infiltration is appropriate and safe for the site based on the available information if there are any areas of geotechnical concern (see section 1.2).
- A description of the applicable Operations and Maintenance (O&M) requirements for the stormwater management system in accordance with the District's Development Bylaw.
- The submission must include drawings, calculation notes, graphs, and digital spreadsheets, as needed to document the sizing and design of the proposed on-lot stormwater management facilities. The submission shall be sealed by a Profession Engineer registered in B.C. and specializing in stormwater management.

3. Stormwater Management Criteria – Single-Family Development

There are two design criteria required under these guidelines to address the impacts of development and redevelopment of single-family lots: detention storage and volumetric capture. Both criteria are needed because they serve separate goals for stormwater management for the District. Detention storage provides rate control for the protection of downstream infrastructure. Volumetric capture retains a portion of the rainfall onsite by infiltrating it into the ground (or storing and releasing it at very low baseflow-equivalent rates) and provides a reduction in the total flow discharged for protection of fisheries values in the receiving creeks.

Both detention storage and volumetric capture apply to the NEW impervious surfaces proposed in the redevelopment plan, i.e., the incremental increase in impervious cover for the proposed development vs. the existing developed condition. **Should no increase in impervious surfaces be planned, no detention storage or volumetric capture will be required**.

3.1 Detention Storage Criteria

For the redevelopment of single-family residential lots, there shall be no net increase in the rate of stormwater runoff from existing conditions. Under no circumstances shall the runoff exceed existing conditions unless approved by the District. Existing conditions are defined as the state of the land prior to any alterations proposed or undertaken as part of a permit application. Existing conditions include mature forest cover, grass lawn, gardens, and impervious roof and pavement areas.

Development or re-development of a site shall include design to handle any runoff increase above existing conditions during the 10-year return period storm event on-site. Only the natural, forested areas can be excluded from the runoff calculations when they are to remain unchanged from the existing to the proposed development conditions.

All sites for which detention is required shall have a storage facility to assist in attenuating stormwater runoff flows for the 10-year event under four design storm durations including 1-hour, 2-hours, 4-hours and 6-hours. Methodology for sizing of detention storage is provided in Section 4 of this document.

3.2 Volume Capture Criteria

In addition to the detention storage, volumetric capture is required for each site where an increase in impervious area is proposed. This criterion is required to mitigate against increasing erosion in creeks and watercourses caused by increasing impervious surfaces. Volumetric capture also lessens the damage to the aquatic environment and improves water quality along the beaches of the District.

Development or re-development of a site shall include the necessary measures to infiltrate or re-use the first 31 mm of rainfall that falls on the incremental increase in impervious area in a storm event of up to 24 hours duration. Note: If the design engineer prefers to use a continuous simulation water balance methodology, the target of capturing 31 mm of rainfall can also be expressed as capturing 75% of the average annual rainfall amount.

Similar to the detention criterion, this volumetric capture requirement shall apply to the incremental increase in impervious surfaces on the site from the existing condition to the proposed condition. Note that for a previously undeveloped lot, the requirement for capture applies to all new impervious surfaces subject to the exceptions noted below.

Exceptions for volumetric capture:

1. Geotechnical Concerns: In areas of geotechnical concern (see section 1.2, above), a professional geotechnical engineer should be engaged by the applicant to review the applicability of infiltration measures. In these areas, the detention storage requirements may be increased to accommodate a slow release of the capture volume to the storm system. The capture volume may be released at a rate-of-discharge that is equal to the infiltration rate of the native soil times the lot area (see Section 5.1: Slow Release Capture Alternative)
2. Roof Leaders: Currently, the District has a mandatory roof leader connection policy where all roof leaders must be connected to the municipal storm drainage system. Consequently, any increase in roof area must be offset by a decrease in the surface level impervious areas, the use of infiltration / re-use measures, or increased storage and slow-release of runoff.

Section 5 outlines the acceptable analysis measures for volumetric capture.

4. Volume Sizing for Detention Storage

Volume sizing shall be performed using a version of the Rational Method provided in this document, unless the design engineer is well-versed in stormwater hydrologic modelling and prefers to use modelling software for sizing the detention volume. All calculations shall be performed and sealed by the Professional Engineer.

4.1 Rational Method Style Calculation

The volume of runoff for any given time step on smaller residential properties can be calculated using the formula:

Runoff Volume (cubic metres) = C * R /1000 * A **Equation 1**

where:

C = Runoff Coefficient (Table 1 below)
R = Rainfall amount over a time interval (mm)
A = Area (sq. m)

Note that Equation 1 uses rainfall amount in mm, not rainfall intensity.

The runoff coefficients are provided below.

Note: These coefficients differ slightly from those used for the traditional "Rational Method" calculation as they are used to calculate a volume rather than a peak instantaneous flow rate.

Table 1: Runoff Coefficient (C)

Surface	10 Year Runoff Coefficient
Driveway	0.95
Roof	1.0
Patio / Deck / Walkway / Artificial Turf[1] Areas	0.95
Lawn (existing development)	0.65
Proposed Lawn (400 mm Topsoil)	0.3
Proposed Gardens (400+ mm Topsoil)	0.3
Pervious Paving	0.5
Natural Woodlands/Mature Forest	0.2

Selection of runoff coefficients for each surface must be clearly identified.

Multiple surfaces can be added together by performing the above equation for each surface then adding together to summarize the entire lot area (including undeveloped areas, but excluding any natural forest that will remain unchanged).

By applying the above Rational Method Style formula (Equation 1) for each rainfall time step, a runoff hydrograph can be created for both the existing development scenario and the redeveloped scenario.

Note: the above equation should only be used for single-family residential sites less than 2,500 sq.m. in size. The equation will overestimate runoff volume on larger sites.

4.2 Rainfall and Elevation Correction

Rainfall amounts for the runoff calculations are provided in the attached Table 2. These depths are derived from a rainfall Intensity-Duration-Frequency (IDF) curve for Metro Vancouver's District of West Vancouver Municipal Hall (VW14) rain gauge. Table 2 is valid for site elevations of less than 100 m geodetic elevation within the District of West Vancouver.

Table 2 lists rainfall amounts for design storms ranging from 1-hour to 6-hours.

[1] If the subgrade is unduly compacted, there is an impervious liner, or there is a hard surface below the artificial turf, then the area must be treated as an impervious patio area rather than as a permeable area. Artificial turf may be used in a similar manner to pervious paving if and only if it is installed with the same care and consideration to ensure that the subgrade below the installation is permeable and allows natural levels of infiltration into the subgrade soil.

For higher elevations, an elevation correction factor shall be applied to adjust the rainfall depth to reflect actual conditions. For single-family residential lots located at elevations ranging from 100 m to 400 m, a factor of 1.45 shall be applied to the rainfall depths. For higher elevations ranging from 401 m to 950 m, a factor of 1.9 shall be applied to the rainfall depths in Table 2.

4.3 Determination of Detention Storage Volume Required

The Rational Method described above shall be used in calculating the storage volume required to detain excess runoff from the proposed development. Excess runoff is defined as the additional peak flow that would be flowing from the site in development or redevelopment conditions that exceeds the peak flow from the site under existing conditions.

To do this, a detention spreadsheet should be created that calculates the amount of runoff leaving the site in both existing conditions and proposed development conditions, and takes the difference between the two conditions. Only the natural, forested areas can be excluded from the runoff calculations in both the existing and proposed development calculations. The calculations will be performed using a time step approach whereby the flow leaving the site is calculated in 5-minute time steps.

Note: This methodology is NOT the "Modified Rational Method" found in textbooks and other guidance and the "Modified Rational Method" is not acceptable as a substitute for sizing the required detention storage volume.

The calculation approach requires the following steps to be carried out:

- Calculate the volume released in each 5-minute time step by using Equation 1 to calculate runoff volume for the rainfall amounts provided in Table 2 (see attached table).
    - This calculation should be done for the 6-hour storm duration for the existing development scenario, which is the target release rate for the site.
    - This calculation should be done for each of the storm durations in Table 2 from the 1-hour to the 6-hour for the proposed development scenario.
- Size an orifice and detention tank volume that limits the release rate in each of the 4 storm durations in the proposed development condition to no more than the 6-hour peak runoff rate in the existing development condition.
    - The calculated orifice flow should be within 10% of the target release rate for the site.
    - The orifice size should be determined by matching the flow through the orifice to the target existing development release rate when the water level is at the maximum head (H_{max}) in the storage unit.
    - The release rate of the 10-year, 6-hour storm can not exceed 31.8 L/s/ha under any circumstances.
    - To determine tank sizing, a spreadsheet should be used to calculate the water level in the tank during the storm event. Five minute time intervals corresponding to the rainfall time series should be used to calculate the water level in the tank.
    - An iterative process should be used to determine the optimum tank size by assuming a tank footprint and height and calculating the maximum water level, and then doing the calculation again using the calculated tank sizing until the process does not generate a different tank size.

   - The maximum tank size calculated for the 1-hour, 2-hour, 4-hour, or 6-hour event shall be the design tank size for the proposed development.
- If runoff from parts of the lot cannot be directed to the detention storage tank, it is acceptable to include a bypass flow for this amount in the calculation of a release rate, providing:
   - The combined orifice flow from the storage tank and bypass flow from the remainder of the site cannot exceed the 6-hour existing development discharge flow for the site.

In other words, the release rate from the storage tank through the orifice will be lower than the target release rate from the site.

This approach as outlined above will provide the tank and orifice size.

Detention is sized by this method for the incremental increase in impervious, however, the calculations for existing development and post-development conditions will be performed on the entire site (excluding only forested area that will remain unchanged) NOT the incremental difference in impervious area.

Figure 1 provides an example of what the results of this calculation process should look like for the 1-hour storm.

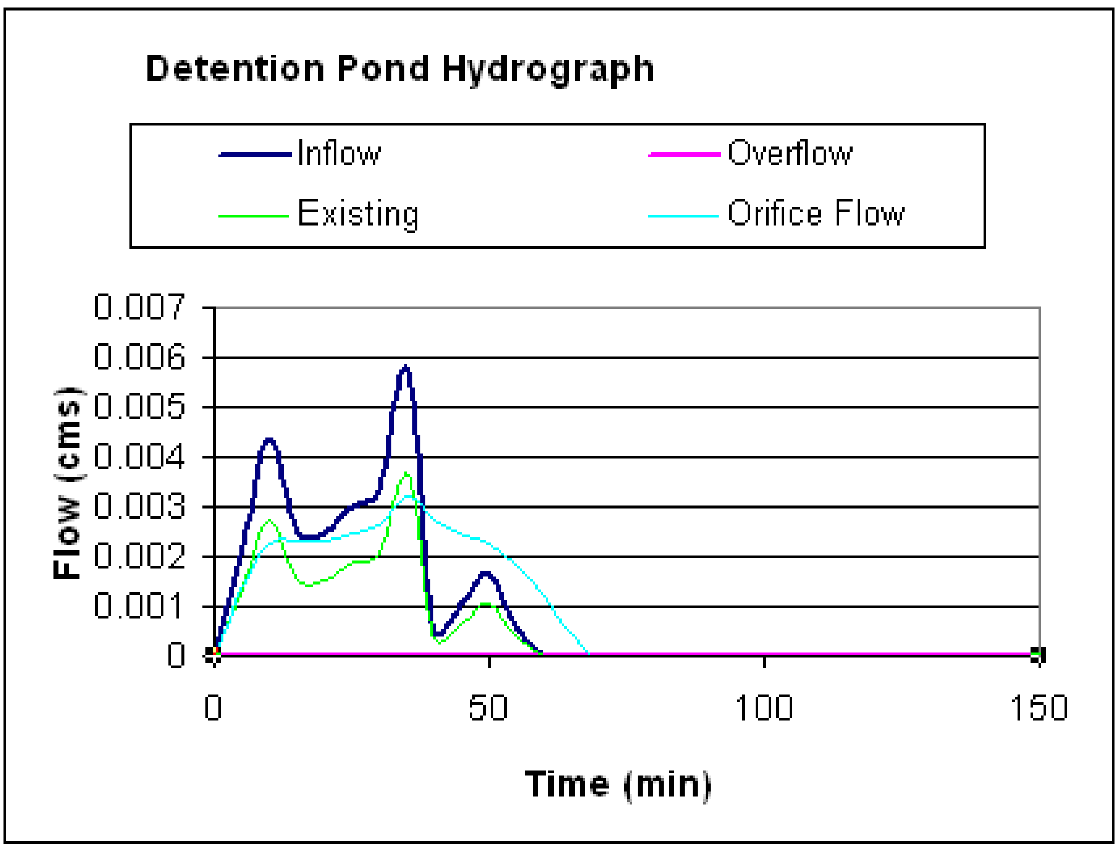

Figure 1: Example of detention pond hydrograph for 10-yr 1-hr storm

4.4 Orifice Outlet to Control Storage Release Rate

The Professional Engineer shall ensure that outlet flow from the storage facility is controlled to not exceed existing runoff conditions by designing and sizing an orifice outlet to control outflows.

A release rate using an orifice can be calculated using the standard orifice equation as follows:

Release Rate (cms) = 0.6 x Orifice Area (sq.m.) x (19.62 x H (m))$^{0.5}$ **Equation 2**

where:

H = the height of water above the orifice centreline

The minimum size of an orifice will be 10 mm for the detention tank. Actual size will be determined based on an iterative process using the above calculations.

The easiest way to perform the above set of calculations is within a spreadsheet. As noted above, the calculation to size the orifice should assume the maximum head/water level in the tank.

The orifice shall be designed to be protected in such a way as to avoid plugging by floatables and other materials, e.g. by a wire basket that covers and holds debris away from the orifice. An access hatch shall be provided to clean out any debris and check and maintain the orifice.

4.5 Storage Facilities

The Design Engineer shall select one storage facility (i.e., tank) that can detain stormwater on-site and limit runoff flows to not exceed existing conditions, using the methodology described above.

The Design Engineer must ensure all stormwater captured on site drains into the storage facility, or that bypass flows are accounted for in the sizing of the orifice and detention storage tank.

The storage facility will have an overflow outlet connected to the District's storm sewer or drainage system. The maximum hydraulic grade line (HGL) of the storage facility will be noted on the drawings along with the minimum building elevation. The minimum building elevation must be above the maximum HGL of the storage facility in order for the system to provide drainage by gravity only.

4.6 Pumping for Downslope Lots

For lots located downslope from the road and below the municipal storm drainage service line to which the lot will be connected, the proposed development will typically require a pump to lift the water up to the road and storm drainage service. If the grades allow, it is preferred to locate the pump upstream of the detention storage tank so that the tank drains by gravity to the municipal storm drainage service line and regulates the flow from the lot.

If it is not possible to achieve gravity drainage from the detention storage tank to the municipal storm service, then the pump may be located downstream of the stormwater detention tank, in a separate sump. The pump will have a higher rate of flow than the tank orifice outlet; it will cycle on and off and only be able to pump the volume of flow that is released from the detention storage tank.

4.7 Perimeter Drains

The sizing for the detention storage facility does not incorporate flow from the foundation perimeter drains. Perimeter drains shall not be connected to the storage facility. The surface collection system shall not be connected to the building footing drain system upstream of the storage facility as this could cause backflow into the perimeter drain system from the surface collection system. Flows from perimeter drains should be connected to the lot's storm service line downstream of the storage facility.

5. Analysis and Methods to Meet Volumetric Capture Criteria

This section provides the background information available to guide the design of the measures required to meet the volumetric capture criteria. The designer is also referred to the supporting documentation: Metro Vancouver Stormwater Source Control Guidelines 2012. Together, these documents form the requirements for achieving the volumetric capture criteria.

5.1 Sizing Methods to Meet Volumetric Capture Criteria

As noted in section 3.2, development or re-development of a site shall include the necessary measures to retain on site the first 31 mm of rain that falls on the incremental increase in impervious surface area on the site from the existing condition to the proposed condition. For example, if the impervious coverage on the lot is proposed to increase by 30 m^2, 31 mm on 30 m^2 or 0.93 m^3 should be captured and infiltrated into the ground.

Note that for a previously undeveloped lot, the requirement for capture applies to ALL new impervious surfaces (except where noted in Section 3.2).

The Stormwater Source Control Guidelines 2012 provides specifications, design details, and sizing criteria for the main capture measures proposed: Pervious Paving, Infiltration Trench and Soakaway, Infiltration Swale System, and Absorbent Landscape.

Sizing for each of the capture measures is proposed as follows:

- **Pervious Paving:** Pervious Paving surfaces shall include a 0.3 m deep rock trench below the sand layer. See Figure 2 for additional design considerations; note that while the figure shows the base of the rock trench as flat, permeable paving can be used on slopes, subject to manufacturers' instructions. If interlocking concrete pavers are used, they must be designed and installed with aggregate-filled openings between solid high-strength durable concrete pavers[2]. The pavers must be consistent with the requirements of CSA231.1:2019 (or current standard) and must be installed according to the manufacturers' instructions and achieve a minimum surface infiltration rate of 100 mm/hr. Individual manufacturers' guidance should be used to determine appropriate slopes for use and methods of installation.
- **Infiltration Trench (Rock Trench/Pits) or Chamber:** Infiltration trenches shall be maximum 1.5 m deep and the ratio of contributing impervious area to trench footprint area shall not exceed 20:1. Infiltration trenches may include an orifice sized to release water at 0.25 L/s/ha of contributing area. See Figure 3 for additional design considerations. Alternatively, an open infiltration chamber using a Brentwood-type modular system is also acceptable, provided the chamber has at most 0.5 m depth of

[2] More information is available from the Interlocking Concrete Paver Institute at: https://www.icpi.org/paving-systems/permeable-pavers

storage. Flow from contributing areas should first run overland or through a sump prior to entering the infiltration facility.

- **Rain Gardens:** Rain gardens shall have rock trenches that are no more than 1.5 m deep and the ratio of contributing impervious area to rain garden storage trench footprint area shall not exceed 20:1. Rain gardens may include an orifice sized to release water at 0.25 L/s/ha of contributing area. See Figure 4 for additional design considerations. Flow from contributing areas should first run overland prior to entering the rain garden if possible.

- **Absorbent Landscape:** Absorbent landscape shall consist of 400 mm of topsoil (growing medium), and be terraced to less than 2% slope. No additional sizing is required. Re-direction of runoff from impervious surfaces to absorbent landscaping can be used to achieve the capture target for the re-directed impervious area provided the ratio of impervious surface to receiving absorbent landscape area does not exceed 2:1. A lawn basin must be installed at a downslope location to intercept any sheet flow prior to discharge on neighbouring lots. The lawn basin shall be connected to the storage facility.

No surface runoff shall be allowed to flow on to neighbouring properties. All surface runoff must be intercepted. As well, all trenches, rock pits, and other underground conduits must be appropriately sealed to prevent uncontrolled groundwater or interflow from leaving the subject property at rates greater than pre-developed rates. This can be accomplished through the use of low-permeability trench dams.

Slow-Release Capture Alternative

In areas where infiltration facilities such as infiltration trenches and rain gardens are not allowed due to geotechnical concerns, the volumetric capture criterion may be met via storage of the capture volume in a tank and release at a baseflow-equivalent rate of 0.25 L/s/ha. This release rate will be lower than the release rate for the detention storage and a separate orifice will be required. The slow-release capture volume must be stored below the detention volume (i.e., below the elevation of the detention volume orifice). This means that the slow-release orifice will also be constructed below the detention volume orifice.

5.2 Absorbent Landscape

All cleared and landscaped areas not covered with hard surfaces shall have a minimum of 400 mm of topsoil and will be terraced as much as possible to maintain vegetated areas of 2% slope or flatter.

Topsoil may be an existing growing medium that was removed during construction, stockpiled, and replaced on the site, or it may be imported topsoil. Where topsoil is imported, it must be shown to meet appropriate landscape standards for organic content (see MMCD “Properties for growing medium”), and the other requirements contained in the “Absorbent Landscape” section of the *Stormwater Source Control Guidelines 2012*. Existing and imported topsoil must have a minimum of 3.5 mm/hr infiltration rate.

Where disconnected impervious surfaces are directed to absorbent landscaping, the ratio of impervious surface area to absorbent landscaping area may not exceed 2 (i.e., a maximum ratio of 2:1).

5.3 Forest Areas

The Design Engineer shall make every effort to limit the reduction of forest cover as much as possible. Tree canopies of mature, existing forest trees are valuable for stormwater management on any site. For the purposes of this guideline, it is assumed that natural forested areas meet the volumetric capture target and no further action is required.

Forested areas cannot be used as treatment measures for re-directed impervious areas.

5.4 Driveways and Patios

If the existing driveway will remain intact and will not be modified in any way, no new measures are required. However, if the driveway surface is increased or the surface is re-constructed, the volumetric capture criterion will apply to the increased impervious area. Volumetric capture methods for driveways could include:

1. Re-direction of runoff to adjacent absorbent landscaping consistent with the requirements for absorbent landscaping, above,
2. Construction of the driveway using pervious paving techniques, such as permeable pavers, permeable concrete, or permeable asphalt,
3. Capture of runoff and direction of flow to a sump for settling and cleanout of sediment and debris followed by an infiltration trench, or
4. Where infiltration is not allowed due to the presence of near-surface bedrock or geotechnical hazard, the driveway runoff may be collected and directed to a sump for settling of sediment and then discharge to a slow-release tank.

Note that the above options are listed in order of preference for water quality treatment of driveway runoff to remove pollutants prior to the runoff entering either an infiltration system or the municipal storm drainage system.

Patios, walkways, and other on-lot impervious surfaces should be sloped to drain to adjacent absorbent landscape areas wherever possible. For large patio areas, a rain garden could be used to provide storage and infiltration of runoff from a patio in a smaller footprint area than absorbent landscaping. If the runoff from patio and walkway areas cannot be directed to adjacent landscaping or a rain garden, then options 2 through 4 listed above for driveways may be used.

5.5 Roof Leaders

Currently, the District requires that all roof leaders must be directly connected to the municipal storm sewer system. This means that the roof leaders be directly tied to the proposed storage tank and roof runoff cannot be distributed at the surface to be infiltrated into the ground. In order to meet the volume capture target, any increase in roof area must be offset by the reduction or disconnection of ground surface impervious area or the use of the “slow-release capture alternative”.

5.6 Infiltration Trenches and Rain Gardens

Direct connection of any ground level impervious surfaces to infiltration trenches (rock pits) and rain gardens is prohibited. Water entering an infiltration trench or rain garden from ground level impervious surfaces must first flow overland through pervious vegetation (minimum travel length 4.0 m).

Infiltration trenches and rain gardens shall be designed with the following features:

- A minimum 600 mm diameter sump c/w 500 mm (minimum) sediment trap and floatables protection must be installed upstream of the infiltration trench. Floatables protection shall be accomplished using a 150 mm diameter tee on the outlet connection.
- A perforated drain shall be installed at the top of the rock layer below the growing medium and must be connected directly to the storage facility;
- The base of the rock layer cannot be more than 2 m below the ground surface;
- Appropriate filter fabric shall be used on the top of the infiltration trench to prevent migration of fines from the topsoil layer (growing medium) to voids in the rock material; and,
- Infiltration testing of native sub-surface soil conditions should be carried out in the area of the proposed infiltration trench. **Under no circumstances will an infiltration trench or rain garden be designed to exfiltrate more than 3.5 mm/hr.** Infiltration trenches and rain gardens must be constructed in native material and cannot be bisected by utility trenches or highly permeable soils. In cases where this cannot be avoided, trench dams comprised of low permeability material can be used to prevent the trench from exfiltration at rates greater than 3.5 mm/hour.

In some cases, blasting of the bedrock may be required to allow for the construction of the storage layer. Raising the ground elevation with imported fill is also acceptable provided that the fill material does not allow the infiltration to exceed 3.5 mm/hr. This will require a lower permeability fill material.

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Reviewed by:

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Attach. : Table 2: Rainfall Amounts
Figure 2 – 4

Statement of Limitations

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision Description	Author
0	January 18, 2021	Final	Issued as final for client copy.	LM

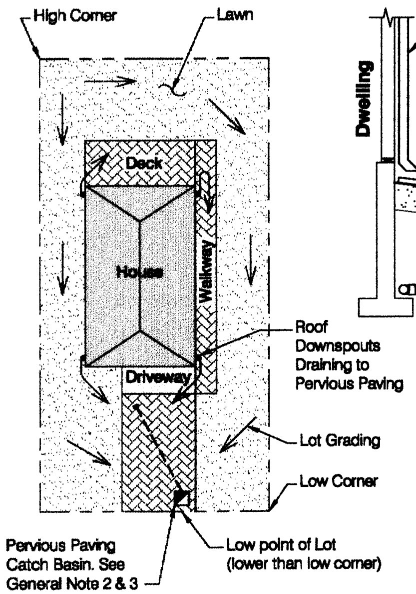
OQM CERTIFIED

Table 2:Rainfall Amounts

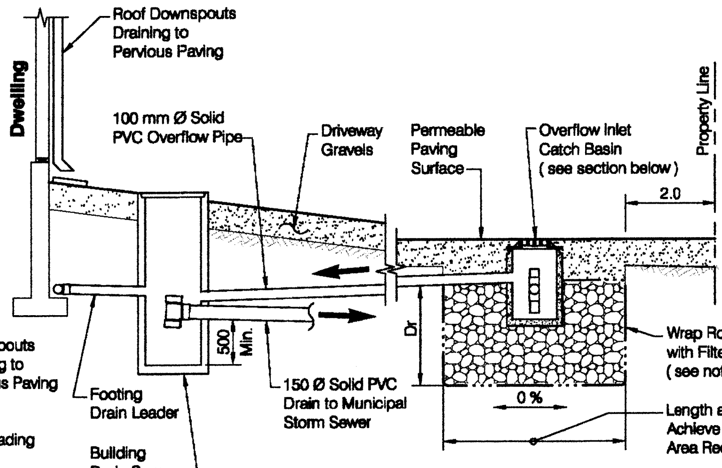
Time (minutes)	Rain (mm)			
	10-yr 1-hr	10-yr 2-hr	10-yr 4-hr	10-yr 6-hr
0	0.00	0.00	0.00	0.00
5	1.53	0.00	0.00	0.00
10	3.06	1.11	0.00	0.00
15	1.72	1.11	0.00	0.00
20	1.72	2.21	0.72	0.00
25	2.10	2.21	0.72	0.00
30	2.29	1.24	0.72	0.50
35	4.01	1.24	0.72	0.50
40	0.38	1.24	1.44	0.50
45	0.76	1.24	1.44	0.50
50	1.15	1.52	1.44	0.50
55	0.38	1.52	1.44	0.50
60	0.00	1.66	0.81	0.58
65	0.00	1.66	0.81	0.58
70		2.90	0.81	0.58
75		2.90	0.81	0.58
80		0.28	0.81	0.58
85		0.28	0.81	0.58
90		0.55	0.81	0.83
95		0.55	0.81	0.83
100		0.83	0.99	0.83
105		0.83	0.99	0.83
110		0.28	0.99	0.83
115		0.28	0.99	0.83
120		0.00	1.08	0.41
125			1.08	0.41
130			1.08	0.41
135			1.08	0.41
140			1.89	0.41
145			1.89	0.41
150			1.89	0.58
155			1.89	0.58
160			0.18	0.58

Time (minutes)	Rain (mm)			
	10-yr 1-hr	10-yr 2-hr	10-yr 4-hr	10-yr 6-hr
165			0.18	0.58
170			0.18	0.58
175			0.18	0.58
180			0.36	1.16
185			0.36	1.16
190			0.36	1.16
195			0.36	1.16
200			0.54	1.16
205			0.54	1.16
210			0.54	0.74
215			0.54	0.74
220			0.18	0.74
225			0.18	0.74
230			0.18	0.74
235			0.18	0.74
240			0.00	0.83
245				0.83
250				0.83
255				0.83
260				0.83
265				0.83
270				0.74
275				0.74
280				0.74
285				0.74
290				0.74
295				0.74
300				0.74
305				0.74
310				0.74
315				0.74
320				0.74
325				0.74

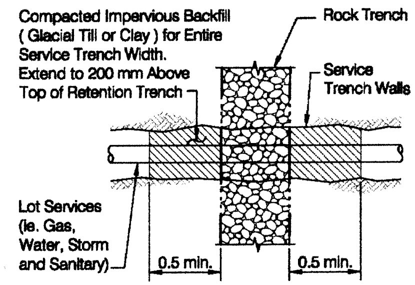
Time (minutes)	Rain (mm)			
	10-yr 1-hr	10-yr 2-hr	10-yr 4-hr	10-yr 6-hr
330				0.58
335				0.58
340				0.58
345				0.58
350				0.58
355				0.58
360				0.58
365				0.58
370				0.58
375				0.58
380				0.58
385				0.58
390				0.00



Drainage Schematic Example

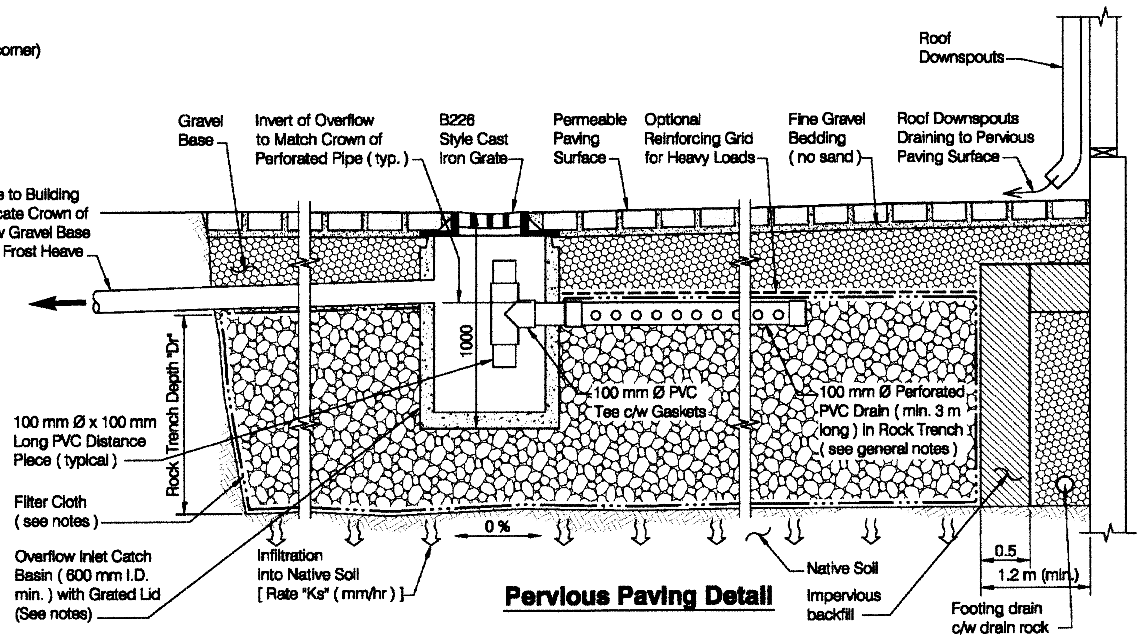


Drainage Schematic Section



Typical Service Trench Crossing Through Rock Trench Detail

(If Required)



Pervious Paving Detail

Land Use	Native Soil Type	
	Poorly Draining 1 mm/hr (Dr = 300 mm)	Well Draining ≥ 10 mm/hr (Dr = 2000 mm)
Single Family Residential (550 m² Lot)	Ar = 1.0 x R	Ar = 0.14 x R
Duplex (750 m² Lot)	Ar = 1.5 x R	Ar = 0.21 x R
Triplex (930 m² Lot)	Ar = 2.2 x R	Ar = 0.30 x R

Metro Vancouver
Region Wide Baseline For
Onsite Rainwater Management

Pervious Paving Areas:

1. Scarify the native soil so that the surface is loose and friable.
2. Install filter fabric and place rock trench stone. Wrap filter fabric overtop rock and overlap by 600 mm minimum.
3. Place backfill over filter fabric.

Pervious Paving Notes:

1. Pervious paving depth shall be calculated based on the following equation:
   Dr = Ks x 24 x 4 / n (min. 300 mm, max. 2000 mm).
   where
   Dr = rock trench depth (mm)
   Ks = infiltration rate into native soil (mm/hr)
   n = porosity of rock trench (unitless, e.g. 0.35)
2. Pervious paving area required shall be calculated based on the following equation:
   $$App = \frac{0.4 \times R \times Ai}{Dr \times n + 24 \times Ks}$$
   where
   App = pervious paving area (m²)
   R = 2-year 24-hour rainfall depth (mm)
   Ai = Impervious area of lot including paver area (m²)
   The pervious paving area "App" is the amount of impervious paving on the lot that needs to be converted to pervious paving.
3. Filter cloth Amoco 4545. Provide 600 mm minimum overlap at all joints.

General Notes:

1. Solid and perforated pipe to be CSA B182.1 or as indicated on drawings. Grade piping at minimum 1% slope.
2. Lawn basin, drainage sump and grate as supplied by Langley Concrete or approved equal.
3. Supply 600 mm x 1000 mm deep catch basin barrels and B226 frame and grate for driveway installation as supplied by Langley Concrete or approved equal.

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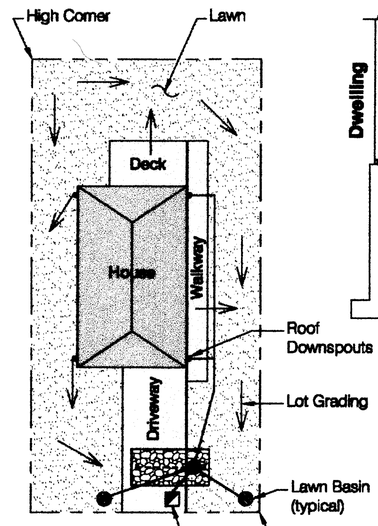
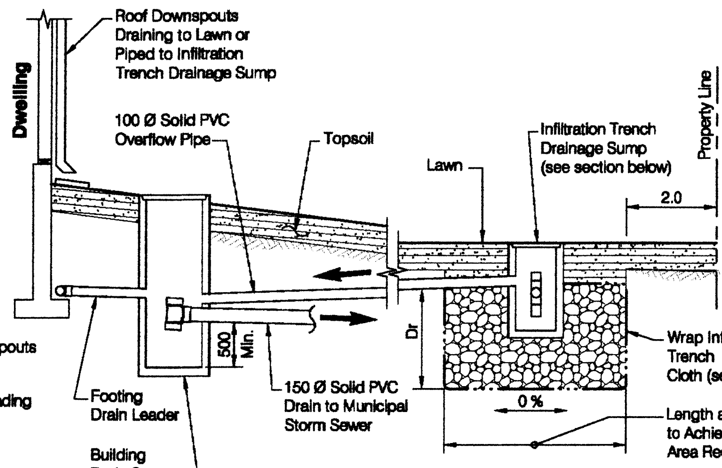
Pervious Paving

Figure 2

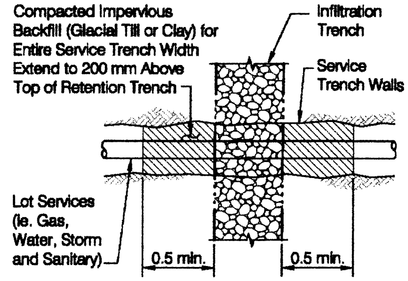
Metro Vancouver
Region Wide Baseline For
Onsite Rainwater Management



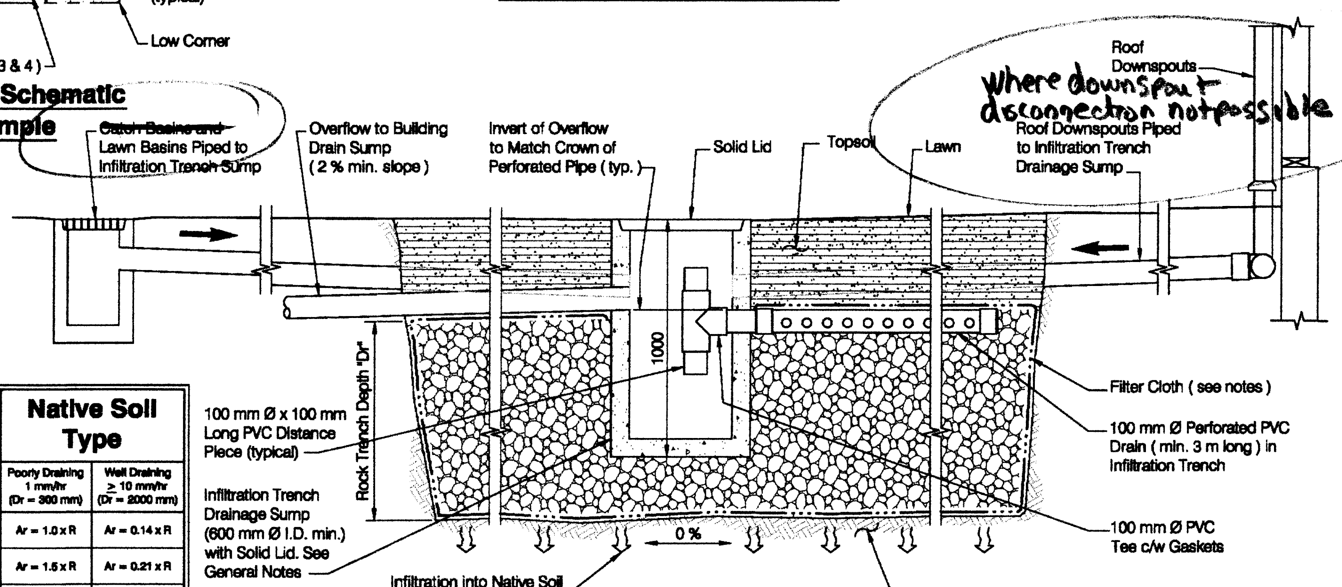
Drainage Schematic Example



Drainage Schematic Section



Typical Service Trench Crossing Through Infiltration Trench Detail
(If Required)



Infiltration Trench Detail

Land Use	Native Soil Type: Poorly Draining 1 mm/hr (Dr = 300 mm)	Native Soil Type: Well Draining ≥ 10 mm/hr (Dr = 2000 mm)
Single Family Residential (550 m² Lot)	Ar = 1.0 x R	Ar = 0.14 x R
Duplex (760 m² Lot)	Ar = 1.5 x R	Ar = 0.21 x R
Triplex (930 m² Lot)	Ar = 2.2 x R	Ar = 0.30 x R

Infiltration Trench Areas:

1. Scarify the native soil so that the surface is loose and friable.
2. Install filter fabric and place rock trench stone. Wrap filter fabric overtop rock and overlap by 600 mm minimum.
3. Place backfill over filter fabric.

Infiltration Trench Notes:

1. Infiltration Trench Depth shall be calculated based on the following equation:
   $Dr = Ks \times 24 \times 4 / n$ (min. 300 mm, max. 2000 mm).
   where
   Dr = rock trench depth (mm)
   Ks = infiltration rate into native soil (mm/hr)
   n = porosity of rock trench (unitless, e.g. 0.35)
2. Infiltration Trench footprint shall be calculated based on the following equation:
   $$Ar = \frac{0.4 \times R \times Al}{Dr \times n + 24 \times Ks}$$
   where
   Ar = infiltration trench bottom area (m²)
   R = 2-year 24-hour rainfall depth (mm)
   Al = impervious area of lot (m²)
3. Filter cloth Amoco 4545. Provide 600 mm minimum overlap at all joints.
4. Infiltration Trench 75 mm dia. to 150 mm dia. round stone (or as approved by engineer). Minimum porosity = 0.35.
5. Two separate trenches in Duplex and three trenches in Triplex are acceptable and the total footprint area of the multiple trenches shall equal the above calculated "Ar".

General Notes:

1. Solid and perforated pipe to be CSA B182.1 or as indicated on drawings. Grade piping at minimum 1% slope.
2. Lawn basin, drainage sump and grate as supplied by Langley Concrete or approved equal.
3. Driveway Catch Basin required if driveway cannot be sloped toward Lawn Basin.
4. Supply 600 mm x 1000 mm deep catch basin barrels and B226 frame and grate for driveway installation as supplied by Langley Concrete or approved equal.

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Infiltration Trench

Figure 3

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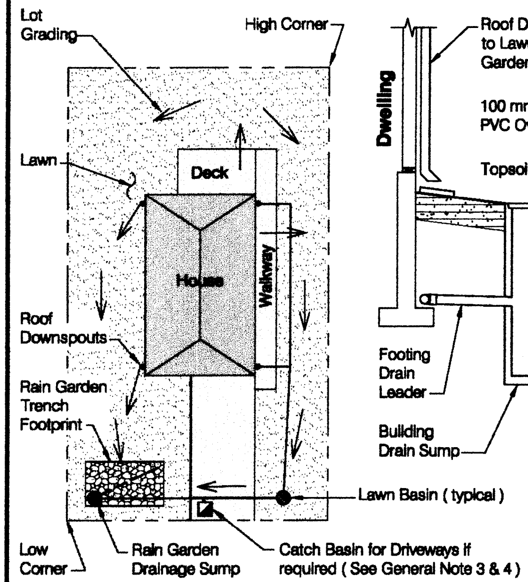
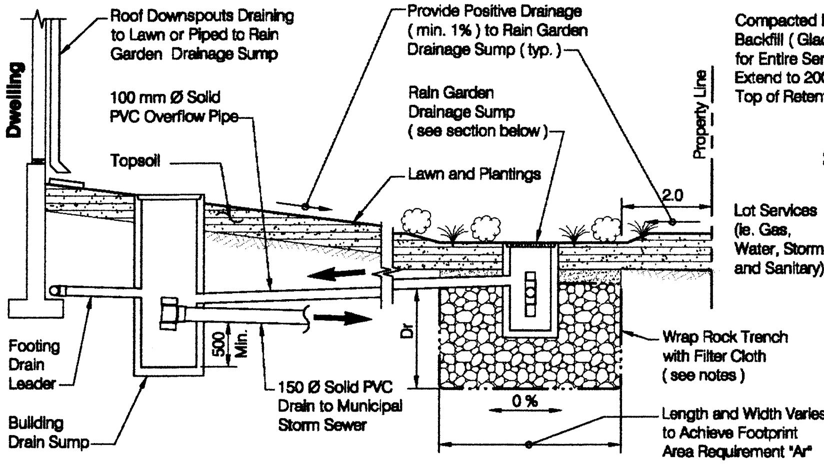
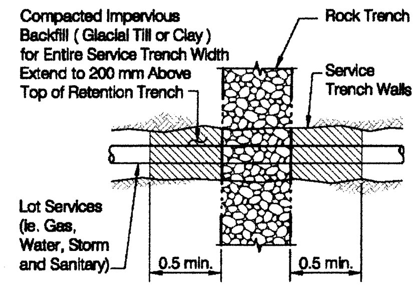


Example Drainage Schematic

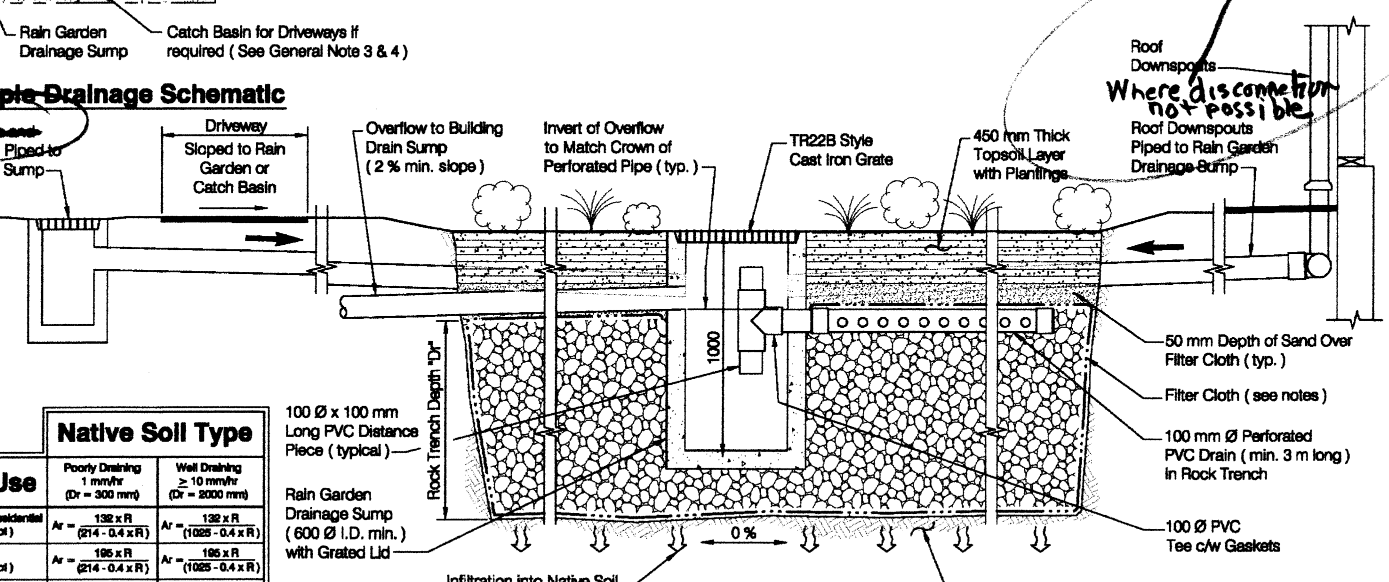


Drainage Schematic Section



Typical Service Trench Crossing Through Rock Trench Detail

(If Required)



Rain Garden Detail

Land Use	Native Soil Type: Poorly Draining 1 mm/hr (Dr = 300 mm)	Native Soil Type: Well Draining ≥ 10 mm/hr (Dr = 2000 mm)
Single Family Residential (550 m² Lot)	$Ar = \frac{132 \times R}{(214 - 0.4 \times R)}$	$Ar = \frac{132 \times R}{(1025 - 0.4 \times R)}$
Duplex (750 m² Lot)	$Ar = \frac{195 \times R}{(214 - 0.4 \times R)}$	$Ar = \frac{195 \times R}{(1025 - 0.4 \times R)}$
Triplex (930 m² Lot)	$Ar = \frac{279 \times R}{(214 - 0.4 \times R)}$	$Ar = \frac{279 \times R}{(1025 - 0.4 \times R)}$

Metro Vancouver Region Wide Baseline For Onsite Rainwater Management

Rain Garden Areas:

1. Scarify the native soil under rock trench so that the surface is loose and friable.
2. Install filter fabric and place rock trench stone. Wrap filter fabric overtop rock and overlap by 600 mm min
3. Place 50 mm of clean river pump sand over filter fabric. If left for more than a few hours, this material must be scarified prior to placing topsoil. Use a hard tyne rake to scarify the top 25 mm of sand, or until the surface is loose and friable.
4. Immediately after scarification, place 450 mm depth topsoil. Compact just to be firm against deep footprinting. Do not over compact. If the topsoil is left exposed to the elements for more than a few hours, the surface will require scarification prior to seeding or planting.
5. Plant to municipal landscape requirements.

Rock Trench Notes:

1. Rock trench depth shall be calculated based on the following equation:
   Dr = Ks x 24 x 4 / n (min. 300 mm, max. 2000 mm).
   where
   Dr = rock trench depth (mm)
   Ks = infiltration rate into native soil (mm/hr)
   n = porosity of rock trench (unitless, e.g. 0.35)
2. Rock Trench footprint shall be calculated based on the following equation:
   $$Ar = \frac{0.4 \times R \times Al}{(Dr \times n + 24 \times Ks + 0.19 \times 450 - 0.4 \times R)}$$
   where
   Ar = Rock trench bottom area (m²)
   R = 2-year 24-hour rainfall depth (mm)
   Al = Impervious area of lot (m²)
3. Filter cloth Amoco 4545. Provide 600 mm minimum overlap at all joints.
4. Infiltration Trench 75 mm dia. to 150 mm dia. round stone (or as approved by engineer). Minimum porosity = 0.35.
5. Two separate rain gardens in Duplex and three rain gardens in Triplex are acceptable and the total footprint area of the multiple trenches shall equal the above calculated "Ar".

General Notes:

1. Solid and perforated pipe to be CSA B182.1 or as indicated on drawings. Grade piping at minimum 1% slope.
2. Lawn basin, drainage sump and grate as supplied by Langley Concrete or approved equal.
3. Driveway catch basins required if driveway cannot be sloped toward lawn basin.
4. Supply 600 mm x 1000 mm deep catch basin barrels and B226 frame and grate for driveway installation as supplied by Langley Concrete or approved equal.

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Rain Garden

Figure 4

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