Builder Guide to Site and Foundation Drainage

Best Practices for Part 9 Buildings in British Columbia

BC HOUSING
RESEARCH CENTRE

This guide was funded and commissioned by BC Housing, and was prepared by Horizon Engineering Inc. with assistance from RDH Building Science Inc. Acknowledgment is extended to all those who participated in this project as part of the project team or as external reviewers.

Authors

Karen Savage, P. Eng. and Diane Meehan, EIT – Horizon Engineering | Graham Finch, P. Eng and James Higgins, AScT – RDH Building Science

External Reviewers and Contributors

Don Pedde, Jun'ichi Jensen, Tommy Dang, Scott Williams – BC Building and Safety Standards Branch

Harshan Radhakrishnan – Engineers and Geoscientists BC

Barbara Robinson – Norton Engineering

Ralph Moore – Aviva Canada

Charles Mougeot – Natural Resources Canada

City of Surrey, City of Vancouver, District of North Vancouver, City of North Vancouver

Disclaimer

This guide is provided for general information only, except where noted. The greatest care has been taken to confirm the accuracy of the information contained herein; however, the authors, funders, publisher, and other contributors assume no liability for any damage, injury, loss, or expense that may be incurred or suffered as a result of the use of this publication for any application, including products, building techniques, or practices. The views expressed herein do not necessarily represent the views of any individual contributor or of BC Housing.

Building products and construction practices change and improve over time, and it is advisable to regularly consult up-to-date technical publications rather than relying solely on this publication. It is also advisable to seek specific information regarding a particular site, on the use of products, as well as the requirements of good design and construction practices, the requirements of the governing authority having jurisdiction (AHJ), and the requirements of the applicable building codes before undertaking a construction project. Consult the manufacturer's instructions for construction products, speak with and retain consultants with appropriate engineering or architectural qualifications, and consult with the governing AHJ and other authorities regarding issues of design and construction practices. Many provisions of the BC Building Code 2018 have been specifically referenced (Division B, unless noted otherwise), but use of the guide does not guarantee compliance with any Code requirements. The Vancouver Building Bylaw 2019 has not been specifically referenced but is assumed to align with the BC Building Code in most areas. The use of systems not covered by this guide does not necessarily preclude compliance. The materials and colours shown as examples in the guide are not intended to represent any specific brands or products, and it is acknowledged that many product options exist.

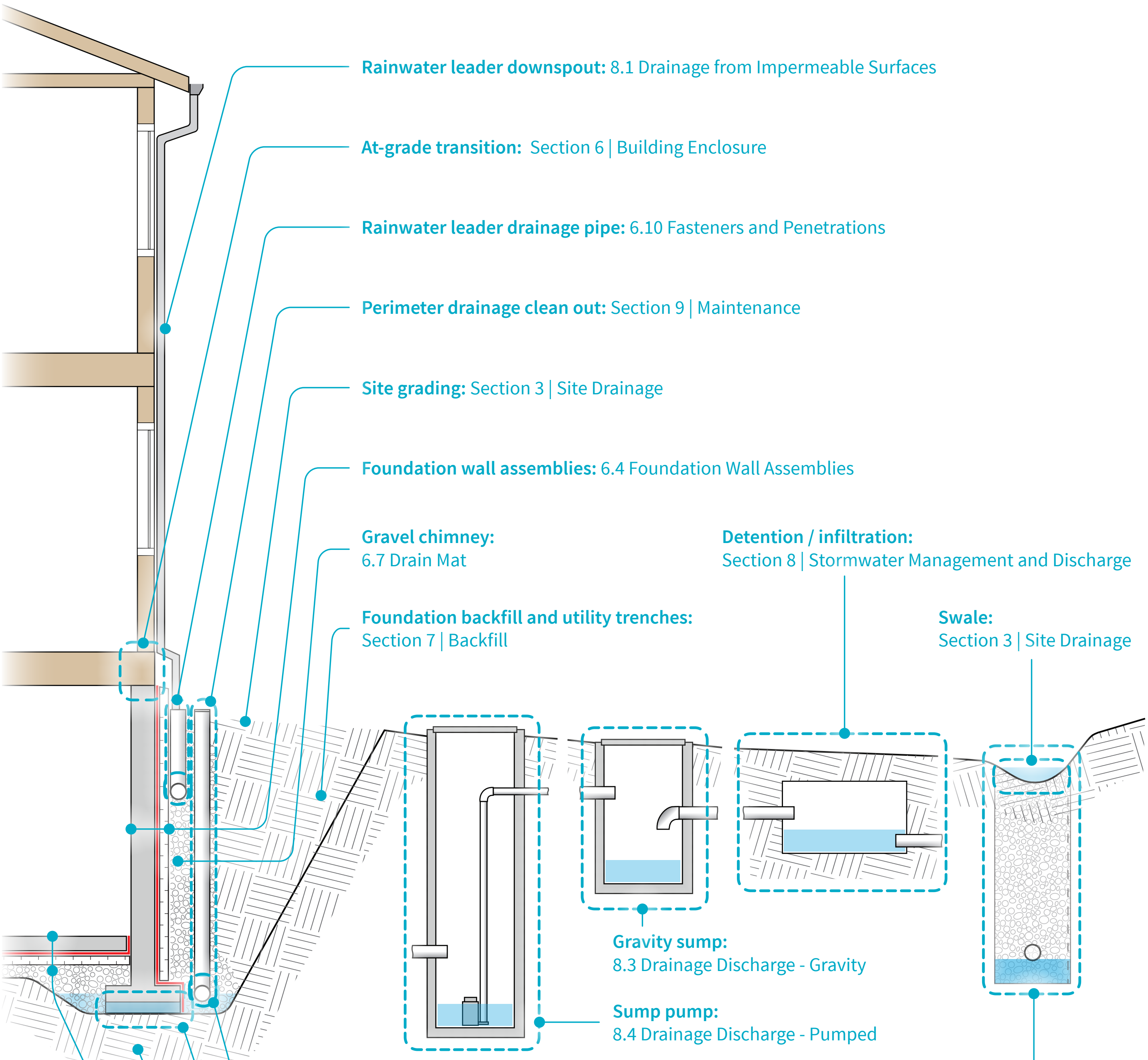
BRITISH COLUMBIA

BC HOUSING
RESEARCH CENTRE

BC Housing
1701 - 4555 Kingsway
Burnaby, British Columbia V5H 4V8

Contents

Wayfinder (Section View)



1 | Introduction

This guide has been prepared to:

- Educate home owners, designers, builders, and building officials on best practices for site and foundation drainage and building enclosure systems for single-family and townhouse residences, and facilitate communication between these parties.
- Serve as a reference tool for Part 9 buildings in conjunction with the 2018 British Columbia Building Code (BCBC), 2018 *BC Plumbing Code*, and the 2019 Vancouver Building By-Law (VBBL) (i.e., the "Codes").
- Provide clarity and guidance where the Codes are vague or silent.
- Present current best practices according to industry design professionals.
- Emphasize some basic Building Code requirements.

About this Guide

This guide was driven by a common experience of various warranty providers encountering foundation drainage and leakage problems with building projects, which may have been avoided had best practices been incorporated into the design and construction. Designers, builders, and building officials alike can benefit from a well-rounded understanding of the design and construction considerations for above- and below-grade site drainage and building enclosure systems.

While the BC Building Code, BC Plumbing Code, and the Vancouver Building By-law serve as a starting point for understanding the minimum requirements of below-grade systems, the actual best practice for the design and construction of these systems may go beyond what is outlined therein. In addition, these publications do not always adequately address every aspect of below-grade work.

This guide focuses on three key considerations: site drainage, foundation drainage, and building enclosure. A discussion of some post-construction remedial measures (i.e. for existing/older homes) is included in Section 10 | Drainage Remediation on page 61. Additionally, designing for Flood Resilience (a topic of a future BC Housing publication) is introduced in Section 11 | Flood Resilience on page 65.

Site drainage is relied upon to direct surface water away from a building. Foundation drainage is relied upon to manage moisture below slabs-on-grade and to remove water that accumulates against foundation walls. The below-grade building enclosure (i.e., wall and slab-on-grade floor assemblies) is the last line of defense for groundwater control.

Specific topics in this guide are discussed in the general order in which they are addressed for a project or constructed on site. Each section starts with a summary of the issues considered to be most important by the guide authors and reviewers and ends with a comparison between Building Code minimum requirements and current "best practices."

The Section Wayfinder (Section View) on page iv illustrates common site and foundation drainage elements and overall building enclosure assemblies, with references to the corresponding sections in the guide where further discussion, design, and construction details are provided. Table 6.4 Dampproofing product selection matrix on page 38 and Table 6.5 Waterproofing product selection matrix on page 39 provide a summary of current dampproofing and waterproofing product types that are used and available locally, application methods for various environments, and foundation construction methodologies that may attain a suitable level of water ingress resistance.

A definition of Site and Foundation Drainage Systems is included in the attached Appendix A on page 72 and is aligned with the published definition in the Engineers and Geoscientists BC Geotechnical Engineering Services for Building Projects professional practice guidelines (see Additional Resources on page 67).

Underlined terms throughout this guide are defined in the Glossary of Terms on page 68.

Below-grade Risks

When there is water ingress into a living space it can have a range of consequences, from being a minor nuisance to resulting in more serious structural damage and health issues. The causes of moisture ingress can be difficult to diagnose and expensive to remediate due to access limitations and the invasive nature of some repairs.

As the availability and quality of developable land decreases and land values increase, there is a trend towards maximizing the habitable square footage of new developments, including more (and deeper) finished basements. This can be a concern for some sites depending on the geology and groundwater conditions. Deeper basements are more likely to be located close to, or below, the groundwater table, and a homeowner's tolerance for water ingress into finished basements is lower than what might have historically been accepted for unfinished basements. These factors, in combination with climate change and an increase in storm event intensity, frequency, and duration, means that well-constructed drainage is more important in order to protect the investments of homeowners.

While some municipalities may issue permits for basements in areas where the local groundwater table is relatively high, most municipalities do not allow pumping of groundwater into the municipal storm sewer system. This may require basements in areas with a high groundwater table to be fully tanked (i.e., fully waterproofed and designed to not become buoyant when submerged), which is often cost prohibitive for typical single-family residences.

Some of the primary causes of water ingress into buildings include inadequate site and foundation drainage, inadequate building enclosure systems, inadequate maintenance, or a combination of these factors. When site grading is ineffective in directing water away from a building or a drainage system fails to adequately remove water that accumulates against foundation walls, water may enter a building through shrinkage cracks, cold joints, and other penetrations in the building foundation wall, as well as through capillary action within the foundation wall and/or slab concrete. Where there is an ingress of moisture to the below-grade area of a building, damage and mould often result, and remediation is usually iterative, expensive, and frustrating for the owner/occupant and the contractor in charge of the repair.

1.1 Owner's Responsibility

Although the builder is the primary audience for the implementation of the strategies discussed in this guide, the 2018 BC Building Code (Article 1.2.1.2., Division A) places responsibility on the owner to conform with Code requirements. This is the case even when the drawings and specifications prepared by design professionals are approved, the building permit is issued, and inspections are carried out by the *authority having jurisdiction (AHJ)*.

Therefore, the owner is responsible for hiring qualified builders and professionals. The owner must also carefully consider post-construction insurance coverage (including exclusion clauses), to be involved in design decisions which may trigger AHJ requirements for covenants (e.g., pumped systems), and carry out routine maintenance as required to protect their investment. For additional information, please refer to the Additional Resources on page 67.

The owner should exercise due diligence by checking the references for, and having written contracts with, all parties involved. Owners should engage contractors who are licensed with BC Housing and licensed in the appropriate jurisdiction. Contracts could assign the responsibility for ensuring adherence to the Code from the owners to their builders. Contracts could also outline a requirement to adhere to a higher standard than the Code, such as this guide, other guidelines (including those referenced in the Additional Resources on page 67) and/or the project-specific details and specifications, prepared by design professionals, that make up the construction documents.

The owner is responsible for ensuring that proper maintenance of the foundation drainage system is carried out in accordance with documentation provided by the warranty provider. The owner is responsible for reporting any leakage to the warranty provider.

1.2 Builder's Responsibility

The builder is typically responsible for the overall delivery of the project. The owner is responsible for meeting the Code requirements and typically assigns this responsibility to the builder via contracts. Actual responsibilities will be dependent on agreements/contracts between the builder and the owner. However, the builder is generally seen to have the following responsibilities:

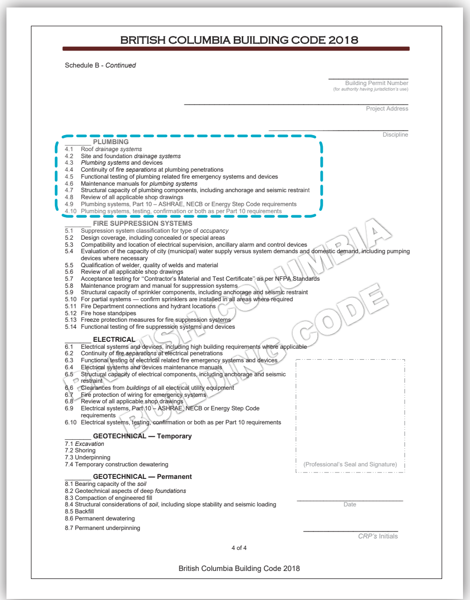
- **Adhere to the current applicable Code.** This is the main reference for the minimum requirements of below-grade works. Local authorities may also enact separate requirements outside of the BC Building Code for below-grade (and other) works, including for excavation.
- **Implement the design as provided by the designer(s)**. Construction documents should include drawings, details, and specifications that outline the work required. These documents should form part of the contract. Engineering drawings from structural, mechanical, civil, geotechnical, and/or building enclosure (as available) designers must be carefully considered, especially during the pricing and bidding process. Below-grade work is highly sensitive, because errors or deficiencies in excavation, concrete, and below-grade dampproofing/waterproofing are difficult and expensive to correct.
- **Enact proper quality assurance and quality control measures**. While professionals and AHJs carry out reviews and inspections during construction, the builder is responsible for ensuring the sound workmanship of their construction, adhering to the design drawings, scheduling appropriate testing/field reviews, and maintaining proper records and documentation.
- **Schedule inspections by the AHJ and field reviews by registered design professionals**. Each construction project, jurisdiction, and design professional will have its own process for inspecting/reviewing the work. As part of the planning process, the builder should confirm the inspections/reviews that are required, and be prepared to give fair notice for the scheduling of such.

1.3 Professional's Responsibility

Letters of Assurance (Schedules) are standard forms contained within the BC Building Code which are signed by registered professionals and submitted to an AHJ. They are sometimes required on Part 9 buildings, and they specify the aspects of a project for which an architect or professional engineer has taken responsibility. Where AHJs do not require the involvement of professionals, Building Officials are typically relied upon.

If a professional engineer has undertaken responsibility for Item 4.2: Site and Foundation Drainage Systems on the Schedule B, they should be provided with the opportunity to review the installation and to test the elements of the system for which they have provided design recommendations. Typically, the professional's responsibility for this item includes elements 'downstream' of a building sump, i.e., outside of a nominal one metre offset from the building foundation wall, and typically not covered by the BC Building Code and BC Plumbing Code. The Building Official often checks those elements 'upstream' of and at the sump, i.e., within a nominal one metre offset from the building foundation wall, and typically covered by the Codes.

Generally, the engineer taking professional responsibility for Item 4.2 for Part 9 buildings prepares drawings showing drainage pipes and pipe invert elevations. *Civil*, *geotechnical* or mechanical consultants may sign off on Item 4.2, depending on the type of project and the extent of the project team. It is important that civil and mechanical consultants reconcile their design recommendations with those of the geotechnical engineer for the project so that the design accounts for local geology, soil permeability, the groundwater table, water stop, and other site-specific geotechnical considerations.


BRITISH COLUMBIA BUILDING CODE 2018

Schedule B - *Continued*

Building Permit Number
(for *authority having jurisdiction's* use)

Project Address

Discipline

PLUMBING
4.1 Roof *drainage systems*
4.2 Site and foundation *drainage systems*
4.3 *Plumbing systems* and devices
4.4 Continuity of *fire separations* at plumbing penetrations
4.5 Functional testing of plumbing related fire emergency systems and devices
4.6 Maintenance manuals for *plumbing systems*
4.7 Structural capacity of plumbing components, including anchorage and seismic restraint
4.8 Review of all applicable shop drawings
4.9 Plumbing systems, Part 10 – ASHRAE, NECB or Energy Step Code requirements
4.10 Plumbing systems, testing, confirmation or both as per Part 10 requirements

FIRE SUPPRESSION SYSTEMS
5.1 Suppression system classification for type of *occupancy*
5.2 Design coverage, including concealed or special areas
5.3 Compatibility and location of electrical supervision, ancillary alarm and control devices
5.4 Evaluation of the capacity of city (municipal) water supply versus system demands and domestic demand, including pumping devices where necessary
5.5 Qualification of welder, quality of welds and material
5.6 Review of all applicable shop drawings
5.7 Acceptance testing for "Contractor's Material and Test Certificate" as per NFPA Standards
5.8 Maintenance program and manual for suppression systems
5.9 Structural capacity of sprinkler components, including anchorage and seismic restraint
5.10 For partial systems — confirm sprinklers are installed in all areas where required
5.11 Fire Department connections and hydrant locations
5.12 Fire hose standpipes
5.13 Freeze protection measures for fire suppression systems
5.14 Functional testing of fire suppression systems and devices

ELECTRICAL
6.1 Electrical systems and devices, including high building requirements where applicable
6.2 Continuity of *fire separations* at electrical penetrations
6.3 Functional testing of electrical related fire emergency systems and devices
6.4 Electrical systems and devices maintenance manuals
6.5 Structural capacity of electrical components, including anchorage and seismic restraint
6.6 Clearances from *buildings* of all electrical utility equipment
6.7 Fire protection of wiring for emergency systems
6.8 Review of all applicable shop drawings
6.9 Electrical systems, Part 10 – ASHRAE, NECB or Energy Step Code requirements
6.10 Electrical systems, testing, confirmation or both as per Part 10 requirements

GEOTECHNICAL — Temporary
7.1 *Excavation*
7.2 Shoring
7.3 Underpinning
7.4 Temporary construction dewatering

GEOTECHNICAL — Permanent
8.1 Bearing capacity of the *soil*
8.2 Geotechnical aspects of deep *foundations*
8.3 Compaction of engineered fill
8.4 Structural considerations of *soil*, including slope stability and seismic loading
8.5 Backfill
8.6 Permanent dewatering
8.7 Permanent underpinning

(Professional's Seal and Signature)

Date

CRP's Initials

4 of 4

British Columbia Building Code 2018

Figure 1.1 *BC Building Code Schedule B Item 4.2.*

1.4 Insurance

Suitable insurance coverage, where available, will help manage risks at sites where there is a risk of water ingress, whether due to pump, electrical, or other failure including that of off-site infrastructure. These risks may increase as a result of climate change. For sites with pumped drainage systems, having an appropriate understanding of the risks associated with these systems is critical for owners so that they can take measures to safeguard against potential damage. Builders should discuss these risks with homeowners so that appropriate steps may be taken during and following construction.

Current and future owners should be aware of the risks involved so they can have the appropriate insurance in place. Home insurance coverage varies based on the presence of pumped drainage. Placing covenants on the property is one way to ensure that such information is passed on to future owners, and some AHJs require this on properties where the stormwater drainage system is reliant on pumps.

1.5 Reference Codes

This document provides guidance specifically relating to the 2018 BC Building and Plumbing Codes and the 2019 Vancouver Building and Plumbing By-laws.

These Codes are available for free online at bcpublications.ca.

It is noted that many Code provisions remain relatively unchanged from previous versions, but this can be confirmed by comparing the Code between versions. The 2012 BCBC and BCPC, 2014 VBBL and VPBL, 2006 BCBC, and 2007 VBBL, are also available at the above link. Many Codes are also available at public libraries.

The plumbing section of these Codes (Part 2) has previously been located within the Building Code publications and not as a separate document. It has also been previously categorized as Part 7, as opposed to Part 2. **Table 1.1** indicates whether the plumbing section was combined with or separate from recent Code publications, and which part number it was categorized as.

Table 1.1 *Location of the plumbing section in current and previous Code publications.*

Code Version (BCBC+BCPC / VBBL+VPBL)	Plumbing Section Location
2018 / 2019	Separate; Part 2
2012 / 2014	Separate; Part 2
2006 / 2007	Combined; Part 7

Key Points:

- Sites underlain by challenging soil conditions may be more difficult and expensive to develop, and may have a higher risk of performance issues in the future. A qualified geotechnical engineer with local experience should be consulted to provide recommendations for design and construction where soil conditions are challenging or unusual.
- In areas underlain by peat or soft silt/organics, lowering the groundwater table (including by pumping out a building excavation), even temporarily, can result in significant off-site impacts.
- Installation of groundwater cutoff features can serve to raise off-site groundwater elevations.
- Infiltration features should not be located in areas underlain by collapsible, swelling/shrinking, or sensitive soils.
- Careful consideration should be given when locating infiltration facilities near crests of slopes, property lines, and in areas underlain by metastable/collapsible soils or swelling/shrinking clays.

2.1 Avoiding Pumps

It is advisable, wherever feasible, to eliminate the need for a pumped foundation drainage system in favour of a gravity drained system. This can decrease construction and operating costs and lessen future maintenance requirements, reduce long-term flooding risks and potentially lead to lower insurance premiums. The need for a pumped system can be eliminated through site selection and building design. In some residential buildings, a gravity drained system is achievable by raising the basement floor slab by a few inches. Therefore, where a gravity drained system is feasible, it is recommended that building elevations are carefully selected so as not to eliminate this possibility, including confirming maximum allowable building heights, minimum depth below grade, and drainage invert elevations. These considerations are discussed in detail in Section 8 | Stormwater Management and Discharge on page 49.

2.2 Challenging Soil Conditions

There are several specific challenging soil conditions which elevate both on- and off-site risks associated with groundwater and stormwater management. These are described below, with relevant Part 9 (and Part 4) Code references provided and discussed. In general, each non-Part 9 Code item requiring action or consideration with respect to a particular building or site condition can be considered a "best practice."

Sensitive or collapsible soils can behave unpredictably when water is introduced, and this can negatively affect bearing conditions for proximate buildings. Thus, water infiltration (e.g., via dry wells, rock pits, or infiltration tanks, trenches, fields or galleries) into these types of soils should be avoided (see 8.2 Stormwater Management on page 52 for more information).

Swelling and Shrinking Clays

Swelling and shrinking clay are soils that can be subject to significant volumetric change associated with the amount of water present in the soil. For this reason, infiltration features are generally not recommended in areas underlain by these soil conditions.

It is recommended that an experienced geotechnical engineer be consulted to identify these soil conditions and assist in providing suitable design and construction recommendations. Refer to Table 2.1 for relevant Code provisions.

Organic Soils, Peat and Muskeg

Organic soils, including peat, are generally relatively weak and can deform excessively when subject to new loads. Sites underlain by these soils can be prone to long-term settlement and/or causing significant off-site impacts that will require consideration during design and construction. For example, lowering the groundwater table in unconsolidated/soft or organic soil conditions could result in settlement due to the weight of the soil transitioning from its "buoyant" weight (i.e., below the groundwater table) to its full weight (i.e., above the groundwater table). See Section 4 | Foundation Drainage on page 15 for more on this. Buildings on these sites often require specialized and/or deep foundations (e.g. raft slab, piles).

Organic soils are also subject to decomposition of the organic material over time. Organic material generally decomposes aerobically (with oxygen), which generally occurs above the local groundwater table, or anaerobically (without oxygen), which generally occurs below the local groundwater table.

Aerobic decomposition occurs at a faster rate than anaerobic decomposition. Therefore, if the groundwater table is lowered (e.g., by the dewatering of a nearby excavation), the rate of settlement in the vicinity (including at adjacent sites) might increase as anaerobic decomposition becomes aerobic.

Note that decomposition of organic soils produces methane gas, which is colourless, odorless, and hazardously flammable. A soil gas barrier (i.e., air barrier system) is required for all homes, and a soil gas extraction rough-in is required to be installed below homes in sensitive areas per BC Building Code Sentence 9.13.4.2. See 5.3 Soil Gas Control on page 22 for additional details on soil gas.

Frost-Susceptible Soils

Frost-susceptible soils are soils that can experience frost heave or expansion with the frost cycle. Frost heave is due to the freezing and expansion of water contained in the soil during below-zero conditions (resulting in the formation of ice lenses). Frost heave and adfreezing can displace and possibly damage structures, such as through the loss of bearing support when ice lenses melt and settlement occurs. Generally, soils in cold climates are frost-susceptible when more than 8% of the soil by weight is composed of fine-grained particles too small to be discernible to the naked eye, such as silt and clay. The bases of structures must be either located below the local frost depth, or insulated from freezing when located in frost-susceptible soils, to reduce the risk of damage.

Frost depth: Also known as the frost line or freezing front, frost depth is the boundary between frozen and unfrozen ground. It is most commonly measured as the lowest depth at which groundwater is expected to freeze in a given year. The frost depth depends on the local climate, and typically extends deeper as winter progresses and exterior temperatures decrease. Per BC Building Code Article 1.1.3.2. (Division A), frost depth is established through local knowledge, and can be determined by a qualified engineer or established by an AHJ. Frost depth correlates to the number of days per year when the ambient temperature is below zero and is specific to each climate region. In the Lower Mainland, the frost depth is generally taken to be 450 mm (18"). However, in some areas of B.C., the frost depth can be much deeper; refer to **Table 2.1** for relevant BC Building Code provisions.

Metastable and Collapsible Soils

Collapsible soils are generally loosely deposited from wind (loess), water (alluvium), gravity (colluvium), debris floods/flows, or other natural events. Loess is predominantly fine-grained, but other collapsible soils can exhibit a range of gradations. Collapsible soils can appear to be competent in dry conditions but may collapse if the water content of the soil increases. Characterization of these types of soils can be challenging, and consultation with geotechnical engineers that have local experience is recommended.

Sensitive Clays

Sensitive clays are generally characterized by a very low remoulded soil strength, meaning that even minor disturbance of these soils can greatly reduce their strength. These soil conditions can be challenging to recognize since the soil can appear to be competent before it is disturbed (e.g., by construction equipment). Reduced soil strength can compromise the building structure or lead to excavation instability. Therefore, it is recommended to involve suitably qualified professionals when encountering sensitive clay soil conditions, or where these conditions may be expected based on local knowledge.

Table 2.1 *Code requirements for challenging soil and groundwater conditions and associated "best practice" recommendations.*

Code requirements for challenging soil and groundwater conditions	Recommendations
9.4.4.4. Soil Movement 1) Where a foundation is located in an area where soil movement caused by changes in soil moisture content, freezing, or chemical-microbiological oxidation is known to occur to the extent that it will damage a building, measures shall be taken to preclude such movement or to reduce its effects on the building so that the building's stability and the performance of assemblies will not be adversely affected. (See Note A-9.4.4.4.(1).) 2) The potential for slope instability and its consequences, such as slope displacement, shall be evaluated based on site-specific material properties and ground motion parameters referenced in Subsection 1.1.3. and shall be taken into account in the design of the structure and its foundations.	Involve suitably qualified professionals. Consult the Authority Having Jurisdiction.
9.12.1.2. Standing Water 1) Excavations shall be kept free of standing water.	Follow Code
9.12.1.3. Protection from Freezing 1) The bottom of excavations shall be kept from freezing throughout the entire construction period.	Follow Code
9.12.2.1. Excavation to Undisturbed Soil 1) Excavations for foundations shall extend to undisturbed soil.	Follow Code
4.2.4.9.1. Ground Water Level Change Where proposed construction will result in a temporary or permanent change in the ground water level, the effects of this change on adjacent buildings shall be fully investigated and provided for in the design.	It is considered "best practice" for Part 9 to use these more stringent Part 4 requirements. Involve suitably qualified professionals. Consult the Authority Having Jurisdiction.
4.2.4.11.1. Swelling and Shrinking Soils Where swelling or shrinking soils, in which movements resulting from moisture content changes may be sufficient to cause damage to a structure, are encountered or known to exist, such a condition shall be fully investigated and provided for in the design.	It is considered "best practice" for Part 9 to use these more stringent Part 4 requirements. Involve suitably qualified professionals. Consult the Authority Having Jurisdiction.

This page is intentionally left blank

3 | Site Drainage

Key Points:

- The ground surface should be graded to slope down and away from buildings (Article 9.14.6.1.(1), Div B) and surface water should be directed to a suitable disposal location.
- Rough grading (i.e., the backfill surface beneath landscaping medium or topsoil) should also slope away from the building.
- The building excavation should be graded towards the storm sump during excavation works and utility trenches should be graded to promote drainage away from the building .
- Any excavation for the footing should allow for sufficient ‘fall’ of the future perimeter foundation drain pipe, without compromising footing stability.
- All temporary excavations should be carried out in accordance with the requirements of WorkSafeBC, including under the supervision of a suitably qualified engineer, where required.
- Interception features should be provided to minimize water entering the excavation and future building perimeter drainage system.
- Infiltration features should not be located within 5 metres (~16 ft) of a basement, or below the groundwater table (9.14.5.3.).
- Professionals should be aware of the need to capture and infiltrate rainwater per the AHJ specific design standards.

The best time to minimize the future risk of water ingress into a building is during the site selection and design phase of a project, when slab elevations are set and site grading is designed. Site grading is the first line of defense against water ingress. Sites that are known to have high groundwater table, or that were the historic locations of ravines, channels, creeks, or other features associated with conducting water, could be expected to have a higher risk of post-construction problems than sites without these features. If consulted early in the project, a geotechnical consultant can provide guidance on site selection, lot grading, and building design in order to reduce the risk of water ingress. However, geotechnical engineers are often not required to be involved in Part 9 building projects.

3.1 Subsurface Drainage

Water that travels through subsurface preferential drainage paths into foundation backfill materials can be of natural origin (i.e. groundwater, infiltrated rainwater/interflow, adjacent bodies of water, buried streams) or from other sources such as irrigation systems, rainwater leader downspouts, leaking utilities, and/or unfavorably sloped buried trenches. In managing water at a site, an important design consideration is the hydraulic conductivity of both the natural soil and the fill materials present. Hydraulic conductivity, often referred to as permeability, describes the ability of water to flow through or infiltrate into a soil. Hydraulic conductivity is based on particle size, compaction, and soil composition.

Lower hydraulic conductivities (e.g., 10^{-6} m/s (0.016 gpm) and below) indicate that a soil is relatively impermeable and that water will likely not effectively infiltrate into this material. In addition, water will not easily travel through this material to other areas of a site or to a drain pipe. Materials with lower hydraulic conductivities include clays, silt, glacial till or "hard pan." Infiltration systems are typically not recommended at sites where the hydraulic conductivity of the soil is relatively low. Higher hydraulic conductivities (e.g., 10^{-5} m/s and above) indicate that a soil is more permeable and that water will be able to infiltrate with relative success. Materials with higher hydraulic conductivities are generally considered free draining and are typically relatively clean sand (free of fines such as silt or clay) or gravel. More flow can occur through these high permeability soils than lower permeability soils.

As discussed in Section 2, some soil types can behave poorly or unpredictably when water is introduced, and this should be considered when planning infiltration features on a site (e.g., via dry wells or stormwater infiltration tanks, trenches, fields, or galleries).

It can be helpful to consider that water flows along the path of least resistance. This path may be down a slope, through pipes or utility trenches, through free draining materials, poorly compacted fills, pockets of debris with a high void ratio, or buried decomposing organics (such as logs), or into openings in a below-grade wall. For this reason, it is important to consider both the overall site conditions and the proposed construction layout when designing a drainage system.

Cutoff and Interception Features

Where a site is sloped, and groundwater flows are significant, it may be possible to control the amount of water reaching a foundation drain by using cutoff and interception features.

Groundwater Cutoff Walls

A groundwater cutoff wall is a low-permeability feature requiring geotechnical design. Groundwater cutoff walls are recommended in high-permeability soils to reduce the amount of groundwater flowing toward a below-grade structure (see **Figure 3.1**). A groundwater cutoff wall possibly extends below the elevation of the basement level, and might comprise either a trench which is backfilled with concrete or well-compacted, fine-grained soil, or a continuous caisson or secant pile wall. Commonly, these features extend through high permeability soil to embed into low-permeability soil. These features would be expected to result in an increased groundwater elevation behind the cutoff wall, possibly off-site. Subsurface investigation, groundwater monitoring, permeability testing, and seepage modeling by a suitably qualified geotechnical consultant would be required to assess the design depth and extent of a groundwater cutoff wall, as well as to quantify the potential off-site impacts that such a feature would have. Depending on the topography and geology, the cutoff wall may be required to completely surround the building.

Interception Trenches

Upslope interception trenches can be constructed to collect groundwater before it enters the building backfill zone (see **Figure 3.2**). In a site drainage plan designed to intercept groundwater, it is imperative to understand the surficial geology governing local groundwater flow. This is best achieved by consulting a geotechnical engineer.

Interception trenches extend into low-permeability soils, are filled with highly permeable material such as with clear gravel, and contain a perforated pipe which collects water and helps facilitate future maintenance. At the transition between this perforated pipe and the solid discharge pipe, a concrete "dam" or seepage collar should be installed, as shown in **Figure 3.3**. Alternatively, a sump could be installed at this transition if the excavation for the sump is backfilled with concrete. Filter fabric, as shown by a dotted line in Figure 3.2, may be recommended to line the upslope portion of the trench (i.e., where there is water seepage), and near the surface of the trench, to inhibit the migration of fines into the gravel. The trench surface is generally swaled to promote surface water infiltration. Maintenance will be required to ensure that silt, leaves, and other debris do not collect in the trench in a manner which could inhibit water infiltration or flow.

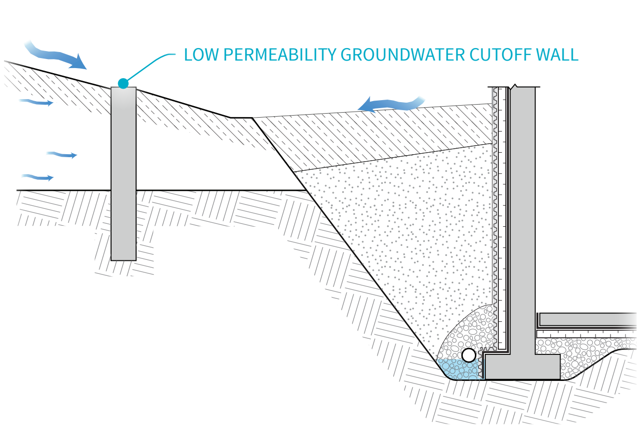


Figure 3.1 *Section view of a concrete ground water cutoff wall.*

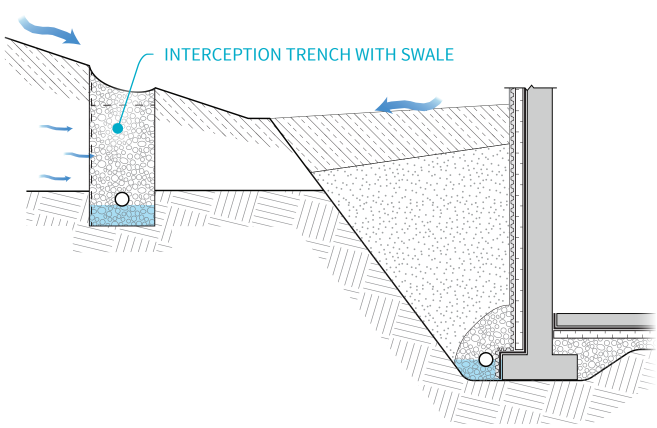


Figure 3.2 *Section view of a gravel interception trench.*

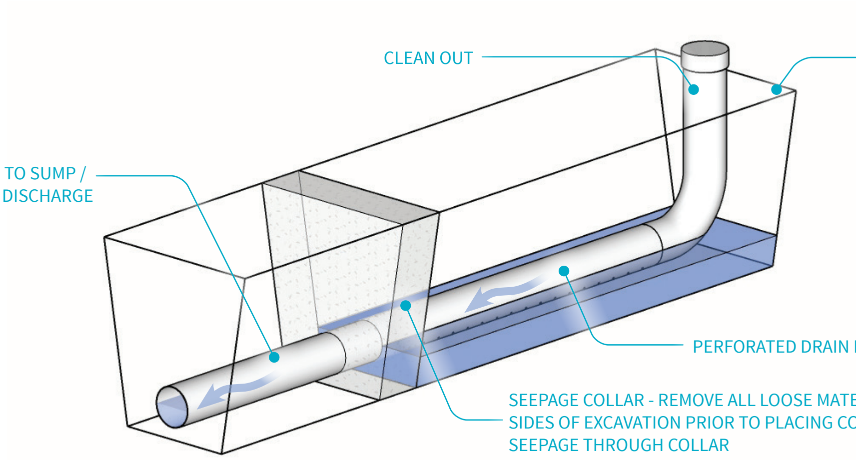


Figure 3.3 *3D schematic of an interception trench with seepage collar.*

Swales

Swales are sloped, shallow ditches at the ground surface, as shown in **Figure 3.4**. Swales are designed to collect and divert surface water to an approved location. Swales can have permeable surfaces (e.g., vegetation) or impermeable surfaces (e.g., asphalt, concrete, etc). Periodic maintenance should be carried out, including removal of accumulated fines and decaying or excessive vegetation should be removed in order to maintain the capacity of the swale.

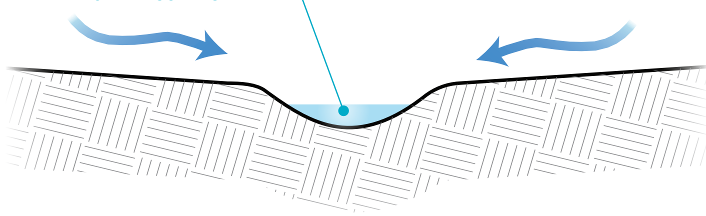


Figure 3.4 *Schematic cross section of a swale.*

French Drains

French drains are gravel-filled trenches, typically with a perforated pipe near the bottom and filter fabric on the top and sides as shown in **Figure 3.5**. French drains can be surfaced with topsoil, though this may limit the infiltration of surface water. Gravel or rounded river rock can also be used. Typically, French drains are oriented perpendicular to the slope direction in order to more effectively intercept surface and near-surface water and divert it to an appropriate location.

Generally, the trench extends down through the surficial, highly permeable soil and into deeper, less permeable soil. This allows perched water above the adjacent less permeable soil to drain into the French drain and be directed elsewhere.

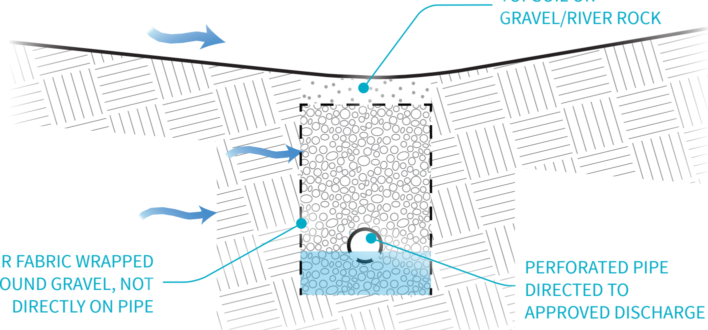


Figure 3.5 *Schematic cross section of a French drain with topsoil cover.*

Excavation Grading

To promote slope stability, areas adjacent to the crests of excavation slopes should generally be graded to direct surface water away from the excavation. This may have the added benefit of reducing the amount of water which must be managed in the excavation. BC Building Code Sentence 9.14.4.3.(1) requires that excavation drained by a granular fill be graded to the drainage discharge. The base of the building excavation should be graded to promote natural drainage toward the storm sump, regardless of the presence of a piped drainage system. The slopes of trenches required for any utility installation should be graded to thoughtfully direct water which collects at the inverts of these trenches. This may be counter to the grading of the pipe or its surface bedding.

All temporary excavations should be carried out in accordance with WorkSafeBC OHS regulations, including under the supervision of a suitably qualified professional engineer where required.

3.2 Surface Drainage

The BC Building Code requires that the building site be graded so that "water will not accumulate at or near the building" (9.14.6.1.(1)). Appropriate grading of sites is the simplest means of controlling surface water, though grading may be combined with other management strategies. Elements that may be incorporated into a grading plan include but are not limited to swales, ditches, lawn basins, french drains, and/or raingardens (see previous and Section 8 | Stormwater Management and Discharge on page 49). These features require ongoing maintenance during the life of the development.

On a sloping property, proper site grading can be more difficult to achieve, particularly when the natural terrain promotes drainage towards the building, (as shown in **Figure 3.1 and Figure 3.2**). The scenarios shown in **Figure 3.6** should be avoided by ensuring that both rough grading (i.e. below topsoil) and final grading of landscaping such as lawns, patios and/or sidewalks are sloped away from the building, as indicated in **Figure 3.7** (see next page).

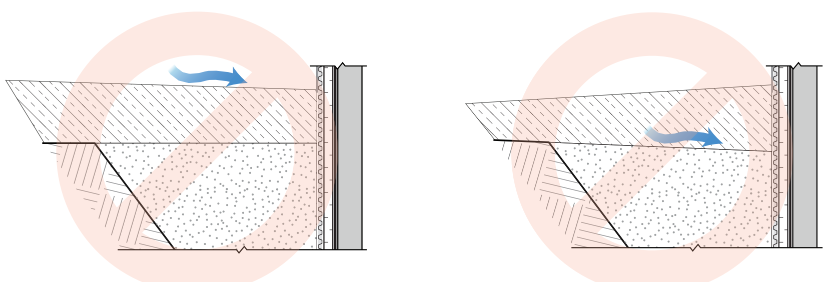


Figure 3.6 *Incorrect rough and/or final grading directs water towards building.*

It is considered "best practice" to grade landscaping away from the building at a minimum 2% slope for a distance of 3 metres (10 ft), or past the backfill zone of the foundation walls as shown in. This surface water can be collected in a swale, lawn basin, French drain, raingarden, or other surface water management feature as discussed previously and in Section 8 | Stormwater Management and Discharge on page 49. All drainage pipes should discharge to a location approved by the AHJ.

Stormwater infiltration features such as dry wells and gravel infiltration trenches or fields should be located sufficiently away from below-grade structures (including those off-site). A minimum distance of five meters is mandated in Article 9.14.5.3. of the BC Building Code. This minimum offset pertains to on- and off-site buildings. Greater distances may be recommended by a geotechnical consultant depending on the subsurface soil and other site-specific and off-site conditions, including proximity to slopes.

The preferred approach is to not incorporate a pumped system if possible. This is best achieved through proper site selection and building design (i.e. setting appropriate finished floor elevations). Eliminating the requirement for a pumped system can substantially reduce the potential for future water ingress. Refer to Section 8 | Stormwater Management and Discharge on page 49 for more information on gravity and pumped systems.

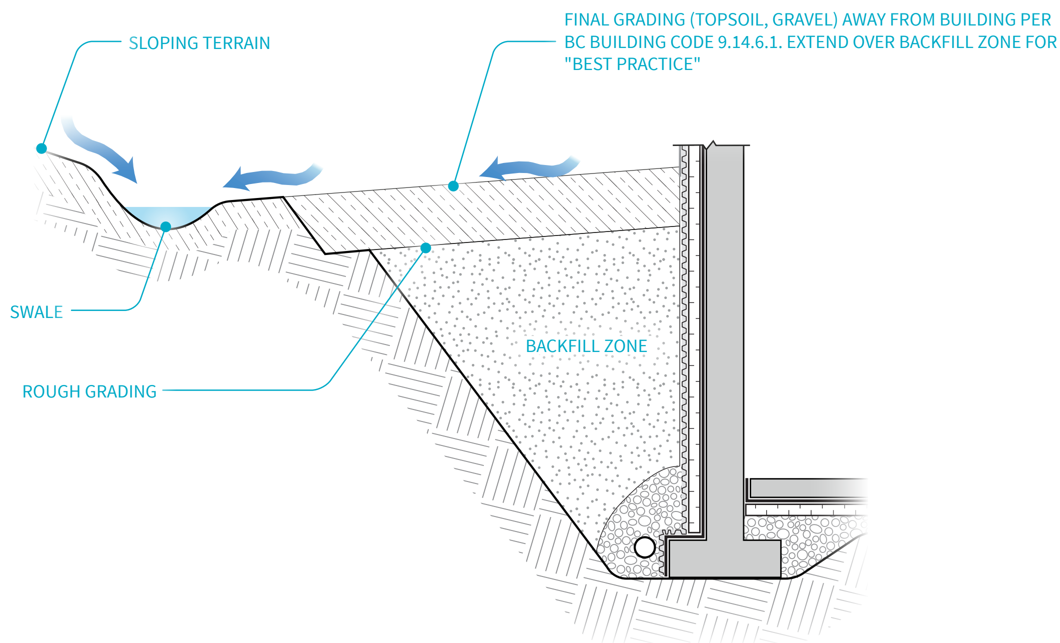


Figure 3.7 *Example of "best practice" site grading on sloping terrain.*

Table 3.1 *Code requirements and associated best practice recommendations for surface and subsurface drainage.*

Code Requirements	Recommendations
9.14.4.3.(1) The bottom of an excavation drained by a granular layer shall be graded so that the entire area described in Article 9.14.4.2. is drained to a sump conforming to Article 9.14.5.2.	Grade the base of an excavation to slope toward the eventual sump location.
9.14.5.3. Dry wells may be used only when located in areas where the natural ground water level is below the bottom of the dry well. Dry wells shall be not less than 5 m from the building foundation and shall be located so that drainage is away from the building.	Dry wells, infiltration fields, rock pits, etc. are recommended to be used only in areas where soil conditions are suitable for infiltration. Alternatively, detention tanks can potentially be used on sites where these features are not appropriate.
9.14.6.1.(1) The building shall be located or the building site graded so that water will not accumulate at or near the building.	Ensure both "rough" grading and final grading is sloped down and away at minimum 2% from a building past the backfill zone of the building.
9.12.3.2.(1) Backfill shall be graded to prevent drainage towards the foundation after settling.	Ensure both "rough" grading and final grading is sloped down and away at minimum 2% from a building past the backfill zone of the building. While the drainage layers are porous and free-draining, a paved surface or an impermeable soil layer (e.g. clay cap) or concrete may be used on top of the backfill to limit surface water infiltration into the drainage system. Refer to Section 7 | Backfill on page 47 for more information on this.

This page is intentionally left blank

Key Points:

- The BC Building Code requires the bottom of every exterior foundation wall to be drained, unless shown to be unnecessary (9.14.2.1.(1)).
- "Best practice" is to grade the base of the excavation (and install sufficient clear gravel bedding) to provide drainage on its own, and to then install perforated drain pipes to allow the system to be accessed and maintained in the future.
- Use rigid perforated PVC pipes with double-45° or long-sweep corners, include regular cleanouts, and use free-draining backfill materials.
- Locate the invert elevations of drain pipes below the footing capillary break, if present.
- Lower the footings to accommodate excavation for perimeter drainage, including an allowance for pipe grading/"fall."

4.1 Design Pressures on Basements

When the soil adjacent to a building foundation wall is dry, it is considered to be optimally drained, and the soil pressure exerted on the wall is based on its dry soil weight (see **Figure 4.1**).

When the soil adjacent to a building foundation wall is moist/damp and not well-draining, it is considered to be partially saturated, and the soil pressure exerted on the wall is based on its wet soil weight. This results in higher loads exerted on the wall, and thus a higher demand on both the structure and the building enclosure features resisting water ingress (see **Figure 4.2**). If the design of a building foundation wall had considered only the dry soil pressure, the addition of these increased soil pressures can result in structural damage to the wall. Additionally, the accumulation of water adjacent to a foundation wall can result in water ingress into the basement. Partially saturated conditions can occur if the building foundation drainage is not adequate, or if backfill materials are not free draining.

When the soil adjacent to a building foundation wall is below the groundwater table, the foundation wall is considered "submerged" and hydrostatic pressure is exerted on the building foundation wall, in addition to a reduced soil pressure due to the effects of buoyancy (see **Figure 4.3**). This scenario requires tanking of the building and although the involvement of professional engineers is not strictly required by the Building Code, it is strongly recommended and often required by the *AHJ*. This is further discussed in Section 6 | Building Enclosure on page 25.

Table 6.4 Dampproofing product selection matrix on page 38 and Table 6.5 Waterproofing product selection matrix on page 39 present typical building enclosure systems for these three foundation wall conditions. In general, optimally drained conditions require dampproofing, partially saturated conditions warrant non-tankable waterproofing, and submerged conditions require tankable waterproofing and professional involvement.

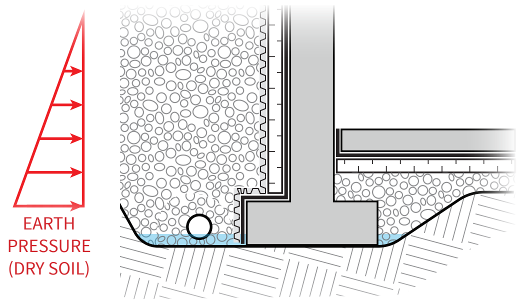


Figure 4.1 Optimally drained *foundation wall; dry soil.*

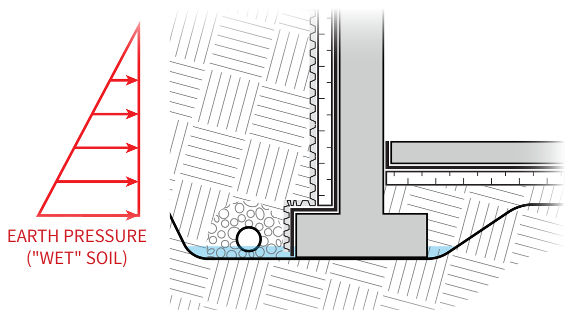


Figure 4.2 Partially saturated *foundation wall; wet soil.*

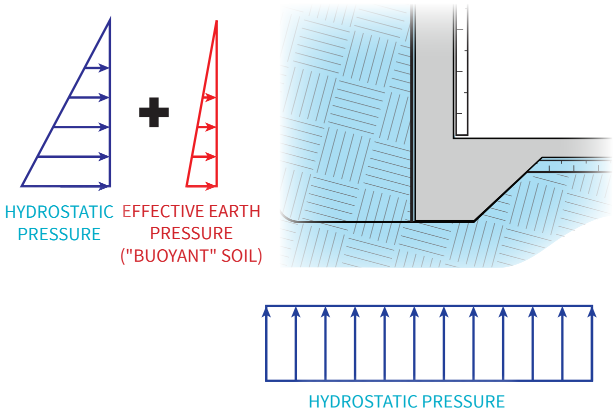


Figure 4.3 Submerged foundation *below the water table. Foundation/slab is tanked; no drain pipe required.*

4.2 Code Requirements

BC Building Code Sentence 9.14.2.1.(1) requires that, "Unless it can be shown to be unnecessary, the bottom of every exterior foundation wall shall be drained by drainage tile or pipe laid around the exterior of the foundation in conformance with Article 9.14.3., or by a layer of gravel or crushed rock in conformance with Article 9.14.4." Foundation drainage is installed at the base of most below-grade structures to reduce the likelihood of water accumulation at below-grade walls, footings, and the slab-on-grade. Foundation drainage in B.C. usually comprises perforated drainage pipes that are placed around the perimeter of the foundation and surrounded by gravel. Although the BC Building Code does not require this "drain tile" to be sloped, many AHJs may request that the foundation drainage be sloped towards the discharge location.

The BCBC Part 9 minimum drainage requirements as shown in **Figure 4.4** and **Figure 4.5** may achieve moderate performance, but a robust solution is desired where reliable long-term drainage is needed, including where interflow groundwater flows may be significant. Among other potential long-term performance concerns, the "Code minimum" requirements may not provide:

- enough drainage capacity,
- access for maintenance, and/or
- protection from potential clogging.

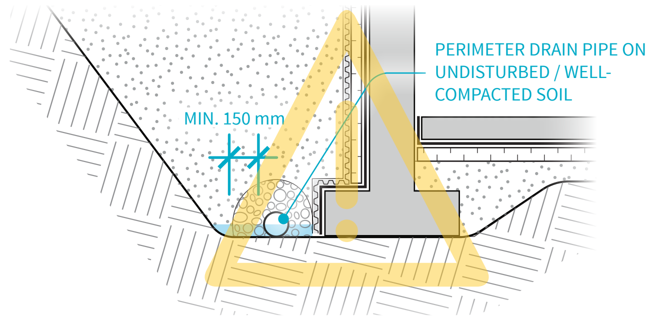


Figure 4.4 *Example of BC Building Code drain pipe option (9.14.3.) for foundation drainage system; not recommended for best practice (does not allow for gravel bedding).*

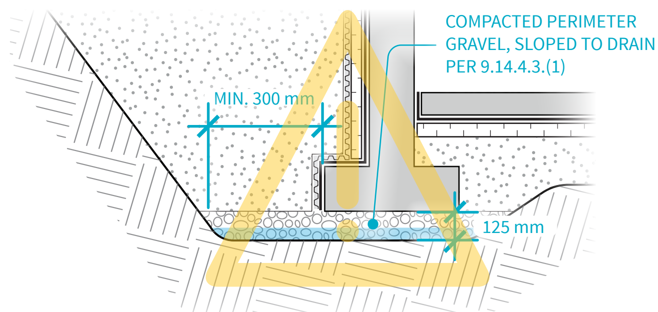


Figure 4.5 *Example of BC Building Code gravel option (9.14.4.) for foundation drainage system; not recommended for best practice (does not allow for maintenance).*

There are some situations where foundation drainage on a subgrade that is not moisture sensitive may provide negligible benefit to a building. This may be the case if it is constructed at-grade in a well-drained area on a subgrade that is not moisture sensitive, or if the building is "tanked". In these scenarios, AHJs typically require a letter from an engineer in lieu of drainage installation. If there is doubt, it is almost always less expensive to install this system during construction, rather than after.

4.3 Recommended Foundation Drainage

A "best practice" perimeter drainage system would comprise 100 mm (4") or 150 mm (6") diameter, rigid, perforated PVC drain pipe, bedded on and covered by a minimum 150 mm (6") thick layer of clear crushed gravel. The pipe should include double-45° or long sweep corners, and it is recommended to include cleanouts at all corners and as otherwise may be required to ensure access to the entire system (see Section 9 | Maintenance on page 59). To be Code-compliant, it is required that gravel bedding be "well-compacted" (9.14.3.3.(1)).

BC Building Code Sentence 9.14.3.1.(1) lists a number of materials that are now understood to perform poorly. These include clay drain tile, which is difficult to access and maintain, and is prone to crushing and degradation, as well as flexible polyethylene ("Big-O" black corrugated pipe), which promotes sediment build-up and is prone to crushing and clogging. In contrast, PVC drain pipe allows for good access for maintenance and performs well with respect to crushing and clogging, especially if installed per "best practices." Perforations should be installed facing downwards (text on pipe facing up) for perimeter drainage applications.

Filter fabric should be used around the gravel to reduce the amount of fines that are able to enter the drainage system. **Filter fabric should not be directly wrapped around perforated drainage pipes**; this may cause clogging and decrease the effectiveness of the perimeter drainage system.

The perimeter drain pipe is typically sloped at 1%. The bottom of the pipe should be placed at least 50 mm (2") below the footing capillary break (if present), or 300 mm (12") below the top of the slab as shown in **Figure 4.6**. Having the drain pipe below the top of the footing reduces the potential for moisture to reach the foundation wall through capillary action in the footing (see Section 6 | Building Enclosure on page 25). Note that the excavation to accommodate pipe grading may lower the required foundation elevation so that footings are not undermined (see also **Table 4.1**). Placement of gravel under the footing should be reviewed by the geotechnical engineer. The thickness of gravel under footings should generally not exceed 125 mm (5") unless reviewed by a qualified engineer.

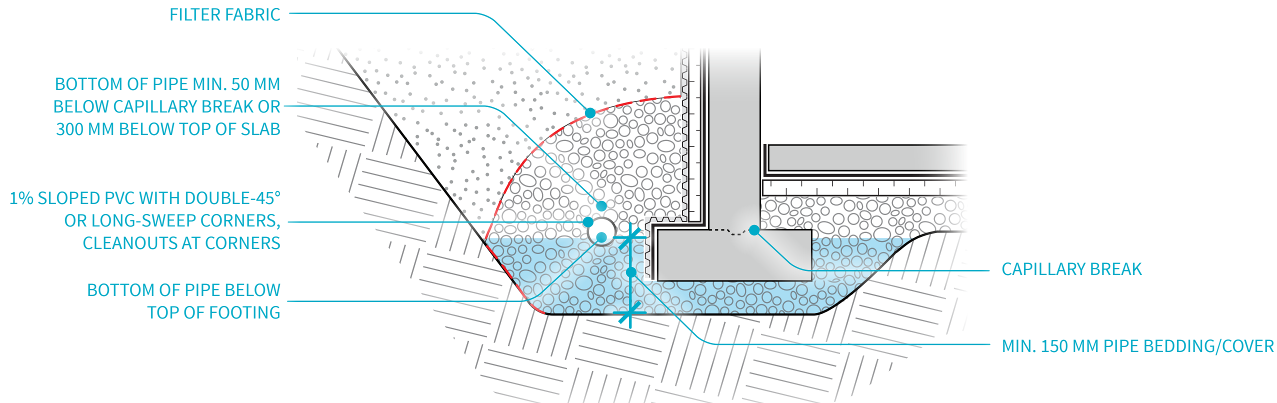


Figure 4.6 *"Best practice" foundation drainage system with drain pipe set below the top of the footing.*

4.4 Basements Below the Groundwater Table

The groundwater table refers to the interface between partially and fully saturated soil, below which hydrostatic pressure is exerted on a structure. The location of the groundwater table often varies within a given year (and possibly over decades) and can be dependent on:

- the time of year
- recent rain events (or lack thereof)
- snowmelt volumes
- tides
- the surface coverage and/or presence of any developments under construction within the watershed
- the presence of groundwater wells or other features that remove groundwater via pumping, and/or
- the presence of underground flow paths or "dams," which could be natural or human-made.

Basements below the groundwater table require special consideration and may warrant the involvement of a suitably qualified engineer. There are several potential design options in this scenario, the most common of which for Part 9 buildings include:

- lowering the groundwater table at the building wall with conventional perimeter drainage (see next page),
- constructing the building as a tanked structure to resist hydrostatic pressures associated with the groundwater table, or
- raising the elevation of the lowest floor of the building to above the groundwater table.

If the drainage system is used to remove groundwater such that the foundation does not require tanking, the groundwater table around the site can be lowered, resulting in potential off-site effects. In less permeable soil, the groundwater level is typically not reduced significantly until it reaches the excavation (**Figure 4.7)**, and off-site effects are typically not an issue. In permeable soils, the groundwater table is gradually pulled lower as it approaches the drainage system (**Figure 4.8)**. In this scenario, the possible off-site effects should be investigated by a geotechnical consultant.

If a tanked building enclosure system is used, consideration will need to be given to material types and specifications, design life, and the *Maximum Design Groundwater Elevation*. Additionally, the design against buoyancy may include expensive tie-down structures to reduce the likelihood of the building floating (see 4.1 Design Pressures on Basements on page 15 for more on this).

Commonly, the extensive design and construction requirements associated with constructing a Part 9 building below the groundwater table (in permeable soil conditions) are considered infeasible, and owners may elect to revise the design such that the building is above the groundwater table.

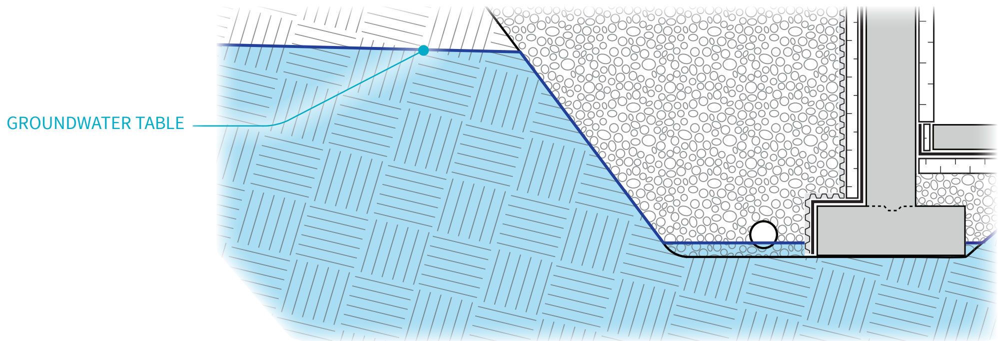


Figure 4.7 *Water table perched on low permeability soil; negligible off-site effects.*

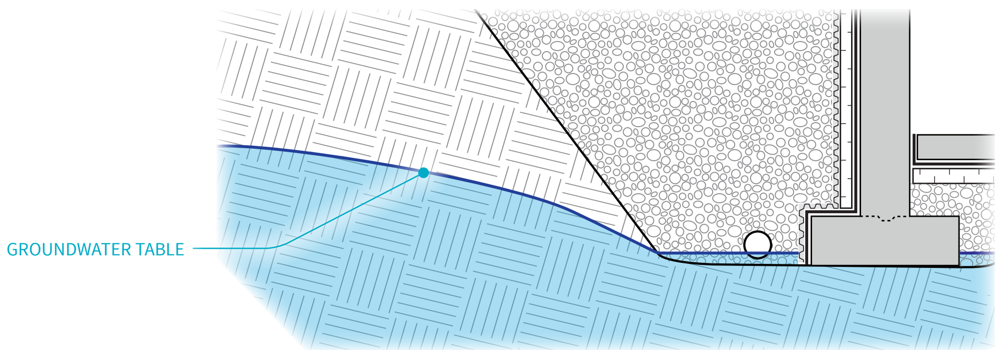


Figure 4.8 *Water table in permeable soil; off-site effects possible.*

Table 4.1 on the following page outlines select basic Code requirements for foundation drainage, and associated recommendations for "best practice" approaches.

Table 4.1 *Code requirements and associated best practice recommendations for foundation drainage.*

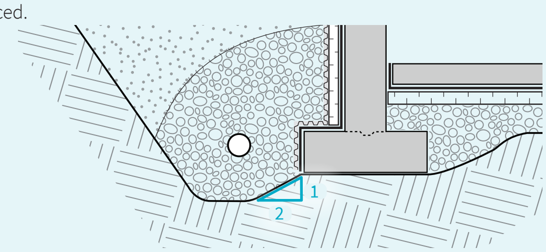
Code Requirements	Recommendations
Unless it can be shown to be unnecessary, the bottom of every exterior foundation wall shall be drained by drainage tile or pipe or by a layer of crushed gravel or crushed rock (9.14.2.1.(1)). BCBC allows for foundation drainage to comprise either: a) drainage pipe or tile laid on undisturbed or well-compacted soil with the top and sides covered by at least 15 cm (6") of clear gravel (9.14.3), or b) a minimum 12.5 cm (5") thick layer of clear gravel beneath the footing, extending 30 cm (12") beyond the outside edge of the footing (9.14.4).	› To allow for maintenance of the drainage system, include a rigid, perforated, PVC pipe installed with perforations facing down, as opposed to using only gravel for drainage. › Place at least 150 mm (6") of clear crushed gravel beneath and surrounding the perforated perimeter drainage pipe so that underlying soil is separated from the pipe to reduce soil migration into the system. Without this gravel layer, as in Option (a), fine-grained soil could seal the perforations on the bottom of the pipe. Wrap the clear gravel with a layer of filter cloth or use a <u>granular filter</u> to reduce soil migration into the system. › Install foundation drain pipes with a slope of 1% towards the sump. › Depending on the foundation design, gravel under the footings may not be appropriate. Where present, this gravel should be suitably compacted. › A 125 mm (5") thick gravel layer beneath the footings will generally not compromise the bearing; consult the geotechnical engineer for project-specific considerations.
9.14.3.3.(1) Drain tile or pipe shall be laid on undisturbed or well-compacted soil so that the top of the tile or pipe is below the bottom of the floor slab or the ground cover of the crawl space.	Install pipes with their invert elevations and perforations at least below the top of the adjacent footing and with a minimum of 50 mm (2") between the top of the pipe and the bottom of the slab, at a slope of 1%. This may result in the drainage system being deeper than the bottom of the adjacent footing. If the excavation for the drainage system is too deep or too close to the footing, the bearing conditions can be compromised. In general, an excavation should not be deeper than a line extending down from the bottom of the foundation at 1 vertical to 2 horizontal (see below). Where this is problematic: › A deeper footing and foundation wall could be designed and constructed (pending confirmation that the structural design is adequate). › In some soil conditions, as determined by the geotechnical engineer, the line extending down from the footing can be steepened to as much as 1 vertical to 1 horizontal. › The thickness of the bedding can be reduced to 100 mm (4"). Filter fabric should be installed at the interface between the natural/exposed soil and the gravel bedding for the drain pipe if the bedding is less than 150 mm (6") thick. › With permission from the plumbing inspector for the Authority Having Jurisdiction or upon approval by the professional undertaking responsibility for Site and Foundation Drainage (Item 4.2 on the Schedule B), the recommended minimum slope of 1% could be reduced. 
9.14.4.3.(1) The bottom of an excavation drained by a granular layer shall be graded so that the entire area described in Article 9.14.4.2. is drained to a sump conforming to Article 9.14.5.2.	› Drain the entire excavation to the future location of the building storm sump.

Table 4.1 *Code requirements and associated best practice recommendations for foundation drainage continued.*

Code Requirements	Recommendations
9.13.3.1.(1) Where hydrostatic pressure occurs, waterproofing is required for assemblies separating interior space from the ground to prevent the ingress of water into building assemblies and interior spaces. 9.16.3.2.(1) Where groundwater levels may cause hydrostatic pressure beneath a floor-on-ground, the floor-on-ground shall be (a) a poured concrete slab, and (b) designed to resist such pressures.	It is strongly recommended to involve suitably qualified engineers where a basement will be constructed below the water table in order to provide recommendations regarding (the requirement for) › waterproofing product selection and installation details, › structural design to resist hydrostatic pressures and buoyancy, including tie-down structures, and › other site-specific and off-site considerations.
9.14.3.3. (4) The top and sides of drain pipe or tile shall be covered with not less than 150 mm of crushed stone or other coarse clean granular material containing not more than 10% of material that will pass a 4 mm sieve.	The gradation of "clean granular material" is not ideal. An ideal gravel is considered to range in size from 19 mm (3/4") to 25 mm (1"), be free of fines, and be angular and thus more compactable.
9.15.3.2.(1) Footings shall rest on undisturbed soil, rock or compacted granular fill.	Placement of gravel under the footing should be reviewed by the geotechnical engineer. The thickness of gravel under footings should generally not exceed 125 mm (5") unless reviewed by a qualified engineer.
BC Plumbing Code Requirements 2.4.7.1.(1) Sanitary drainage systems and storm drainage systems shall be provided with cleanouts that will permit cleaning of the entire system. Table 2.4.7.2. Maximum permitted cleanout spacing in a drainage system for 4-inch diameter pipes is 15 m for one-way rodding, and 30 m for two-way rodding. 2.4.7.4.(1) Cleanouts and access covers shall be located so that their openings are readily accessible for drain cleaning purposes.	The current BC Building Code definition of "drainage system" specifically excludes "subsoil drainage pipes". However, it is recommended for "best practice" to follow the Plumbing Code cleanout spacing recommendation for perimeter drainage pipes: › Ensure that cleanouts are not buried or covered. › Capped perimeter drainage system cleanouts are essential for the long life of a drainage system as they allow for the cleaning of the perimeter drain pipes. › Ensure that sumps are large enough and equipped with ladder rungs to allow access for the purpose of future maintenance. › Cleanouts are recommended at all corners to facilitate cleaning of the entire system. › See Section 9 | Maintenance on page 59 for further details.
BC Building Code Part 5 Requirements (for reference) 5.7.1.2.(1) The building shall be located, the building site shall be graded, or water shall be directed away from building assemblies so as to prevent or accommodate the accumulation of surface water against the building or adjacent buildings. 5.7.1.2.(2) Drainage shall be provided to direct water away from assemblies separating interior space from the ground, except (a) where the assembly is designed in accordance with Subsection 5.7.2. to withstand continuous hydrostatic pressure...	A foundation drain pipe is not required where a building is designed to be tanked and withstand hydrostatic pressures. This requires professional involvement. In all other cases, the foundation wall must be provided with drainage

Key Points:

- Provide at least 100 mm (4") of clear gravel underneath slabs-on-grade, including 50 mm (2") on top of footings. Sand is not suitable.
- A soil gas rough-in requires a fully sealed air barrier, a depressurization zone beneath the floor air barrier using a gas-permeable layer, and a vent pipe connecting all enclosed spaces beneath the floor to the outdoors.
- Fully sealed polyethylene sheeting, clear gravel, and a PVC vent pipe stubbed into the gravel can be used to meet the requirements for soil gas control, although a dedicated underslab perforated soil gas collection pipe traversing the entire underslab area is recommended for "best practice". Perforations should be facing upwards where methane is expected and downwards where radon is expected. Interior sump lids must be sealed to maintain the continuity of the air/soil gas barrier.
- Where a slab in contact with the ground is pile-supported, mechanically affixing the soil gas membrane to the underside of the slab, including via the use of adhering membranes, is recommended.

5.1 Underslab Drainage

Generally, the success of a foundation drainage system relies on a suitable underslab drainage layer to provide a capillary break. All slabs are required to have a drainage layer per Article 9.16.2.1. of the BC Building Code. Sand does not provide a suitable capillary break. Instead, the "best practice" is to provide a layer of compacted clear gravel, 100 mm (4") to 150 mm (6") thick, below the slab, with a minimum of 50 mm (2") on top of footings. Note that, per clause 9.13.2.1.3(c) of the BC Building Code, this underslab drainage layer can be considered to act as the slab dampproofing.

Figure 5.1 *Example of clear crushed gravel placed and compacted for underslab drainage.*

The underslab gravel should be compacted to reduce the risk of settlement, which can manifest as cracks in the slab-on-grade. Clear crushed gravel is often referred to as "self compacting." This is not necessarily accurate, but it requires less effort to consolidate than many other materials. A superior alternative to the BC Building Code minimum specified gravel is an angular, and thus more compactible, gravel with a range in granular size from 19 mm (¾") to 25 mm (1"). Note that polyethylene sheeting alone is not suitable to provide a capillary break, but it is required above the gravel to serve as part of the other assembly control layers beneath the slab (see 5.3 Soil Gas Control on page 22 and Section 6 | Building Enclosure on page 25).

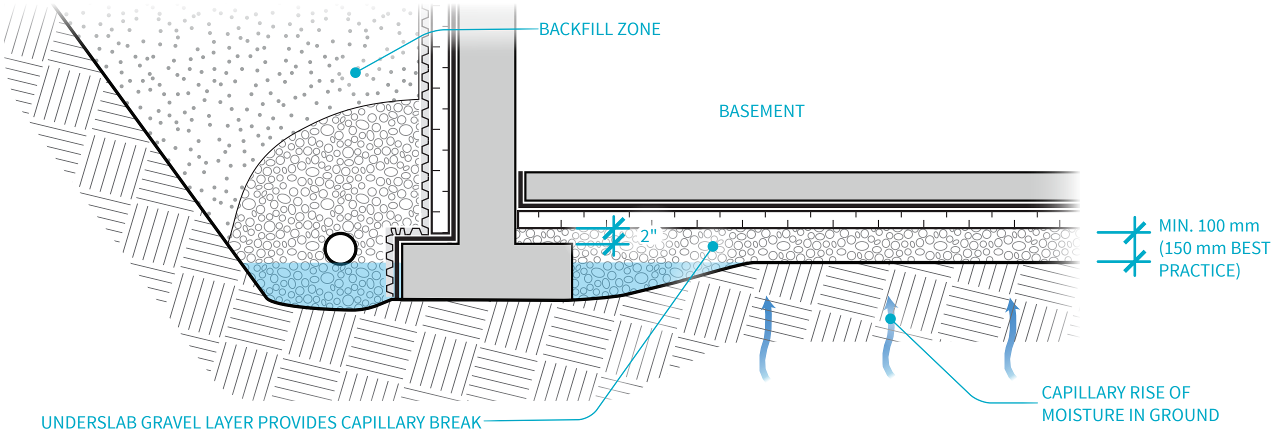


Figure 5.2 *Minimum thicknesses of underslab compacted clear gravel.*

5.2 Footing Weep Holes

It can be beneficial to install weep holes to provide a dedicated drainage pathway between the underslab drainage and the perimeter foundation drainage system. Weep holes should only be installed on the "downstream" side of the building footprint, so that water can drain out of, and not into, the underslab area, as shown in **Figure 5.3**. To benefit from the capillary break between the footing and wall (see Section 6 | Building Enclosure on page 25), weep holes should be installed through footings. This may be counter to the current common practice in construction, where weep holes are typically installed through the foundation wall. The purpose of this recommendation is to reduce capillary rise of moisture in the foundation wall by discouraging moisture above the capillary break. Typically, 50 mm (2") to 75 mm (3") diameter weep holes at 1.8 m (6') to 2.4 m (8') spacing are suitable, or as required by the geotechnical engineer and as acceptable to the structural engineer.

Note that, pending review by the geotechnical engineer, compacted clear crushed gravel placed beneath footings may also serve as a drainage pathway between the underslab drainage and the perimeter foundation drainage system (see **Figure 5.4**). If intended to be used for drainage, the gravel should be at least 100 mm (4") thick and underlain by filter fabric to reduce the risk of becoming clogged with fines.

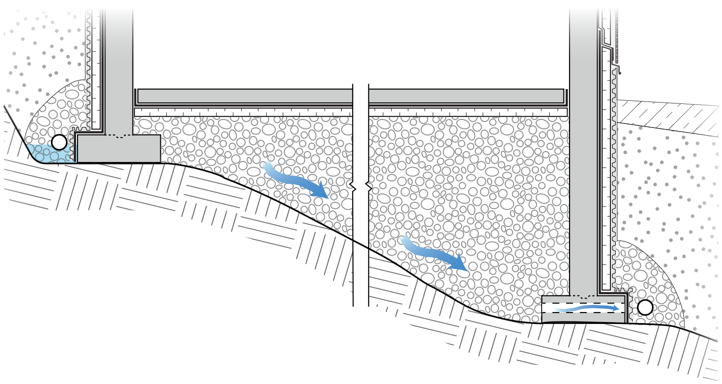


Figure 5.3 *Weep holes through the "downstream" side of the footing can be used as a drainage pathway from the underslab area to the foundation drainage system.*

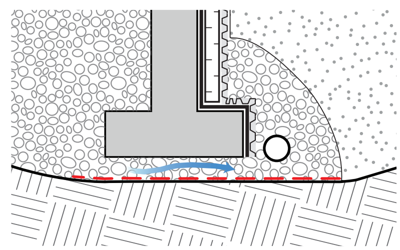


Figure 5.4 *Alternate drainage approach using compacted clear gravel beneath the footing with underlying filter fabric.*

5.3 Soil Gas Control

Careful consideration should be given to soil gas control in the design and construction of the slab assembly. Common types of soil gas encountered in B.C. include radon (produced by the decay of uranium in rocks) and methane (produced by decomposing organics, such as peat, municipal waste or sewage). Methane is colourless, odourless, and highly flammable; as it is lighter than air, it tends to rise, becoming trapped at the underside of floors and ceilings. Conversely, radon is heavier than air and will sink, accumulating in basements and crawlspaces. Radon has been linked to lung cancer and is a key concern where it can accumulate in enclosed spaces. Recent evidence indicates that radon gas may be more prevalent in B.C. than previously thought.

The BC Building Code contains requirements for the installation of soil gas control systems to protect conditioned (i.e., inhabited) space from soil gas that may be present in the ground beneath and around the building (Article 9.13.4.2.). Table C-4 in Appendix C of the BC Building Code indicates which areas of the province require a rough-in for a depressurization system to address radon. However, revisions to the Code have been challenged to keep pace with increasingly available radon data. According to Health Canada, the maximum allowable annual average for indoor radon concentrations is 200 Bq/m^3, but many areas of the province that exceed this guideline are not required by the BC Building Code to provide a means to address radon. Consequently, some local authorities have enacted their own soil gas control requirements. For more resources on radon control, see Section Additional Resources on page 67.

Air Barriers

The BC Building Code requires all wall, roof and floor assemblies separating conditioned (i.e., inhabited) space from the ground to be protected by an air barrier system (Article 9.13.4.2.(1)). An air barrier limits the flow of soil gas through the below-grade walls and floor. Impermeable polyethylene sheeting is often used as a barrier against moisture ingress, and it can double as an air barrier for slabs-on-grade (see Figure 5.6), provided that all seams are sufficiently lapped and sealed, all edges and penetrations are adequately sealed, and any damage to the sheeting that occurs during construction is repaired. For the foundation wall, the concrete is typically sufficient as an air barrier.

For pile-supported slabs, special attention must be paid to affixing the membrane to the underside of the concrete slab and adequately sealing any penetrations, including around all piles and at hangers for underslab services. This may require the use of proprietary products that include sealing accessories such as tapes, termination bars, and sealants. The chosen system should be reviewed by project engineers for project-specific considerations. Adhesion between the concrete slab and the HDPE sheet may be from a specialized chemical reaction or by mechanical means, and must be sufficient to allow the membrane to be supported regardless of potential soil settlement. For piles-supported slabs, a knowledgeable consultant should be involved in the design and construction of this assembly and surrounding components. For further guidance on slab assembly air barrier installation, see Section 6 | Building Enclosure on page 25.

Rough-ins

The rough-in for a depressurization system is intended to allow for future installation of an "active" system if required. The rough-in is also thought to be able to serve as a "passive" system, and helps to ensure the venting of soil gas from beneath the floor air barrier regardless of whether the gases are lighter or heavier than air. The system consists of an underslab gas-permeable layer connected to a vent pipe which terminates outside the building according to the requirements of Article 9.13.4.3., including with suitable offsets from windows, air intakes, property lines, etc. For radon, a powered "booster" fan is often recommended along the vent pipe to mechanically assist in effective depressurization. The underslab gravel layer can serve as the gas-permeable layer, but other proprietary systems, such as insulation with built-in bottom-facing voids, are also available. "Best practice" would be to install a perforated PVC pipe (with the perforations facing up for methane and down for radon) in all enclosed spaces beneath the slab (not just stubbed into gravel) and connected to the vent pipe to provide additional means for the collection and venting of soil gas (see **Figure 5.5**). This perforated pipe allows for better venting and some inspection/maintenance. Interior sumps should be avoided if possible as they may become potential sources of leakage if not properly sealed.

The current BC Building Code does not identify nor require that methane-prone areas include a rough-in for a depressurization system, but it is recommended as "best practice" in these areas to provide a rough-in as specified in the Code in order to limit the accumulation of methane beneath the building. Due to the fact that methane tends to rise, this system is also considered to more effectively function passively than with radon, especially if upward-sloping perforated pipes are provided in all enclosed areas beneath the slab. It is generally understood that methane may be produced in areas underlain by organic-rich soils. A geotechnical engineer will be able to provide insight regarding the locations of these ares, and many AHJs have maps of known areas underlain by organic soils.

Pipe Hangers

Stainless steel pipe hangers should be utilized to suspend ventilation and other pipes from the underside of pile-supported slabs in order to ensure design pipe grading is maintained.

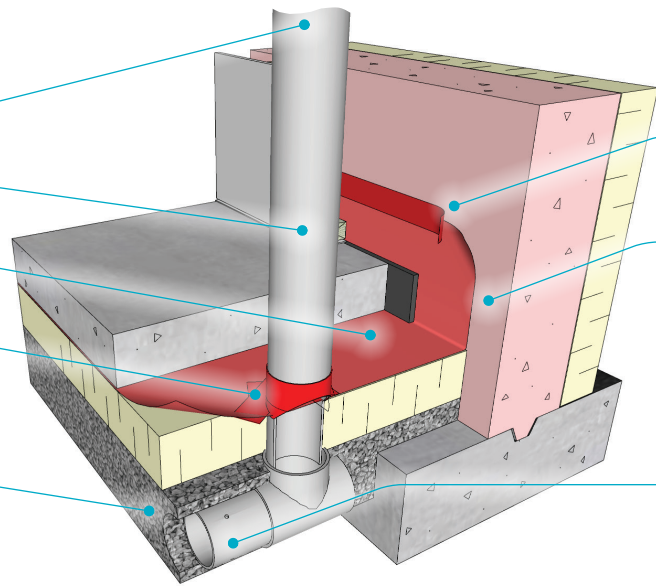


Figure 5.5 *Cutaway schematic illustration of typical "best practice" soil gas control/extraction components.*

Table 5.1 *Code requirements and associated "best practice" recommendations for underslab drainage and soil gas control.*

Code Requirements	Recommendations
9.16.2.1.(1). Except as provided in Sentence (2), a drainage layer shall be installed below floors-on-ground. 9.16.3.1.(1). Except as provided in Article 9.16.3.2. or where it can be shown to be unnecessary, ingress of water underneath a floor-on-ground shall be prevented by grading or drainage.	› Use clear crushed gravel with a gradation between 19 mm (3/4") and 25 mm (1"). › Use a minimum 100 mm (4") thick layer (up to 6" where possible) of clear crushed gravel under floor slabs, with at least 50 mm (2") on top of footings. › Prior to any placement of gravel, formwork, concrete, pipes or backfill, grade the excavation to allow for drainage towards the sump. This promotes drainage through the gravel beneath the slab in a favourable direction.
9.13.4.2.(1). All wall, roof and floor assemblies separating conditioned space from the ground shall be protected by an air barrier system conforming to Subsection 9.25.3. 9.13.4.2.(2). Except as permitted by Sentence (4), unless the space between the air barrier system and the ground is designed to be accessible for the future installation of a subfloor depressurization system, dwelling units and buildings containing residential occupancies shall be provided with the rough-in for a radon extraction system conforming to Article 9.13.4.3.	› The noted depressurization system is intended for areas where radon is envisaged to be present, but the definition of these areas is changing rapidly. › To address methane gas control, the involvement of a suitably qualified professional is recommended for sites with underlying soils that contain organic material. › A clear crushed gravel layer at the underside of the slab, in combination with a vent pipe to the outdoors, serves as a rough-in for a soil gas depressurization system. › A powered fan is recommended in the radon vent pipe to actively assist in effective depressurization.

6 | Building Enclosure

Key Points:

- The below-grade building enclosure is the last line of defense for groundwater control; even the most robust building enclosure assemblies will struggle to stop moisture leakage if adequate site, foundation and underslab drainage is not present.
- "Best practices" for design and construction of below-grade concrete enclosure assemblies includes:
  - Placing the footing concrete separately from the foundation wall with an appropriate water stop between them,
  - Using direct-applied dampproofing/waterproofing membrane and a dedicated drainage layer that includes filter fabric and extends to above grade, and
  - Using exterior rigid insulation and suitable terminations details.

The below-grade building enclosure controls moisture in all forms (groundwater, rain water, snow melt, vapour/condensation), air leakage and soil gas entry, and heat loss/gain. **Figure 6.1** provides a wayfinder tool for the typical enclosure components and assemblies covered in this section. Note that this section pertains to conventional construction techniques using shallow foundations/footings. In some conditions, the building foundation may be supported differently (e.g., on piles or raft footings) and may require specialized construction techniques which are not discussed herein; these projects typically require a team of professionals to provide recommendations in this regard.

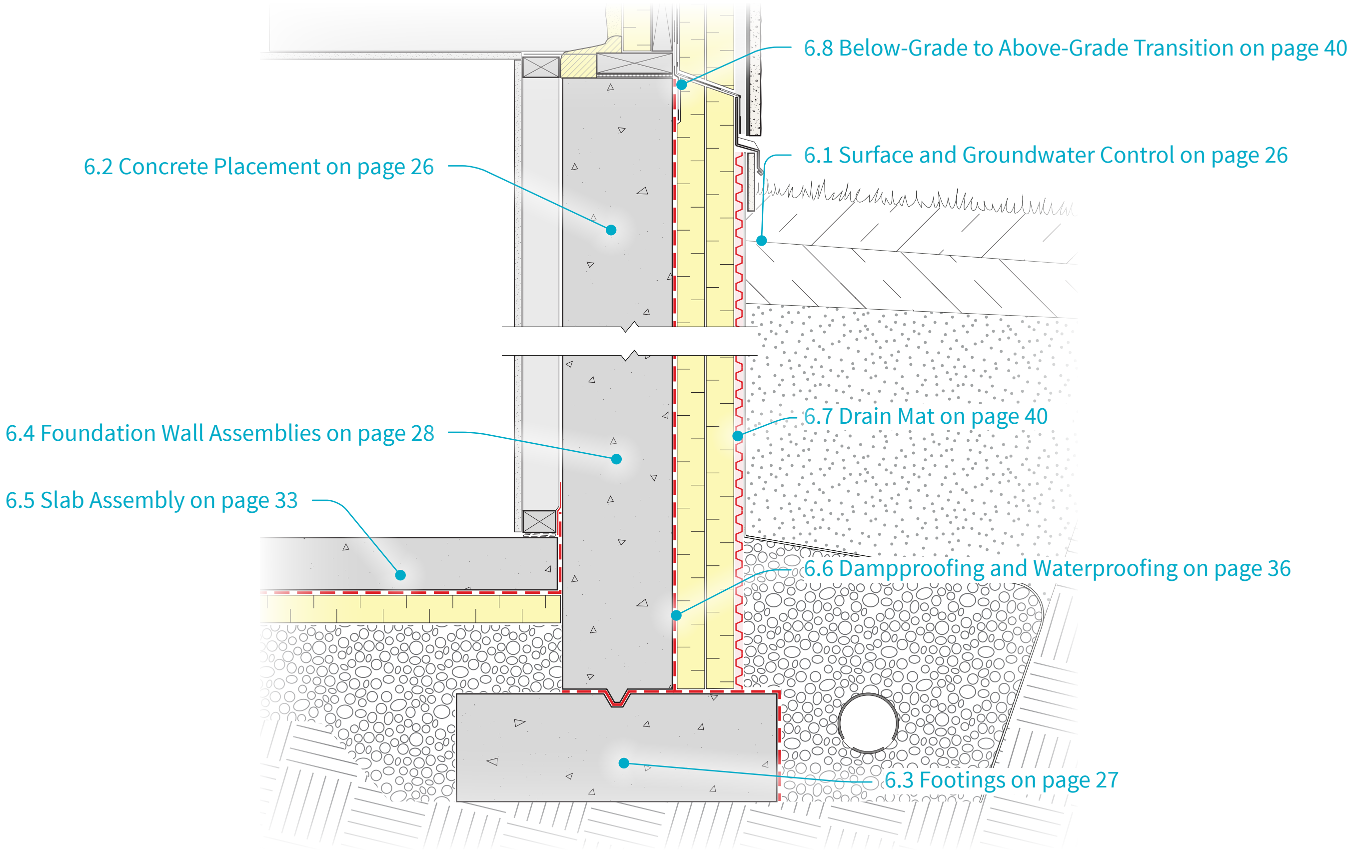


Figure 6.1 *Building enclosure assemblies and components wayfinder.*

6.1 Surface and Groundwater Control

The below-grade building enclosure is the last line of defense for groundwater control after site surface water management and foundation drainage. Site water management should aim to reduce the amount of water that will reach the building and thus its enclosure. For example, sloping backfill away from walls is an effective way to limit moisture exposure. Even the most robust building enclosure assemblies will struggle to stop moisture leakage if adequate site, foundation and underslab drainage is not present. Refer to Section 3 | Site Drainage on page 9, Section 4 | Foundation Drainage on page 15 and Section 5 | Underslab Preparation on page 21 for further information regarding both surface and groundwater control.

6.2 Concrete Placement

In addition to serving as the primary structural support of the building, the below-grade concrete itself often serves as an additional control layer beyond the dedicated materials and membranes. Well-consolidated concrete with limited cracks or voids is itself an excellent moisture barrier. While it is nearly impossible to avoid concrete cracking over the life of the building, utilizing an appropriate design mix and reinforcing steel, suitable consolidation techniques, and optimal placement/curing conditions can help produce concrete assemblies that are less prone to cracking and potential moisture ingress. The following steps should be taken when placing concrete:

- Use a concrete immersion vibrator and focus on areas with tight reinforcing, corners, and deep forms where consolidation may be challenging.
- Keep the concrete from curing too fast in hot weather by covering the pour and maintaining adequate moisture. Do not pour in freezing conditions.
- Provide crack control joints in foundation walls and slabs by installing reveals and including appropriately detailed construction joints. Ensure below-grade construction joints are well sealed using sealant or internal waterstops such as bentonite.

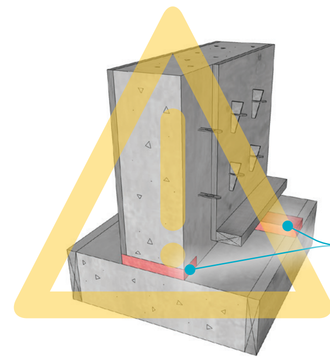


Figure 6.2 *Common practice formwork with cleats left in place after the formwork is removed may pose a long-term moisture ingress risk.*

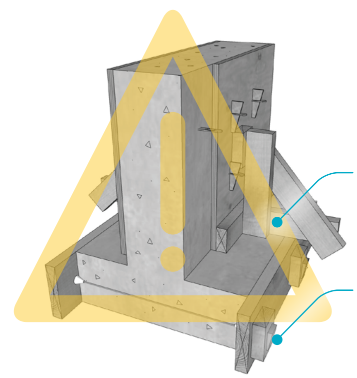


Figure 6.3 *Better practice formwork for monolithic foundation pours.*

Recommended Forming Practices

A condition to consider when placing concrete for monolithic foundations is the partially exposed footing formwork at the base of foundation wall, as shown in **Figure 6.2**. The exposed wood cleats will decay over time and could lead to water ingress below the foundation wall through openings left by the decomposing cleats, although the risk may be small depending on other footing characteristics and the slab elevation. These cleats can also make applying continuous dampproofing/waterproofing on the foundation's exterior difficult. A solution to maintain a monolithic pour is to use long form ties through the footing forms and support the wall formwork on brackets that rest on the footing perimeter forms (see **Figure 6.3).**

However, placing the footing concrete separately from the foundation wall and removing the cleats (or any other formwork that may interfere) before placing an appropriate capillary break and the foundation wall concrete above is "best practice" (see **Figure 6.4**).

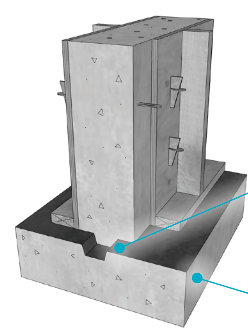


Figure 6.4 *"Best practice" formwork with footing and foundation wall concrete placed separately and waterstop/capillary break installed.*

6.3 Footings

Foundation footings are regularly exposed to groundwater. In some cases, footings will sit directly in contact with groundwater for extended periods of time, which can negatively impact the performance of the building enclosure. Placing the footing and foundation wall monolithically makes it difficult to prevent the moisture around and within the footing from reaching the foundation wall, unless a proprietary footing form "bag" is used, as with ICF systems, or the entire underside of the footing is dampproofed. Instead, a good way to prevent water from reaching the foundation wall through capillary action within the concrete (see **Figure 6.5**) is with a capillary break. Therefore, it is better to place the footing concrete separately from the foundation wall concrete; this separation allows the opportunity to install a capillary break between footing and foundation wall.

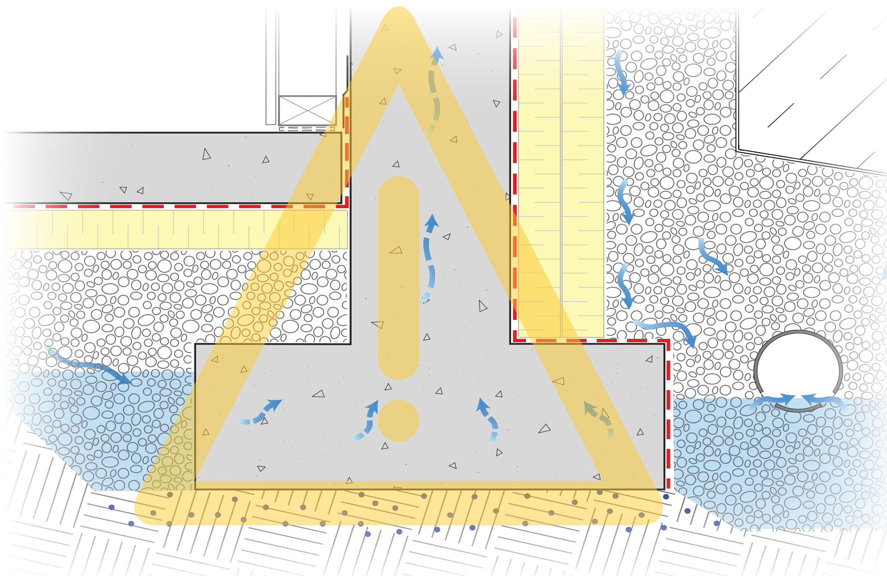


Figure 6.5 *Typical footing and foundation wall poured without a capillary break can be at risk of 'rising damp' within the foundation wall.*

Capillary Break

It is recommended for "best practice" that an impermeable capillary break comprised of a continuous liquid-applied dampproofing or waterproofing membrane be installed between the top of the footing and the foundation wall, especially where partially saturated backfill conditions exists or where significant amounts of water are expected at the footing (see **Figure 6.4** and **Figure 6.7**). The exact specifications of this material should be discussed with the structural engineer since it is located at a sensitive structural connection, but a typical spray-applied dampproofing membrane will often suffice. Liquid-applied membranes are easier to install around reinforcing that protrudes from the footing. This impermeable material helps to reduce the direct uptake of moisture from the potentially wet footing into the foundation wall (i.e., rising damp). This can result in a drier foundation wall and may help protect interior components from moisture damage. Alternately, a capillary break could be installed around the entire footing (such as where exterior insulation is used below the footing). However, this will require a professional to evaluate potential structural and geotechnical implications.

Rising Damp is a physical phenomena in which water travels up through pours in a material due to capillary action. The maximum height of rising damp is dependent on the material pore size and the rate of evaporation from the interior surface of the concrete foundation wall. Rising damp can cause groundwater to travel through the footing and foundation wall and up into the living space above, possibly leading to building damage and unhealthy moisture conditions.

Note that the capillary break is most effective when the perimeter foundation drain pipe is installed below the top of the footing (see **Figure 6.6** and **Figure 6.7**), since water should not be able to rise above the footing before being drained away. See also Section 5.2 Footing Weep Holes on page 22 for more details on providing a drainage pathway around or through the footing.

Another moisture control strategy is to place the footing itself on compacted clear crushed gravel bedding, which can also provide some capillary separation between the soil and the underside of the footing, provided this gravel is not submerged.

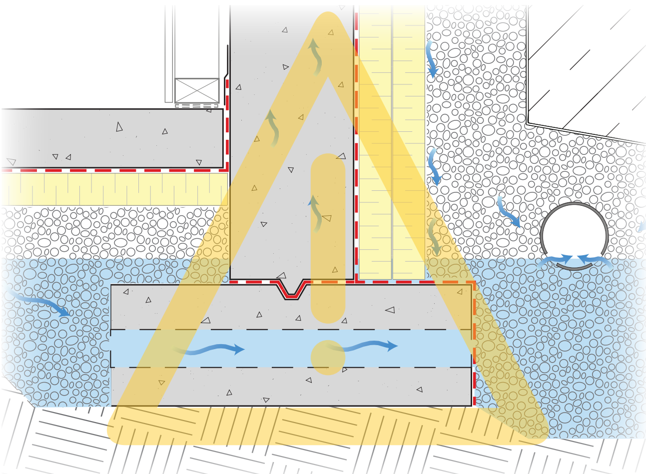


Figure 6.6 *Poor practice: foundation drain pipe installed above the capillary break, potentially allowing the foundation wall to become wet resulting in rising damp.*

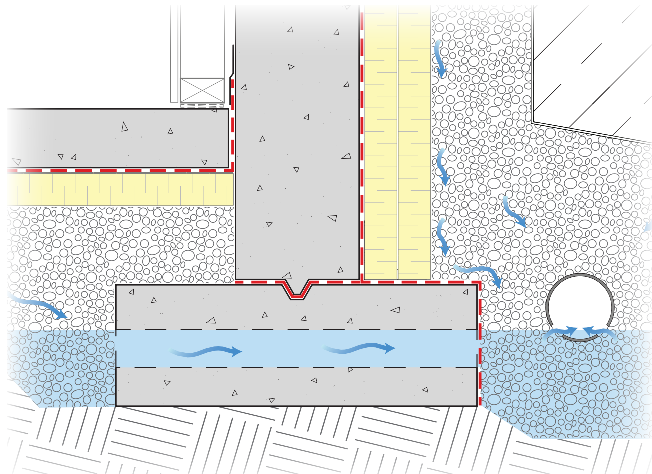


Figure 6.7 *"Best practice" foundation, with capillary break between the footing and foundation wall (requires two pours and the removal of formwork cleats) and positioning of the drain pipe below the top of the footing.*

6.4 Foundation Wall Assemblies

The concrete foundation wall provides several important control functions: it must provide sufficient means of deflection and drainage of incoming site moisture and adequate watertightness against moisture that comes into direct contact with its surface, as well as control of heat and air flow with thermal insulation and airtightness.

There are three general categories of below-grade wall assemblies that are typically used for foundation walls. They are distinguished by the placement of the insulation in relation to the concrete wall:

- **Exterior-Insulated**, with all or most insulation placed against the exterior face of the wall (i.e., outside),
- **Interior-Insulated**, with all or most insulation placed against the interior face of the wall, and
- **Insulating Concrete Forms**, with the foam formwork on both sides of the foundation wall left in place after the concrete is poured to serve as the assembly's insulation.

While all control functions are required for each wall type, insulation placement dictates many of the design and construction constraints. The following pages outline the key components and performance factors for each assembly type. For more guidance on the selection of below-grade foundation wall assembly types, see the BC Housing guides listed in Additional Resources on page 67 of this guide. See 6.6 Dampproofing and Waterproofing on page 36 for more details on the variables that determine what level of moisture protection is needed in the below-grade assemblies.

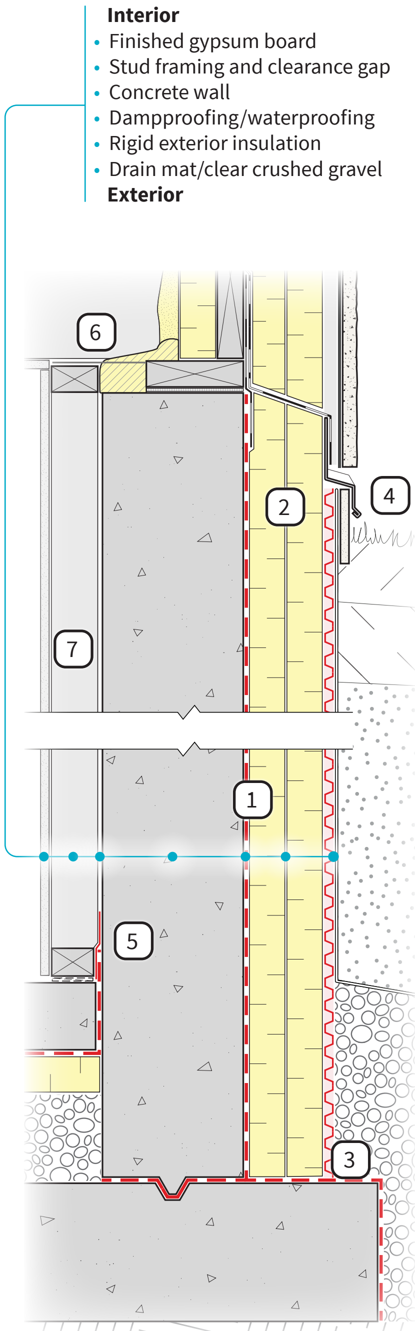


Figure 6.8 *"Best practice": exterior-insulated foundation wall.*

Exterior-Insulated Foundation Wall

This below-grade wall assembly includes rigid insulation placed on the exterior of the concrete foundation wall. A wood stud wall is often constructed on the interior side of the concrete wall to provide room for building services. High effective R-values of the assembly are achieved by using continuous exterior insulation outside of the concrete structure. The insulation product used in this arrangement must be highly moisture tolerant and suitable for below-grade applications. In cold climates, insulation placed on the exterior of the wall allows the concrete to remain warm and consequently often reduces the risk of condensation and associated damage to moisture sensitive interior wall components and finishes. Drainage is provided at the exterior of the insulation to manage hydrostatic pressure on the wall assembly and reduce the risk of water ingress. This is one of the most durable foundation wall assembly configurations and is considered "best practice" for below-grade insulated foundation walls.

Key Design and Construction Considerations (see Figure 6.8):

1. The dampproofing/waterproofing should be applied directly to the concrete wall. The exterior insulation, followed by the drain mat and/or free-draining backfill should be used as the drainage medium and capillary break to protect the assembly.

2. Various types of insulation can be used including extruded polystyrene (XPS), high density expanded polystyrene (EPS) and rigid mineral wool. It is important that the selected insulation product be extremely moisture tolerant as it can potentially be exposed to significant wetting in this below-grade application. The exterior insulation in this assembly will maintain the concrete structure closer to indoor temperatures, consequently reducing the risk of condensation and associated damage.

3. Extending the exterior insulation down to the footing level provides sufficient thermal continuity for the floor slab, and a slab edge thermal break is not necessary (see Slab Insulation on page 34).

4. Where present, the drain mat should continue above-grade and be protected with a durable, UV-resistant cover material (see 6.8 Below-Grade to Above-Grade Transition on page 40).

5. The underslab polyethylene sheet should be sealed directly to the concrete wall to provide airtightness and soil gas control. Where required, a sealant joint should be installed between the floor slab and the foundation wall.

6. Spray foam insulation applied at the floor rim joist should be installed in direct contact with the top of the concrete wall (see 6.8 Below-Grade to Above-Grade Transition on page 40).

7. No interior insulation or vapour control layer is necessary since all insulation is placed at the exterior. The interior framing should be spaced away from the face of the concrete.

For information on termite control refer to Chapter 6 of the *Building Enclosure Design Guide Wood-Frame Multi-Unit Residential Buildings*, published by BC Housing.

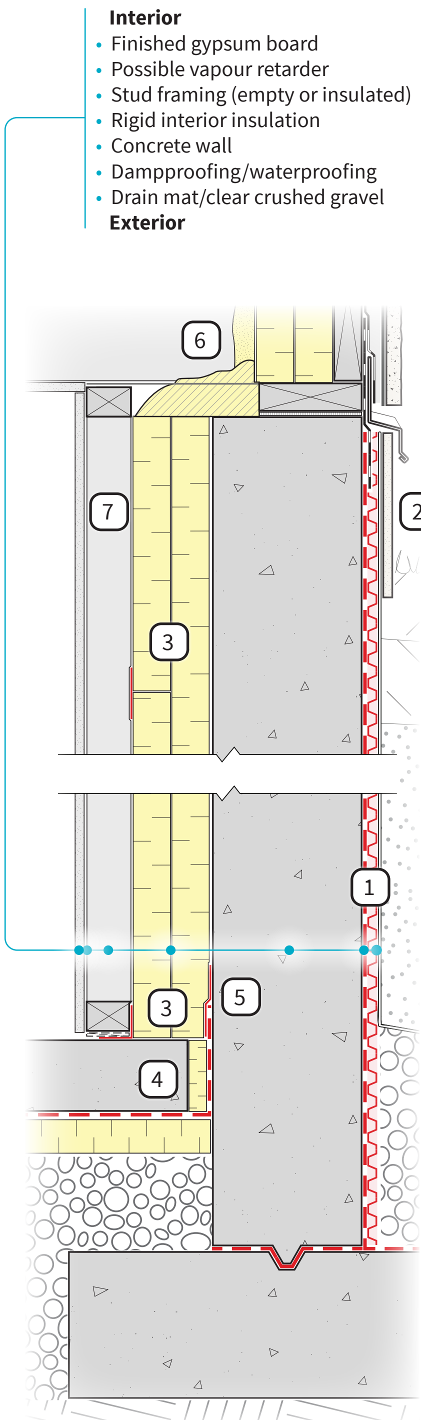


Figure 6.9 *Better practice for conventional interior-insulated foundation wall.*

Interior-Insulated Foundation Wall

This below-grade wall assembly is commonly used in BC and includes rigid or spray-applied, air-impermeable, moisture tolerant insulation placed on the interior of the concrete foundation wall. High effective R-values for interior-insulated assemblies are achieved by using continuous insulation placed between the concrete foundation wall and an interior stud-framed wall. Placement of insulation on the interior of the concrete foundation wall results in cooler interior concrete surface temperatures and consequently an increased risk of condensation on this surface and associated damage. A robust interior air barrier should be installed to limit this risk. This can be in the form of air-impermeable rigid interior insulation with all seams and edges sealed. Interior-insulated assemblies may have higher risk of the foundation wall concrete freezing and spalling, especially in colder climates. This risk can be mitigated by the use of appropriate concrete admixtures and air entrainment.

Key Design and Construction Considerations (see Figure 6.9):

1. The dampproofing/waterproofing should be applied directly to the concrete wall, and the drain mat and/or free-draining backfill should be used as a drainage medium and capillary break to protect the assembly.
2. Where present, the drain mat should continue above grade and be protected with a durable, UV-resistant cover material (see 6.8 Below-Grade to Above-Grade Transition on page 40).
3. Extruded polystyrene (XPS), expanded polystyrene (EPS) with low permeance interior facer, and closed-cell spray polyurethane foam insulation are typically most appropriate for this application because they are insensitive to potential moisture within the concrete and are relatively air- and vapour-impermeable. Permeable insulation products are not appropriate unless other airtightness and vapour control measures are used. When using rigid foam board insulation, the joints, penetrations, and perimeter edges must all be sealed for airtightness.
4. A slab edge thermal break is needed when interior insulation is used (see Slab Insulation on page 34).
5. The underslab polyethylene sheet should be sealed directly to the concrete wall to provide airtightness and soil gas control. Where required, a sealant joint should be installed between the floor slab and the foundation wall.
6. Sprayfoam insulation applied at the floor rim joist should be installed in direct contact with the top of the concrete wall and interior insulation (see 6.8 Below-Grade to Above-Grade Transition on page 40).
7. No dedicated vapour control layer is necessary when low-permeance insulation is used at the interior face of the concrete wall. If higher permeance insulation is used or if the stud cavity is insulated, an airtight smart vapour retarder should be used behind the interior finish.

Traditional Approach

Many below-grade interior-insulated walls in BC have used only batt insulation between wood-framing and with a polyethylene sheet used to provide air and vapour control. However, this assembly has been found to be at risk of having high humidity levels within the stud cavity and with no way to dry effectively, especially for high R-value walls.

Foundation Wall Formed with Insulating Concrete Forms (ICF)

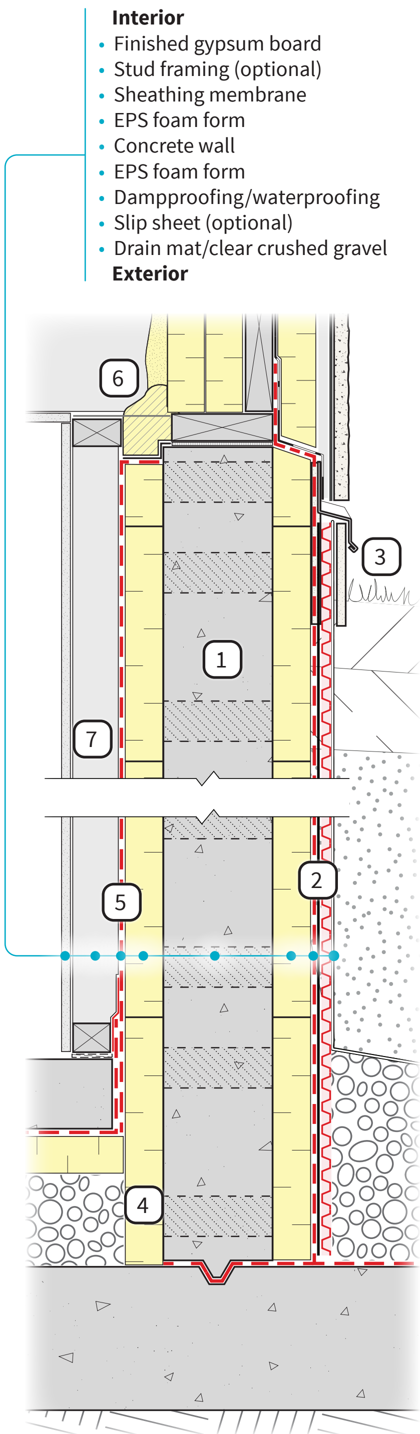


Figure 6.10 *ICF foundation wall.*

Insulating Concrete Forms (ICFs) are comprised of manufactured interlocking modular formwork made of rigid expanded polystyrene (EPS) insulation. Once assembled, these forms are filled with concrete and remain in place to provide insulation for the assembly. High effective R-values of the assembly are achieved by the combination of the continuous interior and exterior formwork layers. The dampproofing or waterproofing material is applied directly to the exterior insulation material. Interior finishes can be installed either directly against the foam using built-in flanges in the ICF (channels in the ICF foam can be used to provide a space for services), or with an interior stud wall.

Key Design and Construction Considerations (see Figure 6.10):

1. Proprietary ICF systems are used for this assembly, and the manufacturer's installation requirements must be followed.
2. The dampproofing/waterproofing should be applied directly to the exterior face of the ICF per Article 9.13.2.3. The membrane and adhesives used must be compatible with the EPS foam, which is sensitive to solvents. Water-based, spray-applied or self-adhered membranes should be used. Drain mat and/or free-draining backfill should be used as a drainage medium and capillary break, although the softer EPS substrate must be protected from potential damage or impressions from membrane dimples. This is often achieved using a slip sheet at the exterior face of the dampproofing/waterproofing.
3. Where present, the drain mat should continue above grade and be protected with a durable, UV-resistant cover material (see 6.8 Below-Grade to Above-Grade Transition on page 40).
4. The ICF down to the footing level provides sufficient thermal continuity for the floor slab, and a slab edge thermal break is not necessary (see Slab Insulation on page 34).
5. The underslab polyethylene sheet should be sealed(for airtightness and soil gas control) either to the concrete wall directly using a cutout in the ICF or to a dedicated interior air barrier over the face of the ICF.
6. Sprayfoam insulation applied at the floor rim joist should be in direct contact with the top of the concrete wall and interior ICF foam form insulation, or an alternate air barrier transition must be used (see 6.8 Below-Grade to Above-Grade Transition on page 40).
7. No additional interior insulation or vapour control layer is necessary. The interior finishes can be installed directly at the interior face of the foam by attaching them to the form ties (ICF system-specific). These interior finishes could be used as the airtight layer in the assembly if installed and detailed correctly. If neither the concrete nor the interior finishes are detailed and installed as airtight, a dedicated air barrier is required as shown.

Footings for ICF systems often use a integrated polyethylene bag as the formwork in monolithic pours. This approach can compromise the friction at the underside of the footing which may be a critical factor for seismic sliding resistance of some buildings on sloping sites. Structural and geotechnical engineers should be consulted.

Table 6.1 *Code requirements and associated "best practice" recommendations for forming footings and foundation walls.*

Code Requirements	Recommendations
9.15.3.2.(1) Footings shall rest on undisturbed ***soil, rock*** or compacted granular ***fill***.	"Best practice" is that footings rest on undisturbed soil.
9.13.2.5.(1) The interior surface of foundation walls below ground level shall be protected by means that minimize the ingress of moisture from the foundation wall into interior spaces, where a) separate interior finish is applied to a concrete or unit masonry wall that is in contact with the soil, or b) wood members are placed in contact with such walls for the installation of insulation or finish.	Do not place interior finishes or untreated wood members directly against concrete or unit masonry foundation walls that are in contact with the exterior soil. "Best practice" is to always separate wood members from the foundation wall and use preservative-treated wood where it must contact the below-grade concrete.
9.13.2.5.(2) Except as provided in Sentence (3), where the protection of interior finishes required in Sentence (1) consists of membranes or coatings, a) the membrane or coating shall extend from the basement floor surface up to the highest extent of the interior insulation or finish, but not higher than the exterior finished ground level, and b) no membrane or coating with a permeance less than 170 ng/(Pa·s·m2) shall be applied to the interior surface of the foundation wall above ground level between the insulation and the foundation wall.	Follow Code requirements where applicable. See previous for "best practice" for protection of interior wood.
9.13.2.5.(3) Where insulation functions as both moisture protection for interior finishes and as a vapour barrier in accordance with Subsection 9.25.4., it shall be applied over the entire interior surface of the foundation wall.	Ensure the interior insulation is installed continuously and is fully taped and sealed, including at perimeter edges and at penetrations.
9.13.2.3.(3) Where the dampproofing material is to be applied on insulating concrete form (ICF) walls, the instructions of the ICF wall manufacturer shall be followed.	Follow the ICF manufacturer's instructions for the application of dampproofing onto the ICF.
9.13.3.3.(2) Where the waterproofing material is to be applied on ICF walls, the instructions of the ICF wall manufacturer shall be followed.	Follow the ICF manufacturer's instructions for the application of waterproofing onto the ICF.

6.5 Slab Assembly

The floor slab assembly generally has fewer design and construction variables than the foundation wall assembly, although it must be carefully designed and constructed to provide the same control functions. Code requirements for when and how the slab is insulated and made airtight are important to understand. **Table 6.2 on page 35** outlines the Code requirements for slab assemblies and associated "best practice" recommendations. The slab assembly must always include a drainage layer, an air barrier, a dampproofing or waterproofing layer, and a vapour control layer. In some cases soil gas control and a thermal insulation layer are also required. **Figure 6.11** shows the basic exterior-insulated concrete floor slab assembly and its components.

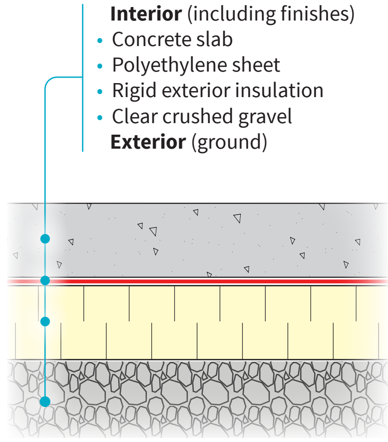


Figure 6.11 *Typical exterior-insulated floor slab assembly components.*

In this approach, the polyethylene sheet beneath the concrete slab provides most of the necessary control functions, and therefore is one of the most important aspects of the assembly. Code minimum requirements for this assembly include:

- Dampproofing (where applicable); Under Article 9.13.2.6. of the BC Building Code, 0.15 mm (6 mil) polyethylene sheet lapped at least 100 mm (4") can serve as the dampproofing.
- Air Barrier; Under Article 9.25.3.6., polyethylene sheet lapped 300 mm (12") can serve as the air barrier.
- Vapour barrier; Under Article 9.25.4.2., polyethylene sheet that has a permeance of less than 60 ng/(Pa·s·m^2) (approximately 1 US Perm) can serve as the vapour barrier.
- Soil Gas Control; Under Article 9.13.4.2., the air barrier may serve as the soil gas control layer.

Because of the importance of this layer, the Code minimum requirements for each of these control functions could be improved upon in order to make a more durable and higher-performing assembly. A thicker and more robust polyethylene sheet is recommended for increased protection. Additionally, simply lapping the polyethylene sheet beneath the slab is not a reliable method of achieving good continuity, especially for airtightness and soil gas control. Instead, the laps should be fully sealed with a compatible sealant and/or tape, including around all penetrations and at the perimeter. At the perimeter, the slab air barrier transition to the wall air barrier depends on the assemblies used, but should include at least a robust sealant joint. Where possible, the polyethylene sheet should be directly adhered to the foundation wall concrete (see **Figure 6.12** and **Figure 6.13**).

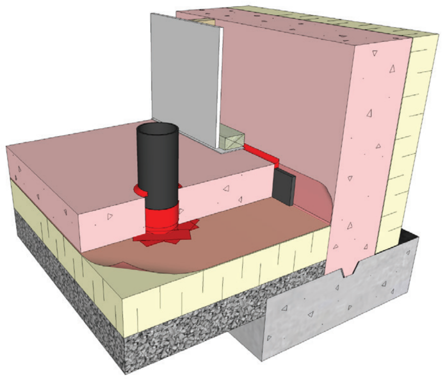


Figure 6.12 *Good practice air barrier transition using sealant at the polyethylene sheet and slab (slab used as part of air barrier).*

RED = AIRTIGHT LAYER

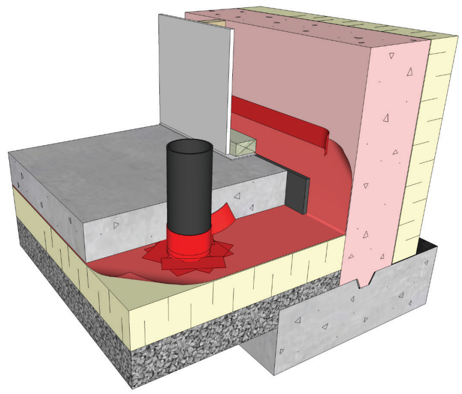


Figure 6.13 *"Best practice" air barrier transition using high-performance tape and the slab polyethylene sheet as the dedicated air barrier.*

Slab Polyethylene

The material itself should be thicker than 6 mil (i.e., six thousandths of an inch). A thicker material such as 12 mil or 15 mil polyethylene is recommended so that it can hold up to potential damage/abrasion during construction and when concrete is poured on top of it. However, selecting a membrane that is excessively thick might be difficult to install and could pose challenges when attempting to seal folds and penetrations. Therefore, a thickness in excess of 15 mil may not be practicable. It is Code compliant to place the polyethylene sheet dampproofing/air barrier/vapour barrier above the concrete floor slab, though this is not recommended.

Slab Assembly Material Compatibility

It is critical to the long-term success of the assembly that all materials being used for the underslab barrier (i.e., membrane, tape, mastic, termination bars, insulation, etc) are compatible with each other. This can be confirmed by the manufacturer(s).

Slab Insulation

Per Sentences 9.36.2.8.(4),(5),(6) and (7) of the BC Building Code, prescriptive floor slab insulation requirements vary depending on if it is a heated slab and also where it is situated in relation to the frost line. For heated slabs the entire underside area of the slab must be insulated (regardless of the frost line) including at the slab edge (see **Figure 6.14** and **Figure 6.15).** Unheated slabs above the frost line must be partially insulated at the perimeter edge of the slab. There are several possible insulation configurations for this condition, all clearly illustrated in the Notes to Part 9 of the Code (see **Table 6.2** and Sentence A-9.36.2.8.(4)). Unheated slabs below the frost line do not require insulation.

These minimum prescriptive Code requirements can be easily met and exceeded, especially in light of the performance-based energy requirements of the BC Energy Step Code: insulating the entire underside of the unheated slab with 50 mm (2") of rigid insulation (i.e., insulating it like a heated slab, see figures below) is an excellent way to improve the overall thermal efficiency and comfort of the living space and can help achieve the performance-based minimum Code energy requirements.

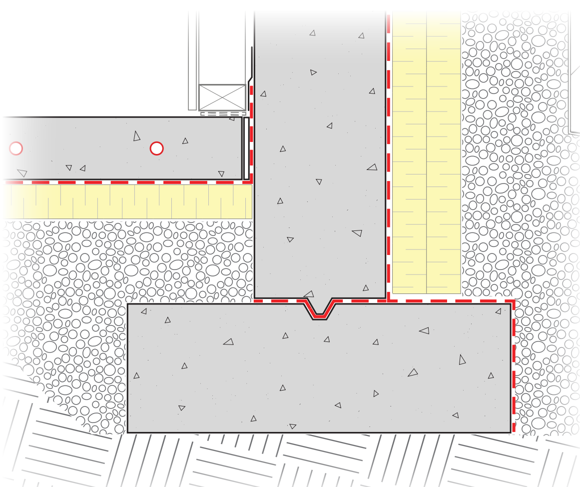


Figure 6.14 *Insulation placement requirements for heated slabs where exterior wall insulation is used.*

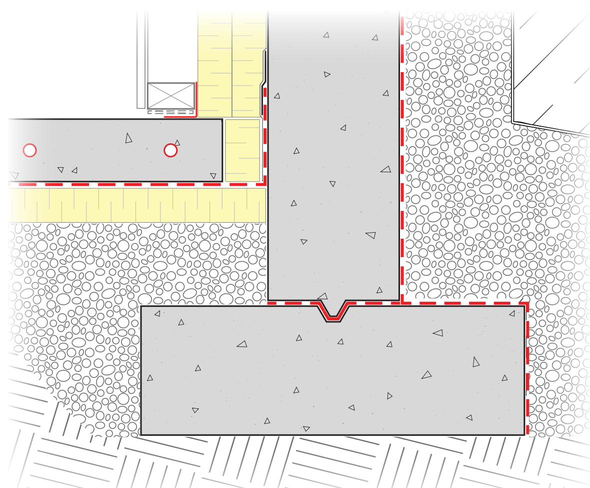


Figure 6.15 *Insulation placement requirements for heated slabs where interior wall insulation is used.*

Table 6.2 *Code requirements and associated "best practice" recommendations for slab assemblies.*

Code Requirements	Recommendations
9.13.2.6.(1) Where dampproofing is installed below the floor, it shall consist of: a) polyethylene not less than 0.15 mm thick with joints lapped not less than 100 mm, b) type S roll roofing with joints lapped not less than 100 mm, or c) rigid extruded/expanded polystyrene with sealed or ship-lapped joints that have i) sufficient compressive strength to support the floor assembly, and ii) a water vapour permeance complying with Clause 9.13.2.2.(2)(a).	The minimum BC Building Code requirement allows for a 6 mil polyethylene sheet that is resistant to soil gas/radon. Better practice is to install a thicker (e.g., 12-15 mil) sheet, which is more durable and less easily damaged during construction. This should be lapped at least 100 mm (4", or according to the manufacturer's recommendations, whichever is greater), taped at the seams, and sealed at penetrations and at its perimeter with a compatible sealant/tape product.
9.16.4.3.(1) Concrete slabs shall not be less than 75 mm thick exclusive of concrete topping.	The minimum recommended slab thickness is 100mm (4"), which is common practice in B.C.
9.16.4.4.(1) A bond-breaking material shall be placed between the slab and footings or rock.	Bond breaker such as asphalt impregnated fiber board or rigid insulation should be used between the slab edge and the concrete foundation wall, and the slab should be placed on gravel above the footing.
9.25.3.6.(3) Where the air barrier installed below a floor-on-ground is flexible sheet material, joints in the barrier shall be lapped not less than 300 mm. (See Note A-9.25.3.6.(2) and (3).)	The air barrier below the slab should be lapped at least 300mm and also be sealed.
9.36.2.8.(4) Unheated floors-on-ground that are above the frost line and have no embedded heating pipes, cables or ducts shall be insulated to the effective thermal resistance required in Table 9.36.2.8.-A or 9.36.2.8.-B a) on the exterior of the *foundation* wall down to the footing, or b) on the interior of the *foundation* wall and, as applicable, i) beneath the slab for a distance not less than 1.2 metres (4 ft) horizontally or vertically down from its perimeter with a thermal break along the edge of the slab that meets at least 50% of the required thermal resistance, ii) on top of the slab for a distance not less than 1.2 metres (4 ft) horizontally from its perimeter, or iii) within the wooden sleepers below the floor for a distance not less than 1.2 metres (4 ft) horizontally from its perimeter.	Follow the Code, where possible use exterior insulation beneath the slab and consider insulating the entire slab.
9.36.2.8.(5) Except as provided in Sentence (6), floors-on-ground with embedded heating ducts, cables or pipes shall be insulated to the effective thermal resistance required in Table 9.36.2.8.-A or 9.36.2.8.-B under their full bottom surface including the edges.	Follow the Code, fully insulate the underside of the slab.

6.6 Dampproofing and Waterproofing

The dampproofing/waterproofing material at the exterior face of the foundation wall and slab is intended to be the primary building enclosure moisture barrier to prevent water ingress, and must be chosen for the moisture conditions to which it will be exposed.

Unlike above-grade assemblies, water can be held against the below-grade assemblies for extended periods, and in some cases for the entire service life of the building. **Table 6.3** on the following page outlines Code requirements for below-grade moisture protection and associated best-practice recommendations. The Design Matrix in **Table 6.4 on page 38** and **Table 6.5 on page 39** provides details on typical dampproofing and waterproofing products currently available.

Installation

Correct installation of the various dampproofing and waterproofing products is key to their success, especially with liquid-applied products that must be applied on site since they can't rely on the quality assurance from ready-to-install factory-made products.

The BC Building Code specifically refers to manufacturers' installation instructions as the source for information regarding the surface preparation and application requirements of the proprietary products (9.13.2.3. and 9.13.2.4. for dampproofing, 9.13.3.3. and 9.13.3.4. for waterproofing), including but not limited to:

- surface priming;
- conditions during application;
- number of layers and reinforcing;
- application quantity and rate; and
- curing times.

The product manufacturer or their local technical representatives should be the first point of contact for guidance on using these products. It is recommended that records of any internet-sourced technical literature be downloaded and retained on file, including information regarding prescribed installation methodologies.

Concrete additives such as hydrophilic crystalline admixture are sometimes used to improve a concrete's water resistance. This approach should only be used with direction from a suitably qualified enclosure consultant. The Section 9.13 of BC Building Code does not currently list this system as a dampproofing or waterproofing material.

The following definitions are for the terms used in **Table 6.4** (see **page 38**):

Cast or cast-in-place concrete refers to concrete that is placed by casting it onsite within formwork in its final location.

Shotcrete, gunite, or sprayed concrete refers to concrete or mortar that is placed by spraying it from a hose at a high velocity onto a surface and does not require formwork.

Backfill refers to the construction methodology where waterproofing or dampproofing can be applied from the exterior to the concrete after the concrete has been placed and cured. This approach facilities direct access to the exterior of the below-grade walls.

Blindside or **pre-applied** refers to waterproofing or dampproofing that is applied from the interior to an excavation soil retention system, shoring wall, or rock before placing the concrete against it. Blindside is commonly used on buildings built close to property lines or where access to the exterior of the below-grade walls is limited.

Table 6.3 *Code requirements, Code interpretation and associated "best practice" recommendations for dampproofing and waterproofing.*

Code Requirement	Code Interpretation	Recommendations
9.13.2.1.(1) Except as provided in Article 9.13.3.1., where the exterior finished ground level is at a higher elevation than the ground level inside the ***foundation walls***, exterior surfaces of ***foundation*** walls below ground level shall be dampproofed. 9.13.3.1.(1) Where hydrostatic pressure occurs, waterproofing is required for assemblies separating interior space from the ground to prevent the ingress of water into ***building*** assemblies and interior spaces. For reference, the applicable non-Part 9 requirements include: 5.7.3.4.(1) Vertical building assemblies that separate interior space from the ground are permitted to be dampproofed where a) such assemblies are not subjected to hydrostatic pressure, b) the substrate is cast-in-place concrete, and c) a drainage layer is installed between the ***building*** assembly and the ***soil***.	The Part 9 Code requirements set out two distinct pathways for below-grade moisture protection; either using dampproofing (9.13.2.), where the assembly is below the exterior finished grade, or waterproofing (9.13.3.), where a hydrostatic pressure occurs. These two categories have distinct moisture exposure characteristics which are interpreted as follows: › **Dampproofing**: where surface drainage is good, groundwater levels are below the foundation and floor slab, and water is not expected to be in long-term contact with the assembly under any significant pressure (i.e., no hydrostatic pressure). This scenario is the most common for most part 9 buildings. › **Waterproofing**: where the ambient water table is higher than the below-grade assemblies, and where water is expected to be in long-term contact with the enclosure under hydrostatic pressure from the height of surrounding water. The below-grade wall and floor assemblies can be considered to be submerged. This scenario is less common in small buildings, and requires careful design and construction practices.	While the two BC Building Code categories offer a clear distinction between the scenarios, they do not capture the more complex site conditions that may exist in wetter sites that don't have a hydrostatic head but still may have saturated conditions depending on the site layout, site drainage and groundwater conditions. The BC Building Code does not provide a definition of hydrostatic pressure, and this term has become jargon in the industry. Therefore, rather than the two Code-specific moisture exposure conditions, it is recommended that the moisture protection of the below-grade assemblies be considered under the following **three** design categories (see also **Table 6.4**): › **Optimally drained conditions**: At sites where site and foundation drainage is good and the surrounding backfill is free-draining and not expected to hold significant amounts of water (e.g., clear crushed gravel). Standard spray-applied or roll-on dampproofing applied to the exterior surface of the concrete foundation wall, along with the appropriate joint and crack control details, and adequate vertical drainage provisions leading to perimeter footing drains is recommended. › **Partially saturated conditions**: Where backfill against foundation walls is poorly drained and is moist/damp and site drainage is not ideal (common if site soil is used as backfill), 'partially saturated' conditions may exist adjacent to foundation walls. Even though hydrostatic pressures are not present (i.e., the building is not submerged and there isn't a head of water against the foundation wall), and foundation drainage is installed, the walls may be subject to increased pressure due to 'wet' soil conditions. In these scenarios it would be prudent to use a higher quality membrane such as multiple layers of asphalt-based coating, or self-adhered bituminous waterproofing membrane. Where possible, free-draining backfill is recommended to minimize the potential for partially saturated soil conditions (see Section 7 | Backfill on page 47). › **Hydrostatic/Submerged conditions:** This occurs where there is a high water table usually with high soil permeability, resulting in 'submerged' conditions. The assemblies in this scenario must be fully tanked and made waterproof using high-quality, fully-bonded systems like roofing membranes or high-density polyethylene sheets. Under these severe conditions, the below-grade assemblies can be thought of as the hull of a ship under water, and the structure needs to be designed to resist bouyant (uplift) forces. Where hydrostatic pressure is present, building enclosure, structural, and geotechnical engineers should be involved.

Table 6.4 *Dampproofing product selection matrix*

	Dampproofing (Optimally Drained)		Non-Tankable Waterproofing (Partially Saturated)		
Product	**Asphalt Cutback**	**Asphalt Emulsion Dampproofing (Thin Application)**	**Liquid Applied**	**Self-Adhered Modified Bitumen Sheets**	**Asphalt Emulsion Waterproofing (Thick Application)**
Description	› Solvent based bituminous liquid membrane › Typically spray- or roller-applied	› Bituminous liquid membrane suspended in water › Typically spray- or roller-applied	Liquid- or spray-applied bitumen membrane modified with polymers for elasticity and puncture resistance	Factory-manufactured, self-adhered bituminous sheet waterproofing modified with polymers for elasticity and puncture resistance	Asphalt emulsion, applied thicker than the dampproofing application and with reinforcement to meet waterproofing requirements
Recommended Application	Relatively dry soil conditions with well drained backfill and dedicated drainage layer (drain mat or clear crushed gravel drainage chimney)		Moderate moisture environments, dedicated drainage layer recommended (drain mat or clear crushed gravel drainage chimney)		
Thickness	10-30 mils	20-50 mils	+50 mils	60 mils	60-80 mils
Concrete and Membrane Application	Cast,Backfill	Cast/Shotcrete, Backfill/Blindside	Cast/Shotcrete, Backfill/Blindside	Cast,Backfill	Cast/Shotcrete, Backfill/Blindside
Concrete Cure Time	0 days		Varies	10-28 days	0 days
Membrane Reinforcement	Unreinforced	Unreinforced	Varies	Integral reinforcement facer	Fully embedded reinforcing fabric recommended
Benefits	› Can be installed at temperatures below freezing	› Light crack bridging potential	› Cold weather application available › Light crack bridging potential when reinforcing	› High solids content › Can bridge large cracks › Easier to install than heat-welded membrane › Factory-manufactured sheets provide enhanced quality assurance	› Medium crack and bug hole bridging potential
Limitations	› Releases VOCs › Low solids content › Does not span cracks or bug holes in concrete	› Must install above 5°C › Low solids content › Does not span cracks or bug holes in concrete	› Performance varies significantly between products due to different chemical compositions	› Attention to penetration detailing required › Must be applied on dry concrete	› Must install above 5°C › Low solids content › Reinforcing fabric is prone to installation error that can lead to 'blisters' › Prone to varying application making contractor experience vital
Required	Except as provided in Article 9.13.3.1., where the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls, exterior surfaces of foundation walls below ground level shall be dampproofed (Sentence 9.13.2.1.(1)).				

Table 6.5 *Waterproofing product selection matrix*

	Tankable Waterproofing (Fully Submerged/Hydrostatic) Professional Involvement Recommended			
Product	**Asphalt Emulsion Waterproofing with HDPE Liner**	**Torch-Applied Modified Bitumen**	**Bentonite Sheets**	**Pressure-Adhered Thick HDPE Membrane**
Description	Asphalt emulsion waterproofing installed with continuous HDPE liner for additional water resistance	Factory-manufactured heat welded bituminous sheet waterproofing modified with polymers for elasticity and puncture resistance	Clay composite sheet waterproofing which absorbs water and swells to form an impermeable layer	Fully-adhered composite sheet membrane comprised of a thick HDPE liner and a pressure sensitive adhesive
Recommended Application	High moisture environments or temporary low intensity hydrostatic pressure anticipated	High moisture environments or sustained hydrostatic pressure anticipated	High moisture environments or sustained hydrostatic pressure anticipated	High moisture environments or sustained hydrostatic pressure anticipated
Thickness	80 mils + liner	115 mils	250 mils	30-50 mils
Concrete and Membrane Application	Cast/Shotcrete, Backfill/Blindside	Cast/Shotcrete, Backfill/Blindside	Cast/Shotcrete, Blindside	Cast/Shotcrete, Blindside
Concrete Cure Time	0 days	10-28 days	0 days	0 days
Membrane Reinforcement	Fully embedded reinforcing fabric recommended	Integral reinforcing within bitumen	Integral geotextile liner, HDPE liner recommended	Continuous HDPE sheet membrane
Benefits	› High crack and bug hole bridging potential › HDPE liner is waterproofing layer	› High solids content › Fully adhered, can bridge large cracks › Heat-welded laps › Recommended for tanking applications › Factory manufactured sheets provide enhanced quality assurance	› High solids content › Recommended for tanking applications › Factory manufactured sheets provide enhanced quality assurance	› Laps become continuous with pressure › Fully adhered, can bridge cracks
Limitations	› Must install above 5°C › Heat welded HDPE laps required, otherwise weak points › Reinforcing fabric is prone to installation error resulting in blisters	› Attention to penetration detailing required › Vertical torch application requires highly skilled trades that are not commonly available for Part 9 construction	› Attention to penetration and lap detailing required › Skilled application by experienced trade required › Shotcrete application heavily dependent on quality and finish of shoring wall construction › Blindside application adds difficulty to application	› Attention to penetration and lap detailing required › Blindside application adds difficulty to installation
Required	Where hydrostatic pressure occurs, waterproofing is required for assemblies separating interior space from the ground to prevent the ingress of water into *building* assemblies and interior spaces (Sentence 9.13.3.1.(1)).			

6.7 Drain Mat

At the exterior of the dampproofing or waterproofing on the concrete (or exterior insulation when present), a robust drainage material should be installed to "shed" and direct any intercepted water towards the perimeter drainage system. This typically consists of a proprietary drain mat or free draining clear crushed gravel at the outside perimeter of the foundation wall (i.e., clear crushed gravel drainage chimney).

Drain mat generically describes either dimpled high-density plastic (also referred to as dimple mat) or woven mesh geotextile membranes (see **Figure 6.16**). Although there are finite limits to the design life of these products, better product choices incorporate filter fabrics or redundant layers to reduce the risk that the drain mat drainage characteristics are compromised over time. Certain products may have testing reports to demonstrate that they provide similar levels of performance to 'Code-minimum' dampproofing membranes, which may negate the requirement for a separate dampproofing membrane. However, reliance on these proprietary products as dampproofing should be carefully considered, with records kept of all technical information and AHJ approvals.

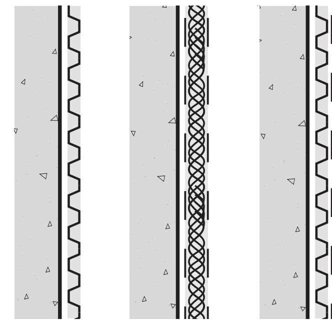


Figure 6.16 *Schematic section view illustrations of dimple mat (left), geotextile (centre), and dimple mat with filter fabric (right).*

The "best practice" approach for dampproofing applications is to use a dedicated dimple mat with filter fabric at the exterior face. The filter fabric's compatibility with adjacent backfill should be checked to reduce the risk of clogging. If there is no filter fabric, ensure the dimples are facing the foundation wall, to avoid potential clogging of the interstitial drainage path from the backfill. Alternately, a clear crushed gravel drainage chimney can be used as the drainage medium in lieu of drain mat, with adequate protection provided to limit potential damage to the below-grade membrane. This is a robust approach for the longterm drainage capability, although it must be done carefully to prevent damage to the below-grade membrane. See Section 7 | Backfill on page 47.

6.8 Below-Grade to Above-Grade Transition

Proper detailing at the top of the foundation wall just above grade is critical to the performance of the below-grade enclosure and to reduce the amount of surface water that can enter the below-grade drainage and dampproofing/waterproofing layers. This detailing is also important to protect sensitive components from potential UV exposure and physical damage.

As discussed in Section 3 | Site Drainage on page 9, surface grading should be down and away from the building at a minimum of 2% slope and extended past the backfill zone. Proper surface grading helps drain surface water away from the foundation wall and building enclosure assembly layers. Where the backfill is free-draining as recommended, an impermeable soil layer (e.g. 'clay cap') or concrete may be installed at the surface of the backfill to limit surface water infiltration into the drainage system.

Per Sentence 9.27.2.4.(1), a minimum distance of 200 mm (8") is required from the finished ground to the bottom of cladding that is adversely affected by moisture. This is to provide additional protection against water entry into the building and to protect the cladding from moisture. Additionally, per Sentence 9.15.4.6.(1), exterior foundation walls must extend a minimum distance of 150 mm (6") above the finished ground level. When a drain mat is utilized, it should extend above grade up to the wall cladding and be protected by parging, concrete board, flashing, or another suitable finish, and should be terminated under a flashing (see **Figure 6.17**).

Alternately, if the drain mat does not extend above-grade, it should be terminated along its top edge with a termination bar and sealed to the foundation wall to prevent water and debris from getting behind it. The exposed concrete above should be parged, painted, or sealed with an appropriate concrete sealer (see **Figure 6.18**).

Note that below-grade walls that include an empty interior stud cavity require a fire block between the wall and floor assembly. Article 9.10.16.2. of the BC Building Code addresses this requirement for Part 9 buildings and permits the use of sheet metal, as shown. For more guidance on below-grade to above-grade transitions, see the detailing resources listed in the Additional Resources on page 67.

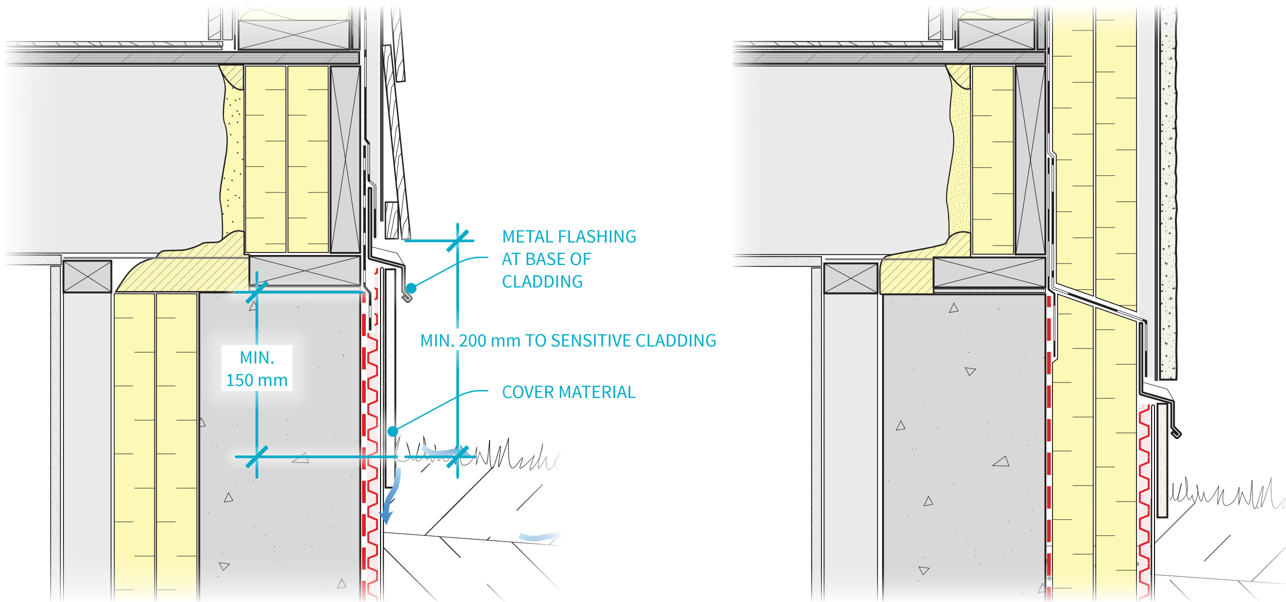


Figure 6.17 *"Best practice": Drain mat that extends above grade must be protected with a suitable UV-resistant and durable material.*

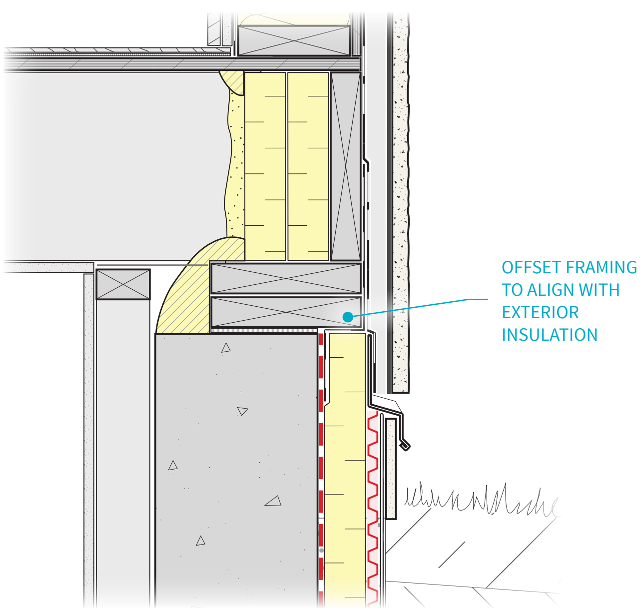


Figure 6.18 *Conventional above-grade walls could be offset over exterior-insulated below-grade walls to align the drainage and finish surfaces.*

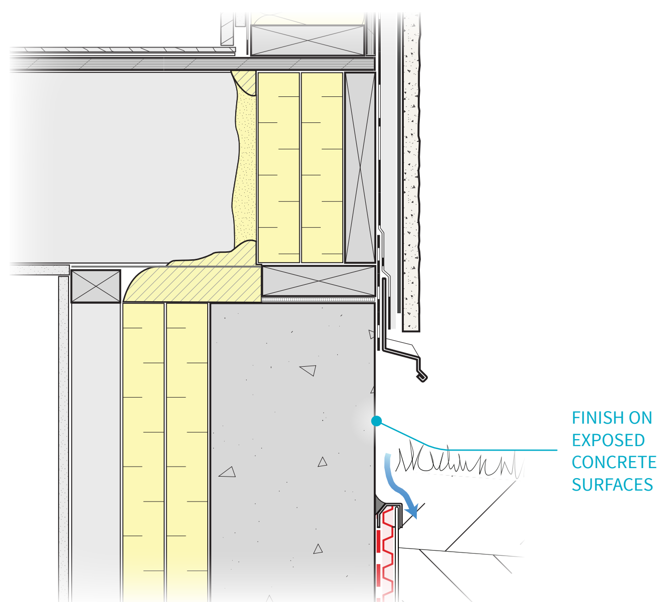


Figure 6.19 *When the drain mat ends below grade, it is important to install the mat with a termination bar sealed to the substrate, and to coat any exposed concrete.*

6.9 Window Wells

Window wells allow windows to be installed in otherwise below-grade walls by holding back the surrounding grade, and providing both a potential means of egress and a light well down to the window. While the exposed portions of the foundation wall should be coated or painted (see **Figure 6.19**), there are several unique design and construction challenges around window wells which. If they are overlooked, they can become a major source of leakage and damage to the wall assembly.

The window well structure can be made of cast-in-place concrete or concrete masonry units (see **Figure 6.20)**, or can be a manufactured product. Timbers or dimension lumber are not recommended for this purpose since damage over the long term from direct prolonged exposure to the ground/moisture is difficult to protect against.

As per Sentence 9.14.6.3.(1), all window wells must be drained to the footing level or other suitable location. A surface drain and free-draining backfill should be used beneath the window well opening, as shown in **Figure 6.20** and **Figure 6.21**. Hard-piping this drain to the foundation or roof drainage system is recommended per "best practice", and allows the system to be maintained.

Window well perimeter terminations and window detailing require careful planning as well as quality control during construction. The window well structure should be installed after the dampproofing/waterproofing is applied to the adjacent foundation wall. It should be noted that the connection between the window well and the wall can become a source of moisture ingress if the reinforcing penetrations are not adequately sealed. Drain mat can also be installed to offer additional protection at this joint.

At the window opening, a wood buck is often installed to size the rough opening in the concrete and allow window attachment. However, the interface between the wood buck and the concrete is highly prone to water ingress if not properly detailed. Where possible, avoid using a wood frame around the window; instead form the opening in the concrete to the dimensions of the window's rough opening. Sealing the window perimeter directly to the concrete dampproofing/waterproofing is the most durable approach and reduces the number of transitions. Where this is not possible, a robust, self-adhered membrane should be installed between the foundation wall over the wood frame, and extending into the window's rough opening using correct surface preparation and priming if needed. Consider using a torch-applied membrane for improved adhesion and durability (see **Figure 6.21** and **Figure 6.22**).

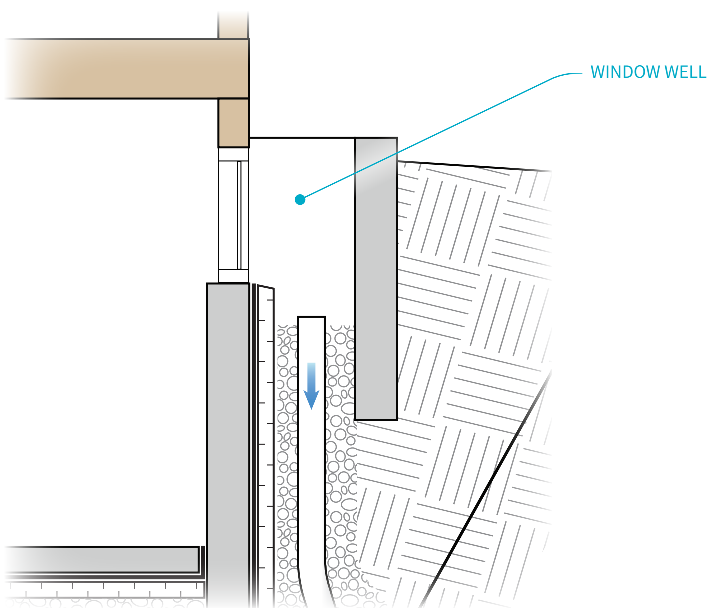


Figure 6.20 *Schematic section view of a typical window well.*

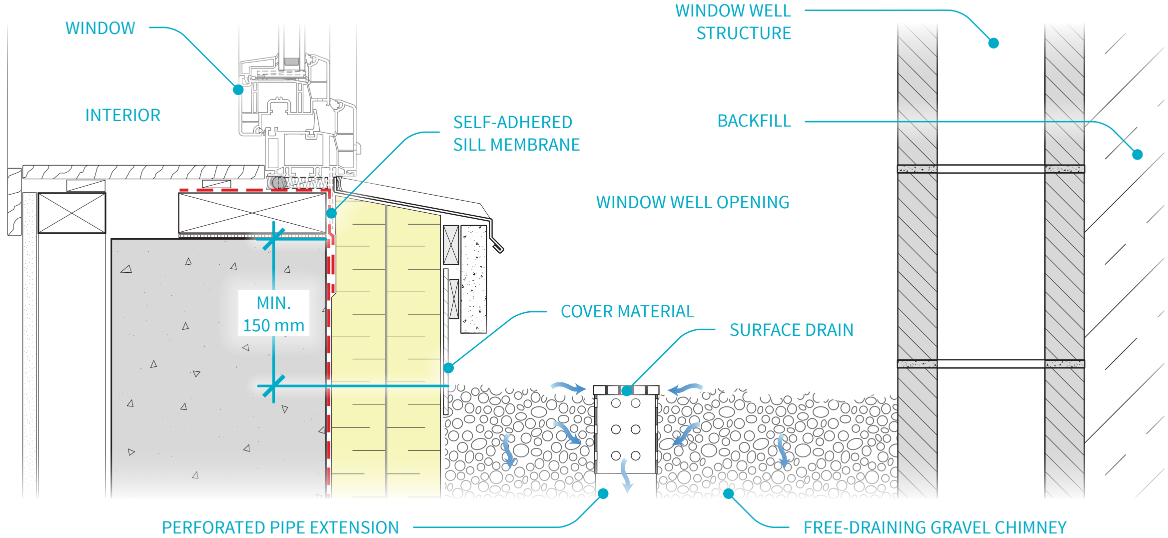


Figure 6.21 *Window well section showing free-draining gravel and surface drain connected to foundation drain complete with perforated pipe extension (section view).*

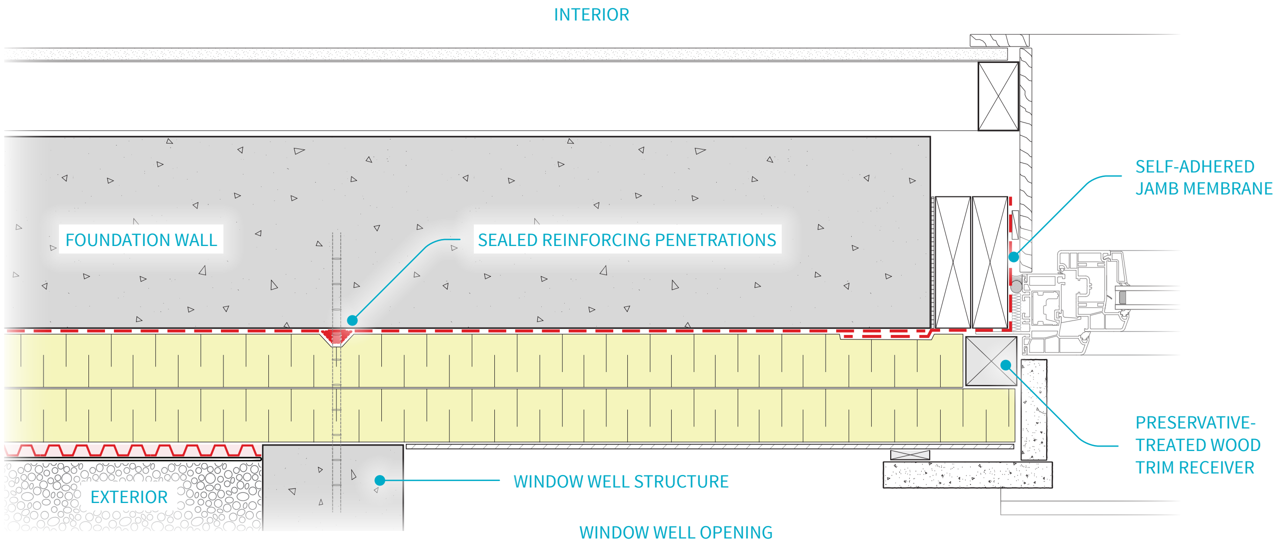


Figure 6.22 *Window well termination and jamb detail (plan view).*

Table 6.6 *Code requirements and associated "best practice" recommendations for window wells.*

Code Requirements	Recommendations
9.14.6.3.(1). Window Wells Every window well shall be drained to the footing level or other suitable location.	A surface drain and free-draining backfill should be used beneath the window well opening. Hard-piping drain to foundation or roof drainage system is recommended and allows for the system to be maintained.

6.10 Fasteners and Penetrations

The robustness of the fastener and penetration seal detail is dependent on the surrounding soil/groundwater conditions (i.e., Optimally Drained, Partially Saturated or Fully Submerged/Hydrostatic). For effective watertightness of below-grade assemblies, it is crucial that all penetrations are sealed directly to the wall dampproofing/waterproofing (per 9.13.2.4(3) and 9.13.3.4 (2)). A secondary seal can also be made between the penetrating component and the drain mat, in order to help reduce the amount of water that reaches the wall dampproofing/waterproofing (see **Figure 6.23**). The materials and details used to seal fasteners and penetrations must be carefully chosen with regard to material compatibility and adhesion. Additionally, all fastener and penetration materials must be corrosion resistant in order to reduce the likelihood of corrosion resulting in discontinuities in the dampproofing/waterproofing, and possible water ingress.

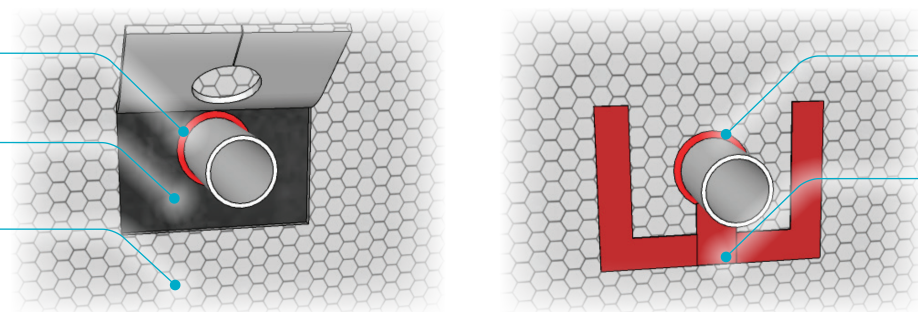


Figure 6.23 *Recommended "best practice" foundation wall penetration sealing approach, with a seal installed both directly at the dampproofing/waterproofing (left) and at the drain mat, where present (right).*

Drain Pipes

A rain water leader (RWL) for each portion of gutter is recommended to be directed to solid drain pipes (e.g., dual pipe systems) (see 8.1 Drainage from Impermeable Surfaces on page 50). These solid drain pipes are part of the storm drainage system described in BC Plumbing Code Article 2.3.4.6. which requires that these pipes be supported on a base that is firm and continuous under the whole pipe. or by using hangers fixed to the foundation or structural slab. Where hangers are used, they must be capable of keeping the pipe in alignment and supporting the weight of the pipe, its contents, and the fill above.

"Best Practice" Installation

In most cases, it is recommended that the solid drain pipe be supported on well-compacted backfill (spaced away from the surface of the foundation wall), as shown in **Figure 6.24**. This should be designed to support the weight of the pipe when full of water, and the backfill above it. Some benefits of this installation method include:

- No need for straps and fasteners to support the drain pipe, reducing the number of fastener penetrations in the building enclosure requiring sealing work.
- Drain pipes are not suspended and at risk of being loaded by the weight of backfill above, potentially damaging the membrane.
- Drain pipes can be offset from the foundation wall allowing for better drainage between the pipe and the wall.

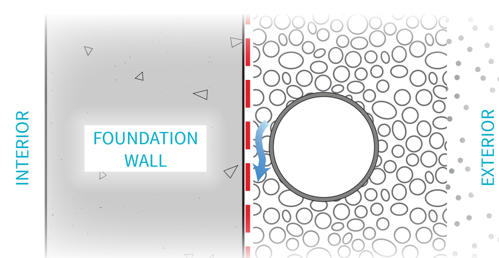


Figure 6.24 *"Best practice" solid rain water leader drain pipe installation, supported by compacted backfill/gravel (section view).*

On the other hand, this approach may require two plumbing inspections: one for the foundation drain pipe (perforated) and one for the roof water drain pipe (solid). It may also involve more complex sequencing of below-grade work. Furthermore, adequate compacting is required to reduce the risk of settlement which can lead to 'bellies' and/or breaks in the pipe.

Typical Installation

Where drain pipes are secured directly to the foundation wall with straps and fasteners per Article 2.3.4.6.(2) of the BC Plumbing Code (see **Figure 6.25**), the following should be considered:

- Straps that support the pipe must be fastened to the concrete, puncturing the dampproofing/waterproofing. This results in multiple fastener penetrations that all need to be sealed in some way. This can be particularly difficult if drain mat is installed instead of a clear crushed gravel drainage chimney.
- Drain pipes are usually placed directly against the foundation wall, potentially impeding drainage between the pipe and the wall dampproofing/waterproofing.
- The settlement of the backfill placed around and beneath the drain pipe can lead to the solid pipe supporting a zone of backfill above it.
- Solid drain pipes secured by galvanized straps are prone to damage during construction and/or placement of backfill. This damage can result in the fasteners pulling out of the concrete, thereby causing discontinuities in the dampproofing/waterproofing, and increasing the risk of water ingress.

A possible solution when using a clear crushed gravel drainage chimney is to intermittently shim the drain pipe off the wall. This would allow for better drainage between the pipe and the wall (see **Figure 6.26** top). Alternatively, if drain mat is used, drainage is already achieved between the pipe and the wall. However, the galvanized straps and fasteners used to support the pipe should be sealed to the exterior of the drain mat as best as possible (see **Figure 6.26** bottom).

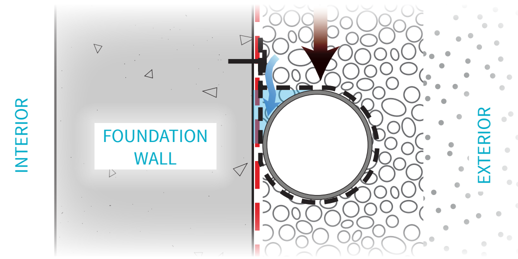


Figure 6.25 *Typical solid rain water leader drain pipe installation method (section view)*

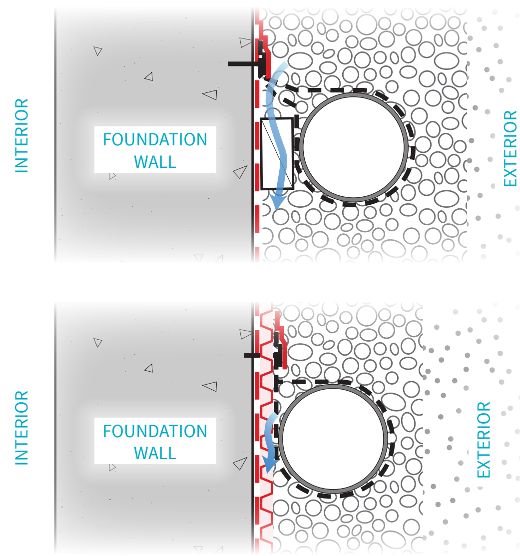


Figure 6.26 *Improved drain pipe support options, with drainage allowed behind the pipe through blocking or drain mat (section view).*

Table 6.7 *Code requirements and associated "best practice" recommendations for rain water leader drain pipes.*

Plumbing Code Requirements	Recommendations
2.3.4.6. Support for Underground Horizontal piping 1) Except as provided in Sentence (2), nominally horizontal piping that is underground shall be supported on a base that is firm and continuous under the whole of the pipe. (See Note A-2.3.4.6.(1).) 2) Nominally horizontal piping installed underground that is not supported as described in Sentence (1) may be installed using hangers fixed to a foundation or structural slab provided that the hangers are capable of a) keeping the pipe in alignment, and b) supporting the weight of i) the pipe, ii) its contents, and iii) the fill over the pipe	These pipes should be supported on a base that is firm and continuous under the whole pipe These pipes can be supported by hangers fixed to the foundation or structural slab. Where hangers are used, they must be capable of keeping the pipe in alignment and supporting the weight of the pipe, its contents and the fill above.

This page is intentionally left blank

Key Points:

- Foundation walls should be backfilled with well-graded, free-draining soil containing less than 8% fines.
- "Best practice": use clear crushed gravel, with a gradation between 19 mm (3/4") and 25mm (1"), for at least the backfill directly against (i.e., within 300–600 mm (12–24")) of the foundation wall.

7.1 Foundation Walls

Generally, soil with more than 8% fines by weight is considered frost susceptible, as it can retain enough moisture to heave during the freeze-thaw cycle. Therefore, foundation walls should be backfilled with free draining soil containing less than 8% fines (i.e., less than 8% passing the #200 sieve) to limit the moisture retained in the soil particles near the foundation wall. This backfill should also be well-graded, and a drain mat should be installed at the exterior of the foundation wall (or exterior insulation, as shown in **Figure 7.1**). If the soil excavated from a given site (site spoil) meets these criteria, it may be suitable for re-use as backfill against foundation walls. Note that "river sand" is not considered to be well graded, and can be prone to erosion.

The recommended "best practice" for foundation backfill is to use clear gravel. Clear gravel is considered to be free-draining and is a proven and preferred material used for drainage purposes, such that it eliminates the need for a drain mat. Clear gravel backfill should be used in areas where significant drainage is required, as a "drainage chimney" against a portion of the foundation wall (see **Figure 7.2**), or to replace the regular backfill (see **Figure 7.3**). Clear gravel may be angular (preferred), or rounded, and should have relatively uniformly sized particles with a negligible content of fine materials.

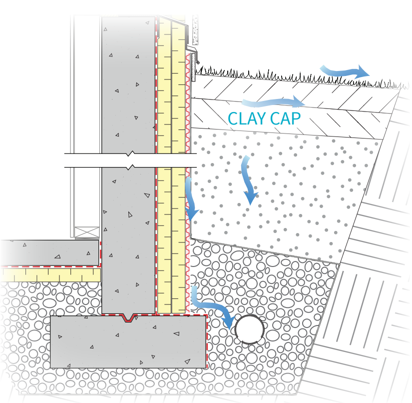


Figure 7.1 *"Clean", well-graded backfill with drain mat.*

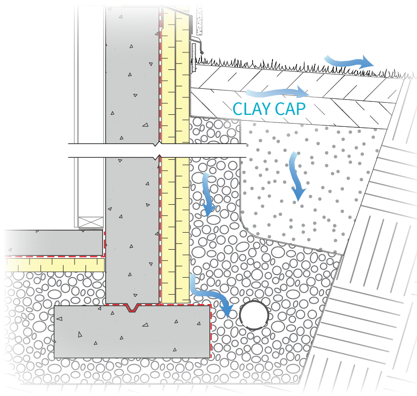


Figure 7.2 *"Best practice" gravel drainage chimney.*

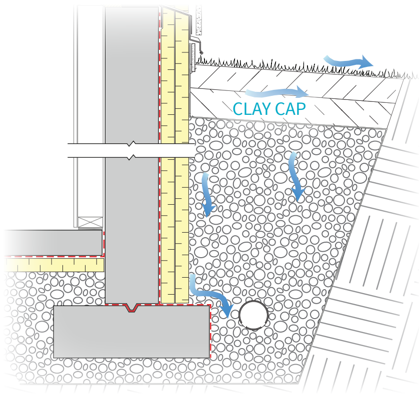


Figure 7.3 *"Best practice" full gravel backfill.*

Backfill areas at the foundation wall perimeter may be topped with an impermeable layer to reduce direct surface water infiltration into the below-grade and foundation drainage system. This can comprise an impermeable sidewalk or a "clay cap" beneath the topsoil (as shown in the figures above). This clay cap will be frost susceptible if situated above the frost depth. The clay cap is recommended to be roughly 100 mm (4") thick and sloped a minimum 2% away from the building. The clay cap may be overlain with growing medium, that is also sloped away from the building.

7.2 Filter Fabric

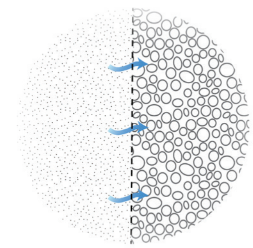


Figure 7.4 *Filter fabric inhibiting the migration of soil particles while allowing water to pass.*

Filter fabric is a generic term used to describe geotextiles with a primary function of allowing water to pass through while inhibiting migration of soil particles. Filter fabric or a mineral filter should be used around gravel to reduce the amount of fines that are able to enter and potentially clog it. For best effect, the filter fabric should completely surround the gravel, with large overlaps.

Filter fabric should not be directly wrapped around perforated drainage pipes - this may promote clogging between the pipe and the filter fabric, decreasing the pipe's effectiveness. Nonwoven filter fabrics are typically preferred for drainage purposes. Filter fabric specification is dependent on soil gradation; this can be provided to a geotechnical engineer for evaluation of compatibility.

7.3 Utility Trenches and Other Underground Conduits

Utility trenches or other backfilled excavations throughout a site can act as underground flow paths. Although not regulated by the Building Code, it is considered "best practice" to minimize the risk of these pathways directing water into the foundation wall backfill zone. This can be done by:

- Grading the base of trench excavations for buried services to slope away from the building
- Backfilling with select well-graded soil
- Compacting, using suitable compaction equipment, in appropriate lift thicknesses
- Using a seepage collar in trenches at strategic locations if necessary (see Figure 3.3 on page 11)

Table 7.1 *Code requirements and associated "best practice" recommendations for backfill.*

Code Requirements	Recommendations
9.12.3.1.(1). Backfill shall be placed to avoid damaging the foundation wall, the drainage tile, externally applied thermal insulation and waterproofing or dampproofing of the wall.	› Before backfill is placed, ensure fill material is free of large rocks, organic material, and construction debris. Placement and compaction of backfill should be done in lifts. Lift thicknesses are based on the material and the compaction equipment being used, and as required to achieve specified compaction. Only lightweight compaction should be used in close proximity to foundation walls; a 1000 lb plate tamper is recommended. › Dumping backfill against the foundation wall assembly can cause damage and should be avoided. Methodically placing and compacting the backfill in lifts will minimize the risk of damage to the foundation wall assembly.
9.12.3.2.(1). Backfill shall be graded to prevent drainage towards the foundation after settling.	› Refer to Section 3 | Site Drainage on page 9
Per 9.14.4.1.(1)a, granular material used for drainage purposes is specified to have "not more than 10% of material that will pass a 4 mm sieve".	Clear gravel with a gradation corresponding to 100% passing the 25 mm (1") sieve and 100% retained on the 13 mm (1/2") or 19 mm (3/4") sieve, is expected to provide greater void volume and a longer design life in many applications where 'clear' gravel is a design element.

8 | Stormwater Management and Discharge

Key Points:

- Wherever possible, discharge should be by gravity.
- Pipes managing rainwater runoff should be installed as high as possible (but below the frost penetration depth) in order to increase the feasibility of gravity discharge.
- Roof runoff should never be directed to foundation drains.
- Avoid splash pads next to buildings walls.

Stormwater management is relied upon to control the water at a site, and the consideration of a discharge location is important for the long-term performance of the system. **Figure 8.1** provides a wayfinder tool for the different stormwater management features covered in this chapter (see also 3.1 Subsurface Drainage on page 9).

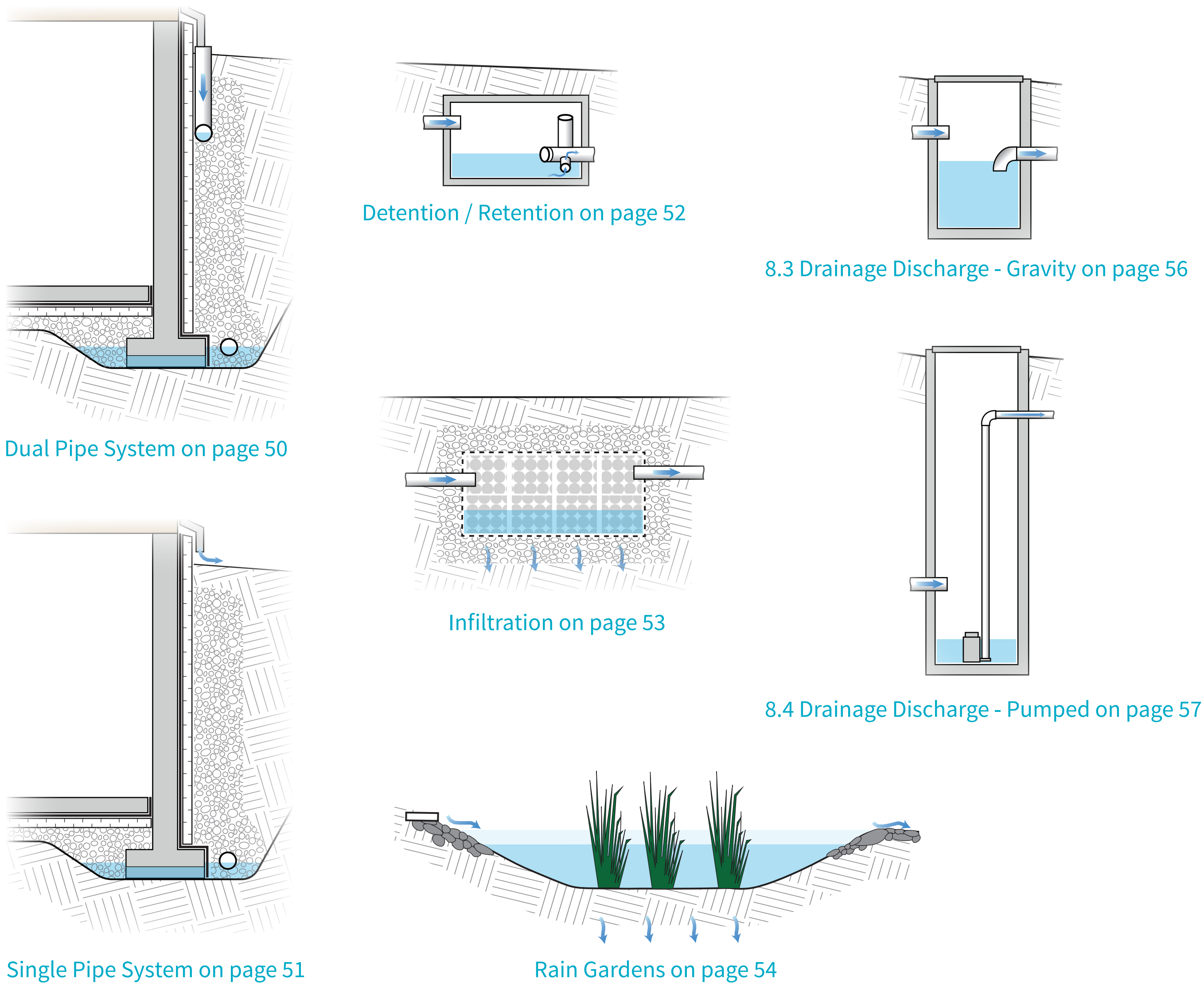


Figure 8.1 *Wayfinder for water management and discharge systems discussed in this chapter.*

8.1 Drainage from Impermeable Surfaces

The drainage from impermeable surfaces should be managed by separate system from the foundation drainage. This approach is commonly referred to as a dual pipe system (see **Figure 8.2)**. The less preferable single pipe system discharges roof and patio runoff either at-grade (see **Figure 8.3**) or, historically, directly into the perimeter drain pipes, though this is not recommended. Piped conveyance of the roof runoff is considered part of the plumbing system. Foundation drainage is regulated by the Building Code and should not be used as a direct discharge for plumbing systems; this would not comply with BC Plumbing Code Article 2.1.2.2.

Dual Pipe System

In a dual pipe system, roof runoff is directed to a separate, shallow, solid drain pipe system. Among many benefits, this will serve to

- decrease the amount of water at the building foundation,
- potentially allow for gravity discharge of roof runoff, as opposed to requiring it to be pumped from the foundation drainage, and
- allow for the controlled on-site management of rainwater (i.e., via infiltration or detention).

Runoff from patios and stair landings may also be directed to the solid pipe drainage system if they are high enough, but are often required to be directed to the perimeter drainage due to their lower elevation. Prior to pumping (if absolutely required) and discharge, all runoff should be directed into a sump to collect accumulated sediment/debris. From there, a solid PVC pipe conveys rainwater directly into the storm sewer. All pipes must be properly laid and jointed. Solid pipes should be installed as high as possible, but below the frost line, and sloped to drain as regulated by the BC Plumbing Code Table 2.4.10.9. For 100 mm (4") diameter pipe, the minimum slope is 1 in 100 (i.e. 1%) and may be up to 4 in 100 (i.e. 4%) if the pipe capacity is high. Sufficient cleanouts should be provided to allow for maintenance of the entire system. Solid pipes can be fastened to the foundation wall (see 6.10 Fasteners and Penetrations on page 44), but the recommended "best practice" is that they are supported by well-compacted gravel/backfill.

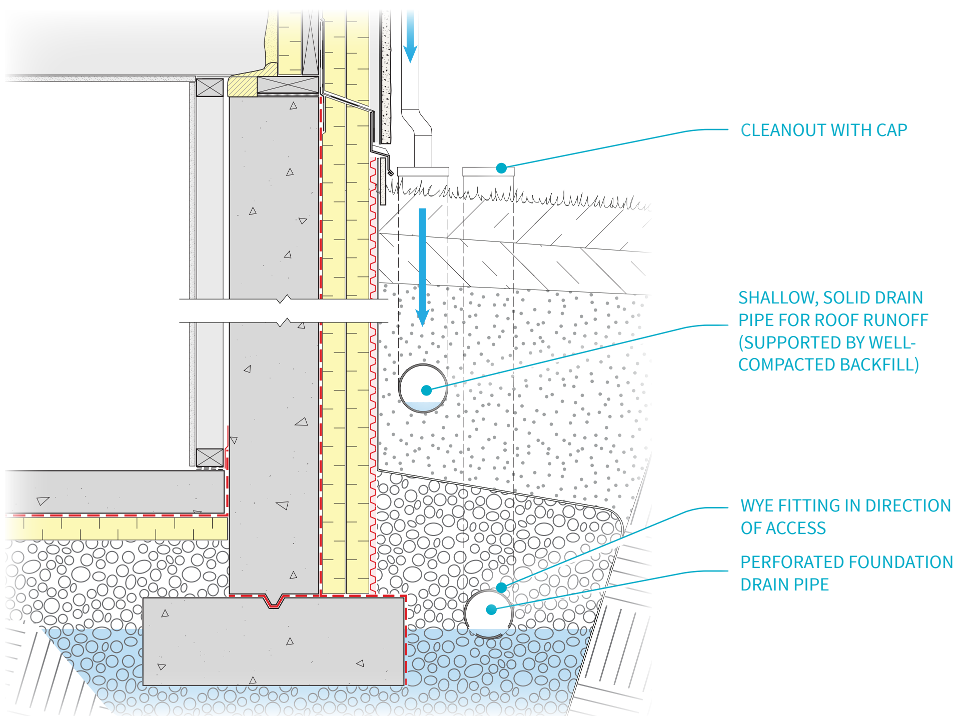


Figure 8.2 *Schematic of a "best practice" dual pipe drainage system: rainwater leader downspouts are directed to shallow, solid pipes separate from the foundation drainage system.*

Single Pipe System

Single pipe systems are not recommended because they usually result in increased loads for the foundation drainage and the increased presence of water around the building foundation wall. In a single pipe system, roof runoff is discharged either directly into the foundation drain pipe (historically common, and against current BC Plumbing Code requirements), onto splash pads at grade, or via extended leaders. Splash pads near foundation walls are to be avoided, as they can result in water splashing directly against building enclosure assemblies (see **Figure 8.3**). Where rainwater downspouts are discharged at-grade, water may seep into the building backfill zone, resulting in increased moisture next to the building foundation wall. If a single pipe system must be used, it is preferable to extend the downspout to discharge onto a splash pad located outside of the backfill zone, where water can seep into the surrounding soil, eventually entering the foundation drainage below (see **Figure 8.4**). If roof runoff is to be discharged at-grade, care should be taken with how this runoff is managed, with consideration given to:

- local geology with respect to the ability for water to infiltrate into subsurface soils;
- type and quality of building enclosure membranes and details used on foundation walls;
- proper grading to ensure water does not accumulate next to the building, and using a clay cap above foundation backfill materials to reduce the amount of water able to infiltrate around the building perimeter;
- locating splash pads outside of the backfill zone to help direct water away from the building foundation wall (see **Figure 8.4**), such as by providing extensions on downspouts per Sentence 9.26.18.2.(1) of the BC Building Code.
- securing splash pads/downspout extensions to the ground or building;
- installing a shallow, solid pipe system to allow for a future connection to be made should drainage problems manifest post-construction. Note that the AHJ should be consulted if this connection is made as they may have additional requirements.

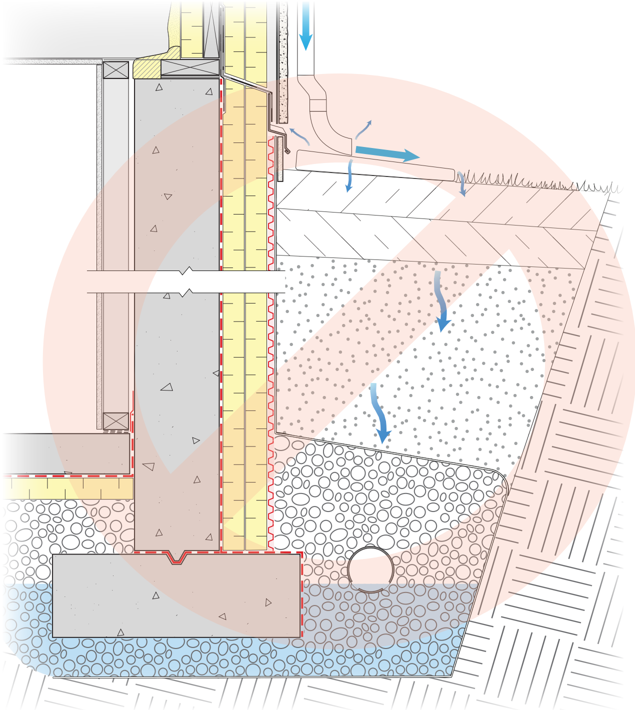


Figure 8.3 *Schematic of a poor single pipe drainage system. The downspout discharges to a splash pad, which can direct water towards the building foundation wall. Refer to* ***Figure 8.2*** *for best practice.*

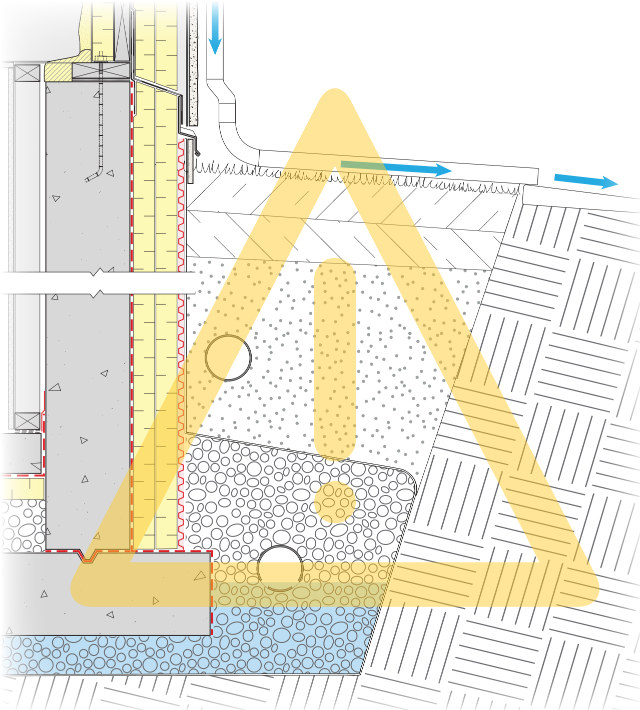


Figure 8.4 *Schematic of an improved single pipe drainage system. The downspout is extended to discharge past the backfill zone. A shallow, solid pipe is shown to allow for future connection if drainage problems manifest. Refer to* ***Figure 8.2*** *for best practice.*

Table 8.1 *Code requirements and associated "best practice" recommendations for impermeable surface drainage discharge*

Code Requirements	Recommendations
9.26.18.2.(1) Where downspouts are provided and are not connected to a sewer, extensions shall be provided to carry rainwater away from the building in a manner which will prevent soil erosion.	Ensure water is carried away from the building and discharged past the backfill zone. Armour discharge locations. Discharging to splash pads adjacent to the building increases risk of moisture ingress.

8.2 Stormwater Management

As climate change increasingly challenges the capacity of municipal stormwater infrastructure, the occurrence of “maximum" design events is becoming more common. In evaluating associated risks, it is important to note that municipal infrastructure is designed to manage surface water flows associated with certain design storm events. It is typically not designed with sufficient capacity to conduct flows in excess of this surface runoff contribution, such as due to groundwater which may be pumped to these systems from private property.

Stormwater management facilities in the context of this guide comprise infrastructure that is engineered to meet location-specific guidelines, bylaws, and/or regulations for managing stormwater within a property, and controlling the amount of water discharged from a property. Consideration should be given especially to including (and maintaining) backwater valves, alarms, and natural gas, diesel, or propane-powered backup pumped systems for select sites.

Stormwater Detention and Infiltration

Many municipalities in B.C. now require on-site infrastructure to manage the stormwater runoff from a property during storm events. The two most common systems are infiltration (where water is discharged to where it can infiltrate into the ground), and detention (where water is held and discharged at a controlled/reduced rate into the municipal storm system).

To reduce the risk of a building flood due to water becoming backed up, infiltration and detention systems should be designed so that discharge locations cannot become flooded or easily blocked (e.g., by ice in a ditch). These systems can also be combined or used in a series, though not all systems are recommended for all sites. Professional civil or geotechnical engineers are often retained to design and review the construction of these systems, and to provide sign-off on Item 4.2 of the BC Building Code Schedule B Letters of Assurance where required. For commercial projects where basement walls extend to property lines, it is generally the mechanical engineer who takes responsibility for Item 4.2. A preliminary definition of Item 4.2 of the Schedule B is included in Appendix A on page 72 of this document. This definition is compatible with the Engineers and Geoscientists BC practice guidelines. In all cases, it is appropriate to consult a geotechnical engineer with respect to site groundwater elevations and the hydraulic conductivity of site soils (e.g. in order to determine infiltration rates), and possibly a water resources engineer with respect to design needs and recommendations.

Detention / Retention

Detention systems manage the release rate of stormwater by collecting it on-site and discharging it at a controlled rate into municipal systems (see **Figure 8.5**). This is typically achieved with an underground "tank" that has a smaller outlet than inlet. These tank structures are typically proprietary systems. If the tank is located below the water table, it should be designed to resist buoyant/uplift forces. Detention systems are typically engineered and should be designed to overflow before backing up in the event of a storm which exceeds the design capacity. Detention systems can be dye-tested to confirm that they do not leak.

Retention systems are considered to be systems that collect stormwater on site and store it for future use (i.e. rain barrels used for irrigation). These systems may not be engineered and may not be effective in controlling the discharge rate of stormwater due to the seasonality of rain events and when this water would be used. For example, watering of plants primarily occurs when rain is infrequent, while during the rainy season these systems may fill up quickly and not be used.

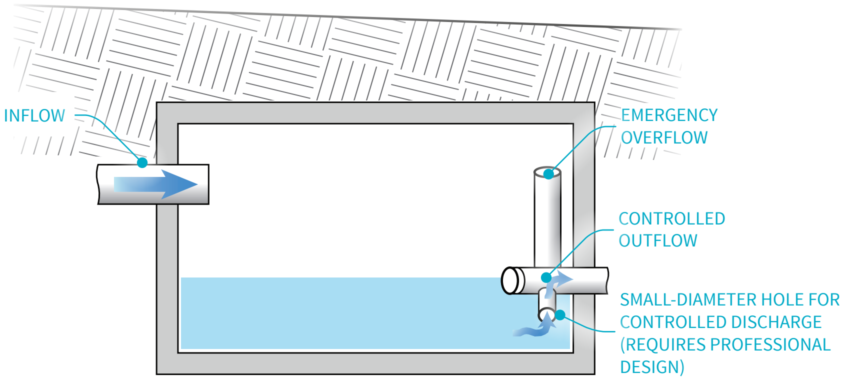


Figure 8.5 *Schematic cross-section of a typical stormwater detention tank (note that the upstand discharge/control pipe is often contained in a separate, proximate "control/orifice" sump.*

Infiltration

Infiltration systems such as dry wells, rock pits, and/or infiltration trenches/galleries dispose of water by allowing it to infiltrate into the ground, as shown in **Figure 8.6**. Infiltration systems are preferred by many AHJs as they mimic the natural process of rainwater percolating into the soil, thus supporting base stream flows and reducing the load on municipal sewers. However, many sites are not suitable for infiltration, including:

- sites with a high water table (note that the water table at a site can fluctuate seasonally, annually, and tidally),
- sites with unsuitable geology, including relatively impermeable soil such as till/hard pan, clay, or bedrock, or with sensitive, metastable, or swelling and shrinking soils,
- sites which are steeply sloping or at the crest of a slope (due to slope stability concerns), and
- sites which are smaller or over-programmed, and do not allow for adequate setbacks from the building and/or property lines.

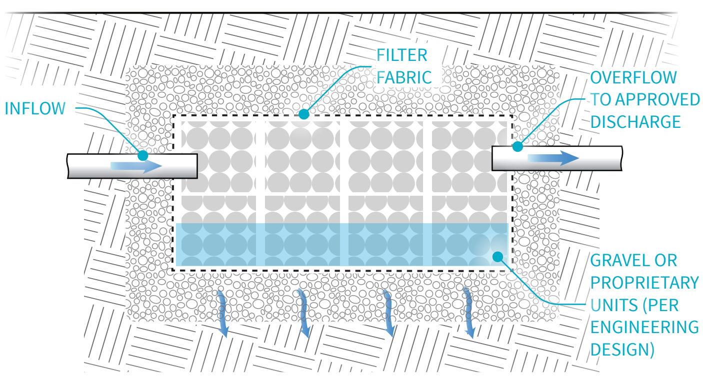


Figure 8.6 *Schematic cross-section of a stormwater infiltration tank.*

The hydraulic conductivity/permeability used for infiltration system design must be representative of the site. This can be determined by a geotechnical engineer through percolation testing.

The BC Building Code requires dry wells (infiltration fields) to be located only in areas where the natural groundwater level is below the bottom of the well, not less than 5 metres (~16 ft) from the building foundation, and located so that drainage is away from the building per Article 9.14.5.3. Infiltration systems should be engineered to overflow before backing up, in the event of a storm which exceeds the design capacity. It is recommended as a "best practice" that excavation for infiltration features be separate from any excavation for sanitary services to limit the ability for stormwater to infiltrate into potentially leaking sanitary sewers. Where possible, infiltration features should be located away from sanitary pipes.

Finally, sites with septic systems have specific setback requirements from stormwater infrastructure, groundwater, or drain pipe break-out points. These setbacks, and other requirements, are outlined in the Sewerage System Standard Practice Manual (see Section Additional Resources on page 67).

Rain Gardens

Rain gardens are shallow areas or depressions in the ground where surface water is intended to collect, as shown in **Figure 8.7**. Rain gardens are typically designed with an inflow and an overflow, and are planted with vegetation tolerant to both wet and dry conditions. The overflow allows for the rain garden to drain to an approved location when its maximum capacity is exceeded. Rain gardens can serve as areas of storage (detention) and infiltration, and can act as a buffer to reduce the volume and intensity of stormwater discharge to municipal storm sewers and local waterways. However, rain gardens may be subject to infiltration location restrictions.

Some rain gardens can filter out pollutants usually carried in stormwater. Rain gardens can also have an environmental benefit, creating habitat for wildlife.

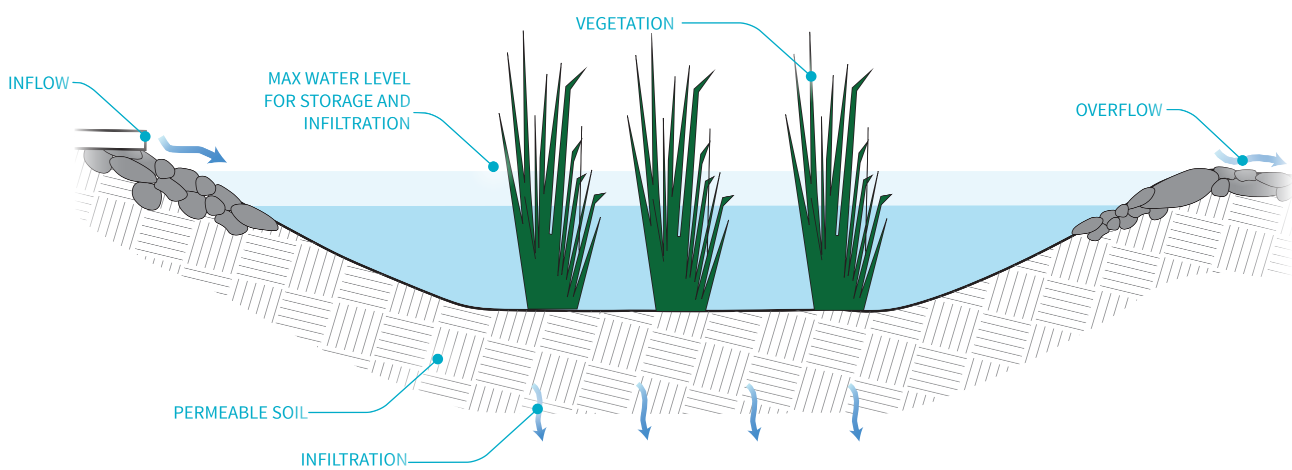


Figure 8.7 *Schematic cross section of a rain garden, complete with inflow and overflow.*

Floodplains

The BC Ministry of Environment's Flood Hazard Area Land Use Management Guidelines (FHALUMG) requires that the underside of the floor system supporting habitable space in a designated floodplain is to be above the Flood Construction Level (FCL), as specified by the local authority or as determined by the engineer (see **Figure 8.8**). The FCL is not the "high water level" determined by a BC Land Surveyor, as there are a number of other considerations that go into its determination. Habitable space below-grade/below the FCL is typically not permitted in a floodplain, unless subject to significant engineering design (and typically requiring more expensive construction techniques).

Alluvial soil deposits (i.e. those deposited by water) can extend beyond the boundaries of designated floodplain areas. While habitable basements are often permitted by municipalities in areas with these deposits, the hydraulic conductivity of alluvial soil should be expected to be high. Therefore, constructing below grade in such areas is challenging and would typically not be recommended by a geotechnical engineer without appropriate groundwater flood protection measures.

Where the risk of flooding is not locally managed by regional dike infrastructure (or even where it is), it may be possible to construct local flood mitigation/resilience measures. Engineering services relating to flood mitigation may include raising site grades, designing an on-site flood protection berm or dike, designing erosion protection of berms and foundation subgrades. They may also include designing groundwater cutoff structures, and/or providing recommendations for waterproofing, dewatering, and increasing the flood resilience of structures both above and below the FCL. The design of these elements should consider reasonable off-site impacts.

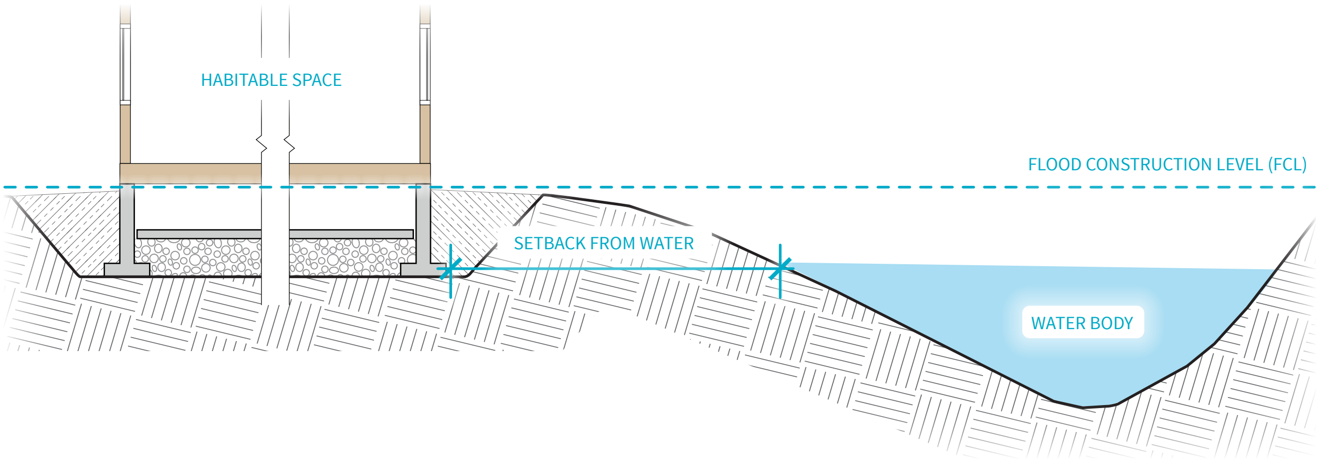


Figure 8.8 *Schematic cross section of the Flood Construction Level (FCL).*

Table 8.2 *Code requirements and associated "best practice" recommendations for on-site water management features.*

Code Requirements	Recommendations
9.14.5.3. Dry Wells (1) Dry wells may be used only when located in areas where the natural groundwater level is below the bottom of the dry well. (2) Dry wells shall be not less than 5 metres (~16 ft) from the building foundation and located so that drainage is away from the building.	Recommended to be used only in areas where soil conditions are suitable for infiltration. Increased offsets from basements may be suitable. Alternatively, detention tanks could potentially be utilized on sites where dry wells (aka rock pits or infiltration fields) are not appropriate.
2.1.2.2.(1) Storm drainage systems shall be connected to a public storm sewer, a public combined sewer, or a designated stormwater disposal system. 9.14.5.1.(1) Foundation drains shall drain to a sewer, drainage ditch or dry well.	Refer to local regulations/bylaws for regional requirements.

8.3 Drainage Discharge - Gravity

A gravity drained system is a discharge system that requires no mechanical assistance or pumping to reach its discharge location. All the pipes and other components that make up a gravity-drained system are sloped down towards an approved discharge location. This is often a municipal storm sewer, ditch, or other stormwater disposal location like a dry well or a stormwater management system. Pipes need to be properly laid and jointed. Gravity-drained systems are not dependent on electrical or mechanical systems, so they should be unaffected by pump failure and off-site power interruptions. Gravity-drained systems also result in decreased construction and operating costs (compared to pump maintenance and power costs), and lower long-term flooding risks (likely leading to lower insurance premiums).

Differential settlement of the soil around the pipes can affect their slope, which makes it important to properly compact the soil before installing the pipe. At some sites and in certain geologies, pipes can be installed at a steeper slope than required, to compensate for potential soil movement. In some cases where pipe slopes are overly steep and/or the discharge of water is significant, it may be prudent to consult with a mechanical engineer or qualified civil engineer in order to develop energy dissipation strategies for the pipe network. Consultation with a hydraulic or qualified civil engineer to design a thrust block/armouring and erosion protection at the discharge location should also be considered.

Invert and Slab Elevations

The invert elevation refers to the elevation of the bottom of a pipe or channel. The minimum slab elevation is the lowest slab elevation that can still facilitate a gravity drained system (see **Figure 8.9**); a slab elevation below this requires a pumped system. The minimum slab elevation is based on the following considerations:

- The invert elevation of the discharge location (typically at the property line).
- The total invert offsets required by the sumps and any infiltration/detention tanks.
- The vertical dimension (i.e., "fall") derived from the slope of the drain pipe over its total horizontal run. The total horizontal run is measured along the pipe from its highest elevation (i.e., at the high side of the foundation drainage system), to the discharge location.
- The thickness of the slab and the elevations of the foundation perimeter drain pipes (refer to 4.3 Recommended Foundation Drainage on page 16 and 5.1 Underslab Drainage on page 21).

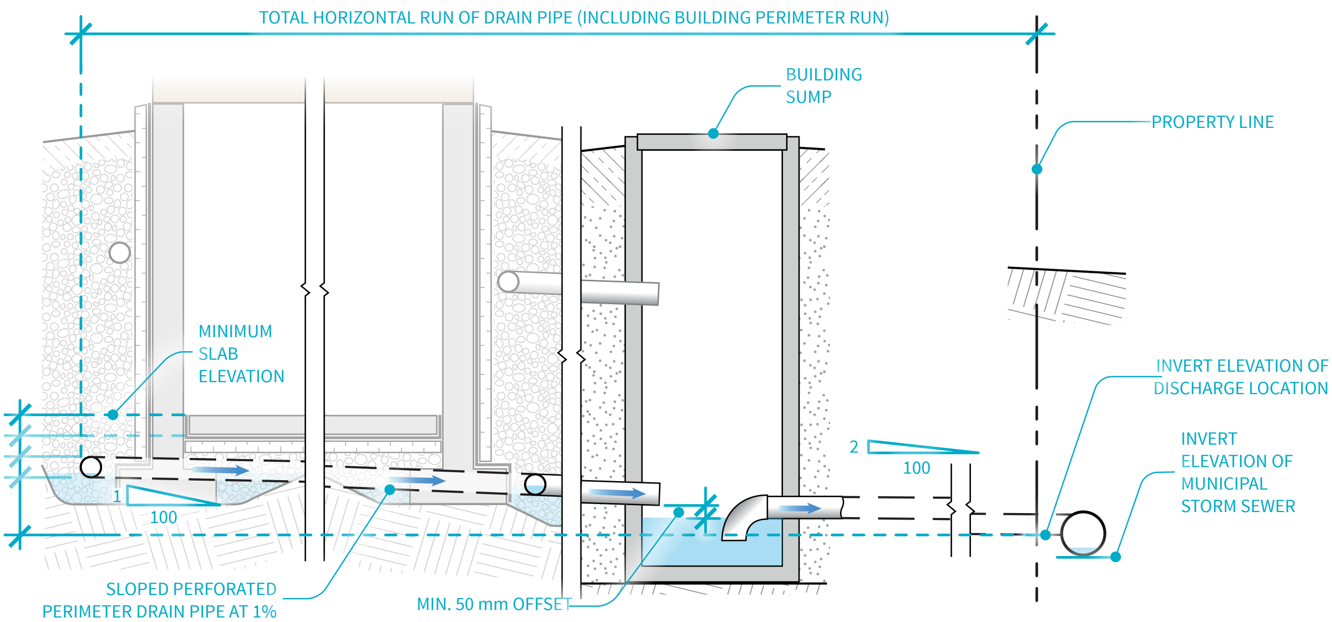


Figure 8.9 *Typical section of gravity-drained foundation drainage system.*

8.4 Drainage Discharge - Pumped

Pumped systems rely on electric pumps at the bottom of the sump to lift the water up to reach the discharge elevation. The design capacity of a pumped system should account for groundwater volumes (perched, interflow, and/or ambient), including for seasonal fluctuations, and consider the hydraulic conductivities of the surrounding soil. The rainwater contribution to the perimeter drainage system (i.e., interflow rainwater that infiltrates through the ground and enters perimeter drain pipes) should also be accounted for. Geotechnical and civil engineers may be able to provide recommendations in this regard. Pumped sump systems should include the following "best practice" features (see **Figure 8.10**):

- Sump volumes should be enough to allow for some storage of water and the proper operation of float switches to reduce the risk of a pump short cycling and burning out.
- The pump system should use dual (duplex) pumps with a primary and backup. Both pumps should be sized to individually manage design flows generated by a 10-year storm event and wired to pump together if design flows are exceeded.
- To minimize the risk of the backup pump seizing from lack of use, the pumps should be wired to alternate such that they both operate on a regular basis.
- The pumps should be connected to an automatically triggered backup power supply and a high water alarm.

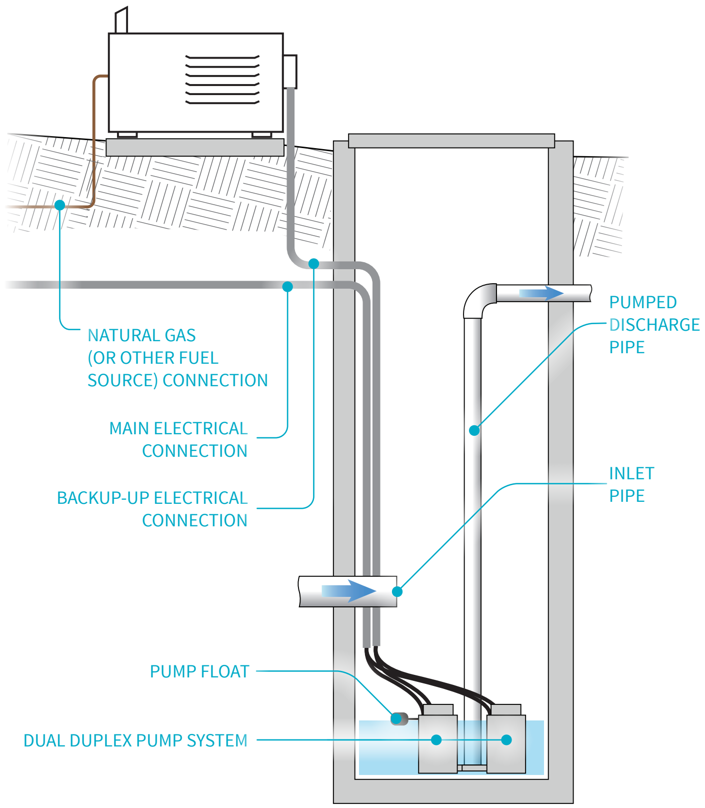


Figure 8.10 *Typical section of pumped sump with back-up generator.*

Backup Systems and Maintenance

Pumped systems require regular maintenance and testing to ensure that pumps, floats, backflow valves, electrical systems, and backup generators are operational. Follow the manufacturer's recommendations with respect to component replacement and maintenance. Since power outages often occur during large storm events when pumps are most needed, an automatically-triggered, hard-wired backup generator or power bank should be provided to supply power to pumps during an outage. However, it is important that even if these "best practices" are followed, pumped systems are still prone to failure.

Drawbacks of Pumped Systems

Avoid the need for a pumped system through site selection or building design, where possible. In some residential buildings, the requirement for a pumped system can be completely eliminated, and the potential for future water damage substantially reduced, if the basement floor slab is raised by only a few inches. Some municipalities do not allow pumping of groundwater into municipal storm systems. **If this is the case,** alternative discharge methods may be required (i.e., via an infiltration field), or the structure must be tanked. Refer to Section 6 | Building Enclosure on page 25 and 8.2 Stormwater Management on page 52.

For some sites where gravity discharge from foundation drains is not possible but its pumped system is not expected to regularly be in use, there is a risk that the pumps may seize due to under-use. In these cases, and with permission from the AHJ, directing rainwater runoff from a small portion of the roof can serve to keep the system operational.

This page is intentionally left blank

9 | Maintenance

Maintain all elements of a drainage system annually at minimum. Expected maintenance includes the cleaning out of forest litter, debris, accumulated sediments and/or other deleterious materials which can clog the system. Components that require cleaning/inspection include but are not limited to

- roof gutters and rainwater downspouts
- trench drains
- sumps, catch basins and lawn basins
- pipes and
- pumps and associated electrical, mechanical, and back-up components.

Clean pipe systems regularly, or as necessary, by snaking and/or hydro jetting. For this reason, it is important that sumps, cleanouts, and other drainage features remain accessible for the life of the building. Over time, sumps and cleanouts often become buried and/or lost if they are not maintained, making it very difficult to access the drainage system. Improperly placed cleanouts/maintenance access points can also make regular maintenance difficult. Service and/or replace pumps and related components in accordance with the manufacturer's recommendations.

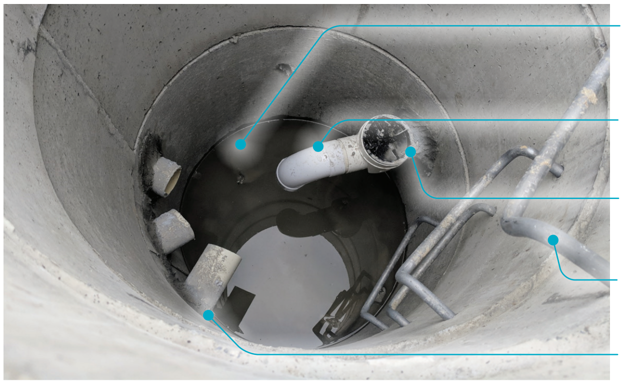


Figure 9.1 *Typical building sump with good access to components for maintenance and inspection (and further sump "best practice" components noted).*

Figure 9.2 *Cleanout blocked by the flashing at the base of the building's wall.*

9.1 Iron Ochre

In areas where iron ochre is known to be a problem, it is particularly important to follow "best practice" design and maintenance procedures. This includes consulting the local building inspector, plumbing inspector and/or other suitably qualified professionals. Iron ochre may be present in areas where a "sheen" is visible on surface water, similar to that of gasoline. Iron ochre is the natural waste generated by bacteria digesting water-soluble organics at the interface with an aerobic environment, such as an oxygen-rich perforated perimeter drainage pipe. Iron ochre of on-site origin typically disappears after three to five years. Iron ochre of off-site origin can pose a long-term clogging risk for a drainage system, shortening the system's service life even with an enhanced maintenance program. Also, the presence of iron ochre may void the warranties of certain pump systems.

Figure 9.3 *Iron ochre in a drainage pipe.*

9.2 Cleanouts

The BC Plumbing Code requires that cleanouts be installed in "drainage systems" every 15 metres (~50 ft) for uni-directional snaking (rodding), every 30 (~100 ft) metres for bi-directional rodding, and at every corner of the building. Although "drainage systems" in the Plumbing Code is interpreted to include below-grade rainwater leader pipes which conduct runoff from roof gutters and patio areas, in its current edition the Code specifically excludes "subsoil drainage pipes," which are interpreted to include foundation drainage pipes. Therefore, the BC Plumbing Code does not require cleanouts on perimeter drainage systems. However, they are best practice and typically required by AHJs.

Roof Drainage System Cleanouts

Some authorities may allow using the vertical pipe that the downspouts connect to as a cleanout while others may not. If this approach is taken, downspouts should be easily removable to allow access into the system (i.e. not permanently fitted). The building sump is also often used as an access point to the system.

Perimeter Drainage System Cleanouts

Considering the difficulty of accessing foundation drainage systems for maintenance after construction, it is recommended to use the BC Plumbing Code as "best practice" for cleanout installation guidelines in perimeter drainage systems. Cleanouts are essential in order to provide access for future maintenance of all drainage systems. If a building has many corners/jogs, consideration should also be given to adding straight runs of pipe and drainage gravel through these jogs, to allow easier access for the future maintenance of the system.

Table 9.1 *Code requirements and associated "best practice" recommendations for cleanouts.*

Code Requirements	Recommendations
2.4.7.1.(1) Sanitary drainage systems and storm drainage systems shall be provided with cleanouts that will permit cleaning of the entire system. 2.4.7.1.(5) A building sewer shall not change direction or slope between the building and public sewer or between cleanouts, except that pipes not more than 6 inches in size may change direction a) by not more than 5° every 3 metres (10 ft), or b) by the use of fittings with a cumulative change in direction of not more than 45°. Maximum permitted cleanout spacing in a drainage system for 100 mm (4") diameter pipes is 15 metres (~50') for one-way rodding, and 30 metres (~100 ft) for two-way rodding (Table 2.4.7.2). 2.4.7.4.(1) Cleanouts and access covers shall be located so that their openings are readily accessible for drain cleaning purposes.	Install cleanouts to allow for access to and maintenance of the entire system. Ensure that cleanout access it not inhibited. Capped system cleanouts are an essential part of a long-life drainage system as they allow for easy access for a maintenance contractor to clean out the perimeter drains. Caps should be threaded. Ensure that sumps are large enough and equipped with ladder rungs to allow access to the sump base for the purpose of future maintenance. The BC Plumbing Code definition of "drainage system" excludes "subsoil drainage pipes". However, it is recommended for "best practice" to follow BC Plumbing Code spacing requirements for foundation drainage pipes.

10 | Drainage Remediation

Key Points:

- Drainage remediation is an often frustrating, iterative and expensive process. Less costly potential solutions are usually implemented first, with others implemented subsequently based on observations of performance.
- The best method to limit water ingress and other issues requiring drainage remediation is to employ "best practices" during the original construction, and to carry out regular maintenance.
- Solutions implemented post-construction should not be expected to be as effective as they would have been during the original construction.
- It is the owner's responsibility to ensure that proper maintenance of the foundation drainage system is carried out.

The amount of water leakage into a below-grade structure that is deemed to be "acceptable" depends on several factors. This includes the moisture sensitivity of the finishes and items stored within the interior space, as well as the comfort level of the owner/occupant regarding moisture ingress. For example, an owner would likely be intolerant of moisture ingress into the finished basement due to the risks of mould growth and damage to interior finishes and belongings. An owner may be more tolerant of moisture ingress into a crawlspace, garage or underground parkade (without storage spaces), especially if seepage is minor and can be collected by floor drains. However, the risk of water corroding structural steel in the foundation walls should still be reviewed. Common signs of moisture ingress include:

- Wet or damp floors or walls
- White powdery stains on exposed concrete (i. e., efflorescence)
- Stains/mould on carpet, finishes, furniture, within framing
- Condensation/mildew on windows or on walls/floors
- Rotting windowsills
- Stuffy, damp, musty smell
- Condensation dripping from cold water pipes

10.1 Common Sources of Moisture

If a drainage problem is suspected, potential sources of water should be investigated, and the functionality of existing drainage systems reviewed. Potential sources of and entry points for water can include the following:

- High groundwater table and hydraulic conductivity (permeability) of adjacent natural soil, resulting in seepage into the backfill zone.
- Upward groundwater flow into the underslab bedding, including by capillary action if sand was used as an underslab support material.
- Flow of perched groundwater into the backfill zone and flow of surface water into the backfill zone, or behind a membrane/drain mat termination, including due to changes in upslope, off-site conditions.
- Cracks in the foundation walls or slab caused by differential settlement, inward frost heave, shrinking concrete, or higher lateral soil or hydrostatic pressure than the foundation walls were designed for.
- Under-capacity drain pipes and plugged drain pipes, including due to iron ochre.
- Shallowly-sloping drainage systems with downstream inverts that are compromised by sedimentation, vegetation, ice, etc.
- Under-capacity, poorly maintained, or inappropriately triggered pumps (including pumps that burn out from short-cycling because sump volumes are too small).
- Leaking plumbing supply lines or fixtures.
- A storm, tide, or flood event, or a combination of events, that exceeds the maximum design event.

- Off-site situations such as a poorly-serviced or inadequate municipal sewer (downstream ditches that are no longer maintained, pipes that are under-capacity or have become under-capacity due to nearby development, climate change, etc.)
- Ultimate discharge elevations that are below flood elevations.
- Compromised building enclosure assemblies below grade, above grade, or at the transition between them (See **Figure 10.1**).

Figure 10.1 *Investigation of moisture ingress should include a detailed review of the exterior assemblies, including at below-grade to above-grade transitions.*

Having a specialty sub-contractor scope existing drain pipes (see **Figure 10.2** and **Figure 10.3)** is a good approach for evaluating the condition of existing drainage systems, although good record-keeping, including accurate documentation of this work and its findings (including noting the plan locations of identified deficiencies), is important to maximize its usefulness. Flow tests are not as conclusive, although insight can be gained by introducing tracer dye into discrete downspouts.

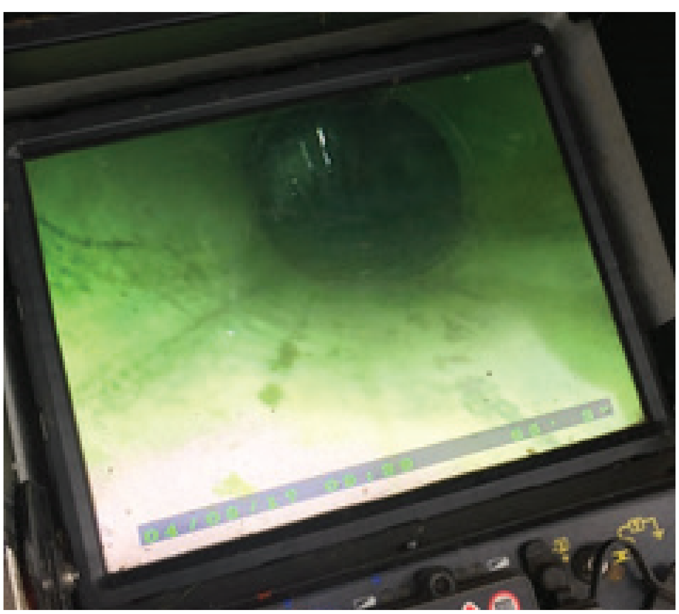


Figure 10.2 *Camera view of relatively clean drain pipe.*

Figure 10.3 *Camera view of drain pipe infilled with roots.*

The most cost-effective solution for a site with ingress/drainage problems will depend on the configuration of, and access to, the existing drainage system. In general, drainage remediation is an iterative process. Less costly potential solutions are usually implemented first, with others implemented subsequently based on observations of performance.

Sometimes, a simple solution can be found, such as re-sloping gutters to drain towards an alternate downspout, but it is common for several procedures to be necessary to eliminate the problem. In general, the solutions which perform the best are those which are implemented from the exterior of the building. Some geotechnical and building enclosure engineers can provide recommendations for moisture ingress and drainage remediation. Experienced plumbers or drainage remediation/basement flood contractors may also offer expertise.

Drainage remediation often involves excavation in confined spaces. Where it may not be possible to properly slope and/or step excavations in conformance with WorkSafeBC's requirements, a geotechnical engineer is required to review the safety of temporary excavations and/or temporary shoring prior to worker entry.

This page is intentionally left blank

11.1 Flood Resilience in British Columbia

When water flows into or accumulates in a location where it is not expected or designed for, it is typically called a flood. A new BC Housing initiative, Mobilizing Building Adaptation and Resilience (MBAR), considers measures to make communities and buildings more resilient to the effects of climate change, including increased and more significant flood events.

Flooding has many different potential sources and is not necessarily limited to specific geographical regions. For example, flooding can occur where a river has overtopped its banks and floods the adjacent community, or where the capacity of sewer infrastructure is exceeded, resulting in flooding in adjacent buildings. It can also occur when extreme rainfall causes excess surface water which flows into adjacent properties.

What most types of flooding have in common is that both the frequency and magnitude of these events are expected to be amplified with climate change. Extreme rainfall, snow and glacial melt are forecast to affect sea, lake, and river levels. In British Columbia, changes in the rainfall regime are anticipated to result in drier summers and produce more frequent and intense rain events during other times of the year. Increased rain events could in turn result in surface water flooding and/or surcharge of municipal sewers, which may result in a cascade of other flood events. Some other potential impacts from climate change, including to the groundwater regime and associated groundwater flooding, are still not well understood, or researched in B.C.

To learn more about climate change impacts in B.C., visit gov.bc.ca/gov/content/environment/climate-change

Impacts from flooding on property can include loss of possessions, damage to interior finishes, contamination from sewage, structural damage, destruction of landscaping and damage of municipal infrastructure. Flooding can also have a significant negative impact on the wellbeing of a community and its residents.

Although the impacts of climate change cannot be completely avoided, some negative effects can be anticipated and reduced through design. The effects of increased flooding can be mitigated by designing a site for flood resilience. Some preliminary considerations for engineering and design services relating to site flood resilience may include:

- **At a community scale**: Constructing area-wide flood protection structures (e.g., sea walls, dikes, etc.) or raising street grades and/or restricting development in flood-prone areas
- **At a neighbourhood scale**: Raising local site grades during building design or implementing flood protection structures in coordination with adjoining neighbors
- **At a site/property scale**: Allowing for future implementation of flood protection structures
- **At a building scale**: Using resilient building finishes, designing to facilitate clean-up of the building after a flood, etc.

Off-site impacts should be considered and the design of many of these elements should be done in conjunction with an hydraulic engineer.

Stay tuned for more information from BC Housing on this subject under the MBAR program. A 'wayfinder' is included in **Figure 11.1** on the following page which outlines some common flood sources that can be considered on a building scale. It also provides associated resiliency measures that can be implemented to reduce the flood risk.

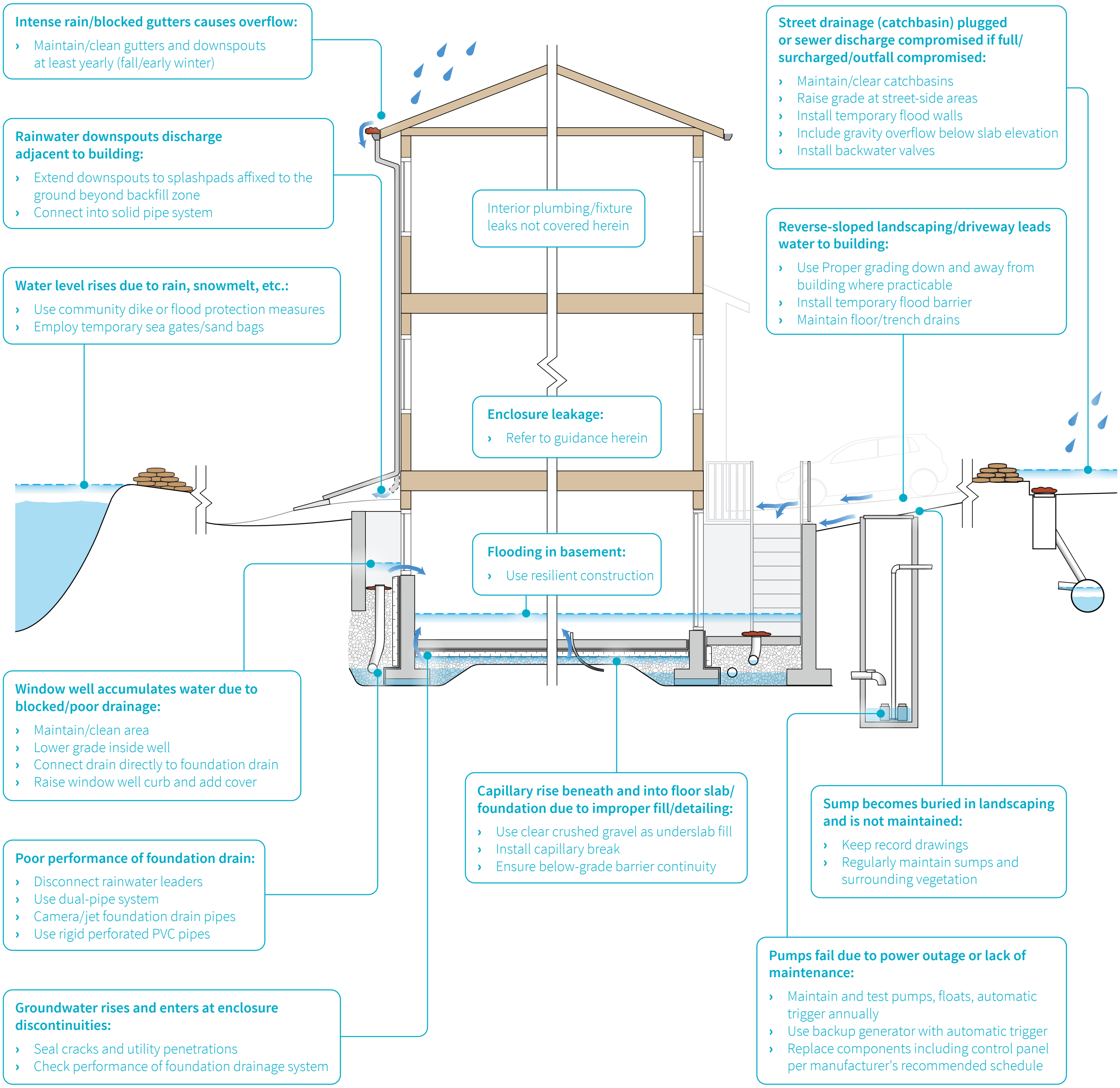


Figure 11.1 *Common flood sources and associated resiliency measures.*

Additional Resources

This guide provides "best practice" recommendations and BCBC 2018 requirements for site and foundation drainage, but it is not exhaustive. Other resources are available that may provide more detailed information, including:

- British Columbia Building Code (BCBC) 2018 published by the Queen's Printer for B.C. (bcpublications.ca/BCPublications)
- British Columbia Plumbing Code (BCPC) 2018 published by the Queen's Printer for B.C. (bcpublications.ca/BCPublications)
- Housing Foundations and Geotechnical Challenges, Best Practices for Residential Builders in B.C. published by BC Housing (bchousing.org/residential-design-construction/housing-foundations-geotechnical-challenges)
- Building Enclosure Design Guide Wood-Frame Multi-Unit Residential Buildings published by BC Housing (bchousing.org /residential-design-construction/building-enclosure-design-guide)
- Guide to the Letters of Assurance in the B.C. Building Code 2006, December 2010 edition, published by the Queen's Printer for B.C. (bccodes.ca/letters-of-assurance)
- Residential Construction Performance Guide 2016 published by BC Housing (bchousing.org)
- Homeowner Protection Act Regulation published by the Queen's Printer for B.C. (bclaws.ca/civix)
- Engineers and Geoscientists British Columbia Geotechnical Engineering Services for Building Projects (egbc.ca/Guidelines-Advisories)
- Interflow - municipal restrictions on pumping groundwater vs interflow appendix item (bylaws.vancouver.ca/bulletin-groundwater-management)
- Engineers and Geoscientists British Columbia Retaining Wall Guidelines (egbc.ca/Guidelines-for-Retaining-Wall-Design)
- Engineers and Geoscientists British Columbia Landslide Guidelines (egbc.ca/Guidelines-Advisories)
- Sewerage System Standard Practice Manual (gov.bc.ca/sewerage-system-standard-practice-manual)
- Mobilizing Building Adaptation and Resilience Primers (bchousing.org/MBAR)
- Vancouver Building By-Law 2019 (bcpublications.ca/BCPublications)
- Vancouver Plumbing By-Law 2019 (bcpublications.ca/BCPublications)
- City of Vancouver Groundwater Management Bulletin (bylaws.vancouver.ca/bulletin/bulletin-groundwater-management.pdf)
- Low Impact Development (LID) Stormwater Management Guidance Manual by the Ministry of the Environment and Climate Change (municipalclassea.ca/Manual; see pages 256-259).
- BC Lung Association, RadonAware (radonaware.ca)

Glossary of Terms

AHJ	Refer to Authority Having Jurisdiction (AHJ).
air barrier	The materials and components that together control/limit airflow through an assembly and the potential for heat loss and condensation.
alluvium	A deposit of clay, silt, sand, and gravel left by flowing streams in a river valley or delta, typically producing fertile soil.
Authority Having Jurisdiction (AHJ)	The governmental body responsible for the enforcement of any part of the Building Code or the official or agency designated by that body to exercise such a function.
backflow	Unwanted flow of water in the reverse direction within a pipe or drainage system.
backwater valve	A backwater valve is a backflow prevention device used in drainage pipes to prevent outbound water from re-entering a home.
base stream flow	The portion of the flow of water in a stream or river that is sustained between precipitation events, fed by delayed pathways.
British Columbia Building Code (BCBC)	A set of rules and standards that are a minimum requirement for the design and construction of buildings in British Columbia.
capillary action	The movement of unpressurized water through a network of narrow spaces between materials.
capillary break	A gap or material in an assembly that prevents or restricts capillary action.
civil consultant	A civil engineer, typically focused on the design, planning, construction, supervision, and overall review of infrastructure in many fields such as residential, industrial, commercial, public structures, etc.
cleanouts	Accessible pipe extensions connected in line with a plumbing discharge system (including sewer and storm) to allow inspection and cleaning of pipes.
clean sand	Sand that is free of fines such as silt or clay.
clear gravel	Rock of a uniform size with a high void ratio and very high hydraulic conductivity.
colluvium	Material which accumulates at the foot of a steep slope.
debris floods/flows	Geological phenomena where water-laden masses of soil and fragmented rock rush down slopes/mountainsides, funnel into channels, and entrain objects in their paths.
final grading	The finished surface where topsoil or other surface landscaping treatment is added. Final grading should be sloped away from the building.
fines	Soil particles that are finer than 0.0075mm (or a No. 200 sieve); distinct soil particles are not visible to the naked eye.

free draining	Of a soil or granular material, the ability to permit the passage of liquid water. The rate of draining differs based on the material.
freezing front	The advancing boundary between frozen (or partially frozen) ground and unfrozen ground. The freezing front will typically extend deeper below grade as the winter progresses.
frost cycle	Related to the occurrence of frost heave and frost expansion over the course of the winter months.
frost heave	Soil displacement from the growth of ice lenses in soil under freezing conditions.
geology	The study of the rocks and materials that form both the interior and exterior solid layers of the Earth.
geotechnical consultant	A geotechnical engineer, typically focused on the composition and mechanics of subsurface materials. Part of their scope is to understand the physical integrity of these materials and how they may impact the design of a structure.
glacial till	Sediment that was produced through the erosion of material due to glacial (ice) movement. Often refers to glacially over-ridden material which is dense.
gravity drained system	A drainage methodology that does not require additional energy input to move water away from the structure.
groundwater	Water that is present underground within soil/rock joints.
groundwater table	Refers to the interface between partially and fully saturated soil, below which hydrostatic forces would be exerted on a below-grade structure.
hard pan	A term for a compact layer of soil that is relatively impermeable.
hydraulic conductivity	Describes the ability of water to flow through or infiltrate into a soil. Related to particle size, compaction, and soil composition. Often referred to as permeability.
hydro jetting	A method of cleaning drainage pipes where a blast of water at high pressure (usually around 35,000 psi) is sent into the pipes to remove blockages and buildup.
hydrostatic pressure	The pressure exerted by a liquid (i.e., water) due to the force of gravity.
ice lenses	Layers of ice which are formed when moisture accumulates in an area and freezes.
infiltration	The process of liquid water permeating (moving through) a material, such as soil.
interflow groundwater	Groundwater in the unsaturated zone.
loess	A form of collapsible soil generally characterized by its fine-grained structure deposited through wind action.

mechanical consultant	A mechanical engineer, typically focused on the use of energy, design and operation of mechanical equipment.
moisture barrier	The materials and components that together control/limit the movement of liquid water through an assembly.
moisture tolerant	Of a material, the ability to be exposed to moisture for long periods without sustaining damage.
monolithic	A concrete structure placed all at once, free of construction/cold joints.
muskeg	A bog or swamp-like area with an accumulation of decayed vegetation and organic matter.
natural drainage	The ability of the material present in an area to transfer water, without the help of human-made components, to a body of water such as a river or lake.
peat	A deposit comprising of partially decayed vegetation and organic matter.
percolating	Filtering gradually through a porous surface or substance.
perched	Of water, an accumulation that is above the ambient groundwater water table, typically on an impermeable layer.
permeability	A measure of the ability of a material to allow liquid water or vapour to pass through it.
pumped foundation drainage system	A system that uses a pump to drain accumulated water (e.g. a sump pump). A backup generator and backup pump system are also recommended. Water is typically pumped up towards a municipal sewer or suitable discharge location.
rain water leader (RWL)	The pipe that connects the downspout on a gutter to the storm drainage system.
rising damp	A physical phenomenon in which water travels up through a material due to capillary action.
rough grading	A surface below the topsoil that should be flattened and sloped away from the structure. This grading is completed before the final grading/landscaping.
seepage	The movement of liquid water through porous material or small holes.
seepage collar	An impermeable dam, commonly concrete, typically used in a utility trench, that restricts the movement of water from one area to the next and directs it into drainage systems.
smart vapour retarder	A relatively more permeable interior vapour retarder that can permit some amount of inward drying.
soil pressure	The pressure, including lateral, exerted by soil against its surroundings due to the force of gravity.

structural consultant	A structural engineer, typically focused on the design of different forms of infrastructure. The main focus of a structural engineer is the physical integrity of the structure being designed.
surficial	Relating to the earth's surface.
swaled	Of a ground surface, having sloped shallow ditches or depressions that are designed to collect and divert surface water to an approved location.
tanked	Refers to a completely waterproofed submerged below-grade structure, designed to not become buoyant.
thermal break	A material with low conductivity that is placed between two conductive materials, such as two pieces of concrete, to reduce heat flow and decrease condensation potential.
thermal insulation	A material that primarily controls conductive heat flow out of the building. Significant for the thermal performance and energy efficiency of the building enclosure.
topography	The surficial layout of the ground and physical features.
Vancouver Building By-Law (VBBL)	A Vancouver-specific set of rules and standards that are required for the design and construction of buildings in Vancouver, based in large part on the BC Building Code.
vapour retarder	A material with low vapour permeability that is located within the assembly to control the flow of vapour.
void ratio	A measure of the ability of a material to allow liquid or gaseous water to pass through it.
void volume	The space between soil particles where air or liquid water may be present.
water ingress	The process of water finding its way into a building. For example, when moisture moves into the basement through openings in the waterproofing and insulation layer combined with cracks in the foundation wall.
water stop	An element of a concrete structure located at construction joints that is intended to prevent the passage of water between the separate pieces of concrete.

Appendix A

Definitions of BC Building Code Schedule B Item 4.2

The following professional practice guidance for Item 4.2 Site and foundation drainage systems is copied from the Engineers and Geoscientists BC document: Geotechnical Engineering Services for Building Projects (dated September 17, 2020):

...

The following professionals are responsible for signing off on the design and Field Reviews of item 4.2 in the Plumbing section of Schedule B.

- *The Geotechnical Engineer of Record (GER) is responsible for aspects of item 4.2 in coordination with and depending on the engagement of other discipline Registered Professionals of Record as noted below, if neither a Mechanical Engineer of Record (MER) nor a Civil Engineer of Record (CER) is engaged on the project (see below):*
  - *The GER should work with the CRP or Owner to determine if a project scope for site and foundation drainage is required and, if so, add it to the GER's scope of services. The GER must then determine if the GER is prepared and qualified to undertake this work or if a mechanical engineer, civil engineer, and/or a Specialty Geotechnical Engineer should be engaged.*
  - *Projects where the GER may be asked to take responsibility for this item include Part 9 buildings and home improvement projects.*
  - *When the GER takes on this work, it must be performed according to the Guidelines for Mechanical Engineering Services for Building Projects (Engineers and Geoscientists BC 1993), including the requirement to coordinate with a civil engineer (if engaged on the project).*
- *If an MER is engaged on the project, they are normally responsible for Item 4.2.*
  - *For sites where below-grade portions of the building do not extend close to the property lines, a civil engineer should be engaged to address surficial site drainage. The MER must coordinate with the project CER for surficial drainage and site services, to determine and confirm scope boundaries related to drainage and site services, which are typically a 1 metre offset from the building perimeter*
  - *The MER must coordinate with the GER to ensure the MER's design is compatible with maximum design groundwater elevation, hydraulic conductivity, estimation of seepage, and/or dewatering approaches. With respect to geotechnical specialty items, coordination with the GER and provision by the GER of Schedule S-B, Assurance of Professional Design and Commitment for Field Review By Supporting Registered Professional is required.*
- *If a CER is engaged on the project, they are normally responsible for the "site service" aspects of item 4.2, as outlined above and according to the agreed project-specific scopes of work for the MER and the CER.*
  - *If the CER's design relies on geotechnical specialty items, such as determination of maximum design groundwater elevation, hydraulic conductivity, and estimation of seepage, coordination with the GER and provision of a Schedule S-B by the GER is required.*

The following responsibilities must be fulfilled by the professionals responsible for signing off on the design and Field Reviews of item 4.2 in the Plumbing section of Schedule B, as described above.

4.2 Site and foundation drainage systems

Site and foundation drainage systems refers to the arrangement of site grading and buried (subsoil) pipes, trenches, and other engineered systems that intercept surface and subsurface (both groundwater and interflow) water flow and direct it away from a building and its below-grade envelope system. In the BCBC Letters of Assurance, this item is pertinent to buildings, and ensures the codified requirements to direct water flow away from buildings are met. Although engineering input to the design of site-grading and other systems to manage surface and subsurface water that do not affect buildings may add value to a project, this is a separate issue and does not require declaration of professional responsibility for item 4.2. Within a nominal 1 metre offset from the perimeter of the building, item 4.2 is normally undertaken by mechanical engineers and is related to the design and Field Reviews of on-site stormwater and groundwater management features. Typical design features may include foundation and perimeter drainage pipes, interior catch basins and sediment sumps,weep holes, pumps, alarm *floats, back-up generators, triggering elevations, and connections to a site drainage system or municipal infrastructure. If appropriate to the site and project, this typical offset distance may be adapted in coordination between the project's mechanical, civil, and geotechnical professionals. Outside of the nominal 1 metre offset from the perimeter of the building, item 4.2 as relates to site service aspects are normally undertaken by a civil engineer. According to the Guide to the*

Letters of Assurance in the BC Building Code (Province of BC 2010), this may include, but is not limited to:

- *site grading;*
- *stormwater piping, including on-site stormwater system features such as sumps, catch basins, inspection chambers, pipes, detention tanks (including proprietary), swales, drains, dry wells (including rock pits, infiltration trenches, fields, galleries, or proprietary stormwater management facilities), pumps, alarm floats, back-up generators, and triggering elevations;*
- *drainage for site retaining walls;*
- *sanitary piping, including on-site sanitary*
- *systems such as septic fields;*
- *domestic water piping;*
- *fire suppression water piping; and*
- *fire hydrants on private property.*

For sites where infiltration of rainwater will be managed as part of a development's drainage systems, the approach must be coordinated with site-specific geotechnical considerations. Site-specific geotechnical considerations should be based on knowledge of the governing groundwater regime (including possible seasonal and tidal effects) and the receiving geology (including hydraulic conductivities and stability of sloping sites), the stability of proximate structures including retaining walls, climate change impacts, and the maximum design groundwater elevation. Potential hydraulic connections from subsurface infiltration features to the building envelope should be considered in, and managed by, the design, such as through the use of seepage collars.

Not included in item 4.2 are:

- *dewatering (temporary or permanent);*
- *design of 'tanking' or waterproofing;*
- *selection of or design of building envelope elements below the maximum design groundwater elevation; or*
- *proprietary stormwater management facilities.*

Likewise, providing maximum design groundwater elevations, hydraulic conductivities, and/or seepage analyses to other members of the project design team who may be designing pumped or other systems (including groundwater cut-off) to maintain groundwater at design levels and pressures is covered in the scope of Geotechnical – Permanent, under item 8.6, Permanent Dewatering.

Evaluation of potential off-site impacts due to rainwater infiltration, drainage discharge, and temporary/permanent dewatering (including lowering or raising of proximate groundwater elevations), including impacts due to seasonal and climate change effects, is out of scope for this line item but is encompassed by item 8.6. Such an assessment for the project may be compelled by the Authority Having Jurisdiction, per their responsibilities as noted in Section 2.2.7 Authority Having Jurisdiction.

...

BC HOUSING
RESEARCH CENTRE

1701 – 4555 Kingsway

Burnaby, BC V5H 4V8

Phone: 604 439 4135

Toll-free: 1 866 465 6873

Email: technicalresearch@bchousing.org

www.bchousing.org