CITY OF
VANCOUVER

ENGINEERING DESIGN MANUAL

First Edition © 2019

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0	November 2019	Initial version	Megan Pate

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1 INTRODUCTION

INTRODUCTION

1.1 PREFACE

This is the first edition of the City of Vancouver's *Engineering Design Manual*. This manual is intended to be a comprehensive guide that documents the typical design processes and criteria to be used for projects conducted by and for the City of Vancouver. In accordance with the City's Organizational Quality Management (OQM) practices, each design assignment should be completed in accordance with a design brief which will stipulate the unique specifications for the assignment, which may differ from this manual as prepared and amended by the City of Vancouver.

The scope of this manual is split into 10 chapters relating to various aspects of design in the City of Vancouver.

Chapter 1: Introduction

Chapter 2: Design Process & Coordination

Chapter 3: Water System

Chapter 4: Sanitary Sewer System

Chapter 5: Storm Drainage System

Chapter 6: Neighbourhood Energy

Chapter 7: Third-Party Utilities

Chapter 8: Streets & Transportation

Chapter 9: Streetscape & Urban Forest

Chapter 10: Street Lighting & Traffic Signals

This *Engineering Design Manual* is to be used in coordination with the *City of Vancouver Standard Detail Drawings*. For construction specifications, see the *City of Vancouver Construction Specifications and the City of Vancouver Supplemental General Conditions.*

1.2 PURPOSE

The purpose of this manual is to consolidate the City of Vancouver's design preferences and criteria into one comprehensive and cohesive document. It is intended to be used by a variety of people including City staff, City officials, and design professionals such as consulting engineers and architects working on behalf of the City, Third-Party Utilities, or developers.

This manual provides general standard design criteria but cannot cover all specific situations. It is up to the designer to interpret these guidelines and apply them appropriately. The City is a design, build, operate, and maintain organization which does have in-house expertise that can assist with the interpretation and application of the standards / criteria in this manual.

This design manual is meant to provide guidance and processes for how design is typically conducted in the City of Vancouver; noting that use of accepted industry standards and specifications will likely still be required. The City reserves the right to review, provide comment on, and accept or reject designs whether they conform to the guidance within this document or not.

The City of Vancouver: (i) accepts no liability for any loss or damage which may be suffered by any person as a result of the use of this document; and (ii) makes no representation or warranty as to the appropriateness of the use of this document in any particular situation. This document is issued on the strict understanding that each user accepts full responsibility and liability for its use. It is the responsibility of designers to use sound professional judgment, knowledge and experience when using this document.

1.3 DESIGN PHILOSOPHY

The City of Vancouver aims to be one of the most sustainable and livable cities in the world today and in the future. The City's design philosophy is paramount to progressing towards and achieving these objectives. This section outlines the context, strategies, and vision that all projects designed in Vancouver must acknowledge and incorporate.

1.3.1 DESIGNING WITHIN CONTEXT

The City of Vancouver's mission is to create a great city of communities that cares about its people, environment, and opportunities to live, work, and prosper.

The City of Vancouver conducts itself based on these six values:

- **Responsiveness** - We are responsive to the needs of our citizens and our colleagues.
- **Excellence** - We strive for the best results.
- **Fairness** - We approach our work with unbiased judgement and sensitivity.
- **Integrity** - We are open and honest, and we honour our commitments.
- **Leadership** - We aspire to set examples that others will choose to follow.
- **Learning** - We are a learning workplace that grows through our experiences.

Consistency, continuity, cohesiveness, and quality are important aspects of design in the City of Vancouver. Historical, cultural, and aesthetical qualities of the surrounding area should be preserved and enriched. Design should align with the goals and vision of the community and future development plans. Community plans and zoning by-laws influence each design; all projects should strive to enhance the livability of the space and promote a vibrant community that is inclusive to all people.

Designers must integrate constructability, operations, and maintenance considerations during design development. Quality of infrastructure is highly important, and it is promoted and upheld by in-house expertise.

1.3.2 CITY STRATEGIES

The City of Vancouver has many strategies and goals that influence engineering design. Below is a list of some of the relevant City strategies:

1) **Engineering Strategic Plan** – The Engineering Strategic Plan outlines 10 common goals of all engineering projects in the City:

   - Goal No. 1: The City provides excellent service.
   - Goal No. 2: The City is financially healthy and administratively effective.
   - Goal No. 3: The City leads the way on green issues.
   - Goal No. 4: The City inspires excellence in the workplace and in its employees.
   - Goal No. 5: The City optimizes strategic partnerships and collaborations.
   - Goal No. 6: Vancouver is a sustainable, affordable, livable and inclusive city.

- Goal No. 7: Vancouver's business climate is dynamic and robust.
- Goal No. 8: Vancouver is a safe city in which people feel secure.
- Goal No. 9: Vancouver offers extraordinary civic amenities.
- Goal No. 10: Vancouver's assets and infrastructure are well-managed and resilient.

  All engineering projects undertaken in the City of Vancouver should strive to meet and incorporate these goals, and projects should be guided by the ideals of the Engineering Strategic Plan.

2) **Greenest City Action Plan -** The Greenest City Action Plan is a strategy for staying on the leading edge of urban sustainability. The City of Vancouver is working with residents, businesses, other organizations, and all levels of government to implement this plan. Vancouver's vision is to create opportunities today, while building, a strong local economy, vibrant and inclusive neighbourhoods, and an internationally recognized city that meets the needs of generations to come.

3) **Transportation 2040 Plan -** Transportation 2040 is a long-term strategic vision for the City that will help guide transportation, land use decisions, and public investments for the years ahead. It provides a blueprint for Vancouver to move forward, build upon past successes, and rise to meet new and emerging challenges. The plan sets long-term targets and includes both high-level policies and specific actions to achieve this vision.

4) **Integrated Rainwater Management Strategy** – The Integrated Rainwater Management Strategy was adopted to support the Greenest City Action Plan and Climate Change Adaptation Strategy through management of rainwater and runoff in order to prepare for climate change and severe weather; protect sensitive waterbodies; and reduce combined sewer overflows. These strategies are necessary to meet regulatory requirements and use City of Vancouver's rainfall as a resource rather than nuisance.

5) **Resilient City -** Vancouver has been selected as a member of 100 Resilient Cities. 100 Resilient Cities (100RC) is a program pioneered by The Rockefeller Foundation that helps a network of cities gain access to tools, funding, technical expertise, and other resources to build resilience to face 21st-century challenges. Natural and manmade shocks and stresses from urban growth will continue to hit the world's cities. 100RC is about preparing and acting to strengthen the City economically, environmentally, and socially.

6) **Climate Change Adaptation Strategy -** Council adopted the Climate Change Adaptation Strategy to ensure a vibrant, livable and resilient city in the face of climate change. The strategy supports the City preparing for the impacts of climate change such as increased intensity and duration of rainfall, sea level rise, and hotter, drier summers. The Coastal Flood Risk Assessment (CFRA) includes floodplain mapping to year 2100. Downscaled city climate projections are available from the City and renewed every 5 – 7 years.

7) **Urban Forest Strategy** – The City of Vancouver's urban forest should be robust, resilient, and well managed such that its beauty and benefits are safely enjoyed by people for present and future generations, and its habitats sustain ecosystems and wildlife. The City of Vancouver plans to plant 150,000 trees by 2020, return Vancouver's tree canopy to 1995 levels (22.5%) by 2050, and to plant, protect, and manage public trees wisely and efficiently so that the City and its public are well served.

8) **Digital Strategy** – Vancouver's Digital Strategy is a road map to enhance how you engage with and access the City through online, mobile, and social media channels; improve and expand the City's digital infrastructure; and support and strengthen Vancouver's digital economy.

9) **Healthy City Strategy** – Vancouver's Healthy City Strategy is a long-term, integrated plan for healthier people, healthier places, and a healthier planet. The Healthy City Strategy is comprised of 13 long-term goals for the well-being of the City and its people.

1.3.3 RETROFIT VERSUS NEW CONSTRUCTION

In general, design in the City of Vancouver typically consists of retrofitting and modernizing existing infrastructure. Since the majority of the City has already been developed, it is less common that new streets are being designed where there was no street previously. New street design and construction is generally limited to new major developments.

Existing conditions can create challenges with design. There can be constraints and limitations that might not exist with new construction. The criteria outlined in this manual is generally for the ideal new street condition and therefore cannot always be fully achieved. When the opportunity exists, the criteria in this manual must be met at a minimum; however, if conditions do not practically allow for it, compromises may be made based on sound and reasonable judgement. If a condition cannot be met due to the existing conditions, it shall be well-justified and documented, and must be accepted by City Staff.

1.3.4 DESIGN FOR CURRENT AND FUTURE RESILIENCE

A resilient project is one built to withstand or recover quickly from natural and human-caused hazards and disasters and that also delivers co-benefits to people and systems in the absence of hazards and disasters. Vancouver is exposed to a range of hazards including but not limited to flooding, sea level rise, earthquakes, fires, hazardous materials incidents, and cyber-attacks.

Infrastructure needs to be designed to function well in today's climate and throughout the functional lifespan of the project when significantly different climate and social conditions may provide new limiting design considerations. Hazard and risk assessments that identify interdependencies within infrastructure systems, and evaluate the consequence of failure, can inform resilient design measures and response options to ensure the continuation of critical infrastructure services.

The City of Vancouver will continue to update and future-cast natural hazard mapping and associated standards, such as floodplain mapping, IDF curves, downscaled climate projections, cybersecurity resources and capabilities, and seismic hazard.

Infrastructure design should incorporate projected climate variables (i.e. precipitation) for the functional lifespan of the project, and should be resilient to earthquakes, cyber-attacks, and other events causing disruption. Designs that can be adapted easily over time, with built in redundancies to minimize disruptions, and that can recover quickly from various shocks and stresses promote resilience.

1.3.5 COMPLETE STREETS DESIGN

The City of Vancouver has developed a Complete Streets framework to deliver better streets for all users and promote sustainable transportation. The Complete Streets approach brings existing transportation policies together under a single holistic framework and helps prioritize corridor-length improvements informed by a street's function within the broader transportation network. Over the fullness of time, it is envisioned that every street will be designed following a Complete Streets philosophy.

From a transportation perspective, a Complete Streets approach considers the needs for people of all ages and abilities and for all modes of travel in planning and design. Safe and comfortable access for people walking, cycling, and using transit is an integral planning feature, ensuring that critical mobility and access functions are met. Complete Street design features allow all people to meet their daily needs and participate in public life regardless of their ability or mode of choice.

From a broader perspective, a Complete Streets approach considers the interplay between land use and transportation, providing the opportunity to achieve broader civic objectives. While allowing for the movement of people and goods, a broader Complete Street lens recognizes the importance of looking at streets holistically, bringing land use, green infrastructure, public space and transportation considerations seamlessly together.

In practice, not every street can be easily retrofitted, and arterials in particular often serve multiple purposes, acting as key transit and / or truck routes, providing access for emergency services, customers, and deliveries, as well as accommodating local and regional motorized traffic.

Given these challenges, the City's immediate priority is not to make every street 'Complete', but to ensure that the broader street network provides for a full array of transportation choices that are safe and convenient. Since most of the City's arterials were designed decades ago to prioritize motorized traffic, retrofitting streets to be more 'Complete' often means ensuring the street is safe and comfortable for people of all ages and abilities to walk and cycle, and is accessible for persons with disabilities.

Key principles to consider when designing Complete Streets include:

- Improving **safety, comfort, and accessibility** for all modes, with a focus on walking, cycling and taking transit for people of all ages and abilities.
- Providing **direct and convenient access** to shops, services, and other destinations for all modes of transportation.
- Carefully **addressing impacts** to transit, emergency services, nearby streets, curbside management, and access to local businesses when reallocating road space.
- Enhancing overall **travel time reliability** on the street network for all modes, with emphasis on transit and goods movements.
- Incorporating **flexible design** approaches where appropriate, to changing usage and to facilitate special events at different times of day, week, or season.
- Considering **adaptable designs** where street infrastructure is likely to change over time, to make future space reallocation easier and less costly.

- Enabling **smart infrastructure** opportunities to support emerging green transportation technologies.
- Supporting a **lively city** that encourages a culture of walking and cycling, increased social interaction, and lingering within streets with vibrant public spaces.
- Encouraging **delightful and attractive** streets that contextually respond to surrounding land uses, providing opportunities for placemaking and art in various street elements.
- Exploring opportunities to improve **local ecology**, such as improving stormwater management and increasing the number, size, and health of street trees.

1.3.6 ACCESSIBILITY

The *Engineering Services Department* is committed to delivering a highly accessible and barrier-free pedestrian environment. *Engineering Services Department* staff have investigated, experimented, consulted, and been trained to explore the best techniques and practices to provide a seamless and socially inclusive public realm.

This manual provides specific information on standards the City is adhering to in efforts to create the best possible pedestrian environment that meets the needs of the largest range of users and to create an environment that provides opportunities to live, work, and prosper within our neighbourhoods. “Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design”- Ron Mace, founder and program director of The Center for Universal Design.

Things to consider when designing a pedestrian environment are the natural surroundings and the many possible users of the space including people who use wheelchairs, scooters, guide dogs, white canes, those who have hearing impairments, and those with learning disabilities. Materials, budgets, sustainability, maintenance, and new technologies are to be considered.

In designing for inclusion, accessibility, and barrier-free pedestrian environments, designers must look to the Seven Principles of Universal Design as follows:

- **Principle One: Equitable Use** - The design is useful and marketable to people with diverse abilities.
- **Principle Two: Flexibility in Use** - The design accommodates a wide range of individual preferences and abilities.
- **Principle Three: Simple and Intuitive Use** - Use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level.
- **Principle Four: Perceptible Information** - The design communicates necessary information effectively to the user, regardless of ambient conditions or the user’s sensory abilities.
- **Principle Five: Tolerance for Error** - The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- **Principle Six: Low Physical Effort** - The design can be used efficiently and comfortably and with a minimum of fatigue.

- **Principle Seven: Size and Space for Approach and Use** - Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

1.3.7 UTILITIES AND UNDERGROUND INFRASTRUCTURE

The City of Vancouver's utilities are an important public service, and the proper design of them is vital to ensure the health of the public. The design of utilities needs to consider long-term performance requirements and access and maintenance needs.

1.3.7.1 WATER SYSTEM

Vancouver's water is collected in the Capilano, Seymour, and Coquitlam reservoirs. On an average day, the water system delivers 360-million litres of high-quality water throughout the City. Reducing water consumption and being aware of what goes into the sewer are important parts of working towards the goal of becoming the greenest city in the world by 2020. Developing and maintaining reliable and resilient water infrastructure throughout Vancouver is a key strategy to help fulfill the City's mission, values and objectives:

- Provide the best drinking water of any major city by 2020.
- Conserve potable water and ensure water is available at all times.
- Upgrade and maintain aging water infrastructure in order to reduce water leakage.
- Reduce City of Vancouver's carbon footprint.
- Ensure the City is prepared for the impacts of climate change, and emergencies, including major disasters.

1.3.7.2 SANITARY SEWER AND STORM DRAINAGE SYSTEMS

Vancouver's sanitary sewer and storm drainage systems protect the public from wastewater by safely conveying flows. With infrastructure dating to the early 1900's, the City of Vancouver is working to improve and modernize its sewer infrastructure. The City of Vancouver is also actively working to protect the waterbodies in and around the City. As such, a prominent focus of sewer development is to fully separate the sewer system to eliminate combined sewer overflows. Developing and maintaining reliable and resilient sewer and drainage infrastructure throughout Vancouver is a key strategy to help fulfill the City's mission, values and objectives:

- Protect Vancouver's waterways and the environment.
- Fully separate the sanitary and storm sewer systems.
- Eliminate combined sewer overflows by 2050.
- Reduce the City of Vancouver's carbon footprint.
- Ensure the City is prepared for the impacts of climate change, and emergencies, including major disasters.

1.3.7.3 GREEN INFRASTRUCTURE

The Vancouver Citywide Rainwater Management Plan calls for green infrastructure to improve and protect Vancouver's water quality, proactively prepare for climate change impacts, and improve our resilience to rain and heat events, while supporting biodiversity and recreational water use. Green infrastructure systems can take many forms and use vegetation, soils, and engineered elements to mimic natural ecosystem processes to slow, clean, and absorb rainwater. They also include rainwater harvest and re-use systems at both the site and district-scales.

At a city scale, green infrastructure is a distributed network of natural areas and engineered practices that contribute to cleaner water and air, habitat, flood protection, and cooler urban environments. From a citywide perspective, a core principle is a decentralized approach; small, widely applied green infrastructure practices across a city collectively will have significant impacts. At a local scale, green infrastructure practices are designed to reduce pollutant loads at the source and create alternate pathways for rainwater. The piped system, also known as the grey infrastructure, serves rainwater flows that cannot be readily accommodated through infiltration, evapotranspiration, and harvest and reuse.

Developing green infrastructure throughout Vancouver is a key strategy to help fulfill the City's mission, values and objectives:

- Improve and protect Vancouver's water quality.
- Increase Vancouver's resilience through sustainable water management.
- Enhance Vancouver's livability by improving natural and urban ecosystems.
- Capture and treat 90% of Vancouver's annual average rainfall on both public and private property.

1.3.7.4 NEIGHBOURHOOD ENERGY

Neighbourhood renewable energy systems supply centralized heating, hot water, and sometimes cooling for multiple buildings. These systems use low-carbon renewable energy sources, such as sewage waste heat, to reduce the use of fossil fuels. They also eliminate the need for boilers in individual buildings, and provide environmentally-friendly, affordable heat and hot water. Developing neighbourhood renewable energy systems throughout Vancouver is a key strategy to meeting the Greenest City Action Plan and Renewable City Strategy goals to:

- Reduce City of Vancouver's carbon footprint.
- Reduce our dependence on fossil fuels.
- Keep energy affordable in the long term.
- Achieve 100% of our energy needs from renewable sources before 2050.

1.3.7.5 THIRD-PARTY UTILITIES

The City's effective management of underground utilities is essential to ensure the optimal use of City streets. The City needs to preserve space for future use, coordinate utility work to minimize disruptions, and use best practices for utility installations in order to minimize maintenance requirements and reduce life cycle costs. It is essential that the City manage all interests for street space with a balanced approach protecting the space for the present and future. In achieving this balance, the City strives to provide streets that safeguard the public and help fulfill the City's mission, values and objectives:

- Provide residents of City of Vancouver with access to utilities now and in the future.
- Safely operate utilities throughout the City of Vancouver.
- Reduce the City of Vancouver's carbon footprint.
- Ensure the City is prepared for emergencies, including major disasters.

1.4 REVISIONS TO THE MANUAL

The City's *Engineering Strategy and Standards Branch's Project Management Office (PMO)* is responsible for maintaining the manual and issuing new editions. Minor revisions to the manual will consist of issued amendments. After multiple amendments are created or when warranted, a new edition of the manual will be issued.

For revisions, changes, errors and ommisions, please contact the PMO at engineering.pmo@vancouver.ca.

1.5 REFERENCE DOCUMENTS

The following reference documents should be used in conjunction with this manual:

- *ACI 522.1 Specification for Pervious Concrete Pavement*
- *ANSI/IES RP-8 Roadway Lighting*
- *ASME B31.1 Power Piping*
- *AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast, for Water*
- *Bridge Condition Index and Implementation Manual and User Guide*
- *British Columbia Commercial Transport Act*
- *British Columbia Commercial Transport Regulations*
- *British Columbia Dike Design and Construction Guide Best Management Practice for British Columbia*
- *British Columbia Dike Maintenance Act*
- *British Columbia Drainage, Ditch and Dike Act*
- *British Columbia Motor Vehicle Act*
- *British Columbia Motor Vehicle Act Regulations*
- *British Columbia Plumbing Code*
- *British Columbia Water Act*
- *CAN/CSA A23.1 Concrete Materials and Methods of Concrete Construction*
- *CAN/CSA A23.2 Methods of Test and Standard practices for Concrete*
- *CAN/CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code*
- *CAN/CSA C22.2 No. 211.2 Rigid PVC (Unplasticized) Conduit*
- *CAN/CSA C22.3 No. 1 Overhead Systems*
- *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver
- *CAN/CSA S6 Canadian Highway Bridge Design Code*
- *Canadian Urban Transit Association (CUTA) Guidelines*
- *Canada Fisheries Act*
- *City of Vancouver Boulevard Gardening Guidelines*
- *City of Vancouver Building By-law*
- *City of Vancouver Complete Streets Policy Framework*
- *City of Vancouver Construction Specifications (Supplement to the MMCD)*
- *City of Vancouver Construction General Conditions (Supplement to the MMCD)*
- *City of Vancouver Design Guideline for AAA Cycling Routes*
- *City of Vancouver Design Guidelines for Large Sidewalk Patios on City Property and Sample Drawings*
- *City of Vancouver Encroachment By-law No. 4243*
- *City of Vancouver Garbage & Recycling Storage Amenity Design Supplement*
- *City of Vancouver Graffiti By-law No. 7343*
- *City of Vancouver Integrated Rainwater Management Plan Volume I, Vision, Principles and Actions*
- *City of Vancouver Integrated Rainwater Management Plan Volume II, Best Management Practices Toolkit*

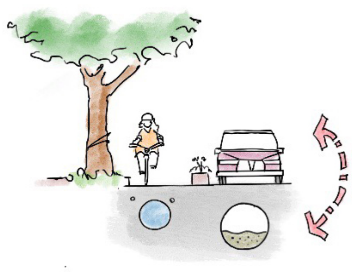
- *City of Vancouver Marine and Coastal Structures Design Reference*
- *City of Vancouver Modular Concrete Block Retaining Wall*
- *City of Vancouver Noise Control By-law No. 6555*
- *City of Vancouver Parking and Loading Design Supplement*
- *City of Vancouver Parking By-law No. 6059*
- *City of Vancouver Parking Meter By-law No. 2952*
- *City of Vancouver Parklet Manual*
- *City of Vancouver Plaza Design Guidelines*
- *City of Vancouver Protection of Trees By-law No. 9958*
- *City of Vancouver Recommended Guidelines for Universal Access to Public Docks in False Creek*
- *City of Vancouver Sewer and Watercourse By-law No. 8093*
- *City of Vancouver Sign Code Inventory*
- *City of Vancouver Standard Detail Drawings (Supplement to the MMCD)*
- *City of Vancouver Standardized C.I.P. Conventional Retaining Wall*
- *City of Vancouver Standardized C.I.P. L-Shape Retaining Wall*
- *City of Vancouver Standardized C.I.P. Zero PL Retaining Wall*
- *City of Vancouver Standardized Soil Bag Wall*
- *City of Vancouver Street and Traffic By-law No. 2849*
- *City of Vancouver Street Tree By-law No. 5985*
- *City of Vancouver Street Utilities By-law No. 10361*
- *City of Vancouver Streetscape Design Guidelines*
- *City of Vancouver Transportation 2040 Plan*
- *City of Vancouver Transportation Assessment and Management Study Guidelines for Consultants*
- *City of Vancouver Water Wise Landscape Guidelines*
- *City of Vancouver Water Works By-law No. 4848*
- *City of Vancouver Requirements and Standards for the Installation of Public Drinking Fountains*
- *City of Vancouver Vegetated Wire Face Retaining Wall*
- *City of Vancouver Zoning and Development By-law No. 3575*
- *CROW Design Manual for Bicycle Traffic (from the Netherlands)*
- *EGBC Professional Practice Guidelines*
- *BC MoTI Bridge Standards and Procedures Manual*
- *BC MoTI Electrical and Traffic Engineering Manual*
- *BC MoTI Pedestrian Crossing Control Manual for British Columbia*
- *BC MoTI Standard Specifications for Highway Construction*
- *BC MOTI Traffic Control Manual for Work on Roadways*
- *Fire Underwriters Survey Water Supply for Public Fire Protection – A Guide to Recommended Practice*
- *ICPI Permeable Interlocking Concrete Pavement*
- *IES DG-4 Design Guide for Roadway Lighting Maintenance*
- *IES DG-5 Recommended Lighting for Walkways and Class 1 Bikeways*

- *IES LM-79 Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products*
- *IES LM-80 Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules*
- *IES TM-15 Luminaire Classification System for Outdoor Luminaires* and *Addendum A: Backlight, Uplight, and Glare (BUG) Ratings*
- *IES TM-21 Projecting Long Term Lumen Maintenance of LED Light Sources*
- *ITDP Bikeshare Planning Guide*
- *ITE Traffic Detector Handbook*
- *Master Municipal Construction Documents (MMCD) Platinum Edition*
- *MMCD Design Guideline Manual*
- *Metro Vancouver Stormwater Source Control Guidelines*
- *NACTO Bike Share Station Siting Guide*
- *NACTO Guidelines*
- *NACTO Transit Street Design Guide*
- *NAPA IS-115 Open-Graded Asphalt Friction Courses, Design, Construction & Maintenance*
- *NAPA IS-131 Porous Asphalt Pavements for Stormwater Management*
- *TAC Accessible Pedestrian Signals Guidelines*
- *TAC Bikeway Traffic Control Guidelines for Canada*
- *TAC Canadian Transit Handbook*
- *TAC Geometric Design Guide for Canadian Roads*
- *TAC Guide for the Design of Roadway Lighting*
- *TAC Guide to Bridge and Combination Barriers*
- *TAC Manual of Uniform Traffic Control Devices for Canada (MUTCD)*
- *TAC Pavement Design and Management Guide*
- *TAC Pedestrian Crossing Control Guide*
- *TAC Synthesis of Practices for Median Design*
- *TransLink Bus Infrastructure Design Guidelines*
- *TransLink Transit Passenger Facility Design Guidelines*
- *TransLink Universally Accessible Bus Stop Design Guidelines*
- *Transport Canada Grade Crossing Standards*
- *Transport Canada Grade Crossing Regulations*
- *Transport Canada Railway Relocation and Crossing Act*
- *Transport Canada Railway Safety Act*
- *Transport Canada RTD-10 Road/Railway Grade Crossing Technical Standards and Inspection, Testing and Maintenance Requirements*
- *UK London Area Travel Survey*

References in this manual refer to the most current version.

2

DESIGN PROCESS & COORDINATION



DESIGN PROCESS & COORDINATION

2.1 INTRODUCTION

This chapter describes the general design process and coordination that must be considered for all design in the City of Vancouver.

The following is a brief description of each section:

- The *Design Coordination* section outlines how the various aspects of design interact among one another. This section includes coordination of disciplines, clearances, rights-of-way, and external agencies.
- The *General Requirements* section outlines general requirements including units, permitting, surveys, test holes, and estimates.
- The *Drawing Standards* section outlines the drawing requirements for submissions to the City of Vancouver.
- The *Design Process* section outlines the typical process from project initiation to record drawings including required deliverables.
- The *Development Design Review Process* section outlines the review process and requirements that all development drawings submitted to the City of Vancouver must undergo.
- The *Third-Party Utility Drawing Submissions* section outlines where requirements for Third-Party Utility submissions are documented.

2.2 DESIGN COORDINATION

A key factor in ensuring a smooth design process is the effective coordination between consultants, the City, and external agencies. This section outlines the methods and interactions that must occur when designing in the City of Vancouver, as well as specifying criteria to mitigate utility conflicts that may arise during design and construction.

2.2.1 INTERACTION BETWEEN DISCIPLINES

When designing in Vancouver, it is critical that the interaction between the various design disciplines is coordinated. Designers shall deliver a well thought-out and functional project which avoids conflicts between the disciplines, accounts for operations and maintenance requirements and considers possible future growth through development. The following are examples to consider:

- Street lighting and utility poles should not hinder the path of pedestrians.
- Bus doors should not be blocked by above-ground utilities or street furniture.
- Water mains and utilities should not be located under curbs or within tree root zones.
- Maintenance holes, valve boxes, and other utility surface obstructions, where possible, should not fall within the wheel path of vehicles or bicycles and should avoid being in the path of pedestrians.
- Civil, landscape and electrical designs are to be coordinated. For example, trees and landscaping must be coordinated with junction box and street light placement and sidewalk treatments.
- Vehicles for street cleaning and garbage pick-up should be accommodated in the design.
- Not all conflicts can be avoided. When conflicts cannot be mitigated, the hierarchy of objectives is:
    - Safety.
    - Asset Health.
    - Public Realm.

2.2.2 EXTERNAL AGENCIES

When a design ties into or crosses infrastructure falling under the jurisdiction of an external agency, the agency should be notified, the design coordinated, and their requirements met. Below are some common external agencies that typically require coordination with City designs:

- BC Hydro.
- British Columbia Rapid Transit Corporation.
- Canada Line.
- Central Heat Distribution Ltd.
- Coast Mountain Bus Company.
- Department of Fisheries and Oceans.
- First Nations (Musqueam, Squamish, Tsleil-Waututh).

- FortisBC.
- Greater Vancouver Sewerage and Drainage District.
- Greater Vancouver Water District.
- Metro Vancouver.
- Ministry of Environment.
- Ministry of Forests, Lands and Natural Resource Operations.
- Ministry of Transportation and Infrastructure.
- Other Municipalities (Burnaby, Richmond, North Vancouver, and others).
- Neighbourhood/ District Energy Systems.
- Railway Companies (BNSF, CN, CP, Southern Railway, and others).
- Telephone, Cable and Communications (i.e.Telus, TeraSpan Networks, A2B Fibre Inc., Novus Entertainment Inc., MTS Allstream, Bell West, MK Telecom, Urban Networks Inc., Business Objects, Navigata, Shaw Communications Inc. etc.).
- TransLink.
- Vancouver Coastal Health.
- University of British Columbia (UBC).
- University Endowment Lands (UEL).
- WorkSafeBC.

2.2.3 STATUTORY RIGHTS-OF-WAY

When a utility is within the road allowance (but located close to the property line), a right-of-way may be required to make up the difference if the extents of the utility horizontal clearance required extend past the property line. Rights-of-way must be wide enough to allow for safe excavation of side slopes and must not fall within the safe angle of repose of building and structural footings. They must also be wide enough to allow for maintenance and planned future widening or twinning. Rights-of-way must be aligned to create minimal impact, avoid environmentally-sensitive areas, and allow practical maintenance vehicle access.

The minimum right-of-way widths are provided in ***Table 2-1***.

Table 2-1: Right-of-Way Widths

Right-of-Way Type	Minimum Right-of-Way Width
Single utility	• 2x the depth to the invert • Minimum 5m wide
Two utilities in a common trench	• 2x the depth to the deeper invert • Minimum 6.0m wide

2.2.4 SEWERS IN COMMON TRENCH

During sewer separation projects, sanitary and storm sewers may be installed in the same trench if the design meets the requirements shown in the *City of Vancouver Standard Detail Drawings G4.4, S16.1*, and *S16.2*.

2.2.5 UTILITY CLEARANCES AND SEPARATION

Table 2-2 outlines required clearances and separations for utilities. All clearances listed are to be measured from outside pipe wall to outside pipe wall, unless specified differently below.

Table 2-2: Utility Clearances

Clearance Type	Clearance Requirement
Greater than 3m horizontal separation (pipe centre to pipe centre) between water mains and sewers	• Preferred configuration, no additional requirements.
Less than 3m horizontal separation (pipe centre to pipe centre) between water mains and sewers	• Water main must have minimum 1.0m vertical clearance above sewer. • Where new sewers are being constructed, the storm sewer should preferably be located nearest the watermain rather than the sanitary whenever practical. • In cases where the minimum 1.0m vertical clearance cannot be achieved, sewer pipe must have the same pressure rating as specified in *Chapter 3: Water System* or water main joints must be wrapped as per the *City of Vancouver Construction Specifications*.
Crossings of water mains and sewers	• Water main must have minimum 1.0m vertical clearance above sewer. • In cases where the minimum 1.0m vertical clearance cannot be achieved, water main joints must be wrapped (3m either side of crossing) as per the *City of Vancouver Construction Specifications*.
Sewer clearances to existing or proposed sewers	• Minimum 1.5m horizontal clearance unless site constraints or sewers in common trench. • Minimum 0.3m horizontal clearance for sewers in common trench. • Minimum 0.3m vertical clearance at crossings.
Structure clearances	• New bridges and structures less than 6.0m wide above utilities must have a vertical clearance of 5.2m directly under the structure and a vertical clearance of 7.6m, 12.0m from the structure on either side. Structures over 6.0m wide to be reviewed individually. All structures within 3m of sewers to be reviewed individually by the *Sewers and Drainage Design Branch*.
Water main clearances to trees	• Existing or proposed trees must have a minimum 2.0m clearance to water mains.

Clearance Type	Clearance Requirement
Water main clearances to Third-Party Utilities	• Third-Party Utilities must have a minimum vertical clearance of 0.3m and a horizontal clearance of 1m from water mains. 90-degree crossings are preferred.
Underground utilities from curbs	• Underground utilities shall have a minimum horizontal clearance of 0.5m from the closest edge of the curb or gutter. Water mains shall have a minimum horizontal clearance of 1.0m from the closest edge of the curb or gutter.
Third-Party Utilities	• See *Section 7.3.3*.
Streetlight and traffic signal pole bases, junction boxes, ducting, and vaults to utilities	• Utilities must have a minimum clearance of 0.3m from all pole bases, junction boxes and electrical vaults. 1m clearance is preferred from water mains.
Streetlighting and traffic signal ducting to edge of tree trunk	• The minimum clearance between edge of tree trunk and ducting shall be 0.3m.

2.3 GENERAL REQUIREMENTS

All projects within the City of Vancouver have a set of general requirements that must be met. This section outlines these requirements and provides general information regarding units, permits, cost estimates, mapping resources, surveys, and test holes.

2.3.1 UNITS

All designs must be provided in metric except where noted otherwise in this manual.

2.3.2 PERMITS

Permits that are required by either the City of Vancouver or external agencies must be applied for and obtained when required. The list of external agencies in *Section 2.2.2* typically require permits. Refer to the *City of Vancouver Construction Specifications* and the *City of Vancouver Construction General Conditions* for the City of Vancouver permitting requirements and the list of typical permits.

2.3.3 COST ESTIMATES

Cost estimates are typically included with the design submission. Refer to *Section 2.5* for an outline of the level of cost estimate that is required at each design stage.

2.3.4 VANMAP

The City of Vancouver maintains a web-based GIS database called VanMap. It can be used for gathering general mapping information and related data such as properties, zoning, utilities, public places, parks, and roads. Although it is useful for obtaining general information, it does not replace surveys and site visits and may not reflect the current condition since the environment is continually changing. The accuracy of the data is not guaranteed; therefore, any information provided by this system must be checked and validated.

2.3.5 SURVEYS

All designs intended for construction must be done based on a topographic survey with property lines “adjusted” by the surveyor. Surveys should be completed by a qualified and experienced surveyor.

2.3.5.1 TOPOGRAPHIC SURVEY STANDARDS

- The survey must be in ground metric coordinates based on the current City Survey Monument Network. Monuments used are to be clearly indicated.
- The current horizontal datum for the City of Vancouver is NAD83(CSRS). All surveys shall meet a minimum horizontal accuracy of 1 in 20,000.
- All elevations shall be based on the CGVD28 vertical reference datum. The vertical accuracy must be plus or minus 0.01m.

2.3.5.2 SUBMISSION REQUIREMENTS

- The finished survey must be submitted in an AutoCAD DWG format showing all the property lines and using the City of Vancouver layers and standards as supplied by the *Engineering GIS and CADD Services*.
- Unedited digital raw survey files, in FBK format, showing all ties and checks.
- A point file is required (Point, N, E, Z, Description) in excel or text format.
- Clearly identify monuments used in the field, their location, elevation and verticle reference datum (CGVD28).
- Ask the City for current point codes. City point codes are suggested.
- Line / point connectivity must be provided. Use survey figures or 3D polylines only.
- Clearly identify all features and include a legend of all survey codes used.
- Title block including surveyor name, organization, and date of survey and verticle datum (CGVD28).

2.3.5.3 REQUIRED DETAILS

The survey will include all (but is not limited to):

- Survey monument ties.
- Lead plugs.
- Iron pins.
- Gutter line at curb face.
- Back of curb.
- Front of walk.
- Back of walk.
- Catch basins.
- Approx. center line of lanes.
- Pavement markings.
- Garages and driveways.
- Concrete pads.
- Points of intersection on the gutter line returns and 1.5m offset, quartered along curb returns.
- Entrance walks (i.e. walk ways, doorways, stairs) to ensure accurate tie-ins.
- Top and bottom of retaining walls.
- Street fixed furniture (i.e. lamp standards, traffic lights, power poles, parking meters, benches, bicycle racks).

- Fire hydrants.
- Bus shelters.
- Kiosks.
- Traffic signs.
- Valves (i.e. water and gas).
- Maintenance holes (specify type. i.e. Sewer, Telecommunications, Hydro, GVRD).
- Trees (located to the road side face and diameter noted), hedges and garden outlines.
- Shots along the property line.
- Ground points at first lane line or a car width from the gutter.
- Any permanent structure, pad, or utility.

If the data does not meet the minimum City of Vancouver survey standards specified in *Section 2.3.5*, the field work could be rejected and the surveyor may be asked to complete the missing information.

2.3.5.4 SURVEY EXTENTS

- The survey shall extend at least 30m either side of the project extents along all properties abutting City property.
- In lanes, the survey must extend across both sides of the lane.

2.3.5.5 SURVEY METHODOLOGY

- The City may accept innovative survey methods and such alternative methodologies should be proposed, where appropriate, for approval. It is the responsibility of the surveyor to assess which survey method or combination of survey methods must be used for a particular survey.
- Survey traverses and networks must consist of closed figures or be confirmed by sufficient redundant measurements to verify the survey standards required by the *Streets Division* and other departments within City of Vancouver.
- The unedited digital survey raw data file must show:
    - Agreement between ties to a minimum of two different City of Vancouver Survey Monuments.
    - Enough redundant measurements to verify that the survey meets the City of Vancouver survey accuracy standards.
    - A backsight check recorded at the beginning and end of each setup.
    - All checks and measurements recorded.
- If level loops are used, the field notes must be supplied (PDF of field notes are acceptable).
- Two-point solutions are not acceptable under any circumstances.
- Pick up cross sections approximately every 10m. If the street is flat or in a curve, the cross sections should be approximately every 7m to ensure proper terrain representation.
- Pick up the back of the curb just beside the gutter shot.
- Pick up high / low points.
- Pick up approximate location of all longitudinal and cross-sectional grade breaks.
- Pick up the drops of the curb in all let downs (wheelchair ramps and driveways).

- Do not cross survey lines in the drawing.
- All 3D polylines should be connected point-to-point between surveyed points and should not be offset or trimmed.

2.3.5.6 SURVEY MONUMENTS

The City of Vancouver's survey control network consists of Provincial Integrated Survey Area monuments, as well as monuments installed and maintained by the City. In addition to these, the City in partnership with the Greater Vancouver Regional District, has installed High Precision Network (HPN) monuments that include a GPS reference network system, meeting First Order survey accuracy standards.

The City has also resurveyed 78 of the City's Standard Integrated Survey Area monuments to provide elevations to First Order survey accuracy. These monuments have been designated as Secondary Benchmarks. The City's existing control monuments are just as important, and are regularly used by the *Engineering Services Department*, British Columbia Land Surveyors and many others, in their daily operations to provide horizontal and vertical control.

Any work occurring at or near any integrated survey monument is required to notify the *Land Survey Branch* prior to construction to verify disturbance of any integrated survey monuments during construction.

Any monument that has been disturbed or removed will require replacement cost payment from the contractor as per *City of Vancouver Construction Specifications* unless otherwise instructed by the City Engineer. Any monument that has been disturbed or removed will be considered destroyed if:

- The grade of the road at the location of the monument is being lowered or raised, as a result construction.
- The installation of any underground utility is occurring within a 2.0m radius from the monument. This will require the monument to be referenced and monitored by the City, to ensure no impact on its location has occurred.
- The installation of any aboveground equipment is occurring within a 2.0m radius from an HPN monument. Such installations may interfere with the GPS Reference Network System.

2.3.5.7 LEGAL SURVEY

In some cases, a legal survey by a registered B.C.L.S. may be required. The City will specify when a legal survey is required.

2.3.6 TEST HOLES

The installation of test holes within the City street right-of-way for environmental or geotechnical investigations or utility locations can be arranged through the *Utilities Management Branch*.

The purpose of this section is to provide for the efficient review of applications made to the City of Vancouver, by outlining requirements for the installation of test holes within the City street right-of-way. The City permits the completion of test holes for environmental and geotechnical testing purposes, and in its review considers location, existing utilities, pedestrian and vehicle volumes, as well as many other issues that may affect the proposed site. Upon approval of the application, the *Utilities Management Branch* will issue a Test Hole Permit, which grants access to the City street for drilling purposes. The following sections provide specific details regarding the test hole application approval process and installation standards.

2.3.6.1 PERMIT APPROVAL PROCESS

Applicants wishing to install test holes within the street right-of-way are encouraged to use this document as a guideline when applying for a permit. This document outlines the requirements that must be met by an applicant, for the efficient review and timely approval of the permit.

Applicants are required to submit a request to the *Utilities Management Branch* e-mail to the streetutilitiespermit@vancouver.ca address. The request should describe the location of the proposed test hole site by address, intersection, or a map clearly identifying the site. All applicants requesting a permit must complete a City of Vancouver Data Licence Agreement. The Agreement only needs to be completed once and remains in effect for the provision of data for future requests, until otherwise advised by the City. The Agreement is available upon request from the *Utilities Management Branch*.

Once the applicant has completed and returned the Agreement and provided payment of the plan review fee, Utilities staff will issue a receipt for the plan review fee, provide a comprehensive map containing all underground utilities at the proposed site, and advise the applicant whether a traffic plan will be required. The applicant is to use the data supplied to produce an engineering drawing for permit approval. Please note that the *Utilities Management Branch* only accepts drawings in AutoCAD format, and does not accept submission of hardcopy drawings.

The following list of items must be submitted by the applicant for permit approval:

- A letter detailing the issues pertaining to the proposed site. This will include the location, number of test holes per street, traffic concerns, overhead obstacles (i.e. this may prevent the set-up of a drill rig) and any additional site issues.
- A proposed construction schedule detailing the start and end dates for the work, including information regarding monitoring activities if a monitoring well is installed.
- A metric scaled drawing of the site, including all existing underground utilities, their size and offset from the property lines as shown on the utility maps. All proposed test hole locations must be referenced to the property line as well as to the closest cross street, and each must be labelled (TH1, TH2, and so on, for test holes and MW1, MW2, and so on for monitoring holes) for identification.

The *Utilities Management Branch* will review applications to ensure all submission requirements have been met. For those applications that do not satisfy all requirements, applicants will be contacted and advised to make the appropriate revisions, and to resubmit the application. When the *Utilities Management Branch* is satisfied that all requirements have been met, the application will be approved. Staff will notify the applicant to:

- Obtain a Test Hole Permit and Temporary Special Zone Permit (if required) a minimum five working days prior to the scheduled start.
- Submit a traffic plan (if required) a minimum ten working days prior to scheduled start.
- Submit any requests for changes to the approved construction schedule a minimum of 48 hours prior to the start of work.
- Obtain a valid BC One Call ticket prior to starting work.

2.3.6.2 TEST HOLE PERMIT

The Test Hole Permit sets out the terms and conditions by which the City grants permission to an applicant for the installation of test holes within the City street right-of-way. The following sections detail the fees associated with issuing the permit including the plan review fee, and deposits for inspection, street restoration and sidewalk protection from damage caused by the drill rig.

2.3.6.3 PLAN REVIEW FEE

All applicants wishing to install test holes within the City street will be charged a plan review fee. The plan review fee covers the costs associated with *Utilities Management Branch* staff undertaking tasks involved in the application approval process. As test hole projects are typically dedicated to a single site containing two to four test holes, one plan review fee per site, regardless of site size, will be charged. Payment of the plan review fee is required at the onset of the permit approval process, and *Utilities Management Branch* staff will only proceed once payment has been received. Please refer to the *City of Vancouver Street and Traffic By-law No. 2849* for current fees or send a request to *Utilities Management Branch* staff.

2.3.6.4 INSPECTION FEE

An inspection fee will be charged to all test hole installation projects. The *Utilities Management Branch* inspector will conduct at least three site inspections for all test hole installation projects where no monitoring wells are installed: one prior to drilling activities, one following restoration, and a final inspection 90 days following restoration to ensure its performance is acceptable. For those test holes to be outfitted with monitoring wells, the *Utilities Management Branch* inspector will conduct four site inspections: one prior to drilling activities, one following the installation of the monitoring well, another following the decommissioning (removal) of the monitoring well and restoration of the pavement, and a final inspection 90 days following restoration to ensure its performance is acceptable. Please refer to the *City of Vancouver Street and Traffic By-law No. 2849* for current fees or send a request to *Utilities Management Branch* staff.

2.3.6.5 STREET RESTORATION AND DEPOSIT

The *City of Vancouver Construction Specifications* provides standards, specifications and procedures for construction works on City streets. It specifies materials and methods for the restoration of works in a safe, proven and consistent manner. The restoration of all test holes installed within the City streets must conform to *City of Vancouver Construction Specifications*.

A deposit for the cost of restoration of each test hole, based on the type of street treatment, will be secured when the permit is issued. All fees are based on the prevailing rate available from the *Utilities Management Branch* office. Deposits secured for those test holes installed in grass boulevard / gravel verge are refundable, while those installed in concrete sidewalk, bus pads and asphalt pavement are non-refundable.

Refundable deposits held for street restoration will be released only if the City inspector considers the 90-day inspection of the restoration to be acceptable. If the restoration is deemed unacceptable, the deposit will be used for the repair of the test hole by City forces. In situations where deposits do not cover the true cost of repair to the test hole, the applicant will be charged for the difference. Similarly, when the cost of repair is less than the deposit secured, a refund for the difference will be issued.

2.3.6.6 SIDEWALK DEPOSIT FOR DAMAGE CAUSED BY THE DRILL RIG

If a drill rig is to be placed on a City sidewalk, there will be an additional fee charged in the event that any sidewalk damage occurs. A $1000 deposit will be secured when the permit is issued and will be refunded if no damage has occurred.

2.3.6.7 UTILITY LOCATES

Applicants are required to contact BC One Call and obtain a valid ticket prior to commencing any excavation or drilling activities. In addition to the utility information provided by BC One Call, information regarding City water, storm and sanitary sewer service connections to properties is available by calling the City.

2.3.6.8 TEMPORARY SPECIAL ZONE PERMIT AND TRAFFIC MANAGEMENT PLAN

A Temporary Special Zone (TSZ) Permit may be required to remove parking to allow for work to be undertaken on a street. Before a TSZ Permit is issued, a Traffic Management Plan must be submitted to traffic.planreview@vancouver.ca and streetutilities.permit@vancouver.ca for review. This plan must conform to *City of Vancouver Construction Specifications* and must include the following additional information:

- The number of traffic lanes on the street in the worksite vicinity, noting any turning lanes.
- The location of the drill rig and any other vehicles involved.
- The area, in meters, of the work site required to be temporarily signed. This must include enough area for traffic control tapers, and other required signage.
- The number of days the no stopping signs are to be installed.

- Any parking regulations in the affected area. This includes regulations on both sides of the street.
- Any loading zones, taxi zones, consular zones or other dedicated zones.
- If any bus zones in the clearance area need to be cancelled or relocated, arrangements must be made with TransLink prior to issuing any permits. This allows the City to sign the temporary bus relocation, as requested by TransLink on the same permit.
- All parking meters to be hooded must be identified. Parking meter numbers, comprising six digits, are located on both the front and back of every meter.
- A traffic coning plan of the worksite that includes all tapers and their dimensions, the number and type of all construction signs, barriers, high level warning devices, in accordance with the *BC MOTI Traffic Control Manual for Work on Roadways*.

With the information provided, the *Utilities Management Branch* will determine the traffic requirements for the project, associated fees and permits, and the hours and days work will be permitted. Arrangements to obtain a TSZ Permit can be made through the *Utilities Management Branch* office. Note that appropriate fees must be paid before a Traffic Management Plan will be reviewed.

2.4 DRAWING STANDARDS

The City of Vancouver has specific requirements for drawings depending on the project and the type of construction the project involves. This section outlines the general requirements for all drawings submitted to the City, as well as the specific requirements for different types of drawings.

2.4.1 GENERAL REQUIREMENTS

This section contains general arrangement for all drawings submitted to the City. All drawings submitted should meet these minimum standards, as well as the specific standards other section specify.

2.4.1.1 SUBMISSION FORMAT

A complete set of construction drawings shall consist of separate drawings of some or all of the following as determined by the City:

- Cover Sheet.
- Site Plan, General Notes, Legend, and Index.
- Key Plan.
- Streets / Transportation Geometrics and Laning Plan and Profile.
- Typical Sections.
- Road Cross Sections.
- Spot Elevation and Curb Return Grading Plans.
- Signage Plan.
- Pavement Markings Plan.
- Stormwater Management / Sanitary Catchment Plan.
- Storm / Sanitary Sewer Plan, Profile, and Details.
- Waterworks Plan and Profile and Details.
- PRV and Chambers.
- Lot Grading Plan.
- Miscellaneous Details.
- Street Lighting / Traffic Signals.
- Streetscape/ Landscape / Street Furniture.
- Third-Party Utilities.
- Land Acquisition.
- Pump Station Design.
- Structures.
- Construction Phasing, Temporary Works, and Staging Plan.
- Traffic Control Plan.
- Tree Protection Plan.
- Sediment Control Plan.
- Green Rainwater Infrastructure Plan.

2.4.1.2 SOFTWARE

The City of Vancouver's Contract Drawings and CADD Standards are based on the current version of Autodesk AutoCAD Civil 3D. All drawings submitted to the City of Vancouver must be in XML and eTransmit DWG format using AutoCAD.

2.4.1.3 PAGE LAYOUT

The following should apply to all drawing layouts:

- Standard full-scale drawings shall be ANSI D (22" x 34").
- Standard half-scale drawings shall be ANSI B (11" x 17").
- Drawings shall be prepared to be fully legible when reproduced at half size.
- Plan and profile drawings shall have the plan view at the top of the page with the corresponding profile on the bottom of the page with the stationing aligned to match in both views.
- North arrow shall be located in the top right or top left corner of the drawing.
- North arrow shall be pointing to the top or right of the drawing.
- The drawings shall be neat and legible with adequate clearance margins between the drawing information and the title block border meeting the City of Vancouver drafting standards.
- Drawing scale is to be clearly identified on all views and details on a drawing sheet.
- Reference to a survey benchmark is to be included on all plan view drawings.
- Legends should be utilized to both clarify any symbols and line types on the drawing and to reduce the extent of drawing annotation required.
- Limits of construction and match lines shall be clearly marked on the drawing.

2.4.1.4 TITLE BLOCK AND TEMPLATES

The drawing title block shall be the City of Vancouver Standard Title Block and shall include the project name, project location, type of drawing (i.e. Key Plan), engineer's name, consultant's name and logo, drawing scale, consultant file number, and the City of Vancouver drawing number and file number which will be provided by the City of Vancouver. A revision block must be included in each title block containing revision numbers, revision reasoning, date, and full initials of both designer and drafter.

The 100% Design, Issued for Tender, Issued for Construction, and Record Drawing submissions shall bear the seal, date, and signature of the professional engineer registered in British Columbia who is responsible for the design. A digital seal is acceptable and all corresponding digital PDF versions must contain the seal.

2.4.1.5 SCALES

Horizontal scales are to be noted on each drawing with a scale bar. Vertical scales are to be noted if relevant and varying from horizontal scales. Drawings shall be according to the scales shown in ***Table 2-3*** unless otherwise approved:

Table 2-3: Drawing Scales

Drawing	Horizontal Scale	Vertical Scale
Site Plan, General Notes, Legend, and Index	1:10000	-
Key Plan	1:500 or 1:250	-
Streets / Transportation Plan and Profile	1:250	1:10 or 1:25
Typical Sections	1:100	-
Road Cross Sections	1:250	1:10 or 1:25
Spot Elevations	1:250	-
Signage and Pavement Markings	1:250	-
Storm / Sanitary / Waterworks Plan and Profile (typical)	1:500	1:100
Storm / Sanitary / Waterworks Plan and Profile (downtown)	1:250	1:100
Stormwater Management / Sanitary Catchment Plan	1:1000	-
Lot Grading Plans	1:250	-
Miscellaneous Details	(Varies)	(Varies)
Street Lighting Plan	1:500 or 1:250	-
Traffic Signal Plan	1:200	-
Traffic Signal Plan Details	1:100	-
Streetscape / Landscape / Street Furniture	1:250	-
Third-Party Utilities	1:250	-
Land Acquisition	1:500	-
Planting Plan	1:100	-
Tree Protection Plan	1:250	-

Notes:
1) Alternatives to the scales required above may be accepted where the City of Vancouver considers them to be appropriate or required.

2.4.1.6 DIMENSIONS

All drawings shall be in metric. Numerical values shown on the construction drawings shall be shown to two decimal places (0.01) unless accuracy warrants otherwise, and with the exception of all coordinates, which are to be in meters and indicated to the nearest three decimal places (0.001). The source and location of the datum shall be clearly noted on each drawing (Updated UTM NAD 83, Zone 10). The drawings must be in ground metric coordinates based on the current City Survey Monument Network and clearly indicate the monuments used.

2.4.1.7 NOTES

Notes and text shall locate and describe the proposed work in sufficient detail to facilitate construction. Text is to be orientated to best suit the layout of sheets which is typically horizontal or parallel to the main alignment. Text shall be minimum 1.8mm text height for full-sized drawings and minimum 0.9mm text height for half-size drawings. Standard City of Vancouver notes should be used when possible and be updated as required to suit specific situations.

Construction notes are to be boxed and located around the perimeter of the drawing and shall be tagged to the drawing feature.

2.4.1.8 COLOUR

All drawings are to be submitted in colour. Colours should be allocated with the understanding that different printers produce different tones. Differentiation should always be easily understood.

2.4.1.9 DRAWING CERTIFICATION

All final drawings must be signed, sealed, and dated by the professional engineer, or the registered landscape architect as appropriate, responsible for the design. This certification indicates that the engineer is in good standing with Engineers and Geoscientists British Columbia (EGBC) and that the drawings have been designed using sound engineering practices. By stamping the drawings, the engineer is also certifying that the design is generally in accordance with the *City of Vancouver Engineering Design Manual*, *City of Vancouver Construction Specifications*, *City of Vancouver Standard Detail Drawings* and the *MMCD*.

2.4.1.10 DELIVERABLES

Unless otherwise specified, expected deliverables for all design phases are:

- One submittal letter on the consultant’s letterhead, signed by the consultant. As a minimum, the letter shall define what is being submitted, confirm appropriate QA/QC has been completed and provide general information on the project and its construction schedule.
- Three complete sets of full-size hardcopy drawings signed and sealed when appropriate, unless otherwise specified.
- One digital submission including one complete PDF version and an AutoCAD version. The AutoCAD version shall include models, surfaces, pipe networks, and all other design elements.

2.4.1.11 CITY REVIEW

The City of Vancouver must be provided with a minimum of 15 working days for review of any submission, unless otherwise agreed upon by the consulting engineer and the City. All reviews must be completed, and comments addressed to the City / City Engineer's satisfaction prior to construction.

2.4.2 GENERAL DRAWING INFORMATION

Each plan and profile drawing shall show, but not be limited to, the following information:

- Title block.
- Scale bar.
- Matchlines with associated reference drawing number, and continuation notes where applicable.
- Benchmarks (including temporary benchmarks) noted in the legend with identification number, location and elevation, and survey monuments shown on the plan view.
- Existing topographic surface features (displayed at 50% transparency) including, but not limited to, the following:
    - Pavement, curbs, sidewalks, bicycle paths, and boulevards.
    - Ditches, watercourses, and culverts.
    - Bus stops, benches, public art, and other street furniture.
    - Trees, vegetation, and landscape features.
    - Retaining walls, buildings and structures.
- All existing underground and surface utilities and services (displayed at 50% transparency) with offsets, size, and material type including, but not limited to, the following:
    - Sanitary sewers, storm sewers, water mains, and appurtenances.
    - Street light poles, conduit, and appurtenances.
    - Hydro poles, underground wiring ducts, and appurtenances.
    - Communications poles, underground wiring ducts, fibre-optic cables, and appurtenances.
    - Gas mains and appurtenances.
    - Traffic control devices, poles, conduits, signs, and painting.
    - Pump stations, PRV's, and operating kiosks.
    - Utility crossings with crossing pipe inverts.
- Legal property information including, but not limited to, the following:
    - All pertinent property lines, right-of-way and easement lines, and road allowances.
    - Lot numbers, existing legal plan numbers, street names, and addresses.
- Offsets for all mains and services referenced from property lines or rights-of-way as appropriate.
- Right-of-way and / or road centerline stationing to metric standards (0+000) and marked at 10m intervals with labels every 50m. Stationing shall be related geometrically to legal property lines or survey monuments. Stationing shall run left to right where possible.
- Stationing referenced to monuments / iron pins with coordinates.

- Horizontal plan views with alignments from west to east or from south to north across the drawing sheet.
- Profile elevations placed at both sides of the profile. Split profiles must show elevations on both sides of the break.
- Labels including the scale of the view.
- The work laid out in an orderly sequence (ex. intersections or pipe junctions not broken up between sheets where possible, and interchanges easily defined).
- Profile views lined up with plan views. Stationing of alignments (T.S., S.C., etc.) coinciding with plans.
- Existing ground lines on profiles.
- Limits of construction.
- Reference data for monuments used in survey.

2.4.3 SITE PLAN, GENERAL NOTES, AND INDEX

A small-scale Site Plan showing the project location in relation to major streets shall be provided. The drawing shall include the general notes and construction notes and an index which includes drawing titles, sheet numbers, and the current revision of each sheet. The drawing shall also include a legend indicating symbols and linetypes used in the drawing set. Line thicknesses shall distinguish between existing and proposed features with bold lines for proposed features.

2.4.4 KEY PLAN

The purposes of the key plan are to present the overall design, show the interaction between various design disciplines, and to check for conflicts among the various existing and proposed features. The following shall be shown in addition to the information required in *Section 2.4.2:*

- All proposed underground and surface utilities and services (with offsets, size, and material type) including, but not limited to, the following:
    - Sanitary sewers, storm sewers, water mains, and appurtenances.
    - Street light poles, conduit, service panels / kiosks, junction boxes, and appurtenances.
    - Hydro poles, underground wiring ducts, and appurtenances.
    - Communications poles, underground wiring ducts, fibre-optic cables, and appurtenances.
    - Gas mains and appurtenances.
    - Pump stations, PRV’s, and operating kiosks.
- All existing and proposed roadworks and landscaping such as community gardens, trees, and bulges.
- Stationing.
- Plan and profile drawing reference numbers.
- Survey control monuments.
- Traffic control devices, poles, conduits, signs, and painting.
- Routing of all major storm flows including the 100-year storm.

2.4.5 STREETS / TRANSPORTATION

Streets / transportation drawings are separated into four distinct categories: plan & profile, typical sections & cross-sections, signage plans, and pavement marking plans. This section outlines the drawing requirements for each of these drawings.

2.4.5.1 STREETS / TRANSPORTATION PLAN AND PROFILE

The drawings will include plan view, profile view, and details. The following shall be shown in addition to the information required in *Section 2.4.2*:

- All proposed roadworks, complete with tie-in points and offsets from road centerline, including pavement, curbs (with types noted), sidewalks, poles, barriers, retaining walls, culverts, and roadside drainage ditches.
- Where there is an elevation difference of more than 0.3m from the design road centerline to an existing or suitable building site on the adjacent parcel, driveway grades and profiles shall be shown on the drawings.

Plan view to include:

- Stations of the beginning of curve and end of curve of the road centerline and curb return horizontal curves with the curve information including delta angle, radius, tangent length and arc length.
- Details of intersections with spot elevations at all critical points.
- Catchbasin locations with station, offset, and rim elevation (using leaders, not in a table).
- Spot elevation plan with spot elevations every 10m or 20m (corresponding with cross section spacing) on all gutter lines, back of walk, crown, and other relevant locations including beginning of curve, ¼ point, ½ point, ¾ point, end of curve, grade breaks, high points, and low points.
- Proposed street furniture and features such as trees, traffic devices / signals, street lighting poles, concrete barriers, guardrails, handrails, and integrated survey control monuments.
- Details of any pedestrian / bicycle refuge area, pedestrian crossing, wheelchair curb ramps, tactile pavers, paint markings, and other surface features.
- Toes of cut and fill labeled C or F.
- Design speed and design vehicles noted.
- Vehicle restriction, greenway related signage, retaining walls, special paving treatment, swales, and special features within greenway.
- Proposed retaining wall alignments, layouts, and construction detailing (on structural drawings).
- Detours shown if applicable (may be separate drawings).
- Additional design details as required.

Profile view to include:

- Existing ground, proposed road centerline, gutter line, intermediate curb, front of walk, and property line profiles along the pavement centerline with elevations at 10m intervals and grades.
- Crown or superelevation information.
- Stations and elevations of beginning of vertical curve, end of vertical curve, and vertical point of intersection.
- Vertical curve and grade information including the length of curve, sag or crest K value, and percent.
- Elevation and station of low and high spots of vertical curves.
- Centerline of any intersecting roads.
- Curb return profiles (shown on separate sheets) extending 10m past either side of curve. Alignments to follow gutter line and not edge of gutter. Curb types to be clearly shown on profiles and plans.
- Impacted utilities at the discretion of the consultant.
- Additional design details as required.

2.4.5.2 TYPICAL SECTIONS AND ROAD CROSS-SECTIONS

Where road cross-sections are required, they may be provided on separate sheets. The following information is to be shown:

- Road cross-sections are required at 20m intervals and additionally at all critical locations including driveway crossings, BC, EC, and crosswalks as required. Sections are required at 10m intervals on curved roads and through intersections. Additional sections may be required where excessive cut or fill is required.
- Cross-sections shall include design road cross-section within the right-of-way and existing ground cross-section extending into the adjacent properties as required.
- Where only a half road is being constructed, full width design cross-sections shall be provided as required to ensure the design suits the future development of adjacent properties. All future works to meet City of Vancouver drafting standards.
- Crossfall or superelevation information is to be shown.
- Proposed elevations of the road centerline, the curb and gutter (or edge of pavement), and property lines are to be noted on the cross-sections.
- A typical cross-section is to be required for each varying road arrangement showing details of right-of-way width, road structure, pavement width, centerline, lane arrangement, sidewalks and curbs, barriers, retaining walls, side and back slopes, road side ditches, surface treatments, proposed and existing underground or above ground utilities including related offsets, cross falls, dimensions, and any other applicable features.
- Impacted utilities at the discretion of the consultant.

2.4.5.3 SIGNAGE PLAN

The Signage Plan shall detail all alterations, additions, and new regulatory and advisory signage. The design shall conform to the *MUTCD* and *Section 8.10*. The standards for line types, and dimensions should be consistent with the most current Transportation AutoCAD Template file. The following information shall be shown:

- Dimensioned location and type of new, existing, removed, relocated, and modified signs displayed with AutoCAD blocks. Existing signs to be in greyscale and new, removed, relocated, and modified signs to be in colour. Installed signs to be outlined with a green box, removed signs to be outlined with a red box, and relocated signs to be outlined with a light-blue box with leaders and text in corresponding colour to be shown. Ensure the drawing is legible in printed format. Signs shall be orientated to indicate the direction the sign is to be installed and viewed from.
- Completed traffic sign table including sign description, sign number, and number of each sign removed, modified, and installed per sheet. Include number of post and sleeves or post and bases.
- Curbs, paint markings, sidewalks, trees, poles, driveways, and all other aspects of the roadway that assist crews to install signs. Streetlight poles are to include ID# (i.e. 01/04). For drawing clarity, remove unnecessary information that clutters the drawing.
- All parking meters (any modification to a parking meter must include the parking meter number) and pay stations.

2.4.5.4 PAVEMENT MARKINGS PLAN

The Pavement Markings Plan shall detail all eradications, alterations, additions, and new line painting. The design shall conform to the *MUTCD*. The standards for line types, and dimensions, should be consistent with the most current Transportation AutoCAD Template file. The following information shall be shown:

- Dimensions, lengths, and colour of proposed lane or curb markings, medians, and crosswalks and paint colour for special treatment areas.
- Lane widths, median radii, and taper ratios.
- Curbs, sidewalks, signage, trees, poles, driveways, and all other aspects of the roadway to assist with installation. For drawing clarity, remove unnecessary information that clutters the drawing.

2.4.6 STORMWATER / SANITARY CATCHMENT PLAN

The drawings will include plan views and details. No profiles are required. The drawings shall show, but not be limited to, the following:

- Catchment boundaries with catchment number and area in hectares.
- Existing sewers and maintenance holes.
- Proposed sewers and maintenance holes.
- Any detention facilities.

- Accumulated flows and pipe capacity for each section between maintenance holes with provision for upstream development potential where applicable.
- Design storms used.
- Flow and pipe capacity calculation table (see *Sections 4.2.3* and *5.2.2.5)*.
- A legend noting all items proposed in the Stormwater / Sanitary Catchment Plan. Applicable general notes should also be included.

2.4.7 STORM / SANITARY SEWER PLAN AND PROFILE

The drawings will include plan view, profile view, and details. The drawings will follow standards outlined in the City of Vancouver Sewers and Drainage Design CADD Standards. The following shall be shown in addition to the information required in *Section 2.4.2*:

- Show all proposed storm and sanitary works including maintenance holes, drop structures, cleanouts, catchbasins, inlet / outlet structures, pipe work, overland drainage, ditches, culverts, inspection chambers, services, and fittings. Drawings to be complete with offsets for mains (from the same property lines, coordinates on curves), rim elevations, stations related to the road centerline, pipe inverts at maintenance holes and pipe grade breaks, and hydraulic grade lines if outside the pipe.
- When possible, show storm and sanitary drawings on the same drawings using centerline stationing. Common trench sewers and sewer separations are required to be shown on the same drawing.
- For any detention ponds, show all pipes with size, inverts, and location; capacity; high water elevation; base elevation; control device particulars; location, size, and elevation of all maintenance holes and catch basins; and any other design elements.
- Show any watercourse diversion information.
- The design flow rate, storm duration, and return period shall be noted on each storm drawing.
- All non-standard connections to be noted.
- Materials, types, sizes, inverts, and flow directions to be shown for all proposed and existing culverts.

Plan view to include:

- Directional flow arrows incorporated into all pipe line types.
- Proposed inverts and offset locations to property line for all service connections and mains.
- Offset distance to include prefix “SAN” for sanitary and “STM” for storm, (i.e. SAN 2.4m or STM 3.0m).
- Location of existing buildings on properties serviced by storm and sanitary sewers.
- Basement elevations for existing buildings at the discretion of the City.
- All existing utilities in the vicinity and their offset.

Profiles must be shown for all storm mains, sanitary mains, sanitary services (for pipes greater than 100mm diameter), and storm services (for pipes greater than 150mm diameter) except where the installation of connections from an existing main is the only work performed. Profile view to include:

- Existing and finished ground profiles of the proposed sewer.
- Invert profiles of the proposed and existing pipes.
- Size, type, material, and class of pipe.
- Stationing.
- Maintenance holes with diameters shown.
- Distance between maintenance holes with proposed grade of pipe.
- Existing and proposed pipe crossings including crossing pipe inverts.
- All infrastructure crossings and tie-ins.
- CCTV bar between plan and profile showing wye locations.
- If flow calulations were performed using a hydraulic model, add design flow (Q_D) in cms and pipe capacity (Q_F) in cms.
- Additional design details as required.

2.4.8 WATERWORKS PLAN AND PROFILE

The drawings will include plan view, profile view, and details. The following shall be shown in addition to the information required in *Section 2.4.2*:

Plan view to include:

- All proposed waterworks including size, type, and class of pipe, hydrants, valves, services, joint restraints, fittings, and all related appurtenances.
- Stations and offsets for all mains, conduits, chambers, hydrants, tees, bends, line valves, air release valves, blow-offs, and horizontal pipe deflections. Offsets to be from the same property lines. Coordinates to be used on curves. Stations to relate to the road centerline.
- Size of each connection and meter chamber details if applicable indicated on the drawing.
- Locations of proposed service connections and fire hydrants including an offset distance from an iron pin or lot corner. Offset distance to include the prefix “WD” (i.e. WD 1.2m).
- The length of the segment of main.
- List of materials for all elements such as pipes, fittings, polybags.
- Special fittings, coating, corrosion protection systems and other elements detailed on the drawings.
- Details in areas such as tee and cross intersections where dimensioning and other information cannot be adequately conveyed at the main drawing scale.
- Extent of work required in making the connection to existing water mains contained in a detail drawing view.
- Joint restraints or thrust blocks that are sized, shaded, labeled, and dimensioned from adjacent fitting showing the length of pipe requiring restraint.
- Any water main protection details.
- Additional design details as required.

Profile views are required and will include:

- Existing ground profile; finished ground or road profile; pipe size, material, and class; and pipe invert and obvert profiles along the centerline of the proposed water main.

- All pertinent service crossings with clearances labelled (ex. sewer mains, gas mains, and duct banks.).
- Station and offset from centerline at each deflection or fitting if the proposed water main alignment or profile varies from the road centerline, where applicable.
- Additional design details as required.

2.4.9 LOT GRADING PLANS

The drawings will include plan views and details. No profiles are required. The lot grading plan shall show, but not be limited to, the following:

- Existing storm sewers, maintenance holes, and connections.
- Proposed storm sewers, maintenance holes, and connections.
- Contours at 1m intervals with labels at 5m intervals showing existing and proposed grades extending a minimum of 20m beyond the project site.
- The proposed building envelope.
- Arrows identifying the positions of the major flow hydraulic grade lines within the Development as follows:
    - Above ground (solid flow arrow).
    - Surcharged (hatched flow arrow).
    - In pipe (hollow flow arrow).
- Existing elevations at all property lines (un-circled).
- Proposed elevations at all property lines (circled).
- Fill over 0.45m (shaded) and fill over 1.0m (hatched).
- Overland flow arrows.
- Lawnbasins and catchbasins, leads, and rim elevations.
- Swales (at time of subdivision development and at building construction).
- Proposed green rainwater infrastructure.
- On-site infiltration systems.
- Storm sewer invert elevation at property line for all lots.
- Retained trees.
- All proposed controls to prevent the release of sediment into any ditch, storm sewer, watercourse or ravine.

2.4.10 MISCELLANEOUS DETAILS

Standard details such as maintenance holes, catchbasins, and hydrants, that are shown and described in the *City of Vancouver Standard Detail Drawings* do not need to be shown in detail on the drawings. Instead, the Standard Detail Drawing number shall be referenced on the drawings. Standard symbols for the various utilities shall be used and may be shown in a legend on the drawings.

The following shall apply to detail sheets:

- Where there is not sufficient room on the plan and profile drawings, design details for the particular drawing may be provided on a separate sheet.
- Scales shall be determined by the designer to suit the design detail. Scales shall be noted on the detail drawing, unless it is not to scale, in which case it shall be noted as such.
- The detail shall reference the parent drawings it pertains to and the parent drawings shall reference the detail.
- A north arrow shall be added to all details that deviate from the page layout north arrow.

2.4.11 STREET LIGHTING

The drawings will include plan views and details. A pole profile showing pole base, pole type and elevation, luminaire arm length, receptacle, street and pedestrian luminaire, banners, and flower baskets is required. The following shall be shown in addition to the information required in *Section 2.4.2*:

- Plan drawings at a scale of 1:500 showing pole locations, conduit and service equipment. For beautification type projects which have more electrical features such as pedestrian scale lighting and pole / tree receptacles, plan drawings at a scale of 1:250 may be required. Poles and service equipment shall be located by offset and dimension from closest property lines. Conduit shall be located by offset from edge of pavement or curb and gutter.
- The proposed installation details and all related existing lighting and electrical information.
- Legend and notes.
- Completed Lighting Design Criteria Table (See *Section 10.3.3*) for each street, cycle path, walkway, mid-block crosswalk, intersection or roundabout.
- A table with City products listed by manufacturer, make, and model number (including any approved alternates), as per current City Lighting and Signal Approved Product List.
- Trench cross sections.
- Service kiosk or panel schematic diagram.
- Lighting calculations in AGi format.
- Any additional information the City may require that the City deems necessary for the review of a design submission.

2.4.12 TRAFFIC SIGNALS

The drawings will include plan views, details and profiles. The traffic signal design drawings shall show, but not be limited to, the following:

- Plan drawings at a scale of 1:200 (ideal) showing pole locations, signals, pushbuttons, audibles, luminaires, junction boxes and vaults, conduit, conductors and cables, detector loops, signs, signal controller cabinet, service equipment, BC Hydro service location including BC Hydro pole ID, underground utilities, all pavement markings, property lines other any other elements of significance. Poles and service equipment shall be located by station and offset. Conduit shall be located by offset from the property line.

- Legend and notes.
- Details including signal phasing diagram, pole elevations with references to roadway pavement markings and curbs, detector loop table and single line diagrams and bill of materials with City approved and current stand product. Kiosk base plan detail for non-City standard service kiosk/cabinets.
- The proposed installation details and all related existing signal, lighting, and electrical information.
- Trench cross-section details.
- A table with City products listed by manufacturer, make, and model number (including any approved alternates), as per current City Lighting and Signal Approved Product List.
- Any additional information the City may require that the City deems necessary for the review of a design submission.

2.4.13 STREETSCAPE/ LANDSCAPE / STREET FURNITURE

All landscape related construction drawings and inspections required under this section shall be undertaken by a Landscape Architect registered with the British Columbia Society of Landscape Architects (BCSLA). The following information shall be shown in addition to the information required in *Section 2.4.2:*

- Clearly identified building footprints and overhead canopies.
- Sight distance triangles at intersections.
- Proposed slopes with slope direction arrow and slope ratio, contours, and top and bottom of slope lines with elevations.
- Proposed tree locations with correct botanical name, showing trunk center and approximate canopy spread at 15 years of age.
- The location of plant material (with correct botanical name) with respect to curb, sidewalk, underground utilities, overhead utilities, driveway locations, mailbox locations, and street lights.
- Plant labels and an associated plant list which indicates quantity, scientific name, common name, plant size, condition (e.g. container or B&B), spacing, and comments.
- Location of all shrubs, groundcover beds, and grass areas. Proposed grass areas shall be defined as sod or seed.
- Extent of proposed standard and decorative paving with details of paving structures.
- Location and type of proposed furnishing products.
- A typical right-of-way cross-section drawing indicating the relationship of all plantings to overhead, above-ground and below-ground utilities, pavement, and other structures referenced and shown on the landscape plan or, if there is insufficient room, on a details and cross-section sheet.
- Typical tree, shrub and groundcover cross-section planting details.
- Existing and proposed ground elevations at property lines.
- Lawnbasin and catchbasin rim elevations and proposed curb cuts.
- Walkway pavement elevations and layouts.
- Proposed fencing layouts and construction detailing.
- Street furniture.

- Drinking water fountains and associated utility boxes.
- Junction box locations.
- Proposed tree pit details for trees planted in sodded boulevards. Trees planted within paved walkways shall conform to the current City of Vancouver standards.
- Structural soil details.
- Interface / relationship details and sections between different paving types.
- Inspection requirements text block:

The applicant must notify the Park Board on the following dates:
When the boulevard or sidewalk has been fully prepared, the trees are on site but ***not*** yet planted and the required root barriers are ***not*** yet installed.
23 months after the planting of the trees.
First inspection date: ______________ PB inspector ______________
Second inspection date: ____________ PB inspector ______________
PB inspector to be onsite during planting. Provide 72 hour's notice for inspections.

2.4.14 LAND ACQUISITION

Where the proposed construction of capital works is over private lands and requires a right-of-way, a separate land acquisition drawing will be prepared for every lot affected.

- The drawing will be on an ANSI B (11" x 17") or ANSI A (8½" x 11") sheet.
- The drawing shall include the legal lot information, adjoining properties and street names, and a north arrow.
- The civic address and registered owners will be listed in the bottom right hand corner above the title block.
- The plan will show the area of the proposed new right-of-way and of the total lot through which the right of way will go.
- The drawing will show the total acquisition area and hatching.
- The drawing will show a dimension perpendicular to the adjacent lot line and any other dimensions required to clarify the extent of the proposed right-of-way.
- The sketch is an attachment required with every right-to-enter form and condition sheet signed by the owner.
- The drawing will show survey monument locations.

2.4.15 PUBLIC BIKE SHARE

At minimum, all drawings must show:

- A site plan overlaid with all relevant information and features that may impact the site including, but not limited to:
    - Curb and property lines.
    - Traffic and bike lane lines.

    - Above and below ground structures
    - Utilities and utility access points.
    - Infrastructure.
    - Street furniture.
    - Trees.
    - Street regulation and other sign posts.
    - Parking meters.
- Dimensions of critical clearances to nearby fixed objects, utility access points (maintenance holes, valve covers, etc.), and above ground access points (building exits, fire department Siamese connections, etc.).
- Consideration of access requirements for operation or maintenance of nearby elements or utilities.
- Any other relevant information requested by the City Engineer.

2.5 DESIGN PROCESS

The design process is to be undertaken in coordination with appropriate project management practices. This section details the expected design process from project initiation to record drawings, including the expected submissions at each stage of the design process.

2.5.1 PROJECT INITIATION AND SCOPE

Project initiation is the first part of the design process. The needs, priorities, and motivations for the project are determined to help decide upon project scope and plans. This phase typically includes some or all of the following: public consultation, a public open house, information sessions, Council approval, design brief, survey, and site investigation.

2.5.2 DESIGN DEVELOPMENT MATRIX

Table 2-4 outlines the specific requirements of each submission. Note that the City will inform a consultant if a requirement listed in the table is not needed. If a project is particularly complex and / or challenging, an interdisciplinary design review process and presentations / workshops in advance of formal submissions may be required.

Table 2-4: Design Development Matrix

Design Level	Typical Drawings	Design Brief Contents	Associated Reports / Documents
Functional Design	• Plan View on Air Photo • Typical Cross-sections • Preliminary Utility Alignments	• Class "D" Cost Estimate • Design Schedule • Project Recommendations	• Traffic / Ped / Cyclist Counts
50% Submission	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Stormwater / Sanitary Catchment Plan and Calculations • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Street Lighting / Traffic Signals • Streetscape/ Landscape / Street Furniture	• Class "C" Cost Estimate • Design Schedule Update • Investigation Summary • Address Comments from Previous Submission	• Survey • Geotechnical • Hydrogeological • Environmental • Archaeological • Traffic Report • Structural • Rainwater Management Plan • Groundwater Management Plan • Streetscape Materials Plan • Other Discipline-Specific Reports

Design Level	Typical Drawings	Design Brief Contents	Associated Reports / Documents
75% Submission	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Signage and Pavement Markings • Stormwater / Sanitary Catchment Plan and Calculations • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Street Lighting / Traffic Signals • Streetscape/Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Class "C" Cost Estimate Update • Design Schedule Update • Project Phasing Plan • Bill of Materials • Address Comments from Previous Submission • Coordination Letter	• Permit Applications • Draft Tender Documents • Updated Reports
90% Submission	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Spot Elevation and Curb Return Grading Plans • Signage and Pavement Markings • Stormwater / Sanitary Catchment Plan and Calculations • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Miscellaneous Details • Street Lighting / Traffic Signals • Streetscape/ Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Class "B" Cost Estimate Update • Design Schedule Update • Project Phasing Plan Update • Bill of Materials Update • Address Comments from Previous Submission • Coordination Letter Update	• Permit Application Updates • Draft Tender Documents • Updated Reports

Design Level	Typical Drawings	Design Brief Contents	Associated Reports / Documents
100% Submission	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Spot Elevation and Curb Return Grading Plans • Signage and Pavement Markings • Stormwater / Sanitary Catchment Plan and Calculations • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Miscellaneous Details • Street Lighting / Traffic Signals • Streetscape/ Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Class “A” Cost Estimate • Project Phasing Plan Update • Construction Schedule • Bill of Materials Update • Address Comments from Previous Submission • Coordination Letter Update	• Final Permit Approvals • Draft Tender Documents • Updated Reports
Issued for Tender	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Spot Elevation and Curb Return Grading Plans • Signage and Pavement Markings • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Miscellaneous Details • Street Lighting / Traffic Signals • Streetscape / Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Class “A” Cost Estimate • Construction Schedule Update • Final Bill of Materials	• Final Tender Documents • Updated Reports

Design Level	Typical Drawings	Design Brief Contents	Associated Reports / Documents
Issued for Construction	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Spot Elevation and Curb Return Grading Plans • Signage and Pavement Markings • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Miscellaneous Details • Street Lighting / Traffic Signals • Streetscape / Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Final Bill of Materials	• Final Contract Documents • Updated Reports
Record Drawings	• Site Plan, General Notes, and Index • Key Plan • Streets / Transportation Plan and Profile • Typical Sections • Road Cross-sections • Spot Elevation and Curb Return Grading Plans • Signage and Pavement Markings • Storm / Sanitary Sewer Plan and Profile • Waterworks Plan and Profile • Lot Grading Plans • Miscellaneous Details • Streetscape / Street Lighting / Traffic Signals • Landscape / Street Furniture • Third-Party Utilities • Land Acquisition	• Revised sewer calculations to reflect changes • Revised streetlight calculations to reflect changes • Closeout Reporting for External Stakeholders	• Planting Record Documents • Service Cards • Statutory Right of Way Drawings • Test Results and Summary • Maintenance manuals • Builders Lien and Deficiency Holdback Payment Requests • As-Constructed Survey • Certificate of Substantial Completion • Certificate of Total Performance • Letter Report Summarizing Maintenance Inspections • Quality Control Documents

2.5.3 CONSTRUCTION COST ESTIMATES

With each submission to the City, a design brief is to be provided including a construction cost estimate. The cost estimates required are defined in ***Table 2-5***, in order of increasing level of design detail and cost certainty and decreasing contingency:

Table 2-5: Construction Cost Estimates

Class of Estimate	Project Stage	Minimum Contingency
D	Planning	20%
C	Preliminary Design	15%
B	Detailed Design	10%
A	Implementation Planning	5%

2.5.4 FUNCTIONAL / CONCEPTUAL DESIGN

The functional / conceptual design submission represents approximately 30% of the design effort and shall be of sufficient detail to show how the project's functional and technical requirements will be met, indicate the consultant's approach to the design solution, show compliance with design criteria, and provide justification for any noncompliance.

Functional / conceptual design submissions typically present various options for a project. The consultant is not to proceed to the detailed design stage until the functional design and report have been reviewed and accepted by the City of Vancouver.

2.5.5 50% DETAILED DESIGN SUBMISSION

The 50% detailed design submission is the first submission of the detailed design. It should reflect the City's preferred functional / conceptual option with any requested conceptual changes to that option addressed. It may not contain all details; however, the majority of the design should be provided. This is the submission where the bulk of the major design comments will be generated.

2.5.5.1 50% GENERAL

General information required at the 50% Design Submission level includes:

- Address any comments on the functional / conceptual design and include a comment resolution sheet detailing how each comment was addressed. Include the original unaltered marked-up set of drawings.
- Key plan to check for conflicts.
- Single stationing.
- Existing topographical survey with identifying text as required.
- Existing sewers, water mains, and Third-Party Utilities with text noting size, material, and type of utility.
- Utility crossings identified.

- Legal lot lines and descriptions, street names, and civic addresses.
- Survey, geotechnical, environmental, hydrogeological, archaeological, groundwater and traffic reports, if not already provided during the conceptual stage.
- A design brief containing a summary of design criteria, calculations (such as pipe capacity) an update of the design schedule, and an investigation summary. Comments from the previous design brief should be addressed. The design brief shall also contain a Class "C" construction cost estimate.
- Stormwater Management Plan.

2.5.5.2 50% STREETS / TRANSPORTATION

The following information shall be shown on 50% Streets / Transportation design submissions in addition to the information listed in *Section 2.5.5.1*:

- Plan and profile drawings showing the proposed design including centerline alignment and stationing, lane assignments, offsets, widths, surface treatments and materials, existing and proposed curb and gutter locations, edge of pavement, sidewalks, pedestrian and cyclist facilities retaining walls, property acquisitions, catchbasins, limits of cut and fill.
- Profiles are to show the existing ground and finished grade profiles at centerline.
- Profiles should also include vertical curve data, k values, superelevation, existing and proposed culvert locations, and surcharge and preload areas.
- Facilities for pedestrian, bicycles, transit vehicle, truck, motor vehicle clearly shown;
- Special treatments for bicycles / pedestrian.
- Intersection phasing diagram.
- Signal timing plan corresponding with network modelling.
- Identifications of high desire lines of pedestrian, bicycle, transit, trucking, motor vehicle facilities through the project area and beyond the project extents shown schematically.
- Existing and proposed transit stop locations identified and tied in with landscaping – all transit routes addressed.
- Turning movements to be shown.
- Coordinate passenger movements with landscaping and pedestrian/bicycle facilities.
- Detailed typical cross-section drawings which span the length of the project.
- Preliminary paint markings.
- Identification of any conflicts between electrical, street lighting, traffic signals, utilities, tree plantings, and other above and below ground infrastructure.
- Existing and proposed structure locations, dimensions, and elevations.
- 3D rendering for presentation if required.
- The design brief should detail high desire lines for all modes and confirm no conflicts exist between such movements as bicycles, pedestrians, vehicles, transit passenger load / unload door zones.

2.5.5.3 50% STORM / SANITARY / WATERWORKS

The following information shall be shown on the 50% Storm / Sanitary / Water design submissions in addition to the information listed in *Section 2.5.5.1*:

- Plan and profile drawings showing the existing and proposed design including centerline alignment and stationing, existing and proposed grades, sizes of pipe, maintenance holes, cleanouts, water valves, hydrants, sanitary, storm and water services, catchbasins, servicing locations, proposed stub outs for future connections, air valves, and blow-off valves.
- Profiles showing proposed pipes, maintenance hole depths, and fitting locations with all crossing pipes shown and identified.
- Proposed utility alignments in plan view, existing utility locations, tie in locations, property lines, lots, rights-of-way, topography, curb lines, preliminary maintenance hole locations, and future extension alignments.
- Possible future alignments and maintenance hole locations.
- Third-Party Utility relocations identified.
- Major utility crossing designs.

2.5.5.4 50% STREET LIGHTING / TRAFFIC SIGNALS

The following information shall be shown on the 50% Street Lighting / Traffic Signals design submissions in addition to the information listed in *Section 2.5.5.1*:

- Traffic Signal drawings.
- Tree planting plan (with existing trees).
- Pole locations (existing and proposed).
- Existing junction box, traffic controller cabinet, and vault locations.
- Traffic controller locations.
- Service panel or Kiosk locations.
- Traffic Signal Management System or BC Hydro service locations.
- Signal phasing and signal sequence diagrams.
- Preliminary Lighting Design Criteria Table.
- Electrical Power Distribution Single Line Diagram and Preliminary Load Calculation.
- The design brief shall highlight any outstanding issues or potential problems (e.g. Hydro conflicts, utility conflicts) It shall contain written confirmation of lighting levels, uniformity ratios, and service voltages.

2.5.5.5 50% STREETSCAPE / LANDSCAPE / STREET FURNITURE

The following information shall be shown on the 50% Landscape / Street Furniture design submissions in addition to the information listed in *Section 2.5.5.1:*

- General planting areas including tree planting.
- Fencing is not required to be shown.
- Plant list.
- Street furniture strategy.
- Location of tree protection fencing.
- Materials Plan.

2.5.6 75% DETAILED DESIGN SUBMISSION

The 75% detailed design submission should contain all planned details and required information such that future stages will only be a refinement of the information provided in this stage.

2.5.6.1 75% GENERAL

General information required at the 75% design submission level includes:

- Address any comments on the 50% design and include a comment resolution sheet detailing how each comment was addressed. Include the original unaltered marked-up set of drawings.
- Typical details, if standard, should be a reference to the *City of Vancouver Standard Detail Drawings*. If details deviate from standard they should be shown on a details sheet.
- Land Acquisition Drawings.
- Lot Grading Plans.
- Third-Party Utility design drawings.
- Major utility permits, crossing approvals, or updates with applications and related drawings for City of Vancouver review.
- Draft tender documents and specifications.
- The design brief should contain an updated design schedule, project phasing plan, bill of materials, and updated Class “C” construction cost estimate. Comments from the previous design brief should be addressed.
- Coordination with all disciplines and letter confirming conflict check.

2.5.6.2 75% STREETS / TRANSPORTATION

The following information shall be shown on the 75% Streets / Transportation design submissions in addition to the 50% submission requirements and the information listed in *Section 2.5.6.1:*

- In the plan view, add information for access details, drainage structures, roadside barriers or flares, clearing and grubbing limits, critical dimensions, utility conflicts, objects / items that are to be relocated or removed, fencing, limits of construction.
- Gutter grades and profiles as required.
- Signage drawings.
- Pavement marking drawings.
- Detailed cross-section drawings.

2.5.6.3 75% STORM / SANITARY / WATERWORKS

The following information shall be shown on the 75% Storm / Sanitary / Water design submissions in addition to the 50% submission requirements and the information listed in *Section 2.5.6.1:*

- Utility tie-in schematics and details.
- Detailed fitting labels.
- Trench restoration details referring to the current *City of Vancouver Standard Detail Drawings*.
- Utility protection provisions.
- Limits of poly bagging or joint wrapping.
- Areas of expected poor soil conditions.
- Service connection elevations at property line shown in profile (sewers only).
- Stormwater / Sanitary Catchment Plan.

2.5.6.4 75% STREET LIGHTING / TRAFFIC SIGNALS

The following information shall be shown on the 75% Street Lighting / Traffic Signals design submissions in addition to the 50% submission requirements and the information listed in *Section 2.5.6.1:*

- Wire / cable termination diagram.
- Traffic controller details.
- Service panel or kiosk details.
- Signal display.
- Traffic controller specifications.
- Proposed junction box, traffic controller cabinet and vault locations.
- Directional guide sign structure location. Sign messages and type of mounting (e.g. overhead or shoulder mounted signs).
- Conduit routings.
- Traffic Signal Management System or BC Hydro service details.

2.5.6.5 75% STREETSCAPE / LANDSCAPE / STREET FURNITURE

The following information shall be shown on the 75% Landscape / Street Furniture design submissions in addition to the information listed in *Section 2.5.6.1:*

- Landscape drawings.
- Open space design, plantings, street furniture.
- Existing vegetation including size and type.
- Proposed boulevard locations, offsets, widths, surface treatments and materials, root protection zones, and planting shown.
- Locations of tree protection fencing.
- Cross section and details showing the relationship between landscape elements.
- Location and type of street furniture.

2.5.7 90% DETAILED DESIGN SUBMISSION

The 90% detailed design submission should be nearly complete. The design submission should be at a stage where only minor changes should be expected between the 90% and 100% stages. Generally, no new drawings, details, or information should be added at this stage; instead, the changes should be refinements of the information already provided.

2.5.7.1 90% GENERAL

General information required at the 90% design submission level includes:

- Address any comments on the 75% design and include a comment resolution sheet detailing how each comment was addressed. Include the original unaltered marked-up set of drawings.
- Permit application updates.
- Updated draft tender documents and specifications.
- Third-Party Utility designs and cost estimates.
- The design brief should contain an updated design schedule, updated project phasing plan, bill of materials, and updated Class "B" construction cost estimate. Comments from the previous design brief should be addressed.

2.5.7.2 90% STREETS / TRANSPORTATION

The following information shall be shown on the 90% Streets / Transportation design submissions in addition to the 75% submission requirements and the information listed in *Section 2.5.7.1:*

- Final design with all required dimensions.
- Spot Elevation and Curb Return Grading Plans.
- Construction notes.
- General notes.

2.5.7.3 90% STORM / SANITARY / WATERWORKS

The following information shall be shown on the 90% Storm / Sanitary / Water design submissions in addition to the 75% submission requirements and the information listed in *Section 2.5.7.1:*

- Final design with all required dimensions.
- Construction notes.
- General notes.
- Details.

2.5.7.4 90% STREET LIGHTING / TRAFFIC SIGNALS

The following information shall be shown on the 90% Street Lighting / Traffic Signals design submissions in addition to the 75% submission requirements and the information listed in *Section 2.5.7.1:*

- Final design with all required dimensions.
- Pole profile drawings.
- Construction notes.
- General notes.
- Details.

2.5.7.5 90% STREETSCAPE / LANDSCAPE / STREET FURNITURE

The following information shall be shown on the 90% Landscape / Street Furniture design submissions in addition to the 75% submission requirements and the information listed in *Section 2.5.7.1:*

- Final design with all required dimensions.
- Construction notes.
- General notes.
- Details.

2.5.8 100% DETAILED DESIGN SUBMISSION

The 100% detailed design submission is the final design submission. It should address all previous comments and include any minor changes from the 90% Submission. The drawings should be signed and sealed and represent the finalized approved design.

2.5.8.1 100% GENERAL

General information required at the 100% design submission level includes:

- Address any comments on the 90% design and include a comment resolution sheet detailing how each comment was addressed. Include the original unaltered marked-up set of drawings.
- All final notes and dimensions.
- “100% Design complete” note in revision box.
- Date, initials, and seal of approving engineer.
- All final reports signed and sealed.
- Final permit approvals.
- Updated draft tender documents and specifications.
- Final design brief with updated project phasing plan, construction schedule, updated bill of materials, and Class “A” cost estimate. Comments from the previous design brief should be addressed. The design brief should also include the following:
    - Existing conditions.
    - Initial project scope.
    - Investigations and reports.
    - Design activities that have resulted in revisiting previous designs, and their outcomes.
    - Subsequent major revisions and / or scope changes and the reasons for them.

- Significant features of the design that could require special attention from the field inspection staff or the City Engineer during construction.
- All utility contacts, potential conflicts, and required relocations and the status of all environmental agency contacts and concerns.
- Critical construction staging and traffic control considerations.
- All provisional sums, including a brief explanation for each. Include details of any factors considered to be beyond the Designer’s control which qualify or are likely to qualify the accuracy of the cost estimate.
- All unresolved design issues, all agreements, and any other special conditions and considerations that may impact on the construction of the Project.
- Variances in design criteria.

2.5.9 ISSUED FOR TENDER SUBMISSION

The Issued for Tender submission should contain the final design from the 100% design submission and be repackaged to reflect an “Issued for Tender” status. The intent is to use this submission for soliciting tenders.

2.5.10 ISSUED FOR CONSTRUCTION SUBMISSION

The Issued for Construction submission should contain the design from the Issued for Tender submission and be repackaged to reflect an “Issued for Construction” status. The intent is to provide this package to the contractor as an approved design to construct the works. The Issued for Construction set shall be updated to reflect any issues and comments raised during the tender process and changes made through addenda.

The City’s Organizational Quality Management requirements (such as RFIs, COs, and CCOs) apply during construction.

2.5.11 RECORD DRAWING SUBMISSION

Record Drawings shall be corrected upon completion of construction to note all works installed, removed, or abandoned during construction. Record Drawings are to reflect as-built conditions for permanent records.

All dimensions, elevations, and inverts shown shall reflect the as-built conditions of the construction and all references to “Proposed” shall be removed. Material changes shall be clearly shown. Record Drawings shall be to scale in accordance with the as-built dimensions shown. The revision table shall be completed indicating the drawings are Record Drawings. Refer to the *City of Vancouver Construction Specifications* for additional record drawing requirements.

2.5.12 DESIGN BRIEFS

A Design Brief shall be included at each submission stage and will include sections for each design discipline (ex. Streets/Transportation, Waterworks). Each section shall outline the scope, purpose, methodology, design criteria, design calculations, any outstanding issues or potential problems, any conflicts, any deviations from standards or design criteria and reasoning, and any other pertinent information. The City may also require other specific documents to be included in the design brief; some examples of these documents are:

- Traffic modeling results including traffic access modeling.
- Field review forms.
- Water and sewer modeling results, complete with assumptions.
- Street lighting calculations.
- A coordination letter.

The Design Brief will be prepared and submitted with the first submission and then updated throughout the submission process until the 100% submission at which point it will become the Final Design Brief. At the time of the record drawing submission, the Final Design Brief will be updated to form the Record Design Brief.

2.6 DEVELOPMENT DESIGN REVIEW PROCESS

The City requires a formal review of all development submissions. The *Development & Major Projects Branch* is responsible for the drawing review and approval process for major land development projects. The *Development & Major Projects Branch* staff circulates the drawings to the various departments and compiles comments. The following section provides the process for drawing review and approval during a development project. Two design scenarios are considered:

1) Works for which the City has an approved geometric design.
2) Works for which the geometric design will be done by the developer's engineer.

2.6.1 DRAWING CIRCULATION

During the review process, development drawing submissions shall be circulated to the following departments by *Development & Major Projects Branch* staff:

- *Parking Management Branch* will coordinate review within the *Transportation Division*, including the *Transportation Planning Branch*, the *Transportation Design Branch*, the *Traffic & Data Management Branch*, and the *Street Activities Branch*.
- *Streets Design Branch* will review the overall street design, including grades and materials.
- *Waterworks Design Branch* will review water works as well as tie-ins or modifications to existing system.
- *Traffic, Electrical, Operations & Design Branch* will review the street lighting design and any signal works.
- *Sewers and Drainage Design Branch* will review sanitary and storm works, as well as tie-ins or modifications to existing systems.
- *Streets Design Branch - Structures* will review if there are works proposed near bridge abutments or other structural assets.
- *Utilities Management Branch* will review utility alignments.
- *City of Vancouver Civic Engagement & Communications* will review communication requirements.
- *Street Activities Branch* will review public realm and streetscape designs.
- As required, the *Planning, Urban Design, and Sustainability Department* will review public realm as to how it meets previous policy or rezoning guidelines.
- The *Vancouver Board of Parks and Recreation (Vancouver Park Board)*, *Street Activities Branch*, and *Streets Design Branch* will review street trees and landscaping. The *Vancouver Park Board* focuses on street trees interfacing with adjacent park spaces.

Minor projects drawing circulation is completed by the *Development & Major Projects Branch* and the *Streets Design Branch* project coordinators. Minor projects are sites that were not part of a policy plan.

2.6.2 REVIEW PROCESS DESIGN

The review process is required to confirm that all drawings have been designed as per design submission requirements outlined in *Sections 2.4* and *2.5*. The review process depends on whether the City or the Developer completes the offsite geometric design. This section outlines the formal review process for each scenario.

2.6.2.1 CITY PROVIDED GEOMETRIC DESIGN PROCESS

1) Pre-design meeting with developer's engineer:

- Geometric design provided to developer's engineer by the City.
- Services Agreement conditions reviewed with the developer's engineer to clarify requirements and scope of work; the *Planning, Urban Design, and Sustainability Department* to be included in this discussion as required.
- Materials and landscaping criteria reviewed.
- GIS data and as-built drawing request process reviewed.

2) 50% design submission:

- Civil design does not need to include electrical or landscaping.
- City review process requires at least four to six weeks for *Development & Major Projects Branch* to review and compile comments and circulate to branches for review.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachement or an email) to refine past comments.
- Meetings with developer's engineer may be necessary for further review.

3) 75% design submission:

- Drawing package to include civil, electrical, and landscaping drawings, including all Third-Party Utilities, as well as a design brief that provides design calculations and rationale.
- City review process requires at least four to six weeks for the *Development & Major Projects Branch* to review and compile comments and circulate to branches for review.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachment or an email).
- Meetings with developer's engineer may be necessary for design clarification or further review.

4) 90% design submission:

- Drawing package should include civil, electrical and landscaping drawings, as well as a table that list previous comments and how they have been addressed.
- City review process requires at least four to six weeks.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachment or an email) to refine past comments.
- Meetings with developer's engineer may be necessary for further review.

5) 100% design submission:

- Drawing package should include civil, electrical and landscaping drawings, as well as a table that list previous comments and how they have been addressed.
- Allow at least four to six weeks for departmental review.
- If there are no issues (or only a few minor comments), a drawing approval letter can be issued. Otherwise, compile comments and provide to developer.
- Meet with developer's engineer if needed (i.e. if there are comments that require further discussion).

6) Drawing Approval Letter:

- Drawings are approved upon receipt of a City issued Letter of Approval.

2.6.2.2 DEVELOPER PROVIDED GEOMETRIC DESIGN PROCESS

The design review process is the same as *Section 2.6.2.1*, with the following exceptions:

1) Pre-design meeting with developer's engineer:

- The City's geometric design expectation are clearly communicated by members of the *Streets and Transportation Divisions* and, as required, the *Planning, Urban Design, and Sustainability Department*.
- Overall direction of geometric design (i.e. minimum lane widths, sidewalk and boulevard widths, specific pedestrian and cycling considerations) provided by City.

2) 50% drawing submission:

- Civil design does not need to include electrical or landscaping.
- City review process requires at least four to six weeks for *Development & Major Projects Branch* to review and compile comments and circulate to branches for review.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachment or an email) to refine past comments.
- Meetings with developer's engineer may be necessary for further review.

3) 75% design submission:

- Drawing package to include civil, electrical, and landscaping drawings, including all Third-Party Utilities, as well as a design brief that provides design calculations and rationale.
- City review process requires at least four to six weeks for *Development & Major Projects Branch* to review and compile comments and circulate to branches for review.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachment or an email).
- Meetings with developer's engineer may be necessary for design clarification or further review.

4) 90% design submission:

- Drawing package should include civil, electrical and landscaping drawings, as well as a table that list previous comments and how they have been addressed.
- City review process requires at least four to six weeks.
- Comments provided to developer's engineer once completed by all departments involved (can be a letter attachment or an email) to refine past comments.

- Meetings with developer's engineer may be necessary for further review.

5) 100% design submission:

- Drawing package should include civil, electrical and landscaping drawings, as well as a table that list previous comments and how they have been addressed.
- Allow at least four to six weeks for departmental review.
- If there are no issues (or only a few minor comments), a drawing approval letter can be issued. Otherwise, compile comments and provide to developer.
- Meet with developer's engineer if needed (i.e. if there are comments that require further discussion).

6) Drawing approval letter

- Drawings are approved upon receipt of a City-issued Letter of Approval.

2.6.3 ADDITIONAL CONSIDERATIONS

All City comments will be managed and provided to the developer's consultant by the *Development & Major Projects Branch*. Any correspondence between the engineering branches and the developer's engineer is to include the *Development & Major Projects Branch*.

As required, the *Planning, Urban Design, and Sustainability Department* is to be included in discussions about street materials and landscaping (generally for public plazas or walkways).

The *Vancouver Park Board* is to be included in discussions about street trees and streets adjacent to parks. Include an arborist report if required as per *Section 2.6.3.1*.

2.6.3.1 ARBORIST REPORT

An arborist report is required when requested by *Urban Forestry* with the *Vancouver Park Board* as a part of the application for a commercial, industrial, multifamily, or comprehensive development.

The arborist report must be prepared by a certified arborist or approved equivalent who is also a holder of a degree in Urban Forestry, Forestry, Landscape Architecture, Biology, or a related professional study. The development permit applicant submits the arborist report. All arborist reports shall be reviewed by impacted engineering branches.

An arborist or landscape architect report shall contain:

- A tree protection plan, upon request, or whenever site work could impact public trees, should address the recommended protocols and practices in the *City of Vancouver Construction Specifications* and *Chapter 9: Streetscape & Urban Forest*.
- A description of the public tree planting project and its proposed function, its proposed zoning, and probable intensity and type of usage on the public realm.
- Site conditions or proposed uses outside the norm that are likely to challenge tree growth.
- Rationale for species selection.
- A qualitative description of the below ground soil resources available to the trees.
- A table showing the quantity of good quality soil resources available per new street tree.

- Landscape plans should contain a warranty statement, for a period of two years from the date of planting. It should provide notation that the project manager or their designate must contact the *Vancouver Park Board* in advance of the trees being brought to site, so that an inspection may be made prior to installation.
- A Certified Consulting Arborist (ISA) or Landscape Architect (BCLSA) statement demonstrating that species, diversity, and minimum soil volumes are in compliance with tables. Rationale for requests for variance from tables to be included when appropriate.
- A Certified Consulting Arborist (ISA) or Landscape Architect (BCLSA) statement that existing public trees will not be impacted, or that an adequate public tree protection plan has been submitted.

2.7 THIRD-PARTY UTILITY DRAWING SUBMISSIONS

Third parties constructing, maintaining and operating utilities within the City of Vancouver are required to meet the requirements of the *Utilities Management Branch*. *Chapter 7* of this manual is dedicated to Third-Party Utility design and submission requirements, specifically:

- Refer to *Section 7.6* for Utility Permit Drawing Submissions.
- Refer to *Section 7.7* for External Utility Submission Standards.
- Refer to *Section 7.5.11* for Attachments to City Structures.

3

WATER SYSTEM

WATER SYSTEM

3.1 INTRODUCTION

Vancouver maintains and operates a complex water system which primarily consists of potable water transmission and distribution mains as well as an earthquake-resilient salt-water dedicated fire protection system.

The following is a brief description of each section:

- The *Demands and Flows* section outlines the analysis required to determine how much demand is placed on the water mains being designed or studied.
- The *Hydraulic Analysis* section outlines the process to determine the capacities of the water mains and services.
- The *Design of Water System Components* section discusses the specific requirements to design various components such as mains, valves, and hydrants.
- The *Seismic Design Standards* section outlines the seismic design of watermains.
- The *Service Connections* section outlines the requirements relating to service connections.
- The *Thrust and Restraint Design* section outlines the requirements relating to thrust restraint.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

3.2 DEMANDS AND FLOWS

In order to determine the proper sizing and configuration of water distribution systems, the flow requirements must be determined. This section outlines the requirements for determining the design flows based on population estimates, per capita usage, fire flows, and building specific requirements.

3.2.1 DESIGN FLOWS

System design flows should be at a minimum based on the ultimate population and fully developed non-residential land as anticipated in the City of Vancouver Community Plans.

Equivalent populations for non-residential flows can be estimated using the established non-residential demands and the Maximum Day per capita demand.

Total design flows, Q_{des}, are to be the greater of the following:

$$Q_{des} = D + F$$

or

$$Q_{des} = H$$

Where:

Q_{des} = Design Flow (L/s)

D = Maximum Day Demand for the Population or Equivalent Population (L/s)

F = Fire Flow (L/s)

H = Peak Hour Demand for the Population or Equivalent Population (L/s)

3.2.2 POPULATION ESTIMATES AND EQUIVALENTS

Commercial, industrial, and institutional demands should be determined using specific data related to the development or zoning.

If detailed population information is not accessible, the design population, P, is determined by using the following equation:

$$P = \frac{A_{lot} \times FSR}{D}$$

Where:

P = Design Population (people)

A_{lot} = Lot Area (m^2)

FSR = Maximum Allowable Floor Space Ratio from the *City of Vancouver Zoning and Development By-law No. 3575*

D = Density (m^2/person) from **Table 3-1**:

Table 3-1: Development Densities

Development Type	Density, D (m^2/person)
Single-Family / Duplex / Triplex / Quadplex	55
Townhouse Complexes / Condos / Apartments	35
Commercial	23
Institutions / Schools / Stadiums / Hospitals	Case-by-case
Industrial	Case-by-case

Notes:
1) In absence of site-specific information, use Industrial: 105pp/property and Institutional: 65pp/property.

3.2.3 PER CAPITA DEMANDS

In the absence of reliable water consumption records, use the per capita demand of 320 L/cap/day. Peaking Factors to be used are Maximum Day Demand: 1.6 and Peak Hour Demand: 2.1.

3.2.4 FIRE FLOWS

Fire flows should be determined in accordance with the requirements of the current edition of *Fire Underwriters Survey Water Supply for Public Fire Protection – A Guide to Recommended Practice*.

Fire flows are also subject to the minimum requirements in **Table 3-2**:

Table 3-2: Minimum Fire Flows

Developments (without sprinklers)	Minimum Fire Flow (L/s)
Single Family Residential / Duplex / Triplex / Quadplex	95
Townhouse Complexes / Condos / Apartments	200
Commercial	200
Institutions / Schools / Stadiums / Hospitals	200
Industrial	250

3.3 HYDRAULIC ANALYSIS

For the design of water mains, the criteria in ***Table 3-3*** must be satisfied:

Table 3-3: Overall Criteria for Watermain Design

Specification	Criteria
Design Velocity- Peak Hour Demand	$V < 3.5m/s$
Design Velocity- Average Day Demand	$V < 1.8m/s$
Hydraulic Grade	$S < 0.005m/m$
Minimum Domestic Use Pressure - Peak Hour Demand	275kPa (40psi) < p_D
Maximum Domestic Use Pressure	p < 1035kPa (150psi)
Fire Flow Residual Pressure	207kPa (30psi) < p_F

This section outlines the design process and factors to determine water distribution within the City.

3.3.1 FORMULAE AND COEFFICIENTS

The City uses the following formulas and coefficients for the determination of flow rate, head loss, and friction factors.

3.3.1.1 HAZEN-WILLIAMS EQUATION

The Hazen-Williams Equation is the following:

$$Q = \frac{CD^{2.63}s^{0.54}}{278780}$$

Where:

Q = Flow Rate (L/s)

C = Hazen-Williams Roughness Coefficient as per ***Table 3-4***

D = Internal Pipe Diameter (mm)

s = Slope of Hydraulic Grade Line (m/m)

Table 3-4: Hazen-Williams Roughness Coefficients

Material	Lining	C Factor	
		Minimum	Maximum
Concrete		110	140
Copper		130	140
Ductile Iron	Cement	120	140
HDPE		135	150
PVC		135	150
Steel		130	140

3.3.1.2 DARCY-WEISBACH EQUATION

The Darcy-Weisbach Equation is the following:

$$h_f = \frac{fLV^2}{2gD}$$

Where:

h_f = Friction Head Loss (m)

f = Friction Factor (from Moody Diagram or Colebrook Equation)

n = Manning's Roughness Coefficient

L = Length of Pipe (m)

V = Flow Velocity (m/s)

D = Internal Pipe Diameter (m)

g = Acceleration due to Gravity (m/s^2)

3.3.1.3 COLEBROOK EQUATION

The Colebrook Equation provides an iterative solution to friction factor and is calculated by the following formula:

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{e}{3.7D} + \frac{2.51}{R\sqrt{f}}\right)$$

Where:

f = Friction Factor

e = Magnitude of Wall Roughness (m)

D = Internal Pipe Diameter (m)

R = Reynolds Number

3.3.2 PRESSURE ZONES

The hydraulic grade line within the water system varies based on location specific pressure zones as shown in ***Figure 3-1***:

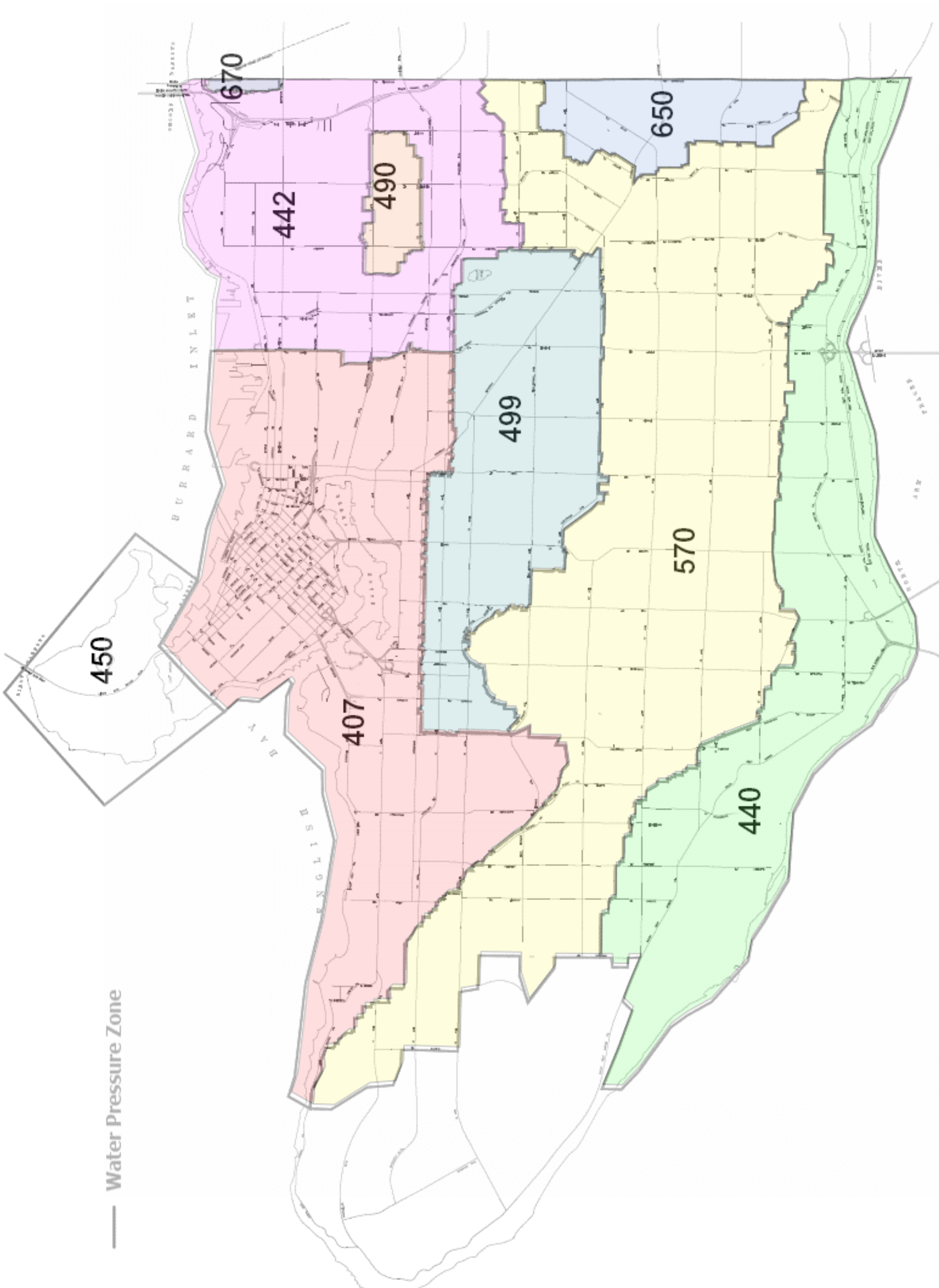


Figure 3-1: Pressure Zones

3.3.3 PRESSURE REQUIREMENTS

Pressure requirements within the City of Vancouver are separated by domestic use and fire flow.

3.3.3.1 DOMESTIC USE PRESSURES

Table 3-5 outlines the minimum domestic use pressure requirements:

Table 3-5: Minimum Domestic Use Pressures

Property	Pressure
Minimum Peak Hour	275kPa (40psi)
Normal Maximum	1035kPa (150psi)

3.3.3.2 FIRE FLOW PRESSURES

The minimum allowable pressure anywhere within the system under fire flow conditions (Maximum Day Demand and Fire Flow) is 207kPa (30psi).

3.3.4 COMPUTER MODELLING

Contact the *Waterworks Design Branch* for more information.

3.4 DESIGN OF WATER SYSTEM COMPONENTS

This section outlines the design requirements for pipes and appurtenances in the water distribution system within the City of Vancouver.

3.4.1 GENERAL CONSIDERATIONS

Water System Components shall be designed with consideration of the requirements outlined in *Chapter 2: Design Process & Coordination*.

3.4.2 TRANSMISSION AND DISTRIBUTION WATER MAINS

3.4.2.1 MAIN CLASSIFICATION

Transmission Mains are classified as mains that are larger than 300mm diameter. These mains primarily serve as links from the Metro Vancouver supply mains to the City's distribution main system.

Distribution Mains are classified as mains that are 300mm diameter and smaller. These mains distribute potable water for fire protection and domestic uses.

3.4.2.2 SIZE AND MATERIALS

The pipe outlined in ***Table 3-6*** is preferred for water mains:

Table 3-6: Watermain Pipe Materials

Pipe	Preferred Material	Min. Size (mm)
Service Connections without Fire Sprinklers	Copper	25
Service Connections with Fire Sprinklers	Copper	40
Fire Hydrant Connections	Ductile Iron Class 52	150
Distribution Mains	Ductile Iron Class 52	200

For looped distribution mains with lengths less than 500m in residential subdivisions, the minimum diameter may be reduced upon approval by the City Engineer, providing that the fire flow requirements can be met.

Distribution main minimum diameters may be reduced to 100mm upon approval by the City Engineer, providing that the main terminates in a short residential cul-de-sac, has a length less than 80m, and serves no fire hydrants.

The engineer of record remains responsible for calculating and confirming pipe sizing despite stated minimums in ***Table 3-6***. Refer to *City of Vancouver Construction Specifications* for material and installation requirements.

3.4.2.3 ALIGNMENT

Water mains are aligned relative to property lines, avoiding existing utilities, trees, poles, curbs, and placed if possible under pavement or in either boulevard or under sidewalk respectively, in descending order of merit. The offset of the water main from the property is not a fixed standard but is determined as to best suit the project site. The design shall meet the offsets required by the City of Vancouver as specified in *Section 2.2.5*.

Water main alignments on straight roads should have uniform offsets from property line between intersections wherever possible. If curved alignments are required, they are to remain parallel to property lines. Design joint deflections should be maximum 3° deflection for distribution mains.

Mains should be located such that every property served has at least one side fronting the water main. When water mains are located within a statutory right-of-way, access must remain available for maintenance vehicles and equipment.

Clearance from sewers is as indicated in *Section 2.2.5*.

3.4.2.4 LOOPING

Water mains are to be looped wherever possible.

Where practical, and approved by the City Engineer, a hydrant may serve a secondary role as a blowoff. Dead end water mains should be sized following the last hydrant to minimize the potential for stagnation. For blowoffs that are not hydrants, refer to *Section 3.4.8*.

3.4.2.5 BACKFILL AND MATERIALS

All backfill and water main-related materials such as bedding and concrete shall be in accordance with the *City of Vancouver Standard Detail Drawings G4.2* and *G4.3* and the *City of Vancouver Construction Specifications*.

3.4.2.6 DEPTH

All water main pipes must have a minimum cover of 0.9m for arterial roads and 0.75m for residential streets to finished grade. The depth must not exceed 1.5m unless approved by the City Engineer. The depth of water main should be designed to minimize the use of trench shoring during construction.

Water mains and services must be of sufficient depth to:

- Prevent freezing - soil type and groundwater levels should be considered.
- Provide adequate clearance to other underground utilities as per *Section 2.2.5*.
- Provide protection from external loads.

Specialized designs are required to provide frost and external load protection in cases where minimum depths cannot be attained, e.g. at bridge crossings and in chambers.

3.4.2.7 GRADE

Water main grades are to be straight lines between defined deflection points. Wherever possible, the minimum grade of water mains is to be 0.1%. Grading should be designed to minimize the number of high points; see *Section 3.4.5* for more information on high points.

When the slope equals or exceeds 10%, joint restraints are required.

3.4.2.8 CORROSION PROTECTION

Native soil conditions within the City of Vancouver have a high potential for encountering corrosive soils. Due to these native soil conditions, corrosion protection measures in accordance with AWWA standards are required to protect metallic pipes and appurtenances. A 10-point test must be completed to determine soil corrosion properties.

Corrosion protection measures are as follows:

- All water mains and service connections equal to or greater than 100m diameter are to be encased in polyethylene prior to backfilling regardless of potential for corrosion.
- Denso tape is to be applied to all rodding and bolts prior to backfilling.
- Existing cathodic protection systems are to be maintained in accordance with the *City of Vancouver Standard Detail Drawings W100.1* to *W120.2*.

If a special corrosion protection method is proposed, a geotechnical report or recommendation is required for review and approval.

3.4.3 DEDICATED FIRE PROTECTION SYSTEM

The City of Vancouver has a Dedicated Fire Protection System installed throughout the Downtown and Kitsilano areas which utilizes False Creek as a reservoir. The system is comprised of pump stations within False Creek, a Coal Tar Enamel Lined Steel Pipe network, and a series of high capacity fire hydrants. Any modifications to the Dedicated Fire Protection System will require specialty designs not covered in this design criteria.

3.4.4 ISOLATING VALVES

Isolating valves shall meet the requirements outlined in ***Table 3-7***:

Table 3-7: Isolating Valve Types and Sizes

Main Size	Valve Type
Up to and including 300mm	Resilient Seat Gate Valve
350mm to 450mm	Resilient Seat Gate Valve Reduced by up to 2 sizes
Larger than 450mm	Butterfly Valve

3.4.4.1 DISTRIBUTION MAIN VALVE SPACING AND CONFIGURATION

In general, valves for distribution mains should be located as follows:

- Typical arrangement of valves at a street intersection are shown on the *City of Vancouver Standard Detail Drawings W3.2*.
- At locations as necessary to ensure that no more than one block is isolated.
- At locations as necessary to ensure that not more than one hydrant or dedicated fire service is isolated, see standard dual fire service valving configuration on the *City of Vancouver Standard Detail Drawings W2a.4*.

3.4.4.2 TRANSMISSION MAIN VALVE SPACING AND CONFIGURATION

Valves should be located no more than 600m apart.

3.4.5 AIR VALVES

Combination air valves should be installed at high points of all mains of 200mm diameter and larger, except as follows:

- Where the difference in elevation between the high and low points is less than 600mm.
- Where it can be shown that air pockets will be carried by typical flows.

Air valves must be vented to an appropriate above-grade location to eliminate any potential for cross connection in a flooded or contaminated chamber. Above ground infrastructure must be integrated into public realm so as to not interfere with pedestrian flow, pedestrian facilities, bicyclists, motorists, or other infrastructure.

Typical air valve sizes, subject to design analysis based on manufacturers recommendations, are as shown in ***Table 3-8***:

Table 3-8: Air Valve Sizes

Water main Size	Valve Size
200mm to 300mm	25mm
350mm to 600mm	50mm
Larger than 600mm	Special Design

3.4.6 FIRE HYDRANTS

Fire hydrants should be positioned in the following locations:

- At street intersections.
- At property lines in mid-block locations.
- No more than 90m walking distance to a building entrance.
- Single / dual family zoning: not more than 180m apart.
- Multifamily / commercial / industrial / institutional zoning: not more than 90m apart.
- 0.6m from the back of curb or 0.5m from the back of sidewalk.
- Minimum 1.7m clear of any other above grade utility structure.
- Minimum 2.0m clearance of any street tree as per *Section 9.3.3.3*.

Hydrants must be integrated into public realm so as to not interfere with pedestrian flow, pedestrian facilities, bicyclists, motorists, or other infrastructure.

Preferred locations for fire hydrants are shown in the *City of Vancouver Standard Detail Drawings W4.1*.

3.4.7 MAINTENANCE HOLES, COVERS, AND FRAMES

Chambers or maintenance holes containing valves, blow-offs, meters, or other appurtenances shall provide sufficient room for maintenance, including headroom and side room. When installing new water mains, care should be taken when placing new valve box covers to avoid sidewalks, and curb ramps where possible. Where valve box lids are placed in a cycle lane, along one edge is preferred. Access openings are to be suitable for removing valves and equipment. The chamber is to be provided with a drain to a storm sewer or channel, complete with backflow prevention, to prevent flooding of the chamber. Rock pits may be considered subject to suitable soil and groundwater conditions. A pumping system may be required for drainage. Insulation to prevent freezing is required when cover is less than minimums outlined in *Section 3.4.2.6*.

Adequate venting should be provided. The City and WorkSafeBC may require provision of forced ventilation, lighting, heating, and dehumidification. Access and ventilation details must comply with WorkSafeBC requirements. The choice of lid should eliminate the need for confined space entry when possible.

Chambers, covers, frames and lids are to be designed for H20 loading or *CAN/CSA S6 Canadian Highway Bridge Design Code*. Chambers must also be designed for hydraulic thrust on the end walls imposed by the main.

3.4.8 BLOWOFFS

All mains 400mm and smaller should be designed so that they can be flushed. Blow offs are required at all terminal ends of the main to allow for flushing. Blowoffs should be designed to allow a flushing velocity of 0.8m/s.

Typical arrangements of blowoffs are shown in the *City of Vancouver Standard Detail Drawings W8.1* and *W8.2*.

3.4.9 PRESSURE REDUCING VALVES

Pressure reducing valves are to be required and designed on a case-by-case basis depending on project conditions. Contact the City for additional information.

3.4.10 BACKFLOW PREVENTERS

Backflow preventers are to be required and designed on a case-by-case basis depending on project conditions. Contact the City for additional information.

3.4.11 DRINKING FOUNTAINS

Refer to **Error! Reference source not found.** document for more detailed specifications.

3.4.12 TRENCHLESS TECHNOLOGIES

Table 3-9 outlines the trenchless methods familiar to the City of Vancouver for watermain installations and rehabilitations:

Table 3-9: Trenchless Technologies for Watermain Installations

New Installation Methods	Rehabilitation Methods
Pipe Jacking	Pipe Bursting
Horizontal Directional Drilling	Cured in Place (Pressure)

The design engineer must be experienced in the design of the proposed trenchless method and shall be responsible for recommending design criteria and specifications for the proposed method. All trenchless technologies proposed shall by approved by the City Engineer.

For casing pipe details, refer to *City of Vancouver Standard Detail Drawings G6.1* and *G6.2*.

3.4.13 WET TAPPING

Tees are the preferred option for a connection to an existing water main. Wet tapping is only acceptable if there is a significant benefit and must be approved by the City Engineer. Wet tapping can be performed only when a tee connection is required and the branch is a minimum of one pipe size smaller than the mainline.

3.4.14 BRIDGE CROSSINGS

When bridge crossings are required, designs should pay particular attention to:

- Joints and restraints.
- Pipe supports and hangers.
- Vertical and lateral structural bracing.
- Expansion and contraction couplings.
- Abutments.
- Corrosion protection.
- Air release.

- Seismic conditions.
- Freezing conditions.
- Structural adequacy of the bridge.
- Vandalism.
- Exposure to traffic/vehicle damage.

3.4.15 FLEXIBLE EXPANSION JOINTS

Flexible expansion joints should be provided when connecting to structures or where permanent grade change is likely due to settlement or residual ground movement such as at preload locations.

3.5 SEISMIC DESIGN STANDARDS

The choice of replacement strategy and pipe material is based on a risk assessment driven by the criticality of the pipeline, the susceptibility of the contextual ground conditions for wave propagation, and potential for Permanent Ground Deformation (PGD).

Awareness and avoidance are the best approaches to protect the water system from risks associated with ground deformation. Strategies include:

- Limiting the number of non-resilient, unlikely to function post seismic activity, feeds in a neighborhood susceptible to ground acceleration.
- Locating feeds to occur outside of liquefaction zones.
- Tunneling under the liquefiable layer.

System mitigation strategies include:

- Provide valves around liquefiable soil areas to allow isolation from the rest of the system.
- Provide connections on either side of liquefiable soil areas to allow quick installation of temporary piping.

Another approach would be to reduce liquefaction susceptibility by installing gravel columns, grouting, or limiting lateral spread by installing earth-retaining structures, as recommended by a geotechnical engineer.

Pipe structural mitigation strategies include:

- Incorporation of expansion sleeves at valve locations to relieve pipe strain.
- Minimizing connections to buildings, tees, crosses and bends to provide additional flexibility.
- Wrap pipe in polyethylene to reduce pipe-soil friction.

3.5.1 REMOTE TELEMETRY AND SUPERVISORY CONTROL (SCADA SYSTEMS)

Using SCADA systems to remotely monitor and control valves (including pressure reducing valves) can provide quick isolation of neighbourhoods or pressure zones that are expected to be heavily damaged in an earthquake.

3.5.2 RESIDENTIAL SERVICE LINES (UP TO 50MM IN DIAMETER)

The City of Vancouver manages approximately 80,000 single / dual family property service connections. The vast majority are copper (20 mm - 40 mm). The best performance for small diameter service pipes, based on direct experience in other earthquake prone areas, is provided by high-density polyethylene (HDPE) and copper. Both materials are ductile and can accommodate moderate levels of permanent ground deformation (PGD).

Copper is the material of choice of Vancouver for the following reasons. Copper pipe is traceable (via EM scope) which is very important in a dense urban environment. Copper pipe also has the advantage as it can be replaced or renewed via “pulling”, a trenchless methodology that significantly reduces the cost and public disruption through limiting the amount of associated roadway repair.

HDPE pipe walls also are known to be permeable to oxygen and petroleum-based contaminants albeit at minor concentrations that are near or lower than health guidelines. HDPE and PVC, as petroleum-based materials, are subject to pricing variability – tied to oil – and have some concerns relating to environmental release through its manufacturing process.

3.5.3 SEISMIC PIPE MATERIAL SELECTION STANDARD

City of Vancouver Waterworks Standard for small service connections: Copper

Seismic Pipe Material Selection Standard Transmission (>300 mm diameter), Distribution (150 mm to 300 mm diameter) and Water Services (75 mm – 100 mm diameter).

For ground acceleration < 40% x gravity and non-liquefiable soils, modern bell-and-spigot joints with nitrile elastomeric gaskets are adequate to accommodate pipe strain by induced wave passage.

- Acceptable: Ductile Iron, Oriented strand PVC, Concrete Cylinder pipe.
- Standard: Ductile Iron bell and spigot joint – due to proven performance and compatibility of maintenance and with cache of repair couplings on hand (vast majority of existing pipe network is iron based).

For ground acceleration 40% x gravity or greater and non-liquefiable soils and where PGD < 5cm:

- Standard: welded steel, restrained joint ductile iron, or HDPE.
- Recommended: Polyethylene encased restrained joint ductile iron pipe – due to proven performance and compatibility of maintenance and with cache of repair couplings on hand (vast majority of existing pipe network is iron based).

For PGD > 5 cm

- Standard: Welded steel, restrained joint ductile iron, or HDPE with expansion couplings.
- Recommended: Polyethylene encased restrained joint ductile iron pipe with expansion sleeves at a regular frequency (minimum 1% elongation and compression) at line valves, tees, and crosses – due to proven performance and compatibility of maintenance and with cache of repair couplings on hand (vast majority of existing pipe network is iron based).

3.5.4 WATER SYSTEMS EXPANSION – LARGE DEVELOPMENTS, NEIGHBOURHOOD PLANS, COMMUNITY PLANS

For newly rezoned large developments, newly design neighbourhoods, or community plans that require water system expansion, particularly in areas with or adjacent to non-optimal soil conditions, the seismic design standards outlined in *Section 3.5* must be applied.

3.6 SERVICE CONNECTIONS

Service connections tie private property into the water distribution system of the City of Vancouver, with the service being operated and maintained by the City within the public right-of-way. As a result, it's important to maintain the service connections in order to maintain the system as a whole. This section outlines the location, type, installation, and maintenance of watermain service connections in the City of Vancouver.

3.6.1 LOCATION OF SERVICES

The location of a service pipe shall be at the discretion of the City Engineer; however, the location requested by the customer will usually be approved providing the service pipe meets the following requirements:

- Is not in line with an existing or future vehicular crossing.
- Is not taken off a transmission main (pipe greater than 300mm in diameter).
- Is 3m (minimum) clear of an existing or future sewer connection for large diameter non-copper services.
- Clears a lamp standard base or other obstruction by 1.5m.
- Remains outside of a tree's drip line where possible.
- Is not located in line with any building entry walk.
- Can be installed at 90˚ to the property line.

The amount of cover over the private service pipe and the City's service pipe is dependent upon the depth of the City's water main and any existing utilities already in the ground. The service depth is usually between 0.75m and 1.5m.

Only one metered service connection is allowed per property unless approved by the City Engineer. If permitted, the fee for the second service will be according to size as indicated in the *City of Vancouver Water Works By-law No. 4848*.

3.6.2 SERVICE TYPES AND WATER METERS

The following defines the various service types:

- Domestic Service (Residential): A service which has a meter in the line and whose water is used exclusively for domestic purposes. The meter is located on the City side of the property line.
- Domestic Service (Non-residential): A service which has a meter in the line and whose water is used exclusively for domestic purposes. The meter can be located on the City side of the property line or on private property.
- Combined Service Twin: A service which branches on City property to provide two service connections, one of which is a metered line and the other of which is a fire line.
- Combined Service Dual: A service which branches on private property to provide two service connections, one of which is a metered line and the other of which is a fire line.

- Combined Service Interconnected: Two combined services which come off either separate water mains or, come off the same water main but have a line valve between them, and connect together on private side. The two services are intended to reduce the likelihood of interrupted service due to water main failure or maintenance.

An interconnected servicing system may be required by the City Engineer in the case of each of the following:

- Multi-family residential building which exceeds 30 units.
- Commercial / retail, industrial or office building which exceeds 40,000ft^2 (3,716m^2).
- Mixed use building which exceeds 40,000ft^2 (3,716m^2) or 30 dwelling units.

3.6.3 CUSTOMER CONNECTION TO CITY SERVICE

Customer connection to City service pipe shall be Tyton, mechanical joint, dresser or similar rubber joint flexible connector, without electrical bonding strap and without restraining lugs or screws.

Customer piping shall be restrained from movement independently of the City service pipe. The design of an adequate restraining mechanism on private side is the sole responsibility of the customer.

3.6.4 SERVICE RENEWALS

These guidelines have been developed to clearly identify the action that is to be taken when a water service is reviewed as a result of a leak, prior to paving a project, or as part of a water main replacement project.

3.6.4.1 PHILOSOPHY

Service renewal philosophy is based on factors that include age, length of service pipe, location on arterial or residential streets, as well as failure history. Recommendations for service pipe replacement are as follows:

- Replace any service pipe that leaks on a residential street due to corrosion, except those which serve properties for which a development permit has been filed.
- Repair any service pipe that leaks on an arterial street, with the exception of those pipes which should be replaced because the renewal cost is less than 80% of the average renewal cost, or those pipes that have previous leak history.
- Repair any pipe without previous leak history that leaks due to substandard installation or damage caused by construction activities.

Refer to *Section 3.6.5* for the decision tree relating to service pipe replacement.

3.6.4.2 REPLACEMENT SIZE SELECTION

When services are renewed at the City's expense, typically the existing service is to be replaced with the same service size. Current replacement methods such as service pulling and directional drilling minimize replacement costs.

Only redevelopment of a site would necessitate the installation of a larger service. The developer of the site is required to renew the service at their own expense. The new service size is based on the new development's firefighting or operational requirements. Generally, the size is determined by firefighting demands.

3.6.4.3 RENEWALS AS PART OF WATER MAIN REPLACEMENT

The cost of service replacement is lower during this type of work. All older services and services with failure histories shall be replaced. Refer to *Section 3.6.5* for more information.

3.6.4.4 PLANNED SERVICE REPLACEMENT

When a capital program is in place to proactively replace aging water services independently of water main construction, this work is often coordinated with large paving projects in order to maximize the cost efficiency of the overall project.

Small services are to be renewed and prioritized based on the following criteria:

- Lead, Galvanized, and Kitec Services are automatically replaced when encountered. The vast majority of these services have been replaced, but poor records may hide some of these services.
- City side leaks as identified in the attached flow charts.
- Older services and services with leak history located on streets scheduled for resurfacing (coordinated with the *Streets Division*).
- Older services or services with leak history located on streets not scheduled for resurfacing or water main replacement. In the situations where the information is unclear the service should be left in place unless it has a leak record.

Services under concrete roads should not be replaced based on the last criterion due to high restoration costs.

3.6.4.5 REPLACEMENT OF LARGE SERVICES

Services larger than 50mm are typically cast or ductile iron. These services have a service life common to that of cast or ductile iron water mains. Replacement of the service prior to water main replacement may be warranted if there is previous failure history or other indications that the pipe will likely fail again. Typically, these decisions are made on a case-by-case basis using the decision tree in *Section 3.6.5* as reference.

3.6.5 DECISION TREES

Water main service connections require case-specific judgement to determine the best course of action. The City of Vancouver requires the following decision trees be adhered to in order to install, change, or repair various sizes of services in the City. The decision trees are intended for internal City of Vancouver use only.

3.6.5.1 SMALL SERVICE LEAKAGE

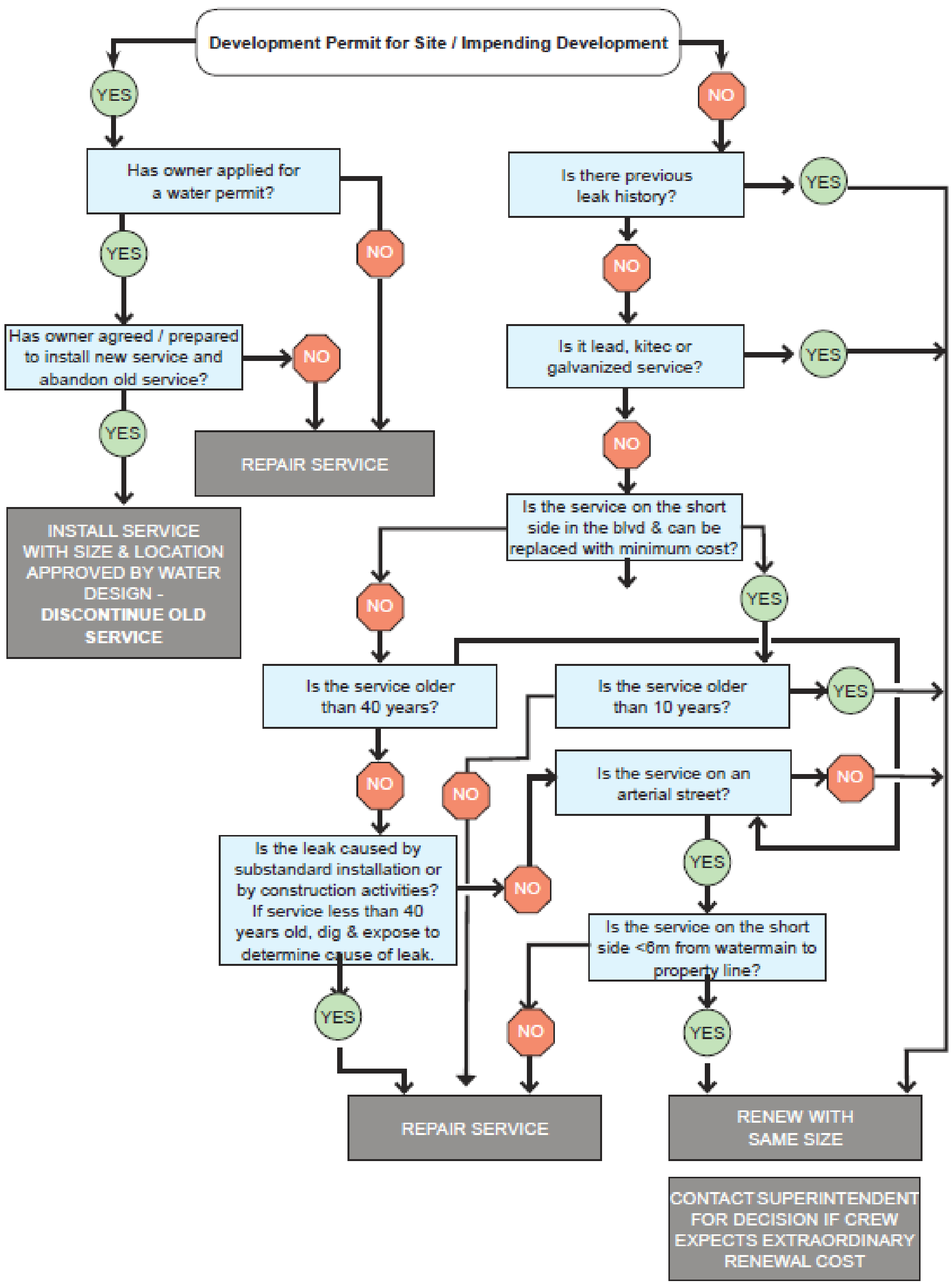


Figure 3-2: Should a Small Service that is Leaking be Repaired or Renewed?

3.6.5.2 SMALL SERVICE REPLACEMENT AS PART OF A DISTRIBUTION MAIN PROJECT

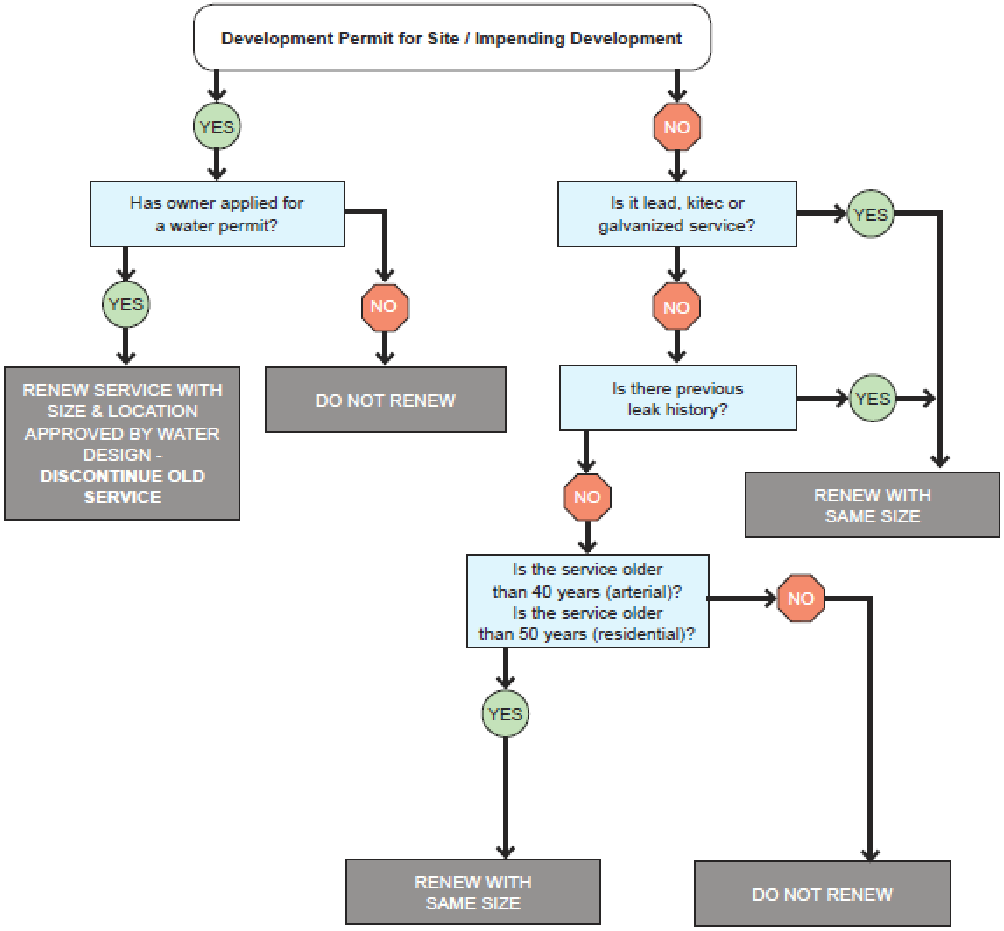


Figure 3-3: Should a Small Service be Replaced as Part of a Water Main Replacement Project?

3.6.5.3 LARGE SERVICE LEAKAGE

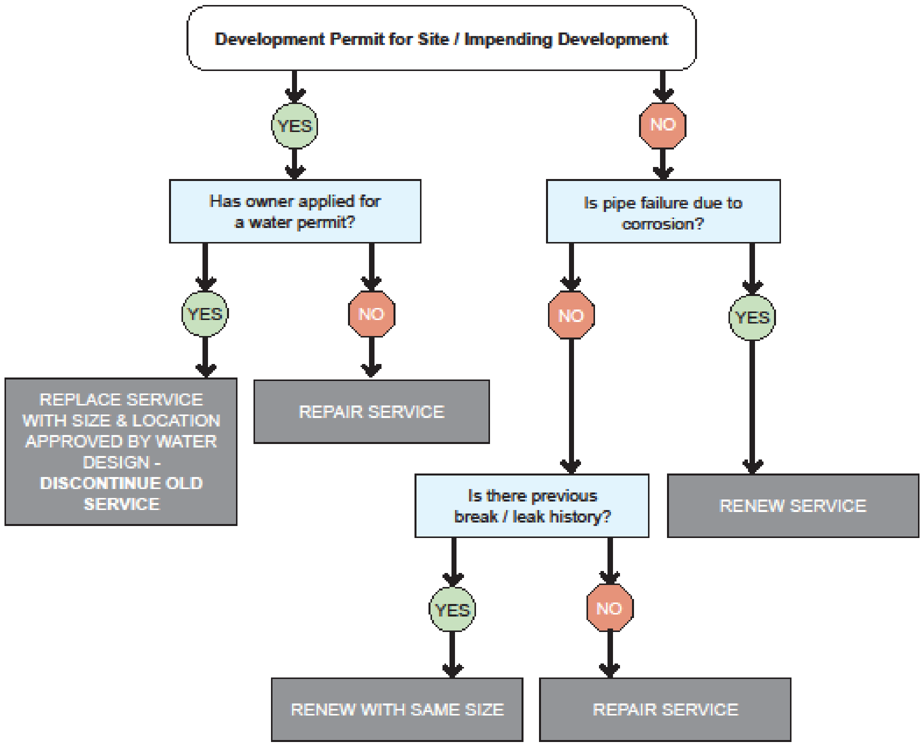


Figure 3-4: Should a Large Service that is Leaking be Repaired or Renewed?

3.6.5.4 LARGE SERVICE REPLACEMENT PROJECT

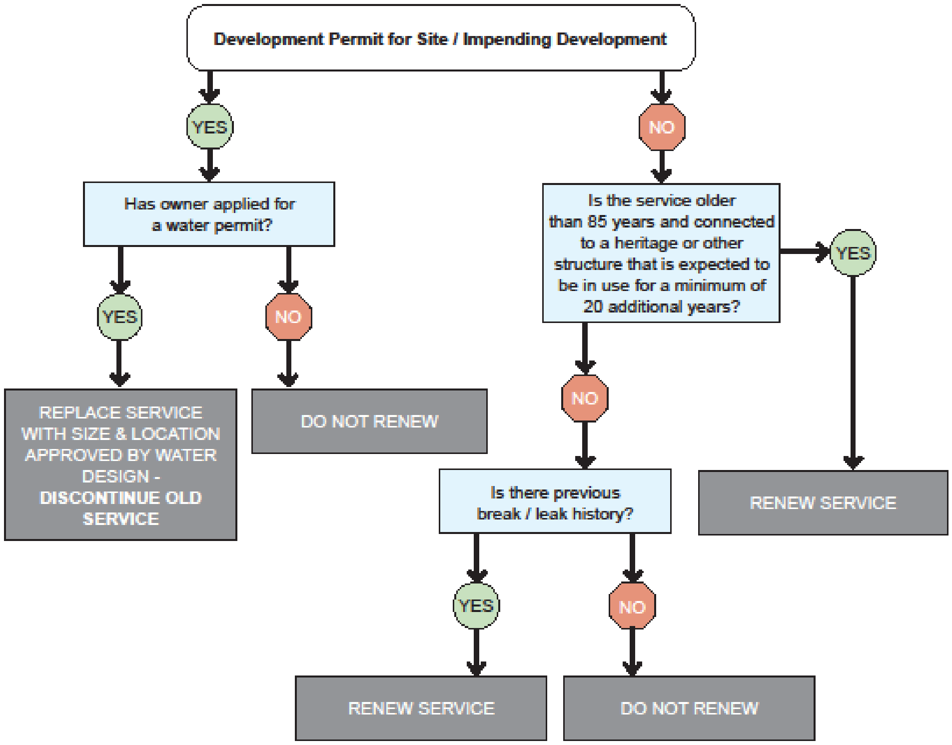


Figure 3-5: Should a Large Service be Replaced as Part of a Water Main Replacement Project?

3.7 THRUST AND RESTRAINT DESIGN

This section identifies recommended methods of restraint for bell and spigot ductile iron piping to be installed in the City's water main distribution network. This section is written for distribution piping from 100mm to 300mm diameter but may be applied to larger diameter piping at the discretion of the City Engineer.

3.7.1 FULLY-RESTRAINED PIPING

In most instances, fully-restrained piping will not be required. The City Engineer may require fully restrained piping if one or more of the following conditions apply:

- The water main is located in an area, which has been identified as having a risk of soil liquefaction in an earthquake.
- The water main is located in saturated soil conditions (bog or marsh where no soil bearing capacity is available).
- The water main has been designated as a seismically-important water main.
- The pipe is located downtown, under an arterial road, or within the hardened grid.

3.7.2 PARTIALLY-RESTRAINED PIPING

Partially-restrained piping refers to ductile iron pipe that is only restrained at bends and other fittings to counteract local thrust forces developed at these locations. In all cases, the method and required restrained length to counter thrust forces shall be clearly indicated on design drawings. As well, soil type used in calculating restraint requirements shall be shown.

The *Waterworks Design Branch* on behalf of the City Engineer will select one of two methods for partially-restrained piping at horizontal and vertical fittings:

- Use of wedge-action restraints to transfer thrust along the pipeline and to soil by bearing friction. Wedge-action restraints are the preferred method of restraint.
- Concrete thrust blocking to transfer thrust to bearing soil when wedge-action restraints cannot be used.

3.7.3 CONCRETE THRUST AND GRAVITY BLOCKING

Concrete thrust and gravity blocks shall be sized and installed according to requirements as shown on the *City of Vancouver Standard Detail Drawings W1.1* to *W1.3*.

3.7.4 USE OF WEDGE-ACTION RESTRAINTS

3.7.4.1 APPROVED MAKES

Wedge-action restraints and restraint harnesses shall be of approved design as specified in the *City of Vancouver Construction Specifications*.

3.7.4.2 LIMITATIONS TO USE

Due to the physical properties of the pipe, wedge-action restraints shall not be used when connecting to cast iron or steel pipes.

3.7.4.3 CALCULATION OF RESTRAINED LENGTH

Restrained length shall be calculated using applicable trench type (generally trench type 5), depth of bury, material type, and soil type. For design pressure and safety factors, refer to *City of Vancouver Standard Detail Drawings W1.1* to *W1.3*.

The restrained length shall be calculated according to an approved restrained length calculation program. Approved restrained length calculation programs are:

- EBAA Iron Inc. *Restrained Length Calculation Program*
- Uni-Flange *Pipe Thrust Restraint Program* (from Ford Meter Box Co.)

For horizontal offsets, combined horizontal offsets, and combined vertical offsets, only the following program should be used:

- DIPRA's *Thrust Restraint Design for Ductile Iron Pipe*

Where fittings are located within the restrained length of neighbouring fittings, the City Engineer may require additional thrust restraint.

Restrained lengths shall be shown on drawings and record drawings. During construction, if a change in soil type is observed or if there is a change in material, the design engineer shall be notified, and the restrained length shall be recalculated using the new criteria.

3.7.5 USE OF TIE RODS

Tie rods shall only be used when other methods of restraint are not practical. See the *City of Vancouver Construction Specifications* for further details.

4

SANITARY SEWER SYSTEM

Sanitary Sewer System

SANITARY SEWER SYSTEM

4.1 INTRODUCTION

The City of Vancouver updates, operates, and maintains a sanitary sewer network to convey liquid wastewater from residences, commercial buildings, institutions, industrial establishments, and unavoidable inflow and infiltration from surface storm water that finds its way into the sanitary system. All discharges to the public sewer shall comply with regulations contained in the *City of Vancouver Sewer and Watercourse By-law No. 8093* governing the admission of wastes into sewers. Metro Vancouver, the regional authority, owns, operates and maintains the treatment facilities and interceptors for Vancouver sanitary sewage.

The sanitary system is not intended to be the primary conveyance for stormwater and groundwater. Vancouver is in the process of separating combined storm and sanitary sewers into two isolated systems. The sewer system consists of lateral sewers and trunk sewers.

The following is a brief description of each section:

- The *Demands and Flows* section outlines the analysis required to determine flow demand placed on the sanitary sewers being designed or studied.
- The *Hydraulic Analysis* section outlines the process to determine the flow capacities of the sanitary sewers.
- The *Design of Sanitary Sewer Components* section discusses the specific requirements to design various components such as sanitary sewers, maintenance holes, and fittings.
- The *Seismic Design Standards* section outlines the requirements for seismic design of sanitary sewer components.
- The *Service Connections* section outlines the requirements relating to service connections.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

4.2 DEMANDS AND FLOWS

In order to determine the proper sizing and configuration of sanitary sewer systems, the flow requirements must be determined. This section outlines the requirements for determining the design flows based on population, peaking factors, and inflow and infiltration.

4.2.1 DEFINITIONS

ADWF = Average Dry Weather Flow = Average flow during dry conditions (no infiltration)

PDWF = Peak Dry Weather Flow = Peak flow during dry conditions (no infiltration)

PWWF = Peak Wet Weather Flow = Peak flow during wet conditions (considers infiltration)

4.2.2 DESIGN FLOW

The Design Flow of sewage is determined by estimating the present and probable future quantities of domestic sewage, commercial and industrial wastes, and infiltration. Generally, the City requires sanitary sewers to have capacity for a projected 100-year period.

4.2.2.1 POPULATIONS

If detailed population information is not accessible, the design population, P, is determined by using the equation below:

$$P = \frac{10{,}000 \times A_{lot} \times FSR}{D}$$

Where:

P = Design Population (people)

A_{lot} = Lot Area (ha)

FSR = Maximum Allowable Floor Space Ratio from the *City of Vancouver Zoning and Development By-law No. 3575*

D = Density (m^2/person) from ***Table 4-1***:

Table 4-1: Development Densities

Development Type	Density, D (m^2/person)
Single-Family / Duplex / Triplex / Quadplex	55
Townhouse Complexes / Condos / Apartments	35
Commercial	23
Industrial	Case-by-case
Institutions / Schools / Stadiums / Hospitals	Case-by-case

4.2.2.2 AVERAGE DRY WEATHER FLOW

The Average Dry Weather Flow, ADWF, is determined by the following equation:

$$\mathrm{ADWF} = \frac{\mathrm{P} \times \text{Per Capita Flow}}{86400}$$

Where:

ADWF = Average Dry Weather Flow (L/s)

P = Design Population

Per Capita Flow (L/person/day) as per the following:

- Residential Areas: 455L/person/day
- Commercial, Institutional, and Industrial Areas: 225L/person/day

Confined industrial and commercial areas may use other methods as approved by the City Engineer.

4.2.2.3 PEAKING FACTOR

The Harmon Formula is used to determine the peaking factor which is given by:

$$\mathrm{PF} = 1 + \frac{14}{4 + (\mathrm{P}/1000)^{0.5}}$$

Where:

PF = Peaking Factor

P = Cumulative Equivalent Population (residential population + 0.5 x commerical population)

If flow data is recorded for similar developments, the peaking factor used should be the larger of the recorded data or the Harmon Formula.

4.2.2.4 INFLOW AND INFILTRATION (I&I)

The Infiltration Flow, $\mathrm{Q_{I\&I}}$, is used as an allowance to account for any infiltration and inflow that makes its way into the sanitary sewer. To determine the infiltration flow, the following formula is used:

$$\mathrm{Q_{I\&I}} = (0.13\ \mathrm{L/s/ha}) \times \mathrm{A}$$

Where:

$\mathrm{Q_{I\&I}}$ = Inflow and Infiltration (L/s)

A = Gross Area (ha)

4.2.2.5 DESIGN FLOW CALCULATION

The design flow is a sum of the Average Dry Weather Flow, $ADWF$, which has been adjusted with the peaking factor, PF, and the inflow and infiltration allowance, $Q_{I\&I}$, as outlined in the following equation:

$$Q_{des} = PWWF = PDWF + Q_{I\&I} = (ADWF \times PF) + Q_{I\&I}$$

Where:

Q_{des} = Design Flow (L/s)

$PWWF$ = Peak Wet Weather Flow (L/s)

$PDWF$ = Peak Dry Weather Flow (L/s) = $ADWF \text{ x } PF$

$ADWF$ = Average Dry Weather Flow (L/s)

PF = Peaking Factor

$Q_{I\&I}$ = Inflow and Infiltration (L/s)

4.2.3 CALCULATIONS SHEET

Sanitary sewer calculations shall be presented in accordance with and ***Figure 4-1*** and ***Figure 4-2***:

SANITARY SEWER CALCULATION SHEET

Project Name:	
Designed by:	
Calculation Date:	
Checked by:	
Company Name:	

Total Catchment Area from Excel (ha)	0
Total Catchment Area from CAD file (ha)	
Percent Error for Catchment Areas	
n	0.013

For combined connection

IDF Used:	2050
Return Period:	
Inlet Time (min):	

No	Location			Pipe Specifications			Catchment Properties						FSR/Density							Population		
	Street Name	U/S MH	D/S MH	Length	Diameter, D	Slope, s	Contributing U/S Catchment Area Numbers	Gross Area, A_G	Lot Area, A_L	Combined Sewer Lot Area, A_C	Zoning	"C"	Population Density	FSR Resid.	FSR Comm.	Equivalent Floor Space Area Resid, EQ FSR	Equivalent Floor Space Area Comm.	Density Residential	Density Commerical	Incremental Population Residential	Incremental Population Commerical	Cumulative Population
																EQ FSR Resid. = A_L x FSR Resid.	EQ FSR Comm. = A_L x FSR Comm.			If Pop/ha available, Pop Res= Polulation Desityx A_G; otherwise EQ FSR Resid.x 10000/Density Residential	Pop Comm.= EQ FSR Comm..x 10000/Density Commercial	Cum. Pop= Pop Res. +Pop Comm.
				m	m	%		ha	ha	ha			Pop/Ha			ha	ha	m^2/person	m^2/person			

Figure 4-1: Sanitary Sewer Calculations Sheet (Page 1)

ConcentrationTime					Flow		Infiltration		Inflow - Combined Conn.		Max Flows				Design Summary				Design Summary- with no combined flow/full separated connection		
Inc.	Inc, without combined flow	Total, t	Total, $t_{no\ comb}$	Intensity	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Peaking Factor, PF*	Q_{Peak}	Q_{Peak} when separated and no combined flow added	Q_{Full}	Q_{Peak}/Q_{Full}	$X=V_{Peak}/V_{Full}$	V_{Peak}	V_{full}	Q_{Peak}/Q_{Full}	Xno com=V_{Peak}/V_{Full}	V_{Peak}
$t_{inc}=\frac{L}{V_{Peak}}\frac{1}{60}$	$t_{no\ comb}=\frac{L}{V_{Peak\frac{w}{o}comb}}\frac{1}{60}$		without combined flow	From 2050 IDF Curve, I= $A^*(t/60)^B$	F_{Incen}= (455x Pop Res.+225x Pop. Comm.)/(1000x24x3600)	F_{cum}	Incremental Finf= 0.13x A_G/1000	Cum F_{Inf}	Inc. Com Flow= Cxl x A_G/360	Fc	$\frac{18+(Cum.\frac{Pop}{1000})^{0.5}}{4+(Cum.Pop/1000)^{0.5}}$	Q Peak= F_{cum}x PF +Cum F_{Inf}+Cum Fc	Q Peak= F_{cum}x PF +Cum F_{Inf}	$Q_{Full}=\frac{1}{n}\frac{D^{2/3}}{4}\frac{s}{100}^{1/2}\frac{\mu D^2}{4}$		from Hydraulic-Elements Graph	V Peak =X x VFull	$V_{Full}=\frac{Q_{Full}}{\frac{\mu D^2}{4}}$		from Hydraulic-Elements Graph	V Peak =X no comx VFull
min	min	min	min	mm/hr	m^3/s		m^3/s	m^3/s	m^3/s	m^3/s		m^3/s	m^3/s	m^3/s	%		m/s	m/s	%	%	m/s

Figure 4-2: Sanitary Sewer Calculations Sheet (Page 2)

4.3 HYDRAULIC ANALYSIS

This section outlines the design process and factors determining sanitary sewer pipe flow within the City of Vancouver. For the design of sanitary sewers, the equations in ***Table 4-2*** must be satisfied:

Table 4-2: Hydraulic Design Requirements

Population	Maximum Flow Depth
5000 and less	$y = 50\% \times D$
Greater than 5000	$y = 70\% \times D$

Where:

y = Maximum Allowable Flow Depth (m)

D = Diameter of Pipe (m)

Refer to ***Figure 4-3*** for pipe flow properties.

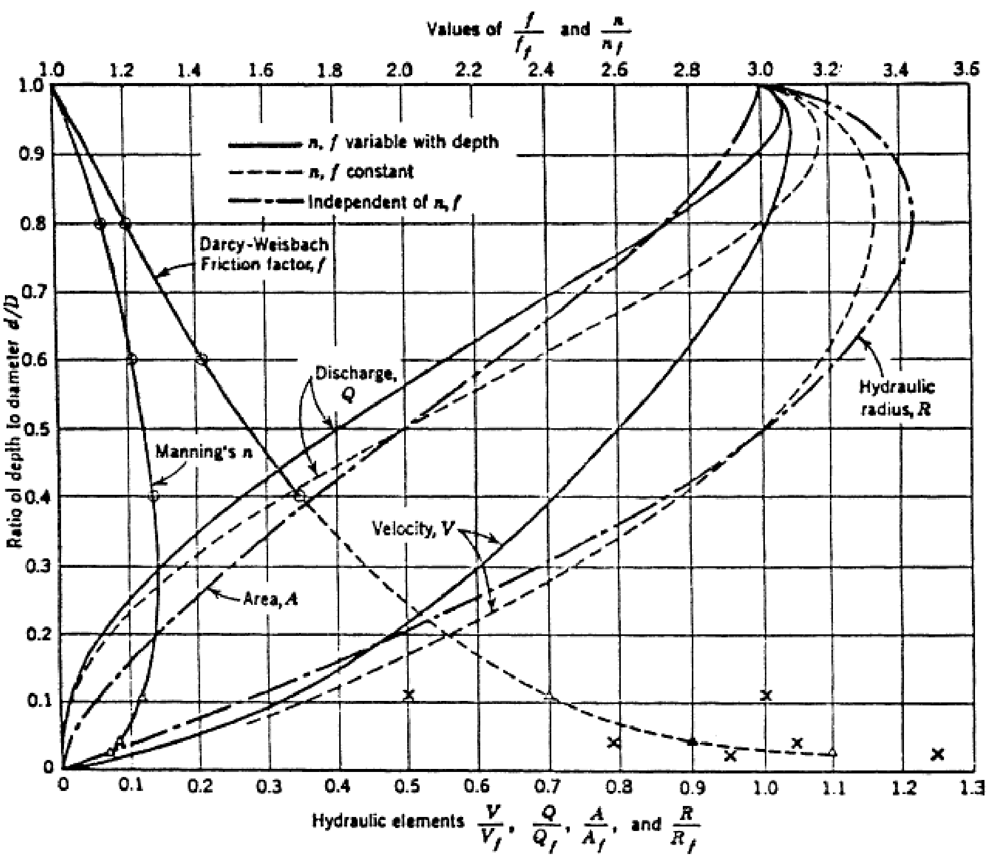


Figure 4-3: Hydraulic Elements Graph for Circular Sewers

From WPCF Manual of Practice No. 9 “Design and Construction of Sanitary and Storm Sewers” 1969 Ed.

Note that other methods may be used as approved by the City Engineer.

4.3.1 MANNING'S FORMULA

Pipe flow rates of unpressurized sanitary sewer pipes are calculated using Manning's Formula which is defined as:

$$Q = \frac{1000}{n} R^{2/3} s^{1/2} A$$

Where:

Q = Flow Rate (L/s)
n = Manning's Roughness Coefficient = 0.013 for all smooth pipes (ex. PVC, Concrete, Clay)
R = Hydraulic Radius (m) = Cross-Sectional Flow Area (m^2) / Wetted Perimeter (m)
s = Slope of Hydraulic Grade Line (m/m)
A = Cross-Sectional Flow Area (m^2)

4.3.2 HAZEN-WILLIAM'S FORMULA

Pipe flow rates of pressurized force mains are calculated using Hazen-Williams Formula which is defined as:

$$Q = \frac{CD^{2.63} s^{0.54}}{278780}$$

Where:

Q = Flow Rate (L/s)
D = Internal pipe diameter (mm)
s = Slope of hydraulic grade line (m/m)
C = Roughness Coefficient = 120 for all pipes

4.4 DESIGN OF SANITARY SEWER COMPONENTS

This section outlines the design requirements for pipes, maintenance holes, and appurtenances in the sanitary sewer system within the City of Vancouver.

4.4.1 GENERAL CONSIDERATIONS

Sanitary sewers shall be designed with consideration of the requirements outlined in *Chapter 2: Design Process & Coordination*.

4.4.2 SANITARY SEWERS

This section outlines the size, material, alignment, and other design criteria related to the installation of the sanitary sewer system in the City of Vancouver.

4.4.2.1 SIZE AND MATERIAL

The pipe outlined in ***Table 4-3*** is permitted for gravity sewer mains:

Table 4-3: Gravity Main Size and Materials

Pipe	Size (mm)	Standard
Vitrified Clay Extra Strength	150 - 375	*ASTM C700 / C425*
Non-Reinforced Concrete Cl. 3	200 - 600	*ASTM C14 / C443*
PVC SDR35	200 – 375	*ASTM D3034 / D2412*
PVC C900 (for low-cover situations)	200 - 375	*AWWA C900*
HDPE DR21	200 – 375	*ASTM D3035 / D3350*
Reinforced Concrete Cl. III, IV, and V	300 - 3050	*ASTM C76 / C443*

Sanitary gravity mains shall not be less than 200mm in diameter unless in a residential area where it cannot be extended. In no case shall it be less than 150mm in diameter.

Downstream pipe size reduction may only be used in special circumstances with City Engineer approval. A downstream pipe must not be reduced in size unless:

- It has increased slope to provide sufficient capacity.
- It is greater than or equal to 525mm.
- It is not reduced by more than two pipe sizes.
- A detailed hydraulic analysis has been done.

The engineer of record is responsible for the selection of materials and shall consider local conditions such as character of industrial wastes, soil characteristics, heavy external loadings, depth of cover, abrasions, and similar problems. Pipe material and class shall be selected by the engineer of record. Signed and sealed structural calculations for the selected material shall be provided to the City. Refer to the *City of Vancouver Construction Specifications* for further requirements.

4.4.2.2 ALIGNMENT

Whenever possible, sewers should be located based on the elevations of the adjacent properties. In cases where only one side of the street is serviced by a sewer, the sewer shall be located on the higher elevation side. In cases where both sides of the street are serviced by a sewer, the sewer shall be located on the lower elevation side. Wherever possible, the sewer shall be at a constant offset from the property line.

The following must also be considered when selecting the sewer alignment (in no particular order):

- Minimize crossing conflicts.
- Meet clearance and separation requirements in *Section 2.2.5*.
- Minimize construction, public, and traffic impacts.
- Minimize construction costs.
- Maximize maintenance access.
- Consider long-term plans for separated and traditional sewer routing.
- Avoid trees and other surface features such as, but not limited to, traffic circles, bulges, landscaping, gate valves, gutters, catch basins, retaining walls, trees, concrete curbs, sidewalks, or ramps.

4.4.2.3 DEPTH

The minimum depth of cover is 1.0m. The sanitary sewer must also be sufficiently deep to:

- Service basements by gravity that were previously serviced by gravity (existing pumped connections are not required to be converted to gravity connections).
- Allow for tie-ins of other mains and services.
- Structurally withstand surface loading.
- Avoid conflicts with other utilities.
- Prevent freezing.
- Accommodate future sewer separations and consider long-term plans for separated sewer routing.

Generally, the maximum depth of cover is such that the trench depth will not exceed 6m; depths greater than 6m or trenches excavated in poor soil conditions require trenches designed by a professional engineer.

4.4.2.4 VELOCITY AND SLOPE

Sanitary mains shall be designed with a pipe slope which provides the minimum velocity at maximum flows as follows:

- Preferred minimum velocity: 0.76m/s
- Absolute minimum velocity: 0.61m/s

The pipe slope shall not be less than 0.5%. If the sewer services a design population of less than 25, the minimum slope is 0.6%.

Provisions shall be made for energy dissipation and movement when the velocity of the design flow exceeds 4.6m/s or as specified by the pipe manufacturer.

When lateral forces are excessive to unseat pipe joints, anchors will be required (i.e. steep slopes).

4.4.2.5 CURVED SEWERS

Horizontal and vertical curves will be permitted under special circumstances. Vertical curves may be required where excessive rock cuts are to be avoided and where energy dissipation is required. The following criteria applies to curved sewers:

- The rate of curvature must be uniform throughout the curve.
- Only one curve (horizontal or vertical) is allowed between consecutive maintenance holes.
- Curves must be formed through joint deflection or bends and not by bending of the pipe.
- The joint deflection must not be greater than 50% of the recommended maximum by the pipe manufacturer.
- The radius must also meet the minimum requirements in ***Table 4-4***.
- Horizontal curves require tracing wire above the alignment and are to terminate at upstream and downstream maintenance holes. Warning ribbon is to be placed 1m above the top of the curved sewer.

Table 4-4: Minimum Curved Sewer Radii

Pipe Type	Pipe Size (mm)	Laying Length (m)	Minimum Radius (m)	Max Deflection[1]
Vitrified Clay	150 – 300	1.5	40	2˚23’
	150 – 300	1.8	45	2˚23’
	375	0.9	30	1˚47’
Concrete Pipe	300	2.5	41	3˚31’
	375	2.5	50	2˚53’
	450	2.5	58	2˚27’
	525	2.5	67	2˚6’
	600	2.5	80	1˚47’
	675	2.5	89	1˚37’
	750	2.5	98	1˚28’
	900	2.5	116	1˚17’
	1050	2.5	113	1˚4’
PVC	150	-	46	Per Manufacturer’s Guidelines
	200	-	61	
	250	-	77	
	300	-	92	
	375	-	107	

Notes:
[1] In no case shall the deflection be greater than 50% of the manufacturer’s recommended maximum deflection

SANITARY SEWER SYSTEM

4.4.2.6 BACKFILL AND MATERIALS

All backfill and sewer-related materials such as pipe bedding and concrete shall be in accordance with the *City of Vancouver Standard Detail Drawings* and the *City of Vancouver Construction Specifications*.

4.4.2.7 STRUCTURAL DESIGN

The design engineer must ensure that the pipe is sufficiently designed to withstand loading that will be applied to it without deflection or damage as per manufacture specifications. The signed and sealed calculations shall be completed using the manufacturers recommendations and submitted to the City.

Concrete Pipe Strength Calculation

$D_{0.3}$ is to be used when calculating the design strength of concrete pipes, where $D_{0.3}$ is the minimum load required to produce a 0.3mm crack in a concrete pipe.

$$\text{Minimum Load (N)} = \text{Strength Class } D_{0.3}\left(\frac{\frac{N}{m}}{mm}\right) \text{ x Length of Pipe (m) x Inside Diameter (mm)}$$

4.4.2.8 ODOUR MITIGATION

To reduce the effect of odour caused by the presence of Hydrogen Sulphide (H_2S), sewers should be designed with the following considerations:

- Steeper sewers should be used when possible since shallower slopes cause higher odours.
- Larger pipe sizes reduce the depth of flow which results in lower odours.
- Maintenance hole drop structures should be avoided since they create turbulence which releases odours.

4.4.3 MAINTENANCE HOLES

4.4.3.1 LOCATIONS

Maintenance holes must be placed at the following locations:

- At terminal ends.
- At all grade changes.
- At all size changes.
- At all alignment changes.
- At all sewer intersections.
- At a spacing of not more than 183m pipe length.
- At the downstream end of a curved sewer.
- At service connections outlined in *Section 4.6*.

4.4.3.2 LOADING

The BC CL-625 vehicle shall be used for loading designs, recognizing that the BC design vehicle includes higher axle load ratings than the CAN/CSA design vehicle.

4.4.3.3 SIZE AND BENCHING

Maintenance holes require a minimum of one 300mm wide bench. ***Table 4-5*** shows minimum sizes of standard maintenance holes based on the largest pipe diameter entering the maintenance hole. The angles, elevation and the number of incoming pipes must also be considered to ensure safe entry and structural integrity of the maintenance hole.

Table 4-5: Minimum Maintenance Hole Sizes

Pipe Diameter (mm)	Minimum Maintenance Hole Barrel Diameter (mm)
150 - 450	1050
525 – 675	1200
750 - 1050	1350
1200	1500
1350 - 1500	1800
1650 - 2100	2400

Precast tee maintenance holes can be used for 1200mm and larger pipe; however, standard maintenance holes may be required in certain site conditions such as overbuild tie-ins to live flows if approved by the City Engineer. Precast tee maintenance hole barrels are to be 1050mm diameter.

It is generally preferred to use a larger concentric maintenance hole with two benches (one on either side) instead of a smaller offset maintenance hole with one bench; however, in certain site conditions, the one-bench arrangement may be beneficial over the two-bench arrangement.

4.4.3.4 INLET AND OUTLET ELEVATIONS

The drop from the inlet invert elevation to the outlet invert elevation in the maintenance hole must meet the requirements in ***Table 4-6***.

Table 4-6: Minimum Maintenance Hole Drops

Alignment Deflection	Minimum Drop (mm)
0˚	10
≤ 45˚	30
45˚ - 90˚	50

The crown of the inlet pipe is to be the same elevation or higher than the crown of the outlet pipe.

SANITARY SEWER SYSTEM

4.4.3.5 DROP STRUCTURES

Drop structures should be avoided by adjusting the grade of the sewer, but where this cannot be achieved, provide drop structures according to ***Table 4-7***:

Table 4-7: Maintenance Hole Drop Structures

Difference in Invert (m)	Drop Type
≤ 0.25	Accommodated in Benching
0.26 – 0.6	Outside Open Ramp
≥ 0.61	Outside Closed Ramp for 200mm to 375mm Pipe Outside Open Ramp for ≥450mm Pipe
≥ 0.9	Inside Drop (minimum 1200mm maintenance hole - upon special approval)

4.4.3.6 MAINTENANCE HOLE COVERS

For safety reasons, all new maintenance hole covers in playgrounds, schoolyards, and other areas that pose a safety hazard shall be buried 150mm below grade and secured using one of the following methods:

- Bolt-down cover and frame.
- Locking pin system.

Watertight maintenance hole covers are to be used when:

- The maintenance hole covers may be flooded by street runoff.
- The top of the maintenance hole is below the 10-year hydraulic grade line elevation.
- The elevation of the top of the maintenance hole is below 3.30m geodetic in the Fraser River floodplain, or 3.80m in the False Creek floodplain.

4.4.4 FITTINGS, COUPLINGS, AND CASTINGS

All fittings, couplings, castings, and appurtenances shall be in accordance with the *City of Vancouver Construction Specifications*.

4.4.5 TRENCHLESS TECHNOLOGIES

The use of trenchless technologies in the City of Vancouver as a means of installing or rehabilitating underground sewer infrastructure must be approved by the *Sewers and Drainage Design Branch* prior to construction. The design engineer and the contractor must be experienced in the proposed trenchless method.

4.4.6 AERIAL PIPE BRIDGES AND INVERTED SIPHONS

Pipe bridges and inverted siphons must be approved before proceeding with design. The following requirements apply:

- Low points require blowdowns.
- High points require blowoffs and air releases.
- Pigging and flushing ports are required.
- Access points are required.
- The design must be able to withstand the operating pressures.
- The minimum velocity for siphons is 0.9m/s (multiple siphons of varying invert may be required).
- Maintenance holes are required at both ends.
- Head losses must be considered.
- Any such “special structures” which require periodic inspection or maintenance need to be considered for addition to the *Sewers Operations Branch* Maintenance Manual as well as proper categorization into the Asset & Work Management system - Hansen.

4.4.7 PUMP STATIONS

Sanitary sewer pump stations are to be avoided where possible. Pump stations are acceptable as an alternative to gravity sewers only in certain cases as directed by the City Engineer or where no other feasible alternative can be designed. Contact the City of Vancouver pump station engineer for the latest version of the sewage pumping requirements document.

4.4.8 FORCE MAINS

4.4.8.1 SIZE AND MATERIAL

The minimum size for mains discharging raw sewage shall be 100mm diameter, unless the entire system is designed as a pressure sewer system with multiple pump installations. The pipe outlined in ***Table 4-8*** is permitted for force mains:

Table 4-8: Force Main Size and Materials

Pipe	Size (mm)	Standard
PVC Schedule 40	75 – 100	*ASTM D1784 / D2241 / D2466*
PVC Cl. 150 DR18	100 - 300	*AWWA C900 / M23*
Ductile Iron Cl. 52	100 - 600	*AWWA C151 / C111*

The selection of force main materials shall consider local conditions such as character of industrial wastes, soil characteristics, heavy external loadings, abrasions, and similar problems.

All force mains shall be designed to prevent damage from superimposed loads or from water hammer or column separation phenomena.

4.4.8.2 VELOCITY AND SLOPE

At the lowest pump delivery rate anticipated to occur at least once per day, a cleansing velocity of at least 0.85m/s should be maintained. The maximum velocity must not exceed 3.5m/s.

Force mains shall be sloped upwards in the direction of flow or be installed level.

4.4.8.3 VALVES

A resilient seat gate valve must be installed in the force main adjacent to the station. Shut-off valves shall be resilient seat gate valves complete with 50mm square nut operator. The valve shall be suitable for buried service.

A telescopic valve box with sewers lid shall be installed over the valve for access to the valve operator.

4.4.8.4 AIR RELEASE VALVES

The use of air release valves shall be discussed with the City.

4.4.8.5 CLEAN-OUT INFRASTRUCTURE

New and replacement forcemains may require clean-out infrastructure and requirements shall be discussed with the City.

4.4.8.6 TERMINATION MAINTENANCE HOLES

Force mains shall terminate in a maintenance hole which shall be connected to the gravity sewer system. The base of this maintenance hole shall be designed to avoid turbulence from the discharge of the force main.

4.5 SEISMIC DESIGN STANDARDS

The choice of replacement strategy and pipe material is based on a risk assessment driven by the criticality of the pipeline, the susceptibility of the contextual ground conditions for wave propagation, and potential for Permanent Ground Deformation. A professional geotechnical engineer shall be retained to perform investigation, review and design for areas with seismic concern or weak ground condition. The City reserves the rights to request for a professional geotechnical engineer to review and design for a project, if the project site is deemed to be high risk for seismic activities and has known poor ground conditions.

Awareness and avoidance of these adverse conditions is the best approach to protect the system from risk associated with ground deformation. Strategies include:

- Limiting the number of non-restrained mains in a neighborhood susceptible to ground acceleration.
- Adding weight to maintenance holes to reduce buoyancy.
- Locating mains to occur outside of liquefaction zone.

4.6 SERVICE CONNECTIONS

Services must meet the most current edition of the *City of Vancouver Sewer and Watercourse By-law No. 8093*, the *City of Vancouver Construction Specifications* and the *City of Vancouver Standard Detail Drawings*.

4.6.1 LOCATION

Unless specifically exempted, all developed sites shall be provided with a connection. The storm service shall be to the right of the sanitary service when looking at the property from the street.

Service connections shall not exceed 30m in length as measured horizontally between the lateral sewer and the property line. If the service must be longer than 30m, a maintenance hole must be placed such that the longest section of service does not exceed 30m.

4.6.2 SIZE AND MATERIAL

All one- and two-family dwellings shall be provided with a 100mm diameter service. All other dwelling sanitary services shall be sized to accommodate peak flows and in accordance with the standards set in the *City of Vancouver Sewer and Watercourse By-law No. 8093*. No gravity sanitary service connection shall be less than 100mm in diameter.

The pipe outlined in ***Table 4-9*** is permitted for service connections:

Table 4-9: Service Size and Materials

Pipe	Size (mm)	Standard
PVC SDR28	100 - 150	*ASTM B182.1 / D2412*
PVC SDR35	200 – 375	*ASTM D3034 / D2412*
PVC Cl.50 DR18 (Forcemains)	150 – 300	*AWWA C900 / M23*
Concrete Cl IV RC	450+	*ASTM C76*

4.6.3 DEPTH

The preferred connection depth to invert at the property line shall be 1.5m below the centerline of the street or lane. The sanitary connection must be installed at the same elevation as the storm connection at the property line.

Exceptions are occasionally approved with the following conditions:

- The new connection by itself shall not preclude raising of the main sewer in the future.
- The new connection depth shall not significantly increase the potential for flooding the new building.
- Where the property has not already been provided with a connection at the City's expense.

In no case shall the connection have less than 1.0m cover or greater than 2.4m depth at the property line.

4.6.4 VELOCITY AND SLOPE

Service connections shall be designed with a slope which provides the minimum velocity at maximum flows as follows:

- Preferred minimum velocity: 0.92m/s
- Absolute minimum velocity: 0.76m/s

The service slope shall not be less than 2%. Service slopes less than 2% to be approved by the City Engineer.

4.6.5 TIE-IN REQUIREMENTS

See *City of Vancouver Standard Detail Drawings S7.1* and *S7.2* for tie-in requirements for service connections to the main.

4.6.6 INSPECTION CHAMBERS

Inspection chambers are required on all new services and are to be located at 0.3m outside of property line. The lid for the sanitary inspection chamber is to be red.

4.6.7 MINIMUM BUILDING ELEVATION (MBE)

In addition to all other requirements as set by this document and the *City of Vancouver Building By-law*, when possible the Minimum Building Elevation should be set such that the building's sanitary plumbing can be serviced by gravity.

5

STORM DRAINAGE SYSTEM

STORM DRAINAGE SYSTEM

5.1 INTRODUCTION

Vancouver's storm drainage system consists of storm sewers and green stormwater infrastructure to convey and manage stormwater. The storm system is not intended to include any sanitary wastewater. Vancouver is in the process of separating combined storm and sanitary sewers into two isolated systems. Vancouver's storm drainage and green infrastructure are important components in the City's strategic plan to mitigate the effects of climate change and include built infrastructure into the natural water cycle of Vancouver. Another important aspect of storm infrastructure is seismic resiliency and adapting materials and construction techniques to site conditions in order to make Vancouver a more resilient city.

The following is a brief description of each section:

- The *Demands and Flows* section outlines the analysis required to determine flow demand placed on the drainage system being designed or studied.
- The *Hydraulic Analysis* section outlines the process to determine the flow capacities of the storm drainage system.
- The *Design of Storm Drainage Components* section discusses the specific requirements to design various components such as storm sewers, maintenance holes, and culverts.
- The *Seismic Design Criteria* section outlines the requirements for seismic design of storm drainage components.
- The *Service Connections* section outlines the requirements relating to service connections.
- The *Green Infrastructure and Integrated Rainwater Management* section gives an overview of the City of Vancouver's criteria for green stormwater infrastructure.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

5.2 DEMANDS AND FLOWS

In order to determine the proper sizing and configuration of storm drainage systems, the flow requirements must be determined. This section outlines the requirements for determining the design flows based on return periods and using either the Rational or Hydrograph method of flow analysis.

5.2.1 DESIGN FLOW

The City of Vancouver's drainage system and design storms consist of the following:

- The Minor System: consists of gutters, catchbasins, open channels, pipes, driveway culverts, watercourses, and stormwater management facilities designed to carry flows with the following minimum return periods (note: design storms may differ from industry standard):

5-Year Return Period	Residential, minor system components not listed in the 10 and 25-year return periods below.
10-Year Return Period	Business, commercial, industrial, downtown core (west of Main Street includes all of the West End peninsula), and the False Creek Comprehensive Development District.
25-Year Return Period	All trunk sewers (sewers with a tributary area greater than 40ha).

- The Major System: consists of roadways, culverts, ditches, surface flood paths, watercourses, and stormwater management facilities designed to carry flows with the following minimum return period (note: design storm may differ from industry standard):

100-Year Return Period	All major system components.

The storm system must be designed using one of the following two methods:

≤ 20ha	The Rational Method as outlined in *Section 5.2.2*
> 20ha	The Hydrograph Method as outline in *Section 5.2.3*

5.2.2 RATIONAL METHOD

The Design Flow, Q_{des}, for drainage areas less than or equal to 20ha is calculated using the Rational Method which is defined as:

$$Q_{des} = \frac{CIA}{360}$$

Where:

Q_{des} = Design Flow (m^3/s)

C = Runoff Coefficient as per *Section 5.2.2.1*

I = Rainfall Intensity (mm/hr) as per *Section 5.2.2.2*

A = Tributary Drainage Area (ha) as per *Section 5.2.2.3*

5.2.2.1 RUNOFF COEFFICIENT

The runoff coefficient, C, is based on ground slope, type of cover, type of ground surface, and development population density. It is up to the designer to select an appropriate runoff coefficient that is representative of the site. The runoff coefficient must account for future development outlined in community plans and / or over a 100-year period.

Table 5-1 provides general coefficients for typical development types:

Table 5-1: Development Runoff Coefficients

Type of Development	Runoff Coefficient, C
Parks	0.30
One Family Dwelling	0.70
Two Family Dwelling	0.70
3-Storey Multiple Dwelling	0.75
6-Storey Multiple Dwelling	0.85
Local Commercial	0.95
3-Storey Commercial	0.90
6-Storey Commercial	0.90
Central Business	0.95
Industrial	0.90

It is generally preferable to develop a composite runoff based on the percentages of different types of surfaces in the drainage area. This procedure is often applied to typical sample blocks as a guide to selection of reasonable values of the coefficient for an entire area.

Table 5-2 provides suggested coefficients for various surface types:

Table 5-2: Surface Type Runoff Coefficients

Character of Surface	Runoff Coefficient, C
Flat (<2%) Lawns, Sandy Soil	0.08
Average (2-7%) Lawns, Sandy Soil	0.13
Steep (>7%) Lawns, Sandy Soil	0.18
Flat (<2%) Lawns, Heavy Soil	0.18
Average (2-7%) Lawns, Heavy Soil	0.23
Steep (>7%) Lawns, Heavy Soil	0.30
Drives and Walks	0.80
Asphalt Streets	0.83
Roofs	0.85
Concrete Streets	0.88

5.2.2.2 RAINFALL INTENSITY

The rainfall intensity, I, is calculated using the City of Vancouver Intensity Duration Frequency (IDF) curves and the IDF Equation which is defined as:

$$I = A * T^B$$

Where:

T = Time (hours)

A,B = Coefficients

I= Rainfall Intensity (mm/hr)

There are three IDF curves used by the City of Vancouver: 2014, 2050, and 2100. These curves are provided below as well as a description of when each curve is to be used.

2014 IDF

The 2014 IDF curve, ***Figure 5-1***, and coefficients in ***Table 5-3***, are to be used for on-site storm water management pre-development estimates.

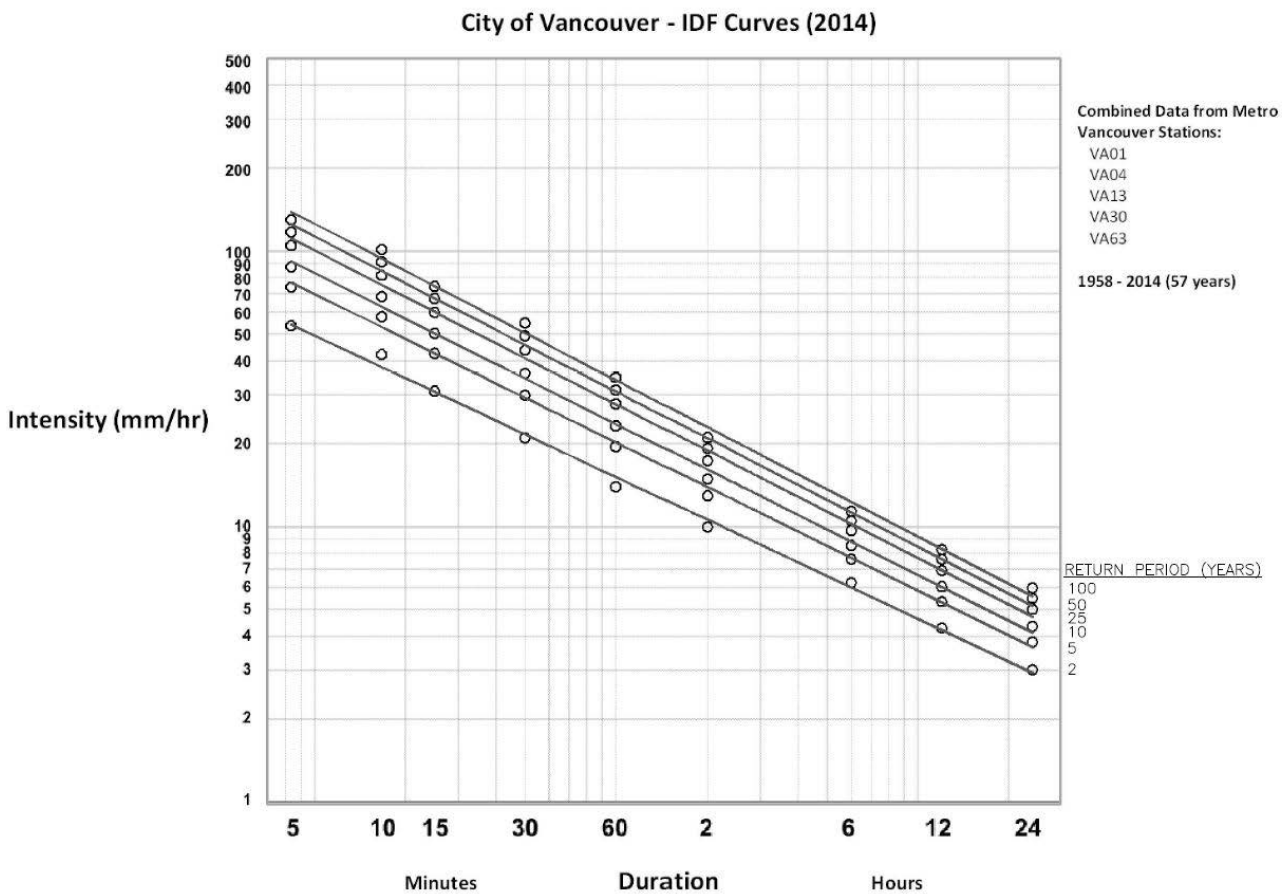


Figure 5-1: 2014 IDF Curve

Table 5-3: 2014 IDF Equation Coefficients

Recurrence Interval	Probability	A	B
1 in 2 year	50%	15.13	-0.514
1 in 5 year	20%	20.21	-0.538
1 in 10 year	10%	23.56	-0.548
1 in 25 year	4%	27.78	-0.558
1 in 50 year	2%	30.90	-0.563
1 in 100 year	1%	34.00	-0.567

2050 IDF

The 2050 IDF curve, ***Figure 5-2***, and coefficients in ***Table 5-4***, are to be used for storm component of sanitary sewer design in a "combined connection to sanitary sewer area".

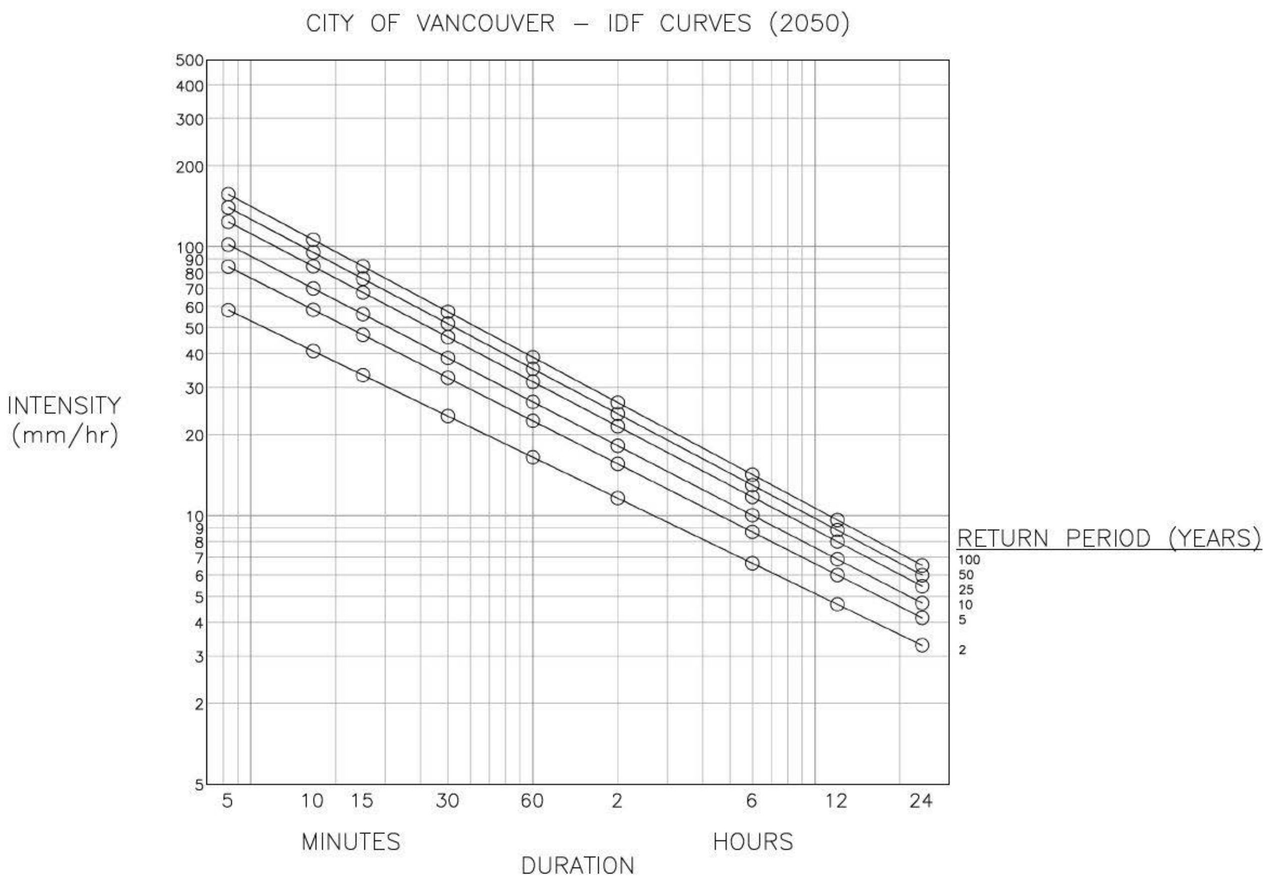


Figure 5-2: 2050 IDF Curve

Table 5-4: 2050 IDF Equation Coefficients

Recurrence Interval	Probability	A	B
1 in 2 year	50%	16.46	-0.507
1 in 5 year	20%	22.47	-0.531
1 in 10 year	10%	26.43	-0.542
1 in 25 year	4%	31.41	-0.551
1 in 50 year	2%	35.10	-0.556
1 in 100 year	1%	38.76	-0.561

2100 IDF

The 2100 IDF curve, ***Figure 5-3***, and coefficients in ***Table 5-5***, are to be used for storm sewer design and on-site storm water management post-development estimates.

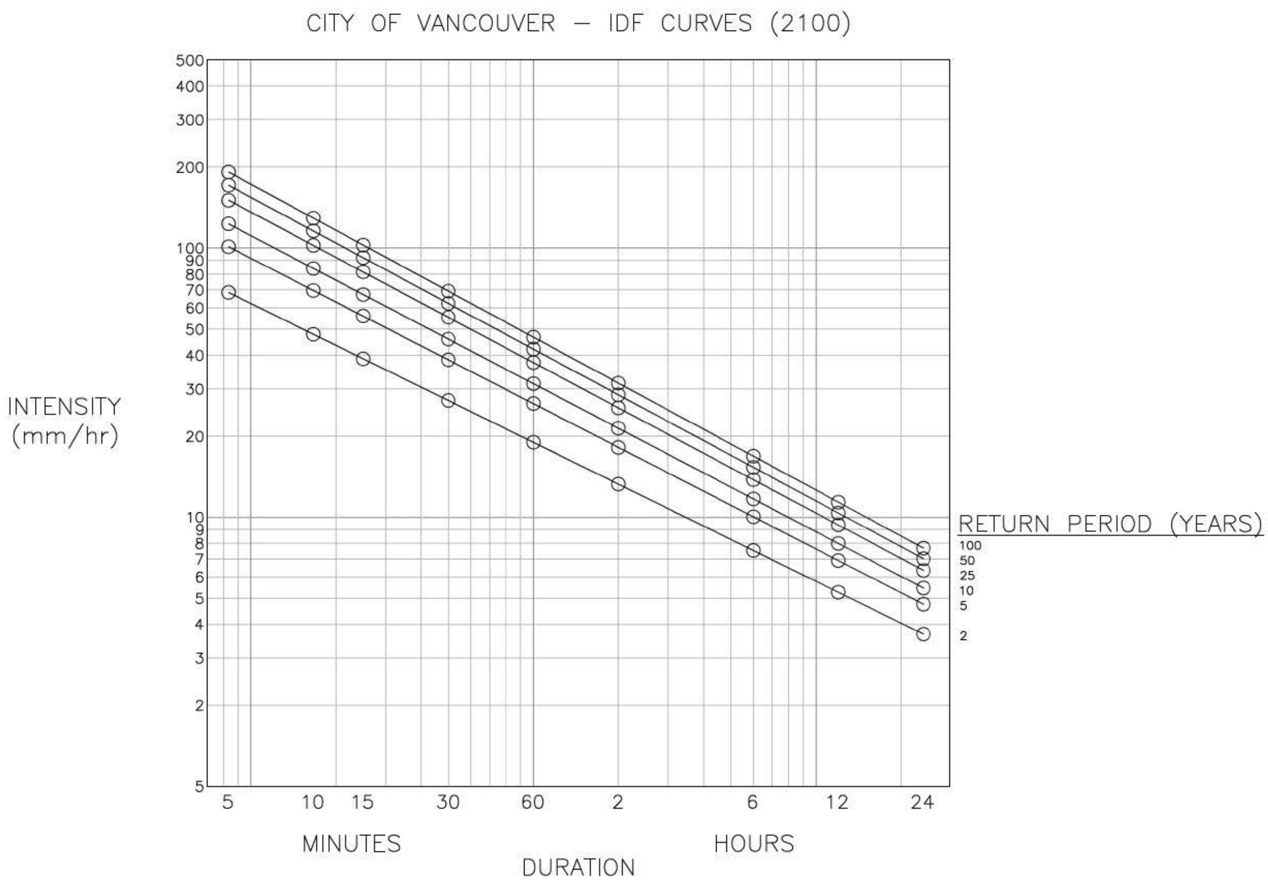


Figure 5-3: 2100 IDF Curve

Table 5-5: 2100 IDF Equation Coefficients

Recurrence Interval	Probability	A	B
1 in 2 year	50%	18.96	-0.516
1 in 5 year	20%	26.41	-0.540
1 in 10 year	10%	31.32	-0.550
1 in 25 year	4%	37.51	-0.559
1 in 50 year	2%	42.09	-0.564
1 in 100 year	1%	46.64	-0.568

5.2.2.3 TRIBUTARY DRAINAGE AREA

The designer must determine the tributary drainage area, A, based on the applicable existing and proposed contours. The cumulative tributary drainage areas must be considered for catchments with multiple subcatchments.

5.2.2.4 TIME OF CONCENTRATION

The time of concentration, t_c, is a sum of the inlet time and travel time in the pipe or channel to the point of interest as shown in the formula below:

$$t_c = t_i + t_t$$

Where:

t_c = Time of Concentration (min)

t_t = Travel Time in Pipe or Channel (min) = Length (m) / Velocity (m/min)

t_i = Inlet Time (min)

The inlet time for developed areas is based on ***Table 5-6***:

Table 5-6: Inlet Times

Return Period	Typical Inlet Time, t_i
5-year Storm	10 minutes
10-year Storm	5 minutes
25-year Storm	5 minutes

The inlet time for undeveloped areas is based on the Kerby Formula which is defined as:

$$T_i = 1.45\left[\frac{NL}{\sqrt{s}}\right]^{0.467}$$

Where:

T_i = Inlet Time (min)

L = Overland Flow Length to Furthest Point (m) (with L<370m)

s = Slope of Overland Flow Terrain (m/m)

N = Kerby Coefficient from ***Table 5-7***

Table 5-7: Kerby Coefficients

Surface Type	N
Smooth impervious surface	0.02
Smooth bare packed soil	0.10
Poor grass, cultivated row crops, or moderately rough bare surfaces	0.20
Pasture or average grass	0.40
Deciduous timberland	0.60
Coniferous timberland, deciduous timberland with deep frost, litter, or dense grass	0.80

5.2.2.5 CALCULATIONS SHEET

Rational Method calculations shall be presented on the form outlined in ***Figure 5-4***:

Project Name:	
Designed by:	
Calculation Date:	
Checked by:	
Company Name:	

IDF Used:	2100
Return Period (yr):	5
n	0.013
Inlet Time (min):	

No	Location			Pipe Specifications			Catchment Properties						Flows			Max Flows		Design Summary			
	Street Name	U/S MH	D/S MH	Length	Diameter, D	Slope, s	Contributing U/S Catchment Area Numbers	Area, A	Zone	C	Travel Time	Time of Concentration	Intensity	Inc. C*A	Total C*A	Q_{peak}	Q_{Full}	Runoff Capacity	Full Velocity		Peak Velocity
											$t_t=\frac{L}{V_{Peak}}\frac{1}{60}$	t_c=t_i for most U/S main or (t_t+t_c)* for other mains; * values from U/S mains	From IDF Curve, I= A*(t_c/60)^B		$\sum CxA$	$\frac{I X \sum CXA}{360}$	$Q_{Full}=\frac{1}{n}\frac{D}{4}^{2/3}\frac{s}{100}^{1/2}\frac{\mu D^2}{4}$	Q_{Peak}/Q_{Full}	$V_{Full}=\frac{Q_{Full}}{\frac{\mu D^2}{4}}$	X=V Peak/ V Full ; from Hydraulic-Elements Graph	V_{Peak} =X x V_{Full}
				m	m	%		ha			min	min	mm/hr	ha	ha	m³/s	m³/s	%	m/s	%	m/s

Figure 5-4: Rational Method Calculations Form

STORM DRAINAGE SYSTEM

5.2.3 HYDROGRAPH METHOD

The hydrograph method shall be used to determine the demands and flows for catchment areas larger than 20ha, or areas that involve complex hydraulics that are beyond the capacity of the rational method. The City may request the hydrograph method or modelling for areas where they are deemed necessary.

The model shall include all pipes within the catchment. The boundary of the catchment shall be defined by Metro Vancouver Trunk or downstream boundary conditions as agreed upon by the City Engineer. The number and size of subcatchments shall be determined by the complexity and scale of the project.

5.2.3.1 MODELLING SOFTWARE

Acceptable modelling software for the Hydrograph Method are to be approved by the City Engineer but may include PCSWMM or alternates.

5.2.3.2 DESIGN STORMS

The following table indicates the design storms to be used for the 2, 5, 10, 25 and 100-year storms in the City of Vancouver. The consultant / designer is to utilize the most conservative storm event for design purposes.

Table 5-8: Design Storm Distribution

AES 1 Hour			AES 2 Hour			AES 6 Hour			24-hour SCS Type 1A		
Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative
0:00	-	0.00	0:00	0.00	0.00	0:00	-	0.00	0:00	-	0.00
0:05	0.050	0.05	0:05	0.02	0.02	0:10	0.020	0.02	0:20	0.007	0.01
0:10	0.060	0.11	0:10	0.02	0.05	0:20	0.020	0.04	0:40	0.007	0.01
0:15	0.090	0.20	0:15	0.03	0.08	0:30	0.020	0.06	1:00	0.007	0.02
0:20	0.090	0.29	0:20	0.03	0.11	0:40	0.023	0.08	1:20	0.008	0.03
0:25	0.100	0.39	0:25	0.04	0.16	0:50	0.023	0.11	1:40	0.008	0.04
0:30	0.110	0.50	0:30	0.04	0.20	1:00	0.023	0.13	2:00	0.008	0.04
0:35	0.140	0.64	0:35	0.04	0.24	1:10	0.030	0.16	2:20	0.010	0.05
0:40	0.110	0.75	0:40	0.04	0.29	1:20	0.030	0.19	2:40	0.010	0.07
0:45	0.080	0.83	0:45	0.05	0.34	1:30	0.030	0.22	3:00	0.010	0.08
0:50	0.070	0.90	0:50	0.05	0.39	1:40	0.027	0.25	3:20	0.012	0.09
0:55	0.060	0.96	0:55	0.06	0.45	1:50	0.027	0.27	3:40	0.012	0.10
1:00	0.040	1.00	1:00	0.06	0.50	2:00	0.027	0.30	4:00	0.012	0.11
			1:05	0.07	0.57	2:10	0.027	0.33	4:20	0.015	0.12
			1:10	0.07	0.64	2:20	0.027	0.35	4:40	0.015	0.14
			1:15	0.06	0.70	2:30	0.027	0.38	5:00	0.015	0.15
			1:20	0.06	0.75	2:40	0.040	0.42	5:20	0.020	0.17
			1:25	0.04	0.79	2:50	0.040	0.46	5:40	0.020	0.19
			1:30	0.04	0.83	3:00	0.040	0.50	6:00	0.020	0.21

AES 1 Hour			AES 2 Hour			AES 6 Hour			24-hour SCS Type 1A		
Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative
			1:35	0.03	0.87	3:10	0.030	0.53	6:20	0.028	0.24
			1:40	0.03	0.90	3:20	0.030	0.56	6:40	0.028	0.27
			1:45	0.03	0.93	3:30	0.030	0.59	7:00	0.028	0.30
			1:50	0.03	0.96	3:40	0.030	0.62	7:20	0.035	0.33
			1:55	0.02	0.98	3:50	0.030	0.65	7:40	0.035	0.37
			2:00	0.02	1.00	4:00	0.030	0.68	8:00	0.035	0.40
						4:10	0.030	0.71	8:20	0.027	0.43
						4:20	0.030	0.74	8:40	0.027	0.46
						4:30	0.030	0.77	9:00	0.027	0.48
						4:40	0.027	0.80	9:20	0.022	0.51
						4:50	0.027	0.82	9:40	0.022	0.53
						5:00	0.027	0.85	10:00	0.022	0.55
						5:10	0.027	0.88	10:20	0.020	0.57
						5:20	0.027	0.90	10:40	0.020	0.59
						5:30	0.027	0.93	11:00	0.020	0.61
						5:40	0.023	0.95	11:20	0.017	0.63
						5:50	0.023	0.98	11:40	0.017	0.64
						6:00	0.023	1.00	12:00	0.017	0.66
									12:20	0.013	0.67
									12:40	0.013	0.69
									13:00	0.013	0.70
									13:20	0.015	0.71
									13:40	0.015	0.73
									14:00	0.015	0.74
									14:20	0.010	0.75
									14:40	0.010	0.76
									15:00	0.010	0.77
									15:20	0.013	0.79
									15:40	0.013	0.80
									16:00	0.013	0.81
									16:20	0.010	0.82
									16:40	0.010	0.84
									17:00	0.010	0.85
									17:20	0.008	0.85
									17:40	0.008	0.86
									18:00	0.008	0.87
									18:20	0.007	0.88
									18:40	0.007	0.88
									19:00	0.007	0.89
									19:20	0.008	0.90
									19:40	0.008	0.91
									20:00	0.008	0.91

AES 1 Hour			AES 2 Hour			AES 6 Hour			24-hour SCS Type 1A		
Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative	Time	Absolute	Cumulative
									20:20	0.007	0.92
									20:40	0.007	0.93
									21:00	0.007	0.93
									21:20	0.007	0.94
									21:40	0.007	0.95
									22:00	0.007	0.96
									22:20	0.008	0.96
									22:40	0.008	0.97
									23:00	0.008	0.98
									23:20	0.007	0.99
									23:40	0.007	0.99
									0:00	0.007	1.00

5.2.3.3 RESULTS

A design report must be prepared and submitted which outlines the following:

- Modelling software name and version.
- Inputs, parameters, and assumptions.
- Design storm data used.
- Hydrographs for pre- and post-development.
- Pipe profile indicating the hydraulic grade line (HGL).
- A plan which shows subcatchment boundaries, tributary area, land use, areas, slopes, contours, soil conditions, flow paths, and existing and proposed storm drainage facilities.

5.3 HYDRAULIC ANALYSIS

This section outlines the design process and factors determining storm drainage flow within the City. For the design of storm drainage components, the following equation must be satisfied:

$$Q_{des} \leq Q$$

Where:

Q_{des} = Design Flow (m^3/s)

Q = Flow Rate (m^3/s)

Refer to ***Figure 5-5*** for pipe flow properties.

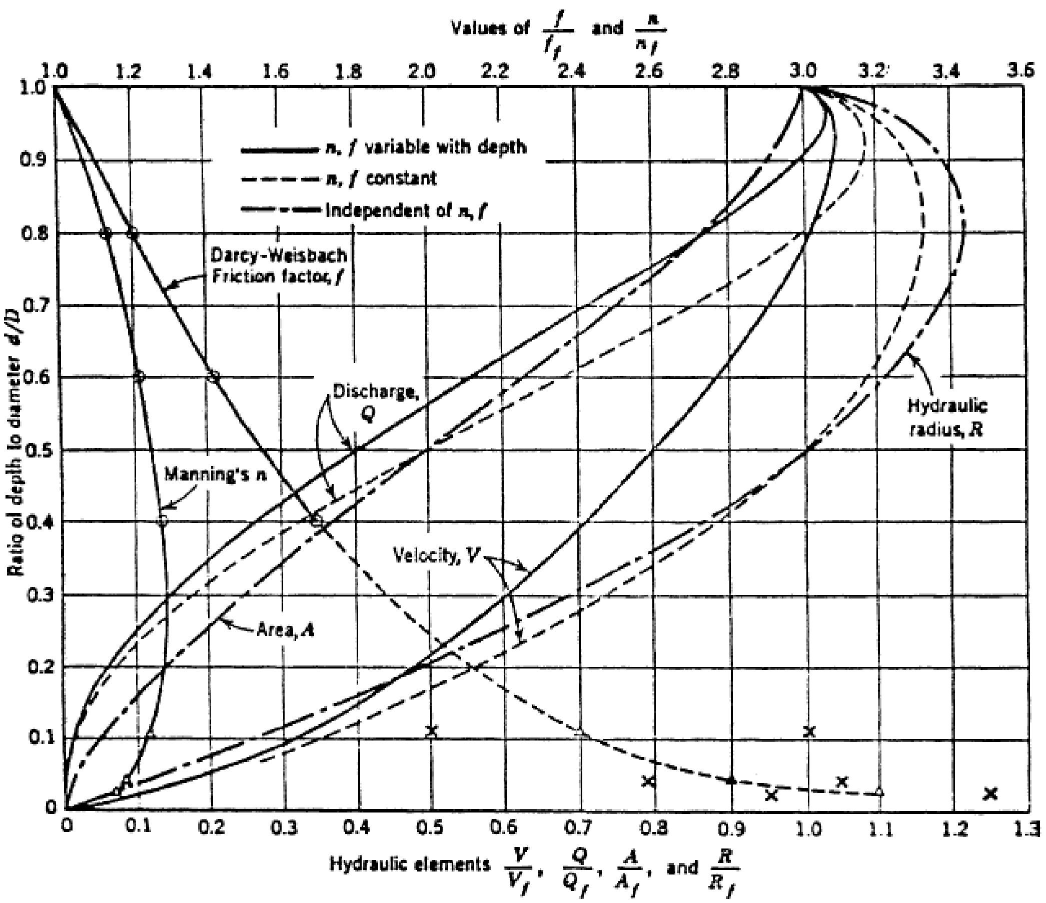


Figure 5-5: Hydraulic Elements Graph for Circular Sewers

From WPCF Manual of Practice No. 9 “Design and Construction of Sanitary and Storm Sewers” 1969 Ed.

5.3.1 MANNING’S FORMULA

Flow capacities of unpressurized gravity storm pipes, open channels, and road surfaces are calculated using Manning’s Formula which is defined as:

$$Q = \frac{1}{n} R^{2/3} s^{1/2} A$$

Where:

Q = Flow Rate (m^3/s)

n = Manning's Roughness Coefficient = 0.013 for all smooth pipes (ex. PVC, Concrete, Clay)

R = Hydraulic Radius (m) = Cross-Sectional Flow Area (m^2) / Wetted Perimeter (m)

s = Slope of Hydraulic Grade Line (m/m)

A = Cross-Sectional Flow Area (m^2)

5.3.2 SURCHARGED PIPES

Under some conditions, it may be advantageous or unavoidable to design sewers to operate under a head or as pressure conduit. In such cases, the Manning's Formula or Darcy-Weisbach Formula for design shall be used. The Darcy-Weisbach Formula is as follows:

$$h_f = \frac{fLV^2}{D2g}$$

Where:

h_f = Friction Head Loss (m)

D = Diameter of Pipe (m)

V = Velocity of Flow (m/s)

g = Acceleration due to Gravity (9.81 m/s^2)

f = Friction Factor

L = Length of Pipe (m)

The friction factor in terms of the Manning Roughness Coefficient shall be given as:

$$f = \frac{125n^2}{D^{0.33}}$$

Where:

f = Friction Factor

n = Manning's Roughness Coefficient

D = Diameter of Pipe (m)

The Hydrograph Method through modelling is an alternative option for designing surcharged sewers.

5.3.3 MAJOR SYSTEM

Provisions shall be made for surface overflow in the event rainfall occurs of greater intensity than the capacity of the minor system.

In every drainage area, surface water should be able to reach an outlet when storm sewers are overloaded without causing overland flooding of buildings. Ideally, and in most cases, particularly where the street pattern cuts across the direction of the natural drainage path, drainage easements must be obtained to a suitable outlet. Common major storm conveyance systems include swales, roadways, culverts and watercourses. Should the roadway be utilized the maximum flow depth shall not exceed the height of curb. A suitable alternative is to design the storm sewers and inlets to handle flows from a major storm.

5.3.4 HEAD LOSSES

Head loss when flow passes through a bend, junction or maintenance hole shall be accounted for in the design of the sewer system.

5.3.4.1 BENDS

The head loss through a bend for a pipe flowing under open channel flow conditions or under pressure shall be given as:

$$h_b = \frac{K_b V^2}{2g}$$

Where:

h_b = Head loss through the bend (m)

V = Velocity of Flow (m/s)

g = Acceleration due to Gravity (9.81 m/s^2)

K_b = See ***Table 5-9***

Table 5-9: Head Loss Coefficients

Bend Angle/Fitting Type	K_b
90˚ bend	1.0
45˚ bend	0.7
45° double-mitre bend	0.32
90° four-mitre bend	0.40
Other deflection angles	to be calculated by engineer

STORM DRAINAGE SYSTEM

5.3.4.1 JUNCTIONS

The head loss through a junction without a deflection shall be given as:

$$h_e = \frac{KV^2}{2g}$$

Where:

h_e = Head loss through the junction (m)

K = 0.1 for accelerating flow and 0.2 for decelerating flow

V = Velocity of Flow (m/s)

g = Acceleration due to Gravity (9.81 m/s^2)

When designing maintenance hole junctions each incoming pipe shall be analyzed separately together with the outgoing pipe. All maintenance hole inverts shall be designed so that all incoming energy grade lines including head losses are equal or greater in elevation to the outgoing energy grade line.

5.3.4.2 MAINTENANCE HOLES

Losses through surcharged maintenance holes shall be given as:

$$h_b = \frac{K_1 {V_1}^2}{2g} + \frac{K_2 {V_2}^2}{2g}$$

Where:

V_1 = Velocity of flow of Incoming Pipe (m/s)

V_2 = Velocity of flow of Outgoing Pipe (m/s)

K_1 = 0.014 for fully developed benching and 1.0 for benching up to spring line of pipe only

K_2 = 0.010 for fully developed benching and 1.0 for benching up to spring line of pipe only

5.4 DESIGN OF STORM DRAINAGE COMPONENTS

This section outlines the design requirements for pipes, maintenance holes, appurtenances, flood control structures, ditches, culverts, and watercourses in the storm drainage system within the City of Vancouver.

5.4.1 GENERAL CONSIDERATIONS

Storm sewers shall be designed with consideration of the requirements outlined in *Chapter 2: Design Process & Coordination* and *Chapter 8: Streets & Transportation*.

5.4.2 STORM SEWERS

5.4.2.1 SIZE AND MATERIAL

The pipe outlined in ***Table 5-10*** is permitted for gravity sewer mains:

Table 5-10: Gravity Main Size and Materials

Pipe	Size (mm)	Standard
PVC SDR35	200 – 375	*ASTM D3034 / D2412*
PVC C900 (for low-cover situations)	200 - 375	*AWWA C900*
HDPE (for trenchless installations)	200 – 375	*ASTM D3035 / D3350*
Vitrified Clay Extra Strength	200 - 375	*ASTM C700 / C425*
Non-Reinforced Concrete Cl. 3	200 - 750	*ASTM C14 / C443*
Reinforced Concrete Cl. III, IV, and V	300 - 3050	*ASTM C76 / C443*

No lateral sewer shall be less than 250mm in diameter unless in a residential area where it cannot be extended. In no case shall it be less than 200mm.

Downstream pipe size reduction may only be used in special circumstances with City Engineer approval. A downstream pipe must not be reduced in size unless:

- It has increased slope to provide sufficient capacity.
- It is greater than or equal to 525mm.
- It is not reduced by more than two pipe sizes.
- A detailed hydraulic analysis has been done.

The selection of materials shall consider local conditions such as soil characteristics, heavy external loadings, depth of cover, abrasions, and similar problems. Pipe material and class shall be selected by the engineer of record. Signed and sealed structural calculations for the material selection shall be provided to the City. Refer to the *City of Vancouver Construction Specifications* for further requirements.

5.4.2.2 ALIGNMENT

Whenever possible, sewers shall be located on the high side of the street where only the high side is served by the lateral and on the low side of the street where both sides are served by the lateral. Wherever possible, the sewer shall be at a constant offset from the property line.

The following must also be considered when selecting the sewer alignment:

- Minimize crossing conflicts.
- Meet clearance and separation requirements in *Section 2.2.5*.
- Minimize construction, public, and traffic impacts.
- Minimize construction costs.
- Maximize maintenance access.
- Consider long-term plans for separated sewer routing.
- Avoid trees and other surface features such as, but not limited to, traffic circles, bulges, landscaping, gate valves, gutters, catch basins, retaining walls, trees, concrete curbs, sidewalks, or ramps.

5.4.2.3 DEPTH

The minimum depth of cover is 1.0m. The storm sewer must also be sufficiently deep to:

- Service basements by gravity that were previously serviced by gravity (existing pumped connections are not required to be converted to gravity connections).
- Allow for tie-ins of other mains and services.
- Structurally withstand surface loading.
- Avoid conflicts with other utilities.
- Prevent freezing.
- Accommodate future sewer separations and consider long-term plans for separated sewer routing.

Generally, the maximum depth of cover is such that the trench depth will not exceed 6m; depths greater than this require trenches designed by a professional engineer.

5.4.2.4 VELOCITY AND SLOPE

Storm mains shall be designed with a pipe slope which provides the minimum velocity at maximum flows as follows:

- Preferred minimum velocity: 0.76m/s
- Absolute minimum velocity: 0.61m/s

The pipe slope shall not be less than 0.5%.

Provisions shall be made for energy dissipation, erosion, and movement when the velocity of the design flow exceeds 4.6m/s, or as specified by the pipe manufacturer. Provisions shall be made when discharging into an open ditch or watercourse (avoid discharging perpendicularly into open watercourses). In addition, appropriate bank protection measures must be in place if discharging into open watercourses.

When lateral forces are excessive to unseat pipe joints, anchors will be required (i.e. steep slopes).

5.4.2.5 CURVED SEWERS

Horizontal and vertical curves will be permitted under special circumstances. Vertical curves may be required where excessive rock cuts are to be avoided and where energy dissipation is required. The following criteria applies to curved sewers:

- The rate of curvature must be uniform throughout the curve.
- Only one curve (horizontal or vertical) is allowed between consecutive maintenance holes.
- Curves must be formed through joint deflection or bends and not by bending of the pipe.
- The joint deflection must not be greater than 50% of the recommended maximum by the pipe manufacturer.
- The radius must meet the minimum requirements in ***Table 5-11***.
- Horizontal curves require tracing wire above the alignment and are to terminate at upstream and downstream maintenance holes. Warning ribbon is to be placed 1m above the top of the curved sewer.

Table 5-11: Minimum Curved Sewer Radii

Pipe Type	Pipe Size (mm)	Laying Length (m)	Minimum Radius (m)	Max Deflection[(1)]
Vitrified Clay	200 – 300	1.5	40	2˚23’
	200 – 300	1.8	45	2˚23’
	375	0.9	30	1˚47’
Concrete Pipe	300	2.5	41	3˚31’
	375	2.5	50	2˚53’
	450	2.5	58	2˚27’
	525	2.5	67	2˚6’
	600	2.5	80	1˚47’
	675	2.5	89	1˚37’
	750	2.5	98	1˚28’
	900	2.5	116	1˚17’
	1050	2.5	113	1˚4’
PVC	200	-	61	Per manufacturer guidelines
	250	-	77	
	300	-	92	
	375	-	107	

Notes:
(1) In no case shall the deflection be greater than 50% of the manufacturer’s recommended maximum deflection

5.4.2.6 BACKFILL AND MATERIALS

All backfill and sewer-related materials such as concrete and bedding shall be in accordance with the *City of Vancouver Standard Detail Drawings* and the *City of Vancouver Construction Specifications*.

STORM DRAINAGE SYSTEM

5.4.2.7 STRUCTURAL DESIGN

The design engineer must ensure that the pipe is sufficiently designed to withstand loading that will be applied to it without deflection or damage as per manufacture specifications. The signed and sealed calculations shall be completed using the manufacturers recommendations and submitted to the City.

Concrete Pipe Strength Calculation

$D_{0.3}$ is to be used when calculating the design strength of concrete pipes, where $D_{0.3}$ is the minimum load required to produce a 0.3mm crack in a concrete pipe

$$\text{Minimum Load (N)} = \text{Strength Class } D_{0.3}\left(\frac{\frac{N}{n}}{\text{mm}}\right) \text{ x Length of Pipe (m) x Inside Diameter (mm)}$$

5.4.3 MAINTENANCE HOLES

5.4.3.1 LOCATIONS

Maintenance holes must be placed at the following locations:

- At terminal ends.
- At all grade changes.
- At all size changes.
- At all alignment changes.
- At all sewer intersections.
- At a spacing of not more than 183m pipe length.
- At the downstream end of a curved sewer.
- At service connections outlined in *Section 5.6*.

5.4.3.2 LOADING

The BC CL-625 vehicle shall be used for loading designs, recognizing that the BC design vehicle includes higher axle load ratings than the CAN/CSA design vehicle.

5.4.3.3 SIZE AND BENCHING

Maintenance holes require a minimum of one 300mm wide bench. ***Table 5-12*** shows minimum sizes of standard maintenance holes based on the largest pipe diameter entering the maintenance hole. The angles, elevation and the number of incoming pipes must also be considered to ensure safe entry and structural integrity of the maintenance hole.

Table 5-12: Minimum Maintenance Hole Sizes

Pipe Diameter (mm)	Minimum Maintenance Hole Barrel Diameter (mm)
200 - 450	1050

525 – 675	1200
750 - 1050	1350
1200	1500
1350 - 1500	1800
1650 - 2100	2400

Precast tee maintenance holes can be used for 1200mm and larger pipe; however, standard maintenance holes may be required in certain site conditions such as overbuild tie-ins to live flows if approved by the City Engineer. Precast tee maintenance hole barrels are to be 1050mm diameter.

It is generally preferred to use a larger concentric maintenance hole with two benches (one on either side) instead of a smaller offset maintenance hole with one bench; however, in certain site conditions, the one-bench arrangement may be beneficial over the two-bench arrangement.

5.4.3.4 INLET AND OUTLET ELEVATIONS

The drop from the inlet invert elevation to the outlet invert elevation in the maintenance hole must meet the requirements in ***Table 5-13***:

Table 5-13: Minimum Maintenance Hole Drops

Alignment Deflection	Minimum Drop (mm)
0˚	10
≤ 45˚	30
45˚ - 90˚	50

The crown of the inlet pipe is to be the same elevation or higher than the crown of the outlet pipe.

5.4.3.5 DROP STRUCTURES

Drop structures should be avoided by adjusting the grade of the sewer, but where this cannot be achieved, provide drop structures according to ***Table 5-14***:

Table 5-14: Maintenance Hole Drop Structures

Difference in Invert (m)	Drop Type
≤ 0.25	Accommodated in Benching
0.26 – 0.6	Outside Open Ramp
≥ 0.61	Outside Closed Ramp for 200mm to 375mm Pipe Outside Open Ramp for ≥450mm Pipe
≥ 0.9	Inside Drop (minimum 1200mm maintenance hole - upon special approval)

5.4.3.6 HYDRAULIC LOSSES

For junctions of large pipes greater than 600mm, surcharged maintenance holes, maintenance holes with significant changes in alignment or grade, and high velocity flows, hydraulic losses must be calculated.

When designing maintenance hole junctions, each inlet pipe shall be analyzed separately along with the outlet pipe. All maintenance hole inverts shall be designed so that all incoming energy grade lines including head losses are equal or greater in elevation to the outgoing energy grade line.

Refer to *Section 5.3.4* for hydraulic loss calculations.

5.4.3.7 MAINTENANCE HOLE COVERS

For safety reasons, all new maintenance hole covers in playgrounds, and schoolyards shall be buried 150mm below grade and secured using one of the following methods:

- Bolt-down cover and frame.
- Locking pin system.

5.4.4 DRAINAGE

All streets and their elements must have adequate drainage. Ponding within City of Vancouver streets is not acceptable. For specific street design criteria, refer to *Chapter 8: Streets & Transportation*.

5.4.4.1 CATCHBASIN TYPES AND LOCATIONS

City of Vancouver's standard catchbasins shall be used. When appropriate soils are present and approved by a qualified geotechnical engineer, percolating catchbasins may be used with approval of the City Engineer.

Catchbasins must be placed to collect the full minor flows as well as the major system flows if the major system is designed to be conveyed in the minor system piping. The following outlines the typical catchbasin requirements:

- Located to meet the catchment areas and spacing requirements in Table 5-15.
- Not located within painted crosswalks or curb ramps.
- Located at the beginning of the curb return or higher side of crosswalk.
- Prevent overflows to driveways, bicycle lanes, private properties, boulevards, and sidewalks.
- All catchbasins located at low points should provide a double catchbasin with leafcatcher (side inlet) if adjacent to treed boulevard (provide alternative overland route, system, or capacity to handle major storm where possible).
- Double catchbasins are to be installed and designed as per *City of Vancouver Standard Detail Drawing S11.1*, two catchbasins with separate sumps. Note that only one sump, on the lower side, is to have a side inlet to maintain the integrity of the curb.

Table 5-15: Catchbasin Catchment Areas and Spacing

Type	Catchment Area / Spacing		
	Minimum	Preferred	Maximum
Typical Catchbasin Catchment Area			
New / Reconstructed Roads up to 4% Grade	$350m^2$	$500m^2$	$600m^2$
New / Reconstructed Roads over 4% Grade	$250m^2$	$400m^2$	$500m^2$
Rehabilitation Projects(1)	$250m^2$	$500m^2$	$750m^2$
Typical Catchbasin Spacing			
All roads	60m	-	150m

Notes:
1) Match or reduce the catchment area from existing for rehabilitation projects when possible.
2) Catchbasin catchment area governs in the event the maximum catchment area produces a spacing requirement below minimum spacing.

For all projects, detailed analysis is required and shall be compared to the areas and spacing requirements outlined in Table 5-15. Catchbasin capacities are calculated using the orifice equation which is given by:

$$Q_{cap} = kCA\sqrt{2gh}$$

Where:

Q_{cap} = Inlet Flow Capacity (m^3/s)

k = Clogging Factor = 0.6

C = Orifice Coefficient = 0.8

A = Open Area (m^2) = $0.080m^2$ for City of Vancouver Grate No. 31

g = Acceleration due to Gravity (m/s^2)

h = Depth of Ponding (m)

Catchbasins shall be in accordance with the *City of Vancouver Standard Detail Drawings* and the *City of Vancouver Construction Specifications*.

5.4.4.2 LAWNBASINS

Lawn basins may be required within boulevards and landscaped areas to prevent flooding or ponding.

Lawnbasins shall be in accordance with the *City of Vancouver Standard Detail Drawings* and *City of Vancouver Construction Specifications*.

5.4.4.3 LEADS

New single catchbasin and lawnbasin leads shall have a minimum diameter of 150mm. Double catchbasin and lawnbasin leads shall have a minimum diameter of 200mm.

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

Leads are typically installed at a depth of 1.5m.

Leads shall be connected to the main in the same manner as service connections. Double catchbasins shall not be connected directly together but rather one basin will be wyed into the lead of the other.

No catchbasin lead shall exceed 30m in length as measured horizontally between the main sewers and the catchbasin unless maintenance holes are provided.

5.4.4.4 FRAMES AND GRATES

Gutter inlet grates are typically used for catchbasins; however, curb inlet types may be acceptable upon approval by the City Engineer. All catchbasin grates shall be designed to accommodate loading from all design vehicles.

All frames, grates, and appurtenances shall be in accordance with the *City of Vancouver Construction Specifications* and the *City of Vancouver Standard Detail Drawings*.

Catchbasin grates are to be set flush to the adjacent asphalt and gutterline.

5.4.5 FITTINGS, COUPLINGS, AND CASTINGS

All fittings, couplings, castings, and appurtenances shall be in accordance with the *City of Vancouver Construction Specifications*.

5.4.6 SUBSURFACE DRAINS

Subsurface drains may be used where appropriate soils allow and where approved by a qualified geotechnical engineer. Designs shall be done on a case-by-case basis and shall have no negative impact on the road structure. Subsurface drains must be able to overflow to the storm drainage system.

5.4.7 TRENCHLESS TECHNOLOGIES

The use of trenchless technologies in the City of Vancouver as a means of installing or rehabilitating underground sewer infrastructure must be approved by the *Sewers and Drainage Design Branch* prior to construction. The design engineer and contractor must be experienced in the proposed trenchless method.

5.4.8 DRAINAGE PUMP STATIONS AND FORCE MAINS

Pump stations and force mains must be designed in accordance with the City of Vancouver's latest pump station and force main requirements. Drainage pump stations and force mains are to be required and designed on a case-by-case basis depending on project conditions. Contact the City for additional information.

5.4.9 FLOOD CONTROL SYSTEMS

5.4.9.1 FLOOD MANAGEMENT INFRASTRUCTURE

Any work relating to flood management infrastructure in the City of Vancouver must refer to the *British Columbia Drainage, Ditch and Dike Act*, the *British Columbia Dike Maintenance Act*, the *British Columbia Dike Design and Construction Guide Best Management Practice for British Columbia*, and any other relevant provincial and federal regulations and standards.

5.4.9.2 TIDE GATES

To control the water levels of the inland side of dikes affected by tides, tide gates may be required. Tide gates shall be designed on a case-by-case basis in coordination with the City of Vancouver. Debris protection should be included in the design to prevent improper operation.

5.4.10 CULVERTS

Culverts must be designed to convey the major system flows (except if it is used as part of the minor system). The inlet and outlet capacity shall be considered when designing the culvert. Culverts must meet provincial and federal environmental requirements such as the *British Columbia Water Act* and the *Canada Fisheries Act*.

5.4.10.1 INLETS AND OUTLETS

All major system culverts require inlet and outlet structures. Inlet and outlet control conditions, erosion control, and energy dissipation must be considered when designing culvert inlets and outlets.

Inlets and outlets must be designed to prevent people from entering the system but allow maintenance and cleaning. Safety grates must be designed to break off in the event of heavy hydraulic loads caused by a blockage. Inlets and outlets shall be designed with aesthetics and safety in mind. Handrails are required where a fall hazard is present.

5.4.11 DITCHES AND SURFACE FLOWS

Manning's formula (*Section 5.3.1*) is used to determine the flow capacity of ditches and roadway surfaces for the major system. Select values for Manning's n values are shown in ***Table 5-16***. The design must consider flow velocities and the need for erosion control measures.

Table 5-16: Manning's Roughness Coefficients

Flow Medium	Manning's Roughness Coefficient (n)
Paved Roadways	0.018
Grassed Boulevards and Swales	0.030
Irregular or Treed Channels	0.040 to 0.100

5.4.12 WATERCOURSES

A watercourse is defined as either:

- A flowing stream with a definite channel, a distinct bed, and distinct banks or edges formed by the water cutting the soil.
- A definite channel provided by natural gullies, ravines, or depressions which when the water is not flowing, there is no distinct bed or any cutting of the soil marking the banks or edges of the channel.

No watercourse shall be diverted, blocked, or abandoned without approval of the City Engineer. The City Engineer may provide approval for:

- Widening, deepening, straightening, diverting, or otherwise improving natural and other watercourses and protecting the same encroachment and injury.
- Determining the position of such watercourses, whether upon City property or upon privately owned property, and for incorporating them into the City's drainage system.

When the City Engineer provides approval, any watercourse may be incorporated into the City's drainage system. However, care must be taken to ensure that the watercourse is improved to the point where it can adequately handle the volume of water diverted into it.

Watercourses must be designed in accordance with the *City of Vancouver Sewer and Watercourse By-law No. 8093*.

5.5 SEISMIC DESIGN CRITERIA

The choice of replacement strategy and pipe material is based on a risk assessment driven by the criticality of the pipeline, the susceptibility of the contextual ground conditions for wave propagation, and potential for Permanent Ground Deformation. A professional geotechnical engineer shall be retained to perform investigation, review and design for areas with seismic concern or weak ground condition. The City reserves the rights to request for a professional geotechnical engineer to review and design for a project, if the project site is deemed to be high risk for seismic activities and has known poor ground conditions.

Awareness and avoidance of these adverse conditions is the best approach to protect the system from risk associated with ground deformation. Strategies include:

- Limiting the number of non-restrained mains in a neighborhood susceptible to ground acceleration.
- Adding weight to maintenance holes to reduce buoyancy.
- Locating mains to occur outside of liquefaction zones.

5.6 SERVICE CONNECTIONS

Services must meet the most current edition of the *City of Vancouver Sewer and Watercourse By-law No. 8093*, the *City of Vancouver Construction Specifications*, and the *City of Vancouver Standard Detail Drawings*.

5.6.1 LOCATION

Unless specifically exempted, all developed sites shall be provided with a connection. The storm service shall be to the right of the sanitary service when looking at the property from the street.

Service connections shall not exceed 30m in length as measured horizontally between the lateral sewer and the property line. If the service must be longer than 30m, a maintenance hole must be placed such that the longest section of service does not exceed 30m.

5.6.2 SIZE AND MATERIAL

Storm services shall be sized based on a 10-year design storm with a 5-minute inlet time and a runoff coefficient of 1.0 for the site area. No gravity storm service connection shall be less than 150mm in diameter.

The pipe outlined in ***Table 5-17*** is permitted for service connections:

Table 5-17: Service Size and Materials

Pipe	Size (mm)	Standard
PVC SDR28	150 - 150	*ASTM B182.1 / D2412*
PVC SDR35	200 – 375	*ASTM D3034 / D2412*
PVC Cl.50 DR18 (Forcemains)	150 – 300	*AWWA C900 / M23*
Concrete Cl IV RC	450+	*ASTM C76*

5.6.3 DEPTH

The preferred connection depth to invert at the property line shall be 1.5m below the centerline of the street or lane. Exceptions are occasionally approved with the following conditions:

- The new connection by itself shall not preclude raising of the main sewer in the future.
- The new connection depth shall not significantly increase the potential for flooding the new building.
- Where the property has not already been provided with a connection at the City's expense.

In no case shall the connection have less than 1.0m cover or greater than 2.4m depth at the property line.

5.6.4 VELOCITY AND SLOPE

Service connections shall be designed with a slope which provides the minimum velocity at maximum flows as follows:

- Preferred minimum velocity: 0.92m/s
- Absolute minimum velocity: 0.76m/s

The service slope shall not be less than 2%. Service slopes less than 2%to be approved by the City Engineer.

5.6.5 TIE-IN-REQUIREMENTS

See *City of Vancouver Standard Detail Drawings S7.1* and *S7.2* for tie-in requirements for service connections to the main.

5.6.6 INSPECTION CHAMBERS

Inspection chambers are required on all new services. The lid for the storm inspection chamber is to be green.

5.6.7 MINIMUM BUILDING ELEVATION (MBE)

The Minimum Building Elevation (MBE) is to be 0.6m plus the higher of:

- The 100-year design storm hydraulic grade line of the main at the connection.
- The invert of the service connection at the building location.

The designer must also check that the onsite connection elevations can meet the building code requirements.

5.6.8 GRAVITY CONNECTION RESTRICTIONS

During the design of a drainage facility, if existing dwellings are found to be below the hydraulic grade of a 5-year (residential) or 10-year (commercial and industrial) flow, any new or existing storm sewer connection shall be installed only as a pumped connection, with a sump pump installed on the private system with no direct connection to any areas below the surcharge level. Only that portion of the development which is below the surcharge level should be pumped. All other areas should flow to the connection by gravity.

5.7 GREEN INFRASTRUCTURE AND INTEGRATED RAINWATER MANAGEMENT

The City's Integrated Rainwater Management Plan (IRMP) sets design targets for green infrastructure in the areas of Vancouver where stormwater is piped directly to either combined sewer or ocean outfalls. Outside of the IRMP study area, two watersheds in Vancouver have remaining surface streams: Still Creek and Musqueam Creek. The Still Creek Watershed Management Plan has goals, but does not set design targets, and the Musqueam Creek Watershed Management Plan has not been completed. In the absence of targets for those watersheds, the Citywide IRMP targets will apply.

For information supplementing this section, refer to the following documents related to the City's Integrated Rainwater Management and Green Infrastructure Plan:

- *City of Vancouver Integrated Rainwater Management Plan Volume I, Vision, Principles and Actions*
- *City of Vancouver Integrated Rainwater Management Plan Volume II, Best Management Practices Toolkit*
- *Metro Vancouver Stormwater Source Control Guidelines* – Available for download from the Metro Vancouver website

5.7.1 INTEGRATED RAINWATER MANAGEMENT TARGETS

Green infrastructure is designed to manage small and frequent storms while allowing larger and extreme storms to safely bypass or be conveyed through the practice. Average annual rainfall varies across the City from 1200mm near the southwest edge of the City near the Fraser River to 1500mm near the Burrard Inlet shoreline. For citywide targets, the larger rainfall amount, 1500mm, was used for calculating volume reduction and water quality targets in ***Table 5-18***.

Table 5-18: Green Infrastructure Design Targets

Objective	Target	Standard
Volume Reduction	Retain the first 24mm of rainfall (50% of the 6 month – 24-hour return period storm, 70% of the average annual rainfall volume)	Infiltrate, evapotranspire, and reuse rainwater to the greatest extent practicable.
Water Quality	Treat the first 48mm of rainfall (6 month – 24-hour return period storm, 90% of the average annual rainfall volume)	Remove 80% of Total Suspended Solids for particles > 50microns(1); the total concentration of sediment can be no more than 75mg/L(2)

Notes:
(1) Criteria comes from the Dept. of Fisheries and Oceans Land Development Guidelines
(2) Criteria comes from the City of Vancouver Sewer & Watercourse Stormwater Discharge

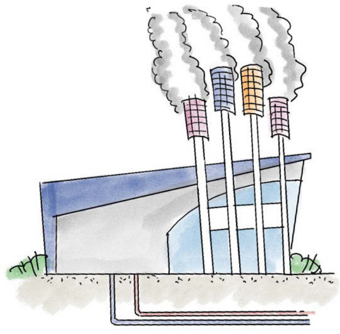
5.7.2 DESIGN GUIDANCE FOR INDIVIDUAL PRACTICES

The *Metro Vancouver Stormwater Source Control Guidelines* provides comprehensive guidance on how to design individual green infrastructure practices. The Guide provides descriptions, applications, design considerations, and sizing for these green infrastructure categories:

- **Absorbent Landscapes** – includes either natural or manmade landscapes that act like a sponge to soak up and slowly release rainfall.
- **Infiltration Swale System -** also known as bioswales or dry swales, includes design guidance for full infiltration, partial infiltration, and lined systems.
- **Infiltration Rain Garden** – also known as bioretention, includes design guidance for full infiltration, partial infiltration, and lined systems.
- **Pervious Paving** – includes porous asphalt, pervious concrete, permeable concrete unit pavers, and grid pavers that may be filled with gravel or vegetation.
- **Green Roofs** – includes thin lightweight ‘extensive’ green roofs and deeper soil publicly accessible ‘intensive roofs’.
- **Infiltration Trench** and **Soakaway Manholes** – subsurface infiltration practices can take many forms from linear gravel filled trenches to dry wells to chambers.

6

NEIGHBOURHOOD ENERGY



NEIGHBOURHOOD ENERGY

6.1 INTRODUCTION

A key strategy to meeting the Greenest City Action Plan and Renewable City Strategy goals is to develop neighbourhood renewable energy systems throughout Vancouver. Neighbourhood renewable energy systems supply centralized heating, hot water, and sometimes cooling for multiple buildings. These systems use low-carbon renewable energy sources, such as sewage waste heat, to reduce the use of fossil fuels. They also eliminate the need for boilers in individual buildings, and provide environmentally-friendly, affordable heat and hot water.

Vancouver currently owns the Southeast False Creek Neighbourhood Energy Utility system which serves the Olympic Village and Southeast False Creek. The design criteria in this manual are specific to the City-Owned South East False Creek Neighbourhood Energy Utility. For work on other Neighbourhood Energy systems check with the utility provider.

The following is a brief description of each section:

- The *Design of Neighbourhood Energy Utilities Components* section outlines general design parameters such as code compliance and design conditions for the components of Vancouver's neighbourhood renewable energy system.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

6.2 DESIGN OF NEIGHBOURHOOD ENERGY UTILITIES COMPONENTS

This section outlines the design requirements for the components that make up the neighbourhood energy utilities system within the City of Vancouver.

6.2.1 GENERAL CONSIDERATIONS

Neighbourhood energy utilities shall be designed with consideration of the requirements outlined in *Chapter 2: Design Process & Coordination*.

6.2.1.1 PROCESS FLUID

All process fluids must be 100% water unless approved otherwise by the City Engineer.

6.2.1.2 CODE COMPLIANCE

All designs must be in accordance with *CAN/CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code*, *ASME B31.1 Power Piping*, and the requirements of the British Columbia Safety Authority.

6.2.1.3 DESIGN CONDITIONS

Table 6-1 outlines the typical design conditions:

Table 6-1: Design Conditions

Property	Specification
Design Pressure Rating	1100kPa (160psi)
Design Temperature Rating	120˚C (115˚C for Kelit PEXR)
Design Pressure Loss in Piping	200-250Pa/m
Design Supply Temperature	95˚C (Winter), 65˚C (Summer)
Maximum Design Return Temperature	55˚C (Winter), 50˚C (Summer)

Notes:
1) Any deviance from these conditions must be approved by the City Engineer.

6.2.2 DISTRIBUTION SYSTEM

Neighbourhood energy systems require a distribution network to deliver heating and to receive waste products. This section outlines the distribution network criteria.

6.2.2.1 PIPING

The following list are approved products for the distribution piping system:

- Logstor Series 1 Piping.
- Kelit PEXR piping.

6.2.3 ENERGY TRANSFER STATIONS

Neighbourhood energy systems are designed around a central heat exchanging system located in an energy transfer station. This section outlines the criteria for energy transfer stations.

6.2.3.1 PIPING

Energy transfer station hot water piping must be standard schedule carbon steel process piping.

The piping must have a minimum 50mm thickness insulation with preformed PVC jacketing. Flanged piping and equipment such as heat exchangers, flow meters, strainers, valves, and unions must be insulated using insulation blankets.

6.2.3.2 HEAT EXCHANGERS

The maximum pressure drop on the cold and hot sides of the heat exchanger is 35kPa (5psi). ***Table 6-2*** outlines the heat exchanger design temperatures:

Table 6-2: Heat Exchanger Temperatures

Type	Primary Inlet	Primary Outlet	Secondary Inlet	Secondary Outlet
Parallel				
Space Heating - Winter	85˚C	55˚C	50˚C	70˚C
Domestic Hot Water – Winter	85˚C	55˚C	4.5˚C	60˚C
Domestic Hot Water – Summer	65˚C	35˚C	18˚C	60˚C
Cascading				
Space Heating - Winter	85˚C	65˚C	50˚C	70˚C
Domestic Hot Water – Winter	65˚C	35˚C	4.5˚C	60˚C
Domestic Hot Water – Summer	65˚C	35˚C	18˚C	60˚C

When the peak domestic hot water load is greater than 50% of the peak space heating load, a cascading arrangement should be considered for the energy transfer station. Selection of a parallel or cascading energy transfer station arrangement is determined on a case-by-case basis in agreement with the City Engineer.

6.2.3.3 CONTROL VALVES

In a parallel arrangement, there will be two control valves in parallel after each heat exchanger, with flow split approximately 70/30.

In a cascading arrangement, there will be two control valves in parallel after the space heating heat exchanger and two control valves in parallel on the line bypassing the space heating heat exchanger, with a flow split of approximately 70/30.

6.2.3.4 INSTRUMENTATION & CONTROLS

The energy transfer station shall have a standalone control system designed with the minimum capability of being able to extract data from local control points. The contractor shall allow for communication with the plant.

- Flow meters will be magnetic style flow meters (unless ultrasonic approved by City).
- Pressure sensors will be transducers installed in threadolet fittings.
- Temperature sensors will be resistance temperature detectors installed in thermowell fittings.
- Valve actuators will have valve position sensors where required.

6.2.3.5 ELECTRICAL

A dedicated 15A, 110V electrical connection shall be provided to the energy transfer station room.

6.2.3.6 CIVIL

The designer will also provide a design for the heat exchanger pad if required.

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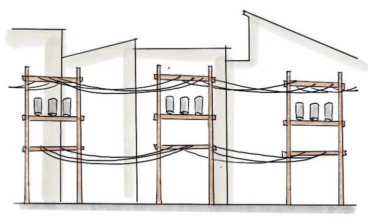
7

THIRD PARTY UTILITIES



THIRD-PARTY UTILITIES

7.1 INTRODUCTION

This chapter describes the utility design requirements for the installation of underground and overhead Third-Party Utilities within the City street right-of-way. The City maintains its design requirements to safeguard the public, protect City staff and contractors, and preserve the integrity of all buried utilities within its streets.

The following is a brief description of each section:

- The *Approval Stamping Procedure* section discusses the approval procedures and coordination between the consultant, Third-Party Utility companies, and the City of Vancouver.
- The *Utilities Design* section outlines the specifics for Third-Party Utility design such as depth of cover, alignment, and clearances.
- The *Construction Requirements* section directs to the City's Construction Specifications that outline the requirements for construction of Third-Party Utilities.
- The *Supplementary Information* section provides additional general information that must be considered during Third-Party Utilities design and construction such as special pavements, abandoning utilities, and encroachments.
- The *Utility Permit Drawing Submissions* section outlines the requirements for utility permit drawings such as title blocks, dimensions and record drawings.
- The *External Utility Submission Standards* section provides information relating to utility submissions such as coordinate systems, survey monuments and security.

Refer to *Chapter 2: Design Process & Coordination* for test hole submission requirements.

7.2 APPROVAL STAMPING PROCEDURE

The objective of the *Utilities Management Branch* is to provide for the efficient review of permit applications submitted by utility companies within the City of Vancouver. This section outlines the mechanisms that the *Utilities Management Branch* utilizes to ensure proper utility approval.

7.2.1 UTILITY STAMPS

Following approval of a utility design, the stamps in ***Figure 7-1*** may be added to the approved drawings to ensure that adequate coordination is completed in advance of construction.

CITY OF VANCOUVER

RECORDS INDICATE THE CITY OF VANCOUVER DUCT IN THE VICINITY OF YOUR CONSTRUCTION MAY CONTAIN ASBESTOS. IF YOUR WORK DOES NOT DISTURB THE DUCT YOU MAY CONTINUE WORKING. IF YOU WORK MUST DISTURB THE DUCT THEN STOP WORK AND CONTACT THE CITY OF VANCOUVER ELECTRICAL DISPATCH AT 604.871.6200

CITY OF VANCOUVER

ATTENTION

THE CITY OF VANCOUVER ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OR COMPLETENESS OF THE FIELD INFORMATION SHOWN ON THIS PLAN. ALL WORK CARRIED OUT IS DONE WHOLLY AT THE RISK OF THE PARTY UNDERTAKING THE WORK WHO AGREES, AS A CONDITION OF SUCH UNDERTAKING, TO RELEASE THE CITY OF VANCOUVER FROM ALL LIABILITY. LOCATION OF UNDERGROUND UTILITIES SHOULD BE CONFIRMED BY MANUAL DIGGING.

CITY OF VANCOUVER

APPROVAL OF THIS UTILITY DRAWING IS RESTRICTED TO THE ALIGNMENT OF THE FACILITY ONLY AND DOES NOT INCLUDE THE LOCATION OF THE SERVICE POINT TO THE SITE. THE PROPERTY OWNER IS RESPONSIBLE FOR DETERMINING THE ACTUAL SERVICE POINT AND ENSURING APPROPRIATE CLEARANCES BETWEEN ALL UNDERGROUND UTILITY SERVICES ARE MAINTAINED TO THE SATISFACTION OF THE RESPECTIVE UTILITY PROVIDER, INCLUDING CITY OF VANCOUVER UTILITY FACILITIES.

CITY OF VANCOUVER

NOTE:

UTILITY OWNER IS REQUIRED TO PROVIDE A NOTIFICATION LETTER TO ALL PROPERTY OWNERS WITHIN THE BLOCK OF WHERE CONSTRUCTION ACTIVITIES ARE TAKING PLACE. NOTIFICATIONS MUST BE PROVIDED A MINIMUM OF TWO WEEKS PRIOR TO THE START OF WORK.

CITY OF VANCOUVER

TRAFFIC PLAN REQUIRED 10 DAYS PRIOR TO COMMENCING WORK. FAX TRAFFIC PLAN TO UTILITIES MANAGEMENT BRANCH @ 604.873.7255

CITY OF VANCOUVER

ATTENTION

VANCOUVER PARKS BOARD @ 604.257.8605 MUST BE CONTACTED 5 WORKING DAYS BEFORE START OF CONSTRUCTION. THE UTILITY COMPANY MUST CONTACT AND ADHERE TO THE CONSTRUCTION REQUIREMENTS AS SET BY THE PARKS BOARD. A COPY OF THE CONFIRMATION MUST BE PROVIDED TO THE UTILITIES MANAGEMENT BRANCH PRIOR TO CONSTRUCTION.

Figure 7-1: Utility Stamps

THIRD-PARTY UTILITIES

7.3 UTILITIES DESIGN

With limited space available, Third-Party Utility locations must be carefully planned and installed. This section outlines the design requirements for pipes, underground conduit, concrete encasement, maintenance holes, surface structures, poles and overhead wires for Third-Party Utilities within the City of Vancouver.

7.3.1 DEPTH OF COVER

The minimum depth of cover for underground utilities within City streets varies depending on utility, plant type and location. The depth of cover for any utility is measured from the street surface to the top of the duct, if direct buried, or top of the concrete if the equipment is concrete encased. If the street elevation is subsequently altered, the utility may require modification to meet the minimum depth of cover requirements. When attempting to locate existing underground utility plant, it must not be assumed that all utilities are at standard depth. ***Table 7-1*** summarizes the minimum depth of cover, as it relates to the utility and plant type.

7.3.1.1 MINIMUM DEPTH OF COVER REQUIREMENTS

Table 7-1 provides the minimum depth of cover requirements:

Table 7-1: Minimum Depths of Cover

Third Party Utility	Type of Plant / Equipment	Placement Requirements	Minimum Depth (mm)
Gas (FortisBC)	Services	Under travelled portion of road, including shoulders within right-of-way	610
		Elsewhere	460
	Mains (150mm diameter)	At crown of road	760
		At low point of road	610
	Mains (200mm diameter)	At crown of road	910
		At low point of road	610
	Mains (250mm diameter and greater)	Profile required	1070
Hydro (BC Hydro)	Laterals (connections)	Site specific	910
	Main Ducts	Profile required	1070
	Maintenance Hole Roofs	Site specific	460
Telephone, Cable and Communications	Laterals (connections)	Site specific	910
	Main Ducts	Profile required	1070
	Maintenance Hole Roofs	Site specific	460
Coast Mountain Bus Company	DC Feeders	Profile required	1070
Neighbourhood Energy Systems (e.g. steam heat and hot water)	Main Pipes (including casing)	Profile required	1070
	Service Pipes	Site specific	910
	Vents and Trap Lines	Site specific	460
Greater Vancouver Water District (Water)	Mains	Profile required	1070
Greater Vancouver Sewerage and Drainage District (Sewer)	Mains	Profile required	1500

7.3.2 ALIGNMENT

With the growth in demand for underground space, utility corridors are becoming a scarce and limited resource. In preserving the City street for present and future use, the *Utilities Management Branch* coordinates its efforts to minimize the amount, while maximizing the efficient use, of underground space occupied by each utility.

To ensure a utility obtains the City's approval, all new utility installations should strive to minimize the amount of plant on and within City streets. Alignments selected for proposed utility installations must adhere to the following conditions:

- Alignments of any new plant should coincide with that of existing plant.
- When installing underground service to the same customer, those services running in parallel alignments are required to share a common trench. Joint trench details must be clearly illustrated on utility company drawings.
- When abandoning plant, the alignment should replace or be placed immediately adjacent to the existing plant.
- Alignments must be parallel or perpendicular to street property lines.
- A continuous alignment for the length of the installation is preferred.
- All horizontal bends must be 90˚ and have a 0.91m radius.
- New and existing plant will occupy one utility corridor per street / lane way.
- Any exceptions require approval from the *Utilities Management Branch*.

Service connection installations to individual properties must maintain a minimum horizontal separation of 0.9m, edge to edge from other utility equipment. The exception to the aforementioned requirement is sewer mains, where there is a minimum horizontal separation of 1.5m, edge to edge. These clearances ensure all health and safety standards are met, as well as affording safe work zones to install and maintain services.

The *Utilities Management Branch* recognizes that existing plant located within the City streets may present obstacles in satisfying the conditions in this section. If a utility company has any concerns selecting an alignment, the *Utilities Management Branch* is available to assist in determining a suitable alignment.

7.3.3 UTILITY CLEARANCES

The City's utility clearance requirements have been developed over many years of field experience and by the application of a pragmatic approach that aims to balance all competing interests. Standard utility clearances between existing underground utilities have been established to minimize conflict and ensure a safe work zone exists around each utility's equipment. When construction activities require a utility to be temporarily or permanently relocated, arrangements that are equitable to all parties affected will be made via the *Utilities Management Branch*.

7.3.3.1 VERTICAL UTILITY CLEARANCE

The minimum vertical clearance when crossing a utility is 0.3m. All vertical clearances are measured from the closest outside edge to closest outside edge of the utility plant. Any exceptions to this clearance will require approval from the affected utility or utilities, as well as the *Utilities Management Branch*.

7.3.3.2 HORIZONTAL UTILITY CLEARANCE

All horizontal clearances are measured from the closest outside edge to closest outside edge of the utility plant. The minimum horizontal clearance between all utilities except sewer, water and energy utilities is 0.3m. Water and energy utilities require 1.0m minimum horizontal separation to maintain sufficient bedding around the pipes. Sewer mains require 1.5m horizontal separation. See below for further information. Any exceptions to this clearance will require approval / agreement from the affected utility or utilities, as well as the *Utilities Management Branch*.

Sewer main construction often requires deep excavations with wider trenches to allow for extra shoring and safe working room. With the added concern of shallower utilities collapsing into deeper sewer trenches, the City places restrictive requirements on utilities, requiring a minimum horizontal clearance of 1.5m from all sewer mains. In addition, the City reserves the right to require additional clearance under special circumstances (e.g. future sewer separation work).

For additional utility clearance and separation requirements, please refer to *Section 2.2.5*.

7.3.4 CONCRETE ENCASEMENT

Encasement in concrete is required for the following utilities:

- BC Hydro.
- Coast Mountain Bus Company.
- Private utility encroachments may require concrete encasements.

The City requires that all concrete encased ducts shall:

- Be able to support their weight over a perpendicularly positioned utility trench.
- Have a minimum 75mm width around the conduit.
- Have both vertical sides of the concrete encased ductbank formed.
- Meet minimum requirements as set by *CAN/CSA A23.1 Concrete Materials and Methods of Concrete Construction* and *CAN/CSA A23.2 Methods of Test and Standard practices for Concrete*.

7.3.5 MAINTENANCE HOLES

The following section outlines the City's design requirements as they pertain to standard maintenance holes. The City's primary concerns focus on the location of maintenance holes within the street corridor, capacity for adjustment, and drainage provisions.

7.3.5.1 LOCATION OF MAINTENANCE HOLES

To preserve utility corridor space for present and future needs, the City requires that installation of maintenance hole or access chambers:

- Have the longer side of the equipment aligned parallel to the property line.
- Be placed directly overtop the utility alignment and not offset to a side, though this may not be possible to achieve.
- Maintain a minimum clearance of 10.0m from street intersections measured from the property line. This requirement ensures ease of access and adequate visibility for vehicle traffic during maintenance activities.
- Preferably, be located in the boulevard or curb lane of the roadway, so as to minimize disruptions during construction and maintenance activities.
- Are not permitted within a lane entrance or intersection curb return areas (refer to items in *Section 7.3.6.2* regarding ramp areas).

7.3.5.2 VERTICAL ADJUSTMENT REQUIREMENT

As there is a potential for vertical grade changes to City roads, maintenance hole lids are required to be adjustable. To accommodate this, the maintenance hole lid frame is to sit on either bricks, pre-cast concrete slabs, or the equivalent. Furthermore, the neck of the maintenance hole must be a minimum 450mm in height to allow vertical adjustment to meet the finished grade of the roadway.

7.3.5.3 SEWERS AND DRAINAGE "D-PERMITS" FOR UTILITY COMPANY MAINTENANCE HOLE DRAINS

A utility access chamber requiring a drainage connection to the City Sewer network is required to have a "D" permit issued by the *Sewers and Drainage Design Branch*. Arrangements to obtain a permit can be made by contacting the Sewer and Water Client Service Centre at 604-873-7357.

During the permit issuing process, the *Sewers and Drainage Design Branch* will determine the ideal location for the maintenance hole drain. To assist in the sewer drain design, the City generally requires a two-week notice and a copy of the utility design drawing. There is an annual charge, per drain, to connect to the City's storm, combined, or sanitary sewer systems. Note that there are some sewer lines that cannot be connected to. The utility company is responsible for doing the connection under the City's inspection.

The City requires that the utility company's installed portion of the maintenance hole drain meet the most current applicable standards as per *Section 4.4* and *Section 5.4*.

When applying for a "D" permit for a maintenance hole drain, the utility permit drawing must show the following:

- Connection including the chainage distance to the nearest perpendicular property line from the sewer main.
- Size of the proposed drain.
- Any connections between maintenance holes to the draining (drainage system) maintenance hole.
- The existing drainage system for each maintenance hole shown on the design drawing (e.g. drain, rock pit, sump).
- Identification numbers for all maintenance holes.

In special circumstances, ductile iron pipe class C52, conforming to *AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast, for Water* should be substituted:

- When the depth of cover is less than 1.2m.
- When the depth of cover is greater than 3.7m.
- If ground conditions are unstable.
- When crossing under railway tracks.
- If crossing a utility less than 450mm away.

Utility companies must be cognizant that the City of Vancouver at no time guarantees the long-term location or availability of any maintenance hole drains. From time to time, upgrades to the City's sewer network system may result in relocation of sewer mains. Costs associated with the relocation or removal of any existing drain, requested by the City, will be the responsibility of the utility company.

7.3.6 SURFACE STRUCTURES

The following sections detail loading and placement criteria of surface structures, including vaults and non-standard maintenance holes.

7.3.6.1 LOADING CRITERIA

The City requires that all structures located within the City street constructed with non-standard maintenance hole frame and lid components, meet or exceed the City's minimum design load requirements. The most current edition of *CAN/CSA S6 Canadian Highway Bridge Design Code*, in conjunction with the *BC MoTI Bridge Standards and Procedures Manual*, shall be the minimum acceptable design standard for these structures. The City recognizes that vehicles of varying size and weight frequently occupy sidewalks and other non-travelled portions of the street; note that the referenced design standard applies equally to structures within these areas. An exception to the aforementioned exists for those structures in boulevard and sidewalk areas, where a design load reduction pursuant to *Section 3.8.4.4* of the most current edition of *CAN/CSA S6 Canadian Highway Bridge Design Code* applies.

- The BC CL-625 vehicle shall be used for loading designs, recognizing that the BC design vehicle includes higher axle load ratings than the CAN/CSA design vehicle.

- Subject to the size of the intended structure, maintenance hole frame and lid components must account for the probability of loading from multiple axles (i.e. loading from axles 2 and 3.).
- As tridem axles are permitted on single-unit vehicles in BC, the City recommends this loading configuration be considered in designs (*British Columbia Commercial Transport Regulations*).
- Several vehicle operators are known to operate vehicles within the City that exceed normal provincial loading regulations (e.g. Coast Mountain Bus Company states they have a provincial exemption to operate their buses to the full axle load rating of their vehicles. Coast Mountain Bus Company has stated that some of their buses have operational axle loads of up to 13,000kg on a single drive axle - approximately 127.5kN - when operating at full capacity).
- There is always variability in the actual vehicle operating loads. While there are provincial regulations and City by-laws regulating allowable axle loading (e.g. *British Columbia Commercial Transport Regulations*, *City of Vancouver Street and Traffic By-law No. 2849*), it cannot be guaranteed that vehicles will not exceed these legal load limits. There are real possibilities that vehicles, particularly overweight vehicles, exceeding legal load limits will enter into sidewalk areas and other non-traveled portions of the street.

7.3.6.2 PLACEMENT CRITERIA

Alongside the aforementioned loading criteria, surface structures shall comply with the following requirements:

- Clearance shall be maintained near standard pedestrian ramps. Placement criteria (applicable to double curb, large single ramp and lane curb ramp designs) shall be the greater of a:
    - 2.0m setback from the beginning or end of the curb radius to the closest edge of the structure, or
    - 3.0m setback from the adjoining street property line to the closest edge of the structure.
- Clearance shall be preserved to allow for construction of standard road configurations where existing curbs, sidewalks or other similar street infrastructure were not built to meet current standards (i.e. the provision for future flared lane entrances, curb ramps).
- Vault installations adjacent to existing buildings shall accommodate future grade changes, where existing elevations and structures (e.g. road, sidewalk, building grades, and curb face height) have not been constructed to current City standards.
- Vaults shall maintain a minimum 1.0m clearance from typical surface features such as poles, fire hydrants and street furniture.
- Vaults shall maintain the greater distance of:
    - 1.5m measured at 1.4m high from a main tree trunk, or
    - Six times the tree trunk diameter (measured at 1.4m high) from the main trunk of the tree at 1.4m high. The *Vancouver Park Board* may conduct an inspection and / or review where proposed equipment is likely to affect the root system.
- Vaults should maintain a minimum 1.0m clearance from residential and business entrance / walkways.
- Standard clearances from all other utilities shall be maintained.

- The ideal location for vaults is between the back of the sidewalk and the property line (as close to the adjacent property line as possible).
- The vault roof is to be installed at the City design grade. In situations where there is an improved boulevard, the vault will meet existing street grade. For those installations in unimproved boulevards, the City will provide design grades at all four corners of the vault.
- Utility equipment is not permitted in roadways or crossings.
- Vaults should not be located in front of or behind bus-stop shelters.
- The maximum gap permitted for all grates shall be 6mm.
- A minimum allowance for a 150mm vertical adjustment of the equipment is required to accommodate changes to street grade and settling.
- All equipment (e.g. lids, covers) must take into account ‘vulnerable street users’ and have a minimum 0.5 and 0.6 wet and dry coefficient of friction, respectively.
- Equipment must be located within the existing utility alignments and / or corridors and will not be permitted where proposed placement may inhibit the use of a future corridor or limit optimum use of such space.
- To minimize the amount of utility corridor space occupied, equipment is to be installed with the longer side parallel to the property line and the width of the equipment should be minimal relative to similar equipment and the width of the duct bank.
- Vault locations should accommodate standard street treatments (e.g. front boulevards, sidewalks, pedestrian lane crossings).
- Property owners shall be notified (depending on the size of the equipment) prior to the submission of any proposed drawing to the City, where equipment may possibly be situated. Notification is not a request for approval from property owners, but awareness for overall design considerations.
- Attention must be paid to overhead encroachments (e.g. awnings, building overhangs, canopies) that may be installed directly over proposed locations.
- Locates for all buried utility equipment and service connections within the immediate area of a proposed alignment must be undertaken and included on proposed drawings.
- Where equipment is to service a new development or redevelopment, plant shall be located on private property.
- FortisBC Gas Regulator Station structures are only permitted on local streets and laneways.

7.3.7 ABOVEGROUND STRUCTURES

The City’s preferred location for aboveground structures is on private property, with the exception of communication and monitoring kiosks. This equipment may be placed on City streets, following review by the *Utilities Management Branch* and neighbourhood notification (includes providing adjacent property owners with an accurate rendering of the proposed facility). Final approval considerations include aesthetics as it relates to the overall streetscape, effects on vehicle and pedestrian movements, sightlines and the position of the equipment. The following sections detail the City’s requirements for aboveground structures.

7.3.7.1 LOCATION OF ABOVEGROUND STRUCTURES

City street space is at a premium throughout most of the City. There are trolley poles, street lights, traffic signs, parking meters, public bike share, fire hydrants, trees, post boxes, benches, bus shelters, garbage cans, sidewalk cafes, bicycle racks, newspaper boxes, street vendors, underground utilities and services including meters, businesses with their entrances and window displays, and other street furniture and public art. The majority of these facilities are located on the City boulevards which causes conflicts with pedestrian movement, the City's number one transportation priority. Therefore, the City's preferred location for any aboveground structures is on private property. That being said, proposals for locations of aboveground structures on City property will be thoroughly reviewed on a case-by-case basis taking into consideration the following placement criteria:

Location:

- Shall be located on flankage streets ("side" streets) where possible or laneways preferably near the back of the property against a hedge, wall or fence, as to minimize the visual impact on the adjacent property.
- Shall be located against the adjacent property line.
- Shall be located within the existing utility alignments and / or corridors and will not be permitted where proposed placement may inhibit the use of a future corridor or limit optimum use of such space.
- Shall be limited to one piece of aboveground equipment per adjacent property.
- Where equipment is to service a new development or redevelopment, this facility shall be located on private property.
- Aboveground equipment shall maintain the following clearances from stated objects:
    - Minimum 1.0m clearance from typical features such as poles, fire hydrants, planters and street furniture.
    - Minimum 1.0m from all vehicle crossings.
    - Minimum 1.0m from pedestrian entrances to residential and commercial properties (not applicable to those located within curb return / pedestrian ramp areas, as defined in *Section 7.3.6.2*).
    - Minimum 0.3m from sidewalks and future sidewalks (not applicable to those located within curb return / pedestrian ramp areas, as defined in *Section 7.3.6.2*).
    - Located between the back of sidewalk and property line, with a maximum offset of 1.2m from the property line to the roadside face of the box.
    - Where boulevards are less than 4.4m in width, a minimum clear path of 3.15m from the gutter-line to the roadside face of the equipment must be maintained.
    - Minimum of 3m from a lane or street property line.
- The *Streets Division* may place additional restrictions on a site-by-site basis, where concerns regarding sight lines arise.
- Aboveground equipment shall not:
    - Be located in front of windows, doors and gates.
    - Be located adjacent to sidewalk cafes.
    - Obstruct driver or pedestrian sight lines, or otherwise compromise public safety.

- Require pedestrians to adjust their line of travel to pass the aboveground equipment.
- Be located in front of or behind bus-stop shelters.
- Be within any transit loading or unloading area in a manner that interferes with boarding, disembarking, or queuing by transit passengers.
- Obstruct the operation of the public bike share system.
- Be permitted within lane entrance or intersection curb return areas (refer to items in *Section 7.3.6.2* regarding pedestrian ramp areas).

Downtown/Commercial Zone Locations:

- Downtown kiosk locations will be reviewed on a case-by-case basis due to the different layout of the downtown streets and the various competing interests for space. Locations will be reviewed primarily for impact to pedestrian movements and adjacent property owners among other considerations.

Aesthetics / Design / Maintenance:

- Height of the aboveground equipment shall be limited to the minimum height needed for the equipment.
- Aboveground equipment shall be maintained free of graffiti at all times.
- In certain locations aboveground equipment shall have a peaked or rounded roof on the top to deter unwanted activity.
- Aboveground equipment shall be positioned with the longer side and / or doors of the aboveground equipment running parallel to the street property line.
- The foundation shall not extend beyond the edges of the aboveground equipment and shall be installed flush to meet street design grade.

Other Criteria:

- Property owners and local Business Improvement Areas shall be notified by letter with a rendering of the facility prior to the final approval of the proposed aboveground equipment location. Utility company contact information shall be included on the letter. Notification is not a request for approval from property owners, but awareness for overall design considerations. The City shall be copied on all notifications and resulting correspondence.
- Attention must be paid to overhead encroachments (e.g. awnings, building overhangs, canopies) that may be installed directly over proposed locations.
- Drawing submittals shall meet the requirements of *Sections 7.6* and *7.7*.
- When choosing equipment locations, consideration should also be given to limiting construction impacts to the street space and to vegetation where possible.

BC Hydro Pad Mounted Transformers and Aboveground Vista Switches:

- This equipment is to be situated in a BC Hydro right-of-way, on private property, and is not permitted within City streets.

Steam Heat Vent Planters:

- Steam vents are to be designed and installed flush with the ground outside of the main pedestrian walking path. The steam vent planter is no longer approved for installation on City streets, with all existing planters eventually being removed.

7.3.8 POLES, PILASTERS, TRANSFORMERS, AND ANCHORS

The following section details the City's design requirements for utility poles, pilasters, transformers and anchors. The City does not permit any utility to install new pole lines or extensions to existing pole lines. Any additional poles proposed within an existing pole line will be discouraged and must be approved by the *Utilities Management Branch*. Moreover, the installation of new "H-frame" poles is not permitted.

7.3.8.1 LOCATION OF POLES

When an additional pole is to be installed on a street or an existing pole is to be relocated, there are standard pole locations for placement. Existing conditions, specifically building setting, will generally restrict available locations. Generally, pole locations shall be:

- At lot lines or projected lot lines.
- A minimum 1.0m clear of vehicular crossings.
- A minimum 1.7m clear of fire hydrants.
- A minimum 1.0m clear of catchbasins.
- A minimum 1.0m clear of crosswalks.

Standard pole offsets (from pole centre to property line) in lanes with a width of:

- Less than 3.1m, are not permitted.
- From 3.2m to 6.1m wide, is 0.40m.
- From 6.2m to 10.1m wide (West End), is a minimum of 0.4m to 0.9m.

Standard pole offsets (from pole centre to property line) in streets with a pavement width of:

- Up to 11.0m is 4.0m.
- From 11.1m to 12.0m is 3.0m.

For street widths greater than 20.0m or for those streets with boulevards narrower than the standard offset, the pole centre should be located 760mm from the centre of pole to the face of curb. Future curb locations must be confirmed with the *Utilities Management Branch*.

7.3.8.2 OVERHEAD TRANSFORMERS

All overhead transformer installations must be reviewed by the *Utilities Management Branch*, to ensure their presence minimizes the impact on the surrounding neighbourhood. Considerations taken into account include location, where overhead transformer installations must be immediately adjacent to the property requiring the service and ensuring that they meet or exceed applicable standards as established by *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver. Notification to adjacent property owners is required for all new overhead transformer placements. Notification shall include property owners with an accurate rendering of the proposed transformer location. Additional notification may be required by the City on a case-by-case basis.

7.3.8.3 DOWN GUY AND ANCHOR

The location of down guy and anchor equipment is determined by either BC Hydro or Telus, based on the needs of their equipment on pole lines. All new anchor locations must be approved by the *Utilities Management Branch*. Due to the serious impact this equipment can have on adjacent properties, a thorough review is carried out to ensure there is a balance between the needs of the utility company and affected property. The presence of existing anchors can also raise concerns for property redevelopment projects, resulting in a need to have the down guy and anchor relocated. The preferred resolution has involved altering the length of the existing down guy and anchor, to suit the proposed development. The following are general location requirements for down guy and anchors installations:

- The down guy must be parallel to the property line, maintain the same offset as the pole line and not extend past the street or lane property line.
- Guy wire in close proximity of or touching a street light pole or luminaire shall be wrapped by approved guy cover.
- A sidewalk guy must be installed at right angles to the property line, with the anchor at a maximum distance of 0.3m from property line.
- Access to existing entrances or driveways must not be compromised.
- The down guy must not cross in front of a gas meter, Pad Mounted Transformer, or any other utility equipment located on private property.

7.3.8.4 STEEL TROLLEY POLES

The location of steel trolley poles must:

- Be at lot lines or projected lot lines.
- Maintain a minimum 1.0m clearance from vehicular crossings.
- Maintain a minimum 1.7m clearance from fire hydrants.
- Maintain a minimum clearance from intersection and lane curb return areas (as defined in *Section 7.3.6.2*).
- Maintain a minimum 1.0m clearance from catchbasins.
- Maintain a minimum 1.0m clearance from crosswalks.
- Be 430mm from the face of the curb to the centre line of the pole for A7E pole types.
- Be 460mm from the face of the curb to the centre line of the pole for A3E pole types.
- Be 535mm from the face of the curb to the centre line of the pole for A20E and A23E pole types.

The installation of anchor guy wires, where new trolley poles and foundations are being installed, is not permitted.

7.3.9 OVERHEAD WIRES

The minimum above ground clearance for any overhead wire or cable installation across or along any street or lane shall be the greater of:

THIRD-PARTY UTILITIES

- The applicable clearance defined in the latest version of *CAN/CSA C22.3 No. 1 Overhead Systems,* or
- 4.9m.

Any utility with overheard wire installations found below the minimum height allowance will be required to be adjusted upon receiving notification from the City.

7.3.10 SURFACE INLAY FIBRE AND MICROTRENCHING

Surface Inlay Fibre (SIF) and microtrenching is permitted on a conditional basis in the City of Vancouver. Utility companies wishing to utilize this installation technique are required to enter into a separate Municipal Access Agreement with the City specifically for the use of SIF and microtrenching and adhere to installation standards.

This section has been developed to accommodate the installation of surface inlay fibre within the City street right-of-way on a conditional basis.

Surface inlay does not meet the utility installation standards for the City of Vancouver. However, considering the benefits of this facility with its ability for low impact installation into sensitive areas such as special pavements, congested utility corridors or areas with major traffic volumes, the City is permitting construction and operation of equipment on a conditional basis, with certain considerations. The installation of this technology at the surface of pavement or sidewalk puts it at extraordinary risk compared to other utility installation technologies, and as such, there can be no liability to the City of Vancouver for damages to this equipment incurred when the City or others undertake any works. With the inherent susceptibility to damage, the City strongly recommends redundancy be built into each installation project.

If these conditions are agreeable, the City of Vancouver will consider surface inlay subject to the following technical specifications:

- Drawing Submissions – Drawings are to be submitted as per *Sections 7.6* and *7.7*.
- Alignment – The existing streetscape is the prime consideration for the choice of a running line. There are three types of settings encountered on the street right-of-way: improved boulevards, unimproved boulevards, and travelled road surface.

7.3.10.1 IMPROVED BOULEVARD

An improved boulevard includes the hard surface structures located between the face of the curb or edge of pavement and the property line. These are the top of curb, the front boulevard (or utility strip), the sidewalk, and the back boulevard (or building strips when adjacent to buildings). Allowable alignments within this area include:

- In the front boulevard (or utility strip), between the back of curb and front of sidewalk.
- In the back boulevard (or building strip), between the back of sidewalk and property line.

7.3.10.2 UNIMPROVED BOULEVARD

An unimproved boulevard includes the grass area and gravel shoulder. Installation is acceptable anywhere within this area and can be installed with up to 225mm cover. The fibre may also be encased within an additional sheath for protection, subject to approval of the *Utilities Management Branch* on an individual basis. Those companies employing SIF within these areas should be aware that any unimproved boulevard may undergo future improvements, with the installation of sidewalks, curbs and gutters, street trees or a portion of an asphalt road.

7.3.10.3 TRAVELLED ROAD SURFACE

The travelled portion of the road includes materials consisting of asphalt, concrete and paving stones. Acceptable alignments in asphalt streets are between the edge of the road and the edge of the gutter, and a crossing perpendicular to the street (refer to depth criteria under *Section 7.3.10.5*). Alignments wholly within the asphalt running parallel to the street will not be permitted, except within lanes. Construction alignments in lanes, paved or unpaved, shall have an offset of 0.3m off the property line unless otherwise approved by the *Utilities Management Branch*. The approved alignment must be adhered to and no deviations around temporary street occupying items such as parked cars, garbage containers, will be accepted. The criteria regarding equipment depth applies equally to installations within lanes.

A concrete road consists of large panels of concrete with thicknesses ranging from 125mm to 300mm, and a joint key that is typically 1/4 to 1/3 the thickness of the panel. Fibre may be installed in the seams between panels if it does not compromise the joint key (must not be disturbed) or cut across a panel. These seams will permit a running line parallel to the street or a crossing perpendicular to the street.

Paving stones come in a wide variety of styles and designs. An alignment for surface inlay fibre will be required to be within an existing seam between bricks. Running lines parallel to or perpendicular to the street are acceptable where they are found in these situations.

Any project that cannot meet the alignment criteria, must apply to the *Utilities Management Branch* for assistance to determine an acceptable alternative. Any alternate alignment chosen that cuts across or otherwise damages a concrete sidewalk stone or curb and gutter, will be charged the full replacement cost of that item.

7.3.10.4 CONSTRUCTION

Surface inlay construction must adhere to all City of Vancouver by-laws and the utilities standards for utility construction, as outlined in the *City of Vancouver Construction Specifications*. When required, the City will request a traffic plan to be submitted as per the *City of Vancouver Construction Specifications*.

7.3.10.5 DEPTH

The depth of installation will vary depending on type of street surface and whether the equipment is “direct buried” or encased within a protective sheath. The minimum depth for all installations will be such that 20mm will be allowed from the road surface to the top of the equipment for appropriate joint sealant adhesion. The following are depth guidelines for typical streets:

- Concrete sidewalk – Maximum 150mm in the joint only.
- Boulevard and gravel verge – Maximum 225mm.
- Gutter / road edge – Maximum 150mm.
- Concrete road panel – In the joint, to the depth of the joint key.
- Asphalt road:
    - Arterial Roads – The acceptable depth for installation in an asphalt road will be one-third the existing pavement depth. The thickness of existing pavement (including the concrete base) will be proven by the utility company prior to installation, with the removal of a 100mm diameter core that must be viewed and approved by the Utilities Inspector.
    - Residential Roads and Lanes – Most residential roads are only 50mm to 150mm thick. The maximum depth in residential streets will be one-third the existing pavement depth.

The permit drawing is required to show the proven depth of pavement at all asphalt installation locations by the removal of asphalt core samples. The core sample locations must be shown on the permit drawing, at least one per block. The *Utilities Management Branch* Inspector must be present when the core samples are taken.

Any project that cannot meet the depth criteria must apply to the *Utilities Management Branch* to determine if an acceptable alternative exists. There will be no exceptions to the maximum depth criteria in an asphalt road.

7.4 CONSTRUCTION REQUIREMENTS

Third-Party utilities have varying construction requirements based on the type of utility and the proposed design. Refer to the *City of Vancouver Construction Specifications* and the *City of Vancouver Standard Detail Drawings* for the requirements common to all Third-Party Utilities during construction for Third-Party Utility installation.

7.4.1 CONSTRUCTION SPECIFICATIONS

The *City of Vancouver Construction Specifications* and the *City of Vancouver Standard Detail Drawings* outline standards, specifications, and procedures for construction and restoration works of street, sidewalk, utility service cuts and trenches, made in the proximity of City streets. The document provides best practices guidelines for City forces and utility companies, ensuring that excavations, backfill material, installation and compaction procedures, density requirements, and surface restoration on City streets are carried out in accordance with the best available standards and procedures.

Any backfill product that is requested for use that is not contained in the *City of Vancouver Construction Specifications* and *City of Vancouver Standard Detail Drawings* will require a review and specific written permission from the City prior to its use.

7.5 SUPPLEMENTARY INFORMATION

The following section provides valuable supplementary information for those engaged in utility design and construction activities within City streets.

7.5.1 CITY UTILITY AND PAVING SCHEDULE

The *Engineering Services Department* provides frequent updates of their planned street construction program including grind and overlay, sidewalk, left turn bay, and sewer and water construction, as well as a host of other street upgrade programs. The comprehensive list contains the current year's projects, as well as long range plans of up to seven years. The *Utilities Management Branch*, in its efforts to promote construction coordination, e-mails project schedule information to utility companies for their internal review. The City's intent is to provide an opportunity for companies to forecast any conflicts with current City projects and assist with their long-range planning schedules.

7.5.2 CITY OF VANCOUVER CONSTRUCTION PROJECTS

The City of Vancouver web site, at www.vancouver.ca/streets-transportation/roadwork.aspx contains information about major roadwork projects within the City such as sewer and water main work, road closures, and other works that may potentially affect the public. The information provided is intended to assist in the planning and scheduling of utility construction and maintenance projects.

7.5.3 SPECIAL PAVEMENTS

In select areas throughout the City, a number of streets have been surfaced with special pavements. In this context, special pavements refer to all non-asphalt and non-concrete surfaces such as brick, and granite. In other areas of the City, namely older streets and lanes, the original "historical" pavement surface (designated and protected under the authority of City Council) may have been repaired or overlaid with asphalt or concrete. For construction requirements for working in special pavement areas, refer to the *City of Vancouver Construction Specifications*.

7.5.4 GEOSYNTHETICS

In select areas throughout the City, the underlying soil contains deep peat deposits, a low strength and highly compressible material that results in varying amounts of settlement when loaded. The pavement structures within these areas have been modified by the addition of geotextile fabric (resembles a heavy white or black cloth), and geogrid (resembles a black snow fence lying flat), to improve their performance.

The *Utilities Management Branch* has identified several known areas of peat deposit within the City that currently employ the use of geosynthetics as a part of the pavement structure, those include:

- 16th Avenue from Sophia Street to St. George Street.
- 17th Avenue from Carolina Street to the lane west of Fraser Street.
- 18th Avenue from Prince Albert Street to Fraser Street.
- Skeena Street from 2nd Avenue to 3rd Avenue.
- 19th Avenue from Fraser Street to Price Albert.

The City recognizes that the list of streets containing peat deposits, noted above, may be amended periodically as new locations are identified.

Companies engaged in utility construction activities within these areas, whether excavating through or restoring the geotextile fabric, must follow the procedure as set out by the City in *Section 33 50 01S: Third-Party Utilities* and *Section 31 32 19: Geosynthetics* of the *City of Vancouver Construction Specifications*.

7.5.5 STREET TREES

Boulevard trees situated on City property are protected by the *City of Vancouver Street Tree By-law No. 5985*. Utility companies and their contractors must make all efforts to protect trees from potential damage during construction and maintenance activities. When conflicts arise between a proposed utility design and existing street trees, the approved utility permit drawing will have a condition noted on it to contact the *Vancouver Park Board* ten days prior to commencing construction. It is important that the requirement to contact the *Vancouver Park Board* be met to provide ample time for the Board to ensure it has the opportunity to assess the construction site and determine construction techniques that will minimize disruption to the existing trees and their root systems. The *Vancouver Park Board* may require an arborist or qualified professional to be onsite during excavation activities to provide supervision.

7.5.6 ABANDONED PLANT

In the event that a utility company no longer requires the use of their authorized plant located within City streets, they must notify the City Engineer promptly in writing of the abandonment. Notification should include details of the plant such as size, depth and material and what hazardous materials are present within the plant such as asbestos. Upon notification, the *Utilities Management Branch* may require the utility company to remove or decommission the abandoned plant within 90 days from the date of the notification. Additional requirements may be put in place depending on presence of hazardous materials. Proper notification ensures that City records are kept current and up-to-date, and that future street space is preserved.

For additional abandonment requirements, refer to the *City of Vancouver Construction Specifications*.

7.5.7 SURVEY MONUMENTS

The City of Vancouver's survey control network consists of Provincial Integrated Survey Area monuments, as well as monuments installed and maintained by the City. In addition to these, the City, in partnership with the Greater Vancouver Regional District, has installed High Precision Network monuments that include a GPS reference network system, meeting first order survey accuracy standards.

The City has also resurveyed 78 of the City's Standard Integrated Survey Area monuments to provide elevations to first order survey accuracy. These monuments have been designated as Secondary Benchmarks. The City's existing control monuments are just as important, and regularly used by the City's *Engineering Services Department*, British Columbia Land Surveyors, and many others in their daily operations to provide horizontal and vertical control.

To ensure every effort is made to protect monuments, the *Utilities Management Branch*, during the utility construction approval process, will review each proposed drawing for potential conflicts with monuments. However, it remains the responsibility of the utility company to take the necessary steps to locate and avoid these monuments, as well as making arrangements with the *Utilities Management Branch* for referencing and monitoring all monuments within the construction area. A map of all control monuments within the City, and a book listing all control monuments, their locations and elevations, is available from the *Land Survey Branch*.

For construction related requirements, refer to the *City of Vancouver Construction Specifications*.

7.5.8 DAMAGE AND GRAFFITI

All aboveground utility structures are at risk of being damaged or defaced. *City of Vancouver Graffiti By-law No. 7343* prohibits the placement of graffiti on private and City property. The *Utilities Management Branch* expects all utility companies will have in place, a regular maintenance program that includes inspection of their aboveground equipment for damage and graffiti, and its repair or removal if required.

7.5.9 NOISY UTILITY EQUIPMENT

The *Utilities Management Branch* will not permit audible noises emanating from utility equipment located within the City streets, at any time. Utility companies with equipment emitting audible noises, such as from a cooling fan, electrical transformer or other device, will be required to repair their apparatus to be effectively silent in operation.

7.5.10 AREAWAYS

Areaways are underground extensions of private property onto City streets. They are considered encroachments. The extent can range from a few square feet, to an underground structure surrounding the entire building perimeter, and extending up to 10 feet from the property line. Normally, an areaway is leased from the City, under the terms and conditions of an agreement, and any utility wishing to access the space as part of the running line would be required to negotiate access from the parties to the agreement.

7.5.11 ATTACHMENTS TO CITY STRUCTURES

The Third-Party Utility company shall submit a completed application form to the *Utilities Management Branch*, requesting approval to attach equipment to a City Structure, in accordance with the requirements in this manual, *City of Vancouver Street Utilities By-law No. 10361*, or applicable agreement.

It is the responsibility of the Third-Party Utility company to provide detailed drawings clearly illustrating the proposed location of the equipment, attachment details including the type, size and depth of fasteners, supports, conduits, and any additional information deemed necessary by the *Utilities Management Branch*.

The *Utilities Management Branch* will forward all information provided by the Third-Party Utility company to the *Streets Design Branch - Structures* for a detailed review. Following its review, the *Streets Design Branch - Structures* will provide the *Utilities Management Branch* with its comments and / or interim approval, with the *Utilities Management Branch* issuing final approval.

The Third-Party Utility company shall not reduce the vertical clearance under a bridge and be mindful of the aesthetics of the proposed attachment, locating conduits within the bridge structure, and ensuring that they are not visible below the bottom edge of the girder, where possible.

There shall be no attachments to pre-stressed I-girders, railings or rail posts on any City Structure.

As a prerequisite for approval, the final design of the equipment attachment to a City structure must be reviewed by the structural engineer of record for the structure (the original engineering consultant firm responsible for designing the bridge or structure), or if not possible, by a qualified engineer acceptable to the *Streets Design Branch - Structures*.

The Third-Party Utility company shall acquire the services of a qualified engineer who shall be directed to:

- Conduct a detailed review of the final design for the proposed utility attachment to a City Structure.
- Provide certification in the form of a signed and sealed letter stating that the utility attachment and / or any activities required to complete the attachment (e.g. coring), will not negatively affect the structural integrity of the City Structure, nor will it create any additional maintenance for the City.

- Provide details regarding acceptable locations for all holes to be cored into a City Structure (if required), as well as technical specifications on how existing rebar and core holes may be located as to minimize cutting of existing reinforcement in the concrete (e.g. with the use of a pacometer). All coring holes shall be laid out by the engineer, with coring work only permitted following the written approval by the *Streets Design Branch - Structures*.
- Provide technical specifications and details on how to locate the existing rebar to minimize cutting of the reinforcement in the concrete (e.g. with the use of a pacometer) for each utility support / fastener attachment of the City Structure.
- Provide details on how the City Structure will be restored to its preconstruction state or condition (e.g. sealing of holes) prior to the Third-Party Utility company's work.
- Provide details regarding any ongoing inspection or maintenance activities required by the Third-Party Utility company. Required activities shall be carried out by the Third-Party Utility company or its agent, and a copy of such activity reports shall be provided to the *Streets Design Branch - Structures* in a timely manner.
- Provide such information noted above, in a form prescribed by the City, to the *Utilities Management Branch* for review. All inspection and maintenance activities must be approved by the City, prior to such work being undertaken.
- Provide personnel to be on-site during the first complete coring operation (if coring is required) and as required thereafter. If coring is required, provide details and confirmation regarding how many additional attachments can be made to the City Structure, and that the proposed utility attachment will not prevent future installations to the City Structure.
- Sign an agreement, in a form prescribed by the City Engineer, specifying the terms and conditions under which the Utility Company has been granted permission to attach the utility to the City Structure.

7.6 UTILITY PERMIT DRAWING SUBMISSIONS

The following section outlines the requirements for utility drawing submissions made to the City of Vancouver. All utility permit application submissions must include an electronic drawing of the proposed installation. As the City will not accept multiple works on a single drawing, applicants must submit separate drawings for each installation. Upon request, the *Utilities Management Branch* will provide the City GIS base information for the area of the proposed utility design. In order to receive this information, the GIS Database License Agreement must first be completed and returned to the City. Submissions to the City include:

- Electronic Submission:
    - See *Section 7.7*. This section provides the submission template for electronic drawing submissions to the City.
- Manual Submission:
    - Underground Construction - 3 copies.
    - Aerial Construction - 1 copy.
    - "Information Only" plans not requiring approval - 1 copy.

In an effort to ensure consistency and accuracy, all submissions must adhere to the *Utilities Management Branch's* drawing standards. Proposed utility designs shown superseded on a previously approved and constructed plan will not be accepted. They should not be included as a revision to an existing drawing, and will require a new drawing number, as well as meet all other approval requirements.

7.6.1 STANDARD METRIC SCALES

Scales:

- 1:500 Horizontal scale for plan drawing.
- 1:250 Horizontal scale for plan drawing in congested areas.
- 1:100 Vertical scale for profile.
- 1:25 Detail of ducts, poles, boxes, and other related infrastructure.
- 1:50 Detail of ducts, poles, boxes, and other related infrastructure.

The metre (m) unit is used for:

- Horizontal distances.
- Elevations (vertical datum CGVD28).
- Offsets.
- Outside dimensions of maintenance holes, boxes, etc.

The millimetre (mm) is unit used for:

- Duct cross-section details.
- Duct or pipe diameters.

7.6.2 BASE PLAN

All base plan submissions to the City should include the following details:

- North arrow (at top corner of drawing).
- Street, lane and easement property lines.
- Street names.
- Lot lines and lot legal descriptions.
- Title.
- Scale.

7.6.3 TITLE BLOCK

Location:

- The title block will include a description of the construction site using north-south and east-west street names (e.g. lane south of Broadway, Laurel Street to Oak Street, or 8th Avenue east of Cambie Street). Where possible, lanes should be described using "lane south" or "lane west" naming convention. For those permit applications with site services, if available the site address should be noted.

Type of installation. This indicates whether the work is overhead or underground. Each work is to be detailed as follows:

- Overhead - Identify whether the work is a new installation or upgrade of existing utility equipment.
- Underground - Identify whether the work is a joint trench. This will reference the drawing number for any other works, another utility company may be installing or have installed in the joint trench construction (i.e. Telus, Hydro, etc.). All utility companies will submit separate utility permit drawings.

Revisions to existing drawings:

- When a change that has been approved by the City is made on the permit drawing and the drawing has been resubmitted for approval, a revision number along with a brief description of the change (e.g. duct offset on Cambie Street) must be included. Any drawing submitted as a revision will require re-approval.

7.6.4 RELATED DRAWINGS

A related drawing is a drawing that includes work that is to be carried out in conjunction with work on the original drawing (e.g. aerial work, utility abandonment). Related drawings are to be referenced by an appropriate drawing number and adhere to the City utility drawing standards.

7.6.5 DIMENSIONS

All utility equipment shown on the permit drawing must be dimensioned as follows:

- Offsets are required from street or lane property lines (perpendicular to the property line), for all poles, ducts, pipes, maintenance holes, boxes and valves.
- Distances are required from the closest street or lane property line (parallel to property line), for all poles, site services, duct bends, maintenance holes, boxes and valves. This is commonly referred to as the "chainage" distance.
- The drawing must show all existing utilities, correctly dimensioned and labelled.
- Include the offset and description of the proposed ducts or pipes.
- Show outside dimensions of all maintenance holes, boxes, etc., in separate detail.
- Radius and angle of all bends.
- Location and height of pole pilasters.
- Cross-section of the duct configuration, showing minimum cover, duct size and the outside dimensions for concrete encasement of ductbank (if applicable).

7.6.6 PROFILE

A profile is required for permit drawings for the following installations:

- All utility mainways.
- Any ductbank with over 16 or more ducts.
- Coast Mountain Bus Company DC feeder ductbanks.
- FortisBC Gas mains over 250mm in diameter.
- Creative Energy steam mains.
- GVRD sewer and water mains.

The profile must clearly identify:

- Vertical scale.
- Size and number of ducts or pipes.
- Cross-section of all utilities being crossed, drawn to scale and labelled.

7.6.7 RECORD DRAWINGS

Record Drawings serve as the final record of what has been installed within the City streets, and the City may be required to rely exclusively on a Record Drawing for design, construction, or maintenance activities. The Record Drawing must show all information incorporated by the City upon approval, alongside those changes made in the field, and shall be provided to the City within 30 days following the completion of construction. All Record Drawings submitted to the City must be certified by the permit holder as the final Record Drawings.

7.6.8 ABBREVIATIONS

Abbreviations are outlined in ***Table 7-2***:

Table 7-2: Abbreviations

Abbreviation	Utility	Owner
C	Steam Heat Pipe	Creative Energy
E	Electrical Distribution Duct	BC Hydro
E#	High Voltage Transmission Duct	BC Hydro
E(TR)	Trolley D.C. Feeder	Coast Mountain Bus Company
E(G)	Cathodic Protection Duct for Gas Main	FortisBC
G	Gas Main	FortisBC
G@	Trunk Pressure Gas Main (operating at 700 kPa pressure)	FortisBC
G*	Trunk Pressure Gas Main (operating at over 700 kPa pressure)	FortisBC
(PTE)	Private Utility	Various
S	Sewer (combined, storm, or sanitary)	City of Vancouver
S(F.M.)	Sewer Force Main	City of Vancouver
S(D)	Collector Sewer	Metro Vancouver
12"/8"S	Twin Sewer (size indicated)	City of Vancouver
8'x 8'S	Box Sewer (size indicated)	City of Vancouver
T	Telephone Duct	Telus
TeraSpan	Surface Inlaid Fibre Optic Cable	TeraSpan Networks
A2B	Surface Inlaid Fibre Optic Cable	A2B Fibre Inc.
Novus	Surface Inlaid Fibre Optic Cable	Novus Entertainment Inc.
T(co. name)	Telecommunications Duct	Telephone Company Name (e.g. Telus, Shaw)
T.V.(Shaw)	Duct (Communication or T.V.)	Shaw Communications Inc.
V.E.D.	Vancouver Electrical Duct (City Communication)	City of Vancouver
S.L.	Street Lighting Duct	City of Vancouver
W	Water Main	City of Vancouver
W(D)	Feeder Water Main	Metro Vancouver

7.6.9 CANCELLED DRAWINGS

The City must be promptly informed of any proposed utility permit drawing that has been cancelled.

7.6.10 UTILITY COMPANY STANDARDS

All utility drawings submitted for permit approval must clearly indicate on the drawing if they require additional considerations for the following:

- Installation methods.
- Vertical or horizontal clearances.
- Special backfill.
- Other issues unique to the utility's equipment.

The *Utilities Management Branch* will assess whether accommodations for the utility plant can be made at the selected location, based on set standards, or if all may be better served with alternate location.

7.7 EXTERNAL UTILITY SUBMISSION STANDARDS

The purpose of this section is to provide guidance on the basic procedures for Computer Aided Design and Drafting (CADD) for external utility plan submissions at the City of Vancouver. These procedures and guidelines ensure consistent products, appearance and accuracy.

7.7.1 INTRODUCTION

Digital spatial data specifications and standards are defined to provide corporate structure to data files. Adherence to these standards will assist in the preparation of drawing files and decrease the amount of verification necessary. In addition, these standards are designed to facilitate transfer of spatial data between branches of the City of Vancouver, software packages, projects, contractors, GIS and general users of the City of Vancouver's digital data. The ability to communicate effectively regarding digital data requires a common understanding regarding current data standards.

7.7.1.1 ROLES AND RESPONSIBILITIES

The *Utilities Management Branch* is responsible for maintaining all communications regarding external utility plan submissions. *Engineering GIS & CADD Services* is responsible for maintaining standard CADD base files and supporting standard layouts, templates, devices, symbols, and server processes. CADD clients are responsible for maintaining the integrity of CADD base files, supporting information and server environment. CADD clients are responsible for the maintenance of base information as input to the City of Vancouver GIS for their specific program areas.

7.7.1.2 SCOPE

All users of the City of Vancouver's CADD server will incorporate and provide input to these standards to develop a citywide understanding of CADD. The information stored and distributed on the CADD server is proprietary. Reproduction or distribution of this data is strictly prohibited.

7.7.2 GENERAL DATA SPECIFICATIONS

The following section outlines the general data specifications as set by the City of Vancouver.

7.7.2.1 PROJECTION

Universal Transverse Mercator Projection (UTM) is the standard projection used by the City of Vancouver.

7.7.2.2 UTM ZONE

The City of Vancouver is in UTM Zone 10.

7.7.2.3 ORIGIN

An origin set at 0,0,0 will be the standard for all digital spatial data files for the City of Vancouver.

7.7.2.4 UNITS OF RESOLUTION

Metres (m) is the resolution for digital data in the City of Vancouver.

7.7.2.5 HORIZONTAL DATUM

North American Datum of 1983. NAD83(CSRS).

7.7.2.6 COORDINATE SYSTEM

Eastings and Northings will be used for coordinate location references. Autodesk Map UTM83-10 is the assigned coordinate system for the City of Vancouver.

7.7.2.7 SPHEROID

Spheroid: WGS 84

7.7.2.8 OBJECTS IN DESIGN DRAWING

Objects in design drawing must correspond to the assigned coordinate system.

7.7.3 SURVEY MONUMENTS

The following section outlines the specifications for survey monuments as set by the City of Vancouver.

7.7.3.1 GRID COORDINATES

Grid coordinates are preferred for electronic record drawing submissions. If grid coordinates are not supplied, the ground transformation formula is required.

7.7.3.2 TABLET MARKING

All surveys will note the tablet markings (e.g. V-2166) of the monument referenced from the City of Vancouver Integrated Survey Area No. 31.

7.7.3.3 ELEVATIONS AND VERTICAL DATUM

All elevations are to be based on the CGVD28 verticlal reference datum. The datum derivation must be clearly stated on all drawings.

7.7.4 SECURITY

7.7.4.1 VIRUS CHECKING

All files from external sources will be scanned for viruses prior to opening or executing.

7.7.4.2 SUBMISSIONS

E-mail address for plan submissions is streetutilitiespermit@vancouver.ca.

7.7.5 GENERAL AUTOCAD FILE FORMAT SPECIFICATIONS

The following section outlines the specifications for AutoCAD files as set by the City of Vancouver.

7.7.5.1 FORMAT AND VERSION

AutoCAD 2007 drawing format (DWG) or newer is the standard file format for the City of Vancouver CADD files.

7.7.5.2 NAMING CONVENTION

All electronic Utility Plan submissions must be named by the Plan Number being submitted (e.g. DS-6709.dwg). Record Drawings must be submitted based upon a copy of the approved permit file number with the "_Record" suffix (i.e. DS-6709_Record.dwg).

7.7.5.3 LAYER DRIVEN FEATURES

All element specifications will be determined by layer (i.e. colour, lineweight). All elements on a layer will conform to the standards and specifications for that layer (see layers).

7.7.5.4 DRAWING ORIENTATION

All drawings, with the exception of site plans (i.e. the inside of a chamber), will use project north alignment rather than true north. True north may be indicated with a north arrow based on current declination to indicate potential view rotation.

7.7.5.5 TOPOLOGICAL VALIDATION

The standards for topology must be met. Digital data must be vector and poly clean. The following errors are unacceptable: dangling nodes, undershoots, intersection errors, loops, open polygons, slivers and zero area polygons.

7.7.5.6 BASE INFORMATION

City of Vancouver base information in AutoCAD format is available upon request. Please contact the *Utilities Management Branch* for additional details.

7.7.6 DRAWING TEMPLATES

An AutoCAD template file, available upon request through the *Utilities Management Branch*, contains the recommended specifications for the submission of plan drawings to the City, including projection and datum information.

7.7.7 LAYERS

Utility layers, listed in ***Table 7-3***, will be electronically processed to update the City of Vancouver GIS system. Layer names and object types (linetype or symbol column) are of primary importance for plan submission, a key to the seamless integration of external data.

When submitting a drawing containing an existing Telco Duct, the duct would be a line on the U_TELCO_DUCT layer. Similarly, if you are submitting a drawing with an existing Telco Maintenance Hole, it would be represented as a symbol on the U_ TELCO_MANHOLE layer. For any new proposed equipment, please append 'PROPOSED' to the layer name (i.e. U TELCO DUCT PROPOSED, U TELCO MANHOLE PROPOSED, U HYDRO DISTRIBUTION DUCT PROPOSED). Reference layers and other drawing layers not included in the layers table, can use their existing naming convention or use the standards set in the City of Vancouver comprehensive template and documentation that is available upon request.

Table 7-3: Layers

Layer Name	Linetype or Symbol	Colour	Description
U_COV_ELECTRICAL_DUCT	Continuous	Black	Electrical Duct
U_COV_ELECTRICAL_DUCT_LBL	Continuous	Black	Electrical Duct Label
U_COV_ELECTRICAL_DUCT_LBL_REF	Continuous	Black	Electrical Duct Label Reference(1)
U_ENCROACHMENT_PRIVATE	Continuous	134	Private Encroachment
U_ENCROACHMENT_PRIVATE_LBL	Continuous	134	Private Encroachment Label
U_ENCROACHMENT_PRIVATE_REF	Continuous	134	Private Encroachment Reference
U_GAS_MAIN	Continuous	Orange	Gas Main
U_GAS_MAIN_ABANDONED	Continuous	White	Abandoned Gas Main
U_GAS_MAIN_LBL	Continuous	Orange	Gas Main Label
U_GAS_MAIN_REF	Continuous	Orange	Gas Main Reference
U_GAS_VAULT	Continuous	Orange	Gas Vault
U_GAS_VAULT_REF	Continuous	Orange	Gas Vault Reference
U_HYDRO_DISTRIBUTION_BOX	Symbol Layer	Red	Hydro Distribution Box
U_HYDRO_DISTRIBUTION_BOX_REF	Continuous	Red	Hydro Distribution Box Reference
U_HYDRO_DISTRIBUTION_DUCT	Continuous	Red	Hydro Distribution Duct
U_HYDRO_DISTRIBUTION_DUCT_LBL	Continuous	Red	Hydro Distribution Duct Label
U_HYDRO_DISTRIBUTION_DUCT LBL_REF	Continuous	Red	Hydro Distribution Duct Label Reference
U_HYDRO_DISTRIBUTION_MANHOLE	Symbol Layer	Red	Hydro Distribution Maintenance Hole
U_HYDRO_DISTRIBUTION_MANHOLE_REF	Continuous	Red	Hydro Distribution Maintenance Hole Reference
U_HYDRO_DISTRIBUTION_POLE	Symbol Layer	Red	Hydro Distribution Pole
U_HYDRO_DISTRIBUTION_POLE_REF	Continuous	Red	Hydro Distribution Pole Reference
U_HYDRO_DISTRIBUTION_STUB	Symbol Layer	Red	Hydro Distribution Stub
U_HYDRO_DISTRIBUTION_STUB_REF	Continuous	Red	Hydro Distribution Stub Reference
U_HYDRO_SUBSTATION	Continuous Symbol Layer	Red	Hydro Substation
U_HYDRO_SUBSTATION_REF	Continuous	Red	Hydro Substation Reference
U_HYDRO_TRANSMISSION_DUCT	ACAD_ISO02 W100	Red	Hydro Transmission Duct
U_HYDRO_TRANSMISSION_DUCT_LBL	Continuous	Red	Hydro Transmission Duct Label

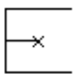
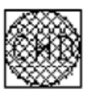
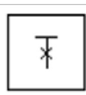
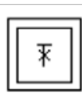
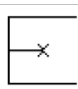
Layer Name	Linetype or Symbol	Colour	Description
U_HYDRO_TRANSMISSION_DUCT_LBL_REF	Continuous	Red	Hydro Transmission Duct Label Reference
U_HYDRO_TRANSMISSION_DUCT_REF	ACAD_ISO02 W100	Red	Hydro Transmission Duct Reference
U_RESERVED_CORRIDOR	Continuous	Cyan	Reserved Utility Corridor
U_RESERVED_CORRIDOR_LBL	Continuous	Cyan	Reserved Utility Corridor Label
U_RESERVED_CORRIDOR_REF	Continuous	Cyan	Reserved Utility Corridor Reference
U_STEAMHEAT_MANHOLE	Symbol Layer	Magenta	Steam Heat Maintenance Hole
U_STEAMHEAT_MANHOLE_REF	Continuous	Magenta	Steam Heat Maintenance Hole Reference
U_STEAMHEAT_PIPE	Continuous	Magenta	Steam Heat Pipe
U_STEAMHEAT_PIPE_LBL	Continuous	Magenta	Steam Heat Pipe Label
U_STEAMHEAT_PIPE_LBL_REF	Continuous	Magenta	Steam Heat Label Reference
U_STEAMHEAT_PIPE_REF	Continuous	Magenta	Steam Heat Pipe Reference
U_TELCO_ABANDONED	Continuous	Yellow	Telco Object Abandoned
U_TELCO_BOX	Symbol Layer	Yellow	Telco Box
U_TELCO_BOX_REF	Continuous	Yellow	Telco Box Reference
U_TELCO_CHAMBER	Continuous	Yellow	Telco Chamber
U_TELCO_DUCT	Continuous	Yellow	Telco Duct
U_TELCO_DUCT_LBL	Continuous	Yellow	Telco Duct Label
U_TELCO_DUCT_LBL_REF	Continuous	Yellow	Telco Duct Label Reference
U_TELCO_DUCT_REF	Continuous	Yellow	Telco Duct Reference
U TELCO_MANHOLE	Symbol Layer	Yellow	Telco Duct Maintenance Hole
U_TELCO_MANHOLE_REF	Continuous	Yellow	Telco Duct Maintenance Hole Reference
U_TELCO_POLE	Continuous Symbol Layer	Yellow	Telco Pole
U_TELCO_POLE_REF	Continuous	Yellow	Telco Pole Reference
U_TELCO_SACPAD	Symbol Layer	Yellow	Telco Sac Pad
U_TELCO_SACPAD_REF	Continuous	Yellow	Telco Sac Pad Reference
U_TELCO_STUB	Symbol Layer	Yellow	Telco Stub
U_TELCO_STUB_REF	Continuous	Yellow	Telco Stub Reference

Notes:
(1) Reference (suffix_REF) layers are intended for those utility objects not included in design submission but necessary for reference.

7.7.8 SYMBOLS

Symbol name (or block name), its location based upon insertion point and layer inserted, are of primary importance and listed in ***Table 7-4***. The symbol configuration or block shape, colour etc. is not critical.

Table 7-4: Symbols

Symbol	Symbol Name	Description
	U_HYDRO_DISTRIBUTION_BOX	Utility Hydro Distribution Box
	U_HYDRO_DISTRIBUTION_MANHOLE	Utility Hydro Distribution Maintenance Hole
	U_HYDRO_DISTRIBUTION_POLE	Utility Hydro Distribution Pole
	U_HYDRO_DISTRIBUTION_STUB	Utility Hydro Distribution Stub
	U_HYDRO_SUBSTATION	Utility Hydro Substation
	U_STEAMHEAT_MANHOLE	Utility Steamed Heat Maintenance Hole
	U_TELCO_BOX	Utility Telephone Company Box
	U_TELCO_MANHOLE	Utility Telephone Company Maintenance Hole
	U_TELCO_POLE	Utility Telephone Company Pole
	U_TELCO_SACPAD	Utility Telephone Company Sacpad
	U_TELCO_STUB	Utility Telephone Company Stub
	SL_NODE_POLE_TROLLEY	Street Electrical Trolley Pole
	U_TRANSIT_POLE	Transit Pole

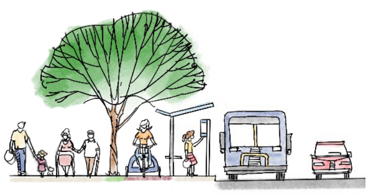
7.7.9 LINE STYLES

Line styles are controlled by layer. Only standard AutoCAD line styles are supplied. Custom line styles are currently created on a per project basis.

THIRD-PARTY UTILITIES

8

STREETS & TRANSPORTATION



STREETS & TRANSPORTATION

8.1 INTRODUCTION

Vancouver operates a large network of streets. These streets link all the various neighbourhoods in the City such as the Downtown Core, Kitsilano, Hastings-Sunrise, and Mount Pleasant. Each district has its own unique qualities which influence various design characteristics.

The following is a brief description of each section:

- The *Design Approach* section outlines the overarching principles involved in complete streets design. It includes sections such as prioritization, street types, and accessibility.
- The *Transportation Assessment and Management Study* section outlines resources available to complete transportation assessments.
- The *Sidewalks and Pedestrian Facilities* section specifies the requirements for pedestrians.
- The *Bicycle Facilities* section outlines specific requirements for designing for bicycles.
- The *Transit Facilities* section discusses how transit fits into the complete streets design.
- The *Motor Vehicle Facilities* section outlines the requirements for motor vehicles.
- The *Intersections* section specifies the requirements for intersection design in Vancouver.
- The *Pavement Markings* section provides information on the specific requirements of pavement markings in the City of Vancouver.
- The *Traffic Signage* section gives signage and wayfinding standards for pedestrians, bicycles, and motor vehicles.
- The *Pavement Design* section outlines the requirements for pavement design and performance and includes a section on specialty pavements.
- The *Structural Design* section provides general requirements for Vancouver-specific structures such as bridges, seawalls, docks, and walls.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

8.2 DESIGN APPROACH

Vancouver is a multi-modal city. The transportation network should be designed to provide people with convenient and delightful options as outlined in the *City of Vancouver Complete Streets Policy Framework*, *City of Vancouver Transportation 2040 Plan*, and other guiding documents. For further information relating to the design philosophy, process, and coordination, refer to *Chapter 1: Introduction* and *Chapter 2: Design Process & Coordination*.

8.2.1 HIERARCHY OF MODES

As outlined in the *City of Vancouver Transportation 2040 Plan*, City street designs should support Vancouver's "hierarchy of modes" for moving people and the efficient movement of goods. Prioritized below is Vancouver's "hierarchy of modes" for moving people:

1) Walking.
2) Cycling.
3) Transit.
4) Taxi, Commercial Transit, and Shared Vehicles.
5) Private Automobiles.

The hierarchy is intended to help ensure that the needs and safety of each group of street users are considered in priority when decisions are being made. Each time a new roadway is designed or an existing one changed, opportunities for improving walking and cycling will be reviewed, and protected bicycle facilities are to be included in all new arterial, collector, and select local roadway design and construction.

In addition to moving people, the efficient movement of goods and City service vehicles will continue to be a high priority for the City. Long distance goods movement is important to provincial and national economies and to Vancouver's role as a port city. Smaller scale local movement is essential to a thriving economy and high quality of life.

Emergency services also require special consideration. Designers must consider measures to help ensure that police, fire, ambulance, and other emergency providers can reach their destinations in a timely fashion.

This is a general approach and in highly constrained urban environments, it is not always possible to provide the ideal facilities for all users' needs. This is especially the case for streets with limited rights-of-way that play a special role for a particular mode or use (such as transit or goods movement).

8.2.2 DESIGN DISCRETION

Street design is a complex endeavor, and designs must respond to varied local conditions and site constraints. Designers must recognize not all streets are the same - some are part of the transit or truck network, for example, while others might be gathering spaces. Some streets may function in different ways depending on the time of day, week, or season. Commercial streets should be lively spaces that attract people and support local businesses.

Design decisions require flexibility to balance the use of available guidance and engineering judgement with innovations in street design and technological advances. This set of criteria is intended to supplement existing manuals and standards including the *MMCD, City of Vancouver Construction Specifications*, the *City of Vancouver Standard Detail Drawings*, and guidance issued by the National Association of City Transportation Officials (NACTO), the Transportation Association of Canada (TAC), and others.

8.2.3 STREET TYPES AND CLASSIFICATION

Generally, all streets in the City of Vancouver are designed to be in an urban context, and features may vary to match adjacent land uses. For example, pedestrian access is a primary consideration in commercial areas while trucking movement is a primary consideration in industrial areas. The City of Vancouver generally uses the street types and classifications outlined in the most current edition of the *TAC Geometric Design Guide for Canadian Roads*. ***Table 8-1*** outlines the specific classifications of roads used in the City of Vancouver:

Table 8-1: Street Classification

Classification	Description
Pathways	Pathways provide safe, accessible, and vehicle-free corridors for people to walk, run and bicycle.
Car Light & Car Free Streets	Car light or car free streets provide quality spaces for people by restricting motor vehicles and encouraging slow speeds. People cycling either share the space with people walking or have a separate facility. Motor vehicles are restricted either by access or by time of day.
Lanes	Land access, loading and sanitation operations are the primary functions of a lane. Traffic movement is not a consideration. Separate facilities for walking and cycling are generally not provided.
Local	Land access is the primary function of a local street while people movement is a secondary consideration. Sidewalks are provided on both sides. People cycling typically share the roadway with motor vehicle traffic, except where there are heavier vehicle volumes. Traffic calming measures may be considered, especially along cycling routes and around schools and parks.
Collector	People movement and land access are of equal importance for collector roads. Sidewalks are provided on both sides. On bicycle routes, protected facilities must be considered.
Arterial	People movement is the primary consideration for arterial roads while driveway access for motor vehicles is typically not permitted. Major arterials often have multiple lanes for moving traffic and regional goods. Arterials also serve as major bus routes and may have bus priority measures including dedicated lanes. Generous sidewalks are required on both sides. On bicycle routes, protected facilities must be considered.

Specialty treatment areas must be respected and incorporated into proposed designs. The location of these areas and specialty treatment details can be found in the *City of Vancouver Streetscape Design Guidelines* available on the City of Vancouver website.

8.2.4 MAJOR ROAD NETWORK

The Major Road Network (MRN), as defined on the TransLink website, is a designated network of arterial streets that are of particular significance to regional transportation for supporting goods movement, transit services, and traffic movement. The network spans Metro Vancouver and is jointly managed and maintained by TransLink and the municipalities. Modifications to the MRN, such as signal installations and left-turn bays, are eligible for cost-shared funding from TransLink. The *City of Vancouver Transportation 2040 Plan* recognizes the importance of the MRN in facilitating the movement of goods and services, transit, and general traffic throughout the region. It identifies the City's desire to include additional roads in the designated MRN.

Several of the City's arterial roads are part of the regional MRN including Broadway, 41st Avenue, Granville Street, Oak Street, Cambie Street, and Knight Street, among several others.

8.2.4.1 TRUCK ROUTES

In addition to the Major Road Network, the City of Vancouver has designated truck routes to maximise trucking efficiency and to minimize roads required to be designed for large vehicles. See the City of Vancouver website for a map of all truck routes in the City.

8.3 TRANSPORTATION ASSESSMENT AND MANAGEMENT STUDY

Transportation studies requested by the City may include a Transportation Impact Study, a Parking Study, and a Transportation Demand Management Plan; collectively called a Transportation Assessment and Management Study (TAMS). The guidelines for such studies can be found on the City's website and establish the scope, form, and analysis required to properly assess the impacts of a proposed development on existing transportation infrastructure, determine the required mitigation measures, and document the results.

8.4 SIDEWALKS AND PEDESTRIAN FACILITIES

Pedestrians are the top priority in the City of Vancouver's transportation hierarchy. Walking is a fundamental part of all trips and inclusive pedestrian design not only accommodates but welcomes people of all abilities, particularly those with disabilities. Pedestrians are vulnerable road users, and safety and comfort for everyone is paramount on all streets. This section outlines the criteria for designing sidewalks and pedestrian facilities in the City of Vancouver.

8.4.1 ACCESSIBLE PEDESTRIAN DESIGN

The City of Vancouver's goal is to prioritize pedestrians, and the greatest area of concern to pedestrians is locations where vehicles are encountered. There are ways to prioritize pedestrians such as shortening crossing distances by providing curb bulges, reducing the number of traveling lanes for vehicles, reducing the number of driveways across sidewalks, normalizing intersections wherever possible to reduce skewed road alignments and slip lanes, and by providing pedestrian activated audible signals.

Vancouver streets must be accessible to all members of the public of varying ages and abilities. All designs must meet the accessibility requirements outlined in *Chapter 2: Design Process & Coordination* as well as in this chapter.

8.4.1.1 DEFINITIONS

It is essential that design for people with mobility challenges should be to the highest possible standards. This requires knowledge of the capabilities of different types of people. This section provides information on the basic human requirements for ease of movement. In designing or modifying pedestrian facilities, the designer should aim to be generous in the allocation of space.

The term disability is a broad one, which includes people with physical, sensory, or mental impairment. Many, though not all, face barriers to movement in the environment. Accessible design intends to remove or reduce these barriers for those with disabilities, as well as many other people not conventionally considered to have a disability who also encounter barriers to movement.

Disability is defined by the World Health Organization (WHO) as the temporary, prolonged, or permanent reduction or absence of the ability to perform certain commonplace activities or roles, sometimes referred to as activities of daily living.

There are various ways or models used to define disability, but accessible design is mainly concerned with the following:

- **Locomotion** - which includes people who use wheelchairs and those who can walk but only with difficulty often using some form of aid such as a stick or walking frame. Almost 70% of disabled people have locomotion difficulties; those with walking difficulties outnumber wheelchair users by about 10:1.
- **Seeing** - which can be subdivided into blind and partially-sighted people.

- **Hearing -** which can also be subdivided into those who are profoundly deaf and those with impaired hearing, ranging from mild to severe deafness.
- **Reaching, Stretching, and Dexterity -** frequently the result of arthritis, which can make these movements painful and difficult, muscular dystrophy causing a loss of muscular strength, or complaints of the nervous system.
- **Learning Disability -** making it hard to understand complicated information or to use complex machines (like some ticket machines).

It should be remembered that these categories are not mutually exclusive. Many disabled people, particularly older people, have more than one impairment. The following sections give some basic information on the space needed by people when they are standing or moving. There is a lot of variation in this, but if the dimensions given below are used, then the great majority of disabled people will be able to move around the urban environment much more easily.

Some specific design features are essential for safe and comfortable movement by those with disabilities or limited mobility, while also benefitting the general public.

Visually impaired people and those of limited vision need a good level of lighting and large and legible street signage. These features also create a greater sense of security and make reading signs easier, and therefore providing an essential service for people with a particular disability but also benefitting a wider group of people. For street lighting design requirements, refer to *Section 10.3*.

Certain types of disabilities may have more specific needs in order to safely navigate. For example, audible tones, accessible signals, and cues at a controlled pedestrian crossing are beneficial if a blind person is to know when the walk signal is displayed.

8.4.1.2 WALKING DISTANCES

Walking distances were researched in some detail in the late 1980s and, based on research, the values in ***Table 8-2*** are recommended for maximum distances between a resting spot, such as a bench:

Table 8-2: Walking Distances

Impaired Group	Recommended Distance Between Resting Spot
Wheelchair users	150m
Visually impaired	150m
Mobility impaired using a stick	50m
Mobility impaired without walking aid	100m

These figures are average measures; there is a lot of variation between individuals. Gradients, weather conditions, and presence of handrails will also affect the distances people are able to walk.

Research based on a follow-up study to the *UK London Area Travel Survey* found that of all the people with a disability who were able to walk at all, approximately 30% could manage no more than 50m without stopping or having severe discomfort and a further 20% could only manage between 50m and 200m.

8.4.1.3 STANDING

Standing is difficult and painful for some disabled people, particularly those with arthritis, rheumatism, and back problems. In the same study as that mentioned above, 9% of the survey respondents could only stand for less than a minute without discomfort, 24% could manage between one and five minutes and a further 22% could stand for up to ten minutes. The findings from this study emphasize the importance of providing plenty of appropriately placed and designed seating at places where people may have to wait and along pedestrian routes.

8.4.2 SIDEWALK DESIGN PRINCIPLES

Sidewalk design should conform to the requirements outlined in this section and the *TAC Geometric Design Guide for Canadian Roads*.

Streets shall be designed to provide safe and comfortable pedestrian movement for people of all abilities. Sidewalks should be generous, unobstructed, and accessible.

In general, the *Engineering Services Department* strives to consistently place sidewalks in a logical order to assist wayfinding and provide guidance throughout the City for all pedestrians and, in particular, people who are blind. The minimum sidewalk width typically allows for people using wheelchairs to pass one another as well as accommodating people walking side by side and communicating through sign language. Curb ramps are installed to provide access for people who use wheelchairs or other forms of mobility aides.

Standards for sidewalks are outlined in the *MMCD* and are generally used by municipalities in British Columbia. The *Engineering Services Department* has the *City of Vancouver Construction Specifications* that is used in conjunction with the *MMCD*. The design standards for sidewalks and curb ramps are contained in the *City of Vancouver Standard Detail Drawings C1.1* to *C2.2* and *C8.1* to *C9.1*.

8.4.3 GEOMETRY

8.4.3.1 SIDEWALK WIDTHS

Sidewalks are located in the space between the back of curb and the property line (or, occasionally, partly or wholly on private property through a statutory right of way). This space, typically 5.5m wide in commercial areas, is divided between sidewalks, which provide clear space for walking, and boulevards, which provide space for trees, utilities, and street furnishings. Sidewalk widths shall be as per ***Table 8-3***. For new development, the preferred width shall be provided.

Table 8-3: Sidewalk Widths

Land Use	Street Type	Minimum Width	Preferred Width
Single Family Residential	Local	1.8m	1.8m
Single Family Residential	Collector or Arterial	1.8m	2.1m to 2.4m
Multi Family Residential	Local	1.8m	2.1m to 2.4m
Multi Family Residential	Collector or Arterial	2.1m	2.4m
Commercial	Local, Collector or Arterial	2.4m	3.0m - 4.0m

Notes:
1) Sidewalk widths shall be modified on a case-by-case basis based on considerations including adjacent land use, pedestrian volumes, transit, being part of a greenway etc.
2) Additional frontage zones may be required on a case-by-case basis.

8.4.3.2 ALIGNMENT

In general, the alignment of the sidewalk should be parallel to the alignment of the property line and road centerline. Sidewalks are to follow straight and consistent alignments with continuity across streets, lanes, intersections, and other interruptions to help improve wayfinding for people with visual impairments. The sidewalk may need to meander around obstacles although this should be avoided when possible. Sidewalks are required on both sides of the road unless specified otherwise by the City Engineer.

8.4.3.3 CROSSFALL AND GRADES

Sidewalks should be designed with a 2% crossfall draining towards the gutterline; however, when site constraints exist, the crossfall may be reduced to a minimum of 1% or increased to a maximum of 4%.

Sidewalks to have a maximum longitudinal slope of 5%. Provide flat landing areas where possible in locations shown in ***Table 8-2*** and with steep longitudinal and crossfall slopes.

8.4.4 SIDEWALK TYPES

The typical sidewalk in the City of Vancouver is Portland Cement Concrete with sawcut joints; however, many areas in the City have special concretes and treatments such as exposed aggregates, exposed glass, pavers, or porous concrete. The location of these areas and specialty treatment details can be found in the *City of Vancouver Streetscape Design Guidelines* at www.vancouver.ca/streetscape. The designer should confirm with the City which sidewalk treatment is to be used for the specific design area.

8.4.5 SURFACE SLIP RESISTANCE

Broom-finished concrete sidewalks with sawcut control joints provide the best surface for wheelchairs users. Vibrations are drastically reduced from those which have troweled control joints.

Concrete pavers, when used, must be laid in a smooth, uniformed manner, have a small chamfer edge 2-6mm and be installed in a 90˚ herringbone pattern to produce lower vibration exposure.

Covers and grates are to be avoided in walking areas, but when they are necessary, they shall be installed flush with the surrounding surface and slip-resistant. The maximum opening on any grate or cover should be 13mm, and if elongated, placed at right angles to the predominant direction of travel.

8.4.6 BOULEVARDS

Front boulevards, also referred to as utility strips, are located between the back of curb or pavement edge and the sidewalk and may contain utility covers, poles, and street trees. Back boulevards, also referred to as building strips, are located behind the sidewalk and are called building strips when adjacent to a building. If widths are constrained, front boulevards take precedence over back boulevards since they act as a buffer to traffic. Sidewalks shall meet design criteria for longitudinal and crossfall slopes; where possible, adjust crossfall slopes within the boulevard width to prioritize pedestrian facilities.

Refer to the *City of Vancouver Boulevard Gardening Guidelines* and *Chapter 9: Streetscape & Urban Forest* for softscape treatments other than grass.

Table 8-4 outlines the widths and materials for boulevards. Additional setbacks and / or rights-of-way may be required where a second row of trees or patio areas are desired.

Table 8-4: Boulevard Widths and Materials

Land Use	Front Boulevard Width (from back of curb)	Back Boulevard Width	Boulevard Material
Residential	• > 1.5m typical for larger street trees • 1.2m minimum for street trees • 0.9m minimum for street lights or trolley poles • 0.6m minimum	• 1.2m - 1.5m typical • 0.3m minimum	• Typically, absorbent Topsoil and Sod (hard surface below 0.6m)
Commercial	• 1.2m typical for street trees • 0.9m minimum for trolley poles • 0.6m minimum	• Minimum 0.3m to accommodate construction	• Hard Surface

Table 8-5 provides the typical slopes for boulevard and cut and fill slopes:

Table 8-5: Boulevard Slopes

Type	Slope		
	Minimum	Preferred	Maximum
Concrete	1%	Match Sidewalk (2%)	4%
Grass	1%	3%	10%
Cut Slope (Non-Walkable, Temporary)	1%	-	50%
Fill Slope (Non-Walkable, Temporary)	1%	-	25%

8.4.7 PATHWAYS

Off-street pathway widths will vary depending on many considerations. In urban areas, where significant through bicycle traffic may be expected, a separate pathway for people walking and biking should be provided. See *Section 8.5.4* for bicycle pathway widths.

Walking paths shall be a minimum of 1.8m wide but in many cases will need to be wider to account for pedestrian volumes and other considerations. For example, the Seaside Greenway walking pathway ranges from a 3.0m minimum width in retrofit areas to a preferred width of 4.5m or wider in newer areas.

8.4.8 STREET TREES

When space permits, front boulevards should be designed with a minimum width outlined in ***Table 8-4*** to accommodate the planting of street trees.

Street trees serve a number of purposes in the urban environment. As well as absorbing CO_2, they create a natural barrier between the road and pedestrian walkways, provide shade to pedestrians, and keep hardscapes cooler in the hot weather. Trees also intercept rainfall to reduce run-off into the storm basins. Along with these attributes, Vancouver has been challenged by the impact to sidewalks. The City has actively pursued species that have less invasive root systems, are hardy, pest / disease resistant, and meet the requirements for their unique location. To try and mitigate the impact of the root systems on sidewalks, Vancouver installs root barriers at all new street trees. These shields deflect the roots down under the sidewalk far enough below the surface to reduce and delay disruption to the sidewalk. Refer to *Chapter 9: Streetscape & Urban Forest* for additional information.

8.4.9 STREET FURNITURE AND ABOVE GROUND UTILITIES

Street furniture and utilities may be an obstacle to pedestrians that use mobility aides and pedestrians who are blind or have low vision. For this reason, the City endeavours to place infrastructure such as posts, poles, and fire hydrants in the front boulevard of the sidewalk area and leave the minimum sidewalk clearance as specified in *Section 8.4.6* behind the front boulevard. When or where placement of furniture, like bus shelters or benches, cannot be accommodated in such a manner, the default is to provide a minimum clear sidewalk, as per ***Table 8-3***. Refer to *Chapter 9: Streetscape & Urban Forest* for additional information.

8.5 BICYCLE FACILITIES

Following pedestrians, people cycling are the next consideration in the City of Vancouver's transportation hierarchy. As another vulnerable road user, the safety and comfort of cyclists and other similar wheeled road users must be maintained through thoughtful design. This section outlines the criteria for designing bicycle facilities as part of a network of complete streets in the City of Vancouver.

8.5.1 BICYCLE FACILITY DESIGN PRINCIPLES

Bicycle facility design should conform to the requirements outlined in this section and the *TAC Geometric Design Guide for Canadian Roads*. Bicycle facility design should also consider design guidance from NACTO, CROW and others.

The following should also be considered when designing bicycle facilities:

- The design should consider the City's transportation policy to build and upgrade bicycle routes that are safe and comfortable for people of all ages and abilities.
- The design should attempt to reduce the risk of a collision between opening parked cars' doors and the person cycling.
- Care should be taken to reduce the risk of a collision between people cycling and motor vehicles or between people cycling and pedestrians. Dangerous configurations must be avoided.

Bicycle design speed is based on the preferred speed of faster cyclists. Typically, the design speed is 30km/hr; however, for bicycle facilities with downgrade hills exceeding 4%, a 50km/hr design speed may be used. The design speed shall be confirmed with the City prior to designing the bicycle facility.

8.5.2 AAA NETWORK

Vancouver has a vision to make cycling safe, convenient, comfortable, and fun for people of All-Ages-and-Abilities (AAA) including families with children, seniors, and new riders. An inviting and connected network of low stress AAA routes will provide a wide spectrum of the population the option to cycle for most short trips. The designer must also consider the various types of bicycles and other wheeled active transportation modes including cargo bicycles, bicycle trailers, skateboards, rollerblades, e-bikes, and emerging electric wheeled mobility devices. The general approach to creating AAA routes on City streets are:

- Ensuring low motor vehicle volumes, < 500/day, and speeds, < 30km/hr, on local streets by using traffic calming and diversionary measures as needed.
- Providing physical separation on busy streets.

Additional considerations when designing AAA routes can be found in the *City of Vancouver Design Guideline for AAA Cycling Routes*.

8.5.3 TYPES OF BICYCLE FACILITIES

Accommodating people of all-ages and-abilities is a key consideration in choosing an appropriate bicycle facility type. It is recognized that this is an ambitious goal requiring significant upgrades to existing bicycle infrastructure to achieve. Therefore, in the short term, infrastructure can be upgraded incrementally moving along the spectrum towards AAA. Potential facility types are shown in ***Figure 8-1***.

Figure 8-1: Spectrum of Facility Types

The selection of a specific facility type may also consider:

- Site constraints such as right-of-way width, existing conditions, grades, and terrain.
- The volume of expected bicycle trips and network connectivity needs.
- The street classification, function, and vehicle speeds.
- Financial and other scope constraints.

8.5.3.1 OFF-STREET BICYCLE PATHWAYS

Off-street bicycle paths are pathways that do not follow the same alignment as a roadway, such as pathways through parks or segments of the Seawall. They are the most comfortable facility for people on bicycles. Off-street bicycle pathways generally should be paved with asphalt. However, paving stones, sawcut concrete, or other special treatments may be considered through parks, plazas, and other context-sensitive areas. While some existing off-street pathways are shared with pedestrians, in most situations new off-street pathways should be designed with separate and intuitive walking and cycling space.

8.5.3.2 PROTECTED BICYCLE LANES

Protected bicycle lanes are paved lanes that are separated from motor vehicles by a physical barrier. The physical barrier protects people on bicycles from motor vehicles in the mid-block enhancing comfort and safety. They may consist of raised buffers such as curbs, gravity barriers, or planters with the bicycle lane at road grade; raised buffers such as curbs with the bicycle lane flush with the buffer; or parking lanes protecting the bicycle lane from motor vehicle traffic.

Special attention must be given to the design of intersections. Protected bicycle lanes may be two-way, one-way on each side of the road, or one-way on one side of the road. In general, due to intersection complexity, two-way protected bicycle lanes are not allowed on one side of two-way roadways. At complex or high turn volume locations protected bicycle signal phases are recommended.

8.5.3.3 LOCAL STREET BIKEWAYS

Local street bikeways are relatively quiet neighbourhood streets where cyclists share the roadway with motor vehicles. To enhance the safety and comfort for people, traffic calming and diversionary measures are often used to reduce motor vehicle volumes and speeds. Enhanced crossing measures for cycling are provided at intersections.

8.5.3.4 PAINTED BICYCLE LANES AND PAINTED BUFFERED BICYCLE LANES

Painted bicycle lanes are separated from traffic by paint lines. Since there is no physical barrier separating the rider from moving vehicles, painted bicycle lanes feel less safe and less comfortable to the person on a bicycle and are generally only used by more experienced riders.

Where space allows, a painted buffer may be added to enhance comfort. Painted buffers can provide clearance from opening vehicle doors and fast-moving motor vehicle traffic. *Section 8.5.4.6* provides preferred space allocation for painted bicycle lanes adjacent to parking.

8.5.3.5 SHARED USE LANES

Shared use lanes are relatively busy streets where cyclists share traffic lanes with motor vehicles. Sharrows are typically used to indicate to cyclists where they should generally position themselves in the roadway.

Shared use lanes provide the least protection from motor vehicles and are generally only used by the most experienced riders. Therefore, this treatment may only be considered for special circumstances such as filling a temporary gap in the cycling network.

8.5.4 GEOMETRY

8.5.4.1 LANE WIDTHS

Table 8-6 provides the minimum and preferred widths for bicycle facilities:

Table 8-6: Bicycle Facility Widths

Bicycle Facility	Absolute Minimum Width	Minimum Width	Preferred Width
Two-Way Protected Bicycle Lane	2.7m	3.0m	3.5m-4.5m
One-Way Protected Bicycle Lane	1.5m	2.0m	2.4m-3.0m
Painted Bicycle Lane	1.2m	1.5m	1.8m-2.0m
Off-Street Bicycle Paths	case-by-case basis, generally according to protected bicycle lanes above		

Notes:
1) For high volumes facilities such as the seawall, use the higher end of the design range.
2) Edge conditions must be considered when determining appropriate bicycle lane width. If vertical obstructions such as lamp poles are present, then an additional width of 0.3m (0.6m preferred) should be added to the values in the table above. Gutter pans and drainage grates must also be considered as they can reduce usable bicycle lane width.
3) The use of absolute minimum widths is intended for short distances (e.g. past bus stops) and requires approval from the Director of Transportation.

8.5.4.2 HORIZONTAL AND VERTICAL ALIGNMENT

Horizontal and vertical alignments including horizontal curvature, stopping sight distances, and vertical curvature shall be based on the *TAC Geometric Design Guide for Canadian Roads*.

8.5.4.3 GRADES

Bicycle facility grades should be kept to a minimum of 1.0%. A 3% grade or less is preferred when designing new bicycle bridges or ramps. Where this is not achievable because of significant costs or impacts, grades up to 5% may be considered. Steeper grades when following topography may be considered for short distances where no reasonable alternatives exist.

8.5.4.4 CROSSFALL

Bicycle facility crossfalls typically match the roadway crossfall outlined in *Section 8.7.3.4* if it is at the same elevation and adjacent to the roadway or the sidewalk crossfall outlined in *Section 8.4.3.3* if it is at the same elevation and adjacent to the sidewalk. For adequate drainage, the bicycle facility cross fall may be 1-4% with a 2% crossfall preferred.

8.5.4.5 BICYCLE LANE BUFFERS

Buffers are lateral spaces separating a bicycle facility from other street features. They may include painted gore areas, different material types, curbs, landscaping, or other physical features.

Table 8-7 provides minimum and preferred widths for buffers separating bicycle lanes from parking lanes, travel lanes, and sidewalks:

Table 8-7: Buffer Widths

Buffer Type (from face of curb or centre of paint line)	Minimum Width	Preferred Width
Between Protected Bicycle Lane and Parking Lane		
Painted Buffer (Bicycle lane at road grade)	0.9m	≥1.3m
Raised Buffer	0.7m	≥1.0m
Raised Buffer with Trees	1.35m	≥1.65m
Raised Buffer Zone Adjacent to High-Volume Drop-off	0.9m	≥1.65m
Bus Stop Island with Shelter	2.75m	≥ 3.0m
Between Bicycle Lane and Travel Lane		
Painted Buffer	0.3m(1)	≥0.6m(1)
Raised Buffer (Bicycle lane at road grade)	0.4m(1)	≥0.8m(1)
Raised Buffer (Bicycle lane flush with buffer)	0.15m(1)	≥0.6m(1)
Raised Buffer with Trees (Including top of curb with bicycle lane flush with buffer)	1.35m	≥1.65m
Between Bicycle Lane and Sidewalk		
Differing Materials or Painted Line	0.0m	0.0m
Bevel Curb (50mm Elevation Difference)	0.15m	0.15m
Treed Median (Same elevation)	1.2m + curb(s)	≥1.5m + curb(s)

Notes:
(1) The minimum widths are for unidirectional bicycle lanes. For bidirectional bicycle lanes, these values are increased to a minimum of 0.6m and >1.0m preferred.

Any exceptions below the minimum widths listed above require approval from the Director of Transportation.

8.5.4.6 SPACE ALLOCATION FOR PARKING, BICYCLE LANE, AND BUFFERS

Table 8-8 shows the potential space allocation for parking, bicycle lanes, and buffers for conventional and parking protected bicycle lanes.

Table 8-8: Space Allocation for Parking, Bicycle Lanes, and Buffers

Total Available Parking and Bike Lane Width	Conventional Painted Bike Lane: Travel Lane Buffer (m)	Conventional Painted Bike Lane: Bike Lane Width (m)	Conventional Painted Bike Lane: Dooring Buffer (m)	Conventional Painted Bike Lane: Parking Width (m)	Conventional Painted Bike Lane: Example	Parking Protected Bike Lane with Painted Buffer: Parking Width[1] (m)	Parking Protected Bike Lane with Painted Buffer: Buffer Width (m)	Parking Protected Bike Lane with Painted Buffer: Bike Lane Width (m)	Parking Protected Bike Lane with Painted Buffer: Example	Configuration Restrictions and Preferences	Width Notes
3.9											Bike facility adjacent to parking not feasible.
4.0	0.0	1.5	0.3	2.2	King Edward Ave.						Absolute minimum for bike lane adjacent to low turnover parking.
4.1	0.0	1.5	0.4	2.2							
4.2	0.0	1.5	0.5	2.2						Parking protected bike lanes not feasible.	
4.3	0.0	1.5	0.6	2.2	Yukon St.						Preferred minimum and absolute minimum where parking turnover is high (commercial areas).
4.4	0.0	1.5	0.7	2.2							
4.5	0.0	1.5	0.8	2.2							
4.6	0.0	1.5	0.9	2.2		2.2	0.9	1.5	Richards St.		Absolute minimum for parking protected bike lane with painted buffer.
4.7	0.0	1.6	0.9	2.2		2.2	0.9	1.6			
4.8	0.0	1.7	0.9	2.2		2.2	0.9	1.7			
4.9	0.3	1.5	0.9	2.2		2.2	0.9	1.8			
5.0	0.4	1.5	0.9	2.2		2.2	0.9	1.9			
5.1	0.5	1.5	0.9	2.2		2.2	0.9	2.0	Beatty St.	Recommend parking protected bike lanes where appropriate.[2]	Preferred minimum for parking protected bike lane with painted buffer.
5.2	0.6	1.5	0.9	2.2		2.2	0.9	2.1			
5.3	0.6	1.6	0.9	2.2		2.2	0.9	2.2			
5.4	0.6	1.7	0.9	2.2		2.2	0.9	2.3			
5.5	0.6	1.8	0.9	2.2		2.2	0.9	2.4			
5.6	0.6	1.9	0.9	2.2		2.2	0.9	2.5	Union St.		
5.7	0.6	2.0	0.9	2.2		2.2	1.0	2.5			
5.8						2.2	1.1	2.5			
5.9						2.2	1.2	2.5			
6.0						2.2	1.3	2.5		Parking protected bike lanes or increasing streetscapes space is preferred.[3]	Nominal width parking protected bike lane with painted buffer.
6.1						2.3	1.3	2.5			
6.2						2.4	1.3	2.5			

(1) Combined parking lane and vehicle travel lane width is typically minimum 5.5m. Additional width may be needed for bus stops or along truck routes.
(2) Consider facility continuity, land use etc.
(3) May use double buffered bike lanes in exceptional circumstances.

STREETS & TRANSPORTATION

8.6 TRANSIT FACILITIES

Transit is the third consideration in the City of Vancouver's transportation hierarchy. Along busy bus routes, facilities for transit vehicle priority may be given greater importance than other modes in the hierarchy. The provision of high-quality transit shelters and waiting areas are also important considerations for complete streets design. This section outlines the criteria for designing transit facilities in the City of Vancouver.

8.6.1 TRANSIT DESIGN PRINCIPLES

Transit facilities are an integral component of the City's transportation network. All street designs are required to make provisions for existing bus routes and stops as well as making considerations for future transit facilities.

Transit designs must correspond to current guidelines such as the:

- *TransLink Bus Infrastructure Design Guidelines*.
- *TransLink Transit Passenger Facility Design Guidelines*.
- *Canadian Urban Transit Association (CUTA) Guidelines*.
- *TAC Canadian Transit Handbook*.
- *NACTO Transit Street Design Guide*.

8.6.2 BUS LANES

Care should be taken when designing the curb lane at bus stops. Refer to *Section 8.7.3.1* for preferred lane widths. Curb lanes at bus stops should be either less than 4.8m wide causing cars to stop behind the loading bus or greater than 5.8m wide allowing cars to pass the loading bus.

8.6.2.1 PRIORITY BUS LANES

Priority bus lanes should be considered along routes with high transit ridership. This may include full-time or time-restricted priority lanes.

8.6.3 BUS STOPS

Bus stop design guidance has been developed by TransLink which has developed the *TransLink Universally Accessible Bus Stop Design Guidelines* as part of their Access Transit Project. The guidelines include consistent placement of bus stops to provide predictable locations for people who are blind and includes tactile cues like poster collars around poles as an indicator of a bus stop ID pole.

Bus stops shall be in accordance with the *City of Vancouver Standard Detail Drawings C16.1*. For floating bus stop islands, refer to emerging guidelines from NACTO and other sources, and contact the City of Vancouver for specific requirements.

8.6.4 STREETCARS

Consideration of streetcar space requirements and operation is required along streets where future streetcar routes are planned. Refer to the latest City plans and streetcar studies for proposed routing.

8.6.5 FERRIES

New and upgraded ferry docks shall be designed for wheelchair accessibility. Other requirements and features shall be determined on a case-by-case basis.

8.7 MOTOR VEHICLE FACILITIES

Motor vehicles will continue to be an important consideration for the foreseeable future. Designing for vehicles includes private passenger vehicles, shared vehicles, buses, and large and small trucks. Improving safety, improving reliability, and managing congestion are important factors as the City develops a complete street network. Also, curbside management including goods loading, passenger loading, and parking must be considered. This section outlines the criteria for designing vehicular facilities in the City of Vancouver.

8.7.1 MOTOR VEHICLE DESIGN PRINCIPLES

Motor vehicle design should conform to the requirements outlined in this section, the *MMCD Design Guideline Manual* and the *TAC Geometric Design Guide for Canadian Roads*.

As outlined in *Section 8.2.1*, it is important to ensure the hierarchy is considered when making design priority decisions.

8.7.2 DESIGN VEHICLES

Design vehicle selection is a key control in specifying geometry of roads and intersections. Design vehicles are separated based on street type and use. All turns at an intersection must be tested in swept path analysis software to ensure the turning movements are accommodated for the design vehicle unless otherwise approved by the City Engineer. In swept path analysis, design vehicles should generally be run at 15km/hr continuous or at 5km/hr following a stop condition. ***Table 8-9*** outlines the typical design vehicles based on street type:

Table 8-9: Design Vehicle Requirements

Street Type	Design Vehicle	Use
Local	Passenger Car (PC), Delivery Truck (SU9), or COV Fire Apparatus (as needed)	Passenger cars (PC) must be able to make all turns. SU9 vehicles are designed to the extent that they can physically negotiate all turns but may have to make special maneuvers such as shortcut a left turn at a traffic circle, roll onto the traffic circle apron, or wait until other traffic clears to make the turn such as a car stopped at a stop sign.
Local (Industrial Areas)	Passenger Car (PC), Delivery Truck (SU9), and Medium Semitrailer Truck (WB-15)	Passenger cars (PC) must be able to make all turns. For designing the turns, the same rules apply for SU9 and WB-15 as for SU9 vehicles on local residential streets.
Collectors	Fire / Delivery Truck (SU9)	Passenger cars (PC) must be able to make all turns. SU9s may straddle lanes in order to make turns but must not cross the Directional Dividing Line (DDL).
Arterials and Truck Routes	Large Semitrailer Truck (WB17), City Bus (B12), or Articulated Bus (A-BUS) depending on street designation	Passenger cars (PC) must be able to make all turns. For left turns, the design vehicle should not cross the DDL and should be able to make the turn entirely from the left-turn bay or left-most lane. Dual left turn lanes are to be designed on a case-by-case basis to accommodate the required design vehicle with a general expectation that large vehicles may require both lanes to physically make the turn. Right turns are designed on a case-by-case basis. On a marked bus route, the bus shall generally turn from the curb lane; however, straddling lanes may be considered if it provides a better pedestrian environment. A bus may turn into multiple receiving lanes. On a truck route, semitrailer truck turns are to be considered on a case-by-case basis, though it is anticipated that semitrailers will straddle lanes or turn from the second lane in order to physically fit.

Table 8-10 provides a description of the common design vehicles in the City:

Table 8-10: Common Design Vehicles

Vehicle Type	Specification	Use
Passenger Car	PC (*TAC-1984*)	Must accommodate all turns at all intersections.
Fire / Delivery Truck	SU9 (*TAC-1984*)	Must accommodate all turns at all intersections.
City Bus	B12 (*TAC-1984*)	Must accommodate all turns at all intersections along the bus route.
Tour Bus / Motor Coach	BUS-14M (*AASHTO-2011*)	Must accommodate all turns at all intersections along the common tour bus routes.
Articulated Bus	A-BUS (*TAC-1999*)	Must accommodate all turns at all intersections along the bus route.
Small Semitrailer Truck	WB-12 (*TAC-1984*)	Must physically accommodate all turns at all intersections along common access routes to and at the delivery access points for certain commercial buildings.
Medium Semitrailer Truck	WB-15 (*TAC-1984*)	Must physically accommodate all turns at all intersections along common access routes to and within light industrial areas and at the delivery access points for certain commercial buildings.
Large Semitrailer Truck	WB-17 (*TAC-1984*)	Must physically accommodate all turns at all intersections between truck routes, in industrial areas, and at the delivery access points for certain commercial buildings. Verify if there is a need to accommodate an even larger truck such as a WB-19 or WB-20 from *TAC-1999*.
Large Semitrailer Truck	WB-20 (*TAC-1999*)	Must physically accommodate all turns at all intersections between truck routes dedicated for servicing the Port of Vancouver.

8.7.3 GEOMETRY

This section outlines the criteria for geometry including lane widths, alignments, grades, crossfall, vehicular clearances, and sightlines in the City of Vancouver.

8.7.3.1 LANE WIDTHS

Design consistency is a factor in traffic safety. Designers should avoid large variations in lane widths and other design elements, where possible. In cases where there is extra width, the pedestrian space, the boulevard, or the treed median should often be widened rather than widening the travel lanes.

Table 8-11 outlines the minimum and preferred lane widths:

Table 8-11: Lane Widths

Lane	Absolute Minimum Width	Minimum Width	Preferred Width
Parking Lanes			
Marked Parking Lane Only	2.2m	2.5m	2.5m
Single Lane with Parking	5.5m	5.5m	5.7m-6.2m
Curb Lane with Full-Time Parking	5.2m	5.5m	5.5m-6.2m
Non-Bus / Truck Route Travel Lanes			
Non-Curb (general) Lane	2.8m	3.0m	3.2m
Curb Lane	2.8m	3.0m	3.4m
Bus / Truck Route Travel Lanes			
Non-Curb (general) Lane	2.8m	3.0m	3.2m-3.4m
Curb Lane	3.0m	3.3m	3.5m-3.7m
Curb Lane with Full-Time Parking	5.8m	6.2m	6.2m-6.5m
Single Lane against curb	3.5m	3.6m	3.6m-3.8m

Notes:
1) Existing City streets may not meet these requirements.
2) Single lane means per direction.
3) Lane widths are measured from gutter line (curb face) when adjacent to curb and gutter.
4) Lane widths for buses and trucks assume large vehicles regularly operating in the lane.

Lane widths along horizontal curves on truck routes require special attention due to the wide turning travel envelope. The lane width on curves should be sufficient to handle the turning travel envelope of the design vehicle plus a minimum 0.2m width on both sides. If necessary, this is typically done by providing a wider lane width through the curve and transitioning the wider lane into the straight segment using compound curves with a 500m radius. A less desirable and effective option is to use simple curves with such radii that would create a wider lane width at the center of the curve (i.e. not a constant offset from the centerline through the curve). This is typically only done with mild deflection angles or when a physical constraint limits the inner curve. In all cases, the lane width should be able to accommodate a street sweeper.

If there is a shortage of width, it is preferred that the minimum lane widths are not compromised. If all other options have been exhausted, a priority should be determined on a case-by-case basis of how the widths will be compromised.

In the City of Vancouver, the typical rights-of-way are 66’ (20m), 80’ (24m) and 99’ (30m) operating as 4 and 6 lane arterial streets. This means that in the majority of the cases, the design lane widths will tend towards the minimum or absolute minimum, as per ***Table 8-11***. In the rare cases when there is a surplus of width, a priority order should be set regarding what to favour. This should be analyzed on a case-by-case basis.

8.7.3.2 ALIGNMENT AND CURVATURE

Alignment and curvature (horizontal and vertical) shall follow the *TAC Geometric Design Guide for Canadian Roads*.

8.7.3.3 GRADES

Roadway grades should meet the requirements of ***Table 8-12***. Exceptions to these values due to site constraints must be approved by the City of Vancouver.

Table 8-12: Longitudinal Grades

Type	Grades		
	Minimum	Preferred	Maximum
Lanes with Asphalt Gutters	1.0%	1.0%	12.0%
Lanes with Concrete Gutters	0.5%	1.0%	12.0%
Streets with Asphalt Gutters	1.0%	1.0%	10.0%
Streets with Concrete Gutters	0.5%	1.0%	10.0%
Curb Returns from BC-EC	1.0%	1.5%	N/A

The maximum change in grade for a roadway not at an intersection is 2.0% over 8m (or 4% over 16m) which corresponds to an equivalent K-value of 4. For grade changes within intersections, see *Section 8.8.4.5*.

8.7.3.4 CROSSFALL

City of Vancouver streets and lanes vary in cross section and may be crowned, center valley, or crossfall. Roadways and lanes should follow crossfalls outlined in ***Table 8-13***:

Table 8-13: Crossfalls

Type	Crossfall		
	Minimum	Preferred	Maximum
Lane Entrances	1.0%	1.0%	5.0%
Lanes	1.0%	2.0% - 3.0%	5.0%
Paver Surfaces	1.5%	2.0%	3.0%
Residential, Collector	1.0%	2.0% - 3.0%	5.0%
Industrial, Commercial, Arterial, Bus / Truck Routes	1.0%	2.0%	4.0%

8.7.3.5 HORIZONTAL AND VERTICAL CLEARANCES

Table 8-14 outlines the required clearances applicable to the roadway:

Table 8-14: Horizontal and Vertical Clearances

Clearance Type	Required Clearance
Horizontal	
Street appurtenances (poles, cabinets, furniture, etc.) clearance to curb face	Preferred Minimum = 0.55m Absolute Minimum = 0.40m
Street light / trolley pole center to curb face	Standard = 0.76m
Vertical	
Roadway to bottom of structure	Minimum = 5.5m
Roadway to communications and guy wires	Minimum = 5.0m
Roadway to electrical conductors up to 90kV	Minimum = 5.5m

Notes:
1) When vertical clearance requirements cannot be met, low clearance signs W-18 and W-19 are to be installed.

8.7.3.6 SIGHT LINES AND DISTANCES

Sight lines and distances shall meet the requirements of the *TAC Geometric Design Guide for Canadian Roads*.

8.7.4 CURB AND GUTTERS

Curbs should be according to the *City of Vancouver Standard Detail Drawings C4.1* to *C6.3*. ***Table 8-15*** provides the typical curbs used in the City:

Table 8-15: Curb Types

Curb Type	Use
Concrete Curb Type A	Wide barrier curb and gutter for collector and arterial streets
Concrete Curb Type B	Medium barrier curb and gutter for local streets and lanes
Concrete Curb Type C	Medium rollover curb and gutter for mountable applications
Concrete Curb Type D	Thick rollover curb and gutter for mountable applications
Concrete Curb Type E	Bicycle / pedestrian mountable separation curb and gutter for separating bicycle lanes and sidewalks
Concrete Curb Type F	Barrier curb with narrow gutter for adjacent to bicycle lanes

8.7.5 MEDIANS AND ISLANDS

Medians and islands are generally designed according to the following:

- *TAC Geometric Design Guide for Canadian Roads*.
- *TAC Synthesis of Practices for Median Design*.

The minimum constructible radius for a standard curb and gutter is 0.6m; therefore, this should be considered when designing median round-offs. If absolutely necessary, this can be reduced for medians built on top of the asphalt instead of using curb and gutter although this is not preferred. Medians shall be in accordance with the *City of Vancouver Standard Detail Drawings C15.1* or *C15.2*.

Median design should consider the needs for emergency vehicle access.

8.7.6 BOLLARDS

The use of bollards should be minimized and only used when necessary. Bollards shall be in accordance with the *City of Vancouver Standard Detail Drawings C12.1* to *C12.8*.

8.7.7 GENERAL PARKING AND CURBSIDE MANAGEMENT

There are seven basic types of curbside regulations used within the City of Vancouver:

- No posted regulations (i.e. unregulated parking).
- Residential Parking Restrictions (i.e. No Parking Except with Permit).
- Time limited parking (i.e. 1-hour or 2-hour time restrictions).
- Metered Parking.
- Rush Hour Regulations (i.e. No Stopping 7 AM – 9:30 AM, 3 PM – 6 PM).
- Special Zones (e.g. Commercial Vehicle Loading Zones, Passenger Zones, etc.).
- Motorcycle Parking.

With the exception of rush hour regulations, the *Parking Management Branch* must be consulted to determine the appropriate types of regulations to be installed on a street. For the installation of rush hour regulations, the *Parking Management Branch* and the *Traffic & Data Management Branch* must be consulted. With the exception of parking meters, all regulatory signage regarding parking regulations can be found in the *City of Vancouver Sign Code Inventory*.

Parking layout shall be in accordance with the following:

- *City of Vancouver Street and Traffic By-law No. 2849*.
- *City of Vancouver Parking Meter By-law No. 2952*.
- *Section 8.7.8*.
- *British Columbia Motor Vehicle Act*.

Typical on-street parallel parking space widths are determined through the geometric design of the street.

The most common parking restrictions in place by by-law, or provincial legislations, are shown in ***Figure 8-2***:

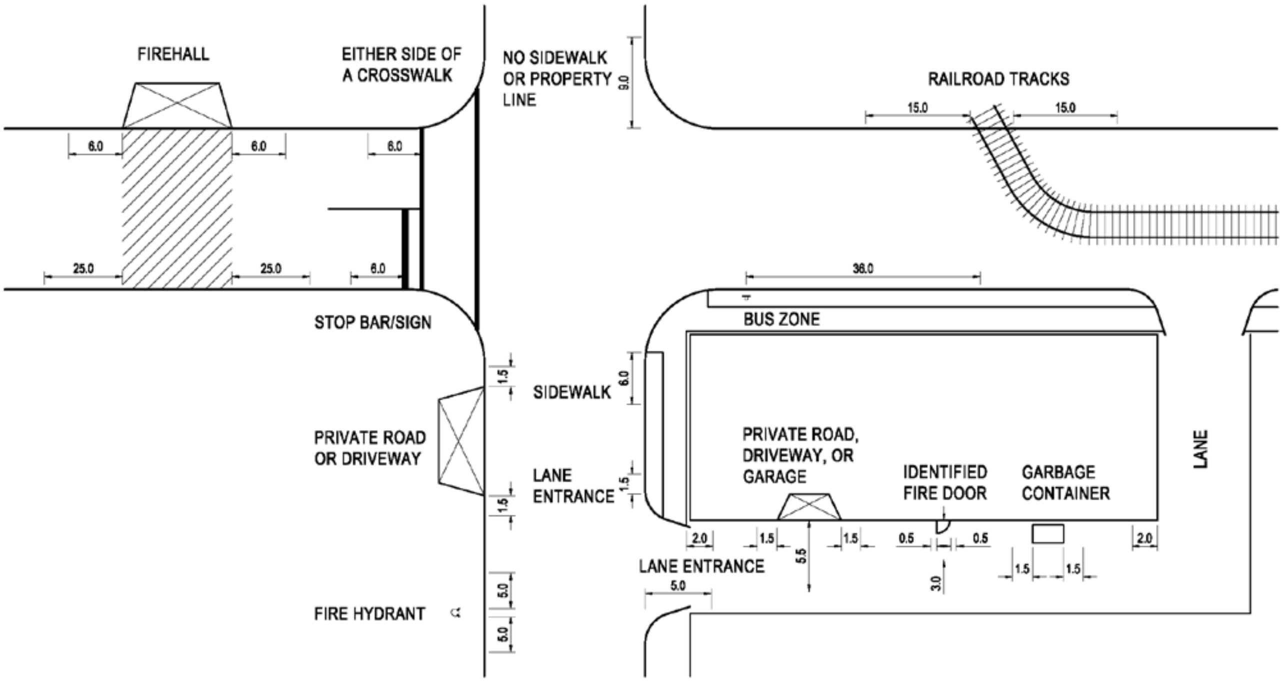


Figure 8-2: Parking Restrictions

8.7.7.1 NO POSTED REGULATIONS

If a street is determined to need no posted regulations, no regulatory parking signage is required. However, in locations of unusual or non-standard geometry, "No Stopping" regulations may be required for clarity.

8.7.7.2 PARKING METERS

Parking meter layout should be in accordance with the *City of Vancouver Standard Detail Drawings R9.1*. The following outlines other parking meter requirements:

- If parking meters are to be installed in a grass boulevard, sleeves should be placed in a concrete pad that consists of $0.4m^3$ of concrete and is at least 100mm thick. At least 100mm of clearance should be between the edge of the concrete pad and the outer edge of the metal sleeve.
- Any parking meter sleeves to be placed on a structure must be coordinated with the *Streets Design Branch*.
- Meter heads shall be placed parallel to the curb line.
- Parking meters (poles and equipment) are to be installed by the *Parking Operations and Enforcement Branch*.

8.7.7.3 DISABLED PARKING SPACES

Street parking spots that are marked with disabled parking signs are installed as close to curb ramps as possible, preferably the first spot after the intersection if this area is not already designated for a bus zone. This location provides easy access to the curb ramp at the intersection and allows someone easy access from the road to the sidewalk.

8.7.7.4 SPECIAL ZONES

The installation of special zones such as commercial vehicle loading zones, loading zones, passenger zones, and taxi zones must be coordinated with the *Parking Management Branch*. Generally, special zones should be placed to easily fit in with existing meter layouts. A typical length for a special zone is two metered spaces which is approximately 12m to 13m.

8.7.7.5 BUS ZONES

Installation of bus zones must be coordinated with the *Transportation Design Branch*. Refer to the *TransLink Bus Infrastructure Design Guidelines* for layout criteria. Bus zones must accommodate the design vehicle, either B12 or A-BUS, and the number of bus services which may vary based on the bus route. The typical length for bus zones may vary from 18m to over 42m.

8.7.7.6 MOTORCYCLE PARKING

Motorcycle parking layout should be in accordance with the *City of Vancouver Standard Detail Drawings R8.15*.

8.7.8 PRIVATE PROPERTY LOADING ZONES

Refer to the *City of Vancouver Parking and Loading Design Supplement* on the City's website for designing private property loading zones in the City of Vancouver.

8.7.9 TRAFFIC CALMING

This section outlines the criteria for traffic calming measures in the City of Vancouver.

8.7.9.1 SPEED HUMPS

Speed humps are selected based on the desired speed reduction. Speed humps are not located on arterial streets, collector streets, truck routes, industrial areas, transit routes, roads that are part of an emergency route, roads part of a major road network, or local roads with a slope of 8% or higher.

The following two types of speed humps are used and can be found in the *City of Vancouver Standard Detail Drawings C18.1* to *C18.3*:

- 3.6m long / 80mm high sinusoidal speed hump for 30km/hr zones.
- 4.0m long / 80mm high sinusoidal speed hump for all other streets.
- 3.6m long / 102mm high sinusoidal speed hump for lanes.

Speed humps must be accompanied by the required paint markings and signage. Signage includes speed hump warning signs (WA-22) and speed limit tab (WA-7S for 30km/hr & WA-7S1 for 40km/hr) on both directions. In the case of T-intersections, additional warning signs and speed limit tab should be placed at the top of the T. Paint markings include shark's teeth.

8.7.9.2 CURB BULGES

Curb bulges may be used for the following reasons:

- At street corners and mid-block crossings, bulges provide the crossing pedestrian with a shorter crossing distance and a safe waiting area and lookout point from behind parked cars.
- Curb bulges can define the required parking clearances.
- Curb bulges can be used to restrict certain turning movements.
- In combination with traffic circles, they can serve as a traffic calming device.
- Curb bulges can be used at bus stops to prevent cars from passing while the bus is stopped.

The following criteria applies to the design of curb bulges:

- See the *City of Vancouver Standard Detail Drawings R4.1*.
- The desired effect should be maximized without causing other unwanted inconvenience or driving hazard.
- Vehicles should be able to park as close as possible to the legal corner clearance of an intersection but not closer.
- Bulges should not be wider than 2.5m or narrower than 1.5m.
- All bulges must have object markers on the approach side.
- The reverse curbs must be a minimum of 2.0m from the intersection curb return (shown as T in the *City of Vancouver Standard Detail Drawings R4.2*)
- *City of Vancouver Standard Detail Drawings R4.2* provide typical curb bulge configurations.

8.7.9.3 DIVERTERS

Diversionary traffic calming measures are implemented on local streets to reduce the volume of vehicles on the street. Typically, diversionary traffic calming is installed as part of a bikeway project to reach the City's AAA goals, or it may be a requirement of development to reduce the impact of increased trips from the development on surrounding streets. Traffic diverters are a custom design for each intersection, and depending on the goal of the project, different vehicle turns may be prohibited. Some examples of diversionary traffic calming to restrict vehicle movements are right-in / right-out only, no-entry, right / left turn only (diagonal diverter), full closure, or a center median where turns are restricted on and off an arterial street. The diverter should be designed so that it is physically challenging for a vehicle to disobey the turn restrictions. Roll-over curbs or aprons should be used to narrow the road for passenger vehicles while still allowing larger vehicles, such as fire / garbage trucks to physically make the turn.

Care should be taken when designing traffic diverters to ensure that they comfortably accommodate pedestrians and cyclists. Generally, while diverters restrict vehicle turns, bicycles will be exempted from the prohibition with "except bicycles" on the sign restriction.

8.7.9.4 TRAFFIC CIRCLES

The City of Vancouver installs traffic circles in residential areas to help to reduce vehicle speeds and collisions at intersections. Traffic circles shall be considered on local residential streets, and they shall be avoided under the following conditions:

- Bus routes, emergency response routes, school zones, and industrial areas.
- Offset intersections or intersections with unusual geometry.
- Cycling routes where there are steep grades approaching the intersections.

Traffic circles shall be designed with the following requirements:

- Typically, there are two design vehicles when designing a traffic circle: a passenger car (PC) and a larger vehicle like an SU9 or an emergency vehicle (fire truck).
- The design vehicles must be able to maneuver all turns in all directions with parked cars at all legal locations nearest to the intersections (typically 6m from the nearest edge of the closest sidewalk).
- The center of the circle should be at the center of the two intersecting streets.
- The inner circle shall be the largest possible to allow the larger design vehicle to physically make all movements while getting as close to the curb returns as possible and without the need to drive over the inner circle.
- As a general guide, the outer circle (apron) shall be offset from the inner circle by 0.6m if the inner circle is less than 2.0m in diameter or 1.0m if the inner circle is 2.0m in diameter or greater. The larger design vehicle is allowed to drive over the outer circle apron.
- Passenger car vehicles should not intrude on the pedestrian's path across the intersection (the crosswalk) when making any legal turns, should not mount over the outer circle, and should not conflict with corner radii or parked vehicles.

- Passenger cars shall not be able to drive straight through the intersection without being obstructed by and maneuvering around the traffic circle so that they cannot speed through the intersection.
- The traffic circle shall have appropriate signage such as corner clearance signs and obstruction signs.
- If the circle has vegetation in the centre, planting should be selected and maintained to guarantee proper sightlines.

8.8 INTERSECTIONS

Intersections are where the majority of collisions occur between road users due to the complex decision-making required and potential conflicts between road user movements. Where practical, modes should be separated in both space and time at the intersections to minimize conflicts. This section outlines the criteria for designing intersections in City of Vancouver.

8.8.1 DESIGNING FOR PEDESTRIANS

Pedestrians with disabilities are the most vulnerable road users at intersections, and so intersections must be designed around making pedestrian movements safe, visible, and protected for everyone. This section outlines the criteria for ramps and crosswalks at intersections.

8.8.1.1 CURB RAMPS

Curb ramps are designed for the access of wheelchairs, scooters, strollers, and people with limited mobility. They are also a key cue for blind people using canes or guide dogs. Ramps shall be installed at all corners, should land wheelchair users safely in the crosswalk and in the desired direction of travel, and ideally should be aligned with the adjacent sidewalks. The preferred design is to install double curb ramps wherever possible.

Directional score lines are designed to assist people with visual impairments. They shall guide pedestrians safely into the crosswalk, line up with the ramp across the street, and be parallel with the crossing or marked crosswalk.

Curb ramps shall be installed with a maximum grade of 8% (ranges between 5% and 7% are best). Any grade less than 5% may be undetectable to a pedestrian who is blind or has low vision, thus removing a cue that they are leaving the sidewalk. Where there is sufficient public space, a preferred level landing area of 1.2m (min. 0.9m) shall be provided along the rear side to provide easy passage for wheelchair users who are not crossing the road.

For double curb ramps:

- Where a greener treatment is desired, grass may be installed between the two ramps where there is a reasonable expectation that the adjacent property owner will mow the grass.
- A minimum 1.0m of full height curb between the flares of two adjacent ramps is required.

For large single curb ramps:

- They are used when double curb ramps cannot be accommodated due to obstructions such as poles, utility boxes, and property lines that would result in less than 1.0m of full curb between the two ramps.
- The ramp must adequately land a pedestrian in either crosswalk.

For lane curb ramps:

- Consideration should be given to utilizing a standard commercial lane crossing which gives the impression of running the sidewalk through the lane.
- In residential areas where a grass boulevard exists, a concrete flare may not be required.

Curb ramps shall be designed in accordance with the *City of Vancouver Standard Detail Drawings C8.1* to *C9.1*.

8.8.1.2 MARKED CROSSWALKS

Marked crosswalks are the simplest pedestrian crossing treatment. The minimum standard involves pavement markings indicating the crosswalk and accompanying signs. Marked crosswalks are used to alert motorists to expect pedestrians crossing and to direct pedestrians to the preferred crossing location. Most intersections (e.g. local streets) are not marked with any kind of paint but are legal crossings for pedestrians unless prohibited with signage.

The following reference documents shall be used:

- *MUTCD*.
- *BC MoTI Pedestrian Crossing Control Manual for British Columbia*.
- *TAC Pedestrian Crossing Control Guide*.
- *City of Vancouver Construction Specifications*.
- *City of Vancouver Standard Detail Drawings R8.1* and *R8.9* to *8.13*

Key aspects to consider when selecting the preferred crossing are listed below:

- Natural pedestrian desire lines.
- Presence of favorable pedestrian supporting infrastructure (i.e. curb, sidewalk, curb ramps, and curb bulges if possible).
- Shortest distance for pedestrians to cross the street.
- Proximity to pedestrian generators (i.e. bus stops, schools, playgrounds).
- Guaranteed adequate sightlines of pedestrians crossing.
- Avoidance of potential obstacles such as utility poles, fire hydrants, trees, catch basin grates, and raised traffic islands.
- Avoidance of conflict zones such as driveways.
- No crossings in front of the stop-controlled legs of the intersection.

Marked pedestrian crosswalks must have side mounted back-to-back Pedestrian Crosswalk (RA-4R (right) or RA-4L (left)) signs (*MUTCD Sec A6.4.1*). In the case of marked crosswalks adjacent to an elementary or secondary school, back-to-back School Crosswalk (RA-3R (right) or RA-3L (left)) signs (*MUTCD Sec A6.4.1*) must be placed. The pedestrian crosswalk signs shall be oriented so that the symbolized pedestrian is facing towards the roadway. If visibility of the marked crosswalk is limited, Crosswalk Ahead warning signs (WC-2R/L or WC-16R/L for school crosswalks) are required.

Marked crosswalks are recommended only at arterial or collector streets with the exception of school and playground related crossings on residential streets. Additionally, marked crosswalks are not recommended at multilane roads.

Marked crosswalks are installed at non-signalized intersections when recommended after a detailed study is conducted. The following factors must be considered as part of the review:

- Pedestrian volumes.
- Age and ability of pedestrians.
- Nearest alternative pedestrian crossings.
- Traffic speed and volume.
- Adequate gaps in traffic to cross safely.
- Crosswalk warrants as per the *TAC Pedestrian Crossing Control Guide* and the *BC MoTI Pedestrian Crossing Control Manual for British Columbia*.
- Presence of pedestrian generators.
- Pedestrian collision data.
- Driver's courtesy.
- Road geometry and visibility.

The use of zebra markings is recommended for all marked crosswalks due to their increased visibility. Zebra markings consist of 0.6m wide bars with 0.6m gaps in between. The length of the bars (width of the crossing) is typically 3.0m, but wider crosswalks can be used when higher pedestrian volumes exist (e.g. downtown). There must be a minimum 0.3m gap at each edge of the crossing so that there is a contrasting strip of asphalt between the concrete sidewalks and the white pavement markings.

8.8.1.3 SCHOOL CROSSWALKS

School crosswalks generally follow the principles outlined for zebra crosswalks above. School crosswalks are usually marked on the side of an intersection closest to the school; however, the far side may be marked where conditions warrant and where it is recommended by school staff in consultation with City staff. Requests for school crosswalks are referred to City staff by the school for their investigation and recommendation. City staff investigate on the basis of number of children crossing, routes used by children to go to and from school, available gaps in traffic flow, and adjacent crossing facilities.

Pavement markings shall be installed as described in the *MUTCD (Fig C3-1)* at locations described above. *Section 8.9.1.7* outlines the material requirements for crosswalk markings.

School crosswalks require extended corner clearances (minimum 6m) to be established by using No Stopping Anytime signing. Refer to *Section 8.8.1.2* for the installation of signs. School crosswalk signing remains in place during the summer months. Additionally, certain crosswalks leading to schools with summer classes may be augmented with tab signs indicating summer school.

8.8.1.4 BICYCLE LANE CROSSWALKS

Pedestrian crossings at separated bicycle lanes and bicycle paths are modified zebra crossings as follows:

- 3.0m long by 0.3m wide bars aligned with the movement of bicycle traffic.
- Minimum 0.15m gap (maximum 0.3m) at each edge of the crossing so that there is a contrasting strip of asphalt between the concrete sidewalks and the white pavement markings.
- Remaining gaps between bars to be spaced evenly, but preferably around 0.3m and no greater than 0.45m.

In cases where a pedestrian crossing traverses both a bicycle lane and adjacent motor vehicle lane where there is no physical separation, the standard 0.6m wide zebra crossings shall be used.

8.8.1.5 RAISED CROSSWALKS

Raised crosswalks shall generally follow the principles outlined for zebra crosswalks above but must also be in accordance with the *City of Vancouver Standard Detail Drawings C17.1* to *C17.4*.

8.8.1.6 LANE CROSSINGS

Lane crossings shall be designed in accordance with the *City of Vancouver Standard Detail Drawings C9.2* and *R7.1*.

8.8.1.7 STANDARD MARKED CROSSWALKS

Standard marked crosswalks are limited to signalized intersections. Marked crosswalks shall consist of two white parallel lines. The width of each line shall be 0.2m (*MUTCD Fig. C1-1* or *BC MoTI Pedestrian Crossing Control Manual for British Columbia Figure 1.1*).

The width between the crosswalk lines shall be determined by guidelines described in the *BC MoTI Pedestrian Crossing Control Manual for British Columbia*. Generally, the width will be 3.0m unless pedestrian volumes indicate that a greater width is required or unless physical features indicate that a narrower crosswalk should be installed. In the latter case, the crosswalk should not be less than 2.5m wide. When possible, crosswalks in the downtown core will be a minimum of 4.0m wide and a maximum of 6.0m wide.

The marked crosswalk line nearest the intersection shall be inset a minimum of 0.6m from the projected edge of the street curb line (*MUTCD Section A6.3*) and no greater than 2.0m. In the case of intersections with intersecting crosswalks, it is desirable that the point where the intersection-side crosswalk lines intersect be a distance of 1.0m or less from the edge of the curb return with a maximum of 2.0m where possible.

Standard crosswalks do not require side mounted Pedestrian Crosswalk signs to accompany them.

8.8.2 DESIGNING FOR BICYCLES

Special care must be used when designing bicycle facilities at intersections. Designers should minimize conflicts between all modes by heightening visibility, denoting a clear right of way, and facilitating eye contact and awareness of all users. Safe and comfortable intersections also reduce the risk of injury for all users in the event of a crash. A variety of design treatments may be used depending on the facility type and context. Refer to design guidance from TAC, NACTO, CROW, and other emerging sources. Contact *Transportation Design Branch* staff for the latest guidelines and advice on complex intersection designs.

Sections 8.9.1.12 and *8.9.1.13* outline bicycle pavement markings including the typical use of green treatments at intersections and bicycle stencils and sharrows.

8.8.3 DESIGNING FOR MOTOR VEHICLES

While motor vehicle occupants are the least vulnerable road users at intersections, motor vehicle drivers also carry the most responsibility to ensure the safety of others. Designing intersections to provide drivers with clear visibility and easily understood information is key to designing safer intersections. This section outlines the criteria for vehicular design at intersections.

8.8.3.1 DESIGN VEHICLES

The design vehicle determined in *Section 8.7.2* shall be used for the design of intersections.

8.8.3.2 TURNING MOVEMENTS

The designer shall ensure that the intersection design is suitable to handle the turning movements of the largest design vehicle without mounting the curb (except in the case of rollover curb applications).

8.8.4 INTERSECTION GEOMETRY

This section outlines the required geometry for intersection in the City of Vancouver.

8.8.4.1 INTERSECTION ALIGNMENTS AND SPACING

Intersection alignments and spacing shall follow the *TAC Geometric Design Guide for Canadian Roads*.

8.8.4.2 TURN LANES

Turn lanes shall be designed according to the *TAC Geometric Design Guide for Canadian Roads*. Left-turn bays and lane transition radii are outlined in the *City of Vancouver Standard Detail Drawings R4.3*.

8.8.4.3 OFFSET INTERSECTIONS

Through traffic lanes which have no pavement markings across an intersection should have a deflection less than 1:60 with an absolute maximum of 1:40. Guidelines should be marked across the intersection if the maximum offset is exceeded.

8.8.4.4 CURB RETURNS

Curb returns shall generally be in accordance with the *TAC Geometric Design Guide for Canadian Roads*. Compound curves may be required on arterial streets for specific situations and design vehicles. All new curb returns are to be constructed with standard curb ramps or include curb cuts to allow for future curb ramps where there are not already sidewalks. ***Table 8-16*** outlines the typical curb return radii.

If curb returns larger than as shown in ***Table 8-16*** are desired, the design must be confirmed with swept path analysis software for the design vehicle.

Table 8-16: Curb Return Radii

Location	Curb Return Radius
Lane Entrances	2.0m with Flare
Bicycle Lane Only (No Vehicles)	3.0m
Residential and Commercial	5.5m
Industrial and Bus Route	5.5m or compound curve to best accommodate design vehicle turn
Turn Restricted	1.0m

Curb returns shall be designed with a preferable continuous grade of 1.5% and an absolute minimum grade of 1.0%.

8.8.4.5 GRADES, CURVATURE, AND SIGHT LINES

Intersections shall meet the grading, curvature, and sight line distance requirements outlined in the *TAC Geometric Design Guide for Canadian Roads*. For roads of different classification, the crossfall and profile of the lower classification road should be varied to suit the profile and crossfall of the higher classification road. The maximum changes in grades through an intersection are outlined in ***Table 8-17***:

Table 8-17: Intersection Changes in Grade

Intersection Type	Maximum Change in Grade	Equivalent K Value
Signalized Intersections	2.5% over 8m (or 5% over 16m)	3.2
Stop Sign Only Intersections	3.0% over 5m (or 6% over 10m)	1.6
Driveway and Lane Entrances	12.0% over 5m	-

8.8.5 RAILWAY CROSSINGS

For the design of railway crossings, the following acts, regulations, and standards must be followed:

- *Transport Canada Grade Crossing Standards*.
- *Transport Canada Grade Crossing Regulations*.
- *Transport Canada Railway Relocation and Crossing Act*.
- *Transport Canada Railway Safety Act*.
- *TAC Geometric Design Guide for Canadian Roads*.
- *MUTCD*.
- Applicable railway operator regulations (CN Rail, CP Rail, BNSF, SRY).

8.9 PAVEMENT MARKINGS

Pavement markings are important to separate road users into their respective spaces. Pavement markings in the City of Vancouver generally follow the *MUTCD* with the exception of the specific requirements outlined in this manual. This section outlines the criteria for pavement markings in the City of Vancouver. For material specifications and installation requirements, refer to the *City of Vancouver Construction Specifications*.

8.9.1 ROADWAY MARKINGS

This section outlines the types of roadway markings in the City of Vancouver and the general criteria for their design.

8.9.1.1 LINE PATTERNS

For roadway pavement markings, standard line patterns shall be in accordance with the *MUTCD* and the *City of Vancouver Standard Detail Drawings R8.1*.

8.9.1.2 REFLECTIVE PAVEMENT MARKERS

In general, reflective pavement markers shall be used to define directional dividing lines and lane lines on all new paving or road marking projects.

Reflective pavement markers shall be placed in line with and in front of lane line and directional dividing line dashes, leaving approximately 0.2m of clear pavement between the marker and the dash. For directional dividing line dashes, reflective pavement markers shall be placed at the approach end of the dash.

For solid lane lines and directional dividing lines, reflective pavement markers shall be placed abutting the line on the north side of the line for east / west streets and on the west side of the line for north / south streets, leaving approximately 25mm of clear pavement between the marker and the lane line. For double solid directional dividing lines, the markers shall be placed between the lines.

Where a directional dividing line or lane line separates into two lines for a gore area or for an obstacle in the roadway, reflective pavement markers should be installed on the traffic side of the lines.

Reflective pavement markers shall not be placed on guide or continuity lines.

8.9.1.3 MEDIAN GORE AREAS

Median gore areas are defined to be those gore areas where traffic passes in opposite directions past the gore area. Diagonal lines painted on the roadway for these installations should be marked 0.6m wide and spaced at 3.15m intervals. Gore areas are to be installed in accordance with the *MUTCD* and the *City of Vancouver Standard Detail Drawings R8.2* and *R8.3*.

8.9.1.4 BICYCLE LANE BUFFER GORE AREAS

Bicycle lane buffer gore areas are defined to be those gore areas where there is a vehicle travel lane adjacent to a buffered bicycle lane. Diagonal lines painted on the roadway for these installations should be marked 0.1m wide and spaced at 4.0m intervals.

8.9.1.5 ARROWS

Thermoplastic shall be used for marked turn arrows, and paint shall be used for merge arrows.

New arrow markings for turn bays shall be located as shown in the the *City of Vancouver Standard Detail Drawings R8.4* to *R8.5* and the *MUTCD*. For through or turning lanes where there is no fixed-length turning bay, new arrow markings shall be installed according to the general spacing specifications in the *MUTCD*.

The *City of Vancouver Standard Detail Drawings R8.4* to *R8.5* and the *MUTCD* illustrates the design shapes for marked arrows and the alignment specifications for multi-lane applications. Existing marked arrows shall be remarked in their present locations. However, if the pavement is resurfaced or sandblasted, new arrows should be installed according to the standards discussed above.

New merge arrow markings to indicate the termination of a travel lane will be located as illustrated in the the *City of Vancouver Standard Detail Drawings R8.6* to *R8.7* and the *MUTCD* unless otherwise specified by the *Traffic & Data Management Branch*. Existing merge arrows will be remarked in their present configuration. However, if the pavement is resurfaced or sandblasted new arrows will be installed according to the above standards.

8.9.1.6 RESERVED LANES

Reserved lanes shall be marked as per the design shown in the *City of Vancouver Standard Detail Drawings R8.8* and the *MUTCD*. Reserved lane pavement markings shall be centered in the lane and spaced 50m apart.

8.9.1.7 CROSSWALKS

Crosswalks shall be marked in thermoplastic. *Section 8.8.1* outlines specific requirements for crosswalk layouts.

8.9.1.8 STOP BARS

New stop bars at marked crosswalks shall be 0.3m wide, oriented perpendicular to the path of the vehicle travel, and located 1.0m clear distance from the marked crosswalk line furthest from the intersection (*MUTCD Sec A6.3, Fig C1-1, Sec C3.2*). For multilane arterials, each lane should have a separate stop bar staggered along the 1.0m clear offset from the pedestrian crossing. For skewed intersections, stop bars shall meet the requirements in the *City of Vancouver Standard Detail Drawings R8.14.*

Where there are protected bicycle lanes, the bicycle stop bar may be located 0.5m clear distance from the marked crosswalk. Vehicle stop bars are recommended to be set back 2m from the bicycle stop bar.

Where stop signs are installed, stop bars must also be installed to show the intended stopping location for the front bumper of vehicles. For new markings, stop bars shall be installed according to the dimensions shown in ***Figure 8-3*** for each specific case. Stop bar locations may need to be adjusted to accommodate vehicle movements or other site-specific requirements.

When remarking existing stop bars, the old bar can be remarked provided the front of the existing bar is within 0.3m of the front of the stop bar location for a new install. Existing painted stop bars should be remarked 0.3m wide, regardless of their original width. Thermoplastic stop bars should be patched the same as their original width, either 0.3m or 0.4m. If old locations are not within this tolerance, the *Traffic & Data Management Branch* shall be consulted. In no case shall marking result in two lines.

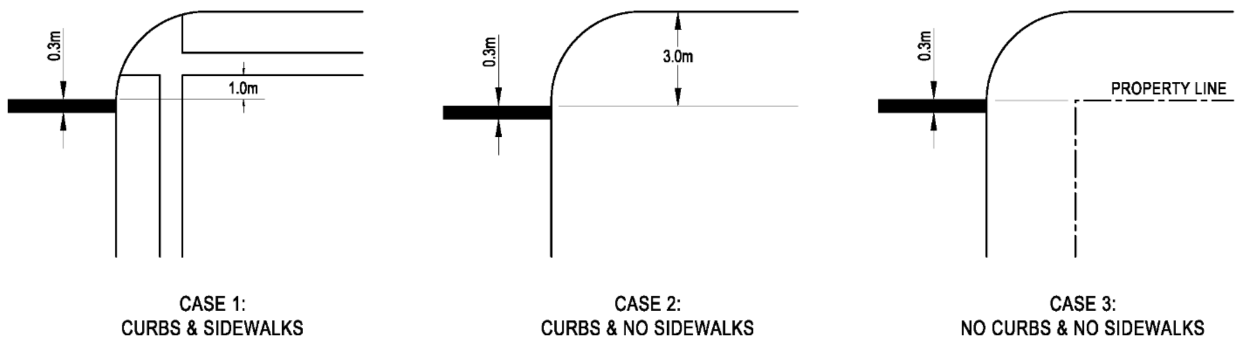


Figure 8-3: Stop Bar Placement

8.9.1.9 YIELD MARKINGS

Yield bars are 0.4m wide by 0.6m long blocks with 0.6m gaps when painted on the road. On separated bicycle facilities, the yield bar consists of blocks 0.2m wide by 0.3m long with 0.3m gaps.

Yield teeth may be implemented as an alternative to yield bars and will be considered for approval by the *Transportation Design Branch*. Yield teeth are 0.3m wide and 0.45m long with 0.1m gaps when painted on the road. On separated bicycle facilities, the yield teeth consist of blocks 0.15m wide by 0.3m long with 0.1m gaps.

8.9.1.10 PAINTED CURBS AND MEDIANS

Curbs shall not be painted to indicate traffic regulations such as parking restrictions.

The end of the traffic island facing approaching traffic shall be painted. The end of the island is defined as the area from the tip of the island to 1m beyond the point where the curved section joins the straight section in the island's structure (see ***Figure 8-4***).

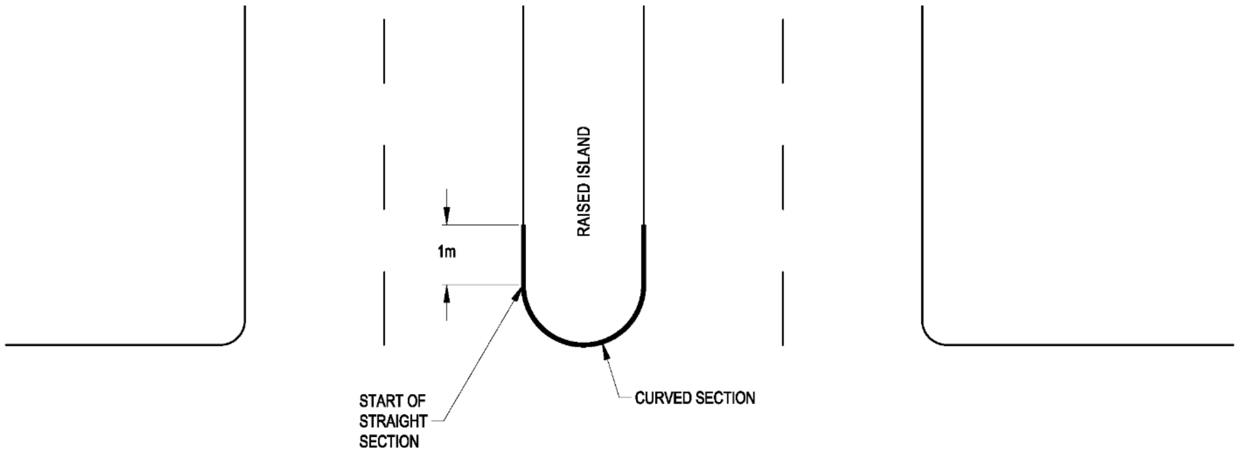


Figure 8-4: Painted Medians

Directional dividing lines shall be painted up to the edge of the median only.

8.9.1.11 DIRECTIONAL DIVIDING LINES

A Directional Dividing Line (DDL) is used to separate two-way traffic on arterial and collector roadways when traffic volumes, vehicle size, and geometric conditions dictate. Directional dividing lines are generally installed on the following two-way roadways:

- Arterials.
- Streets in the Central Business District.
- Bus routes.
- Collectors with greater than 8000 vehicles/day.
- Collectors where steep grades and sharp curves limit visibility.

Directional dividing lines may also be installed on:

- Protected bicycle lanes.
- Two-way left turn lanes.
- Collectors with 5000-8000 vehicles/day.
- Truck routes.
- On local streets 10m in advance of a full traffic signal.

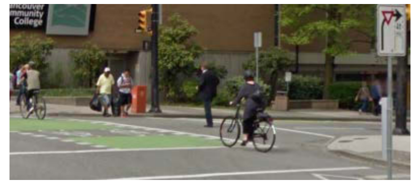
Directional Dividing Lines shall consist of a 0.1m wide solid yellow line broken at intersections. At uncontrolled intersections, a 3.0m dashed yellow line shall be marked in the centre of the intersection.

8.9.1.12 BICYCLE GREEN SURFACE TREATMENT

In 2011, the Transportation Association of Canada (TAC) and the US Federal Highway Administration (FHWA) reserved the colour green to be used on street surfaces to denote cycling facilities.

The City of Vancouver uses green paint to identify areas where people biking cross and share the road with motor vehicles. In addition, the City uses green colour to highlight bicycle boxes which identify a safe refuge place for people biking as they wait to turn. ***Table 8-18*** highlights in general terms those locations where green treatment should and should not be used. Note, however, that every installation, including ones not covered in the guidelines, requires professional judgement and evaluation on a case-by-case basis.

Table 8-18: Green Treatment Uses

Location and Description	Example
Generally, Includes Green Treatment	
✓ Bicycle crossings with conflicts: Example conflicts include permissive left and / or right turns or compliance problems with turn restrictions. Green treatment may be limited to the portion(s) of the crossing where conflicts occur.	
✓ Bicycle crossings forming part of an "All Ages and Abilities" corridor: During network build-out, green paint will generally be included in all bicycle crossings of busier streets. This is intended to aid wayfinding and awareness of quality bicycle facilities.	
✓ Major driveway crossings: This includes painted / separated bicycle lanes, bicycle paths, and some shared-use lanes (next item).	
✓ High volume mixed-use or "sharrow" lanes: Green-backed sharrows (white sharrows on green rectangles) may be used to increase the visibility of sharrows or to highlight driveway conflicts. These would typically be limited to areas with heavy bicycle traffic or significant crossing conflicts.	
✓ Painted bicycle lanes approaching intersections (away from curb): Green paint should be used where motor vehicles merge across or travel on both sides of a bicycle lane approaching an intersection; this includes bicycle-only turn lanes as well as painted bicycle lanes between through and right-turn motor vehicle lanes, parking lanes, and bus lanes. Green paint should be limited to intersection approaches.	
✓ Merging and Mixing Zones: Green backed sharrows should be used where protected bicycle lanes merge into a shared use lane. This includes mixing zones where turning vehicles and through bicycles share a lane approaching intersection.	 *Example from San Francisco*

Location and Description	Example
✓ Bicycle boxes: All configurations are filled with green, including advance stop bars and two-stage left turn boxes.	
✓ Other locations where frequent crossing conflicts can be expected.	
Generally, Doesn't Include Green Treatment	
✗ Bicycle crossings without conflicts (outside metro core): Where all turns are appropriately restricted or on separate signal phases, and where compliance is good, green treatment is unnecessary. Along non-AAA routes and routes outside the metro core, the desire for wayfinding or corridor consistency should be weighed against the risk of overuse.	
✗ Painted bicycle lanes approaching intersections (against the curb): In this situation, green paint may discourage drivers from merging into the bicycle lane to make a right turn, as required under the *British Columbia Motor Vehicle Act*. Where turning across the bicycle lane is preferred over merging into the bicycle lane, a buffer (painted or raised) on approach with green treatment in the crossing itself and appropriate yield signage and / or signalization is generally appropriate.	
✗ Shared crossings for walking and cycling: Where crossbike markings ("elephants' feet") are combined with a marked crosswalk with no separation for different users, green treatment is inappropriate. Green helps to identify dedicated bicycle crossings as distinct from crosswalks in other locations, potentially discouraging people from walking in the crossing. Consider zebra crossing markings or other patterns instead to increase visibility for drivers, and separate crossings for walking and cycling wherever possible.	

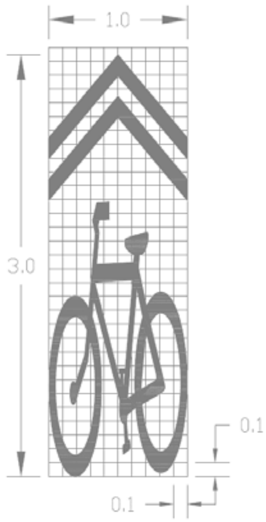
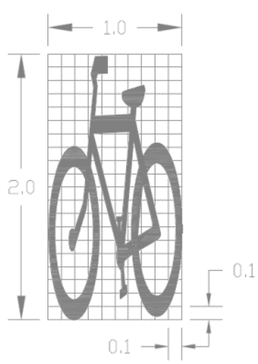
Location and Description	Example
✘ Bicycle crossings where bicycle traffic never has right-of-way: At bicycle crossings where two-way stop control (or similar) favours cross traffic, the addition of green paint may imply bicycles have the right-of-way and lead to undesired / incorrect yielding behaviour. Green paint is similarly not recommended across the major street at half-signals. Consider full signalization, providing all-way stop control, reorienting the stop signs, or otherwise.	

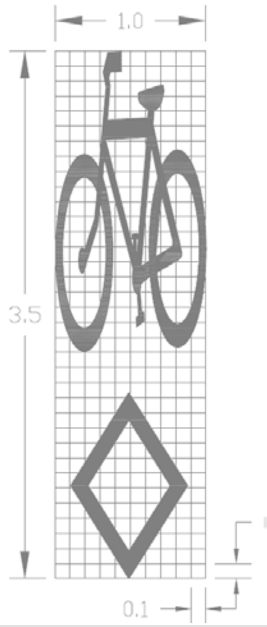
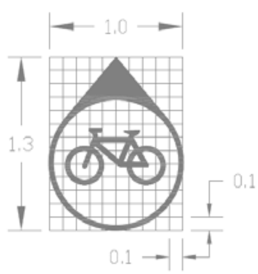
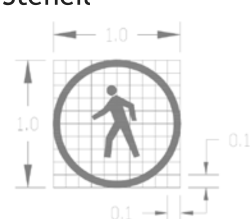
8.9.1.13 STENCILS

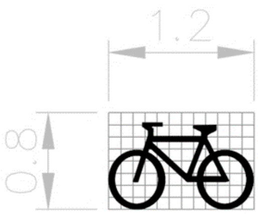
Sharrows, or shared lane markings, are symbols placed on the pavement surface in the intended area of bicycle travel. They help cyclist position themselves in a lane that is shared with motor vehicles. Sharrows are often positioned to the left of parked vehicles to encourage cyclists to ride outside of the 'door zone' along local streets. They are also occasionally used to fill short gaps on the bicycle network along major streets and through transitions such as where bicycle lanes merge into turn lanes. Sharrows are also sometimes used for wayfinding or to highlight the presence of people cycling through challenging intersections. ***Table 8-19*** provides more details on Vancouver's use of sharrows and other standard bicycle stencils.

Sharrows alone are not sufficient to create a cycling facility on local streets. They must be used in conjunction with other engineering measures to control vehicle speeds and volumes as well as appropriate crossing measures at busy intersections.

Table 8-19: Stencils

Stencil	Typical Use	Placement	Lateral Placement
TAC Standard Bicycle Sharrow  	• Local streets where people biking share the roadway with motor vehicles. • Transitions where bicycle only space transitions into shared bicycle / vehicle space such as where bicycle lanes transition into turn lanes through an intersection. (optional green backing). • Through some intersections for wayfinding and to bring greater bicycle visibility.	• Typically, one entrance sharrow per block offset approximately 15m from the general alignment of the cross street. • Optional second set of staggered sharrows evenly spaced mid-block for long blocks >180m or busy downtown bikeways. • Optional paired sharrows at intersections and lanes where the bicycle facility has right of way. • See ***Figure 8-5*** for placement details	• Typically, centred in the travel lane or, • Centred in the right half of the travel portion of a local street. The travel portion is the curb to curb width minus 2.5m for each side of parking. • Where parking is allowed, 3.4m min. from curb face to the centre of the sharrow. • Away from gutter pans where there is no parking, 1.0m min. from curb face to centre of sharrow.
TAC Standard Elongated Bicycle Stencil  	• Protected Bicycle Lane adjacent to roadway where vehicles are physically prevented from driving on.	• General bicycle stencils placement is 50m. • On facilities adjacent to parked cars the general spacing is 18m.	• Centred in bicycle facility for unidirectional lanes. • Centred in the right half of bicycle facility for bidirectional protected bicycle lanes.

Stencil	Typical Use	Placement	Lateral Placement
TAC Standard Bicycle Stencil with Elongated Diamond 	• Painted bicycle lane where vehicles are not physically prevented from driving on. • Paint buffered bicycle lanes. • Also used as the first stencil at the entrance to protected bicycle lanes.	• General bicycle stencils placement is 50m. • On protected bicycle lanes adjacent to parked cars the general spacing is 18m. (every third parking space).	• Centred in bicycle facility for painted unidirectional lanes. • Centred in the right half of bicycle facility for bidirectional buffered bicycle lanes.
Off-Street Bicycle Path Stencil 	• Off-street bicycle pathway away from road or through a park.	• General bicycle stencils placement is 50m. • Tighter spacing may be considered near sharp corners. • Stencils should also be used at pathway entrances and on the far side of marked pedestrian crossings.	• Centred in the right half of a bidirectional bicycle path or in the middle of a unidirectional one.
Pedestrian Path Stencil 	• Off-street pedestrian pathway adjacent to bicycle pathway separated by paint only.	• Same as for the off-street bicycle stencil placement and should go adjacent to them on the pedestrian part of the pathway.	• Centred in middle of the pedestrian part of the pathway.

Stencil	Typical Use	Placement	Lateral Placement
Non-Elongated Bicycle Stencil 	• Within protected bicycle lane crossings bound by elephant's feet.	• Aligned consistent with direction of bicycle traffic. • One stencil centered the path of each motor vehicle lane between the typical tire path. • Staggered on two-way bicycle crossings so only one stencil for each travel lane.	• Centered in the crossing where there is one-way bicycle traffic. • Centered in the right half of the crossing where there is two-way bicycle traffic.

The typical sharrow placement along local streets is provided in ***Figure 8-5***:

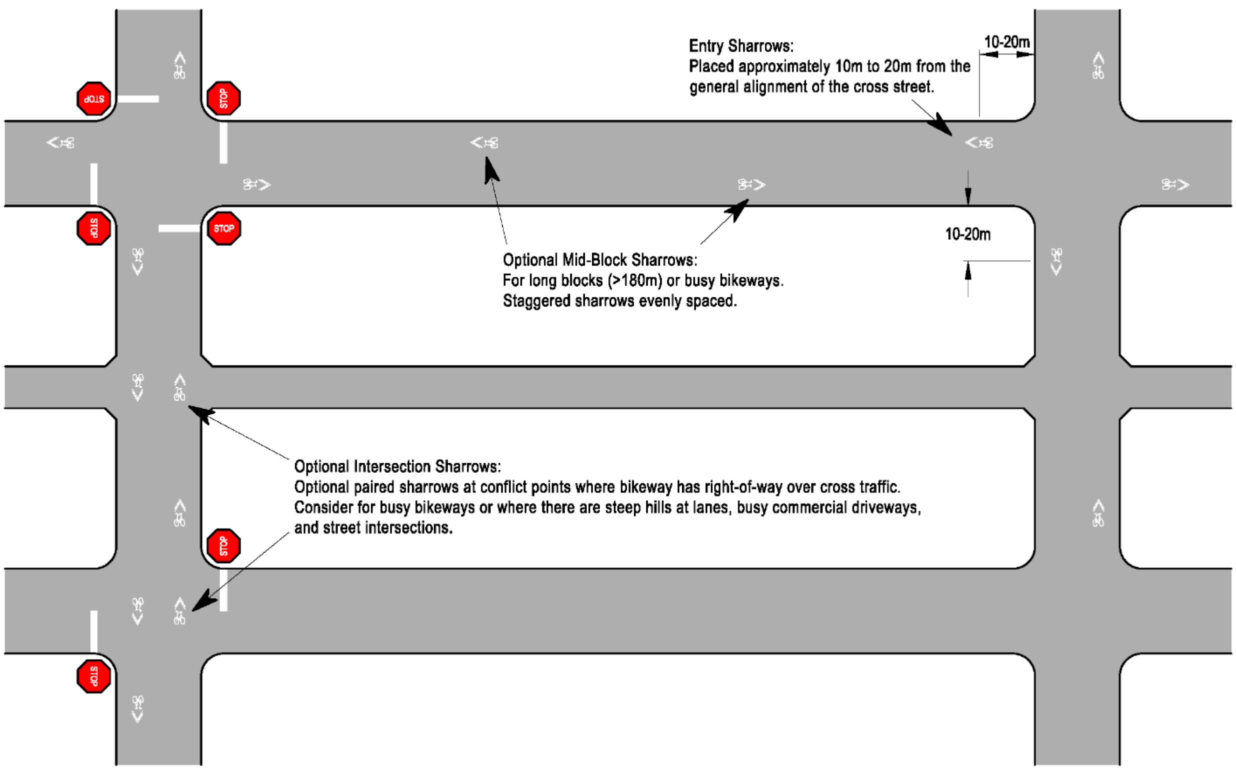
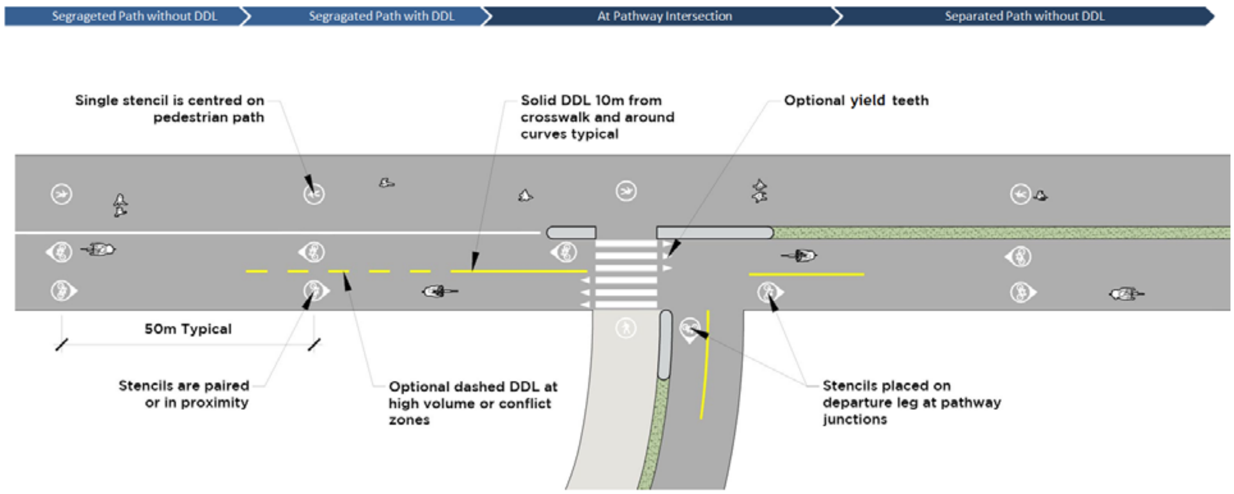


Figure 8-5: Sharrow Placement

Figure 8-6 shows the typical stencil placement for off-street pathways.



Notes:
- Directional arrows to be used on stencils involving bicycle only traffic.
- Bike stencils to be oriented to indicate the direction of bike traffic.
- Closer stencil placement is suggested along high conflict areas and along curves so that one set of stencils is visible at all times.
- DDL is 10cm wide per the city standard for bike paths. The white line between the bike and walking path is typically 20cm wide.

Figure 8-6: Typical Stencil Placement for Off-Street Pathways

8.9.1.14 BUS LANE RED SURFACE TREATMENT

Red surface treatment may be considered at key locations to highlight bus priority lanes and bus stops. Consult the *Traffic & Data Management Branch* for specific applications.

8.10 TRAFFIC SIGNAGE

Traffic signs regulate, warn, and inform road users in the City of Vancouver. Detailed sign plan drawings prepared for the City of Vancouver are to be consistent with the *MUTCD* with the exception of specific requirements outlined in this manual.

8.10.1 SIGN CODE INVENTORY

Contact the *Traffic & Data Management Branch* to obtain the most current *City of Vancouver Sign Code Inventory*. The *City of Vancouver Sign Code Inventory* includes regulatory, warning, guide and information, and temporary condition signs. Any custom / wayfinding signs shall be approved by the City prior to use. When requesting the installation or removal of signs, they should be identified by message and sign number.

8.10.2 SIGN ARRANGEMENT

When there is to be more than one sign on a pole, the following rules should be observed (see ***Figure 8-7*** for more details):

- For two signs, position the more restrictive sign above the other. It is also acceptable to have them side-by-side with the more restrictive one to the left of the other provided the directions in which the regulations extend do not conflict.
- For three signs, the most restrictive sign is placed above the other two which are placed side-by-side. The positioning of the bottom two will depend on which one is more restrictive or in which direction the regulations extend.
- The sign arrangement must be consistent throughout any one block (either all stacked one above the other or all side-by-side).
- On all regulatory parking or stopping signs, arrows shall be used to indicate the zone covered by a regulation.

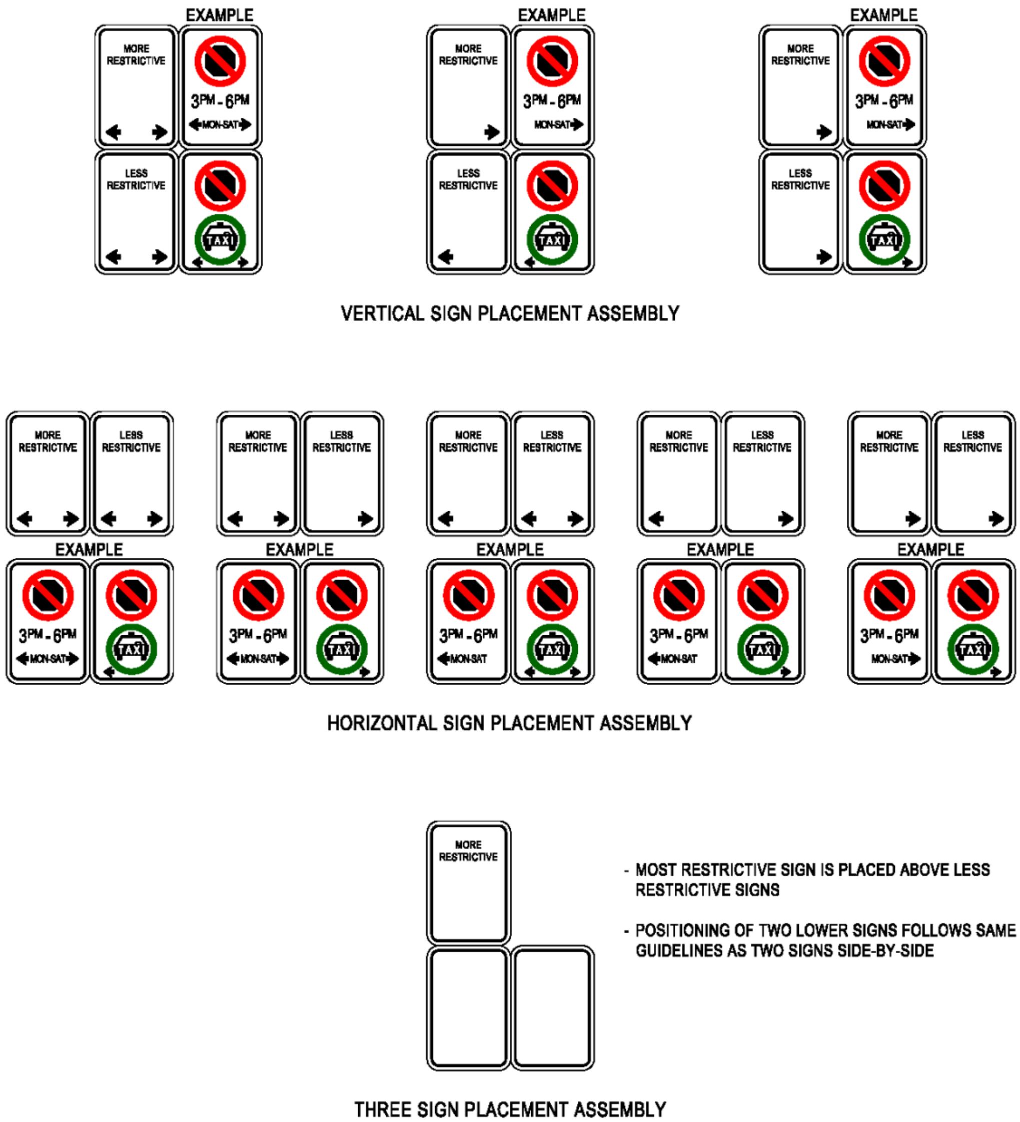


Figure 8-7: Sign Arrangement Guidelines

8.10.3 SIGN PLACEMENT

Whenever possible, steel utility poles should be used to support most signs. Accordingly, sign layouts should be coordinated with steel utility pole layouts or designs.

The minimum height to the bottom of any sign shall be 2.1m, and the maximum height to the top of any sign shall be 3.3m as shown in ***Figure 8-8***. One exception would be median signs which shall have a minimum height as shown in ***Figure 8-9***. Another exception is for signs mounted along bicycle paths where there are different visibility and clearance considerations, and the minimum is 2.3m. These heights are shown in ***Table 8-20***.

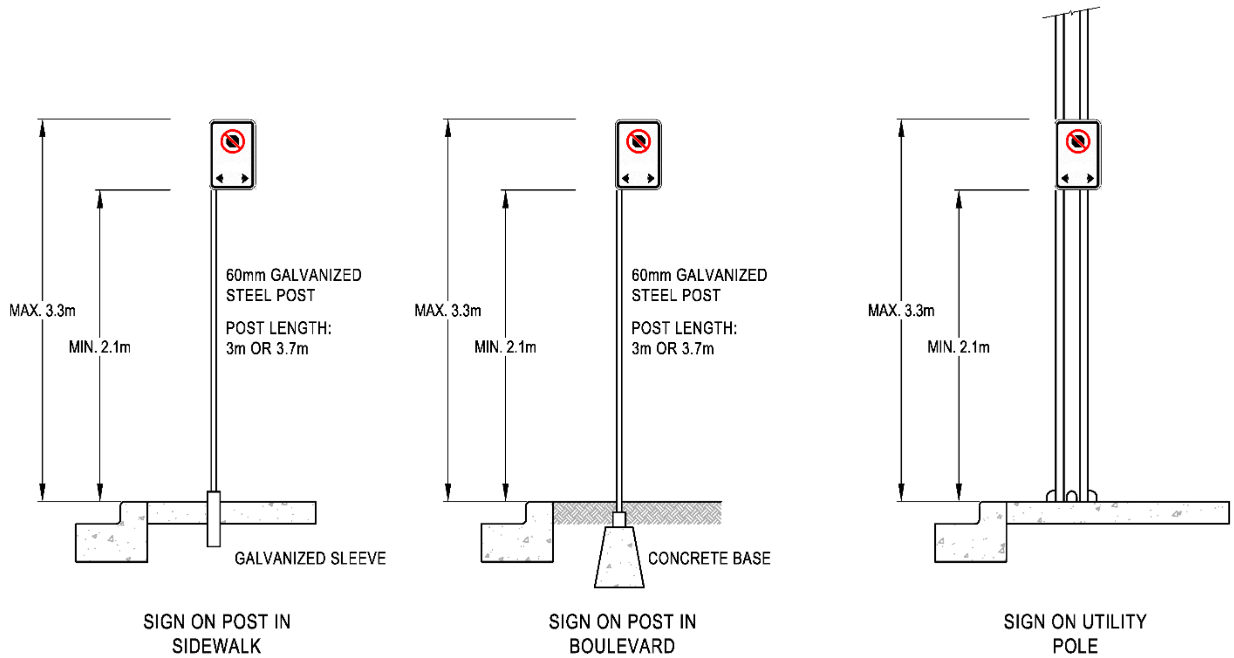


Figure 8-8: Typical Sign Installation

Table 8-20: Typical Sign Mounting Heights Along Off-Street Bicycle Pathways

Sign Type and Placement Situation	Height to Bottom of Sign
• Bicycle size object marker (150mm x 450mm).	0.3m (typical)
• Small signs less than 300mm wide that do not overhang by more than 150mm. • Larger signs placed in a median > 0.3m from pathway edge and placed in a space where people are physically discouraged from walking and biking under (e.g. if there are plantings, a physical feature or raised concrete median to discourage walking under the sign).	1.2m – 1.6m
• Walking/cycling delineation signs (IB 23-1 & 2). • Large signs (>300mm wide) where it is possible for people to walk or ride under or in areas prone to heavy vandalism.	2.3m - 2.4m

8.10.3.1 KEEP RIGHT SIGNS

Keep Right signs are mounted 1.2m above the island surface unless specified otherwise. They are installed 2.5m from the end of the traffic islands and shall generally be accompanied by a hazard marker. Where medians continue for several blocks and are broken at intersecting streets, a hazard marker shall be installed below the Keep Right sign at the approach of the first median (***Figure 8-9*** Case 1), and only the Keep Right sign shall be mounted on the subsequent medians (***Figure 8-9*** Case 2). The Keep Right signs shall be mounted on obstructions where possible. Keep Right Signs in traffic circles shall be as per *City of Vancouver Standard Detail Drawings R5.1*.

While these are normal practices, in some cases the installation of a Keep Right sign may cause vision restrictions. In these cases, the Keep Right sign may be omitted providing an object marker is used. In cases where traffic islands are narrow, a narrow object marker (WA 36-1) may be used to prevent it from being struck by vehicles. Care should be taken when installing Keep Right signs and object markers on refuge traffic islands so that the signage itself does not hide pedestrians from view.

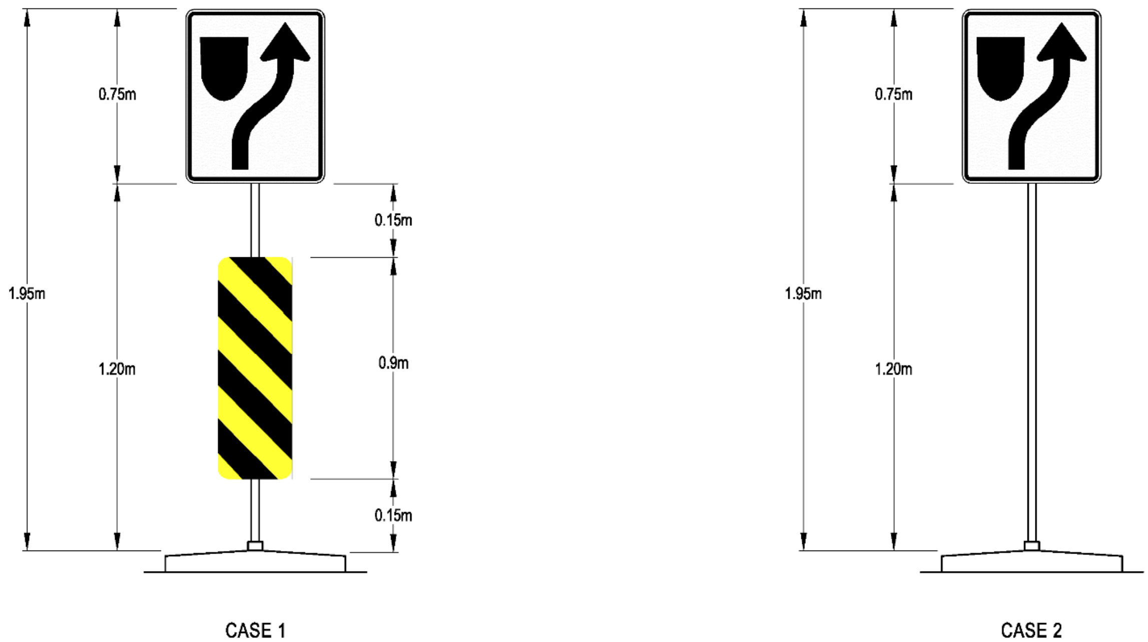


Figure 8-9: Keep Right Sign Placement

8.10.3.1 OBJECT MARKERS

On traffic islands where a Keep Right sign is not used, the object marker (***Figure 8-10***) shall be installed 1.0m from the end of the island. In cases where traffic islands are narrow, a narrow object marker (WA36-1) may be used to prevent it from being struck by vehicles.

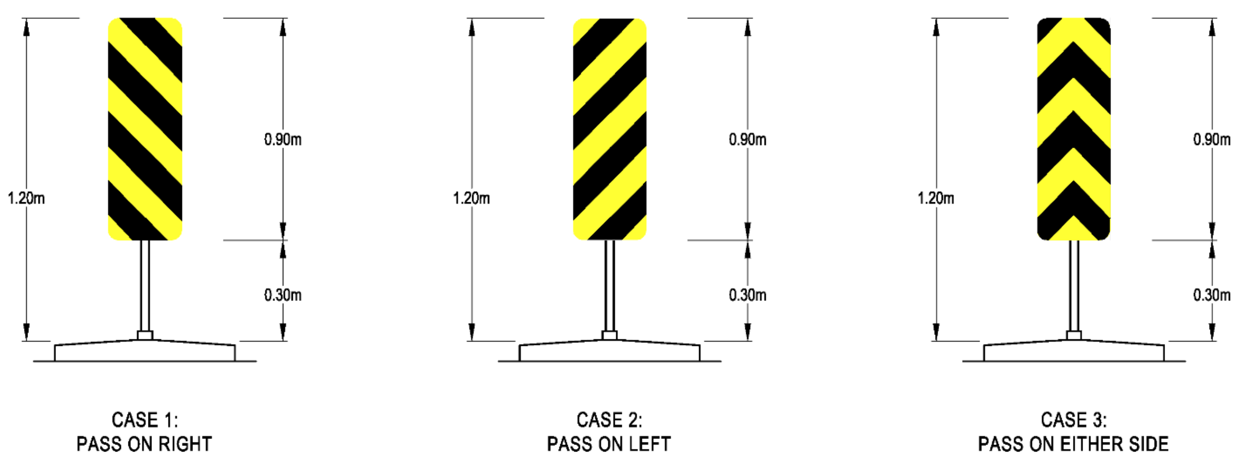


Figure 8-10: Object Marker Sign Placement

8.10.3.2 PARKING REGULATION SIGN SPACING

For block-long regulations, sign spacing should be every second pole on most arterials where curbside activity is light, provided that the view of the sign is not obstructed and the pole spacing is 33m or less. In general, if utility poles are not available, the spacing between signs should be a minimum of 30m and a maximum of 60m.

For partial-block curbside regulations that end at a lane, no sign is required to terminate the regulation. Legally, lanes are defined as streets and as such define the end of the curbside regulation.

For partial-block regulations that end at a driveway, a sign is required to terminate the regulation. Driveways are not legally defined as streets and do not define the end of the regulation.

8.10.3.3 SCHOOL / PLAYGROUND AHEAD SIGNS

The School Ahead sign (WC1) shall be used on all streets adjacent to elementary and secondary schools, and the Playground Ahead sign (WC3) shall be used on all streets adjacent to playgrounds. School signage is installed where playgrounds and school grounds coincide. School Ahead signs (WC1) may also be installed in advance of major intersections which are signalized and where school students cross the street. Private and independent schools are included for this type of signage. Unless the street is an arterial street, 30km/h tabs shall also be used for playgrounds and 30km/hr 8-5pm School Days for schools. These reduced speed zones when signed are enforceable under *Section 44* of the *City of Vancouver Street and Traffic By-law No. 2849*. The reduced speed zones near playgrounds are in effect all year while reduced speed zones near schools are in effect only on days when school is regularly held.

The signs shall be installed at the beginning of the property. If there are any T-intersections adjacent to this property, a sign will be erected facing the leg of the intersection as shown in ***Figure 8-11*** Case 1. In the case of a mid-block installation, the sign will be erected at the start of the property on the right side of the street as shown in ***Figure 8-11*** Case 2.

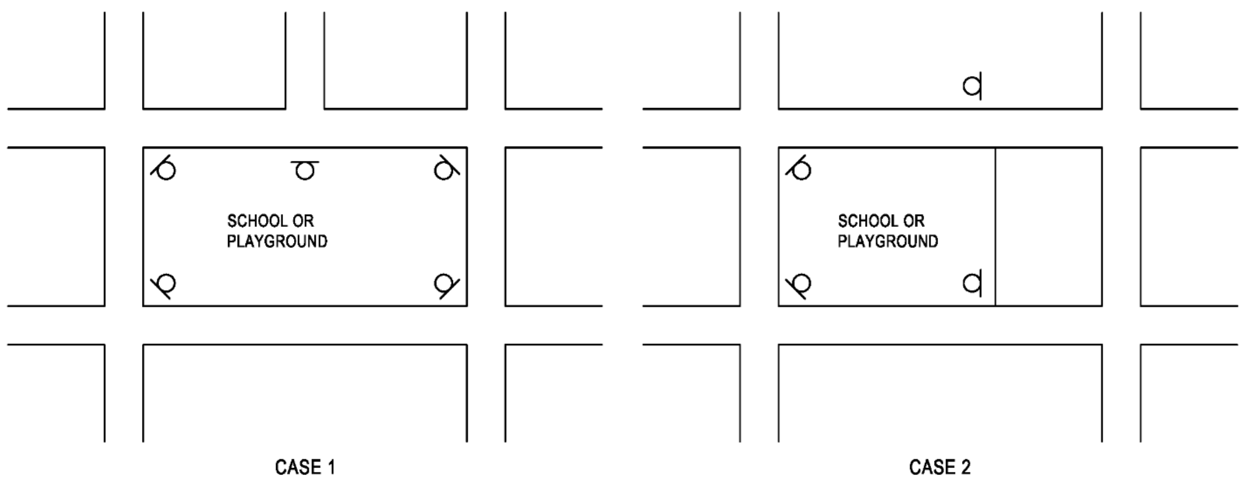


Figure 8-11: School and Playground Zone Sign Locations

8.10.4 STREET NAME SIGNS

Side-mounted and overhead signs should include street name and type such as street, avenue, etc. Side mounted street name signs should also include the appropriate block number. If a street has been designated as a cycling route, the bicycle icon shall also appear on the street name sign.

Street names should always be written in full. The following are the only acceptable abbreviations:

- Avenue: AVE
- Boulevard: BLVD
- Court: CRT
- Crescent: CRES
- Diversion: DIV
- Drive: DR
- Highway: HWY
- Place: PL
- Square: SQ
- Street: ST
- East: E
- West: W
- North: N
- South: S
- Great: GT

Side-mounted street name sign blades should be installed on existing poles, such as street lighting or trolley poles, if such poles are within 6m of the intersecting curb line. Preference should be given to a pole which provides good visibility from all directions and is near a source of street lighting. If no existing pole satisfies these conditions, then a galvanized steel post shall be installed in accordance with above location guidelines. Side-mounted street name sign blades should be staggered in height. Minimum installation height from the ground to the lowest mounted blade is to be 3.3m.

Overhead street name signs should be installed on existing signal davit arms or signal span wires on the far side of the intersection facing oncoming traffic. They are to be centered on the approach lanes at the height of the center of the red lens in the signal head.

8.11 PAVEMENT DESIGN

Pavement design influences the lifespan, maintenance requirements, and driveability of the road. This section outlines the criteria for pavement design in the City of Vancouver.

8.11.1 DESIGN PRINCIPLES

Pavement design should be based on one of the following methods:

- Past history of successful pavements in adjacent similar areas.
- Where specific pavement design is required by the City, the pavement structure can be determined using the *TAC Pavement Design and Management Guide* or other industry best practices as appropriate.

Pavement design is to include consideration of the subgrade condition, frost susceptibility, moisture conditions, and subgrade drainage provisions.

Regardless of the method used for pavement structure design, pavement component thicknesses should be equal to or greater than the minimum thicknesses shown in *Section 8.11.2*.

Minimum design life for all classifications of roads is 20 years.

8.11.2 ASPHALT PAVEMENT DESIGN

In the City of Vancouver, asphalt pavement design shall follow the minimum as shown in ***Table 8-21***:

Table 8-21: Asphalt Pavement Structures

Classification	Minimum Pavement Thickness
Local / Residential (Light Duty) Streets and Lanes	35mm AC Surface Course 40mm AC Lower Course 150mm Granular Base 300mm Granular Subbase
Higher Zoned Collector / Residential Streets	50mm AC Surface Course 90mm AC Lower Course 150mm Granular Base 300mm Granular Subbase
Higher Zoned Collector / Residential Lanes	50mm AC Surface Course 75mm AC Lower Course 150mm Granular Base 300mm Granular Subbase
Arterial / Industrial Streets (New Infrastructure)	50mm AC Surface Course 150mm AC Lower Course (2x75mm lifts) 150mm Granular Base 300mm Granular Subbase
Bus Routes	50mm AC Surface Course 180mm AC Lower Course (2x90mm lifts) 150mm Granular Base 300mm Granular Subbase
P.C.C. Base (Rehabilitation only to match existing)	50mm AC Surface Course 75mm AC Lower Course 175mm PCC Base 150mm Granular Base 300mm Granular Subbase
Protected Bicycle Lanes	50mm MMCD Upper Course #2/9.5mm 150mm Granular Base
Overlay of Existing Pavements	50mm AC Surface Course

8.11.3 CONCRETE PAVEMENT DESIGN

Concrete pavement design should follow the method chosen in *Section 8.11.1*; however, minimum thicknesses should match existing.

8.11.4 SPECIAL PAVEMENTS

There are numerous alternatives to conventional asphalt or Portland-cement concrete pavements. The City of Vancouver has previously applied special pavements as outlined in the following sections and may specify special pavement use on certain projects. All special pavements must be approved by the City Engineer.

8.11.4.1 PERMEABLE OR PERVIOUS PAVEMENTS

Traditional pavements can be replaced with permeable pavements to decrease the impervious area and the Urban Heat Island Effect (UHIE). Permeable pavements include interlocking pavers or porous / permeable concrete or asphalt. These options promote infiltration and groundwater recharge while preventing the heating and conveyance of storm water into the storm drainage system. Pervious paving is most suitable for low-traffic areas such as lanes, unimproved shoulders, driveways, parking areas, and other locations as approved by the City Engineer.

The base of infiltration beds should be flat to maximize the infiltration area. The maximum slope of a porous surface should be limited to 5%.

Permeable Pavement Structure

From the bottom up, the standard porous asphalt pavement structure consists of:

- An uncompacted subgrade to maximize the infiltration rate of the soil.
- A geotextile fabric that allows water to pass through but prevents migration of fine material from the subgrade into the stone recharge bed.
- A stone recharge bed consisting of clean single-size crushed large stone with about 40 percent voids (this serves as a structural layer and also temporarily stores stormwater as it infiltrates into the soil below).
- A stabilizing course of “choker course” consisting of a clean single-size crushed stone smaller than the stone in the recharge bed to stabilize the surface.
- An open graded porous surface with interconnected voids that allows storm water to flow through the pavement into the stone recharge bed.

The surface component of pervious pavement can be:

- Porous asphalt or porous concrete.
- Concrete modular pavers with gapped joints that allow water to percolate through.

Details about the types of permeable pavements for stormwater management can be found in the following publications:

- *NAPA IS-131 Porous Asphalt Pavements for Stormwater Management*.
- *ACI 522.1 Specification for Pervious Concrete Pavement*.
- *ICPI Permeable Interlocking Concrete Pavement*.

8.11.4.2 QUIET PAVEMENT

Quiet pavement is porous asphalt, often referred to as Open Graded Friction Course, placed as a surfacing layer over conventional impervious asphalt to reduce traffic noise. An additional benefit is the splash and spray from tires is reduced and thus visibility and traction is improved.

Additional design information for the porous asphalt can be found in:

- *NAPA IS-115 Open-Graded Asphalt Friction Courses, Design, Construction & Maintenance*.

8.11.4.3 REDUCE, REUSE, RECYCLE

The interest in reusing and recycling construction materials is growing. Coupled with the need to preserve non-renewable resources by reducing aggregate mining and the increasing cost of transporting and disposing of spent materials, there may be significant savings realized in the recycling of construction materials. Any proposed designs including recycled or reclaimed asphalt must be approved by the City Engineer. The resulting asphalt mix properties of the mix with RAP or other recycled materials need to meet the same requirements as the conventional asphalt mixture.

8.12 STRUCTURAL DESIGN

8.12.1 GENERAL

8.12.1.1 CHANGING EXISTING STRUCTURES

Unless otherwise stipulated, prior to the implementation of a proposed change of use or change in functional programming of an existing structure, the structure is to be assessed to determine if any safety upgrades are warranted. Examples of safety upgrades could include, but not be limited to, the strengthening of deficient structural elements resulting from recommendations of a load rating study or seismic assessment or the installation of new or modifications to existing handrails and barriers as a result of recommendations from a safety assessment or road safety audit.

8.12.1.2 MAINTENANCE MANUALS

Maintenance manuals shall be prepared and submitted for all new City-owned heavy civil assets such as bridges, shoreline structures, and tunnels. The maintenance manual shall be signed and sealed by a professional engineer. The maintenance manual must include, but not be limited to, the following sections:

- Table of Contents.
- Section 1: Design Information (code, performance criteria, loading data, design team information, etc.).
- Section 2: Asset Value (broken down by component).
- Section 3: Construction Material Information (material grades, specifications, catalog data, mill certificates, shop drawings, etc.).
- Section 4: Operations and Maintenance Plan.
- Section 5: IFC Drawings (11x17 format) and Construction Specifications.
- Section 6: Construction Photographs.
- Section 7: Construction Logs, Field Reports, and Site Instructions.
- Section 8: Post Earthquake Assessment Guide Insert.
- Section 9: Quality Reports.
- Section 10: Permits.
- Section 11: Background Reports – Geotechnical, Environmental, Archeological, Other.
- Section 12: Record Drawings (11x17 format).
- Section 13: Legal Agreements.
- Section 14: Inspection Report – (Post-Construction).
- Section 15: As-Built Survey (Post-Construction – signed by a B.C.L.S.).
- Section 16: Final Letter Recommending Acceptance with signed Certificates (substantial and total performance) attached.

The following documents should also be submitted separately with the maintenance manual:

- Record Drawings – half-size record drawings are to be submitted in both hard copy (one full set) and soft copy formats (pdf and dwf).
- Inspection Report (Post-Construction) - the report is to follow the *Bridge Condition Index and Implementation Manual and User Guide*.
- As-Built Survey (Post-Construction – Signed by a B.C.L.S.) – half-size record drawings are to be submitted in both hard copy (one full set) and soft copy formats (pdf and dwg). The survey shall be based on the City of Vancouver's Standard Datum NAD83 (CSRS).
- All elevations shall be based on the CGVD28 verticle reference datum.

8.12.2 BRIDGES

8.12.2.1 DESIGN CODE

All bridge designs must be in accordance with the following most current design codes, standards, and guidelines:

- *CAN/CSA S6 Canadian Highway Bridge Design Code*.
- *BC MoTI Bridge Standards and Procedures Manual*.
- *TAC Guide to Bridge and Combination Barriers*.

8.12.2.2 BRIDGE LOADING

Vehicular Loading

Bridges shall be designed with the following vehicular loads:

- CL-625 and BC-625.
- City of Vancouver Fire Apparatus - Where the bridge provides fire access to adjacent development sites, the bridge shall be designed to accommodate the City of Vancouver fire apparatus with outriggers placed and ladder extended at maximum reach and angle causing the greatest outrigger load. A review with the *Vancouver Fire and Rescue Services* and the *Planning, Urban Design, and Sustainability Department* will be required to fully delineate access requirements.

Pedestrian Loading

Where portions of the bridge pedestrian facility support or facilitate public gatherings, full pedestrian loading may need to apply locally without reduction.

8.12.2.3 DESIGN LIFE, DURABILITY, AND MAINTENANCE

Unless otherwise directed by the City Engineer, the bridge shall be designed to have a durability that will ensure a minimum design service life of 75 years without replacement of any major components including the bridge deck. Design calculations for corrosion and other time-related durability analysis shall use a design service life of 100 years.

Maintenance considerations such as worker access, equipment access, widths, etc. must be included in the bridge design.

8.12.2.4 SEISMIC DESIGN

Importance Category

Major Route importance category shall apply to all bridges that:

- Are located within or connected to the downtown core.
- Are located on a major arterial (truck route, MRN transit route, or evacuation route).
- Provide street grade access to adjacent developments.
- Are located above habitable space.
- Are located above critical infrastructure.

Performance Based Design

Performance based design shall be required for all Major Route importance category bridges (regular and irregular) with a seismic performance category of 3. Minimum seismic analysis requirements must be adjusted accordingly.

Seismic Monitoring System

All new bridges and bridges undergoing seismic upgrades shall be pre-serviced with power cabling, communications cabling, and predefined monitoring locations to tie into the BCSims network. Seismic analysis shall identify and recommend multiple movement and acceleration thresholds for key primary and secondary locations on the bridge structure. Movement thresholds shall be at a minimum Green, Amber (inspection required), and Red (closure).

8.12.2.5 WEARING SURFACES

The design of wearing surfaces must consider urban design principles for the area and may result in either an asphalt or concrete wearing surface as follows:

- For concrete wearing surfaces, stainless steel reinforcing is preferred. The bridge must be designed (including loading and detailing requirements) to accommodate for a possible future, thin, high-performance overlay.
- For asphalt wearing surfaces, waterproofing membranes must be installed.

For the design of all new structures, a financial and lifecycle analysis shall be prepared to review the benefits and costs associated with either system.

8.12.2.6 EXPANSION JOINTS

Jointless bridges are preferred. Expansion joints are to be minimized and, where introduced, strip seals are preferred to compression seals. Finger joints are to be avoided where possible. Where possible, gaps are to be minimized to ensure better ride quality and reduce noise propagation.

8.12.2.7 HANDRAILS

Handrail design shall consider and be compatible with area urban design principles. Handrails shall be simple, easy to maintain, and easily sourced from readily available materials. Tensioned cable handrails are generally not acceptable except in very unique situations. Glass panels shall not be allowed.

Refer to *Section 8.12.2.8* for additional design requirements.

8.12.2.8 MEANS PREVENTION

Crisis Phones

Unless otherwise specified, all bridges shall be pre-serviced with communications, power, and supports to accommodate crisis phones. The quantity and location must be determined in consultation with *Emergency Management*. As a guide, a minimum number of two phones, one per side, shall be accommodated; however, on longer bridges, more locations shall be considered and pre-serviced.

Means Prevention Fencing

Unless otherwise specified, on all medium to high level bridges or bridges situated over large volumes of vehicular traffic where there is a significant drop, handrails including supports shall be designed for the inclusion of means prevention fencing. Means prevention fencing does not need to be implemented at initial construction, but the design process shall prepare a 100% design of the means prevention fencing as well as a conversion design for the modification of the regular handrail. Means prevention fencing design shall consider and be compatible with adjacent urban design principles.

8.12.2.9 COATINGS

Where coatings are introduced, the service environment shall consider Vancouver as having at least a C3 Atmospheric Corrosivity Category for a medium coastal area with low salinity. The coating system shall have a minimum practical service life of 20 years.

In addition, where micro climate (C4 and C5) zones are identified, coating performance shall be adjusted accordingly.

8.12.3 MARINE AND COASTAL STRUCTURES

In addition to industry standards and codes, the design of marine and coastal structures should be in accordance with the following:

- *City of Vancouver Marine and Coastal Structures Design Reference*.
- *City of Vancouver Recommended Guidelines for Universal Access to Public Docks in False Creek*.

8.12.4 RETAINING WALLS

Cast-in-place retaining walls are the standard and preferred wall type in the City and should be in general conformance with the following:

- *City of Vancouver Standardized C.I.P. Conventional Retaining Wall.*
- *City of Vancouver Standardized C.I.P. L-Shape Retaining Wall.*
- *City of Vancouver Standardized C.I.P. Zero PL Retaining Wall.*

Other types of retaining wall may be considered for approval and should be in general conformance with the following:

- *City of Vancouver Modular Concrete Block Retaining Wall.*
- *City of Vancouver Vegetated Wire Face Retaining Wall.*
- *City of Vancouver Standardized Soil Bag Wall.*

Retaining walls designs must also meet the following criteria:

- Retaining wall designs must be signed and sealed by a professional engineer.
- Railings and / or guardrails are required where excessive drops exist.
- Control joints must be incorporated in the wall.
- Special relief motives may be embedded in the face of the wall provided minimum cover requirements are met.
- Private wall systems may not rely on passive soil pressure.
- Private wall systems must be wholly contained on private property unless authorized via a registered encroachment agreement or similar means. Approval of encroachment shall be obtained through the *Utilities Management Branch*.
- A drainage system must be connected on the private side. Weep holes are discouraged and may not be approved.

8.12.5 AREAWAYS

Areaways are below-grade structures adjacent and attached to buildings that encroach into City streets. They are considered encroachments. They are the responsibility of the property owner.

Areaway encroachments are permitted subject to the approval of the City. Where an encroachment is permitted, the terms of its existence are typically contained within a legal document (areaway or encroachment agreement) registered on title. However, in some instances, agreements are not in place, and the terms and conditions of the *City of Vancouver Encroachment By-law No. 4243* apply.

8.12.5.1 APPLICABLE BY-LAWS AND STANDARDS

The following by-laws and standards apply to areaways:

- *City of Vancouver Encroachment By-law No. 4243* (applies since the areaway encroaches into a City street).
- *City of Vancouver Building By-law* (applies since the areaway is part of a building).

- *City of Vancouver Construction Specifications* (applies to the restoration, backfill material, and functional design and performance of the surface of the areaway (the sidewalk surface)).

8.12.5.2 ENCROACHMENT BY-LAW NO. 4243

The *City of Vancouver Encroachment By-law No. 4243* lays out the terms and conditions for an encroachment that exists or is proposed to exist in, on, and / or under a City street. The terms cover items such as liability, indemnity, responsibility for maintenance, repairs, default, and removal.

The owner of the encroachment, and for the sake of further clarification meaning not the City, is responsible and liable for maintenance, repair, and removal.

Refer to the building encroachment guide at the following link:

www.vancouver.ca/files/cov/building_encroachment_guide.pdf

8.12.5.3 VANCOUVER BUILDING BY-LAW

The *City of Vancouver Building By-law* prescribes the minimum design and structural requirements for the repair or removal of areaways. A number of pertinent sections from the *City of Vancouver Building By-law* are highlighted for information below. It should be noted that other sections of the By-law may also apply, and it is up to the professional of record to ensure the most recent version of the By-law is referenced.

1. *Division C, Part 1, Section 1.8 - Street Regulations*
    a. *Section 1.8.1 - Encroachment*
    b. *Section 1.8.2 - Existing Encroachments*
    c. *Section 1.8.3 - New Encroachments*
    d. *Section 1.8.4 - Repair or Removal of Encroachment*
    e. *Section 1.8.5 - Areaways*
        i. *Section 1.8.5.1 - Areaway Defined*
            - An areaway means an existing underground or building appurtenance, which encroaches in a street and forms part of or serves an adjacent building.
        ii. *Section 1.8.5.2 - Design and Structural Requirements*
            - The Chief Building Official shall refuse to issue a permit for alteration of an areaway unless the design has been first approved by the City Engineer.
            - Areaways shall be constructed with reinforced concrete walls and roofs capable of supporting the street, any superimposed live loads, surcharge loads, and seismic loads to the satisfaction of the City Engineer.

- Notwithstanding the above, the Provisions of Part 4, Division B, Book I of the *City of Vancouver Building By-law* apply to the construction of the areaway.
- Note: The City Engineer considers the *City of Vancouver Building By-law* to be the minimum design criteria, and in some cases may require design loading in excess of the *City of Vancouver Building By-law*. An example situation would be if an areaway was located in the vehicular travel portion of a service road / lane, in which case the City Engineer would request an assessment from the professional engineer of record. After which, it may be determined that the most current edition of *CAN/CSA S6 Canadian Highway Bridge Design Code* CL-625 vehicular load case applies.

iii. *Section 1.8.5.3 - Surface Construction Requirements*

If the areaway interfaces with the street surface, the areaway shall be:

- Non-combustible material.
- Constructed with solid non-slip surfaces at the street surface interface.
- Level with the street surface interface.

iv. *Section 1.8.5.4 - Removal of Areaway*

A person who wishes to remove an areaway shall:

- Apply for and obtain all necessary permits.
  Note: A Building Permit is required for modifications to the building i.e. installation of an engineered cut-off wall at the property line and recommended waterproofing. In addition, a Street Use Permit is required for the restoration of excavations surrounding the building site, this includes the removal of areaway wall, backfilling, and restoration of the sidewalk.
- Install a cut off wall integral to the building to the satisfaction of the Chief Building Official.
- Waterproof the cut-off wall to the satisfaction of the Chief Building Official.
- Backfill and restore the street surface in accordance with the *City of Vancouver Encroachment By-law No. 4243* and to the satisfaction of the City Engineer.

2. *Division B, Part 4 - Structural Design*

   a. *Section 4.1.5 - Live Loads Due to Occupancy and Use*

      i. *Table 4.1.5.3 - Specified Uniformly Distributed Live Loads on an Area of Floor or Roof* – 12.0kPa

      ii. *Table 4.1.5.9 - Specified Concentrated* Loads on an Area of Floor or Roof – 54kN

8.12.5.4 CITY OF VANCOUVER SUPPLEMENTARY MMCD

The purpose of the *City of Vancouver Construction Specifications* is to provide standards, specifications, and procedures to ensure that construction works on City streets are carried out in accordance with the best available standards and procedures. Refer to the *City of Vancouver Construction Specifications* for information on the most applicable methods for dealing with areaway removal or repair.

8.12.5.5 DOCUMENTATION SUBMISSION REQUIREMENTS

When permits are applied for to either repair, modify, or remove an areaway, the following document types, including but not limited to, shall be submitted during the permit process:

- Signed and sealed design drawings and specifications.
- Quality Documents (refer to the *City of Vancouver Construction Specifications*).
- Letters of Assurance:
    - *Schedule B-1 "Assurance of Professional Design and Commitment for Field Review"*.
    - *Schedule B-2 "Summary of Design and Field Review Requirements"*.
    - *Schedule C-B "Assurance of Professional Field Review and Compliance"*.
- Record Drawings.

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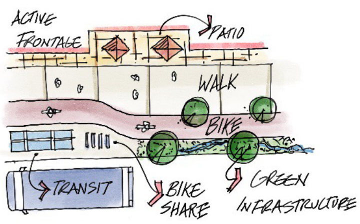
STREETSCAPE & URBAN FOREST



STREETSCAPE & URBAN FOREST

9.1 INTRODUCTION

This chapter outlines the requirements for streetscapes including horticulture, urban forest and public realm features in the City of Vancouver. Quality streetscapes contribute greatly to the quality of life of Vancouver's inhabitants and provide a wide variety of environmental, social, and economic benefits.

The City of Vancouver provides, preserves, and advocates for a rich and diverse streetscape while balancing competing street right-of-way uses and considerations in order to enhance the wellbeing of individuals and communities in the City. These guidelines are administered by the City Engineer, in consultation with the General Manager of the *Planning, Urban Design, and Sustainability Department* and the General Manager of the *Vancouver Board of Parks and Recreation* (*Vancouver Park Board*).

The following is a brief description of each section:

- The *Streetscape* section outlines the design requirements for features such as street furniture and public bike share within Vancouver's street right of way.
- The *Urban Forest* section outlines selection and placement requirements for street trees within the street right of way, including street trees required as part of a development permit process.
- The *Street Horticulture* section outlines design requirements for shrubs, groundcovers, grass, sod, and seeding.
- The *Growing Medium* section outlines requirements for engineered soil use.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

9.2 STREETSCAPE

Vancouverites — like people around the world — value inviting, interesting and creative public spaces. The City of Vancouver recognizes that a high quality public realm benefits our health, generates economic activity, fosters social connections and makes our city more exciting and inspiring.

Vancouver's public realm aims to preserve historical and contextual aesthetics of the various neighbourhoods in the City of Vancouver. This section outlines criteria and background documentation for streetscapes and the public realm in order to make the City of Vancouver safe, accessible, and aesthetically appealing.

9.2.1 STREETSCAPES

The following standards and guidelines shall be used for the design of streetscapes in the City of Vancouver:

- *City of Vancouver Streetscape Design Guidelines*.
- City of Vancouver Council-approved Community Plans and Public Realm Plans.
- *City of Vancouver Boulevard Gardening Guidelines*.
- *City of Vancouver Design Guidelines for Large Sidewalk Patios on City Property and Sample Drawings*.
- *City of Vancouver Plaza Design Guidelines*.
- *City of Vancouver Parklet Manual*.

For more on streetscapes please visit: https://vancouver.ca/streets-transportation/streetscape-design-guidelines.aspx

9.2.2 STREET FURNITURE

This section describes guidelines for siting, installation and ownership of street furniture which apply to all streetscape classifications.

For more information on street furniture call 3-1-1, visit vancouver.ca/streets-transportation/sidewalk-fixtures-and-amenities, or email: Street.Furniture@vancouver.ca
For specific sidewalk clearances refer to section 8.4.

9.2.2.1 GENERAL CONSIDERATIONS

Some general principals to be followed in the placement of street furniture:

- Setback from intersections to ensure adequate sightlines;
- Placed in the furnishing strip of the sidewalk (unless stated otherwise);
- Allow sufficient clearance for pedestrians to pass, based on expected pedestrian volumes;

- Placed outside of fire, loading and taxi zones etc., and must be well integrated with surroundings;
- Clustered as much as possible to reduce sidewalk clutter;
- Accessible to people with disabilities and special needs;
- Provide appropriate clearance within bus zones;
- Provide sufficient clearance to open a car door;
- Located in such a manner as to avoid underground utilities and access covers; and
- Located away from parking meters, trees and other sidewalk amenities.

9.2.2.2 BENCHES

Benches promote walking and provide moments for rest, relaxation, and access to views. Benches encourage people to linger in one place, which in turn enhances the walkway as a public space.

Benches should be located in:

- areas where it is desireable to linger, or where a resting area is needed. See section 8.4.1.2 for information on accessible walking distances.
- hghly visible locations to improve safety and deter vandalism.

Bench placement should take into consideration the following:

- Not permitted over or near utility access points such as maintenance holes and catch basins. A minimum of 1.5m distance must be maintained.
- Not obstructing sightlines of sidewalks, intersections, pedestrian crossings, entrance to driveways or other conflict areas. Typically 10m setback from these elements is required to protect sightlines.
- No part of the bench shall be closer than 0.6m to the face of the curb.
- Avoid underground utilities, loading and fire zones.

Ownership is site specific: Street Furniture Contractor, Vancouver Engineering Services, and/or Vancouver Park Board

9.2.2.3 BIKE RACKS

Well located safe and secure bike racks are an important factor in encouraging people to cycle in the City of Vancouver.

Ideal locations for bike racks include:

- highly visible areas
- vibrant retail and commercial areas
- areas where existing demand is noted due to existing bikes being locked up
- areas near formal cycling routes

Bike rack placement should take into consideration the following:

- allow for at least 1.8m of clear space to nearest obstruction to allow bicycle access to rack;
- be placed adjacent to the curb in the furnishing strip;

- be placed a minimum of 0.75m back from the face of the curb in curb parking areas, or such that the placement of bicycles does not obstruct car doors from opening;
- provide bicycle parking parallel to the curb where possible, with no parked bicycles extending into the adjacent sidewalk;
- be bolted to the sidewalk or footing using tamper proof bolts;
- be weather protected where possible.

Ownership is site specific: Street Furniture Contractor, Vancouver Engineering Services, and/or Vancouver Park Board

9.2.2.4 MAP STANDS (WAY FINDING SIGNAGE)

Map stands help visitors and residents alike navitgate the city's streets, and further encourages walking.

Preferred locations for Map Stands include:

- close to intersections
- in high traffic corridors, tourist and business improvement areas
- in close proximity to transit interchanges
- close to places of interest such as tourist/visitor destinations and amenities.

Map Stand placement should take into consideration the following:

- Not permitted over or near utility access points such as maintenance holes and catch basins. A minimum of 1.5m distance must be maintained.
- Not obstructing sightlines of sidewalks, intersections, pedestrian crossings, entrance to driveways or other conflict areas. Typically a 10m setback from these elements is required to protect sightlines.
- No part of the map stand shall be closer than 0.6m to the face of the curb
- Avoid underground utilities, loading and fire zones.

Ownership: Street Furniture Contractor

9.2.2.5 AUTOMATED PUBLIC TOILETS (APT)

In order to supplement the amount of public restrooms in the city, automated public toilets have been installed in many areas. These facilities offer comfort, hygiene, accessibility and security to the public.

Public Toilets should be:

- located at places of high public use such as major urban spaces, near parks, transit interchanges, tourist/ visitor destinations, where people have lunch outdoors, close to street vendors selling food and beverage
- placed in high visibility areas
- located in well lit areas
- located with ample space for pedestrian flow
- located through joint consultation with property owners, BIAs and/or neighbourhood groups or associations

Located away from:

- establishments such as outdoor cafes/restaurants
- areas where a lot of people can see a patron entering the amenity
- areas where patrons waiting for access do not impede normal pedestrian flow

Engineering design drawings are required for APT installation. These designs shall take into account water, sewer, electrical and civil works required for APT installation.

Ownership: Street Furniture Contractor

9.2.2.6 WASTE RECEPTACLES

Well located waste receptacles have a signifcant role in preventing litter and maintaining cleanliness of the public realm.

Waste receptacle placement should be:

- close to food and beverage outlets especially those establishments that generate disposable containers
- near intersections with larger pedestrian flows
- at least 900mm from a bench placement to minimize odour and insect impacts
- away from parking meters and other sidewalk amenities
- where possible, to include recycling receptacles
- along pedestrian routes to and from areas of public assembly
- near places where people assemble frequently
- near urban parks and public open spaces
- near fire hydrants, to allow ease of collection
- at bus stops.

For specific waste management and resource recovery design standards, refer to *City of Vancouver Garbage & Recycling Storage Amenity Design Supplement*

Ownership varies between the City of Vancouver Engineering Services and the Street Furniture Contractor.

9.2.2.7 BUS SHELTERS

Bus shelters protect waiting passengers from poor weather and provide additional amenities such as benches, route maps, and lighting.

Shelters should be provided wherever possible. As a minimum, shelters are recommended at the following locations:

- Bus stops with high boarding and alighting volumes
- Bus stops at terminals or major transfer points

- In the vicinity of schools, seniors' housing developments, community and recreation centres, HandyDART bus stop, and other major generators such as shopping malls

Bus shelter placement should take into consideration the following:

- Not farther than 9m from the Bus Stop I.D. post for passenger convenience
- There shall be a minimum of 3m width direct clear path from the bus ID pole to the sidewalk to allow for ramp deployment and access to the front doors of the bus
- The shelter interior should be illuminated by its own light source or by adjacent street lighting
- Bus shelters shall have a minimum clearance of 1.8m from the curb to allow pedestrian circulation and queuing in front. The closest portion of the overhead shelter should maintain a minimum lateral clearance of 0.6 m from the curb face to avoid contact with a bus (to account for the maximum rear sweep of a bus).
- If side panels are installed, they should not be of materials that interfere with waiting passengers' ability to see approaching buses. The narrower side panel, if any, should be placed in the upstream position.
- Benches should be located to minimize obstruction to the public right-of-way and access to/from the bus for all users, including those in wheelchairs.
- The minimum setback for a bus bench from the curb face should be 1.8m.
- In narrow areas where adequate space is not available to site a bus shelter, it may be prudent to put the shelter immediately downstream. Passengers waiting in the shelter should be able to clearly see approaching buses.
- To provide adequate lateral clearance, street furniture at bus stops, including the bus stop I.D. post, lamp standards, etc., should be set back at least 0.6 m from the curb face.
- Bus shelter canopy may extend over clear sidewalk provided minimum vertical clearance of 2.25m is maintained.
- Bus shelters shall not conflict with underground utilities

For further details refer to *section 8.6*.

Ownership varies between the City of Vancouver Engineering Services and the Street Furniture Contractor.

For additional information on bus shelters, refer to *TransLink's Bus Infrastructure Design Guidelines section 3.5.5*.

9.2.3 PUBLIC BIKE SHARE

Vancouver's public bike share is an important part of the City of Vancouver's commitment to green transportation. By partnering with third parties to provide a safe and accessible bike share system, the City of Vancouver can support the extension of transit and walking trips, reduce the need for personal vehicle trips, and trigger greater interest in cycling.

9.2.3.1 ROLES AND RESPONSIBILITIES

The Public Bike Share (PBS) system in Vancouver is owned and operated by a third party. All stations must be approved by the City Engineer or their designate. City staff review station documentation for site safety, competing uses of street space, impacts to development, transportation network connectivity, and other site-specific considerations.

In order to optimize system utilization and maximize ridership, stations will be located on the street, on City-owned land, parks (including other land under the jurisdiction of the Board of Parks and Recreation), land owned by other public agencies or institutions, or on private property. No more than sixty percent (60%) of stations shall be located on City Street.

9.2.3.2 GUIDING PRINCIPLES FOR STATION SITING

Opportunities for station siting prioritize safe access, connections to transit, proximity to comfortable cycling facilities, convenience to destinations, and maintaining system network density. Stations will be located proximal to commercial / shopping districts; residential neighbourhoods; parks; destinations and attractions; community facilities and amenities; large sporting, performance, and event venues; and educational institutions. Where applicable, stations should be visible from all rapid transit station entrances, express bus (B-Line) stops, and other transportation hubs. As well, stations need to be located for maximum visibility with unrestricted public access 24 hours a day, 365 days a year.

Based on industry-leading practices, stations will be located every 200-300m, or approximately every 2-3 blocks. The size of each PBS station is based on the relative demand expected taking into consideration adjacent land uses, population, transit nodes, recreational destinations, and other trip generating sources.

Throughout the service area, stations will be spaced no greater than 300m apart to serve 150m radius catchment areas, maintaining a minimum station density of 10 stations per square kilometer. In areas of high demand, station density and station size will be increased to support increased ridership.

PBS stations will be located on both public and private-zoned lands, in parks, and on street rights-of-way. Due to limitations on street rights-of-way (grades, curved streets, pedestrian clearances, landscaping, parking, loading, art, vending, utilities, etc.), space for stations on privately-zoned lands is being secured as part of the development permit and rezoning application process.

Where applicable, the Vancouver Public Bike Share system follows the *NACTO Guidelines* and the *ITDP Bikeshare Planning Guide*.

9.2.3.3 SITE SPECIFIC REQUIREMENTS

Stations may be located on public rights-of-way, on private property, or on other zoned lands. Site specific requirements for stations are shown in ***Table 9-1***:

Table 9-1: Bike Share Facility Requirements

Property	Public Right-of-Way	Private Property and Other Zoned Land

Size	The length of stations varies based on demand and availability of street space.	The minimum length of station is 16m.
	The full length of the space is to be continuous. The physical station with docked bicycles is 2m wide and has a required bicycle maneuvering zone of 2m for a total width of 4m. There is also an option for bi-directional stations which require a total width of 8m.	
Location	The station must be clearly visible to the public with 24/7 public access and easy access to the street.	
Surface Treatment	A hard surface is required with no utility access points within the public bike share station. Any utility access point within 1m of the public bike share space is to be identified and shown in a detailed drawing submitted. Acceptable surfaces include cast-in-place concrete (saw cut or broom finished), asphalt, and pavers. Other firm, paved materials are subject to approval.	
Grades	The surface must be leveled with a maximum cross slope of 3% and have a consistent grade (i.e. no grade transitions) along the length with a maximum slope of 5%. At a minimum, spot elevations at the four corners of the station must be provided.	
Sun Exposure	Since the station operates on solar power, no vertical obstructions including awnings or canopies are permitted. Ideally, the station should receive 5 hours of direct sunlight per day.	
Power	There is no requirement for provision of power. Sun exposure must be provided.	Provision of an electrical service and electrical power is to be available at the public bike share station.
Access	There shall be no conflicting site features near the PBS space (e.g. drain, tree, vault, etc.). Any site feature within 1m of the PBS space is to be identified on a detailed drawing (see *Section 2.4.15*). Site features at the boundaries of the PBS space such as landscaping, windows, vents, or hose bibs are subject to approval. Consideration shall be made for nearby uses such as access, maintenance, or privacy that may interact / interfere with the station operations. Access and maintenance must not disrupt the PBS station, noting that some features have different access requirements (e.g. fire department connections require uninterrupted road access).	

9.3 URBAN FOREST

The City of Vancouver is committed to increasing the Urban Forest as outlined in the Urban Forest Strategy and Greenest City Action Plan. Vancouver's Urban Forest contributes to the health of the environment and of every resident and visitor. This section outlines criteria for selecting and locating trees in the City of Vancouver to ensure that the Urban Forest is healthy and resilient.

9.3.1 TREES

The *City of Vancouver Street Tree By-law No. 5985* stipulates that the *Vancouver Park Board* has care and custody of all trees growing on Vancouver street rights-of-way. *Vancouver Park Board* staff are responsible for overseeing or conducting tree planting, risk assessments, and general maintenance of trees on streets.

The development community, utility contractors, and other City of Vancouver departments also have an important role to play in the management of the urban forest. They are frequently called upon to provide and plant new trees, or work near existing trees while protecting their value. There are many challenges to the task of integrating urban forest management with other elements of urban function. This section, in conjunction with the *City of Vancouver Construction Specifications*, the *City of Vancouver Standard Detail Drawings,* and the Development Permit process, outlines the criteria for tree planting in the City of Vancouver.

9.3.2 GENERAL AUTHORITY

This section outlines the authority in charge of maintenance of trees and the general rules for all trees in the City of Vancouver. All trees within the boundaries of Vancouver form part of the Urban Forest.

9.3.2.1 STREET TREES ON RIGHT-OF-WAY

Trees located on street rights-of-way, including lanes, are administered under the terms of the *City of Vancouver Street Tree By-law No. 5985*. The by-law stipulates that:

- Trees planted on City boulevards are property of the City of Vancouver and the care and custody of these trees resides with the *Vancouver Park Board*.
- The planting of any tree in a boulevard shall be in compliance with standards set by the City Engineer and the General Manager of the Vancouver Board of Parks and Recreation.
- No person shall plant, remove, destroy, cut, deface, trim or in any way injure, impair, or interfere with any street tree except as expressly authorized to do so by the City Engineer and the General Manager of the Vancouver Board of Parks and Recreation.
- The species / cultivated variety / form of trees being planted on public property must be approved by the *Vancouver Park Board*.

- The placement of those trees must be approved by the *Streets Design Branch* or their designate, in consultation with the *Vancouver Park Board*.

9.3.2.2 LANE TREES

Trees planted in lanes exist throughout Vancouver even though the City does not plant or give permission to plant trees in lanes. Most lane trees are volunteers that established themselves as part of natural propagation or were planted by adjacent property owners without City approval.

Where the lanes are open to public traffic, trees fall within the care and custody of the *Vancouver Park Board*. Where the lanes have been closed off to traffic access by private property extensions, enclosures, hedges, or structures, the duty of care resides with adjacent beneficiaries of the land around its base, including any costs of mitigation and removal of hazard trees.

Application for the removal of lane trees may be made through the City, with consent from the adjacent property owner(s).

9.3.2.3 PRIVATE PROPERTY TREES

Trees located on private property are the responsibility of the property owner. The removal of those with a diameter over 20cm is administered by the Community Services Group, as mandated by the *City of Vancouver Protection of Trees By-law No. 9958*.

9.3.3 STREET TREE PLACEMENT

9.3.3.1 GENERAL GUIDELINES

The optimum spacing of trees in the public realm is achieved by balancing site capacity, aesthetic and environmental values with the physical form of the tree being used. The City of Vancouver strives for maximum canopy coverage on City streets, recognizing that transportation corridors are required to accommodate many competing interests such as space for people, goods movement, and infrastructure. The following are considerations:

- Plant so that the species / cultivar planted will grow to close canopy at about the age of 20 in high-density areas, and the age of 30 in low-density areas where the trees are able to grow to a larger size, and the landscape is softened already by existing greenspace.
- Consider public safety and lighting factors.
- Plant only if the street is curbed.
- Indicate existing trees and existing and proposed utilities and amenities on tree planting plans.
- Plant street trees with approved tree grate or surround as specified by the *City of Vancouver Streetscape Design Guidelines* or City staff.

9.3.3.2 SPACING AND SOIL VOLUME REQUIREMENTS

Tree spacing and soil volume requirements are outlined in ***Table 9-2***:

Table 9-2: Tree Spacing and Soil Volumes

Tree Size Category	Average Spacing	Soil Volume Per Solitary Tree	Soil Volume (Shared /Row of Trees)
Large	9m - 11m	$30m^3$	$20m^3$
Medium	8m - 10m	$20m^3$	$15m^3$
Small	7m - 10m	$10m^3$	$5m^3$
Columnar	7m - 10m	$20m^3$	$15m^3$

Soil Volumes may be achieved through various methods. Ideally, access to good native soil is preferred. When this is not obtainable, due to existing conditions or construction practices, volumes may be obtained through the installation of engineered soil (calculated at 50% volume) or soil cells when appropriate and approved by the City Engineer.

Engineered soil and soil cells are only permissible when installing new trees. Soil cells may only be used during new road construction when utilities will not be impacted, no native soil is available due to extenuating circumstances, and the City Engineer approves.

In addition, soil cell installations must meet the appropriate City loading requirements.

9.3.3.3 CLEARANCES

Table 9-3 lists the preferred minimum clearance (measured from outer edge of infrastructure) of trees from:

Table 9-3: Minimum Clearances

Object	Minimum Clearance
Lamp Standards	1.5m - 4.5m
Electrical / Communications / Trolley Poles	1.5m
Driveways / Crossings	1.8m
Signalized Intersection from stop bar	6.0m
Or from traffic signal pole	1.5m
Fire Hydrants	2.0m
Water Mains	2.0m
Service Connections	2.0m
Catchbasins / Valve Boxes	1.5m
Corner Clearances (From Extended Property Line)	3m
Stop Signs	6m
Parking Meters	Clear of Tree Pit / Surround
Buildings (Spreading Trees)	3m
Buildings (Columnar Trees)	2m

Trees shall not be planted in the following locations:

- Over building encroachments under the sidewalk (areaways).
- Under canopies or overhead signs.

- In bus zones, except in bus bulges in line with other trees on block.
- In between signal poles at an intersection.
- In loading or passenger zones.

Where double rows are required by the City of Vancouver, the back row must be on private or park property.

The curb side edge of a tree surround must be at least 0.3m from the back of the curb.

Space trees appropriately away from existing street and private trees.

Spacing is approved by the *Streets Design Branch*, in conjunction with the *Vancouver Park Board*. All final locations must be approved by the *Streets Design Branch*.

9.3.4 TREE SPECIES SELECTION

The *Vancouver Park Board's Urban Forestry* provides full care and custody of public trees (following a two-year warranty period, if trees were delivered through development). Stewardship is intended to last for many decades. It is essential to ensure that the proper tree is planted and, consequently, the *Vancouver Park Board* has final authority over the species selection. In order to obtain species selection approval, contact the *Vancouver Park Board*, at: pbdevelopment.trees@vancouver.ca. Species selection criteria are as follows:

- Compatibility with local growing conditions.
- Adequate space to reach its natural form at maturity.
- Branch failure or wind-throw resistance.
- Pest resistance.
- Freedom from significant nuisance problems (large nuts, allergenic properties).
- Low maintenance.
- Diversity within Vancouver's public tree population.

The *Vancouver Park Board* manages the City-wide street tree population so that there is diversity and resilience as per ***Table 9-4***.

Table 9-4: Citywide Street Tree Diversity

Taxa Level	Maximum Percentage of Total Street Trees
Family	30%
Genus	20%
Species	10%
Variety	3%

Tree species diversity requirements are listed in ***Table 9-5***:

Table 9-5: Project Level Tree Species Diversity Requirements

Number of Trees in Development Project	Maximum Percentage of One Genus	Maximum Percentage of One Species
> 100	40%	25%
50 - 100	50%	30%
25 – 49	100%	50%
1 - 24	100%	100%

The *Vancouver Park Board* must authorize all tree species selections prior to the planting of any street trees. Selecting the proper street tree for a site should follow this order:

2) Match mature size of tree to available overhead space.
3) Determine how adequate soil volume can be attained.
4) Determine species trunk size at maturity to ensure the tree pit opening is sufficient to not cause undue damage to adjacent infrastructure.
5) Where adjacent and cross street trees do not occur in the preferred street tree species list, in *Section 9.3.4.1*, trees should be selected that have similar:
    - Mature size.
    - Crown shape.
    - Branch density.
    - Leaf texture.
6) If requesting substitutions to the preferred street tree species list, they must have the following characteristics:
    - A well-behaved root system.
    - Tolerant of urban conditions (pollution, weather extremes, low nutrient conditions).
    - Free of nuisance habits (messy, prone to pests, weak branches, aggressive roots).

9.3.4.1 PREFERRED STREET TREE SPECIES LIST

In order to meet City of Vancouver tree diversity criteria, the City of Vancouver has preferred tree species for planting. These species may change depending on the needs and changing conditions within the City. The *Vancouver Park Board* may require different species than those listed in this document depending on site conditions or project needs. The tree species are separated by large trees, medium trees, small trees, columnar trees, coniferous trees, and broadleaf evergreen trees.

Large Trees

Large trees are trees with a mature height between 15m and 25m and a canopy radius of 5m from the trunk. They are suitable for boulevards with no overhead obstructions and greater than 3m of width, with building setbacks of 8m or greater. See ***Table 9-6*** for acceptable large tree species.

Table 9-6: Large Tree Species List

Botanical Name	Common Name
Acer cappadocicum	Caucasian Maple
Aesculus x Carnea ('Briottii' Or 'Baumanni')	Red-flowered Horse Chestnut
Cercidiphyllum japonicum	Katsura Tree
Fagus sylvatica	European Beech
Quercus acutissima	Sawtooth Oak
Quercus phellos	Willow Leaf Oak
Quercus palastris	Pin Oak
Tilia tomentosa	Silver Linden
Zelkova serrata	Zelkova

Medium Trees

Medium trees are trees with a mature height between 8m and 15m and are generally suitable for a boulevard with a width of 1.5m or greater between curb and sidewalk. See ***Table 9-7*** for acceptable medium tree species.

Table 9-7: Medium Tree Species List

Botanical Name	Common Name
Acer campestre 'Queen Elizabeth'	Field Maple
Acer truncatum	Shantung Maple
Carpinus betulus, orientalis, or *caroliniana*	Common Hornbeam
Corylus colurna	Turkish Hazel
Davidia involucrata	Dove Tree
Fraxinus ornus	Flowering Ash
Gleditsia triacanthos	Honey Locust
Magnolia kobus	Japanese Magnolia
Nyssa sylvatica or *N. sinensis*	Black Tupelo
Parrotia persica cvs.	Persian Ironwood
Rhamnus purshiana	Cascara Sagrada
Sorbus alnifolia	Korean Mountain Ash
Sorbus aria	Whitebeam
Zelkova serrata 'GreenVase'	Zelcova

Small Trees

Small trees are trees with mature height less than 8m and may be suitable for locating at or below overhead electrical conductors, or where the below ground soil environment is very restrictive. See ***Table 9-8*** for acceptable small tree species.

Table 9-8: Small Tree Species List

Botanical Name	Common Name
Acer griseum	Paperbark Maple
Acer palmatum (Tree Form Varieties)	Japanese Maple
Amelanchier Canadensis	Treeform Service Berry
Cercis Canadensis	Eastern Redbud
Cornus x 'Eddies White Wonder'	Eddies White Wonder Dogwood
Cornus kousa var. chinesnis and 'Satomi'	Japanese Dogwood
Crataegus phaenopyrum 'Treeform'	Washington Hawthorn
Crataegus monogyna	Singleseed Hawthorn
Crataegus x lavallei	Lavalle Hawthorn
Magnolia stellate	Star Magnolia
Styrax japonica	Japanese Snowbell
Syringae reticulate	Tree Lilac
Fagus sylvatica 'Tricolor'	Tricolor Beech
Stewardia pseudocamelia	Japanese Stewartia
Carpinus japonica	Japanese Hornbeam
Cornus controversa	Giant Dogwood
Magnolia kobus	Kobus Magnolia
Stewardia mondelpha	Orangebark Stewartia
Stewardia koreana	Korean Stewartia
Styrax obassia	Fragrant Snowbell Tree

Columnar Trees

Columnar trees are trees exhibiting a distinct upright branch arrangement and may be suitable for locating in confined situations or in boulevards offset from overhead electrical conductors. See ***Table 9-9*** for acceptable columnar tree species.

Table 9-9: Columnar Tree Species List

Botanical Name	Common Name
Acer nigrum 'Green Column'	Black Maple
Carpinus betulas 'Fastigiata'	European Hornbeam
Fagus sylvatica 'Dawycki'	Dawycki Beech
Gingko biloba 'Sentry" or 'Lakeview'	Maidenhair Tree
Parrotia persica 'Vanessa', 'lnges Ruby Vase' or 'Vanessa' or 'Upright'	Persian Ironwood
Quercus frainetto	Hungarian oak
Acer campestre 'Panecek'	Panacek maple
Magnolia 'Galaxy'	Galaxy magnolia
Sorbus alfnifolia	Korean mountain ash

The following two sections on recommended Conifer and Broadleaf Evergreen street tree species are aspirational and a guide only. In all cases, site-specific criteria such as quantity and quality of available soil, sightlines, and surrounding space and associated public functionality must be considered. Trees not on the list may be requested for special situations but may be restricted due to known maintenance issues.

Conifers

Cone bearing trees are not generally planted on boulevards due to their low branching habit when young. Nonetheless, they are a desirable type of tree to plant where space allows. Traffic medians may be a suitable location. See ***Table 9-10*** for acceptable conifer tree species.

Table 9-10: Coniferous Tree Species List

Botanical Name	Common Name
Calocedrus decurrens	California Incense Cedar
Cedrus atlantica 'Glauca'	Blue Atlas Cedar
Chamaecyparris nootkatensis	Nootka Cypress
Pinus nigra	European Pine
Pinus flexilus	Limber Pine (ornamental varieties)
Picea omerika	Serbian Spruce
Metasequoia glyptostroboides	Dawn Redwood
Taxobium distichum 'Ascendens'	Bald or Pond Cypress
Abies grandis	Grand fir

Broadleaf evergreens

These are trees which are broadleaved, non-cone bearing, and keep their leaves throughout the winter season. Many are more commonly available in shrub form and therefore are typically unacceptable for street tree usage, but forms trained on a single stem are sometimes available. They often have very specific growing requirements or habits that need to be considered on a site-specific basis. The *Vancouver Park Board* supports an increase in their usage. See ***Table 9-11*** for acceptable broadleaf evergreen tree species.

Table 9-11: Broadleaf Evergreen Tree Species List

Botanical Name	Common Name
Arbutus unedo	Strawberry Tree
Cotinus obovatus	American Smoketree
Lithocarpus densiflorus or *L henryi*	Tan Oak
Maqnolia virginiana	Northern Sweetbay
Quercus ilex	Holly Oak
Quercus myrsinifolia	Bamboo-leaf Oak
Prunus lusitanica	Portuguese Laurel
Umbellularia californica	Oregon Myrtle

9.3.5 AWNING AND CANOPY SETBACKS FROM TREES

The City of Vancouver recognizes that street trees are an important element along commercial corridors and downtown streets. All new awnings and canopies must be able to accommodate the maturing crowns of existing and future trees. ***Table 9-12*** provides a quick reference for those who wish to install an awning or canopy overhanging City property. The accompanying drawings illustrate typical situations that arise and show minimum setbacks of awnings from trees. These setbacks recognize that trees grow, and that conflicts can be ratified with branch pruning only so far as to not cause damage or disfigurement to the tree.

Table 9-12: Awning Setbacks

Type of Tree / Situation	Minimum Awning Setback
New Columnar Trees (Narrowly Shaped at Maturity)	120cm
New Large, Medium, or Small Spreading trees	180cm
Existing Tree	180cm or more depending on size and shape of tree

9.3.5.1 TYPICAL COMMERCIAL STREET

On typical commercial streets, the overhang of the awning should come no closer than 180cm to the centre of the tree trunk. ***Figure 9-1*** and ***Figure 9-2*** show typical commercial street awning configurations.

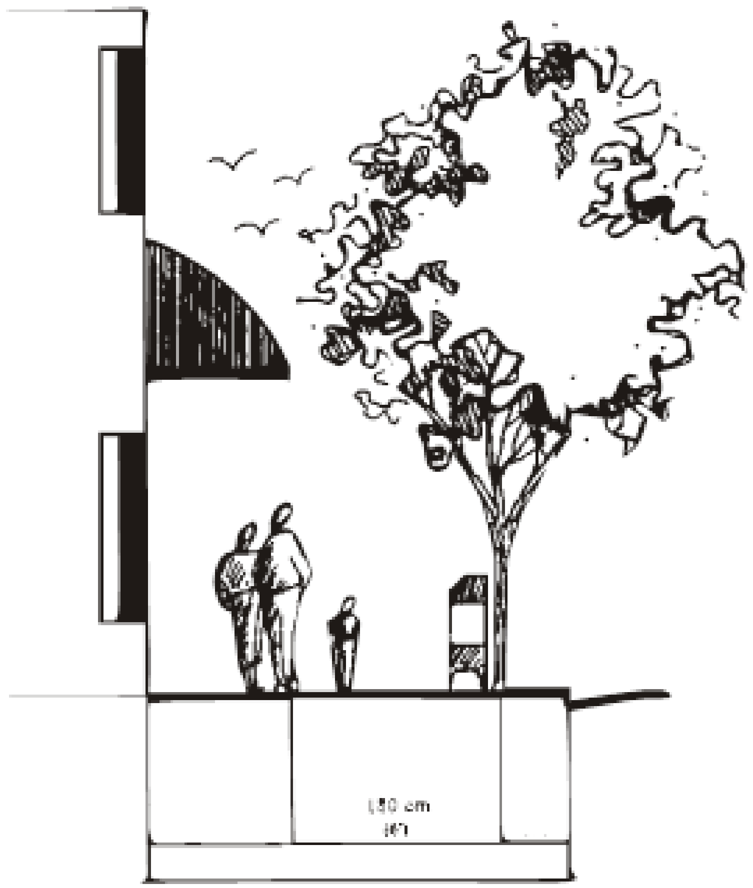


Figure 9-1: Typical Commercial Street Awning Section

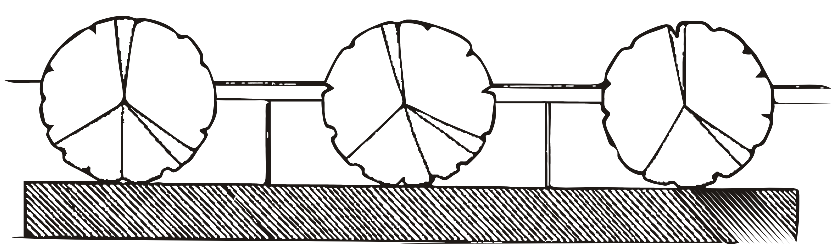


Figure 9-2: Typical Commercial Street Awning Plan

9.3.5.2 EXISTING TREE CROWN – PROPOSED AWNING CONFLICTS

Canopies must be variably shaped in order to accommodate existing trees when pruning would be harmful to them. ***Figure 9-3*** and ***Figure 9-4*** show awning configurations for proposed awnings that conflict with existing tree crowns.

Figure 9-3: Existing Tree Crown - Proposed Awning Conflict Section

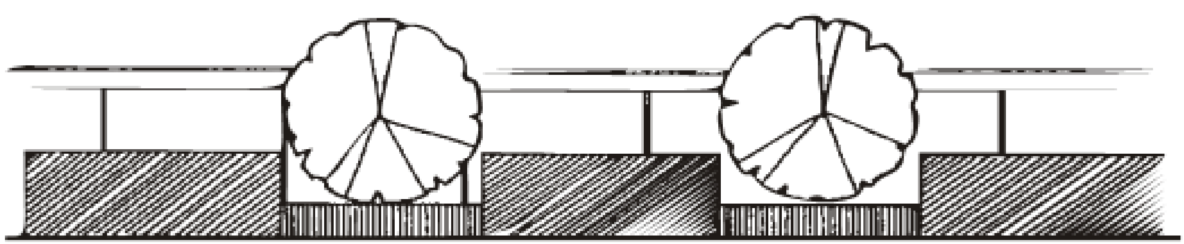


Figure 9-4: Existing Tree Crown - Proposed Awning Conflict Plan

9.3.5.3 NARROW BOULEVARDS

The *Vancouver Park Board* specifies wider growing trees wherever space allows. The overhang of the awning should come no closer than 120cm to the centre of the tree trunk. ***Figure 9-5*** and ***Figure 9-6*** show awning configurations for narrow boulevards where trees with a columnar habit are being used.

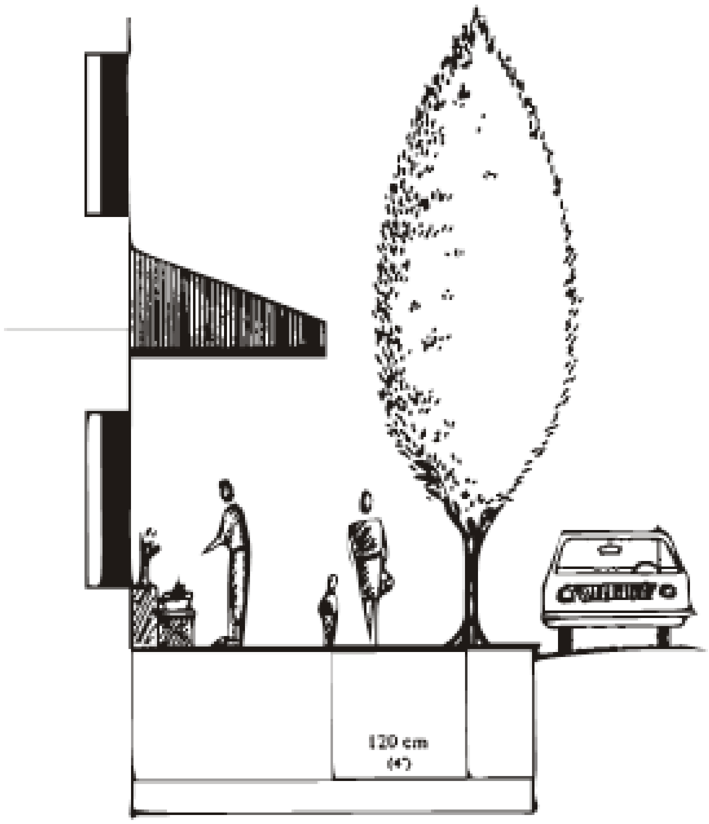


Figure 9-5: Narrow Boulevard Columnar Tree Awning Section

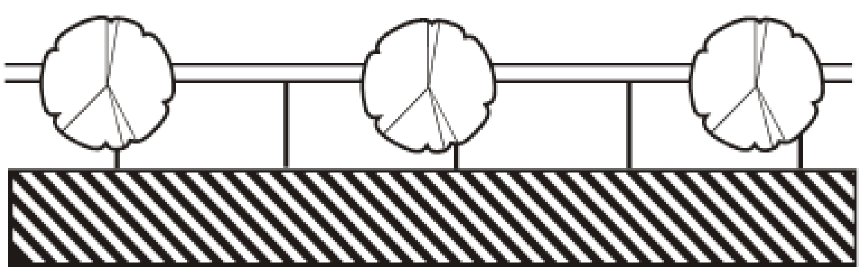


Figure 9-6: Narrow Boulevard Columnar Tree Awning Plan

9.4 STREET HORTICULTURE

Shrub plantings and street trees serve an important purpose both aesthetically and in terms of rainwater management and should be considered around the stations whenever possible.

Plantings should be:

- Native or adapted species that require little maintenance and thrive in the local climate
- Drought tolerant, observing *City of Vancouver Water Wise Landscape Guidelines*
- Diverse species that attract pollinators

Plantings should not:

- Conflict with weather protection
- Obstruct sightlines for vehicle movement; or
- Obstruct the movement of pedestrians or cyclists.

9.4.1 SHRUBS AND GROUNDCOVERS

Contact the *Engineering Services Department* for information on shrubs and groundcovers.

9.4.2 GRASS

The proper installation of grass boulevards in high-use areas, particularly adjacent to commercial and higher-zoned residential properties, is critical to provide a long-lasting streetscape treatment that will meet the expectations of the City and adjacent residents / businesses. Refer to the *City of Vancouver Construction Specifications* for soil mixtures. Artificial turf is not an acceptable boulevard treatment.

9.4.2.1 SOD AND SEEDING

If sod is used, it must be suitable for high-traffic areas, offer good wear tolerance, shall be grown on sand or sandy loam based medium and shall be un-netted. Netted sod and sod grown on silt-clay based medium are not acceptable. Preference will be for sods that include drought tolerant grass species like creeping red fescues. If drought tolerant species are not present in the sod, it is recommended that these be introduced.

For seeded areas, the seed mix shall be a premium grade suitable for high-traffic areas and offer good wear and drought tolerance. Refer to the *City of Vancouver Construction Specifications* for acceptable seed mixes.

9.5 GROWING MEDIUM

9.5.1 GROWING MEDIUM

The location of growing medium placement dictates which mix to use. Typically, in boulevards with new trees and sod lawn or planting, the Street Shrub Mix, as specified in the *City of Vancouver Construction Specifications*, is used at a depth to give a sufficient soil volume for each tree. When planting trees in the boulevard, the Street Turf Mix, as specified in the *City of Vancouver Construction Specifications*, does not provide enough organics for satisfactory long-term growth. The Street Turf mix is suitable for boulevard areas with grass only.

9.5.2 ENGINEERED SOIL

The City of Vancouver aims to soften the urban hardscape with trees planted on City property. However, in heavily hardscaped areas, there are often inadequate soil resources on site in order to achieve a healthy tree canopy. Further, typical resilient sidewalk subgrade is a poor growing medium for trees, and either prevents them from growing or causes the roots to stay shallow beneath the concrete surface.

While the typical tree pit provides approximately 3m^3 of soil, success for the tree will only be possible if there is accessible native soil to augment available resources. In locations where native soil is not accessible, trees will not thrive or live long enough to achieve the desired effect. These situations typically occur on filled-in tidal flats or places where large volumes of soil have been removed prior to the construction of a major project.

Engineered soil, sometimes referred to as structural soil, can be used to mitigate insufficient or inadequate native growing medium as a subgrade that performs the dual purpose of supporting loadbearing hardscapes while also providing a suitable growing environment for tree roots. It consists of a measured mix of rock and soil whereby the load bearing is fully accomplished by an angular granite matrix while the pore space is filled with soil. Engineered soil can promote stable, healthy, long-lived trees while reducing the potential negative implications of large-scale root development under hard surface areas such as adjacent Portland-cement concrete sidewalks. For the City of Vancouver's accepted engineered soil mix and installation requirements, refer to the *City of Vancouver Construction Specifications*.

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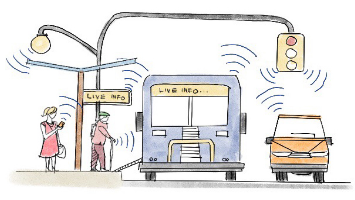
STREET LIGHTING & TRAFFIC SIGNALS



STREET LIGHTING & TRAFFIC SIGNALS

10.1 INTRODUCTION

Vancouver's street lighting and traffic signals are a crucial part of making the City of Vancouver's streets safer and more accessible. By keeping roads and sidewalks illuminated, pedestrians, cyclists, and motorists are all visible and able to share the roadway safely. Through the effective use of traffic signals, pedestrian movements are kept separate from cyclists and vehicles, and vehicular traffic flows smoothly. This chapter outlines the design criteria for street lighting and traffic signals in the City of Vancouver.

The following is a brief description of each section:

- The *General Design and Analysis* section outlines the general codes, regulations and standards for street lighting and traffic signal design.
- The *Street Lighting Design and Analysis* section outlines the analysis required for street lighting and the possible conflicts street lighting may encounter.
- The *Design of Street Lighting Components* section outlines the design components of the street lighting system in use.
- The *Traffic Signal Design and Analysis* section outlines the analysis required for traffic signal design and the process for phasing, timing, and coordination of traffic signals.
- The *Design of Traffic Signal Components* section the outlines the design components of the traffic signal systems in use in the City.

Refer to *Chapter 2: Design Process & Coordination* for specific submission requirements.

10.2 GENERAL DESIGN AND ANALYSIS

This section outlines general design criteria and other requirements for street lighting and traffic signals.

10.2.1 GENERAL CONSIDERATIONS

Street lighting and traffic signals shall be designed with consideration of the requirements outlined in *Chapter 2: Design Process & Coordination*, *Chapter 7: Third-Party Utilities*, and *Chapter 8: Streets & Transportation*. All electrical drawings must be signed and sealed by a qualified professional engineer registered with EGBC.

10.2.2 ABBREVIATIONS

Abbreviations are as follows:

- CD Candela.
- CEC *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver.
- CCT Correlated Color Temperature.
- CMBC Coast Mountain Bus Company.
- CSA Canadian Standards Association.
- EGBC Engineers and Geoscientists British Columbia.
- IESNA Illuminating Engineering Society of North America.
- ITE Institute of Transportation Engineers.
- K Kelvin.
- LED Light Emitting Diode.
- MoTI Ministry of Transportation and Infrastructure.
- NEMA National Electrical Manufacturers Association.
- TAC Transportation Association of Canada.
- UPD Unit Power Density (Watts/m^2).

10.2.3 STANDARDIZATION

The City uses standardized products and methods that are defined in the *City of Vancouver Construction Specifications* and the *City of Vancouver Standard Detail Drawings*. The designer should follow the products and methods of the City's standards unless otherwise directed by the City Engineer.

Traffic signal displays (signal heads) and general operation are standardized throughout British Columbia to avoid potential confusion of the travelling public. These elements are defined in the *British Columbia Motor Vehicle Act*. Standardized items include:

- Vertical mounted signal heads.
- Left and right-side secondary heads.
- Order of signal indication.

10.2.4 CODES, REGULATIONS, AND STANDARDS

The most current edition of the following documents provide background and direction for street lighting and traffic signal design in the City of Vancouver:

10.2.4.1 CODES AND REGULATIONS

- BC Hydro regulations.
- *CAN/CSA Canadian Electrical Code with* bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver.
- *CAN/CSA S6 Canadian Highway Bridge Design Code*.
- Coast Mountain Bus Company regulations.
- FortisBC regulations.
- Railway regulations.
- Regulations issued by municipal, provincial and federal authorities.
- Telus regulations.
- *Transport Canada Grade Crossing Regulations*.
- WorkSafeBC regulations.

10.2.4.2 STANDARDS AND GUIDELINES

- *ANSI/IES RP-8 Roadway Lighting*.
- BC Hydro standards.
- *British Columbia Motor Vehicle Act*.
- *British Columbia Motor Vehicle Act Regulations Division 23 – Traffic Control Devices*.
- *BC MoTI Electrical and Traffic Engineering Manual*.
- *BC MoTI Pedestrian Crossing Control Manual for British Columbia*.
- CAN/CSA standards.
- *City of Vancouver Construction Specifications*.
- *City of Vancouver Standard Detail Drawings*.
- *Chapter 2: Design Process & Coordination*.
- *Chapter 7: Third-Party Utilities*.
- *Chapter 8: Streets & Transportation*.
- Coast Mountain Bus Company standards.
- Fortis BC standards.
- *IES LM-79 Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products*.
- *IES LM-80 Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules*.

- *IES TM-15 Luminaire Classification System for Outdoor Luminaires* and *Addendum A: Backlight, Uplight, and Glare (BUG) Ratings*.
- *IES TM-21 Projecting Long Term Lumen Maintenance of LED Light Sources*.
- ITE standards.
- *TAC Accessible Pedestrian Signals Guidelines*.
- *TAC Bikeway Traffic Control Guidelines for Canada*.
- *TAC Guide for the Design of Roadway Lighting*.
- *TAC Manual of Uniform Traffic Control Devices for Canada (MUTCD)*.
- Telus standards.

10.2.5 PERMITS

Permits will generally be as follows:

- Interconnection permits from rail companies, Ministry of Transportation and Infrastructure, or other authorities.
- Right-of-way and utility crossing permits for crossings of electrical transmission lines; railways; highways; and regional, provincial and federally regulated pipelines.
- Electrical permits.

10.2.6 UNDERGROUND AND OVERHEAD CONFLICTS

It is the designer's responsibility to investigate proposed and existing underground utilities and resolve all conflicts to the best of their ability based on the information available. The designer is required to add a note to drawings putting the onus on the contractor to contact BC One Call prior to any construction work. Utility information shall be confirmed by the *Utilities Management Branch*. All underground utilities shall be shown on the drawings clearly with unique line types and confirmed by cross-referencing GIS data with City of Vancouver utility plate maps.

The designer shall obtain permits and approvals for crossings of electrical transmission lines, railways, and regulated pipelines.

The note in ***Figure 10-1*** shall be added onto the design drawings.

CHECK BEFORE YOU DIG

CONTRACTOR SHALL REFER TO MUNICIPAL RECORD / CIVIL DESIGN DRAWINGS FOR ALL OTHER UTILITIES, SERVICE LOCATIONS, AND DETAILS. THE EXACT LOCATION OF THESE UTILITIES SHALL BE DETERMINED ON SITE BY THE CONTRACTOR. CONTACT BC ONE CALL, CALL BEFORE YOU DIG AT 1-800-474-6886. CALL AT LEAST 3 FULL WORKING DAYS BEFORE YOU PLAN TO DIG.

Figure 10-1: Overhead and Underground Drawing Notes

Overhead power lines in proximity of poles can represent significant risk and safety concerns if safe working and operating clearances are not met. The designer shall confirm clearances from overhead power lines to poles and luminaires. Where overhead lines exist, the designer shall survey lines with a laser range finder or appropriate device. Where new power lines are proposed, the pole and line heights shall be confirmed with BC Hydro. A one-sided spacing or a shorter pole may also be considered where overhead power line clearances can't be met. The designer shall add the note in ***Figure 10-2*** onto the drawings to put the onus onto the contractor to meet all safety requirements prior to installing the pole.

OVERHEAD POWER LINE CONFLICTS

CONTRACTOR SHALL CONFIRM ON SITE PRIOR TO CONSTRUCTION
THAT POLES & EQUIPMENT WILL MEET WorkSafeBC CLEARANCE
REQUIREMENTS FOR OVERHEAD PRIMARY AND SECONDARY LINES.
CONTRACTOR TO REPORT ANY CONFLICTS OR DISCREPANCIES
TO THE ENGINEER OF RECORD PRIOR TO CONSTRUCTION

Figure 10-2: Overhead Power Line Conflict Note

It is the designer's responsibility to contact BC Hydro for the required clearances for higher voltages, and to contact Coast Mountain Bus Company for the required clearances for trolley wires close to signs, signal heads, signal arms, luminaires, luminaire arms, and poles.

10.3 STREET LIGHTING DESIGN AND ANALYSIS

The City of Vancouver operates, updates, and maintains a street lighting system to light streets and roadways including sidewalks, crosswalks, intersections, roundabouts and multi-use pathways. The principal purpose of street lighting is to enhance visibility at night. For a pedestrian, this generally means better visibility of their surroundings while on the sidewalk. For cyclists and motorists, street lighting means more time to stop when needed or to safely avoid an obstacle. This section outlines design criteria and other requirements for street lighting.

10.3.1 REQUIREMENTS

Designs shall meet the lighting requirements of the applicable Illuminating Engineering Society (IES) standards as the primary reference and the *TAC Guide for the Design of Roadway Lighting* as a secondary reference. These requirements and standards are applicable except where noted in this document. Where conflicts arise between the *TAC Guide for the Design of Roadway Lighting* or IESNA documents and the *City of Vancouver Engineering Design Manual*, the *City of Vancouver Engineering Design Manual* shall take precedence. The information in this document is based on IESNA and TAC lighting standards as well as the *MMCD*.

All consultants are required to consult with the City to determine and receive acceptance of specific design requirements. Some lighting designs will be new, while others will be modifications to existing lighting to suit road modifications or a rehabilitation or upgrade of the existing system.

The City is committed to reducing community-based greenhouse gas emissions through energy efficient lighting using LED light sources. Designs that meet lighting requirements while reducing energy consumption are required, unless otherwise specified by the City Engineer.

Lighting is generally required on all streets, intersections, roundabouts, mid-block crosswalks and at all at-grade railway crossings where warranted by *Transport Canada Grade Crossing Standards* and *Transport Canada RTD-10 Road/Railway Grade Crossing Technical Standards and Inspection, Testing and Maintenance Requirements*. Lighting is not required on laneways and sidewalks unless specifically defined by the City. Lighting requirements for multi-use pathways shall be confirmed with the City on a case-by-case basis.

Lighting of guide signs will not be required where retro-reflective sign sheeting material is ASTM Grade IV or better. Signs will be illuminated via sign luminaires where lower grade sheeting is used or where car headlights will not illuminate sign sheet due to road curvature. Where lighting is required, it shall meet the requirements defined in the *TAC Guide for the Design of Roadway Lighting*.

Street lighting is also installed as part of a traffic signal installation; refer to *Section 10.5* and *Section 10.6* for more information.

Where possible, communication ducting is common-trenched with street lighting. Consult the *Traffic, Electrical, Operations & Design Branch* to define communication ducting requirements as part of the street lighting design.

10.3.2 MEASUREMENTS

10.3.2.1 ILLUMINANCE

Light that is incident upon a surface will create "illuminance" on that surface. Illuminance is a measure of the light landing on a defined area. The more lumens on a given surface area, the greater the level of illuminance. The illuminance method of design is used for lighting sidewalks, walkways, bikeways, crosswalks, intersections and roundabouts, and sections of curved roads.

10.3.2.2 LUMINANCE

Luminance is the concentration of light (intensity) reflected towards the eyes per unit area of surface. As road surfaces do not reflect light uniformly, reflectance varies depending on the angle of the incident light in both the vertical and horizontal planes and on the angle that the driver views the pavement. For a luminance calculation, the driver's viewing angle is fixed at one degree below the horizontal and an observer distance of approximately 83m. The luminance design method is used for all straight sections of road.

10.3.2.3 UNIFORMITY

Uniformity is the evenness of the light over a given area. Even lighting throughout an area would have a uniformity ratio of 1:1. A high degree of uniformity of street lighting has generally been accepted as desirable. As lighting calculations consist of a series of grid points with calculated luminance or illuminance levels, uniformity is expressed as the ratio of the average-to-minimum levels and / or the maximum-to-minimum levels. Uniformity ratios are used for all lighting scenarios.

10.3.2.4 VEILING LUMINANCE

As glare limits visibility, veiling luminance is an important consideration. Veiling luminance (also referred to as disability glare) may be numerically evaluated. Because of contrast reduction due to disability glare, visibility is decreased. Increasing the luminance level will counteract this effect by reducing the eye's contrast sensitivity. The effect of veiling luminance on visibility reduction is dependent upon the average lighting level, or average luminance level, of the pavement. Veiling luminance is expressed as a ratio of the maximum to the average veiling luminance. Veiling luminance is applied where luminance is calculated.

10.3.3 LIGHTING DESIGN AND CRITERIA

All over-lighting designs will not be accepted. Minimum wattage luminaires providing the desired lighting at the optimized pole spacing are the preferred design solution. This involves selecting the most effective luminaire photometric files and then optimizing the spacing via computer lighting design software. Pole spacing must be adjusted to suit intersections, driveways, and lot configurations. In cases where the lighting poles pre-exist the design, the luminaire wattage, distribution, and driver current to meet light level requirements will be specified by the designer.

To meet intersection light levels, luminaires must be installed on signal poles to minimize the number of poles at the intersection. The pole spacing at intersections is governed by the proposed signal pole locations. Additional street light poles may be required to meet recommended vertical illumination levels. Pole locations at signalized intersection are defined in *Section 10.6.1.1* and *City of Vancouver Standard Detail Drawings E7.20*.

Where existing luminaires are being replaced with new luminaires of a different technology (i.e. High-Pressure Sodium to LED), the street lighting conversions should just exceed minimum performance criteria. Where it is not possible to meet or come close to meeting recommended light levels, maintain the same levels as provided by the existing installation. The designer shall model the existing lighting installation using computer software in order to determine existing light levels. The designer shall provide the lighting calculations (AGI files) to the City, documenting the process and results prior to finalization of the design package. The City will review all AGI calculations.

Lighting design requires use of computer lighting design software (AGI32) and the photometric files from lighting suppliers in IES format. Typically, luminaire photometric files are based on a lamp that can vary from the actual lamp used in the test, provided it is similar. This is referred to as “relative” photometry. For LED lighting, the photometric files should be “absolute”, which means the photometric file shall be for the exact luminaire tested.

The designer shall select the photometric file for luminaires that light the roadway and sidewalks and reduce spill light and glare impacts on local residents. This shall be done by analyzing luminaire optical systems using the BUG method defined in *IES TM-15 Luminaire Classification System for Outdoor Luminaires* and *Addendum A: Backlight, Uplight, and Glare (BUG) Ratings*. The maximum nominal BUG rating of luminaires shall be B2-U0; however, a lower BUG rating should be used where possible. The glare rating is to be considered and shall be kept to a minimum value where possible. Exceeding the backlight rating (B) limit is acceptable if required to achieve the specified sidewalk lighting levels. Refer to *Section 10.4.1.2* for luminaire selection.

The designer shall apply a Light Loss Factor (LLF) to the lighting design. For LEDs, the LLF is a combination of several factors representing deterioration of the lamp and luminaire over their life span which is applied to a lighting design. The LLF is incorporated into the design calculations.

LLF = LLD x LDD x LATF

- Lamp Lumen Depreciation (LLD) shall be based on 100,000 hours of operation using the supplier's *IES TM-21 Projecting Long Term Lumen Maintenance of LED Light Sources* data for the selected luminaire.
- Luminaire Dirt Depreciation (LDD) = 0.90, as per *IES DG-4 Design Guide for Roadway Lighting Maintenance* for an enclosed and gasketed roadway luminaire installed in an environment with less than 150µg/m^3 airborne particulate matter and cleaned every eight to ten years.
- Luminaire Ambient Temperature Factor (LATF) = +15˚C.

Typical LLFs for different types of luminaires are shown in ***Table 10-1***.

Table 10-1: Typical Light Loss Factors

Luminaire Type	Light Loss Factor	
LED	0.8	(Unless higher LLD can be proven)
High Pressure Sodium	0.72	(Calculating light loss factors for High Pressure Sodium and Metal Halide is defined in the *TAC Guide for the Design of Roadway Lighting*)
Metal Halide	0.6	

Streets, sidewalks, intersections, and roundabouts require different levels of lighting based on the road classification and level of pedestrian activity. Arterial, collector, and local street classifications appropriately describe general levels of vehicular traffic and conflict. However, a second type of conflict, which is responsible for a disproportionate number of nighttime fatalities, is the vehicle / pedestrian interaction. The magnitude of pedestrian flow is nearly always related to the abutting land use. Three classifications of pedestrian night activity levels and the types of land use they are typically associated with are the following:

- **High** - Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. This includes streets in commercial areas with 100 pedestrians or more in the one-hour period with the highest average annual nighttime pedestrian volume. Local roads will typically not warrant a high level unless they can be proven to have a high level of pedestrian activity. The most common streets with high activity will be collectors and arterial classifications.
- **Medium** - This shall apply to all roads with the exception of those defined as high or low.
- **Low** - Areas with low numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. This will include streets in industrial and residential areas with 10 pedestrians or fewer in the one-hour period with the highest average annual nighttime pedestrian volume. The most common street will be a local classification.

The pedestrian activity along with the road classification will be determined by the designer to define the required luminance or illuminance, uniformity, and veiling luminance lighting requirements listed in ***Table 10-2*** and ***Table 10-3***. It is important to note that a high level of pedestrian activity may require additional poles and luminaires to meet the required levels of lighting on the sidewalks. In all cases, lighting design criteria and calculations shall be provided in a table as shown in ***Figure 10-3***.

LIGHTING DESIGN CRITERIA TABLE				
ITEM	**REQUIRED VALUES**	**CALCULATED VALUES**	**REQUIRED VALUES**	**CALCULATED VALUES**
STREET NAME(S)	McLean Ave		Intersection of McLean Ave and Caspers St	
LAND USE CLASSIFICATION	Residential		Residential	
ROADWAY CLASSIFICATION & WIDTH	8.6m Local		8.6m Local/12.2m Collector	
PEDESTRIAN ACTIVITY LEVEL	Low		Medium	
LUMINAIRE DESCRIPTION, MANUFACTURER & MODEL	ATB0 20BLEDE xx MVOLT Rx NL SH Px		ATB0 20BLEDE xx MVOLT Rx NL SH Px	
PHOTOMETRIC FILE NUMBER	XXXXXXX		XXXXXXX	
LUMINAIRE WATTAGE and LIGHT SOURCE	50W, LED		50W, LED	
LIGHT LOSS FACTOR	0.8		0.8	
LUMINAIRE DISTRIBUTION CLASSIFICATION AND BUG RATING	Type II, B1-U1-G1		Type II, B1-U1-G1 Type III, B2-U0-G2	
POLE HEIGHT (m)	9m		9.0m	
POLE ARRANGEMENT	one sided		n/a	
POLE SPACING (WORST CASE)	48m		n/a	
INTERSECTION ILLUMINANCE LEVEL (Eavg)	n/a	n/a	16 Lux	18 Lux
INTERSECTION UNIFORMITY RATIO (Eavg:Emin)	n/a	n/a	4.0:1	3.8:1
ROADWAY LUMINANCE LEVEL (Lavg)	0.3 cd/m2	0.4 cd/m2	n/a	n/a
ROADWAY UNIFORMITY RATIO (Lavg:Lmin)	6.0:1	5.1:1	n/a	n/a
ROADWAY UNIFORMITY RATIO (Lmax:Lmin)	10.0:1	9.1:1	n/a	n/a
ROADWAY VEILING LUMINANCE RATIO (Lvmax:Lavg)	0.4:1	0.37:1	n/a	n/a
SIDEWALK HORIZONTAL ILLUMINANCE LEVEL (Eavg)	3 Lux	4 Lux	n/a	n/a
SIDEWALK VERTICAL ILLUMINANCE LEVEL (EV Min)	1 Lux	1.2 Lux	n/a	n/a
SIDEWALK HORIZONTAL UNIFORMITY RATIO (Eavg:Emin)	6.0:1	5.1:1	n/a	n/a

note 1 - Required only for intersections, roundabouts, cul-de-sacs.

Figure 10-3: Example Lighting Design Criteria Table

10.3.3.1 STREETS

Street lighting levels for various street types and pedestrian activity levels are defined in ***Table 10-2***. This table is based on information listed in the *TAC Guide for the Design of Roadway Lighting* and *ANSI/IES RP-8 Roadway Lighting*.

Table 10-2: Luminance Criteria

Pedestrian Activity	Average Luminance cd/m²	Average-to-Minimum Uniformity Ratio	Maximum-to-Minimum Uniformity Ratio	Maximum-to-Average Veiling Luminance Ratio
Arterial				
High	≥ 1.2	≤ 3.0	≤ 5.0	≤ 0.3
Medium	≥ 0.9	≤ 3.0	≤ 5.0	≤ 0.3
Low	≥ 0.6	≤ 3.5	≤ 6.0	≤ 0.3
Collector				
High	≥ 0.8	≤ 3.0	≤ 5.0	≤ 0.4
Medium	≥ 0.6	≤ 3.5	≤ 6.0	≤ 0.4
Low	≥ 0.4	≤ 4.0	≤ 8.0	≤ 0.4
Local				
High	≥ 0.6	≤ 6.0	≤ 10.0	≤ 0.4
Medium	≥ 0.5	≤ 6.0	≤ 10.0	≤ 0.4
Low	≥ 0.3	≤ 6.0	≤ 10.0	≤ 0.4

When undertaking lighting calculations on a two-lane roadway, the maximum lane width used in the calculation shall be 3.6m unless a marked bicycle lane is present. Where the lane is wider than 3.6m, a 3.6m wide lane shall be applied for the travelled portion of the roadway or 3.6m on either side of the road centerline. Where bicycle lanes are marked by pavement markings, then the travel lane adjacent to the bicycle lane shall be widened to include the bicycle lane. In this case, the lane shall typically be wider than 3.6m.

Where bicycle lanes are separated from roadways by barriers or curbs, the levels on the bicycle lane shall meet or exceed those on a multi-use pathway as per *Section 10.3.3.2*.

Where part-time parking lanes exist or are proposed, lighting shall be calculated as if they are full-time general purpose lanes. Full-time on-street angled or parallel parking, where there is no chance the parking lane will be used as a travel lane, shall not be included in lighting calculations.

For single-sided spacing with two-way traffic, a separate calculation grid should be undertaken for the lanes in each direction of travel (red and yellow areas in ***Figure 10-4***). The worst-case luminance, uniformity, and veiling luminance ratio for either direction shall take precedence. Refer to ***Figure 10-4***; the area in yellow will typically be the worst case and therefore form the design requirements.

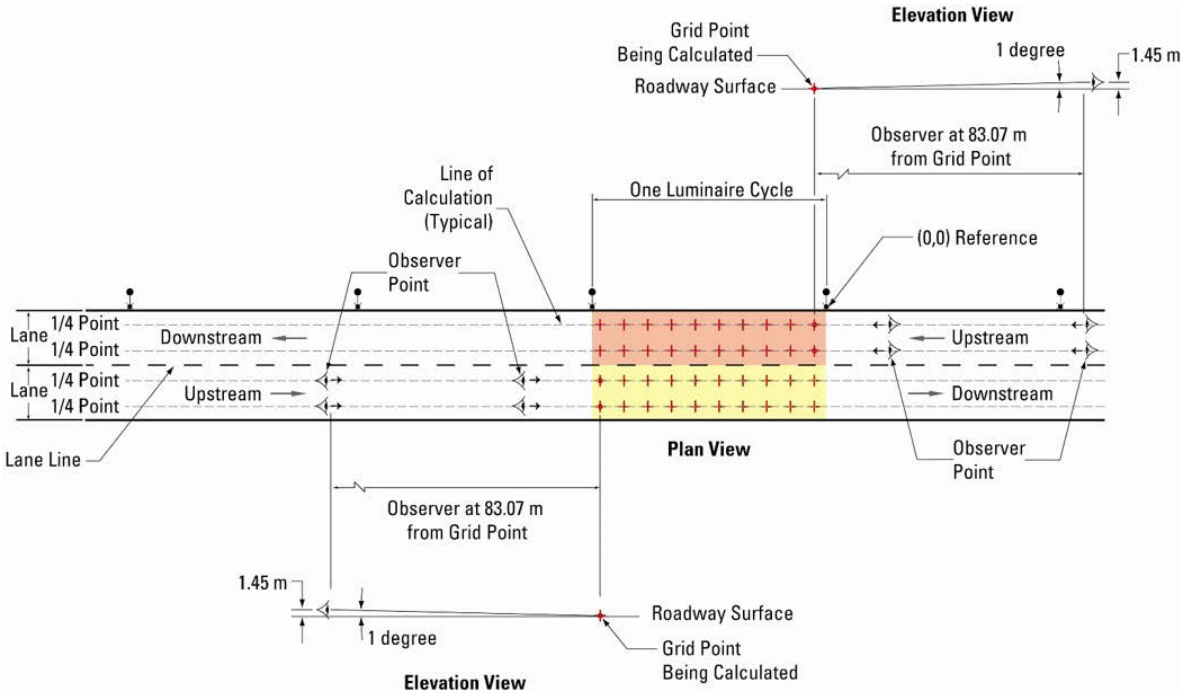


Figure 10-4: One-Sided Pole Spacing Calculation Grids

Where tying into or modifying an existing system, the system shall be designed so existing lighting is operational during hours of darkness. The designer shall provide a design for temporary roadway lighting.

In areas where only one side of a road is to be developed, the lighting shall be designed for the complete road width, but only poles and luminaires along the property frontage being developed shall be installed. Locations and types of all future poles and luminaires shall be clearly indicated on the drawings and the lighting calculations included. Provisions shall be made for future extension of the conduit system to the opposite side of the roadway by providing empty conduits across the roadway where future lights will be located.

Curved roadway sections (less than 600m radius) or roads with steep and variable grades (6% or greater) can be calculated using the horizontal illuminance method using a 1m grid spacing on the travel lanes and bicycle lane only.

Field validation of a lighting system’s performance may be done by illuminance. Field validation will only be performed where specifically required by the City.

10.3.3.2 SIDEWALKS AND MULTI USE PATHWAYS

The designer shall confirm with the City whether additional pedestrian lighting is required on sidewalks. Where defined by the City, sidewalk lighting shall meet lighting levels for various pedestrian activity defined in *ANSI/IES RP-8 Roadway Lighting*. In all cases, lighting shall always meet the minimum recommended values.

Lighting levels for multi-use pathways and bicycle lanes / paths that are remote from the roadway shall be as follows:

- Maintained Average Horizontal Illuminance: 5 Lux or greater for general guidance. Where security is of concern, then a maintained minimum vertical level of 5 Lux shall be applied. For vertical illumination, sidewalk reflectance should be included. Semi-cylindrical illuminance can also be used as defined in *IES DG-5 Recommended Lighting for Walkways and Class 1 Bikeways*.
- Maximum to Minimum Horizontal Uniformity Ratio: 10:1 or less for guidance and 5:1 or less for security. Uniformity shall not apply for vertical illumination.

Levels for guidance or security shall be determined in consultation with the City.

Multi-use pathway levels are based on levels listed in *IES DG-5 Recommended Lighting for Walkways and Class 1 Bikeways*. Refer to the *TAC Guide for the Design of Roadway Lighting* for calculation grids.

10.3.3.3 INTERSECTIONS

Intersection lighting levels for various road classifications and pedestrian activity levels are defined in ***Table 10-3***. This table is based on levels listed are based on the *TAC Guide for the Design of Roadway Lighting* and *ANSI/IES RP-8 Roadway Lighting*.

Table 10-3: Intersection Horizontal Illuminance Criteria

Road Classification	Average Maintained Horizontal Illuminance (Lux) at Pedestrian Activity Levels			Average-to-Minimum Uniformity Ratio
	High	Medium	Low	
Arterial / Arterial	≥34.0	≥26.0	≥18.0	≤ 3.0
Arterial / Collector	≥29.0	≥22.0	≥15.0	≤ 3.0
Arterial / Local	≥26.0	≥20.0	≥13.0	≤ 3.0
Collector / Collector	≥24.0	≥18.0	≥12.0	≤ 4.0
Collector / Local	≥21.0	≥16.0	≥10.0	≤ 4.0
Local / Local	≥18.0	≥14.0	≥8.0	≤ 6.0

Refer to the *TAC Guide for the Design of Roadway Lighting* for calculation grids.

10.3.3.4 CROSSWALKS

An average maintained vertical illuminance of greater than 20 Lux measured at 1.5m above the road surface is required at crosswalks in rural areas as per *ANSI/IES RP-8 Roadway Lighting*. For urban areas, refer to the *TAC Guide for the Design of Roadway Lighting* for crosswalk lighting requirements and calculation grids. This vertical illuminance requirement can be achieved by placing poles in advance of the crosswalk to create high levels of vertical illumination that improve the driver's view of pedestrians. For further information, refer to ***Figure 10-5*** and the *TAC Guide for the Design of Roadway Lighting*.

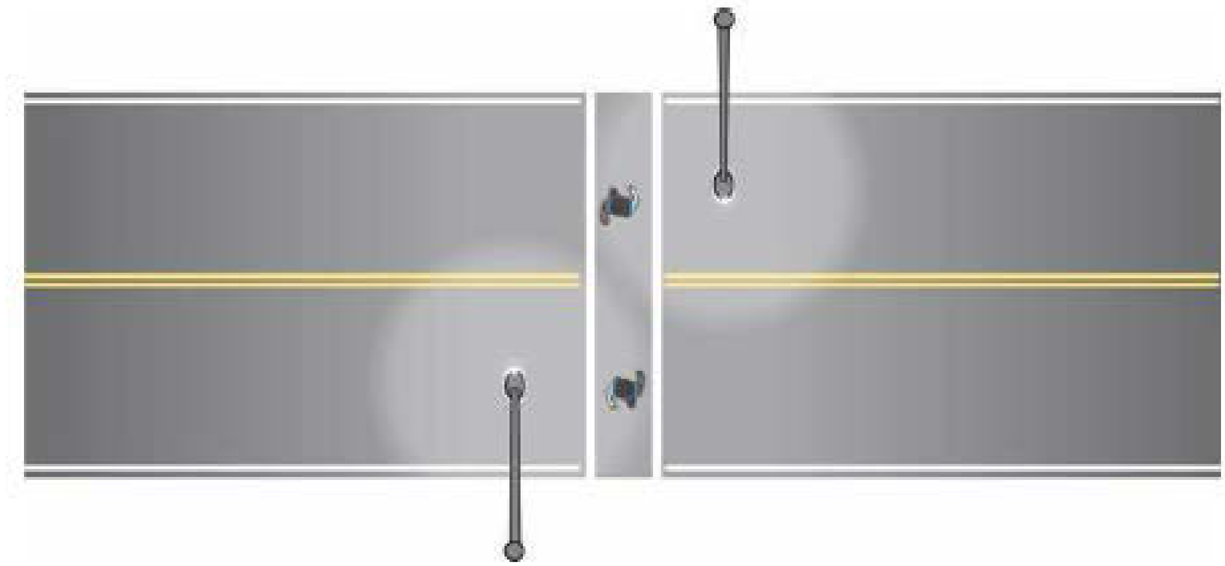


Figure 10-5: Crosswalk Lighting Pole Placement

10.3.3.5 ROUNDABOUTS

Roundabouts have more complex visibility considerations than typical intersections. Motor vehicle headlight effectiveness is limited in a roundabout due to the constrained curve radius, making the street lighting system a necessity to increase nighttime visibility of obstructions, hazards and pedestrians in crosswalks. Lighting for a roundabout shall meet or exceed the levels defined for intersections (refer to ***Table 10-3***). Lighting levels in crosswalks within the roundabout shall meet vertical lighting levels listed for crosswalks. For further information on roundabout lighting refer to the *TAC Guide for the Design of Roadway Lighting* or *ANSI/IES RP-8 Roadway Lighting*.

Where there is no lighting on the approach street, lighting should be added on the approach street for a distance of approximately 80m from roundabout crosswalks.

10.3.4 STREET TREES

The City of Vancouver supports a diverse and healthy urban forest. It is estimated that City streets have over 140,000 trees. Trees, existing or proposed, pose a challenge to lighting design as they block light and reduce lighting below required levels. ***Figure 10-6*** shows an existing residential road in the City with a very large tree canopy. In this case, the davit style poles would have the majority of their light blocked out when the trees are in full bloom. Though this is an extreme scenario in terms of light blockage, the potential for street tree conflicts throughout the City is a design consideration for existing and proposed street lighting.

Figure 10-6: Existing Tree Canopy

All designs need to take into consideration light blockage from landscaping and street trees. Where trees exist or are proposed, lights may have to be installed on custom arms that extend out over the roadway beyond the ultimate tree canopy. With the lighting extended over the roadway, additional pedestrian scale lighting will often be required to properly light the sidewalks. The proposed locations, spacing, pole height, arm length and spacing of trees may also need to be adjusted in conjunction with lighting pole spacing.

Some examples of lighting layouts and trees are provided in ***Figure 10-7*** and show some options for locating lighting poles and trees. The height and size of tree canopy (drip line), light level requirements, and pole heights are factors when defining the lighting layout. Typically, using only pedestrian-scale lighting will not be suitable for roads with trees that are over two lanes wide in commercial areas. The key is to take the impacts of the tree trunk and canopy (at fully maturity) into account in the lighting design. This may mean using lower level pedestrian-scale lighting under the tree canopy to reduce light blockage.

For new installations with trees, the tree type and layout will typically be designed by a landscape architect. It is imperative that the lighting be designed and integrated into the landscape design as the tree spacing will often have to be adjusted. The lighting can’t be designed in isolation from the landscape design as the landscape design will impact the lighting levels.

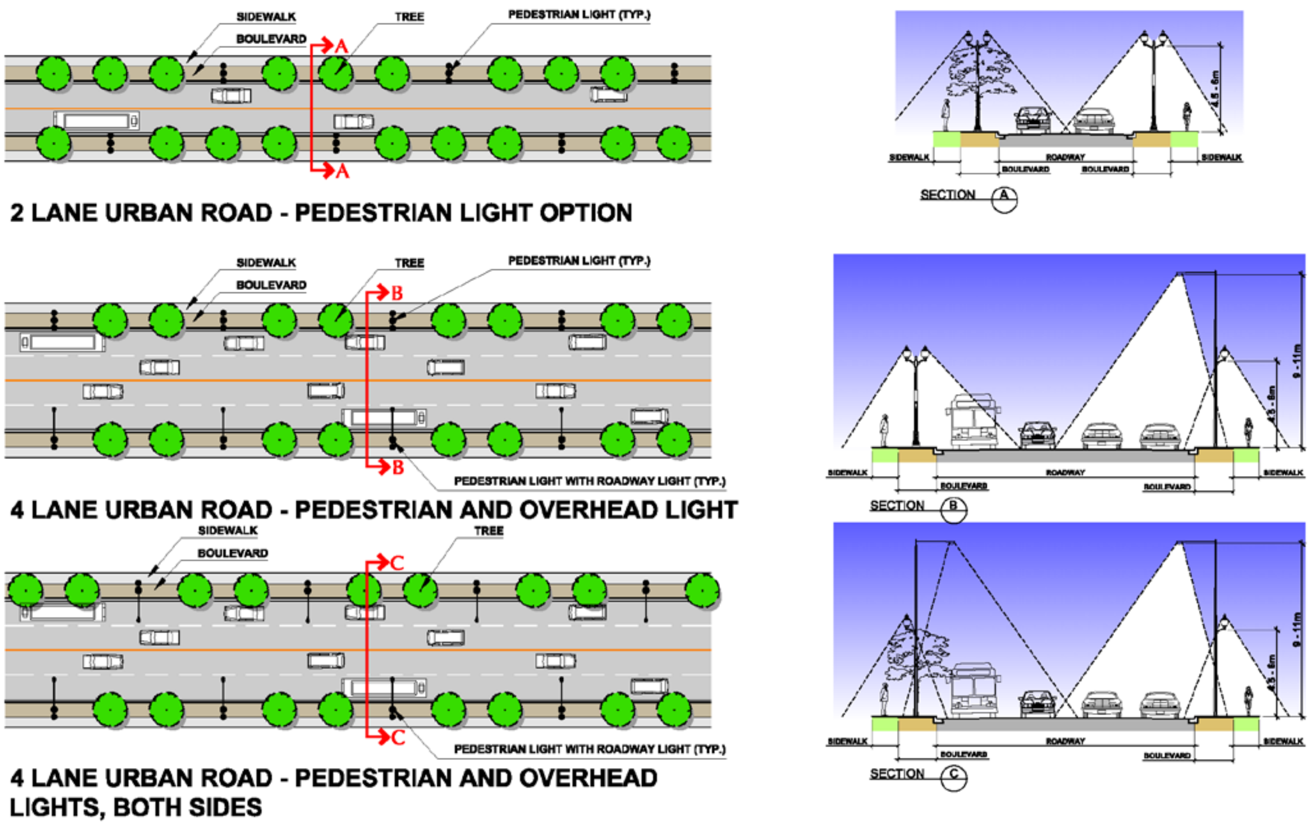


Figure 10-7: Tree and Lighting Layout Options

Where trees exist and impact the lighting, tree pruning can be considered. ***Figure 10-8*** shows the recommended procedure for assessing and mitigating the impacts of trees via pruning. Where pruning is required, its viability shall be discussed with the City and their arborist. As trees vary in foliage, shape, and size, it is not practical to calculate the exact impacts.

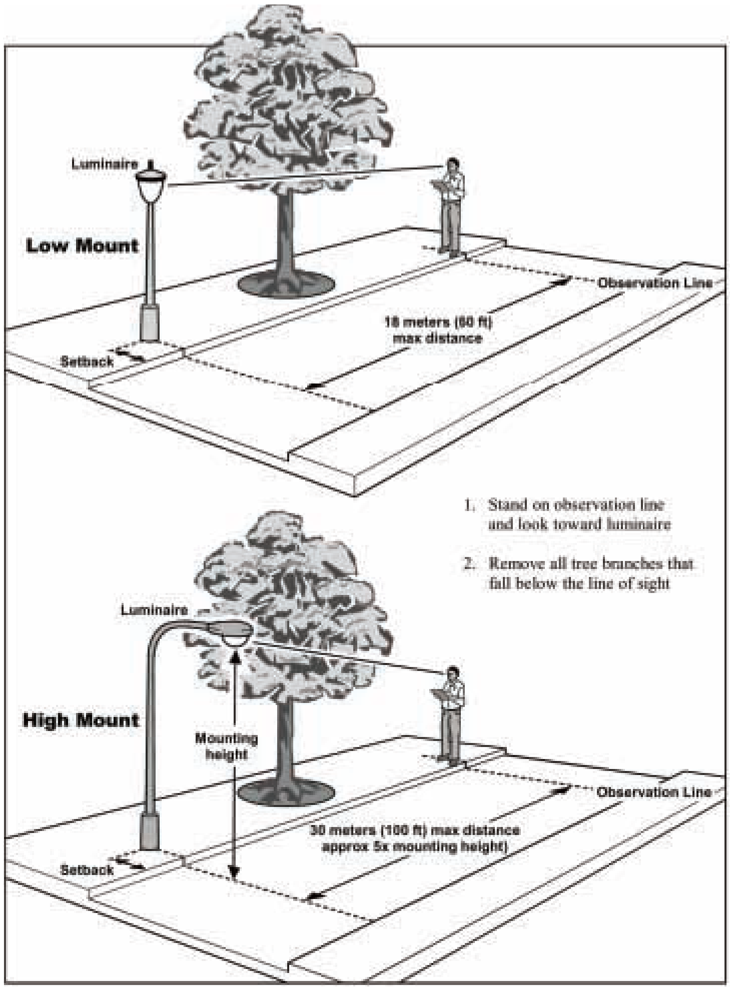


Figure 10-8: Tree Pruning

Another impact of trees is the need to work around root systems when installing a conduit trench or pole foundation. It is recommended that the City Arborist be contacted to review impacts before working around trees. Street lighting conduit should be laid at the back of curb to minimize impact on trees.

10.4 DESIGN OF STREET LIGHTING COMPONENTS

The principal purpose of street lighting is to enhance the safety of pedestrians, cyclists, and vehicles. Street lights are also important to the accessibility and appeal of neighbourhoods and communities. This section outlines the design requirements for all street light components, including poles, luminaires, conduit, junction boxes, kiosks, and other components that make up street lighting systems in the City of Vancouver.

10.4.1 POLES AND POLE MOUNTED DEVICES

Unless a special decorative pole style is required by the *Streets & Electrical Design Branch*, approved poles shall be the City of Vancouver standard davit pole as per the *City of Vancouver Construction Specifications*. Davit pole heights shall be 7.5m or 9m high. Where trolley poles exist or are proposed, lighting can be mounted on these poles with a luminaire arm that clamps onto the pole shaft that meets the approval of the Coast Mountain Bus Company and is as per the *City of Vancouver Standard Detail Drawings*. For consistent appearance, where trolley poles are required on only one side of the road, similar looking lighting poles shall be supplied on the other side of the road.

Poles shall be provided with a galvanized and powder coated finish. It is the designer's responsibility to confirm colour by RAL number. The RAL number shall be confirmed with the City.

Decorative pedestrian scale poles shall be 4m to 6m high to suit existing poles or City requirements. Pole details are defined by the *City of Vancouver Standard Detail Drawings*. Decorative poles may have specific shapes, colours, and styles along with banner arms and flower basket hangers. Where decorative street lighting is used to enhance the streetscape, the following details are required as part of the decorative lighting design:

- Shop drawings of the street light poles proposed complete with pole design criteria, sealed by the supplier's professional engineer registered with EGBC.
- Detailed information and specifications of the luminaires proposed.
- Detailed information on pole accessories (i.e. decorative bases, banner arms, and receptacles).
- Drawings detailing the assembled pole and luminaire units.

10.4.1.1 POLE PLACEMENT

Poles shall be located at the outer edges behind the curb and gutter or edge of pavement or, in special circumstances, in the median of the street. Where median lighting is being considered, the lighting levels on any sidewalks shall be met, or additional supplemental sidewalk lighting may be required.

The pole shall typically be 760mm from the centre of pole to the face of curb. Pole bases shall be installed parallel to the curb. Poles shall be located at curb returns or property lines and suit intersections and pedestrian walkways while staying clear of driveways and wheelchair ramps. Further, pole spacing shall be governed by roadway width, road configuration, and intersecting property lines. For power lines, the proposed poles shall meet the minimum clearance from buildings and street lights as outlined in BC Hydro standards. For CMBC lines, clearances specified in the CMBC standards are to be met.

Poles shall meet the clearance requirements in *Chapter 2* and *Section 7.3.8.1*.

Pole spacing patterns include staggered, opposite, one-side, and median-mount arrangements, depending on the roadway classification and road geometrics. The pole arrangements shall generally be as follows:

- Roads 8.5m and narrower – One-sided spacing.
- Roads over 8.5m wide - Staggered or opposite spacing.
- Poles should only be located in medians if a clearance of 0.5m from the pole to curb face can be maintained and posted speed is 60km/h or greater. A minimum of two consecutive poles should be required before considering poles in medians.

10.4.1.2 LUMINAIRES

The City has gone exclusively with LED luminaires for any new or replacement lighting installations. The designer shall refer to the City's approved products list by requesting a current copy from the City.

As the style, shape, and appearance of LED luminaires vary greatly from supplier to supplier, any alternate products proposed by the lighting designer shall be reviewed with the City prior to commencing design. If considering an alternate luminaire that is not listed in the City's approved products list, the designer shall be responsible to ensure that the luminaire meets or exceeds all requirements and meets all required lighting levels.

In the case of decorative lighting, the luminaire colour shall match the pole, so the exact RAL colour number shall be defined on the design drawings.

Though the City has an approved product list, it is up to the designer to define the exact luminaire make and model number including wattage, operating current and photometric distribution, colour temperature, and voltage on the design drawings. The luminaire selected shall match that used for the lighting calculations. The City shall define a required CCT for all new LED lighting on roadways, intersections, roundabouts, mid-block crosswalks, and walkways. The City requires all luminaires to have a minimum 3G vibration rating.

10.4.1.3 CONCRETE BASES

The *City of Vancouver Construction Specifications* and *City of Vancouver Standard Detail Drawings* define typical concrete bases to go with standard lighting poles. These are typically poured-in-place as defined on the *City of Vancouver Standard Detail Drawings CE1.1* to *CE1.7,* which better accommodates existing utilities than pre-cast concrete bases. The designer shall fully investigate utilities to determine whether concrete bases will fit in the locations proposed. Where a concrete base needs to be customized to accommodate utilities, it shall be designed by a structural engineer registered with EGBC. Concrete bases shall be based on the pole base reaction forces for a fully loaded pole and shall take into account the soil conditions present.

The City has identified areas under *Section 7.5.4* where deep peat deposits and other poor soil conditions have been encountered. In these areas, structural and geotechnical review of the concrete bases shall be undertaken. Contact the City for further information on general soil conditions within project limits.

10.4.2 CONDUIT

All conduits shall be shown on the electrical drawings. Conduit shall be RPVC as per *CAN/CSA C22.2 No. 211.2 Rigid PVC (Unplasticized) Conduit* or DB2 for communications conduits. The designer shall review and meet requirements listed in *Chapter 7: Third-Party Utilities*.

Designers should allow for the possibility of future expansion using stub out conduits at the last streetlight pole and / or into a temporary junction box at end of the development. All empty conduits shall have a 6mm nylon pull string installed and capped ends.

Conduit alignments shall be designed to avoid tree roots and tree protection zones as outlined by the landscape architect and / or arborist. Conduits shall be located to meet standard clearances to existing and other utilities as specified in *Chapter 2*. The designer shall prepare trench cross-section drawings for all typical scenarios. The drawings shall show conduits in the trench along with other conduits and utilities as per the *City of Vancouver Standard Detail Drawings*, specifically *G4.7*, which outlines the required minimum number of conduits in low and high density areas.

10.4.3 JUNCTION BOXES

Junction boxes shall be shown on the drawings to scale. They shall be used where required to connect conduits, where the conduits will run in multiple directions, or to terminate conduit runs. Pull boxes are required every 75m to allow cable pulling through the duct bank. Junction boxes shall be located outside of driving surfaces, driveways, wheelchair ramp areas and, where possible, outside of walking areas (sidewalks) and cycle paths. Placement of junction boxes shall be coordinated with landscape and streetscape designs. Junction boxes shall also be accessible with a workable space around. Junction boxes shall be a minimum of Type 3 (521mm x 343mm x 610mm deep) with tamper proof screws. The lid shall be labelled with the “COV” logo and shall have Tier 22 load rating.

The various types of junction boxes available are listed in the *City of Vancouver Construction Specifications* and shown in the *City of Vancouver Standard Detail Drawings*. Preferred junction box locations are shown in the *City of Vancouver Standard Detail Drawings E7.20*. Refer to ***Figure 10-9*** for an example of a junction box and wiring.

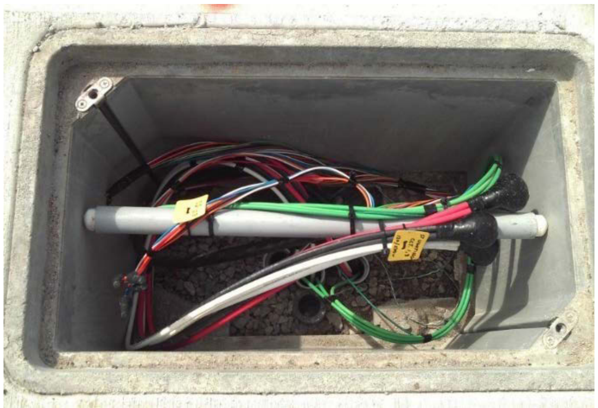


Figure 10-9: Street Lighting Junction Box Example

10.4.4 POWER SUPPLY AND DISTRIBUTION

Power is generally supplied by BC Hydro through an unmetered service when servicing only streetlights and traffic signals. Where tree lights and pole receptacles are included, BC Hydro may require a metered service. This shall be confirmed with the City and BC Hydro.

The designer shall confirm the voltage and location of suitable power sources for the proposed lighting system. The designer shall confirm if a new service is required or an existing power system in the area is suitable for extension. Signals require a 120V single phase power supply. A service will typically feed the streetlighting and signal devices.

Services are to be “pole dip” type or underground to a BC Hydro service box. Overhead services are also acceptable on special cases; this shall be confirmed with the City and BC Hydro. The designer shall select a suitable service location based on availability and what meets the City and BC Hydro standards. The designer shall also confirm the service location with BC Hydro as part of the design process.

The BC Hydro power supply shall feed into a pole-mounted service panel, cabinet, or kiosk that shall contain, but is not limited to, the following: panel boards, breakers, lighting contactors, a surge protection device, and a hand-off-auto switch. The lighting is controlled by a single photocell located on a luminaire or on a pole.

Pole mounted service panels for 120/240V, 120/208V, or 240/480V BC Hydro power supplies are defined on the *City of Vancouver Standard Detail Drawings E7.7* to *E7.8C*. The City has various standard 120/208V cabinet sizes (small, medium, and large) which can also be used where a service panel is not suitable. They are defined on the *City of Vancouver Standard Detail Drawings E7.9A* to *E7.9C*. Where an alternate voltage such as 347/600V is the only power supply available, a custom service kiosk with transformer will be required as per *City of Vancouver Standard Detail Drawings E7.9C*. In this situation, the designer shall define the specific cabinet layout and single line diagram on the design drawings.

The *City of Vancouver Standard Detail Drawings E7.7* to *E7.9C* show general single line diagrams and equipment layouts. The size, rating, and number of contactors and breakers will vary and must be defined on the design drawings. The designer shall define the interrupting capacity (kAIC) of the breakers on the design drawings. ***Figure 10-10*** shows a typical medium-size service kiosk. As the cabinets are large, they will require planning to define a suitable location. When sizing the service kiosk cabinet, the designer shall select the appropriate cabinet design to suit the future loads.

The service cabinet shall be located:

- Off the roadway where it is not likely to be impacted by motor vehicles.
- Preferably not on private property. In the case where the only option is on private property, approval must be received from the property owner and it must be accessible to City crews with no restriction at all times.
- Where it will not be a hazard or obstruction to pedestrians.
- Where it does not block sight lines.
- Where it can be easily accessed for servicing.
- Where it does not impact business and is not a cause for complaint (follow the same requirements and process as defined in *Section 10.6.6*).

Power distribution requirements include:

- Wiring to be installed in minimum 53mm Rigid PVC conduits.
- Power wiring to be colour coded per the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver.
- The maximum voltage drop for branch circuits is 3%.
- Circuit load not to exceed 80% of feeder breaker rating (as per the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver).

When tying into an existing system, designers shall confirm to best of their ability that the system meets requirements in the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver and, if necessary, modify the system so it meets current requirements in the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver. This is particularly important in the case of two different sources of power for a street lighting and traffic signal system. Where a system is non-conforming to the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver, advise the City and discuss recommended corrections.

Figure 10-10: Medium Service Kiosk Example

The cabinet colour (RAL number) shall typically match the pole colour and shall be confirmed with the City.

10.5 TRAFFIC SIGNAL DESIGN AND ANALYSIS

The City of Vancouver operates, updates and maintains traffic signals throughout the City. The signals are connected to a Traffic Signal Management System that collects traffic flow data via detection systems and monitors traffic conditions with CCTV cameras. Connecting to the system is an integral part of traffic signal design. Specific communications and system requirements for each traffic signal will be required for every design and shall be reviewed with the City. There may be substantial underground conduit installation required to connect to the nearest network access point.

This document is intended to provide specific City traffic signal and electrical requirements to aid in the design of traffic signals. Street lighting is required at all signalized intersections; however, some scenarios may not be defined in this document.

Traffic signal designs shall meet the requirements listed under *Section 10.2.4* except where listed in this document. Where conflicts arise between the documents listed in *Section 10.2.4* and the *City of Vancouver Engineering Design Manual*, the *City of Vancouver Engineering Design Manual* shall take precedence with the exception of the *British Columbia Motor Vehicle Act* which overrides all.

The sections below outline the processes, procedures and other requirements for traffic signals and their connection to the Traffic Signal Management System.

10.5.1 REQUIREMENTS

Before signal design, the designer must consult with the *Traffic & Data Management Branch* to establish the specific project requirements. Signal designs may be new, modifications to existing signals to suit road modifications, or rehabilitations or upgrades to existing signals; each situation is unique and requires a tailored approach.

When modifying existing signals, the design must ensure that the signal can remain in operation with no or minimal down time. Where shut down is required, it shall be in off-peak periods, and all required flagging and traffic control shall be defined and provided. In some cases, the designer may be required by the City to provide a traffic management plan as part of the design package.

The *City of Vancouver Engineering Design Manual* shall be used in conjunction with the *British Columbia Motor Vehicle Act Regulations Division 23 - Traffic Control Devices* and the *British Columbia Motor Vehicle Act*.

10.5.2 SIGNAL PHASING, TIMING, AND COORDINATION DESIGN

10.5.2.1 PHASING, TIMING, AND COORDINATION PLANS

The *Traffic & Data Management Branch* prepares all signal timing and coordination plans. Where signals are within a 400m spacing, coordination is required to optimize operation and reduce delay. Signals within a 100m spacing typically require pre-emption through hard-wire connection. This requirement shall be confirmed with the *Traffic & Data Management Branch*. Signal phasing must be supported by traffic capacity analysis (i.e. Synchro) and approved by the *Traffic & Data Management Branch* before initiating traffic signal design.

10.5.2.2 LEFT TURN PHASING

Left-turn phase options at signalized intersections are as follows:

- Permissive - Green ball display. A permissive left turn has no left-turn arrow display, which permits a left turn while yielding to opposing traffic.
- Protected Only - Green arrow display. A protected left turn has a solid green arrow indication while all conflicting movements are held by a red display. A protected left turn is always terminated with a yellow ball display.
- Protected / Permissive - Flashing green arrow display. A protected / permissive left turn presents a flashing green arrow followed by a solid amber arrow. During the flashing phase (advanced lagging movements), opposing through traffic is held by a red display. After the amber arrow has timed out, left-turn traffic is presented with a green ball display permitting the movement while yielding to opposing traffic.

Care should be taken when considering a left-turn phase, as it can impact the intersection level of service by increasing the total cycle length. Refer to the *BC MoTI Electrical and Traffic Engineering Manual Section 402.4.2* for the use of left-turn phases.

Protected / permissive phasing is generally used for left turns because of its greater efficiency. However, protected only phasing should be considered based on the criteria outlined in *BC MoTI Electrical and Traffic Engineering Manual Section 402.4.3*.

10.5.2.3 SIGNAL PRE-EMPTION

Signal pre-emption allows the normal signal operation to be replaced by a special pattern for a specific temporary use. Common types of pre-emption are for railway or emergency vehicles. Railway pre-emption is hard-wired from the traffic controller to the railway signal control cabinet. Contact the City to define the need and specific requirements for railway and emergency vehicle pre-emptions.

10.6 DESIGN OF TRAFFIC SIGNAL COMPONENTS

Traffic signals are traffic control devices positioned at road intersections, pedestrian crossings, and other locations to control competing flows of traffic. Traffic signals alternate the right of way accorded to all road users by displaying lights of standard colors that are defined in the *British Columbia Motor Vehicle Act*. In addition to information about traffic signals, this section also includes pedestrian / cyclist signals and Rectangular Rapid Flashing Beacons that are focused on safe pedestrian and cyclist movements.

The principal purpose of traffic signals is to enhance the safety of vehicular traffic, cyclists, and pedestrians. They are also important to increase intersection capacity. The City is committed to accessible pedestrian signals and signals that accommodate cyclists; designs shall take this into account.

The key elements of traffic signals are sensors to detect vehicles, pushbuttons to sense pedestrians, displays (signal heads) to indicate stop and go and a control device referred to as a controller. Other elements include poles, concrete bases, conduit, wiring, signages, cameras, and an electrical service.

This section outlines the design requirements for all traffic signal components, including signal heads, poles, vehicle detection loops, conduit, junction boxes, kiosks, and other components that make up traffic signals and intelligent transportation systems in the City of Vancouver.

10.6.1 POLES AND POLE MOUNTED DEVICES

Signal poles are defined in the *City of Vancouver Standard Detail Drawings* and the *City of Vancouver Construction Specifications*. Traffic signal poles and anchor bolts shall be designed to accommodate the weight and length of the arms and the items mounted on the poles as well as wind and ice loading. Pole type shall be determined based on pole design criteria. The designer shall provide the pole design criteria in the electrical drawings for the City's approval. Pole loading shall be confirmed from a City-approved pole supplier's structural engineer and submitted to the City. The City no longer allows cable spans to support signal heads. All cable spans must be replaced with signal poles and arms, except for temporary signals.

Trolley or custom poles shall have upper (at signal arm) and lower (above base plate) hand-holes. A large handhole is required at the base plate.

Where existing trolley poles will be used for signals, the City's clamp-on adapter for signal and luminaire arms shall be used and shall be designed to meet the City and Coast Mountain Bus Company standards. CMBC must be informed and will approve any proposed attachment on existing trolley poles. Generally, CMBC is responsible for supplying and installing all trolley poles. Refer to the *City of Vancouver Standard Detail Drawings E4.23* and *E4.24* for luminaire arm details. Signal heads, equipment and signs that will be attached to the adapter must be approved by the pole supplier's structural engineer based on pole, anchor bolt, and foundation capacity. These adaptors shall be designed by a structural engineer and shall meet the approval of CMBC. Pole bases should be installed parallel to the curb. In the case of skewed crosswalks, the signal arm orientation shall be customized to be parallel to the crosswalk but outside of the crosswalks. However, to avoid custom pole design, City will review possible means to keep the pole standard.

The designer shall include custom signal and trolley pole shop drawings complete with pole design criteria, signed and sealed by the supplier's professional engineer registered with EGBC.

Poles shall be provided with a powder coat finish. It is the designer's responsibility to confirm the colour by RAL number with the City.

10.6.1.1 POLE PLACEMENT

Poles shall be located at the outer edges behind the curb and gutter or edge of pavement to accommodate accessible pedestrian signal requirements and to provide the required access for pedestrians of all abilities. Refer to the *TAC Accessible Pedestrian Signals Guidelines*.

Street or signal poles shall typically be located 760mm from the centre of the pole to the face of the curb. However, they can be offset further away from the curb if required. One benefit of locating the poles further from the curb is better accommodation of truck turning. Poles shall be located to accommodate intersections, property corners, and pedestrian walkways. Locate poles at curb returns and clear of driveways and wheelchair ramps. Cyclist poles shall be located 510mm from the center of pole to the face of curb. Trolley poles shall be located in coordination with CMBC.

Poles shall meet the clearance requirements in *Chapter 2* and *Section 7.3.8.1*.

Signal poles should be placed as shown in the *City of Vancouver Standard Detail Drawings E7.20*. Intersections shall have a signal pole and a signal post or luminaire with signal heads at the curb return.

Pole arms should be oriented at 90° to the centre-line of the road, except where the intersection is skewed. When laying out a skewed intersection, the signal arms shall be parallel with the pedestrian crosswalks, so the signal arms do not block the view of the signal heads for other approaches. However, to avoid custom pole design, the City will review possible means to keep the pole standard.

Key considerations for pole placement are:

- Ease of access to pushbuttons for all pedestrians, including those with disabilities.
- Maintaining wheelchair access around poles and from pushbuttons to wheelchair ramps.
- Locating poles outside vehicle turning radiuses to avoid damage.
- Underground and overhead utility conflicts.
- Visibility of vehicle and pedestrian heads.

- Access to cyclist pushbutton without dismounting the bicycle.

10.6.1.2 SIGNAL HEADS

Signal heads must be visible to vehicles, pedestrians, and cyclists; therefore, proper signal head placement is essential. Major factors to consider in assessing signal head visibility are road geometry, design speed, spacing between vehicles, and the horizontal and vertical signal head locations.

All signal displays are to be LED.

General locations of signal heads are as follows:

- Primary: Mounted over the roadway that a vehicle is to enter.
- Secondary: Mounted to the left and right side of the roadway that a vehicle is to enter.
- Tertiary: Mounted to the right of the primary head or other location to enhance visibility. Contact the City to define specific needs and requirements.
- Pedestrian: Mounted on the far side of the intersection in line with the painted crosswalk.
- Bicycle: Mounted on the near side and far side of the intersection where the cyclist is to enter and depart the intersection. Contact the City to define specific needs and requirements.

All primary and tertiary signal heads have yellow backboards to improve signal head visibility. A 75mm fluorescent yellow retro-reflective tape border (ASTM Type 9 or higher sheeting) on the outside edge of the entire backboard is also required to further increase signal visibility.

Signal visibility distance is defined as the distance in advance of the stop line from which a signal must be continuously visible for approach speeds varying between 40 and 80km/h. Visibility distance guidelines are shown in ***Table 10-4***.

Table 10-4: Signal Head Visibility Distance Guidelines

85th Percentile Speed (km/h)	Minimum Visibility (m)	Desirable Visibility (m)	Add for % Downgrade (m)		Subtract for % Upgrade (m)	
			5%	10%	5%	10%
40	65	100	3	6	3	5
50	85	125	5	9	3	6
60	110	160	7	16	5	9
70	135	195	11	23	8	13
80	165	235	15	37	11	20

Notes:
1) Source *MUTCD Section B3.2 Table B3-1.*

Visibility of a signal head is influenced by three factors:

- Vertical, horizontal, and longitudinal position of the signal head.
- Height of driver's eye.
- Windshield area.

Lateral vision is considered to be excellent within 5° degrees of either side of the centre-line of the eye position (10° cone) and adequate within 20° (40° cone). Horizontal signal position as defined in the *MUTCD Section B3.2.1* and *Figure B3-1* shall be as follows:

- Primary heads within the 10° cone for each approach lane.
- Secondary heads within the 40° cone for each approach lane.
- Where the 40° cone of vision cannot be met for a far-left side secondary head and there is only one primary head or where there are protected left turn signals, an additional right side mounted auxiliary head will be required.

Vertical vision is limited by the top of the windshield. Signal heads should be placed within a 15° vertical sight line as defined in the *MUTCD Section B3.2.1* and *Figure B3-1*. Overhead signals should be located a minimum of 15m beyond the stop line. For any further information on signal head visibility refer to the *MUTCD Part B*.

The effectiveness of flashing signals is influenced by flash rates. Recommended rates are:

- Red and amber signals: 60 flashes per minute.
- Arrows: 120 flashes per minute.
- Red-hand: 60 flashes per minute.

The ON and OFF flash periods should be equal.

Visors are required on all signal heads. Cowl-type visors are standard, except in the following cases, where tunnel visors should be considered:

- Fully protected left-turn signal heads.
- At skewed intersections, where the signal heads may be viewed from other approaches.

Signal head sizes are shown in ***Table 10-5***:

Table 10-5: Signal Displays

Signal Head Type	Display Colour, Size, and Shape
Primary	300mm R-Y-G round with backboard
Secondary	200mm R-Y-G round 300mm Y-G bimodal arrow or 300mm G Arrow
Tertiary	300mm R-Y-G round with backboard
Pedestrian	450 x 400mm walk / don't walk indication with countdown timer

Signal mounting heights and mounting are as follows:

- Primary - Mounted with adjustable bracket on signal arm 5.0m to 6.0m from bottom of backboard to roadway.
- Secondary - Mounted on signal pole shaft or on signal post 3.2m from bottom of head to roadway.
- Tertiary - Mounted on signal pole shaft 4.8m from bottom of backboard to roadway.

- Pedestrian - Mounted on pole shaft 2.5m from bottom of head to roadway.

As per the *British Columbia Motor Vehicle Act*, each approach to an intersection requires a minimum of one primary and one secondary signal head. The City requires two secondary heads where possible to improve visibility.

The general City standard is protected / permissive for left turn signals. The use of protected only left turns is defined in *Section 10.5.2.2* and must be approved by the City.

General signal head placement is defined in ***Table 10-6*** and ***Table 10-7***:

Table 10-6: Signal Head Placement for Straight Through Lanes

No. of Lanes	No. of Primary Heads	Placement of Primary Heads
One	One	Centred over through lane.
Two	One	Centred over lane line, or
		Centered over first through lane, if second lane is for parking.
Three	Two	Centered over each lane line with the exception of where a protected / permissive left turn display is required then that head shall be positioned as noted below.

Table 10-7: Signal Head Placement for Left Turn Lanes

Left Turn Type	Primary Head Type	Placement of Primary Heads
Protected / Permissive	4 Sections with Flashing Green Arrow and Steady Yellow Arrow	Located over left most through lane however signal head may need to be moved left within the lane to meet the cone of vision requirements.
Protected - Single Left Turn Lane	3 Sections with Steady Green Arrow	Centred on the left turn lane, either pole mounted in the median or signal-arm mounted. Signal arm mounted is preferred.
Protected - Dual Left Turn Lanes	3 Sections with Steady Green Arrow	Centered between the left turn lanes, (one signal head) either pole mounted in the median or signal-arm mounted. Signal arm mounted is preferred.

Signal head placement will also be determined by traffic signal phasing. Prior to starting a design, review of signal head locations and phasing must be approved by the *Traffic & Data Management Branch*.

10.6.1.3 PEDESTRIAN AND CYCLIST PUSHBUTTONS

Pushbuttons shall be located to accommodate pedestrians and shall be fully accessible. Pedestrian pushbutton placement shall meet the *TAC Accessible Pedestrian Signals Guidelines*.

Refer to the *MMCD* and *City of Vancouver Standard Detail Drawings* for details of a pushbutton sign unit. The designer shall indicate left, right, and bi-directional arrows to suit. Pushbutton mounting heights are as follows:

- Ped Pushbutton (standalone) - 1.07m from the centre of the pushbutton to sidewalk grade.
- Cyclist Pushbutton (standalone) - 1.07m from the centre of the pushbutton to the cyclist grade.
- Combined Pedestrian Cyclist Pushbutton – 1.07m from the centre of the pushbutton to sidewalk (pedestrian refuge at protected intersection) grade.

Cyclist pushbuttons or another detection system shall be provided at or in advance of the traffic signal. Cyclist push buttons shall be installed on a pole located at the end of the curb radius or where a cyclist does not have to dismount to push the button. An example of a cyclist pushbutton is shown in ***Figure 10-11***.

Where a heavy volume of cyclists is present or where a pushbutton can't be provided in an accessible location, consider using a suitable detection system for cyclists (i.e. micro-radar, camera, or loops). Consult the City for details of cyclist detection systems.

Figure 10-11: Cyclist Pushbutton

10.6.1.4 AUDIBLE PEDESTRIAN SIGNALS

Audible pedestrian signals may be required to assist visually impaired pedestrians. The audible signal is interconnected with the walk signal and produces a "Cuckoo" or "Chirp" sound, depending on the direction of crossing. The "Cuckoo" sound is used for north-south walk direction crossings and the "Chirp" is used for east-west walk direction crossings. Where the streets are not oriented north-south and east-west, maintain consistency with adjacent signals.

Audible signals shall follow the guidelines defined in *Section A.6.10* of the *TAC Pedestrian Crossing Control Guide* and the *MUTCD*. As outlined in the *TAC Pedestrian Crossing Control Guide,* factors that influence when they may be required are:

- Intersection and pedestrian safety, including intersection configuration, crossing width, and vehicle speeds.

- Pedestrian usage, including pedestrian volume and proximity to pedestrian generators and transit.
- Traffic conditions, including volume, distribution, level of congestion, and flow characteristics.
- The difficulty in crossing the road without an accessible pedestrian signal (which is affected by signal phasing, ambient noise, the amount of right turning volume, the present of right turn islands or right turn signals, the presence of a single crosswalk at the intersection, and the level of recurrent congestion and queues through the intersection).

The *TAC Pedestrian Crossing Control Guide* also notes that an engineering study should be conducted to determine the demand for an audible pedestrian signal. The manual identifies the following conditions which may require an audible pedestrian signal:

- Very wide crossings.
- Major streets intersected by secondary streets that have little traffic.
- Non-orthogonal or skewed crossings.
- T-shaped intersections.
- Intersections with high volumes of turning vehicles.
- Intersections that have split-phase signal timing.
- Intersections with exclusive pedestrian phasing.
- Exceptionally noisy locations.
- Intersection with pedestrian collision history.
- Intersections in proximity to facilities used by blind or visually impaired pedestrians.

The use of audible signals shall be approved by the City prior to design. Audible pedestrian signals are typically the Novax Industries type and are located on signal poles as per the *City of Vancouver Standard Detail Drawings E5.12*. Audible units may also be Polara or Novax audible pedestrian pushbutton type. Confirm the exact type of audible unit needed with the City. In all cases, the signal shall have wiring for the audible pedestrian signal units even if they are not used.

10.6.1.5 PEDESTRIAN / CYCLIST CROSSING CONTROL

Signalized crossing control can be via overhead flashing beacon, full traffic signals, or pedestrian traffic signals (referred to in the *TAC Pedestrian Crossing Control Guide* as half signals). A decision support tool has been developed as part of the *TAC Pedestrian Crossing Control Guide*. The tool consists of a preliminary assessment to identify whether a location is a candidate for pedestrian crossing control and treatment selection. The tool shall be used to confirm the type of signal crossing control. The City also uses the *BC MoTI Pedestrian Crossing Control Manual for British Columbia* and a custom warrant calculation tool that measures adequate gaps with infrared counting equipment.

A pedestrian / cyclist signal is a traffic signal with signal heads placed on the main street only. Minor street traffic is controlled by stop signs. The pedestrian / cyclist signal rests in flashing green. Once the pedestrian pushbutton is pressed and the minimum flashing green time is exceeded, the yellow and red clearance interval is displayed, and the pedestrian phase is serviced. The signal then returns to flashing green.

The type and use of pedestrian signals shall be confirmed with the City, but generally Rectangular Rapid Flashing Beacons are used. An example is defined in ***Figure 10-12***.

Figure 10-12: Rectangular Rapid Flash Beacons

10.6.1.6 SIGNS AND OTHER DEVICES

Street name signs shall be located on signal pole arms between signal heads as shown on ***Figure 10-13*** and ***Figure 10-14***. Other regulatory signs mounted on signal poles may include turn-restriction signs, lane-use signs, one-way signs, transit signals, firehall signals, and cyclist signals (display), as defined by the *British Columbia Motor Vehicle Act* and the *MUTCD*. Signs shall be mounted with sign mounting brackets defined on the City's approved products list (can be obtained by requesting from the City). Railway crossing blank-out signs may be required where the signal is in close proximity to a railway and a turning movement is restricted to periods during railway pre-emption. Signs shall be located to provide good visibility to the driver, with regulatory signs located directly beside signal heads to aid in driver comprehension. The designer shall show all signs on the design drawings.

Figure 10-13: Sign Location Example 1

Figure 10-14: Sign Location Example 2

The designer shall confirm with the City the requirements for pedestrian, cyclist, and vehicle count stations with the use of varying technology, for example loops, pucks, and cameras. These may all be required as part of a standard signal design and the data may be collected and transmitted via the City's Traffic Signal Management System.

PTZ cameras, radios, and antennas may also be required on signal poles arms. Radios and antennas would have a similar mount. These devices shall be mounted to provide the required view in the case of cameras and line-of-sight to the next device in the case of antennas and radios. The designer shall define the locations of these devices on the design drawings. The City will require cameras to be included as part of the signal design at all major intersections. The designer shall confirm the requirements for cameras with the City.

All devices mounted on signal arms shall be safety-cabled or chained to the signal arm. Signs shall have two safety cables.

10.6.1.7 ADVANCED WARNING FLASHERS

Advanced warning flashers and signs (***Figure 10-15***) should be used where sight distance to an intersection is less than optimal or where design speed of the road is sufficiently high to justify warning motorists of signal status. Refer to the *BC MoTI Electrical and Traffic Engineering Manual* for warrant, design, and placement of advanced warning flashers.

Figure 10-15: Advanced Warning Flashers and Sign

10.6.1.8 CONCRETE BASES

For concrete base requirements, see *Section 10.4.1.3*.

10.6.2 CONDUIT

All conduits shall be shown on the electrical drawings. Conduit shall be RPVC as per *CAN/CSA C22.2 No. 211.2 Rigid PVC (Unplasticized) Conduit* for power cabling. For communications conduits, DB2 (orange) is to be used if buried at a minimum cover of 900mm and RPVC (orange) is to be used if buried at minimum cover of 600mm. The designer shall review and meet requirements listed in *Chapter 7: Third-Party Utilities*.

Signals shall be designed with at least one empty conduit for future signal upgrades. All empty conduits shall have a 6mm nylon pull string installed and capped ends.

General conduit locations, number, type and size for signalized intersections are shown in the *City of Vancouver Standard Detail Drawings E7.20 and E7.21*. The minimum traffic signal and communications conduits at signalized intersections shall be as follows:

- 5-53mm RPVC electrical and 2-78mm DB2 communications (orange) conduits around the intersection.
- 2-53mm RPVC electrical, 2-53mm RPVC streetlight (if applicable) and 1-78mm DB2 communications (orange) conduits from the junction boxes to each pole base as per the *City of Vancouver Standard Detail Drawings E7.20*.
- 7-53mm RPVC electrical conduits from the main signal junction box, close to the controller, to the controller base.
- 1-53mm RPVC electrical conduit from the junction boxes at the signal or luminaire pole to junction boxes for remote loops or other devices.
- 1-53mm DB2 communications (orange) conduit from the communications junction box close to controller to the controller base.
- Vehicle loops shall have 1-27mm (1”) poly electrical conduit (compliant with the *CAN/CSA Canadian Electrical Code* with bulletins issued by Electrical Safety Branch of the Province of British Columbia and the City of Vancouver) per lane from the junction box to the edge of pavement.
- Conduit to other devices shall be determined depending on specified wiring requirements.

For larger intersections (more than four through lanes), additional conduits may be required ((6-53mm for electrical and 2-103mm for communications). The City may request more conduits than listed above. The required number of conduits must be provided across all legs of the intersection.

Service electrical conduits shall be concrete encased with 1000mm minimum cover from the BC Hydro service to the panel or cabinet / kiosk. Main trunk and sub trunk line fibre communications duct at road crossings shall be concrete encased with 900mm minimum cover.

Conduit alignments shall be designed to avoid tree roots and tree protection zones as outlined by the landscape architect and / or arborist. Conduits shall be located to meet standard clearances to existing and other utilities as specified in *Chapter 2*.

The designer shall prepare trench cross-section drawings for all typical scenarios. The drawings shall show conduits in the trench along with other conduits and utilities as per the *City of Vancouver Standard Detail Drawings*, specifically *G4.7*, which outlines the required minimum number of conduits in low- and high-density areas.

10.6.2.1 SIGNAL WIRING

Signal wiring shall be via a 25 conductor signal cable that shall run from the controller to the junction box beside each signal pole. Signal cable colour coding is defined in the *City of Vancouver Standard Detail Drawings E7.13*. Single No. 14 AWG RW90 conductors shall be run from the junction box to the signal equipment, and single No. 10 AWG RWU90 conductors with a 5 Amp in-line fuse shall run from the junction box to the luminaire. Conductors shall be spliced in the junction boxes or at the lower pole hand holes.

Each pair of detector loops shall be feed with an outdoor-rated No. 20 AWG shielded cable.

Antennas, radios, and PTZ cameras shall typically be fed with fibre and then outdoor rated coax or CAT 5 cable to the device. All wiring shall be labelled in the junction boxes. Signal and communications wiring shall be installed and tagged by the contractor. The contractor shall flash out and check that all wiring is properly connected to the required device.

10.6.3 VEHICLE DETECTION AND DATA COLLECTION

For general information and further background on vehicle detection systems, refer to the *ITE Traffic Detector Handbook*.

Detector loop locations and details shall be as per the *City of Vancouver Standard Detail Drawings*. Where protected / permissive left turns are proposed, a second set of queue loops is required.

In addition to intersection vehicle detection loops, system detector loops for data collection may be required on the far side of each intersection approach to collect traffic volume, speed, and classification data.

Typically, data will be collected via system detector loops that shall be 0.6m x 1.8m diapole rectangular as per the *City of Vancouver Standard Detail Drawings E8.11*. The loops shall have no more than eight turns (six turns or less is preferred for mechanical protection and increased longevity). As an alternative to detector loops, the City may use wireless micro-radar pucks, infrared, and cameras.

Confirm the requirements and type of data collection with the City.

10.6.4 JUNCTION BOXES AND VAULTS

Junction boxes and vaults shall be shown on the drawings to scale. They shall be used where required to connect conduits where the conduits will run in multiple directions or to terminate conduit runs. Pull boxes are required every 75m to allow cable pulling through the duct bank. Junction boxes shall be located outside of driving surfaces, driveways, wheelchair ramp areas and, where possible, outside of walking areas (sidewalks) and cycle paths. Placement of junction boxes and vaults shall be coordinated with landscape and streetscape designs. Junction boxes and vaults shall also be accessible with a workable space around. Junction boxes shall be used as follows:

- Type 3 - Typically used for street lighting, on end conduit runs for detector loop feeds, and bicycle counter equipment.
- Type 4 - Typically used for signals depending on number of conduits (seven or less) entering and leaving the box.
- Type 5 - Typically used for signal and or communications at corners of intersections as shown in the *City of Vancouver Standard Detail Drawings E7.20* or when the box exceeds seven conduits.
- Type 6 - Typically used for signal main junction boxes and placed by the signal controller and for pull boxes for communication ducts between 243 vaults.
- Type 243 – Typically used for communications straights runs.

- Type 1.5 – Typically used for communications T-runs.

The various types of junction boxes available are listed in the *City of Vancouver Construction Specifications* and shown on the *City of Vancouver Standard Detail Drawings*. Preferred junction box locations are shown in the *City of Vancouver Standard Detail Drawings E7.20*. Refer to ***Figure 10-16*** for an example of signal wiring in a junction box.

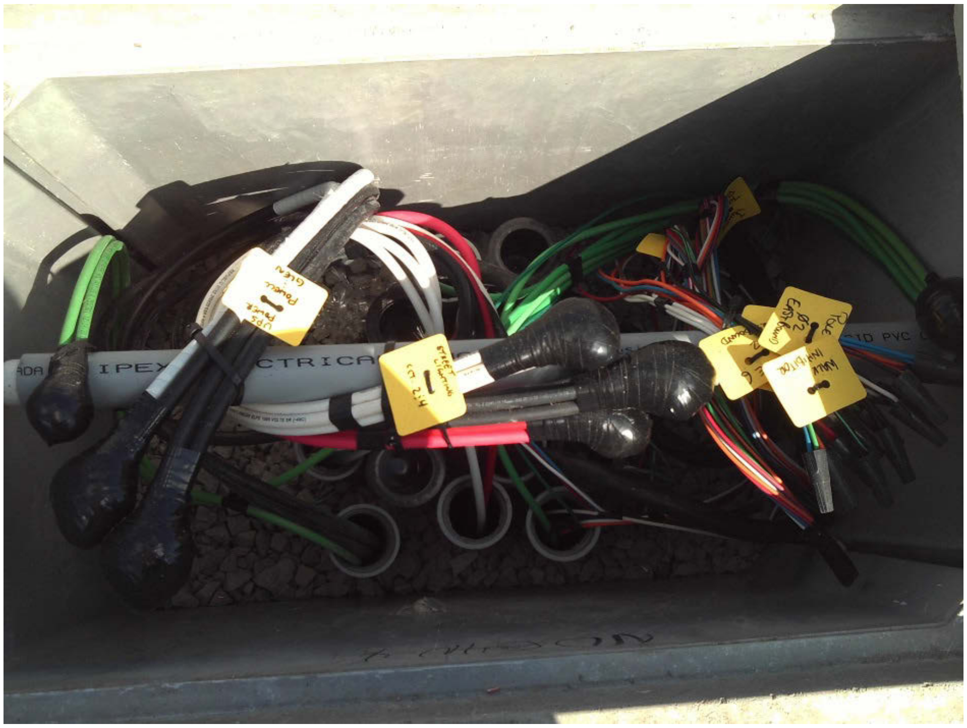


Figure 10-16: Junction Box Signal Wiring Example

Communications vaults are used to connect communications duct banks. Vaults are typically Type 243 as shown in ***Figure 10-17***. Vault placement and type are also specified in the *City of Vancouver Standard Detail Drawings*.

Figure 10-17: Communications Vault

10.6.5 COMMUNICATIONS SYSTEM

The design shall provide a complete communications system design including conduit, vaults, and fibre / copper cables which shall connect to and integrate with the City signal communications and CCTV system.

Communications ducting, vaults, and junction boxes are always required at new signals and may also be required at existing signals where ducting doesn't exist. A general communications ducting system layout is defined in the *City of Vancouver Standard Detail Drawings E7.21*. The communications ducting shall be installed in a common trench with signal and lighting and shall be detailed on those drawings. Communications conduit must use sweeping bends to avoid damage to the cables during installation. Within a single conduit run, there shall be no more than 180 degrees in total bends. Conduits shall enter the junction boxes horizontally and parallel to the long side of the No. 5 and No. 6 junction boxes. 90-degree bends in the junction boxes are not allowed, and conduit entering the junction boxes shall have bell ends.

It is the responsibility of the designer to coordinate and design the communications connectivity to the City's Traffic Signal Management System. Assigned communications circuit numbers shall be reflected in the drawing's title block. The designer shall define cable installation, testing, and commissioning to the point of connection, which may be outside of their project boundaries. The design shall also update the City network diagram drawings.

Modifications or upgrades may be required at the communications connection point to accommodate communications connectivity.

Additional conduit runs are to be included with any required electrical conduit runs for roadway lighting, to provide additional capacity for City needs, such as telecommunications.

At a minimum, install the following conduit runs in high-density areas (all arterial and secondary arterials and all downtown areas):

- 2-53mm diameter RPVC conduits.
- 2-78mm diameter RPVC conduits.
- 2-103mm diameter RPVC (orange only) conduits or 2-103mm diameter DB2 (orange only) conduits.
- The total number of conduits will be six as per the *City of Vancouver Standard Detail Drawings G4.7*.

At a minimum, install the following conduit runs in low-density areas (areas not designated as high-density areas, e.g. local residential roads):

- 2-53mm diameter RPVC conduits.
- 1-78mm diameter RPVC conduits.
- 1-103mm diameter DB2 (orange only) conduits or 1-103mm diameter DB2 (orange only) conduits.
- Total number of conduits will be four as per the *City of Vancouver Standard Detail Drawings G4.7*.

The conduits shall be developed from property line to property line (always passing the last junction box). All communication conduits at road crossings need to be concrete encased.

When reconstructing or constructing a new intersection, separate 5-53mm diameter RPVC and 2-78mm diameter DB2 (orange) conduits shall be placed across the road in addition to the ducts required above.

10.6.6 TRAFFIC CONTROLLERS

Controller cabinets are available in various sizes and styles depending on equipment requirements. Controller cabinets shall be Type 332 (Model 170). The designer shall confirm the type of controller with the City.

Cabinets should be located entirely within the City right-of-way, including the maintenance pad and door swing. Location should be behind the sidewalk with the access door on the side away from the sidewalk. The cabinet shall be located:

- Where the signal is fully visible from the cabinet for maintenance personnel.
- Where it does not impact business and is not a cause for complaint.
- Where it avoids restricting sight lines.

Early in the design stage, the designer shall prepare a preliminary electrical drawing identifying the location, dimension, and position of the controller cabinet to scale for the City. The City will submit the drawing to local businesses for consultation. If there is a concern, the cabinet may need to be relocated and the design adjusted.

An Uninterruptable Power Supply (UPS) shall be used for all new signals or existing signals where modifications are required. ***Figure 10-18*** shows a controller cabinet with a UPS. The UPS battery is located between the controller cabinet and the concrete base.

The RAL colour of the controller cabinet and the UPS shall match those of the signal poles and shall be confirmed with the City.

Traffic controllers, cabinets, and the UPS shall be supplied, installed, set-up, tested, and commissioned by the City's electrical crews. The contractor shall install the concrete base and coil and tag the wiring for the City to perform the connection. Refer to the *City of Vancouver Standard Detail Drawings* for controller base details.

Figure 10-18: Type 332 Controller Cabinet with Battery Box

10.6.7 POWER SUPPLY AND DISTRIBUTION

Power is generally supplied by BC Hydro. Refer to *Section 10.4.4* for power supply and distribution criteria.