District Department of Transportation

Design and Engineering Manual

~~June 2017~~January 2019

District Department of Transportation

DISTRICT OF COLUMBIA

DEPARTMENT OF TRANSPORTATION

~~LEIF DORMSJO~~JEFFREY MAROOTIAN, DIRECTOR

SAMUEL ZIMBABWE, CHIEF PROJECT DELIVERY OFFICER

DAWIT MULUNEH, PE, CHIEF ENGINEER

~~SUZETTE ROBINSON, CHIEF OPERATIONS OFFICER~~

WASI KHAN, PE, CHIEF QUALITY ASSURANCE AND QUALITY CONTROL DIVISION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

FOREWORD

Washington, DC is a thriving and growing city with a rich history whose continued success relies on its transportation infrastructure. Our transportation solutions require engineered designs that are thoughtful of all users, contexts and the environments.

The District of Columbia Department of Transportation (DDOT) Design and Engineering Manual was updated in 2017 and again in 2019 after not having ~~has not~~ been updated since 2009. This edition updates critical aspects of the manual to reflect advances in industry guidance, provides information on topics that were not previously covered, eliminates inconsistencies and redundancies, and updates references and coordination with other DDOT manuals. The transportation field is dynamic and continues to evolve, and therefore, this manual will be updated on a recurring schedule to stay current.

The users of this manual will notice several meaningful improvements to key areas. For example, Green Infrastructure has been incorporated into a newly formed, comprehensive Drainage, Stormwater Management and Hydraulics chapter. Chapters on structures and geotechnical engineering have been clarified and simplified, while new chapters such as Value Engineering, Project Deliverables, Bridge Load Rating Analysis and Reporting, and Intelligent Transportation Systems have been added.

DDOT believes in fair and equitable transportation decisions for all of the traveling public and all users of the public space. DC is robust in supporting a variety of transportation infrastructure, public realm amenities, sustainable practices, and multimodal accommodations. We hope with this revision, engineers, designers and consultants find an improved resource at their fingertips to enhance the quality and livability for all residents and users. We also value your feedback should you identify potential improvements or recommendations that may be considered during future revisions.

Respectfully,

~~Leif Dormsjo~~Jeffrey M. Marootian
Director

12.4. Required Number of Plans

Table 12-1 lists the number of copies that will be required for each submittal.

Table 12-1 | Required Number of Plans

Stage of Design Process	Number of Copies
Pre-Design Report (When Requested)	5 Copies
30% Preliminary Design	30 sets of half-size plans 2 copies of Preliminary Construction Costs 2 sets of full-size stormwater management (SWM) plans
65% Review Design	30 sets of half-size plans 30 sets of Special Provisions 2 copies of Preliminary Construction Costs
Final Review Design	30 sets of half-size plans 30 sets of Special Provisions (double spaced) 2 copies of Construction Costs and Pay Item Schedule (hard copy and on disk)
PS&E Submittal	2 sets of stamped half-size plans 2 sets of Special Provisions 2 sets of Pay Item Schedule and Cost Estimates 4 sets of full-size SWM plans 1 set of full-size SWM plan on Mylar
Final Bid Documents	8 sets of half-size final Contract Plans 8 sets of Special Provisions, Bid Forms and Appendices One set of full-size reproducible final contract drawings on tracing linen or tracing plastic and five full-size prints Two computer disks of final contract drawings (in latest version of Microstation and GIS, as requested by DDOT) and two disks of final Special Provisions and Pay Item Schedule

NOTE: The number of Final Contract Plans, Special Provisions, Pay Item Schedules and Appendices may be modified by DDOT by written notice to the Consultant.

12.5. Cost Estimate Preparation

The Designer will prepare a project cost estimate for DDOT's use in obligating funds for project construction. An updated estimate will be submitted concurrently with each milestone submission (30%, 65%, Final and PS&E). The Engineer of Record must prepare supporting documentation for the quantities and cost estimate for DDOT's review. This supporting information must detail how the quantities and rates were determined for each item.

12.5.1. Bid History

The DDOT Project Manager will provide bid histories of recent and comparable projects to help determine current unit prices.

14 Bridge Load Rating Analysis and Reporting

The primary purpose of a bridge load rating is to determine the live load that the structure can safely carry to preserve public safety. In addition, a load rating is required by the **National Bridge Inspection Standards (NBIS), Title 23 of the Code of Federal Regulations, Section 650**, and may be required if heavier traffic is anticipated in future. The following guidelines are to be used to rate bridge loads within the jurisdictional boundary of the District of Columbia. All new and rehabilitated bridges, including widened structures, must be load rated as part of the design phase, and the load rating must be based on the as-built plans and the bridge's present condition. The Inventory and Operating ratings must appear on the plan cover sheet. A load rating must also be performed when findings from routine inspections warrant or when changes in bridge features warrant. Such features include new bridge barriers or wearing surface.

14.1. Methodology

- Bridge evaluation must follow The American Association of State Highway and Transportation Officials (AASHTO) Manual for Bridge Evaluation, current edition with Federal Highway Administration memorandums
- All bridges designed using **AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications** must be load rated using Load and Resistance Factor Rating (LRFR).
- In-service bridges that have been designed by a method other than LRFD must be load rated by the Load Factor Rating (LFR) method. In some special cases, where DDOT would like to know more about the behavior of a structure under live loads, DDOT may request the Consultant to rate the loads of a specific bridge using the LRFR method, in which case the bridge must be load rated for the HL-93 loading.
- For structure where load rating results in a lower rating capacity, LRFR, LFR, Allowable Stress, or engineering judgment may be used.

14.2. Loads to Be Evaluated

- For routes where permitted or overweight trucks are likely, bridges must be load rated for the following loads:

a. AASHTO Design Loads, HS-20-44, HS-25-44 or HL-93, based on design loads.

AASHTO Legal Loads, Type 3, Type 3S2, Type 3-3.

AASHTO Notional Rating Load (NRL) for screening all AASHTO Specialized Hauling Vehicles (SHVs). Bridges that do not pass the NRL loading must be investigated for ~~Type 3 and~~ SHVs to determine posting requirements.

The FAST Act's Emergency Vehicles; Type EV2 and Type EV3

DDOT Permit Truck, 90,000 lbs. (See Figure 14-1).

DDOT Permit Truck, 147,000 lbs. (See Figure 14-1).

- For routes where Permit Trucks are unlikely, bridges must be load rated for the following loads:

  a. AASHTO Design Loads, HS-20-44, HS-25-44 or HL-93, based on design loads.
  b. AASHTO Legal Loads, Type 3, Type 3S2, Type 3-3.
  c. AASHTO NRL for screening all AASHTO SHVs. Bridges that do not pass the NRL loading should be investigated for ~~Type 3 and~~ SHVs to determine posting requirements.
  d. The FAST Act's Emergency Vehicles; Type EV2 and Type EV3

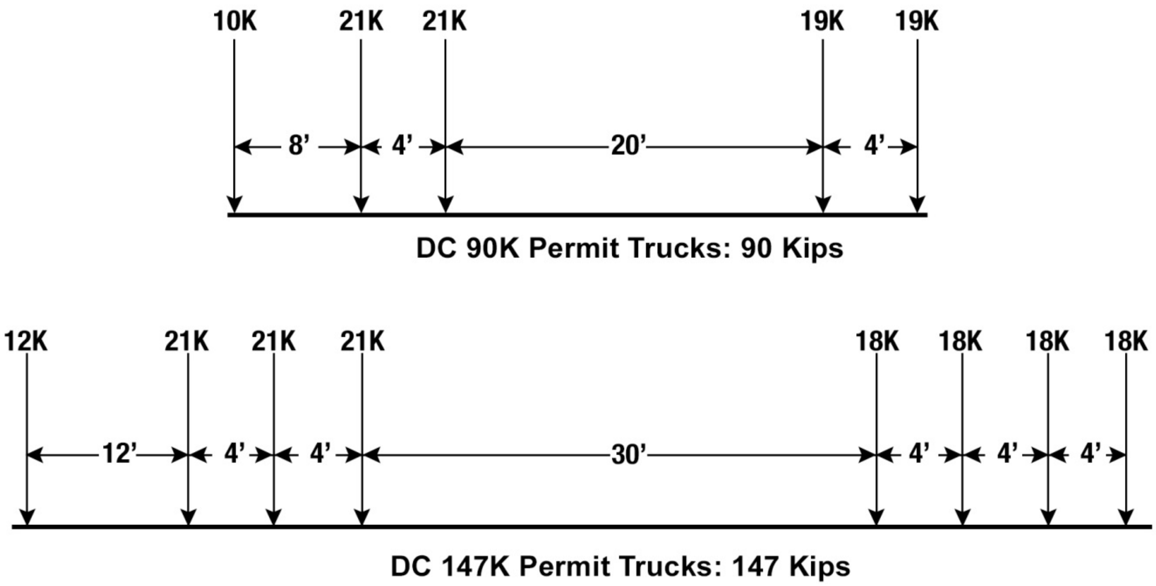

Figure 14-1 | DDOT Permit Truck Loadings

14.3. Selection of Bridge Elements

Prior to rating an existing bridge, the most recent detailed inspection report must be thoroughly reviewed and used as the basis for assessing the present condition of the bridge. In addition, as-built plans and any modifications since the bridge was built must be completely reviewed. When load rating

28 Drainage, Stormwater Management and Hydraulics

28.1. General

Proper drainage from roadways and bridges is critical to providing safe roadway conditions and maintaining the integrity of the transportation infrastructure. The design of drainage structures must adequately convey design flows while meeting the needs of the multi-modal roadway users. Additionally, designs must provide consideration for environmental concerns, including reducing pollutants and attenuating peak flows, by using Green Infrastructure (GI) practices. Furthermore, bridges and culverts need to be protected from scouring, undermining, or overtopping during design flow conditions. Finally, proper soil erosion and sediment control (SESC) measures need to be in place during construction to keep sediment from entering rivers and streams and prevent further erosion.

This chapter explains the design requirements and provides guidance for managing water in the public right-of-way (ROW). Stormwater retention and treatment methods must be included to meet regulatory requirements in District of Columbia Municipal Regulation **(DCMR) Title 21-5**, and are generally achieved using GI practices such as bioretention, permeable pavement, trees, and other best management practices (BMPs). This chapter also addresses the design of culverts and bridge structures, and SESC measures.

28.1.1. Regulations and Guidelines

All current federal and District of Columbia regulations pertinent to the design of drainage and stormwater management are applicable to this chapter unless the provisions in this design manual are more stringent. If differences exist between the District and federal regulations, the more stringent of the two will apply. For any deviation from the design standards outlined in this chapter, please refer to **Section 12.8, Design Exceptions and Waivers**.

In the absence of information on criteria and requirements in this manual, the Designer, in consultation with and approval of DDOT, must use, at a minimum, requirements and guidelines established in other guidelines and manuals. These documents include:

- American Association of State and Highway Transportation Officials (AASHTO) Highway Drainage Guidelines (2014 or latest version)
- Current District of Columbia Municipal Separate Storm Sewer System (MS4) Permit
- DC Sustainable DC Plan (2013)
- DC Water Standard Design Guidelines, Drawings, and Specifications

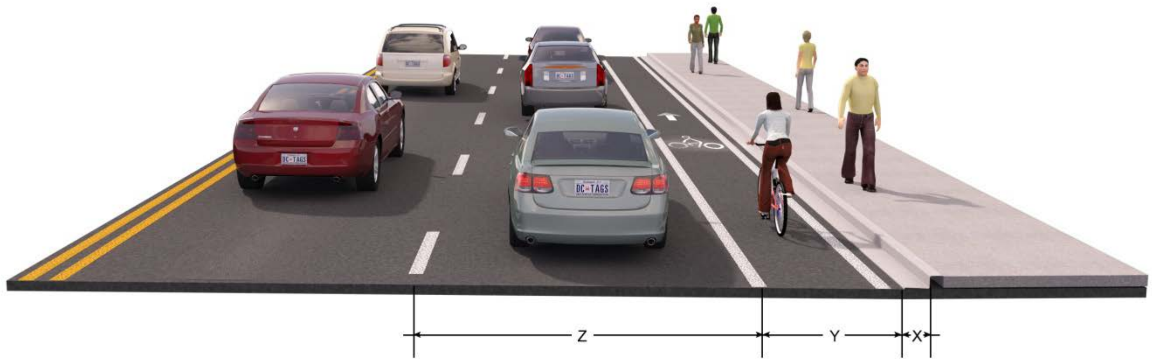

Figure 28-1 | Maximum "Spread" for DDOT-Maintained Roadways

28.2.2.2. Sidewalk Chases

Concentrated stormwater discharge must drain to storm manholes or other methods approved by DDOT and DC Water. Stormwater must not flow over sidewalks or pedestrian routes. A sidewalk culvert must not be located within a curb ramp, curb cut, or driveway.

Refer to the District Plumbing Code for stormwater discharge requirements from properties.

28.2.3. Drainage Control Methods

28.2.3.1. General

This section describes design requirements for storm drainage system design within the street/highway ROW.

28.2.3.2. Stormwater Inlets

There are several types of inlets approved for use by DC Water. Inlets are classified as being on a continuous grade or in a sump. The term "continuous grade" refers to an inlet located such that the grade of the street has a continuous slope past the inlet and ponding does not occur at the inlet. The sump condition exists when the inlet is located at a low point. A sump condition can occur at a change in grade of the street from negative to positive or at an intersection as a result of the crown slope of a cross street.

Grated inlets should be bicycle-friendly; grates should be perpendicular to the travel direction.

General Requirements for Inlets

- All basins are to be located a minimum of 5 feet (8 feet is preferred) from the point of curvature (PC) of corner radii, except to drain sags where one basin may be placed on the PC.

- At a “T” intersection, inlets should be avoided where crosswalks meet the top of the “T.”
- With few exceptions, place one inlet at the low point in the sag and place one flanking inlet on each side 3-1/2 inches above the low point.
- A trap or special catchment chamber must be provided for all inlets tying directly into a storm sewer for debris-trapping purposes.
- A water quality catch basin must be used in the Separated Sewer System area where no other retention or treatment device is used to treat runoff in that drainage area.
- A water seal connection must be provided for ~~all~~ inlets connected to the Combined Sewer System. DC Water must approve the connection.
- All basin inlets must connect directly to a manhole.

Standard Curb Opening Inlets

Use standard inlets as required by DC Water. If a basin larger than the Triple Standard basin is required, construct an auxiliary basin and manhole approximately 50 feet upstream from the proposed basin. Maintain a smooth and level surface in bike lanes.

Highway with Full Control of Access

Use a gutter opening inlet with safety grate (paved shoulders with barrier curb) as detailed in the **DDOT Standard Drawings**.

Depressed and Elevated Highways

Use a combination curb and inlet with P-grate or special design (limited lateral clearance).

Field Inlet

Use a standard inlet with safety grate as detailed in the DDOT Standard Drawings.

28.2.3.3. Connecting Pipe

- Basin to manhole connecting pipe must be at least 15 inches in diameter. Check for conflicts with existing utilities.
- Length of connecting pipe must be 50 feet or less.
- Cover over connecting pipe must be a minimum of 3 feet from top of pipe to finished grade.
- No more than three connecting pipes are allowed to tie into any one manhole.

28.8.3. Requirements and Calculations

28.8.3.1. Designing to the Maximum Extent Practicable – Overview

Projects in the existing public ROW are required to implement stormwater retention in accordance with District stormwater regulations to the Maximum Extent Practicable (MEP). This process must be a serious attempt to comply with the regulation to achieve the full retention of the regulated stormwater volume. In situations where the full regulated stormwater volumes cannot be met, the project must meet the maximum stormwater treatment volume practicable, considering every opportunity within and adjacent to the project limits. Projects in new public ROW are required to meet full stormwater retention. Construction projects in the ROW have a multitude of site constraints that vary widely. Limited space outside of the roadway restricts opportunities for infiltration and evapotranspiration, and in many cases, the width of the roadway cannot be reduced to create additional space. The specific steps that must be explored for MEP design are stipulated in the **DOEE Stormwater Management Guidebook**, and include:

- Identify drainage areas and calculate stormwater retention volume
- Evaluate infiltration
- Demonstrate full consideration of opportunities with existing infrastructure
- Demonstrate full consideration of land cover conversions and optimum BMP placement
- Size BMPs
- Address drainage areas where no retention practices are installed

The **DOEE Stormwater Management Guidebook** defines the applicability of the design steps described below to DDOT public ROW projects and to parcel development projects that reconstruct the adjacent existing public ROW as a portion of the project (Type 1 and Type 2 projects, respectively).

28.8.3.2. Stormwater Management Submissions

For Type 1 projects in the public ROW, Stormwater Management Plan (SWMP) submissions will be made with the 30 percent, 65 percent, 90 percent and Final (100 percent) design packages. The SWMP will contain a stormwater management map (SMM), MEP worksheet and project narrative.

The submissions will include increasingly more detail commensurate with the design stage. See Sections 28.8.3.4, 28.8.3.5 and 28.8.3.6 for details on submittals at the 30 percent, 65 percent and 90 percent design phases, respectively. The submission will be reviewed by the DDOT Project Manager prior to submission to DOEE. The SWMP is first submitted electronically through the DOEE Stormwater Database at the 30 percent stage. After the SWMP is uploaded and a Stormwater Plan Number assigned, submit a

Geotextiles and Liners:

- Geotextile meeting requirements of the current DDOT specification for use in stormwater facilities must be placed on the sides of open graded stone to prevent migration of adjacent fine material into the permeable pavement stone.
- Impermeable waterproof membranes should be used in permeable pavement systems as follows:
    - On the side adjacent to any facilities within 10 feet of a structure (e.g., an existing building)
    - At the interface between pervious pavement and traditional pavement
    - In areas where infiltration is not permitted, such as hot spots and for utility protection as necessary
    - In facilities designed for water re-use or harvesting
    - Where the installation is located on expansive soils, as determined by a geotechnical engineer

Stormwater Conveyance and Retention for Permeable Pavement

Stormwater conveyance from all impervious areas including standard pavement must, to the extent feasible, drain to permeable pavement as sheet flow. Otherwise, pre-treatment for energy dissipation and sediment control may be required where any concentrated flow is directed onto permeable pavement. Level spreaders may be designed to convert concentrated flow to sheet flow into the permeable pavement facility.

Reservoir and Underdrain Sizing for Retention Volume

Permeable pavement must be designed to store water volumes that meet the requirements of the **2013 Stormwater Rule**, including applicable MEP procedures. Storage design must meet the following:

- Subsurface drainage will consist of a 4-inch- to 6-inch-diameter perforated underdrain in the reservoir layer or a separate layer of open graded stone below the reservoir layer. Subsurface drainage must be installed beneath all vehicular use permeable pavement installations unless otherwise approved by DDOT. Permeable pavement may be installed in alleys and low traffic-volume roads without underdrains if infiltration rates are sufficient and underdrain connections are not feasible.
    - For sites where native soil design infiltration rate is sufficient to drain the volume below the underdrain within 48 hours, the subsurface pipes may be elevated or eliminated to create

infiltration sumps of reservoir stone. ~~Raising the underdrain~~Creating a sump for enhanced designs is encouraged and enhances retention. An alternative approach to a raised underdrain is an underdrain with an up-turned elbow outlet.

- For designs with a waterproof membrane on the bottom as required in the "Geotextiles and Liners" section above, the minimum slope of the subsurface drainage pipes is 2 percent and must match the bottom (invert) slope of the facility.
- For designs without a waterproof membrane, the minimum slope of subsurface drainage pipes is 0.5 percent when placed above the frost line.
- Clean-outs are required for all permeable pavement facilities with underdrains. Clean-outs should be spaced at 100-foot maximum intervals. Where a storm drain structure such as a catch basin, manhole or overflow structure is within 100 feet of a clean-out, the structure may be used as a clean-out.
- Observation wells are required for facilities without underdrains and must be shown on design plans. Observation wells should be spaced at 100-foot maximum intervals.

- ~~Drawdown time for 1.2 inches of runoff volume over the contributing drainage area is 48 hours maximum.~~ Drawdown time should meet the maximum ~~i~~as calculated using the **DOEE Stormwater Management Guidebook** equations.
- The reservoir should be sized to accommodate the 2-year, 24-hour frequency storm below the wearing surface at all points along the length of the facility.

  - Overflow conveyance for higher-frequency storms should be designed to flow into existing or new storm sewer systems adjacent to the permeable pavement.

- To achieve the design volume, the profile of the pavement should be designed in one of the following scenarios, which will be selected based on topography of the site, location of utilities and other underground features, project budget, and any other constraints related to the specific site:

  - Continuous bottom slope, 2 percent maximum.
  - Terraced invert with 2 percent maximum slope between steps. The vertical drop of a terraced invert should generally be 6 to 12 inches, but can vary to achieve design requirements.
  - Check dams with variable bottom slopes located so that the 2-year, 24-hour runoff volume does not surcharge the low end of the wearing course. Check dam material options include waterproof membrane, polyvinyl chloride (PVC) sheeting, acrylic sheeting, plastic lumber,

rocks, concrete or other material explicitly approved by DDOT. Membranes and sheeting are the most cost-effective and generally preferred options. A transverse underdrain may be needed in check dam systems if the base of a step does not slope to the longitudinal underdrain or if the permeable pavement system is very wide.

Permeable Pavement Structural Design

For alleys, driveways and parking lanes using permeable pavement, the **DDOT Green Infrastructure Standard Drawings** will be used.

For other pavements subjected to vehicle traffic loading, pavement design calculations are required. Pavement design may result in modifications to the pavement cross section in the DDOT-approved standard drawings to meet or exceed the pavement strength requirements. The following methods should be used for structural design of each type of permeable pavement:

- Pervious concrete: AASHTO methods for rigid pavement design
- Porous asphalt: AASHTO methods for flexible pavement design
- Interlocking permeable unit pavers: AASHTO methods for flexible pavement design, with appropriate layer coefficients as applicable to the interlocking, shape and thickness of the pavers. Guidance for layer coefficients is provided by the Interlocking Concrete Pavers Institute.

Testing of the bearing capacity for underlying soils is required for all permeable pavements for vehicular use, is site-specific, and must be in accordance with **ASTM D4429-09a, Standard Test for California Bearing Capacity of Soils in Place**.

Other requirements for pavement design include:

- Edge restraints must be used for all permeable unit pavers. Edge restraints may also be used for porous asphalt and pervious concrete as necessary.
- In soft soils with low bearing capacity where infiltration is planned, geo-grid is preferred over removal of the material and placement/compaction of select backfill.

Limitations of Permeable Pavement

- The bottom of permeable pavement systems, including storage layers and underdrains, must be located at least 2 feet above the seasonally high water table.
- Permeable pavements with infiltration are not allowed in hot spots as defined in the **DOEE Stormwater Management Guidebook**.

- Permeable pavement requires more frequent maintenance if it is installed where sand use is expected or in drainage areas with risk of high sedementation~~, such as in residential areas where adjacent homeowners may treat walkways with sand~~. Avoid installation of permeable pavements in these areas or ensure, during design, that the required level of maintenance will be achieved after installation.

28.8.4.3. Bioretention

When applicable, bioretention may be installed in a public ROW to retain or treat stormwater runoff. Bioretention should be placed in existing or proposed vegetated areas and landscaped with a selection of plants from the current DDOT-approved planting list. The Designer will select areas for bioretention using the MEP process as detailed in the **DOEE Stormwater Management Guidebook** and in **Section 28.8.3**. Possible areas for bioretention include tree space, parking lanes, bump-outs for traffic calming, intersection triangles, open areas and areas adjacent to sidewalk.

Bioretention design must be consistent with the **DOEE Stormwater Management Guidebook** with the following additional requirements.

Types of Bioretention Facilities

- **Bioretention Basins in Open Areas:** This type is a subset of DOEE's Traditional Bioretention and is a moderate to large-scale bioretention cell with ponding depths up to 18 inches. These facilities will include shrubs and groundcover, and sometimes tree plantings. Basins in open areas will typically have sloped sides, and can be online or offline as defined by the **DOEE Stormwater Management Guidebook**.
- **Curb Extension Bioretention:** This type is a subset of DOEE's Streetscape Bioretention and is generally placed in locations where a new curb is constructed into a parking lane to create an opportunity for bioretention, which may or may not incorporate a portion of the street tree space. Curb extensions may have sloped or vertical sides. In most cases, curb extensions will be designed as online facilities.
- **Streetscape Bioretention Planters:** This type is a subset of DOEE's Streetscape Bioretention and is typically a small-scale bioretention cell, often located between the curb and sidewalk. These facilities may include tree, shrub and groundcover plantings. Streetscape bioretention planters usually have vertical sides, but may have sloped sides if sufficient space is available. In most cases, bioretention planters will be designed as offline facilities.
- **Bioswales:** This facility type is consistent with DOEE's Dry Swale/Bioswale category, and includes a drainage channel or linear infiltration basin adjacent to either the roadway or the sidewalk,

and vegetated with trees, shrubs, groundcover or turf. Bioswales may be designed to convey or retain stormwater. Swales adjacent to roadways that receive stormwater runoff from roadway surfaces must be designed according to the requirements of the **DOEE Stormwater Management Guidebook** as open channels. Bioswales without curbs are online facilities.

Bioretention Cross Sections

Soil types used in bioretention facilities must be in accordance with the DDOT-approved soil specification (**DDOT Green Infrastructure Standard Specifications**).

In addition to following DOEE requirements, bioretention facilities must be designed as follows:

- A layer of 3 inches of triple shredded mulch is placed on top of bioretention media.
- The soil profile within basins, curb extensions, planters and bioswales must consist of 18 to 36 inches of bioretention soil (per **DOEE Stormwater Management Guidebook** for Filter Media, Chapter 3.6.4), sized to meet the retention volume requirements to the maximum extent practicable (where applicable). Areas with trees must contain a minimum of 24 inches of soil, and 30 inches is preferred. Meet requirements for tree space design described in **Section 37**.
- For underdrain layers, see "Bioretention Sizing and Hydraulic Design Requirements for Stormwater Retention Volume" later in this section.
- Additional stone may be placed beneath the underdrain layer, or beneath the bioretention soil in cases where no underdrain is present, to enhance the infiltration volume of the facility and achieve additional stormwater retention volume.
- Impermeable liners are required in bioretention facilities as follows:
    - Facilities within 10 feet of a structure (e.g., an existing building) must be lined on the side adjacent to the structure.
    - Facilities within 5 feet of the roadway face of curb must be lined on the side adjacent to the roadway.
    - Facilities in specified clearances from utilities are described in **Section 28.8.4.4**.
    - In areas where infiltration is not permitted, such as hot spots, facilities must be lined on all sides. In this case, subsurface drainage is required.

Contributing Drainage Areas

The impervious cover areas that drain into bioretention facilities should be limited in size to prevent excessive saturation of soils and the consequent development of anaerobic soil conditions. The maximum contributing impervious area to bioretention surface area ratio is recommended as follows:

- For bioretention basins, curb extensions and streetscape bioretention planters without subsurface drainage: 20:1
- For bioretention basins, curb extensions and streetscape bioretention planters with subsurface drainage: 33:1
- For other bioswales and open drainage channels: based on engineering design

For ratios above these limits, the runoff inflow to the bioretention area must be controlled to not allow excessive water into the facility.

Allowable Ponding Depths

- Allowable ponding depths in bioretention facilities will be determined based on the adjacent land use, expected pedestrian activity and the associated need for barriers around the facilities as described in the "Safety and Access" section below. The maximum allowable ponding depth in bioretention is 18 inches. The average ponding depth across a bioretention surface must meet the requirements set in the **DOEE Stormwater Management Guidebook**.
- Bioretention in high-volume pedestrian and residential areas will typically have a 6-inch maximum ponding depth. The ponding depth may vary based on slope conditions.
- Bioretention basins may be designed at depths that will require safety barriers or fencing.
- Bioswales must be designed with depths and/or side slopes that do not require barriers.
- Streetscape bioretention planter and curb extensions may be designed at depths that will require railings or curb.

Bioretention Sizing and Hydraulic Design for Stormwater Retention Volume

Bioretention facilities must be sized with volumes to meet the regulatory requirements promulgated by DOEE, including applicable MEP procedures. Storage design must meet the following:

- Maximize bioretention soil depth (filter depth).
- Design for a maximum drawdown time ~~of 72 hours for the designed runoff volume. Drawdown time must be~~ calculated using the **DOEE Stormwater Management Guidebook** equations.
- Where subsurface drainage is required by **DOEE Stormwater Management Guidebook**:

- A choker layer consisting of a minimum of 3 inches of sand and gravel must be placed beneath the bioretention soil to prevent the soil from migrating into the underlying stone.
- A reservoir layer of 10 to 12 inches of open graded #57 stone must be placed beneath the choker layer, with perforated pipes embedded in the #57 stone. Geotextile must be placed on the sides of the #57 stone.
- A minimum of one clean-out is required for basins and curb extensions, and must be shown on design plans. For other bioretention facilities, a clean-out must be provided within 10 feet of the underdrain connection to the catch basin, sewer or manhole.
- Connect underdrains to catch basins, manholes or directly to storm sewer pipe. Design connections to meet **DC Water Green Infrastructure Utility Protection Guidelines**. ~~Connection to a catch basin is usually the most cost-effective option.~~ When directly connected to the Combined Sewer System, place a backflow preventer valve on the underdrain connection.

- For bioretention facilities without underdrains, observation wells are required and must be shown on the design plans. The maximum spacing of observation wells is 100 feet.
- Use curb openings with depressed gutters to convey runoff to bioretention facilities adjacent to curbed roadways. Size the openings to deliver the volume of runoff to the facility that the size of the facility can handle, per DOEE requirements:
  - Use the method in the **DOEE Stormwater Management Guidebook** Appendix H.6 to convert the flow associated with the stormwater retention volume for which the BMP is being designed into peak discharge.
  - Use the method in **FHWA HEC No. 22** to size the curb opening to achieve 100 percent interception, while meeting the spread requirements of **Section 28.2.2** for the 15-year storm. Multiple curb openings can be used for each facility to deliver the required volume.

- Curb cuts across sidewalks and step-out zones require trench covers. Trench covers adjacent to vehicular areas must be designed for a vertical wheel load of 8.5 Kips (1/2 of tandem axel weight specified in FHWA HOP-06-105). Plates over curb cuts may be omitted or revised from the standard with DDOT approval.
- Check dams in bioswales and curb extension bioretention facilities may be necessary to allow ponding depth, achieve the storage volume and/or accommodate slow velocities. Check dams will be placed in sloped facilities at intervals to maintain ponding depth and facility depth within allowable limits.
- Pre-treatment devices are required to trap coarse sediment. Applicable choices include:

- The bottom of bioretention facilities must be at least 2 feet above the seasonally high water table.
- Bioretention with infiltration is not allowed in hot spots as defined by DOEE.

28.8.4.4. Utility Clearances at GI Facilities

Utilities are allowed to be colocated in GI facilities subject to acceptance by the utility owner. Individual projects should be coordinated with the utility owners for specific requirements. Current guidelines for clearances of utilities are as follows:

Communications/Power

- Communication and electric lines in concrete conduits may run through GI facilities.
- Communication and electric lines not in concrete conduits will have 6-inch minimum vertical clearance and 2-foot minimum horizontal clearance.
- Utility poles may be located in permeable pavement facilities, but may not be located within bioretention unless additional stabilization is provided for the pole.
- Manholes may be located in permeable pavement facilities, but may not be located within bioretention.

Gas

- For gas lines within 6 to 24 inches of GI facilities, the Contractor must install a protective shield around the pipe. The shield must be made of fiberglass-reinforced plastic or other approved insulating material, in either a 12-inch by 12-inch flat tie plate or clip-on configuration. The shield must be placed over the gas pipe and secured in place.
- For gas lines that are less than 6 inches from the GI facility or within the GI facility, the Contractor must install a combination of a protective shield and sleeve. The protective sleeve must consist of either a gray PVC semi-circular sleeve, which comes in 60-inch lengths, or a larger plastic pipe. This protective sleeve must be installed over the gas pipe so that the protective sleeve extends at least 9 inches on either side of the area in conflict. The shield must meet requirements described above.
- Maintain a minimum of 12 inches of separation from underdrains to a gas facility.
- For excavations within 2 feet of gas facilities, the Contractor must install sheeting and shoring protection to protect pipe during construction if directed by the DDOT Engineer.
- A 4-foot minimum clearance is required between the top of gas facilities and the finished road surface grade.

- A 3-foot minimum cover is required over gas facilities in open drainage or road ditches.
- Utility replacement or relocation may be required, based on age and condition, as coordinated with the utility company.

31 Sidewalks, Public Parking, Alleys and Curb Cuts

31.1. General

All facilities must be designed in accordance with the most current Americans with Disabilities Act (ADA) standards and guidance, the requirements of this manual and all other DDOT requirements. This chapter sets forth the minimum criteria to be used in the design of all sidewalks, curb ramps and other pedestrian and ADA facilities within rights-of-way (ROWs), and other public easements.

31.1.1. Regulations and Guidelines

This chapter is based on criteria from the following references:

- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets
- AASHTO, Guide for the Planning, Design, and Operation of Pedestrian Facilities
- DDOT, Downtown Streetscape Regulations
- DDOT, Public Realm Design Manual
- Federal Highway Administration (FHWA), Accessible Sidewalks and Street Crossings
- National Association of City Transportation Officials (NACTO), Urban Street Design Guide
- U.S. Access Board, Americans with Disabilities Act Accessibility Guidelines (ADAAG)
- U.S. Access Board, Public Rights-of-Way Accessibility Guidelines (PROWAG)
- U.S. Department of Justice, ADA Standards for Accessible Design (2010)

31.1.2. Designated Street Distribution

DDOT maintains a historic "Designated Street Distribution Card" for each street in the District of Columbia, which allocates the ROW for each roadway, sidewalk and public parking area (a landscaped "park-like" area between the sidewalk and property line). The Designated Street Distribution Card contains width information for each street, and whenever any changes or improvements are made within the public space area of a street, the designated widths must be maintained as a minimum. These designated street widths may vary from block to block. Whenever any changes to the distribution are made in a street ROW, a written justification is required stating what part of the street's ROW is being changed and the reason for this change. DDOT requires all affecting agencies within the District of Columbia to document the reasons for any proposed change of a street's ROW, and these changes are subject to approval by the DDOT Director.

Alley cross sections will be V-shaped with transverse slopes leading 2 to 9 inches above and toward a center V gutter that directs runoff to a catch basin, either in the alley itself or to the connecting street gutter system. The transverse slope or "dish" may be modified to meet existing features or conditions and to provide proper drainage. See DDOT's **Standard Drawings** for details.

31.4.1. DDOT Requirements for Alleys:

a) When entering and exiting any private or public space alley, all traffic must head-in and head-out from any District street. Vehicles are not allowed to back into a public alley from a District street.

b) Private and public alleys must allow safe vehicular exit via a minimum 15-foot sight-distance from the edge line of the alley on a 45 degree angle from the property line to the back edge line of the sidewalk. If no sidewalk exists, then use the curb line of the street. No over-height fencing or vegetation over 42 inches in height at maturity is allowed within this area, excluding city trees.

c) Curb radii for alleys must be 10 feet.

d) All alleys must be flush with the grade of the sidewalk at the sidewalk crossing area. No step-down curbs or ramps are allowed at alley entrances.

31.5. Curb Cuts

While curb cuts can be necessary to provide vehicular access to private property, DDOT aims to minimize their presence for the following reasons:

- A curb cut creates an additional conflict point between vehicles, pedestrians and bicycles
- A curb cut removes on-street parking spaces
- A curb cut detracts from the site aesthetically and removes trees and landscaped pervious areas

Therefore, the number and impact of curb cuts and driveways on public space should be minimized to improve pedestrian circulation and safety by:

a) Restricting the number of curb cuts at all properties, regardless of land use. The maximum number of curb cuts, including those intended for circular driveways, must be no more than two for a property abutting one street, and no more than three for a property abutting two or more streets (see DCMR Title 24, Subsection 605.9). Despite these limits, DDOT policy is that, absent a compelling need, there should be no more than one curb cut per building.

b) Consolidating curb cuts for different uses, such as loading and parking garage entrances.

c) Providing, prioritizing, and pursuing all opportunities for inter-parcel connections with adjacent properties.

d) Providing a through connection (alley, driveway, or street) from one public or private street to another, within a public access easement or by right-of-way dedication, to reduce the length of a block to an ideal distance of 400 feet or less, consistent with the typical block size in the District of Columbia. Access to the site should then be provided from the new through connection to minimize curb cuts on adjacent streets.

e) Providing curb cuts only where leading to multiple vehicular parking spots, since a curb cut typically removes at least one on-street vehicular parking space.

f) Limiting the number of curb cuts for multi-phased developments and adjacent developments through shared curb cuts, potentially requiring easements.

g) Locating the curb cut on the street with the lower volume of vehicular traffic when a property fronts on two or more streets and when consistent with area planning and historic preservation objectives.

h) Prohibiting backing movements through public space due to safety concerns. Turning movements must be accommodated on private property to ensure head-in/head-out vehicle movements through public space as established in this manual.

i) Choosing a driveway design that is as narrow as practical and meets the standards established in this manual.

j) Establishing appropriate distances between curb cuts and other disruptions to the sidewalk; see **Section 31.5.5** for minimum setbacks for driveways.

k) Providing adequate line-of-sight setbacks behind sidewalks at parking garage exits.

l) Using driveway paving materials that continue the paving color and texture of the adjoining sidewalk across the driveway as an indication to drivers that they are crossing a pedestrian pathway.

m) Maintaining a continuous canopy of street trees.

n) Maintaining a pedestrian clear path width across the driveway or alley that is no less than the minimum required width for the sidewalk as specified in this manual.

o) Complying with the ADA sidewalk slope requirements, as specified in this manual, for the full width and length of the pedestrian clear path crossing the driveway or alley.

p) Complying with the sidewalk surface requirements set forth in the ADA standards for the full width and length of the pedestrian clear path crossing the driveway or alley.

31.5.1. Curb Cut Requirements

a) A new curb cut or driveway is not permitted from any property with alley access, potential access through an improved alley, alley widened onto private property or with potential access to an expanded alley network on private property, unless the applicant provides documentation demonstrating that alley access is not possible due to topography, or that alley access would conflict with existing land uses and is not supported by guidelines in the current **DC Comprehensive Plan**, Zoning Regulations (DCMR Title 11, Subtitle I § 601), and those outlined in **Section 31.4**.

b) For all curb cuts to a property that do not lead to a legal and accessible vehicle parking space on private property, in a garage, or in a carriage house, the property owner should close the curb cut. If the property owner does not close the curb cut, DDOT may initiate the curb cut closure procedures set forth in the DDOT *Right of Way Policies and Procedures Manual*.

~~a)~~c) For all curb cuts to a property that have not been permitted, are not vested with the property, and do not meet current DDOT standards, the property owner should upgrade the non-conforming curb cut to meet DDOT standards, obtain a public space permit, or close the curb cut. If the property owner does not take one of these actions, DDOT may initiate the curb cut closure procedures set forth in the DDOT *Right of Way Policies and Procedures Manual*.

d) Driveway entrances should be constructed perpendicular to the curb line of the street through the entire public space area to the property line.

e) All driveways must be flush with the grade of the sidewalk when crossing the entire sidewalk area. No step-down curbs or ramps are permitted.

f) The grade of any driveway within a public space must not exceed 16 percent, and the algebraic difference of the driveway grade with the counter slope must not be greater than 20 percent.

g) A curb cut and/or respective portion of the driveway, including the flare or radius at the curb cut, must be within the public space abutting the same lot with the building or structure it is intended to serve.

h) Sight-distance for safely exiting driveways and parking garages must be a minimum of 15 feet from the edge line of the driveway on a 45-degree angle from the property line or building line at the garage exit, as applicable, to the back edge line of the sidewalk. No over-height fencing or vegetation over 42 inches in height at maturity is allowed in this area, excluding city trees.

i) Signalized driveways must be designed to meet all intersection guidelines.

j) All driveway entrances must be constructed of poured concrete in accordance with the **DDOT Standard Drawings and DDOT Standard Specifications for Highways and Structures**.

k) Driveway paving materials must continue the paving color and texture of the adjoining sidewalk across the driveway as an indication to drivers that they are crossing a pedestrian pathway.

l) Driveways and parking pads must be constructed so that the parking of a motor vehicle thereon does not cause any portion of the vehicle to intrude in part or whole over any portion of the public space.

m) When changes are made at a property due to redevelopment or new businesses, all existing driveways must be restored with new curb and gutter, tree space and sidewalk to current DDOT standards.

n) Any existing curb cut proposed for new use must be applied for as a new curb cut and driveway at the DDOT Public Space Permit Office, and the above requirements must be met.

31.5.2. Commercial Curb Cut Requirements

a) Commercial curb cut requirements apply to driveways serving office, retail, commercial, or mixed-use properties. These requirements also apply to driveways serving 15 or more vehicle parking spaces at a residential property or senior-living facility.

b) Driveway entrances must be constructed with 6-foot-radius curb returns at the street in accordance with the "Type A" driveway entrance specified in the **DDOT Standard ~~Specifications for Highways and Structures~~Drawings**.

c) ~~Driveways~~ Curb cuts accessing a street must be a minimum of 10 feet wide from edge line to edge line for one-way circulation of motor vehicles, but must not exceed 12 feet wide.

d) ~~Driveways~~ Curb cuts accessing a street must be a minimum of 18 feet wide from edge line to edge line for two-way circulation of motor vehicles, but must not exceed 24 feet for two-way circulation when unusually heavy vehicular traffic is anticipated. Narrower driveways matching residential width standards may be considered for small commercial projects.

e) Where unavoidable, ~~driveways~~ curb cuts that must be more than 24 feet wide to accommodate large, heavy and frequent vehicles must have a minimum 6-foot-wide pedestrian safety island. This pedestrian island must be paved as an 8-inch-thick sidewalk that matches the material used for the existing or proposed adjacent sidewalk. The pedestrian island must have minimum 3-foot-radius curb returns at the street. This 6-foot-wide island must be designed to prohibit vehicles from crossing within the public space area and may be landscaped.

f) A commercial driveway entrance must be at least ~~8~~ 6 feet from the ~~adjacent~~ property line extended onto public space as measured from the edge line of the driveway closest to the ~~adjacent~~ property line extended. The curb cut flare must be fully contained within the property lines extended.

g) Adjacent ~~driveways~~ curb cuts that access two different properties must be no less than 24 feet from edge line to edge line.

h) Two ~~driveways~~ curb cuts accessing a single property must be at least 12 feet apart. (This does not apply to a single driveway with ingress/egress separated by a 6-foot-wide pedestrian island.)

i) ~~Driveways~~ Curb cuts for loading docks with entrances on the roadway must be a minimum of 12 feet wide from edge line to edge line, but must not exceed 24 feet wide, regardless of the number of loading bays.

j) All motor vehicles accessing a loading dock ~~driveway~~ curb cut from a roadway must both enter and exit the driveway entrance in a forward direction to avoid vehicles backing into the public space.

k) All turning and backing movements associated with accessing a loading dock from a driveway entrance on a street must take place on private property.

l) All parking and standing associated with the use of a loading dock must be on private property, and no portion of a standing or parked motor vehicle is allowed to intrude in part or whole over any portion of the public space.

m) Driveways within the Downtown Streetscape area and other areas designated by DCMR Title 11, Hotel-Residential Incentive Overlay District, must be constructed at a right angle (90 degrees) to the curb line of the roadway through the entire public space area to the property line, and must have 6-foot-radius curb returns at the roadway. ~~Driveway~~ Curb cut edge lines must be located a minimum of 8 feet from any interior property line.

31.5.3. Residential Curb Cut Requirements

a) Residential curb cut requirements apply to driveways serving 14 or fewer vehicle parking spaces at a residential or senior-living property.

b) A residential curb cut is defined as typically having a "Type D" driveway entrance with a ~~6-foot-radius curb returns~~2-foot flare that ~~are~~ is used to access single-family residences, flats and duplexes, but not condominiums, ~~or~~ apartment buildings, or senior living facilities, which should utilize a Type B or C design.

c) Off-street parking accessed by a curb cut and driveway must measure a minimum of ~~9~~8 feet wide by 19 feet long and must not cause any portion of the vehicle to intrude into any portion of the public space.

d) ~~Driveways~~ Curb cuts from any roadway at a ~~single-family residence~~residential property, must have a minimum width of ~~9~~ 8 feet measured edge line to edge line within the public space, but must not exceed 12 feet wide.

e) Adjacent curb cuts that access two different properties must be no less than 24 feet from edge line to edge line.

f) Driveway entrances must be flared (Type D) or have a maximum radius of ~~6~~ 2 feet at the roadway, if Type B or C, in accordance with the **DDOT Standard** **~~Specifications for Highways and~~**

~~Structures~~Drawings. The type of entrance constructed depends on the standard for the specific neighborhood.

g) When two adjacent dwellings are being constructed or permitted at the same time, and where alley access is not available or feasible, a curb cut and driveway shared by the two adjacent dwellings is required, provided no more than 7 feet of the driveway width is located on one side of the shared lot line extended.

h) Any driveway entrance or exit on an alley must be at least 30 feet away from a roadway as measured from the driveway edge line to the intersection of the alley edge line and roadway curb line extended.

31.5.4. Circular Driveway Requirements

a) Circular driveways are allowed ~~in accordance with DCMR Title 24, Subsection 607.4, and~~ when written documentation is provided to the DDOT Public Space Permit Office to substantiate a compelling need for one-way circulation of motor vehicles for drop-off and pick-up, and other options are not viable.

b) Circular driveways within public space must not be used for stacking parked vehicles, as these driveways are intended to give passengers closer access to a building entrance for drop-off and pick-up. A clear drive width for the entrance and exit must be maintained for the entire length of the driveway in the public space.

c) A circular driveway entrance or exit on any roadway must be at least 60 feet away from a roadway intersection as measured from the intersection of the driveway edge line and the roadway curb lines extended to the intersection of the roadway curb lines extended.

d) The 6-foot curb radius for a circular driveway entrance must not be located less than 8 feet from an interior lot line extended.

e) There are two types of circular driveways. One is designed on a 60-degree angle with the street curb, and the other is a "U" shaped designed on a 90-degree angle with street curb. ~~See drawing details for the layouts of these driveways.~~

31.5.5. Minimum Setbacks for Driveways

a) The minimum acceptable distance between the edge line of an intersection and the edge line of an adjacent driveway or alley is 60 feet as measured along the roadway curb between the near edge lines of the driveway or alley.

b) The minimum acceptable distance between the edge line of a ~~driveway~~ curb cut and the edge line of an adjacent ~~driveway~~ curb cut or alley is 24 feet, as measured along the roadway curb between the near edge lines of the driveway or alley. However, where a tree is located between driveways and/or alleys, the minimum acceptable distances shown on Figure 31-1 apply.

c) ~~A driveway must be at least 8 feet from the adjacent property line extended onto public space as measured from the edge line of the driveway closest to the adjacent property line extended. Adjacent driveways that access two different properties must be no less than 24 feet from edge line to edge line.~~Adjacent driveways that are 24 feet wide or narrower and that access a single property may be located 12 feet apart provided the driveway entrances have 6-foot-radius curb returns that are flush with the sidewalk.

d) The minimum distance between the edge line of a driveway or alley and the near side of an adjacent existing or proposed street tree must be no less than the following:

- 10 feet for driveways having a Type B, C or D driveway entrance as specified on the current **DDOT Standard Drawings** and typically used at residential dwellings.
- 12 feet for driveways having a Type A driveway entrance, typically with 6-foot curb returns as specified on the current **DDOT Standard Drawings** and typically used to support commercial traffic or higher volumes of traffic.
- 16 feet for alley entrances typically having 10-foot curb returns as specified on the **DDOT Standard Drawings** for Type A or Brick Paving alley entrances.
- 16 feet for any driveway or alley entrance when the existing tree is 37 inches in circumference or greater at breast height.

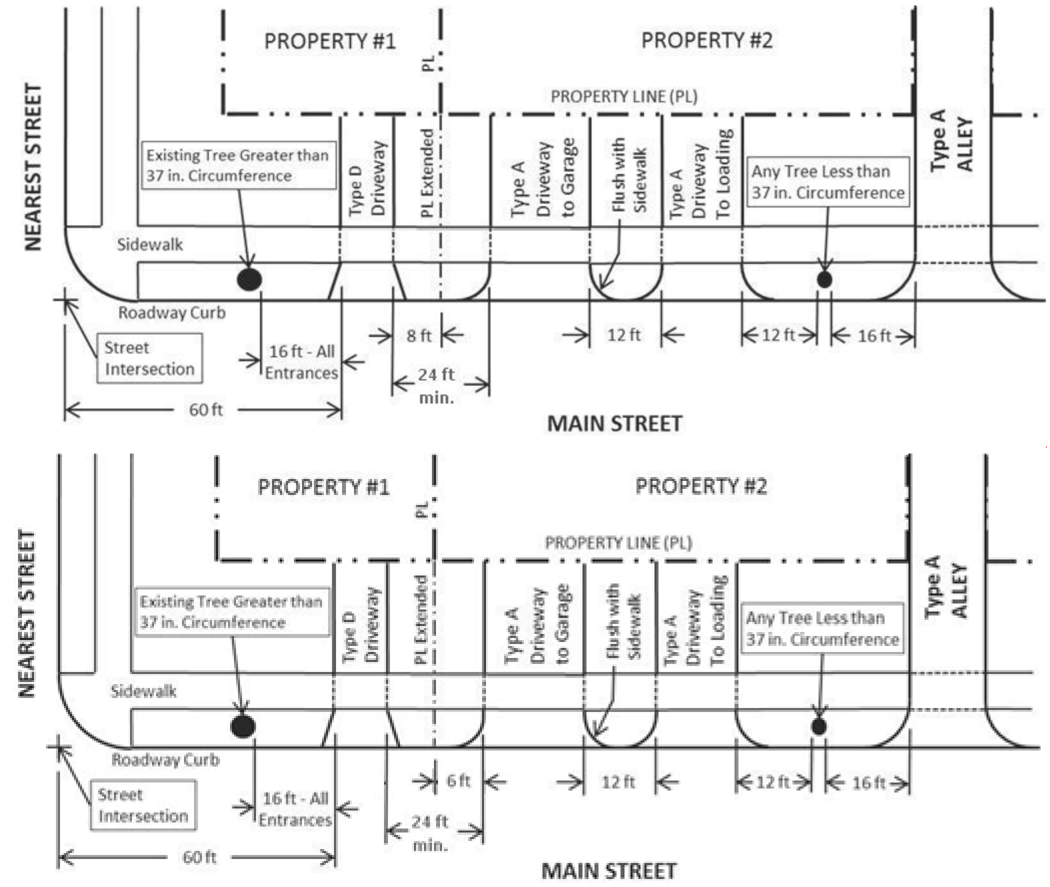

Figure 31-1 | Minimum Setback Distances

31.6. Curb Ramps

Curb ramps are critical to providing access between the sidewalk and the street for people who use wheelchairs. Curb ramps are most commonly found at intersections, but they may also be used at other locations such as on-street parking, loading zones, bus stops and midblock crossings.

Curb ramps are categorized by their structural design and how they are positioned relative to the sidewalk or street. The structure of a curb ramp is determined by how the components, such as ramps and flares, are assembled. The type of curb ramp and the installation site will determine its accessibility and safety for pedestrians with and without disabilities. Curb ramp types are summarized in Table 31-2.

34 Public Transportation

The bus stop guidelines in this chapter are based on the physical design criteria that must be integrated with any plan that incorporates transit: transportation plans, land use ordinances, pedestrian plans, traffic control plans and street design guidelines. Developers and builders should consult these design guidelines for any project that interfaces with public transit.

34.1. Manuals, Guidelines and Reports

The related manuals, guidelines and reports that the Designer should use when designing transit accommodations, such as bus stops, shelters and bulbs are listed below.

- American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Street
- AASHTO Roadside Design Guide
- DDOT Bikeways Work Plan
- District Department of Energy and the Environment (DOEE) Stormwater Management Guidebook
- Federal Highway Administration Manual on Uniform Traffic Control Devices
- National Association of City Transportation Officials Urban Street Design Guidelines
- Transportation Research Board (TRB) Highway Capacity Manual (HCM)
- TRB Transit Capacity and Quality of Service Manual
- TRB Transit Cooperative Research Program (TCRP) Report 65: Evaluation of Bus Bulbs
- Washington Metropolitan Area Transit Authority (WMATA) Guidelines for the Design and Placement of Transit Stops
- WMATA Station Site and Access Planning Manual

34.2. Bus Stops and Bus Zones

34.2.1. Siting of Bus Stops

All bus stop locations in the District must be sited with the approval of DDOT. Metrobus stop locations will be determined by joint decision of the DDOT ~~Progressive Transportation Services Administration~~ Transit Delivery Division (TDD) and the WMATA Metrobus Planning, with public input from the Advisory Neighborhood Commissions. DC Circulator stop locations will be determined by DDOT ~~and the DC Circulator operator,~~ with public input from Advisory Neighborhood Commissions. Commuter bus stops will be sited by DDOT's Commuter Bus Planner and the commuter bus agency.

~~WMATA Metrobus and DC Circulator bus stops have the following minimum requirements for distance from crosswalks:~~

- ~~Near side: 5 feet~~
- ~~Far side:~~
    - ~~Single 40-foot bus: 50 feet~~
    - ~~Single 60-foot articulated bus: 70 feet~~
    - ~~Every additional 40-foot bus requires an additional 50 feet from the crosswalk~~
    - ~~Every additional 60-foot articulated bus requires an additional 70 feet from the crosswalk~~
- ~~Mid-block: N/A~~

34.2.2. Bus Stop ADA Compliance

All new bus stops in the District must conform to DDOT and Americans with Disabilities Act (ADA) standards. At a minimum, all bus stops must have a 6-foot wide by 8-foot deep (from the perspective of an alighting passenger) unobstructed concrete landing pad aligned with the location where the front door of the bus will open. This area must not be obstructed by trees, poles, fire hydrants, trash cans or other street furniture. This landing pad must be constructed at a less than 2 percent slope, with connections to the sidewalk and closest intersection via accessible sidewalks and ramps.

Sidewalk and landing pad materials should be concrete and other smooth surfaces, but not slick (see **Chapter 31** of this manual for details on sidewalks and curbs). Materials such as cobblestone are not considered accessible. An accessible path a minimum of 4 feet wide must exist beyond the landing pad to connect the passenger to an accessible path around any sidewalk obstruction, such as a bus shelter.

See **Chapter 31** for more detailed information on ADA compliance beyond the bus stop.

34.2.3. Bus Zones

The length of a bus zone is dependent on the location with respect to the intersection and the type and number of buses that use that stop at the same time. These zones are identified by red and white signs that say “No Parking. No Standing. Metrobus Zone” with directional arrows showing the extent of the zone.

WMATA Metrobus and DC Circulator bus zones have the following minimum length requirements (distances are listed in the direction of travel):

- Near side:
    - Single 40-foot bus: bus zone must be at least 100 feet in length prior to the bus stop pole. The pole ~~which~~ must be no closer than 5 feet from crosswalk
    - Single 60-foot articulated bus: bus zone must be at least 120 feet in length prior to the bus stop pole. The pole ~~which~~ must be no closer than 5 feet from crosswalk
    - Every additional 40-foot bus requires 50 feet added to the zone
    - Every additional 60-foot articulated bus requires 70 feet added to the zone
- Far side ~~(distance from crosswalk)~~:
    - Single 40-foot bus: bus zone must be at least 95 feet in length starting at back of crosswalk
    - Single 60-foot articulated bus: bus zone must be at least 115 feet in length starting at back of crosswalk
    - Every additional 40-foot bus requires 50 feet added to the zone
    - Every additional 60-foot articulated bus requires 70 feet added to the zone
- Mid-block:
    - Single 40-foot bus: 80 feet prior to the bus stop pole and 30 feet after the pole
    - Single 60-foot articulated bus: 100 feet prior to the bus stop pole and 50 feet after the pole
    - Every additional 40-foot bus requires an additional 50 feet for the zone prior to the bus stop zone
    - Every additional 60-foot articulated bus requires an additional 70 feet for the zone prior to the bus stop zone

All design drawings for construction areas near bus zones should include the location of the bus zone signs.

34.2.4. Bus Pad Requirements

For bus pad locations, the Designer should coordinate with the DDOT Infrastructure Project Management Administration. The minimum pad width is 9 feet excluding gutter, but 10 feet is desirable. The minimum pad length is 40 feet. Mid-block pads should be 80 feet long. Block pads must be a minimum of 12-inch-thick concrete in composite roadways with 10 inches of plain Portland Cement Concrete (PCC) base. The bus pad must be 10-inch-thick reinforced concrete.

Bus pad widths vary depending on the roadway. All buses that travel along asphalt concrete roadways must have bus pads constructed of concrete. Bus pad lengths vary depending on the bus characteristics.

Standard single-unit bus lengths range from 40 to 45 feet, while articulated buses are usually 60 feet long.

DDOT's ~~Progressive Transportation Services Administration~~Transit Delivery Division should be consulted for verification of all bus pad dimensions. Refer to the **DDOT Standard Drawings** for a typical section for a 12-inch PCC bus pad.

34.2.5. Bus Stop Relocation (Temporary)

If a bus stop needs to be temporarily relocated due to construction, the Applicant must propose a new location that can fulfill the requirements of **Sections 34.2.1** through **34.2.3**. The relevant agencies listed in **Section 34.2.1**, including DDOT, must approve of the temporary location. DDOT will determine whether the Designer is required to make any upgrades to bring the temporary stop into ADA compliance based on how long the temporary stop will be used.

After a plan for temporary stop relocation is approved by the relevant agencies, the Applicant must provide at least 30 days' notice to the transportation provider (e.g., WMATA, DC Circulator) before the temporary stop will go into effect, unless there is an emergency need to relocate sooner.

The Applicant is responsible for removing any regulatory signage, such as "No Standing. No Parking. Metrobus Zone" signs, from the permanent stop and placing them appropriately at the temporary stop, based on approved distances from the crosswalks listed in **Sections 34.2.1** through **34.2.3**. The Applicant is also responsible for placing the signs in the approved locations at the permanent stop when the temporary location is no longer needed. The transportation provider (e.g., WMATA, DC Circulator) is responsible for moving its pole and flag to the temporary stop and back to the permanent location when the temporary stop is no longer needed.

All signage for permanent and temporary stops should be marked on plans submitted through the permitting process.

If metered parking spaces need to be removed temporarily for the creation of the temporary bus stop, the Applicant will be responsible for paying for those spaces during the relocation at the behest of DDOT's Parking Group. If Residential Parking Permit spaces must be removed for the temporary bus stop, the DDOT Parking Group must be notified 30 days in advance of the relocation.

34.3. Bus Shelters

DDOT determines the placement of bus shelters.

38 Requirements for Traffic Impact Analysis

DDOT requires all projects that are expected to modify roadway capacity to undergo a Traffic Impact Analysis (TIA). This applies to any project that may generate a transportation-related impact, including streetscape projects, roadway diets, new roadway construction and other proposed roadway design or operational changes. A TIA will include the analyses described in this chapter.

For development projects, the TIA functions as a portion of the greater Comprehensive Transportation Review (CTR). Based on the size and zoning action of the proposed development, the Applicant may be required to complete a CTR without a TIA component. Designers should refer to the latest version of the **DDOT** ~~Guidelines~~ Guidance **for Comprehensive Transportation Review (CTR) Requirements**, which outlines the elements required for a CTR.

38.1. Purpose of a Traffic Impact Analysis

The primary purposes of a TIA are to evaluate the impacts of a roadway project or proposed development on the transportation network and to assess the efficacy of a proposed transportation improvement.

For roadway projects, the TIA helps inform the design of the project, assesses the potential impacts of the project on roadway users, and determines if improvements are required to mitigate the potential impacts of the project. For development projects, the TIA assists in DDOT's decision-making process on whether to support a proposed development project and helps determine what mitigation measures may be required to accommodate the additional traffic generated by the development.

For the purpose of these guidelines, the "Applicant" is defined as the designated agent responsible for preparing the TIA.

38.2. When Is a Traffic Impact Analysis Required?

For roadway projects, a TIA is required when any of the following are proposed:

- Reduction or addition of travel lanes;
- Change in street directionality or one-/two-way operation;
- Installation of or modification to an existing traffic control device;
- Geometric modifications to an intersection; or
- As deemed necessary by DDOT.

The requirement to prepare a TIA for development projects may be waived if all of the following conditions are met:

- Daily trip generation for the proposed development will be less than 300 vehicles;
- Peak hour trip generation will be less than 25 total vehicle trips[1] in the peak direction. The peak direction is defined as the highest total of inbound or outbound site-generated vehicle trips during any of the critical peak hours; and
- No more than 250 vehicles per day are projected to access an existing collector or local road.

A waiver from the TIA requirement must be submitted in writing to DDOT, and the Applicant must show that the above conditions are met. A waiver from the requirement must be obtained in writing from DDOT; a verbal authorization is not acceptable. Of note, a waiver from the TIA requirement does not waive the requirement to complete a CTR. Refer to the latest version of the **DDOT ~~Guidelines~~ Guidance for Comprehensive Transportation Review**, which outlines CTR thresholds.

When an Applicant proposes to amend or update a previously completed and approved TIA, a new TIA is required if any of the following conditions are met:

- The original TIA was prepared for a phased project and needs to be updated for subsequent phases; or
- The data used in the original TIA is more than 2 years old.

The following sections outline the scope and requirements for a TIA.

38.3. Traffic Impact Analysis Scope

This section defines the scope of the TIA. For a roadway project, this scope should be confirmed with the DDOT Transportation Operations Administration before conducting the study. For development projects, the scope of the TIA will be determined during the scoping process for the CTR; see the latest version of the **DDOT ~~Guidelines~~ Guidance for Comprehensive Transportation Review** for details.

38.3.1. Planning Horizons

To assess the impacts of the proposed project, the TIA must present an analysis with and without the proposed project at short-term and long-term horizon years. The intent of the short-term planning horizon is to investigate the immediate impact of the proposed project on the roadway network. The

[1] When determining whether a TIA is required for a land development application, reductions for pass-by trips, internal capture, or existing site traffic may not be taken. However, they may be used in the analysis, as appropriate, if a TIA has been triggered.

intent of the long-term planning horizon is to evaluate the impacts of the proposed project on the long-range transportation conditions.

For roadway projects, the short-term horizon is typically based on the existing conditions. For large infrastructure projects or phased projects, the number of years in the short-term horizon is based on the construction timeline for the project. The long-term horizon is based on a 20-year planning horizon.

For development projects, the short-term horizon is typically defined as the full build-out and occupancy of the project. The long-term horizon is based on a 20-year planning horizon. The short- and long-term horizons for development projects are to be approved by DDOT during the CTR scoping process.

The baseline surface transportation network (without the proposed project improvements) assumed for the short-term planning horizon should reflect existing facilities plus any firmly committed improvements by the District and other development projects in the study area. All planned surface transportation facilities in the study area must be included in the baseline assumptions for the long-term planning horizon analysis.

38.3.2. Study Area Selection

The TIA study area must be defined to include all portions of the transportation network that may be affected by the proposed project.

At a minimum, the study area for roadway projects must include the following:

- All major signalized and unsignalized intersections located within the project boundaries
- The nearest signalized and unsignalized intersections of the project roadway with major streets, including arterials and collector roadways
- Any signalized intersections along the project roadway at a minor street that are between the project boundary and the nearest intersection with a major street where the signals are synchronized
- Signalized intersections along adjacent arterials and major collector roadways that are expected to realize large numbers of new through trips or a moderate number of turning movements due to the proposed project
- All major turning points along anticipated travel routes for site-generated traffic
- A minimum of one major intersection in each direction away from the site
- Adjacent intersections where traffic resulting from the proposed project may necessitate a change in traffic control

For development projects, see the latest version of the **DDOT ~~Guidelines~~ Guidance for Comprehensive Transportation Review**, which outlines the requirements for each study area by mode. Study areas may differ by mode (vehicular, transit, bicycle, and pedestrian), and must be approved by DDOT during the CTR scoping process.

38.3.3. Selection of Analysis Periods

The critical time periods for analysis are typically the weekday morning and afternoon peak hours of the transportation system, when commuter volumes on District roadways are heaviest; these are the most likely times traffic will be affected by a proposed roadway or development project. In general, the weekday morning peak period occurs between 7:00 AM and 9:00 AM, and the weekday afternoon peak period occurs between 4:00 PM and 6:00 PM, although local area characteristics may result in slightly different weekday peak periods.

At a minimum, the TIA must include an analysis during the weekday morning and afternoon peak hours. However, additional analysis periods may be required by DDOT based on the project location. This includes weekend peak periods for developments with significant retail uses, Sunday peak periods for projects including or adjacent to church uses, and weekday evening game-day peak periods for projects adjacent to major sporting facilities, such as Nationals Park.

For development projects, see the latest version of the **DDOT ~~Guidelines~~ Guidance for Comprehensive Transportation Review**, which outlines the requirements for analysis periods. The periods of analysis must be approved by DDOT during the CTR scoping process.

38.3.4. Project-Generated Traffic

For roadway projects, the traffic generated by the project is typically normal traffic volumes rerouted by the proposed project. For projects consisting of a reduction or addition of travel lanes, the installation or modification of an existing traffic control device, or geometric modifications to an intersection, traffic would be rerouted due to changes in capacity and drivers adjusting their travel routes accordingly. For changes in street directionality or one-/two-way operation, traffic would be rerouted due to changes in vehicular circulation.

For development projects, potential impacts are forecast for the planning horizons as outlined in **Section 38.3.1**. The steps in this process include trip generation, modal choice, trip distribution, and traffic assignment. See the latest version of the **DDOT ~~Guidelines~~ Guidance for Comprehensive Transportation Review** for details.

An intersection LOS analysis (reported by approach and intersection average, when available) must be conducted for each intersection in the study area. The impact of the project on the intersection LOS is assessed by comparing the LOS results for each peak period with and without the proposed project during the short- and long-term planning horizons.

Mitigation measures must be recommended if the proposed project results in a significant impact on intersections in the study area. A significant impact is defined as:

- When the proposed project causes any one or more intersection approaches to exceed the established LOS threshold. This threshold will be set for each project and will be defined as LOS "E" or "F" as requested by DDOT; or
- When the proposed project causes any one or more intersection approaches with an existing LOS "E" or "F" to experience an increase in vehicle delay of 5 percent or more.

38.3.5.2. Average and 95th Percentile Queue Lengths

The average and 95th percentile queue lengths are critical factors in determining the length of turn lanes, the location of driveways and curb cuts, the spacing and timing of signalized intersections, and other traffic engineering tasks.

At a signalized intersection, the average and 95th percentile queues are estimated for the duration of the red signal. The queue lengths are based on the number of vehicles that do not clear the intersection during a given green phase. Queue lengths at signalized intersections are defined as the distance between the intersection signal and the last car in the queue.

At unsignalized intersections, the 95th percentile queues can be estimated at two-way stop controlled intersections only. The queue length is based on the number of vehicles waiting to proceed across an approach controlled by a stop sign or waiting to turn across a free-flowing approach.

Queue lengths must be calculated using the procedures outlined in the most recent edition of the HCM or other DDOT-approved method. For projects along major arterials or in congested areas, micro-simulation using SimTraffic, VISSIM, or other approved software may be requested by DDOT.

Queue length analyses (reported by lane group) are highly desired and may be required for each signalized and unsignalized intersection in the study area. The impact of the project on the queue lengths is assessed by comparing the queue results for each peak period with and without the proposed project during the short- and long-term planning horizons.

Mitigation measures must be recommended if the proposed project results in a significant impact on study area intersections. A significant impact is defined as:

- When the proposed project causes the 95th percentile queue length to exceed the available capacity of an approach or turn lane; or
- When the proposed project causes any 95th percentile queue lengths that exceed the available capacity in the short- or long-term planning horizon to experience an increase in queue of 150 feet or more.

38.3.5.3. Merge/Diverge/Weave Analysis

When the study area for the TIA includes uninterrupted-flow roadways, roadways that have no fixed causes of delay or interruptions external to the traffic stream, a merge, diverge, and weave analysis must be performed based on the procedures outlined in the most recent edition of the HCM or other DDOT-approved method.

Traffic enters and exits an uninterrupted-flow roadway via ramps. Merge segments focus on locations where two or more traffic streams combine to form a single traffic stream; diverge segments are where a single traffic stream divides to form two or more separate traffic streams. Where merge and diverge segments are closely spaced and the traffic streams to and from the ramps must cross each other, a weave segment exists.

The HCM defines LOS for uninterrupted-flow roadways as a function of the density in the segment. For uninterrupted-flow roadways, the boundary between stable and unstable flow (LOS “E” and “F”) occurs when the demand flow rate exceeds the capacity of the segment.

An LOS grade is assigned to each merge/diverge segment based on the traffic densities shown in Table 38-2.

Table 38-2 | LOS for Merge/Diverge Segments

LOS	Density (passenger cars per mile per lane)	Comments
A	≤ 10	Unrestricted operations
B	> 10 to 20	Merging and diverging maneuvers noticeable to drivers
C	> 20 to 28	Influence area speeds begin to decline
D	> 28 to 35	Influence area turbulence becomes intrusive
E	> 35	Turbulence felt by virtually all drivers
F	Demand exceeds capacity	Ramp and roadway queues form

41 Traffic Signal Design

41.1. Introduction

A traffic signal is an electrically powered traffic control device, other than a barricade warning light or steady burning electric lamp, by which traffic is alerted and directed to take some specific action. The objective of traffic signal design is to properly distribute the right-of-way to approaching traffic so that vehicles and pedestrians can move through an intersection or a specific area smoothly and safely.

The following types and uses of traffic signals are discussed in this chapter: Traffic Control Signals, Pedestrian Crossing Signals, Pedestrian Hybrid Beacon (HAWK) Signals**,** Street Car Signals, Transit Priority Signals, Bicycle Signals, Ramp Metering Signals, Flashing Beacons, Lane-Use Control Signals, Traffic Control at Movable Bridges, Preemption Control of Traffic Signals, Traffic Signals for One-Lane, Two-Way Facilities, School Warning Flashers, Electric Signs and Displays and Traffic Signals for Construction Zones.

Traffic control signals:

- Assign the right-of-way to various traffic movements
- Have one or more of the following advantages:
  - Provide for the orderly movement of traffic
  - Can increase the traffic handling capacity of the intersection
  - Reduce the frequency of certain types of accidents, especially the right angle type
  - Can be coordinated to promote continuous or nearly continuous movement of traffic at a definite speed
  - Permit minor street traffic, vehicular or pedestrian, to enter or cross continuous traffic on the major street

Data compiled over a number of years indicate that, while the number of right-angle collisions decreases after traffic signals are installed, the number of rear-end collisions increases. In addition, the installation of signals may increase overall delay and reduce intersection capacity. Consequently, it is of the utmost importance that a thorough study of traffic and roadway conditions be conducted by an experienced and trained engineer in the field before considering signal installation and selection of equipment. Equally important is the need to check the efficiency of a traffic signal in operation to determine the degree to which the type of installation and timing program meet current traffic demands.

- The most current edition of the DDOT Standard Specifications for Highways and Structures
- Standard Drawings (DDOT)
- Manual on Uniform Traffic Control Devices for Streets and Highways (FHWA)
- The 1994 Deregulation Agreement between the District of Columbia Government and the Potomac Electric Power Company for Traffic Signal Service

Additional references that may be used include:

- Transportation and Traffic Engineering Handbook, Institute of Transportation Engineers (ITE)
- Manual on Traffic Signal Design (ITE)
- Traffic Control Systems Handbook (FHWA)
- Transportation Research Board National Cooperative Highway Research Program Publications
- Traffic Control Systems Standards, National Electrical Manufacturers Association
- American Association of State Highway and Transportation Officials (AASHTO) Publications
- Traffic Control Devices Handbook (FHWA)
- Signal and Lighting Design Guide (California Department of Transportation [CALTRANS])
- Ramp Meter Design Guidelines (CALTRANS)
- Highway Design Manual (CALTRANS)
- DDOT Guidelines for Basic Timing Parameters
- MUTCD Interim Approval for the Optional Use of Bicycle Signal Face (IA-16) and Following Official Ruling 9(09)-47(I)
- DC Streetcar Concept of Operations

41.5.2. Traffic Signal Operation

A prime factor to consider in selecting the type of traffic signal operation is adequacy. While it may be true that a sophisticated signal control will operate satisfactorily at any intersection, the intersection should not be provided with a type of control that is unnecessarily complex and expensive.

The type of traffic signal operation to be used will depend on the variations in traffic and pedestrian demand. The two main types of signal operation are pre-timed and traffic-actuated. Traffic-actuated operation can be further classified as full-traffic-actuated or semi-traffic-actuated. With full-traffic-actuated operation, all traffic movements or phases are sensed by detectors. In semi-traffic-actuated operation, certain phases (usually the coordinated phases) do not have detectors.

If pedestrians are present during the majority of the signal cycles for a particular leg of an intersection (typically the major street crossing), the pedestrian signal phase should be automatic (“pre-timed”), and pedestrian actuation should not be used. However, in areas with intermittent pedestrians, pedestrian actuation may be used to reduce unnecessary stops and delays for vehicular traffic. While this policy is applied during the design of new signal installation and rehabilitation projects, the final determination will be made on a case-by-case basis to achieve a balance between all modes of traffic.

Pre-timed and semi-traffic-actuated operation should be used in coordinated systems only. They should not be installed at isolated intersections (more than 1 mile from the closest signalized intersection).

Where the distance between signalized intersections is 1/2 mile or less, coordination of signals must be considered, and a time-space diagram and evaluation of the cost-effectiveness of coordination must be prepared.

A new traffic signal shall not be installed within 300 feet of an adjacent traffic signal. An exception may be made in such cases where the proposed signal is to be installed at an intersection that is part of the existing District street network and the new signal can be integrated with the existing adjacent signal under a single traffic controller operation (as determined by DDOT in its sole discretion). An intersection must be shown on the latest District of Columbia Functional Classification Map to be considered under this exception.

Discretion should be used with phasing at offset intersections, as it may introduce operational problems, which should be recognized and avoided. The most critical of these problems is where one approach right-of-way is terminated while the opposing approach continues with a green indication.

41.5.2.1. Detection Options for Signals

Signal detection has two basic sensory modes: presence and passage.

- Presence Detection

  Presence detection senses when a vehicle is in the detection zone; once a vehicle leaves the detection zone, the call is dropped. These detectors are typically used on side streets and left turn bays at the stop line when it is critical to detect if a vehicle is waiting for green.

- Passage Detection

  Passage detection uses a point or pulse sensor that indicates that a vehicle has gone through a detection zone, and the memory of the vehicle is stored in the controller. The passage detection in the controller extends the green time for that movement. These detectors are typically used on mainlines and as system detection.