Chapter 4 – BMP Selection and LID Site Design

Table of Contents

Figures

Chapter 4 – BMP Selection and LID Site Design

4.1 Purpose, Content, and Organization

The purpose of this chapter is to provide guidance for selecting permanent BMPs for new development and redevelopment sites (including retrofitting of redevelopment sites).

The City of Lacey's pollution control strategy is to emphasize pollution prevention first, through the application of source control BMPs. Then the application of appropriate on-site, runoff treatment, and flow control BMPs fulfills the statutory obligation to provide AKART, or "all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the State of Washington" (RCW 90.48.010).

This chapter presents seven steps in selecting runoff treatment and flow control BMPs, and includes low impact development (LID) site design BMPs for preserving native vegetation, restoring site vegetation, reducing effective impervious area, and improving site design.

4.2 BMP Selection Process

Step 1: Determine and Read the Applicable Core Requirements

Chapter 2 establishes project size thresholds for the application of core requirements to new development and redevelopment projects. Figures 2.1 and 2.2 provide the same thresholds in a flow chart format. Calculate total new hard surfaces, replaced hard surfaces, and converted vegetation areas to determine which core requirements apply to the project.

Step 2: Select Source Control BMPs

If the project involves construction of areas or facilities to conduct any of the activities described in Chapter 9, the required structural source control BMPs described in that chapter must be constructed as part of the project. In addition, the residential or planned business enterprise that will occupy the site needs to review the required operational source control BMPs described. Structural source control BMPs must be identified on all applicable plans submitted for City review and approval.

Refer to Chapter 9 and Volume IV of the 2019 Ecology Manual for source control BMP selection, design, and maintenance. In addition, the project may have additional source control responsibilities as a result of area-specific pollution control plans (e.g., watershed or basin plans, water cleanup plans (TMDLs), groundwater management plans, lake management plans), ordinances, and regulations.

Step 3: Determine Threshold Discharge Areas and Applicable Requirements for Runoff Treatment, Flow Control, and Wetlands Protection

Core Requirement #6 and Core Requirement #7 have specific thresholds that determine their applicability (see Chapter 2, Sections 2.2.6 and 2.2.7). Core Requirement #8 uses the same size thresholds as those used in #6 and #7. Those thresholds determine whether certain areas (called threshold discharge areas or TDAs) of a project must use runoff treatment and flow control BMPs, designed by a professional engineer, or whether just Core Requirement #5 can be applied instead (see Chapter 2, Section 2.2.5).

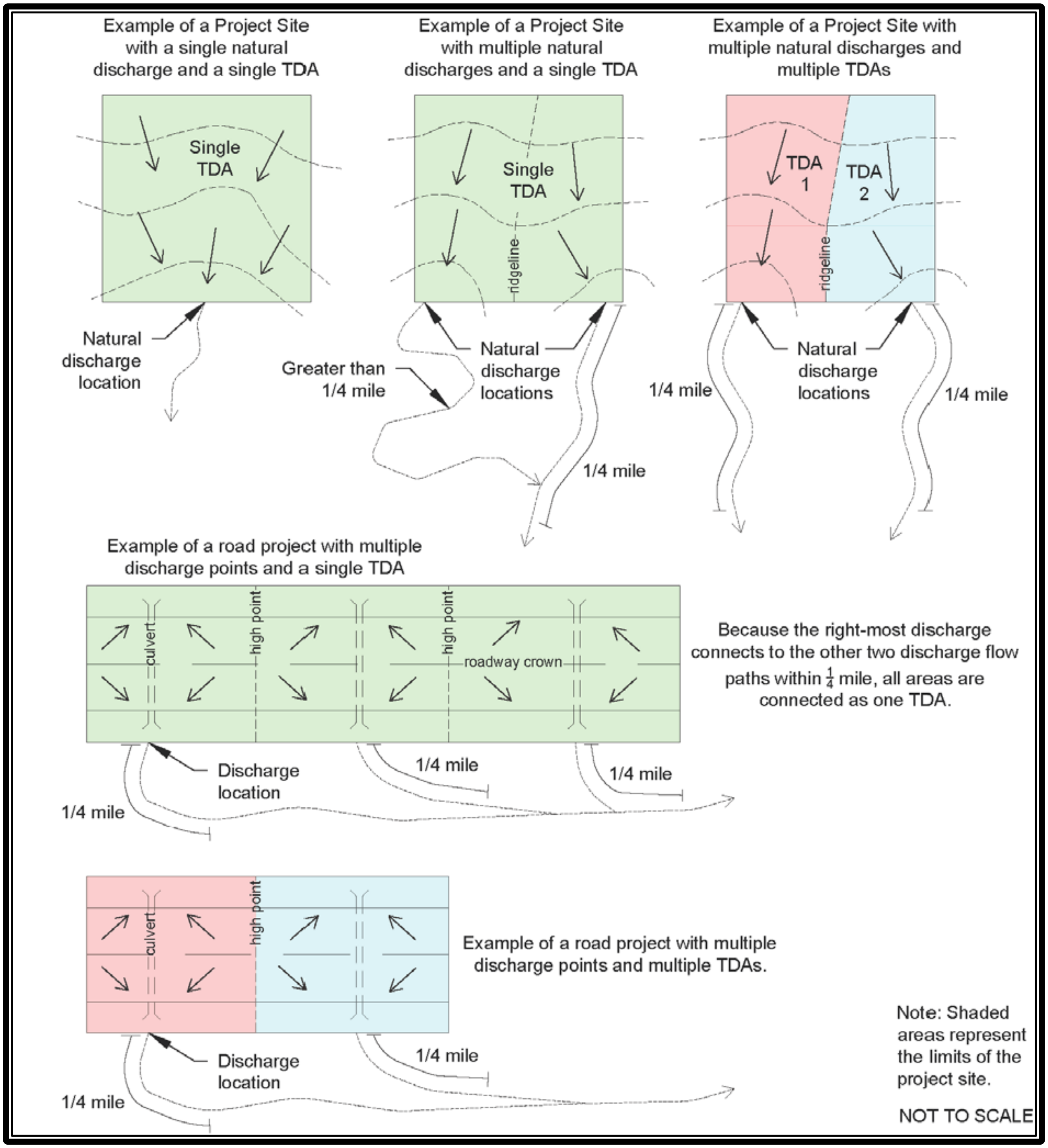
Step 3a: Review Definitions

Review the definitions in the Glossary to become acquainted with the following terms, at a minimum: effective impervious surface, impervious surface, hard surface, pollution-generating impervious surface (PGIS), pollution-generating hard surface (PGHS), pollution-generating pervious surface (PGPS), and converted vegetation areas.

Step 3b: Outline Threshold Discharge Areas

Outline the TDAs for your project site.

TDA **–** An area within a project site draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). The examples in Figure 4.1 below illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.



Source: Ecology

Figure 4.1. Threshold Discharge Areas.

Step 3c: Determine Hard Surface Areas

Determine the amount of pollution-generating hard surfaces (including pollution-generating permeable pavements) and pollution-generating pervious surfaces (not including permeable pavements) in each TDA. Compare those totals to the project thresholds in Chapter 2, Section 2.2.6, to determine where runoff treatment BMPs are necessary. Note that evaluation of on-site stormwater management BMP feasibility (Core Requirement #5) is always applicable.

Step 3d: Implement LID Site Design Strategies

Where feasible, projects shall maximize the use of LID site design strategies to minimize effective impervious areas, vegetation loss, and stormwater runoff (before selecting permanent flow control and runoff treatment BMPs). Smart site design can reduce the cost and land area required for both flow control and runoff treatment. See Chapter 1, Section 1.4, and Section 4.3, for additional details and recommended BMPs. Refer to Chapter 3, Section 3.3.3 for requirements related to documenting the feasibility and implementation of LID site design strategies.

Step 3e: Determine Effective Impervious and Converted Vegetation Areas

Compute the totals for effective impervious surface and converted vegetation areas in each TDA. Compare those totals to the project thresholds in Chapter 2, Sections 2.2.7 and 2.2.8, to determine whether flow control BMPs (Core Requirements #7 and #8) are needed. If neither threshold for flow control BMPs is exceeded, proceed to Step 3f. If one of the thresholds is exceeded, proceed to Step 4 below.

Step 3f: Model Hard Surfaces and Converted Vegetation

For each TDA, use an approved continuous simulation model (e.g., WWHM) to determine whether there is an increase of 0.15 cfs or greater in the 100-year return frequency flow using 15-minute time steps. This requires a comparison to the 100-year return frequency flow predicted for the existing (pre-project; not the historical) land cover condition of the same area. If the above threshold is exceeded, flow control—Core Requirements #7 and #8—is potentially required. See the “Applicability” sections of those core requirements. Note that evaluation of on-site stormwater management BMP feasibility (Core Requirement #5) is always applicable.

This task requires properly representing the hard surfaces and the converted vegetation areas in the runoff model. Hard surfaces include impervious surfaces, permeable pavements, and vegetated roofs. Impervious surface area totals are entered directly. Permeable pavements are entered as lawn/landscaping areas over the project soil type if they do not have any capability for storage in the gravel base (more typical of private walks, patios, and private residential driveways). Additional modeling guidance is found in the BMP design criteria in Chapters 7 and 8.

Step 4: Select Flow Control BMPs

A determination should have already been made whether Core Requirement #7 and/or Core Requirement #8 apply to the project site. On-site stormwater management BMPs must be applied in accordance with Core Requirement #5. In addition, flow control BMPs must be provided for discharges from those TDAs that exceed the thresholds outlined in Chapter 2, Section 2.2.7. Use an approved continuous simulation runoff model and the details in Chapter 7 to size and design the BMPs.

The following describes a selection process for those BMPs.

Step 4a: Determine Whether Infiltration Is Feasible

There are two possible options for infiltration. The first option is to infiltrate through rapidly draining soils that do not meet the site characterization and site suitability criteria for providing runoff treatment (see Chapter 8, Section 8.6.3). In this case, any runoff from pollutant generating surfaces must first be treated in accordance with Core Requirement #6 prior to discharge to a flow control BMP that relies on infiltration (and ultimately to the ground via infiltration). The runoff treatment BMP could be located off-line with a capacity to treat the water quality design flow rate or volume to the applicable performance goal (see Chapter 8, Section 8.4). Volumes or flow rates in excess of the water quality design volume or flow rate would bypass untreated into the infiltration BMP. The infiltration BMP must provide adequate volume such that the flow duration standard of Core Requirement #7, or the wetland protection requirements of Core Requirement #8, will be achieved.

The second option is to infiltrate through soils that meet the site characterization and site suitability criteria for runoff treatment outlined in Chapter 8, Section 8.6.3. If designed to meet both Core Requirements #6 and #7, the BMP must be designed to meet the requirements for both runoff treatment and flow control. Because such a BMP would have to be located on-line it would be quite large. Therefore, this option may, in some cases, be cost and space prohibitive.

In addition, because large portions of the City are within groundwater protection areas and critical aquifer recharge areas, projects proposing to infiltrate stormwater within a wellhead protection area or critical aquifer recharge area must be aware of the additional applicable runoff treatment and/or setback requirements that apply in these areas. Refer to Chapter 8, Sections 8.2.1 and 8.3, as well as the maps of wellhead protection areas and critical aquifer recharge areas in Appendix 8B as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>, for additional details and requirements. See Chapter 7, Section 7.2, for design criteria for infiltration BMPs intended to provide flow control without runoff treatment.

Deep UICs should only be used when surface infiltration is infeasible. Refer to Chapter 7, Appendix 7C for guidance and requirements related to UIC wells.

If infiltration is feasible, select an infiltration BMP from Chapter 7, then proceed to Step 5. If infiltration BMPs are not planned, proceed to Step 4b.

Step 4b: Use an Approved Continuous Simulation Runoff Model To Size a Detention BMP

Refer to Chapter 6, Section 6.2, for an overview of the use of continuous simulation models for flow control BMP sizing. Additional information may be available from the model developers, depending on the specific model being used.

Note that the more the site is left undisturbed, and the less impervious surfaces are created, the smaller the detention/flow control BMP. Greater use of on-site stormwater management BMPs can lead to a smaller detention BMP when supported by engineering.

Step 5: Select Runoff Treatment BMPs

Please refer to Chapter 8, Section 8.2 for step-by-step guidance to selection of runoff treatment BMPs.

- ✓ Step 1: Determine the receiving waters and pollutants of concern based on off-site analysis
- ✓ Step 2: Determine whether the BMP will be City-owned or privately owned
- ✓ Step 3: Determine whether an oil control BMP is required
- ✓ Step 4: Determine whether infiltration into the native soil for pollutant removal is practicable
- ✓ Step 5: Determine whether a phosphorous treatment BMP is required
- ✓ Step 6: Determine whether an enhanced treatment BMP is required
- ✓ Step 7: Determine if additional water quality requirements apply
- ✓ Step 8: Select a basic treatment BMP (unless previously selected treatments also meet basic treatment standards)

Step 6: Review Selection of BMPs

The list of on-site, runoff treatment, flow control, and source control BMPs should be reviewed. The site designer may want to re-evaluate site layout and design to reduce the need for stormwater BMPs or the size of the BMPs by reducing the amount of impervious surfaces created and increasing the areas to be left undisturbed. This step presents another opportunity to maximize the use of on-site stormwater management BMPs and LID site design strategies to reduce stormwater BMP needs.

Step 7: Complete Development of Permanent Stormwater Control Plans and Submittals

The design and location of the BMPs on the site must be determined using the detailed guidance in Chapter 3. Maintenance requirements for each runoff treatment and flow control BMP (see Chapter 10) are also required as part of the Maintenance and Source Control Manual submittal. Please refer to Chapter 3 for guidance on the contents of required Stormwater Site Plans and submittals.

4.3 LID Site Design BMPs

Reducing impervious areas and maximizing on-site infiltration reduces the amount of runoff generated by a project site, thereby reducing stormwater management BMP costs. The following BMPs are to be implemented to the maximum extent practicable:

- Preserving Native Vegetation (Ecology BMP T5.40) and Restoring Site Vegetation
- Reduce Effective Impervious Areas
- Better Site Design (Ecology BMP T5.41)

4.3.1 Preserving Native Vegetation (Ecology BMP T5.40) and Restoring Site Vegetation

Native soil and vegetation preservation is the single most effective strategy to reduce stormwater impacts on site, and has the added benefit of enhancing base flow in streams and recharge of aquifers. Preserving native vegetation shall be the first priority wherever feasible. Native vegetation preservation and restoration areas shall be incorporated to the maximum extent feasible and where most effective (i.e., where there is intact native vegetation and soils and/or unconcentrated flows from developed areas).

The following sections present the strategies and practices for meeting the native vegetation preservation requirements. Per Chapter 7, Section 7.4.2, it is preferable that 65 percent or more of the project site be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors. Additional details on flow dispersion to native vegetation areas are presented in Chapter 7, Section 7.4.2, under Full Dispersion.

Applicability

Preserving Native Vegetation

Native vegetation preservation areas may be required for any of the following conditions:

- Areas reserved for stormwater dispersion for flow control or treatment
- Wetland or other critical area buffers required by the Lacey Municipal Code (LMC)
- Riparian areas and buffers and habitat areas
- As required by the LMC

New development often takes place on tracts of forested land. Unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed.

With vegetation preservation, the primary goal is to retain large, connected tracts of native vegetation areas, either through a cluster design or on individual lots, to maintain the natural hydrologic function and provide infiltration areas for overland flows generated in developed portions of the site. Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging groundwater for summer stream flows and reducing surface water runoff that creates erosion and flooding. Conifers can retain up to roughly 50 percent of all rain that falls during a typical storm. Of this rainfall, 20 to 30 percent may never reach the ground but evaporates or is taken up by the tree.

On lots that are 1 acre or greater, preservation of 65 percent or more of the site in native vegetation will allow the use of flow dispersion techniques presented in Chapter 7, Section 7.4.2, under Full Dispersion. Sites that can fully meet the requirements of full dispersion are not required to provide runoff treatment or flow control BMPs (as required by Chapter 2, Core Requirements #5, #6, and #7).

Restoring Site Vegetation

In situations where it is not feasible to preserve existing trees and vegetation of sufficient size and quantity to achieve the target amount of tree cover, additional tree cover shall be provided where feasible through supplemental tree and vegetation plantings. In addition, on those sites where vegetation cover does not exist due to previous removal, vegetation cover shall be reestablished to the maximum extent feasible.

Design Criteria

Preserving Native Vegetation

Vegetation Preservation Standards

The goals for native vegetation preservation/retention on a development site are as follows:

- Low-density residential (0 to 4 dwelling units/acre): 50 percent of the development site
- Low-density residential (3 to 6 dwelling units/acre): 50 percent of the development site
- Moderate density (8 to 16 dwelling units/acre): maximum practical extent
- High density (minimum 12 dwelling units/acre): maximum practical extent.

At a minimum, requirements for native vegetation preservation and/or replacement as set forth in applicable sections of the LMC, including critical areas, zoning, and grading shall be implemented.

Siting

Selection of areas for natural vegetation preservation shall be made in consultation with a landscape architect. Native vegetation and soil protection areas should be prioritized by location and type as follows:

- Large tracts of riparian areas, that connect, create, or maintain contiguous protected riparian areas
- Large tracts of critical and wildlife habitat area, that connect, create, or maintain contiguous protected areas
- Tracts that create common open space areas among or within developed sites
- Protection areas on individual lots
- Protection areas on individual lots that connect to protection areas on adjacent lots

Other minimum standards for siting include:

- The preserved area shall be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- Where feasible, trees and other native vegetation shall be retained in groups of sufficient size to maintain adequate growing conditions to support natural successional patterns and develop diverse multilayer canopy structure, snags, large woody debris, understory vegetation, and forest duff. Growing conditions include slope, aspect, soil structure and moisture, sun exposure, humidity, wind, co-dependence on or competition among adjacent plants as well as other microclimatic factors.
- The preserved area shall be shown on all property maps and shall be clearly marked during clearing and construction on the site.
- Maximize the amount of preserved area that can be located downslope from the building sites, to optimize the use of full dispersion.
- For trees that are adjacent to existing or proposed structures or other impervious surfaces, it is important to also review Chapter 7, Section 7.4.3, Tree Retention and Tree Planting, to identify possible flow control credits that may be achieved through targeted tree retention.

Restoring Site Vegetation

Vegetation Restoration Standards

The following standards shall be utilized:

- Vegetation restoration and planting methods shall conform to published standards

- The applicant shall comply with the provisions for tree replacement as set forth in Section 14.32.066 LMC.

- Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system.

- Coniferous and broad leaf evergreen trees shall be no less than 4 feet in height at time of planting. Deciduous trees shall be a minimum of 8 feet in height or have a minimum caliper size of 1.5 inch at time of planting.

Construction and Operation

Conversion of a developed surface to native vegetation landscape can require the removal of impervious surface and ornamental landscaping; de-compaction of soils; and/or the planting of native trees, shrubs, and ground cover in compost-amended soil according to all of the following specifications:

1. Existing impervious surface and any underlying base course (e.g., crushed rock, gravel) must be completely removed from the conversion area(s).

2. Underlying soils must be broken up to a depth of 18 inches. This can be accomplished by excavation or ripping with either a backhoe equipped with a bucket with teeth, or a ripper towed behind a tractor.

3. At least 4 inches of well-decomposed compost must be tilled into the broken up soil as deeply as possible. The finished surface should be gently undulating and must be only lightly compacted.

4. At least 4 inches of hog fuel or other suitable mulch must be placed between plants as mulch for weed control. It is also possible to mulch the entire area before planting; however, an 18-inch-diameter circle must be cleared for each plant when it is planted in the underlying amended soil. *Note: plants and their root systems that come in contact with hog fuel or raw bark have a poor chance of survival*.

5. The area of native vegetated landscape must be planted with native species trees, shrubs, and ground cover. Developments shall use native trees for replacement in areas separate from residential lots, or storm drainage areas adjacent to roadway or parking lots. Species must be selected based on the underlying soils, shade, and moisture conditions; as well as the historical, native indigenous plant community

type for the site. Vegetation shall be selected in accordance with the following requirements:

- Trees: a minimum of two species of trees must be planted, one of which is a conifer. Conifer and other tree species must cover the entire landscape area at a spacing recommended by a professional landscaper or in accordance with City requirements. No individual species of replacement tree shall exceed 50 percent of the total, nor shall any individual species be less than 10 percent of the total. Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system. Coniferous and broad leaf evergreen trees shall be no less than 3 feet in height at time of planting. Deciduous trees shall be a minimum of 5 feet in height or have a minimum caliper size of 1 inch at time of planting.

  Note: Avoid the use of a single species of tree for replacement purposes. No individual species of replacement tree should exceed 50 percent of the total, and no individual species should be less than 10 percent of the total.

- Shrubs: a minimum of two species of shrubs shall be planted. Space plants to cover the entire landscape area, excluding points where trees are planted.

- Groundcover: a minimum of two species of ground cover shall be planted. Space plants so as to cover the entire landscape area, excluding points where trees or shrubs are planted.

  Note: For landscape areas larger than 10,000 square feet, planting a greater variety of species than the minimum suggested above is strongly encouraged. For example, an acre could easily accommodate three tree species, three species of shrubs, and two or three species of groundcover.

- Refer to Chapter 16.80 LMC for additional landscaping requirements.

Conversion of an area that was under cultivation to native vegetation landscape requires a different treatment. Elimination of cultivated plants, grasses, and weeds is required before planting and will be required on an on-going basis until native plants are well-established. In addition:

1. The soil shall be tilled to a depth of 18 inches. A minimum of 8 inches of soil having an organic content of 6 to 12 percent is required, or a 4-inch layer of compost may be placed on the surface before planting, or 4 inches of clean wood chips may be tilled into the soil, as recommended by a landscape architect or forester.

2. After soil preparation is complete, continue with steps 3 through 5 above. Placing 4 inches of compost on the surface may be substituted for the hog fuel or mulch. For large areas where frequent watering is not practical, bare-root stock may be

substituted at a variable spacing from 10 to 12 feet on center (with an average of 360 trees per acre) to allow for natural groupings and 4 to 6 feet on center for shrubs. Allowable bare-root stock types are 1-1, 2-1, P-1, and P-2. Live stakes at 4 feet on center may be substituted for willow and red-osier dogwood in wet areas.

Vegetation Protection and Maintenance

The following steps must be taken to protect preserved or restored vegetation after construction:

- Mechanisms shall be put in place to ensure long-term protection of vegetation preservation and restoration areas. Mechanisms to protect these areas include setting aside conservation areas into separate tracts, permanent easements, homeowner covenants, maintenance agreements, and education (see Chapter 3 for additional detail).

- Maintenance plans and agreements must be in compliance with Chapter 3, and must address issues including but not limited to:

    - Pest and disease management practices
    - Pruning requirements
    - Irrigation requirements
    - Fertilization requirements
    - Fire fuel management practices.

- Maintenance shall include intensive site preparation, including weed control and soil amendment. Ongoing maintenance shall include weeding and watering for a minimum of 3 years from installation so as to achieve a minimum 90 percent survival of all planted vegetation. If during the 3-year period survival of planted vegetation falls below 90 percent, additional vegetation shall be installed as necessary to achieve the required survival percentage. Additionally, the likely cause of the high rate of plant mortality shall be determined and corrective actions shall be taken as needed to ensure plant survival. If it is determined that the original plant choices are not well suited to site conditions, these plants shall be replaced with plant species that are better suited to the site.

- Permanent signs shall be installed indicating that removal of trees or vegetation is prohibited within the native vegetation preservation and restoration areas (with the exception of the removal of dangerous and diseased trees).

- Permanent fencing is required around the limits of the vegetation preservation and restoration areas. The type, size, and location of the fencing must be submitted for approval by City review staff and should be made of materials that blend in with the natural surroundings (e.g., wood split-rail, pinned if necessary) and located in such a manner as to not impede the movement of wildlife within the vegetation preservation and restoration areas.

Additional Requirements

In addition to the general requirements outlined above, criteria specified in Chapter 7, Section 7.4.3, Tree Retention and Tree Planting, are pertinent to vegetation retention. In particular, developers should be aware of the specific measures to protect trees during construction.

4.3.2 Reduce Effective Impervious Areas

Roads, shared accesses, alleys, sidewalks, driveways, and parking areas are a substantial portion of total urban impervious area and often have highly efficient drainage systems. Reducing the effective area of these surfaces (roofs excluded) is a key concept of LID. The following sections contain strategies for reducing the impacts of impervious surfaces associated with transportation and mobility related networks.

Road Design

The objective for an LID roadway system design is to reduce the amount of impervious area associated with the road network. This may be achieved by utilizing permeable pavement, examining alternative street layouts, and determining the best option for increasing the number of homes per unit length of road, as well as aligning roads to maximize opportunities for discharging to adjacent dispersion or bioretention BMPs. Strategies to be applied (where feasible) for reducing the amount and impact of impervious area associated with the road network include:

- Design the road layout to follow the existing topographic contours to minimize cuts and fills.

- Design the road layout to avoid crossing natural resource protection areas, thereby minimizing the disruption of sheet flow within these areas.

- Natural resource protection areas or bioretention BMPs shall be located downgradient of roads, alleys, and other impervious surfaces when feasible.

- Minimize effective impervious area and concentrated surface flows on impervious surfaces by eliminating hardened conveyance structures (e.g., pipes, curbs, and gutters).

- Infiltrate or slowly convey storm flows in roadside bioretention cells and swales, and through permeable pavement and aggregate storage systems under the pavement. (Note that if using infiltration and/or conveyance under roads and parking areas in a retrofit setting the design must consider the integrity and protection of adjacent infrastructure.)

- Roads should be designed to service clusters of development located within the buildable portions of the site (i.e., cluster housing), thereby reducing the overall length of the roadway network.

- In higher density residential neighborhoods with narrow roads and where no on-street parking is allowed, pullout parking can be used. Pullouts (often designed in clusters of two to four stalls) should be strategically distributed throughout the area to minimize walking distances to residences. Depending on the street design, the parking areas may be more easily isolated and the impervious surface rendered ineffective by sloping the pavement to adjacent bioretention swales or bioretention cells.

Road Layout

One type of road layout cannot be used in all situations, so it is usually necessary for a designer to explore different strategies and decide which ones will work best for the existing site. At a minimum, the following types of layouts must be considered:

- Grid layouts: Grid patterns provide multiple access routes to each parcel and may include alleyways between blocks with garages located at the back of the house. However, it should be noted that the use of alleys may increase the total road network and associated impervious surface, unless permeable pavements are utilized.

- Cul-de-sacs: In instances where cul-de-sacs are used, techniques must be used to reduce or disconnect the impervious area. This can be accomplished by increasing the diameter of the cul-de-sac, but including a bioretention BMP in the center where stormwater can be directed.

- Hybrid road layouts: Hybrid layouts integrate the grid layout and cul-de-sac approach to minimize impervious coverage per dwelling unit and improve fire and safety access. The loop road design in Figure 4.2 provides an example of the hybrid layout and includes bioretention installed in the interior of the loop for stormwater management that also offers a visual buffer for homes.

Road Cross Sections

The objective of modifying road cross sections is to reduce the roadway width to the minimum amount of impervious surface necessary, while still accommodating emergency vehicle access, and utilizing permeable pavements where feasible. Note: Existing applicable road standards still apply except as modified below:

Roads

- For projects that trigger Core Requirements #1 through #5 or #1 through #9 (Chapter 2, Section 2.2), permeable pavement is one option that must be evaluated for on-site stormwater management for roads with very low traffic volumes and very low truck traffic (see Chapter 7, Section 7.4.6 for additional details). If permeable pavement surfaces are used adjacent to conventional impervious road sections for sidewalks or pullout parking, use design techniques described in Chapter 7, Section 7.4.6 to prevent saturation of the impervious road section and migration of aggregate base material from the impervious to the permeable section.

- Cement/concrete pavement strips (1-foot-wide strips of concrete that act as a transition between the traveled lane and non-rigid permeable pavement surfaces adjacent to the traveled way) may be utilized to delineate the traveled lane areas. These delineator strips shall be at least 6 inches thick with expansion joints every 10 feet.

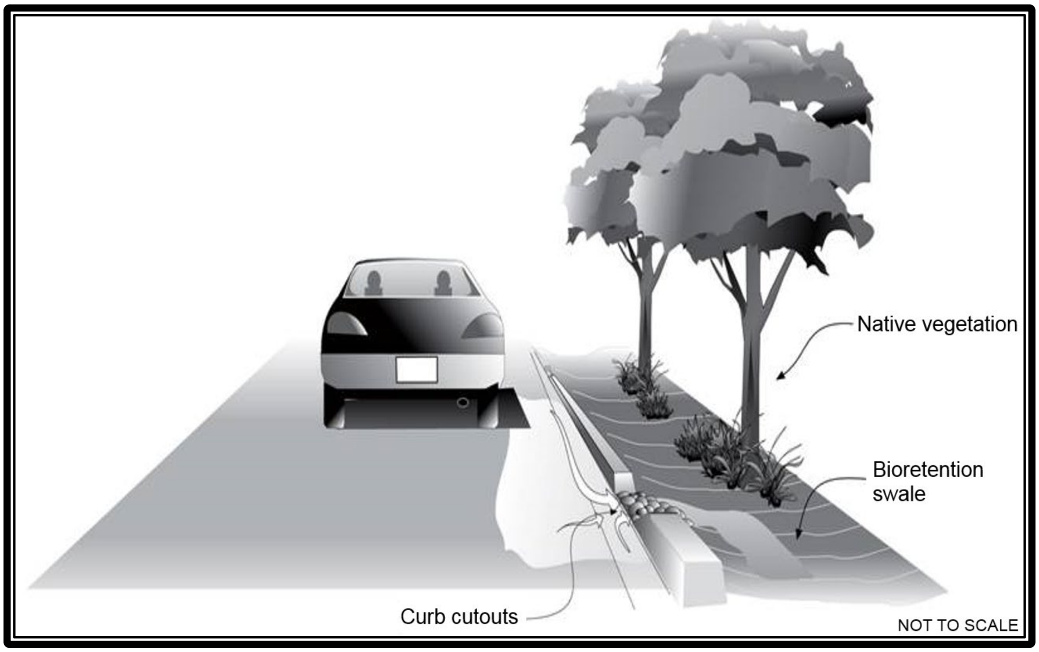
Source: Pierce County

Figure 4.2. Hybrid Road Layout.

- Curbs and gutters are highly discouraged for use as stormwater collection systems in conjunction with catch basins and pipes. Where there is a legitimate need for constructing a curb and gutter system, the "Curb and Gutter Alternatives" subsection below provides guidance for designing curb and gutter alternatives.

The following general requirements apply to curb and gutter applications for LID designs:

- o Curbs are allowed when the sidewalk is adjacent and connected to the traveled way provided they are used only on one side of the road and the road cross slope is away from the curb or if curb cuts are utilized, as shown in Figure 4.3, and drain to a vegetated open channel or bioretention BMP behind the curb.



Source: Pierce County

Figure 4.3. Curb and Gutter Cutouts.

- Alleys shall be constructed with permeable pavement, provided that the runoff through the material will not be directed towards the subgrade of the traveled lane portion of a roadway (unless the subgrade is designed to handle these flows).

- The use of additional pullout parking spaces is required to compensate for narrower road widths, which restrict roadside parking. An example design is provided in Figure 4.4.

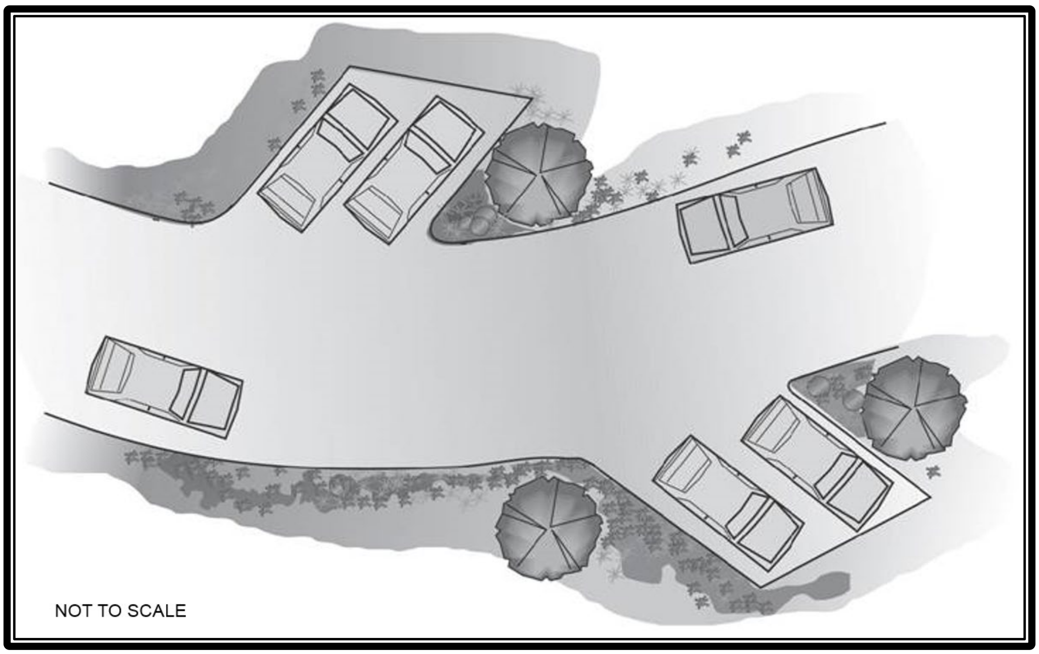
- Bioretention should be incorporated into traffic calming designs associated with retrofit or new streetscapes.

Sidewalks

- Sidewalks and trails must be disconnected from the traveled way portion of the road, to the maximum extent feasible. Every lot shall have pedestrian access to an abutting trail or to a sidewalk located on at least one side of the road. Sidewalks may be separated from the roadway by placement of a vegetated open channel or bioretention BMP between the sidewalk and the roadway.

- Sidewalks and trails shall be constructed of permeable pavement, provided that the runoff through the material will not be directed towards the subgrade of the traveled lane portion of a roadway (unless the subgrade is designed to handle these flows). Permeable pavement with subsurface engineered soil systems can be particularly beneficial in areas surrounding newly planted trees, as they provide soil volume and sustained root development in a manner compatible with pavement and other subsurface infrastructure. Permeable pavement for sidewalks and trails which abut lots, in lieu of a roadside sidewalk, shall be Americans with Disabilities Act (ADA) compliant.

- Where feasible, sidewalks should be "reverse slope" or sloped away from the road and onto adjacent vegetated areas.



Source: Pierce County

Figure 4.4. Alternative Parking.

Parking Lots

The objective of alternative parking lot designs is to eliminate excessive impervious areas dedicated to parking and to minimize the effective impervious area of parking areas, while still providing adequate parking for various land use classifications.

Parking Lot Requirements

- Utilize the minimum off-street parking requirements for non-residential uses (Refer to Chapter 16.72 LMC, Table 16T-13). However, any parking lot space above the required minimum amount shall be constructed of permeable pavement or accommodated in a multi-storied or underground parking structure.

- The designer must incorporate permeable pavement to the maximum extent feasible into the parking lot to promote infiltration of runoff (see also Chapter 7, Section 7.4.6, as well as Chapter 2, Core Requirement #5).
- Bioretention BMPs shall be used to maximize infiltration and attenuation of surface runoff (see also Chapter 7, Section 7.4.4).

Driveways

Driveways are typically constructed with impervious surfaces and as such represent an opportunity to further minimize impervious surfaces and their hydrologic impacts. The following methods shall be used to reduce the amount and hydrologic impact of impervious surfaces associated with driveways:

- Driveways shall be constructed using permeable pavement and graded in such a manner to prevent stormwater runoff from saturating the subgrade of the traveled lane portion of the roadway (if not using permeable pavement for the adjacent road). Surface and subsurface (e.g., discharge from the permeable pavement) stormwater runoff should drain to the adjacent permeable road, vegetated infiltration areas such as soil amended lawns, vegetated open channels, or bioretention BMPs.
- Runoff from driveways constructed of impervious surfaces shall be directed to vegetated infiltration areas such as soil amended lawns, dispersion areas, or bioretention BMPs.
- Minimize driveway width
- Reduce driveway length, where possible
- Design “clusters” of homes with shared driveway

Curb and Gutter Alternatives

The discussion below is intended to give guidance for appropriate LID methods for designing curb and gutter alternatives in situations where there is a need for constructing a curb and gutter system.

Applicability

- Some road types may require use of curb and gutter. Refer to Title 16 LMC and Title 12 LMC to determine if curbs and gutters are required.
- Where curb and gutters are required in all or part of the road network, alternative curb and gutter designs (discussed below) must be considered that will still meet the functional requirements.

Design Criteria

- Where curb and gutters are required in a community to provide a means of separation between the pedestrians and the motorized traffic, an alternative design using placement of a vegetated channel between the sidewalk and the roadway should be considered. In addition, a visual barrier consisting of a 1-foot-wide concrete strip along the edge of the pavement at the same surface elevation of the pavement shall be constructed. This concrete strip gives drivers a visual cue of the edge of the driving surface and can help protect the vegetated channel from tire ruts.

- Another alternative is to provide cuts in the curb at 10- to 15-foot spacing to allow runoff to enter adjacent stormwater management areas. See Chapter 6 for additional flow spreading options.

4.3.3 Better Site Design (Ecology BMP T5.41)

Fundamental hydrological and stormwater management concepts must be applied at the site design phase to help projects better integrate with natural topography and to support the natural site hydrology.

Design Criteria

Knowing how the site processed stormwater historically is important in determining appropriate Better Site Design strategies. This information will aid the designer in determining preferred site layout options, and in deciding what appropriate site design BMPs will help either maintain or restore natural predeveloped stormwater processes.

Initial delineation, site management, and site design strategies to be considered and implemented as feasible include:

Define Development Envelope and Protected Areas

- Based on the site inventory, delineate the best areas to direct development. Building sites, road layout, and other site infrastructure shall be configured within these development areas to minimize soil and vegetation disturbance and take advantage of a site’s natural stormwater processing capabilities.

- Minimize clearing and grading by incorporating natural topographic depressions into the development, and in particular limiting the amount of cut and fill on those portions of the site with permeable soils.

- Delineate natural resource protection areas with appropriate fencing and signage to provide protection from construction activities.

- Eliminate stream crossings with roads and conveyance systems whenever possible.

Minimize Directly Connected Impervious Areas

- Establish limits of disturbance to the minimum area required for roads, utilities, building pads, landscape areas, and the smallest additional area needed to maneuver construction equipment.

- Limit overall impervious land coverage.

- Minimize directly connected impervious areas—i.e., any impervious surfaces that drain directly into a catch basin or other conveyance structure.

Maximize Permeability

- Preserve the existing upper soil horizon to the maximum extent feasible. Where excavation is necessary, excavated topsoil shall be utilized elsewhere on the site to amend areas with sparse or nutrient deficient topsoil.

- Any portion of the site with permeable soils shall be closely considered for preservation to promote infiltration of stormwater runoff.

- Maximize permeability by minimizing impervious areas, paving with permeable pavements (e.g., porous asphalt pavement, pervious concrete pavement, and pavers for roads, driveways, alleys, parking lots, or other types of drivable or walkable coverage), clustering buildings, and reducing the land coverage of buildings by smaller footprints. Applicable strategies shall be reflected at all levels of a project, from site planning to materials selection.

- Layout roads, lots, and other proposed site features to follow topographic contours to minimize soil and vegetation disturbance and loss of topsoil or organic duff layer.

Use Drainage as a Design Element

- Maintain predevelopment flow path lengths in natural drainage patterns whenever possible.

- Where concentrated flow conveyance systems must be used (in lieu of the preferred sheet flow and infiltration approaches), vegetated open channels must be used where feasible instead of piped conveyance systems. Vegetated open channels are most applicable adjacent to roadways where the linear nature of the road can make it difficult to provide enough area within the right-of-way for infiltration or dispersion options.

- Manage stormwater as close to the origin as possible.

- Maximize the use of small, dispersed stormwater management BMPs to capture, store, and infiltrate stormwater on site.

Site Planning and Site Management

- Meet and walk the property with the owner, engineers, landscape architects, and others directing project design to identify problems and concerns that should be evaluated when implementing the site plan.
- Meet and walk the property with equipment operators prior to clearing and grading to clarify construction boundaries and limits of disturbance. Pay particular attention to subgrade preparation for permeable pavement and bioretention installations and techniques to avoid subgrade compaction.
- Encourage erosion and sediment control training for operators.
- See Chapter 5, Section 5.3 for additional requirements specific to protection of LID BMPs during construction (in accordance with Chapter 2, Core Requirement #2, Element #13).
- Finally, designers should also refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012), specifically Chapter 3, for additional guidelines and graphics for better site designs and layouts.