SUSTAINABLE GREEN PARKING LOTS

MONTGOMERY COUNTY PLANNING COMMISSION

MCPC

This guidebook received a 2015 Star Award in the Green Infrastructure category from Communities in Motion.

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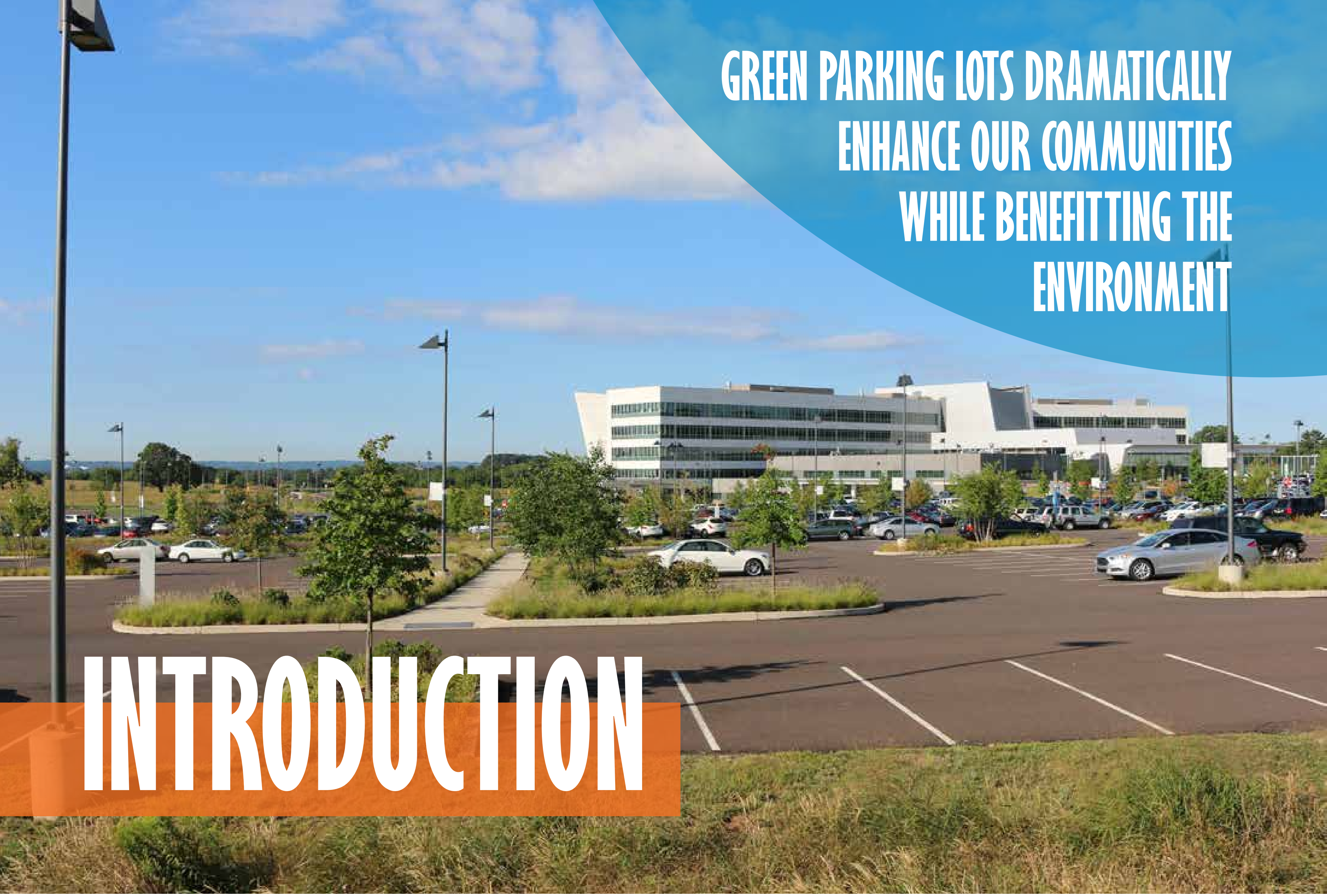
SUSTAINABLE GREEN PARKING LOTS GUIDEBOOK

INTRODUCTION

GREEN PARKING LOTS DRAMATICALLY ENHANCE OUR COMMUNITIES WHILE BENEFITTING THE ENVIRONMENT



Einstein Medical Center Montgomery, *East Norriton Township*

TRANSFORMING OUR PARKING LOTS

Parking is essential for economic growth and business success. Almost every development in Montgomery County includes a parking lot. They play a major role in how our communities look and the quality of the environment. Unfortunately, parking lots can pollute stormwater runoff and increase local flooding. They can pose safety issues for pedestrians and can aggravate the urban heat island effect. For something that occupies such a vast amount of land, causes various impacts, and is used on a daily basis by so many people, the surface parking lot should receive more attention than it has.

Parking lots can be retrofitted or built more sustainably. Using innovative site design, including best practices in stormwater management, consideration for community character, and safer pedestrian connections, we can transform our parking lots and reduce impacts. By incorporating green and sustainable practices, over time these improvements could have a significant positive impact on the county's communities.

WHAT IS A GREEN AND SUSTAINABLE PARKING LOT?

Green parking lots use innovative stormwater management practices, vegetation, and sustainable paving materials to mitigate adverse environmental impacts of large expanses of paving. Green parking lots also incorporate sustainable practices such as adding energy-efficient lighting and renewable energy sources, providing safe pedestrian circulation, and creating significant public spaces that could contribute to the overall local community fabric. These parking lots go above and beyond traditional lots by improving the natural environment and the quality of life enjoyed by Montgomery County residents, workers, and visitors.

THE BENEFITS

Green and sustainable parking lots:

- Integrate into the surrounding built and natural environment.
- Manage water as a resource by promoting infiltration and natural retention system.
- Protect local water quality through effective filtration and biological systems.
- Minimize the heat island effect through effective shading and alternative pavement material.
- Conserve energy usage and encourage the placement of sustainable energy infrastructure.
- Provide safe walkways.
- Use land more efficiently.

ABOUT THIS GUIDEBOOK

In this guidebook, the Montgomery County Planning Commission takes a detailed approach to making parking lots more green and sustainable. It provides design guidance to community leaders; developers; architectural, planning, and design professionals; and citizens. This guidebook explores the issues associated with traditional parking lots and provides the design elements necessary to create green parking lots. It also focuses on rewriting policy on parking lot design, providing ordinance language that could be enacted to ensure the successful use of green design in new parking lots and in the redevelopment of existing lots. Included in this guidebook is a short menu of options to reduce parking demand in our communities.

Chapter 1

WHAT'S WRONG WITH TODAY'S PARKING LOTS?

RETHINKING SURFACE PARKING

Over the past 40 years, as Montgomery County has continued to develop, surface parking lots have become a dominant landscape feature in many communities. The cumulative impact of multiple parking lots can have a significant effect on the environment, character, and overall quality of life in our communities. While parking lots are a realistic necessity, their large expanses of asphalt generate stormwater runoff, air and water pollution, flooding, and excess heat. They may lack safe pedestrian connections, energy-efficient lighting, and effective landscaping that could enhance a community.

In suburban communities, many parking lots were developed prior to design standards that emphasize stormwater, landscaping, lighting, and overall design qualities. As new parking lots are built and existing parking areas are reconstructed, opportunities to create greener parking lots emerge, helping to create more sustainable, pedestrian-friendly, and attractive environments throughout our communities.

IMPACTS OF TRADITIONAL PARKING LOTS

URBAN HEAT ISLAND

The large expanse of paved asphalt parking lots absorbs sunlight and can generate a significant amount of heat on sunny days. The temperatures in parking lots can be 20-40 degrees higher than the surrounding areas. During summer days, parking lots often create a heat island effect where they can actually raise temperatures in the surrounding areas. The increased temperatures place greater demand for energy to cool surrounding buildings.

The excess heat within the parking lots can lead to more rapid deterioration of the pavement surface and heating of vehicles. In less than an hour, a closed car in an unshaded parking lot can achieve temperatures in excess of 140 degrees. Not only does this produce an extremely dangerous condition, but it forces drivers to use excess air-conditioning to cool down their vehicles. Excessive heat in parking lots makes them unpleasant places for pedestrians and people.

WATER QUALITY

Parking lots can cause water quality issues. Motor vehicles drip oil, grease, and various coolants and other materials when parked that are harmful to the environment. The surface of the parking lot too can be eroded, creating additional pollutant sources. For example, tar-coating sealants can be rubbed off the surface by tires and carried off with stormwater. In the winter time, road salts can wash from parking lots, and during rainstorms overheated paved surfaces can heat stormwater,which results in negative impacts to local stream health.

The most significant concentrations of chemicals, oils, and heated stormwater occur within the first several minutes of a storm. This first flush of pollutants from parking lots can produce significant degradation of adjoining streams. In some cases, runoff from streets and parking lots has caused fish kills and other significant impacts to stream aquatic life.

STORMWATER

Conventional parking lots contain impervious surfaces that prevent infiltration of water into the ground. Without infiltration, the volume of stormwater exiting a parking lot is increased. Traditionally, parking lots were designed to quickly remove stormwater runoff, usually through a connected underground piping system. Doing this increases the rate and velocity of stormwater, causing water to exit at higher velocities. These conditions can lead to downstream flooding and can also create erosion, leading to further water impairment.

COMMUNITY CHARACTER

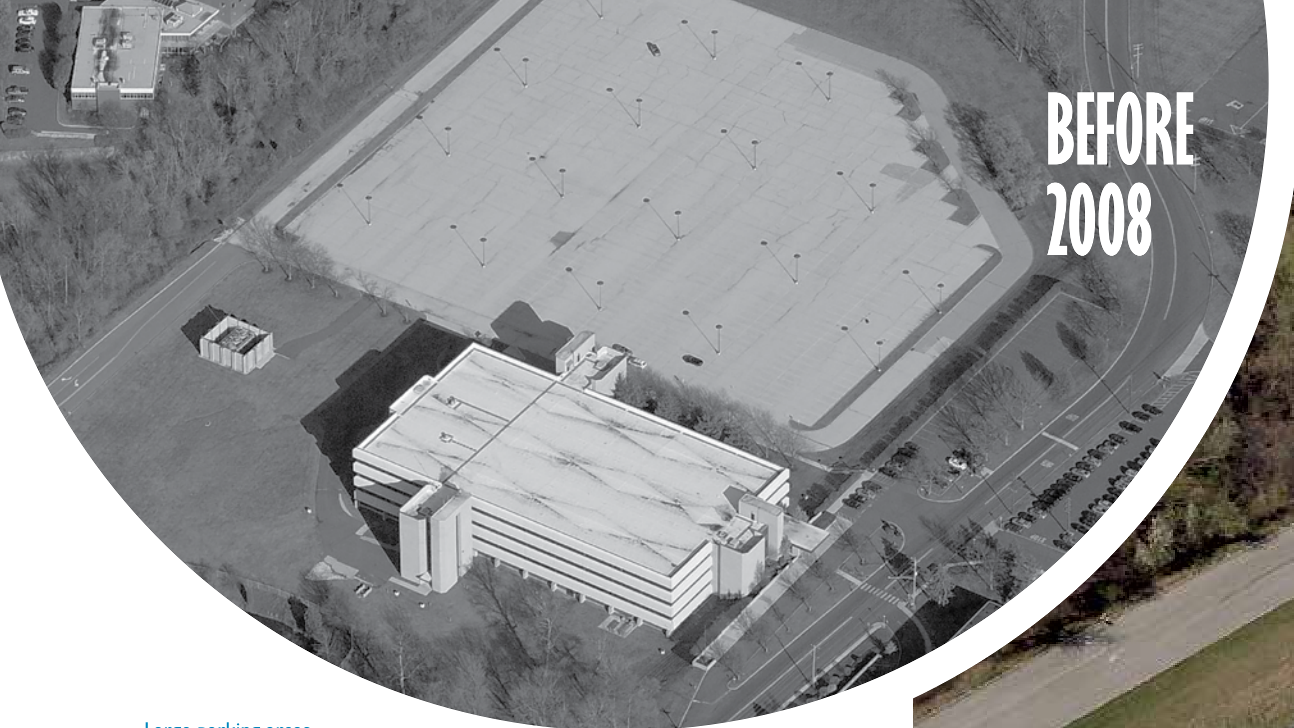
Numerous underutilized and under-designed parking lots may have a detrimental impact on the character of a community. Large, poorly designed parking lots could diminish a community's overall environment by detracting from the surrounding architectural or natural views along roadways. A large amount of community space is usually consumed to provide parking that may only be used periodically. Parking lots are often not well integrated into the community to provide pedestrian connections.

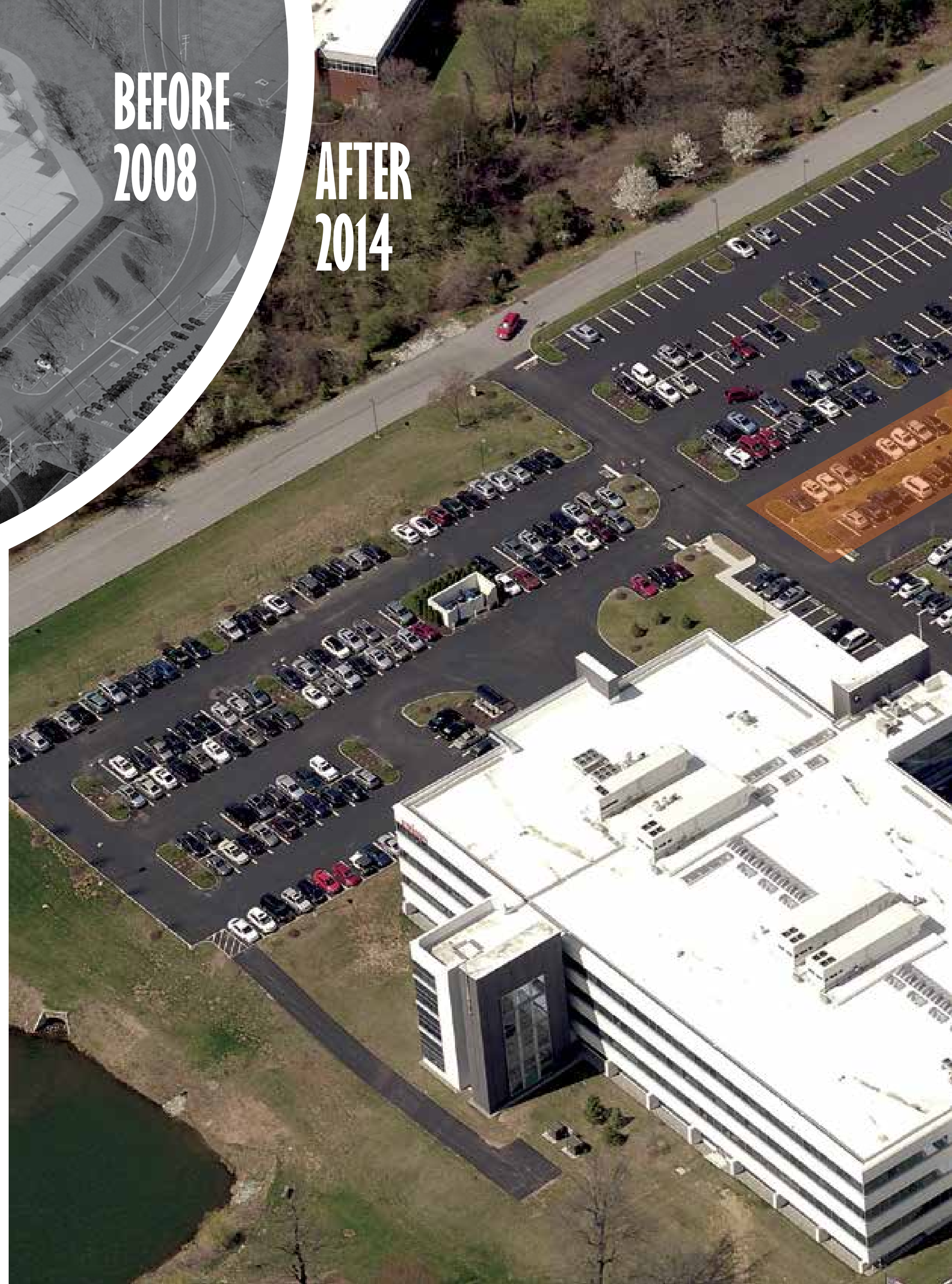
LIGHTING

Parking lots generally contain lighting to provide safety and security for users and adjoining facilities. In many parking lots, inappropriate lighting structures do not effectively direct the light onto paved surfaces and shield it from adjoining uses resulting in light trespass. Light escaping from parking areas can negatively impact the well-being of surrounding neighborhoods. In some cases, this can create unsafe conditions for motorists on adjoining roads. Excess lighting can waste energy and diminish dark sky vistas.

DRIVER AND PEDESTRIAN SAFETY

Parking lots can be dangerous places both for pedestrians and vehicles. Even though pedestrians have the right-of-way in parking lots, many drivers don't always see or yield to pedestrians. In some communities, more than 20% of pedestrian injuries occur in parking lots. Often, parking lots can be more hazardous than streets. On streets, the direction of traffic is predictable, but in parking lots, vehicles may be moving in all directions. Drivers are often distracted searching for parking spaces or maneuvering through the lot. Even at low speeds, many vehicle crashes occur in parking lots due to lack of visibility and traffic controls at many parking lot intersections.





Large parking areas
contain no landscaping, no pedestrian
walkways, and no stormwater management
Arborcrest, Blue Bell

ARBORCREST
A SUCCESS STORY

New landscaped islands
with large shade trees

Pedestrian circulation
safety improvements

Gateway greening improves
community character

Chapter 2

HOW TO GREEN YOUR PARKING LOTS

DESIGN ELEMENTS FOR GREEN AND SUSTAINABLE PARKING LOTS

Creating green and sustainable parking lots involves several design elements. These elements include maximizing shading and greening, incorporating naturalized drainage, utilizing paving that infiltrates, using energy-efficient lighting and renewable energy generation, adding safe pedestrian circulation, and successfully integrating and connecting parking in the community. Any combination of these elements can be used in new parking lots or the redevelopment of existing lots.

These elements provide many options to make our parking lots more sustainable. When natural drainage systems, including bioretention, are combined with permeable paving systems, extensive greening, and sustainable practices, a parking lot can be transformed into an environmental asset.

ANATOMY OF A GREEN AND SUSTAINABLE PARKING LOT

Naturalized drainage is designed to absorb stormwater

Interconnected landscaped bioretention areas capture, slow, clean, and infiltrate stormwater

Maximize shading and greening

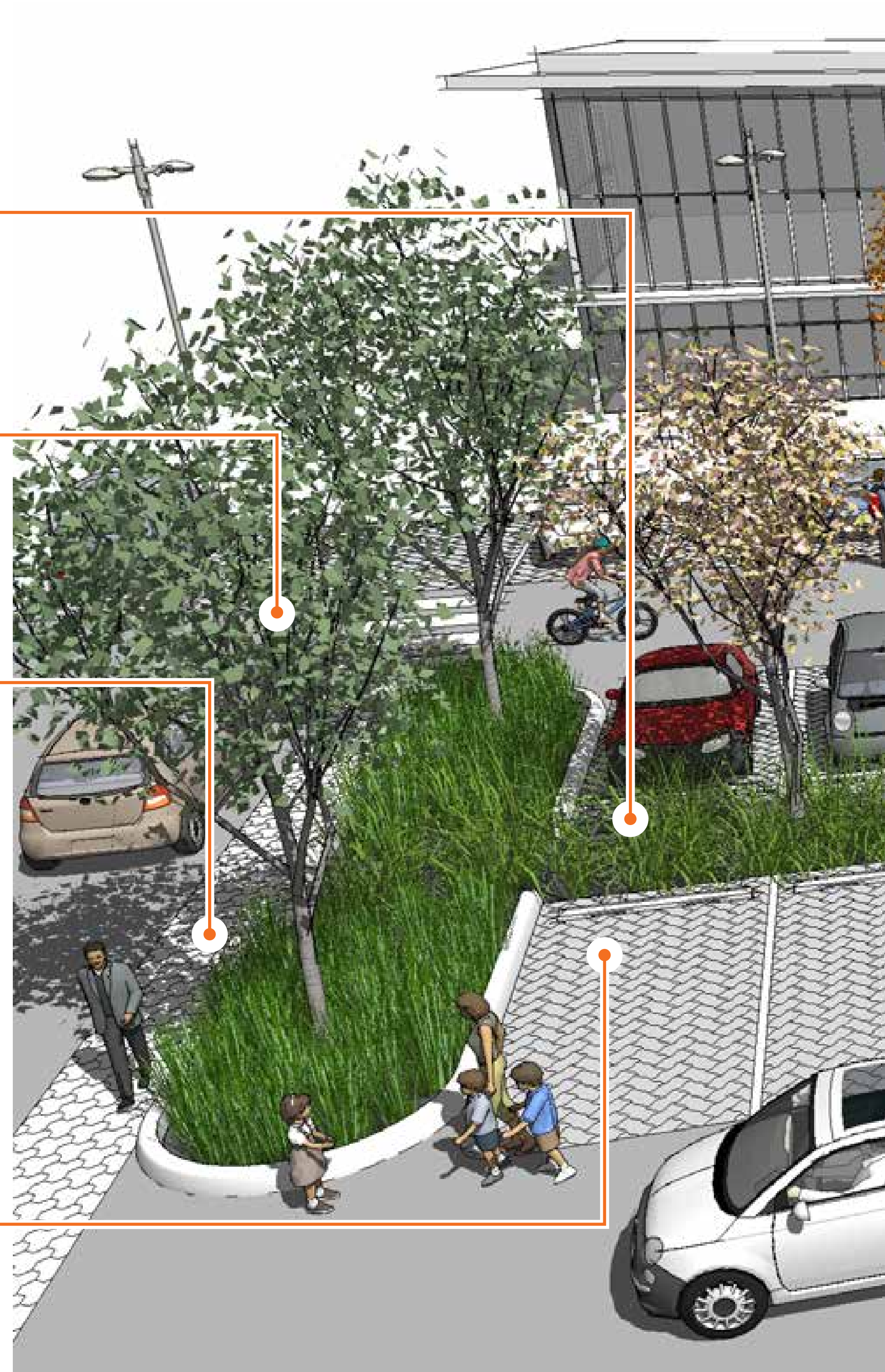
Provide generous planting areas for large shade trees and a combination of shrubs and grasses

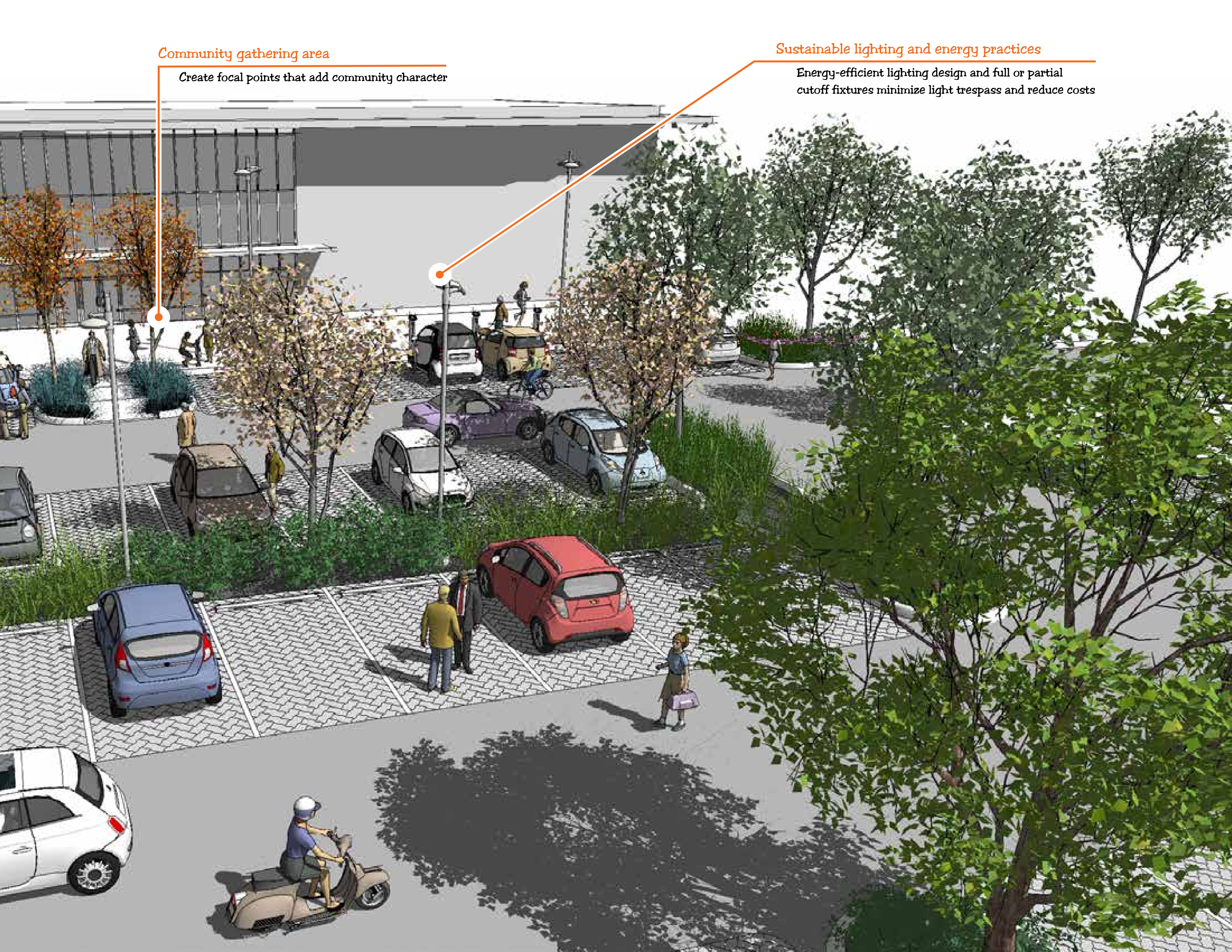
Use safe pedestrian and vehicular strategies

Create safe pedestrian connections through the parking lot to building entries and adjacent sidewalks

Use pavements that infiltrate

Numerous types of permeable paving options, such as grass pavers, porous asphalt, and permeable pavers, exist to infiltrate and manage stormwater on site




Community gathering area
Create focal points that add community character
Sustainable lighting and energy practices
Energy-efficient lighting design and full or partial cutoff fixtures minimize light trespass and reduce costs

MAXIMIZE SHADING AND GREENING

Landscaping and shade trees make parking lots more aesthetically pleasing while improving adjacent property values, enhancing air quality, and reducing stormwater runoff. Tree canopy, vegetation, and pervious green space can work together to mitigate the impacts of the urban heat island effect and provide other environmental health and economic benefits.

BENEFITS OF SHADING & GREENING

Environmental

- Enhance air and water quality
- Reduce greenhouse gas emissions
- Reduce stormwater runoff quantity and improve quality
- Improve habitat

Health/Social

- Improve air quality
- Create visual and sound barriers

Economic

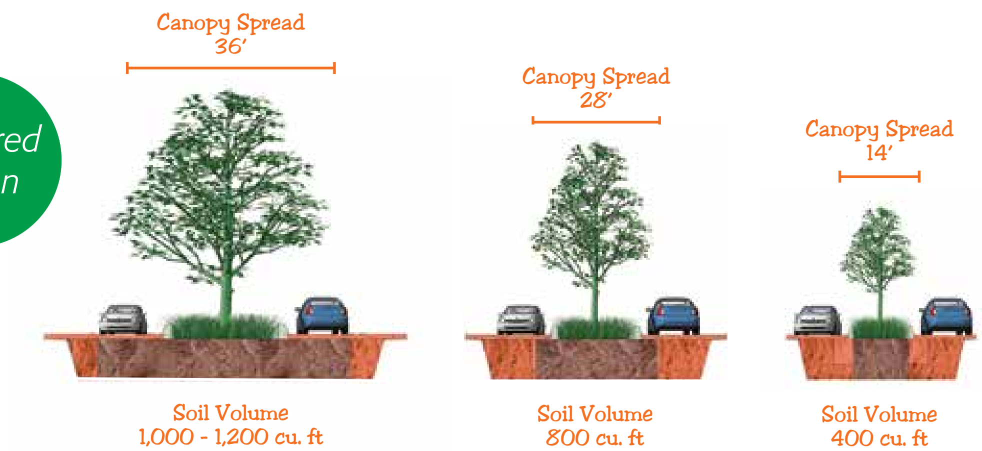
- Increase property values
- Increase pavement lifespan
- Reduce infrastructure costs
- Improve customer experience (encourage patrons to linger longer and spend more money)

Large canopy trees provide maximum shading in parking lots
Bala Cynwyd, Lower Merion Township

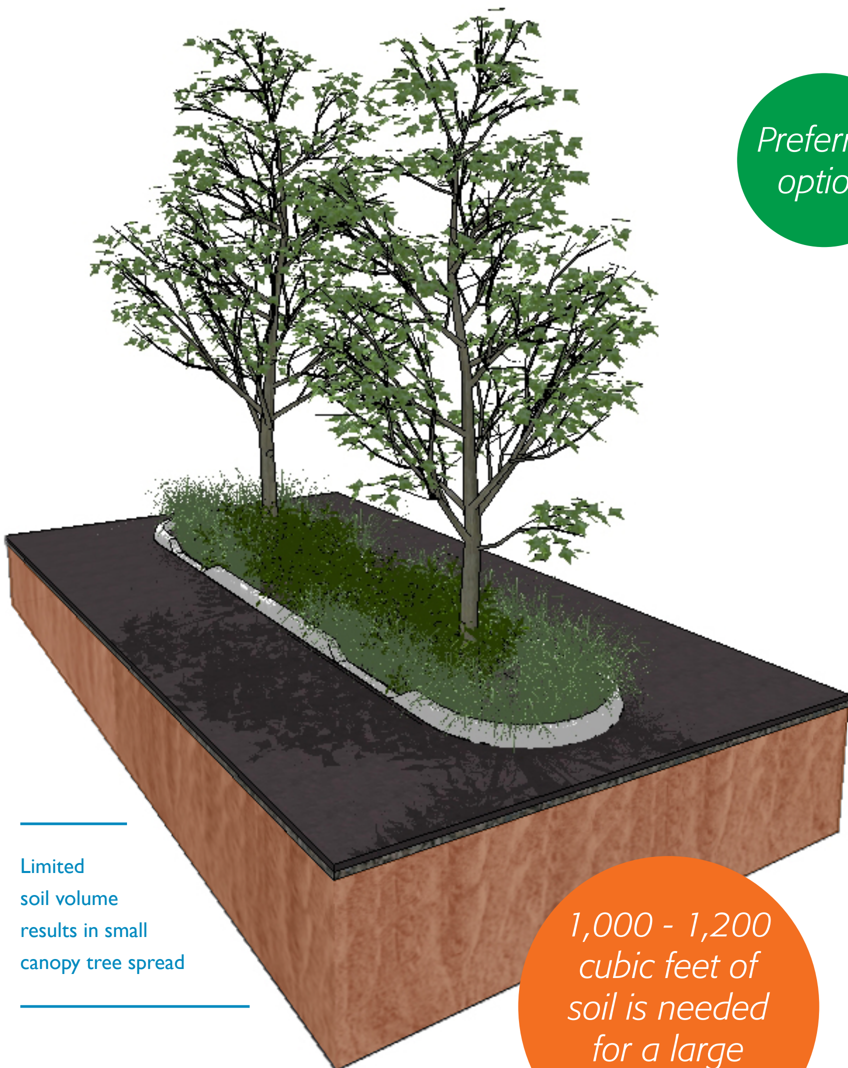
Generous tree rooting area provides for effective tree growth, health, and shading
Germantown Academy, Whitemarsh Township

HOW MUCH SOIL TO GROW A LARGE TREE?

Preferred option



Data is courtesy of Deep Root Green Infrastructure



Limited soil volume results in small canopy tree spread

1,000 - 1,200 cubic feet of soil is needed for a large canopy tree

PLANTING FOR SUCCESS

When planting trees, it is essential to provide what a tree needs to grow—adequate space, soil, and water. The landscaping choices made in a parking lot must meet several objectives. Every plant chosen should be appropriate for the particularly harsh conditions found in most lots. Landscape diversity throughout the parking lot is important to enhance habitat and provide visual interest and color.

To provide sufficient shade, larger shade trees should be strategically spaced throughout the parking lot since they can provide two to six times more shade than small trees. Large canopy trees require equally large areas for their roots which generally extend the width of the spread of their branches. Unfortunately, in many instances, large trees planted in parking lots never achieve their full size and width of canopy due to the lack of sufficient soil volume provided. Several nationally recognized arborists have studied the minimum soil volume needed to support shade trees in confined situations, and they have concluded that 1,000 - 1,200 cubic feet or more of soil volume is needed for a large shade tree to grow in confined rooting environments such as parking lot islands.

GENEROUS PLANTING AREA GIVES YOUNG TREES ROOM TO GROW AND PROVIDE SHADING

Arborcrest, Whitpain Township

Mature shade trees in large planting area
Spring Valley YMCA, Limerick Township

Shade trees planted in rain garden with shrubs and perennials to enhance growing conditions
Montgomery County Community College West Campus, Pottstown Borough

PROVIDE A SUITABLE GROWING ENVIRONMENT

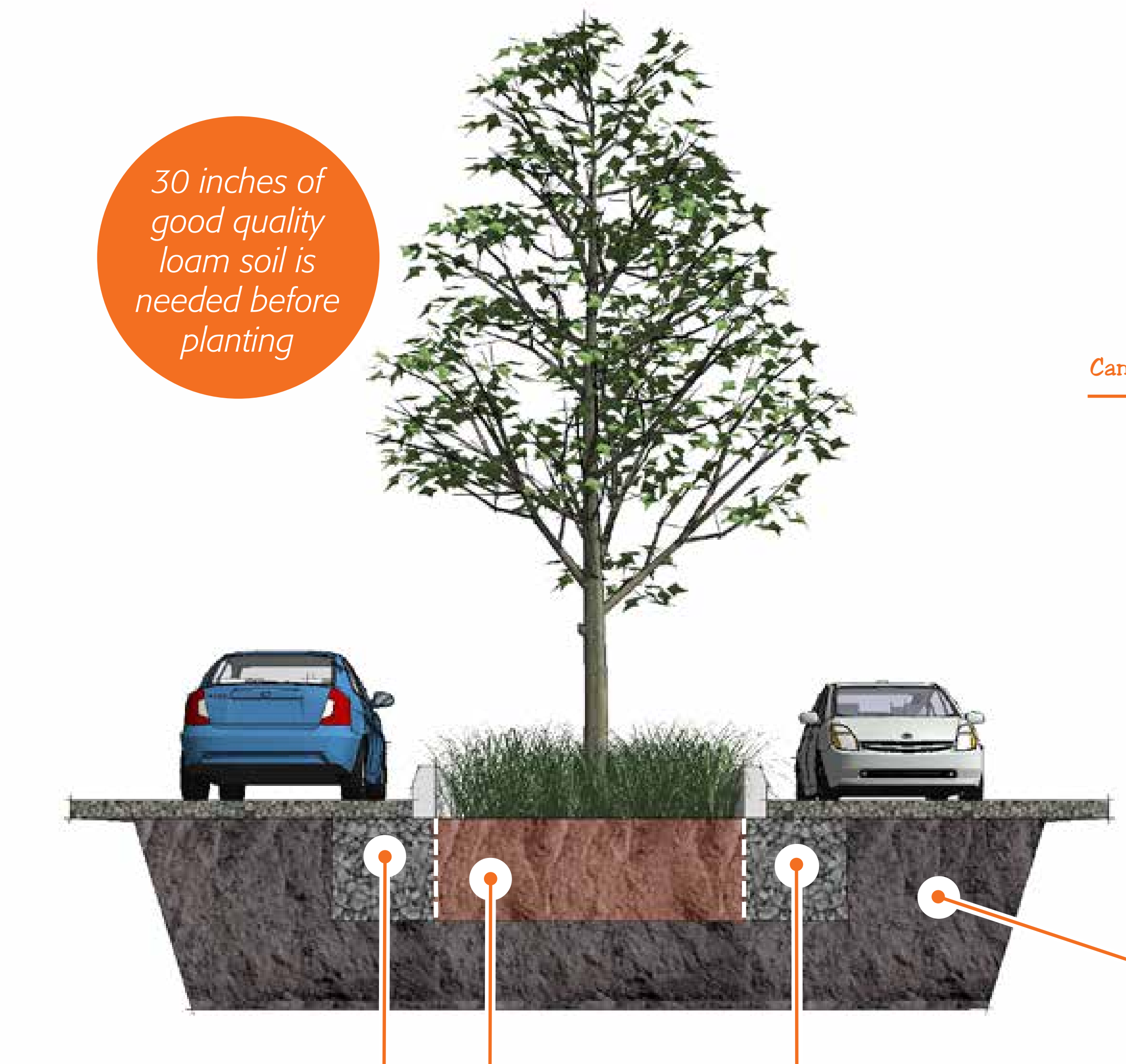
Soil fertility in tree planting areas in parking lots is often poor for various reasons. Most parking lots are graded with heavy equipment that compacts soil. Additionally, the top soil is often stripped off the entire parking lot prior to earth moving. Lastly, tree planting areas are often times used for dumping of construction debris and excess concrete. In order to improve the soil in tree planting areas, designers first need to determine the porosity and bulk density of the planting soils. Prior to planting, all debris and compacted construction soils need to be removed from planting areas and replaced with good quality loam soils to a depth of 30 inches. When renovating parking lots or designing new surface lots, it is important to ensure that soils are improved to allow trees to thrive in these difficult environments within surface parking lots. Trees also need to be protected from damaging conditions such as vehicle impacts, snow piling, and road salt.

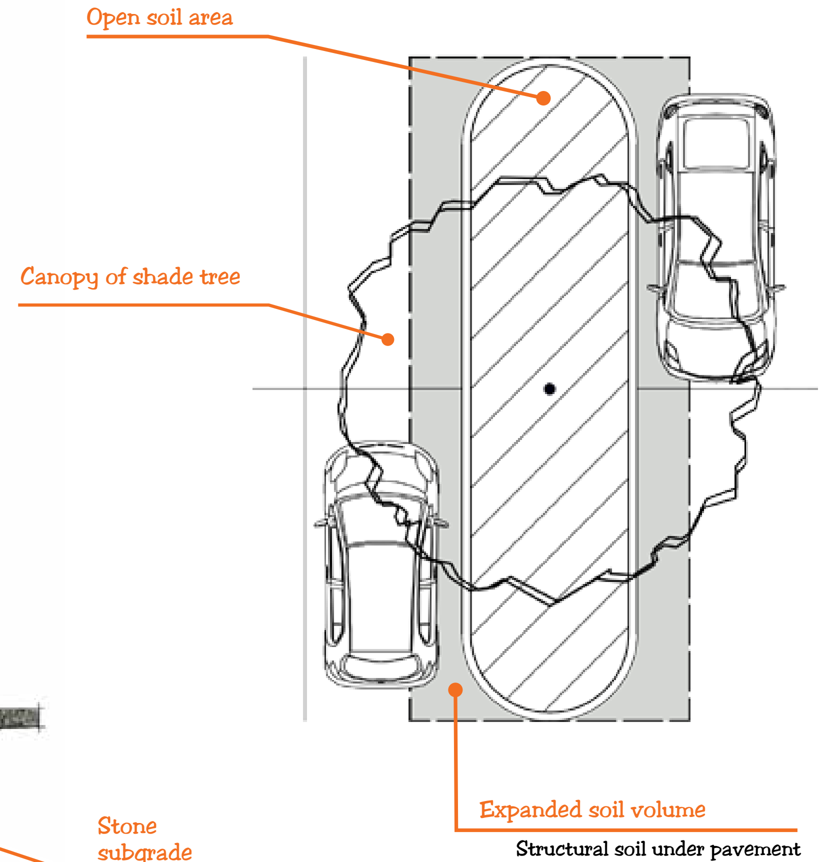
Since tree roots need water, it is important to ensure that the stormwater management drainage system in the parking lot provides sufficient moisture to tree roots. Also, tree species should be selected based upon expected moisture conditions. In areas that will collect significant stormwater, it may be necessary to select trees whose root systems can withstand submerged conditions. A consistent, sustainable supply of water is an essential ingredient for long-term planting success. (For more information, please see Recommended Planting Lists for Green Parking Lots in appendices.)

Grouping trees with other shrubs and perennials can enhance the growing conditions. Another consideration in tree selection and location involves safety and lighting. Consideration of tree size and growth should be made to ensure that trees and shrubs do not block key sight lines of motorists at important areas in the parking lot such as intersections. Also, the placement of trees should be done in conjunction with the lighting system and the need to ensure adequate lighting in parts of the parking lot for safety.

To achieve a balance between suitable tree growth areas and the need for a sufficient number of surface parking spaces, several proven technologies have been developed to enhance tree root growth and plant success. The following technologies not only improve root zone conditions but also can be used to better manage stormwater. Technologies, such as structural soils, modular parking support structures, and tree trenches, can be used to ensure that trees have access to larger and uncompacted soil that is suitable for improved root growth.

TREE PLANTING ISLANDS: PROMOTE EFFECTIVE TREE GROWTH WITH EXPANDED SOIL VOLUME





Stone subgrade

Expanded soil volume

Using structural soils

Expanded soil volume

Using structural soils

Planting island soil

Excavate and amend to 30" depth (as necessary)

STRUCTURAL SOILS

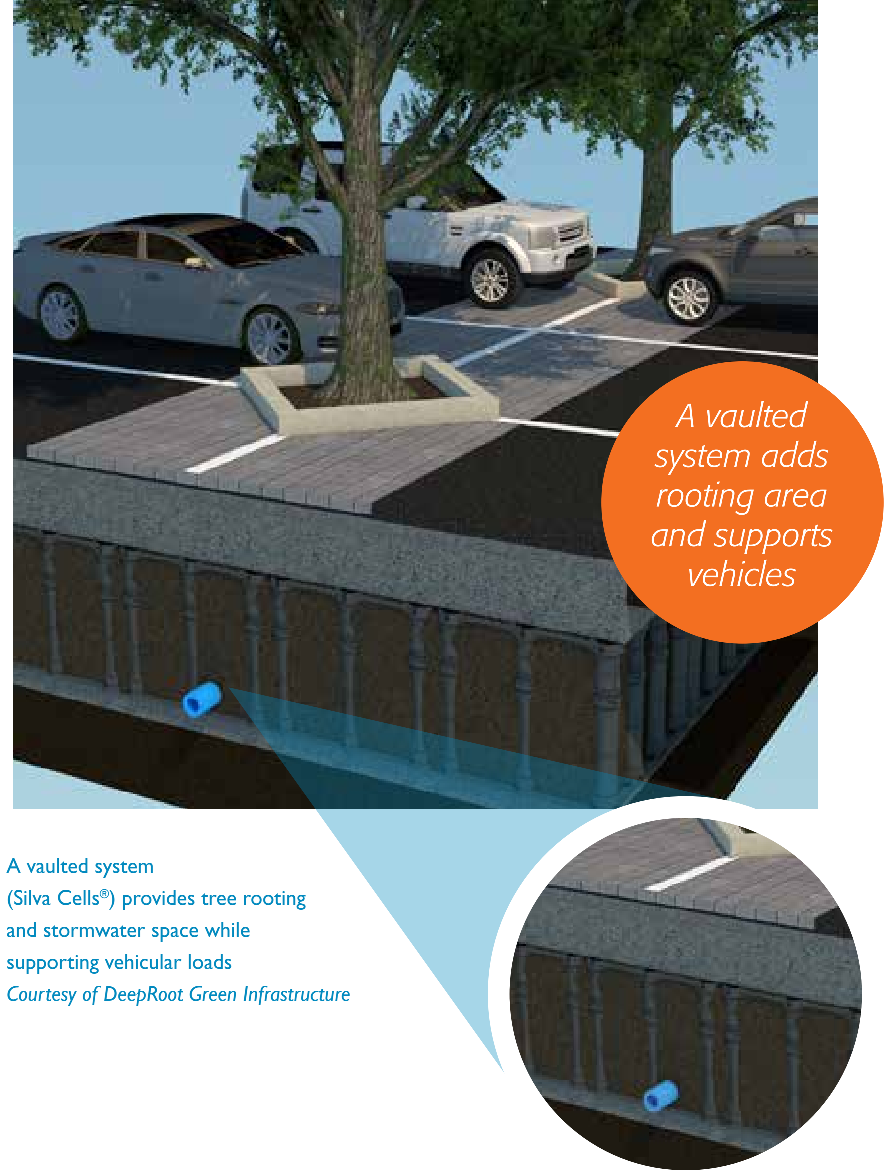
Structural soils are a soil improvement technology that can provide increased opportunities for root and healthy plant growth while supporting vehicles and other load requirements within the parking lot. These soils, often known as engineered soils, are composed of 80% stone and 20% loam soils, along with a small amount of water retention material which keeps pore spaces open. Engineered soil mix is designed to prevent soil compaction and preserve large air spaces necessary to provide oxygen to tree roots. Generally, structured soils create approximately 20% void spaces. The structural soil mix can be used to expand the tree island area beyond the island curbs while supporting pavement areas. In parking lots with limestone gravel subbases and other concrete materials, it may be necessary to have structural soils that reduce alkalinity to create a slightly acidic soil environment more suitable for growing most tree species.

INNOVATIVE PARKING SUPPORT STRUCTURES

Modular suspended or cantilevered pavement systems that are generally constructed with plastic can enable tree roots to use an uncompacted soil underneath parking surfaces. In addition to providing for enhanced soil porosity for tree roots, these structures provide underground stormwater storage. They provide up to 90% void space for loam soil versus the 20% in stone-based structural soils. Larger volume of available soils results in healthier, larger tree growth and canopy spread than structural soils. The main drawback of the use of these modular pavement support structures is the initial cost of installation.

TREE TRENCHES

Tree trenches can be used in parking lots where a walkway system is being developed along shade trees. A tree trench is a system of trees connected by an underground infiltration structure. On the surface, a tree trench looks just like a series of street tree pits. However, under the sidewalk there is an engineered system to manage the incoming runoff. This system is composed of a trench dug along the sidewalk which is lined with a permeable geotextile fabric, filled with stone or gravel, and topped off with soil and trees. Stormwater runoff flows through a special inlet (storm drain) leading to the tree trench. The runoff is stored in the empty spaces between the stones, watering the trees and slowly infiltrating through the bottom. If the capacity of this system is exceeded, stormwater runoff can bypass it entirely and flow into an existing street inlet or other conveyance system.



A vaulted system (Silva Cells®) provides tree rooting and stormwater space while supporting vehicular loads
Courtesy of DeepRoot Green Infrastructure

NATURALIZED DRAINAGE SLOWS STORMWATER FLOW, IMPROVES WATER QUALITY, AND INFILTRATES RAINWATER ON SITE.

Einstein Montgomery Medical, East Norriton

PROMOTE NATURALIZED DRAINAGE

Bioretention structures, such as bioswales or rain gardens, are planted with appropriate trees, shrubs, grasses, and perennials to slow stormwater flow and improve water quality. These structures enable plants to filter out and adsorb various dissolved chemicals in stormwater, improving water quality. Bioretention systems enable the soil microbes to further breakdown stormwater contaminants.

Dansko Headquarters, *West Grove, PA*

WHAT IS A NATURAL DRAINAGE STRATEGY?

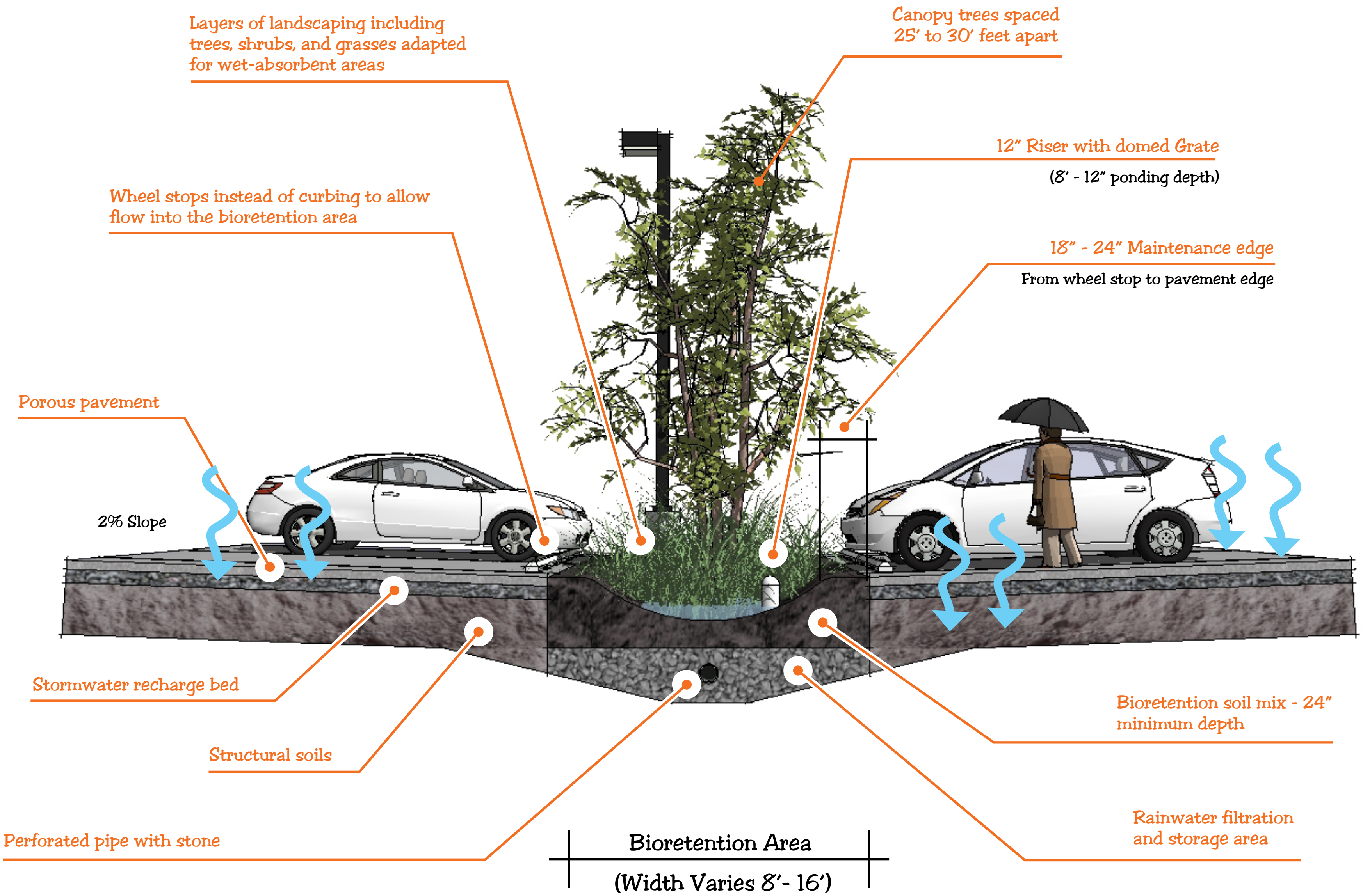
This practice is best designed as a series of connected landscape spaces and treatment areas which absorb and infiltrate stormwater into landscape islands and other green areas around the parking lot. Through the use of a natural drainage strategy in a parking lot, rainwater is managed as a resource, and the water quality and flooding problems associated with stormwater from a parking lot are mitigated. This approach closely mimics nature's water cycle and enables the treatment of parking lot stormwater closer to where it falls as opposed to a more centralized stormwater management system with pipes and detention basins. In addition to treating stormwater, these bioretention areas also provide an attractive green amenity that can add color and habitat in a parking lot.

Bioswales and rain gardens are two types of bioretention structures that are particularly suited for parking lot applications. Bioswales are shallow depressed channels that can be placed between parking stalls and around the perimeter of parking lots. Bioswales can function as stormwater conveyance structures as well as serving to treat stormwater runoff and reduce water discharge through infiltration. Rain gardens are simply planted depressions with highly permeable soils to enable water infiltration. The structures are most effective when connected into a stormwater management system.

BENEFITS OF USING NATURAL DRAINAGE IN PARKING LOTS

- Captures stormwater runoff closer to the source, reducing the cost of traditional curbing, gutters, and piping by as much as 15%-50%
- Removes a large percentage of total suspended solids; 50-60% of nitrogen and phosphorus and 75% of heavy metals
- Provides an attractive landscape asset
- Reduces stormwater and pollutants (oils, grease, and other substances) from entering our local streams

NATURALIZED DRAINAGE AND POROUS PAVEMENT IN PARKING LOT



HOW DOES IT WORK?

To work effectively, bioretention structures are designed to capture and temporarily retain stormwater to enable sedimentation and infiltration. They also provide for plant filtration and absorption of pollutants while managing excess stormwater flow. Bioretention components include flow entrance, ponding area, soil planting mix, drainage structures, and vegetation.

FLOW ENTRANCE

Stormwater flowing across the parking lot can enter the bioretention structure as sheet flow along curbless parking lot edges or can be directed through curb cuts in raised curb areas. In curbless areas, a concrete edge with tire stops can be installed to protect the pavement edge and prevent cars from leaving the parking area. This enables stormwater to enter the bioretention structure along its entire length rather than only at selected inlets. In some cases, gravel filter strips are placed between the parking lot edge and landscaped portion of the bioretention structure to filter and reduce the velocity of stormwater flow. This assures stormwater velocity does not cause eroding conditons.

PONDING AREA

A shallow ponding area, usually no more that 1-2 feet in depth, can provide temporary stormwater storage.

Typically, the amount of ponding is based on the design of the outlet structure. Overall, the ponding depth is often very shallow to ensure the safety of people using the adjoining parking lot. Also, since plants are vital to the success of bioretention systems, the health of the plants is a big consideration in amount and duration of water storage.

SOIL PLANTING MIX

The bioretention soil mix consists of a specific ratio of sand, fine soils, and organic material to promote vigorous plant growth and the infiltration of stormwater. Adding a bioretention soil mix is important in many locations in Montgomery County since existing soils often possess insufficient permeability to enable adequate infiltration. The permeability of existing soils becomes even worse due to compaction occurring throughout site construction.

DRAINAGE STRUCTURES

Though some of the stormwater in bioretention structures infiltrates into the soil, an outlet structure is needed to convey excess flow to maintain ponding conditions. Typically, a PVC outlet with some type of clog-proof filter cap is installed within a stone bed at the lower end of the bioretention structure. For ease of maintenance, clean-outs are provided every 50 feet of the outlet pipe.

Water flows from the depressed curb and between wheel stops into the bioswale where it allows infiltration and supports vegetation; any overflow exits through the drain

Madison at New Britain, Chalfont, PA

USING VEGETATION IN NATURAL DRAINAGE

Plants function to provide evapotranspiration of water, improve infiltration through the development of root structure, and contribute to healthy soil bacteria, which provide an essential role in stormwater treatment. Plants also provide habitat and contribute to color and aesthetic interest. The choice of vegetation is dictated by several variables including root growth and tolerance to wet conditions. In general, native plants that provide ornamental qualities should be selected to provide local habitat as well as color and attractiveness. Though plant diversity is desirable, bioretention system design should also take maintenance needs into account. Typically, in the early years, significant weeding is required. To make weeding more efficient, plants needing to be protected should be clearly apparent to maintenance workers. Also, it is wise to place plants as densely as possible to ensure vigorous growth and the ability of the desired plants to crowd out any undesirable species.

Redeveloped parking lot features bioswales using layered landscape consisting of trees, shrubs, and grasses
Bala Cywyd Shopping Center, Lower Merion Township

MAINTENANCE

Bioretention structures can have significant maintenance requirements that need to be continually addressed to keep them functional and attractive. Initially after planting, watering and mulching may be necessary. Until the vegetation becomes firmly established, selective weeding will be required. Managers of bioretention areas should plan on some level of maintenance for each season.

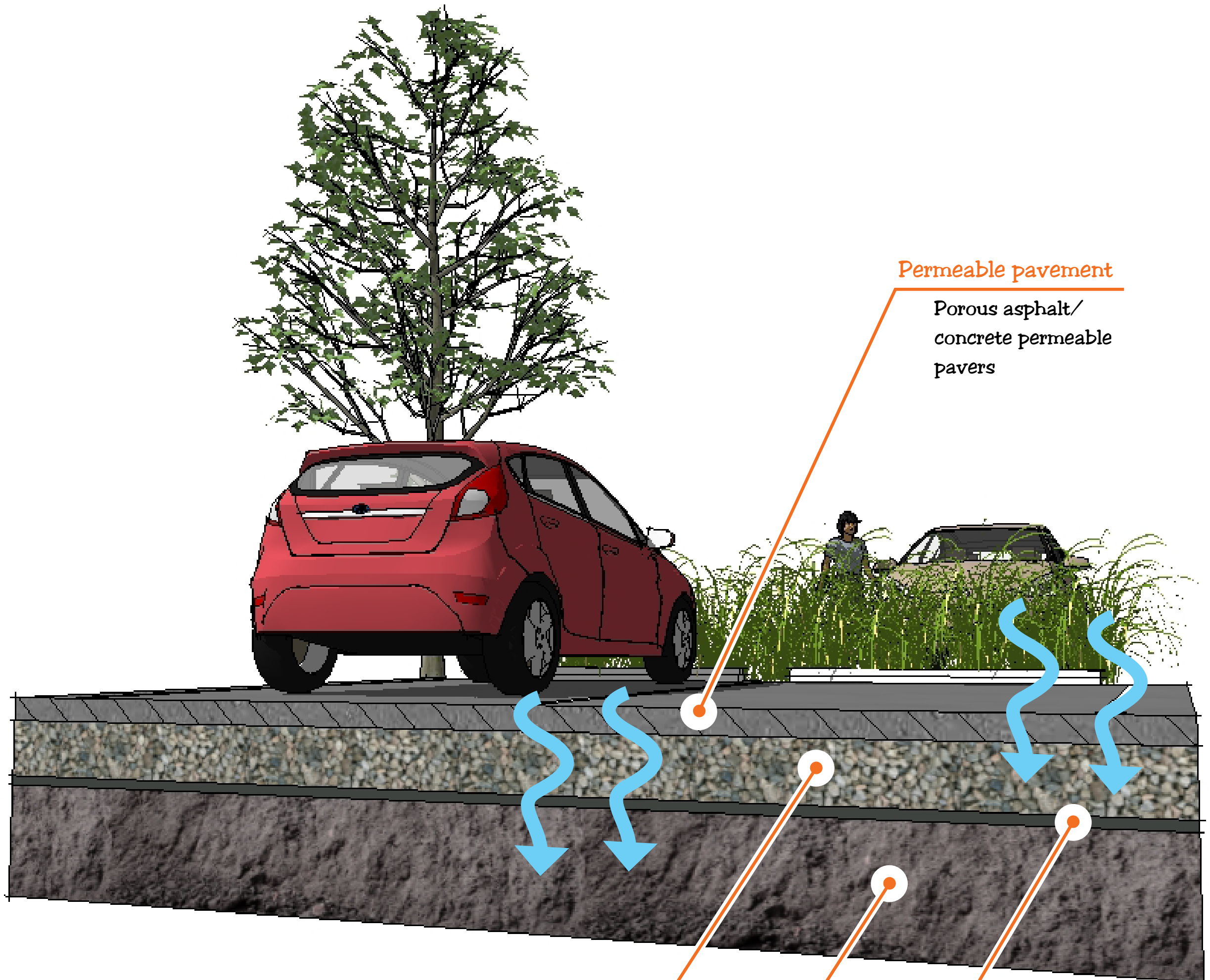
- Monitoring is needed throughout the growing season to identify potential problems.
- Dense planting of groundcover landscape plugs in bioretention areas and islands will enable them to quickly establish and prevent the growth of undesirable plants. Plants, such as lilyturf (Liriope spp.); sedges (Carex spp.); and warm-season native grasses (Panicum spp., Andropogon spp.) can create a weed barrier by covering previously exposed soil areas, keeping undesirable plants from populating the planting and helping to reduce weeding.
- Newly planted bioretention areas and rain gardens require the most maintenance in the first two years. Watering must be performed periodically to ensure the successful establishment of landscape plugs, trees, and shrubs.

A bioswale planted with both native and ornamental plants arranged in large swaths helps minimize maintenance/weeding costs
Einstein Medical Center Montgomery, East Norriton Township

Bioswale planted with native vegetation
Fischers Park, Towamencin Township

- Weeds and invasive plants will need to be removed by hand and by selective herbicide application to prevent them from interfering with other beneficial plants.
- The moisture level of the bioretention areas/rain garden must be assessed. Moisture levels vary depending upon grading and plant selection, and arrangement should be responsive to the conditions.
- The use of stone and riverjack as a groundcover within rain gardens should be limited since these areas may require weeding. The stone is most effectively used as an erosion control device near edges of pavements that receive sheet-flow during storms.
- Interpretive signage can be effective tool in explaining naturalized planting areas.

Interpretive signage promotes and explains naturalized drainage

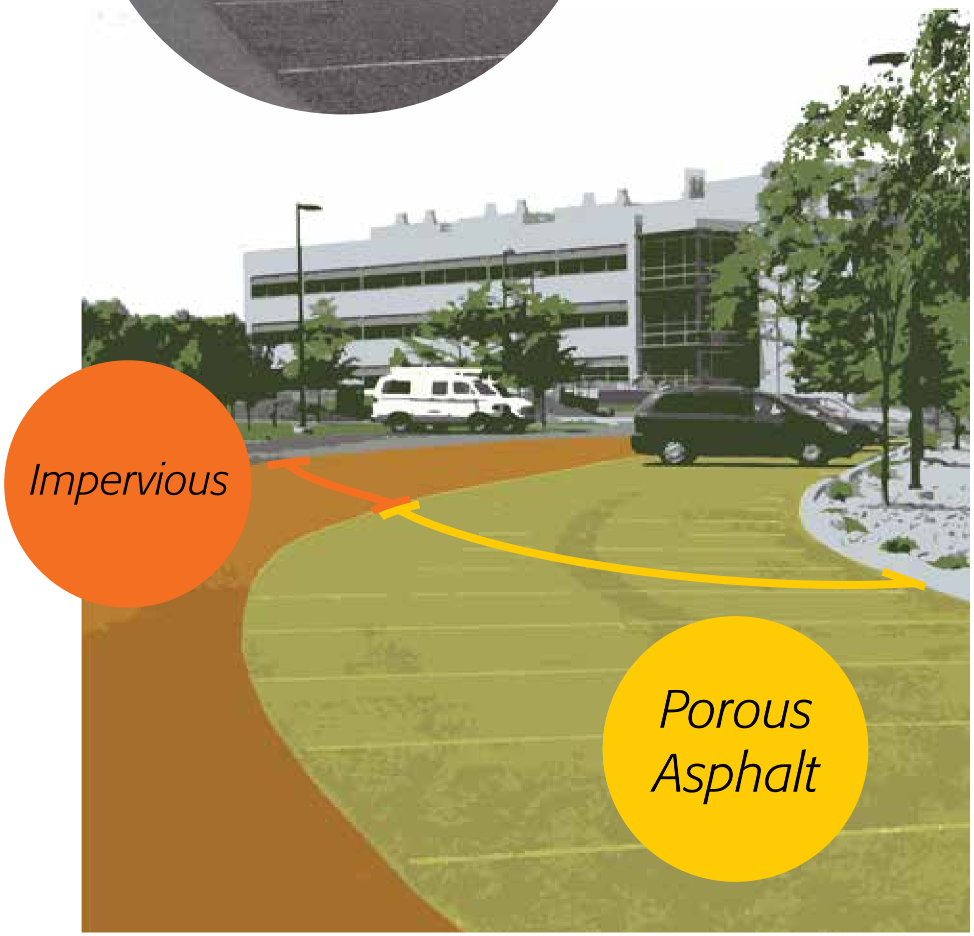


USE PAVEMENTS THAT INFILTRATE

Most surface parking lots use traditional, impervious asphalt paving materials. Using permeable pavement systems reduces stormwater runoff while dramatically improving stormwater quality and groundwater recharge. Typically, this is performed by allowing stormwater to pass through the parking lot surface into open graded gravel storage beds or detention chambers below. Stormwater detained below permeable pavement can infiltrate into the soil or be collected in pipes for off-site discharge.

Permeable paving systems can meet the loading requirements of most parking lot areas. In parking lot areas that receive heavy loads and a high volume of traffic or sustain heavy vehicle turning movements, permeable pavement may be restricted to just parking stalls. Pavement materials differ in color and design application, with the interlocking concrete pavers offering the most interesting possibilities for aesthetically interesting designs. Permeable pavement systems may also be used on walkways and other types of hardscape material within the parking lot.

Porous asphalt in the parking bays adjacent to bioretention islands
Johnson & Johnson, Lower Gwynedd Township



TYPES OF PERMEABLE PAVEMENT

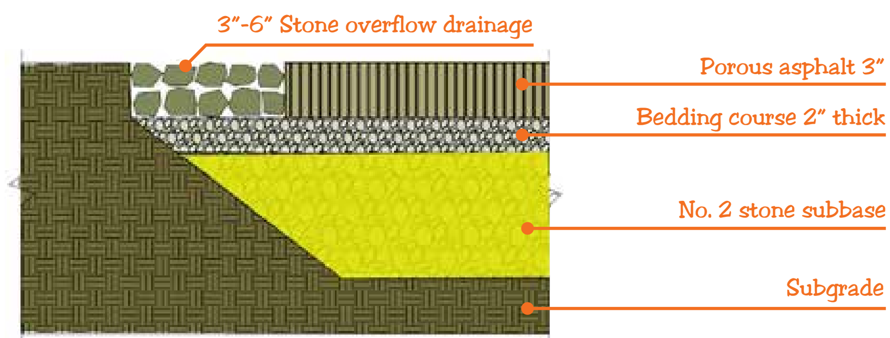
The three permeable pavement systems are porous asphalt and concrete, permeable interlocking concrete pavers, and reinforced grass/gravel pavement systems. All of these offer high infiltration rates to conduct rain directly into underlying soil or into stone beds or chambers underneath the parking lot.

POROUS ASPHALT & CONCRETE

Porous asphalt or concrete is formed by removing fine gravels and particles in the pavement mix. A binder, consisting of tar or cement, works to adhere consistently sized aggregates so that voids form in the paving material to allow water to pass through it. The material has the consistency of popcorn or a rice cake. Porous asphalt and concrete can be mixed on site in the same manner as conventional asphalt, but installation requires more expertise.

Due to its make-up, porous asphalt and concrete are rougher and provide for better traction and safer driving conditions during rain. Yet, porous asphalt loses some of its strength by the removal of fine particles. Snow plowing and the application of deicing materials need to be done very carefully in porous pavement lots. Annual vacuum cleaning of porous pavement can improve porous conditions by removing any grit or dirt that clogs pavement pores.

POROUS ASPHALT



PERMEABLE INTERLOCKING PAVEMENTS SYSTEMS

Permeability occurs within joints between interlocking concrete pavers. Water enters through these joint spaces and flows through an open graded base into a crushed stone recharge bed. The recharge bed allows water to infiltrate back into the soil. The stones in the joints provide 100% surface permeability, and the base filters stormwater and reduces pollutants. Permeable interlocking concrete pavers can support more weight than porous asphalt and come in colors with a lower heat radiance index so that they do not contribute to the urban heat island effect. They can be removed and replaced easily for pavement repairs. While concrete pavers are more costly than traditional pavement, recent technologies that enable faster installation have been lowering installation costs. Also, when considering the cost savings of reduced stormwater infrastructure, the relative cost of concrete pavers improves.

GRASS-BLOCK SYSTEMS

Reinforced grass unit pavers are a permeable pavement system that can be made of interlocking concrete blocks or plastic or synthetic webs that provide openings for grass or small stones. Several types of these pavements exist. These grass pavement systems have varying loading capabilities depending upon the design strength of the supporting structure. With a grass surface, these pavement systems can be attractive and allow the transpiration of water through the ground to cool the surrounding atmosphere. These pavement systems are suited for infrequent parking areas that are open generally during the summer or as reserve parking at larger venues.

Interlocking concrete porous pavement systems offer environmental benefits and allow various decorative paving treatments
Community shopping center, Hilton Head SC

Interlocking concrete pavers work together with curb inlets to provide rainwater to the bioretention area
Morton Arboretum, Lisle, IL. Courtesy of Morton Arboretum

Reinforced grass-block system
Gwynedd Wildlife Preserve, Ambler Borough

This reserve parking area uses a grass-rigid plastic modular system
Dansko International Headquarters, West Grove, PA

DESIGN FOR PEDESTRIAN AND VEHICULAR SAFETY

Parking lots need to be designed to efficiently direct vehicles to available parking spaces while providing for the safety of pedestrians and motorists. Key design considerations include developing a hierarchy of driveways and parking aisles that equally distribute vehicles to enable traffic to flow effectively. For example, access into a parking lot should not align with the building entrance, which may cause conflicts with pedestrians. A safe and functional parking lot should have clear signage and visual cues to help navigation, designated pedestrian routes, traffic-calming features, and good visibility.

SAFE AND ACCESSIBLE PEDESTRIAN ROUTES

A key ingredient for the safe access of pedestrians is to have clear pathways integrated into the parking lot. They should provide convenient access from the street frontage and interior parking areas to the building entrances. Safer pedestrian routes are accomplished by separating the pedestrian areas from vehicles, particularly in locations with significant vehicle traffic. This can be accomplished by using landscape islands and medians for pedestrian walkways, separating vehicles from pedestrians along driveways, and providing pavement striping and markings, especially for persons with disabilities. Generous tree islands and vegetative buffer areas that incorporate pedestrian pathways can provide safe and attractive pedestrian routes through parking lots. Crosswalks in parking lots should be carefully designed to attract pedestrian use and to ensure motorists yield for pedestrians in crosswalks. The use of different types of paving materials for a crosswalk and prominent signage is important. In some situations, a raised walkway should be considered at important pedestrian crossings.

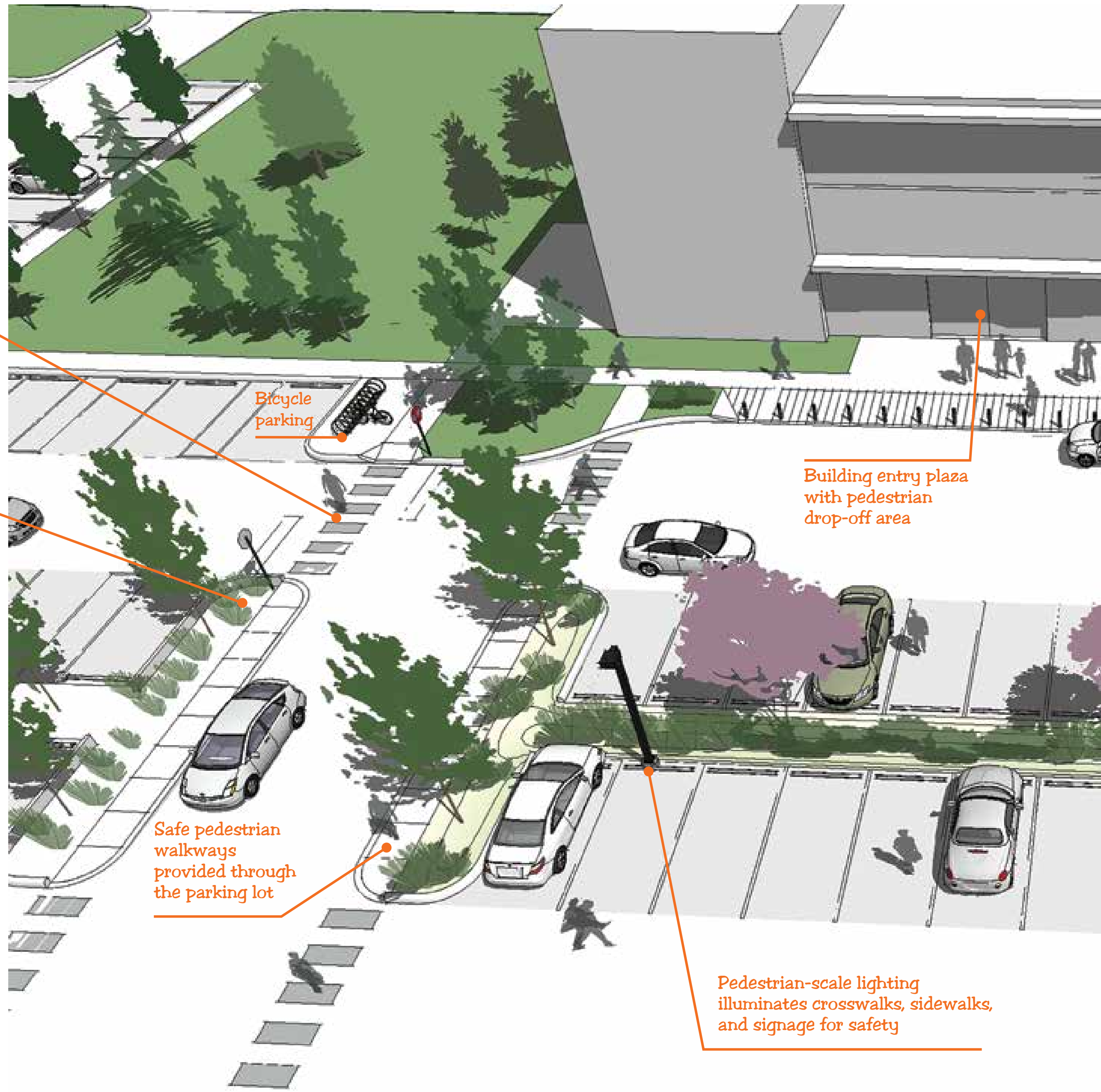
Pedestrian access through parking lot
Einstein Medical Center Montgomery, East Norriton Township

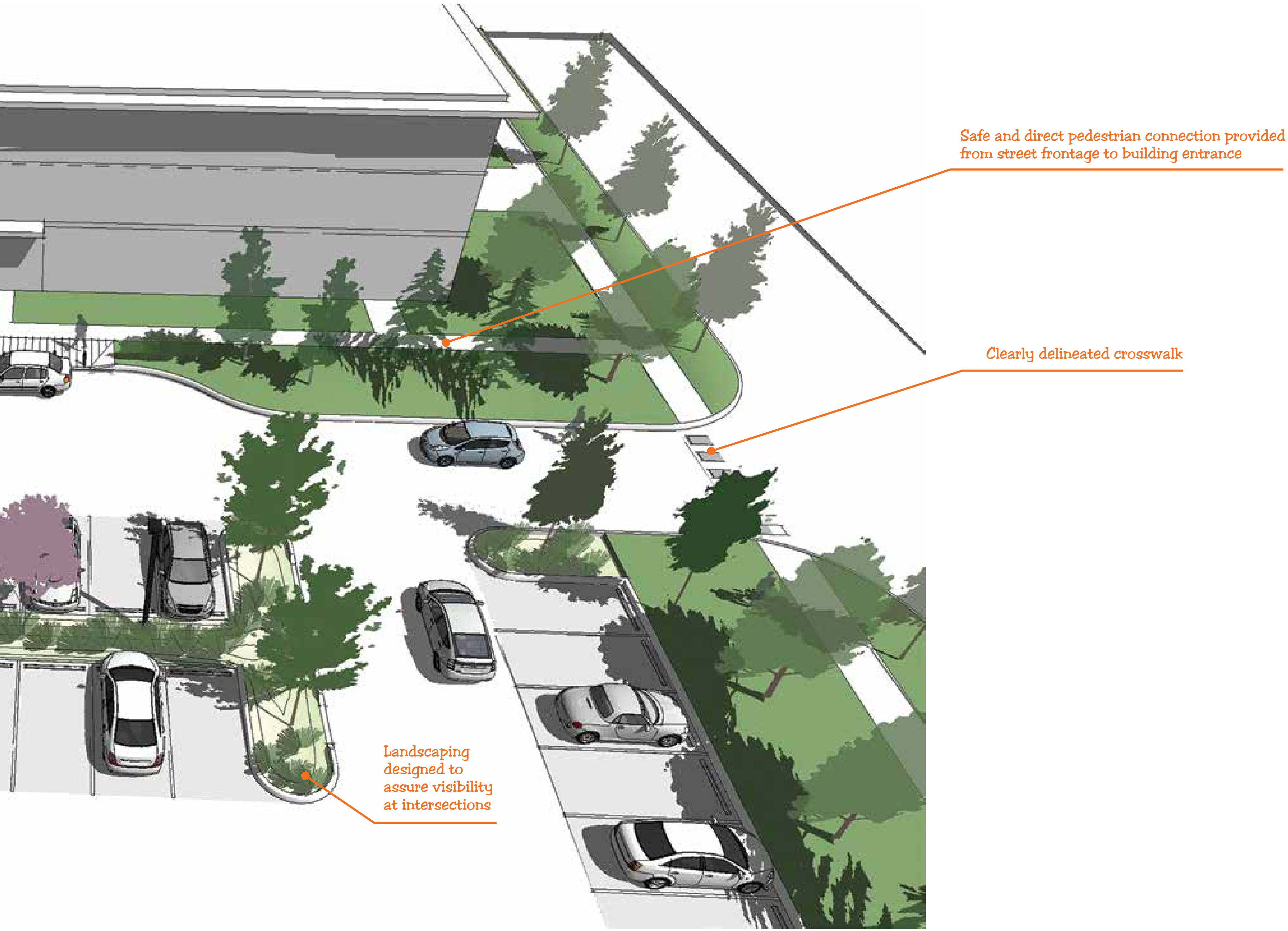
Walkway and seating plaza
Upland Square Shopping Center, West Pottsgrove Township

SAFE PEDESTRIAN CIRCULATION

Traffic-calming features, such as speed tables and clearly delineated crosswalks, slow traffic

Pedestrian crossing signs and other intersection controls




Safe and direct pedestrian connection provided from street frontage to building entrance
Clearly delineated crosswalk
Landscaping designed to assure visibility at intersections

TRAFFIC CALMING

A parking lot should be designed to encourage very slow speeds to promote safety. Long, straight sections where vehicles are likely to speed should be avoided. To reduce vehicle speeds, various types of traffic-calming devices, such as speed bumps, speed tables, roundabouts, the use of different pavement material, and stop signs, should be used throughout the parking lot. Also, in many large parking lots it is important to prevent drivers from cutting across empty rows. This can be done by dividing a large parking lot into smaller units or by placing landscape strips between parking areas.

INTERSECTIONS

A parking lot is comprised of many intersections. Each intersection becomes a safety challenge. When using landscaping in a parking lot, installation and maintenance are important considerations to avoid blocking the visibility of intersections.

A raised table, varied paving materials, and bollards create safe access from the parking lot
CHOP, Upper Merion Township

Pedestrian signage and pavement markings highlight pedestrian area for motorists
Arborcrest, Whitpain Township

Traffic control signage and pedestrian crossing markings provide a safe area at the store's entrance
Wynnewood Shopping Center, Lower Merion Township

PEDESTRIAN AND VEHICLE SAFETY STRATEGIES

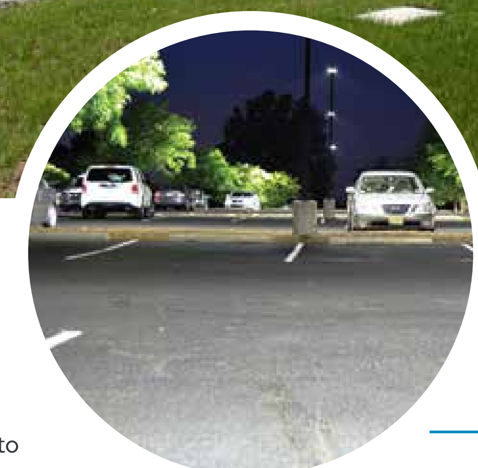
- Separate the pedestrian area near the building entrance from access and service driveways with a shared safety zone, using distinctive pavement materials or extensive pavement markings to delineate a safety zone.
- Align pedestrian connections in parking lots with the main building entry or a focal area using landscape islands, where possible, for safety.
- To help pedestrians reach building entrances safely, parking lots should delineate walkways by a change in pavement texture, pattern, color, or materials. Choose a crosswalk material that is highly durable and requires low maintenance.
- Use raised tables and crosswalks where needed, and incorporate traffic-calming features that make crosswalks visible, give pedestrians the right-of-way, and slow traffic.
- Clearly define the circulation pattern throughout the parking lot with pavement markings, safety control devices, directional arrows, crosswalks, and other traffic-calming devices.
- For banks and restaurants with drive-through windows, separate pedestrian access from the drive-up areas to minimize conflicts. To increase motorist awareness of pedestrians, use lighting, raised crosswalks, pavement material changes, signage, and other safety devices.
- The design of building entries can promote pedestrian safety by creating a more social space with setbacks between the pedestrian and pavement areas. Outdoor spaces for seating, displays, landscaped areas, and other aesthetic enhancements can create a pedestrian-friendly space.
- Provide walkways or a safe, direct, and continuous pedestrian route from the street frontage to interior of commercial developments that are well lit with appropriate scale lighting. Provide one (at a minimum) direct pedestrian route between the public sidewalk and right-of-way.
- Pedestrian-scale lighting improves pedestrian accessibility by illuminating crosswalks, sidewalks, ADA curb-ramps, signs, and potential hazards. Pedestrian-scale lighting at lower heights and more frequent locations is preferred over scattered and taller lighting fixtures in parking lots.

A dedicated walkway from the office building entrance leads to perimeter areas of the parking lot

USE SUSTAINABLE LIGHTING AND ENERGY PRACTICES

Parking lots require lighting to provide safety and security for pedestrians and motorists as well as adjacent facilities. Illumination priorities generally focus on three different parts of the parking lot: high-use areas, the main parking lot area, and outer perimeter parking. The high-use areas receiving the brightest light include the interface between the parking lot and the building, key intersections, and the building entrance. Effective lighting in these areas is essential for the safety and security of all parking lot users and also promotes the business use. The main parking area is moderately lit to provide for the safety of pedestrians and drivers. Any perimeter parking areas that are less frequently used may receive reduced lighting.

Lower height, full cut off fixtures minimize light trespass
Shelly Square Shopping Center, Upper Salford Township

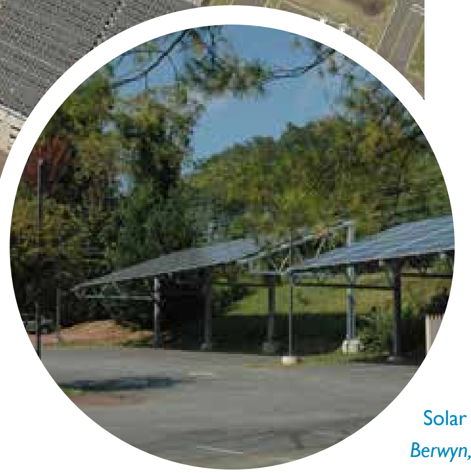


Appropriate lighting location between trees
Spring Valley YMCA
Limerick Township

LIGHTING DESIGN

To achieve the required illumination appropriate for each use, designers make choices in the location, height, and type of illumination device or luminaire. The location is determined by analyzing lighting patterns to achieve effective illumination at different areas on the parking lot surface. Also, the location of trees and other obstacles needs to be considered in determining the placement of light structures. The height of the structure is important in providing effective lighting without creating off-site impacts. In smaller parking lots, the height of luminaires should be limited to 20 feet or less. In much larger lots, higher structures may be appropriate. Fixtures should direct light onto the surface and be designed as full cutoff fixtures, where no light is emitted at or above a horizontal plane at the bottom of the fixture. Additional shielding can be provided with perimeter fixtures to block light from shining on adjoining properties. Ideally, perimeter fixtures should also be oriented perpendicular to the property line.

Solar panels over parking area
Merck Pharmaceutical, Upper Gwynedd Township



Solar Carport
Berwyn, PA

COST COMPARISON

Lamp Type and Cost per 100 Lumens

Estimated Lifespan (1,000 hours)	Lamp Type	Cost Per 100 Lumens*
100	LED	$0.98 to $1.16
18	Low Pressure Sodium	$0.31 to $0.57
24	High Pressure Sodium	$0.66 to $1.21
15	Metal Halide (standard)	$0.86 to $1.01
20	T12 Fluorescent	$0.83 to $1.26
10	Compact Fluorescent	$0.94 to $1.26
4	Halogen	$3.04 to $3.29
1	Standard Incandescent	$3.61 to $8.71

LAMPS

The type of lamp used in lighting can increase efficiency, resulting in increased sustainability and cost savings. While LED (Light Emitting Diode) lighting is a great choice for use in green parking lots, there are other energy-efficient lamp options including sodium vapor, metal halide, T fluorescent, and compact fluorescent. In addition to energy costs, maintenance costs can be significantly reduced through the use of energy-efficient lighting, since the lamps last 2 to 5 times longer than conventional lighting. A generalized cost comparison is provided here to aid in decision-making.

OPERATION

Energy efficiency can be achieved in the operation of parking lot lighting as well. The use of intelligent lighting systems to dim and shut off parking lot lights when no longer needed reduces electric use and minimizes impact on the surrounding neighborhood.

SOLAR FIXTURES AND ENERGY GENERATION

Solar energy technologies offer an efficient means of providing lighting without needing utility lines. The solar cell is sized according to the energy need and the number of hours of operation required. Solar panels can also be mounted on a frame canopy above the parking area, providing the additional benefit of shade.

CONSIDER COMMUNITY CHARACTER

Parking lots comprise a significant portion of a community and can be a prominent visual feature along roadways. Parking lots form the entry space or gateway through which many customers, visitors, employees, and residents must pass. The experience of driving or walking by a parking lot, and the impression it provides, can affect the character of a community.

Parking lots are generally viewed as places to store vehicles and not often thought of as an integrated feature of a community. Parking lots should be designed and located so that they fit seamlessly into the existing community by incorporating aesthetic, environmental, and social considerations.

Community character objectives:

- Establish a planted landscape buffer between the street and parking lot with vegetation landscaping that will screen parked cars and provide a mixture of plant material that blends with the surrounding properties.
- Incorporate other design elements, such as fences and walls, to provide additional screening while not blocking the visibility of buildings or facilities serviced by the parking lot.
- Enable parking lots to accommodate multiple uses such as event spaces for farmers' markets, carnivals, outdoor theaters, food truck areas, or other types of social functions.
- Integrate parking lots with other modes of transportation, including transit and bicycles, by providing bus shelters and bike storage racks.
- Provide renewable energy generation and use.
- Create feature spaces or plazas with landscape elements to provide attractive pedestrian gathering areas and focal points for the community.

Define the parking lot edges with landscaping and/or decorative walls

Rite Aid, Pennsburg Borough

Support alternative energy vehicle parking

King of Prussia Mall, Upper Merion Township

Provide bicycle parking

Fort Washington Train Station, Whitemarsh Township

Provide community gathering spaces

Hatfield Township

Chapter 3

LET'S REWRITE POLICY ON PARKING DESIGN

Gwynedd Wildlife Preserve, Ambler Borough

GUIDELINES TO CREATE GREEN & SUSTAINABLE PARKING LOTS

Several different municipal policies, regulations, or incentives should be established to ensure that elements of green and sustainable parking lots are incorporated into new developments. Typically, many aspects of parking lot design are regulated through municipal subdivision and land development codes.

Generally, these ordinances provide overall design guidance applicable for parking lots built throughout the municipality. Some municipalities have also addressed parking lot design standards within specific zoning districts. Though this approach enables them to target certain zoned uses for different parking standards, zoning regulations allow less flexibility and can only be modified through a variance request made to the municipal zoning hearing board. Parking lots also come under the requirements of separate stormwater management regulations, landscaping ordinances, or lighting standards also adopted by many municipalities.

Because parking lots may be regulated by several different approaches, multiple mechanisms to achieve green parking may be necessary. Discussed below are recommended strategies, guidelines, and regulatory language to advance green parking lots.

1. PURPOSE AND INTENT STATEMENT

A strong legislative intent and purpose statement is a fundamental element in updating or establishing greener and more sustainable parking lot guidance in any type of ordinance. Many existing development codes do not recognize the significant role of green stormwater management, shade trees, pedestrian amenities, lighting control, internal traffic circulation, and overall public space design approaches in parking lot design.

Sample Language for Legislative Intent statement

"It is the intent of this article to provide well-designed parking lots in conformance with the goals and objectives of the Township/Borough's Comprehensive Plan and to promote the following goals:

- Integrate stormwater management and landscape design by the use of plants and soils to naturally detain, treat, and infiltrate runoff from impervious surfaces.
- Shade paved surfaces to mitigate the urban heat island effect by planting large canopy trees and using paving materials that do not absorb heat.
- Incorporate hardy native and other appropriate plants in parking lots.
- Distribute landscape elements throughout the parking lot to screen undesirable views, mitigate incompatible uses, and interrupt large impervious expanses.
- Comply with state water quality mandates and the Township/Borough's Stormwater Ordinance through detention, treatment, and infiltration of stormwater runoff.
- Ensure the public safety of pedestrians while providing them with mobility options and access to buildings, amenities, sidewalks, and public areas on site and off-site.
- Improve the performance of existing parking lots in an equitable manner when redevelopment is proposed.
- Reduce the impact of lighting from parking lots.
- Connect parking lots with other parking lots, driveways, and roads.
- Enable parking lots to serve various functions.

2. APPLICABILITY

It may be necessary to establish a threshold for when specific green parking lot standards apply. Such a standard can be either based upon the overall size of the lot or the number of parking spaces. Some municipalities use the total square footage, such as 8,000 square feet, while others use 20 or more parking spaces. Also, green parking lot requirements may apply in situations where 25% or more of the building square footage is subject to redevelopment. Another approach is to require green parking lot standards when more than 10 parking spaces are added to an existing lot. Finally, green parking lot standards may be linked to bonus provisions in a zoning ordinance or to conditional use approval.

3. DEFINITIONS

There are many terms used in the design and implementation of green and sustainable parking lots which may not be defined in existing municipal codes, including bioretention, bioswales, porous pavements, structural soils, porous pavers, rain gardens, and urban heat island. These terms should be defined.

4. INTERNAL PARKING LOT PLANTING REQUIREMENTS

The following standards are intended to promote shading and healthy, vigorous growth of larger shade trees and create generous physical space to accommodate rain gardens or depressed absorbent areas for stormwater detention and infiltration in the interior of the parking lot.

A. Establish general standards for planting areas, islands, and strips

Planting areas, tree islands, and planting strips provide opportunities for shading, bioretention, and other greening techniques within the parking lot. Adequate space needs to be provided for these elements to ensure their continued successful functioning.

Saving existing trees and groves of trees is an important consideration. Wherever possible, existing trees should be preserved in the parking lot's landscape areas. Many considerations must be weighed in the decision to preserve healthy trees and vegetation, including the existing and proposed grading conditions, age, condition, and type of trees, and the percentage of the critical root area that will be impacted by site improvements and disturbance. An evaluation by a certified arborist is encouraged and can assist in determining the extent of the critical root zone disturbance and whether a tree can be saved.

1. Planting islands shall be placed so as to provide safe movement of traffic without interference with proper surface water drainage. All rows of parking spaces must be terminated by a parking lot island or landscape areas, unless handicap parking is provided at the end of a row.

2. Planting areas shall have curbs and wheel stops and be protected to prevent erosion or damage from automobiles. Curb cuts and inlets are encouraged to provide rainwater to enter the planting areas. Bollards may be used to afford protection of trees from vehicular movement.

3. Tree islands are required to have a planting area of at least 340 square feet and the width of tree islands measured face-of-curb to face-of-curb is a minimum of 9 feet.

4. Minimum Soil Volume & Improvement. In addition to the minimum square footage requirements for tree islands stated above, requirements for minimum soil volume and planted area dimensions are needed to ensure adequate soil volume for tree health and adequate space for growth. All planting islands, strips, and bioretention areas should have soils improved to a depth of 30 inches. A soil improvement detail and notes, including the removal of all construction debris and existing compacted soil and the proposed soil improvement mix, should be provided with the landscape plan.

5. Planting Strip. In addition to minimum greening requirements for parking lots using either Option A or Option B, planting strips or spaces are required for large parking lots with 100 spaces (+/- 40,000 square feet) or more. For example, for a parking lot with three parking modules, a continuous planting strip with a minimum 10-foot width (measured from inside curb) is required for every third parking module.

To allow flexibility in addressing the opportunities for shading, bioretention, and other greening techniques in new surface parking lots and in parking lot retrofits, two different options for incorporating green landscape areas are allowed.

B. Option A: Establish a minimum interior greening requirement

1. Establish the parking area subject to internal greening requirements.

For the purposes of calculating the total area of any parking lot subject to interior planting requirements, all areas within the perimeter of the parking lot shall be counted, including planting islands, curbed areas, corner areas, parking spaces, aisles and all vehicular surfaces. Landscape areas situated outside of the parking lot, such as perimeter areas, landscape strips, and areas surrounding the buildings, shall not be counted as an interior planting area.

2. Establish a minimum interior greening requirement

The parking lot interior planting requirement shall be calculated as a percentage of the parking lot area based on the size of the parking lot subject to greening as stated above. A minimum required percentage for greening in the interior of the parking lot can range from 0-15% depending upon the size of the parking lot. (See Table 1.)

To establish greater shading with the parking lot, the following minimum planting standards can be utilized to achieve Table 1 requirements.

3. At least one (1) shade tree shall be provided for each 300 square feet of interior landscape area provided or fraction thereof.

Example

- For an interior parking area of 50,000 square feet, 5,000 square feet interior landscape is required.
- 5,000 ÷ 300 = 16.6 trees or – 17 shade trees in the interior of parking area.

4. Shade trees may be planted in tree islands, continuous planting strips, or bioretention areas. Shade trees should be selected from the recommended plant list in this guidebook. Tree islands and other interior planting areas with shade trees shall be distributed throughout the parking lot to ensure well-distributed canopy coverage of the paved surfaces.

5. Tree islands are required to have a planting area of at least 340 square feet; the width of tree islands measured face-of-curb to face-of-curb is a minimum of 9 feet.

6. Landscape areas and tree islands may be consolidated into larger islands to provide greater soil volume for plants or to accommodate stormwater Best Management Practices (BMPs).

7. Parking lots less than 7,000 square feet are exempt from interior landscape requirements. However, the perimeter landscape and buffer landscape requirements do apply. If additional spaces are later added so that the lot is greater than 7,000 square feet, then the percentage of interior planting area required shall be calculated for the entire lot.

TABLE 1: PARKING LOT INTERIOR PLANTING REQUIREMENTS

Parking Lot Area	Minimum Percent of Interior Planting Area Required
0–6,999 square feet	0
7,000–49,999 sq. ft.	8
50,000–99,999 sq. ft.	10
100,000–149,999 sq. ft.	13
150,000 sq. ft. or larger	15

C. Option B: Establish an appropriate minimum parking lot island/ parking space ratio

Planting islands provide opportunities for shading, bioretention, and other greening opportunities. Adequate space needs to be provided for these elements to ensure their continued successful functioning. The following minimum greening standards should be adhered to in addition to the general standards stated above:

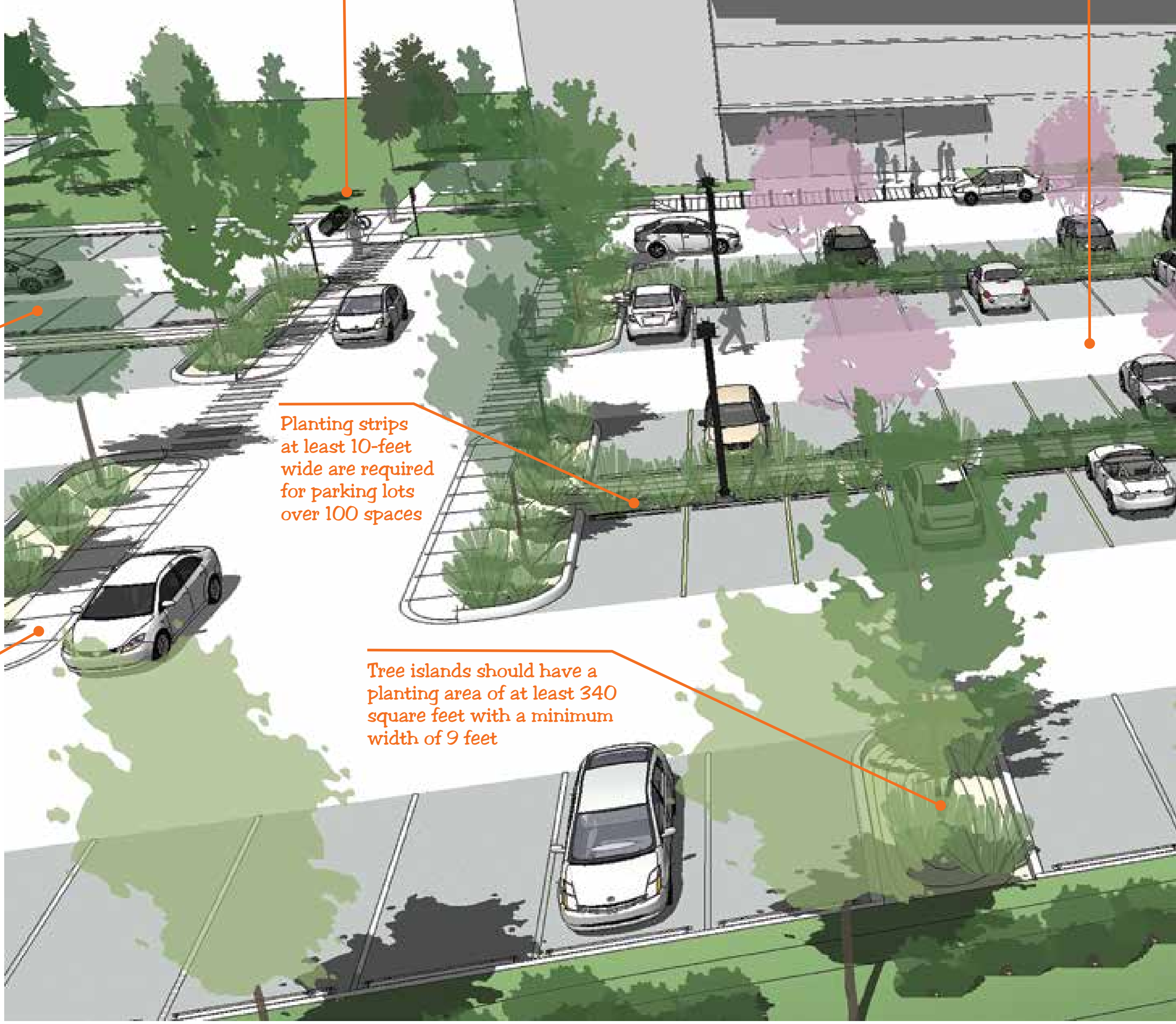
1. For every 8-10 parking spaces, there shall be one (1) planting area of at least 340 square feet. At the discretion of the municipal engineer and/or arborist, the ratio of parking spaces to planting areas required may be altered for reasons of public safety and/or to provide a continuous planting area for greening or bioretention.

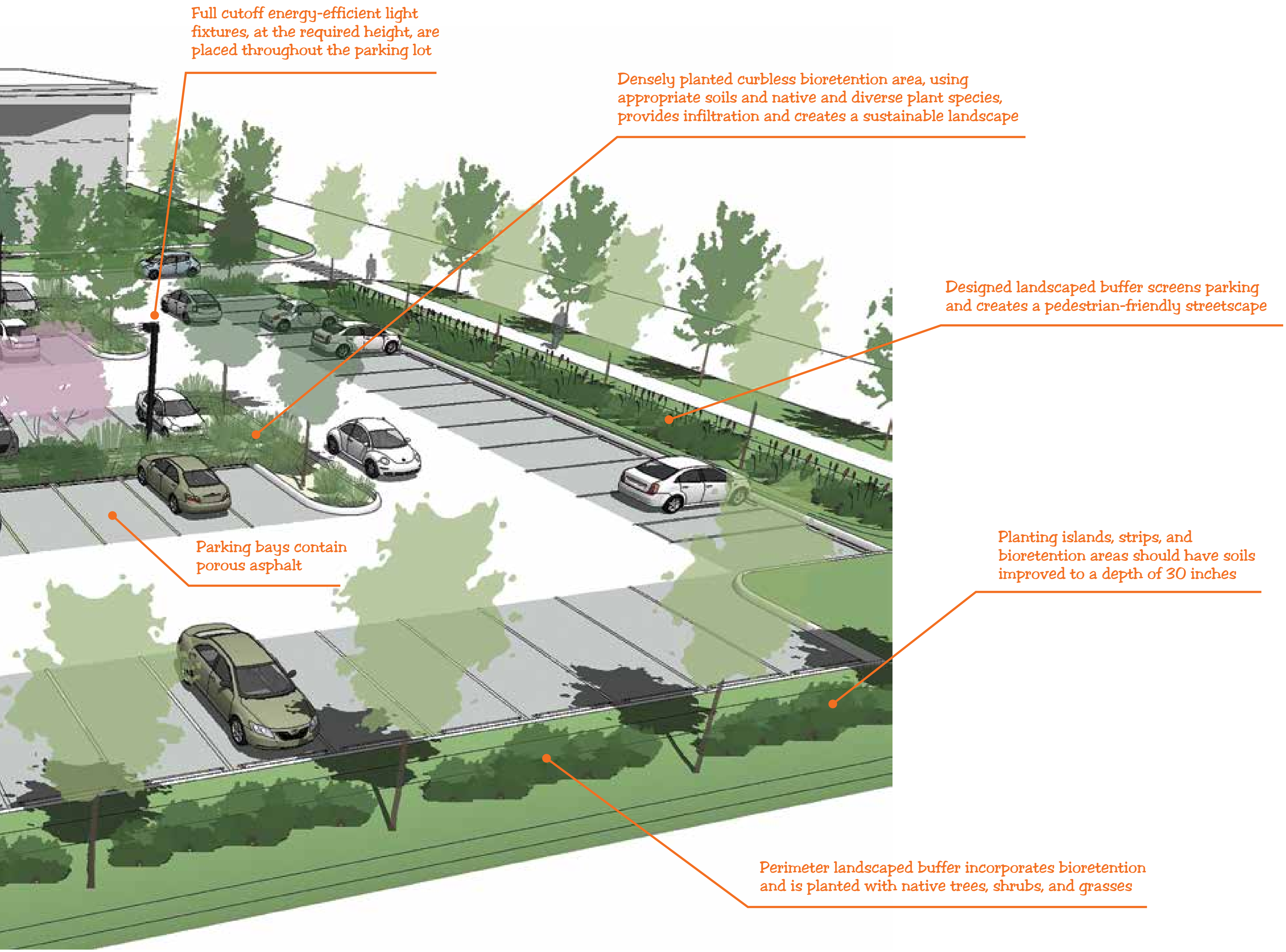
2. One (1) large shade tree is required for each tree island unless signage or lighting fixtures conflict with the normal growth of the tree. In case of conflicts, a sub-canopy tree or taller shrub grouping may be substituted.

3. This requirement applies to new or redeveloped parking lots, but existing parking lots which are being resurfaced or restriped are exempt.

4. Tree islands and planting areas should be distributed throughout the parking lot to maximize tree canopy coverage over the entire parking lot. Large canopy trees shall be required to meet this requirement. Required planting areas may be consolidated into larger islands to provide greater soil volumes for plants or to accommodate stormwater BMPs.

GUIDELINES TO CREATE GREEN & SUSTAINABLE PARKING LOTS




Full cutoff energy-efficient light fixtures, at the required height, are placed throughout the parking lot
Densely planted curbless bioretention area, using appropriate soils and native and diverse plant species, provides infiltration and creates a sustainable landscape
Designed landscaped buffer screens parking and creates a pedestrian-friendly streetscape
Parking bays contain porous asphalt
Planting islands, strips, and bioretention areas should have soils improved to a depth of 30 inches
Perimeter landscaped buffer incorporates bioretention and is planted with native trees, shrubs, and grasses

5. PERIMETER AND BUFFER AREA PARKING LOT PLANTING REQUIREMENTS

Buffer areas that abut the street and sidewalks are opportunities for greening and bioretention areas, if space is adequate and grading is appropriate. Size and planting density are important considerations for the perimeter area. Grading and drainage need to be considered for bioretention in the perimeter area.

A. Trees in the Parking Lot Perimeter

Canopy trees with a minimum of 2-inch caliper are required to be provided for every 25 feet of open parking area along a street frontage. The remainder of perimeter landscaped areas are required to be densely planted with shrubs at a distance of 24 inches on center and should be a minimum height of 3 feet.

B. Parking Lot Perimeter for Bioretention

Perimeter shall be designed to accept stormwater runoff and be designed as bioretention areas if site conditions are appropriate. The bioretention area may have an inverted slope to allow infiltration and ponding of water. Curbs separating landscape areas from parking shall have cuts or other features to allow stormwater to flow to the bioretention area.

6. PROMOTE BIORETENTION AND RAINWATER INFILTRATION WITHIN THE SITE

Landscape design standards and planting requirements can ensure that areas set aside for bioretention are planted and established to function as intended.

Proposed bioretention or other vegetated stormwater management features shall be depicted on the site development plans, along with enough details (area, depth of soil, plant species) to establish the viability of the proposed features. Plans show how these stormwater management features within the parking lot are integrated with other stormwater management elements for the entire site. The design and planting schemes for all bioretentiion or other stormwater management features should take into account future maintenance capacity. Specific maintenance guidelines should be provided with the plans.

A. Soil Characteristics

Soil characteristics in bioretention areas are as important as location, size, and stormwater volume. The soil must allow runoff to infiltrate while promoting and sustaining robust vegetation. Significant nutrient and pollutant removal is accomplished in the soil. Soil and mulch should be used instead of stone to support biotic communities above and below ground.

1. Planting Soil Characteristics. Soil should consist of native soils with appropriate proportion of amendments, including 20-25% leaf compost or leaf mulch.

2. Soils should provide adequate infiltration rates and be suitable for healthy tree growth and have a permeability of at least 1 foot per day (0.5 inches per hour).

3. Bioretention soil should be free of stones, stumps, roots, or other woody material over 1 inch in diameter. It should be free of seed and live roots from noxious weeds and invasive exotics plants. Placement of soil should be done in lifts of 12-18 inches, loosely compacted (tamped lightly) with a dozer or backhoe.

4. Stones, such as riverjack and similar stone, which serve as a widespread ground-cover in bioretention areas are prohibited.

5. For parking areas without curb inlets that use wheel stops and a continuous parking edge, a stone buffer area between the paved surface and planting area is required to retard sheet flow and minimize erosion into the absorbent areas. Stones can be used at curb inlets to dissipate sheet flow along parking lots.

B. Planting Requirements

1. The bioretention areas shall be planted with the following plant densities to ensure that at least 85% of the area is vegetated:

Trees - A minimum of 1 large canopy tree per 100 feet of bioretention area

OR

Small trees - A minimum of 2-4 trees (ornamental under 30 feet) per 100 linear feet of bioretention area

AND

Shrubs/grasses - A minimum of 6 shrubs and 8 grasses per 200 square feet of bioretention area.

2. To encourage flexibility, the number of shrubs can be reduced up to 50% to allow greater use of grasses and perennials in a design.

C. Planting Guidance - Ensuring Sustainable Landscapes with Plant Diversity

1. The plant list is used to promote diversity while restricting the use of less effective trees and shrubs. Often planting plans use too few plants and too little variety. This can result in premature decline of the overall landscape. Including a diversity requirement for planting plans can limit the risk of a devastating plant pest or disease. To ensure plant diversity and the sustainability of the installation in parking lots, the following plant diversity is required:

TABLE II. PLANT DIVERSITY REQUIREMENTS

Minimum number Required trees	**Minimum number** of Tree species	**Maximum %** any 1 species
0-5	1	100%
6-15	2	50%
16-30	3	40%
31-50	5	30%
51+	6	20%

2. In addition to the requirements of Table II, the following shall be adhered to:

a. No one tree or shrub shall comprise more than 25% of the total number of plants of the same species.

b. Native plants must comprise at least 50% of the planting material and should be chosen from the recommended plant lists in the appendices of this guidebook.

c. Parking lot tree islands shall use tree species from the recommended plant list.

d. Sixty percent (60%) of trees in parking lots must be large shade tree species.

7. SCREENING AND BUFFERS THAT ABUT A SIDEWALK OR STREET

The landscape treatment between the parking lot edge and the sidewalk/street right-of-way can be an environmental asset and visual amenity. This area should screen parked vehicles but not completely obstruct views into and out of the parking lot for the purpose of pedestrian safety. Screening can consist of a continuous planting or can be combined with decorative low walls or decorative fence or berm. If space is available along the edge, bioretention areas may be appropriate.

The following planting standard should be followed for the parking lot edge/sidewalk areas (choose one option):

Option A

One (1) shade tree and 10 shrubs shall be planted for each 30 feet of buffer length and 1 square foot of perennial planting for every linear foot of total buffer. All required plants shall be selected from the recommended plant list.

Option B

A low-wall fence or berm not to exceed 3 feet in height or 3:1 slope as measured from the adjoining sidewalk, along with 1 tree per 30 feet of buffer length and three shrubs for every 20 feet of buffer length. All required plants shall be selected from the recommended plant list.

Note: Warm-season grasses may be substituted for shrubs at the same ratio.

8. REDEVELOPMENT OF EXISTING PARKING LOT

The following requirements can be used to address existing parking areas. Parking lot area improvements can be linked to building area being retrofitted. For example, expansion of the building by 50% translates into 50% of the parking area being brought into compliance with contemporary standards. Sample language would include the following:

A. All parking lots areas which were in existence prior to the effective date of this article may continue as nonconforming until such time a building permit is issued to rehabilitate a structure on the property exceeding fifty percent (50%) of the current replacement cost of the structure. At such, fifty percent (50%) of the existing parking lot area shall be brought into compliance with these requirements and shall continue to be in full compliance on a graduated scale based upon the percentage of the renovation costs.

9. PROMOTE ENVIRONMENTALLY FRIENDLY PAVEMENTS

Municipalities can promote the use of permeable pavement alternatives in parking lots within stormwater management ordinances. One approach for encouraging permeable pavement systems is to not count a portion of the surface area as impervious coverage under various zoning district requirements. For example, only 20% of such pervious surfaces shall be counted as part of the overall allowable impervious lot coverage in appropriate zoning district requirements.

Recommended pervious paving locations in parking lots:

A. Grid/grass structures should be promoted in perimeter parking areas that are seldom used or used seasonally in the summer months.

B. Permeable pavement systems, including interlocking concrete pavers, and grid systems should be promoted in low-traffic areas such as parking bays, residential parking pads, driveways, and reserve areas or overflow parking areas.

10. PROMOTE PEDESTRIAN-FRIENDLY DESIGN

Parking lots should include direct, continuous pedestrian walkways that connect building entrances to parking spaces, public sidewalks, transit stops, and other pedestrian destinations. Landscape areas and pedestrian lighting should be integrated within the plans. Provisions should also be made for bicycle parking, bus shelters, and traffic calming.

A. Walkways

Walkways shall be located where motorists can anticipate pedestrians and react accordingly. Walkways should be designed to give the pedestrian full view of oncoming vehicles with minimum interference from trees, shrubs, and parked cars.

B. Pedestrian Circulation

Pedestrian circulation shall take precedence over vehicular circulation. Where pedestrian circulation crosses vehicular routes, a crosswalk with a different paving material, ladder-striping, speed tables, or signage shall be provided. Walkways in parking areas shall be barrier-free, and a minimum of 5 feet wide to allow two people to pass comfortably; additional width may be needed in some areas with heavy pedestrian traffic.

C. Pedestrian Connection to Entrances

At least one pedestrian route shall be provided and aligned within the parking lot with the main entry of a building to facilitate pedestrian movement. Clear separation/division from vehicular areas with landscaping, a change in grade, or a change in surface material shall be provided.

D. ADA Compliance

All site facilities and amenities shall be accessible to people with disabilities in accordance with the provisions of the 2010 Americans Disabilities Act (ADA) or its most recent update and the accessibility standards of the Pennsylvania Uniform Construction Code.

E. Bicycle Parking

All new retail and office/commercial development shall provide a minimum of one (1) bicycle parking rack per 20,000 square feet of gross floor area or fraction thereof. A minimum of one (1) bicycle parking rack shall be provided for every 10,000 square feet of public open space. Attractive bicycle racks should be in a highly visible, well-lit location near building entrances and should not obstruct walkways.

11. PROMOTE CONSERVATION/ENERGY EFFICIENCY IN LIGHTING PARKING LOTS

Municipalities should require energy-efficient lighting in new and renovated surface parking lots for energy conservation and sustainability. LED and other types of energy-conserving lighting are available at competitive pricing. Municipalities can also promote energy conservation by requiring diminished illumination levels during off-peak hours. In drafting regulations, public safety, avoiding light trespass, and reducing nuisance glare can be incorporated by considering the light direction, placement, and shielding.

Parking lot lighting fixtures need to be placed to avoid conflicts between lighting effectiveness and tree health. A minimum setback of 12 feet is needed between the lighting fixture and shade trees.

A. Lighting Fixture Design

For the lighting of predominantly horizontal surfaces, such as pedestrian walkways, building entrances, sidewalks, and surface parking areas, fixtures shall be aimed straight down and shall be full cutoff or fully shielded.

B. Illumination Levels

The intensity and uniformity of lighting shall be in accordance with the Illuminating Engineering Society of North America (IESNA) Lighting Handbook, 9th edition or most recent edition, and relevant IESNA Recommended Practices.

C. Control of Nuisance Glare and Energy Conservation

All lighting shall be aimed, located, designed, fitted, and maintained to avoid hazards to drivers or pedestrians and to avoid creating a nuisance by projecting or reflecting onto a neighboring use or property.

Unless otherwise permitted by the municipality, lighting for commercial, industrial, public recreational, and institutional applications shall be controlled by programmable timers that accommodate seasonal and annual variations and battery or mechanical (e.g., spring-wound) backup to permit extinguishing sources between 11 pm and dawn or within 1 hour of the close of business, whichever is earlier, to conserve energy and mitigate nuisance glare and sky lighting consequences.

Solar panels on light fixtures
Montgomery Township Community Center, Montgomery Township

Security lighting proposed for use after the normal hours of operation until the start of business in the morning for commercial, industrial, institutional, or municipal applications shall employ no more than 25% of the number of fixtures used during normal business hours.

D. Lighting Fixture Installation

Pole-mounted fixtures for roadways, pedestrian walkways, parking lots, and similar uses shall be aimed straight down.

The following mounting heights shall prevail:

1. Full cutoff fixtures with 44,000 lumens lamps maximum, in parking lots-the fixture mounting height of not more than 20 feet above the finished grade (AFG).

2. Full cutoff fixtures with 115,000 lumens lamps maximum shall be permitted only in large (100 spaces or more) commercial, institutional, and industrial parking lots except when the facility is adjacent to a residential district or use or an environmentally sensitive area—not less than 25 feet or more than 30 feet AFG. Mounting heights of 25 feet-30 feet shall not be permitted when located less than 100 feet from a residential district or use.

Chapter 4

HOW TO NEED LESS PARKING

Fort Washington Train Station
Whitemarsh Township

PARKING DEMAND MANAGEMENT

The design standards developed in this report will enable the development of greener, more sustainable parking lots. However, developments can also find ways to reduce their need for parking spaces. Parking lots could then be smaller. A number of methods for using parking more efficiently and promoting alternative modes of transportation exist and are briefly decribed in this section.

SHARED PARKING

Shared parking usually involves parking facilities that can service multiple users or destinations. Facilities that are close in proximity to a parking lot and have different peak usage times, such as churches, recreation facilities, stores, and restaurants can be ideal for shared parking. Successfully implementing shared parking may involve physical connections to various uses from a parking lot, legal agreements, and an understanding of shared maintenance responsibilities.

REDUCING PARKING REQUIREMENTS

Reduction of minimum parking requirements for new development will result in smaller parking lots. To address other impacts associated with a new development's parking needs, existing street parking or other parking resources can be examined as part of the parking lot minimum requirements. This will ensure that peak parking needs for any new use can be accommodated without impacting existing development using the same parking. Typically, an existing parking needs survey is conducted as part of a new development proposal to document current parking conditions in areas that could be impacted.

VARIABLE RATE PARKING PRICING

Various pricing systems, such as higher peak hour pricing, can be an effective tool in reshaping parking patterns to better utilize the parking lot capacity at critical times. With new types of digital parking metering systems in place, variable pricing could be easily established.

UNBUNDLED PARKING

By separating costs of parking from the rental or sale of real estate, incentives are provided to limit the demand for parking. Typically, the buyer or renter of a property acquires a fixed share of the parking along with the purchase of a house, office, or retail property. No financial incentive is offered to use fewer spaces. If parking is acquired separately, alternative transportation and parking choices may be made.

FEE-IN-LIEU

Developers could choose whether to provide parking or pay a fee in order to comply with minimum parking requirements. The municipality would set fees equal to parking space construction costs for municipal parking structures to be built nearby by the municipality, an authority, or through a public private partnership. In this way, developers would be contributing to more efficiently used joint parking facilities.

TRANSIT INCENTIVE PROGRAMS

Parking requirements can be altered for development near transit, particularly where property owners offer transit ridership incentives to patrons or renters to utilize transit. In a study of transit-oriented development areas within Portland, Oregon it was demonstrated that homes near transit generally had about a half of the number of autos as housing located away from transit. The study also revealed that several of the trips taken by homeowners in these areas were by walking and biking to nearby locations due to the mixed-use development near transit in the city.

LAND BANKING/RESERVE PARKING

In some areas, minimum parking requirements could be waived or relaxed, provided that suitable land is made available to locate parking should the need arise. Reserve parking areas can be depicted on recorded plans. The obligations of property owners to construct parking, if necessary, in these areas can be established through legal agreements between the property owners and the municipality.

RECOMMENDED PLANT LISTS FOR GREEN PARKING LOTS

The plants listed here are mostly native to the mid-Atlantic region and Eastern North America. There is variation as to their tolerance and adaptability to soil moisture (varying from tolerant of very wet to dry). Selection for bioretention areas varies from very wet to lower slope to upper slope. Plants should be selected according to their adaptability to moisture and their placement within the slope of a swale. This list is not exhaustive and is intended to give local governments and designers a palette of varied plant materials to choose in improving parking lots with greening. Other species may be used, and the acceptability of proposed plant material should be reviewed by the municipality.

TREES AND SHRUBS FOR TREE ISLANDS AND PLANTING STRIPS WITH RAISED CURBING

Latin Name	Common Name	Comments/Recommended Cultivars & Varieties	Native	Height X Spread	Spacing	Salt?
Acer buergerianum	Trident Maple	multi-stem tree	no	25’-35’	30’	
Acer campestre	Hedge Maple	multi-stem tree	no	30’ x 30’		
Amelanchier canadensis	Serviceberry	tree	yes	20’	20’	Y
Betula nigra	River Birch	Dura-Heat; Heritage	yes	40’-70’	30’	
Carpinus caroliniana	American Hornbeam		yes	20’-30’	25’	N
Cercis canadensis	Eastern Redbud	Forest Pansy; spring-flowering	yes	25’ - 30”		
Chiaonanthus retusus	Asian fringetree	tree	no	25’ - 25’		
Chionanthus virginicus	White fringetree-	multi-stem, spring-flowering,	yes	20’- 20’		
Crataegus viridis ‘Winter King’	Winter King Hawthorn	spring flowering	yes	20’-35’	20’-30’	Y
Crataegus viridis ‘Winter King’	Winter King Hawthorn	spring flowering	yes	20’-35’	20’-30’	Y
Ginkgo biloba - male only	Ginkgo	tree	no	50’-80’	30’	Y
Gleditsia triacanthos var. inermis	Thornless Honeylocust	tree	yes	30’-70’	30’	Y
Ilex opaca	American Holly	tree	yes	40’-50’	30’	Y
Juniperus virginiana	Eastern Red Cedar	tree	yes	50’-75’	30’	Y
Liquidambar styraciflua ‘Rotundiloba’	Sweetgum	tree	yes	60’-75’	30’	Y
Magnolia ‘Galaxy’	Hybrid Magnolia	upright; spring flowering	no	25 x 15’		
Magnolia stellata	Star magnolia	early-spring flowering	no			
Magnolia virginiana	Swamp Bay Magnolia	multi-stem small tree; summer flowering	yes			

Latin Name	Common Name	Comments/Recommended Cultivars & Varieties	Native	Height X Spread	Spacing	Salt?
Nyssa sylvatica	Black Gum	tree	yes	30’-50’	30’	Y
Platanus x acerifolia	London Planetree	tree	hybrid	70’-100’	30’-40’	Y
Prunus x ‘Okame’	Okame Cherry	tree	hybrid	20’-30’	20’-30’	
Prunus x ‘Yeodensis’	Yoshino Cherry	tree	hybrid	20’-30’	20’-30’	
Quercus palustris	Pin Oak	tree	yes	60’-70’	30’	Y
Syringa reticulata spp., reticulata	Japanese tree lilac	tree	no			
Taxodium distichum	Bald Cypress	tree	yes	50’-70’	30’	
Ulmus parvifolia	Lacebark Elm	tree	no	40’-50’	30’	Y
Zelkova serrata ‘Green Vase’ or ‘Village Green’	Japanese Zelkova	tree	no	50’-80’	30’	Y
Baccharis halimifolia	Groundsel-tree	shrub	yes	6’-12’	8’	Y
Clethra alnifolia	Summersweet	shrub	yes	4’-8’	8’	Y
Hypericum frondosum ‘Sunburst’	Golden St. Johnswort	shrub	yes	3’-4’	6’	
Iex glabra	Inkberry	shrub	yes	6’-8’	8’	
Iex glabra ‘Shamrock’	Inkberry	shrub	yes	3’-5’	6’	
Itea virginica ‘Henry’s Garnet’ or ‘Little Henry’	Virginia Sweetspire	shrub	yes	3’-4’	6’	N
Myrica pennsylvanica	Bayberry	shrub	yes	8’	8’	Y
Rhus aromatica	Fragrant Sumac	shrub	yes	4’	8’	Y
Rosa hybrida ‘Radtko’	Double Knockout Rose	shrub	hybrid	3’-4’	6’	
Spiraea x bumalda ‘Goldflame’	Bumald Spiraea	shrub	hybrid	3’-4’	6’	
Spiraea x bumalda ‘Goldflame’	Bumald Spiraea	shrub	hybrid	3’-4’	6’	
Viburnum dentatum	Arrowwood Viburnum	shrub	yes	8’-10’	8’	Y

TREES FOR BIORETENTION AND MOIST SOIL AREAS

Latin Name	Common Name	Comments/Recommended Cultivars & Varieties	Native	Height X Spread	Spacing	Salt?
Acer rubrum	Red Maple	tree	yes	40'-60'	30'	N
Acer rubrum 'Red Sunset'	Red Sunset Maple	tree				
Acer rubrum 'Ocotber Glory'	October Glory Red Maple	tree				
Acer saccharinum	Silver Maple	tree	yes	50'-70'	35'	N
Acer saccharum	Sugar Maple	tree	yes	60'-75'	35'	N
Amelanchier canadensis	Serviceberry	tree	yes	20'	20'	Y
Amelanchier X grandiflora 'Autumn Brillance'	Autumn Brillance Service-berry	hybrid tree	yes	25'	20'	Y
Amelanchier laevis	Allegheny Serviceberry	hybrid tree	yes	25'	20'	Y
Betula lenta	Yellow Birch	tree	yes	40'-55'	30'	N
Betula nigra	River Birch	tree	yes	40'-70'	30'	N
Betula nigra 'Heritage'	Heritage River Birch	tree	yes	40'-70'	30'	N
Carpinus caroliniana	Ironwood	tree	yes	20'-30'	25'	N
Celtis occidentalis	Hackberry	tree	yes	40'-60'	30'	Y
Chamaecyparis thyoides	Atlantic White Cedar	tree	yes	50'	30'	N
Chionanthus virginicus	fringetree	tree	yes	15'-25'	15'	N
Crataegus viridis 'Winter King'	Winter King Hawthorn	tree	yes	20'-35'	20'-30'	Y
Fraxinus pennsylvanica	Green Ash	tree	yes	50'-80'	30'-40'	N
Ginkgo biloba - male only	Ginkgo	tree	no	50'-80'	30'	Y
Gleditsia triacanthos var. inermis	Thornless Honeylocust	tree	yes	30'-70'	30'	Y
Juniperus virginiana	Eastern Red Cedar	tree	yes	50'-75'	30'	Y
Liquidambar styraciflua 'Rotundiloba'	Sweetgum	tree	yes	60'-75'	30'	Y
Magnolia virginiana	Sweetbay Magnolia	tree	yes	10'-20'	20'	Y
Metasequoia glyptostroboides	Dawn Redwood	tree	no	70'-100'	30'-40'	
Nyssa sylvatica	Black Gum	tree	yes	30'-50'	30'	Y
Quercus bicolor	Swamp White Oak	tree	yes	50'-60'	30'	Y
Quercus palustris	Pin Oak	tree	yes	60'-70'	30'	Y
Taxodium distichum	Bald Cypress	tree	yes	50'-70'	30'	n

SHRUBS - DECIDUOUS & EVERGREEN SUITABLE FOR BIORETENTION AREAS AND ABSORBENT PARKING LOT ISLANDS

Latin Name	Common Name	Comments/Recommended Cultivars & Varieties	Native	Height X Spread	Spacing	Salt?
Alnus serrulata	Smooth alder		yes	6'-25'	10'-15'	
Aronia arbutifolia	Red Chokeberry	Brilliantissima	yes	6'-10'	3'-5'	
Aronia melanocarpa	Black Chokeberry		yes	5'-8'	5'-10'	
Callicarpa americana	American beautyberry		yes	4'-8'	4'-8'	
Calycanthus florida	Sweetshrub	Athens; Michael Lindsey	yes	3'-9'	6'-12'	
Cephalanthus occidentalis	Common Buttonbush		yes	3'-10'	3'-10'	
Clethra alnifolia	Summersweet	Ruby Spice; a naturalizing shrub	yes	6'-8'	4'-8'	
Comptonia peregrina	Sweet fern	deciduous shrub, grows in full-sun, adaptable to poor and wet soils; suckering and nitrogen fixing plant	yes	2'-5'	4'-8'	
Cornus amonum	Silky dogwood		yes	6'-10'	6'-10'	
Cornus sericea (stolonifera)	Redosier dogwood	naturalizing shrub forms thickets; cultivar, Baileyi, bright, winter-red stems	yes	7'-9'	8'-10'	
Hydrangea arborescens	Smooth hydrangea	intolerant of drought	yes	3'-5'	3'-5'	
Hypericum densiflorum	Bushy St. John's wort	tolerates wide variety of moisture conditions	yes	4'-6'	3'-4'	
Ilex glabra	Inkberry holly	Densa; Shamrock	yes	6'-8'	8'-10'	
Ilex verticillata	Winterberry holly	male pollinator needed- Red Sprite-dwarf cultivar pollinates with Jim Dandy; Southern gentleman pollinates Winter Red® –	yes	6'-10'	6'-8'	
Itea virginica	Virginia sweetspire	naturalizing shrub forms thickets	yes	3'-8'	5'-10'	
Lindera benzoin	Spicebush	valued pollinator, butterfly, and wildlife attracting shrub	yes	6'-12'	6'-12'	
Myrica pensylvanica	Northern Bayberry	tolerates wide variety of moisture conditions and salt	yes	5'-10'	5'-10'	yes
Rhododendron viscosum	Swamp azalea	tolerates moist and wet soils	yes	3'-8'	3'-8'	
Rhus aromatica	Fragrant sumac	Gro-Lo - dense, low-growing shrub/ groundcover	yes	2'-6'	6'-10'	
Samabucus canadensis	Elderberry	tolerates hard pruning	yes	10'-15'	10'-15'	

SHRUBS - DECIDUOUS & EVERGREEN SUITABLE FOR BIORETENTION AREAS AND ABSORBENT PARKING LOT ISLANDS *(CONTINUED)*

Latin Name	Common Name	Comments/Recommended Cultivars & Varieties	Native	Height X Spread	Spacing	Salt?
Sambucus racemosa var. racemosa	Red Elderberry		yes	5’-8’	5’-8’	
Spirea latifolia	Meadowsweet		yes	3’-4’	3’-4’	
Viburnum cassanoides	Witherod	dense, rounded, multi-stemmed, upright-spreading, deciduous shrub that typically grows to 5’- 6’	yes	5’-12’	5’-12’	
Viburnum acerifolium	Mapleleaf viburnum		yes	3’-6’	3’-4’	
Viburnum dentatum	Southern arrowwood	great wildlife and butterfly value	yes	6’-10’	4’-8’	
Viburnum lentago	Nannyberry	large upright, suckering, naturalizing shrub	yes	10’-18’	6’-12’	
Viburnum nudum	Smooth withrod viburnum	Brandywine- more compact cultivar- 5’-6’	yes	5’-12’	5’-12’	
Viburnum prunifolium	Blackhaw viburnum	small specimen tree or large shrub	yes	12’-15’	6’-12’	

GRASSES AND SEDGES FOR MEADOWS, BIOSWALES, AND BIORETENTION AREAS

Latin Name	Common Name	Recommended Varieties/Comments	Native	Height	Exposure	Soil Moisture
Andropogon gerardii	Big bluestem	rich fall color- orange & copper-red	yes	5-8 ft.	S	dry
Andropogon glomeratus	Bushy beardgrass	fall color- orange & copper-red	yes	2-4 ft.	S	
Andropogon virginicus	Broomsedge bluestem	warm season grass with reddish-brown flowers, adapted to disturbed soils, and drought tolerant	yes	3-6 ft.	S	
Boutelloua gracilis	Blue grama	C4 perennial grass/deep rooted	yes	12-18”	S	
Carex crinita	Fringed sedge	native to wet meadows- eastern N. America	yes	12”-36”	S,PS	
Carex lurida	Shallow sedge	wildlife value	yes	2-4 ft.	S,PS	
Carex morrowii ‘Ice Dance’	Ice dance sedge	border/edging groundcover, spreads by rhizomes	no	12”-18”	S,PS	
Carex pensylvanica	Pennsylvania sedge	mowable groundcover	yes	6”- 12”	S,PS, SH	
Carex siderosticha	Creeping broad leaf sedge	durable, long-lived creeping groundcover, suited for moist, fertile soils	no	6”-8”		
Chasmanthium latifolium	River oats	changes from green-summer to bronze in fall; self sows can be aggressive	yes	3-4 ft	S,PS	wet
Deschampsia flexuosa	Chrinkled hairgrass	dense tufts, self sows manageably	yes	12”-24”	S,PS	
Elymus canadensis	Canadian wild rye	nurse grass for prairie species	no	3-4 ft	S	
Eragrostis spectabilis	Purple love-grass	self-seeding	yes	18”-24”	S	
Festuca rubra	Red fescue	spread by rhizomes: low-growing stabilizing turf	yes	6”-12”	S	
Juncus effusus	Smooth rush	upright, bright, yellow-green foliage	yes	3-4 ft		
Muhlenbergia capillaris	Purple muhly grass	clump forming, with masses of pink-red flowers in autumn	yes	3 ft.	S	dry
Panicum virgatum	Switchgrass	versatile native grass, adapted ranges from dry soils to rain gardens, clump forming, blue, glaucous leaves	yes	3-5 ft.	S,PS	dry
Panicum virgatum ‘Cloud Nine’	Tall switchgrass	erect, tall through winter, gold in autumn	yes	5-8 ft.	S, PS	dry
Panicum virgatum ‘Dallas Blues’	Blue switchgrass	cultivar with wide blue foliage	yes	5-7ft.	S	dry
Panicum virgatum ‘Hanse Herms’	Red Switchgrass	cultivar with dark red foliage in August, turning burgundy in autumn	yes	4 ft.	S	dry
Panicum virgatum ‘Northwind’	Switchgrass	cultivar with steel blue, wide leaf foliage	yes	6 ft.	S	dry
Panicum virgatum ‘Shenandoah’	Switchgrass-Shenandoah	cultivar with bright red foliage	yes	2-4 ft.	S	dry

GRASSES AND SEDGES FOR MEADOWS, BIOSWALES, AND BIORETENTION AREAS *(CONTINUED)*

Latin Name	Common Name	Recommended Varieties/Comments	Native	Height	Exposure	Soil Moisture
Schizachyrium scoparium	Little bluestem	widely adaptable native grass, clump forming, apricot- winter color	yes	2-4 ft.	S	dry
Schizachyrium scoparium ‘The Blues’	Little bluestem- The Blues	cultivar with blue stems, purple fall color, clump forming	yes	2-4 ft.	S	dry
Panicum virgatum	Switchgrass	versatile native grass, adapted ranges from dry soils to rain gardens, clump forming, blue, glaucous leaves	yes	3-5 ft.	S,PS	dry
Panicum virgatum ‘Cloud Nine’	Tall switchgrass	erect, tall through winter, gold in autumn	yes	5-8 ft.	S, PS	dry
Panicum virgatum ‘Dallas Blues’	Blue switchgrass	cultivar with wide blue foliage	yes	5-7ft.	S	dry
Panicum virgatum ‘Hanse Herms’	Red Switchgrass	cultivar with dark red foliage in August, turning burgundy in autumn	yes	4 ft.	S	dry
Panicum virgatum ‘Northwind’	Switchgrass	cultivar with steel blue, wide leaf foliage	yes	6 ft.	S	dry
Panicum virgatum ‘Shenandoah’	Switchgrass-Shenandoah	cultivar with bright red foliage	yes	2-4 ft.	S	dry
Schizachyrium scoparium	Little bluestem	widely adaptable native grass, clump forming, apricot- winter color	yes	2-4 ft.	S	dry
Schizachyrium scoparium ‘The Blues’	Little bluestem- The Blues	cultivar with blue stems, purple fall color, clump forming	yes	2-4 ft.	S	dry
Scirpus cyperinus	Woolgrass bulrush	large wooly inflorescence in mid-summer	yes	5-6 ft.	S	wet
Sorghastrum nutans	Indian grass	wpright habit, tan flowers	yes	6 ft-7 ft.	S	dry
Sorghastrum nutans ‘Sioux Blue’	Indian grass-Sioux Blue	metallic blue leaves, arching habit	yes	5 ft- 6 ft.	S	dry
Sporobolus heterolepsis	Prairie dropseed	fine textured mounding, with open panicles held high above foliage	yes	12”-24”	S, PS	dry
Tridens flavus	Purple-top	red-purple panicles, bronze in fall	yes	3 ft.-4 ft	S, PS	wet; dry

SH = full shade PS = part shade S = full sun

PERENNIALS FOR MEADOWS, BIOSWALES, AND BIORETENTION AREAS

Latin Name	Common Name	Recommended Varieties / Comments	Native	Height	Spread	Exposure	Soil Moisture
Aquilegia canadensis	Red columbine	tolerates moist or dry sites	yes	24”-36”	12”-18”	S,PS	Dry-medium
Acorus americanus	Sweet flag	hardy, perennial bog plant, found at waters edge	yes	4 ft.	4 ft.	S	Moist-Wet
Agastache foeniculum	Anise hyssop	easily grown in medium moisture, well-drained soils	yes	4 ft.	3 ft.	S	Dry-medium
Amsonia hubrichtii	Thread-leaf bluestar	grown in well-drained soils, striking yellow fall color	yes	2-3 ft.	2-3 ft.	S	Dry-medium
Asclepias incarnata	Swamp milkweed	Erect, clump forming, grown in wet soils, full sun; tolerates well drained soils	yes	4-5 ft.	2-3 ft.	S	Dry-medium -wet
Asclepias tuberosa	Butterfly milkweed	does well in dry, poor soils, wildlife value	yes	12”-36”	18”-24”	S	Dry-medium
Aster (Eurybia) divaricatus	White wood aster	good for dry shade or moist, shaded areas	yes	12”-36”	18”-24”	S	Dry-medium
Aster (Symphyotrichum) novae-angliae	New England aster	many excellent cultivars available, profuse blooms late-summer-fall	yes	3-6 ft.	2-3 ft.	S	Dry-medium
Aster (Symphyotrichum) novi-belgii	New York aster	tolerates drought and periodic flooding; showy flowers August-October	yes	3-4 ft.	2-3 ft.	S	Dry-medium
Bidens cernua	Nodding beggarticks	tolerates wide range of soils, attractive to songbirds and wildlife	yes	24”-42”	24”-48”+	S	Dry-medium
Echinacea purpurea	Purple coneflower	drought-resistant, best in well drained soils	yes	24”-48”	12”-24”	S	Dry-medium
Eupatorium coelestinum	Blue mist flower / wild ageratum	naturalizes, blue-violet flowers, attracts butterflies	yes	24”-36”	24”-36”	S,PS	Wet soil tolerant
Eupatorium (Eutrochium) dubium ‘Little Joe’	“Little Joe’ Dwarf Joe-pye Weed	well-suited for margins of rain gardens, dwarf selection; prefers moist fertile, humus soils which do not dry out	yes	36”-48”	24”-36”	S,PS	Wet soil tolerant
Eupatorium fistulosum	Joe-pye weed	naturalizes, forms pink-purple flowers attractive to wildlife	yes	2-6 ft.	2-4 ft.	S	Wet soil tolerant
Helenium autumnale	Common sneezeweed	bright yellow flower, prefers rich, moist soils	yes	3-5 ft.	2-3 ft.	S,PS	Wet soil tolerant
Helianthus angustifolius	Narrow leaf sunflower	large, erect mass, common in road-side ditches, may spread by rhizomes in fertile, moist soils	yes	4-6 ft.	2-3 ft.	S,PS	Wet soil tolerant
Helianthus decapetalus	Ten-petaled sunflower	upright rhizomatous perennial wildflower; grows best in an evenly moist soil, tolerates some drought after establishment.	yes	4-6 ft.	2-3 ft.	S	Dry-medium

PERENNIALS FOR MEADOWS, BIOSWALES, AND BIORETENTION AREAS *(CONTINUED)*

Latin Name	Common Name	Recommended Varieties / Comments	Native	Height	Spread	Exposure	Soil Moisture
Iris pseudacorus	Yellowflag iris	native to Eurasia, naturalized extensively in N. America, clump-forming	no	12"-24"	12"-24"		Wet soil tolerant
Iris versicolor	Blueflag iris	erect, sword like foliage, native to marshes, clump-forming	yes	24"-30"	24"-30"	S, PS	Wet soil tolerant
Loebelia cardinalis	Cardinal flower	biennial, long period of bloom, wildlife value	yes	24"-48"	12"-24"	S, PS	
Monarda didyma	Beebalm	attracts pollinators and wildlife	yes	24"-48"	12"-24"	S,PS	Wet soil tolerant
Pycnanthemum tenuifolium	Slender mountain mint	vigorous grower, in average, dry-medium drained soils	yes	2-3 ft.	2-3 ft.	S, PS	
Onoclea sensibilis	Sensitive fern	naturalizes in wet areas, needs consistent moisture	yes	1-3 ft.	24"-48"	S, PS,FS	Wet soil tolerant
Physostegia virginiana	Obedient plant	attracts pollinators, wildlife; naturalizes, can escape cultivation	yes	24"-48"	18"-36"	S	
Rudbeckia fulgida	Early coneflower	naturalizes, attracts butterflies and songbirds	yes	18"-36"	12"-24"	S	
Rudbeckia hirta	Black-eyed Susan	naturalizes, attracts butterflies and songbirds	yes	12"-36"	12"-24"	S	
Rudbeckia lanciniata	Cut-leaf coneflower	naturalizes, grows in average, medium moisture soils	yes	24"-48"	24"-48"	S	
Solidago canadensis	Common goldenrod	rhizomatous, upright perennial of the sunflower family	yes	4-5 ft.	4-5 ft.	S	
Solidago rigida	Stiff goldenrod	rhizomatous, well-drained soils, drought-tolerant	yes	3-5 ft.	18"-30"	S	
Solidago rugosa	Rough or wrinkleleaf goldenrod	cultivar- Fireworks - bright yellow flowers borne in dense, plume-like panicles, typically growing 36-42" tall.	yes	3-5 ft.	18"-30"	S	Wet soil tolerant
Solidago sempervirens	Seaside goldenrod	waxy leaves, coastal goldenrod tolerant of salt spray, useful in rain gardens subject to winter salting	yes	3-6 ft.	18"-30"	S,PS	Wet soil tolerant
Vernonia noveboracensis	New York Ironweed	spreading, tall, upright wildflower with brilliant purple flowers, grows in wet areas	yes	4-8 ft.	24"-36"	S	Wet soil tolerant

SOURCES

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May 2012, St. Louis, MO

Native Trees, Shrubs, and Vines for Urban and Rural America, Gary L. Hightshoe,
Van Nostrand & Reinhold, 1998

Missouri Botanic Garden: Plant Finder
http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx

USDA - Natural Resources Conservation Service Plants Database
USDA, NRCS. 2015. The PLANTS Database
(http://plants.usda.gov, 21 September 2015). National Plant Data Team,
Greensboro, NC 27401-4901 USA.

http://www.dcnr.state.pa.us/cs/groups/public/documents/document/
dcnr_20026634.pdf

ADDITIONAL RESOURCES

US Environmental Protection Agency (EPA)
The URL below outlines approaches to manage and design green infrastructure.
www.epa.gov/green-infrastructure/what-green-infrastructure

EPA – Green Parking Lot Resource Guide—February 2008
This guide discusses issues and solutions to environmental challenges of conventional surface parking lots. Search "Green Parking Lot Resource Guide" at the link below.
www.epa.gov/nscep

EPA – Permeable Paving
For more information on permeable paving materials and their performance, explore "Experimental Permeable Pavement Parking Lot and Rain Garden for Stormwater Management" at the link below.
www.epa.gov/water-research/experimental-permeable-pavement-parking-lot-and-rain-garden-stormwater-management

DeepRoot Green Infrastructure
This website provides research and discussion of policies related to how to sustain and promote tree canopy, soil quality, and natural processes in urbanized environments including parking lots.
www.deeproot.com/blog

Delaware Valley Regional Planning Commission (DVRPC)
"The Automobile at Rest: Toward Better Parking Policies in the Delaware Valley" is a detailed study of various parking management strategies and landscape requirements for better stormwater practices.
www.dvrpc.org/reports/08081A.pdf

Casey Trees
Casey Trees offers "Green Issue Briefs – Green Parking Lots" and "Tree Space Design: Growing the Tree Out of the Box," which advocates for incorporating strategies to grow large and effective canopy trees within restricted rooting environments.
www.caseytrees.org/issues
www.caseytrees.org/resources/publications/treespacedesign

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