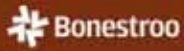


PILOT VERSION



# CITY TREES

sustainability guidelines & best practices



AUGUST 2007

**Copies of this report can be downloaded at**

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- Walter G. Dahlberg, ASLA, Chairman / Senior Landscape Architect, Lambert's Landscape Company
- Janette Monear, Director, Urban Forestry, Tree Trust
- Jonee Kulman Brigham, AIA, Center for Sustainable Building Research, University of Minnesota

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Donald C. Willeke, Kit Richardson, Lorrie Stromme, Scott Vreeland, Elizabeth Storey, George Wells, Peggy Booth, John Uban, Janette Monear, Rolf Svendsen, and Dr. Gary Johnson.

Both groups have helped advise this process and guided the City of Minneapolis toward adoption of new Streetscape standards.



Copies of this report can be downloaded at [www.treetrust.org](http://www.treetrust.org) and [www.bonestroo.com](http://www.bonestroo.com). Tree Trust is a Minnesota nonprofit whose mission is to improve the community environment by investing in people.

Founded in 1956, Bonestroo is a planning and engineering firm headquartered in St. Paul, MN. Bonestroo employs more than 400 personnel who provide expertise in a comprehensive range of service areas for public and private clients throughout the Upper Midwest. Bonestroo is a U.S. Green Building Council member and seeks to incorporate the sustainability principals set forth by the USGBC.



A project of this magnitude requires dedication on behalf of staff, many of whom donated their own time; as well as corporate support from the firm's principals. We are grateful to Bonestroo's management team for their acknowledgment of the importance and timeliness of this project and for their support in dedicating the resources necessary to develop these guidelines.

Graphics by Nathan Ekhoﬀ  
Cover Photos by Lorin W. Culver



## Contacting the Authors

Bonestroo's experience serving municipalities for the past 50 years has been driven by its underlying philosophy to improve places and improve lives. The firm's growth and development of service offerings has been in direct response to the diversifying needs of its clients and an increased attention on preserving and protecting the natural environment. As a full-service planning and engineering firm and USGBC Member, Bonestroo implements sustainable design strategies through an integrated design approach among its many service disciplines.

Bonestroo's staff includes planners; civil, structural, and electrical engineers; landscape architects and urban designers; water and natural resource scientists and engineers; traffic and transportation engineers; GIS specialists; water and wastewater engineers; funding specialists; and recreation engineers. The draft guidelines resulted from the collaboration and input from staff from many of these specialty areas.

We welcome information on study data, research and construction projects, products, or methods with general relevance to implementing trees within cities. Please email information to the following Bonestroo staff members who have been involved with the development of the guidelines.

C. John Uban is Principal Landscape Architect at Bonestroo and has over 30 years of experience assisting communities, agencies, and developers with design and implementation of urban tree plantings. As co-chair of the Minneapolis Tree Advisory Commission, he has led the efforts to integrate trees into the City infrastructure system as part of the City sustainability and community outreach. Mr. Uban is also on the faculty of the Minnesota Government Training Service and H.W.S. Cleveland Lecturer at the University of Minnesota. He is also principal-in-charge for this project.

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Corey Markfort, M.S., E.I.T., is a Water Quality Engineer focusing on the treatment of stormwater in urban areas. He is involved with numerous lake management plans and Total Maximum Daily Loads (TMDLs) for the protection and restoration of urban lakes as well as designing stormwater Best Management Practices (BMPs). In addition to conducting the literature review for this project, he has conducted literature reviews for the treatment of industrial runoff, urban stormwater runoff to lakes and streams as well as studying the hydrologic response of key natural resources to agricultural runoff. He performed the literature review examining the benefits of trees in urban stormwater management.

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As is the nature of research projects, it is impossible to locate and review all relevant available research, and especially in such a broad and dynamic field. As funding becomes available, new research will be reviewed as it is published and the guidelines will be periodically updated. For example, one particularly exciting process which has yet to be fully addressed within the guidelines is that of phytoremediation, which uses trees and plants to extract or promote degradation of toxic substances in soils, ground water, surface water, wastewater, and sediments. We anticipate exciting possibilities to naturally remove stormwater pollutants in an environmentally sensitive way and again, we welcome research results on this and other relevant topics.

Help us keep comments manageable by including “City Trees” in the subject line, and starting the email message with a short written description, including contact(s) and contact information. Images sent via email should be kept under 1 MB. Comments and information received will be kept on file and we will call or email the contact person for clarifications as necessary when the guidelines are updated next. We cannot guarantee a response to each email. Thank you.



## Foreword

The City Tree Guidelines and Best Management Practices were created to better institutionalize codes and standards for designing communities with trees. The impact that trees make on our communities is tremendous and although we can quantify some of their benefits, we cannot always quantify the social and psychological values. But, we know they exist. People in communities mourn the loss of trees from storms or from other problems. And, people will rally around planting, protecting and ensuring that trees are a part of their neighborhoods and communities.

I believe that we as humans have an inherent connection with trees. There is a symbiotic relationship that we are not always conscious of and, because of this we create communities that are lifeless in terms of our place in the ecosystem. We talk about creating livable communities, but just what does that mean? To me, it means that we create communities that provide for the needs of the people, the physical, social, environmental, cultural, and psychological needs. At the core of this, we protect and enhance the natural systems that reflect and integrate our relationship with nature, especially the trees.

The great writers like Thoreau, Frost, and John Muir wrote some of their best compositions amongst trees. The trees inspired them to write not only from their heads, but from their hearts. This is how we must now look at how we design our communities.

The City Tree Guidelines and Best Management Practices will guide us to this end. These guidelines will hopefully be embraced by decision makers, engineers, planners, developers and builders, architects, and others as they create “livable” communities. It is our hope that they will be taken and implemented into standards and policies that will guide how we integrate, protect, enhance, and develop our communities for our children and grandchildren.

How we create our communities is how we define our legacy. Trees and people need each other to have a truly “livable” organic community.

Janette K. Monear  
Director, Urban & Community Forestry  
Tree Trust

August 2007



## Introduction

The City Trees Sustainability Guidelines and Best Practices were developed to support the new and innovative project, Hawthorne Eco Village, in the City of Minneapolis. Tree Trust, in partnership with Project for Pride and Living and the Hawthorne Area Community Council are creating a demonstration project that combines urban trees and landscape design with Leadership in Energy and Environmental Design (LEED) certified affordable housing. The goal is to create a sustainable green neighborhood – inside and out! To better guide the process for the long term health of the trees and the greening of the neighborhood, Tree Trust contracted with Bonestroo to create better landscape guidelines and best management practices that can be adopted by the City of Minneapolis (and possibly other communities) and will provide the basis for better decisions and long term sustainability of this new LEED Neighborhood Development project.

More broadly, the goal is to provide much-needed direction and recommendations for how to accommodate, care for, and locate urban trees, both within the public right-of-way and on private property. In each case, the starting point should be the community vision and goals as outlined in the city comprehensive plan or other planning document. Codes and policies are tools in the toolbox to be used to achieve the vision or reach the goals. The City of Minneapolis' Urban Forest Policy was considered in developing the guidelines.

The guidelines were specifically developed to work in conjunction with and build on the *Green Communities Criteria* and the accompanying Minnesota Overlay ([www.greencommunitiesonline.org/Minnesota](http://www.greencommunitiesonline.org/Minnesota)). They contribute to and directly support the guiding principles behind the Green Communities criteria by helping produce a green, affordable exterior environment that:

- **RESULTS IN A HIGH-QUALITY, HEALTHY LIVING ENVIRONMENT,**
- **LOWERS RESIDENTS' UTILITY COSTS,**
- **ENHANCES RESIDENTS' CONNECTION TO NATURE,**
- **PROTECTS THE ENVIRONMENT BY CONSERVING ENERGY, WATER, MATERIALS AND OTHER RESOURCES, AND**
- **ADVANCES THE HEALTH OF LOCAL AND REGIONAL ECOSYSTEMS.**

The process of developing these guidelines included reviewing other recognized guidelines and standards for information, topic organization, and inspiration. These included LEED-NC, LEED-ND, and the B3 Minnesota Sustainable Building Guidelines, as well as the Sustainable Sites Initiative currently under development by the American Society of Landscape Architects (ASLA) and the Lady Bird Wildflower Center.

The focus of these guidelines is to develop the best ways to mitigate global warming by planting trees to sequester and store carbon and integrate trees for stormwater management and water quality. Planting trees is easily understood and widespread, and the best practices presented here introduce green building and sustainable design practices to a site. The guidelines and best practices are applicable to many different types of communities ranging from ultra urban environments to small communities, and encompass many different project types and locations. The intent is to develop guidelines and best practices that are universally applicable and yet allow for modifications to address regional differences.



## The Benefits of City Trees

Trees are generally overlooked as an important and integral part of the urban infrastructure. Municipalities must be compelled to always include the aspects and needs of trees when they make decisions about water quality, energy costs, beautification, and climate change mitigation. Urban trees are sometimes placed in poor locations in conflict with other city infrastructure and often suffer from long-term maintenance neglect. These trees can only provide maximum benefits when coordinated with the complex city infrastructure.

Numerous studies have quantified the real values and benefits urban trees provide to the surrounding community and environment. These trees need to be understood as necessary infrastructure, similar to water, power, and sanitary sewer.

Urban watersheds are critical to the hydrologic health of a community and region. The combined use of urban trees and other stormwater quality best management practices will provide effective ways to improve water quality for our urban centers, suburbs, and surrounding communities (Figure 2).

A primary goal is to assure that healthy urban trees reach maturity, continue to thrive, and not create future problems or conflicts with other infrastructure. To achieve this will require compromises during the initial phases of laying out the infrastructure. Utility line locations should be adjusted to accommodate a continuous tree planting trench that doubles as a stormwater filter and also facilitates infiltration. Each project and site will have unique conditions requiring thorough consideration of which best practices to select and endorse to meet the guidelines.

The term “City Trees” includes trees subjected to tough urban conditions including street trees and those planted along boulevards, in medians, in parking lots, and in urban open spaces. Their health and vitality are compromised primarily through limited soil volume and heavily compacted soils. Trees planted in concrete vaults suffer from limited root capacity as are trees in planting areas surrounded by heavily compacted soils that create natural vaults (Figure 1).

These guidelines promote considering city trees as major and important urban infrastructure. They outline best practices to incorporate them into the urban framework. This notion might seem radical and will no doubt challenge existing thought. Increasing knowledge of the measurable benefits of urban trees, combined with greater annual urbanization and a greater number of people spending vastly more time in urban areas, force municipalities to have a responsibility to ensure the success of their provision and care for urban trees.

Trees have many positive impacts on the environment and community. Their primary benefits include:

- Mitigating global warming by reducing Green House Gases (GHG)
- Storing and sequestering carbon dioxide
- Improving air quality<sup>1</sup>
- Removing pollution



- Phytoremediation
- Increasing energy savings (shade and windbreaks)
- Reducing energy use in buildings when located to produce shade and windbreaks, thereby reducing carbon dioxide emissions from fossil-fuel based power plants<sup>1</sup>
- Reducing urban heat island effect
- Reducing pavement temperature, which reduces the rate of asphalt deterioration<sup>5</sup>
- Intercepting rainfall<sup>1</sup>
- Stormwater rate control
- Improving water quality
- Facilitating stormwater infiltration/treatment

Additional benefits of urban trees include:

- Increased property values
- Social and psychological benefits (offsets symptoms of ADD/learning disabilities)<sup>3</sup>
- Crime reduction<sup>15</sup>
- Increased aesthetics
- Willingness of consumers to pay more for products in business districts with trees<sup>14</sup>
- Human health benefits
- Wildlife habitat
- Moderating temperature of water prior to entering natural water bodies
- Creating micro-climates for humans along urban streets

With this myriad of benefits, trees are becoming recognized as a critical component of the urban and suburban infrastructure. As such, consideration must be given and efforts made to strategically place trees to maximize their value and ensure their long-term success. Equally important is selecting the right tree for a location to prevent future conflicts with infrastructure. On average, sidewalk, curb and gutter repair, and legal costs ranged from \$3.70 in the Midwest to \$11.22 in California per tree annually. When repair costs for damaged sewer lines, building foundations, parking lots, and other hardscape items are included, Midwest cities spent more than \$50 million per year rectifying root-sidewalk conflicts.<sup>4</sup> Therefore, proper planning and careful attention to tree and utility locations can translate into substantial savings over time.

Maximum benefits are accrued by incorporating best practices for achieving long-lived trees that improve air quality, wind (climate) control, and water quality and provide an increased annual net value to the community.<sup>9</sup> The next section provides innovative, yet practical, best practices to achieve the guidelines.



## City Tree Sustainability Guidelines & Best Practices

The goal is to provide specific guidance on locating, planting, and caring for trees within the urban and suburban infrastructure. This needs to be done in a truly sustainable way that provides for the trees' long-term viability and maximizes as many benefits as practicable. Developers are encouraged and expected to use creative strategies to achieve the intents and benefits of these guidelines.

Trees must be strategically located to:

- Allow for their long-term survival
- Maximize their ability to improve air and water quality
- Increase on-site infiltration through site design and construction techniques that direct water to combined tree planting and infiltration reservoir (tree bio-filtration device)
- Prevent erosion

For municipalities and organizations who adopt the guidelines to assist in shaping the development of their communities, a point system has been provided for use in assessing credit compliance. A maximum of fifty points is possible and each adopting agency will need to determine what point levels to enforce, however, we provide the following recommendation:

- 40-50 Points      Exemplary
- 30-40 Points      Excellent
- 20-30 Points      Good
- 0-20 Points      Fair



## Sustainability Guidelines & Best Practices Criteria Checklist

Yes	No	?	Credit	CREDIT TITLE AND DESCRIPTION	Possible Points
			<b>1.1</b>	<b>City Tree Development Plan</b> Submit a written development plan outlining the integrated design approach taken for this development that demonstrates involvement of the entire development team and urban infrastructure.	<b>Mandatory</b>
			<b>1.2a</b>	<b>Selection &amp; Location – Optimum Tree Locations</b> Locate trees on site at the source of pollution. Correlate tree size with street width and development density. Use construction techniques that sustain tree health and longevity, while minimizing tree stress.	<b>Optional</b> (5 Points)
			<b>1.2b</b>	<b>Selection &amp; Location – Infrastructure Coordination</b> Acknowledge City trees as a <i>critical</i> piece of the urban infrastructure by creatively locating utilities around the trees' identified optimal location.	<b>Optional</b> (10 Points)
			<b>1.3</b>	<b>Design Implementation &amp; Surface Conditions</b> Provide the greatest degree of permeability immediately around each tree (100 square feet, minimum). Provide open, planted surface area or covered soil. Use structured soil and expandable pavement openings.	<b>Optional</b> (5 Points)
			<b>1.4</b>	<b>Improving Air Quality – Large Canopy Trees</b> Provide trees with high relative Leaf Area (LA) and of the largest canopy practicable for the location and climate zone with relatively high carbon storage and carbon sequestration capabilities	<b>Optional</b> (5 Points)
			<b>1.5</b>	<b>Reducing Heat Island &amp; Increasing Shade</b> Use large canopy trees to shade streets, sidewalks, and parking lots. For industrial and ultra urban areas provide at least 25%. For residential provide at least 75% within 15 years of development. Use light colored/high-albedo materials and/or open grid pavement with a minimum Reflective Index of 0.6 for pavements.	<b>Optional</b> (5 Points)
			<b>1.6</b>	<b>Improving Water Quality – Stormwater Interception, Rate Control, Filtration, &amp; Infiltration</b> Use water-permeable surface materials in 50% or more of pavements and immediately around each tree, with a structural soil infiltration bed and direct stormwater runoff into it. Provide an adequate drainage system. In conjunction with these, use detention basins, bio-filtering swales, and rainwater gardens to pre-treat stormwater to remove pollutants.	<b>Optional</b> (15 Points)
			<b>1.7</b>	<b>Maintenance</b> Provide a long-term management plan and risk management plan that employs best management practices for tree care maintenance.	<b>Optional</b> (5 Points)



## 1.1 City Tree Development Plan

Mandatory

### INTENT

An integrated design process incorporates sustainability and city trees from the beginning. Considerable efforts have been made to produce the policies, master plans, and codes, which typically address concerns of the immediate area and will provide beneficial direction and a superior result.

### HOW

Submit a written development plan outlining the integrated design approach taken for this development that demonstrates involvement of the entire development team.

The plan must provide the following:

- The name and role of each member of the professional design and development team.
- A statement of the project's overall city tree sustainability and development goals, and the expected outcomes from addressing those goals.
- A statement listing all relevant policies affecting city trees and how compliance will be met.
- A statement indicating how existing trees of considerable size, considered significant, have heritage status, or are culturally important, are to be preserved and protected.
- A description of the process used to facilitate interdisciplinary coordination to select city tree incorporation strategies, systems, and materials into the project.
- A description of the rationale for choosing each of the city tree sustainability features, and a description of how each of the mandatory and optional items will be included in the project.
- Identification of which members of the design and development team are responsible for implementing the green features.
- A description of follow-up measures to be taken through the completion of design, permitting, construction and operation to ensure the City Tree Sustainability Guidelines are included, implemented, and correctly installed, and that the owners or tenants receive information about the function and operation of the features.
- Instructions to establish an escrow account active for two seasons to ensure the trees' establishment.

### CONSIDERATIONS

- Conduct a city tree sustainability design charrette with the full development team.
- Consult the *City of Minneapolis Urban Forest Policy* ([http://www.ci.minneapolis.mn.us/cped/docs/urban\\_forest\\_policy.pdf](http://www.ci.minneapolis.mn.us/cped/docs/urban_forest_policy.pdf)) and *Master Plan* to determine tree species type and management practices.



## 1.1 City Tree Development Plan (continued)

- Preserve irreplaceable and significant urban trees in good health and of stable form by protecting them from development and incorporating them into the project site design.
- Maintain the existing grade and limit the overburden around a tree's protected root zone (PRZ) as defined in the *City of Minneapolis Urban Forest Policy*, Item 5.6.
- Manage risk by weighing the benefits of urban trees against level of acceptable risk.
- Provide an effective storm response program.
- Implement a replacement program for any "city tree" to be removed. (Caliper inch replacement with approved species and a total equal caliper inch.)

**1.2a****Selection & Location –  
Optimum Tree Locations****Optional**  
(5 points)**INTENT**

Trees, especially large canopy trees, located at the source of the pollution provide the most benefit in mitigating air pollution and sequestering carbon dioxide. Therefore, trees lining a busy street sequester the carbon as the cars produce it, and provide cleaner air where high pedestrian and bicycle traffic occurs.

**HOW**

Provide a landscape plan and details showing that the location and selection of new trees and construction techniques that:

- Allow for continuous tree rows along streets with overlapping canopies forming distinct urban forest cover when practical and possible (shade at least 50% of streets, sidewalks, and parking lots within 15 years of development).
- Relate tree size with street width (traffic volumes) – as the street width increases so should the tree (its canopy) and the boulevard in which it is planted (10 feet minimum).
- Relate tree size with development density (population and building height) – as the density increases so should the tree and its canopy.
- Provide adequate space to accommodate the tree's mature structure and canopy without adversely affecting other utilities (10 feet minimum).
- Locate trees in areas that are the most favorable in sustaining tree health and longevity, minimizing tree stress, and providing adequate sunlight.
- Locate trees in site soils and microclimates most favorable to their long-term health.
- Locate trees to provide shading in the summer and allow for heat gain in the winter. (i.e., deciduous versus evergreen)

**CONSIDERATIONS**

- Consider the use of bump-outs, traffic circles, and roundabouts to accommodate a greater number of trees nearer the source of pollution. Roundabouts benefit from having vertical elements such as trees because users are discouraged from proceeding in the wrong direction.
- Balance planting trees in small groups (copses). Give a group of trees enough space to allow them to achieve their full potential. Copses of trees are healthier than specimen trees in an urban environment.
- Select and locate trees to provide summer shade (east and west face of building), shield against winter winds (north face of building), and allow winter solar gain (south face of building). (See *Green Communities Criteria 3-3 Landscaping*.)

**1.2a****Selection & Location –  
Optimum Tree Locations** (continued)

- On sites within 50 feet of a water body or wetland, provide a buffer of native vegetation and pervious surfaces, and as a means to cool water prior to its entering.
- Assess future risks of close overhead utilities, universal accessibility, fire access, storm damage, etc.
- Consider relationship to pedestrians, bike lanes, buildings, streets, parking, traffic signs, etc. (i.e., height (clearances), species, and sight lines).
- Consider installing conduits (sleeves) to accommodate future utilities to avoid disturbing roots.
- Consider using removable sidewalk panels over continuous utility vaults to allow for maximum flexibility and minimal disturbance to tree roots.

**1.2b****Selection & Location –  
Infrastructure Coordination**Optional  
(10 points)**INTENT**

Trees are critical elements of the urban infrastructure and should not be an afterthought relegated to incidental open spaces. They should be given high priority in the urban fabric and be given prime consideration with other utilities yielding to them. A concerted effort must be made to consider suitable locations for trees at the beginning of the design process. Strategies must be employed to increase available soil mass, water, air, and the ability to provide a quality growing medium.

The monetary benefits and costs of trees have been quantified many times. In the study conducted by McPherson and others, and as presented in *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting* (August 2005) these benefits are quantifiable. Average annual net benefits for large trees ranged from \$58 to \$76 per tree. In a similar study, the City of Davis, California, concluded that on average there is a \$71 per tree annual benefit.

**HOW**

Acknowledge city trees as *critical* pieces of the urban infrastructure by creatively locating utilities around the trees' identified optimal locations. Submit a written coordination plan outlining the integrated design approach taken to achieve infrastructure coordination.

**CONSIDERATIONS**

- Avoid planting shallow-rooting species near sidewalks, curbs, and pavement.
- Adjust locations of above-ground utilities, including power lines and street lights to accommodate mature tree size and prevent future conflicts.
- Adjust locations of below-ground utilities to accommodate future mature tree roots and prevent conflicts (Figures 2 - 6).
- For below-ground utilities, consider using buried conduits to accommodate additional future utilities without disturbing tree roots.
- Locate clean-outs and access points away from trees.
- Creatively reduce street widths and add bump-outs, central medians, and traffic circles to provide increased flexibility in coordinating street tree and utility locations.



## 1.3 Design Implementation & Surface Conditions

Optional  
(5 points)

### INTENT

Appropriately sized tree planting areas (permeable surface area, structured soil depth, and volume) result in larger, healthier, and longer-lived trees with fewer conflicts with surrounding pavements. The highest degree of permeability at the ground plane allows air and water to pass through to the root zone. Example treatments of permeability from most to least are as follows:

- Open planting area
- Porous pavers
- Porous pavements
- Pavers
- Regular pavements

Urban soils are often highly compacted due to surrounding development. Compaction makes the soil highly inadequate as a planting medium, and requires mitigation steps to sustain tree growth.

### HOW

Provide a combined landscape and paving plan indicating the degree and limits of permeability (50% minimum). The greatest permeability must be immediately around each tree (100 square feet, minimum, of open and/or planted surface area). The limits of structural soil, tree locations, and any soil depth limitations need to be identified. Soil and subsoil should be protected from chemical contaminants, equipment storage, and compaction. Test soil and subsoil for agricultural suitability, chemical contaminants, and compaction, and provide appropriate remediation. Provide an expandable pavement opening to accommodate future tree growth. Provide continuous open planting areas (5 feet, 6 inches minimum width) and/or structural soil trenches to ensure adequate root growth and infiltration. Provide automatic irrigation system as appropriate for soil type, tree species, location, and climate.

### CONSIDERATIONS

- Provide continuous open planting beds flush with grade where practicable.
- Consider using permeable pavers and porous paving for sidewalks and other surfaces to reduce stormwater runoff and allow the trees and landscape to benefit from the available water.
- Consider using a concrete curb with metal landscape edging in high salt use areas to prevent snow melt from entering tree wells and planting areas. This will also direct pedestrian traffic and discourage trampling root zones. (Figure 7).
- Provide a pavement opening that is expandable to accommodate the future buttress roots of the mature tree (i.e., removable pavers, segmented tree grates, or mulching the plant pit) (Figure 8).



### 1.3 Design Implementation & Surface Conditions (continued)

- Use of tree grates and tree guards is strongly discouraged, except in ultra urban areas or where insufficient clearance and high pedestrian traffic volumes require it. Consult the *City of Minneapolis Urban Forest Policy*.
- See [www.treetrust.org](http://www.treetrust.org) for “Plant a Tree – the right way.”
- A wide tree planting area (greater than 4 feet) generally produces stronger tree root structures, resulting in fewer incidents of tip-over.
- Use bump-outs and mid-block medians to reduce street width and provide larger planting areas to accommodate trees while also providing shorter street crossing distances.
- Use traffic circles to provide additional tree locations and promote traffic calming.
- Use trees in roundabouts as vertical elements to control views and discourage drivers from attempting to proceed in the wrong direction.
- Use an automatic irrigation system capable of being turned off after establishment and on during drought conditions.
- Consider using drip irrigation with structured soil as recommended by the product developer (and possibly an irrigation bubbler sleeve/root watering system depending on soil type). See *Green Communities Criteria 4-2 Efficient Irrigation*.
- Design root zone area underneath planting and adjacent paved surfaces to accommodate tree species used. Address soil type, depth, and extent.
- Compensate for compacted urban soils by increasing depth of structured soil.
- Avoid shallow rooting tree species.
- Do not use in-ground tree boxes/vaults (“coffins”).

**1.4****Improving Air Quality –  
Large Canopy Trees****Optional**  
(5 points)**INTENT**

Large mature trees provide the most benefit in cleaning air pollution.<sup>13</sup> “Healthy Leaf Area (LA) equates directly to tree benefits provided to the community.”<sup>1</sup> Use pollution-tolerant trees in polluted or heavily populated areas to maximize the trees’ air quality benefits.

**HOW**

Provide trees with high relative Leaf Area and the largest canopy practicable for the location and climate zone. Select trees that provide relatively high carbon storage and carbon sequestration, as well as those that are long-lived, and to the extent possible, disease and pest resistant.

**CONSIDERATIONS**

- Trees store and remove carbon from the atmosphere, thereby helping mitigate climate change. Therefore, the amount of carbon sequestered by new tissue growth is increased with healthier trees and larger diameter trees.<sup>1</sup>
- Strategically located large-stature trees provide more benefits over a longer period of time and are more cost effective when compared to small-stature and medium-stature trees.<sup>9</sup>
- Tree species with the greatest existing CO<sub>2</sub> sequestration and storage capacities for the Minneapolis area include the American elm, *green ash (not recommended for use due to the impending arrival of the Emerald ash borer)*, and silver maple.<sup>1</sup> Each city and region should select appropriate tree species for their locale.
- Trees in Minneapolis were found to be roughly four times more effective at removing air pollution than shrubs on an individual basis.<sup>1</sup>
- Pollution removal by trees, in order of most to least, includes particulate matter less than 10 microns (PM<sub>10</sub>), ozone (O<sub>3</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), and carbon monoxide (CO).<sup>1</sup>
- Avoid planting trees with high or moderate biogenic emissions (may not be a significant concern in all regions). There are only a few trees classified by their biogenic emissions; see Low-Emitting Urban Forests: A Taxonomic Methodology for Assigning Isoprene and Monoterpen Emission Rates, by Michael T. Benjamin, Mark Sudol, Laura Bloch and Arthur M. Winer. Atmospheric Environment. Vol. 30, No.9, pp. 1437-1452, 1996, or at the Urban Forest Ecosystems Institute ([www.ufe.org](http://www.ufe.org)) Selectree program.
- Use species with salt tolerant characteristics to match their expected exposure in the soil and above ground spray.
- Encourage the use of native species as appropriate. (See *Green Communities Criteria 3-3 Landscaping* and refer to local *EPA Native Plants* list).

**1.4****Improving Air Quality –  
Large Canopy Trees** (continued)

- Use local ecotypes where immediately adjacent to a water corridor/watershed.
- Consider using drought tolerant and/or low-water consuming species with water needs to match available stormwater runoff; irrigate if necessary.
- Avoid species considered invasive or fire hazards (see *Green Communities Criteria 3-3 Landscaping*).
- Promote species biodiversity. For information specific to Minneapolis, contact the City of Minneapolis Park and Recreation Board Forestry Department regarding the *City of Minneapolis Master Planting Plan*. <http://www.minneapolisparcs.org/default.asp?PageID=531#master>
- Select disease and pest resistant species.
- Choose trees with sun requirements appropriate for the location.
- Plant bare root trees when possible, as they are easier to handle and have additional benefits for the trees' establishment.
- Although promoting local food production is beneficial, the appropriateness of certain fruiting trees must be carefully considered, especially adjacent to high pedestrian and vehicle traffic areas. Street trees dropping fruits and nuts create messes and hazards and attract birds and insects.
- Reduce street widths, and add bump-outs and central medians to provide increased flexibility in locating street trees closer to the source of pollution. For design ideas see *Creating Livable Streets: Street Design Guidelines Green Streets*.
- Use iTree software's STRATUM model to inventory the city tree resource, and quantify the increase in water and air quality provided by the trees. Produce an assessment that includes values of forest structure, risk of insect pests and diseases, air pollution removal, carbon storage, and annual carbon removal (sequestration). [www.itreetools.org](http://www.itreetools.org)
  - The urban forest of Minneapolis removes approximately 384 tons of pollutants annually, with a value to society of \$1.9 million annually.<sup>1</sup>
- Consider tree canopy shapes to match site conditions (i.e., columnar canopy in narrow areas).
- Consider possible future conflict of tree canopies with transmission of digital signal and wi-fi.
- Consider possible future conflict of tree shade with solar collectors.

**1.5 Reducing Heat Island Effect & Increasing Shade**Optional  
(5 points)**INTENT**

Reduce the heat-island effect through tree shade and by using paving surfaces that do not retain heat (see *Green Communities Criteria 6-5b Reducing Heat-Island Effect – Paving*). Reduce pavement deterioration and maintenance and replacement costs through shaded streets. Reduce energy use through tree shade and water transpiration, thereby reducing carbon dioxide production at power plants.

**HOW**

Use large canopy trees to shade streets, sidewalks, and parking lots within 15 years of development.

- For industrial and ultra urban at least 25%
- For residential at least 75%

Use light-colored/high-albedo materials and/or open grid pavement, with a minimum reflective index of 0.6 for pavements.

**CONSIDERATIONS**

- See *Assessing Urban Forest Effects and Values* for recommended trees to plant that reduce carbon dioxide, provide significant transpiration, and provide shade to reduce energy use.<sup>1</sup>
- Mitigate heat island effect by using deciduous trees in northern climates and evergreen trees in southern climates.
- Implement continuous tree cover to reduce the urban heat island effect.
- Shaded streets are cooler and deteriorate at a slower rate than those without trees.<sup>5</sup>
- Shade extends life of buildings, asphalt roads, and parking areas.
- Increased energy savings are realized from tree shade provided during the middle of the day when energy costs (peak rates) are the highest.
- Use iTree software's STRATUM to quantify the energy conservation savings provided by the city tree resource. [www.itreetools.org](http://www.itreetools.org)
- Shaded streets create a more pleasant urban fabric and a more successful urban center.

**1.6****Improving Water Quality –  
Stormwater Interception, Rate Control, Filtration & Infiltration**Optional  
(15 points)**INTENT**

Implement a city tree planting plan that incorporates acceptable stormwater Best Management Practices (BMPs) into the city tree planting continuous tree well. Maximize stormwater runoff captured/diverted on wider streets with high Average Daily Traffic (ADT) as defined by the Minnesota Department of Transportation (Mn/DOT). Trees can essentially act as vertical rainwater gardens in urban areas where space is limited. Stormwater runoff is intercepted by the tree's canopy, drawn up by its roots, and transpired through its leaves.

**HOW**

Use water-permeable surface materials in 50% or more of pavements and immediately around each tree. Also use a structural soil infiltration bed which provides a permeable direct stormwater runoff benefit. (Figure 2). Adequate drainage systems connected to the storm sewer or drainage system ensure that trees do not sit in water for extended periods. Use large canopy trees with a high relative Leaf Area (LA).

Use detention basins, bio-filtering swales, and rainwater gardens to pre-treat stormwater to remove pollutants harmful to trees (may be tree species specific).

**CONSIDERATIONS**

- Adequate subsurface conditions are critical to the long-term health of the tree.
  - Assess the permeability of the sub-grade by testing for adequate drainage using locally acceptable methods. Take necessary steps to ensure water will drain completely from root zone, allowing ample air supply. Locate drainage pipes deep enough to ensure proper drainage.
  - Perform a soil analysis and amend soil to support vigorous tree growth. Modify the composition to allow for adequate drainage (i.e., clay soils will require the addition of different soil types and/or compost to promote drainage, etc.).
  - Using structural soil as a planting medium and ground water recharge bed is a relatively new and exciting concept. No conclusive test data exists of the long-term effect water fluctuations have on the structural soils' nutrient values, fertilization requirements, tree health, fluctuation in water regime, and affects from chemicals in stormwater. See USDA Center for Urban Forest Research Project Profile – *Green Streets: Storm Water Management System for Paved Areas*<sup>11</sup> and *Engineered Soil, Trees and Stormwater Runoff: The UC Davis Parking Lot Project*.<sup>12</sup>
  - Provide as large of a volume of structural soil as possible. A 36-inch depth from building face to back of curb is preferred, with a minimum 24-inch depth by 5 feet - 8 feet wide continuous trench parallel to the curb.

**1.6****Improving Water Quality –  
Stormwater Interception, Rate Control, Filtration & Infiltration** (continued)

- Use alternative planting medium (e.g., engineered soil, CU Structural Soil™, Carolina Stalite, or Davis soil) suitable for sustaining long-term tree growth and able to accommodate rainwater storage and infiltration. It is imperative to use the appropriate type of soil. There are two general categories:
  - Structural soil is designed to accommodate traffic
  - Engineered soil is designed for tree wells/swales where there is no vehicular traffic
- Use water tolerant trees to match sub-grade characteristics, or where design conditions are unable to ameliorate poorly draining soils.
- Combine city tree/landscape plan with stormwater management plan to provide stormwater runoff infiltration/filtration and aesthetic benefits.
- Use pervious surfaces and structural or engineered soil to promote surface rainwater to penetrate the “urban skin” and infiltrate. Use pervious paving such as permeable pavers, porous concrete, or porous asphalt (with a guaranteed maintenance plan) to allow for “at-the-source” treatment – infiltration and bioretention (See 1.3, *Green Communities Criteria 6.4a Water-Permeable Walkways and 6.4b Water-Permeable Parking Areas*).
- For pervious pavement maintenance practices, follow the manufacturer’s or supplier’s recommendations for the particular application and climate zone.
- Consider using permeable pavers and porous paving for sidewalks and other surfaces to distribute stormwater to tree wells and open space for recharge and to reduce peak flows.
- Ensure designs meet the Americans with Disabilities Standards and relevant safety codes. [www.usdoj.gov/crt/ada/stdspdf.htm](http://www.usdoj.gov/crt/ada/stdspdf.htm)
- Select salt tolerant species for areas that will be heavily salted in winter.
- Provide subsurface drainage at an appropriate height (elevation) to promote the dissipation of stormwater from the recharge beds.
- Use traffic circles and roundabouts to provide additional tree locations and increase permeable surface area.
- For central median plantings, use techniques to divert and collect stormwater within these areas. Where trees are separated from adjacent planting areas by concrete walks, provide structural soil passageways to allow the trees’ roots to access them.
- Consider directing surface water to plant beds of water-cleansing species before it is directed to the city trees and/or structural soil infiltration beds. Where high winter salt use occurs, ensure plants are salt tolerant. Areas for diverting stormwater to trees listed in order of priority:
  - Pervious paving immediately above roots
  - Adjacent non-road surfaces
  - Adjacent roofs
  - Adjacent roads

**1.6****Improving Water Quality –  
Stormwater Interception, Rate Control, Filtration & Infiltration** (continued)

- The amount of stormwater runoff treated by a tree is related to the amount intercepted by the leaf canopy (which can exceed 59% for old growth trees<sup>6</sup>), the amount infiltrated by the bio-infiltration BMP (depends on design), and by the amount taken up by the roots (2.7 gal/day<sup>7</sup>).
- Develop *Tree Biofiltration Devices* to treat the first ½-inch of stormwater runoff. A *Tree Biofiltration Device* consists of a permeable surface (planting area and porous pavements) over structured soil used for the dual purpose of tree growth and stormwater management, as described in this document.
- Incorporate tree biofiltration devices with other stormwater BMPs (bioswales, rainwater gardens, etc.).
- The Minnesota Stormwater Manual addresses the use of trees as part of stormwater management in multiple sections. Credits are specifically discussed in Chapter 11 “Applying Stormwater Credits to Development Sites,” Section 3.2 “Site Reforestation or Prairie Restoration Credits.”

NOTE: There is interest in developing a site-specific credit system for stormwater BMPs based on trees, similar to the system for stormwater ponds under the National Urban Runoff Program (NURP). This is being pursued by a number of state and national organizations, including Tree Trust, Bonestroo, MN watershed districts, MPCA, MN cities, and the U.S. Forest Service.

**1.7 Maintenance**Optional  
(5 points)**INTENT**

City trees, due to their prominent location within the urban framework, typically require some active maintenance. Cities should practice Integrated Pest Management (IPM) and use organics and/or slow-release fertilizers. They should also prohibit chemical inputs such as fertilizers, pesticides, or herbicides. The amount of tree canopy is positively correlated with phosphorus runoff from streets, and the City Tree Program should not add to it.<sup>10</sup> Effective interdepartmental communication and coordination is critical to the long-term success of a City Tree Program.

**HOW**

**Provide a long-term management plan and risk management plan that employs best management practices** for tree maintenance and is adaptable to changing climate conditions. Provide a risk management plan that details the level of acceptable risk and how that translates into tree maintenance procedures. Provide a storm response approach that details approaches and methods. Specifically addresses the following:

- Delivery of supplemental water if required
- Deicing methods other than salt on pervious paving
- Neutralize salt in northern climates
- Aerate compact soils
- Annual flushing
- Fertilizing
- Trimming and inspection
- Annual mulch and root collar examination
- Proper disposal of tree waste that is diseased or contains pests
- Removal of staking and guying after tree establishment
- Pest and disease prevention
- Tree and stump removal
- Mulch recycle program
- Leaf litter removal and compost program
- Citizen tree watering campaign
- Sun scald, winter burn, and wind damage
- Utility interference
- Visibility interference to traffic movement and traffic signs



## 1.7 Maintenance (continued)

### CONSIDERATIONS

- Annual spring flushing helps rid soils of salt (not applicable in clay soils) while the tree is mainly dormant and prior to the new growth being burned.
- Implement a tree waste utilization program and a composting program.
- Absence of a visible root collar, or flared base, means the tree is either planted too deep, or the roots are girdling the trunk, or both, which may result in a decline in tree health and premature death.<sup>8</sup>
- Implement a tree waste utilization program to generate revenue to offset maintenance costs.
- Consider using tree waste for biomass energy production.
- Implement a composting program that minimizes the release of carbon into the atmosphere.
- Implement a leaf/seed/litter management program with leaf and seed pick-up and street sweeping corresponding to the trees' leaf and seed drops.
- Trim to direct growth, for structure (prune when young), form, and risk management.
- Provide bicycle racks to discourage locking bikes to young trees.
- Promote citizen group endorsement and/or area "adoption" programs.
- Implement an effective interdepartmental communication approach and coordination methods.
- No net loss of stored carbon to the atmosphere by utilizing quality tree waste for products.



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- <sup>2</sup> City of Davis Community Forest Management Plan (September 2002)
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- <sup>4</sup> *Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting* (McPherson and others, August 2005)
- <sup>5</sup> USDA Center for Urban Forest Research; *Effects of Street Tree Shade on Asphalt Concrete Pavement Performance: Why Shade Streets?*
- <sup>6</sup> Xio, McPherson, Ustin, Grismer, Simpson; *A New Rainfall Interception Measuring System*; USDA Forest Service
- <sup>7</sup> Sivyer, David; Harris, J. Roger; Persaud, Naraine; and Appleton, Bonnie: *Evaluation of a Plan Evaporation Model for Estimating Post Planting Street Tree Irrigation Requirements*
- <sup>8</sup> Johnson, Gary R.; Hauer, Richard J.; *A Practitioner's Guide to Stem Girdling Roots of Trees: Impacts on Trees, Symptomology, and Prevention*, Regents of the University of Minnesota; 2002.
- <sup>9</sup> USDA Forest Service, *The Large Tree Argument: The Case for Large-Stature Trees vs. Small-Stature Trees*, 2004.
- <sup>10</sup> Pitt, R.; Bannerman, R.; Sutherland, R. Water Word and Environmental Resources Conference 2004. *The Role of Street Cleaning in Stormwater Management*
- <sup>11</sup> USDA Center for Urban Forest Research; *Green Streets: Storm Water Management System for Paved Areas* (June 2006)
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- <sup>15</sup> Kuo, Frances E. May 2003. *Social Aspects of Urban Forestry: The Role of Arboriculture in a Healthy Social Ecology*. Journal of Arboriculture 29 (3).



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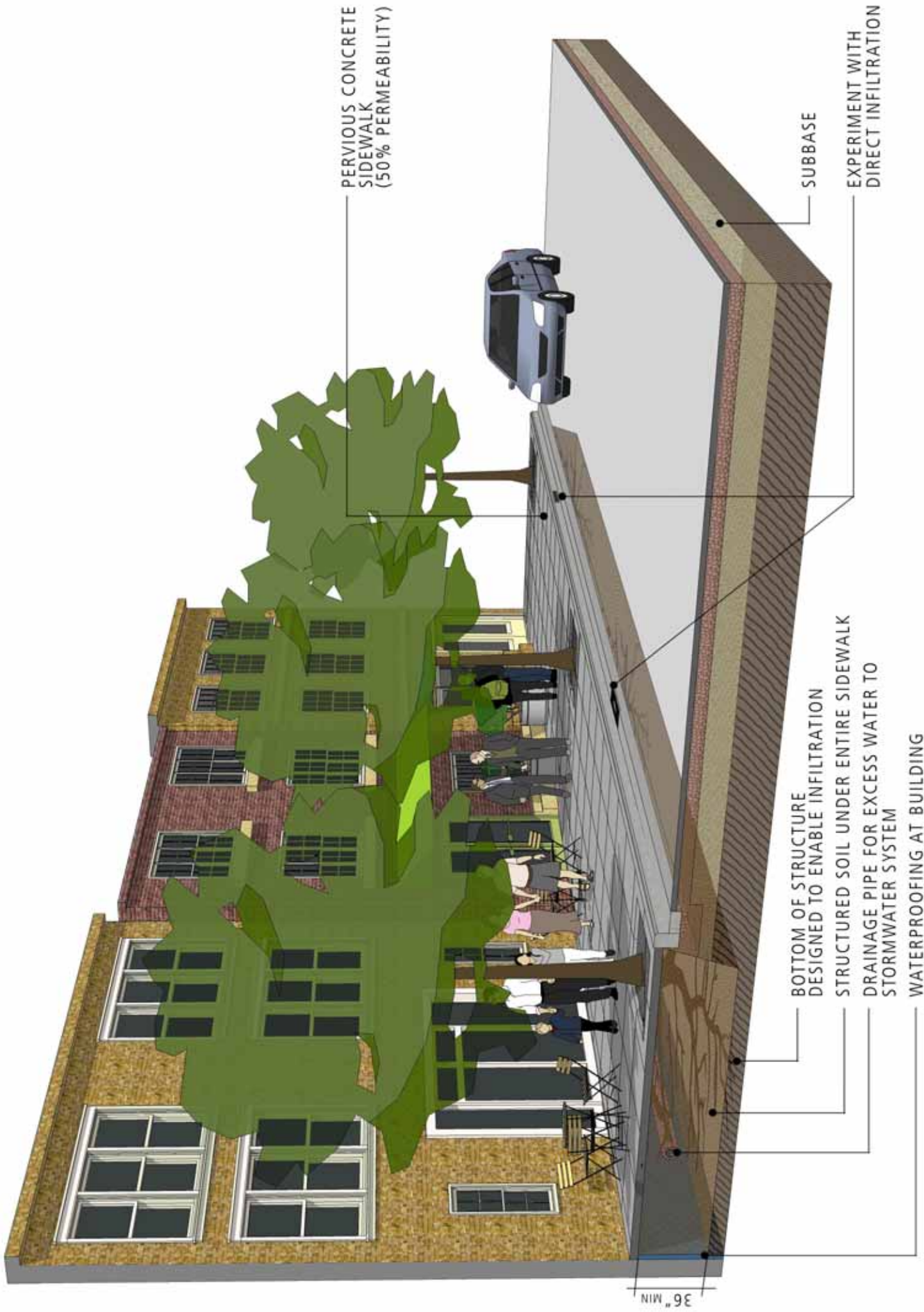
## Useful Links and Resources

[159.121.9.10/wq/pubs/factsheets/uic/uicstormwater.pdf](http://159.121.9.10/wq/pubs/factsheets/uic/uicstormwater.pdf)  
[research.cals.cornell.edu/entity?home=6&id=20639](http://research.cals.cornell.edu/entity?home=6&id=20639)  
[www.arboday.org/programs/buildingwithtrees/index.cfm](http://www.arboday.org/programs/buildingwithtrees/index.cfm)  
[www.ecosmart.gov/](http://www.ecosmart.gov/)  
[www.enterprisefoundation.org/](http://www.enterprisefoundation.org/)  
[www.epa.gov/greenskapes/](http://www.epa.gov/greenskapes/)  
[www.firewise.org/](http://www.firewise.org/)  
[www.greencommunitiesonline.org/](http://www.greencommunitiesonline.org/)  
[www.greenhighways.org/](http://www.greenhighways.org/)  
[www.lid-stormwater.net/](http://www.lid-stormwater.net/); <http://www.lowimpactdevelopment.org/>  
[www.nsrwa.org/greenskapes/](http://www.nsrwa.org/greenskapes/)  
[www.stopwaste.org/home/index.asp?page=188](http://www.stopwaste.org/home/index.asp?page=188)  
[www.sustainabilityproject.org/DesktopDefault.aspx?pageid=88](http://www.sustainabilityproject.org/DesktopDefault.aspx?pageid=88)  
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[www.anjec.org/pdfs/Stormwtr.pdf](http://www.anjec.org/pdfs/Stormwtr.pdf)  
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[www.eoainc.com/download/3\\_Tree\\_Well\\_Filter\\_Technical\\_Guidance.pdf](http://www.eoainc.com/download/3_Tree_Well_Filter_Technical_Guidance.pdf)  
[www.fs.fed.us/psw/programs/cufr/products/cufr\\_665\\_GreenstreetsStructuralSoilsPub6-20-06.pdf](http://www.fs.fed.us/psw/programs/cufr/products/cufr_665_GreenstreetsStructuralSoilsPub6-20-06.pdf)  
[www.fs.fed.us/psw/programs/cufr/products/psw\\_cufr686\\_UCDParkingLot.pdf](http://www.fs.fed.us/psw/programs/cufr/products/psw_cufr686_UCDParkingLot.pdf)  
[www.fw.vt.edu/UrbanForestry/Posters/Trees\\_and\\_StructuralJB.pdf](http://www.fw.vt.edu/UrbanForestry/Posters/Trees_and_StructuralJB.pdf)  
[www.itreetools.org](http://www.itreetools.org)  
[www.nrdc.org/water/pollution/storm/chap12.asp](http://www.nrdc.org/water/pollution/storm/chap12.asp)  
[www.pca.state.mn.us/publications/wq-strm9-17.pdf](http://www.pca.state.mn.us/publications/wq-strm9-17.pdf)  
[www.shinglecreek.org/comloc.shtml](http://www.shinglecreek.org/comloc.shtml)  
[www.unh.edu/erg/cstev/](http://www.unh.edu/erg/cstev/)  
[www.unh.edu/erg/cstev/fact\\_sheets/tree\\_box\\_filter.pdf](http://www.unh.edu/erg/cstev/fact_sheets/tree_box_filter.pdf)  
[www.urbanext.uiuc.edu/lcr/LGIEN2002-0017.html](http://www.urbanext.uiuc.edu/lcr/LGIEN2002-0017.html)  
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[www.walkable.org/download/22\\_benefits.pdf](http://www.walkable.org/download/22_benefits.pdf)

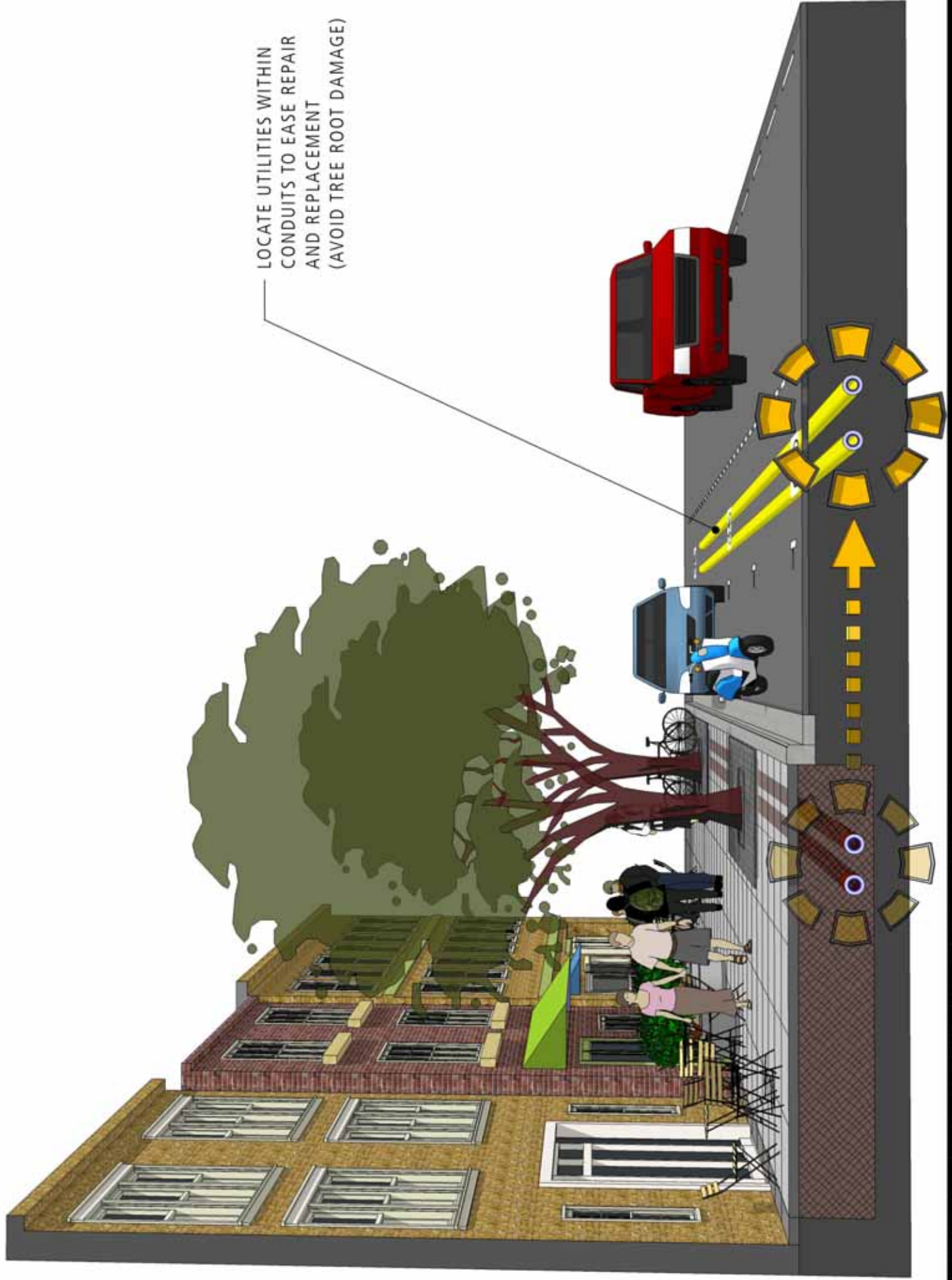


TREE VAULTS (COFFINS- RESTRICTIVE PLANTER OR COMPACTED URBAN SOIL)  
 IMPERVIOUS CONCRETE WALK (TOTAL RUNOFF)

**FIGURE 1: TYPICAL STREET TREE VAULT INSTALLATION**



**FIGURE 2: TREE BIOFILTRATION DEVICE (STRUCTURED SOIL TREE INSTALLATION)**



LOCATE UTILITIES WITHIN  
CONDUITS TO EASE REPAIR  
AND REPLACEMENT  
(AVOID TREE ROOT DAMAGE)

FIGURE 3: SHIFT UTILITIES TO STREET

UTILITIES LOCATED UNDER  
BIKE LANE REDUCES TRAFFIC  
DISRUPTION DURING REPAIR

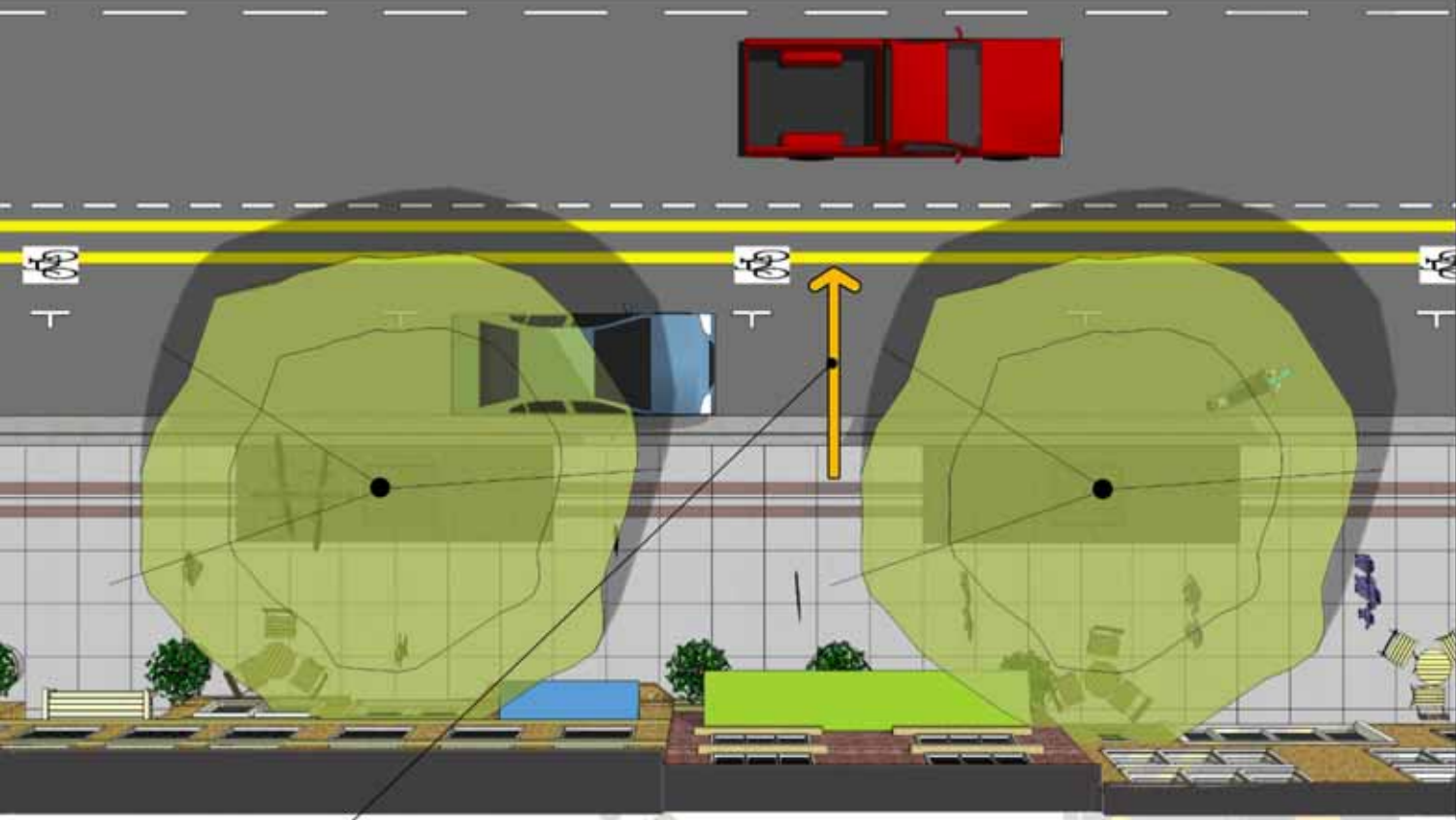


FIGURE 4: SHIFT UTILITIES TO STREET

CITY TREES - SUSTAINABILITY GUIDELINES & BEST PRACTICES

PILOT VERSION - AUGUST 2007



REMOVABLE SIDEWALK PANELS  
TO EASE UTILITY MAINTENANCE

TREE SHADE REDUCES  
DETERIORATION OF ASPHALT  
PAVING

FIGURE 5: BUMP OUTS SHIFT UTILITY LOCATIONS TO SIDEWALK

UTILITIES LOCATED UNDERNEATH  
PEDESTRIAN CORRIDOR MAY  
ALLOW LARGER PLANTING AREA  
AT THE STREET

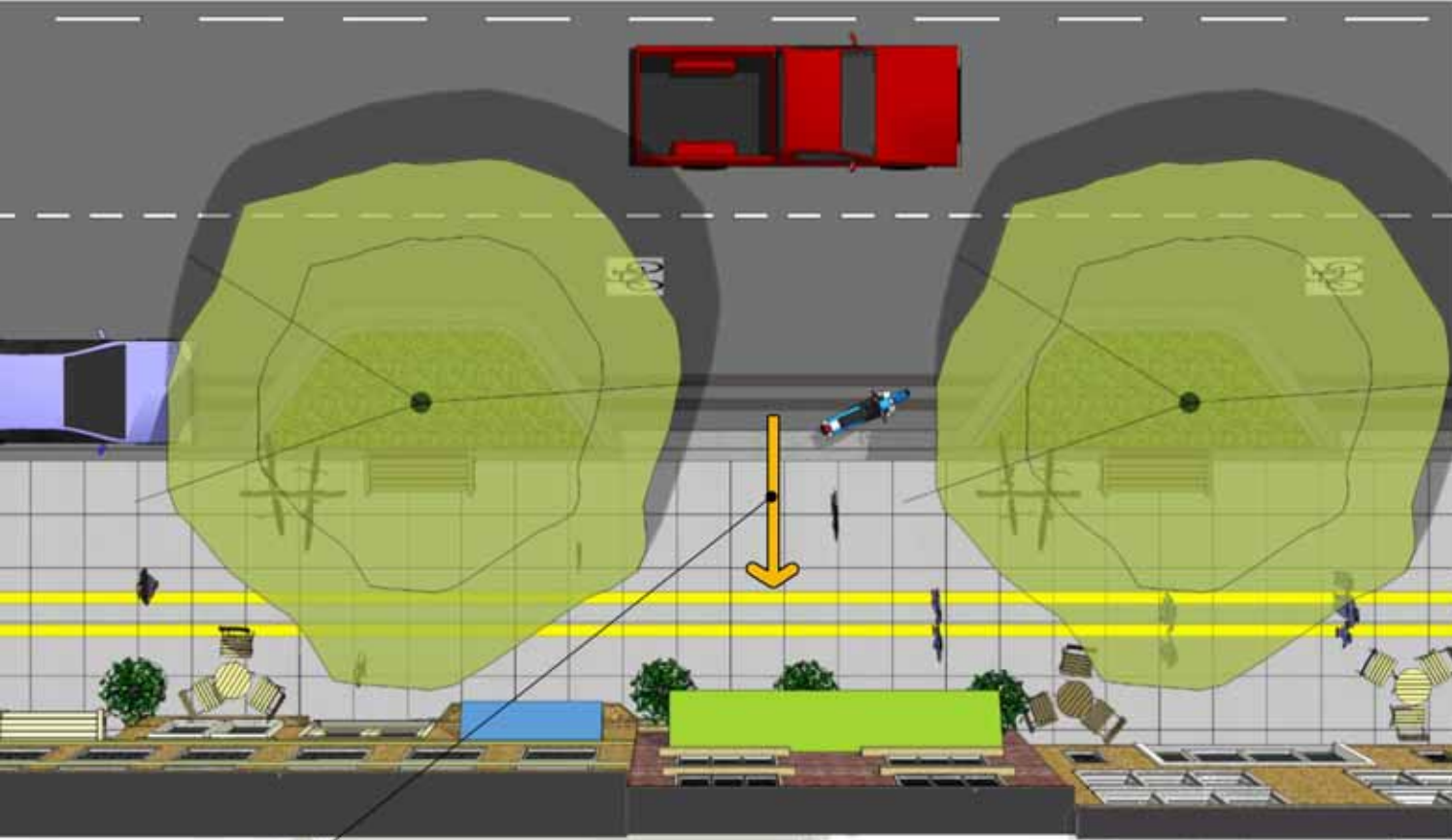


FIGURE 6: BUMP OUTS SHIFT UTILITY LOCATIONS TO SIDEWALK



TREES AND PERENNIALS PLANTED IN AMENDED SOIL  
4" TO 6" RAISED CONCRETE CURB WITH METAL PLANTER EDGE HOOPS  
STRUCTURED SOIL (EXTENT VARIES)  
STRUCTURED SOIL BETWEEN TREE PLANTINGS (MINIMUM)

FIGURE 7: RAISED PLANTERS WITH LANDSCAPE EDGING



TREES IN CONTINUOUS  
STRUCTURED SOIL TRENCH (MINIMUM)

CRUSHED GRANITE AND FINES

STRUCTURED SOIL (EXTENT VARIES)

PERMEABLE PAVERS OVER  
STRUCTURED SOIL

**FIGURE 8: PERMEABLE PAVERS AND EXPANDABLE OPENINGS**

PILOT VERSION

# CITY TREES

sustainability guidelines & best practices

AUGUST 2007

