Chapter 4: Low Impact Development Site Design

Introduction

Site design measures are used to reduce the project's impact on water quality and beneficial uses. Site design measures are not treatment measures. Including site design measures in a project does not meet the C.3 requirements for stormwater treatment, but it can help reduce the size of treatment measures (see Section 4.1). Site design measures can be grouped into two categories:

- Site design measures that ***preserve sensitive areas*** and high-quality open space**,** and
- Site design measures that ***reduce impervious surfaces*** in a project.

This chapter focuses on site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into smaller treatment measures than would have been required without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. Site design measures to reduce stormwater runoff can be incorporated in the project in various ways described in this chapter and organized in the following sections.

- Tree Preservation/Planting and Interceptor Tree Credits
- Self-Treating Areas
- Self-Retaining Areas
- Reducing the Size of Impervious Areas
- Rainwater Harvesting and Use
- Site Design Requirements for Small Projects

Where landscaped areas are designed to have a stormwater drainage function, it is important that they be installed and maintained without the use of fertilizers and pesticides. Consult ***Bay-Friendly Landscaping*** (see Resources) and the Planting Guidelines in Appendix A. Landscaped areas with stormwater drainage functions also need to be carefully integrated with other landscaping features on the site early in project design. This may require coordinating separate designs prepared by different professionals.

> **Warning**
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> Site design measures used to reduce the size of stormwater treatment measures must not be removed from the project without a corresponding resizing of the stormwater treatment measures.

Remember that any site design measures (including self-treating areas) used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures. For this reason, the municipality may require site design measures to be included in the maintenance agreement or maintenance plan for stormwater treatment measures, or otherwise recorded with the deed. Depending on the municipality, site design measures may be subject to periodic operation and maintenance inspections. Check with the municipal staff regarding local requirements.

4.1 Tree Preservation/Planting and Interceptor Tree Credit

Trees perform a variety of functions that reduce runoff volumes and improve water quality. Leaf canopies intercept and hold rainwater on the leaf surface, preventing it from reaching the ground and becoming runoff. Root systems create voids in the soil that facilitate infiltration. Trees also absorb and transpire large quantities of groundwater, making the soil less saturated, which allows more stormwater to infiltrate. Through the absorption process, trees remove pollutants from stormwater and stabilize them. Finally, tree canopies shade and cool paved areas.

A project may earn stormwater treatment credits in limited areas by planting new trees and preserving existing trees at the project site. For each qualifying tree that is planted or preserved, the project earns stormwater treatment credits, which reduce the surface area (measured in square feet) of the project that must receive stormwater treatment. In other words, the stormwater treatment credit can be subtracted from the amount of impervious area requiring treatment. Interceptor trees are usually chosen as a measure to address small, difficult to treat areas. ***Interceptor tree credits should not be used for more that 5-10% of the impervious area requiring treatment, and may be reduced or not allowed based on the judgment of the municipality.***

As shown in Table 4-1, different amounts of stormwater reduction credit are assigned to new evergreen and new deciduous trees, and existing trees receive credit for the square footage that is under the existing tree canopy. To be eligible for these credits, the trees need to meet the minimum requirements listed in Section 4.1.1. Guidance for planting and protection during construction is provided in Section 4.1.2. Additional information about planting trees in dense, urban settings is provided in Section 4.1.3.

4.1.1 Minimum Requirements for Interceptor Trees

The following requirements are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions. Table 4-1 presents the credits allowed for different types of trees that meet the interceptor tree requirements. These credits only apply to the drainage management area within which the trees are located.

Table 4-1: Stormwater Treatment Credits for Interceptor Trees

	New Evergreen Trees	New Deciduous Trees	Existing Trees
Credits for new and existing trees that meet interceptor tree minimum requirements	200 square feet	100 square feet	Square footage under the tree canopy for trees with an average DBH of 12 inches or more.
*DBH: Diameter at breast height (4.5 feet above grade) Source: BASMAA LID Feasibility Criteria Report, 2011 (based on the tree credit system in the State Construction General Permit standards for post-construction stormwater control)			

Design Guidance for New Interceptor Trees

To be eligible for stormwater interceptor tree credits, trees planted as part of the project must meet the following minimum requirements:

- The new tree shall be located within 25 feet of ground-level impervious surface (as included in the project's calculation of impervious surfaces).
- Do not compact soil or install pavement within 2 feet of the tree trunk – provide an unpaved soil planting area (with mulch) in a minimum 2 foot-diameter area around the tree trunk.
- If any pavement or compaction of soil beyond 85% is needed within a distance of 2 to 10 feet from the tree trunk, consider using suspended pavement systems to avoid soil compaction (see Section 4.1.3 for more information) or pervious pavement, where feasible.
- Maintain appropriate distance from infrastructure and other structures that could be damaged by roots; avoid overhead power lines, underground utilities, septic systems, sidewalks, curbs, patios, etc.
- Space trees so crowns do not overlap at 15 years of growth.
- Dwarf and small tree species are not acceptable; tree species to be planted must be at least of medium height and spread at maturity. (Sizes of trees are defined by their height at maturity for their species: small trees are up to 20 feet in height; medium are 21- 40 feet; large are over 40 feet.)
- Clearly label on project plans the trees designated for stormwater interceptor tree credits and the areas near each tree that are being credited.
- Interceptor tree credits may not be used for trees installed as part of a stormwater treatment measure (e.g., flow-through planter, green roof or bioretention area.)

Design Guidance for Preserving Existing Interceptor Trees

To be eligible for stormwater interceptor tree credits, existing trees that have been evaluated and considered worthy of preservation at the project site must meet the following minimum requirements:

- The tree trunk must be located within 25 feet of ground-level impervious surface that is included in the project's calculation of the amount of stormwater runoff that will require treatment.
- If the tree to be preserved is large, the roots should be protected from compaction by keeping the impervious surface at the edge of the tree canopy (also known as the drip line).
- Dwarf species are ineligible.
- Clearly label on project plans the trees designated for stormwater interceptor tree credits.
- The tree's trunk must be located within the property limit of the site, or if outside the site boundary, the tree may only be used for credit per agreement with the permitting jurisdiction.

4.1.2 Interceptor Tree Planting and Construction Guidelines

The following guidelines are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions with additional recommendations from Bay Area sources including the City of Palo Alto, City of Emeryville, and tree advocacy organizations Canopy and Our City Forest.

Planting New Interceptor Trees

- Sufficient rootable soil volumes must be provided for each tree – see Section 4.1.3 for discussion of soil volumes and recommended quantities per tree.
- Specified trees must be 15-gallon container minimum size at planting.
- Drainage and soil type must support selected tree species.
- Avoid compaction of soil in planting areas for new pavement – see Section 4.1.3 for more information.
- Avoid contamination of planting areas by construction related materials such as lime or limestone gravel.
- Avoid planting turf grass within the drip line of trees – the irrigation needs of turf grass conflict with the water needs of trees.
- Place a 3-6 inch layer of composted arbor mulch, but leave bare soil within 6 inches of the tree trunk.
- A permanent irrigation system may be required.
- Avoid the use of pre-emergent herbicides with tree planting.
- Avoid the use of synthetic fertilizer tablets with tree planting – use compost and other natural fertilizers to build soil health.
- Avoid excess irrigation due to mosquito issues and tree health.
- Provide proper maintenance for trees, especially during the first 10 years. Pruning and removal and replacement of diseased/damaged trees may be required (**see Chapter 6 of the GI Design Guide for more guidance on proper tree pruning and maintenance).**
- During construction, protect trees with high-visibility protective fencing at the outer limit of the critical root zone area (CRZA) to keep heavy machinery out of the CRZA and use other tree protection measures per the recommendations of a qualified arborist.

Preserving Existing Interceptor Trees

- Plan new appropriate landscaping under existing trees to avoid grade changes and excess moisture in the trunk area, depending on the tree species. Preserve existing plants that are compatible with irrigation requirements (in the correct hydrozone) and are consistent with the landscape design. Avoid planting turf within the drip zone of existing trees as the irrigation needs of turf conflict with tree water needs.
- Avoid grade changes greater than 6 inches within the critical root zone.
- Avoid soil compaction under existing trees – do not install pavement within the drip line of the canopy unless hand-digging and suspended pavement systems are used to avoid damage to existing roots and soil compaction.
- Protect existing trees during construction to avoid damage to the tree and its root systems. Prepare and implement a tree protection plan with a qualified arborist, including the use of high-visibility construction fencing at the outer limit of the critical root zone area. The fence must prevent equipment traffic and storage of materials under trees. Excavation in this area should be done by

hand and roots ½-inch and larger should be preserved or per the tree protection plan recommendations. Pruning of branches or roots should be done by, or under supervision of, an arborist.

- For maintenance of trees and other guidance, see **Chapter 6 of the GI Design Guide**.
- Plans and specifications shall clearly state protection procedures for interceptor trees to be preserved.
- Provide irrigation of trees during and after construction.

4.1.3 Tree Planting in Dense, Urban Areas

Figure 4-1. London plane tree leaves blocking an inlet (Credit: EOA, Inc.)

In general, trees should only be ***planted in bioretention systems*** when the tree species is appropriate for sandy soils (or where adjacent loamy/clayey soils can be utilized and accessed by tree roots) and sufficient soil volumes and space are provided for the tree to reach mature size without causing problems with surrounding infrastructure, pavement, and buildings. Overhead infrastructure, such as lighting, awnings, and utilities can also reduce space for trees or limit the list of tree species for selection to smaller stature types. The design of the system and tree species selected should also be carefully considered for future irrigation needs (especially with large tree species, as irrigation demand may increase as the tree grows, possibly causing problems in a future drought scenario.) Hybrid systems that are able to use different soil types in different sectors of the landscape can also assist in providing water retaining soils for large trees.

Retrofitting or modifying an existing planting area with a tree into a bioretention area with that tree can be done, but there are many design and construction issues. An arborist or landscape architect should be consulted before attempting that advanced strategy. Similarly, ***if a stormwater treatment measure is proposed for a location adjacent to an existing tree of value***, then the impacts to and protection measures for the tree should be discussed with an arborist. The design of the measure might also have to be modified to protect the tree. Trees that have not previously been inundated with water during the rainy season and become inundated after modification into a bioretention area can experience health impacts. This can occur when pavement surrounds the tree and that pavement is removed as part of the retrofit.

High volumes of leaf drop in a short period of time can create inlet blockages in stormwater treatment measures, so leaf collection or accommodation of degradation of leaves within the stormwater landscape needs to be assessed and/or incorporated into the design before large broadleaf deciduous trees (such as the London Plane or Sycamore) are selected. Figure 4-1 shows an example of an inlet with leaf blockage. Another species of tree, the Brisbane Box, native to Australia but commonly planted in the Bay Area, is a broadleaf evergreen with large waxy leaves. Its leaves drop over longer periods of time, so this could create fewer stormwater treatment measure maintenance and inlet blockage problems. Coniferous evergreen trees generally have needles or other smaller leaf growth that is also dropped gradually. Another category of tree type is coniferous deciduous, such as the Dawn Redwood (native to China but also commonly planted in the Bay Area). Its soft leafy needles drop every autumn but are smaller in size.

Trees can be a** valuable **tool in the stormwater landscape design kit. Integrating trees and stormwater treatment can be a significant aspect of a site plan. Here are some of the benefits provided by trees:

- Moderate the urban climate reducing heat-related stress and energy usage;
- Intercept water before it reaches impervious surfaces;
- Mitigate air pollution from vehicles;
- Sequester carbon from fossil fuel combustion;
- Improve the public's perception of the site;
- Increase walking and cycling activity;
- Increase community health;
- Provide shade for events;
- Add beauty to the urban environment;
- Reduce frequencies of neighborhood crime;
- Provide habitat for birds and other animals; and
- May provide treatment with a lower long-term maintenance cost.

The last item in the list is an important one to consider. Using trees to treat stormwater may be a better option than using bioretention with small plants only. Landscaping increases maintenance costs. However, over the long-term trees can be less expensive to maintain than bioretention with small plants. Trees – especially large ones - can provide multiple benefits as demonstrated in the list above. Installation costs can be higher with tree-based systems but can pay off in the long term.

Soil volume, soil compaction, structural trimming, and compost, along with appropriate irrigation during the first three years, are important to long-term tree health. Other aspects that influence how street trees perform include exposure (wind and heat) and resistance to disease and pest infestations. See Chapter 6 of the GI Design Guide for extensive information on tree maintenance.

Rootable soil volume is one of the most important metrics to use for achieving tree health and growth. At the average planting site, street trees and trees in parking lots are often dropped into holes with 30-100 cubic feet of soil volume for roots to grow in. Around the hole, compacted soil supports pavement. This tiny hole with compacted soil all around it is woefully inadequate for tree growth and explains why so many trees either die, become stunted or heave adjacent pavement and curbs in order to find places to grow. In order to thrive, trees need soil that can provide oxygen, water, nutrients, microbial life, and structural support.

More and more developers (and public agencies) around the world are realizing that a minimum volume of soil must be provided in order to allow trees to have healthy and long lives without impacting surrounding infrastructure. Pavement lifted by roots is a tripping hazard which can result in expensive lawsuits. Therefore, standards that require the provision of minimum amounts of soil volume at the time of planting based on the size of the tree species at maturity, space available, and/or other metrics have been developed. A Bay Area example of a typical new tree planting requirement is that used in the City of Emeryville, which requires a minimum of 600, 900, and 1200 cubic feet of soil volume per new tree for small, medium and large species respectively. A minimal depth of 3 feet is also typically recommended (see GI Design Guide).

By requiring minimum rootable soil volumes, a key aspect of the long-term growth of a tree is planned for, which reduces the risk of it becoming a liability. In fact, if proper planting standards are met and strategic pruning is provided, trees can yield a net positive triple bottom line benefit instead of a negative one – even with the increased up-front costs of providing more soil volume for a new tree. In one study[15] by DeepRoot Green Infrastructure, the costs and benefits of planting trees in the standard way were compared with the costs and benefits of planting trees with increased soil volumes and then the results were modeled over a 50-year period. In the standard case, the model assumed that the trees would be replanted three times over the 50-year period using an average tree life expectancy of 13 years. The model yielded a net cost of $3,094 per tree, compared to a net benefit of $25,427 per tree in the alternative case with increased soil volumes, over the 50-year period. This is in spite of the much higher upfront costs for the new tree with more soil volume. The study used a cost of $1,000 per standard new tree and $14,000 per tree with increased soil volume using suspended pavement systems to provide the increase. The study shows that large species trees that are planted correctly at the beginning of their lives will reap long-term benefits far surpassing the upfront costs.

Strategies for planting small, medium and large species of trees with different soil volume amounts are shown in Figure 4-2. The image is taken from Washington D.C.'s District Department of Transportation (DDOT) and its Greening DC Streets Manual. The figure illustrates examples of how rootable (85% or less compaction) soil volumes can be achieved in three different scenarios:

1. An open soil area in a typical planter strip;
2. A combination of open soil area and partial underground area using suspended pavement systems; and
3. A combination of open soil area with the majority of soil volume provided underground using suspended pavement systems.

The typical depth of the soil volume provided is 3 to 4 feet. The soil volume quantities of 600, 1,000 and 1,500 cubic feet are the required amounts for DDOT (local permitting jurisdiction standards may vary). Narrow canopy trees are not recommended for stormwater interception and treatment systems. Adjacent trees may also be allowed to share soil volumes in some jurisdictions resulting in a lower total amount of soil volume needing to be provided per tree.

[15] www.deeproot.com/silvapdfs/resources/articles/LifecycleCostAnalysis.pdf

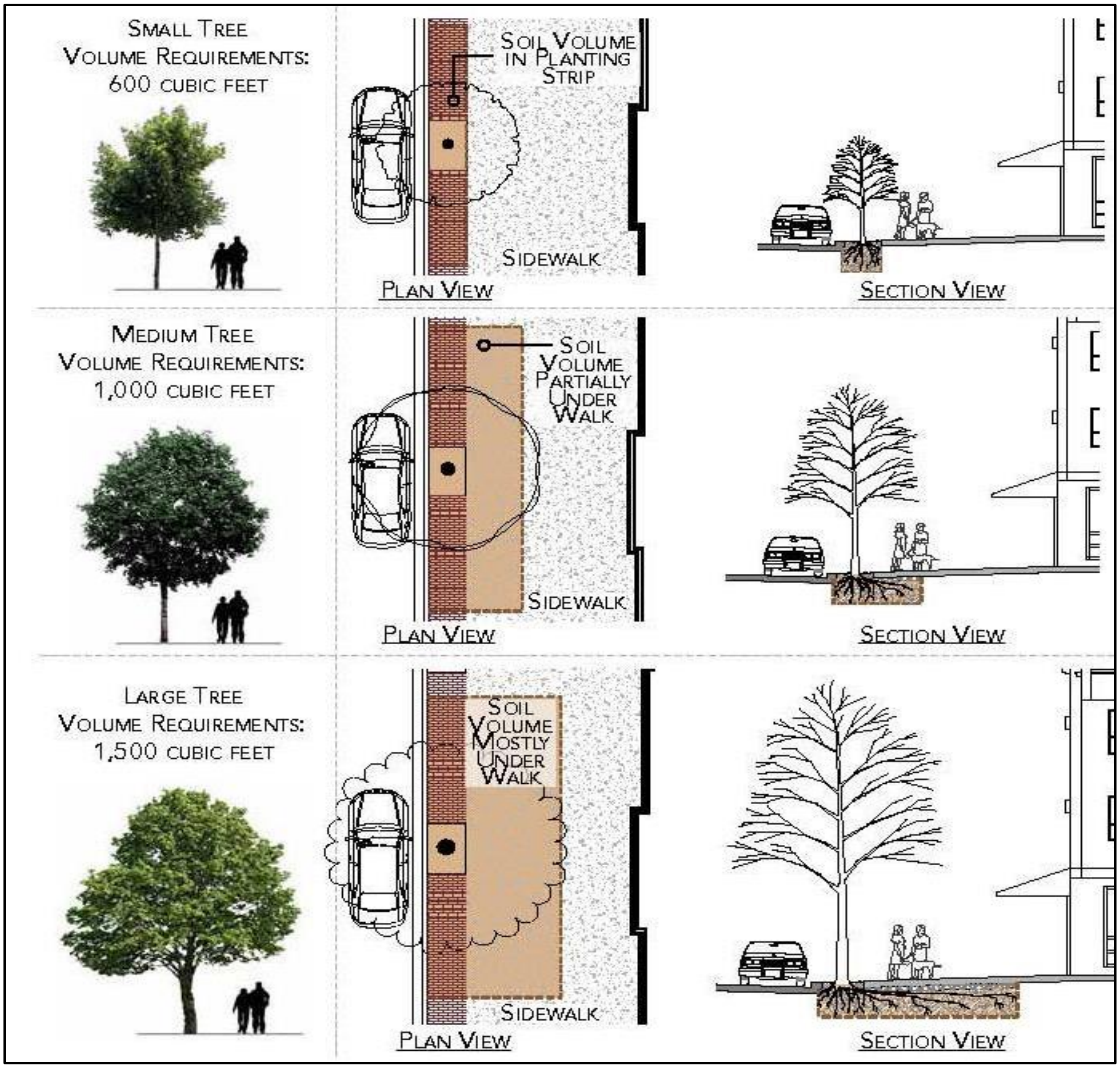


Figure 4-2. Strategies for small, medium and large tree species. (Courtesy of DDOT)

Soil volumes can be provided using open landscaped areas such as planting strips (as long as the soil is not overly compacted and is a good quality soil to a depth of at least three feet). Where limited open space is available for planting trees and roots may damage hardscape, consider the use of ***suspended pavement systems***. One type of suspended pavement system is ***structural soil***. It is a planting medium that consists of a stone skeleton structure for strength and clay soil for water retention, which allows trees to grow under pavement. The structural soil system creates a load-bearing matrix with voids filled with soil and air - essential for tree health. Increased void space and reduced compaction allows for larger amounts of

Key Point

Suspended pavement systems can be used to create planting areas for large trees in narrow medians and planting strips where trees might otherwise conflict with other infrastructure.

oxygen in the soil, improved tree growth rates, better overall health of trees, and reduced pavement uplifting by tree roots. The voids that benefit the tree roots also provide increased stormwater storage capacity, allowing tree pits in paved areas to serve as a series of small detention basins[16]. However, structural soils provide minimal (approximately 20%) amounts of soil because the majority of the space is taken up by the rock and void space.

Modular suspended pavement systems (also known as load-bearing modular grid products), use modules such as the Silva Cell and Stratavault systems, to support pavement and provide improved tree rooting conditions. These products were developed to allow the planting of trees in lightly compacted topsoil or biotreatment soil media (BSM), extending under sidewalks and other areas of pavement. With the Silva Cell product, each cell is composed of a base, six posts and a deck (see Figure 4-3). The posts come in different heights depending on the design and depth of soil to be achieved. The posts are placed on the base, filled with soil and topped with a deck to create a maximum amount of soil volume for tree root growth and stormwater treatment under pavement. Modules can be installed laterally as wide as necessary. Modules can also be designed to accommodate utilities. An additional strategy used to provide trees with adequate soil volumes is related to the planting of trees in places where there is an adjacent landscaped area. If the adjacent area is separated from the tree planting location by impervious surfaces such as sidewalks or parking areas, then suspended pavement systems can be used to provide an uncompacted soil "bridge" or "root channel" between the two landscaped areas allowing roots to grow through and under that pavement to the adjacent landscaped area without heaving of the pavement over time. This strategy can be even more important if the adjacent landscaped area contains a clayey/loamy soil with good water retention compared to the sandy BSM used in bioretention areas. With the expectation of recurrent droughts in the future, loamy soils are a good option for retaining water for trees during the dry season, thereby reducing the need for irrigation. This is important to consider in areas where irrigation with potable water and other types of water such as recycled water, harvested rainwater and graywater may be limited and needed for other purposes. *S*tormwater treatment landscapes can be more resilient if they are not dependent on irrigation alone – especially irrigation with potable water. Techniques to reduce or eliminate irrigation using potable water should be considered. For more information on how to integrate trees and bioretention, refer to Section 6.3.

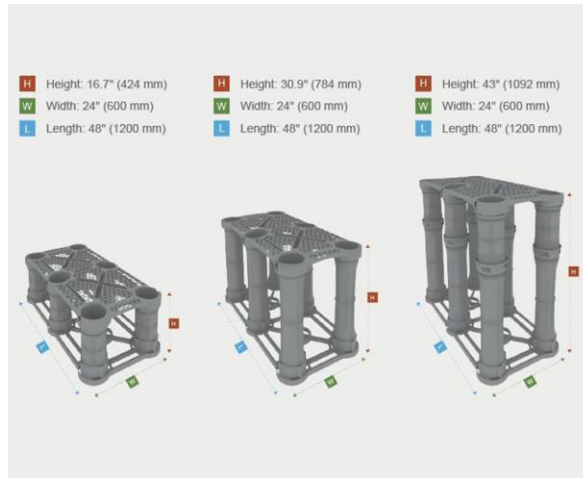


Figure 4-3: Silva Cells, in three heights. (Credit: DeepRoot Green Infrastructure)

[16] See https://blogs.cornell.edu/urbanhort/outreach/cu-structural-soil/ for more information on structural soils.

4.2 Self-Treating Areas

Some portions of the site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, landscaped areas (such as parks, green roofs and lawns), and pervious pavement. These areas are considered "self-treating" because ***infiltration and natural processes that occur in these areas prevent stormwater and pollutants*** from being discharged. Areas of pervious pavement – such as pervious concrete, porous asphalt, or permeable interlocking concrete pavers – and artificial turf may function as self-treating areas if they are designed to store and infiltrate (into native soil) the runoff volume described in Provision C.3.d of the MRP.

> Key Point
>
> If self-treating areas do not receive runoff from impervious areas, runoff from self-treating areas may discharge directly to the storm drain.

As long as the self-treating areas are not used to receive runoff from other impervious areas on the site, and are installed and maintained without the use of pesticides or synthetic fertilizers, the drainage design may route the runoff from self-treating areas ***directly to the storm drain*** system or other receiving water. Consult Appendix A for guidance on using Bay-Friendly landscaping and integrated pest management to avoid the use of pesticides and synthetic fertilizers. Stormwater runoff from the self-treating areas should be kept separate from the runoff from paved and roofed areas of the site, which requires treatment.

Even vegetated areas will generate some runoff. ***If the runoff from the self-treating area commingles with the C.3.d amount of runoff*** from impervious surfaces, then the stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating areas and the impervious areas. This does not apply to the high flows of stormwater that are in excess of the C.3.d amount of runoff, because stormwater treatment measures are not designed to treat these high flows. If the project requires hydromodification management, then the runoff from self-treating areas will need to be included in the sizing calculations for HM treatment measures.

Figure 4-4 compares the size of the stormwater treatment measure that would be required to treat the runoff from a site, depending on whether the runoff from a self-treating area discharges directly to the storm drain system or other receiving water. In the first (upper) sequence, runoff from the self-treating area is directed to the stormwater treatment measure. In the second (lower) sequence, runoff from the self-treating area bypasses the treatment measure and flows directly to the storm drain system or other receiving water, resulting in a smaller volume of stormwater that will require treatment. This results in a ***smaller stormwater treatment measure***.

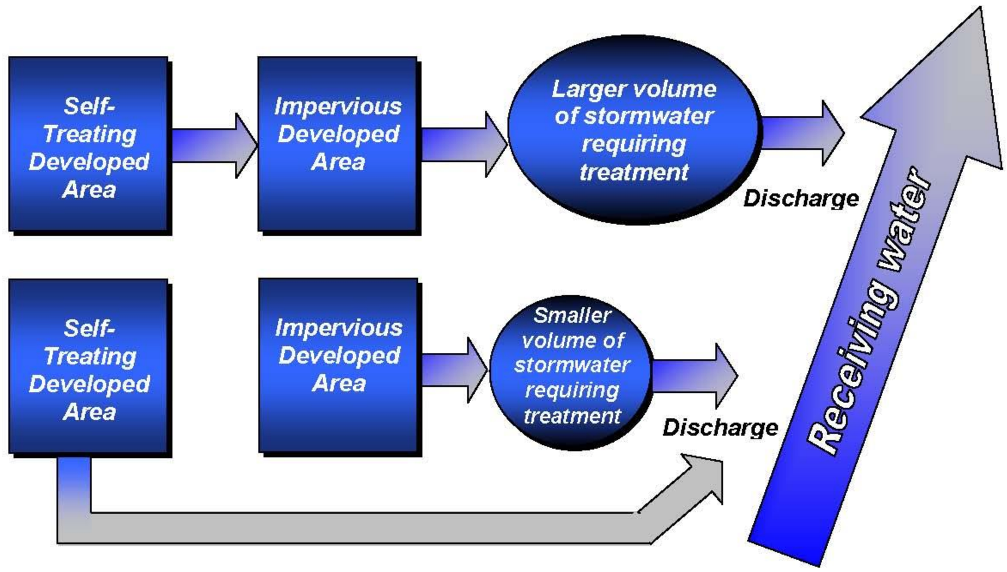
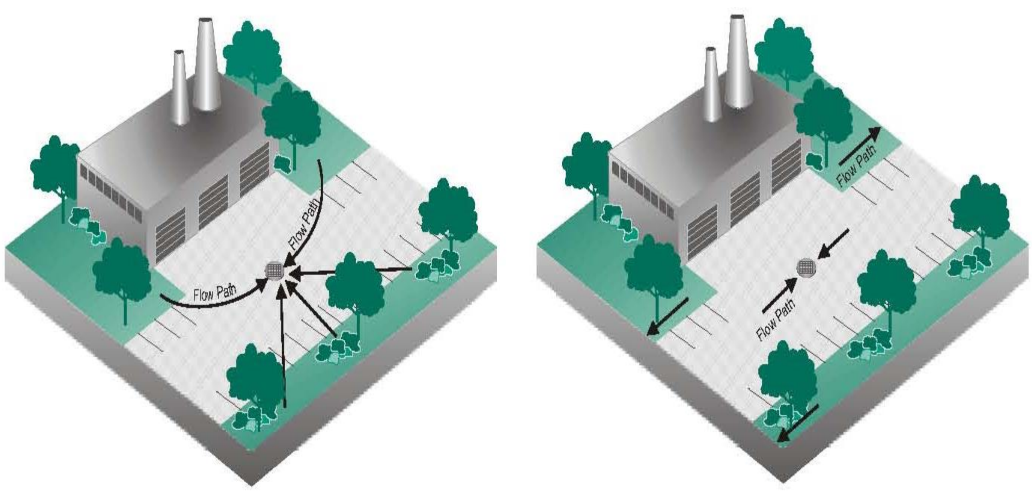


Figure 4-4: Self-Treating Area Usage (Source: BASMAA, 2003)

Figure 4-5 compares the conventional drainage approach to the self-treating area approach. The conventional approach combines stormwater runoff from landscaped areas with the runoff from impervious surfaces. Assuming the parking lot storm drain leads to a treatment measure, in the conventional approach, the treatment measure will need to be sized to treat runoff from the entire site. The ***self-treating area approach*** routes runoff from appropriately designed and maintained landscaped areas directly to the storm drain system. In this approach, the treatment measure is sized to treat only the runoff from impervious areas.



Conventional Drainage Approach *Self-Treating Area Approach*

Figure 4-5: Commercial/Industrial Site Compared to Same Site with Self-Treating Areas (Source: BASMAA 2003)

Figure 4-6 (below) shows an example site in which the runoff from impervious areas must flow to the stormwater treatment measure before discharging to the storm drain, while runoff from the self-treating area may discharge directly to the storm drain. This is allowable because the self-treating area ***does not accept runoff from the impervious areas*** on the site.

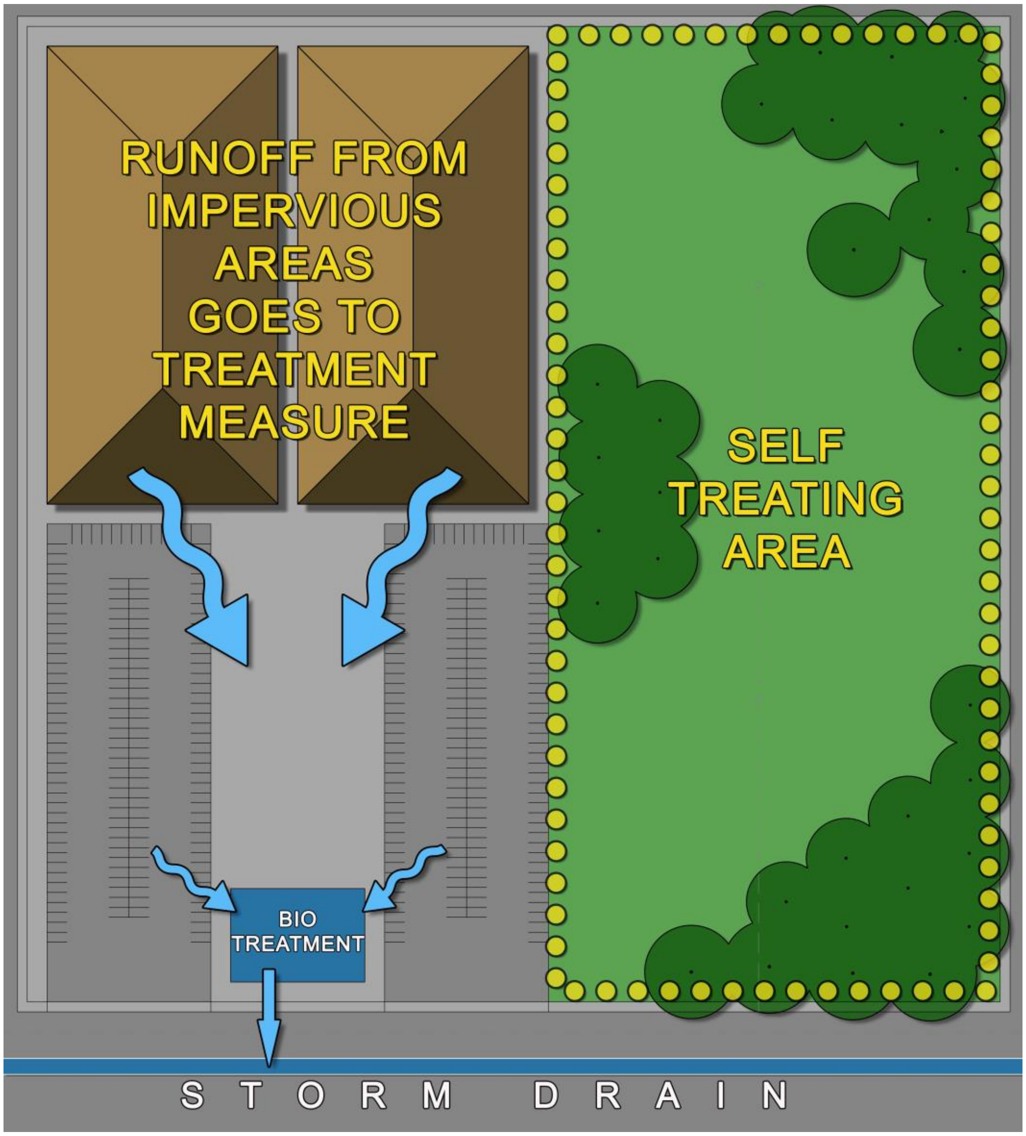
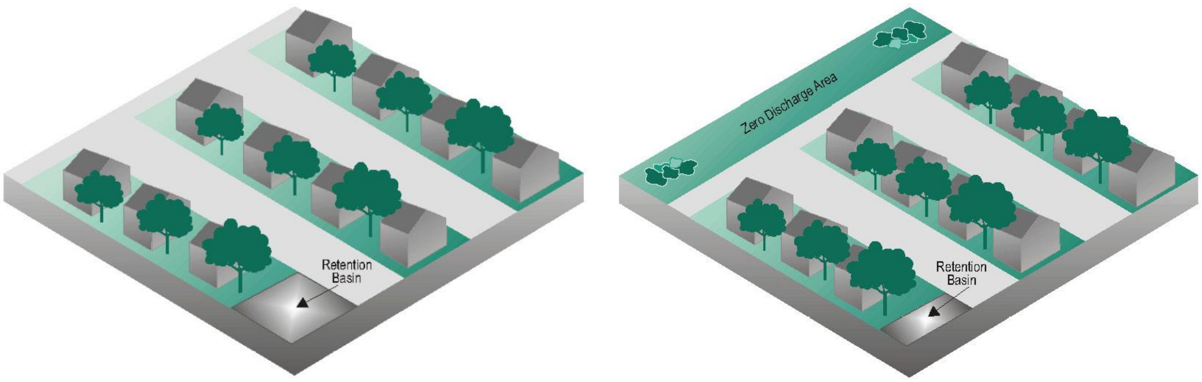


Figure 4-6: Schematic Diagram of a Site with a Self-Treating Area (Credit: SCVURPPP)

4.3 Self-Retaining Areas

In "self-retaining areas" or "zero discharge areas," a portion of the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas, or in properly-designed areas of pervious pavement. If it is possible to create a self-retaining area on the site, smaller stormwater treatment measures can be designed (as illustrated in Figures 4-7 and 4-8). ***Drainage from roofs and paving is directed to the self-retaining area***, where it can be temporarily stored before infiltrating into the soil. Self-retaining areas may be created by designing concave landscaped areas at a lower elevation than surrounding paved areas, such as walkways, driveways, sidewalks and plazas (as illustrated in Figure 4-5); or by designing areas of pervious pavement to accept runoff from impervious surfaces. The following design considerations apply to self-retaining areas.

- Landscaped self-retaining areas are designed as concave areas that are bermed or ditched to retain the first one-inch of rainfall without producing any runoff. Modeling conducted for the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report) demonstrated that a ponding depth of 3 inches is sufficient to meet the C.3 stormwater treatment objective (at a 2:1 impervious to pervious area ratio).
- Pervious pavement designed as a self-retaining area must provide adequate storage in the void space of the gravel base layer to accommodate the volume of runoff specified in Provision C.3.d of the MRP for both the area of pervious pavement and the impervious surfaces that contribute runoff. The area must allow for infiltration of water and not be lined with impervious materials or constructed over an impervious barrier.
- Runoff may enter the self-retaining area as sheet flow, or it may be piped from a roof or area of impervious pavement. The elevation difference between a landscaped self-retaining area and adjacent areas should be sufficient to allow build-up of turf or mulch within the self-retaining area.
- ***A maximum 2:1 ratio of impervious area to the receiving pervious area is acceptable.*** Modeling conducted for the BASMAA LID Feasibility Criteria Report confirmed that a 2:1 ratio is sufficient to achieve the C.3.d stormwater treatment objective, even for soils with very low hydraulic conductivity. The 2:1 ratio applies to both landscaped areas, pervious pavement, and artificial turf areas that are designed as self-retaining areas.
- Drainage from self-retaining areas (for amounts of runoff greater than the first one-inch) must flow to off-site streets or storm drains without flowing onto paved areas within the site.
- If overflow drains or inlets to the storm drain system are installed within a landscaped self-retaining area, set them at an elevation of at least 3 inches above the low point to allow ponding. The overflow drain or storm drain inlet elevation should be high enough to allow ponding throughout the entire surface of the self-retaining area.
- Any impervious pavement within the self-retaining area (e.g., a sidewalk through a landscaped area) cannot exceed 5 percent of the total self-retaining area.
- Slopes may not exceed 4 percent.
- The municipality may require amended soils, vegetation and irrigation to maintain soil stability and permeability.
- Self-retaining areas shall be protected from construction traffic and compaction.



Conventional Design | Design with "Self-Retaining" or "Zero Discharge" Area

Figure 4-7: Allowing some runoff from impervious surfaces to be retained and infiltrate in a "self-retaining" or "zero discharge" area can reduce the size of the required stormwater treatment measure. (Source: BASMAA 2003)

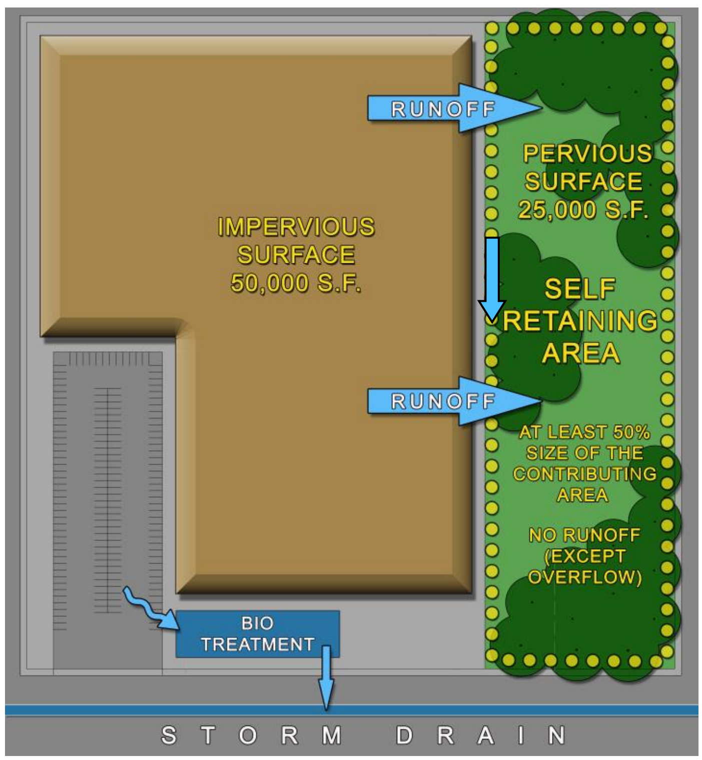


Figure 4-8: Schematic Drainage Plan for Site with a Self-Retaining Area (Credit: SCVURPPP)

If considering the use of a self-retaining area in a project that must meet hydromodification management (HM) requirements, then the Bay Area Hydrology Model should be used to identify the appropriate sizing of the self-retaining area to meet the HM objective of matching post-project stormwater flows and durations to pre-project patterns for smaller, frequent storms (ranging from 2-to 10-yr storm events). See Chapter 7.

4.4 Reducing the Size of Impervious Areas

A variety of project features can be designed so that they result in a smaller "footprint" of impervious surface. These techniques generally need to be incorporated very ***early in the project design***. Several techniques for reducing impervious surfaces are described below.

> **Key Point**
>
> Site designs that reduce the size of impervious area generally need to be incorporated very early in the project design.

Figure 4-9: Installation of permeable interlocking concrete pavers in Oakland. Water infiltrates through gravel in the joints between the pavers. (Courtesy of the City of Oakland)

Alternative Site Layout Techniques

Check with the local jurisdiction about its policies regarding the following site design measures:

- Reduce building footprints by using compact, ***multi-story structures,*** as allowed by local zoning regulations.
- ***Cluster buildings*** to reduce the length of streets and driveways, minimize land disturbance, and protect natural areas.
- *Design* ***narrow streets*** and driveways, as allowed by the local jurisdiction.
- *Using* ***sidewalks on only one side*** of the street may be appropriate in areas with little pedestrian and vehicular traffic, as allowed by the local jurisdiction.

Minimize Surface Parking Areas

A variety of techniques can be used to minimize surface parking areas, in terms of the number and size of parking spaces, as allowed by the local jurisdiction. These solutions focus on either reducing the demand for parking, maximizing efficient use of parking space, or implementing design solutions to reduce the amount of impervious surface per parking space. See Chapter 3 of the GI Design Guide for more guidance on maximizing the efficiency of parking areas.

- Reduce parking demand by ***separating the cost of parking*** from the cost of housing or leasable space. This allows the buyer or tenant to choose how much parking they actually need and are willing to pay for.
- Maximize efficient use of parking space with ***shared parking*** that serves different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evening, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends.
- ***Parking structures*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings that also house office or residential space, or include ground-floor retail lining the street. Shared parking strategies can work very well with structured parking.
- ***Parking lifts*** are another way to reduce the amount of impervious surface needed for parking. A parking lift (shown in Figure 4-10) stacks two to three cars using a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. With proper training for residents, employers, or parking attendants, this strategy can be a practical way to double or triple the parking capacity given a set amount of land.

Figure 4-10: Parking Lifts in Parking Garage, Berkeley (Courtesy of City of Berkeley)

- Another way to maximize the efficient use of parking area is ***valet parking***, where attendants park cars much closer than individual drivers would in the same amount of parking space.

4.5 Rainwater Harvesting and Use

Technical guidance for rainwater harvesting and use is provided in Section 6.9 and Appendix I. A rainwater harvesting system is considered a stormwater treatment measure if it is designed to capture and use the full amount of rainwater runoff that is required to be treated per Provision C.3.d of the MRP. A rainwater harvesting system is considered a site design measure if it is designed to capture and use less than the C.3.d amount of runoff. If the project will include a rainwater harvesting system as a site design measure, follow the guidance in Section 6.9, with the exception of meeting the C.3.d stormwater treatment sizing criteria.

4.6 Site Design Requirements for Small Projects

As stated in section 2.3.3, Provision C.3.i of the MRP requires small projects that meet either of the following thresholds to include one of six site design measures listed below:

- Projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface; or
- Individual single-family home projects that create and/or replace 2,500 square feet or more of impervious surface.

Applicable projects must implement at least one of the following site design measures:

- Direct roof runoff into cisterns or rain barrels for use;
- Direct roof runoff onto vegetated areas;
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas;
- Direct runoff from driveways and/or uncovered parking lots onto vegetated areas;
- Construct sidewalks, walkways, and/or patios with pervious pavement; or
- Construct bike lanes, driveways, and/or uncovered parking lots with pervious pavement.

To help select site design measures appropriate for small projects that meet the thresholds described above, the Countywide Program collaborated regionally through the Bay Area Stormwater Management Agencies Association (BASMAA) and developed the following four fact sheets.

- Managing Stormwater in Landscapes
- Rain Gardens
- Pervious Paving
- Rain Barrels and Cisterns

These factsheets, and further detail on implementing site design for small projects, are presented in Appendix L.

To supplement guidance provided in the regional fact sheets, refer to Table L-2 to identify key opportunities and constraints for the site design measures listed in Provision C.3.i. Choose one or more site design measures that are a good match for the project site. Only one site design measure is required for small projects, but additional measures may be selected to increase the water quality benefits of the project.

Additional information on site design measures can be found in the GI Design Guide.