

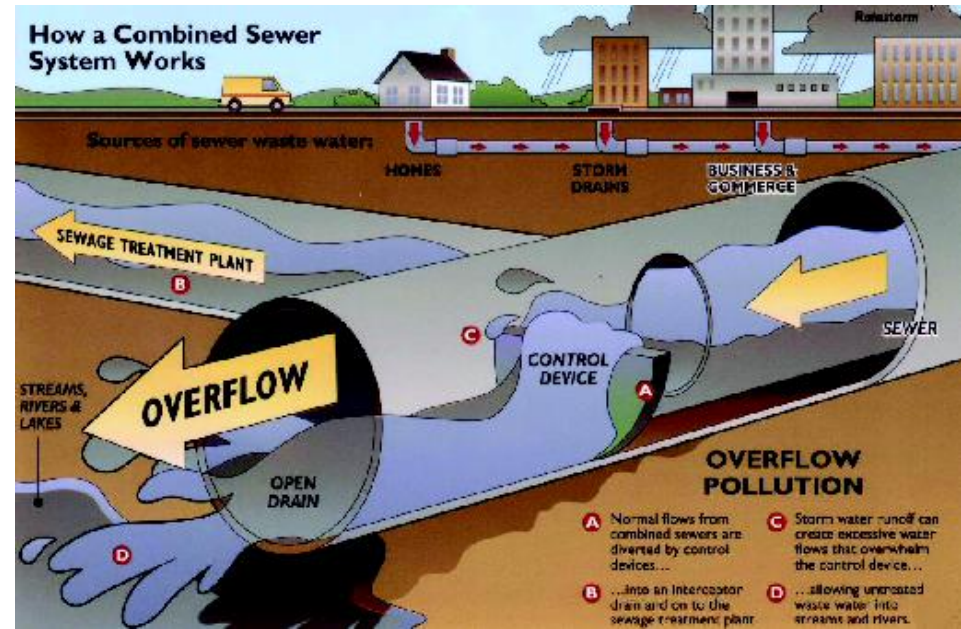
GREEN INFRASTRUCTURE



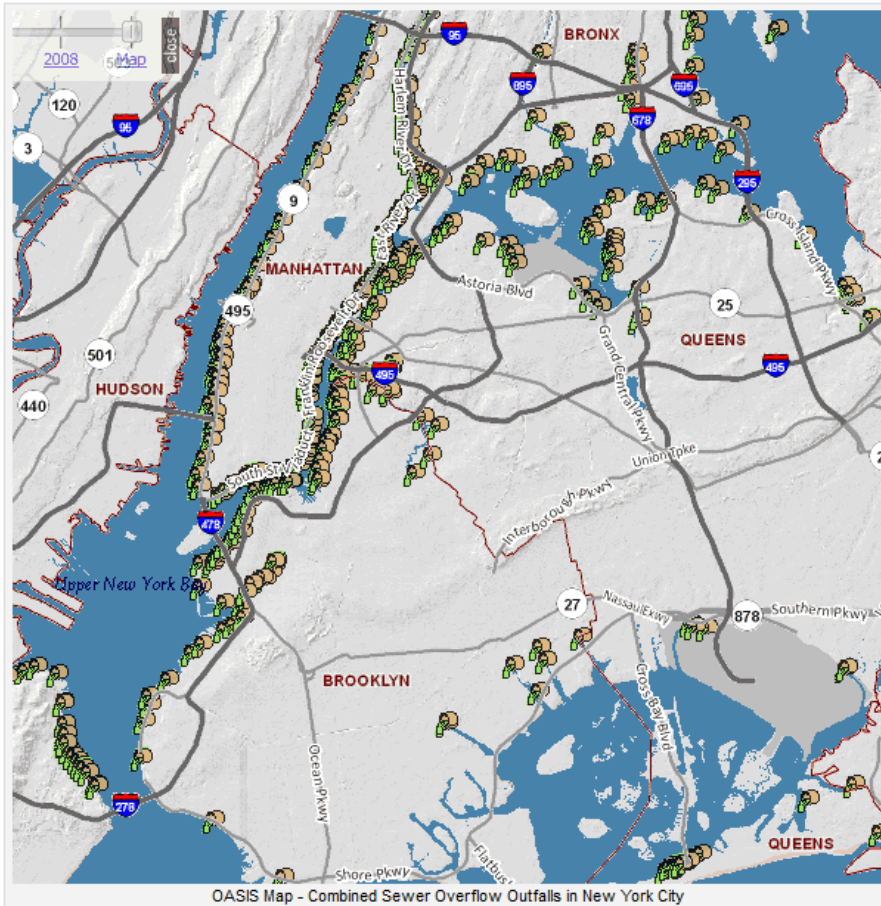
COMBINED SEWER SYSTEMS

Are sewers that are designed to collect water runoff, domestic sewage, and industrial wastewater in the same pipe. During rain events storm water enters the sewer system and causes the system to exceed its intended capacity. In New York City wastewater treatment plants, rain events will cause all of the water to be directed to the waterways around the city creating what are called Combined Sewer Overflows or CSOs. Every year, more than 27 billion gallons of sewage and dirty rainwater are discharged into New York Harbor during CSO's

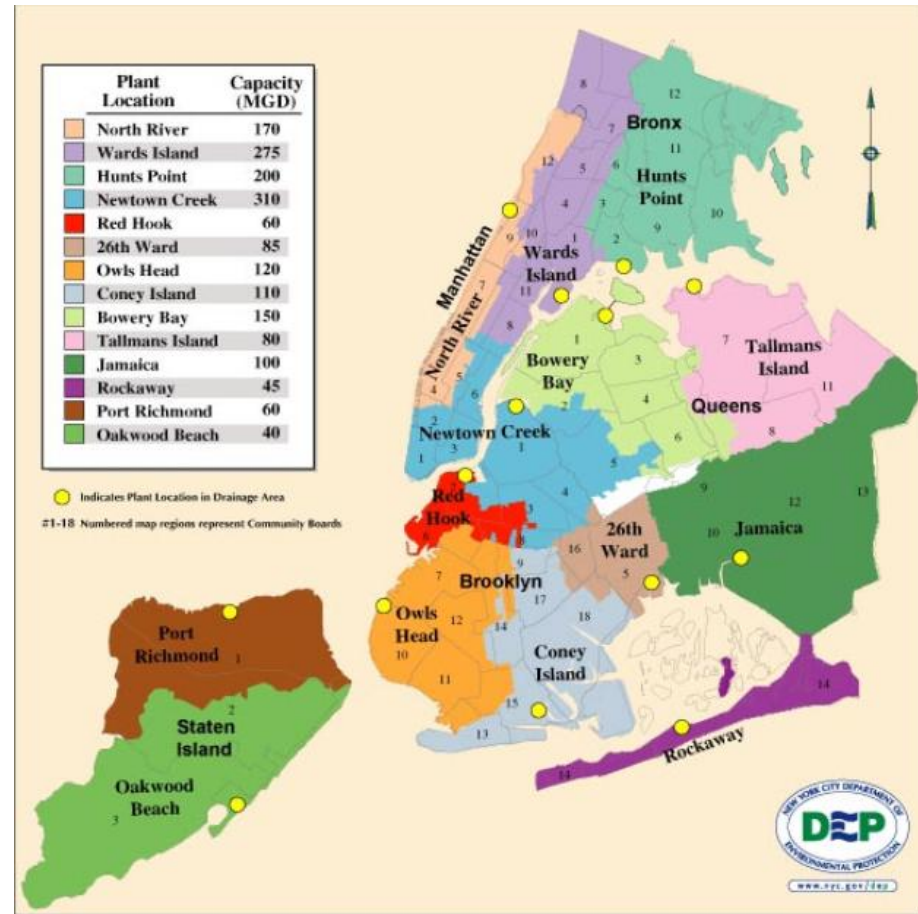
THE PROBLEM



OUTFALLS!



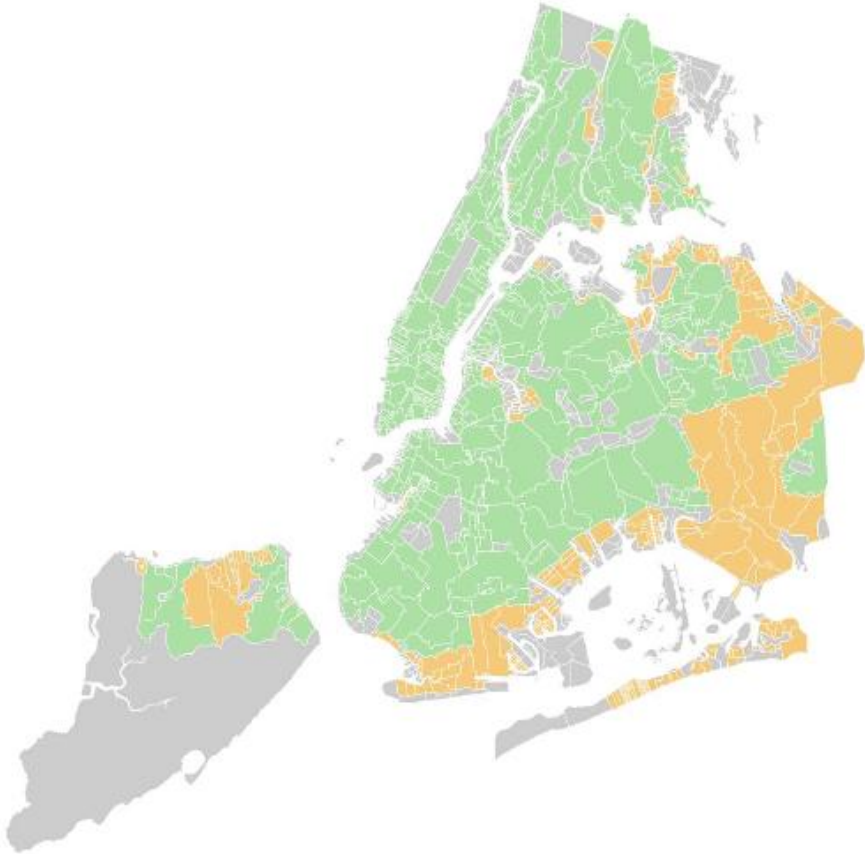
SEWERSHEDS!



Queens Botanical Garden is in the drainage area for Bowery Bay Sewage Treatment Plant
Capacity: 150 MGD
Population Served: 848,328
Drainage Area: 15,203 Acres



NYC SEWER SYSTEMS



- COMBINED
- SEPARATE
- OTHER (Direct Drainage, Surface Drainage, Blue Belts, etc.)



The problem can be solved with more sustainable solutions, called Green Infrastructure. This consists of ideas and principals that allow the natural processes to work more smoothly. Rainwater Harvesting, bioswales, rain gardens, downspout planters, green roofs, permeable paving, and enhanced tree pits are just a handful of green infrastructure techniques. In relation to large scale grey infrastructure, small scale distributed infrastructure projects are easy and less expensive ways to implement a sustainable infrastructure.



GREEN ROOFS



A green roof is a vegetative layer grown on a rooftop. Green roofs are not only important because they hold rain water, but they also reduce temperatures of the roof surface by removing heat from the air through evapo-transpiration. Green roofs can be ornamental and low profile or be used to grow vegetables and larger plant material on rooftops.



An intensive green roof will have greater than 2 inches of soil and can support much larger plant material. Some green roofs are urban farms growing vegetables for market. Wet soil can weigh more than 120 pounds per cubic foot of soil but the climate of a rooftop can be hotter than at street level and more windy which will tend to dry out soil and desiccate plants. A drip irrigation system can help insure that the soil does not dry out.



Green roofs need flat or nearly flat roofs to work. It is also important to know the weight bearing capacity of the roof. Often additional support is necessary. Check zoning codes that may limit the amount of roof area that can be covered by a green roof.

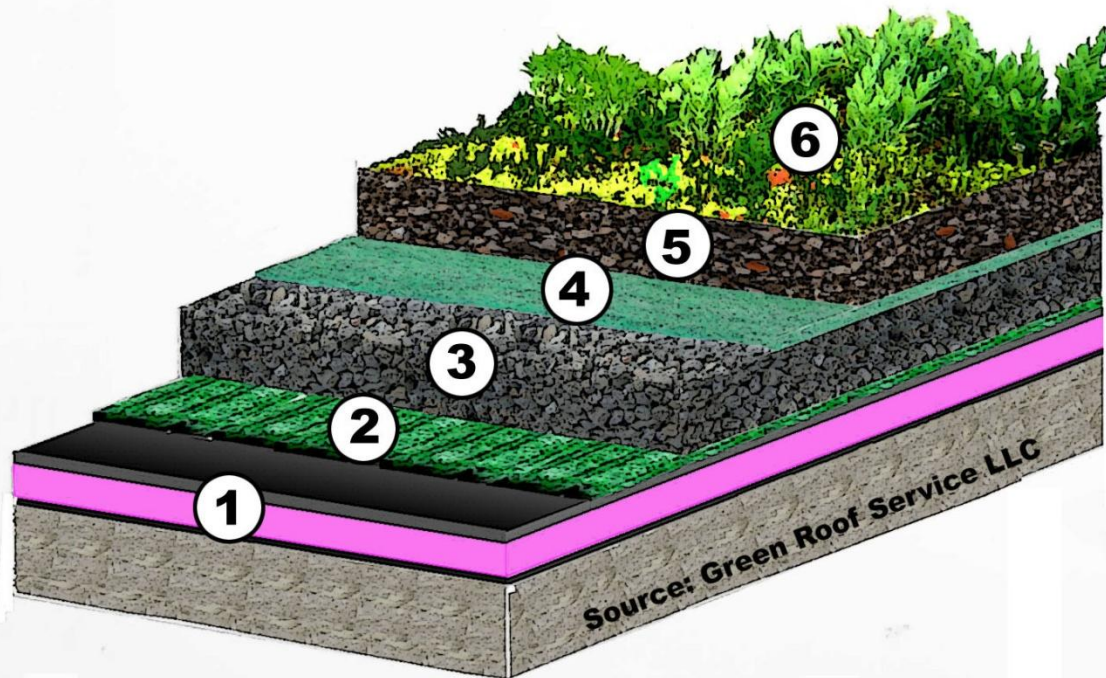


Extensive green roofs use as little as 2 inches of soil and grow mainly grasses and sedums. This type of roof will weigh much less than an intensive green roof but provide the same temperature reduction benefits and require less maintenance.



In most cases the planters or planting medium is separated from the roof by membranes that protect the roof. There are commercially available systems for green roofs which supply any fabrics or membranes as well as grid and modular systems.

Functional layers of a typical extensive Green Roof



- | | |
|--|-------------------------------|
| ① Roof deck, Insulation, Waterproofing | ④ Root permeable Filter Layer |
| ② Protection- and Storage Layer | ⑤ Extensive Growing Media |
| ③ Drainage- and Capilarity Layer | ⑥ Plants, Vegetation |





A drip irrigation system can help insure that the soil does not dry out. An inexpensive green roof can be made with recycled planters.



PERMEABLE PAVEMENT

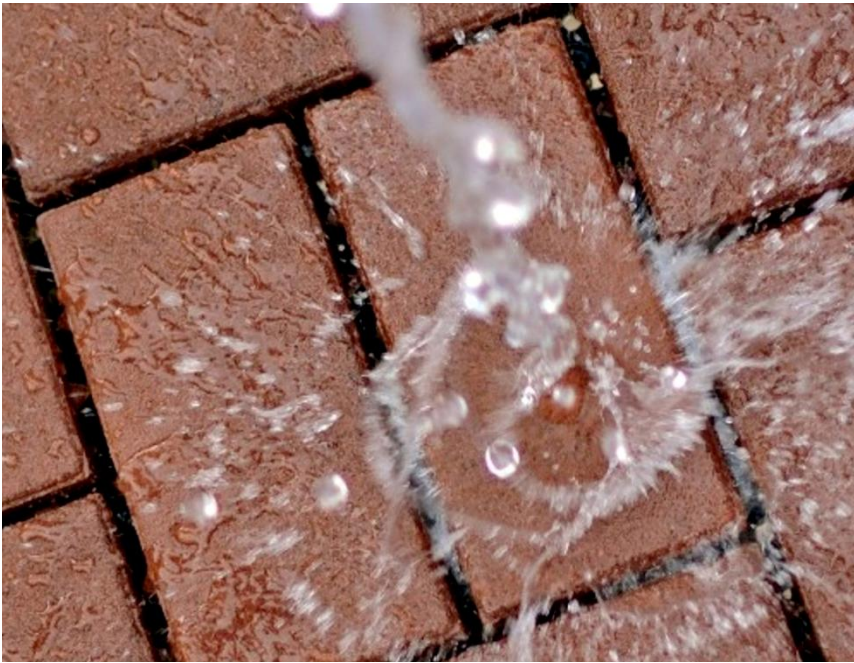
Permeable pavement is designed to allow percolation or infiltration of stormwater through the surface into the soil below where the storm water is naturally filtered and pollutants are removed. In contrast, normal pavement is an impervious surface that sheds rainfall and associated surface pollutants forcing water to run off paved surfaces directly into nearby storm drains and then potentially contribute to Combined Sewage Overflows.





Permeable concrete, permeable asphalt and other engineered systems are used depending on the amount and type of foot or vehicle traffic. These types of permeable paving like permeable concrete or permeable paving using aggregates like crushed glass will require a contractor.





Permeable Paving should not be placed at the end of slopes in order to minimize flooding. Also, the existing soil underneath the pavement should have an infiltration rate of 0.5 in. per hour. Follow manufacturer's instructions. Paving blocks that are permeable can also be easily installed by a homeowner or gardener .





Some types of permeable pavement like geo-grids can be installed by a do it yourselfer.



Look for paved areas that frequently have flooding or puddles. This pavement is usually solid and does not allow water to percolate through it into the ground. Because permeable paving is not as solid as impermeable pavement and cannot bear the same load, it should not be used on heavily trafficked areas, but should be limited to parking or foot traffic.



ENHANCED TREE PITS



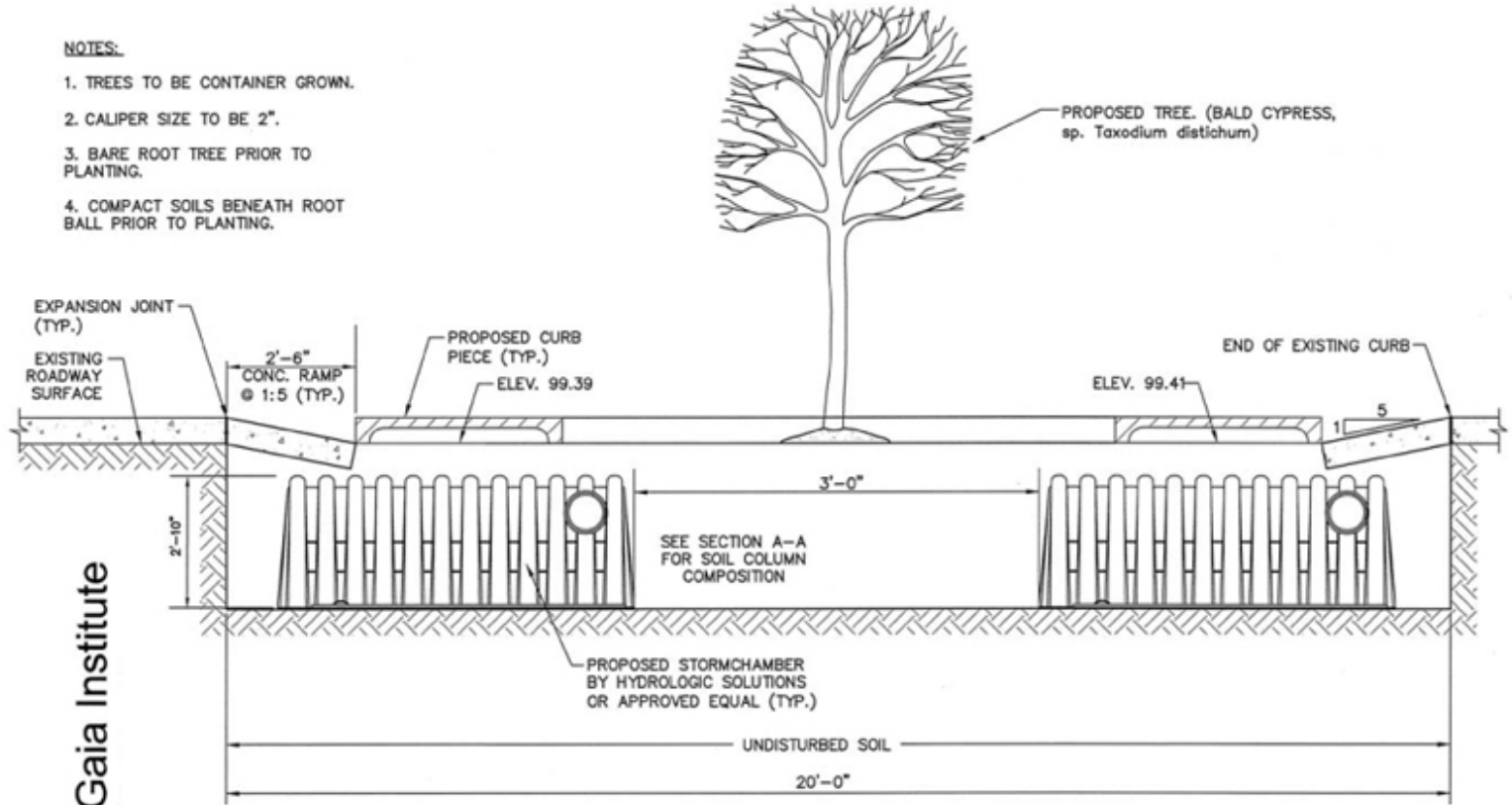
Enhanced tree pits are designed to allow rainfall flowing along the curb into tree pits. Amending the soil with gravel to accommodate the inflow of large amounts of water is important for the enhanced tree pit to work properly. These improvements will require heavy equipment as well as permits and approvals. As a simple do it yourself project, a homeowner or a community gardener with a tree in their garden could direct rainwater that runs along an impervious surface in the garden or backyard toward that tree.



As with all of the storm water management techniques some allowance has to be made for overflow in heavy rains.



To be most effective an enhanced tree pit will include an underground storage tank or several feet of gravel to increase the amount of storm water retained.



- NOTES:**
1. TREES TO BE CONTAINER GROWN.
 2. CALIPER SIZE TO BE 2".
 3. BARE ROOT TREE PRIOR TO PLANTING.
 4. COMPACT SOILS BENEATH ROOT BALL PRIOR TO PLANTING.

The Gaia Institute

ENHANCED TREE PIT (ETP-15) - SECTION B-B
Sutter Avenue, Brooklyn, NY

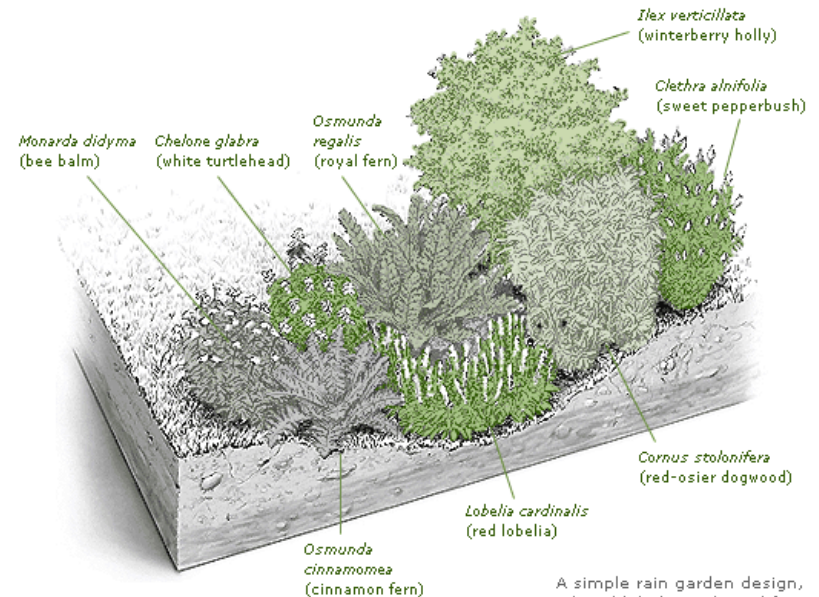


For most people installing an enhanced tree pit themselves will not be an option. In this case, if sidewalks, streets or curbs are being redone in the neighborhood, folks can request that the city install enhanced tree pits.



RAIN GARDENS

A rain garden is a garden of native shrubs, perennials, and grasses which can withstand both drought and occasional flooding planted in a small depression, generally on a low point of a natural slope. Gravel or well drained soil is added to make the rain garden work more efficiently. It is designed to temporarily hold and soak in rain water runoff that flows from roofs, driveways, patios or lawns. The rain garden is dry most of the time and typically holds water only for the day following a rainfall event.



A simple rain garden design, with red lobelia and royal fern occupying the lowest, wettest zone.

Look for any sort of depression or flooded areas in the garden that will temporarily hold rain water runoff that flows from roofs, driveways, patios, lawns or overflows from rainwater harvesting systems. Usually if a depression or flooded area is present, there is a slope leading into it, allowing the water to flow towards the low point.



Rain gardens can be any shape but usually are shaped longer than they are wide and positioned perpendicular to the slope of the land in order to catch the maximum amount of rainfall. Rain gardens should be placed at least 10 feet away from building foundations and should not be located where water ponds for an extended period of time (less than 0.5 in. per hour percolation rate).





A rain garden can be any size but a typical rain garden is between 100 and 400 feet but could be smaller if that is all the space can accommodate.



The soil in the interior, lower area of the rain garden should be amended with sand and gravel to improve drainage. There are specific plants that will thrive in both drought conditions and can withstand flooding. Rain gardens are easy to construct, mostly requiring digging in the area in order to add the soil amendments or to increase the depth of the rain garden.



DOWNSPOUT PLANTERS

Downspout planters take the idea of a rain garden but put it in a different context. A downspout planter places plants along or at the end of a downspout to capture the water before it enters the sewer. Downspout planters range from very simple planters on the ground to one or more planters along the downspout. Rainfall is captured by the planter allowing for infiltration and capture of pollutants.





In cases where there isn't room for a rainwater harvesting tank or you want to have a planter at the base of your downspout, downspout planters are an easy alternative.



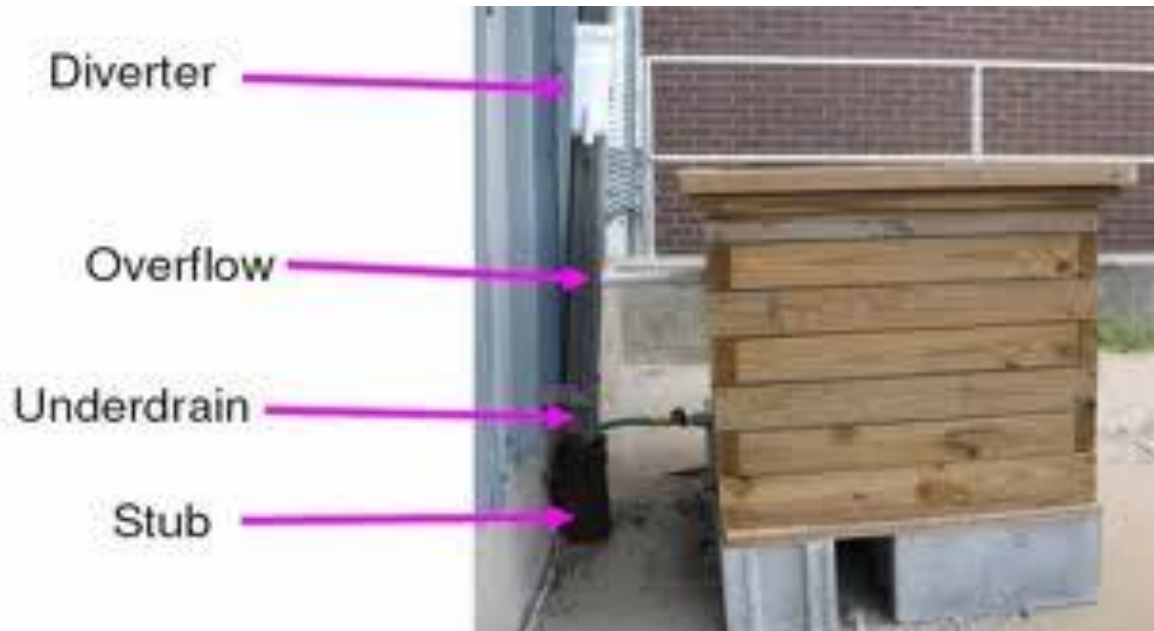
A Downspout Planter can be as simple as placing a large pot or planter at the bottom of or next to your downspout.



A planter box will last longer if it is lined with plastic as the soil will tend to be moist and will rot much quicker than a normal planter. Plastic lumber is an option as it will last indefinitely.



An overflow outlet is important as the planter will be close to the building and could cause moisture problems if the overflow is not directed into a drain or away from the building.





**Downspout
planters range
from very simple
planters on the
ground to one or
more planters
along the
downspout.**





Downspout planters installed somewhere along the downspout will slow down the flow of water, act as a bio-filter and take advantage of vertical planting options. An inline planter should be properly secured considering the weight of moist soil and if it will be inaccessible, low maintenance plants like grasses will work best.





BIOSWALES

Bioswales are used to convey water to plants, rain gardens, or storm drains, while allowing the water to infiltrate into the soil and be soaked up by the vegetation, therefore reducing flooding .

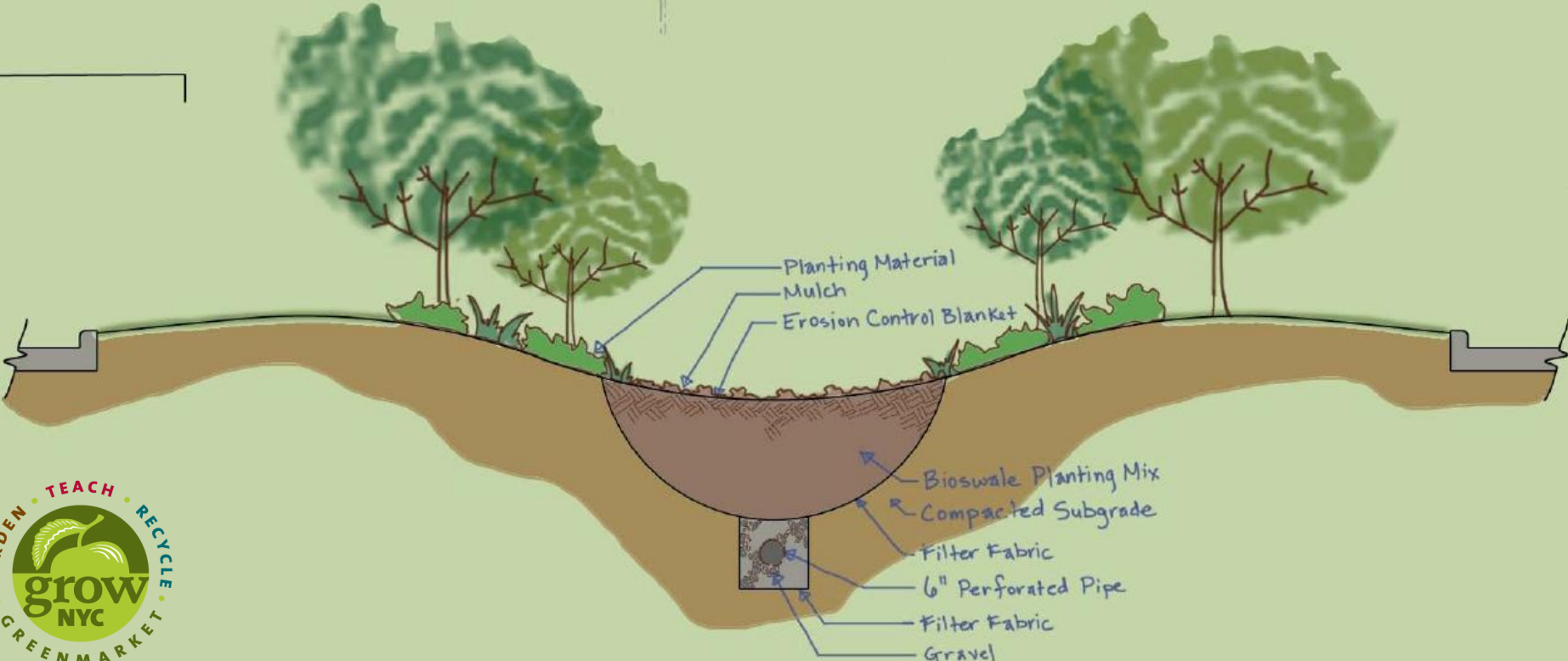
<http://vimeopro.com/cerasalepictures/the-bioswale>



The sloping sides of the bioswale allow water to flow into the bioswale and if possible planted with native species. It is best to follow the contour of the slope for a bioswale to be most effective. A lot of hand digging is required to create the depression. In some cases mechanical digging equipment may be necessary.



In order to increase the water retention capacity perforated pipe can be placed in the trench similar to a French drain.(see below) This also allows excess flow to be directed where you want it to go. Landscape fabric is used to cover the perforated pipe to keep the soil from washing in and clogging the pipes. Larger plant material like berry bushes or fruit trees can be planted at the top of the swale to provide an additional protection against erosion.





The slope should be fairly flat, but somewhat depressed to minimize the velocity of the water and erosion, and to allow maximum infiltration.



This type of infrastructure is usually found on larger sites. Look for a sloped linear depressed area.



NATIVE PLANTS FOR RAIN GARDENS AND BIOSWALES

Herbaceous Plants for Sunny Wet Zone Sites

These choices are best beneath newly planted trees.

Flowers

Sweet flag (*Acorus calamus*)
Canada anemone (*Anemone canadensis*)
Swamp milkweed (*Asclepias incarnata*)
Marsh marigold (*Caltha palustris*)
Turtlehead (*Chelone glabra*)
Boneset (*Eupatorium perfoliatum*)
Joe-pye weed (*Eupatorium maculatum*)
Bedstraw (*Galium boreale*)
Bottle gentian (*Gentiana andrewsii*)
Sneezeweed (*Helenium autumnale*)
Giant sunflower (*Helianthus giganteus*)
Oxeye sunflower (*Heliopsis helianthoides*)

Blue flag (*Iris versicolor*)
Spike gayfeather (*Liatris spicata*)
Great blue lobelia (*Lobelia siphilitica*)
Prairie phlox (*Phlox pilosa*)
Virginia mountain mint (*Pycnanthemum virginiana*)
Meadowsweet (*Spiraea alba*)
New England aster (*Symphotrichum novae-angliae*)
Tall meadow rue (*Thalictrum dasycarpum*)
Blue vervain (*Verbena hastata*)
Culver's root (*Veronicastrum virginicum*)
Golden Alexander (*Zizia aurea*)

Grasses and Sedges

Big bluestem (*Andropogon gerardii*)
Sedges (*Carex*, *Scirpus*, and other species)
Rushes (*Juncus* species and others)
Indian grass (*Sorghastrum nutans*)

Blue joint grass (*Calamagrostis canadensis*)
Canada wild-rye (*Elymus canadensis*)
Rice cutgrass (*Leersia oryzoides*)
Cordgrass (*Spartina pectinata*)



http://www.bbg.org/pdf/tipsheets/NativePlantsforNYCRain%20Gardens_1212.pdf

NATIVE PLANTS FOR RAIN GARDENS AND BIOSWALES

Herbaceous Plants for Shady Wet Zone Sites

Flowers

- Wild sarsaparilla (*Aralia nudicaulis*)
- Marsh marigold (*Caltha palustris*)
- Turtlehead (*Chelone glabra*)
- Joe-pye weed (*Eupatorium purpureum*)
- Virginia waterleaf (*Hydrophyllum virginianum*)
- Spotted touch-me-not (*Impatiens capensis*)
- Cardinal flower (*Lobelia cardinalis*)
- Canada mayflower (*Maianthemum canadense*)
- Virginia bluebells (*Mertensia virginica*)
- Woodland phlox (*Phlox divaricata*)
- False dragonhead (*Physostegia virginiana*)
- Tall meadow rue (*Thalictrum dasycarpum*)
- Foamflower (*Tiarella cordifolia*)

Ferns

- Ostrich fern (*Matteuccia pennsylvanica*)
- Sensitive fern (*Onoclea sensibilis*)
- Cinnamon fern (*Osmunda cinnamomea*)
- Interrupted fern (*Osmunda claytoniana*)
- Royal fern (*Osmunda regalis*)
- Marsh fern (*Thelypteris palustris*)



NATIVE PLANTS FOR RAIN GARDENS AND BIOSWALES

Herbaceous Plants for Sunny Upland Zone Sites

Flowers

Giant Hyssop (*Agastache foeniculum*)

Wild columbine (*Aquilegia canadensis*)

Butterfly weed (*Asclepias tuberosa*)

Tickseed 'Moonbeam' (*Coreopsis verticillata* 'Moonbeam')

Purple coneflower (*Echinacea purpurea*)

Oxeye sunflower (*Heliopsis helianthoides*)

Blazing star 'Kobold' (*Liatris spicata* 'Kobold')

Beebalm (*Monarda didyma*)

Black-eyed Susan (*Rudbeckia hirta*)

New England aster (*Symphotrichum novae-angliae*)

Showy goldenrod (*Solidago speciosa*)

Grasses

Switchgrass (*Panicum virgatum*)

Little bluestem (*Schizachyrium scoparium*)



NATIVE PLANTS FOR RAIN GARDENS AND BIOSWALES

Shrubs for Wet Zone Sites

Most of these species do well in sun or shade.

Black chokeberry (*Aronia melanocarpa*)

Silky dogwood (*Cornus amomum*)

Red-osier dogwood (*Cornus sericea*)

Hazelnut (*Corylus americana*)

Winterberry (*Ilex verticillata*)

Meadowsweet (*Spiraea alba*) (needs sun)

New York aster (*Symphyotrichum novi-belgii*)

American cranberry (*Viburnum trilobum*)

American cranberry 'Compacta' (*Viburnum trilobum* 'Compacta')

Buttonbush (*Cephalanthus occidentalis*)

Gray dogwood (*Cornus racemosa*)

Red-osier dogwood 'Isanti' (*Cornus sericea* 'Isanti')

Dwarf bush honeysuckle (*Diervilla lonicera*)

Fragrant sumac (*Rhus aromatica*)

Snowberry (*Symphoricarpos alba*)

Nannyberry (*Viburnum lentago*)

Herbaceous Plants for Shady Upland Zone Sites

Green-and-gold (*Chrysogonum virginianum*)

Wild geranium (*Geranium maculatum*)

Coral bells (*Heuchera americana*)

Virginia bluebells (*Mertensia virginica*)

Virginia creeper (*Parthenocissus quinquefolia*)

Partridgeberry (*Mitchella repens*)

Blue wood aster (*Symphyotrichum cordifolium*)

Shrubs for Shady Upland Zone Sites

Serviceberry (*Amelanchier canadensis*)

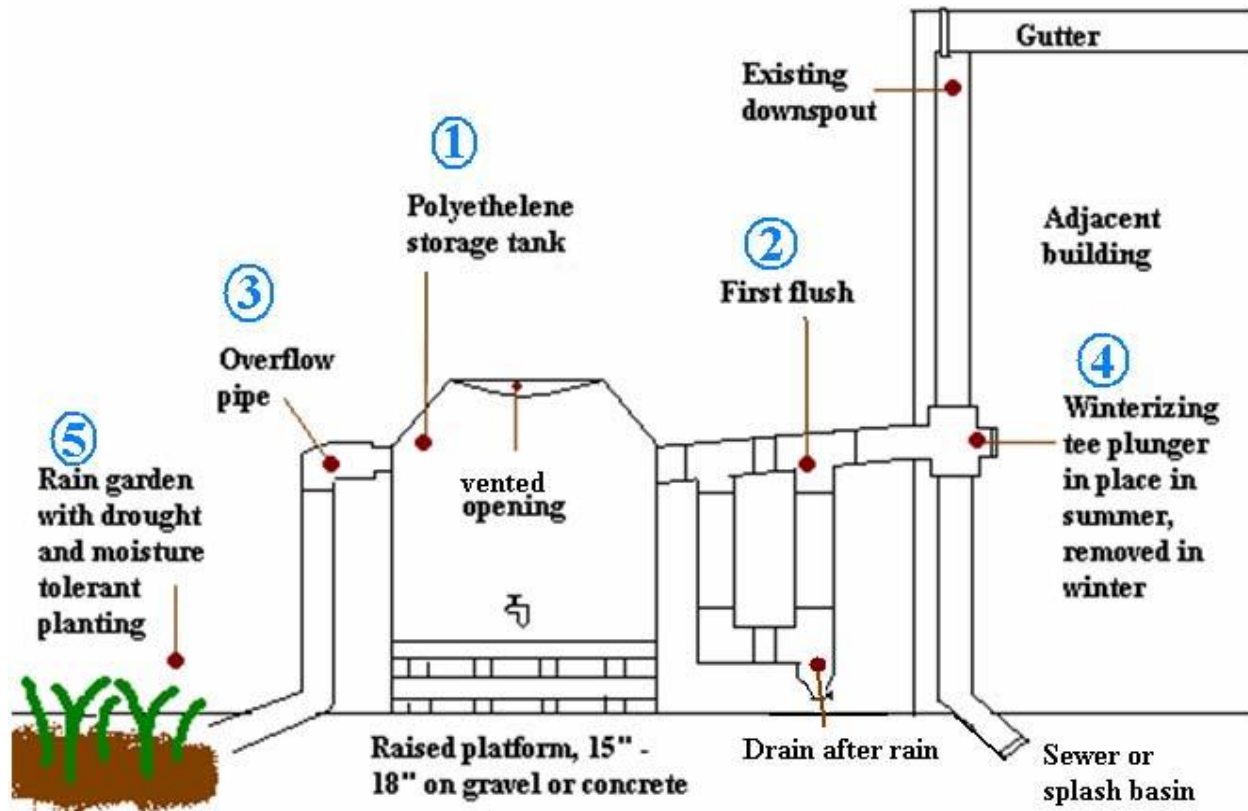
Ferns

Interrupted fern (*Osmunda claytonia*)

Christmas fern (*Polystichum acrostichoides*)



RAINWATER HARVESTING



FORMULA TO CALCULATE HOW MUCH WATER YOU CAN COLLECT WHEN IT RAINS 1 INCH

**YOU CAN COLLECT $\frac{1}{2}$ GALLON OF
WATER
PER SQUARE FOOT**

**SQ FT OF ROOF X .5 =
AMOUNT OF WATER COLLECTED**

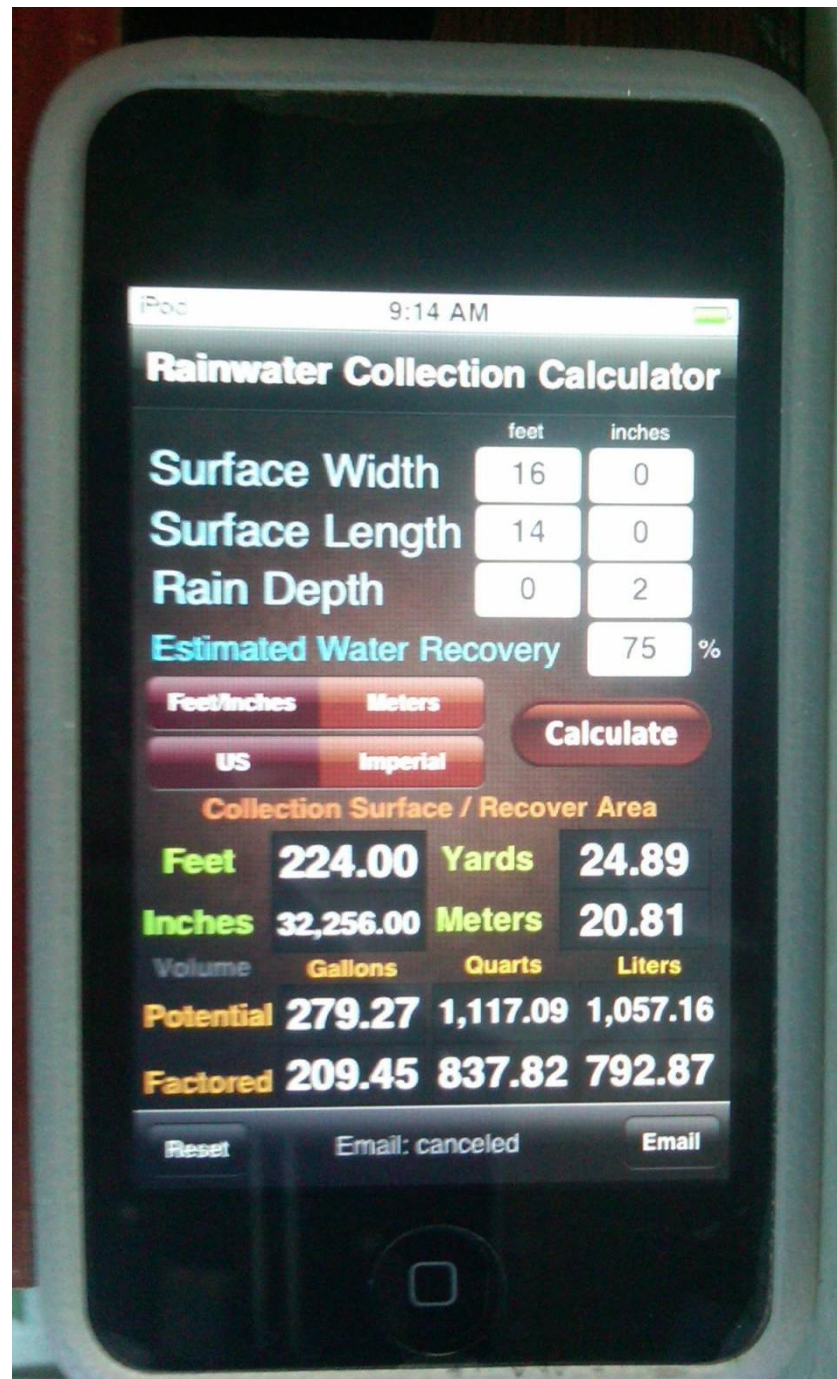
EXAMPLES

**30 ftX40ft = 1200 SQ FT ROOF X .5
= 600 GALLONS**

**25 ftX20ft = 500 SQ FT ROOF X .5
= 250 GALLONS**

**20 ftX10ft = 200 SQ FT ROOF X .5
= 100 GALLONS**

**10ftX8ft = 80 SQ FT ROOF X .5
= 40 GALLONS**





Rainfall can be collected from building rooftops by diverting water from downspouts



**Summer:
plunger
diverts water
into system**

**cap to
remove
plunger**

**Winter: plunger
is removed so
water does not
enter system**



Barrels must be covered to avoid mosquito problems



Rainwater can be collected from sheds, shade structures, chicken coops or gazebos using recycled barrels



Shade structures can be set up to collect rainwater



<http://www.youtube.com/watch?v=ZNaCrCer8UQ>

Larger Amounts of rainfall can be collected by diverting water from adjacent buildings



Several 50 Gallon barrels Connected together.



**Barrels can be connected
close to the bottom. All barrels
fill and drain together.**



Overflow can be sent to a rain garden, bioswale or pond as long as it is diverted away from any structures



Making the connection to the tank or barrel



***Important: Seal the connection with a waterproof sealer like Silicone.**





Rainwater Harvesting and Green Roof





A Rainwater System can help correct problems





Rainwater Harvesting can provide most of your irrigation needs if you practice water conservation in your garden.



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