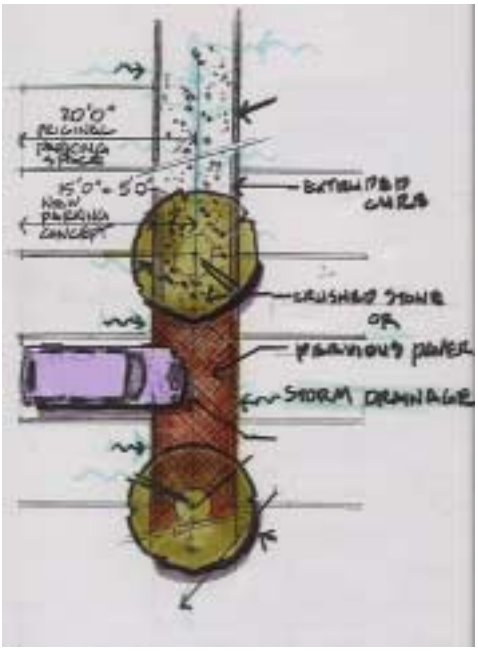
Stormwater Manual

CITY OF NASHUA, NEW HAMPSHIRE
ALTERNATIVE STORMWATER MANAGEMENT METHODS

PART 2 – DESIGNS & SPECIFICATIONS



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PART 2 – DESIGNS & SPECIFICATIONS

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1.0 Planning & Engineering

Design Selection

Several design options are shown in Section 2, with a conceptual drawing and description followed by cross-sections and design details. General specifications then follow in Section 3.

The purpose of these conceptual designs of Runoff Prevention Methods is to give planners, developers, engineers and homeowners some ideas of techniques for reducing runoff from sites. Although some of the techniques are similar to each other, multiple options are shown where available from the design process.

All the designs shown are conceptual only and will require adaptation to the specific site. They all have some similar design basis, including:

1. Pretreatment is always used to remove the large volumes of sediment usually found in stormwater (roof leader treatments are the exception here);
2. Treatment of runoff is at the source rather than typical end of pipe treatment system;
3. Multiple techniques are required for best effectiveness on each site; however, since they blend into the landscape or provide an aesthetic benefit, they provide a portion of the useable space onsite.

Tables 1 and 2 include selection matrices for Commercial/Industrial/Retail and Residential, respectively, that may be helpful in identifying which options are useful for each site.

Table 1. Commercial/Industrial[a]/Retail Selection Matrix

	Roof runoff	Parking Lots	Commercial Driveways	Roadways	Alleys	Sidewalks	Comments
1. Infiltration dividers		✓	✓	✓			Allows retention of all parking spaces.
2. Infiltration islands		✓	✓	✓			Potentially used for ends of parking strip.
3. Biocells & Bioislands	✓	✓					Provides shade and pedestrian benefits. May reduce spaces.
4. Dry stream infiltration		✓	✓	✓		✓	Use where vegetation cannot be supported.
5. Containment swale		✓	✓	✓			Where grades allow, standpipe can be added.
6. Driveway drainage strip		✓	✓			✓	Channel in driveway to route stormwater to cells in landscaping.
7. Stormwater drywell	✓						Place 10 or more feet from building.
8. Grassed infiltration strips		✓	✓	✓			Can be used to intercept any runoff.
9. Curbside treatment		✓	✓	✓		✓	Other utilities may preclude its use in some areas.
10. Alley infiltration	✓				✓		Building foundations must be inspected.

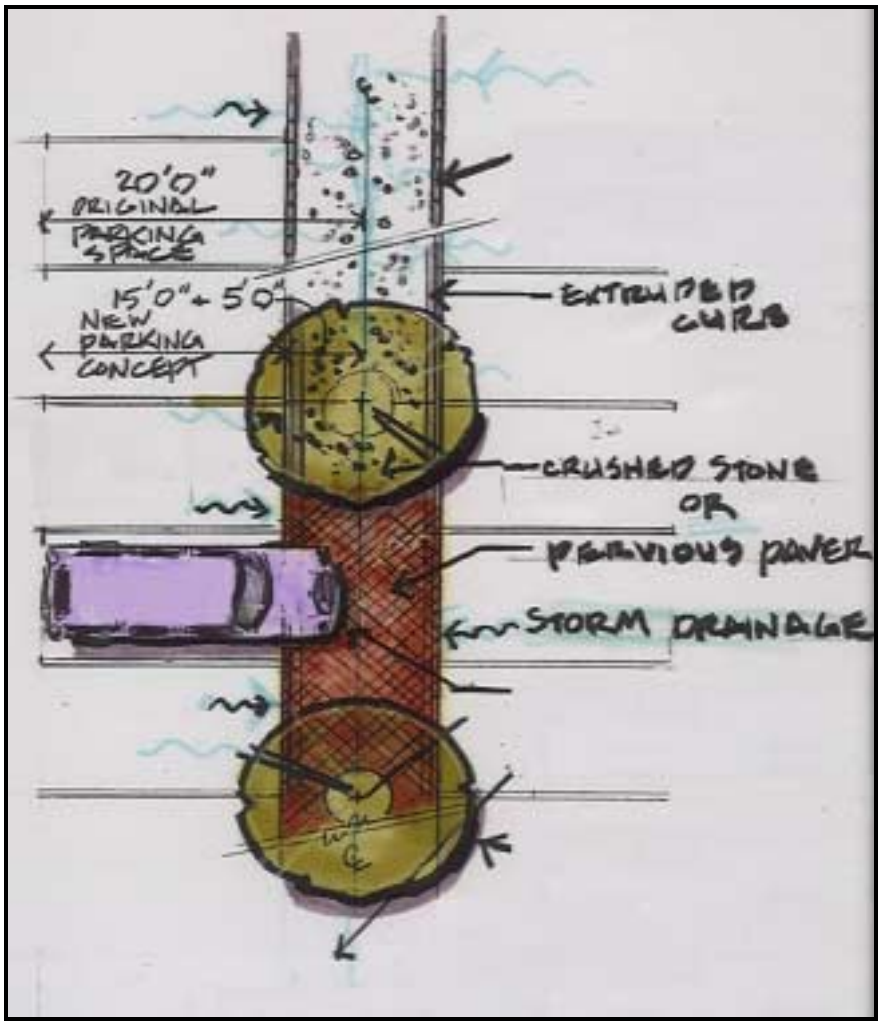
[a] Industrial developments may have special concerns in Wellhead Protection Areas. Industrial sites should not infiltrate stormwater from areas where hazardous materials could be spilled or high concentrations of pollutants exist, so as not to contaminate water in Wellhead Protection Areas.

Table 2. Residential Selection Matrix

	Roof leaders	Driveways	Sidewalks	Roadways	Patios, decks	Lawn	Comments
1. Raingarden Strip	✓	✓	✓	✓	✓	✓	Particularly good along roads and drives. Use as drought tolerant hedgerow.
2. Raingarden Planter	✓	✓	✓	✓	✓	✓	Alternative layout of above.
3. Pocket raingarden	✓	✓	✓	✓	✓	✓	Alternative layout of above.
4. Decorative Planters	✓						Decorative feature that also handles roof runoff /waters plants.
5. Containment swale		✓	✓	✓		✓	Where grades allow, standpipe can be added for more storage.
6. Driveway drainage strip		✓	✓		✓		Channel in driveway to route stormwater to cells in landscaping.
7. Stormwater drywell	✓					✓	Place 10 or more feet from building.
8. Grassed infiltration strips		✓	✓	✓	✓	✓	Can be used to intercept any runoff.
9. Curbside treatment		✓	✓	✓	✓		Other utilities may preclude its use in some areas.

2.0 Alternative Designs

The table below lists the Runoff Prevention Method (RPM) design and corresponding page number found in this section.



Infiltration Divider

Description

A stone filled depressed infiltration strip accepting sheet flow from adjacent paving. Typically 3-4 feet deep and of variable width and length. Surfacing options include pavers, or ¾ inch stone (plain or ornamental). Trees and a strip of grooved pavement are recommended for delineation of the divider and in place of curbing.

Application

This is an infiltration device used to collect runoff from the parking space and travel aisle. It occupies the space usually reserved for vehicular overhang (front wheel to bumper) and is an efficient use of this normally paved und unutilized area. As the name divider implies, it is used to separate two rows of face-in parking and serves to break up the expanse of pavement with moderate sized trees.

Advantages

By using the overhang space in a parking lot the device does not compromise the number of parking spaces attainable at the site. The island can serve the same traffic routing function as raised parking islands. Impacts from foot traffic through the infiltration divider are minimal.

Cost is mainly affected by surface treatment. The plain stone surface treatment is not as costly and performs as well as the more expensive pavers which can be used by those who wish to add more distinction and aesthetic appeal to their parking lot.

Disadvantages

Planting choices may be limited by drought tolerance and width of island (shrubs may be too wide at the car bumper level and become deformed/injured).

The low organic content within the island unit may not provide optimal treatment of organic pollutants if it is located in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Design Considerations

Designs are optimized at 8-10 feet in width which is the normal distance between front axles of vehicles parked nose to nose. The divider handles runoff from the centerline of a typical 20 foot wide travel aisle and the 15 foot parking space. This width also protects trees and cars from butting up to each other. When used as a true divider to separate two rows of parking, widths should not be less than 6 feet.

Depths can vary, but the floor of the structure should be at least two feet from the seasonal high water table. Depths from the inlet surface elevation to the floor of the structure of 2 feet or less are only appropriate if infiltrating the first ½-inch of runoff.

A deeper surface depression can maximize the volume retained within the structure as no stone occupies this space and all of it can be used for retention. Curbing or wheel stops could be used in this application to prevent cars from entering the depression. In some cases, curbing would prevent an even distribution of water to the surface of the structure and the gaps between wheel stops may become blocked and glazed over from snow plowing operations. Alternately, grooves should be cut in the pavement 6" from the edge, around the perimeter of the structure. The grooves will provide a reasonable assurance that cars will come to a stop as they pull forward in the parking space and will provide no restriction for water entering the structure.

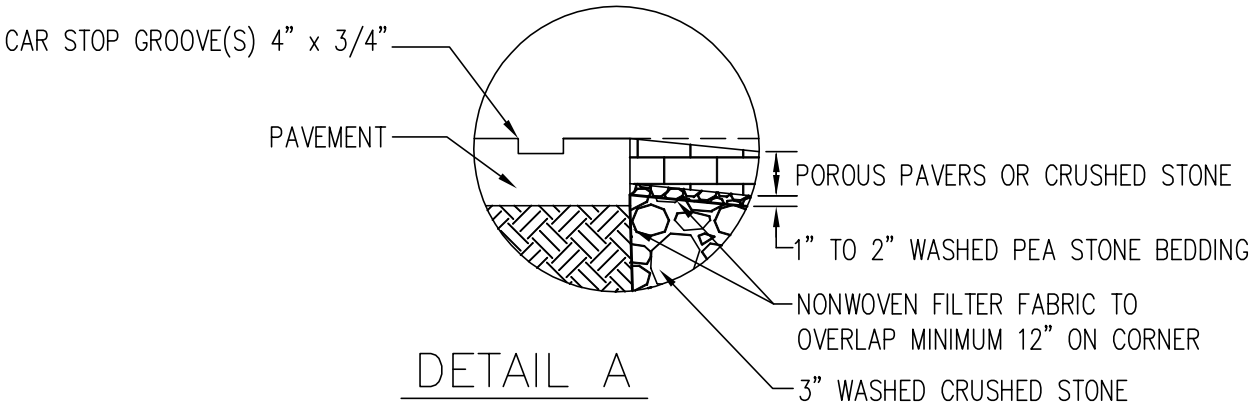
Surface treatment materials must be highly porous and durable. They can range from ¾ inch stone (ornamental or plain) to pervious pavers. Cost will play a large part in the choice of surface materials since pavers are more expensive than stone.

Treatment of stormwater in this device is accomplished by the stormwater passing first though the filter fabric and then through the native soil surrounding the main chamber. The main distinction of the Infiltration Divider is its ability to rapidly accept stormwater below grade. Organic material and the associated decomposition matter can hinder the ability of the surface to accept runoff.

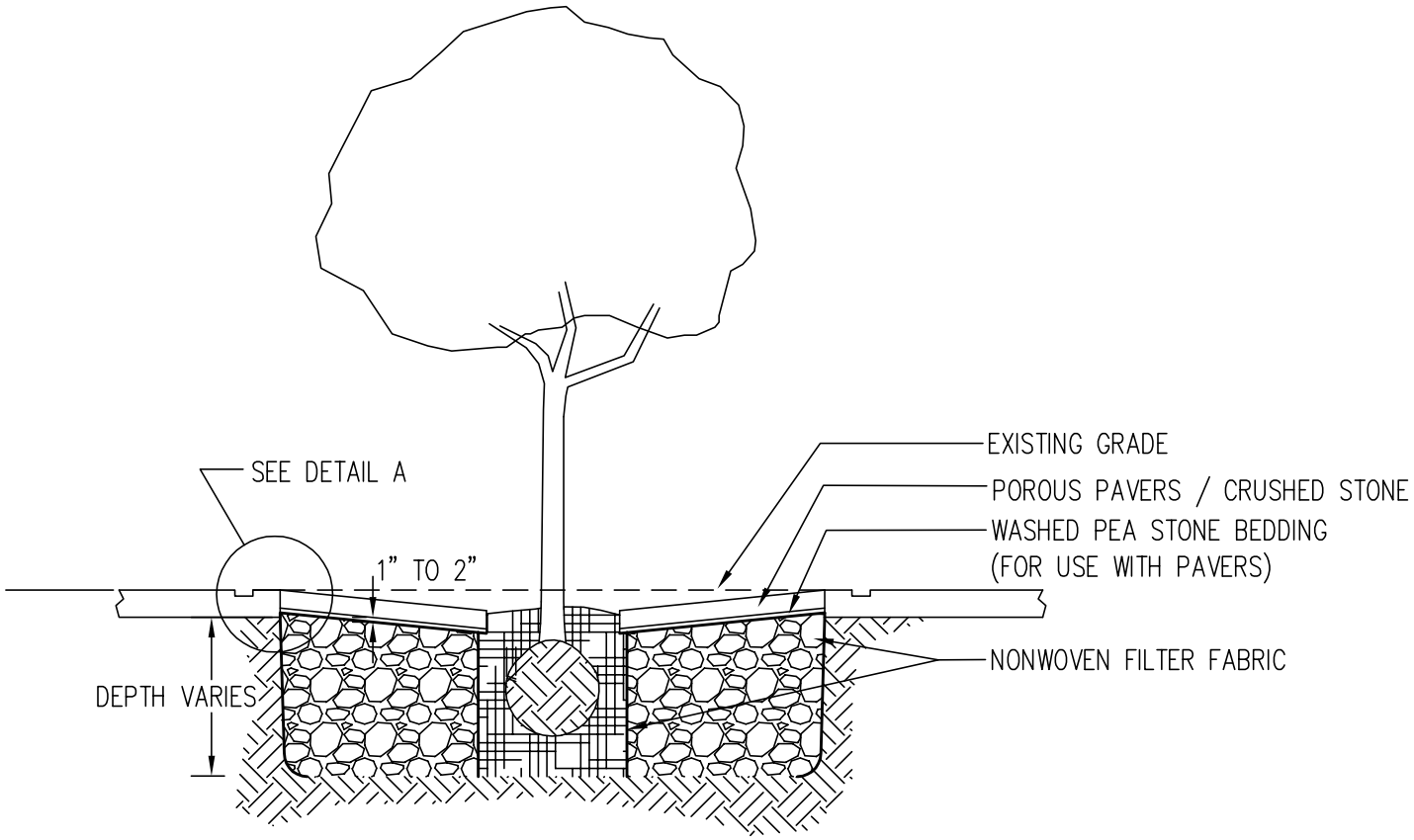
Shade trees are recommended, to assist in delineating the Infiltration Divider from the traveled portions of the parking lot. This RPM offers a balance between rapid infiltration and aesthetic and traffic control objectives.

Maintenance

The frequency of surface rehabilitation can vary from 1-5+ years based on sand application rates and sweeping of the parking lot). Rehabilitation involves use of a vacuum truck or manual labor to remove the top 6 inches of material and replacement of the filter fabric pre-filter zone. Although stone may be screened from the accumulated sand and sediment and reused, it may be more practical and cost effective to send the removed material to a gravel facility for reprocessing and replace it with a new 6 inch stone layer after each cleaning



DETAIL A



Note: Not to Scale, For Conceptual Design Purposes Only

Infiltration Divider

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64 DILLA STREET
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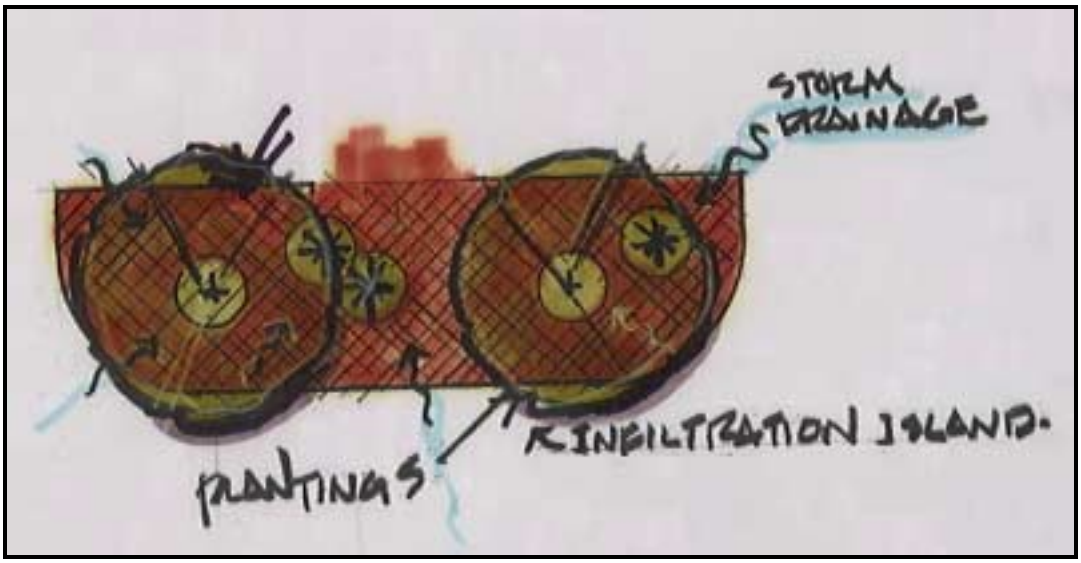


Infiltration Islands

Description

A medium sized surface infiltration structure with a durable surface that can withstand occasional vehicle traffic. Plantings are sparse and infiltration capacity at the surface is high.

Application

These islands are meant to be used in parking lots at the end of parking rows or in areas where vehicles and pedestrians are likely to cut corners. The limited low-growing vegetation aids in providing sufficient line of sight for vehicular turning movements. Durable surface elements provide pedestrians space while waiting to cross from the parking lot to building entrance.

Advantages

Durable with the use of pavers so that it can withstand occasional traffic with little to no damage. Selection and variation of colors and style of pavers can help delineate parking for one store vs. another in a large parking lot.

Clear line of site for vehicle turning movements and pedestrian crossing.

With slight modifications to flatten side slopes, islands may provide additional adjacent space for access in and out of vehicles by handicapped persons.

Disadvantages

Planting choices may be limited by line of sight considerations and drought tolerance.

Pavers are more costly than a simple crushed stone surfacing.

Design Considerations

Although compaction of material is generally discouraged with RPMs, it may be warranted in the areas likely to be trafficked by vehicles.

If used at the downgradient end of a row of parking spaces and attached to another RPM such as the Infiltration Divider, the design should be graded such that each RPM provides the maximum amount of storage and infiltration. If both RPMs are sloped in one direction, placing one RPM downgradient from the other, the downgradient RPM could become overwhelmed with water, leading to frequent use of the overflow and underutilization of the available storage space in the upgradient structure.

The low organic content within the structure may not provide optimal treatment of organic pollutants if the structure is sited in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Maintenance

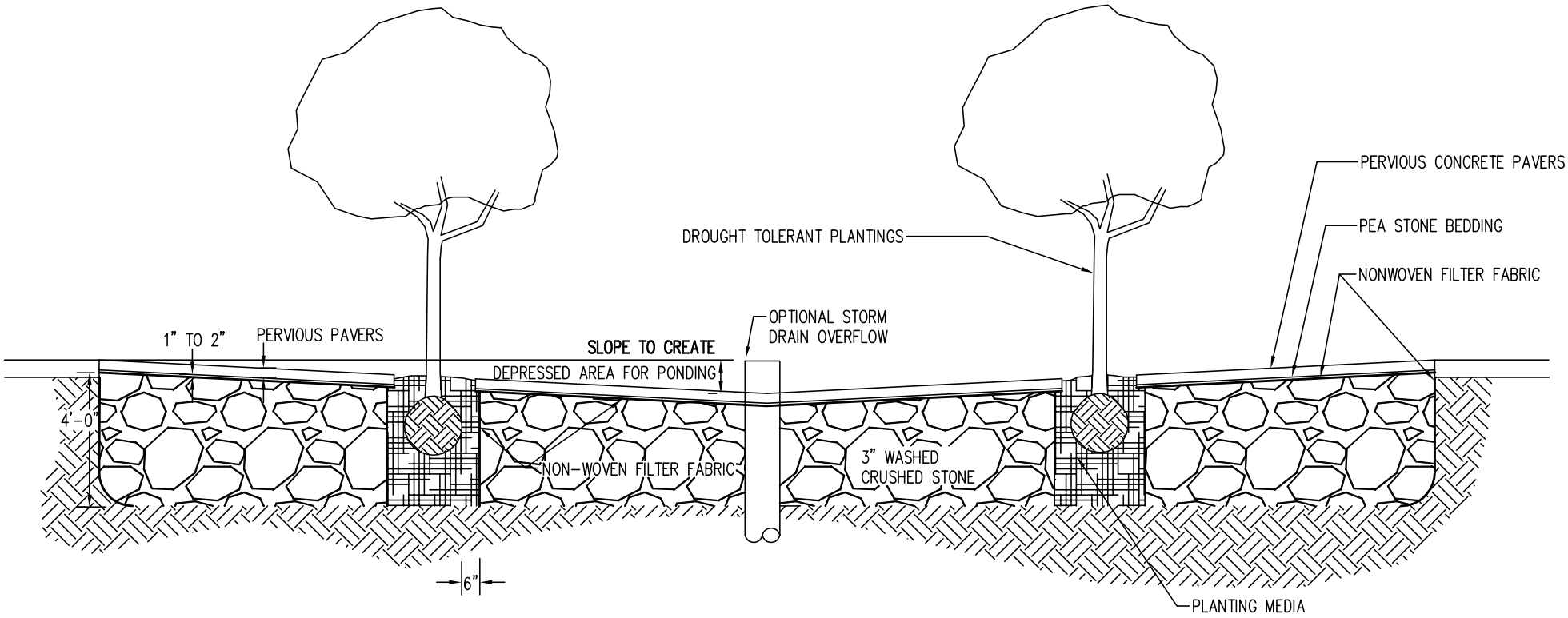
Paver surfaces located in traffic areas will require periodic inspection for deflection (raised or uneven surfaces) to ensure that they will not be pulled up during winter plowing activities. This is best inspected in the Fall, before snowfall. If deflection approaches half of the paver thickness, the affected paver(s) will need to be re-leveled flush to the others.

Sand deposits that have accumulated on the surface of the RPM will need to be removed periodically. A wet/dry vacuum is ideal for this and will prolong the life expectancy of the surface of the structure before the pavers, bedding material, and filter fabric must be completely removed and replaced and/or reassembled. The use of a push broom to remove deposits may be quicker in the short run, however may result in redistribution of much of the accumulated sediments and debris over the surface. If sediment removal maintenance is not conducted, the surface may require rehabilitation on a more frequent basis.

It is advisable to occasionally monitor the RPM during a rainstorm to determine if "preferential flow paths" have developed and or if water seems to make its way to the overflow before using up the capacity of the reservoir/depression area. Forty-eight hours after the storm has stopped[1] the reservoir/depression area should have completely drained. Surface ponding conditions that exceed 48 hours are undesirable as nuisance conditions can develop soon thereafter. Prolonged surface ponding (over 48 hours) indicates that the surface area needs to be rehabilitated by removing and cleaning or

[1] This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.

replacing the surface material down to and including the first filter fabric barrier encountered. An observation well can be installed in the structure to determine whether the infiltration media below the filter fabric has clogged.



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Infiltration Island

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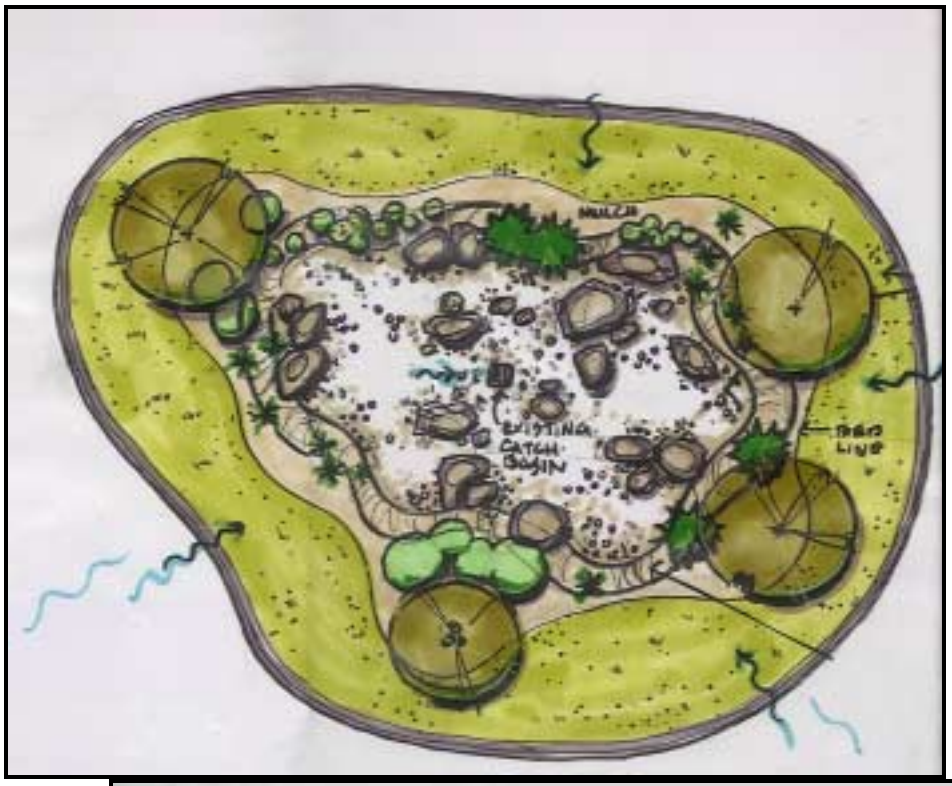
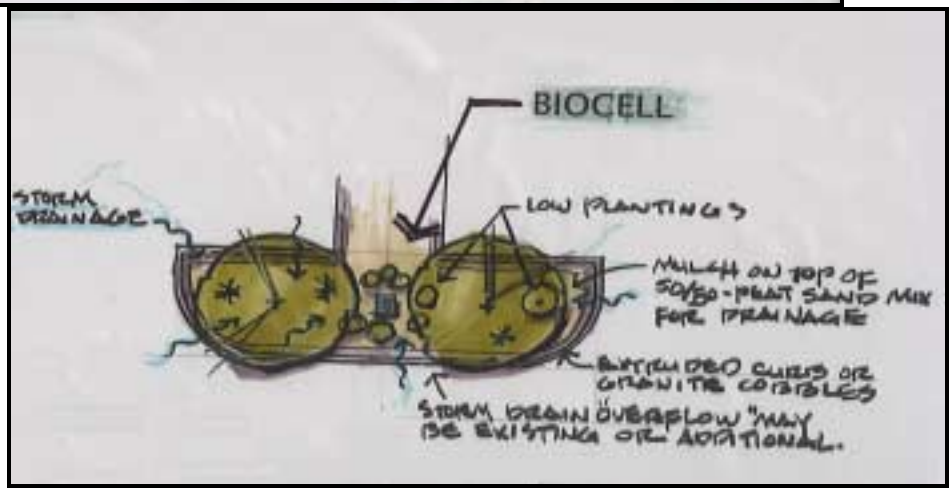




Bio-Islands & Bio-Cells

Description

An installation of varying proportions (Bio-Cell being small to medium in size and Bio-Island being a larger more centralized treatment and landscaping feature) that may be designed to support a wide variety of plantings and provides a beneficial “habitat” for pollutant removal.

Application

Other than scale, both Bio-RPMs may be used at a variety of sites. Their high organic component means that it can be used as a landscape focal point in a prominent location on the site, however infiltration rates may be compromised for the same reason. These systems (particularly the smaller Bio-cell) are better adapted to handling drainage from smaller, flatter, less “flashy” drainage areas.

Advantages

These systems provide a more complete habitat for beneficial microorganisms and thus excellent stormwater treatment can be expected. The high organic content and free form nature of the Bio-Island lends it to a wealth of colors and textures in the plantings. Separate planting zones within these structures can be created to support plants of complementing treatment efficiency and appearance.

Disadvantages

The trade off for having a higher organic content with greater planting choices is that the ability of the device to accept and quickly infiltrate water may be compromised.

Design Considerations

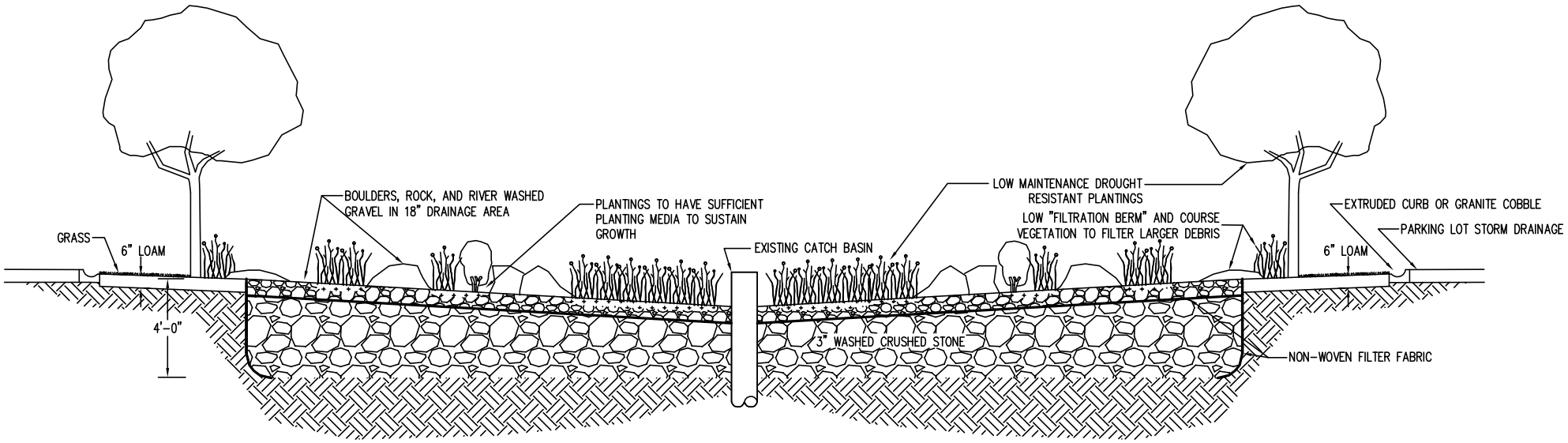
Care must be taken in estimating the proper storage volume within the reservoir area. Different blends of planting media (which occupy a substantial portion of the subsurface area) will yield considerably different available storage space.

When bark mulch is used for the surfacing material, fresh mulch is preferable to aged for nutrient assimilation. If shredded wood chips are used as a substitute, hardwood varieties are known to be less likely to float when the structure has surface ponding.

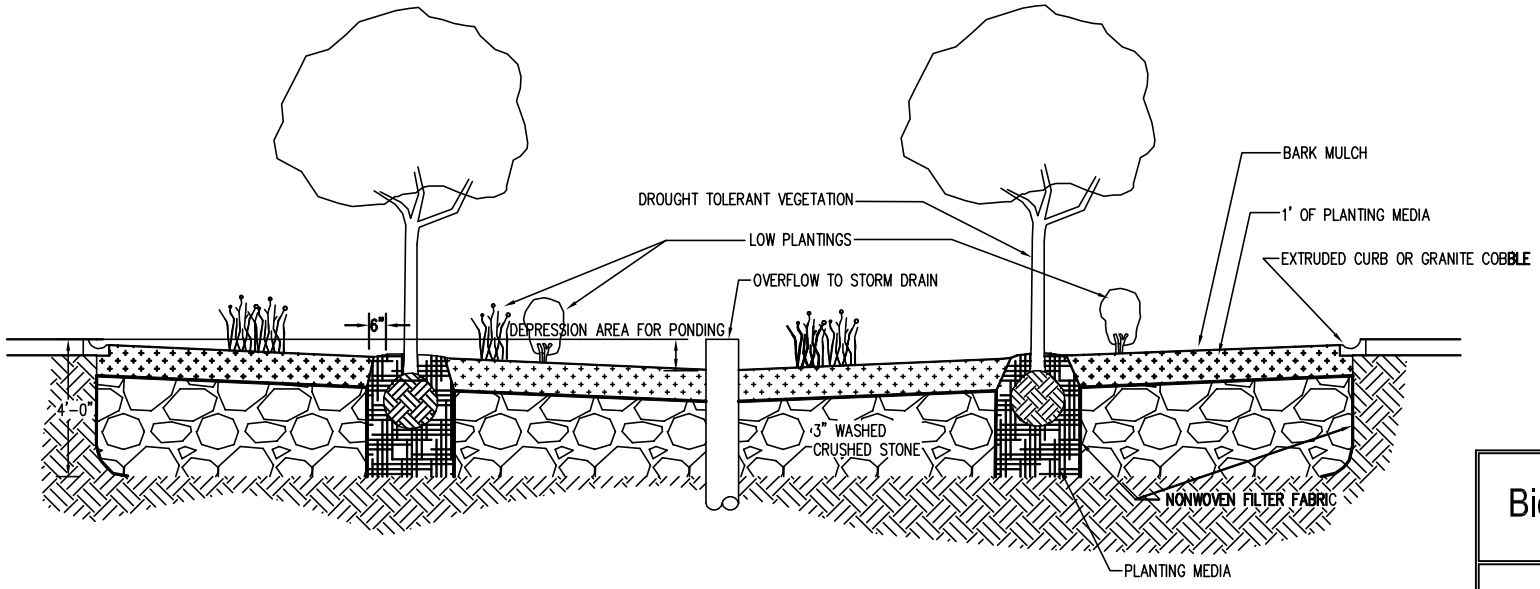
In the larger Bio-Island application, designers should note that two treatment areas are intended. The outer layer is meant to settle out and assimilate reasonable amounts of sand and the coarse grass is meant to act as a living leaf/debris rack. This enables the inner area to receive water that is relatively free of debris and particulates, and thus preserves the surface infiltration rate and prolongs the time needed between clean up.

Maintenance

The leaves that fall onto the surface of these structures can quickly form a surface barrier to incoming water and so a Spring and Fall clean-up is recommended. The higher maintenance frequency in these structures relative to other RPMs is a function of their landscaping requirements. Owners want these structures well maintained to preserve and support their planting investment for a number of years.



BIO-ISLAND



BIO-CELL

Note: Not to Scale, For Conceptual Design Purposes Only

Bio-Islands and Bio-Cells

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Grassed Infiltration Strips

Description

A grassed area located at the edge of pavement to filter contaminants by flowing through vegetation and through infiltration. A typical strip size is 10 feet wide with a minimum depth of 6 inches to allow for temporary ponding of water. Grassed Infiltration Strips are aesthetically pleasing and perform a similar function to filter strips along a river.

Application

This infiltration device is used primarily for filtering overland stormwater flow from an impervious surface. It also incorporates infiltration into its treatment mechanism. It is ideally used when there is sufficient space around a parking lot or impervious drive.

Advantages

Grass is easily mowed and therefore is a low maintenance surfacing. The area used for this device is typically unused space around parking lots or along the edge of a road and can therefore easily conform to this treatment option. It has a sufficient storage capacity even though it is easily mistaken for a normal lawn. Occasional nonvehicular traffic is permitted by the surfacing.

Disadvantages

Infiltration rates through the planting media may not be as rapid as through other surfacing options. Should not be used in areas where perimeters of parking lots and drives slope towards the parking lot or drive, unless an overflow device is implemented.

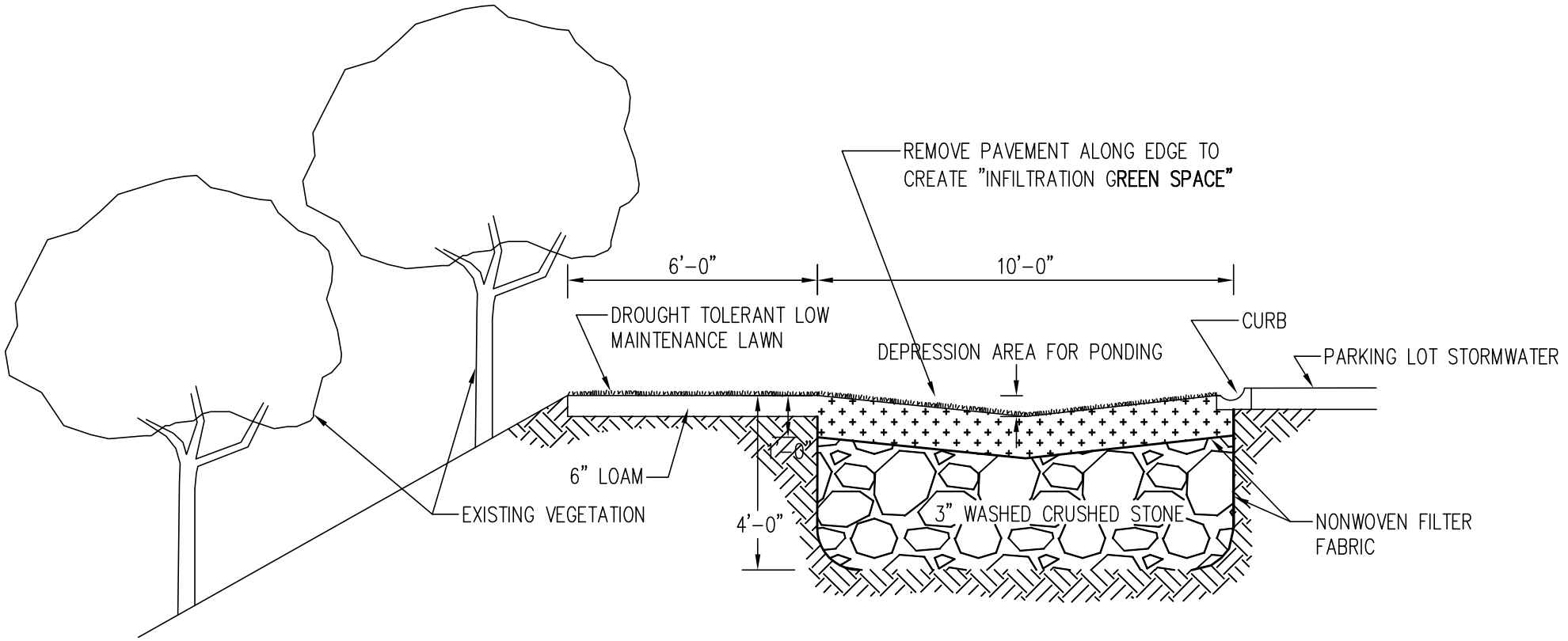
Design Considerations

Parking lots and drives with perimeters sloping into them are not feasible for this device. Water must be able to flow across the device and away from the parking lot. Runoff flows with high concentrations of sediment will cause the depression to fill in. This will necessitate frequent maintenance for the strip and should be avoided. These strips should be located where they are not frequently crossed or a small walking bridge could be placed to allow crossing after periods of high rainfall. The downhill side of the crushed stone area should be a minimum of 6 feet from any steep slopes.

High traffic areas should be avoided because of compaction and the potential for water to pond in the depression. If many people were to walk over the strip, the infiltration capacity will be greatly reduced. This compaction could also kill the vegetation and destroy the overall treatment effectiveness of the RPM.

Maintenance

The grass is a low maintenance surface which should be maintained at typical height. Occasional high flows may carry a lot of sediment into the depression. Upon removal of this sediment care must be taken to not dig up the current vegetative layer. The 1 foot planting media filter layer and the filter fabric will prevent silt from entering the crushed stone. When infiltration rates are greatly reduced from this silt, the planting media may be removed along with the filter fabric and new materials put in place. Maintenance costs are relatively cheap until the filter layer is excavated.



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Grassed Infiltration Strips

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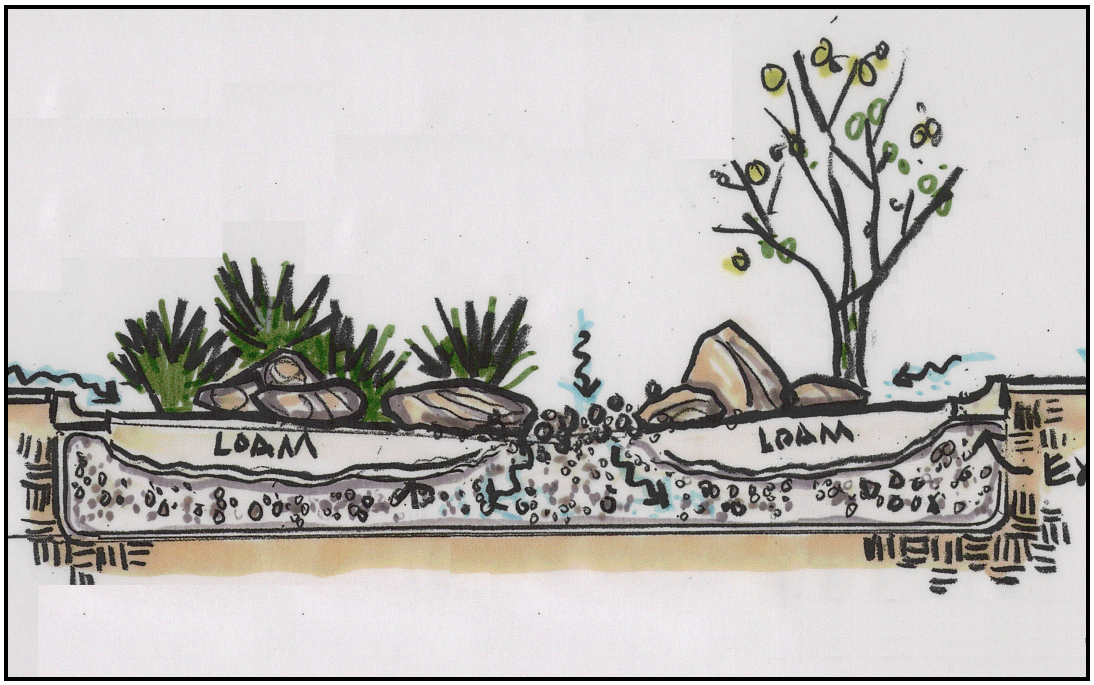


Dry Stream Infiltration Bed

Description

A large structure designed to contain and infiltrate large volumes of stormwater. A dry riverbed theme has been chosen, and certain landscape elements added (boulders, etc.) to showcase what might otherwise be a large stark infiltration strip. Other elements such as ornamental bridges and picnic tables allow the area to be used as an informal outdoor lunch area during good weather.

Application

This RPM is intended to handle large volumes and rates of stormwater typical of a commercial parking lot. Providing a picnic area can make the installation have even greater utility on the typical tightly constrained office parking lot.

Advantages

This RPM has the ability to handle large volumes of stormwater. The “themeing” of the structure can allow it to be used as an amenity and add character which may differentiate the property from others. Perhaps a good selling point to prospective buyers.

Disadvantages

The limited use of vegetation will provide little shade or cooling effects to the parking lot as a whole. As a large centralized device, this structure provides a greater vehicle restriction. The abundance of ornamental features (such as boulders and picnic tables) can add cost with no gain in capacity.

Design Considerations

Volume calculations should account for ornamental features that are proposed to be located below the invert of the overflow.

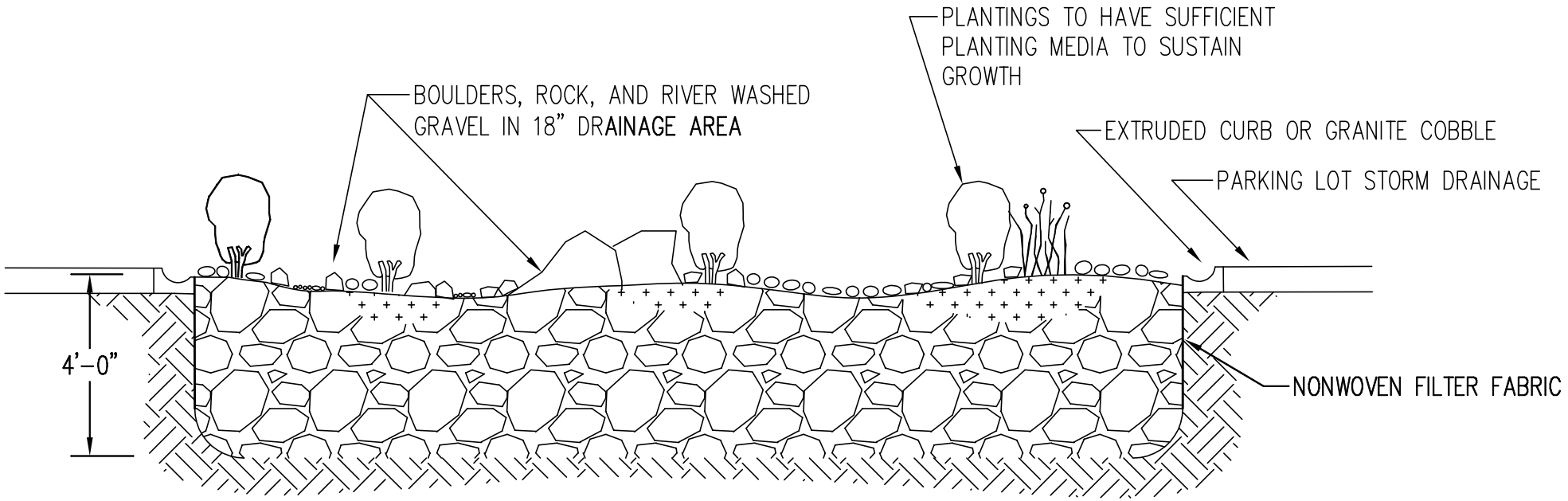
When bark mulch is used for the surfacing material, fresh mulch is preferable to aged for nutrient assimilation. If shredded wood chips are used as a substitute, hardwood varieties are known to be less likely to float when the structure has surface ponding.

Because of its size, a significant slope throughout the length of the structure (when installed parallel to the slope) can cause ponding, and associated overflows at the downgradient end and underutilized storage volume at the upper end. Installing the structure perpendicular to the slope is the preferred orientation, but in cases where it must be installed parallel, impervious walls should be installed down to the floor of the leaching area. These barriers serve as grade checks and should extend through the surface (and perhaps hidden by a footbridge) with sufficient reveal to compartmentalize the structure so that lateral movement is minimized.

If picnic tables and other pedestrian attractive features are used, localized compaction may occur resulting in less stormwater infiltration in these areas. Stepping stone walkways or seating areas can be added and are one way to concentrate use within the structure. These impervious features should always be surrounded by pervious materials.

Maintenance

Because the mulched areas serve as pretreatment zones they must be managed as such. The mulched planting area will require periodic inspection for sediment buildup. Sediments collected in specific areas that are not retained by the planting bed will require periodic removal. The RPM should also be inspected occasionally during a storm event to ensure that the RPM is not short-circuiting (creating preferential flow paths for the runoff) which minimizes the pretreatment effects of the mulched planting area.



Note: Not to Scale, For Conceptual Design Purposes Only

Dry Stream Infiltration Bed

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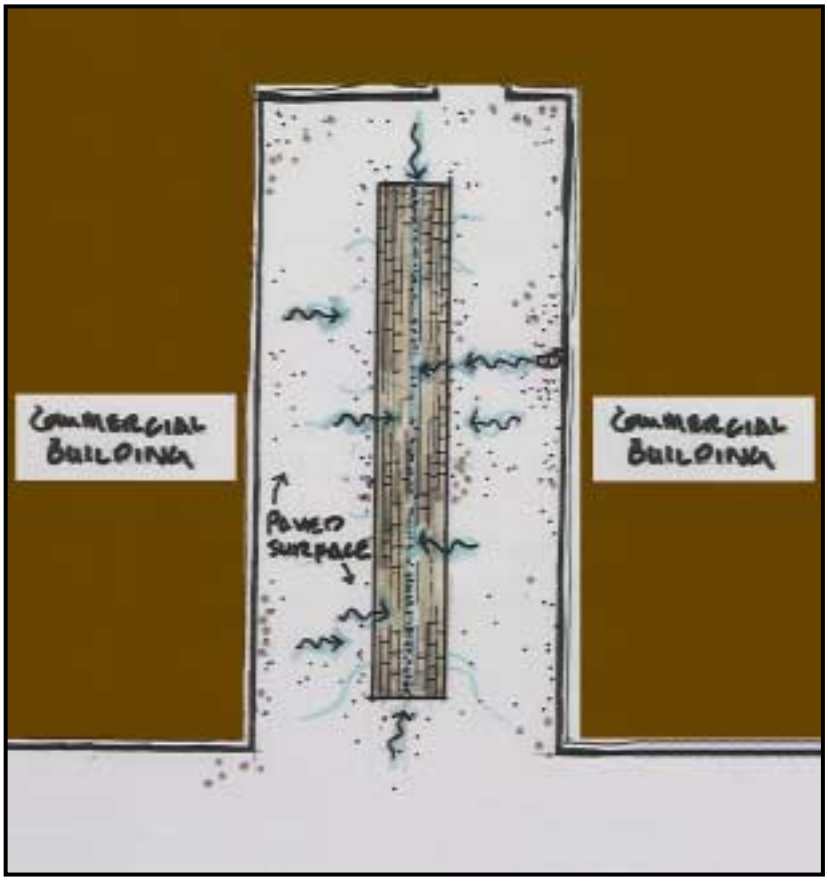


Alley Infiltration

Description

A surface infiltration area with a narrow entrance comprised of a durable surfacing such as cobble stones or pavers. No vegetation is used in this structure.

Application

Alley Infiltration is meant to be used in narrow areas where vehicular traffic is concentrated. Areas with roof leaders that discharge to a paved surface may also be served by these installations. Designers who wish to disconnect roof leaders from a current underground storm drain connection and allow them to discharge to a paved surface (for entrance into the Alley Infiltration) should consider safety issues that may arise in winter due to icing.

Advantages

At sites with little or no existing access to the underlying soil, these installations allow for stormwater infiltration with no loss in serviceability of the area.

Disadvantages

Surfacing the Alley Infiltration structure with a durable material such as pavers or cobblestones can comprise a significant portion of the cost of the installation.

Proximity to foundations may necessitate underdrains and/or installation of impervious barriers that may affect the level of groundwater recharge.

Design Considerations

If Alley Infiltration is used in service entrances, areas where heavy vehicles are likely to be turning and tracking across the pervious surface, or any other traffic patterns where the vehicles don't straddle the pervious surface, designers provide structural support (more compaction of subgrade and bedding materials) while maintaining sufficient surface infiltration rates.

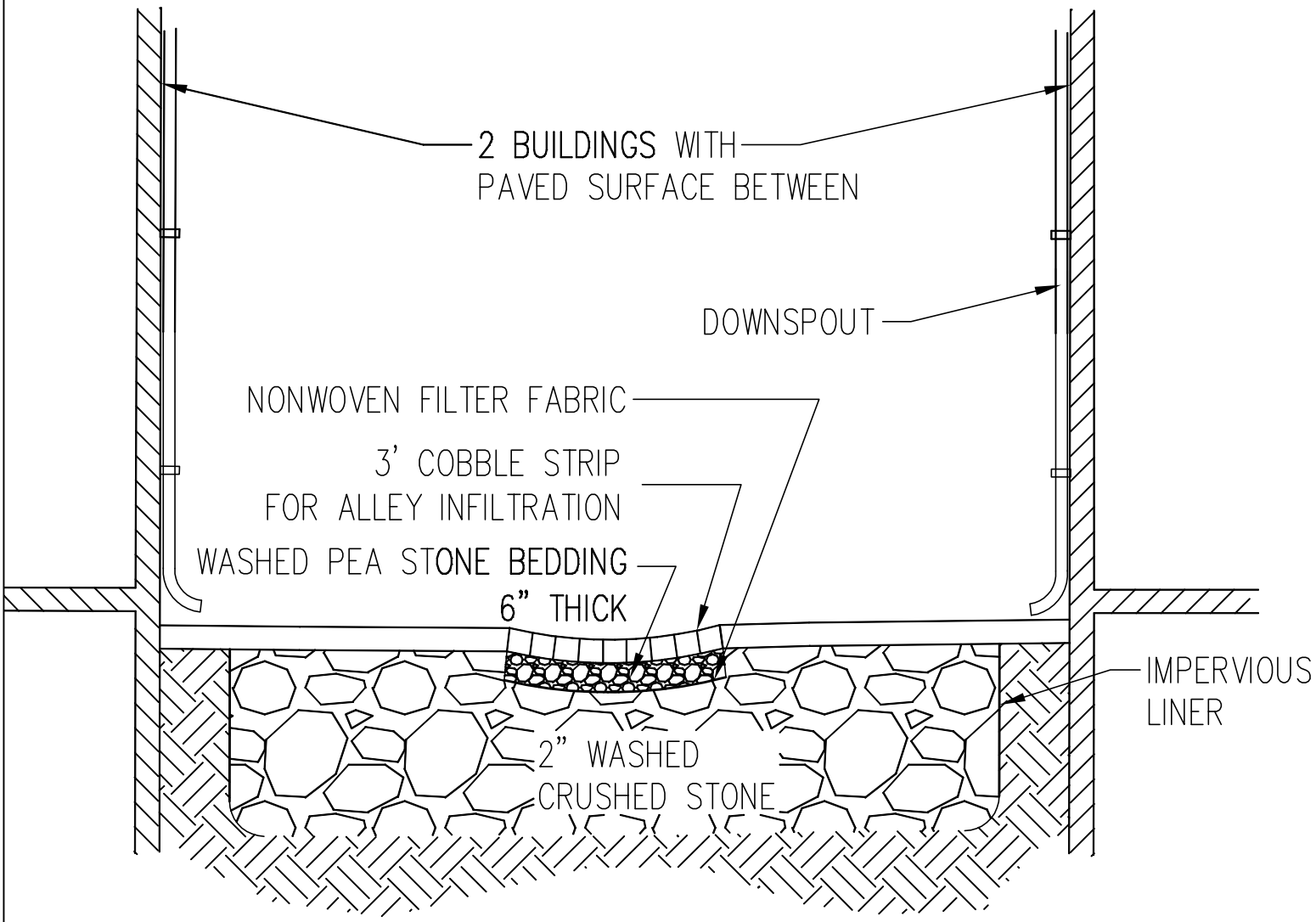
If foundations or other subsurface structural features are located nearby (within 10') or downgradient of the Alley Infiltration, advice from a geotechnical engineer should be sought.

The low organic content within Alley Infiltration may not provide optimal treatment of organic pollutants if the structure is sited in rapidly draining sandy soils. Some augmentation with coarse peat at the bottom of the stone reservoir (6" thick) area may be warranted in these cases.

Maintenance

Paver/cobblestone surfaces located in traffic areas will require periodic inspection for deflection (raised or uneven surfaces) to ensure that they will not be pulled up during winter plowing activities. This is best inspected in the Fall, before snowfall. If deflection approaches half of the paver/cobblestone thickness, the affected paver(s)/cobblestone(s) will need to be re-leveled flush to the others.

Sand deposits that have accumulated on the surface of the RPM will need to be removed periodically. A wet/dry vacuum is ideal for this and will prolong the life expectancy of the surface of the structure before the pavers, bedding material, and filter fabric must be completely removed and replaced and/or reassembled. The use of a push broom to remove deposits may be quicker in the short run, however may result in redistribution of much of the accumulated sediments and debris over the surface. If sediment removal maintenance is not conducted, the surface may require rehabilitation on a more frequent basis.



Note: Not to Scale, For Conceptual Design Purposes Only

Alley Infiltration

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21 DEPOT STREET
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Decorative Planters

Description

A self-contained upright structure that provides stormwater treatment and attenuation, but usually little groundwater recharge. With similarities to window box planters or raised planting beds, these designs are very ornamental.

Application

The Planters are designed to capture and treat stormwater originating from rooftops, by intercepting water from roof leaders prior to it entering an existing underground piped drainage system.

Advantages

For sidewalks and other areas with constricted spaces, the planters can be designed to be narrow, and yet still perform well and look attractive.

The generous volume of planting media used in these designs should allow for a wide variety of annuals to thrive.

Disadvantages

Planters are not designed to provide recharge to groundwater.

Because the Planters must be disconnected in Winter (downspouts must be disconnected from the planters and redirected to their original point of discharge), the volume of water treated annually is less than that of other RPMs that receive at least a portion of meltwater during freeze thaw conditions of late Fall and early Spring.

Design Considerations

Depending on space constraints, the planters can be tall and flush with a wall as might be the case with an installation on a sidewalk, or they can be shorter and wider making it similar to a raised planting bed.

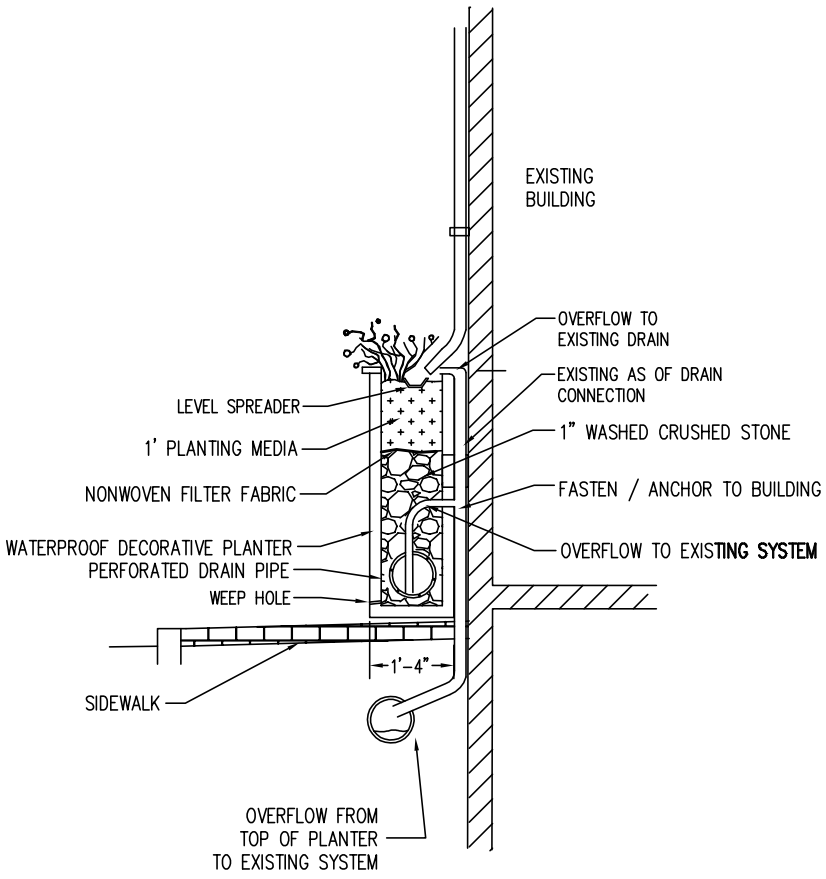
Designers and owners should understand that during the Winter the Planters will be exposed to the elements and therefore may not be conducive to the survival of perennial flowers. For this reason, the beds will need to be planted annually, and thus annuals with their vibrant colors may be a good choice.

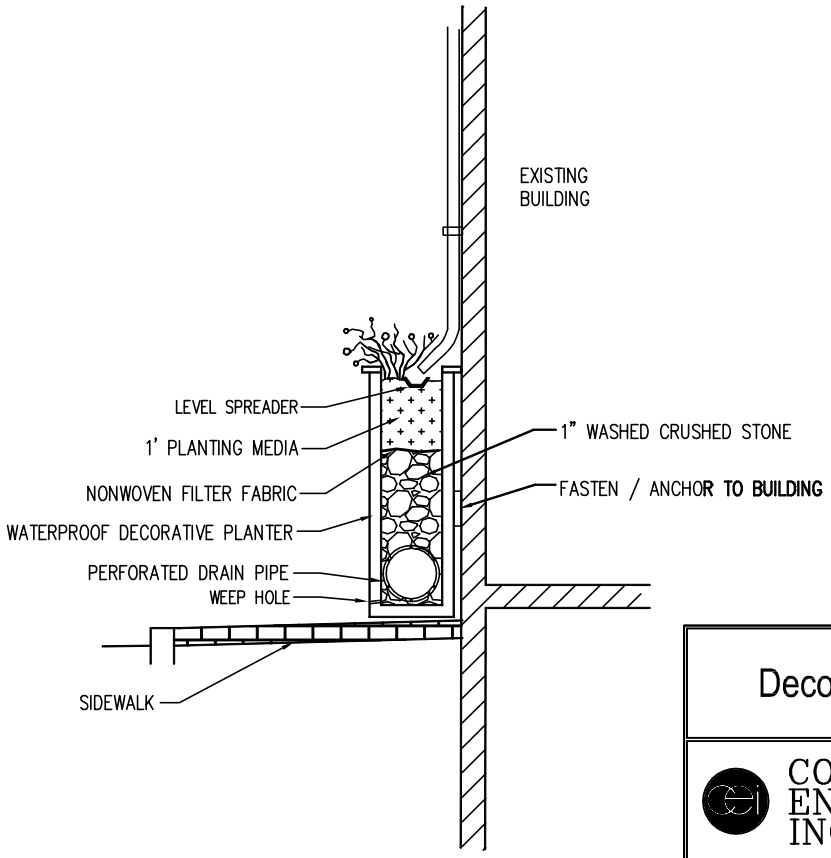
Weep holes should be provided at the lowest point in the structure to allow the system to drain between storms. The weeps could drain to the overflow pipe and thus back into an existing underground drainage system. This would be desirable if the planters are located on a sidewalk so that water does not flow across the sidewalk. If the planters are to be located on a pervious surface the weeps can drain directly to the ground, however foundation concerns (see discussion in Design Constraints Section) may need to be addressed.

Designers may want to install an access port on the side of the planters. This would allow access to the end of the perforated pipe for cleaning out debris and roots every couple of years.

Maintenance

Maintenance for the Planters is similar to that of normal flower beds, however the application of soluble fertilizer is discouraged. Those maintaining the plants and flowers should be careful not to overly compact the planting media and prevent percolation.





Note: Not to Scale, For Conceptual Design Purposes Only

Decorative Planters

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21 DEPOT STREET
MERRIMACK, NH 03054
64 DILLA STREET
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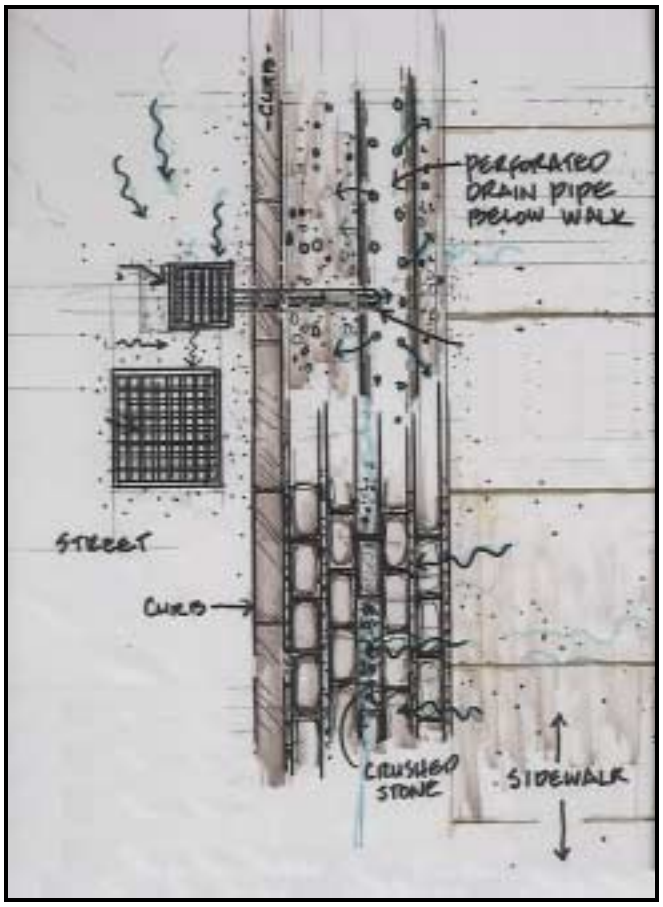


Curbside Treatment

Description

Curbside treatment has been developed to meet the stormwater management needs of downtown streets and sidewalks where pervious surfaces do not exist. The RPM involves the construction of a pervious sidewalk underlain by a perforated drain pipe. Runoff generated from the sidewalk can percolate through the pervious materials into the underdrain system, while runoff from the roadside can be collected in a catch basin and connected to the underdrain below ground. Normal difficulties relating to access for maintenance or replacement have been reduced in the design through the use of pretreatment devices and removable surfaces.

Application

Curbside treatment is meant to be used to treat runoff from sidewalks and curbed streets where few onsite options exist.

Advantages

Using cobblestones or pavers in place of concrete for sidewalks allows any runoff from the sidewalk to percolate into the ground. This treatment can add beauty and distinction to the streetscape. Most important from a maintenance/longevity standpoint, the removable (non-grouted) surface allows for easier access to the perforated pipe for cleaning or eventual replacement when it reaches the end of its service life.

Disadvantages

Pretreatment provided in the upgradient diversion catchbasin will not be as effective as most RPMs with pretreatment occurring at the surface and will be dependent upon frequency of catch basin cleaning operations.

Conflicts with underground utilities may limit the use of curbside treatment in some areas.

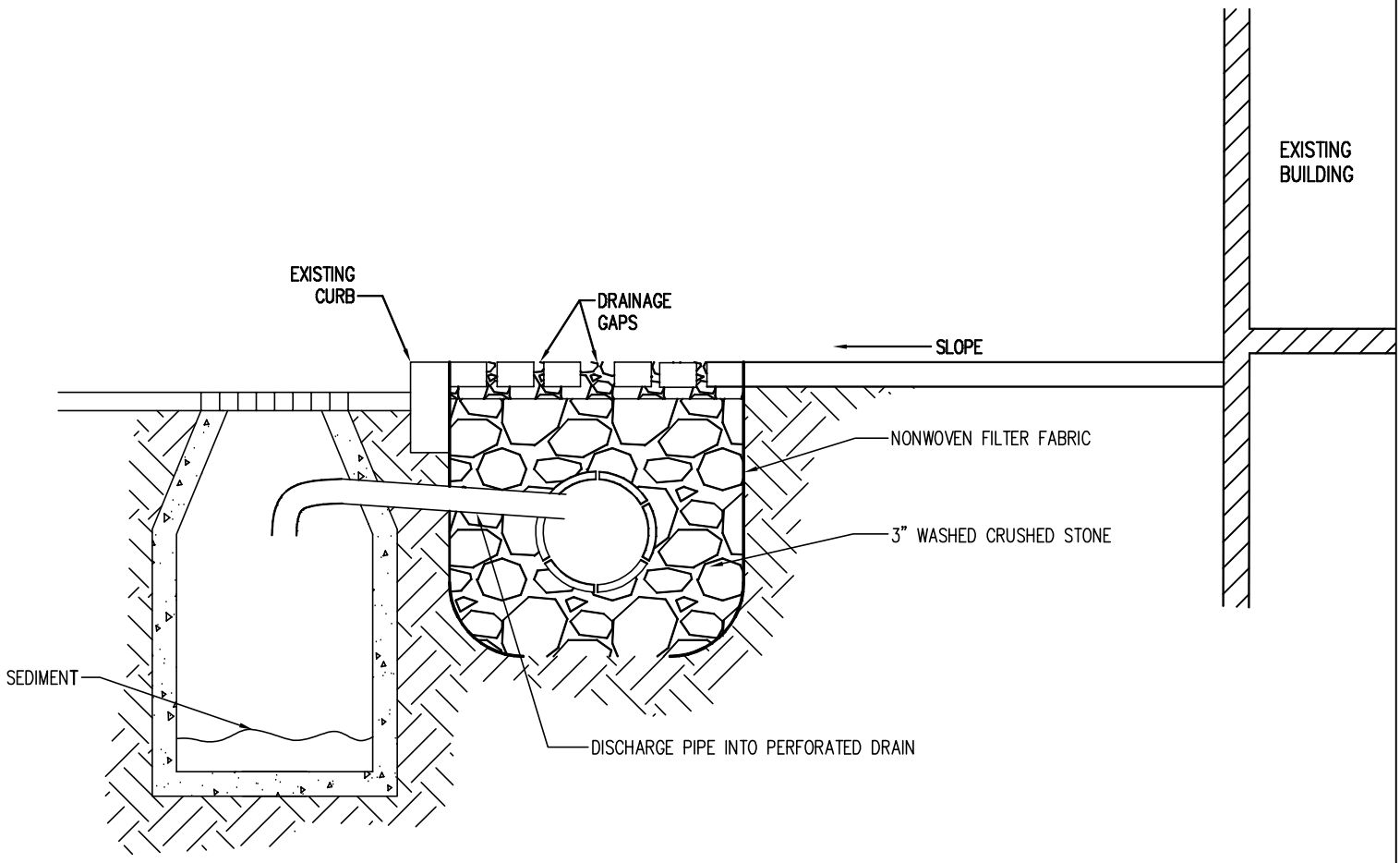
Design Considerations

Pretreatment of the roadway runoff is provided in a new upstream catchbasin. To enhance the removal rate of particles, trash and floatables, a hooded outlet cover may be installed. The sump in the catchbasin should be as deep as is practical to further enhance settling.

A variety of pervious surfacing choices exist for use in this design since the runoff from most sidewalks can be captured and infiltrated sufficiently even with a brick (ungrouted) sidewalk. In areas where sidewalks are plowed, designers should confer with local personnel on this matter and utilize surfacing options that do not hinder these operations.

Maintenance

The long-term operation of Curbside Treatment relies heavily upon the removal of particles in the new upgradient diversion catchbasin. To this end, a commitment must be made to clean catchbasins before they are filled with sediment to the outlet invert. A good rule of thumb is to clean the catchbasin when the level of accumulated sediment is within 18” of the outlet invert.



Note: Not to Scale, For Conceptual Design Purposes Only

Curbside Treatment

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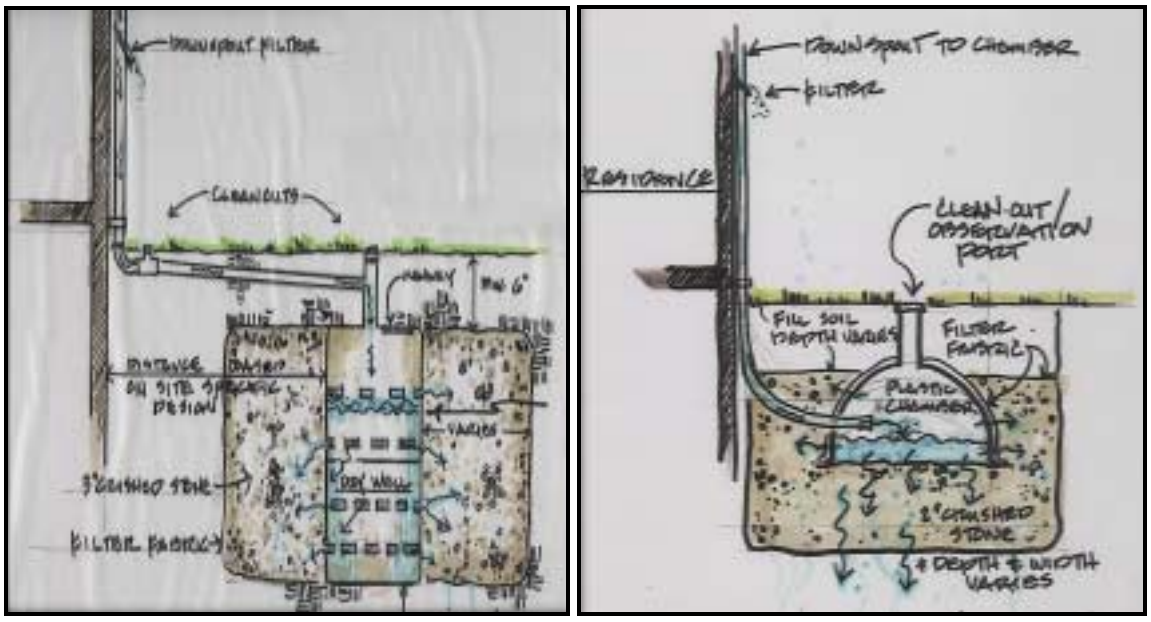


Drywells

Description

Drywells are underground areas that have been excavated and filled with stone. The voids between the stone are where stormwater is stored until it can be leached to the underlying native soils. The greatest benefit of using drywells is to remove roof runoff from the flowstream, and to recharge groundwater. This preserves the capacity of other RPMs to address runoff from other sources that may contain higher pollutant loads.

Application

Drywells have been used for a variety of purposes, usually as a passive drain for foundations, or to receive periodic discharges from sump pumps. More recently, drywells have been used to accept roof runoff. The drywells presented here are mainly used to accept roof runoff, which typically is free of most material that would otherwise clog a system.

Sizes of drywells can range from small installations that handle under 100 gallons in small lightweight plastic chambers, to very large installations using preformed concrete leaching chambers.

Advantages

Drywells are simple structures that are typically inexpensive to install and with the variety of products available to construct them, many homeowners will find installation within their capabilities.

Drywells can be fully hidden from view. Because there are few above ground features, maintenance is minimal.

Drywells may be installed deep enough (below the frost line) that they would continue to infiltrate meltwater from roofs during the freeze thaw cycles that occur in late Fall and early Spring.

Disadvantages

Installations near foundations can cause leaky basements.

Design Considerations

Drywells have been historically used to capture water from one area and disperse it over another, however the drywells presented in this manual have a number of features that address weaknesses inherent in some of the past designs.

The improved drywells presented in this document utilize filter fabric to preserve the capacity of the leaching structure and stone reservoir. Early drywells were just stone filled pits with no protection against slumping and migration of the surrounding soil into the void spaces. A gradual reduction in capacity resulted. Small sinkholes or areas where the earth has settled are usually an indication that the drywell has failed. The use of non-woven filter fabric to completely encapsulate the stone reservoir area will prevent both of these conditions. The common practice of using straw as a pervious separation barrier is discouraged since over time is can consolidate and form a semi-pervious layer.

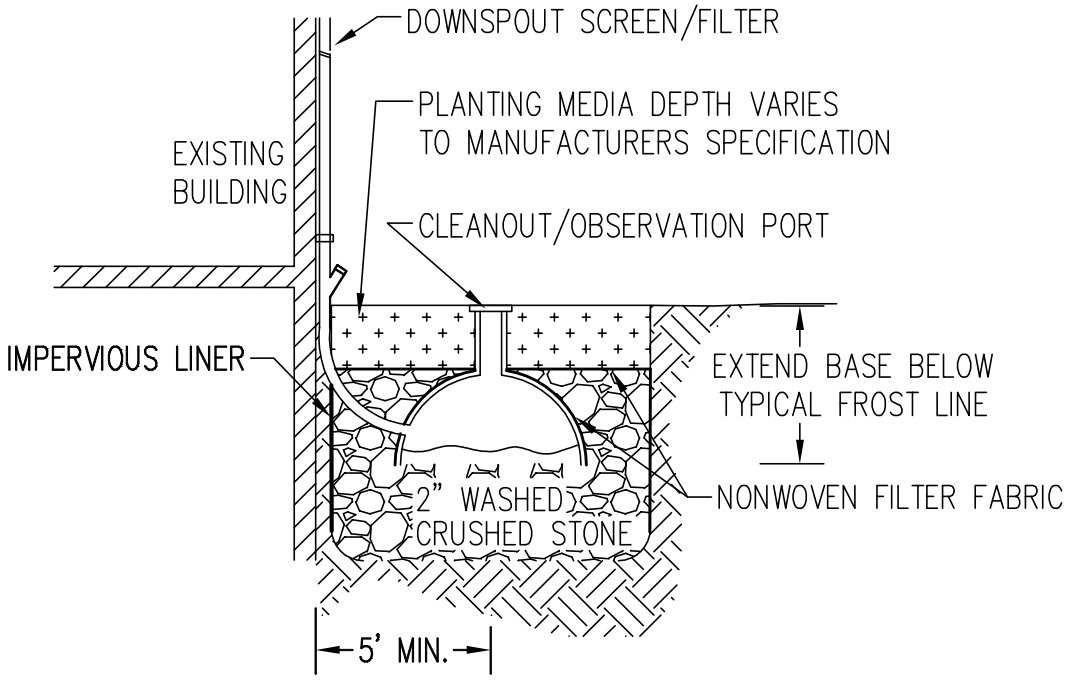
Cleanouts should be installed wherever acute bends in the pipe occur. One cleanout/observation port should be provided directly into the main leaching area so that the interior can be inspected without disturbing the ground surface over the Drywell. This port can be designed to serve as an overflow for large storms, so that once the capacity of the drywell has been used up water will just overflow to the ground.

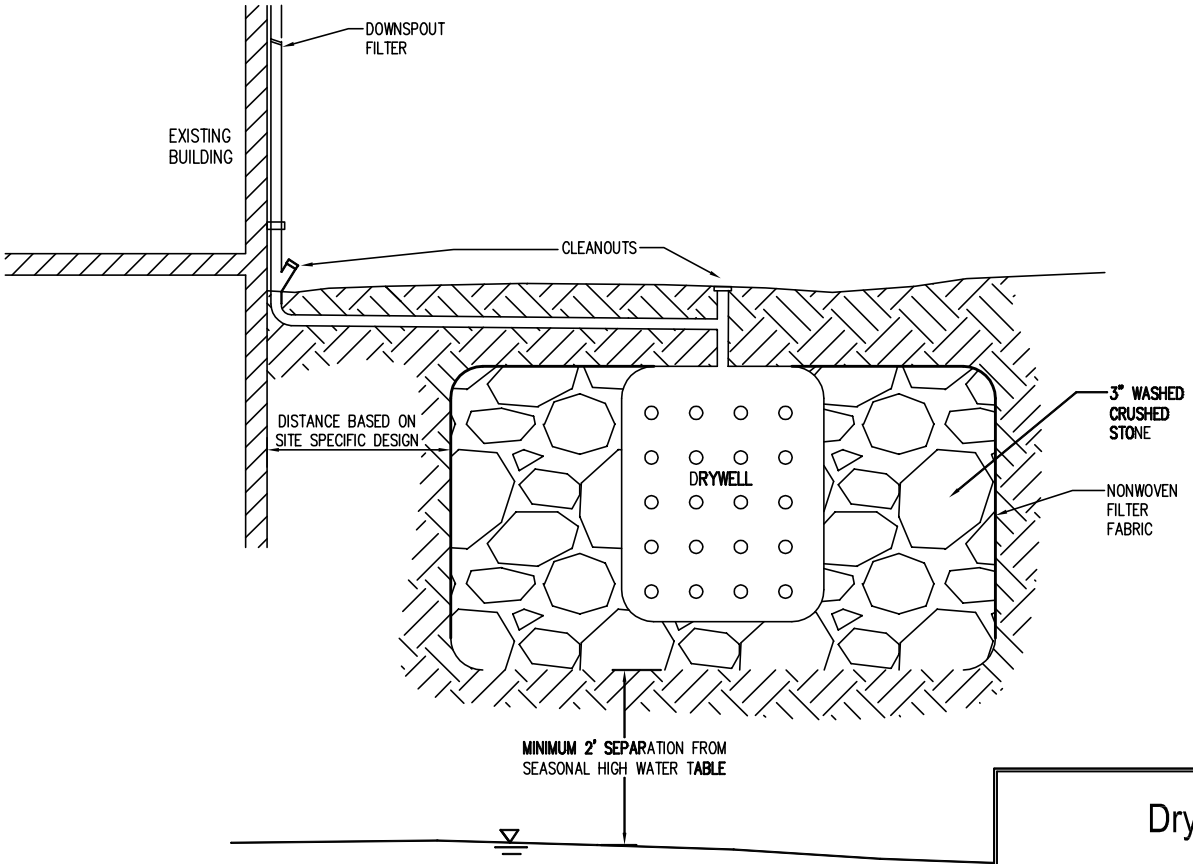
Because leaves could quickly “seal” off the interior of a drywell, some form of gutter screen should be installed for all gutters contributing stormwater to the drywell.

Maintenance

Maintenance for drywells is mainly preventative. Gutter screens should be cleaned as needed and drywells should be inspected through the observation port occasionally to ensure that they are draining completely within 3 days of the end of a storm.

In larger Drywells, manways are usually a standard component in the concrete leaching chamber. The location of these manways should be noted on plans or as-builts so that once buried, they can be found later and used to provide access for cleaning the inside of the structure.





Note: Not to Scale, For Conceptual Design Purposes Only

Drywells

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21 DEPOT STREET
MERRIMACK, NH 03054
64 DILLA STREET
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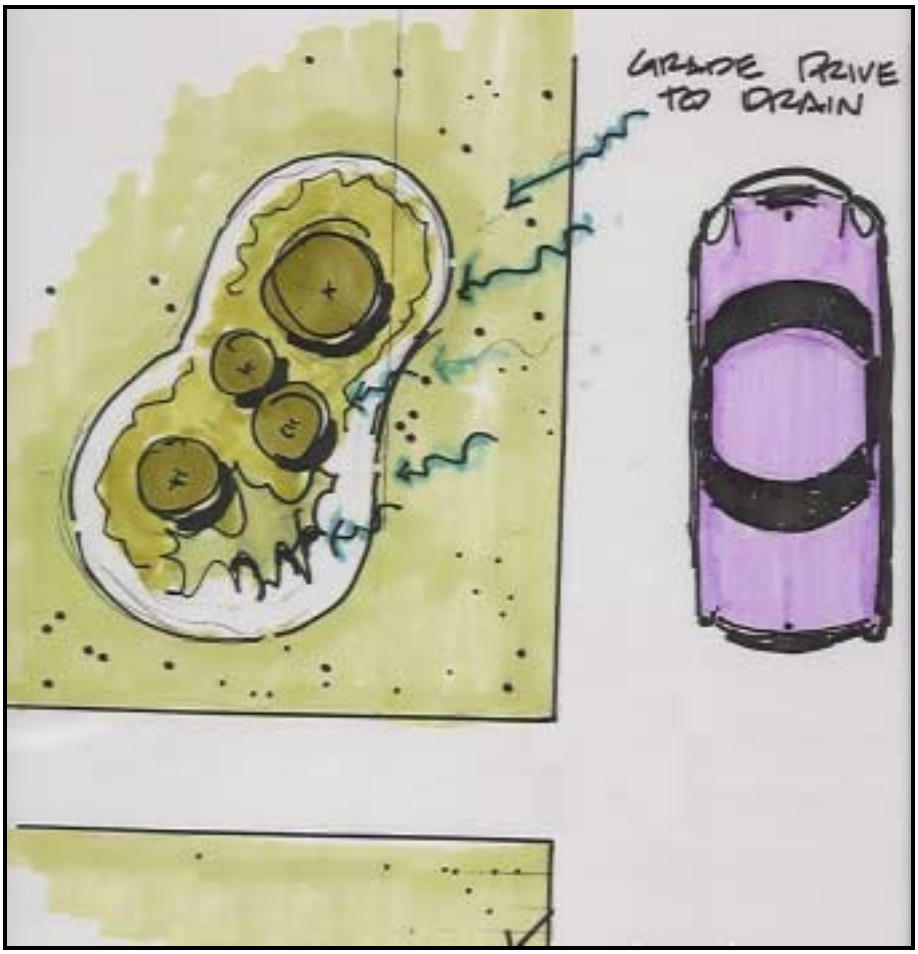


Pocket Raingarden

Description

A small surface fed infiltration device used to decorate driveway entrances and receive driveway runoff. Pocket Raingardens are modeled after planting beds commonly found in residential settings.

Application

Although Pocket Raingardens can be used on larger commercial properties, they are best suited to residential application. On a commercial property the amount and rate of runoff generated on these substantial impervious areas would quickly overwhelm them, and so other RPMs are usually chosen for their higher infiltrative surfaces. On a residential property, a number of Pocket Raingardens are typically installed on a site for proper landscaping balance and due to their small size and capacity.

Advantages

The generous volume of planting media used in these designs should allow for a wide variety of plants and shrubs to survive. The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

Disadvantages

The relatively thick layer of planting media that supports plant growth will tend to have a lower infiltration rate than other more porous surfacing options such as stone. This is generally not a problem for residential applications if the contributing drainage area is not excessive.

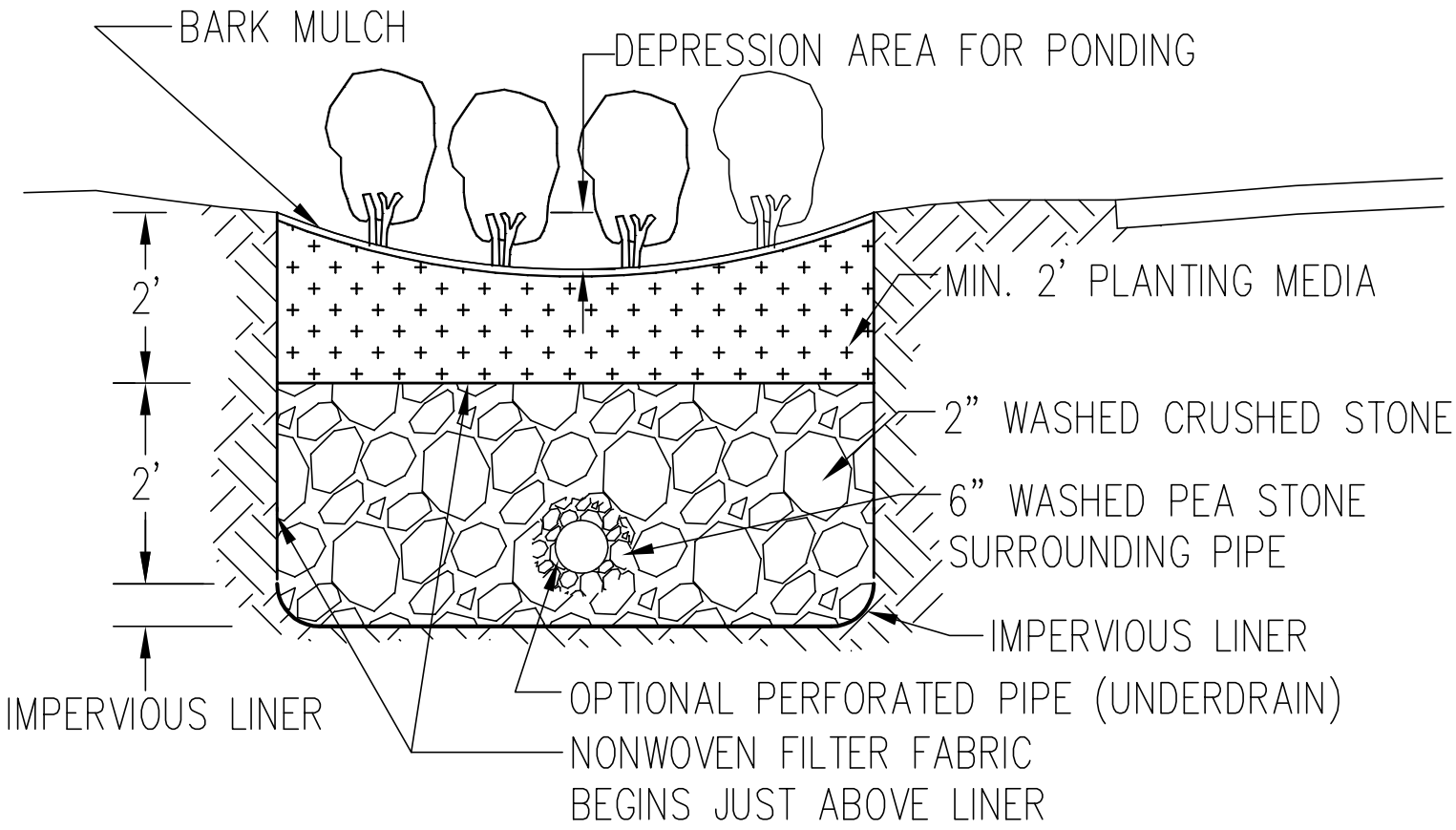
Design Considerations

Designers and installers of Pocket Raingardens should be careful not to let the surface ponding depth exceed 8 inches, or let the water stay on the surface for more that 48 hours as nuisance conditions can develop in 3 to 4 days. The installation of an underdrain may be helpful in promoting shorter drain times if these conditions are anticipated and cannot be avoided. Remember however, that true groundwater recharge will not be provided if the underdrain discharges to a nearby municipal storm drain.

To aid in the degradation of certain NPS pollutants such as nitrogen, designers may want to consider adding an impervious liner under the leaching area of a Pocket Raingarden (if an underdrain is also provided). The liner should be placed 8-18” inches below the invert of the underdrain pipe so that water that pools in this pocket stays there for a sufficient time to become anoxic and promote denitrification. Underdrain discharge points should be located far enough away from living areas so that the “earthy” smell that sometimes develops under these conditions does not bother the homeowners.

Maintenance

The Pocket Raingarden is vulnerable to compaction and homeowners need to be aware of this when performing the simple maintenance that this RPM requires. Because all stormwater must pass through the thick layer of planting media, compaction within it will limit its overall capacity and can increase the period of time that water is ponded on its surface. To lessen compaction associated with foot traffic or maintenance activities, a bark mulch surfacing over the planting media is recommended. Additionally, homeowners should be discouraged from using fungicides or other persistent pesticides in or around Pocket Raingardens because, in addition to killing the undesirable targets, other organisms that aerate the soil (worms, ants etc.) may be killed. If this principle of preserving the infiltration rate is observed, the maintenance of a Pocket Raingarden is no different from any other conventional planting bed.



Pocket Raingarden

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21 DEPOT STREET
MERRIMACK, NH 03054
64 DILLA STREET
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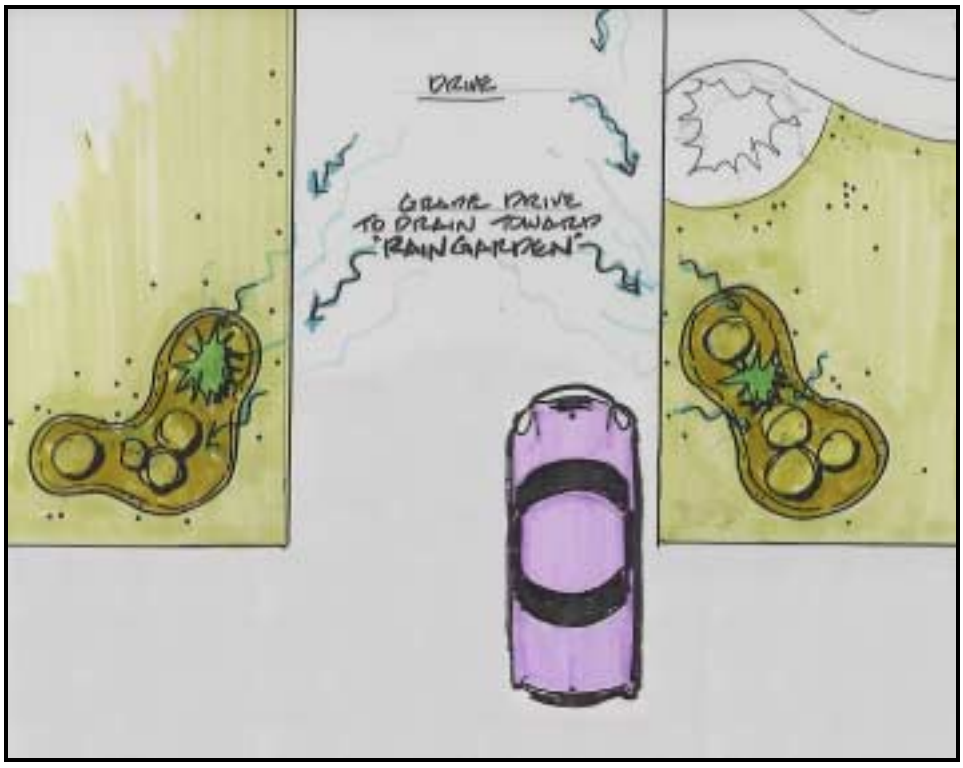
Note: Not to Scale, For Conceptual Design Purposes Only



Raingarden Planter

Description

A small surface fed infiltration device used to decorate driveway entrances and receive driveway runoff. Raingarden Planters are similar to conventional planting beds found in residential settings, however they have a crushed stone edging along their downgradient side which serves as a conduit to the stone infiltration reservoir, once the organic planting media has become saturated.

Application

Raingarden Planters can be used on commercial or residential properties. A number of Raingarden Planters are typically installed on a site for proper landscaping balance and due to their smaller size and capacity.

Advantages

The depth of planting media used in these designs should allow for a wide variety of plants and shrubs to survive.

The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

The lack of filter fabric over the surface of the planting area makes cleaning easier since care is not needed to prevent tearing of the filter fabric.

Disadvantages

Because there is no filter fabric pre-filter in the planting design, more material within the structure may require removal to ensure all of the clogging media has been removed.

Design Considerations

Raingarden Planters do not utilize a filter fabric pre-filter which means that the structure's overall design life will be shorter, however the frequency of and type of maintenance will be far less than other stormwater treatment devices, and mainly involve replacing the mulch.

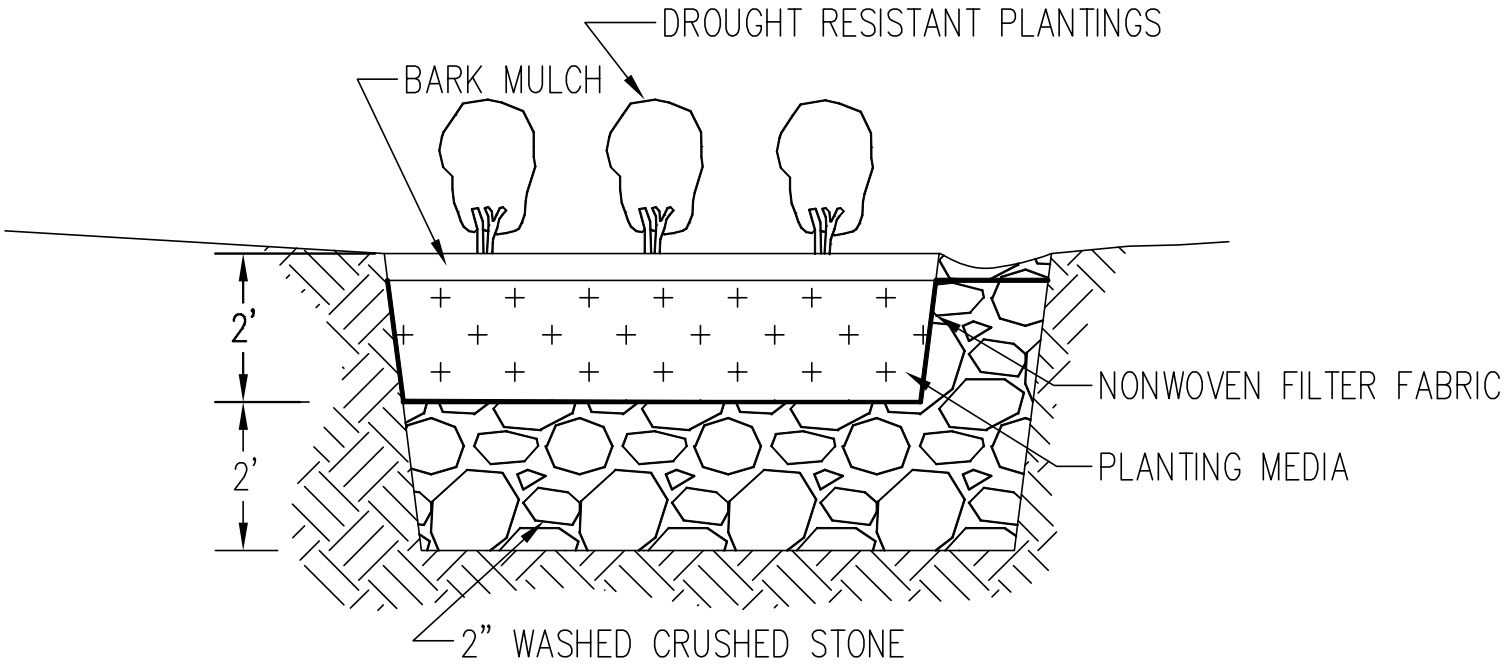
Designers and installers of Raingarden Planters should be careful not to let the water stay on the surface for more than 48 hours after a rain event[1] as nuisance conditions can develop in 3 to 4 days.

Maintenance

The Raingarden Planter is vulnerable to compaction and so homeowners need to be aware of this when performing the simple maintenance that this RPM requires. Maintenance will involve the periodic removal of sediments from the surface. The duration for the system to drain can be used as an indicator of when the system has clogged.

Homeowners should be discouraged from using fungicides or other persistent pesticides in or around Raingarden Planters because, in addition to killing the undesirable targets, other organisms that aerate the soil (worms, ants etc.) may be killed.

[1] This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.



Note: Not to Scale, For Conceptual Design Purposes Only

Raingarden Planter

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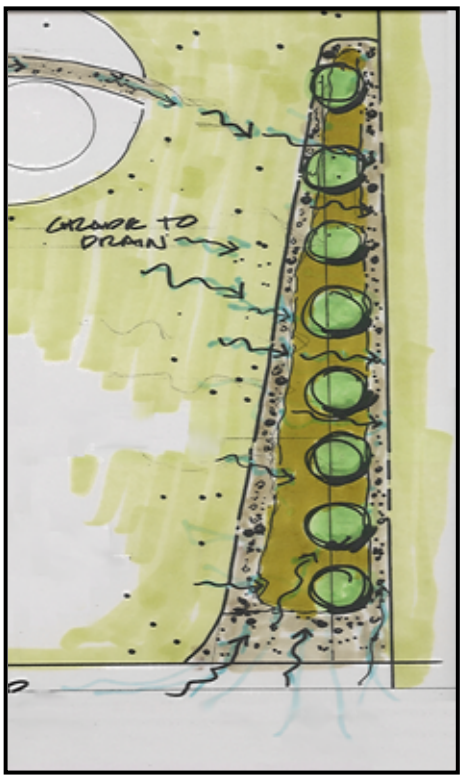
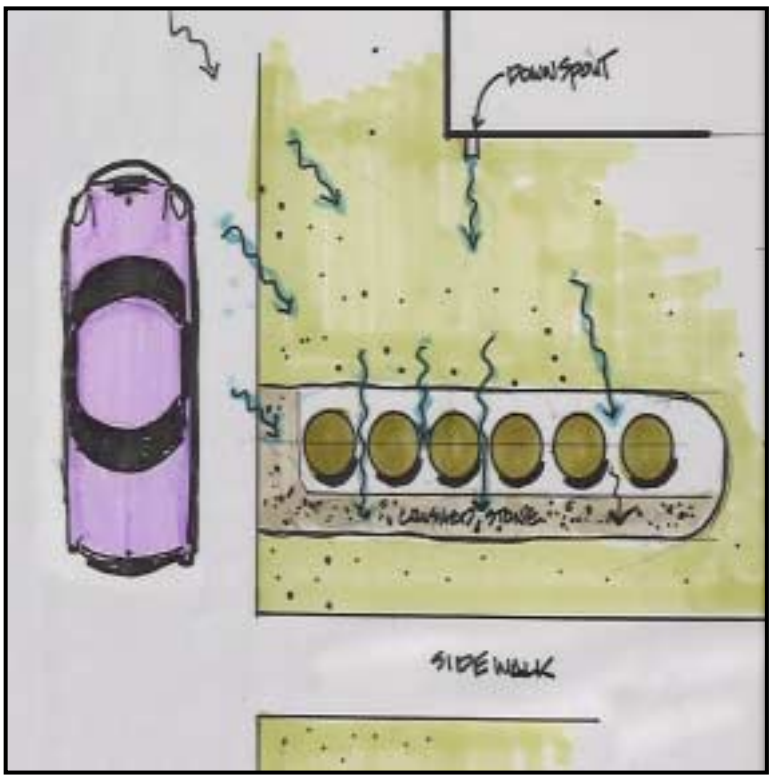
21 DEPOT STREET
MERRIMACK, NH 03054
64 DILLA STREET
MILFORD, MA 01757





Raingarden Strip

Description

A Raingarden strip is a redesigned hedgerow or garden border that has an enhanced ability to intercept and infiltrate stormwater runoff from residential streets, driveways and sheet flow from adjacent lawn areas, if needed.

Application

Raingarden strips can be used in either a commercial or residential setting with the appropriate modifications to the scale of the structure.

Because of the linear shape of these designs, locating them downgradient of other smaller RPMs can provide a backup or duplicity of treatment on sites where this is desirable. For instance, if because of space constraints, an undersized drywell is installed, it may overflow during moderate storms. The excess water may then flow across a lawn picking up fertilizer residues and other NPS pollutants. These would be captured however, by the Raingarden strip that is located downgradient at the edge of the lawn.

Advantages

The generous volume of planting media used in these designs should allow for a wide variety of plants and shrubs to survive.

The presence of organic material provides a habitat for beneficial organisms that break down NPS pollutants.

Disadvantages

The appearance and orientation of this RPM may limit its landscaping appeal as people have different landscaping taste and needs. These RPMs are intended to be located in close proximity to a driveway or street and may look awkward placed in the middle of a lawn.

Design Considerations

When located to receive runoff from streets or large driveways some stabilized surface is needed where the stormwater enters the Raingarden Strip. This can be stone or some other durable material that is not likely to be moved by the force of the water entering the Strip in this concentrated location.

Care must be taken when designing the Raingarden Strip to ensure that the planting media is not so isolated from the incoming flow that only large storms that fill the structure are able to moisten the planting media and roots. This is obviously less of a concern if drought tolerant plantings have been selected. For installations where sheet flow will comprise a major portion of the contributing stormwater, the planting media should extend to the upgradient edge of the Strip with the stone on the downgradient side. This lets the stormwater contact the media first and when it can no longer absorb moisture the flow continues across to the stone surface that provides a conduit to the stone reservoir area underneath.

Maintenance

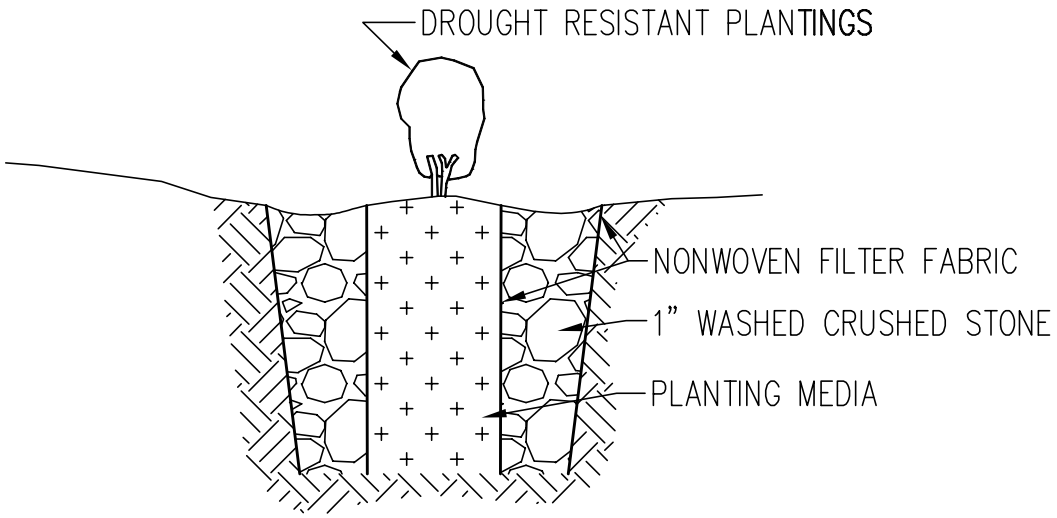
If a stabilized entrance is provided, maintenance activities will include removal of surficial sediment deposits and replacing/raking stone that has been moved during large storms.

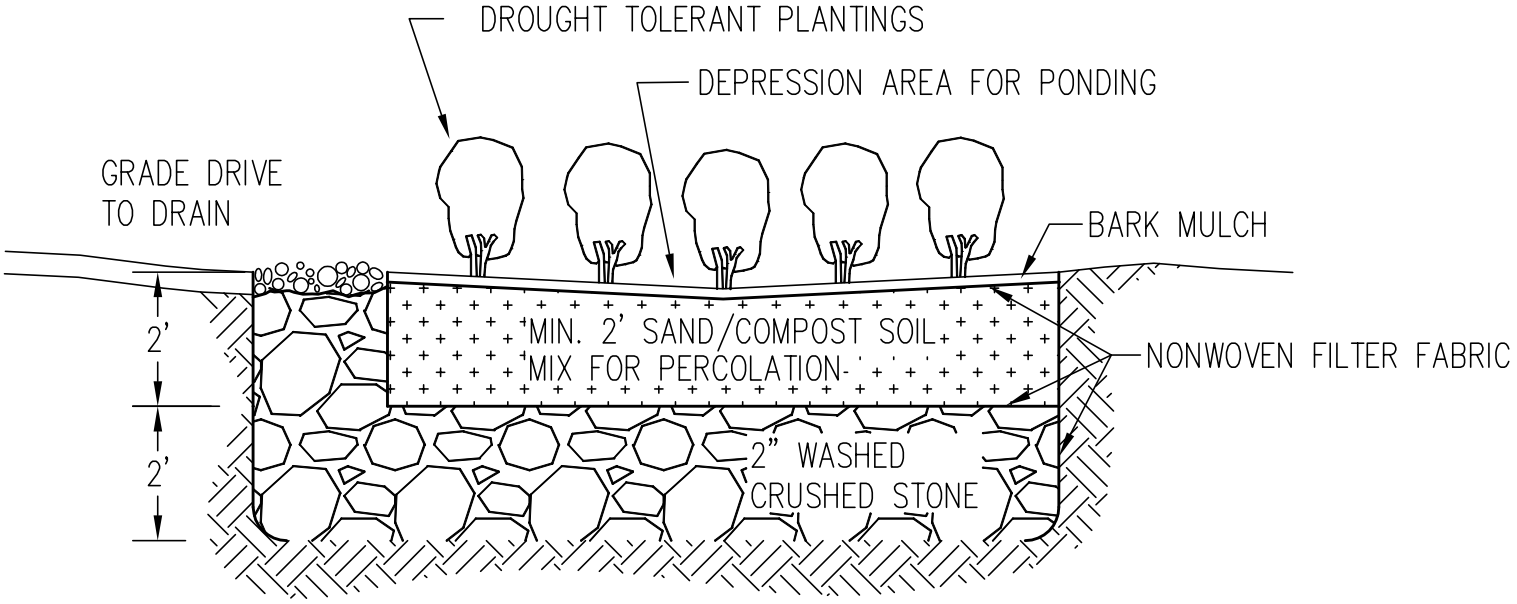
The bark mulch that covers the planting media should be replaced as needed.

If stormwater ponds on the surface of the structure for longer than 48 hours after the end of a storm[2], the filter fabric pre-filter may be clogged. In this case, the filter fabric and material covering the upper most layer of filter fabric should be removed. Owners may then either replace both the filter fabric and the cover material or, alternatively, clean the clogging material from them and reuse them. This material should not need to be disposed of at a landfill, however it should not be placed on an area that will be subject to runoff which might resuspend it.

[2] This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.

The frequency of this rehabilitation will depend on the ratio of filter fabric surface to contributing drainage area, the amount of sand applied to the impervious drainage area, and the frequency with which preventative maintenance has been performed.





Note: Not to Scale, For Conceptual Design Purposes Only

Raingarden Strip

COMPREHENSIVE
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21 DEPOT STREET
MERRIMACK, NH 03054
64 DILLA STREET
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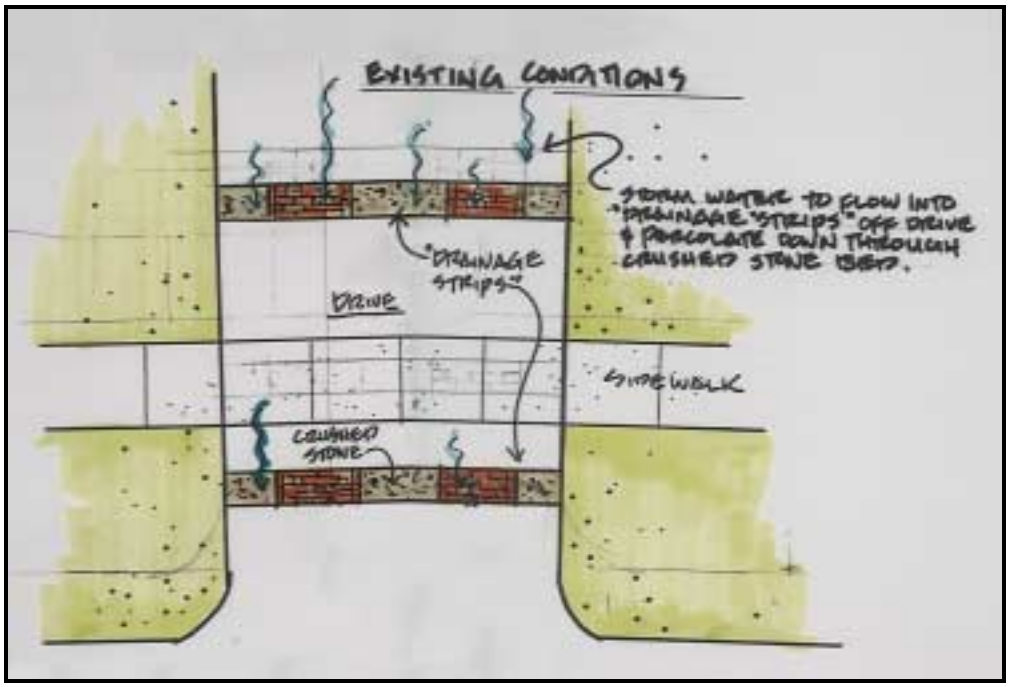


Driveway Drainage Strip

Description

This consists of an infiltration trench located in a driveway, and oriented perpendicular to the direction of travel. This RPM may be driven on and accepts stormwater runoff from driveways with low volumes of traffic (such as residential).

Application

This RPM is suited to residential drives or those with very low volumes of traffic with uniform vehicles types.

Advantages

These RPMs are very inexpensive to construct and can be used to delineate parking from travel areas or add some definition between shared drives.

Disadvantages

If the driveway is plowed in the winter, the operator should be made aware of the Strip so that they do not disrupt the surfacing materials.

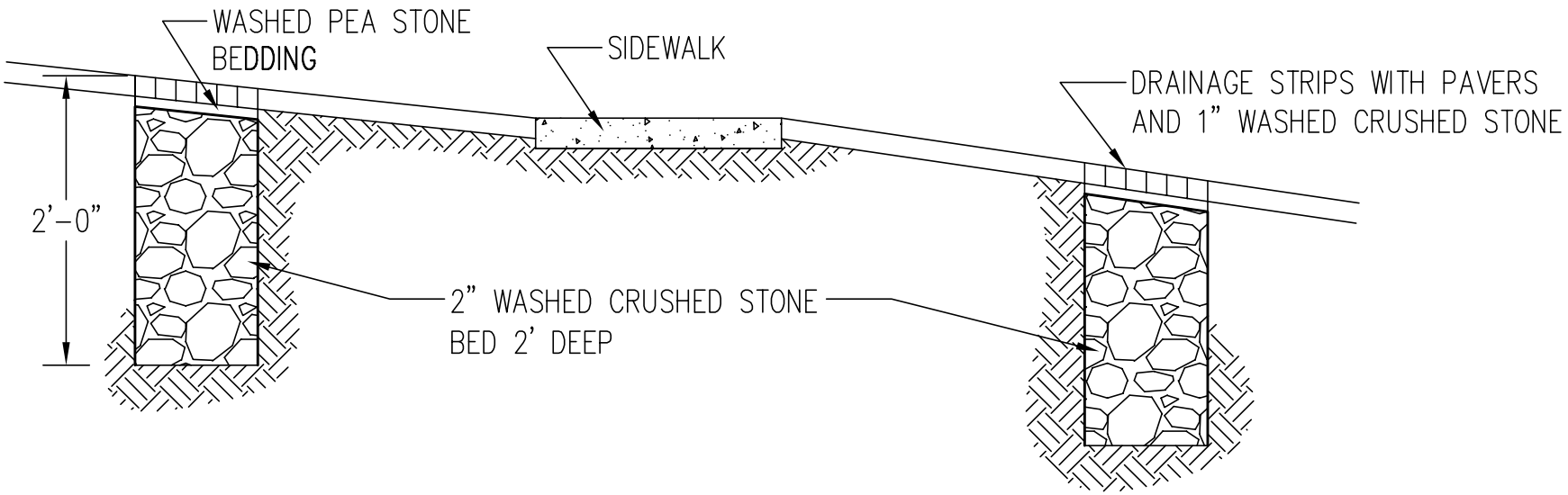
Design Considerations

In driveways where there is a high degree of crown or cross-slope, a Driveway Drainage Strip may subject the adjacent pavement to abuse from plows. As with most plowing obstacles, prior scouting of the site (before it snows) by the plow operator and sufficient markings (reflectors or similar object) can alleviate most potential problems

Maintenance

When stormwater no longer collects and infiltrates in the Strip or sediment can be seen occupying the void space of the stone, the stone and sediment must be removed and replaced.

If the pavers or other tracking material is protruding by more that half of its thickness, the bedding material should be re-leveled and the pavers re-layed to create a level surface with the surrounding pavers and pavement.



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Driveway Drainage Strip

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64 DILLA STREET
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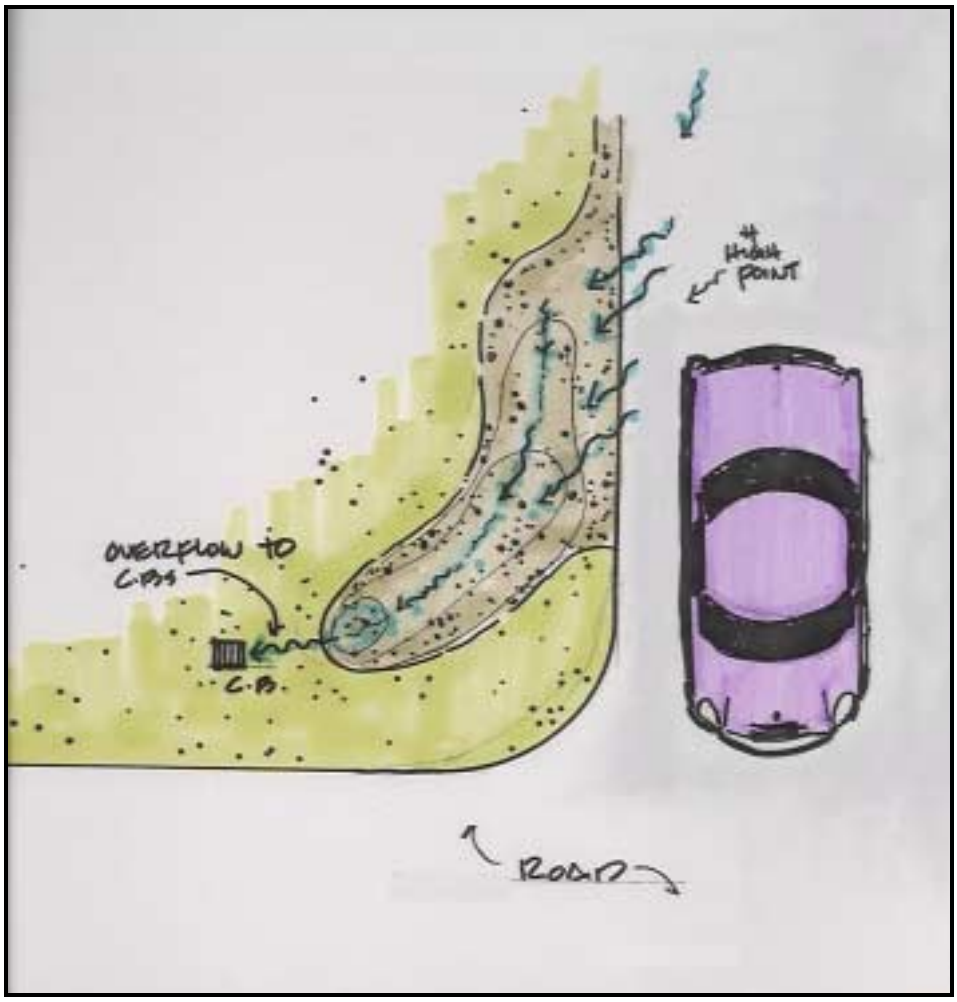


Containment Swale

Description

A shallow depression located adjacent to a roadways shoulder that is used to capture and infiltrate roadway runoff and/or lawn runoff before it enters a catchbasin. Although similar to a typical swale, this RPM is designed to pond and infiltrate water to the maximum extent possible, rather than as a means of conveyance. Excess water overflows into a nearby catch basin.

Application

There are two applications for this design. The first would be to collect roadway runoff from a street without an existing curb and gutter system. The RPM is constructed along the edge of the street allowing runoff to enter into it before discharging to a downgradient catch basin. The second application is to collect runoff from lawn areas that would

normally flow into the roadway. The RPM could be installed between the lawn area and roadway. When the unit fills with water, it would overflow back into the street drainage system (as if the RPM had not been there).

Advantages

Roadside Stormwater Diverters are relatively inexpensive given the large amount of water that can be captured, treated, and recharged.

Disadvantages

Some road agents may be resistant to infiltrating water adjacent to a road's subgrade for fear of frost damage.

Design Considerations

Shoulder slopes should be maintained particularly in areas where the roadway is narrow and around corners.

Using an impervious barrier to shield a road's subgrade may be necessary to ameliorate concerns of frost heaves damaging pavement.

Maintenance

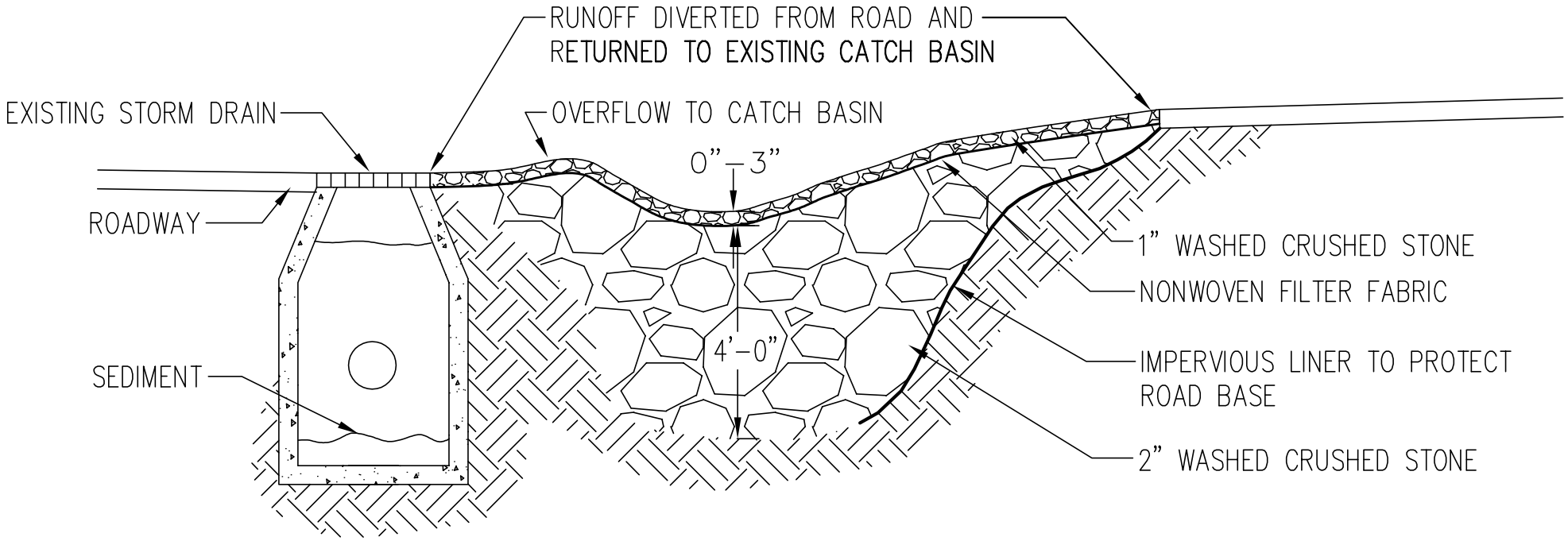
Sediment and accumulated debris should be removed in the Spring and late Fall after the leaves have dropped.

If stormwater ponds on the surface of the structure for longer than 48 hours after the end of a storm[3], the filter fabric pre-filter may be clogged. In this case, the filter fabric and material covering the upper most layer of filter fabric should be removed. Owners may then either replace both the filter fabric and the cover material or, alternatively, clean the clogging material from them. This material should not need to be disposed of at a landfill, however it should not be placed on an area that will be subject to runoff which might resuspend it.

The frequency of this rehabilitation will depend on the ratio of filter fabric surface to contributing drainage area, the amount of sand applied to the impervious drainage area, and the frequency with which preventative maintenance has been performed.

The Diverter should be inspected occasionally to make sure erosion is not occurring on any of its surfaces.

[3] This is a storm of normal duration during the growing season and would not include prolonged periods of rainfall, or spring thaw conditions for example.



Note: Not to Scale, For Conceptual Design Purposes Only

Containment Swale

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21 DEPOT STREET
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3.0 Technical Specifications

Technical specifications were developed as part of this manual to provide the City and developers with guidance on the materials and construction practices that should be used to construct the various runoff prevention measures (RPMs) presented previously.

Please note that the following specifications are provided as typical standards and that modifications will be required to suit the specific design chosen based on site conditions, design preferences (i.e., planting choices) and maintenance requirements.

The following typical specification sections have been included for RPM construction:

200	EARTHWORK FOR RPMs
400	GEOTEXTILE FABRICS
500	PAVERS AND EDGING
600	UNDERDRAINS
800	WETLANDS CREATION
900	LANDSCAPE WORK

To make it easier for the City and developer to find specific RPM components within the above specifications, the following directory has been provided. The directory breaks the RPMs down into three major construction components: 1) surface components (i.e., pavers, stone, mulch); 2) subsurface components (i.e., stones, fabrics and liners); and 3) vegetation.

Surface Components

Bark Mulch	Section 900 Landscape Work
Boulders, Rock and River Washed Gravel	Section 200 Earthwork for RPMs
Crushed Stone	Section 200 Earthwork for RPMs
Cobble Stone	Section 500 Pavers and Edging
Pavers	Section 500 Pavers and Edging
Reverse Curbing	Section 500 Pavers and Edging
Granite Curbing	See City of Nashua Standard Specifications for Sidewalk Construction

Pavement (i.e., repairs)	See City of Nashua Standard Specifications for Road Construction

Subsurface Components

Crushed Stone	Section 200 Earthwork for RPMs
Processed Gravel	Section 200 Earthwork for RPMs
Pea Stone Bedding	Section 200 Earthwork for RPMs
Nonwoven Filter Fabric	Section 400 Geotextile Fabrics
Impervious Liner	Section 400 Geotextile Fabrics
Underdrains	Section 600 Underdrains
Drywells	See City of Nashua Standard Specifications for Sewers and Drains
Pipes (i.e., overflows)	See City of Nashua Standard Specifications for Sewers and Drains

Vegetation

Coarse Vegetation	Section 900 Landscape Work
Drought Resistant Plantings	Section 900 Landscape Work
Low Plantings	Section 900 Landscape Work
Planting Media	Section 900 Landscape Work
Wetlands	Section 800 Wetlands Creation

A reference list of plantings that could be used in the various RPM designs, once site specific design investigations have been made, is included in Appendix B.

SECTION 200

EARTHWORK FOR RPMs

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Earthwork includes the preparation of RPMs.

B. "Excavation" consists of removal of material encountered to subgrade elevations indicated, and subsequent relocation or disposal of materials removed.

1.02 QUALITY ASSURANCE

A. Codes and Standards:

1. Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

2. The following standard forms a part of these specifications and indicates the minimum standards required:

American Society for Testing and Materials (ASTM)

ASTM D422	Method for Particle Size Analysis of Soils
ASTM D1557	Tests for moisture-density relations of soils and soil-aggregate mixtures using 10 pound hammer and 18-inch drop.
ASTM D4253	Test Methods for Maximum Index Density of Soils Using a Vibratory Table
ASTM D4254	Test Methods for Minimum Index Density of Soils and Calculation of Relative Density

B. Owner will engage soil testing and inspection service for quality control testing to meet material specifications or during earthwork operations.

1.03 JOB CONDITIONS

A. Existing Utilities:

1. Locate existing underground utilities in areas of work. Utility companies shall be contacted a minimum of 72 hours prior to excavation and/or site work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

2. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

3. Do not interrupt existing utilities serving facilities occupied and used by owner or others, during occupied hours, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.

4. Provide minimum of 48-hour notice to Engineer, and receive written notice to proceed before interrupting any utility.

B. Protection of Persons and Property:

1. Barricade open excavations occurring as part of this work and post with warning lights.

2. Operate warning lights as recommended by authorities having jurisdiction.

3. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

4. Perform excavation within drip-line of large trees to protect the root system from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with burlap. Paint root cuts of 1" diameter and larger with emulsified asphalt tree paint.

PART 2 - MATERIALS

2.01 STONE/SOIL MATERIALS

A. Crushed Stone

1. Crushed Stone shall not contain vegetation, masses of roots, loam and other organic matter, clay and other fine or harmful substances.
2. Crushed Stone shall be washed and shall consist of one or the other of the following material:

a. Durable crushed rock consisting of the angular fragments obtained by breaking and crushing solid shattered natural rock, and containing less than 15% by weight of flat, elongated or other objectionable pieces.

b. Durable crushed gravel stone obtained by artificial crushing of gravel boulders or fieldstone with a minimum diameter before crushing of 8 inches.

*Thin or elongated pieces are defined as follows: Thin stones shall be considered to be such stones whose average width exceeds four (4) times their average thickness. Elongated stones shall be considered to be such stones whose average length exceeds four (4) times their average width.

3. The Crushed Stone shall have a maximum percentage of wear of 45 as determined by the Los Angeles Abrasion Test (AASHTO-T-96). The Crushed Stone shall be uniformly graded according to the grading requirements for the respective stone sizes shown in the following Table:

Required Grading For Crushed Stone		
Sieve Size	**2 inch**	**3 inch**
3 inch	--	100
2 inch	100	0-10
1-1/2 inch	0-10	--
1 inch	--	--
¾ inch	--	--

B. Processed Gravel

1. Compacted processed gravel for subbase shall be used where a free draining gravel material is required and shall consist of inert material that is hard, durable stone and coarse sand, free from loam and clay, surface coatings and deleterious materials. The coarse aggregate shall have a percentage of wear, by the Los Angeles Abrasion Test, of not more than 50.

2. The processed material shall be stockpiled in such a manner to minimize segregation of particle sizes. All processed gravel shall come from approved stockpiles.

3. The gradation shall conform to the following:

Sieve	**Percent Passing**
3 in.	100
1 ½ in.	70-100
¼ in.	50-85
No. 4	30-60

No. 200 0-10

C. Pea Stone Bedding

1. Pea Stone Bedding shall consist of sound gravel, essentially free of organic matter, plastic fines (clay) and debris.

2. The stone shall be uniform round stone with 100 percent by weight passing through a 5/8 inch sieve and less than 5 percent by weight passing through a ¼ inch sieve. The stone shall be washed free of dirt and particles.

D. Boulders, Rock and River Washed Gravel

1. Boulders, Rock, and River Washed Gravel shall consist of sound, gravel, essentially free of organic matter, plastic fines (clay) and debris, and shall meet the gradation requirements below:

Gradation Requirements	
Sieve Size/Diameter	Percent Passing Weight
18”	100
12”	70
8”	40
3”	20
1"	10

2. The material shall have an in-place coefficient of permeability in the vertical direction equal to or greater than 1.0×10^{-2} cm/sec.

E. Sand:

Sand shall consist of bank run sand conforming to the following requirements determined by ASTM D422:

Sieve Opening	Percent Passing Weight
1-inch	100
1/2-inch	50-100
No.20	20-95
No.50	10-60
No.200	0-8

F. Gravel Borrow:

Gravel Borrow shall consist of sound, durable sand and gravel, essentially free of organic matter, plastic fines (clay) and debris, and shall meet the gradation requirements below:

Sieve Opening	Percent Passing Weight
3-inch	100
1/2-inch	50-85
No. 4	40-75
No. 40	10-45
No. 200	0-8

G. Backfill Materials:

1. Backfill Materials shall be satisfactory soil materials and meet the approval of the Engineer. Materials shall be of such a nature that they will form a stable dense fill. Materials shall not contain vegetation, masses of roots, individual roots more than 12 inches long or more than 1/2-inch in diameter, trash, clays, frozen materials, or plastic fines. Organic matter shall not exceed 2%. Non-plastic fines shall not exceed 20% (silts).

2. Backfill materials are subdivided according to the maximum allowable size of stone or blacktop pieces as follows:

Type	Largest Stone Diameter (inches)
1. Select Backfill	3
2. Class B Backfill	6
3. Class C Backfill	12

H. Loam materials shall be as specified in Specification Section 900 LANDSCAPE WORK.

PART 3 - APPLICATION

3.01 EXCAVATION

A. Excavation includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.

B. Material Storage:

1. Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.

2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

3. Dispose of excess soil material and waste materials as herein specified.

C. Excavation for Structures:

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10', and extending a sufficient distance from stormwater treatment device structures to permit placing of devices, connections, other construction, and for inspection.

D. Excavation for Trenches:

1. Dig trenches to the uniform width required for particular item to be installed, sufficiently wide to provide ample working room.

2. Trenches in pavement shall have the traveled way surface cut in a straight line by a concrete saw or equivalent method, to the full depth of pavement. Excavation shall only be between these lines. Cutting operations shall not be done by backhoe, gradall, or other ripping equipment.

3. Excavate trenches to depth indicated or required. Keep bottoms of trenches sufficiently below finish grade to avoid freeze-ups.

E. Earth Excavation and Backfill Below Normal Grade

1. If, in the opinion of the Engineer existing material below trench grade is unsuitable for properly placing treatment material, the Contractor will excavate, remove, and dispose of the unsuitable material to the required width and depth and replace it with gravel borrow as directed by the Engineer.

2. Do not backfill trenches until tests and inspections have been made and backfilling is authorized by Engineer. Use care in backfilling to avoid damage or displacement of pipe systems.

3. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F (one degree C).

3.02 BACKFILLING

1. Place backfill and fill materials evenly to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping or conduit to approximately same elevation in each lift.

3.03 FIELD QUALITY CONTROL

Quality Control Testing During Construction: Allow testing service to inspect and approve subgrades and fill layers before further construction work is performed.

3.04 MAINTENANCE

A. Protection of Graded Areas:

1. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

2. Repair and re-establish grades - in settled, eroded, and rutted areas to specified tolerances.

B. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.09 DISPOSAL OF EXCESS AND WASTE MATERIALS

Excavated material shall be transported off Owner’s property.

END OF SECTION

SECTION 400

GEOTEXTILE MATERIALS

PART 1 – GENERAL

1.01 WORK INCLUDED:

This section of the specification covers the installation of geotextile materials.

1.02 SUBMITTALS

Submit to the Engineer product data and samples for geotextile fabrics and liners.

1.03 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper completion of the work under this Section.

B. Use equipment of adequate size, capacity, and quantity to accomplish the work of this Section in a timely manner.

C. Comply with the directions of the Engineer and the requirements of governmental agencies having jurisdiction.

D. Install according to manufacturers recommendations.

PART 2 – MATERIALS

2.01 GEOTEXTILE FILTER FABRIC

A. Geotextile filter fabric shall be a nonwoven, needlepunched geotextile composed of continuous filament fibers.

B. Geotextile filter fabric shall have the following minimum roll values:

Physical Requirements	Test Method	Minimum Requirements
Weight	ASTM D3776	5.7 oz./sy
Grab Tensile Strength	ASTM D4632	150 lbs
Grab Tensile Elongation	ASTM D4632	50%
Puncture	ASTM D4833	80 lbs
Mullen Burst	ASTM D3786	275 lbs
Coefficient of Permeability	ASTM D4491	0.25 cm/sec
Apparent Opening Size	ASTM D4751	No. 70-100 Sieve

2.02 IMPERVIOUS LINER

A. Impervious Liner shall be made from plastic, polyethylene or other approved polymeric chemically stable material and be resistant to ultraviolet radiation degradation.

B. The liner shall meet the following minimum specifications, tested using the ASTM standard methods:

Test Parameter	Test Method	Minimum Specification
Density	ASTM D1505	0.935 g/cu.cm.
Black Carbon Content	ASTM D4216	2%
Environmental Stress Crack	ASTM D5397	1500 hours
Low Temperature Brittleness	ASTM D746	-70 °C
Dimensional Stability	ASTM D1204	2.0 % (max.) 212^{N}F, 15 min.
Tensile Strength (Yield)	ASTM D638	2100 psi
Tensile Strength (Break)	ASTM D638	3800 psi
Elongation (Break)	ASTM D638	560 %
Thickness	ASTM D5199	30mils
Tear Resistance	ASTM D1004	44 lbs

C. A sample of the liner shall be tested by an independent laboratory at no expense to the City, to verify conformance with the specifications. Certified copies of the test results shall be supplied to the City/Engineer.

PART 3 – APPLICATION

3.01 FILTER FABRIC INSTALLATION

A. Installation of geotextile fabrics shall be strictly in accordance with manufacturer's instructions and specific layout plans and details reviewed by the Engineer.

B. Geotextile fabrics shall be installed at locations as shown on the drawings or as directed by the Engineer.

C. The filter fabric in place shall cover the entire vegetation/rockfill area.

D. Each width of fabric shall be overlapped by the subsequent width a minimum of two feet.

E. The Contractor shall follow the manufacturer's installation recommendations to ensure proper completion of the fabric installation.

3.02 IMPERVIOUS LINER INSTALLATION

A. The liner shall be laid out by the Contractor in a manner to avoid wrinkles, puncture, cuts, tears, or any other imperfections. All labor and equipment needed for the application of the liner shall be arranged by the Contractor. The Contractor (and manufacturer or his representative) shall approve all site grading and preparations to assure no underlying materials will puncture the liner during or after its application.

3. The membrane material shall be cleaned of all debris and materials which may negatively affect the performance of the system.

4. Each panel of the membrane shall be laid out and installed in accordance with the approved drawings prepared by the Contractor. The layout shall be designed to keep field joining of the membrane to a minimum and consistent with proper methods of membrane installation.

5. Sufficient slack shall be provided to allow for geomembrane shrinkage and contraction during placement. Methods for quantifying the additional material shall be subject to the approval of the Engineer.

6. During installation and exposure of geomembrane liner:

   a. Pedestrian and equipment activity over the liner shall be kept to a minimum and restricted to that which is necessary for liner construction.

   b. Construction workers shall take precautions not to damage the liner surface, including not dragging tools across the liner surface. No smoking shall be permitted on the geomembrane liner.

   c. Construction staff shall be informed of the restricted access to areas of liner placement barriers and signs shall be posted as necessary to provide restricted access.

   d. No tracked equipment or other equipment which poses a risk of puncturing, tearing or otherwise damaging the liner will be permitted for use in placement of material directly over the exposed liner.

3.03 FINAL INSPECTION AND ACCEPTANCE:

A. The Contractor shall, at his expense, have a manufacturer's representative inspect the work at completion of the installation. Any work found to be unsatisfactory shall be corrected at the Contractor's expense.

B. The Engineer, at the Contractor's expense, reserves the right to have a manufacturer's representative inspect the installation process at any time during construction.

END OF SECTION

SECTION 500

PAVERS AND EDGING

PART 1 – GENERAL

1.01 WORK INCLUDED:

This section of the specification covers the installation of pavers, cobblestones and reverse curbing.

1.02 SUBMITTALS

A. Ten typical pavers of each color and type specified by the designer.

B. A letter of guarantee that the pavers will not fade or discolor substantially for a period of five years.

1.03 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods required for proper completion of the work under this Section.

B. Use equipment of adequate size, capacity, and quantity to accomplish the work of this Section in a timely manner.

C. Comply with the directions of the Engineer and the requirements of governmental agencies having jurisdiction.

PART 2 – MATERIALS

2.01 CONCRETE PAVERS

A. Pavers shall be precast concrete with beveled top edges and be designed to withstand vehicular traffic (HS-20) loading.

B. Pavers shall be no greater than 10 inches square.

C. Paver colors to be specified by the designer.

D. Pavers shall have a compressive strength of 8,000 p.s.i. at twenty eight days. Portland Cement shall conform to ASTM C 150, Type I or II.

E. Pavers shall have an absorption of less than five percent.

F. Freeze thaw: Fifty cycles in three percent salt solution, weight loss less than one percent of dry weight.

G. Porous pavers shall be used where specified.

2.02 COBBLE STONE

A. Cobble Stone shall consist of granite stone with a sufficient thickness to permit vehicular traffic from deforming the stones and as per Manufacturers Specifications.

B. The Cobble Stones shall be greater than 4 inches square and no greater than 10 inches square.

C. Dimensional tolerance of stone shall conform to the latest addition of American Institute of Architects (AIA) Specifications.

2.03 REVERSE CURBING

A. Reverse curbing shall be precast combination concrete curb and gutter.

B. Minimum compressive strength of concrete shall be 5,000 psi at 28 days.

PART 3 – APPLICATION

3.01 INSTALLATION

A. Pavers and Cobble Stone

1. Install pavers/cobblestones to the lines, grades and patterns shown on the Drawings. Cross slope shall be a minimum of ¼ inch per one foot in the direction of surface drainage where grades are not shown.

2. Pavers and cobble stone shall be installed with a minimum ½ inch space between pavers/cobblestones, or in accordance with manufacturers recommendations to allow for infiltration of water through spaces.

3. Cut pavers when necessary with motor-driven saw equipment with diamond blades designed to cut masonry with clean, sharp, unchipped edges. Use full units without cutting wherever possible.

4. After laying, sweep sand into all joints. Water the sand into joints to assure that all voids are filled.

B. Reverse Curbing

1. Reverse curbing shall be installed between paved areas and Runoff Prevention Measures (RPMs) as shown on the details.

2. The top of the curbing adjacent to the pavement shall be set at the same grade as the top of the pavement so as to allow runoff to flow unimpeded from the pavement over the curb.

3. The top of the curbing gutter located adjacent to the RPM shall be set a minimum of six inches below the pavement grade.

3.03 FINAL INSPECTION AND ACCEPTANCE:

A. The Contractor shall, at his expense, have a manufacturer's representative inspect the work at completion of the installation. Any work found to be unsatisfactory shall be corrected at the Contractor's expense.

B. The Engineer, at the Contractor's expense, reserves the right to have a manufacturer's representative inspect the installation process at any time during construction.

END OF SECTION

SECTION 600

UNDERDRAINS

PART 1 – GENERAL

1.01 WORK INCLUDED

This section of the specification covers the installation of underdrains.

1.02 QUALITY ASSURANCE

A. Use equipment of adequate size, capacity, and quantity to accomplish the work of this Section in a timely manner.

B. Comply with the directions of the Engineer and the requirements of governmental agencies having jurisdiction.

PART 2 – MATERIALS

2.01 POLYVINYL CHLORIDE PIPE

A. Smooth-wall perforated polyvinyl chloride pipe shall conform to AASHTO M 278. Perforated polyvinyl chloride profile wall pipe shall conform to AASHTO M 304.

B. Corrugated polyethylene drainage tubing 150 mm (6 in) in diameter shall conform to AASHTO M 252, with Class 2 perforation except that the required pipe stiffness shall be a minimum of 400 kPa (60 psi). Perforated corrugated polyethylene pipe of nominal sizes 300 to 900 mm (12 to 36 in) diameter shall conform to AASHTO M 294, with Class 1 perforations. Lengths for all sizes shall not exceed 6 m (20 ft).

C. Sand cushion shall be so graded that 90 to 100 percent by weight will pass a 12.5 mm (1/2 in)sieve, and not more than 15 percent will pass a 0.075 mm (No. 200) sieve.

PART 3 – APPLICATION

3.01 INSTALLATION

A. Trenches shall be excavated to the dimensions and grade shown or ordered. A minimum 50 mm (2 in) sand cushion in common excavation and a 150 mm (6 in) sand cushion in rock excavation shall be placed in the bottom of the trench for its full width and length to the grade of the bottom of the pipe.

B. Perforated pipe shall normally be placed with the perforations down, and sections shall be securely joined with the appropriate couplings, fittings, or bands.

C. Nonwoven support membrane shall be installed so as to minimize the number of fabric seams within the trench section. Seams shall be constructed by overlapping the

fabrid at least 300 mm (12 in) and folding to create a joint which will ensure that soil infiltration will be retarded. Sharp pieces of rock shall not be placed immediately adjacent to the fabric.

D. After the pipe installation has been inspected and approved, underdrain backfill materials shall be placed to a height of 300 mm (12 in) above the tope of the pipe, care being taken not to displace the pipe. The remainder of the backfill material shall then be placed to the required height and compacted in lifts not to exceed 300 mm (12 in).

E. Pipes shall be laid with 45 degree bends where changes in direction are indicated on the plans.

F. Except at structures, up grade ends of all underdrain pipe installations shall be closed with suitable plugs to prevent entry of soil material.

END OF SECTION

SECTION 800

WETLANDS CREATION

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This specification includes excavation and placement of soils, grading, planting, seeding and maintenance for the creation of wetlands.

1.02 QUALITY ASSURANCE

A. A Wetlands Specialist shall be on site to inspect/monitor the delivery of plant materials and organic amendment, planting, seeding, and completion of construction.

B. No material from excavation and/or backfilling activities shall be discharged into existing wetlands or waterways.

C. All stockpiled materials and staging areas shall be located in upland portions of the site and shall not impact waterbodies in the vicinity of the project.

1.03 DELIVERY

A. Plant and seed material shall be inspected by the Wetlands Specialist, after arrival at the site, for conformance with the project requirements. Dead, unhealthy, injured, or otherwise unacceptable plant material shall not be accepted and shall be removed from the site.

B. Plants are to be protected until installed to prevent damage to the root balls or desiccation. As much of the rhizome, root material, and attached soil as possible shall be retained with each plant stalk so that a viable propagule is planted.

C. Plants shall be protected during transport and delivery to prevent damage or desiccation of the roots or leaves.

D. Soils shall be protected during delivery to prevent desiccation, minimize compaction, and maintain the integrity of the material. Soils shall be kept moist at all times.

E. Soil conditioners and amendments shall be delivered to the site in their original, unopened containers bearing the manufacture's guaranteed chemical analysis and name.

1.05 STORAGE

A. Plants not installed on the day of arrival at the site shall be stored and protected in a location shaded and protected from the wind and excessive heat. Plants stored onsite shall be protected from drying by covering the roots with moist sawdust, wood chips, shredded bark, or other similar mulching material. Plant roots must be kept in a moist, but not wet, condition until planted by watering with a fine mist spray.

B. Soils not installed on the day of excavation, or on the day of arrival at the site, shall be stored and protected. Excavated soils shall be kept moist until placement in the wetland creation sites.

C. Any plants which have been permitted to dry out, to become overheated, or for any reason in the judgement of the Wetland Specialist, do not clearly show a viable condition shall be rejected for use.

D. Soil conditioners and amendments will be kept in dry storage separated from contaminants.

1.06 HANDLING

A. Care shall be taken to avoid drying or damaging plants, particularly roots and rhizomes, being transported to the planting site. Balled and burlapped plants shall be handled carefully to avoid cracking or breaking the earth ball. Plants shall not be handled by the stems. Damaged plants shall be rejected by the Wetland Specialist and shall be removed from the site.

1.07 SUBMITTALS

A. Certificates from the plant stock supplier shall be submitted for each group of plant stock to the Wetlands Specialist for approval, at least 4 weeks prior to planting. The certificates shall state the botanical name, common name, origin, age, date of packaging, and name and address of supplier.

B. For each seed mixture, certificates from the seed vendor shall be submitted to the Wetlands Specialist for approval, at least 4 weeks prior to application. The certificates shall state the botanical name, common name, number of seeds per unit of weight, percentage of seeds by weight in a mixture, date of production and of packaging, and name and address of supplier.

C. Documentation of the source of the topsoil and organic soil amendment shall be submitted to the Wetlands Specialist for approval at least 4 weeks prior to placement. A sample of the amended topsoils shall be submitted to the Wetlands Specialist for approval.

PART 2 – MATERIALS

2.01 BACKFILLING AND TOPSOIL

A. The final planned elevation of the wetlands shall be achieved by backfilling with organic soil. Organic soil shall achieve a percent organic composition of approximately 12% by weight. Undecomposed wood chips shall not be used as an organic amendment. The organic mixture used as topsoil shall have a pH approximately within the range of 5.5 – 7.5.

B. The topsoils must not be compacted during excavation, backfilling, or grading activities. The substrate should be soft enough to permit relatively easy insertion of plants into the soil. If the wetland soil is compacted, the soil must be physically disturbed (for example, by roto-tilling) before flooding and planting. The Wetlands Specialist shall inspect and approve the backfilled topsoil prior to planting.

C. Acceptable topsoil must be reasonably free from underlying sub-soil, clay lumps, objectionable weeds, litter, brush, toxic substances or any material that might be harmful to plant growth or be a hindrance to grading, planting or maintenance operations. Topsoil shall not contain more than 5 percent by volume of stones, stumps or other objects larger than 1 inch in any dimension.

2.02 PROPAGULES

A. The wetland shall be planted with indigenous wetland species, representative of local species. The plantings shall consist of those shown on the planting details in the contract drawings unless substitutions due to availability are approved by the Wetlands Specialist. Plants will be purchased from a supplier approved by the Wetlands Specialist.

B. Container-grown shrubs shall be in that container a sufficient time that fibrous roots are formed so the shape will remain and the medium will hold together when removed from the container (ANSI Z60.1).

C. Balled and burlapped plants shall have ball sizes and ratios conforming to ANSI Z60.1. Plants shall be balled with firm, natural balls of soil. Balled and burlapped plants shall be wrapped firmly with burlap, strong cloth, or plastic and tied.

D. Planting stock shall be well-formed, sound, vigorous, healthy, and free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and shall have healthy, normal, and unbroken root systems.

E. Plants shall have been grown under climatic conditions similar to those in the vicinity of the site. Plants budding into leaf or having soft growth shall be sprayed with an antidesiccant at the nursery before digging. If spraying of an antidesiccant is used, it shall not be required again prior to the transporting of plant materials.

2.03 SEEDING:

A. The wetland areas will be hand sown with a wetland seed mix comprised of native wetland grass, rush, sedge, and/or wildflower species. The wetland seed mix shall not include invasive or non-native species. The species composition shall be similar to the composition of the New England Wetmix produced by New England Wetland Plants, Inc. The wetland seed mix shall be applied at a rate of 1 lb/5,000 sq. ft unless otherwise directed by the manufacturer and approved by the Wetland Specialist.

2.04 FERTILIZER

A. Fertilizer shall be Osmocote or a similar slow-releasing fertilize mixture.

PART 3 – APPLICATION

3.01 BACKFILL

A. Handling of the wetland topsoil shall be performed so as to maintain the integrity of the material. The soils shall be spread throughout the wetland to a minimum thickness of 12 inches. The final surface elevation shall be as shown on the Drawings.

B. The sites shall be graded in a sequence which shall leave the top 12 inches of topsoil uncompacted. Final grading shall be free of ditches or ruts caused by equipment.

3.02 IRRIGATION

A. Once grading is complete, soils in the wetlands shall be saturated. For optimal plant growth, the soil must be partially saturated with water (no standing water) immediately before planting and should not be allowed to completely dry for two weeks after planting.

3.03 PROPAGULES

A. Planting of shrubs will occur between April 15 and June 1 or between August 30 and October 30. No planting shall occur when the ground is frozen, snow covered, or in an otherwise unsuitable condition for planting.

B. The width of the hole for each propagule shall be twice the diameter of the rootball and the depth shall be twice the height of the rootball.

C. Propagule backfill mixture (PBM) for each propagule shall consist of an organic soil mixture as specified in Part 2.01.

D. All non biodegradable wrappings must be removed when the rootball is placed in hole. Plastic pots must be removed prior to placing the plant in hole.

E. PBM shall be placed in the bottom of each hole and compacted so that when the rootball is placed in the hole, the top of the rootball is level with the top of the hole. PBM shall then be placed around the sides of the rootball and compacted.

F. Soil shall be raised between 2 and 6 inches around edges of the hole to create a slight depression to collect water.

G. All plants shall be watered by flooding the backfilled hole within the same working day upon which they were planted. During and immediately after watering, all plants shall be adjusted as necessary to ensure correct depth of planting, vertical alignment and/or natural profile. Additional soil shall be added around each plant to compensate for settling, if settling exceeds 1 inch.

3.04 SEEDING

A. Spring seeding shall occur between April 1 to June 15. Fall seeding shall occur between October 1 to November 15, unless otherwise approved by the Wetlands Specialist due to special conditions.

B. The application rate of the wetland seed mixture to be hand broadcast on the wetlands shall be as shown on the planting details in the Drawings.

C. The seedbed shall be inspected prior to seeding by the Wetlands Specialist. The backfill and regrading of the site shall leave the top 2 inches of the soil loose and friable. Any stones larger than 2 inches will be removed from the soil surface. Any other debris will be removed including wire, cable, tree roots, concrete pieces, clods or lumps.

D. In the event vegetative cover has not been established prior to November of the year of planting, well composted organic mulch or jute netting shall be used to stabilize the sites. Mulch shall not include bark or wood chips, unless the wood materials are very well decomposed.

E. Seeding shall not occur when the ground is frozen or snow covered, and shall occur after the planting of the wetlands.

3.05 FERTILIZER APPLICATION

A. Osmocote or a similar slow-releasing fertilizer mixture will be applied in accordance with the directions and warranties offered by the supplier for each of the species and varieties planted.

3.06 WARRANTY PERIOD AND REPLACEMENT

A. All propagules and seeds planted under this contract shall be healthy and in a flourishing condition of active growth 3 years after the conclusion of planting and seeding at a particular wetland replication site.

B. The seeds and plants shall be reasonably protected from herbivores and other vectors which threaten the establishment of the vegetation.

C. The Contractor shall reseed and/or replace vegetation, all vegetated areas not in a vigorous, thriving condition and any dead vegetation, as determined by the Wetlands Specialist during and at the end of the warranty period.

D. Seeded areas shall bear foliage of a normal density size and color 3 years from the conclusion of planting and seeding.

END OF SECTION

SECTION 900

LANDSCAPE WORK

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

A. This specification shall cover landscape development work.

1.02 QUALITY ASSURANCE

A. Subcontract landscape work to a single firm specializing in landscape work.

B. Source Quality Control:

1. Ship landscape materials with certificates of inspection required by governing authorities. Comply with regulations applicable to landscape materials.

2. Do not make substitutions. If specified landscape material is not obtainable, submit proof of non-availability to Engineer, together with proposal for use of equivalent material.

3. Package standard products with manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists, wherever applicable.

1.03 SUBMITTALS

A. Submit certificates of inspection as required by governmental authorities. Submit manufacturer's or vendors certified analysis for soil amendments and fertilizer materials. Submit other data substantiating that materials comply with specified requirements.

B. Submit seed vendor's certified statement for each grass seed mixture required, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed for each grass seed species.

C. Submit typewritten instructions recommending procedures to be established by Owner for maintenance of landscape work for one full year. Submit prior to expiration of required maintenance period(s).

1.04 DELIVERY, STORAGE AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

1.05 JOB CONDITIONS

A. Proceed with the complete landscape work as rapidly as portions of site become available, working within seasonal limitations for each kind of landscape work required.

B. Utilities: Determine location of underground utilities and perform work in a manner which will avoid possible damage. Hand excavate as required. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

C. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Engineer before planting.

D. Planting Time: Plant or install materials during normal planting seasons for each type of landscape work required. Correlate planting with specified maintenance periods to provide maintenance from date of substantial completion.

PART 2 – MATERIALS

2.01 GENERAL

A. Plant material shall meet the current specifications of the "American Standard for Nursery Stock" as published by the American Association of Nurserymen unless otherwise specified.

B. All plants shall be first class and shall be representative of their normal species or varieties. All plants must have a good healthy, well formed upper growth and a large, fibrous, compact root system. Plants shall be durable and able to survive

C. Unless otherwise specified, so-called exposed or "bare-root" material will be accepted. Container grown plants may be furnished in lieu of balled and burlapped plants, provided they meet the current specifications in the American Standard for Nursery Stock.

D. All plants shall be free from plant diseases and insect pests, and shall comply with all applicable State and Federal laws with respect to inspection for plant diseases and infestations.

2.02 COARSE VEGETATION

A. Coarse Vegetation shall be durable and have a thick stem to be able to withstand water flow. Coarse Vegetation shall consist of healthy plants that will grow to a height of at least

18 inches. Coarse vegetation may consist of but is not limited to: sedges, rushes, reeds, cattails, and tall grasses.

2.03 DROUGHT RESISTANT PLANTINGS

A. Deciduous Trees:

1. Non-flowering trees shall have been transplanted 3 times, the last transplanting within 2 years. They shall have a single straight leader not cut back. They shall have a symmetrical development of strong, healthy branches beginning 5 feet to 6 feet from the ground; and below this point, the trunk shall be clean for street trees, although park trees will be permitted to branch lower.

2. Flowering trees shall have been transplanted twice, the last transplanting within 2 years. The trunk shall be clean and straight up to the first branch, which shall be about 4 feet from the ground. Grafted and budded trees may branch lower and be pruned off 2 feet from the ground where directed. Flowering trees shall be balled and burlapped and kept moist for delivery.

B. Evergreen Trees:

1. Evergreen trees shall have been transplanted 3 times, the last transplanting within 2 years. They shall have a good colored top growth and shall be balled and burlapped and kept moist for delivery. Evergreen trees shall conform to AAN specifications; specified spread shall govern over height requirements.

2.04 LOW PLANTINGS

A. Low Plantings shall be durable and capable of living in low water conditions. Plantings shall be healthy and disease free. Plantings shall be able to grow in shallow soil layers.

B. Deciduous Shrubs:

1. Deciduous shrubs shall be fully representative of their species and variety. They shall have been transplanted twice; the last transplanting within 2 years. They shall have 4 to 6 branches coming from the roots, shall have a well-branched root system and shall be of good weight for the height specified.

C. Evergreen Shrubs:

1. Evergreen shrubs shall have been transplanted twice and shall have a heavy dark-green foliage. Each clump shall have not less than 4 stems. Plants shall be balled and burlapped and kept moist for delivery.

2.05 PLANTING MEDIA

A. General

1. Planting Media shall be reasonably free of stumps, roots, and heavy or stiff clay, stones larger than 2-inches in diameter, lumps, coarse sand, noxious weeds, sticks, brush or other litter.

B. Planting Media shall be composed of the following percentages of materials:

Loam	50%
Sand	30%
Compost or Peat	20%

C. Loam

1. Loam shall consist of loose friable topsoil with no admixture of refuse or material toxic to plant growth. Loam shall be generally free from stones, lumps, stumps, or similar objects larger than 50 mm (2 in) in greatest diameter, subsoil, roots, and weeds. The term as used herein shall mean that portion of the soil profile defined technically as the "A" horizon by the Soil Science Society of America. The minimum and maximum pH value shall be from 5.5 to 7.6. Loam shall contain a minimum of 3 percent and a maximum of 10 percent of organic matter as determined by loss by ignition. Not more than 65 percent shall pass a 0.075 mm (No. 200) sieve as determined by the wash test in accordance with ASTM D 1140. In no instance shall more than 20% of that material passing the 4.75 mm (No. 4) sieve consist of clay size particles.

2. For a particular source of loam, the Engineer may require the Contractor to send approximately 10 pounds of loam to an approved testing laboratory and have the following tests conducted:

    1. Organic concentrations
    2. pH
    3. Nitrogen concentration
    4. Phosphorous concentration
    5. Potash concentration

    These tests shall be at the Contractor's expense. Results and soil conditioning and fertilizing recommendations shall be forwarded to the Engineer.

3. Obtain loam from local sources or from areas having similar soil characteristics to that found at project site. Obtain loam only from naturally well-drained sites where topsoil occurs in a depth of not less than 4 inches; do not obtain from bogs or marshes.

D. Sand

1. Sand shall consist of bank run sand conforming to the following requirements determined by ASTM D422:

Sieve Opening	Percent Passing Weight
1-inch	100
1/2-inch	50-100
No.20	20-95
No.50	10-60
No.200	0-8

E. Compost

1. Compost shall be a stable, humus-like organic material produced by the biological and biochemical decomposition of source separated compostable materials, separated at the point of generation, that may include, but are not limited to, leaves and yard trimmings, food scraps, food processing residuals, manure and/or other agricultural residuals, forest residues and bark, and soiled or non-recyclable paper. Compost shall not be altered by the addition of materials such as sand, soil or glass. Compost shall contain no substances toxic to plants and shall not contain more than 0.1 percent by dry mass of man-made foreign matter. Compost shall pose no objectionable odor and shall not closely resemble the raw material from which it was derived. Compost shall have a minimum organic matter content of 30 percent dry unit weight basis as determined by loss on ignition in accordance with ASTM D 2974. Compost shall be loose and friable, not dusty, have no visible free water and have a moisture content of 35 - 60 percent in accordance with ASTM D 2974. The particle size of compost shall be 100 percent less than 25 mm in accordance with AASHTO T27 and shall be free of sticks, stones, roots or other objectionable elongated material larger than 50 mm in greatest dimension. The pH of compost shall be in the range of 5.5 - 8.0. The maturity of the compost shall be tested and reported using the Solvita Compost Maturity Test and must score 6 or higher to be acceptable. The soluble salt content of compost shall not exceed 4.0 mmhos/cm as determined by using a dilution of 1 part compost to 1 part distilled water.

F. Peat

1. Peat shall have an ash content of less than 15%, a pH range of 4.9 to 5.2, and a loose bulk density of 0.12 to 0.15 g/cc. Peat shall be free of foreign objects and shall have no particles greater than 1 inch in diameter. The material must be Reed-Sedge Hemic Peat, shredded, uncompacted, uniform, and clean.

G. Soil Amendments

1. Standard commercial ground limestone containing at least 50 percent total oxides (calcium oxide and magnesium oxide), and 50 percent of the material must pass through a No. 100 mesh sieve with 98 percent passing a No. 2 mesh sieve.

2. Aluminum Sulfate: Commercial grade.

3. Bonemeal: Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.

4. Superphosphate: Soluble mixture of treated minerals; 20% available phosphoric acid.

H. Bark Mulch

Materials to be used in mulching shall conform to the following requirements:

1. Bark Mulch shall be wood and/or bark chippings graded to be approximately 10 to 50 mm (3/8 to 2 in) in width.

2. The Bark Mulch shall be inspected prior to delivery to insure that it has not been stored under conditions that have caused the material to decompose sufficiently, such that it has lost its fibrous texture.

3. Bark mulch shall be free from long, stringy material and from live growth, except that 35% or less by volume of the Bark Mulch may consist of “slabwood”, chipped to an acceptable size. Bark Mulch with an excess of fine particles (greater than 5% by volume) is not acceptable for use.

I. Other Mulch

1. Hay Mulch shall consist of mowed and properly cured grass, clover or other acceptable plants. No salt hay shall be used.

2. Straw Mulch shall consist of stalks, or stems of grain after threshing.

2.06 GRASS MATERIALS

A. Seed shall be a "state slope" mixture. Seed shall be the previous year's crop, clean, high in germination value, and low in weed seed. Seed shall be obtained from a reliable seed company and shall be accompanied by certificates relative to mixture purity and germinating value.

B. "State slope" mix shall be of a perennial variety and conform to the following requirements:

	Proportion by Weight Percent	Germination Minimum Percent	Purity Minimum Percent
Creeping Red Fescue	50	85	95
Kentucky 31 Fescue	30	85	95
Domestic Rye	10	90	98
Red Top	5	85	92
Ladino Clover	5	85	96

2.07 TEMPORARY COVER CROP

A. Temporary cover crop shall conform to the following requirements:

	Weight Percent	Germination Minimum Percent
Winter Rye	80 Min.	85
Red Fescue (Creeping)	4 Min.	80
Perennial Rye Grass	3 Min.	90
Red Clover	3 Min.	90
Other Crop Grass	0.5 Min.	
Noxious Weed	0.5 Min.	
Inert Matter	1.0 Max.	

PART 3 - APPLICATION

3.01 PREPARATION

A. Layout individual tree locations and areas for multiple plantings. Stake locations and outline areas, and secure Engineer's acceptance before start of planting work. Make minor adjustments as may be requested.

B. Preparation for Grass Seeding: After approval of the underlying surface, loam shall be placed on areas as indicated on the drawings. Spread loam to a minimum depth of 6 inches required to meet lines, grades and elevations shown, after light rolling and natural settlement.

Remove stones over 1-1/2" in any dimension and sticks, roots, rubbish and other extraneous matter. Limit preparation to areas which will be planted promptly after preparation.

C. Soil Amendments: Lime shall be applied to bring the pH to 6.5 or, without a soil test, at the rate of 2-3 tons of lime per acre. Fertilizer shall be applied according to the soil test, or without a soil test, at the rate of 1,000 pounds per acre. Loam shall be worked a minimum of 4 inches deep, thoroughly incorporating the lime and fertilizer into the soil. The loam shall then be raked until the surface is finely pulverized and smooth.

D. Dispose of subsoil removed from planting excavations. Do not mix with planting soil or use as backfill.

3.02 SEEDING

A. Seeding shall be done when weather conditions are approved as suitable, in the periods between April 1 and May 30 or August 15 to October l, unless otherwise approved.

B. If there is a delay in seeding, during which weeds grow or soil is washed out, the Contractor shall remove the weeds or replace the soil before sowing the seed, without additional compensation. Immediately before seeding is begun, the soil shall be lightly raked.

C. Seed shall be sown in the locations designated by the Engineer on a calm day by machine. Water seeding (hydroseeding) will be permitted after approval by the Engineer.

D. Seed shall be sown at the rate of 200 pounds per acre or as approved by the Engineer.

E. One-half the seed shall be sown in one direction and the other half at right angles. Seed shall be raked lightly into the soil to a depth of 1/4-inch and rolled with a roller weighing not more than 100 pounds per linear foot of tread.

F. The surface shall be kept moist by a fine spray until the grass shows uniform germination over the entire area. Wherever poor germination occurs in areas larger than 3 square feet the Contractor shall re-seed, roll, and water as necessary to obtain proper germination.

G. The Contractor shall water, weed, cut and otherwise maintain and protect seed areas as necessary to produce a dense, healthy growth of perennial lawn grass.

3.03 PLACING MULCH

A. Mulch shall be loosely spread to uniform depth over all areas designated on the plans, at the rate 4-1/2 tons per acre, or as otherwise directed.

B. Mulch may be applied by mechanical apparatus, if in the judgment of the Engineer the apparatus spreads the mulch uniformly and forms a suitable mat to control slope erosion.

3.04 MAINTENANCE

A. Begin maintenance immediately after planting.

3.05 CLEANUP AND PROTECTION

A. During landscape work, keep pavements clean and work area in an orderly condition.

B. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.06 INSPECTION AND ACCEPTANCE

At the beginning of the next planting season after that in which the permanent plantings are planted, the planted areas will be inspected. Any section not showing growth at that time shall be promptly replanted by the Contractor at this own expense. The planted areas shall be watered, weeded, cut and otherwise maintained by the Contractor until the end of that planting season, when they will be accepted.

END OF SECTION

Appendix A – Workshop Participants

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Appendix B
Suggested Plant List

Upland Plant Species

The following is a suggested list of upland plant species that may be suitable for use in the Runoff Prevention Measure (RPM) designs. Plant selection should be based on the application of the RPM, specific site conditions and runoff considerations.

Shrubs

Cornus amomum	Silky Dogwood
Viburnum dentatum	Arrowwood
Ilex verticillatata	Winterberry
Clethra alnifolia	Sweet pepperbush
Myrica pennsylvanica	Bayberry
Lindera benzoin	Spicebush
Cornus sericea	Red-oiser dogwood

Trees

Hamamelis virginiana	Witch Hazel
Acer rubrum	Red Maple
Fraxinus pennsylvanica	Green Ash
Quercus rubra	Red Oak
Amelanchier Canadensis	Shadblow
Betula nigra	River birch

Perennials

Panic virgatum	Switch grass
Aster noviae angliae	New England Aster
Eupotorium perfoliatum	Boneset
Eupotorium maculatum	Joe-Pye Weed
Lupinus	Lupine
Iris versicolor	Blue flag iris
Onclea sensibilis	Sensitive fern
Lobelia cardinalis	Cardinal flower
Monarda didyma	Beebalm
Cimicifuga racemosa	

Wetland Plant Species

The following is a suggested list of wetland plant species that may be suitable for use in created wetlands. It should be noted that plant species should be selected based on the volume and frequency of water expected to be present. Species should be chosen after survey of other natural reference wetlands in the area to ensure selected plants are native to the area and are tolerant of the site's microclimate and habitat.

Shrubs

Alnus incana	Speckled Alder
Alnus serrulata	Smooth Alder
Cephalanthus occidentalis	Buttonbush
Clethra alnifolia	Sweet Pepperbush
Cornus amomum	Silky Dogwood
Cornus racemosa	Gray Dogwood
Cornus stolonifera	Red-osier Dogwood
Hamamelis virginiana	Witchhazel
Ilex verticillata	Winterberry
Lindera benzoin	Common Spicebush
Rhodendron viscosum	Swamp Azalea
Rosa palustris	Swamp Rose
Sambucus canadensis	Common Elderberry
Vaccinium corymbosum	Highbush Blueberry
Viburnum dentatum	Northern Arrowwood

Trees

Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Acer Saccharum	Sugar Maple
Amelanchier canadensis	Serviceberry
Betula populifolia	Gray Birch
Quercus bicolor	Swamp White Oak
Quercus rubra	Red Oak
Quercus palustris	Pin Oak
Viburnum lentago	Nannyberry

Herbaceous

Acorus calamus	Sweetflag
Aster novae-angliae	New England Aster
Aster puniceus	Swamp Aster
Calamagrostis canadensis	Blue Joint Grass
Carex spp.	Various Sedge Species

Eleocharis palustris	Spike Rush
Eleocharis quadrangulata	Square-stemmed Spikerush
Eupatorium maculatum	Joe-pye Weed
Impatiens capensis	Jewelweed
Juncus canadensis	Canada Rush
Juncus effusus	Soft Rush
Panicum virgatum	Switchgrass
Peltandra virginica	Arrow Arum
Pontederia cordata	Pickerelweed
Sagittaria latifolia	Northern Arrowhead
Scirpus acutus	Hard-stem Bulrush
Scirpus americanus	Three-square Bulrush (Olney)
Scirpus validus	Soft-stem Bulrush
Onoclea sensibilis	Sensitive Fern
Osmunda cinnamomea	Cinnamon Fern
Osmunda regalis	Royal Fern
Thelypteris palustris	Marsh Fern

A wetland seed mixture may be used to help develop the herbaceous vegetation layer. The wetland seed mixture should include grass, rush, sedge or wildflower species listed as FAC or wetter in the U.S. Fish and Wildlife Service 1988 National List of Wetland Plants, excluding FAC- species and invasive species (including but not limited to *Phragmites australis, Lythrum salicaria, Typha spp., and Phalaris arundinacea).*

Appendix C
Reference List

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