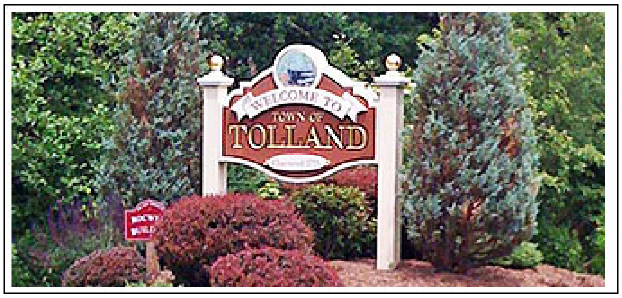
Revised: July 1, 2011

Town of Tolland

Low Impact Development and Stormwater Management Design Manual



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The LID component of this Design Manual contains information developed by Steven Trinkaus, PE including results of independent observations of LID systems in the field. This document also includes information on Low Impact Development obtained from highly regarded sources, such as academic institutions other technical manuals . These sources are identified where this material has been used.

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1.0 Preamble – The Town of Tolland

The Town of Tolland consists of approximately 41 square miles. It is divided by Interstate I-84, with approximately two thirds of the land area being located north of I-84 and the other third south of I-84.

There are four significant watersheds in the Town of Tolland. The Willimantic River, Skungamaug River, Shenipsit Lake and Gages Brook. Each of these aquatic systems provide a unique environmental benefit to not only the Town of Tolland, but other adjacent communities as well. In addition to the named watercourses, there are many other high quality natural resources, such as the Tolland Marsh and Skungamaug Marsh. A brief description of each watershed is provided below.

The eastern 25% of the Town of Tolland is tributary to the Willimantic River. At the present time, approximately 75% of this watershed has an average impervious coverage of less than 5%. The remaining 25% of the land area has an average impervious coverage of 6.5%. These low extents of impervious cover are very desirable as they are indicative of good water quality in the receiving waterway.

The water quality in the Skungamaug River is classified as B/A as determined by the CT DEP. According to the map entitled "Water Quality Classification Map of Connecticut" by James Murphy and prepared for the CT DEP in 1987 defines this rating as follows: May not be meeting Class A water quality criteria or one or more designated uses. The goal is to restore it to Class A. In order to restore the Skungamaug River to Class A, it is important to not increase connected impervious areas for future developments wherever feasible.

Shenipsit lake is located in the northwest portion of the town and extends into the neighboring towns of Vernon and Ellington. Shenipsit Lake is a drinking water supply reservoir for the Towns of Vernon, Tolland and surrounding communities. Based upon GIS mapping by the Town of Tolland, the average impervious coverage in the Shenipsit Lake watershed is between 4.5 to 6.5%.

Gages Brook is the headwaters of the Tankerhoosen River, which flows through the Town of Vernon. In addition, the CT DEP Belding Wildlife Refuge is located a couple of miles downstream from the lake. Due to the proximity to I-84, a majority of the commercial and industrial development has occurred in this watershed in the past. The impervious coverage in this watershed is greater than 15%. There is clear evidence of adverse water quality impacts due to the high percentage of impervious coverage in this watershed. A significant cause of water quality impacts is the runoff from I-84.

In order to protect and improve the water quality in these watersheds for current and future generations of residents, the Town of Tolland has adopted Low Impact Development (LID) as a strategy to achieve these goals. The implementation of LID for new development will prevent adverse changes in the water quality. On redevelopment sites, the retrofitting of LID storm water treatment systems will have the ability to slowly improve the water quality of the storm water runoff from these sites.

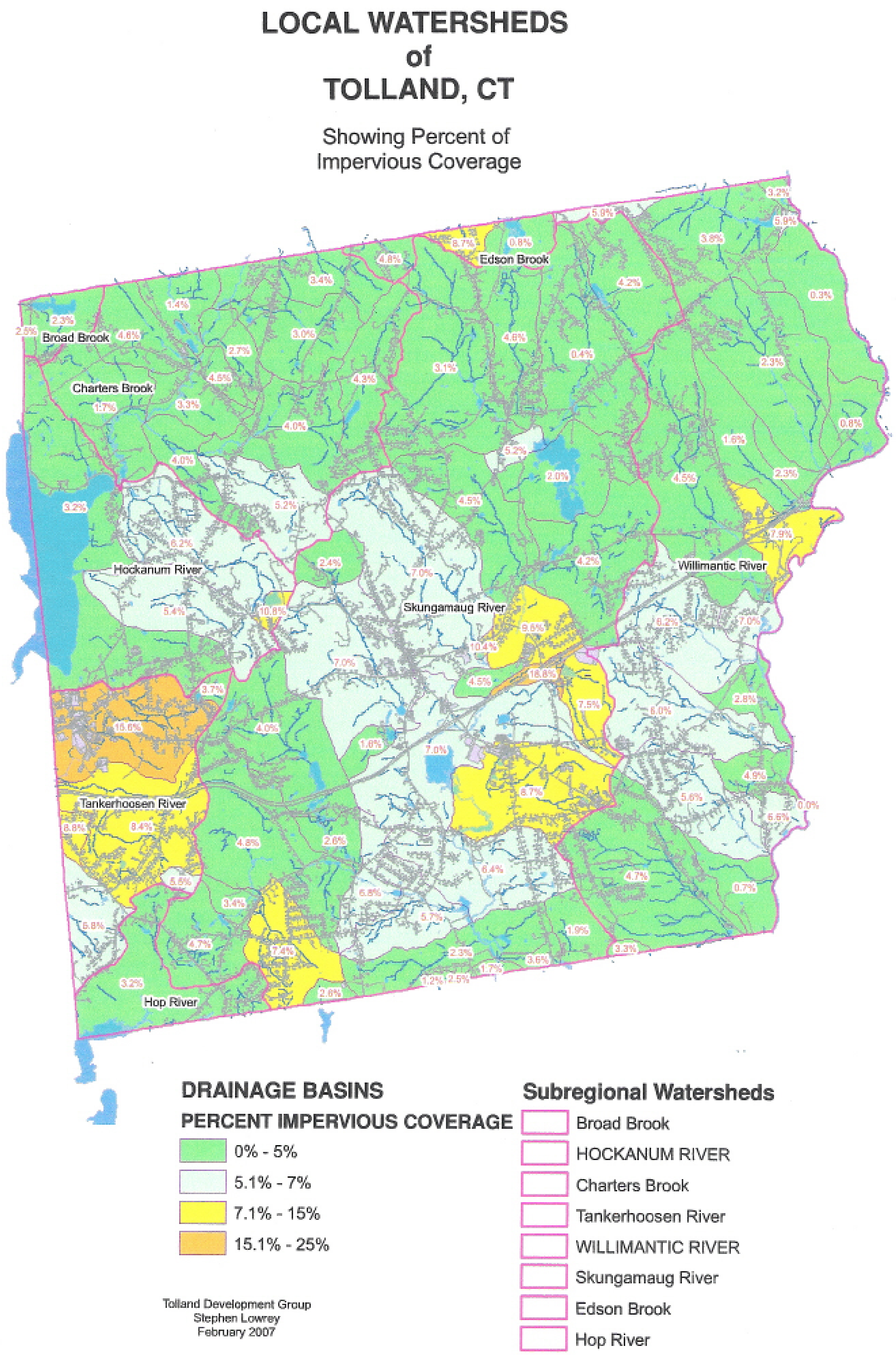


Figure 1.0.a – Impervious Cover within Tolland Watershed Areas

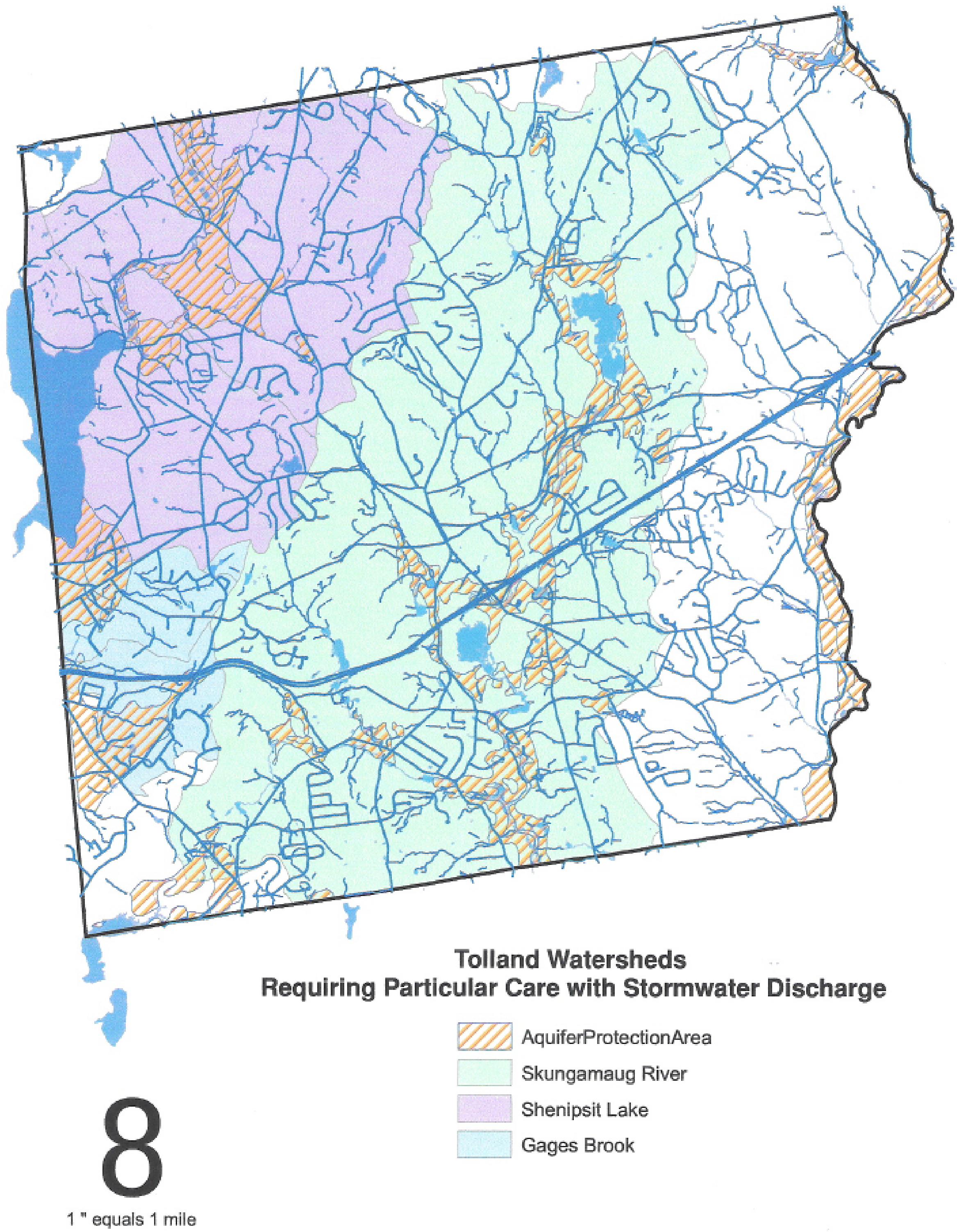


Figure 1.0.b – Tolland Watersheds and Aquifers

Aquifer Protection Areas: There is numerous aquifer protection areas located within the three watershed areas discussed above. With the exception of the large aquifer along the Willimantic River, which is used for drinking water for the town, the other aquifer areas have not be developed into water supply systems at this time.

The LID goal for these aquifer protection areas will be to maintain their future ability to provide a water supply source for the town.

2.0 Introduction

2.1. Purpose of the Manual

Stormwater discharges in the Town of Tolland have clearly caused pollution and adverse impacts on the aquatic and natural environment. These impacts range from increased flows, which cause erosion of natural stream channels; to limitations on the use of certain waters for recreational uses due to high levels of pollutants in the water and increased flooding potential due to increases of runoff volume.

The purpose of this manual is to provide the technical framework to implement development and stormwater strategies that will lead to the improvement of surface water quality and groundwater quality to achieve the water quality goals in Section 1.0 by the application of Low Impact Development (LID) Strategies. Without the implementation of the requirements in this manual, long term adverse impacts to both surface and groundwater will continue to occur in the Town of Tolland.

2.2 Applicability of the Manual

The standards and processes stated in this manual shall apply to all new development projects proposed in the Town of Tolland. Where feasible, new development project initiated by the town itself shall comply with the standards set forth in this manual. Specific performance standards have been developed for new development, as well as commercial/industrial redevelopment which may change the extent of impervious cover on a site. The manual is to be used by design engineers, property owners, developers, homeowners, municipal officials and others who are involved with the design of development and redevelopment projects in the Town of Tolland. While it cannot be required, it is strongly suggested that all of the stormwater management practices outlined in this manual be applied to the maximum extent practicable on existing approved single family lots that have not been build on as of the date of the adoption of this manual.

The specifications found in this manual shall be implemented by individuals with a demonstrated level of professional expertise in stormwater management, such as licensed professional engineers in the State of Connecticut. The manual can also be read by non-technical individuals who are interested in the stormwater management and LID fields, but the application of these stormwater requirements must be prepared by a licensed professional engineer in the State of Connecticut.

All designers must adhere to all of the applicable stormwater and performance standards found in the manual. The schematic details provided for the various types of treatment and storage systems are to demonstrate the various components that must be included in the design of the treatment system to function effectively. Final design plans for any type of treatment or storage system must include all relevant design specifications for that particular system.

It is important that the homeowners and individuals who will have LID treatment systems on their property have an understanding of the adverse impacts of stormwater on our environment and how the LID systems can mitigate these impacts. LID systems are easy to install and easy to maintain over the long-term for the end users.

The standards and performance requirements have been specified to address the specific stormwater issues which exist or potentially exist in the Town of Tolland.

2.3 How to Apply this Manual

Low Impact Development represents a paradigm shift of the current processes which drive the development process. It is imperative that the professionals who will use this manual understand the concepts which created LID. Links to various LID resources are provided in **Appendix C** for additional educational information.

The manual will be used by four main groups; design engineers, municipal land use agencies and staff, reviewers for regulatory programs, and property owners. Design engineers are the group that will use this manual the most. The design engineers need to familiarize themselves with all the stormwater requirements, performance goals and design parameters of the various treatment and storage systems.

The full benefits of LID can only be realized by the application of the processes outlined in this manual. LID is the site component of creating sustainable designs.

The manual has been divided into eight major technical sections, each of which is more fully described in this manual. The processes outlined in Section 4.0 must be followed as stated to realize the full benefits of Low Impact Development strategies.

2.4 What is Stormwater Runoff?

Before we can apply LID concepts, all users of this manual must have an understanding of the natural hydrologic cycle and how development affects the hydrologic cycle and causes adverse impacts to our environment.

The natural hydrologic cycle shows how water travels through our environment in the many forms that provide a myriad of environmental benefits. It is a continuous cycle of the movement of water in our environment.

There are five key elements to the hydrologic cycle: condensation, precipitation, infiltration, runoff, and evapotranspiration/rainfall abstraction. These occur simultaneously and, except for precipitation, continuously. The NASA's Observatorium website provides the following definitions for each element of the Hydrologic Cycle:

A. Condensation is the process of water changing from a vapor to a liquid. Water vapor in the air rises mostly by convection. This means that warm, humid air will rise, while cooler air will flow downward. As the warmer air rises, the water vapor will lose energy, causing its temperature to drop. The water vapor then has a change of state into liquid or ice.
B. Precipitation is water being released from clouds as rain, sleet, snow, or hail. Precipitation begins after water vapor, which has condensed in the atmosphere, becomes too heavy to remain in at-

mospheric air currents and falls. In many cases, precipitation evaporates as it falls through the atmosphere and returns as water vapor.

C. Infiltration is that portion of the precipitation that reaches the Earth's surface and seeps into the ground. The amount of water that infiltrates the soil varies with the degree of land slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated by water. The more openings in the surface (cracks, pores, joints), the more infiltration occurs. Water that doesn't infiltrate the soil flows on the surface as runoff.

D. Runoff is the amount of rainfall which is left after evapotranspiration and infiltration occur. Under natural conditions, 10-30% of the annual rainfall becomes runoff. As impervious areas increase, both evapotranspiration and infiltration are reduced, thus increasing runoff.

E. Evapotranspiration is water evaporating from the ground and transpiration by plants. Evapotranspiration is also the way water re-enters the atmosphere. Evaporation occurs when radiant energy from the sun heats water, causing the water molecules to become so active that some of them rise into the atmosphere as vapor. Transpiration occurs when plants take in water through the roots and release it through the leaves, a process that can clean water by removing contaminants and pollution. Rainfall Abstraction is the physical process of interception of rainfall by vegetation, evaporation from land surfaces & upper soil layers, evapotranspiration from plants, infiltration of rainfall into the soil surface and surface storage within natural depressions. Rainfall abstraction can be estimated as a depth of water on a site. (http://physics.ship.edu/~mrc/astro/NASA_Space_Science/observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html)

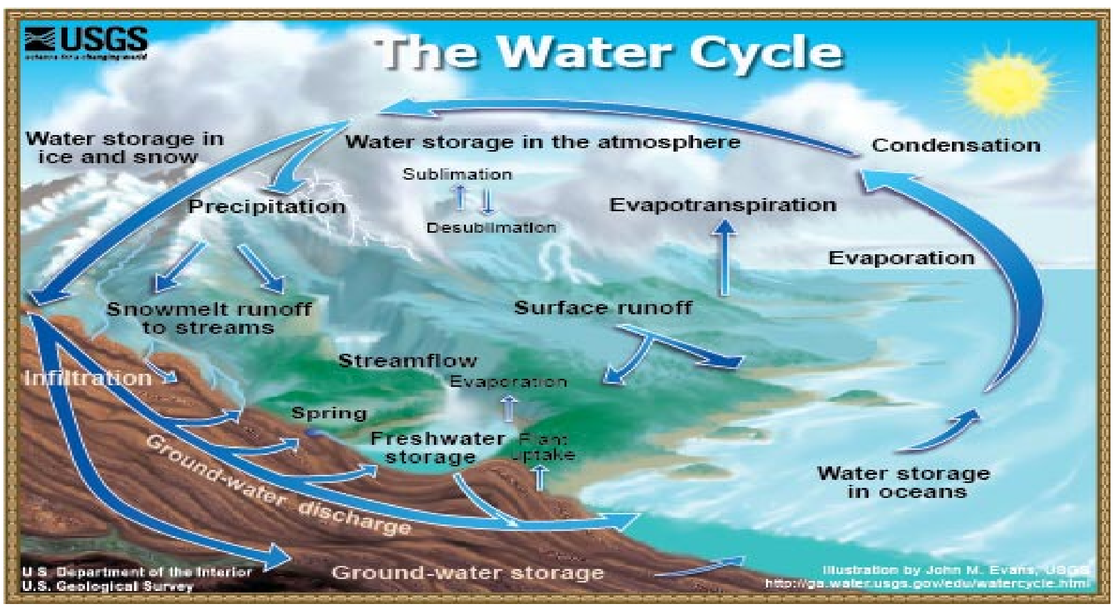


Figure 2.4.a – The Hydrologic Cycle

When development occurs on a site, many changes to the hydrologic cycle will result from the disturbance of the natural land form, the creation of impervious surfaces and the application of chemical compounds which can adversely affect our environment. All of these changes affect the stormwater which is generated on the site.

The 2004 Connecticut Stormwater Quality Manual prepared by the CT DEP defines stormwater as follows:

"Storm water runoff is a natural part of the hydrologic cycle, which is the distribution and movement of water between the earth's atmosphere, land and water bodies. Rainfall, snowfall, and other frozen precipitation send water to the earth's surfaces. Storm water runoff is surface flow from precipitation that accumulates in and flows through natural or man-made conveyance systems during and immediately after a storm event or upon snowmelt. Storm water eventually travels to surface water bodies as diffuse overland flow, a point discharge, or as groundwater flow. Water that seeps into the ground eventually replenishes groundwater aquifers and surface waters such as lakes, streams and oceans. Groundwater recharge also helps maintain water flow in streams and wetland moisture levels during dry weather. Water returned to the atmosphere through evaporation and transpiration to complete the cycle."

When the stormwater is being generated by the natural environment, there are very little adverse impacts associated with stormwater. However, when development occurs on the land, there are profound impacts that occur which can significantly modify the natural hydrologic cycle. The adverse impacts can be summarized as reduced rates of infiltration, reduced evapotranspiration, increased rates and volumes of runoff, and increased pollutant loads in the runoff. These changes can be seen in Figure 2.4.b.

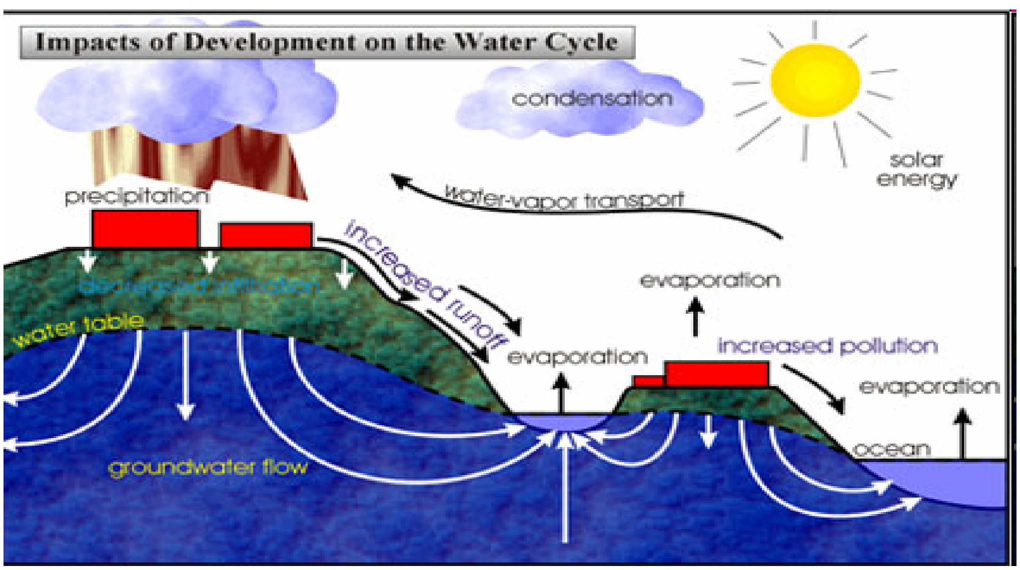


Figure 2.4.b – Changes to the Hydrologic Cycle as a result of development

It can be seen from Figure 2.5.a that as impervious cover increases, there is less base flow into the ground, less evapotranspiration from the vegetation and increased runoff from the impervious areas.

2.5 What are the Impacts of Development and Stormwater?

Land development has the potential to create many adverse impacts on the environment both during the construction period and after construction has been completed. When land is cleared, and stripped of the natural organic layer on top of the soil, the soil loses its ability to infiltrate runoff, thus more runoff is created, which in turn increases the likelihood of erosion of the soil and subsequent sedimentation. After construction has been completed, the large, interconnected impervious area prevents rainfall from infiltrating into the ground. Because of this, more of the rainfall is converted to runoff, which is demonstrated in Figure 2.5.a.

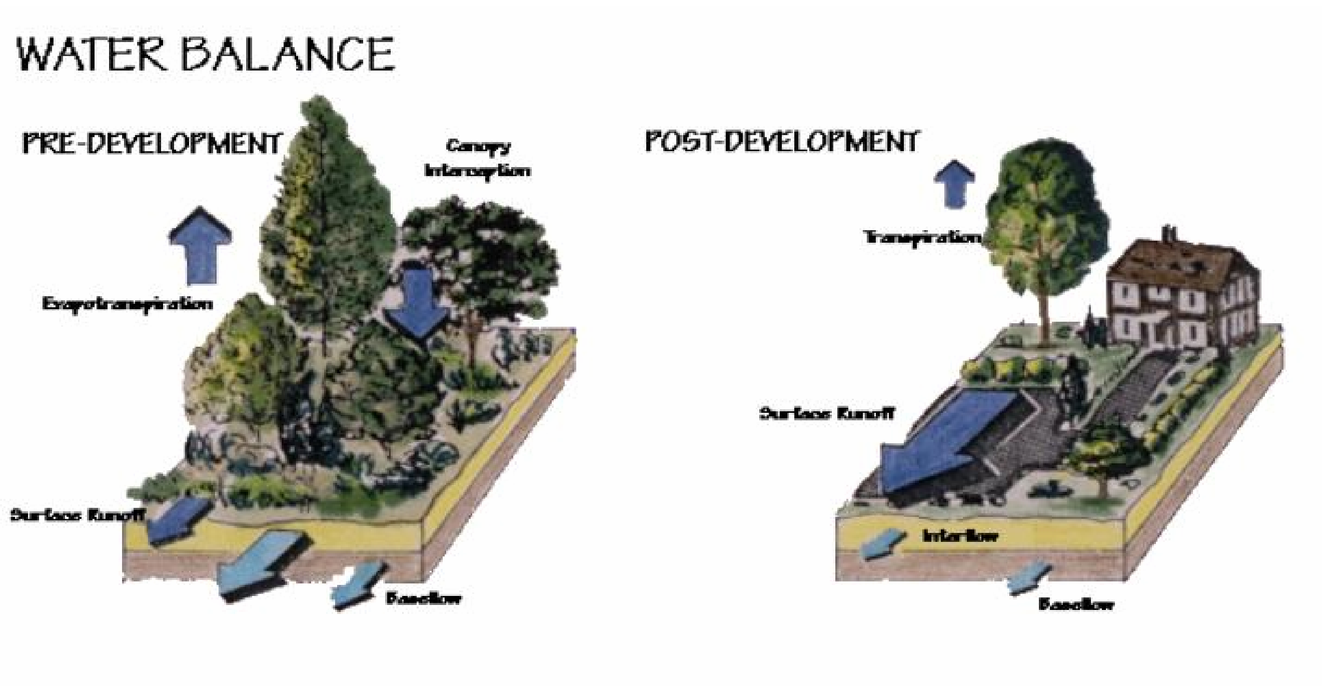


Figure 2.5.a – Effects of Impervious Cover on Water Balance

While the addition of a small amount of impervious area on a single lot may not appear to create an issue, the cumulative impact of many small increases of impervious area can quickly become significant. It has been well documented that when the total impervious cover in a watershed is between 10% and 25% that the natural aquatic environment can be adversely affected. Once the impervious coverage exceeds 25% in a watershed, the adverse impacts to the aquatic ecological systems are often irreversible. There have been some studies which have shown that adverse water quality impacts can occur with impervious cover being between 5 – 7% (RI DEM Stormwater Manual).

The following table highlights the typical percentages of impervious cover for various land uses.

Table 2.5.a – Typical Amounts of Impervious Cover Associated with Different Land Uses

Land Use	**Percent Impervious Cover**
Commercial & Business Districts	85%
Industrial	72%
High Density Residential (1/8 acre zoning)	65%
Medium-High Density Residential (1/4 acre zoning)	38%

Land Use	**Percent Impervious Cover**
Medium-Low Density Residential (1/2 acre zoning)	25%
Low Density Residential	
1 acre zoning	20%
2 acre zoning	12-16%
3 acre zoning	8%
5 acre zoning	5-8%
10 acre zoning	2.4%

(Source: RI DEM Stormwater Manual, April 2010)

The 2004 CT DEP Stormwater Quality Manual states the following adverse impacts which can occur in our environment due to changes in the Hydrologic Cycle:

Hydrologic:

- Increased runoff volume
- Increased peak discharges
- Decreased runoff travel time
- Reduced groundwater recharge
- Reduced stream baseflow
- Increased frequency of bankfull and overbank floods
- Increase flow velocity during storms
- Increase frequency and duration of high stream flows

Figure 2.5.a – Stream Channel Impact from increased runoff volumes (S. Hayden photo)

Stream Channel and Floodplain Impacts:

- Channel scour, widening and downcutting
- Streambank erosion and increased sediment loads
- Shifting bars of coarse sediment

- Burying of stream substrate
- Smothering of aquatic insects and fish eggs
- Loss of pool/riffle structure and sequence
- Man-made stream enclosures or channelization
- Floodplain expansion

Figure 2.5.b – Stream Channel Impacts (R.Claytor file photo)

Figure 2.5.c – Deposition of sediment in a wetland (S. Hayden photo)

Water Quality Impacts:

- Excess Nutrients (Nitrogen and soluble phosphorous)
- Sediments
- Pathogens
- Organic Materials
- Hydrocarbons
- Metals
- Synthetic Organic Compounds

- De-icing Constituents
- Trash and Debris
- Thermal Impacts
- Freshwater discharge to estuarine systems

Figure 2.5.d – Nutrient impacts in freshwater river

The water quality impacts associated with storm water runoff is called non-point source pollution. The United States Environmental Protection Agency defines non-point source pollution as follows:

Non-point source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

A. *Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;*
B. *Oil, grease, and toxic chemicals from urban runoff and energy production;*
C. *Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;*
D. *Salt from irrigation practices and acid drainage from abandoned mines;*
E. *Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;*
F. *Atmospheric deposition and Hydromodification are also sources of non-point source pollution.*

The most common pollutants which are found in non-point source runoff are Litter, Sediment and Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorous (TP), Metals, such as Zinc (Zn) and Copper (Cu), Hydrocarbons, Thermal Impacts, Oxygen demanding substances and Pathogens. Each pollutant and its impact on the natural environment are stated below.

Litter

Litter while not causing toxic impacts on the environment, the presence of litter is an aesthetic issue that is not well received by the public.

Total Suspended Solids (TSS) and Sediment

Total Suspended Solids are particles dissolved in water. In excessive amounts it causes turbidity in water. The turbidity blocks light in the water column which causes reduced photosynthesis, which in turn reduces the oxygen levels in the water. Coarse and fine sediments can clog the gravel substrate in breeding streams thus affecting the biological community ability to reproduce. Common sources of TSS and sediment are runoff from construction sites, winter sanding operations, atmospheric deposition and decomposition of organic matter, such as leaves.

Nutrients

Excessive levels of Phosphorous in fresh water are a concern as these nutrients encourage excessive growth of plants and algae. When these plants die, the decomposition of the organic matter reduces oxygen levels in the water, thus adversely affecting the biological community in the water body. Nitrogen, in the form of nitrate, is a direct human health hazard and an indirect hazard in some areas where it leads to a release of arsenic from sediments. While not a major concern for freshwater systems, nitrate can cause environmental impacts in tidal regions, even though the source of nitrate can be far away from coastal regions. When the algae dies and sinks to the bottom, its decomposition consumes oxygen, depriving fish and shellfish in those deep waters of oxygen, a condition known as hypoxia. Sources of nutrients are organic and inorganic fertilizers, animal manure, biosolids and failing sewage disposal systems.

Metals

Metals in non-point source runoff are very toxic to aquatic life. The adverse effects of metals are far reaching for both aquatic and human health. Many metals can bioaccumulate in the environment, which can affect higher living organisms. While the concentration of zinc or copper in stormwater generally is not high enough to bother humans, these same concentrations can be deadly for aquatic organisms. Many microorganisms in soil are especially sensitive to low concentrations of cadmium. Cadmium is also very harmful to humans. Chromium is very toxic to fish and can cause birth defects in animals.

Of the above discussed metals, zinc and copper are the two metals which are found dominantly in non-point source runoff. Metals commonly bind themselves to sediment and organic matter in stormwater and thus are transported to the receiving waters. Since natural rainfall is slightly acidic, metal roofs or components on the roof can be a significant source of the metal concentrations in stormwater.

Hydrocarbons

Total Petroleum Hydrocarbons are highly toxic in the aquatic environment, especially to aquatic invertebrates. The primary sources of petroleum hydrocarbons are oil, grease and gas spills, along with vehicle exhaust. Polycyclic Aromatic Hydrocarbons are also toxic to aquatic life. The primary source of these hydrocarbons is the incomplete burning of fossil fuels. PAH's generally deposited by atmospheric deposition on an impervious surface, especially large flat roof areas. When it rains, the accumulations of pollutants due to atmospheric deposition are carried off in the stormwater.

Thermal Impacts

Impervious surfaces, such as roofs and paved areas can heat up during sunny days and hold onto this heat. When rainfall occurs on these heated surfaces, the resulting runoff has its temperature raised. As this heated runoff is discharged into receiving waters, the temperature of the receiving water is raised to a level which can exceed the tolerance limits for fish and invertebrates, thus lowering their survival rates. Elevated water temperatures will also contribute to reduced oxygen levels in the water.

Oxygen Demanding Substances

Oxygen demanding substances are plant debris and soil organic matter which when they decompose in an aquatic environment require a significant amount of oxygen for the chemical reaction. This results in less available oxygen in the water for other aquatic organisms. Less than 5 mg O/l become harmful to fish.

Pathogens

Pathogens are bacteria and viruses, which can cause disease in humans. Most pathogens are found in discharges from overflowing sanitary sewers or in combined sanitary/stormwater systems. Both fecal coliform and enterococci are used as indicators for the presence of pathogenic organisms, yet their presence does not mean a pathogen is present, just that there is a higher risk of being present.

3.0 Overview of Low Impact Development

3.1 What is LID?

Low Impact Development (LID) is an ecologically friendly approach to site development and stormwater management that aims to mitigate development impacts to land, water and air. This approach emphasizes the integration of site design and planning techniques that conserve natural systems and hydrologic functions on a site. Figure 3.1.a demonstrates the water quality benefits that can be achieved by the shift to Low Impact Development from conventional stormwater management.

The concept of Low Impact Development (LID) utilizes five major tools to reduce the impact of development on the environment. These primary tools are:

i. Encourage Conservation Measures,
ii. Reduce Impervious Areas,
iii. Slow runoff by using landscape features,
iv. Use multiple measures to reduce and cleanse runoff,
v. Pollution prevention.

Each LID tool is enumerated below:

i. Encourage Conservation Measures

- Implement Open Space or Cluster Development Regulations to preserve large tracts of the site,
- Implement “Site Fingerprinting” to minimize land clearing & soil disturbance,
- Minimize soil compaction,
- Provide low maintenance landscaping & plant native species which will minimize the use of fertilizers and pesticides,
- Use Source Erosion Control measures.

ii. Reduce Impervious Areas

- Disconnect impervious coverage to the maximum extent practical to encourage overland flow conditions across vegetated surfaces,
- Reduce pavement widths for local roads,
- Use Permeable Pavement, Porous Concrete, and Open Course Pavers for parking areas and other low traffic areas,
- Use Porous Concrete for sidewalks.

iii. Slow runoff by using landscape features

- Maintain Pre-Development Time of Concentration by long flow paths on vegetated Surfaces,
- Minimize the extent of flow on impervious surfaces,
- Maintain and encourage overland flow conditions across vegetated areas for at least 75’, where feasible.

iv. Use multiple measures to reduce and cleanse runoff

- Maintain pre-development infiltration rates by preserving those soils with moderate to high infiltrative capacities,
- Maintain existing vegetation to Maximum Extent Practical,
- Remove pollutants from runoff by flow thru vegetated systems, allow natural infiltration to occur,
- Encourage the use of rain gardens for roof runoff,
- Encourage the use of rain barrels or cisterns to collect & reuse runoff.

v. Pollution prevention

- Minimize applications of sand and salt on roads & parking areas,
- Use “Source Controls” such as weekly sweeping of large impervious areas,
- Minimize application of fertilizers on turf areas.

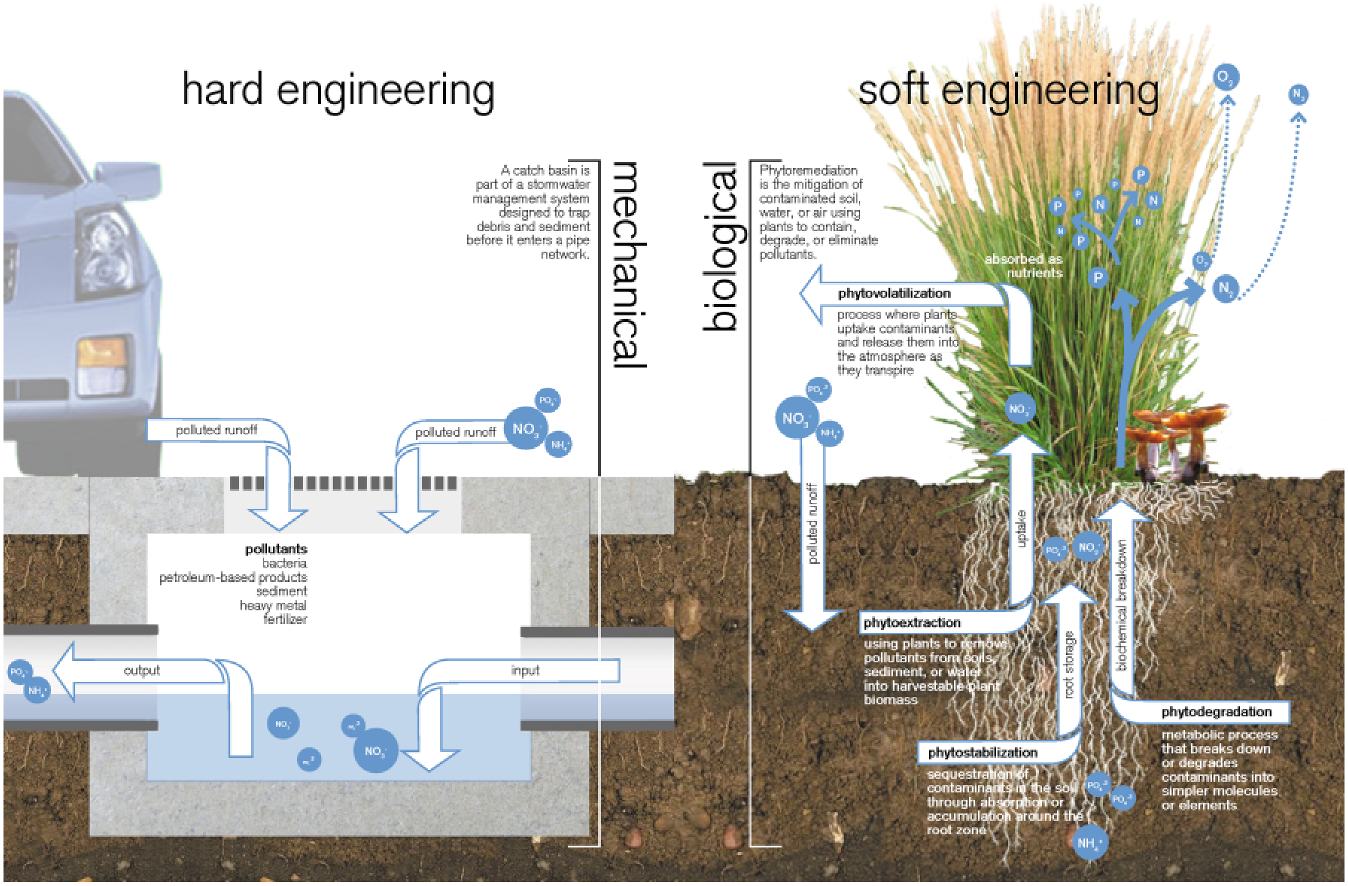


Figure 3.1.a – "The paradigm shift of stormwater quality management" (University of Arkansas Community Design Center)

3.2 Measures to Evaluate the Effectiveness of LID

A primary objective of Low Impact Development is to mimic the pre-development hydrologic conditions on a site. At the current time, this objective is measured by two metrics.

The first is the reduction of the post-development runoff volume to the pre-development runoff volume for the 90% rainfall event. The second metric is to match the Runoff Curve Numbers (RCN) for post-development conditions to pre-development conditions. Along with the matching of the RCN, it is also important to have the post-development time of concentration (Tc) match or closely approximate the pre-development Tc.

By achieving the second metric, there should be no or little change in the post-development run-off rate, which minimizes the need for detention facilities. In either case, the overall goal is to have a developed site mimic or come as close as possible to the pre-development hydrologic conditions. This condition is known as "Hydrologic Transparency".

3.3 Goals and Benefits of LID

The overriding goal of LID is to create developments which are in harmony with the natural environment while ensuring that the vision of the developer can also be achieved. The general goals for LID are listed below:

- Preservation of environmentally sensitive areas, and naturally vegetated systems to reduce changes to the hydrology of the watershed,
- Focus on maintaining natural drainage patterns as a key goal in the design of the site,
- Prevent direct adverse impacts to wetlands, watercourses (both perennial & intermittent), to the maximum extent practical,
- Minimize the extent of impervious cover and thus reduce the increases in runoff volume,
- Implement source controls for water quantity and water quality, while minimizing the extent of structural drainage systems,
- Create a landscape environment that is multi-functional for all users.

A primary benefit of LID is a better balance between Conservation of Natural Resources, Growth, Ecosystem Protection and the Public Health. There are many benefits associated with the adoption of Low Impact Development strategies for all of the stakeholders in the development field. The three primary stakeholders in the development field are the environment, the public, and the developer. The benefits of LID for each stakeholder group are stated below.

a. Environmental Benefits:
    i. Preserve the biological and ecological integrity of natural systems through the preservation of large extents of contiguous land,
    ii. Protect the water quality by reducing sediment, nutrient and toxic loads to the wetland/watercourse aquatic environments and also terrestrial plants and animals,
    iii. Reduce runoff volumes in receiving streams

b. Public Benefits:
    i. Increase collaborative public/private partnerships on environmental protection by the protection of regional flora and fauna and their environments,
    ii. Balance growth needs with environmental protections,
    iii. Reduce municipal infrastructure and utility maintenance costs (roads and storm water conveyance systems)

c. Developer Benefits:
    i. Reduce land clearing and earth disturbance costs, reduce infrastructure costs (roads, storm water conveyance and treatment systems),

ii. Reduce storm water management costs by the reduction of structural components of a drainage system,
iii. Increase quality of building lots and community marketability.

3.4 How to apply LID Strategies to land development projects

The analyses and calculations stated in **Sections 4.1 thru 4.9** are one part of the LID equation, the second part is the application of the stormwater strategies on the land. A sample process for application of LID stormwater strategies for residential and commercial / Industrial applications is provided below. These requirements do not apply to existing approved single family lots that have not been build on as of the effective date of this manual.

Residential Applications:

1. After the site analyses and processes required under **Section 4.2** – Environmental Site Designs have been applied to a site, and a Conceptual Development Plan has been done, the concept for handling stormwater can be developed for the site.
2. If road grades are less than 5% with a crown, the primary process would be to eliminate curbing and utilize vegetated swales (dry or wet) along both sides of the road. The swales can convey water to an appropriate LID treatment system. A grass filter strip could be utilized to convey flow to the swale.
3. If the road grades are less than 5% and used a uniform cross slope of 2%, runoff can be directed to a number of LID treatment systems, such as a filter strip, wet or dry swale, infiltration trench (with appropriate pretreatment), or Bioretention system.
4. If road grades are less than 5% with a crown or uniform cross slope with bituminous curbing, notches can be cut in the curbing (minimum length of notch = 24”) at appropriate intervals (minimum 50’ apart) to convey runoff to a LID treatment system along the road, such as a Bioretention system or wet swale.
5. For roads with grades greater than 5%, standard curbing with catch basins will likely be necessary to collect stormwater. However, instead of conveying the runoff down the road in a pipe system, an outlet pipe shall be installed from the rear of the catch basin to an appropriate LID treatment system(s). This is a form of “source control” and moves away from the “end of the pipe” treatment of stormwater.
6. Runoff from residential roofs can be handled in one of two ways: Rooftop disconnection which provides a minimum of 75’ of overland flow across a well vegetated surface, such as a well developed lawn area (average grade of less than 8%) or an undisturbed wooded area with an average grade of 15% or less; or connection of roof drains to Bioretention facility.
7. For those driveways which are located below the grade of the road, impervious disconnection which provides a minimum of 75’ of overland flow across a well vegetated surface, such as a well developed lawn area (average grade of less than 8%) or an undisturbed wooded area with an average grade of 15% or less can be used to treat and infiltrate runoff from the driveway.

8. For those driveways which drain toward to the road, runoff shall be intercepted prior to reaching the road and directed to a swale or Bioretention system.

Commercial / Industrial Applications:

1. Commercial / Industrial designs shall utilize LID site strategies, such as respecting the natural land form to the maximum extent practical. This will have the effect of reducing site grading requirements and the potential for erosion and sedimentation issues.
2. As parking / loading facilities are constructed with grades less than 5%, there are ample opportunities to grade the site to direct runoff to Bioretention facilities in parking islands or along the perimeter of the parking facility.
3. Permeable pavement can be used for parking spaces with standard bituminous concrete being used for driveways and parking aisles on commercial sites, such as office or retail uses. For industrial sites, any type of LID filtering or infiltration system must incorporate an impermeable liner and underdrain, which connects to a component of a structural drainage system.
4. Porous concrete can be used for both parking aisles and parking spaces. For industrial sites, any type of LID filtering or infiltration system must incorporate an impermeable liner.
5. On retail sites, open course pavers with either topsoil/grass or crushed stone can be utilized for those parking spaces which only may be needed during certain calendar periods.
6. The gravel storage layer under permeable pavement or porous concrete can be increased in depth to increase the storage volume for the runoff from commercial roofs. Pretreatment of runoff from large commercial / Industrial uses must be provided by a LID vegetated system.
7. Impervious area disconnection can be utilized if there is sufficient space on the parcel.
8. Recommended design standards for commercial parking facilities in the Town of Tolland.
    a) Provide a 20 to 30 percent of the overall parking spaces as compact spaces versus standard spaces. This change can reduce impervious coverage, especially in large parking areas, such as for shopping centers and retail strip malls.
    b) If the land area permits, utilize diagonal parking spaces as stated in Section 170-105 with a one-way aisle. This change can reduce impervious area by 5 to 10% as the aisle width will be reduced from 24' to a maximum of 18' (60 degree spaces).
    c) Encourage shared parking agreements with adjacent or nearby properties (walking distance) that serve land uses with non-competing hours of operation. An example of this is use of a parking area for an office building after 5 pm for an adjacent retail use which stays open to 9 or 10 pm.
    d) Where feasible and not cost prohibitive, place parking under a building. This will help reduce the total impervious area on a site.

3.5 LID Systems for Water Quality Retrofits for Commercial Sites

In the Town of Tolland there may be some opportunities to apply stormwater retrofits to small commercial areas of the town utilizing LID concepts to reduce runoff volumes and provide some attenuation of non-point source pollutants. The retrofits can be incorporated within the existing infrastructure in the commercial sites. LID planters, curb extensions, modular wetland systems, and Filterra Bioretention systems are acceptable LID systems for commercial retrofits. These systems are simply adaptations of proven LID technologies and designs for retrofit situations. An image of each type of system is provided below with more detailed design information provided in **Section 6.0** of this manual.

4.0 Low Impact Development Strategies & Performance Requirements

4.1 Overview of Strategies

The key to addressing adverse impacts associated with land development is to change the development paradigm which is applied. In the application of LID, the application of Environmental Site Design (ESD) strategies, when coupled with the flexible zoning standards for residential development (Section 170-38 of the zoning regulations) in the Town of Tolland provides the highest environmental benefit. The requirements of Section 4.2 shall apply to all residential subdivisions, where the site area is greater than five (5) acres and to commercial / industrial sites which contain a minimum of two (2) acres.

The Flow Chart shown below outlines the steps and sequence of steps that a designer should follow to maximize the environmental benefit of implementing LID. An example for applying the ESD approach is found in **Section 8.0** of this manual.

Conveyance Flow, Flood Protection and Water Quality Flow shall be applied for a particular project as warranted.

The specifications found in this guidance document shall be implemented by individuals with a demonstrated level of professional expertise in stormwater management, such as professional engineers licensed in the State of Connecticut. All calculations, including pollutant renovation analysis and the design of LID treatment systems must be prepared by a licensed professional engineer in the State of Connecticut. All designers must adhere to all of the applicable stormwater and performance standards found in the guidance document. The typical details provided for the various types of treatment and storage systems are schematic in nature and may be adjusted by the designer to fit particular site conditions. Final design plans for any type of treatment or storage system must include all relevant design specifications for that particular system.

The standards and performance requirements have been specified to address the specific stormwater issues which exist or potentially exist in the Town of Tolland.

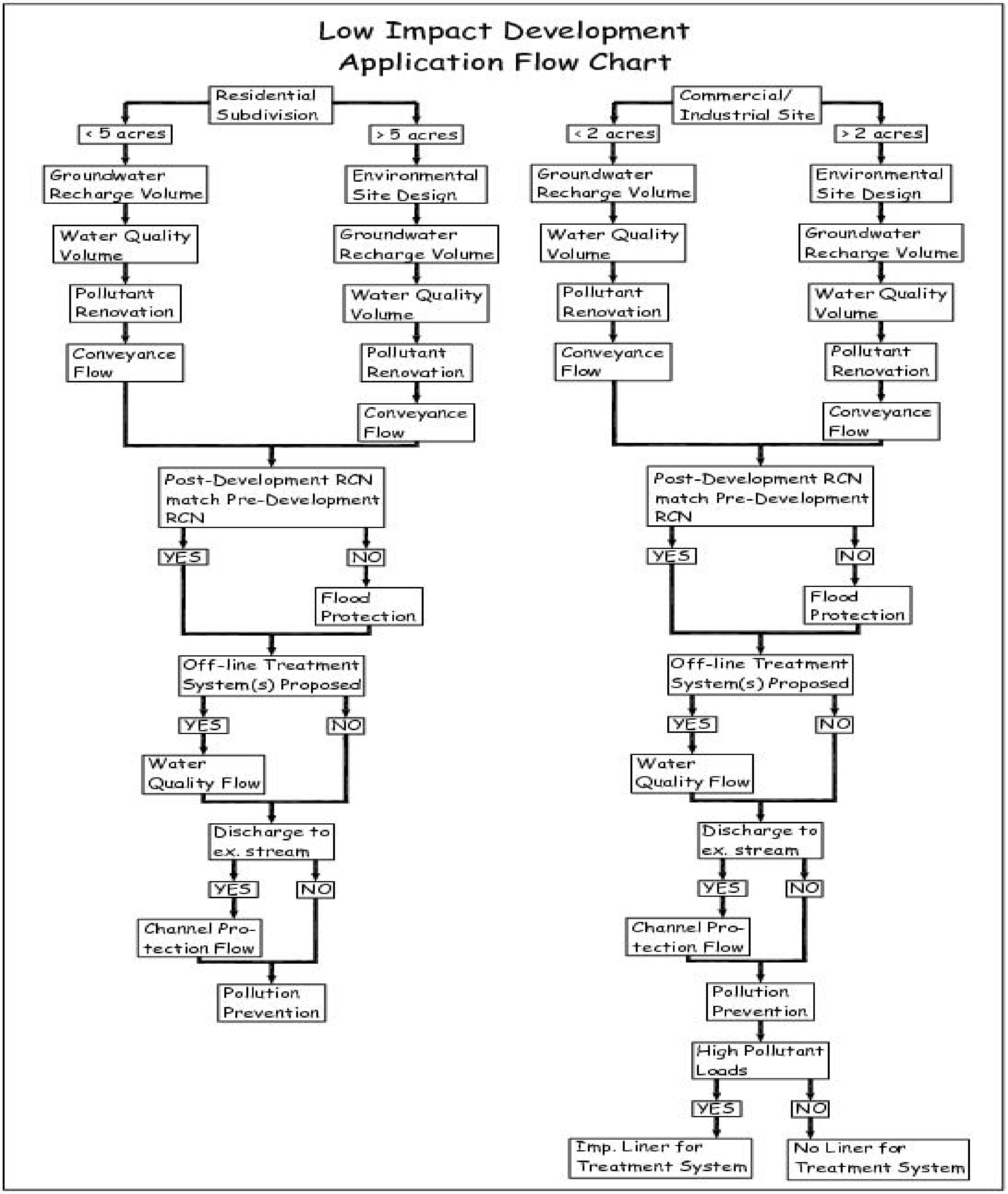


Chart 4.1.a – LID Flow Chart

4.2 Environmental Site Design (ESD) – Requirement #1

A key aspect for the successful implementation of LID is to utilize Environmental Site Design Strategies. The strategies of Environmental Site Design (ESD) are the base building blocks for the application of Low Impact Development. The ESD process focuses on the natural land form and the natural environmental systems. There are many environmental systems on a parcel of land, including wetlands, watercourses, vernal pools, flood plains, steep slopes (>20%), significant individual trees, unusual vegetative communities and soils with moderate to high infiltrative capacities. The ESD process requires that these natural environmental systems are fully evaluated prior to the creation of a development concept for residential projects. The ESD process is enumerated below and must be applied and documented by the appropriate design professional as part of a subdivision application.

Evaluation of the Natural Resources:

1) Obtain field delineation of inland wetlands and watercourses on the site by a Certified Soil Scientist. In Connecticut, wetlands are solely determined by the presence of low chorma coloring within the upper 20" of the soil. The criteria used to determine inland wetlands should always reflect local requirements. The soil scientist should also approximate the boundaries and types of upland soil types on the site. These boundaries are typically sketched on a preliminary map of the site.
2) Obtain an inspection of the site by an environmental consultant to determine the presence of vernal pools or other high quality wetland areas.
3) Identify and locate all significant or unusual tree species in the field by a qualified individual.
4) Identify large ledge (600 square feet or larger) outcrops in the field.
5) Obtain a topographic base map of the property based upon current aerial photographs which will provide existing contours at a 2' interval.
6) Investigate the presence of 100-year flood boundary limits on the site from the available mapping by the Federal Emergency Management Agency (FEMA).
7) Obtain a boundary survey of the site along with the field location of all delineated inland wetlands and watercourses, significant trees, ledge outcrops and natural stone walls.

Creation of Base Map:

A base map incorporating all of the above information shall be prepared so all the resources can be fully evaluated.

a) Boundaries of upland soil types shall be added to the plan. Determine the potential infiltrative capacity of the soils by using data available from the Natural Resources and Conservation Service (www.websoilsurvey.nrcs/usda.gov/app/). Highlight the extent of these soils on the plan.
b) Determine and delineate the existing sub watershed boundaries on the site.
c) Determine the generalized vegetative types on the site, whether they are deciduous, coniferous, a combination of both, or meadow areas.
d) Determine which of the significant trees located in the field warrant protection from development. This could be a 200 year old Oak Tree in the middle of a field.
e) Delineate extent of 20% slopes on the parcel. The 25% slopes shall be defined as those areas where there is a 10' change in grade across 50' in horizontal distance.

Determination of Developable Area:

The Developable area results from the removal of the wetlands, watercourses, vernal pools and steep slopes from the site area. In addition, a portion of the upland area adjacent to wetland/watercourse systems shall be removed to provide a biological connectivity to the wetland resources. The width of the upland area to be preserved shall be based upon a scientific evaluation by an environmental consultant and documented in writing. This report shall be submitted as part of the subdivision application.

The designer shall then develop plans for the site utilizing the following LID strategies:

Avoidance of Impacts:

1. Protect as much undisturbed land as possible to maintain pre-development hydrology and allow rainfall to infiltrate into the ground.
2. Protection of the natural drainage systems, such as wetlands, watercourses, ponds, vernal pools to the maximum extent possible.
3. Minimize the disturbance of the land necessary for clearing and grading.
4. Implement techniques to prevent the compaction of natural soils

Reduction of Impacts:

1. Utilize low maintenance landscapes that will encourage the retention and planting of native types of vegetation, and minimize the extent of lawn areas, which will reduce the potential application of fertilizers and pesticides
2. Minimize the extent of impervious areas on the site, particularly the directly connected impervious areas.
3. Increase the "Time of Concentration" for post-development conditions to match the "Time of Concentration" for pre-development conditions, where the "Time of Concentration" is defined as the time it takes for runoff to travel from the hydrologically most distant point of the watershed or sub-watershed area to the design point.

Management of Impacts:

1. Use vegetated conveyance and treatment source controls to infiltrate runoff as close as possible to the point rainfall reaches the ground surface.
2. Disconnect impervious areas to the maximum extent possible to reduce runoff over the impervious surface.
3. Implement procedures to prevent or minimize the use of compounds which are responsible for the pollutants found in non-point source runoff.
4. Utilize source controls to minimize or prevent the discharge of pollutants to receiving wetlands or watercourse systems.

4.2.a LID Site Design Strategies

These LID strategies are applied as follows during each stage of the design process as described below.

4.2.a.1 Road Design:

- Road alignments shall follow the existing contours to the maximum extent practical to minimize excessive cuts and fills.
- Minimize the extent of directly connected impervious area to the maximum extent practical. This can be achieved by the minimization of drainage structures on the road, such as catch basins and connecting pipe and the use of vegetated swales along the road in appropriate locations.
- Utilize LID treatment strategies to treat runoff at the source and not at the end of the pipe.
- Utilize multiple LID treatment systems in a series to increase the effectiveness of the pollutant removal from the stormwater.

4.2.a.2 Driveway Layouts:

- Use impervious area disconnection strategies to intercept and infiltrate driveway runoff prior to the runoff reaching the road.
- Allow runoff from driveways to travel across vegetated areas for a minimum of 75' to facilitate infiltration.

4.2.a.3 Lot Designs:

- Layout lots in such a manner as to minimize site clearing by the implementation of "site fingerprinting". Site fingerprinting is delineating the smallest possible area for clearing and site disturbance where roads, structures and other improvements are to be constructed.
- Layout house, driveway and on-site sewage disposal systems in such a manner as to minimize the extent of soil disturbance and grading on the lot.
- Utilize the natural topography when siting the proposed house to minimize site disturbance. An example of this is to create a walkout basement for a house on a natural 15-20% slope.
- Don't randomly disturb areas of the site that aren't necessary, this will preserve the infiltrative capacity of native soils.
- Use "source" controls such as rain barrels for roof runoff to collect and reuse runoff; rain gardens for roof runoff to infiltrate runoff into the ground; impervious area disconnection to allow runoff to occur as overland flow across a vegetated surface.
- Consider the use of meadow filter strips at the downhill limits of development to filter runoff prior to leaving the lot.

4.3 Groundwater Recharge Volume (GRv) – Requirement #2

To maintain pre-development hydrology, post-development stormwater must be infiltrated to maintain the appropriate pre-development infiltration rate. The required Groundwater Recharge Volume is defined as a function of the annual pre-development recharge rate for site-specific soil conditions, the 90% rainfall event (1" of rain/24 hrs), and the extent of impervious cover on a site. The objective of this requirement is to maintain groundwater levels to protect the average depth of the groundwater, stream and/or wetlands, and general soil moisture levels. The infiltration of stormwater does provide significant water quality benefits, such as reducing the amount of nutrients, metals, and pathogens in the stormwater. By the maintaining the pre-development recharge rate, compliance with this requirement can reduce the volumetric requirements for other sizing criteria (channel protection and flood protection). Groundwater recharge must occur in such a manner that protects groundwater quality. All stormwater must pass through a pre-treatment facility under this requirement.

The volume required for Groundwater Recharge shall be based upon the amount of impervious area. The recharge requirements are based upon the pre-development natural hydrologic soil group (HSG). The groundwater recharge volume is defined as follows:

GRv = (P)(D)(I)/12

Where:

GRv = Groundwater Recharge volume (acre-feet)
P = 1" (90% rainfall event)
D = Recharge Factor, see Table 4.3.1
I = Impervious area (acres)

Table 4.3.a - Recharge Factors Based on Hydrologic Soil Group (HSG)

HSG	**Recharge Factor (D)**
A	0.60
B	0.40
C	0.25
D	0.10

The National Conservation Resource Service Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) may be used to determine the preliminary Hydrologic Soil Group for a project. The hydrologic soil group must be verified by field data in the vicinity of the proposed recharge system. This data can be provided by a Certified Soil Scientist's field inspection of the site or soil tests performed by a professional engineer.

The groundwater recharge volume is part of the required water quality volume that must be provided for a project. Recharge must be provided in each separate, and distinct drainage area, where there is any impervious cover proposed. Runoff from a residential roof may be infiltrated without pre-treatment. Runoff from commercial or industrial roofs must be directed through a pre-treatment facility prior to infiltration.

Description of Hydrologic Soil Groups (NRCS):

Group A: Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively well drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B: Soils having a moderate infiltration rate when thoroughly wet. These soils consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C: Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

4.4 Water Quality Volume (WQv) – Requirement #3

Stormwater runoff from a site must be adequately treated prior to discharge to a receiving wetland or watercourse. Different stormwater treatment systems may be utilized, both non-structural and structural. The objective of this standard is to minimize the adverse water quality impacts from non-point runoff on receiving water systems. Pollutant removal performance standards must be achieved at each discharge location based upon the water quality volume from 1" of runoff which is the runoff generated from a rainfall event of 1.2" per 24 hours. This is known as the water quality storm. All stormwater must pass through a pre-treatment facility under this requirement. The Water Quality Volume and required pollutant removal efficiencies are below.

The Water Quality volume is defined as follows:

$$WQv = (1")(I)/12$$

Where:

WQv = Water Quality Volume (acre-feet)
I = Impervious area (acres)

For those developed sites, such as a golf course which have little or no impervious areas, a minimum WQv of 0.2 watershed inches (0.2" over the entire disturbed area) is required. This minimum treatment volume is necessary to fully treat the runoff from the pervious surfaces. For the sizing of facilities to fully treat the WQv, the basis for the hydrologic and hydraulic evaluation shall be as follows:

- Impervious coverage shall be measured from the site plan and shall include all impermeable surfaces (paved/gravel roads, driveway and parking lots, sidewalks, roof tops and patios set on a impermeable base)

Any off-site area which is tributary to a proposed treatment facility must be accounted for the sizing of that specific practice. However, treatment is only required for the on-site areas. If there is a substantial off-site tributary area (>1 acre), the designer should design a by-pass system for the off-site drainage area.

Table 4.4.a Required Minimum Pollutant Removal Efficiencies

Pollutant Type	Minimum Pollutant Removal Rate
Total Suspended Solids	90%
Total Nitrogen	40%
Total Phosphorous	60%
Zinc	75%
Total Petroleum Hydrocarbons	80%
Dissolved Inorganic Nitrogen	40%

4.5 Pollutant Renovation Analysis – Requirement #4

4.5.a Pollutant Concentrations per Land Use Type:

A pollutant renovation analysis is necessary to demonstrate that the proposed stormwater treatment system will achieve the required water quality goals. Achievement of these goals is a function of an accurate assessment of the pollutant loads expected to be seen by the treatment system and the design of the actual treatment system. In order to achieve the pollutant removal efficiencies stated in **Section 4.5.b** for a particular practice, the practice must be designed and constructed in accordance with all of the required parameters as found in **Section 6.0**. Table 4.5.a provides concentrations of the pollutants of concern for common land uses. All concentrations are in mg/l.

Table 4.5.a – Pollutant Concentration per Land Use Type

	Pollutant Concentration (mg/l)					
Land Use	TSS	TP	TN	Zn	TPH	DIN
Large Lot Residential (1 unit/5-10 ac)	60	0.38	2.1	0.161	0.50	0.51
Low Density Residential (1 unit/5 ac – 2 units/ac)	60	0.38	2.1	0.161	0.50	0.51
Medium Density Residential (2-8 units/ac.)	60	0.30	2.1	0.176	1.25	0.344
High Density Residential (8+ units/ac.)	60	0.30	2.1	0.218	1.5	0.344
Commercial	58	0.25	2.6	0.156	3.0	0.324
Industrial	80	0.23	2.1	0.671	3.0	0.569
Institutional (schools, churches, etc)	58	0.27	2.0	0.186	3.0	0.521
Open Urban Land	50	0.25	1.3	0.0	0.0	0.0
Transportation (roads only)	99	0.25	2.3	0.156	3.0	0.375
Decidous Forest	90	0.10	1.5	0.0	0.0	0.215
Evergreen Forest	90	0.10	1.5	0.0	0.0	0.215
Mixed Forest	90	0.10	1.5	0.0	0.0	0.215

Land Use	Pollutant Concentration (mg/l) TSS	TP	TN	Zn	TPH	DIN
Brush	90	0.38	1.5	0.0	0.0	0.215
Wetlands	0.0	0.38	1.5	0.0	0.0	0.10
Beaches	0.0	0.10	1.5	0.0	0.0	0.0
Bare Ground	1000	0.38	1.5	0.0	0.0	0.0
Row & Garden Crops	357	1.0	2.92	0.0	0.0	0.65
Cropland	357	1.0	2.92	0.0	0.0	0.215
Orchards/vineyards/horticulture	357	1.0	2.92	0.0	0.0	0.215
Pasture	145	0.38	2.2	0.0	0.0	0.65
Feeding Operations	145	0.38	2.2	0.0	0.0	0.8
Agricultural building, breeding & training facilities	145	0.38	2.2	0.0	0.0	0.8

4.5.b Pollutant Removal Efficiencies for Treatment Systems:

Pollutant removal efficiencies are taken from the best available data for each type of treatment system. The sources of this information include the Center for Watershed Protection, the University of New Hampshire Stormwater Center, the EWRI/ASCE BMP Database, and the Massachusetts Stormwater Guidance Document.

Table 4.5.b - Pollutant Removal Efficiencies (percent removal)

Type of System	Pollutant Removal Efficiencies (percent)					
	TSS	TN	TP	Zn	TPH	DIN
Extended Detention Shallow Wetlands	69	56	39	0	0	35
Subsurface Gravel Wetland	99	90	56	99	99	98
Pond/Wetland System	71	19	56	56	0	40
Wet Extended Detention Pond	80	35	55	69	0	36
Infiltration Basin	90	60	65	88	90	50
Infiltration Trenches/Chambers	80	55	60	99	99	50
Bioretention (Option 1 – see list below)	87	17	34	77	99	44
Bioretention (Option 2 – see list below)	87	60	34	77	99	60
Bioretention (Option 3 – see list below)	87	17	60	77	99	44
Bioretention (Option 4 – see list below)	87	60	60	77	99	60
Surface Sand Filter	87	32	59	77	98	33
Organic Filter	88	41	61	89	0	35
Dry Swale w/filter berms	50	0	8	50	81	0
Wet Swale	75	40	40	33	0	41
Vegetated Filter Strip	68	40	45	88	0	0
Permeable Pavement	99	0	60	75	99	0
Porous Concrete	97	0	0	99	99	0
Standard Sump Catch Basin (24”)	3	0	0	0	0	0
Deep Sump Catch Basins (48”)	9	0	0	0	14	0
Oil / Grit Separator	0	0	0	17	0	47

LID Urban Planter	99	29	5	99	99	29
LID Curb Extension	99	29	5	99	99	29
Modular Wetland System	82	80	5	79	90	70
Filterra Bioretention System	85	40	60	62	80	40

(Values taken from A.P.L.E.T.S. water quality software by Steven Trinkaus, PE)
Bioretention Option 1 (P-Index greater than 30)
Bioretention Option 2 (P-Index greater than 30 with IWS)
Bioretention Option 3 (P-Index less than 30)
Bioretention Option 4 (P-Index less than 30 with IWS)

4.5.c Equation and Process:

In 1987, Tom Schueler developed the Simple Method as a way to estimate pollutant loads for various chemical constituents on an annual basis. The Simple Method requires a small amount of information to be utilized; annual precipitation, pollutant concentrations, percent impervious cover and subwatershed areas. The formula of the Simple Method is as follows:

$L = [(P)(Pj)(Rv)]/12(C)(A)(2.72)$ or reduced to $L = 0.226(P)(Pj)(Rv)(C)(A)$, where

L = Pollutant load in pounds
P = Rainfall depth over desired time period (inches)
Pj = Factor that corrects P for storms that produce no runoff, use Pj = 0.9
Rv = Runoff coefficient, fraction of rainfall that turns to runoff,
$Rv = 0.05 + 0.009(I)$
I = Site Impervious coverage (percent)
C = Flow weighted mean concentration of pollutant (mg/l)
A = Area of site (acres)
0.226 = Unit Conversion Factor

The Simple Method provides reasonable estimates of changes in pollutant amounts resulting from different types of development. There are three aspects of the Simple Method that engineers need to keep in mind when using the equation.

1. It only estimates the pollutant load from storm events and does not consider pollutants from baseflow volumes. For large low density residential developments, where I < 5%, up to 75% of the annual runoff volume may be comprised of baseflow, the annual nutrient load associated with the baseflow may be equal to the annual load associated with the development.
2. Its primary usefulness is for calculating and comparing the relative storm water pollutant loads from various development concepts.
3. It provides an estimate of the pollutant loads that are likely close to the “true” but unknown value for a development project.

The Simple Method shall be used to calculate the pollutant load for the six pollutants required to be evaluated for stormwater discharges in the Town of Tolland. The following process shall be followed for the calculation of the pollutant loads and the effectiveness of the stormwater treatment systems.

<u>Pre-Development Conditions:</u>

1. Delineate the watershed areas on the site for undeveloped conditions for each design point or point of interest. A design point would typically be the point where a water-course or overland flow would leave the site boundary. A point of interest could also be the limit of a delineated wetland or watercourse, located within the site's boundary.
2. Label and determine the area of each watershed on the site.
3. Determine the type of land cover for each watershed area. (For a retrofit or redevelopment site, the design engineer needs to make an assumption as to the type of land use cover which existed on the site prior to any type of development)
4. Obtain annual rainfall amount in inches for the general location of the site.
5. Use the Simple Method to calculate the pollutants loads for the pre-development conditions.

<u>Post-Development Conditions:</u>

1. In order to fully integrate water quality into the site design, the type and location of the treatment systems need to be evaluated during the design phase and not at the end of the design period. The pollutant loading analysis should be prepared twice during the process; first during the Conceptual Design Phase in order to determine the type of treatment systems needed to achieve water quality goals. The second time is when the final site plan is complete and accurate values for impervious cover are available.
2. Prepare Conceptual Development Plan for project.
3. Delineate the watershed boundaries on the site for future conditions. Divide the watershed area into the area above the treatment system, which contributes to the treatment system, and the area below the treatment system.
4. Calculate area of each watershed area.
5. Based upon proposed land use, estimate impervious coverage within each watershed area above the treatment systems.
6. Calculate land area below the treatment system to the design point or point of concern. Only that area above the last treatment facility is run through the treatment system analysis. Pollutant loads from land below the last treatment system need to be calculated separately and can be added to the remaining load from the treatment system to determine the total load reaching the design point for future conditions. This is very important if TMDL limits are applicable to the receiving waterway.
7. Use the Simple Method to calculate preliminary pollutant loads for post-development conditions on the site based upon the Conceptual Development Plan.
8. After the loads have been calculated for post-development, use the pollutant removal efficiencies provided and the formula below to determine the type(s) of treatment systems needed to achieve water quality goals.

9. After the design engineer has determined what type of treatment system(s) are required, they can proceed with the final site design and incorporate the necessary storm water treatment system(s) as they prepare the final site design.
10. After the site design is complete, steps #3 through #8 are repeated with the accurate areas of the final watershed areas and impervious cover.

Pollutant Removal Calculation Procedure

1. (total load * 1st removal efficiency)
2. (total load – (load removed in #1))*2nd removal efficiency
3. (total load – (load removed in #1 + #2))*3rd removal efficiency
4. (total load – (load removed in #1 + #2 + #3))*4th removal efficiency …

Total Percentage Removed by Treatment Systems

(load removed in #1+load removed in #2+load removed in #3….)/total load * 100

4.6 Channel Protection Flow – Requirement #5

Natural stream channels must be protected from both changes in the peak rate and volume of post-development stormwater. The matching of the pre-development infiltration rate can address one of the major adverse impacts to stream channel morphology, however, the other major adverse impact, increases in the peak rate of runoff must be addressed. The Channel Protection Flow addresses the increases in the peak rate of runoff and the adverse impacts on the hydromorphology of the stream channel.

One of two methods may be applied to achieve this goal as stated in the CT DEP 2004 Stormwater Quality Manual:

- Control the 2-year, 24-hour post-development peak flow rate to 50% of the 2-year, 24-hour pre-development level or,
- Control the 2-year, 24-hour post-development peak flow rate to the 1-year, 24-hour pre-development level.

The goal for this requirement is to maintain the depth and flow rate within a natural stream channel. This will minimize the adverse impacts to the stream channel itself as well as the benthic organisms which live in the bottom of the stream channel.

4.7 Conveyance Flow – Requirement #6

Open drainage or enclosed conveyance systems shall be designed to provide adequate capacity for the flows, leading to, from and through stormwater management systems for the 10-year, 24-hour storm event.

4.8 Flood Protection – Requirement #7 (If applicable)

The matching of the pre-development infiltration rate is an important metric measuring the effectiveness of a LID design. Once the volumetric requirement has been met, the designer can then focus on the metric measuring the matching of the RCN values and then the potential changes to the peak rates of runoff.

Those impervious areas which are directed to infiltration systems, which will fully contain and infiltrate the required WQv can be removed from the calculation of the impervious area for that subwatershed area. In addition, other impervious areas where runoff occurs as overland flow and will flow across a minimum of 100' of a pervious, vegetated surface (dense lawn, forest litter or meadow) can also be removed from the calculation. The total area of the subwatershed area shall remain unchanged, with only those connected impervious areas be included in the peak rate calculation for post-development conditions. The area of the excluded impervious area shall be considered as Forest in Fair Condition for the purposes of the hydrologic analysis.

For residential projects, where large extents of the site are preserved as undisturbed areas, this analysis will show how the RCN for post-development conditions can be reduced to become closer to or equal to the RCN for pre-development conditions. If the post-development calculation still shows an increase in the peak rate of runoff from the subwatershed area, then attenuation of the peak rate shall be required.

The increases in the peak rate of runoff for the 10-year, 24-hour and potentially the 100-year, 24-hour storm event must be reduced to the pre-development peak rate. These increases shall be reduced by the design and construction of appropriate structural measures.

- For those sites no greater than 10 acres, and having no more than 20% total impervious coverage, the 10-year, 24-hour storm shall be used to design the facility.
- For a 10 acre site with more than20% impervious coverage, or a site greater than 10 acres, both the 10-year, 24-hour and 100-year, 24-hour storm event shall be accommodated.

The primary objective of this sizing criteria is to prevent the increase in magnitude and frequency of storm events which exceed the bank full condition and spread out into the flood plain. A secondary objective is to prevent flood damage from the infrequent, but very large storms, protect the integrity of the stormwater management practice as well as maintain the existing boundaries of the pre-development flood plain.

4.9 Water Quality Flow – Requirement #8 (If applicable)

The Water Quality Flow is a peak rate associated with the water quality storm event. The WQf is used to design off-line treatment systems. These systems must have a mechanism to by-pass those flows greater than the WQf. The WQf calculation uses the WQv and a modified curve number for small storm events. The following equation shall be used to determine the modified CN. The modified CN will then be used in a standard TR-55 model to estimate the peak rate for small storm events.

Using the WQv, a modified CN is calculated by the equation shown below:

$$CN = 1000/[10 + 5P + 10Q * \sqrt{(Q * Q + 1.25 * QP)}]$$

Where:

P = Rainfall in inches (use 1.2” for Water Quality Storm that produces 1” of runoff)

Q = Runoff Volume, in watershed inches (equal to total WQv / total drainage area)

Professional Engineers can use a TR-55 spreadsheet to find the WQf. Using the CN from the above equation, the time of concentration (Tc) and drainage area (A), the peak rate discharge (WQf) for the water quality event can be determined by the following procedure:

1. Read initial abstraction (Ia) from TR-55 Table 4.1 or calculate using Ia = 200/CN – 2
2. Compute Ia/P (P = 1.2 inches)
3. Approximate the unit peak discharge (qu) from TR-55 Exhibit 4-III using Tc and Ia/P
4. Compute the peak discharge (WQf) using the following equation:

WQf = qu * A * Q

Where:

WQf = the peak discharge for water quality event in cubic feet per second (cfs)

qu = the unit peak discharge, in cfs/mi(squared)/inch

A = drainage area, in square miles

Q = runoff volume, in watershed inches (equal to WQv / A)

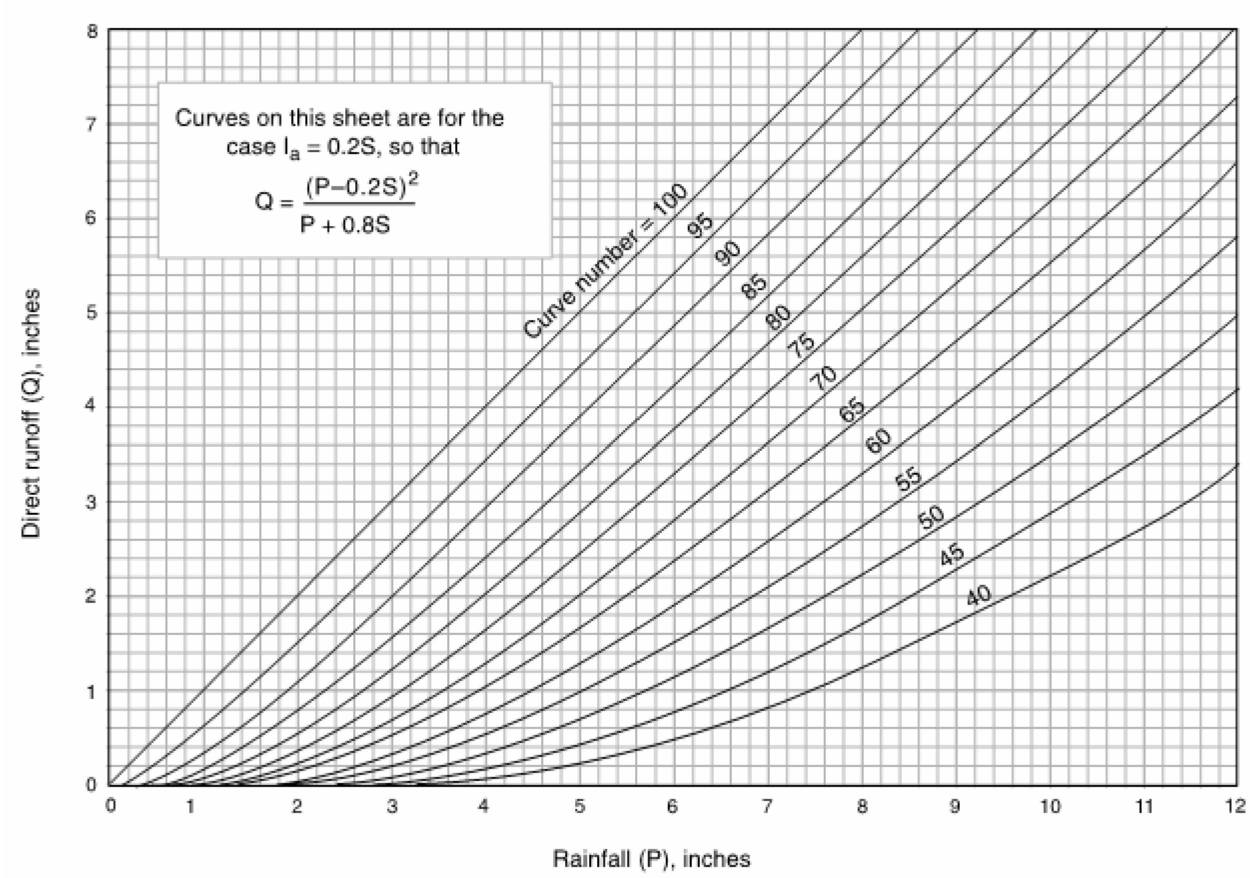


Figure 4.9.a – "Figure 2-1: Solution of Runoff Equation (TR-55 manual)

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Figure 4.9.b – "Table 4-1: Ia values for Runoff Curve Numbers" (TR-55 manual)

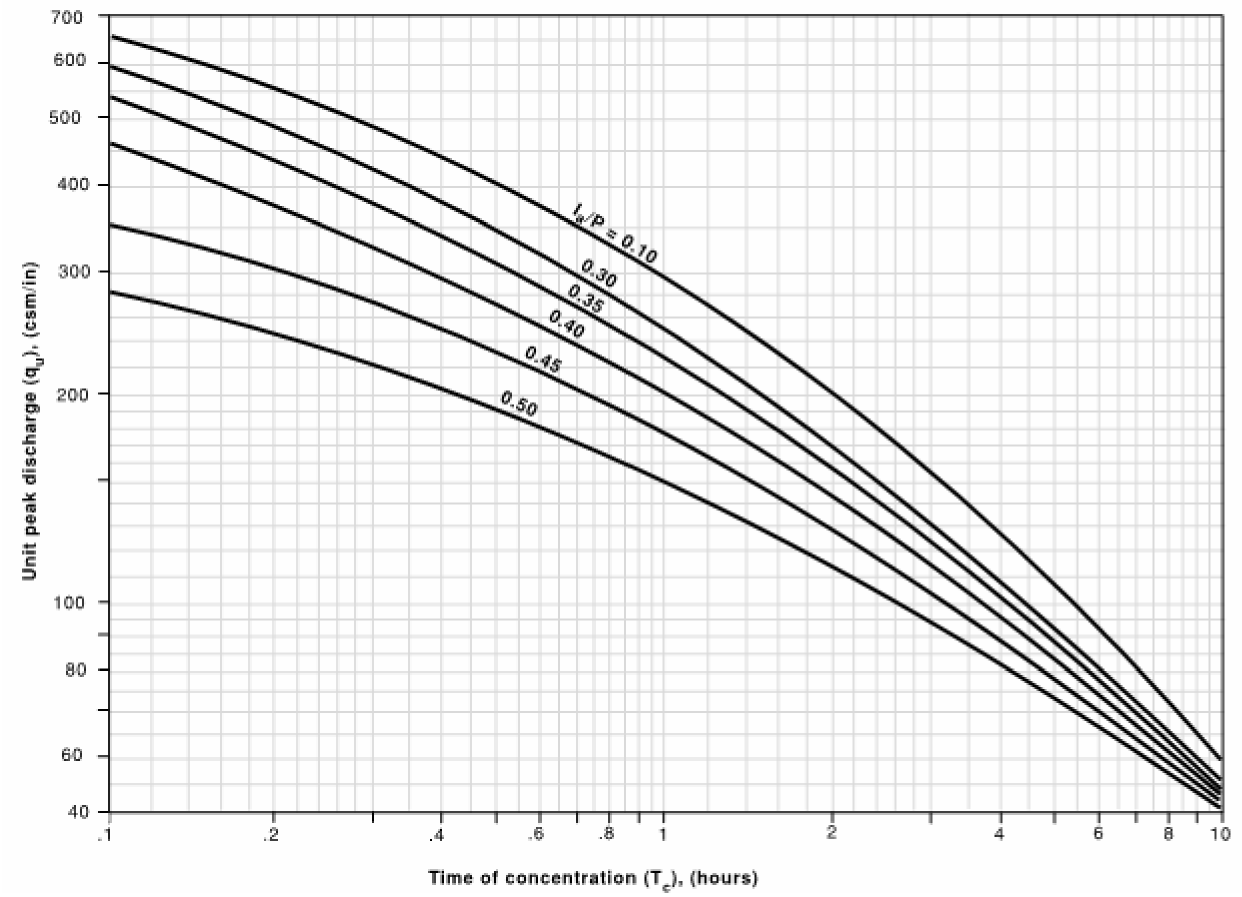


Figure 4.9.c – "Exhibit 4-III: Unit peak discharge (qu) for NRCS (SCS) type III rainfall distribution (TR-55 manual)

4.10 Pollution Prevention – Requirement #9

All development projects require the application of pollution prevention measures to minimize the impacts that the runoff from the project will have on stormwater quality. The objective of this requirement is to minimize or prevent to the maximum extent practicable, pollutants coming in contact with the stormwater runoff. An application shall clearly state what measures will be applied to the post-development conditions to achieve these requirements.

These measures include the following pollution prevention strategies:

- Minimal applications of sand and/or salt to large connected impervious areas, such as parking lots,
- Weekly sweeping of large connected impervious areas during the seasons when sand is applied to these surfaces,
- No or minimal application of fertilizers and pesticides on green spaces which are in close proximity to connected impervious areas,
- Prompt cleaning out of catch basin sumps during the spring after the snowmelt season.

4.11 High Density Residential / Commercial / Industrial Redevelopment Projects

Many existing developed sites, particularly those containing high density residential, commercial or industrial uses lack adequate stormwater treatment measures to remove pollutants from stormwater. The purpose of this section is to provide a set of standards which will apply to these sites. The standards in this section shall only apply to those redevelopment projects which will cause 10,000 square feet of the current site area to be modified. This requirement will apply to high density multi-family, commercial and industrial projects. If an industrial redevelopment project is to consist of a use with a high pollutant load then the requirements found in **Section 4.12** shall apply.

In order to apply the stormwater requirements on the site, the extent of the existing impervious area must be determined. All of the existing impervious areas (paved/gravel roads, parking areas, sidewalks, and buildings) shall be calculated from an existing survey of the site conforming to Class A-2 standards. The site area shall be defined as all of that area upon which the current development is located. It may include multiple lots or parcels. Wetlands, watercourses, open water bodies, and lands protected by easement from development shall be excluded from the lot area for the calculation of percent impervious coverage.

- Provide full compliance with groundwater recharge and water quality standards for the entire site.

A waiver of this requirement may be requested from the Zoning Commission in accordance with Section 4.14 of this design manual.

4.12 Land Uses with High Pollutant Loads

Certain types of development have the potential for significantly higher pollutant loads. Care must be taken with the stormwater from these sites to prevent adverse impacts on surface and groundwater. Those uses shown in Table 4.12.a have the capability to generate high pollutant loads and need to be treated differently than other land uses.

Due to the potential of high pollutant loads in the stormwater, the Groundwater Recharge Volume for ground surface impervious areas do not have to be met for these sites, but the GRv shall be provided for the roof areas. The Water Quality Volume must be fully provided and adequately treated.

Table 4.12.a – Land Uses with High Pollutant Loads

1. Industrial Sites,
2. Outdoor storage and loading/unloading of hazardous substances,
3. Storage of road salt and associated loading areas (if unprotected from rainfall),
4. Gas stations,
5. Exterior vehicle maintenance and service facilities, & equipment storage areas

All filtering or infiltrating LID treatment systems must be equipped with impermeable liners and underdrains, which must discharge to conventional conveyance systems. Infiltrating treatment systems which are not lined are not permitted on these sites as the potential for groundwater contamination is high.

4.13 Tolland Village Area

Low Impact Development Regulations for the Tolland Village Area

This is a supplemental section to the Low Impact Development Design Manual for the Town of Tolland and the standards and specifications found here are applicable to the proposed Tolland Village Area.

Overview:

In the Tolland Village Area, density and impervious area will be increased over and above what the current zoning regulations would permit for this area. Due to the proximity of watercourses, which are tributary to Tolland Marsh, there are two major concerns from a storm water standpoint. The first is the quality of the water which will be discharged to these systems. The second issue is the amount of runoff, particularly the increase of volume that will be generated by the denser development. These two issues will be addressed in the following manner.

The intensification of development and land disturbance within the Tolland Village Area will require a standard greater than the Water Quality Volume (WQV) as defined in the 2004 Storm Water Quality Manual (The Manual) as prepared by the CT DEP. The design of the stormwater treatment should follow the following Performance Standards and pollutant removal to the Maximum Extent Possible (MEP) as outlined in the Tolland Design Manual.

The following is a list of Low Impact Development treatment systems to be utilized within the Tolland Village Area:

- Bioswales (both grass and landscaped)
- Porous Gravel Mats (precast units with gravel base & underdrain)
- Open pavers on porous base
- Porous Concrete (underdrain optional)
- Permeable Pavement (underdrain optional)
- Bioretention/Rain Gardens
- Underground Infiltration systems, such as large diameter ADS perforated pipe,
- Shallow Water Planters (with raised underdrain)
- Green Roofs (flat roof buildings)
- Impervious area disconnection (overland flow over at least 75' of vegetated surface with slope < 6%)
- Subsurface Gravel Wetland Treatment System
- Modular Wetland Treatment System

Design Process

Infiltration Systems (Permeable Pavement, bioretention, porous concrete, open course pavers, underground perforated systems):

a) Sufficient number of deep test holes shall be performed in the area of the proposed storm water treatment systems to determine the following information: Description of the soil type using Hydrologic Soil Group criteria, depth to seasonally high groundwater, depth to bedrock. The depth of the test pit shall be a minimum of six (6') below the anticipated finish grade elevation.
b) An assessment of infiltrative capacity shall be made of the soil layer anticipated to be primarily responsible for the infiltration of runoff. Horizontal permeability tests are the preferred measure of the infiltrative capacity for permeable pavement or porous concrete. A percolation test is adequate for a shallow bioretention system, and open course pavers.
c) If the underlying soils consists of Soil Class "A" (unconsolidated sands and gravels with a seasonally high groundwater table a minimum of five (5') below the bottom of the infiltration system, then no underdrain is required.
d) For all other soil conditions, a raised underdrain shall be installed in the gravel storage layer. The invert of the underdrain shall be set a minimum of 12" above the bottom of the treatment system.
e) If a system is located in an area which consists of ledge, then the entire underground portion of the system shall be lined with an impermeable PVC liner.
f) The Treatment Volume (Tv) shall be calculated for each LID treatment system.
g) It shall be demonstrated by calculations that each LID treatment system will provide the required Tv as a "fixed" storage volume either on the surface (rain garden) or in the porous base (permeable pavement, porous concrete). The storage volume under permeable pavement shall be sized to handle the Tv from the adjacent and tributary dense mix pavement.
h) A pollutant loading analysis shall be prepared to clearly demonstrate compliance with the stated removal goals for the Tolland Village Area.

Impervious Area Disconnection:

a) Runoff must flow across a minimum of 75' of vegetated/forest litter area with a maximum slope of 6.0%.
b) When the overland flow is across a lawn area (managed turf) environment, it must be demonstrated that the surface and underlying soils have not been compacted, thus adversely affecting the bulk density and infiltrative capacity of the soils. If the soils have been compacted, they shall be required to be remediated by deep scarification (18") prior to placement of topsoil, or amended with the addition of compost and mixed in the upper 12" of soil prior to the placement of topsoil.
c) The site design should be done in such a manner as to provide at least 50% of the 75' overland flow length in undisturbed woodlands as the forest floor has a significant capacity for infiltration.

The following Low Impact Development treatment systems should be considered in the design of any stormwater management system:

1. Permeable Pavement for on street parking areas located on both sides of access roads.
2. Permeable Pavement for any alleyways and associated parking for residential development.
3. Disconnection of roof drains from residential units for those units on the perimeter of the development area. A minimum of 75' overland flow across a stable and well vegetated area must be provided for this measure. If roof drain disconnection is utilized for this area, the Tv is not required to be provided.
4. A bioretention system, providing the required Tv may also be utilized for the same residential units, as stated in #3 above.
5. Vegetated swales shall be provided as a conveyance/treatment system for the residential component. These swale systems shall be located at the rear of the residential units, found in the central portion of this transect.

6. Modular Wetlands shall be used with the central core of the transect to treat runoff from the impervious areas prior to discharge.

Figure 4.13.a – Tolland Village Master Plan

4.13.1 Eastern Portion of Village Area - Mixed Uses and Residences

Performance Standards:

1. Groundwater Recharge Volume (GRv) shall be provided for all development in this area as required by this LID Design Manual as amended. In this particular area, there has been excavation work done which has exposed bedrock in numerous locations. Exposed bedrock shall be treated as a “D” soil, thus requiring minimal infiltration to be provided by the GRv.
2. Water Quality Volume (WQv) shall be provided for all development in this area as required by this LID Design Manual as amended. For those areas where surface or shallow bedrock is present, the treatment systems shall be lined with an impermeable barrier to prevent the introduction of pollutants into the groundwater.
3. The following pollutant removal performance standards shall be achieved for this area:

Pollutant	Required Removal Efficiency
Total Suspended Solids	90%
Total Nitrogen	40%

Pollutant	**Required Removal Efficiency**
Total Phosphorous	65%
Zinc (as an indicator for other metals)	85%
Total Petroleum Hydrocarbons	80%
Dissolved Inorganic Nitrogen	40%

4. All stormwater conveyance systems, such as pipes or open swales shall be designed to the standards found in this LID Design Manual as amended.
5. For downstream flood protection the peak rate of runoff for post-development conditions shall be reduced to the pre-development peak rate of runoff for both the 10-year and 100-year storm event. This requirement is necessary due to the high percentage of connected impervious area proposed in this area.

Figure 4.13.b – Eastern Portion of Tolland Village

4.13.2 Northeast Section - Residences

Performance Standards:

1. Groundwater Recharge Volume (GRv) shall be provided for all development in this area as required by the Design Manual as amended, the GRv is based upon the soil class of the area (A, B, C, & D) under undeveloped conditions.
2. Water Quality Volume (WQv) shall be provided for all development in this area as required by the Design Manual as amended. For those areas where surface or shallow bedrock is present, the treatment systems shall be lined with an impermeable barrier to prevent the introduction of pollutants into the groundwater.
3. The following pollutant removal performance standards shall be achieved for this area:

Pollutant	**Required Removal Efficiency**
Total Suspended Solids	80%
Total Nitrogen	40%
Total Phosphorous	65%
Zinc (as an indicator for other metals)	85%
Total Petroleum Hydrocarbons	75%
Dissolved Inorganic Nitrogen	40%

4. All stormwater conveyance systems, such as pipes or open swales shall be designed to the standards found in the Design Manual as amended.
5. If the LID metric of meeting the pre-development Runoff Curve Number (RCN) for post-development conditions can not be achieved, then the peak rate of runoff for post-development conditions shall be reduced to the pre-development peak rate of runoff for the 10-year storm event.

Figure 4.13.c – Northeast Section of Tolland Village

4.13.3 Southwest Section - Residences, Limited Commercial and Transportation

Performance Standards:

1. Groundwater Recharge Volume (GRv) shall be provided for all development in this area as required by the Design Manual as amended, the GRv is based upon the soil class of the area (A, B, C, & D) under undeveloped conditions.

2. Water Quality Volume (WQv) shall be provided for all development in this area as required by the Design Manual as amended. For those areas where surface or shallow bedrock is present, the treatment systems shall be lined with an impermeable barrier to prevent the introduction of pollutants into the groundwater.
3. The following pollutant removal performance standards shall be achieved for this area:

Pollutant	**Required Removal Efficiency**
Total Suspended Solids	90%
Total Nitrogen	40%
Total Phosphorous	65%
Zinc (as an indicator for other metals)	85%
Total Petroleum Hydrocarbons	80%
Dissolved Inorganic Nitrogen	40%

4. All stormwater conveyance systems, such as pipes or open swales shall be designed to the standards found in the Design Manual as amended.
5. If the LID metric of meeting the pre-development Runoff Curve Number (RCN) for post-development conditions can not be achieved, then the peak rate of runoff for post-development conditions shall be reduced to the pre-development peak rate of runoff for the 10-year storm event.

Figure 4.13.d – Southwest Section of Tolland Village

In order to protect Tolland Marsh and tributary watercourse, two Subsurface Gravel Wetland treatment systems shall be installed along the western portion of the proposed Tolland Village Area as a storm water polishing system prior to discharge into Tolland Marsh. All underdrains and conventional pipe systems shall be directed to one of the Subsurface Gravel Wetland Treatment System.

4.14 Waiver of LID Requirements

An applicant may apply for a waiver of any of the requirements found in **Section 4.0** of this Design Manual from the Planning and/or Zoning Commission "Commission" for a redevelopment application. The applicant's consultant shall provide the necessary material to support his waiver request. The Commission shall obtain the professional opinion from the town engineer regarding the waiver request. The Commission may take one of the following actions:

i. The Commission may grant the waiver,
ii. Deny the waiver,
iii. Offer the applicant the option of obtaining a third party review, subject to the provisions below with no guarantee that the waiver will be granted.

The third party review shall be provided by an independent professional engineer licensed in the State of Connecticut with significant expertise in Low Impact Development. The retaining of this independent engineer is subject to the following provisions:

1. Such engineer is hired by the Commission, and
2. The fee for such consulting engineer is paid for by the applicant.

5.0 Stormwater Treatment Practices to Meet Groundwater Recharge and Water Quality Goals

5.1 List of BMPS for Groundwater Recharge and Water Quality Treatment

FILTERING SYSTEMS

Bioretention: A shallow depression with vegetation that treats stormwater as it filters through a specific soil mixture. In order to be utilized for groundwater recharge, the bottom of the system must be unlined to infiltrate stormwater into the underlying soils.

Figure 5.1.a – Bioretention System

Tree Filter: A Bioretention system contained within a precast unit for use in retrofit situations in a commercial environment.
Figure 5.1.b – Filterra Tree Filter (www.filterra.com)

Surface Sand Filter: This system treats stormwater by the removal of coarse sediments in a sediment chamber or forebay, which is easily maintained prior to the stormwater filtering through a surface sand matrix. In order to be utilized for groundwater recharge, the bottom of the system must be unlined to infiltrate stormwater into the underlying soils.
Figure 5.1.c – Surface Sand Filter (UNHSC)

Organic Filter: This filtering practice uses an organic soil component such as compost or a sand/peat moss mixture to filter the stormwater. In order to be utilized for groundwater recharge, the bottom of the system must be unlined to infiltrate stormwater into the underlying soils.
Figure 5.1.d – Organic Filter

Dry Swale: These are vegetated open swales or depressions which are specifically designed to detail and infiltrate stormwater into the underlying soils. They use a modified soil mixture to enhance the infiltrative capacity of the system. In order to be utilized for groundwater recharge, the bottom of the system must be unlined to infiltrate stormwater into the underlying soils.
Figure 5.1.e – Dry Swale (UCONN NEMO)

INFILTRATION SYSTEMS

Infiltration Trenches: These are infiltration practices that store water volume in open spaces in a chamber or within the void spaces of crushed stone or clean gravel prior to the water being infiltrated into the underlying soils. These practices are permissible for runoff from residential roofs or small commercial roofs (<3,000 sq.ft.). For larger commercial roofs, pre-treatment via one of the filtering systems list above must be provided prior to discharge into this type of infiltration system.
5.1.f – Infiltration Trench (www.washco-md.net)

Infiltration Chambers: These are infiltration practices that store water volume in open spaces both within the chamber and the void spaces in the crushed stone.
Figure 5.1.g – Infiltration Chamber (www.tritonsws.com/Images/case-studies)

Infiltration Basin: This is an infiltration practice that stores stormwater in a flat, vegetated surface depression prior to infiltrating into the underlying soils.
Figure 5.1.h – Infiltration Basin – (www.wash-md.net)

Alternative Paving Surfaces: These are practices that will store and filter stormwater in the void spaces of a clean gravel base prior to infiltrating into the underlying soils.
Figure 5.1.i – Porous Pavements (www.stormwaterenvironments.com)

5.2 List of BMPs for Water Quality Treatment

WET VEGETATED TREATMENT SYSTEMS

Extended Detention Shallow Marsh: A stormwater basin that provides treatment by the utilization of a series of shallow, vegetated permanent pools within the basin in addition to shallow marsh areas.
Figure 5.2.a – Extended Detention Shallow Wetlands (www.wetlands.com.au)

Subsurface Gravel Wetlands: A stormwater system where water quality is provided by the movement of stormwater through a subsurface, saturated bed of gravel with the soil surface being planted with emergent vegetation.

Figure 5.2.b – Subsurface Gravel Wetlands (UNHSC)

Pond / Wetland System: A treatment system which combines the shallow, vegetated aspects of a marsh with at least one pond component.

Figure 5.2.c – Pond/Wetland System (www.starenvironmentalinc.com)

Wet Swale: This is a vegetated depression or open channel designed to retain stormwater or intercept groundwater to provide water quality treatment in a saturated condition.

Figure 5.2.d – Wet Swale (Dr. Bill Hunt, NCSU)

5.3 List of BMPs for Pretreatment for Water Quality Systems

Filter Strips: These vegetated systems that are designed to treat stormwater from adjacent impervious area which occurs as overland flow. These systems function by slowing flow velocities, which allows the removal of sediments and other pollutants.

5.3.a – Filter Strip (www.trinkausengineering.com)

Sediment Forebay: This is a depressed vegetated area prior to a larger stormwater treatment facility which will trap coarse sediments and reduce maintenance requirements of the larger treatment facility.

Figure 5.3.b – Sediment Forebay (www.vwrrc.vt.edu)

Deep Sump Catch Basin: These systems are modified structures that are installed as part of a conventional stormwater conveyance system. They are designed to trap trash, debris and coarse sediments. While the hooded outlet provides the potential to trap oil and grease, frequent maintenance is required to remove the oils from the water surface.

Proprietary Treatment Devices: These are manufactured systems which were engineered to provide a cost-effective approach to stormwater quality in a contained space. These systems include oil/grit separators, hydrodynamic separators, and a wide range of filter systems with specialized media. Research by the Center for Watershed Protection, University of New Hampshire Stormwater Center in the past few years have shown that many of these systems are not able to achieve the water quality goals as specified in Section 4.3.3. They may be appropriate for pretreatment in some situations. In order to use a proprietary treatment device, independent research documentation must be provided to justify the pollutant removal efficiency.

5.4 List of BMPs for Water Quantity Control

Wet Extended Detention Pond: This practice is primarily designed to address stormwater quantity increases. They have a deep permanent pool, but do not effectively remove stormwater pollutants. These systems may be located in areas of seasonally high groundwater.

Figure 5.4.a – Wet Extended Detention Pond (NCSU)

Dry Detention Pond: This practice has a dry bottom and is also designed to address changes in stormwater quantity only.

Figure 5.4.b – Dry Detention Pond (www.dhn.iihr.uiova.edu)

5.5 List of BMPs for Commercial Water Quality Retrofits

LID Urban Planter: These systems provide a "greening" of the urban streetscape while providing pollutant attenuation and potential reductions of runoff volume

Figure 5.5.a – LID Urban Planter (City of Portland, OR)

LID Curb Extension: These systems are used to reduce runoff volumes by infiltration as well as pollutants from runoff. They provide a “greening” benefit to any green in addition to a traffic calming device

Figure 5.5.b – LID Curb Extensions (City of Portland, OR)

Modular Wetland System: This system provides treatment of urban runoff in a small footprint. It utilizes the benefits of a Gravel Wetlands along with proprietary filters to remove pollutants.

Figure 5.5.c – Modular Wetland (modularwetland.com)

Filterra Bioretention System: This system is a Bioretention facility for urban applications. By the flow through a proprietary media, the amount of pollutants in urban runoff are reduced.

Figure 5.5.d – Filtera Bioretention (Filterra.com)

5.6 List of Alternative BMPs for Increases of Imperviousness on Residential Lots

Rain Barrel: A barrel made of PVC, metal or wood which is connected to a roof drain downspout to collect roof runoff from reuse for non-potable uses.

Figure 5.6.a – Rain Barrel (www.ferncreekdesign.org/images)

Gravel Drip Bed: A gravel drip bed is a system consists of crushed stone installed below the drip line of a residential roof without gutters to collect and infiltrate runoff from the roof into the ground.

6.0 Design Requirements for Stormwater Systems

There are six categories for required design elements and guidelines for each type of stormwater recharge, water quality, pretreatment and water quantity systems. The categories are feasibility, conveyance, pretreatment, sizing criteria, treatment and maintenance. The following pages provide detailed design parameters for each type of LID treatment system to be used to address stormwater issues in the Town of Tolland.

As the LID approach to stormwater management focuses on treating runoff at its source, both short term and long term maintenance of these systems are very important. Legally binding maintenance agreements for these LID systems must be prepared and filed in the Office of the Town Clerk for the Town of Tolland. Each maintenance agreement must include the maintenance requirements as specified for each system.

Table 6.0.a and 6.0.b have been developed to assist the design engineer in determining the optimum configuration of treatment systems to meet stormwater and water quality goals as specified in **Section 4.0** of this manual.

Table 6.0.a – Stormwater System Matrix (NEED TO CHANGE TABLES)

Stormwater Treatment Device Selection Matrix

Stormwater Treatment Systems	GRv	WQv	PT	FP
FILTERING SYSTEMS				
Bioretention (page 56)	■	■		
Tree Filter (page 60)	■	■		
Surface Sand Filter (page 62)	■	■		
Organic Filter (page 64)	■	■		
Dry Swales (page 66)	■	■		
INFILTRATION SYSTEMS				
Infiltration Trenches (page 68)	■	■		
Infiltration Chambers (page 70)	■	■		
Infiltration Basins (page 72)	■	■		
Alternative Paving Surface (page 74)	■	■		
WET VEGETATED TREATMENT SYSTEMS				
Extended Detention Shallow Wetlands (page 77)		■		■
Subsurface Gravel Wetlands (page 79)		■		
Pond / Wetland System (page 81))		■		■
Wet Swales (page 83)		■		
PRETREATMENT FOR WATER QUALITY SYSTEMS				
Filter Strip (page 85)			■	
Sediment Forebays (page 87)			■	
Deep Sump Catch Basins (page 89)			■	
Proprietary Treatment Devices (page 91)			■	
WATER QUANTITY CONTROL				
Wet Extended Detention Pond (page 93)				■
Dry Detention Pond (page 95)				■
WATER QUALITY CONTROL FOR COMMERCIAL RETROFITS				
LID Urban Planter (page 97)	■	■		
LID Curb Extension (page 99)	■	■		
Modular Wetland System (page 102)		■		
Filterra Bioretention System (page 104)		■		

GRv: Groundwater Recharge Volume
WQv: Water Quality Volume
PT: Pretreatment
FP: Flood Protection

Table 6.0.b – Treatment System Matrix

POLLUTANT REMOVAL RATING	Excellent	Very Good	Good	Fair	Minimal
Pollutant Removal Efficiency	80 – 95%	70 – 80%	55 – 70%	40 – 55%	< 40%
Color Coded System	dark green	yellow-green	bright green	orange	yellow

Stormwater Treatment System Pollutant Removal Selection Matrix

Stormwater Treatment Systems	TSS	TN	TP	Zn	TPH	DIN
FILTERING SYSTEMS						
Bioretention (page 56) – Option 1	Excellent	Minimal	Minimal	Very Good	Excellent	Fair
Bioretention (page 56) – Option 2	Excellent	Good	Minimal	Very Good	Excellent	Good
Bioretention (page 56) – Option 3	Excellent	Minimal	Good	Very Good	Excellent	Fair
Bioretention (page 656) – Option 4	Excellent	Good	Good	Very Good	Excellent	Good
Tree Filter (page 60)	Excellent	Minimal	Minimal	Very Good	Excellent	Minimal
Surface Sand Filter (page 62)**	Excellent	Minimal	Good	Very Good	Excellent	Minimal
Organic Filter (page 64)**	Excellent	Minimal	Good	Excellent	Minimal	Minimal
Dry Swales (page 66)	Fair	Minimal	Minimal	Fair	Very Good	Minimal
INFILTRATION SYSTEMS						
Infiltration Trenches (page 68)	Excellent	Good	Good	Excellent	Excellent	Fair
Infiltration Chambers (page 70)	Excellent	Good	Good	Excellent	Excellent	Fair
Infiltration Basins (page 72)**	Excellent	Good	Good	Excellent	Excellent	Fair
Permeable Pavement (page 74)	Excellent	Minimal	Good	Very Good	Excellent	Minimal
Porous Concrete (page 74)	Excellent	Minimal	Minimal	Excellent	Excellent	Minimal
Open Course Pavers (page 74)	Good	Minimal	Minimal	Good	Good	Minimal
WET VEGETATED TREATMENT SYSTEMS						
Extended Detention Shallow Wetlands (page 77)**	Very Good	Good	Minimal	Minimal	Minimal	Minimal
Subsurface Gravel Wetlands (page 79)**	Excellent	Excellent	Good	Excellent	Excellent	Excellent
Pond / Wetland System (page 81)**	Very Good	Minimal	Good	Good	Minimal	Minimal
Wet Swales (page 83)	Very Good	Minimal	Minimal	Minimal	Minimal	Fair
PRETREATMENT FOR WATER QUALITY SYSTEMS						
Filter Strip (page 85)	Good	Minimal	Fair	Excellent	Minimal	Minimal
Stand Alone Sediment Forebays (page 87)	Very Good	Minimal	Minimal	Good	Good	Minimal
Deep Sump Catch Basins (page 89)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Oil/Grit Separator (page 91)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
WATER QUANTITY CONTROL						
Wet Extended Detention Pond (page 93)**	Excellent	Minimal	Fair	Good	Minimal	Minimal
Dry Detention Pond (page 95)**	Fair	Minimal	Fair	Fair	Excellent	Minimal
WATER QUALITY CONTROL FOR COMMERCIAL RETROFITS						
LID Urban Planter (page 76)	Excellent	Minimal	Minimal	Excellent	Excellent	Minimal

Stormwater Treatment Systems	TSS	TN	TP	Zn	TPH	DIN
LID Curb Extension (page 97)						
Modular Wetland System (page 99)						
Filterra Bioretention System (page 102)						

(Table developed by Steven Trinkaus, PE)

** Includes Forebay as part of treatment system

TSS: Total Suspended Solids
TN: Total Nitrogen
TP: Total Phosphorous
Zn: Total Zinc
TPH: Total Petroleum Hydrocarbons
DIN: Dissolved Inorganic Nitrogen

6.1 – BIORETENTION (GRv & WQv)

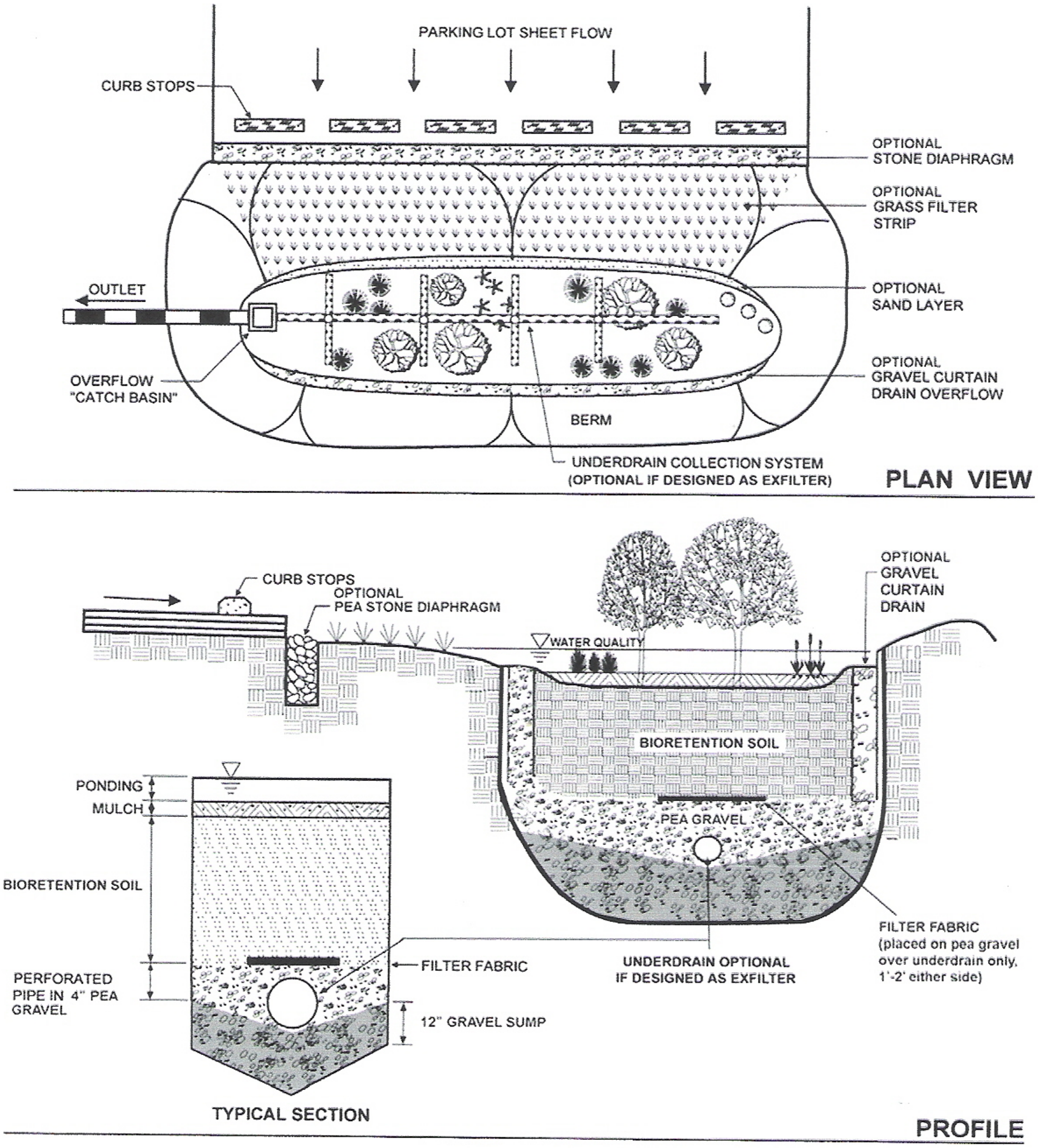


Figure 6.1.a – Typical Bioretention (RI DEM, 2010)

Table 6.1.a – Bioretention Design Parameters

Design Parameter	Residential Roof or Driveway Runoff	Runoff from Commercial Roof	Runoff from Commercial Driveway or Parking Area
Deep Test Pit	Yes, min. 6' in depth	Yes, min. 8' in depth	Yes, min. 8' in depth
Percolation Test	Yes, 24-30" deep	Yes, 30-36" deep	Yes, 30-36" deep
Depth of Soil Media	18"	24"	24"
Separation to SHGW from bottom of soil media	12" for A Soils 6" for B & C Soils*	24" for A Soils 6" for B & C Soils*	24" for A Soils 12" for B & C Soils*
Underdrain (raised) & Outlet to Daylight	Not required for A & B soils Required for C Soils	Not required for A soils Required for B & C Soils	Not required for A soils Required for B & C Soils
Depth of Pea Gravel Layer above underdrain	3"	3"	3"
Depth of 1-1/4" crushed stone for underdrain layer (if required)	12"	12"	12"
Enhanced Nitrogen Removal (Internal Water Storage)**	Saturate bottom 6" of Soil Media Layer	Saturate bottom 12" of Soil Media Layer	Saturate bottom 12" of Soil Media Layer
Overflow Provisions – Top of pipe set at max. ponding depth	No, for A Soils Yes, for B & C Soils	No, for A Soils Yes, for B & C Soils	No, for A Soils Yes, for B & C Soils

* Separation to SHGW may be reduced by 50% provided that the surface ponding depth is reduced by 50% and the surface area of the Bioretention facility is increased accordingly to contain required WQv.
** See Detail below for Internal Water Storage Design
(Table 6.1.a is based upon research and literature review by Steven Trinkaus, PE

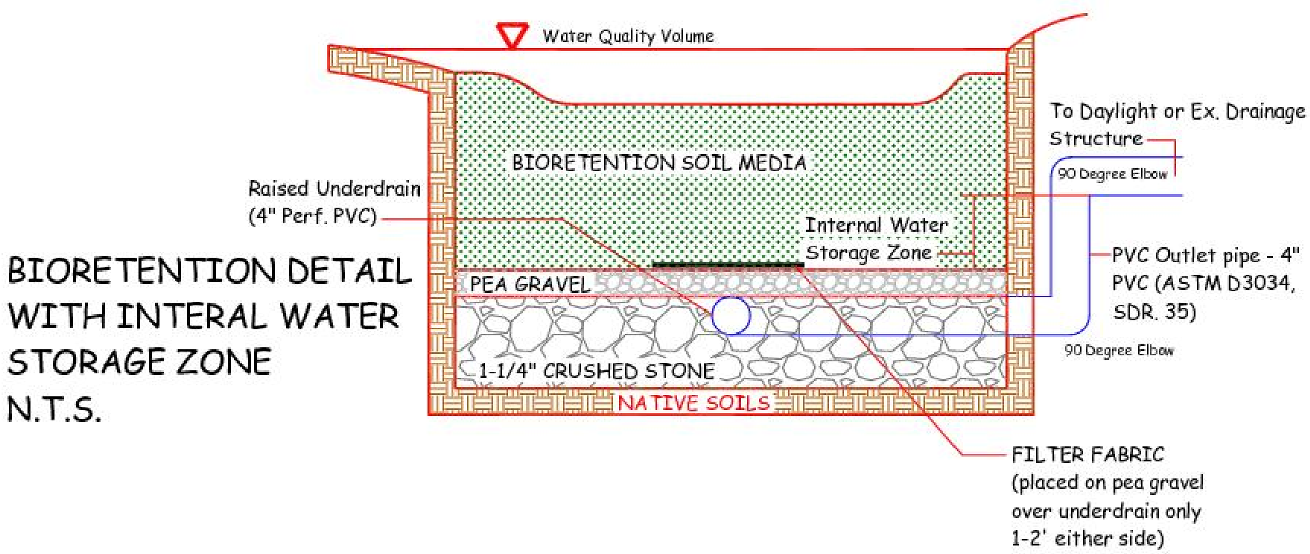


Figure 6.1.b – IWS Concept by Dr. William Hunt, NCSU)

Required Design Elements for Bioretention

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level for systems serving roads, parking lots & commercial roofs.
- Vertical separation from bottom of soil media to SHGW shall conform to the requirements found in Table 7.1.a
- The maximum drainage area to a Bioretention system shall be five (5) acres.
- Deep test pit and percolation test must be performed within 15' of proposed Bioretention system.

CONVEYANCE:

- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- Conveyance to the facility shall overland flow from the adjacent land area or via a 4-6" drain pipe (roof drain outlet) onto a pad of field stones to dissipate flow velocities.

PRETREATMENT:

- Pretreatment shall be required for runoff from connected impervious areas as flow across a vegetated filter strip or grass swale to the facility. A gravel diaphragm can be used for the discharge of sheet flow from the edge of a parking facility.
- No pretreatment is required for runoff from residential or small commercial building roofs (4,000 sq.ft. or less).

SIZING CRITERIA:

- The maximum permissible ponding depth shall be 12"(1.0') for a Class A soil, 9"(0.75') for a Class B soil and 6"(0.50') for a Class C soil. Bioretention systems shall not be permitted in Class D soils.
- The surface area of the Bioretention system shall be determined by the following equation:

SA = (WQv)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of ponding above soil surface in feet (use values above per soil class)

TREATMENT:

- The Bioretention facility must fully contain 100% of the required WQv for the contributing area.
- Depth of soil media shall be as specified in Table 7.1.a.
- Soil media shall have a **P-Index** (Phosphorous Index) of 0 – 30 (A low P-Index creates an enhanced environment to remove phosphorous from stormwater, high concentrations of Iron or aluminum in the soil)
- Soil Mixture shall consist of sand (85%), Compost (10%), Organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each Bioretention system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the Bioretention system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the Bioretention system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

Bioretention in Parking Islands

The application of Bioretention systems in parking islands is a practical method of addressing Water Quality and Volumetric Reductions for commercial parking facilities. The Bioretention systems shall be installed in parking islands as shown in the picture below. The design parameters stated on page 52 would apply to this application.

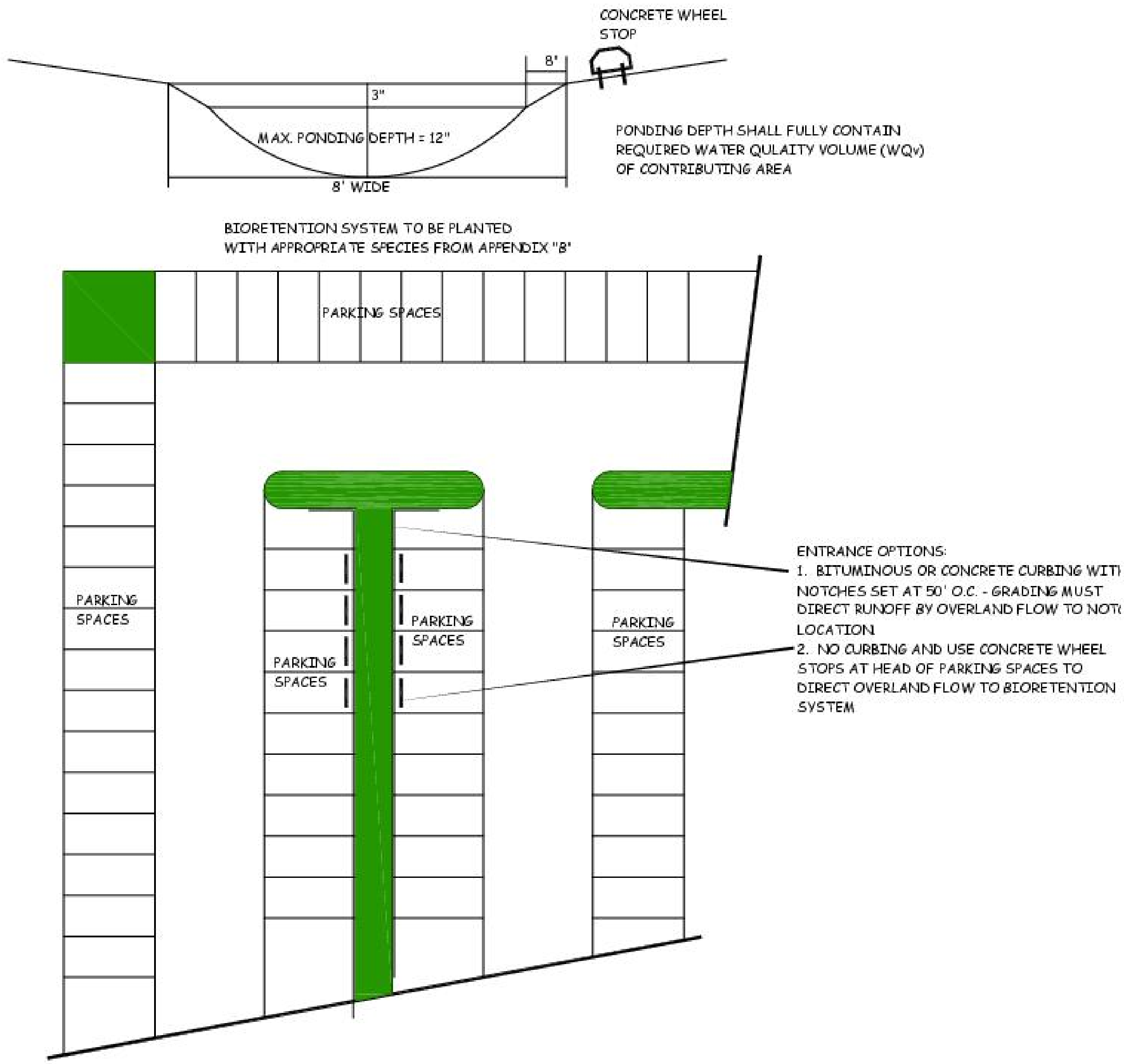


Figure 6.1.c – Bioretention in Parking Islands (Trinkaus Engineering, LLC)
(This sketch is for schematic purposes only. All parking facilities must conform to the Town of Tolland Zoning Regulations with regard to landscaped spaces within the parking facility)

6.2 – TREE FILTER (GRv & WQv)

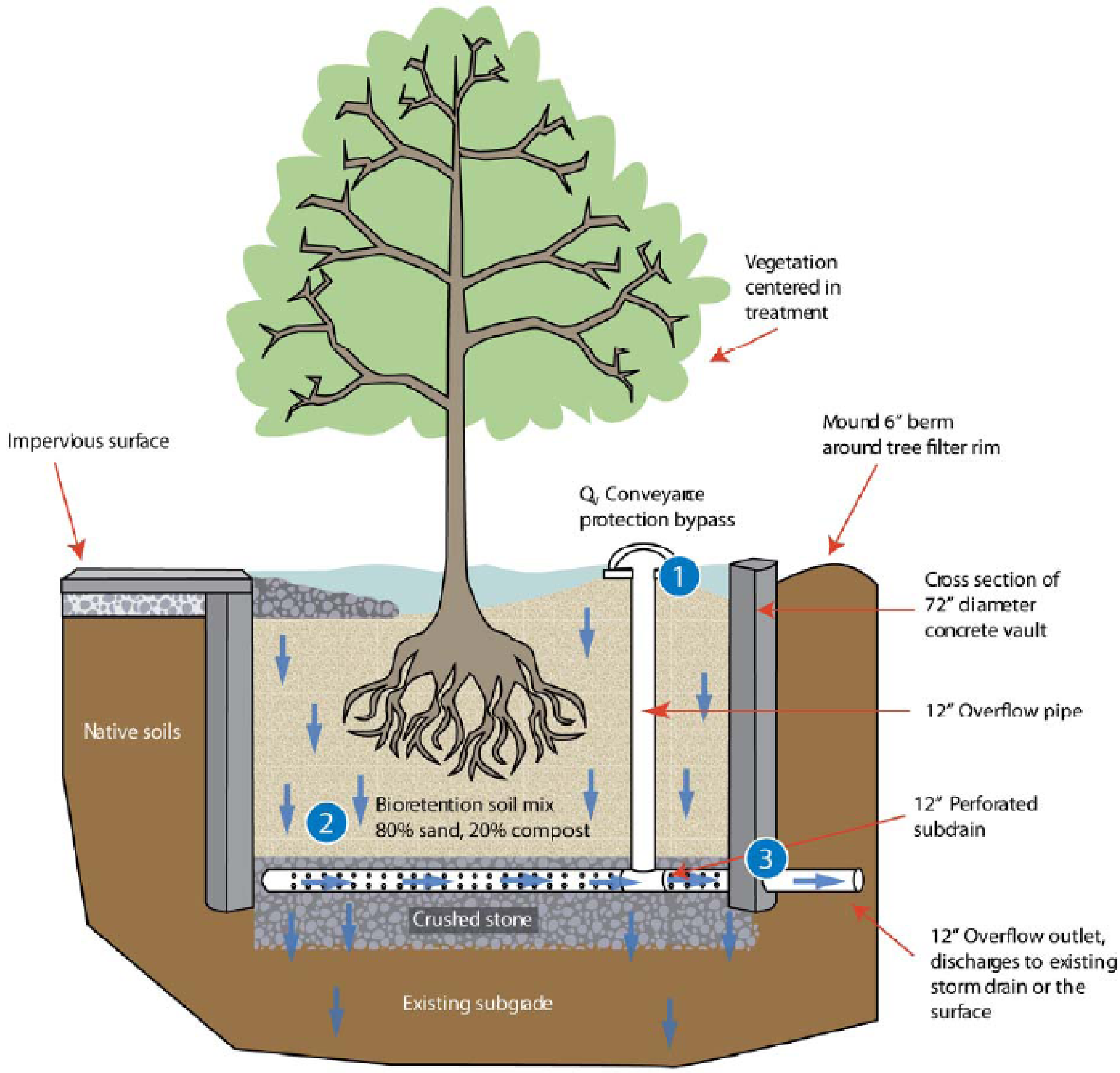


Figure 6.2.a - Tree Filter (UNHSC)

Required Design Elements for Tree Filter Systems

FEASIBILITY:
- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a tree filter shall be 5,000 square feet (0.12 acres)

CONVEYANCE:
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- At a minimum the underdrain pipe shall consist of 6" perforated PVC pipe. The minimum diameter of the overflow pipe shall be 6". The overflow pipe shall be sized to convey the Channel Protection Flow for each particular system.

PRETREATMENT:
- No pretreatment is required for a tree filter.

SIZING CRITERIA:
- The maximum permissible ponding depth shall be 12".
- A minimum surface area for ponding within the tree filter is 36 square feet (6' x 6').
- The stone reservoir, consisting of ¾" washed crushed stone (no fines) shall be 24" in depth.

TREATMENT:
- The tree filter system must fully contain 100% of the required WQv.
- Minimum depth of soil mixture shall be 48".
- Soil Mixture shall consist of sand (80%), and Compost (20%).
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around tree stem.
- Only deciduous tress shall be used. Appropriate tree species shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:
- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the tree filter system (gravel storage zone, and modified soil mixture).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of tree. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

6.3 - SURFACE SAND FILTER (GRv & WQv)

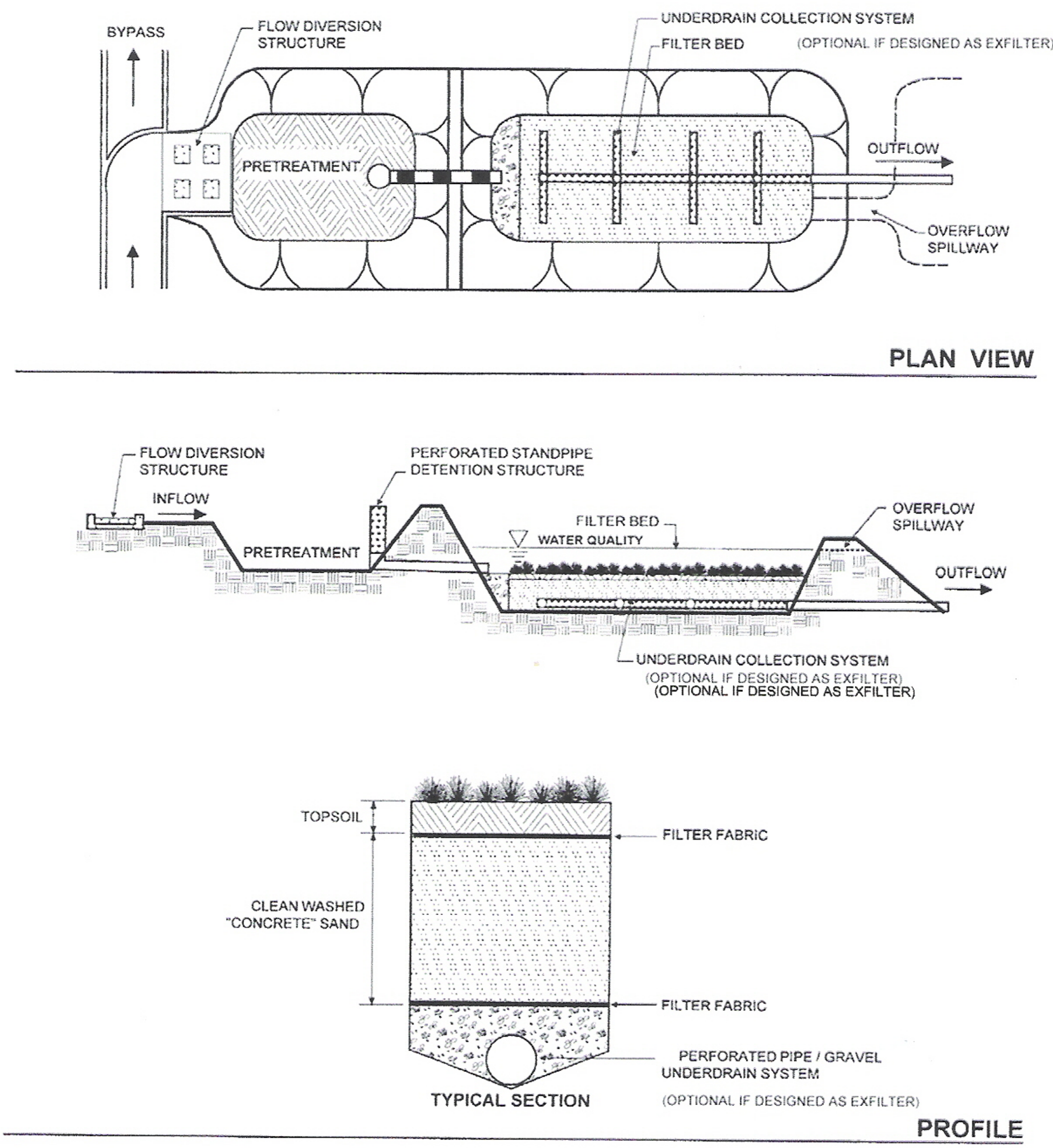


Figure 6.3.a – Surface Sand Filter (RI DEM, 2010)

Required Design Elements for Surface Sand Filters

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a surface sand filter shall be ten (10) acres.

CONVEYANCE:

- Surface sand filter must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Only WQv shall be directed to "off-line" filter with by-pass for larger flows.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- The surface sand filter shall have an underdrain unless it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be provided by a sediment forebay. The pretreatment area shall provide 25% of the required WQv.

SIZING CRITERIA:

- The surface area of the sand filter shall be determined by the following equation (RI DEM, 2010):

Af = (WQv)*(df)/[(k)*(hr + df)*(tf)] where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of sand media, use k=3.5 ft/day
hf = Depth of ponding above soil surface in feet
tf = Design filter bed drain time (days), use tf = 1.0 for surface sand filter

TREATMENT:

- The surface sand filter including the pretreatment component must fully contain 100% of the required WQv. A porosity value of 0.33 shall be used to determine the storage volume within the media. Storage volume within the media can be used to meet the WQv requirement.
- Sand meeting ASTM C-33 specification must be used for filter media.
- Contributing area to surface sand filter must be permanently stabilized prior to directing runoff to filter.
- Minimum depth of sand shall be 24".
- A minimum diameter of 4" shall be used for the underdrain pipe.
- Surface of sand filter shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the sand filter system (gravel storage zone, and sand treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Removal of sediment from forebay when accumulated depth is 6".
- The surface of the filter shall be inspected every six months and trash/debris removed.
- If water is ponding for more than 2.0 days, the surface has likely become clogged with fine sediments. The surface shall be raked to a depth of 2" and reseeded. If clogging still occurs, the top 3" of material shall be removed and replaced with new sand meeting the design specification and reseeded.
- Facilities shall be inspected annually for proper growth of grass material.
- Grass shall be maintained at a height of 3 – 4".

6.4 - ORGANIC FILTER (GRv & WQv)

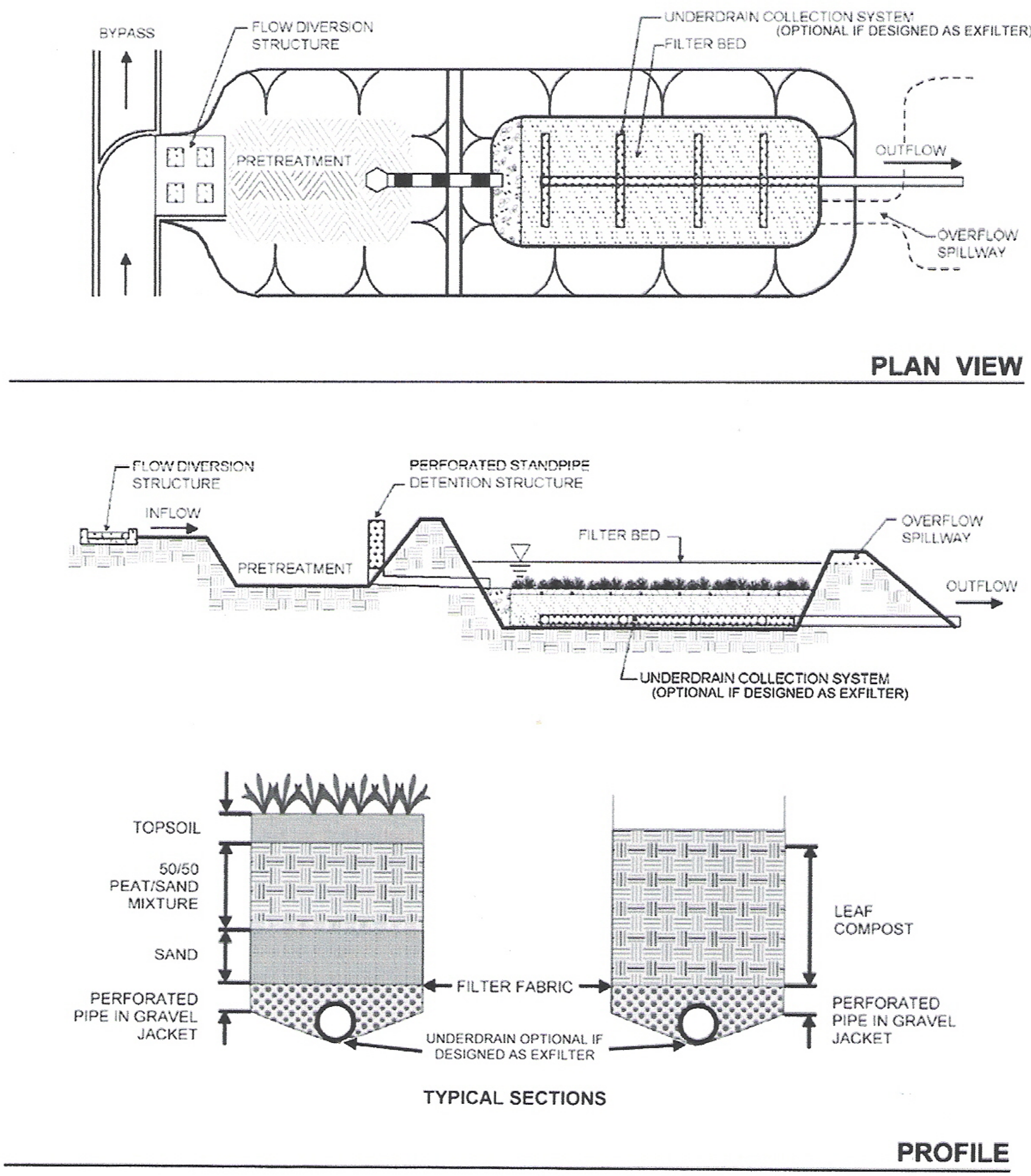


Figure 6.4.a – Organic Filter (RI DEM, 2010)

Required Design Elements for Organic Filters

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to an organic filter shall be ten (10) acres.

CONVEYANCE:

- Organic filter must be designed as “off-line” if stormwater is delivered by standard pipe system.
- Only WQv shall be directed to “off-line” filter with by-pass for larger flows.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- The organic filter shall have an underdrain unless it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be provided by a sediment forebay.
- 25% of the required WQv shall be provided by a sediment forebay.

SIZING CRITERIA:

- The surface area of the organic filter shall be determined by the following equation (RI DEM, 2010):

Af = (WQv)*(df)/[(k)*(hr + df)*(tf)] where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of sand media, use k=3.5 ft/day, for peat use k = 2.0 ft/day, and for leaf compost, use k = 8.7 ft/day
hf = Depth of ponding above soil surface in feet
tf = Design filter bed drain time (days), use tf = 2.0 for organic filter

TREATMENT:

- The organic filter including the pretreatment component must fully contain 75% of the required WQv. A porosity value of 0.33 shall be used to determine the storage volume within the media. Storage volume within the media can be used to meet the WQv requirement.
- Soil mixture for organic filter shall be either a mix of sand/peat mix or leaf compost. Peat shall be a reed-sedge hemic peat (partially decomposed).
- Contributing area to organic filter must be stabilized prior to directing runoff to filter.
- Minimum depth of media material shall be 24”.
- A minimum diameter of 4” shall be used for the underdrain pipe.
- Surface of organic filter shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the organic filter system (gravel storage zone, and media treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Removal of sediment from forebay when accumulated depth is 6”.
- The surface of the organic shall be inspected every six months and trash/debris removed.
- If water is ponding for more than 4.0 days, the surface has likely become clogged with fine sediment. The top 6”(minimum) of material shall be removed and replaced with new media meeting the design specification and re-planted.
- Facilities shall be inspected annually for proper growth of grass material.
- The height of vegetation on the surface of an organic filter shall not exceed 18”.

6.5 – DRY SWALES (GRv & WQv)

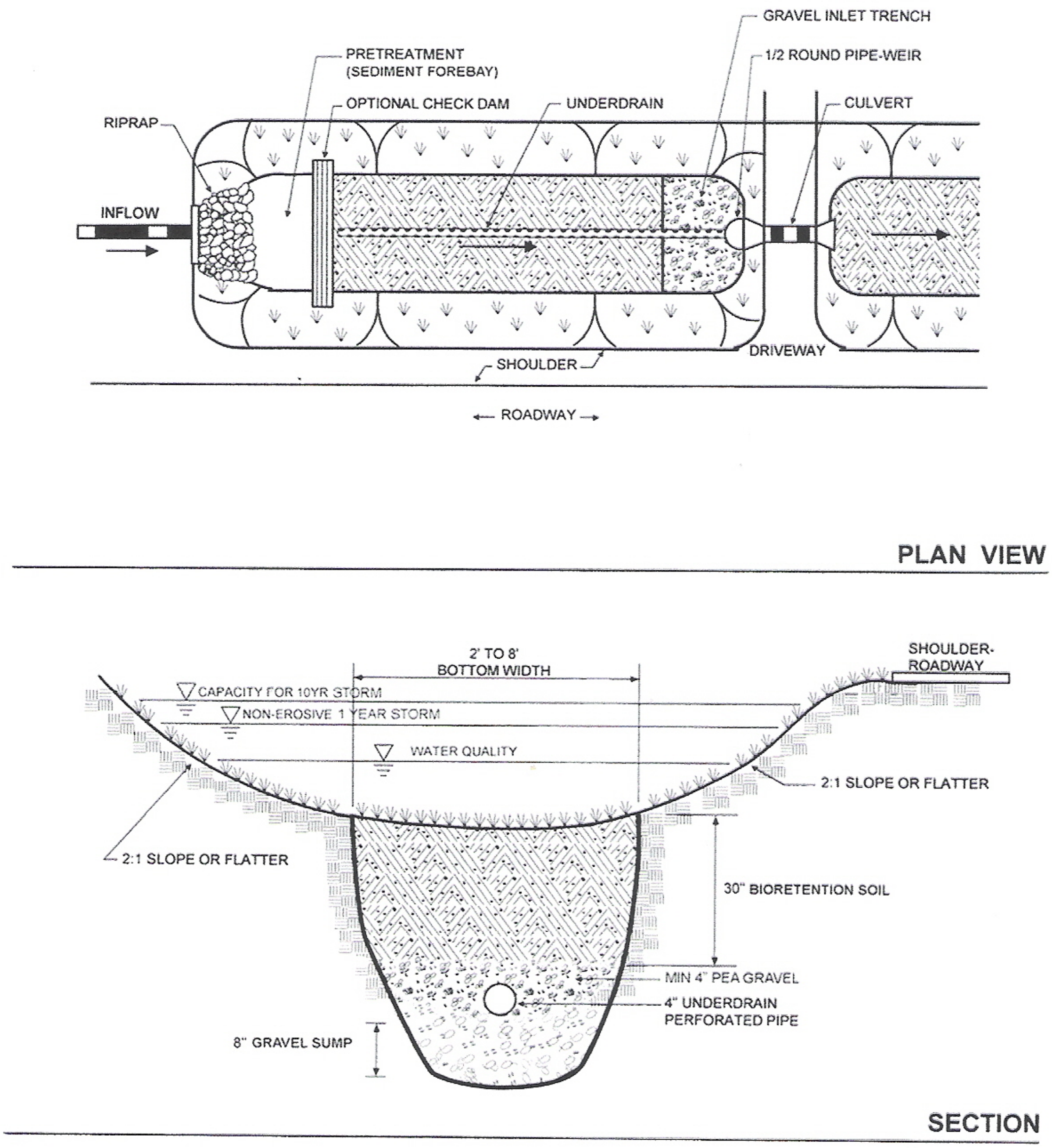


Figure 6.5.a – Dry Swale (RI DEM, 2010)

Required Design Elements for Dry Swales

FEASIBILITY:

- Maximum slope along flow length shall be 4.0% without check dams.
- Invert of underdrain pipe (if provided) or bottom of soil mixture shall be at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a dry swale shall be five (5) acres to one inlet.
- Primary use is along linear systems, such as roads, residential development and pervious areas, such as ballfields.

CONVEYANCE:

- Swale shall be able to handle 10-year, 24-hour peak rate from contributing area.
- Swale side slopes shall be a minimum of 3:1. If there are space constraints, then 2:1 slopes may be used.
- Non-erosive velocities shall be provided (3-5 fps) for 1-year, 24-hour storm event.
- Temporary ponding within the dry swale shall drain within 48 hours. If necessary, an underdrain shall be utilized to achieve this requirement. An underdrain is not required if it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be required as ponding behind stone check dams located within the swale itself.
- Flow across a vegetated filter strip along a road shall be appropriate pretreatment measure.
- 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The surface area of the filter bed (bottom of swale) shall be determined by the following equation (RI DEM, 2010):

$$Af = (WQv)*(df)/[(k)*(hr + df)*(tf)]$$ where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of Bioretention soil mixture (1.0 feet/day)
hf = Average height of water above swale surface (feet)
tf = Design filter bed drain time (days), use tf = 2.0 for dry swale

- Bottom width of swale shall not be greater than eight (8) feet nor less than two (2) feet.

TREATMENT:

- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Appropriate grass mixtures shall be used for the bottom and side slopes of a Dry Swale.
- Contributing area to dry swale must be stabilized prior to directing runoff to filter.
- Minimum depth of Bioretention soil mixture shall be 30".
- Surface of dry swale shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the organic filter system (gravel storage zone, and media treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Shall be inspected annually and after storms greater than 1-year, 24-hour storm event
- Removal of sediment, when accumulation exceeds 25% of the WQv storage value.
- Vegetation shall be mowed as necessary to maintain 4-6" height. Woody vegetation shall be removed from the dry swale.
- If ponded water is regularly observed more than 48 hours after a rainfall event, then the surface shall be roto-tilled to a depth of 12" and reseeded.

6.6 - INFILTRATION TRENCHES (GRv & WQv)

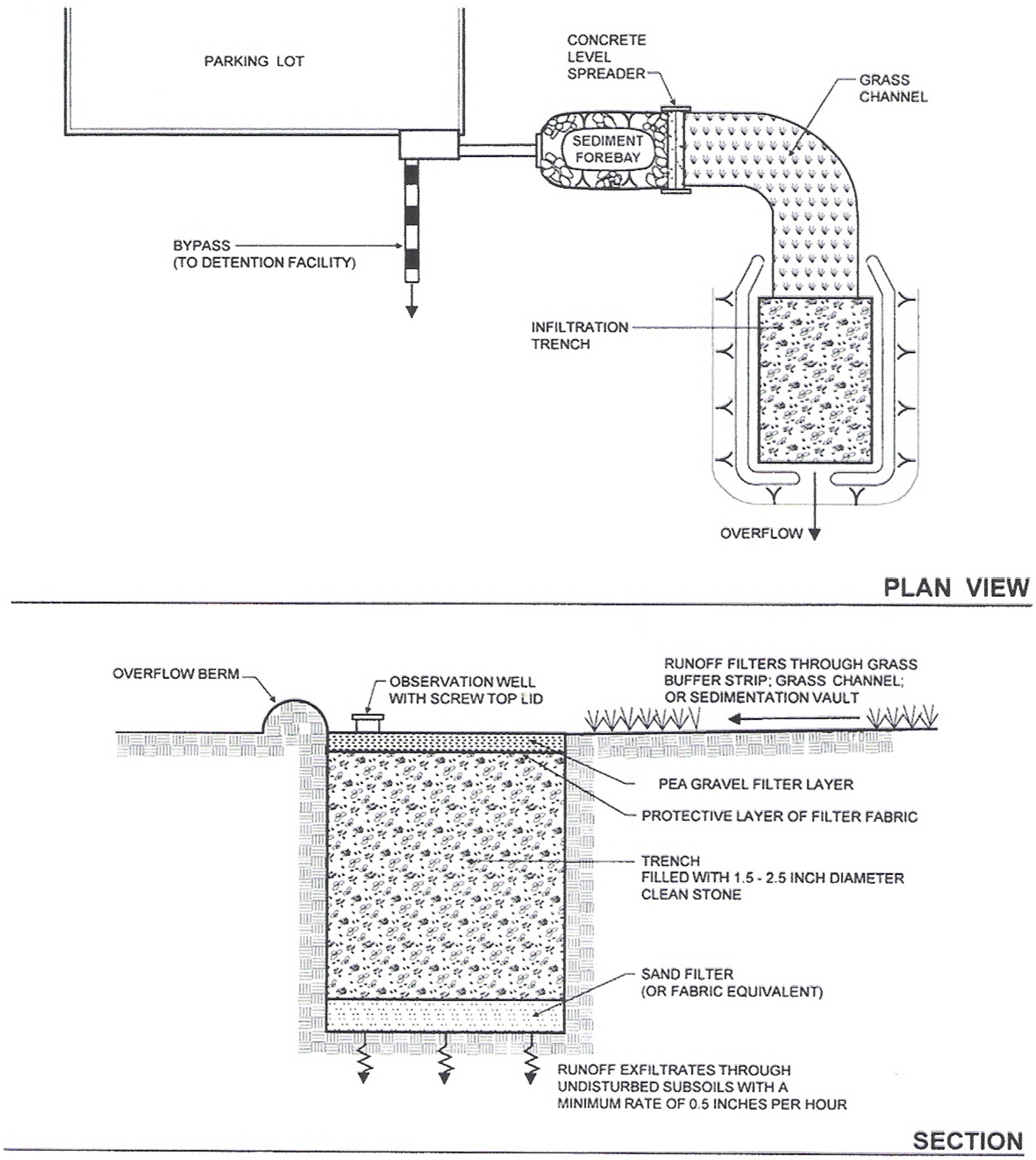


Figure 6.6.a – Infiltration Trench (RI DEM, 2010)

Required Design Elements for Infiltration Trench

FEASIBILITY:

- Three (3) foot vertical separation from bottom of infiltration trench to SHGW and bedrock. For residential applications, this separation can be reduced to two (2) feet.
- Must be installed on slopes < 15% and parallel to contours.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- The maximum drainage area to an infiltration trench shall be five (5) acres.

CONVEYANCE:

- Infiltration trench must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- All infiltration trenches shall be designed to fully dewater the entire WQv 48 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay.
- 25% of the required WQv shall be provided by an appropriate pretreatment system.
- Flow velocities from pretreatment system to infiltration must be non-erosive for 1-yr storm event.
- The sides of the infiltration trench shall be lined with a non-woven filter fabric to prevent soil piping.

SIZING CRITERIA:

- The bottom area of an infiltration trench shall be determined by the following equation (RI DEM, 2010):

$$Ap = V / (ndt = fct/12) \quad \text{where:}$$

Ap = Surface area at the bottom of the trench (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel fill (use 0.33)
dt = Trench depth (feet)
fc = Design infiltration rate (in/hr)
t = Time to fill trench (hours), assume t = 2.0

TREATMENT:

- Infiltration trench shall be designed to fully exfiltrate the entire WQv through the bottom of the trench only.
- Design infiltration rates (fc) for above sizing equation shall be taken from the following table.

Table 7.6 Design Infiltration Rates for Various Soil Textures (Rawls et al., 1982)

USDA Soil Texture	Design Infiltration Rate (fc) (in/hr)
Sand	8.27
Loamy Sand	2.41
Sandy Loam	1.02
Loam	0.52
Silt Loam	0.27

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration trenches shall never be used for sediment control during an active construction period.
- The area of the infiltration trench must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration trench.
- Inspections of an infiltration trench shall be made after any storm greater than the 1-year, 24-hour storm.
- The design engineer shall oversee the preparation of the area and the installation of the stone filter.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

6.7 – INFILTRATION CHAMBERS (GRv & WQv)

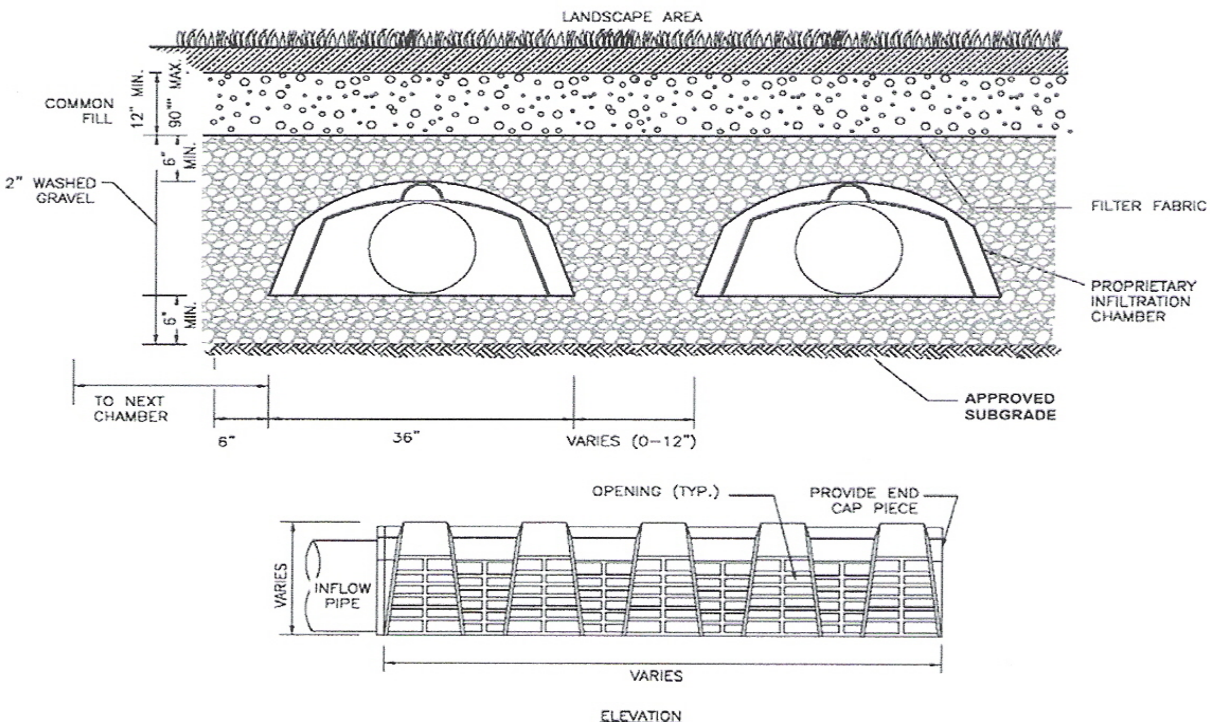


Figure 6.7.a – Infiltration Chamber (RI DEM, 2010)

Table 6.7.a Minimum Setbacks for Infiltration Systems (horizontal measurement in feet) (RI DEM 2010)

	Infiltration Systems for Single Family Residential Uses	**Infiltration Systems for all other uses**
Public Potable Water Supply Well (Drilled)	200	200
Public Potable Water Supply Well (Gravel well)	400	400
Private Potable Wells	25	100
Potable Water Supply Reservoir	100	200
Streams which are tributary to Water Supply Reservoir	50	100
Other Surface Waters	50	50
Top of 15%+ Slopes	50	50
Buildings (up-gradient)	10	25
Buildings (down-gradient)	10	50
On-site Subsurface Sewage Disposal Systems	25	25

Note: These setback requirements shall apply to Infiltration Trenches, Infiltration Chambers, and Infiltration Basins

Required Design Elements for Infiltration Chambers

FEASIBILITY:

- Three (3) foot vertical separation from bottom of crushed stone under the infiltration chambers to SHGW and bed-rock. For residential applications, this separation can be reduced to two (2) feet.
- Must be installed on slopes < 15%.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification.
- The maximum drainage area to infiltration chambers shall be five (5) acres.

CONVEYANCE:

- Infiltration chambers must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- All infiltration chambers shall be designed to fully dewater the entire WQv 72 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay for infiltration chambers. This requirement shall not apply to runoff from a residential roof.
- 25% of the required WQv shall be provided by an appropriate pretreatment system for infiltration chambers.
- The sides of the infiltration chambers shall be lined with a non-woven filter fabric to prevent soil piping.

SIZING CRITERIA:

- One method to calculate the storage volume of manufactured chambers is as follows (RI DEM, 2010):

$$V = L*[(wdn) - (\#Acn) + (\#Ac) + (wfct/12)]$$ where:

V = Design volume (WQv) (cubic feet)
L = Length of infiltration facility (feet)
w = Width of infiltration facility (feet)
d= Depth of infiltration facility (feet)
# = Number of rows of chambers
Ac = Chamber cross sectional area (square feet) (see manufacturers specifications)
n = Porosity (use 0.33)
fc = Design infiltration rate (in/hr)
t = time to fill chambers (use 2 hours for design)

TREATMENT:

- Infiltration chambers shall be designed to fully exfiltrate the entire WQv through the bottom of the facility only.
- Design infiltration rates (fc) for above sizing equation shall be taken from Table 7.6 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration chambers shall never be used for sediment control during an active construction period.
- The area of the infiltration trench must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration chambers.
- The design engineer shall oversee the preparation of the area and the installation of the infiltration chambers.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

6.8 – INFILTRATION BASIN (GRv & WQv)

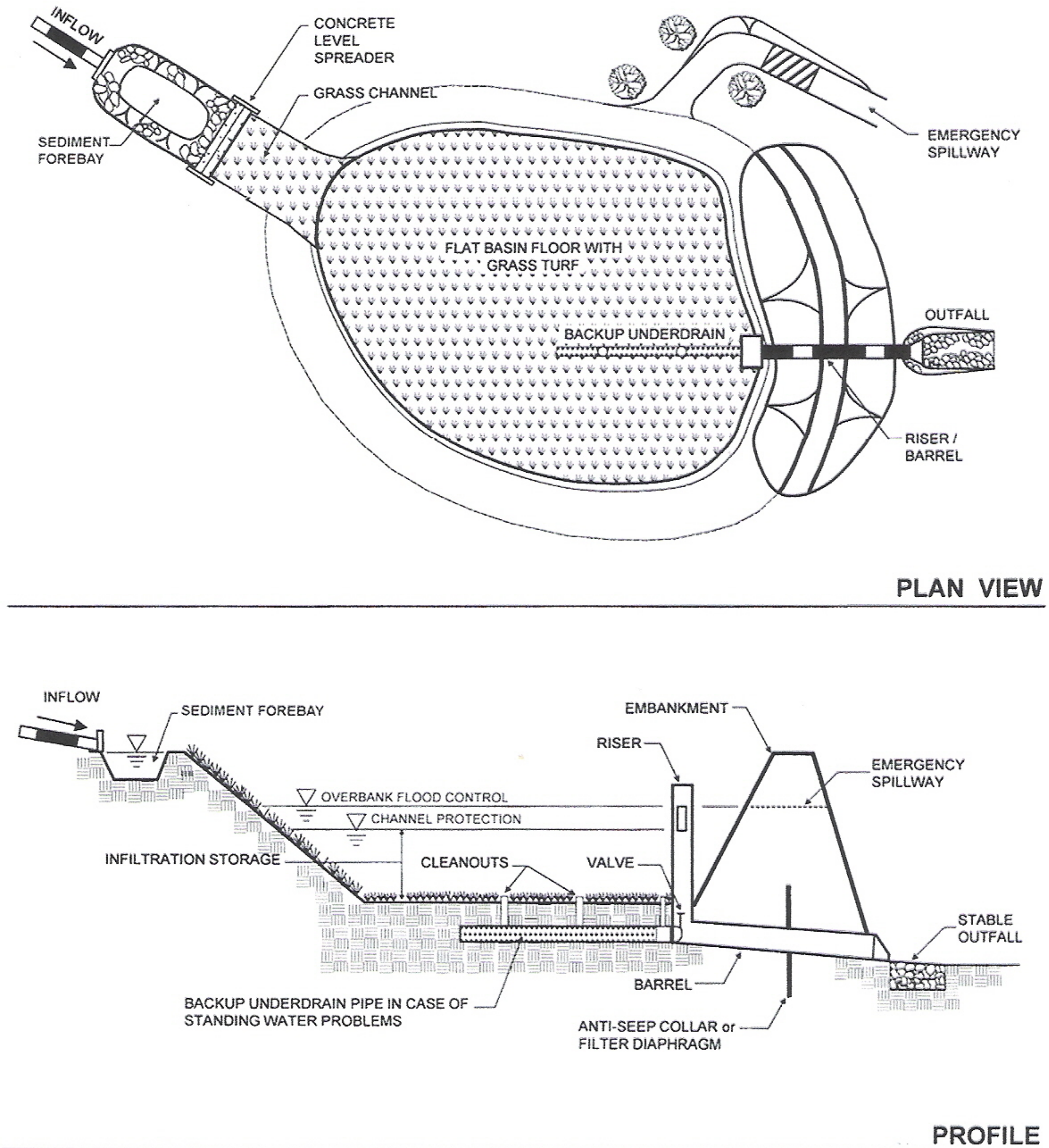


Figure 6.8.a – Infiltration Basin (RI DEM, 2010)

Required Design Elements for Infiltration Basin

FEASIBILITY:

- Three (3) foot vertical separation from bottom of infiltration trench to SHGW and bedrock.
- Must be installed on slopes < 15%.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- The bottom of the infiltration basin shall be constructed in either the A or B soil horizon.
- The maximum drainage area to an infiltration trench shall be ten (10) acres.

CONVEYANCE:

- Infiltration basin must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- Infiltration basins shall be designed to fully dewater the entire WQv 48 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps)
- A minimum of 25% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- Maximum ponding depth above soil surface shall be 2'.
- The bottom area of an infiltration basin shall be determined by the following equation:

Ab = V/d Where:

Ab = Surface area at the bottom of the basin (square feet)
V = Design Volume (WQv)
d = Depth of basin (feet)

TREATMENT:

- If the in-situ soil infiltration rate is greater than 8.27 in/hr, then the entire WQv shall be fully treated by an appropriate measure prior to the infiltration basin.
- Infiltration basin shall be designed to fully exfiltrate the entire WQv through the bottom of the basin only.
- Design infiltration rates (fc) for above sizing equation shall be taken from Table 7.6 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration basins shall never be used for sediment control during an active construction period.
- The area of the infiltration basin must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- If there is an accumulation of organic debris or sediment on the surface of the basin, the top 6" shall be removed, and the exposed soil surface roto-tilled to a depth of 12". After this work has been done, the bottom of the basin shall be restored to its original condition.
- Inspections of an infiltration basin shall be made after any storm greater than the 1-year, 24-hour storm.
- The design engineer shall oversee the preparation of the area and the construction of the infiltration basin.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

6.9 – ALTERNATIVE PAVING SURFACES (GRv & WQv)

Refer to UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds – Rev. October 2009 (http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_spec_10_09.pdf)

Open Course Pavers with gravel or topsoil/grass

Required Design Elements for Open Course Pavers

FEASIBILITY:

- Three (3) foot vertical separation from bottom of reservoir base to SHGW and bedrock.
- Use on gentle slope (<5%)
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- The bottom of the reservoir base shall be constructed in either the A or B soil horizon.

CONVEYANCE:

- Open course pavers shall only treat runoff generated from the actual area of the practice. Runoff from adjacent areas shall not to be treated by the open course pavers.
- Open course paver systems shall fully dewater the entire WQv 24 hours after a storm event.

PRETREATMENT:

- Pretreatment is not required for open course pavers.
- Frequent maintenance is required to prevent clogging of the open course pavers.

SIZING CRITERIA:

- The surface area of the open course pavers shall be determined by the following equation (RI DEM, 2010):

Ap = V / (n8dt + fct/12) Where:

Ap = Surface area (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel (assume 0.33)
dt = Depth of gravel base (feet)
fc = Design infiltration rate (in/hr), see Table 7.6
t = Time to fill (hours) (use 2 hours for design purposes)

TREATMENT:

- Topsoil mix shall consist of 50% sand, 35% compost and 15% native soils. Alternative surface shall be pea gravel.
- Open course paver systems shall fully exfiltrate the entire WQv through the bottom of the practice.
- The reservoir course shall be 12 – 24” in depth. The base course shall consist of native bank run sand and gravel. It shall be sufficiently compacted to provide the required bearing capacity.
- Area of open course pavers must be protected from compaction and erosion during the construction period.
- This system is best used with other systems to address other stormwater issues such as flood protection.
- Vegetation used with open course pavers shall be drought tolerant species.
- To account for the use of open course pavers in hydrologic models in determining the Channel Protection Flow and Flood Protection Flow rates, the following Curve Number values shall be applied.

Table 6.9.a – Curve Numbers for Infiltrating Permeable Pavement Surfaces (MDE, 2009)

Reservoir Depth	Hydrologic Soil Group			
(inches)	A	B	C	D
6	76	84	93	-
12	62	65	77	-
>12	40	55	70	-

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of open course pavers shall never be used for sediment control during an active construction period.
- The area of the open course pavers must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the open course pavers.
- Attach rollers to bottom of plows to prevent the catching of paver edges during snow removal operations.
- Do not stockpile snow on areas of open course pavers.
- The design engineer shall oversee the preparation of the area and the installation of the alternative paving surface.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

Permeable Pavement or Porous Concrete

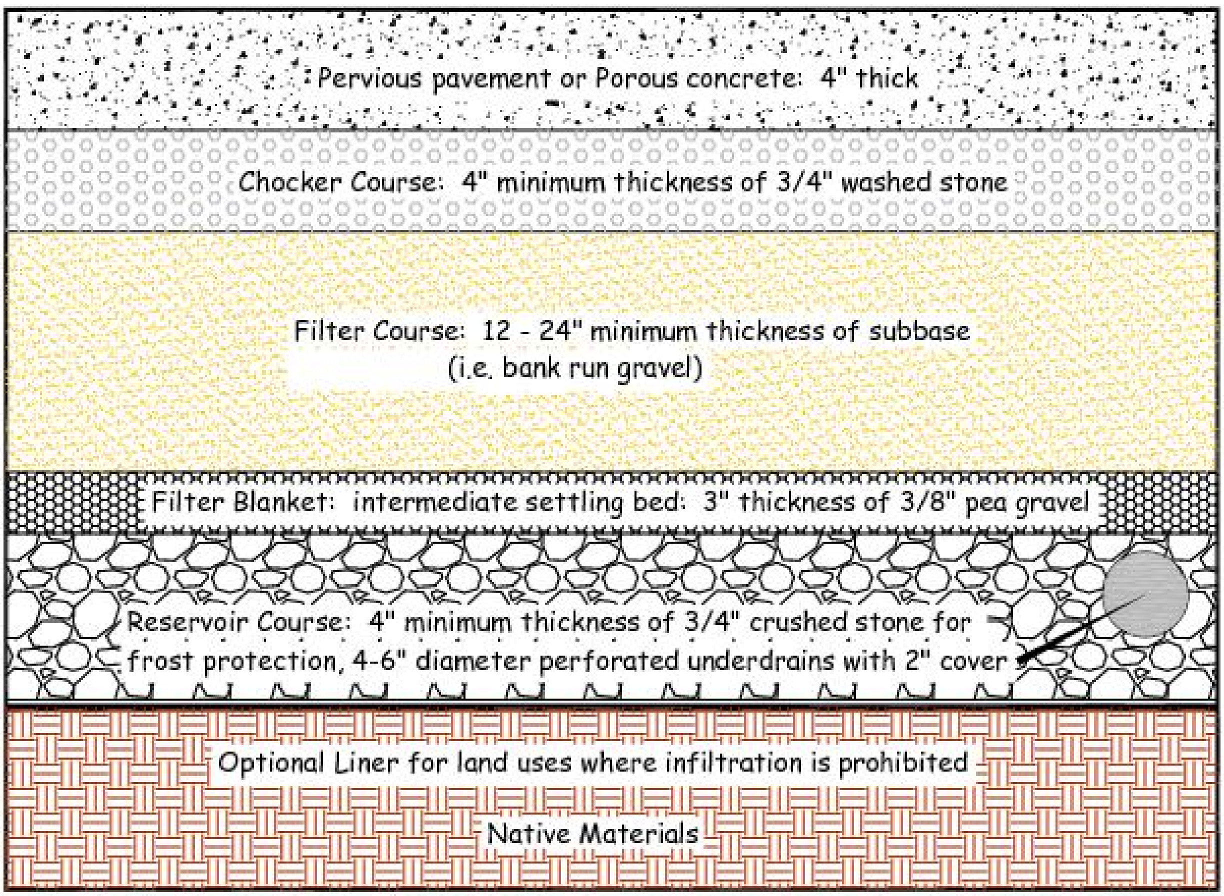


Figure 6.9.a – Permeable Pavement (UNHSC)

Required Design Elements for Permeable Pavement or Porous Concrete

FEASIBILITY:

- Three (3) foot vertical separation from bottom of reservoir base to SHGW and bedrock.
- Use on gentle slope (<5%)
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- The bottom of the reservoir base shall be constructed in either the A or B soil horizon.

CONVEYANCE:

- Permeable pavement or porous concrete shall only treat runoff generated from the actual area of the practice. Runoff from adjacent areas shall not to be treated by permeable pavement or porous concrete. These systems shall fully dewater the entire WQv 24 hours after a storm event.

PRETREATMENT:

- Pretreatment is not required for permeable pavement or porous concrete.
- Frequent maintenance is required to prevent clogging of the permeable pavement or porous concrete.

SIZING CRITERIA:

- The surface area of the permeable surface shall be determined by the following equation (RI DEM, 2010):

$$Ap = V / (n8dt + fct/12)$$ Where:

Ap = Surface area (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel (assume 0.33)
dt = Depth of gravel base (feet)
fc = Design infiltration rate (in/hr), see Table 7.6
t = Time to fill (hours) (use 2 hours for design purposes)

TREATMENT:

- Permeable pavement or porous concrete shall fully exfiltrate the entire WQv through the bottom of the practice.
- The reservoir course shall be 12 – 24" in depth. The reservoir course shall consist of native bank run sand and gravel. It shall be sufficiently compacted to provide the required bearing capacity. A filter blanket shall be provided between the filter course and the reservoir course.
- An impermeable liner with an underdrain may be provided if underlying soils lack adequate infiltrative capacity for WQv.
- This system is best used with other systems to address other stormwater issues such as flood protection.
- To account for the use of open course pavers in hydrologic models in determining the Channel Protection Flow and Flood Protection Flow rates, see Table 7.9 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of permeable pavement or porous concrete shall never be used for sediment control during an active construction period.
- The area of the permeable pavement or porous concrete must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of permeable pavement or porous concrete.
- Every three months, the permeable surface shall be vacuum swept to minimize the potential of clogging.
- Do not stockpile snow on areas of permeable pavement or porous concrete.
- Sand shall not be applied to permeable pavement or porous concrete surface.
- The design engineer shall oversee the preparation of the area and the installation of permeable pavement or porous concrete.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

6.10 – EXTENDED DETENTION SHALLOW WETLANDS (WQ treatment)

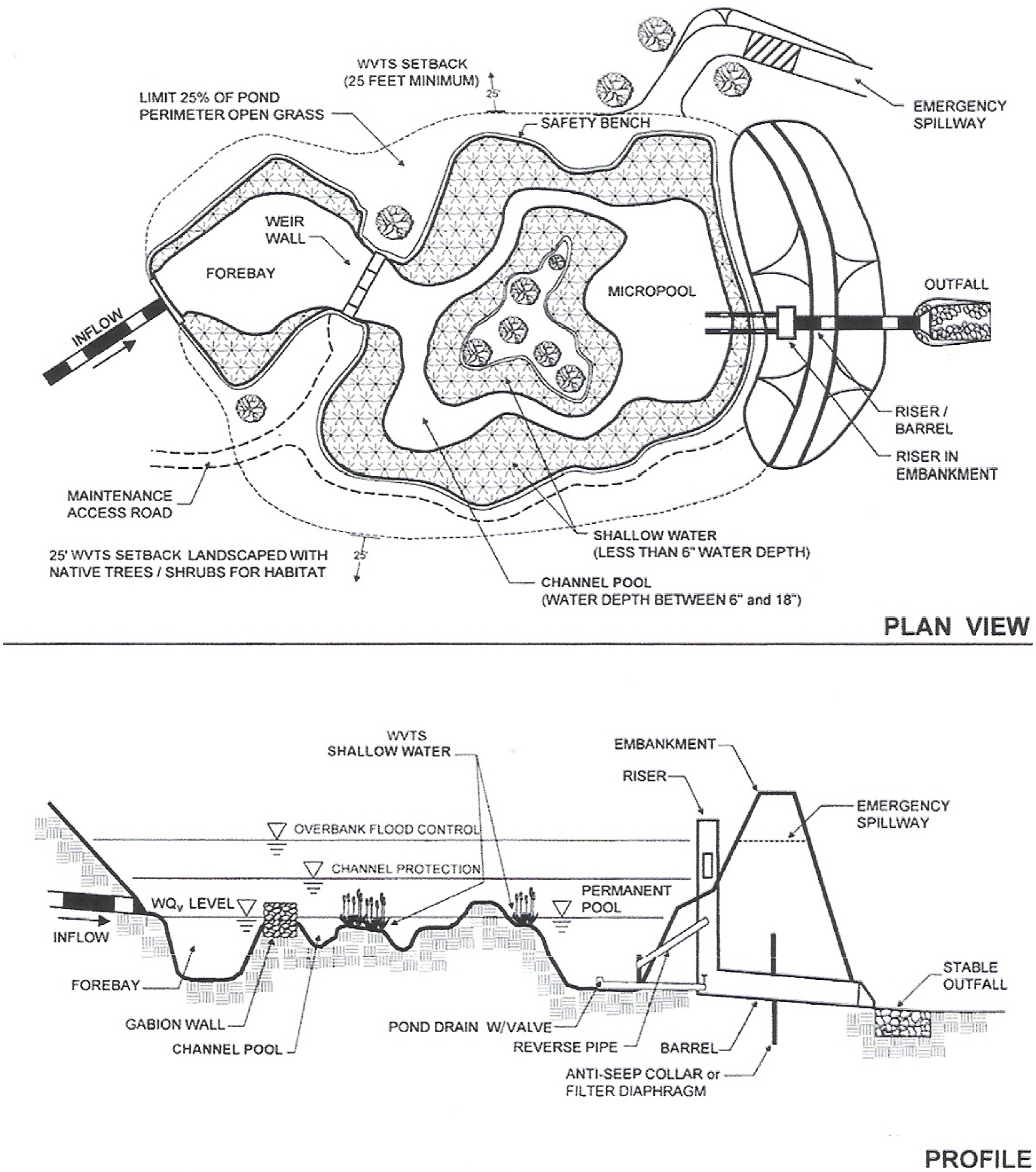


Figure 6.10.a – Extended Detention Shallow Wetland (RI DEM, 2010)

Required Design Elements for Extended Detention Shallow Wetland

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in such a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to extended detention shallow wetlands shall be ten (10) acres.

CONVEYANCE:

- Flows within the system shall be maximized by the use of islands and submerged berms.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) shall be provided for all discharges.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The surface area of an extended detention shallow wetland shall be a minimum of 1.5% of the tributary drainage area. Curvilinear configurations shall be used for the basin.
- 65% of the total surface area of the basin shall have a depth of less than 18".
- 35% of the total surface area of the basin shall have a depth of less than 6".
- Deep water areas within the basin shall provide a minimum of 25% of the required WQv, where the depth is greater than 4.0'.
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

TREATMENT:

- If site conditions permit, the extended detention shallow wetland shall be located "off-line". If this is not feasible, then both the Channel Protection Flow and Flood Protection requirements shall be designed into the basin.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of an Extended Detention Shallow Wetland.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the basin.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the basin shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.

6.11 - SUBSURFACE GRAVEL WETLANDS (WQ Treatment)

Refer to UNHSC Subsurface Gravel Wetland Design Specifications – June 2009 (http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_gravel_wetland_specs_6_09.pdf)

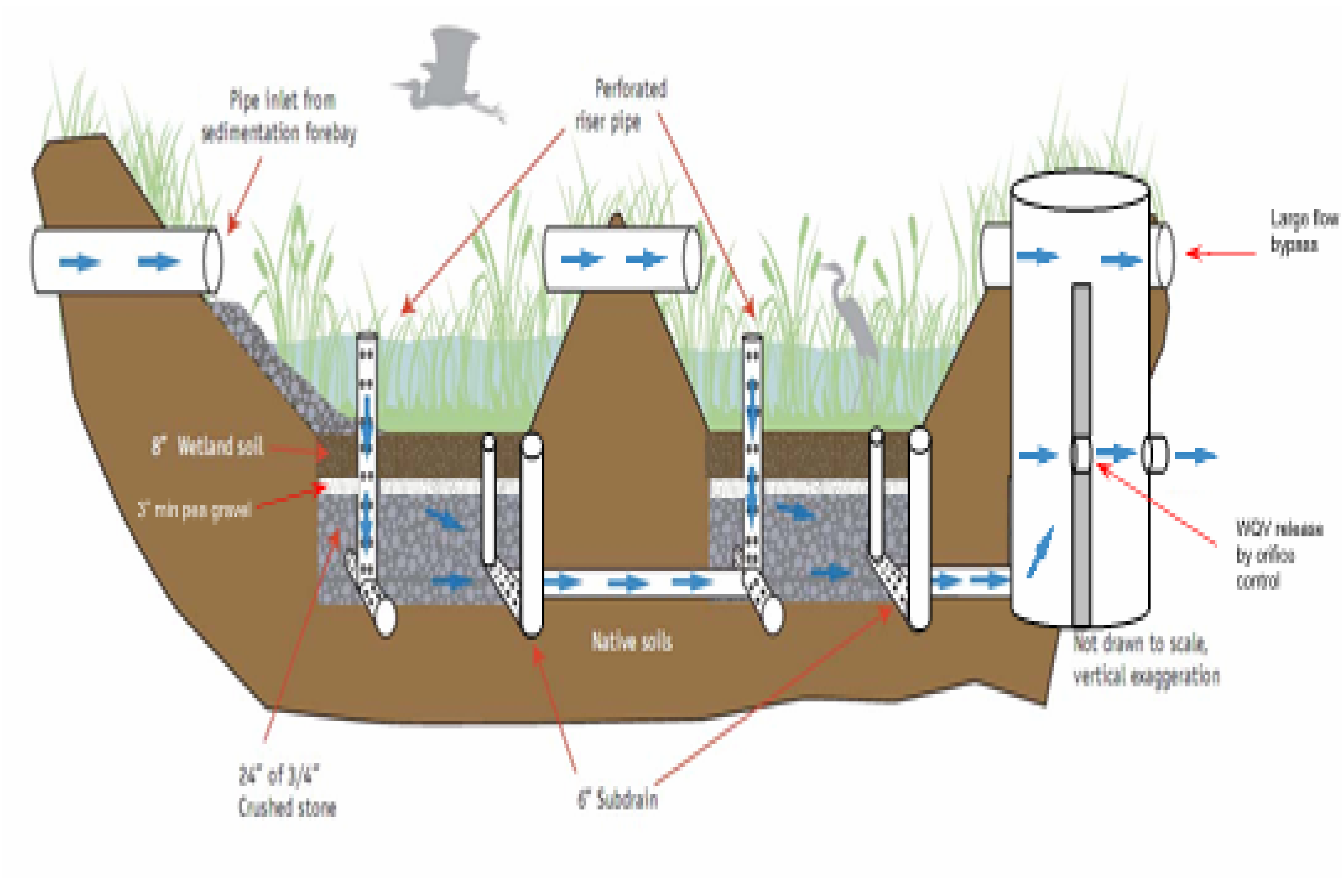


Figure 6.11.a – Subsurface Gravel Wetland (UNHSC)

Required Design Elements for Subsurface Gravel Wetlands

FEASIBILITY:

- Shall be located in soil with low infiltrative capacities or the system bottom & sides shall be lined with impermeable liner or soil with permeability being less than 0.03 ft/day.
- Must be installed on slopes < 5%. Level sites are best.
- The maximum drainage area to an infiltration trench shall be ten (10) acres.

CONVEYANCE:

- Subsurface gravel wetland can be designed as "online" system. System can also provide required Channel Protection Flow above WQv.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).

PRETREATMENT:

- Pretreatment shall be provided with a sediment forebay (Section 7.15).
- Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).

SIZING CRITERIA:

- Forebay provides 10% of the required WQv, each treatment cell provides 45% of the required WQv. The full required WQv must be retained and filtered through the system.
- The invert of primary outlet pipe shall be set 4" below surface of wetland soil to maintain saturated conditions.
- An overflow outlet shall be provided with adequate capacity to handle the peak rate of the 10-year, 24-hour storm event.

TREATMENT:

- Top layer of system is growing media (wetland soil) shall be eight (8) inches in depth with zero slope.
- Intermediate layer is pea gravel three (3) inches thick.
- Treatment layer is 24" in thickness of ¾" crushed stone.
- Berms and weir shall be constructed of non-conductive soils to prevent seepage or piping.
- Length to width ratio for gravel treatment shall be 0.5 (L:W) with a minimum length of fifteen (15) feet.
- Vertical perforated risers shall direct stormwater to treatment layer. Top of vertical riser shall be set at water surface elevation where WQv is provided. Minimum diameter of vertical riser shall be six (6) inches, can be increased to eight (8) inches to minimize clogging potential.
- Vegetation shall consist of obligate and facultative wetland species consisting of grasses, forbs, shrubs.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Subsurface Gravel Wetland.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Inspect system to ensure that the ponded water drains down to the soil surface within 24-72 hours after any storm event greater than 1.2" of rain in 24-hours.
- Inspect plants, water plants during 1st year, replace plants as needed, ensure good root establishment across the wetland surface during 1st two years.
- Check stability of slopes during 1st year, repair as needed.
- Inspect inlets, vertical riser pipes and outlet system twice a year.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Remove decaying vegetation, litter and debris.

6.12 – POND / WETLAND SYSTEM (WQ Treatment)

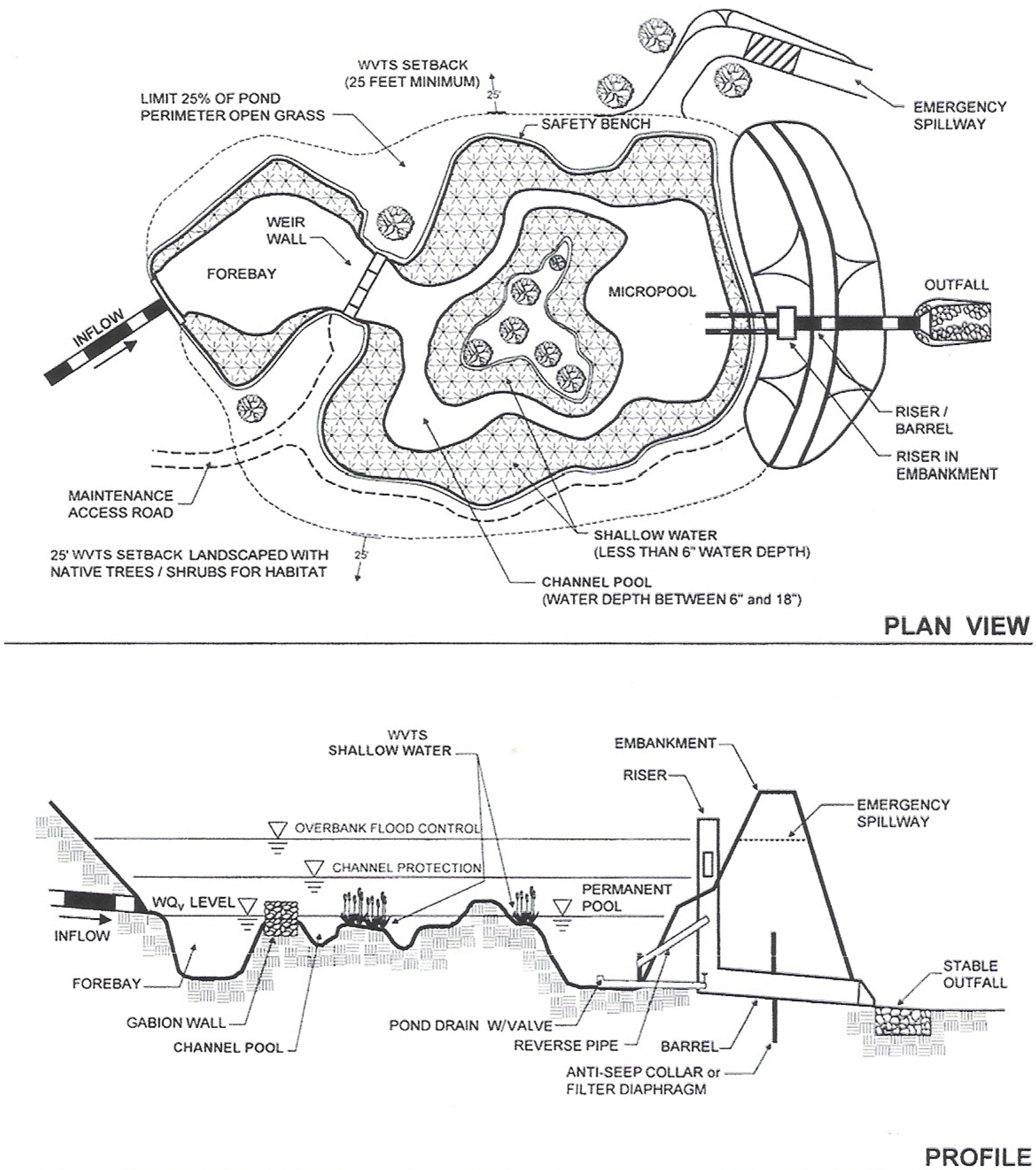


Figure 6.12.a - Pond / Wetland System (RI DEM, 2010)

Required Design Elements Pond / Wetland system

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in such a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to a pond / wetland system shall be twenty five (25) acres.

CONVEYANCE:

- Flows within the system shall be maximized by the use of submerged berms and microtopography.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) shall be provided for all discharges.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The surface area of an extended detention shallow wetland shall be a minimum of 1.5% of the tributary drainage area. Curvilinear configurations shall be used for the basin.
- The outlet pool shall also provide a minimum of 10% of the required WQv and shall be 4-6' in depth.
- 35% of the total surface area of the basin shall have a depth of less than 6".
- 50% of the total surface area of the basin shall have a depth of less than 18".
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

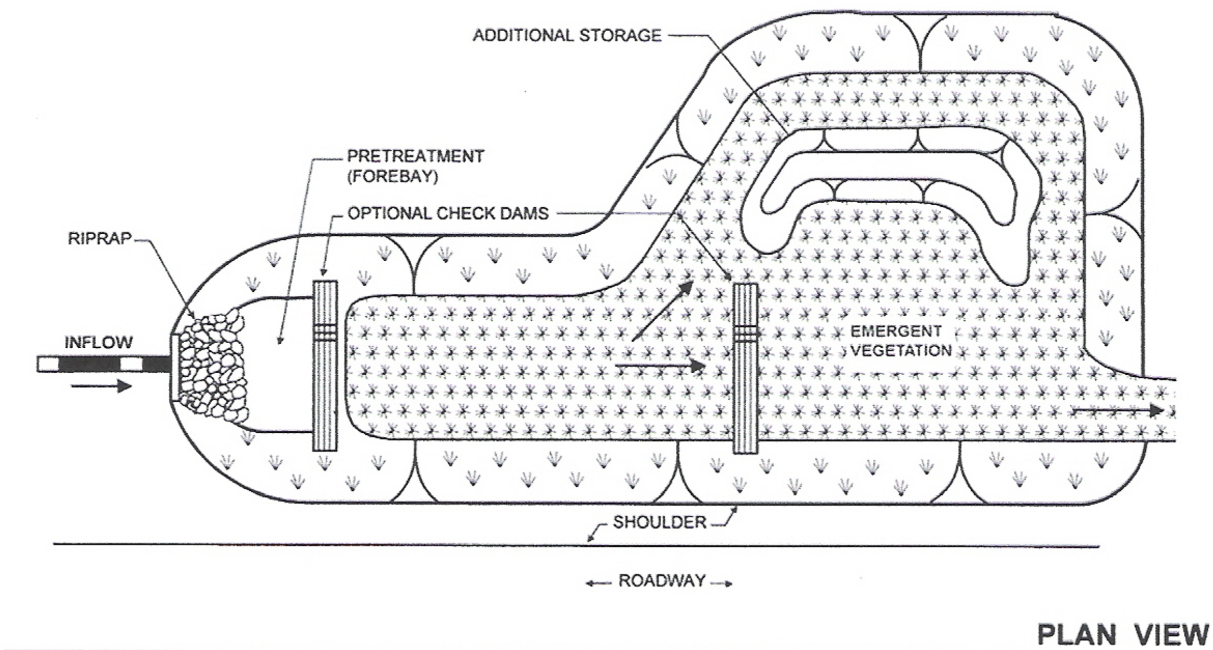
TREATMENT:

- Long, irregular flow paths shall be created by the location and height of the marsh components to increase contact time with vegetation and enhance pollutant removal.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Pond / Wetland System
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the basin.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event for the first year.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the basin shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- Vegetation in the basin shall be inspected annually for two growing seasons. Plants shall be replaced during this period as necessary.

6.13 – WET SWALES (WQ Treatment)



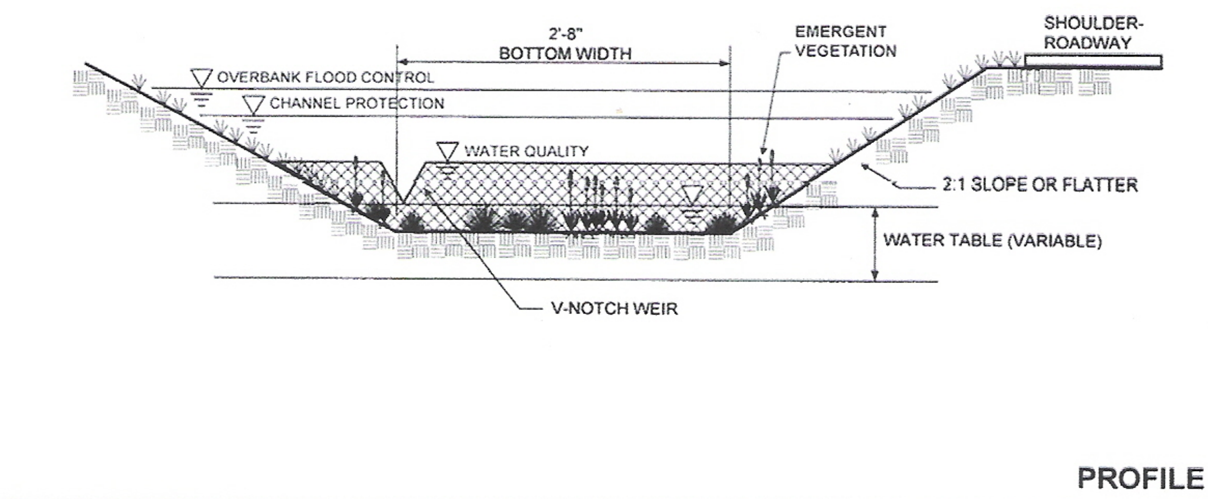


Figure 6.13.a - Wet Swale (RI DEM, 2010)

Required Design Elements for Wet Swales

FEASIBILITY:

- Maximum slope along flow length shall be 4.0% without check dams.
- Wet swales must intercept shallow groundwater level.
- The maximum drainage area to a wet swale shall be five (5) acres.
- Primary use is along linear systems, such as roads, residential development and pervious areas, such as ballfields.

CONVEYANCE:

- Swale shall be able to handle 10-year, 24-hour peak rate from contributing area.
- Swale side slopes shall be a minimum of 3:1. If there are space constraints, then 2:1 slopes may be used.
- Non-erosive velocities shall be provided (3-5 fps) for 1-year, 24-hour storm event.

PRETREATMENT:

- Pretreatment shall be required as ponding behind stone check dams are located within the swale itself.
- Flow across a vegetated filter strip along a road shall be an appropriate pretreatment measure.
- 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The required WQv shall be provided as surface ponding within the wet swale. The length, width and depth shall be designed to achieve this requirement.
- Wet swales shall be designed to provide for a maximum 12" ponded depth.
- Bottom width of swale shall not be greater than eight (8) feet nor less than two (2) feet.

TREATMENT:

- Appropriate emergent plants shall be used for the bottom and side slopes of a wet swale.
- Contributing area to wet swale must be stabilized prior to directing runoff to the wet swale.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Wet Swale.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- The Wet Swale shall be inspected annually and after storms greater than 1-year, 24-hour storm event.
- Sediment shall be removed when accumulation exceeds 25% of the WQv storage value.
- Plant shall be inspected annually for 1st two growing seasons. Dead or dying plants shall be replaced as necessary.

6.14 – FILTER STRIPS (Pretreatment)

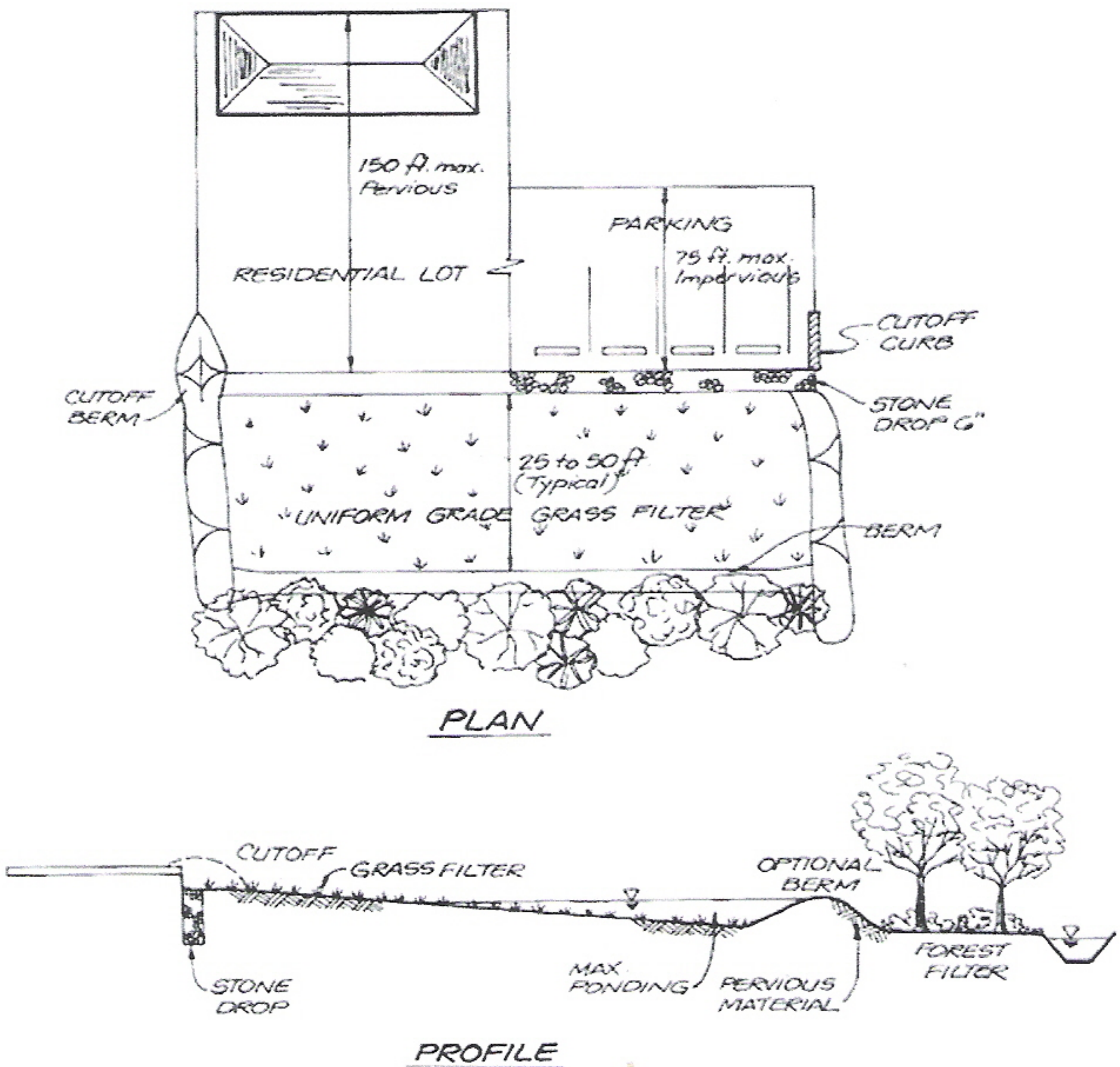


Figure 6.14.a - Filter Strip (RI DEM, 2010)

Required Design Elements for Filter Strip

FEASIBILITY:
- The best application for filter strips is for treating stormwater from roads, small parking areas and roof runoff.
- They can be used as a pretreatment system for other stormwater practices.
- Maximum contributing area to a single filter strip is 0.5 acres.

CONVEYANCE:
- Flows across filter strips must occur as overland flow.
- A stone diaphragm or concrete edge shall be used to ensure uniform overland flow from impervious area.
- If no edge treatment is used, the top of the soil mixture shall be set a minimum of 1” below the pavement edge to allow runoff to “fall off” the impervious edge onto the filter strip.

PRETREATMENT:
- This is a pretreatment system.

SIZING CRITERIA:
- Filter strips shall not be permissible on soils with high clay content.
- Filter strips shall be designed in accordance with the following Table.

Table 6.14.a – Sizing Criteria for Filter Strips

Design Parameter	Impervious Area	Pervious Area
Max. allowable flow length	75’	150’
Filter Strip Slope	4.0%	4.0%
Min. length of filter strip	35’	15’

TREATMENT:
- Sediment is trapped within the grass matrix. If a stone diaphragm is used, this will improve the removal of sediment.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:
- The design engineer shall oversee the preparation of the area and the construction of a Filter Strip.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Grass must become established as soon as possible. If one species does not grow well, it shall be promptly replaced with an alternative species.
- The majority of trapped sediment will occur at the beginning of the filter strip. Sediment shall be removed from this area on an annual basis.
- The area of the filter strip must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the filter strip.
- The height of the grass shall be maintained at 4”.

6.15 – SEDIMENT FOREBAYS (Pretreatment)

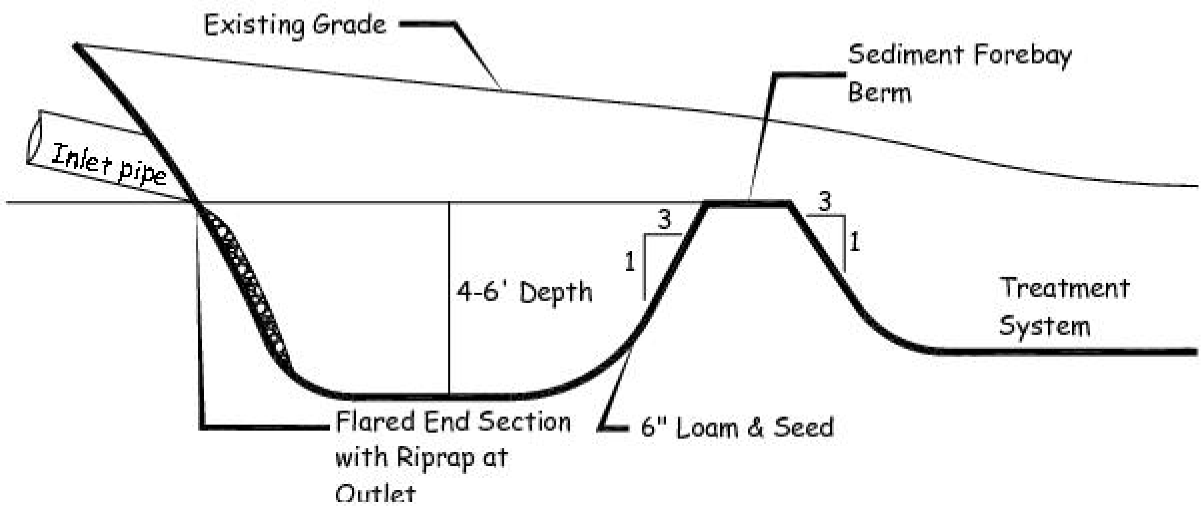


Figure 6.15.a - Forebay (RI DEM, 2010)

Required Design Elements for Sediment Forebay

FEASIBILITY:

- This is a pretreatment practice whose primary purpose is to minimize maintenance requirements of other stormwater treatment systems.
- The sediment forebay shall be made part of another stormwater treatment system and shall not be constructed as a stand alone device.

CONVEYANCE:

- A riprap pad shall be utilized at the inlet to the forebay to reduce flow velocities to non-erosive levels (3-5 fps).

PRETREATMENT:

- This is a pretreatment system for other stormwater management practices.

SIZING CRITERIA:

- A minimum of 10% of the required WQv shall be provided within the sediment forebay.
- The length to width ratio of the sediment forebay shall be 3:1. If site constraints exists this ratio may be reduced to 2:1.
- The forebay shall be a minimum of four (4) feet in depth with a preferred depth of six (6) feet.
- A barrier shall separate the sediment forebay from the treatment facility. The barrier shall be armored as necessary to prevent erosion.
- The invert of the inlet pipe shall be set at the water surface elevation for 10% of the WQv.
- The outlet from the sediment forebay shall be designed in an appropriate manner to convey the flow. This could be a culvert, weir or spillway.
- The outlet elevation must be set, so that the 10% of the required WQv is provided below this elevation.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the installation of a sediment forebay.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Access must be provided to the sediment forebay to facilitate removal of accumulated sediments.
- A fixed vertical marker shall be installed in the sediment forebay to allow the depth of sediment to be easily measured and observed.
- The depth of the sediment in the forebay shall be inspected annually and removed when the depth is more than 25% of the total depth of the sediment forebay.

6.16 – DEEP SUMP CATCH BASIN (Pretreatment)

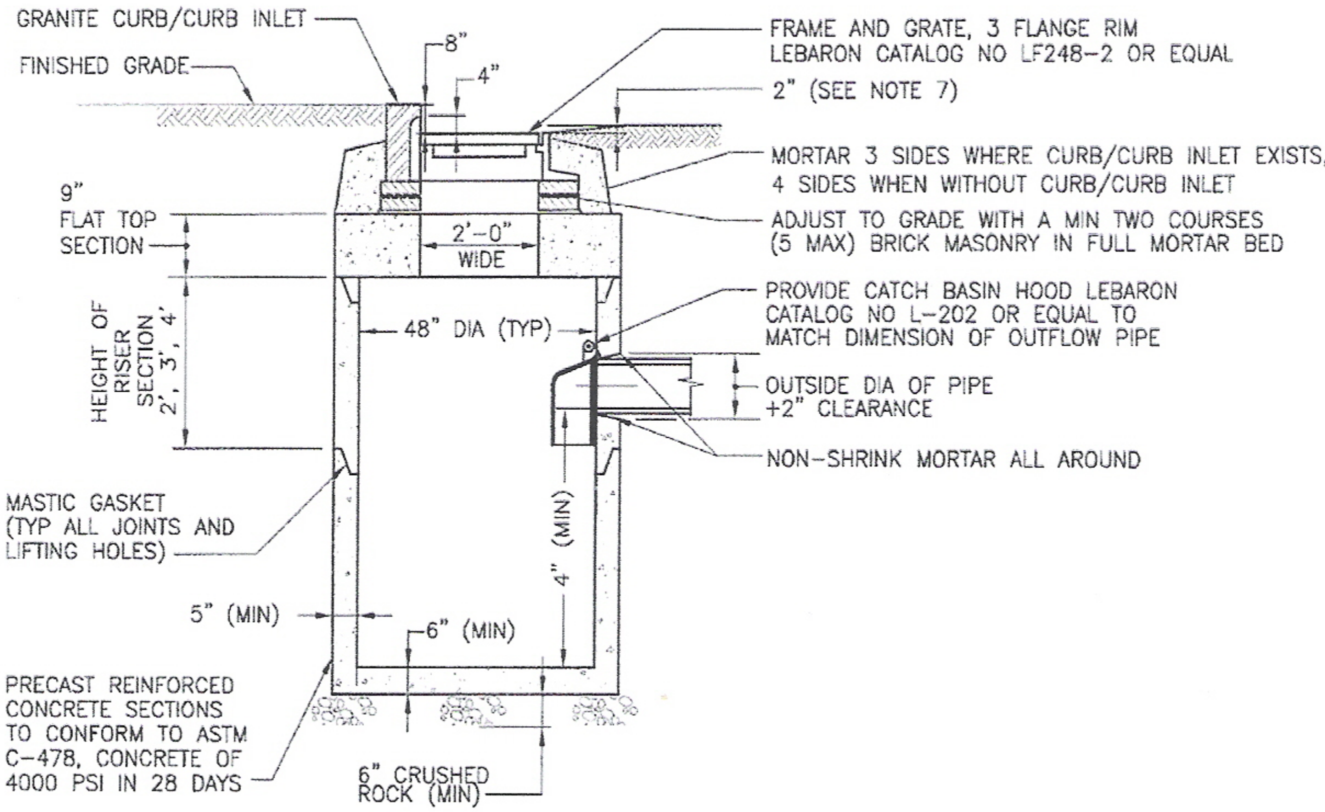


Figure 6.16.a - Deep Sump Catch Basin (RI DEM, 2010)

Required Design Elements for Deep Sump Catch Basins

FEASIBILITY:

- A deep sump catch basin shall be used in a catch basin to manhole alignment as a by-pass.
- The maximum drainage area to a deep sump catch basin shall be 0.5 acres.

CONVEYANCE:

- The deep sump catch basin will see the Water Quality Flow.
- Larger flow rates will by-pass this structure by the utilization of the manhole configuration.
- Hooded outlets shall be used on all deep sump catch basins to trap litter and lighter than water emulsions.

PRETREATMENT:

- This is a pretreatment system.

SIZING CRITERIA:

- The invert of the outlet pipe from a deep sump catch basin shall be set a minimum of four (4) feet above the bottom of the structure.
- The hooded outlet shall be installed in such a manner as to facilitate the easy removal and replacement of the hood.

TREATMENT:

- Coarse grained sediments will settle out in the deep sump.
- Litter and lighter than water emulsions (oils and grease) will be trapped on the water surface by the hooded outlet.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Design Engineer shall inspect the installed Deep Sump Catch Basin and certify that the required design elements have been provided.
- Inspections shall be made twice a year (fall and spring).
- Sediment shall be removed when it has reached two (2) feet in depth.
- Sufficient access into the structure shall be provided from the grate to facilitate maintenance.

6.17 – PROPRIETARY TREATMENT DEVICES (Pretreatment)

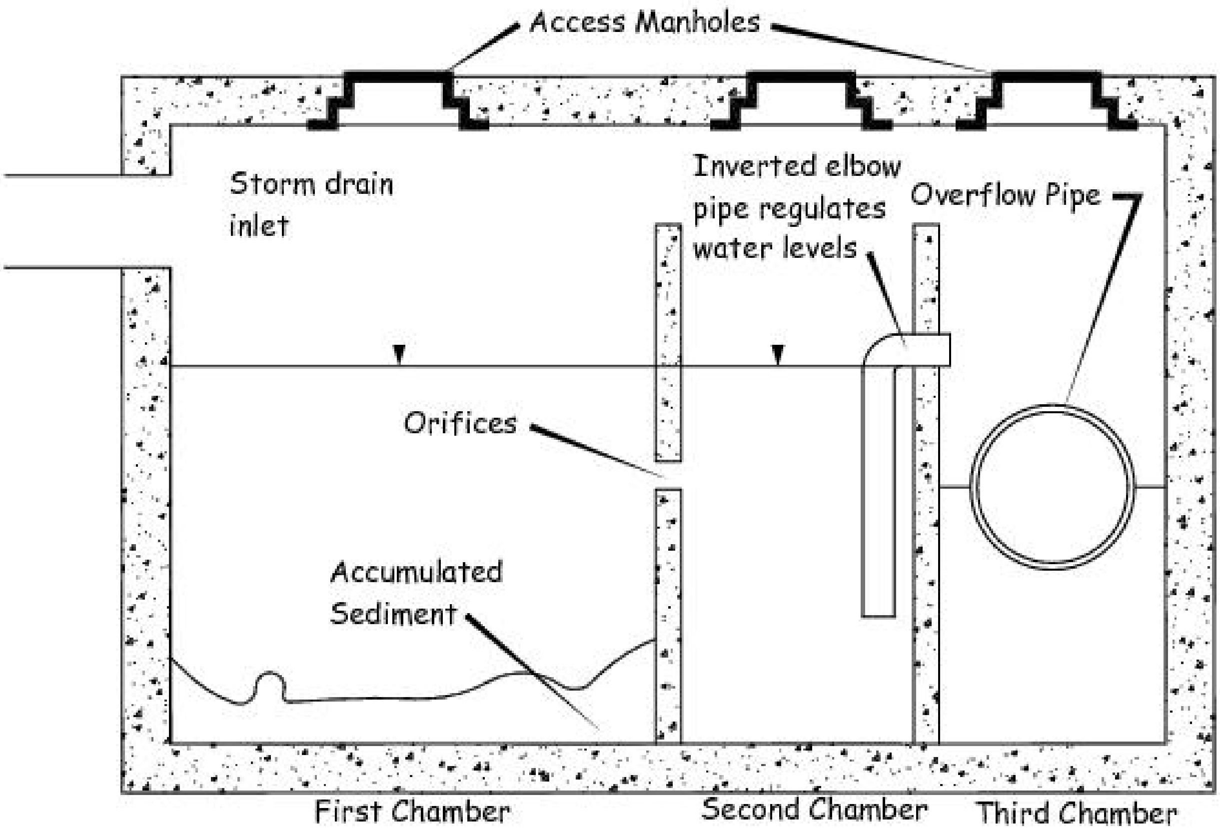


Figure6.17.a - Oil Grit Separator (Mass Highway 2004)

Required Design Elements for Proprietary Treatment Devices

FEASIBILITY:

- System must be capable of removing a minimum of 25% of Total Suspended Solids to be considered an appropriate pretreatment device. This requirement must be independently verified and supported by necessary written documentation.
- Systems must be designed in accordance with the manufacturer's specifications.
- Contributing area to system shall not exceed one (1) acre of impervious area.

CONVEYANCE:

- System shall be designed as "off-line" to treat full water quality flow. Flows in excess of the water quality flow shall be by-passed around the system.

PRETREATMENT:

- This is a pretreatment device.

SIZING CRITERIA:

- The full water quality flow must be treated by the system.
- A minimum detention time of 60 seconds is required for the water quality flow.

TREATMENT:

- These devices are capable of trapping coarse sediments, litter and lighter than water emulsions by proprietary treatment systems by each manufacturer.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the installation of an Oil Grit Separator.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Maintenance shall be performed in accordance with manufacturer's requirements.
- The devices shall be sited in such a manner as to provide quick, easy access for emergency removal of oils.
- Inspections shall be performed twice a year and cleaned twice a year.
- Debris removed from these systems is considered a hazardous material and must be removed and disposed off by a properly licensed contractor.

6.18 – WET EXTENDED DETENTION POND (Water Quantity Control)

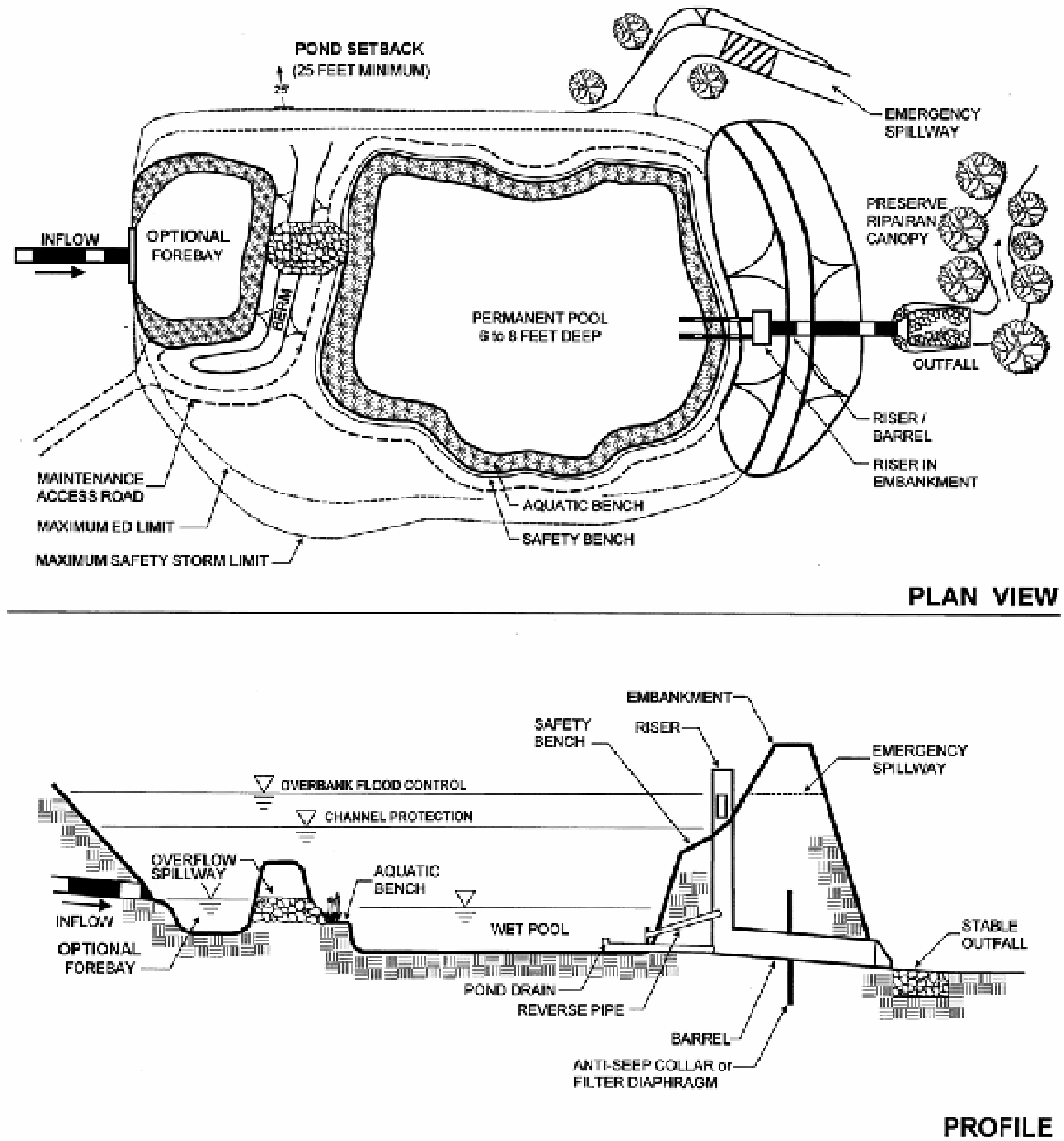


Figure 6.18.a - Wet Extended Detention Pond (RI DEM, 2010)

Required Design Elements for Wet Extended Detention Pond

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to a Wet Extended Detention Pond shall be twenty five (25) acres.

CONVEYANCE:

- The outlet of the inlet pipe shall be stabilized to provide non-erosive velocities.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) for all discharges.
- An emergency spillway, sized to handle the 100-year, 24-hour storm event must be provided.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The outlet control system of the wet extended detention pond shall provide for the Channel Protection Flow as well as meet the Flood Protection requirement.
- The wet extended detention pond shall not be considered as a water quality treatment system.
- Water quality treatment shall be provided upstream as an "off-line" system.
- The wet extended detention pond shall utilize curvilinear geometry.
- 65% of the total surface area of the basin shall have a depth of less than 18".
- 35% of the total surface area of the basin shall have a depth of less than 6".
- Deep water areas within the basin shall provide a minimum of 25% of the required WQv, where the depth is greater than 4.0'.
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

TREATMENT:

- If site conditions permit, the extended detention shallow wetland shall be located "off-line". If this is not feasible, then both the Channel Protection Flow and Flood Protection requirements shall be designed into the basin.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the construction of a Wet Extended Detention Pond.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the pond.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the pond shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.
- Inspections of the wet extended detention pond shall be made after any storm greater than the 1-year, 24-hour storm.

6.19 – DRY DETENTION POND (Water Quantity Control)

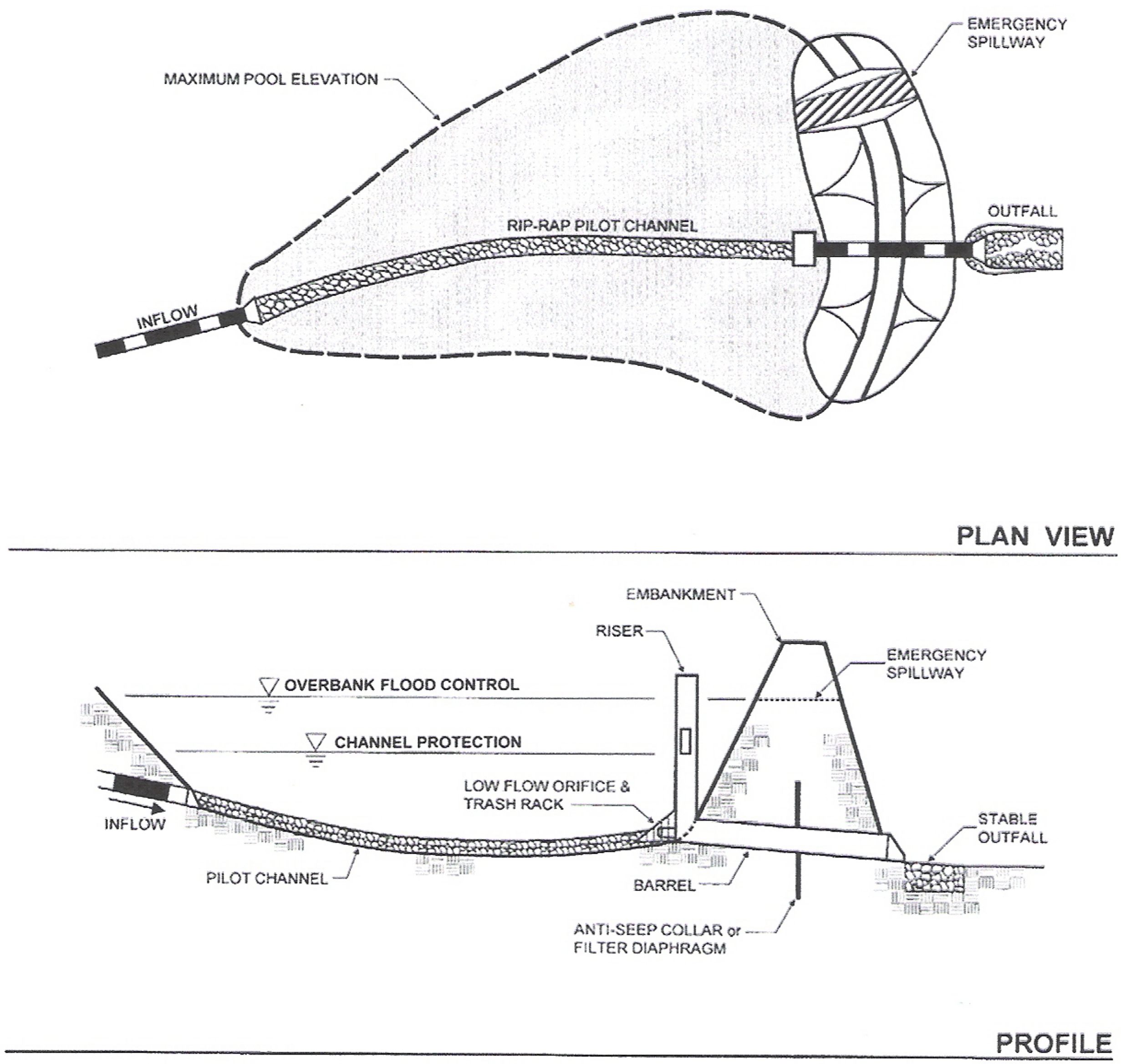


Figure 6.19.a - Dry Detention Pond (RI DEM, 2010)

Required Design Elements for Dry Detention Pond

FEASIBILITY:

- Must be installed on slopes < 15%.
- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The maximum drainage area to a dry detention basin shall be twenty five (25) acres.

CONVEYANCE:

- Infiltration basin must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The storage capacity of a dry detention pond shall be sufficient to detain the increases in the peak rate of runoff for the 10-year, 24-hour storm and potentially the 100-year, 24-hour storm event as necessary.

TREATMENT:

- A dry detention pond is used for water quantity control only.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the installation of a Dry Detention Pond.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- A dry detention pond can be used for sediment control during an active construction period.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- If there is an accumulation of organic debris or sediment on the surface of the basin, it shall be removed and the area reseeded.
- Inspections of a dry detention basin shall be made after any storm greater than the 2-year, 24-hour storm.

6.20 – LID URBAN PLANTER (Commercial Retrofit)

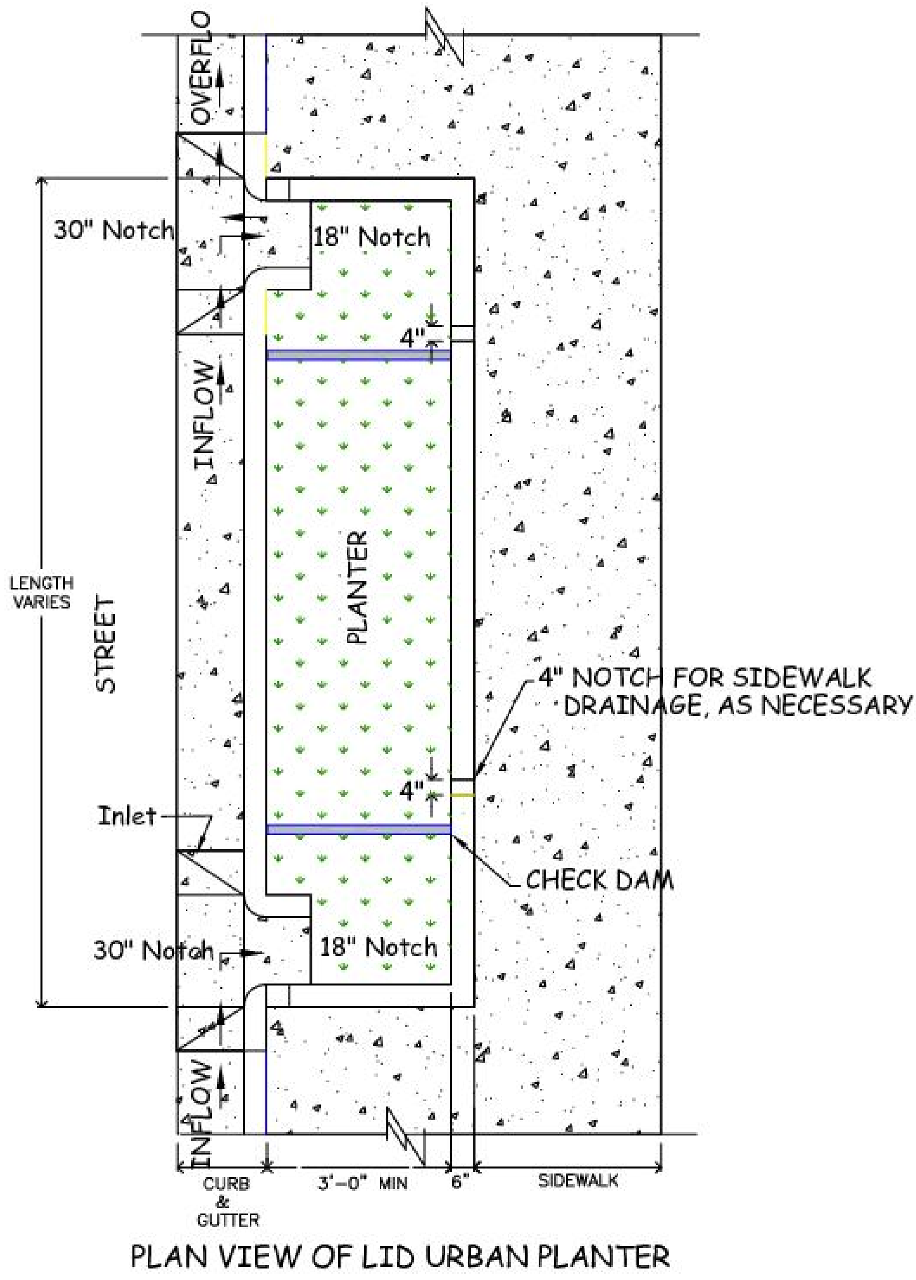


Figure 6.20.a – LID Urban Planter (City of Portland, OR)

Required Design Elements for LID Urban Planter

FEASIBILITY:

- Must be installed on slopes < 5%.
- Shall not be located closer than ten (10) feet to the foundation of a building, unless the system is lined with an impermeable liner.
- The maximum drainage area to a LID Urban Planter shall be 10,000 square feet (0.22) acres.

CONVEYANCE:

- Conveyance to a LID Urban Planter shall be via notches installed in the existing curb along the pavement edge as shown.
- An overflow pipe shall be installed in the system that will provide a freeboard of 4" prior to overtopping the curb height.

PRETREATMENT:

- No pretreatment is required.

SIZING CRITERIA:

- At least 50% of the required water quality volume (WQv) of the drainage area shall be provided as fixed storage with the LID Urban Planter.
- The surface area of the bottom of the LID Urban Planter system shall be determined by the following equation:

SA = (WQv)*(.50)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of maximum ponding above soil surface in feet (0.67')

TREATMENT:

- Minimum depth of soil mixture shall be 18". The maximum depth shall be 24"
- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each LID Urban Planter system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the LID Urban Planter system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the LID Urban Planter system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

6.21 – LID CURB EXTENSION (Commercial Retrofit)

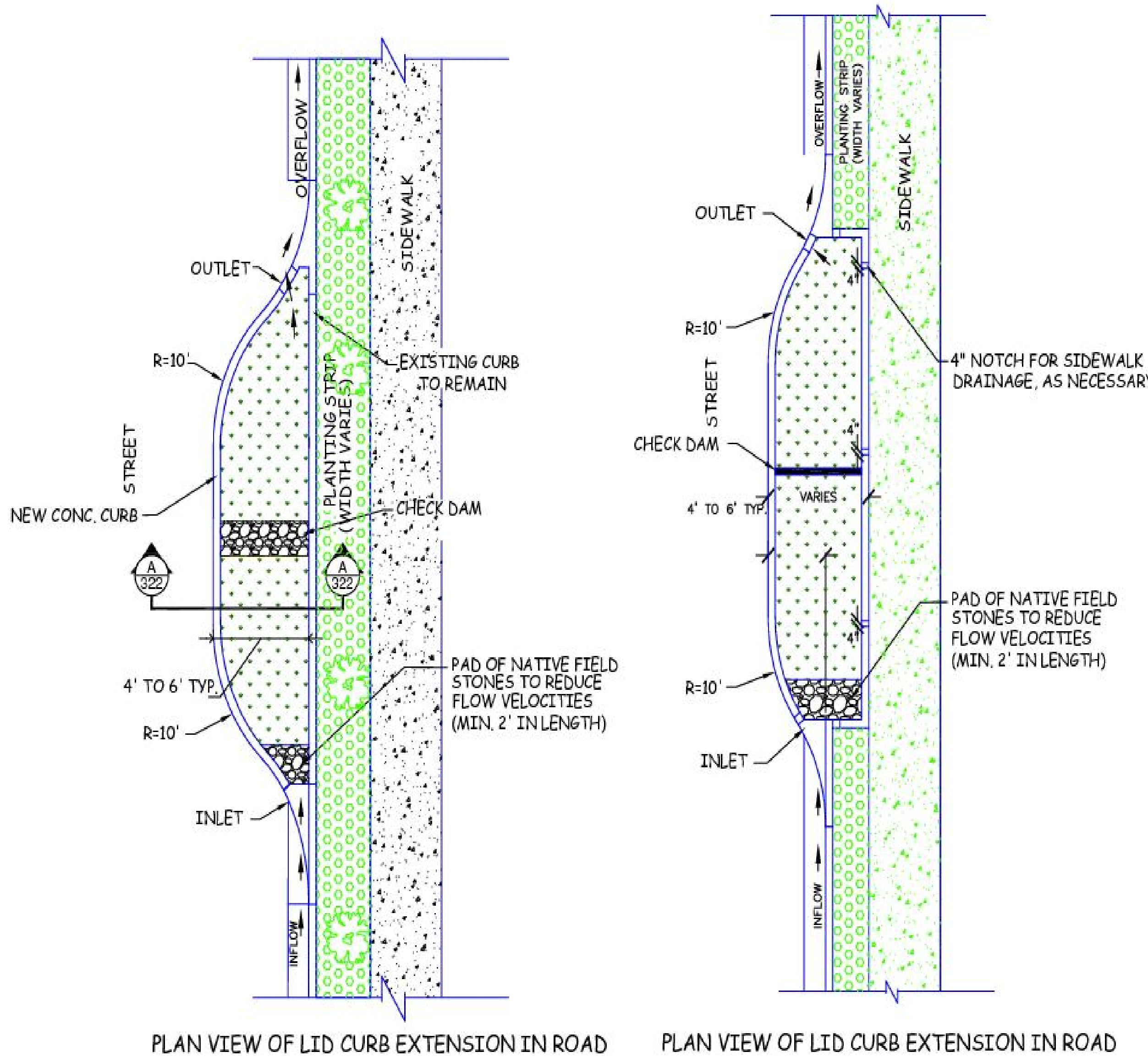
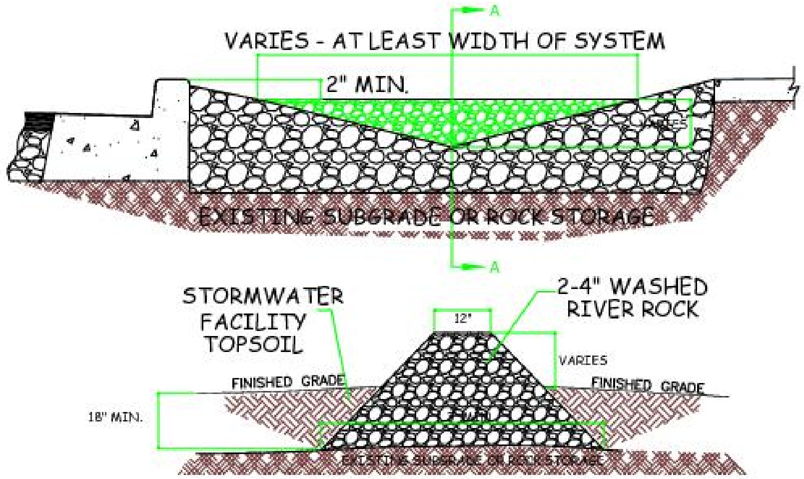
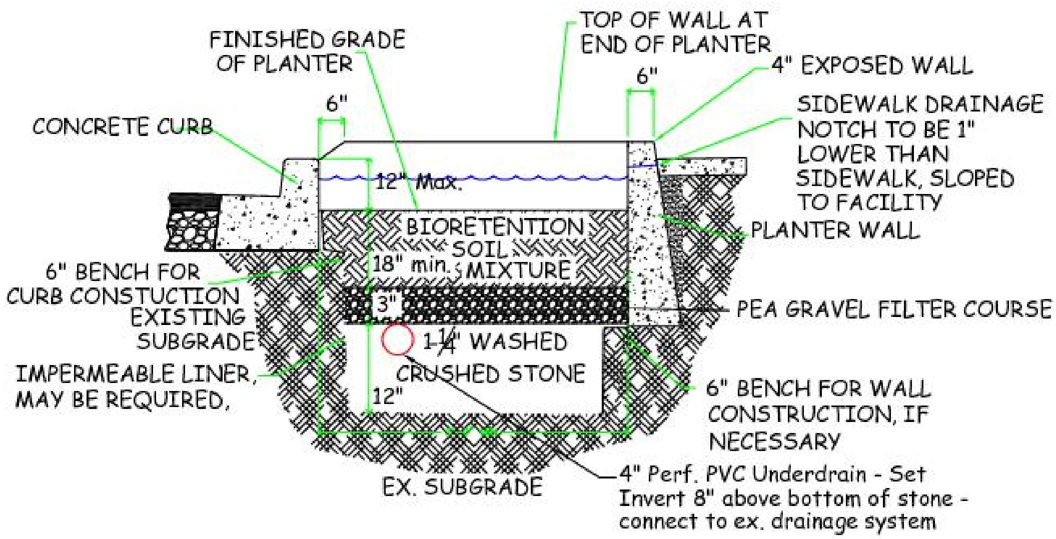


Figure 6.21.a – LID Curb Extension (City of Portland, OR)



STONE CHECK DAM TYPICAL DETAIL



CROSS SECTION VIEW OF LID URBAN PLANTER

Figure 6.21.b – Cross Section of LID Curb Extension / LID Urban Planter (City of Portland, OR)

Required Design Elements for LID Curb Extensions

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not interfere with existing underground utilities.
- The maximum drainage area to a LID Urban Planter shall be 0.5 acres.

CONVEYANCE:

- Conveyance to a LID Curb Extension shall be via a new inlet located on the existing gutter line of the street.
- An outlet shall discharge larger storm flow back to the existing gutter line.

PRETREATMENT:

- No pretreatment is required.

SIZING CRITERIA:

- At least 10% of the required water quality volume (WQv) of the drainage area shall be provided as fixed storage with the LID Urban Planter.
- Stone check dams shall be constructed as needed to provide the required storage water quality volume.
- The surface area of the bottom of the LID Curb Extension system shall be determined by the following equation:

SA = (WQv)*(0.10)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of maximum ponding above soil surface in feet (0.5')

TREATMENT:

- Minimum depth of soil mixture shall be 18". The maximum depth shall be 24"
- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each LID Curb Extension system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the LID Curb Extension system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the LID Curb Extension system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

6.22 – MODULAR WETLAND SYSTEM (Commercial Retrofit)

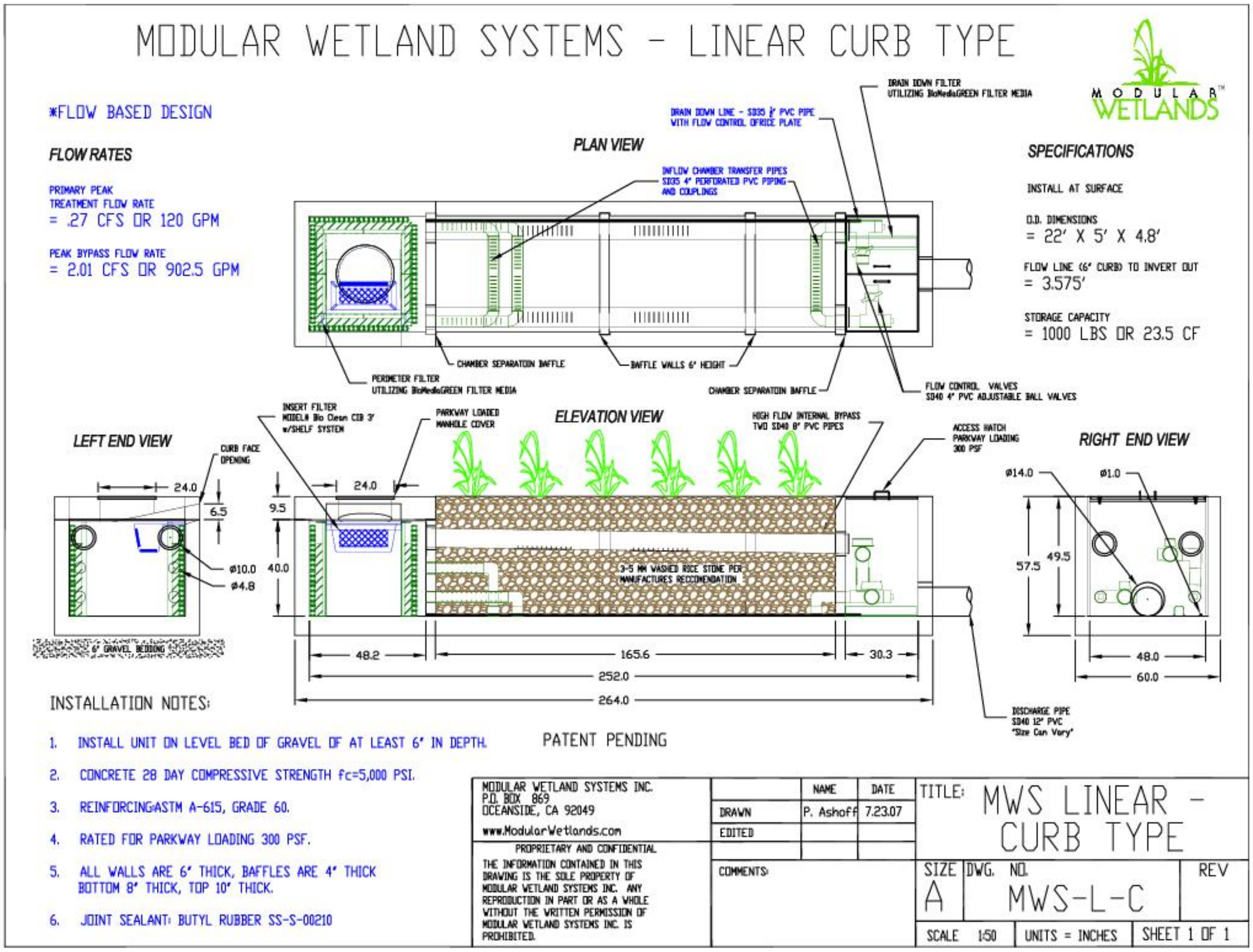


Figure 6.22.a – Modular Wetland System (Modularwetlands.com)

Required Design Elements for Modular Wetland

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not conflict with existing underground utility lines.
- Outlet pipe shall connect to existing stormwater conveyance system in the stream
- The maximum drainage area shall be 2 acres, unless sizing calculations will demonstrate that the system can handle a larger area.

CONVEYANCE:

- Conveyance to the system is by a field inlet structure that is an integral part of the treatment structure.

PRETREATMENT:

- Pretreatment is provided in the inlet structure of the modular wetland system.

SIZING CRITERIA:

- The Modular Wetland system may be sized for either the Water Quality Flow or the Water Quality Volume.
- Sizing calculators are available online at www.modularwetlands.com for this purpose.

TREATMENT:

- The Modular Wetlands provides filtration, sedimentation and biological uptake to remove pollutants from stormwater.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Modular Wetland System must be installed in accordance with all the specifications provided by the manufacturer. (www.modularwetlands.com)
- Clean screening filter device a minimum of twice a year (15 minute service time).
- Clean separation (sediment) chamber once a year (30 minute service time).
- Evaluate primary filtration media on an annual basis and replace primary filtration media (BioMediaGREEN blocks) as needed.
- Evaluate condition of wetland media on annual basis. Replacement of media may need to occur once every 5 to 20 years depending upon pollutant loads.
- Replace drain down filter media (BioMediaGREEN blocks) once a year (5 minute service time).
- Trim vegetation as needed (15 minute service time).

6.23 – FILTERRA BIORETENTION SYSTEM (Commercial Retrofit)

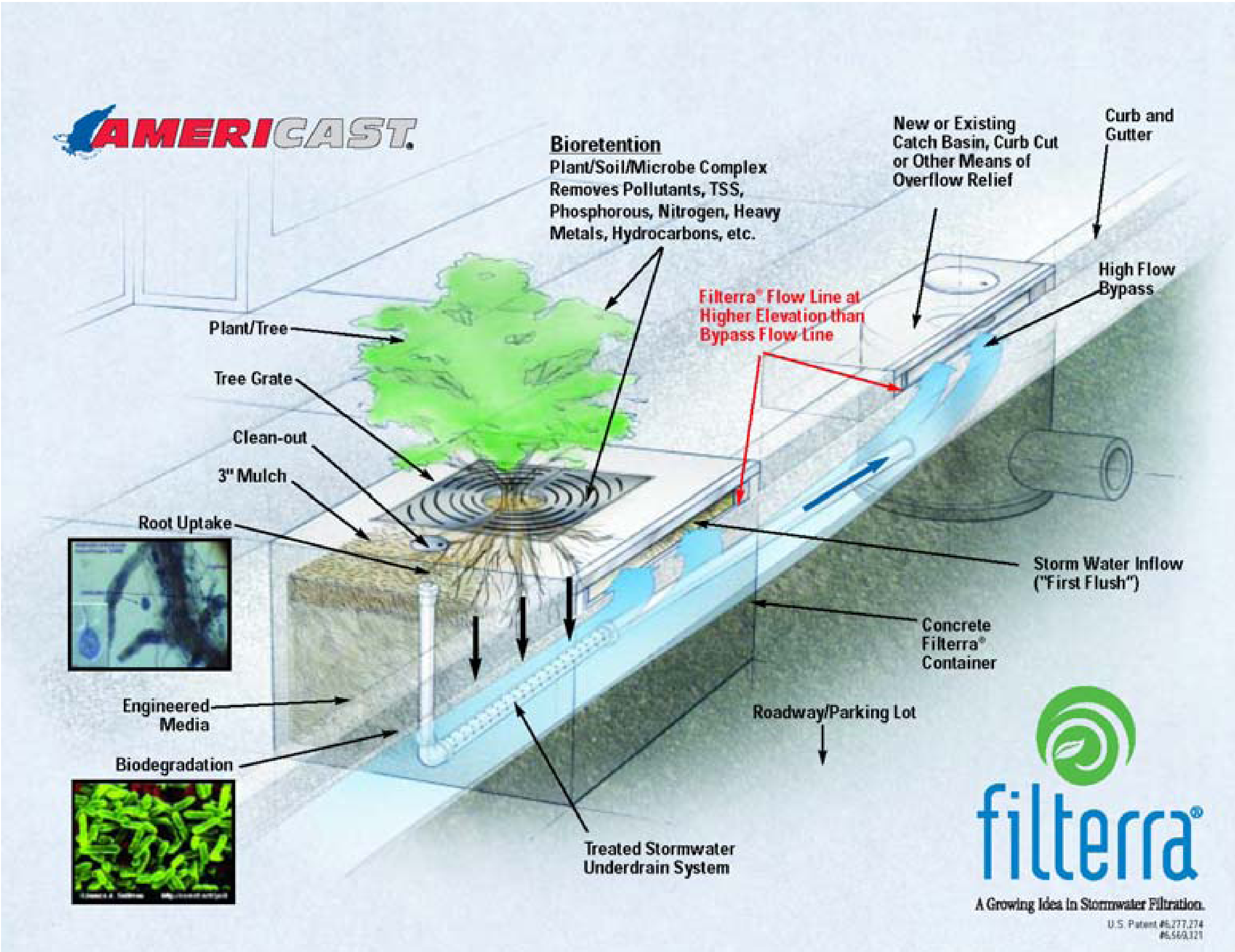


Figure 6.23.a – Filterra Bioretention (Filterra.com)

Required Design Elements for Filterra Bioretention System

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not conflict with existing underground utility lines.
- Outlet pipe shall connect to existing stormwater conveyance system in the stream
- The maximum drainage area shall be 1 acre, unless sizing calculations will demonstrate that the system can handle a larger area.

CONVEYANCE:

- Conveyance to the system is by a field inlet structure that is an integral part of the treatment structure.

PRETREATMENT:

- Pretreatment is provided in the inlet structure of the modular wetland system.

SIZING CRITERIA:

- The Filterra Bioretention system may be sized for either the Water Quality Flow.
- Sizing calculators are available online at www.filterra.com for this purpose.

TREATMENT:

- The Filterra Bioretention system provides filtration, sedimentation and biological uptake to remove pollutants from stormwater.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Filterra Bioretention System must be installed in accordance with all the specifications provided by the manufacturer. (www.filterra.com).
- Inspection of Filterra and surrounding area shall be done twice a year.
- At time of inspection, remove tree grate and erosion control stones to access media surface.
- Remove trash, debris and mulch layer.
- Replace mulch on top of Bioretention media.
- Replace erosion control stones and clean area around Filterra.
- Complete written maintenance report and submit copy to municipality.

6.24 – RAIN BARREL

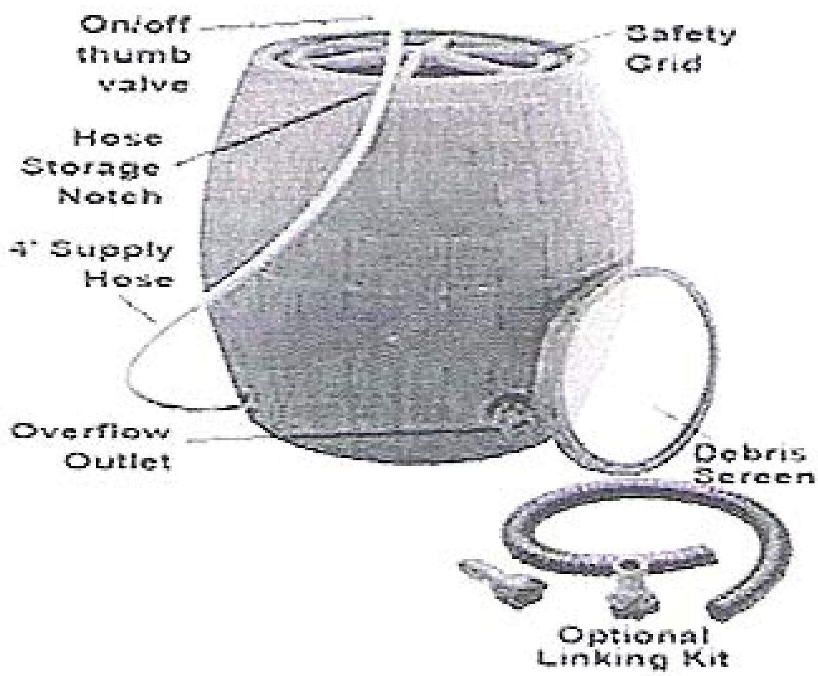


Figure 6.24.a – Rain Barrel

Required Design Elements for Rain Barrel

FEASIBILITY:

- Any residential roof with existing or proposed downspouts.

CONVEYANCE:

- Gutter downspout shall direct runoff to rain barrel, an overflow pipe shall be provided to by-pass rain barrel for large storm events or when rain barrel is full,
- Overflow pipe shall be located a minimum of 10' away from building foundation and direct runoff across a vegetated surface.

PRE-TREATMENT:

- No pre-treatment is required.

SIZING CRITERIA:

- Rain barrel shall have a minimum capacity of 55 gallons per 100 square feet of contributing roof area.

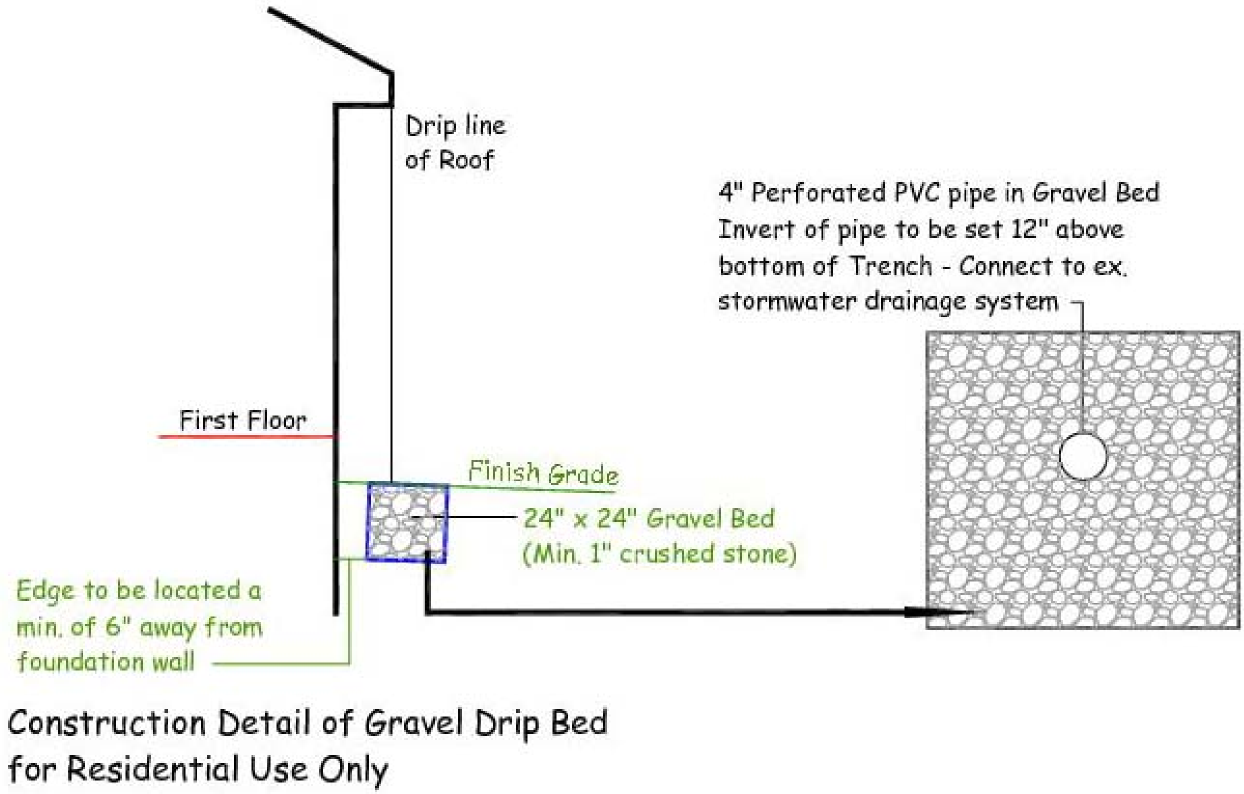
TREATMENT:

- This is a water reuse system, no treatment of runoff is required.

CONSTRUCTION AND MAINTENANCE:

- Rain barrel shall be drained each fall to prevent freezing of water in the barrel.
- An inline filter, if utilized on downspout shall be inspected twice a year and any debris promptly removed from the filter.
- The discharge line from the downspout to the rain barrel shall be disconnected during the winter months to prevent the accumulation of water in the barrel during freezing weather.

6.25 – GRAVEL DRIP BED



Gravel Drip Bed: A gravel drip bed is a system consists of crushed stone installed below the drip line of a residential roof without gutters to collect and infiltrate runoff from the roof into the ground.
Figure 6.25.a – Gravel Drip Bed (Trinkaus Engineering)

Required Design Elements for Gravel Drip Bed

FEASIBILITY:

- Any Single Family Residential House without gutters and downspouts
- Shall be located in Class A or B soils. It is not suitable for use in Class C or D soils.
- Edge of gravel shall be located a minimum of 6” away from foundation wall

CONVEYANCE:

- Not Applicable

PRETREATMENT:

- No pretreatment required

SIZING CRITERIA:

- Not Applicable

TREATMENT:

- Not Applicable

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The finish grade must pitch away from the foundation wall at 2% for a minimum of ten (10) feet.
- When the trench is excavated for the gravel, the sides and bottom of the excavation shall be scarified by hand raking prior to the placement of the gravel.
- The gravel must be a minimum of 1” in size, but shall not exceed 2.5”. It shall consist of washed native bank run stone or quarried rock, no stone dust shall be permitted.

7.0 Road Design, Storm Drainage & Driveway Design Standards

Section I General

The following design provisions apply to the extension of existing Town roadways and the construction of new roadways intended for acceptance by the Town of Tolland. The intent of these guidelines is to provide minimum standards for materials and construction practices regarding subdivisions, roadways and associated improvements. The requirements herein may be modified under special circumstances only with the joint consent of the Planning & Zoning Commission and the Town Engineer.

Section II Design and Designation of Roadways

A. Classification of Roadways

Roadways in the Town of Tolland shall be classified into four (4) categories based on their function and capacity.

1. Arterial Roads

    a. Roadways that are characterized by a capacity to quickly move relatively large volumes of traffic and provide limited access to abutting properties.

    b. Generally, design speeds and capacity are high.

2. Collector Roads

    a. Roadways that are characterized by a roughly even distribution of their access and mobility functions. Generally, Collector Roads function as a conveyance for traffic traveling from town to town or population cluster to cluster. These roads have been designated as: All State highways, Old Stafford Road, Goose Lane, Old Post Road, Grant Hill Road, Browns Bridge Road, Grahaber Road, and Buff Cap Road.

    b. Generally, design speeds and capacity are higher than Primary Local and Secondary Local Roads.

3. Primary Local Roads

    a. Roadways characterized by moderate access to both residences and businesses located along its length; Roadways functioning as a conveyance for through traffic on a neighborhood to neighborhood scale.

    b. Generally, design speeds are less than 30 mph and capacities are less than that of Collector Roads.

4. Secondary Local Roads

a. Roadways characterized by mainly providing access to residences within a single neighborhood; roads that will not create inter-neighborhood cut throughs or dead end roads without future interconnection potential.

b. Generally, design speeds are less than 25 mph and capacities are less than that of Primary Local Roads.

c. Proposed Secondary Local Roads shall meet the requirements set herein and the Planning & Zoning Commission must be satisfied that adequate access and capacity are provided.

B. Right of Way

1. State Arterial and Collector Roads

   a. The right of way of State Arterial and Collector Roads shall be defined by the Connecticut Department of Transportation's Right of Way Survey. If a Right of Way Survey does not exist, the right of way shall be established by the Department of Transportation. The Town shall request that the front right of way be established at least 30 feet from the centerline of the traveled way, notwithstanding any other property information indicating that the right of way line is a greater distance from the centerline of the traveled way.

2. Town Collector Roads

   a. The right of way of existing Town Collector Roads shall be established at least 30- feet from the centerline of the traveled way, notwithstanding any other property information indicating that the right of way line is a greater distance from the centerline of the traveled way.

   b. The right of way of new Town Collector Roads shall be established at least 30 feet from the centerline of the traveled way, notwithstanding any other property information indicating that the right of way line is a greater distance from the centerline of the traveled way.

3. Primary and Secondary Local Roads

   a. The right of way of existing Primary Local Roads shall be established at least 25-feet from the centerline of the traveled way, notwithstanding any other property information indicating that the right of way line is a greater distance from the centerline of the traveled way.

   b. The right of way of new Primary Local and Secondary Roads shall be established at least 25-feet from the centerline of the traveled way, notwithstanding any other property information indicating that the right of way line is a greater distance from the centerline of the traveled way.

   c. All new Primary and Secondary Local Roads shall have a minimum Right of Way width of 50-feet. The paved surface of the roadway shall be centered in the right of way.

<u>Section III Construction of Town Roadways</u>

A. General

The latest version of the State of Connecticut Department of Transportation "Standard Specifications for Roads, Bridges and Incidental Construction Form 816 (ConnDOT 816)", as amended, is included for reference. Construction shall comply with the provisions of ConnDOT 816, except where more stringent requirements are stated. The Town of Tolland reserves the right to require more stringent practices/specifications if it is deemed that it would serve the best interest of the community.

1. Intersections

   a. Minimum Separation Distance Between Intersections

      i. Intersections of new roads with other new roads or existing roads shall have a minimum separation distance (as measured from the centerline of one intersection to the centerline of another intersection) of:

         - 350' from any intersection on a Collector Road.
         - 250' from any intersection on a Primary Local Road.
         - 150' from any intersection on a Secondary Local Road.

         Additional separation distance between intersections, than that noted above, may be required due to design speeds, geometry and/or sight distance.

   b. Intersections of Primary and Secondary Local Roads with Collector Roads

      i. Intersections shall generally meet at a 90-degree angle or radial to the curvature of the Collector Road, if applicable. In no case shall such an intersection be greater than 5° from the right angle line or radial line.

      ii. This line of approach shall extend at least 80 feet (measured along the centerline of the road, beginning at the point of intersection) prior to transitioning into a horizontal curve.

   c. Intersections of Primary and Secondary Local Roads with other Primary and Secondary Local Roads

      i. Intersections shall generally meet at a 90-degree angle or radial to the curvature of the intersected road, as applicable. In no case shall such an intersection be greater or less than 10° from the 90-degree angle line or radial line.

      ii. This line of approach shall extend at least 75 feet (measured along the centerline of the road, beginning at the point of intersection) prior to transitioning into a horizontal curve

   d. Intersection Grading

      i. Intersections shall be located a point where the existing road has a grade of 5% or less. Intersections of roadways with grades of greater than 5% shall require special approval from the Planning & Zoning Commission and the Town Engineer.

      ii. The line of approach (measured 75 feet from the point of intersection) of new intersecting roads shall not exceed 3%.

e. Transition Radii at Intersections

   i. Intersections of Collector Roads with other Collector Roads shall have minimum transition radii of 25-feet.

   ii. Intersections of all Roads with Primary Local Roads shall have transition radii of 25-feet.

   iii. Intersections of all Roads with Secondary Local Roads shall have transition radii of 20-feet.

f. Sightlines at Intersections

   i. Adequate sightlines shall be provided at all intersections and shall meet the guidelines set forth in the State of Connecticut Department of Transportation's Highway Design Manual.

   ii. Alterations to existing conditions, including but not limited to grading, vegetation removal, easements and provisions to maintain such features may be required and shall be provided by the Applicant.

2. Roadways

a. Roadway Design

The following criteria shall be incorporated in the design of proposed roads and extensions of existing roads:

	Minimum Grade	Maximum Grade	Roadway Width
Collector Road	1.5%	8.0%	28 feet
Primary Local Road	1.5%	8.0%	24 feet
Secondary Local Road	1.5%	8.0%	22 feet

Any reduction or increase in the above roadway widths shall require approval by the Planning & Zoning Commission and Town Engineer. Reductions shall not negatively impact public safety or emergency response.

b. Cul-de-sacs

   i. Dead-end roads shall terminate in a cul-de-sac either centered along the alignment of the road or offset to one side.

   ii. Cul-de-sacs shall have a paved radius of 45-feet to facilitate the reversal of traffic flow.

iii. Primary Road cul-de-sacs shall have a minimum right of way radius of 35.5 feet and shall be concentric with the paved cul-de-sac.

iv. Secondary Road cul-de-sacs shall have a minimum right of way radius of 36.5 feet and shall be concentric with the paved cul-de-sac.

c. Vertical and Horizontal Alignments

i. In no such case shall a roadway grades exceed 10%. Roadways with grades greater than 8% shall require approval by the Planning & Zoning Commission and the Town Engineer. Roadway grades greater than 8% shall only be considered if the proposed increased grade reduces environmental impact or the need for additional cut or fill.

ii. Roadway grades shall mimic the existing topography wherever possible. Horizontal and vertical alignments shall be designed to minimize cuts and fills.

iii. The overall design of the roadway and adjacent lots should promote lots being at or above roadway grade.

iv. Secondary Local Roads shall be designed to promote slower traffic speeds. The maximum length of any horizontal tangent or curve with a centerline radius of 400-feet or greater shall be 500 feet. Horizontal curves with a center line radius of 200-feet or less shall be used to transition these elements. Alternative traffic calming methods in lieu of these design guidelines may be used with the approval of the Town Engineer.

d. Grading and Right of Way Improvements

i. Roadways and rights of way shall be selectively cleared of existing vegetation per VPPP guidelines to promote pedestrian safety and to facilitate stormwater management.

ii. Cut and fill slopes shall be stabilized with a minimum of 4-inches of topsoil and turf establishment or other vegetation as accepted by the Planning & Zoning Commission.

iii. A 5-foot wide snow shelf shall be provided adjacent to all roadways. Slopes of snow shelves shall not exceed 12:1 (horizontal to vertical).

iv. Roadway cross-slopes shall be ¼” per foot.

v. All slopes within the right of way shall not exceed 4:1 (horizontal to vertical) without approval of the Town Engineer.

vi. No cut or fill slope shall exceed 2:1 (horizontal to vertical).

e. Roadway Pavement Markings

i. A 4-inch wide white pavement stripe 10 feet from the centerline of the roadway shall be painted on both sides of the road.

ii. No centerline marking shall be permitted.

iii. A 12-inch wide white stop bar shall be painted at all stop sign/traffic signalization locations.

iv. Additional roadway markings may be required.

v. Roadway pavement markings not listed above shall be approved by the Town Engineer.

f. Traffic Calming Measures

i. The Town reserves the right to require traffic calming measures if it is deemed that geometry, proximity to Collector Roads and/or other factors may contribute to excessive speeds or impede pedestrian safety.

3. Construction

a. General Requirements

Prior to roadway construction, the Applicant's contractor shall submit a construction schedule to the Town Engineer for approval.

Each phase of construction shall be inspected and approved by the Town Engineer or authorized representative prior to beginning the next phase of construction. The Applicant's contractor shall notify the Town Engineer 48 hours prior to requiring an inspection.

The Applicant shall retain the services of a professional engineer and surveyor licensed in the State of Connecticut to periodically inspect construction progress. The Applicant's engineer shall submit an As-Built Plan(s) to the Town and certify that roadways, grading and utilities that were constructed are generally consistent with the approved design plans. As-Built Plans shall include, but not be limited to:

- All utility locations and sizes.
- Stormwater structure locations, top of frame elevations, invert elevations and pipe sizes.
- Sanitary sewer structure locations, top of frame elevations, invert elevations and pipe sizes.
- All aboveground structures within the right of way.
- Location of curbing, sidewalks and right of way lines.
- Grading in 2-foot intervals.

Subgrade shall be stable and prepared per ConnDOT 816. If rock, ledge or any other unsuitable material is encountered, it shall be removed to 6-inches below subgrade and replaced with suitable material as approved by the Town Engineer.

Underdrains shall be installed at the direction of the Town Engineer.

Borrow materials used for fill shall be approved by the Town Engineer. The Applicant shall submit sieve analysis of all borrow materials to the Town Engineer for review and approval.

All drainage and utilities to be constructed below pavement shall be installed and tested prior to the installation of the subbase. All manhole/catch basin frames, gate valves and similar structures shall be set at final grade prior to paving.

If water is encountered during utility installation or roadway construction, dewatering measures shall be provided.

If deemed necessary due to field conditions, the Town Engineer reserves the right to require additional construction methods and/or materials as needed to ensure proper construction of the road.

Paving shall not take place between November 1 and April 1 without approval of the Town Engineer.

General roadway construction procedures, practices and standards not outlined above shall conform to ConnDOT 816.

b. Materials

   i. Subbase material shall be gravel conforming to section M.02.02 of ConnDOT 816. Roadway subbase shall be a minimum of 10-inches thick (where required).

   ii. Base material shall be processes aggregate conforming to section M.05.01 of ConnDOT 816. Roadway base shall be a minimum of 8-inches thick.

   iii. Bituminous concrete pavement shall be conform to section M.04 of ConnDOT 816 for Class I and II pavement. The two-course pavement shall be constructed with a 2-inch thick Class I binder course overlaid by a 2-inch Class II wearing course.

B. Full depth pavement repair

Description

This work shall consist of the isolated replacement of existing pavement and base by providing a full depth sawcut, removing all existing pavement and base, compacting the existing subbase material, furnishing and installing processed aggregate base, tack coat, and bituminous concrete to the thickness specified on the plan or as directed by the Public Works Operations Manager (PWOM) and/or the Engineer. It also includes the sealing of the joint between new and existing pavement.

1. Materials

   a. Bituminous Concrete shall conform to the requirements found in the Town of Tolland Design Manual.

b. All materials will be supplied from a plant certified and approved by the State of Connecticut Department of Transportation.

c. If it is found that any Bituminous Mixture, even though meeting the requirements of the Job Mix Formula, fails to perform satisfactorily, the producer shall on notice (1) immediately cease furnishing the material, (2) take immediate corrective steps to provide a mix which does perform satisfactorily.

d. Only material conforming to the requirements of these specifications and approved by the PWOM and/or the Engineer shall be used in the work. If tests of samples removed from the work reveal that the mixture is inconsistent or that other than approved materials have been incorporated in the mixture, or that the mixture is not in accordance with the specifications and the product proves unsatisfactory, the Town reserves the right to demand the replacement of the unsatisfactory bituminous concrete. All expenses of the Town incidental to such replacement, including all costs incurred in putting the road in satisfactory condition, shall be paid by the Contractor.

e. Processed Aggregate Base shall conform to the requirements found in the Town of Tolland Design Manual.

f. Tack coat shall conform to the requirements found in the Town of Tolland Design Manual.

g. Joint sealant shall be a hot liquid bituminous material that conforms to the following properties:

   i. Asphalt: Paving grade specifications asphalt cement AC-20.
   Composition: 5% minimum by weight of the bituminous material.

   ii. Cover Materials: Cover materials to eliminate tracking from traffic will be Black Beauty or equal or as directed by the PWOM.

   iii. The sealant shall be composed of a mixture of materials that will form a resilient and adhesive compound capable of effectively sealing cracks in asphalt pavements against infiltration of moisture and foreign material throughout repeated cycles of expansion and contraction with temperature changes, and that will not, at ambient temperatures, flow from the crack or be picked up by vehicle tires. The material shall be capable of being brought to a uniform pouring consistency suitable for completely filling cracks without inclusion of large air holes or discontinuities and without damage to the material. It shall remain relatively unchanged in application characteristics for at least six hours at the recommended pouring temperature in the field.

1. Construction Methods

   a. Transportation of Mixtures: The mixture shall be transported from the paving plant in trucks having tight bodies, which have previously been cleaned of all foreign material. The use of kerosene, gasoline, fuel or similar products for the coating of the inside of truck bodies is strictly prohibited. Such coatings may consist of soapy water or commercial oil emulsions (also known as soluble oils) in the proportion of one (1) part oil to six (6) parts water. When such coatings are applied, truck bodies shall be raised immediately prior to loading to remove any excess coating material. Loaded trucks shall be covered with waterproof canvas or other suitable covers. The mixture shall be delivered at a temperature within 25 degrees Fahrenheit of the approved job mix formula.

b. Method of Patching: All patches with a width 8' or larger and a length 25' or longer shall be paved using a paving machine. Patches not meeting the minimum width and length requirements for a paving box may be spread and screeded by hand. The PWOM will specifically delineate the work locations and areas to be restored in the field. No payment will be rendered for any work performed outside of the designated area(s).

c. Paving Equipment: The paving machine to be used shall be a self-powered type with an adapter to provide guidance of the screeding action. The screed or strike-off member shall be adjustable to the shape of the cross section of the existing pavement. Some method shall be provided for the tilting of the screed while in operation to secure the proper "pulling" and to result in a uniformly screeded surface. The machine shall have sufficient number of driving wheels so that there will be no undue amount of slippage. Means shall be provided for heating the screeding members by some method that will prevent accumulations of bituminous materials. Refueling of equipment in such a position that fuel might be spilled on bituminous concrete mixtures already placed or to be placed is prohibited. Solvents and cleaners for use in cleaning mechanical equipment or hand tools shall be stored well clear of areas paved or to be paved.

e. The Contractor shall sawcut to the limits of the area marked out by the PWOM with a cutting saw. The saw cut shall be vertical and in straight lines. After the existing pavement and base material is removed, the existing subbase material shall be thoroughly compacted to the methods and satisfaction of the PWOM prior to the placement of any pavement material. The Contractor shall install processed aggregate base in maximum lifts of 6" to the depth shown on the plan or directed by the PWOM. The Contractor shall take the appropriate protective measures to protect the base course from contamination. Cold joints and contact surfaces of curbing, manholes, etc. shall be painted with a thin uniform coat of tack coat just before the material is placed against them.

f. Placing of Mixture: The mixture shall be laid only when the surface is free of frost, dried to the satisfaction of the PWOM, and when the weather is not foggy or rainy. Operations shall be carried only when the atmospheric temperature in the shade is not less than 40 degrees Fahrenheit unless approval is given by the PWOM. Upon arrival, the mixture shall be immediately spread and struck-off to the width required and to such appropriate loose depth so that the compacted pavement will conform to the specified depth. In order to obtain tight and well-compacted longitudinal joints, the sequence of the bituminous concrete placing operations shall be subject to the control of the PWOM. Before any compaction is started, the surface shall be checked and inequities adjusted; all "drippings," i.e. fat, sandy accumulations, and all fat spots from any source, shall be removed and replaced by satisfactory material.

g. Compaction: After spreading and when sufficient set has developed to permit proper compaction, each course shall be compacted by rolling, consisting of initial or breakdown rolling, intermediate rolling and final or finish rolling. Initial rolling shall be performed with a power driven steel wheel tandem or three wheel rollers weighing not less than ten (10) tons. Intermediate rolling shall be done by a power driven steel wheel tandem roller. Final rolling shall be done with a self-propelled pneumatic tire roller equipped with Wide-tread compaction tires capable of exerting an average contact pressure from 60 to 90 pounds per square inch uniformly over the surface, adjusting ballast and tire inflation pressure as required. The Contractor shall furnish evidence regarding tire size, pressure and loading to confirm that the proper contact pressure is being developed and that the loading and contact pressure are uniform for all wheels.

h. Rolling: Rolling shall proceed continuously and in such a manner that all roller marks are eliminated. The rollers shall be in good condition. They shall be operated by experienced roller operators. The rolling shall begin at the sides and progress toward the center, parallel to the centerline of the roadway. and must be kept in continuous operation as nearly as practicable in such manner that all parts of the pavement shall receive substantially equal compression. Alternate trips of the roller shall be terminated in stops at least three feet distant from any preceding stop.

   i. Rolling shall be discontinued if the surface shows signs of excessive cracking or displacement and shall be continued later as directed. If it is found that the cracking and displacement continues, the paving operation shall be discontinued until the cause of the condition is corrected. In no case shall the Contractor use methods or equipment, which will result in fractured aggregate or lateral displacement of the material.

   ii. Placing of the pavement shall be as nearly continuous as possible and the roller shall pass over the unprotected end of the freshly laid mixture only when laying of the pavement is discontinued or interrupted for an appreciable period and joints shall be formed at such point. Where joints are to be formed, the edge of the existing pavement shall be cut square with the pavement. Before new material is laid, a thin coating of hot asphalt emulsion shall be applied to the vertical face of the cut pavement.

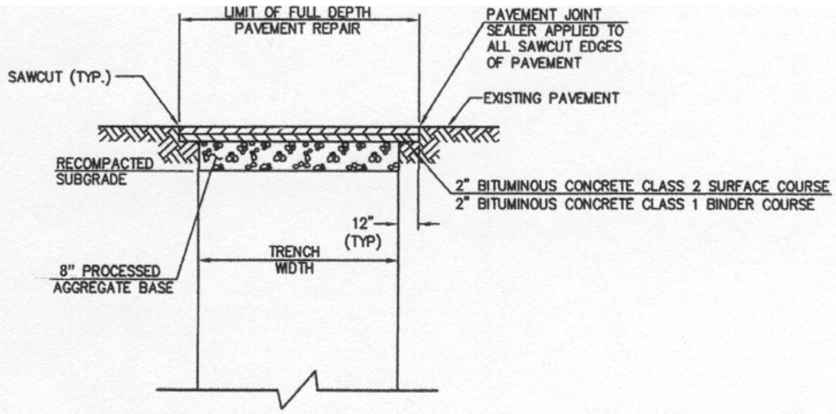
   iii. Depressions which may develop after initial rolling shall be remedied by scarifying the surface mixture laid and adding new material to bring such depressions to a true surface.

   iv. All joints between new and existing pavements shall be sealed with an approved joint sealant.

i. Protection of the Work: Sections of the newly finished bituminous work shall be protected from traffic to prevent damage to the finished mat.

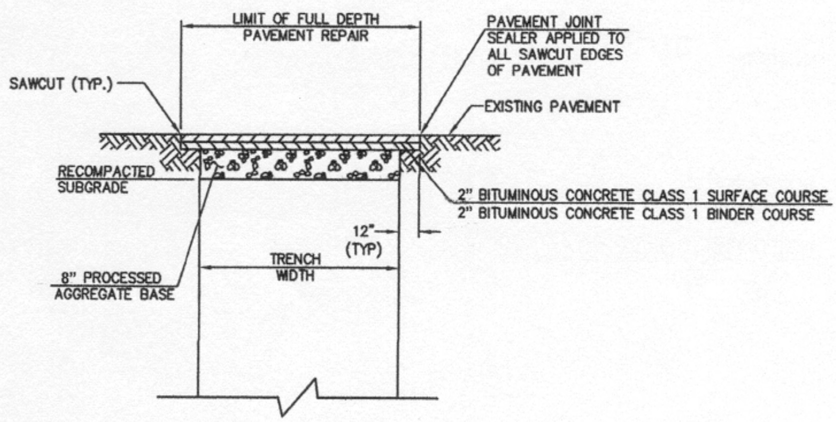
j. Other rolling procedures may be directed by the PWOM, as conditions may require.

See illustrations on following page.



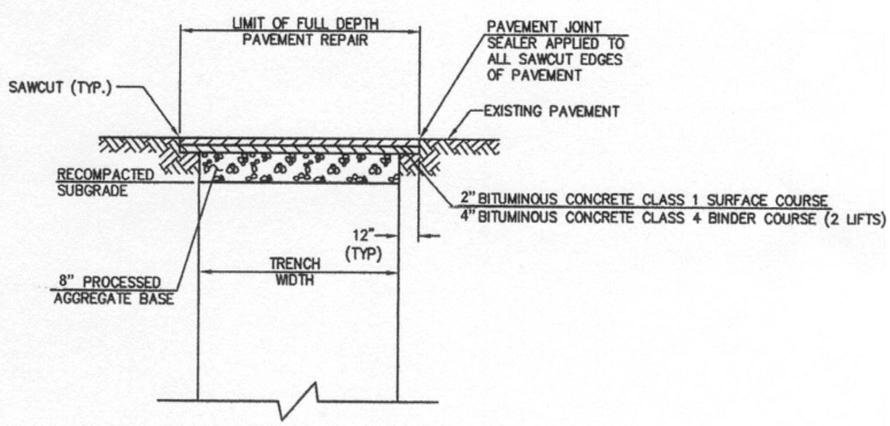
TRENCH PAVEMENT REPAIR (LOCAL ROAD)

NOT TO SCALE



TRENCH PAVEMENT REPAIR (COLLECTOR)

NOT TO SCALE



TRENCH PAVEMENT REPAIR (ARTERIAL)

NOT TO SCALE

Section IV Stormwater Management and Facilities

A. Stormwater Piping & Structures

1. Stormwater piping structures shall be installed to facilitate the conveyance of stormwater, as well as the crossing of inland wetlands and watercourses. Stormwater piping and structures located beyond the right of way shall be located within a drainage easement. Drainage easements shall be in favor of the Town of Tolland and shall permit access and maintenance. Stormwater outlet points and adjacent property shall be encumbered with an unrestricted Right to Drain in favor of the Town of Tolland.

2. Stormwater piping shall meet the following criteria:

   a. The minimum internal diameter for stormwater pipes shall be 15 inches.
   b. The minimum grade of all stormwater pipes shall be 0.5%.
   c. Stormwater pipes installed under pavement shall be Class IV RCP.
   d. Stormwater pipes installed in areas other than under pavement may be Class IV RCP or ADS (n-12).
   e. Stormwater pipes shall have a minimum cover of 30-inches.

3. Catch basins shall be pre-cast concrete and shall be provided at all significant changes in vertical or horizontal pipe alignment, at low points and at intervals not exceeding 300 feet along the road. Stormwater piping shall be prohibited from cutting the center of the roadway when connecting basins along a curve. Stormwater piping that crosses the road shall cross at a right angle or radial to the road alignment.

4. Subdivisions of five lots or greater shall provide recharge facilities that achieve a "zero increase" of stormwater runoff for a 10-year storm event.

5. Curbing shall be mountable curbing (also referred to as "Cape Cod Curbing") and constructed of bituminous concrete with a 4-inch minimum reveal.

6. Stormwater facilities shall meet the following requirements:

Structure	**Watershed Area**	**Design Frequency**	**Minimum Bridge Under Clearance for Design Frequency**
Stormwater Piping	-	25 years	-
Detention Structures	Area < 1 mi^2	50 years	-
	1 mi^2 ≤ Area < 10 mi^2	100 years	-
Culverts & Bridges	Area < 1 mi^2	25 years	-
Culverts & Bridges	Area < 1 mi^2	50 years	-
Culverts & Bridges	1 mi^2 ≤ Area < 10 mi^2	100 years	1.0 feet
Culverts & Bridges	10 mi^2 ≤ Area < 1,000 mi^2	100 years	2.0 feet

Section V Miscellaneous Items

A. Utilities

Utilities within the right of way shall be placed underground whenever possible, unless otherwise approved by the Planning & Zoning Commission.

B. Sidewalks

Sidewalks (if required) shall meet the following criteria:

Walk Type	**Subbase**	**Base Course**	**Surface Treatment**
Stone Dust Path	N/A	8-inches Gravel	4-inches of Stone Dust
Bituminous Walk	8-inches of Gravel	4-inches Process Gravel	3-inches of Class II Bituminous Concrete
Concrete Walk	N/A	6-inches of Process Gravel	4-inches of 3000 psi Reinforced Concrete

C. Final Acceptance of Roadway by the Town of Tolland
Prior to acceptance of a road by the Town of Tolland, the right of way shall be marked in the field with 36-inch long reinforced concrete monuments set at all points of curvature and tangency. Monuments shall generally be set no more than 4" above finished grade. Property corners shall be marked with iron pins or pipes with a minimum diameter of 5/8" and length of 36". Property corners shall generally be set not more than 4" above the finished grade. A Land Surveyor licensed by the State of Connecticut shall certify that all pins and monuments have been set to the standards of an A-2 Survey.

D. Sedimentation and Erosion Control.

Sedimentation and Erosion Control measures shall be detailed in the proposed design consistent with Town and State regulations. The Sedimentation and Erosion Control Plan(s) shall show details of proposed controls and a narrative outlining the construction schedule and corresponding measures. The Town reserves the right to require additional measures beyond those specified on the approved construction documents if field conditions necessitate such measures as directed by the Town Engineer.

E. Guiderails

Guiderail may be required on roadways where the vertical difference from the edge of the snow shelf to the toe of the slope exceeds 5-feet and the overall slope is 3:1 (horizontal to vertical). Alternatively, the Planning & Zoning Commission and/or the Town Engineer may require that the slope section be extended to eliminate or reduce the need for guiderail.

F. Driveways

Driveways shall have a minimum width of 10-feet and the average grade may not exceed 10%, with no grade in excess of 12%. Driveways in excess of 10% shall be paved. Entrances to residential driveways shall provide a transition radius of 5-feet and have a maximum slope of 5% for the first 50-feet of its length, beginning at the intersection of the drive and roadway. Driveway entrances shall be perpendicular or radial to the roadway alignment. Appropriate sightlines at all driveways shall be provided. Driveways accessing Primary Local and Secondary Local Roads shall have minimum sightlines of 200-feet. Stormwater runoff from driveways and adjacent land shall not cause hazardous conditions on the traveled way. Unpaved driveways accessing a paved roadway shall have paved aprons 12-feet long, measured from the edge of roadway pavement. Aprons shall be constructed with 4” thick Class II bituminous concrete placed on 8” of compacted processed aggregate.

G. Shared Residential Driveways

The shared portion of residential driveways shall be a minimum of 15-feet and maximum of 20-feet in width and constructed with 8-inches of bank run gravel, 6-inches of processed gravel and 3-inches Class II bituminous concrete. Non-shared portions of the driveways shall be a minimum of 10-feet and maximum of 20-feet in width.

8.0 Computational and Design Examples

8.1 – Groundwater Recharge Volume and Water Quality Volume

Sample Site: A 25 acre site shall be developed as single family residential units. The total impervious cover shall be 9 acres; 5 acres on HSG "A", 3 acres on HSG "B" and 1 acre on HSG "C". The Groundwater Recharge Volume is calculated as follows:

GRv = (1")(D)(I)/12

GRv for HSG A: (1")(0.60)(5)/12 = 0.25 acre-feet
GRv for HSG B: (1")(0.40)(3)/12 = 0.10 acre-feet
GRv for HSG C: (1")(0.25)(1)/12 = 0.02 acre-feet

On the same site, the post-development conditions will divide the site into two subwatershed areas. One area contains 13 acres with 6 acres of the impervious cover, the second contains 12 acres with 3 acres of impervious coverage. The Water Quality Volume will be calculated for each area.

WQv = (1")(I)/12

WQv for Area 1: (1")(6)/12 = 0.50 acre-feet
WQv for Area 2: (1")(3)/12 = 0.25 acre-feet

8.2 – Application of Environmental Site Design Strategies

Sample Site: A 104 acre site, located in Winchester, CT to be developed as single family residential units. Site is mostly wooded with hardwoods being the dominant species. Some meadow areas exist from past farming operations.

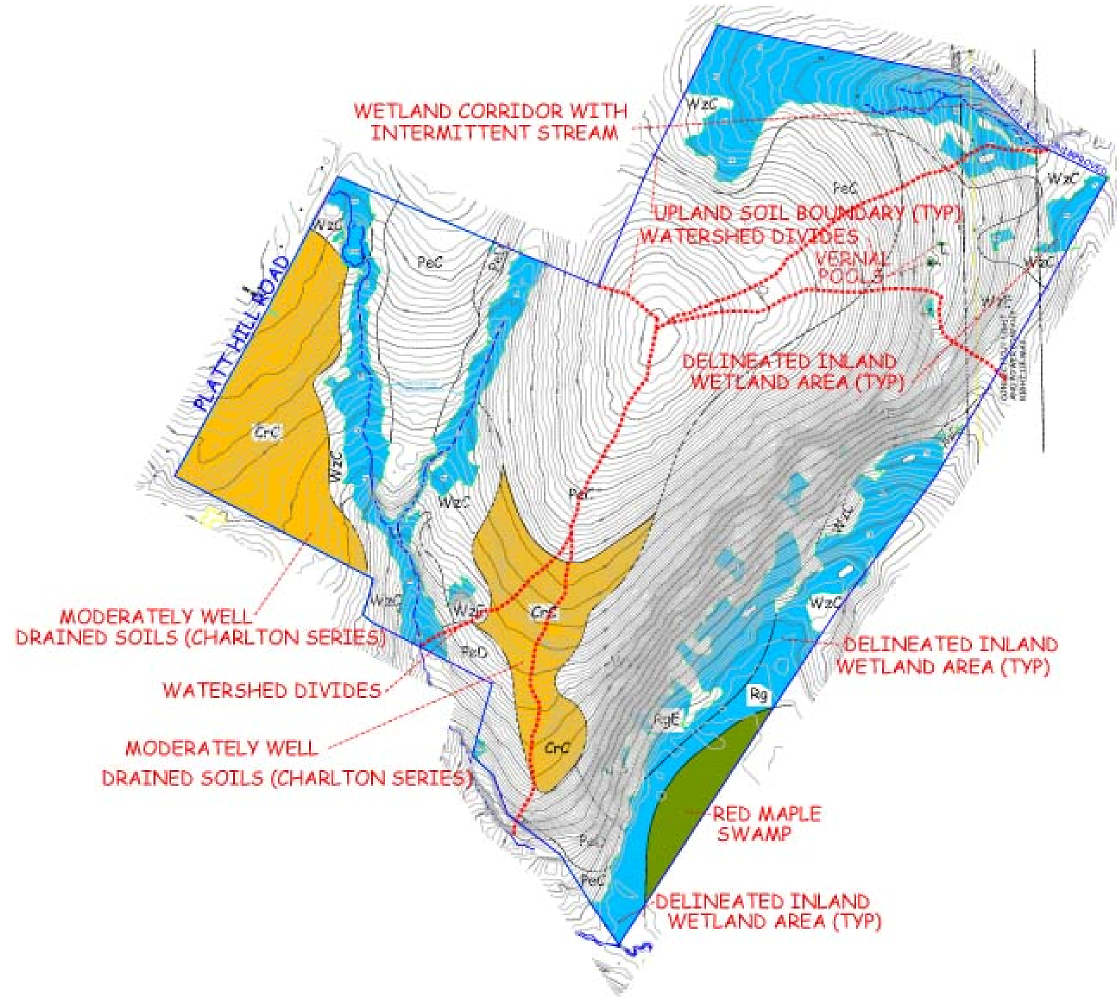


Figure 8.2.a - Wetlands/Watercourses/Soils/Drainage Divides

Figure 8.2.a shows the results of the initial assessment of the natural resources on the site. The wetlands, watercourses, red maple swamp and vernal pools have been highlighted on the plan. In addition, those soils with good to moderate infiltrative capacities have been determined by the soil scientist and verified by soil testing. The existing subwatersheds on the site have been delineated.

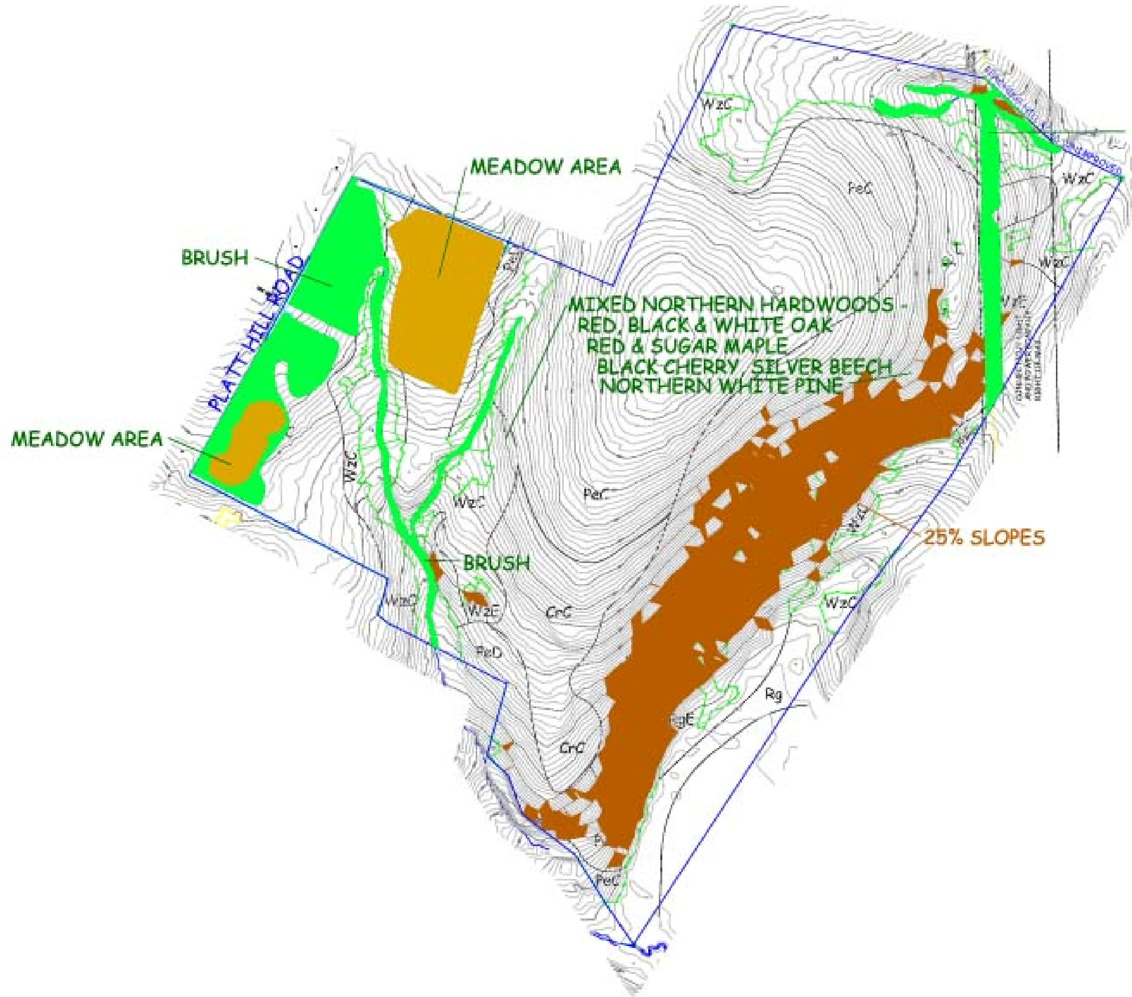


Figure 8.2.b - 25% Slopes/Vegetation Types

Figure 8.2.b shows the extent of 25% slopes on the site, along with the generalized vegetative communities.

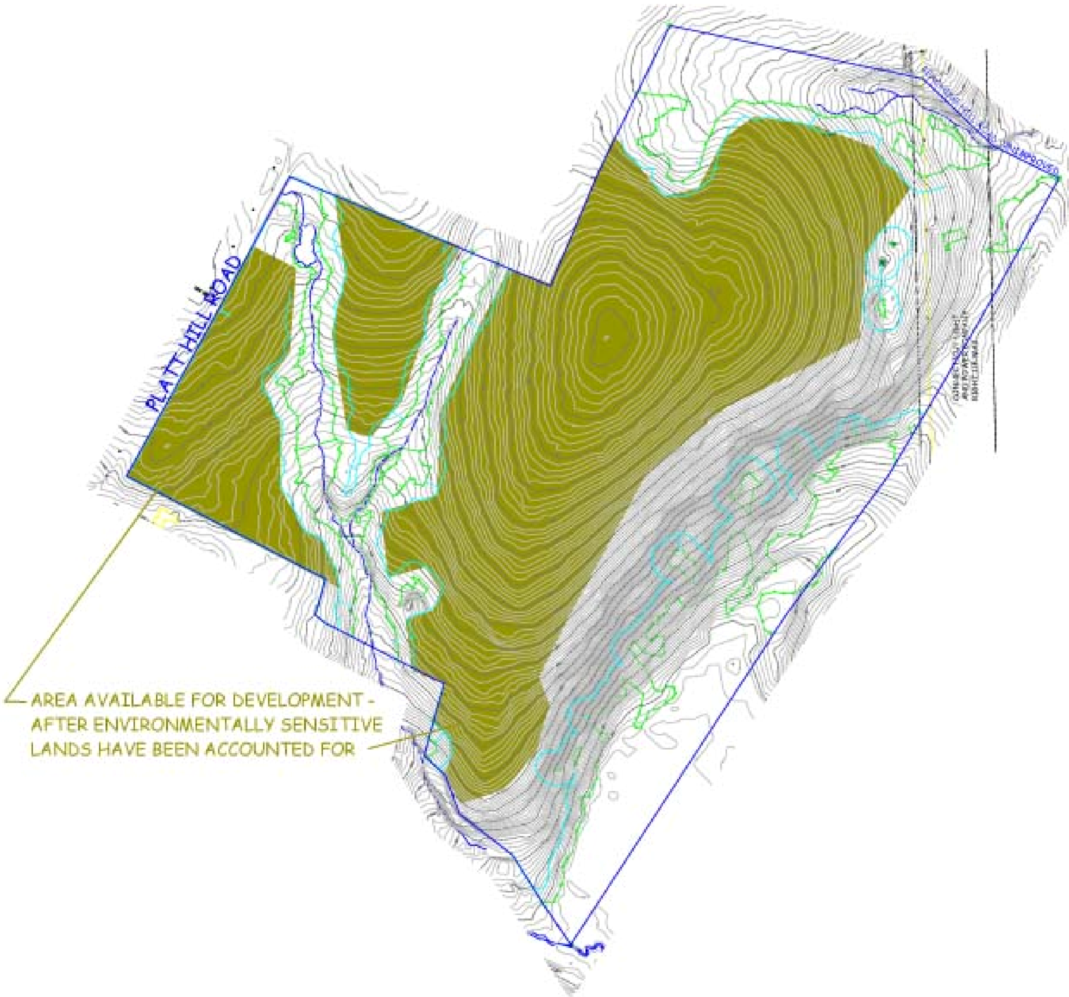


Figure 8.2.c - Developable Area

Figure 8.2.c shows the land remaining after the environmentally sensitive areas have been removed from development consideration. At this point, the good infiltrative soils and the ridge top are included as part of the developable area.

The designer can then evaluate the previously performed soil test results to determine the best locations on the site to support on-site sewage disposal systems. Once ideal conceptual locations are determined for on-site sewage disposal systems, potential home locations shall be determined. The goals of LID, such as working with the land, minimizing site clearing and site disturbance, and addressing stormwater at its source will also be considered during this time. As the designer begins to formulate the development concept for the property, it is important to balance potential unavoidable direct impacts on wetlands and watercourses with the LID strategies. At this point the strategies discussed in Section 3.4 for the layout of roads, driveways and lots shall be applied to the site.

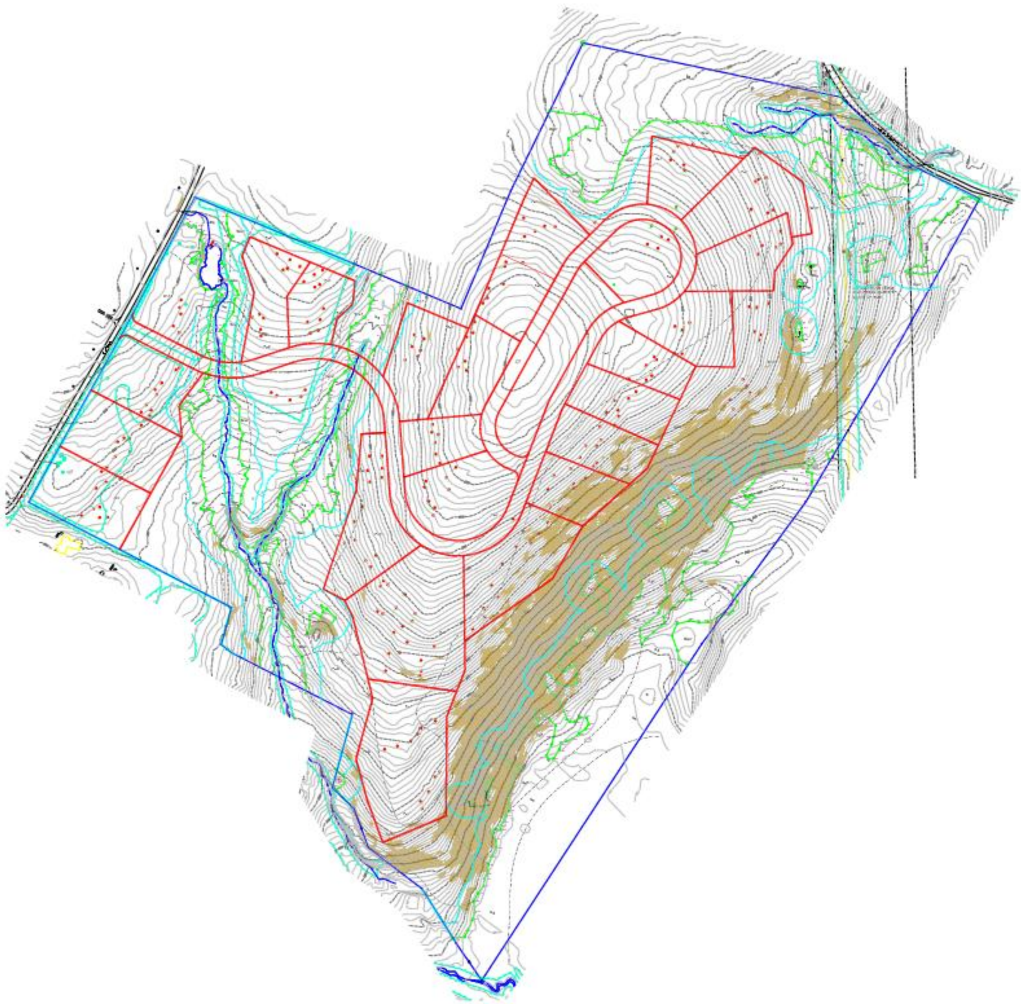


Figure 8.2.d – Road & Lot Layout

In Figure 8.2.d, roads have been laid out to follow the existing contours to the maximum extent possible. This will minimize clearing limits as well as grading requirements. Lots are laid out in the area defined as developable area. Most of the density is concentrated on lands having Class C soils, while the density is less on those soils with high to moderate infiltration rates.

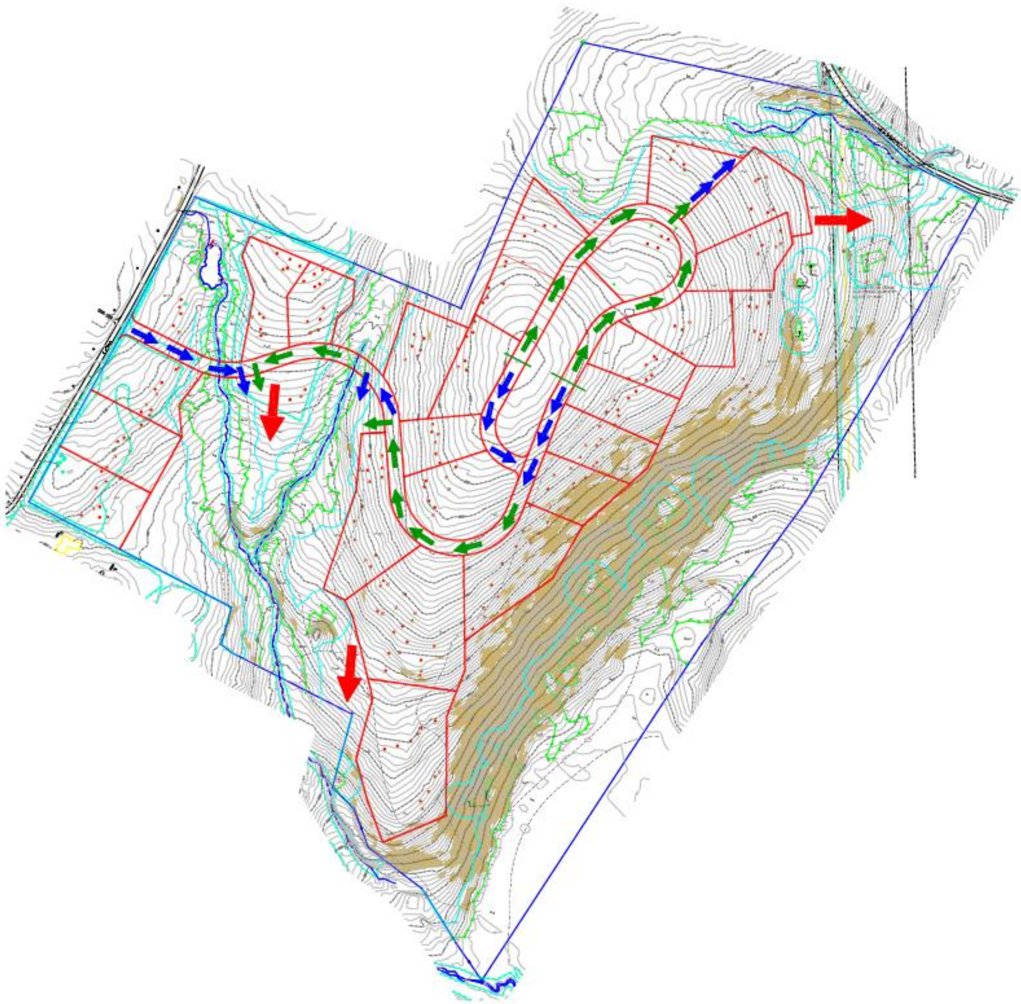


Figure 8.2.e – Preliminary stormwater layout

Figure 8.2.e demonstrates the conceptual layout of the stormwater conveyance system. The Red arrows connote discharge locations for post-development stormwater which will maintain pre-development watershed boundaries. Green arrows show locations where vegetated conveyance systems can be utilized due to topographic conditions. Blue arrows show the extent of conveyance drainage systems (catch basin & pipe).

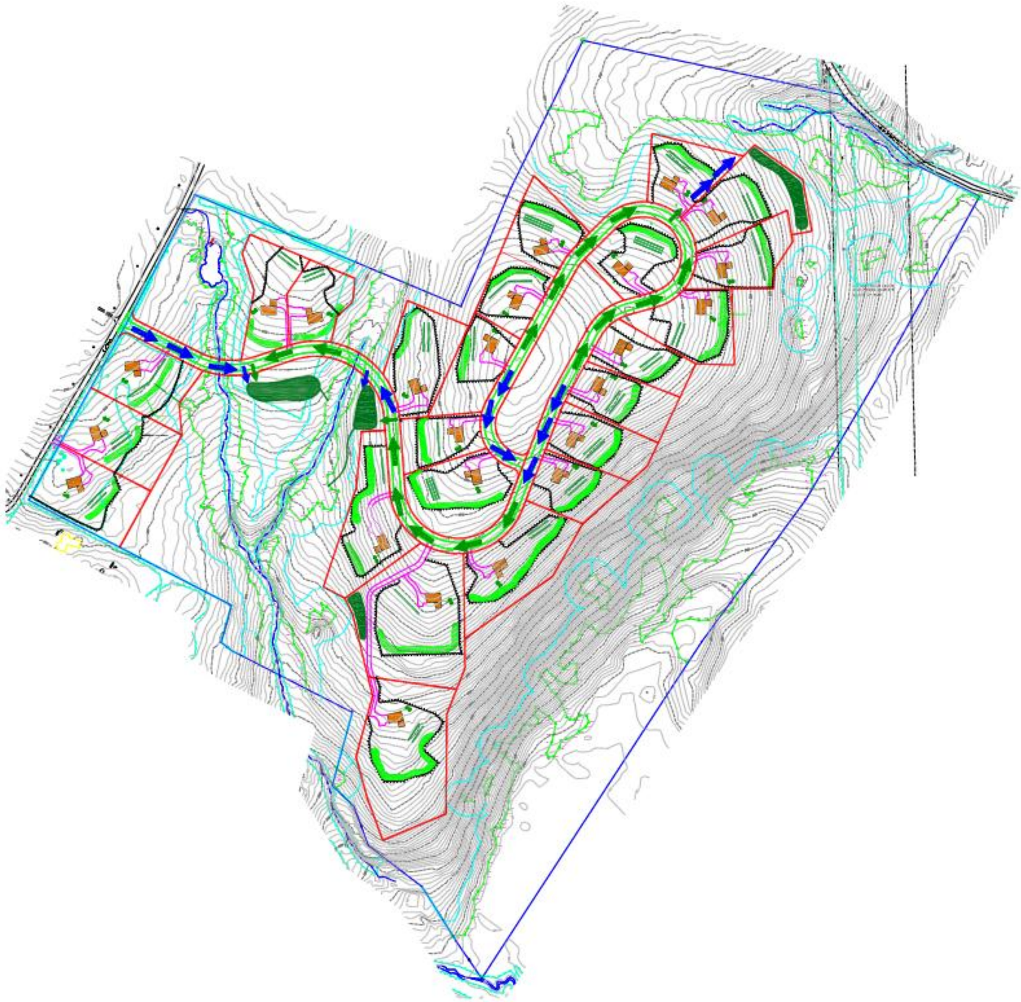


Figure 8.2.f – Implementation of LID Concepts

Figure 8.2.f demonstrates how several LID strategies can be applied to the site. Site fingering is utilized to define clearing limits of each lot. Rain gardens are utilized for the runoff from roof areas. Impervious area disconnection to encourage flow across vegetated surfaces is used for driveways down-gradient of the road. Meadow filter strips are installed at the downhill edge of all lawn areas to filter runoff prior to entering undisturbed woodlands.

Figure 8.2.g – Final Site Design

Figure 8.2.g clearly demonstrates how the use of Open Space Subdivision Concepts results in the preservation of 60% of the site area. Stormwater from the connected impervious areas are directed to either a Subsurface Gravel Wetland, Constructed Wetland, grass swale with filter berms, linear vegetated level spreader, or infiltration trenches for both groundwater recharge and water quality.

By the implementation of these LID strategies and treatment system, both metrics for LID were achieved. Pre-development groundwater recharge rates were met as well as matching the pre-development Runoff Curve Number after development.

As a key goal of LID is meeting of the pre-development hydrologic conditions, the design will likely go through several iterations to reach the desired result. This particular project went through three design iterations before the LID goals were achieved. The paradigm shift from "end of the pipe" to "source control" for handling stormwater will become second nature for the designer with time.

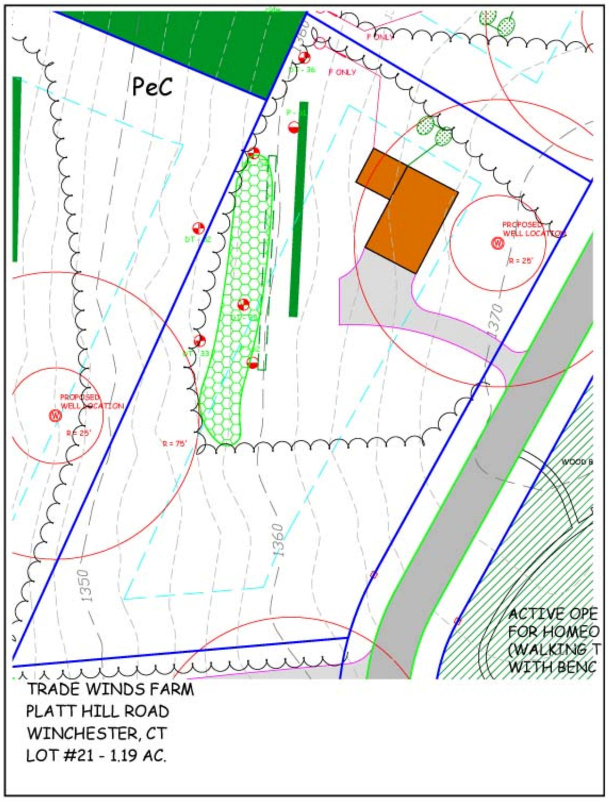


Figure 8.2.h – Individual Lot Design

This figure demonstrates the application of the following LID strategies: Site fingerprinting to define percentage clearing limit on lot, rain gardens for roof drains, meadow filter strip at downhill limit of lawn area, and impervious area disconnection as runoff from driveway will occur as overland flow across rear yard.

9.0 Definitions

Adverse Impact: Any deleterious effect on waters or wetlands, including their quality, quantity, surface area, species composition, aesthetics or usefulness for human or natural uses which are or may potentially be harmful or injurious to human health, welfare, safety or property, to biological productivity, diversity, or stability or which unreasonably interfere with the enjoyment of life or property, including outdoor recreation.

Bank full Discharge: Stream discharge that fills the channel to the top of the banks and just begins to spread onto the floodplain. Bank full discharges occur on average every 1 to 1.5 years in undisturbed watersheds and are primarily responsible for controlling the shape and form of natural channels.

Biological Oxygen Demand: A measurement of the oxygen demand of organic material which, when breaking down in water, consumes oxygen in the water column.

Bioretention: On-lot retention of storm water through the use of vegetated depressions engineered to collect, store, filter and infiltrate runoff.

Best Management Practice (BMP): The practice or combination of practices that are the most effective and practical means of reducing or eliminating the discharge of pollutants to surface waters from point or non-point source discharges, including storm water.

Buffer: A vegetated zone adjacent to a stream, wetland, or shoreline where development is restricted or controlled to minimize the effects of development.

Channel Protection Flow (CPf): Control the 2-yr, 24 hour post-development peak flow rate to 50 percent of the 2-yr, 24 hour pre-development level or to the 1-yr, 24 hour pre-development level.

Clear Cutting: The removal of all of the trees from a given land area.

Clearing: The removal of trees and brush from the land, but shall not include the ordinary mowing of grass.

Cluster (Open Space) Development: A development concept by which lots or buildings are concentrated in specific areas to preserve large, contiguous area of the natural environment while minimizing infrastructure and development costs. The preservation of large, contiguous areas of the natural environment allow for passive recreation, common open space, and preservation of environmentally sensitive features.

Conveyance Protection: Design the conveyance system leaching to, from, and through storm water management facilities based upon the 10-year, 24 hour storm event.

Curbs: Concrete or bituminous concrete barriers on the edge of streets used to direct storm water run-off to an inlet or storm drain and to protect lawns and sidewalks from vehicles.

Denitrification: Reduction of nitrate (commonly by bacteria) to nitrogen gas in an anaerobic environment.

Design Storm: A rainfall event of specific size, intensity, and return frequency that is used to calculate runoff volume and peak rate discharge.

Detention: The temporary storage of storm water to control discharge rates, allow for infiltration, and improve water quality.

Dry Detention Basin: A permanent structure for the temporary storage of runoff, which is designed so as not to create a permanent pool of water.

Dry Well: Hollow concrete or plastic structure, surrounded by crushed stone placed in the ground to control and infiltrate roof top runoff.

Easement: A grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes.

Erosion: The process of soil detachment and movement by forces of wind and water.

Environmental Site Design (ESD): The process of assessing and evaluating the natural resources on a site prior to the creation of development plans and the application of LID strategies to minimize the impact on the environment.

Evapotranspiration: Collective term for the processes of water returning to the atmosphere via interception and evaporation from plant surfaces and transpiration through plant leaves.

Exfiltration: Movement of water from an infiltration management practice into the surrounding soil layers.

Flow Attenuation: Prolonging the flow time of runoff to reduce the peak rate of discharge.

Grading: The act by which soil is cleared, stripped, stockpiled, excavated, scarified, and filled or any combination thereof.

Groundwater Recharge Volume (GRv): Maintain pre-development annual groundwater recharge volume to the maximum extent practicable through the use of infiltration measures.

Hydrologically Functional Landscape: Term used to describe a design approach for the built environment that attempts to more closely mimic the overland and subsurface flow, infiltration, storage, evapotranspiration, and time of concentration characteristic of the native landscape of the area.

Hydrologic Transparency: The use of LID design strategies and storm water treatment systems for a development scenario which yields hydrologic conditions matching or in extremely close proximity to the hydrologic conditions of the natural site prior to development.

Hydromodification: The alteration of a natural drainage system through a change in the system's flow characteristics.

Impervious Area: A hard surface that prevents or severely retards the entry of water into the soil, thus causing water to run off the surface in greater amounts and at an increased rate of flow when compared to natural conditions. The surfaces include, but are not limited to, conventional asphalt or concrete roads, parking areas, sidewalks, alleys and roof tops.

Infiltration: The downward movement of water from the land surface down into the soil.

Integrated Management Practices: The application of multiple storm water treatment systems to address increased runoff volumes from development. IMP offers several techniques including storm water harvest (to reduce the amount of water that can cause flooding), infiltration (to restore the natural recharge of groundwater), biofiltration or Bioretention (e.g., rain gardens) to store and treat runoff and release it at a controlled rate to reduce impact on streams and wetland treatments (to store and control runoff rates and provide habitat in urban areas).

Low Impact Development: The integration of site ecological and environmental goals and requirements into all phases of urban planning and design from the individual lot level to the entire watershed.

Nitrification: Process in which ammonium is converted to nitrite and then nitrate by specialized bacteria.

Non-point Source Pollutants: Pollutants in water caused by rainfall or snowmelt moving both over and through the ground and carrying with it a variety of pollutants associated with human land uses. A non-point source is any source of water pollution that does not meet the legal definition of point source in Section 502(14) of the Federal Clean Water Act.

NPDES: National Pollutant Discharge Elimination System is a regulatory program in the Federal Clean Water Act that prohibits the discharge of pollutants into the surface waters of the United States without a permit.

Open Space: Land set aside for public or private use within a development that is not built upon and is legally preserved in its natural state for perpetuity.

Phosphorous (P)-Index: The measure of the amount of phosphorous a soil contains. A low P-Index means a soil can absorb more phosphorous from the stormwater. Soils with high levels of Iron and Aluminum will have a low P-Index thus providing Cation Exchange Capacity (CEC) for removing phosphorous.

Peak Runoff Attenuation: Control the post-development peak discharge rates from the 10-yr, and 100-yr 24 hour storm events to the corresponding pre-development peak discharge rate, as required by the local regulatory authority.

Permeable: Soil or other material that allows for the infiltration or passage of water.

Recharge Zone: A land area in which surface water infiltrates the soil and reaches the zone of saturation or shallow groundwater table.

Retention Basin: A permanent structure that provides for the storage of runoff by means of a permanent pool of water.

Retrofitting: The construction of a BMP (both structural and non-structural) in a previously developed area, the modification of an existing BMP (both structural and non-structural), to improve the water quality over current conditions.

Runoff: Water from rain, snow melt or irrigation that flows over the land surface.

Runoff Curve Number (RCN): The runoff curve number is an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess. The curve number method was developed by the USDA Natural Resources Conservation Service, which was formerly called the *Soil Conservation Service* or *SCS* — the number is still popularly known as a "SCS runoff curve number" in the literature. The runoff curve number was developed from an empirical analysis of runoff from small catchments and hillslope plots monitored by the USDA. It is widely used and is an efficient method for determining the approximate amount of direct runoff from a rainfall event in a particular area.

Sediment: Soils or other surfical materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

Site fingerprinting: The delineation of the smallest possible area for clearing and site disturbance where roads, structures and other improvements are to be constructed.

Stabilization: The prevention of soil movement by any of various vegetative and/or structural means.

Storm water Management Plan: A set of drawings or other documents submitted by a person(s) as a prerequisite to obtain a storm water management approval, which contains all of the information and specifications pertaining to storm water management and conforms to the standards found in the Design Manual.

Swale (generic): An open channel designed to convey storm water.

Time of Concentration: The time that it takes surface runoff to reach the outlet of a sub-basin or watershed from the most hydraulically distant point in that watershed.

Vegetated Swale: An open channel which is planted with grasses (primarily) convey runoff.

Water Quality Volume (WQv): The volume needed to capture and treat the runoff from the 90 percent of the average annual rainfall at a development site. Methods for calculating the water quality volume are specified in the Design Manual.

Watercourse: Any natural or artificial stream, river, creek, ditch, channel, canal, conduit, culvert, drain, waterway, gully, ravine, or wash in and including any adjacent area that is subject to inundation from overflow or flood water.

Watershed: The topographic boundary within which water drains to a particular stream, river, wetland or other body of water.

Water Quality Flow (WCf): Peak flow associated with the water quality volume calculated using the NRCS Graphical Peak Discharge Method.

Water Quality Storm: A rainfall event of 1.2” of rain in 24-hours which results in 1” of runoff from an impervious surface.

Wet Swale: A vegetated conveyance system also used to remove pollutants from storm water runoff.

10.0 Manual References

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D. Innovative Land Use Planning Techniques – A Handbook for Sustainable Development; NH Department of Environmental Services, October 2008

E. Low-Impact Development Design Strategies, An integrated Design Approach; Prince George's County, Maryland, Programs and Planning Division of the Department of Environmental Resource, June 1999

F. Low-Impact Development Hydrologic Analysis; Prince George's County, Maryland, Programs and Planning Division of the Department of Environmental Resource, July 1999

G. Low Impact Development – Technical Guidance Manual for Puget Sound, January 2005; Puget Sound Action Team – Washington State University Pierce County Extension

H. Natural Approaches to Stormwater Management – Low Impact Development in Puget Sound, March 2003; Puget Sound Action Team

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J. National Pollutant Removal Database, 2nd Edition; March 2000; Center for Watershed Protection

K. National Pollutant Removal Database, Version 3.0, Center for Watershed Protection, September 2007

L. National Stormwater Quality Database, Version 1.1 – A compilation and Analysis of NPDES Stormwater Monitoring Information; Alex Maestre and Robert Pitt, Department of Civil Engineering, University of Alabama, Center for Watershed Protection, September 4, 2005

M. New Hampshire Stormwater Manual, Volume 1 – Stormwater and Antidegradation, NH Department of Environmental Services, December 2008

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O. Rhode Island Stormwater Design and Installation Standards Manual and Appendices, April 2010

P. The Practice of Watershed Protection, Center for Watershed Protection, 2000

Q. The Sustainable Sites Initiative – Guidelines and Performance Benchmarks, 2009. American Society of Landscape Architects

R. The Sustainable Sites Initiative – The Case for Sustainable Landscapes, 2009. American Society of Landscape Architects

S. University or New Hampshire Storm Water Center, 2007 and 2009 Annual Reports

T. UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds, October 2009. University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH

U. UNHSC Subsurface Gravel Wetland Design Specifications, June 2009. University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH

APPENDIX A
STORMWATER MANAGEMENT PLAN CHECKLIST

Stormwater Management Plan Checklist for Projects

A.1 General Information

- ☐ Appliant’s name, mailing address, telephone number, email
- ☐ Name, address, phone and email of licensed professional engineer responsible for the preparation of the stormwater management plan
- ☐ Street address of project site
- ☐ Vicinity map at a scale of 1” = 1000’ or larger
- ☐ Current zoning and land use
- ☐ Proposed use of property

A.2 Mapping Requirements for Existing Natural Resources

- ☐ Overall plan at a scale not to exceed 1” = 100’
- ☐ North arrow
- ☐ Existing topography (2’ contours based upon aerial or field mapping)
- ☐ Location of all man-made features on or adjacent to the site, such as roads, drainage systems, utilities, and buildings
- ☐ Location of inland wetlands and watercourses as defined by Certified Soil Scientist in the field and flags located by a licensed land surveyor
- ☐ Location of vernal pools, swamps, or bogs by qualified environmental consultant
- ☐ Location of 100-year flood plans, if applicable from current FEMA mapping
- ☐ Mapping of upland soil types by either soil scientist or NRCS mapping
- ☐ Extent and type of different vegetative communities on the site
- ☐ Delineation of existing watershed boundaries on the site
- ☐ Delineation of 25% slopes on the site

A.3 Mapping Requirements for Proposed Project

- ☐ Location & results of soil test pits performed on the site
- ☐ Delineation of proposed watershed boundaries on the site
- ☐ Location of proposed roads, lot lines, buildings, driveways and other improvements to the site

- ☐ Location of all proposed stormwater management conveyance and LID treatment systems

A.4 **Compliance with Section 4.0 Stormwater Management Requirements**

4.2 Environmental Site Design

- ☐ Identification of environmentally sensitive resources on the site
- ☐ Maintain existing drainage patterns on the site to the maximum extent practical
- ☐ Maintain as much of the site in the natural condition to maintain pre-development hydrology
- ☐ Protection of natural drainage systems, such as wetlands, watercourses, ponds, vernal pools to maximum extent practical
- ☐ Minimize the extent of land disturbance for clearing and grading
- ☐ Demonstrate that soil compaction has been minimized or will be remediated on the site
- ☐ Layout of roads, lots, driveways, buildings, etc to minimize the extent of impervious coverage on the site
- ☐ Utilize LID stormwater strategies to adjust the post-development time of concentration to match or closely approximate the pre-development time of concentration in each subwatershed area
- ☐ Application of source controls to collect, convey and treatment stormwater runoff at its source
- ☐ Demonstrate that impervious areas have been disconnected to the maximum extent practical
- ☐ Demonstrate that the application of pollutant causing substances have been minimized on the site
- ☐ Demonstrate that flow velocities are reduced to non-erosive levels

4.3 Groundwater Recharge Volume

- ☐ Provide amount and type of impervious cover in each subwatershed area
- ☐ Provide calculations of Groundwater Recharge Volume for each post-development subwatershed area and for each soil type within the area
- ☐ Provide the amount of volume required to meet the Groundwater Recharge Volume

4.4 & 4.5 Water Quality Volume and Pollutant Renovation Analysis

- ☐ Provide amount and type of impervious cover in each subwatershed area

☐ Provide calculations for the Water Quality Volume for each subwatershed area

☐ Provide the amount of volume required to meet the Water Quality Volume

☐ Provide pollutant renovation analysis to demonstrate that all Water Quality Goals will be achieved by the proposed stormwater treatment systems

4.6 Channel Protection Flow

☐ Calculate the Channel Protection Flow for each discharge point of the stormwater management system as applicable

☐ Demonstrate how the reductions in peak rate for the 2-year post-development storm will be reduced to comply with this requirement

☐ Provide time of concentration calculations for each area for pre- and post-development conditions

☐ Provide Runoff Curve Numbers for each area for pre- and post-development conditions

☐ Provide routing analyses for stormwater management system being used to meet this requirement

4.7 Conveyance Flow

☐ Provide drainage area, time of concentration, and peak rate of runoff for each conveyance system

☐ Provide calculations to demonstrate that any open or enclosed drainage conveyance systems have been sized in accordance with this requirement

4.8 Flood Protection

☐ Calculate the peak rate of runoff for the 10-year, 24-hour storm event and the 100-year, 24-hour storm event, if necessary for each watershed area as applicable

☐ Provide time of concentration calculations for each area for pre- and post-development conditions

☐ Provide Runoff Curve Numbers for each area for pre- and post-development conditions

☐ Provide routing analyses for stormwater management system being used to meet this requirement

4.10 Pollution Prevention

☐ Provide a written statement describing how pollution prevention will occur on the site both during construction and the post-construction period

☐ Describe maintenance requirements for the pollution prevention plan and who will be responsible for compliance with these requirements.

4.11 High Density Residential / Commercial / Industrial Redevelopment

☐ Demonstrate that the requirements for Groundwater Recharge Volume and Water Quality Volume have been met for a redevelopment project

☐ Identify the specific land use which will be present on the site

☐ Provide survey showing the proposed increase of impervious area proposed

☐ Provide calculations for Groundwater Recharge Volume for building roof and Water Quality Volume for all impervious areas as required

☐ Demonstrate how these requirements will be addressed on the site

APPENDIX B
PLANT LIST FOR LID TREATMENT SYSTEMS

Plant List for LID Treatment Systems

There are six distinct hydrological planting zones for Low Impact Development Treatment Systems. Table B defines the hydrological characteristics of each planting zone.

Table B – Hydrologic Planting Zones

Zone #	Hydrologic Condition	Zone Description
1	1-6' deep permanent pool	Deep Water Pool
2	6 inches to 1 foot deep	Shallow Water Bench
3	Regularly inundated	High & Low Marsh
4	Periodically inundated	Riparian Fringe, Aquatic Bench
5	Infrequently inundated	Upland terraces within pond/wetland system
6	Rarely inundated	Upland slopes

ZONE 1 – Deep Water Pool

Trees and shrubs: not recommended for this zone

Herbaceous Plants:

Coontail	Submergent
Duckweed	Submergent/Emergent
Pond Weed	Submergent
Waterweed	Submergent
Wild Celery	Submergent

ZONE 2 – Shallow Water Bench

Trees and shrubs:

Buttonbush	Deciduous shrub

Herbaceous Plants:

Arrow arum	Emergent
Arrowhead, Duck Potato	Emergent
Blue Flag Iris	Emergent
Blue Joint	Emergent
Broomsedge	Perimeter
Bushy Beardgrass	Emergent
Cattail	Emergent
Duckweed	Submergent/Emergent
Hardstem Bulrush	Emergent
Long-leaved Pond Weed	Rooted Submerged Aquatic
Pickerelweed	Emergent
Sedges	Emergent
Soft-stem Bulrush	Emergent
Smartweed	Emergent

Herbaceous Plants:	
Soft Rush	Emergent
Switchgrass	Perimeter
Sweet Flag	Herbaceous
Wild Rice	Emergent
Wool Grass	Emergent

ZONE 3 – High & Low Marsh

Trees and shrubs:

Arrowwood Viburrium	Deciduous shrub
Bald Cypress	Deciduous tree
Black Ash	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Elderberry	Deciduous shrub
Larch	Coniferous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Silky Dogwood	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Winterberry	Deciduous shrub

Herbaceous Plants:

Arrow arum	Emergent
Arrowhead, Duck Potato	Emergent
Blue Flag Iris	Emergent
Blue Joint	Emergent
Broomsedge	Perimeter
Bushy Beardgrass	Emergent
Cattail	Emergent
Duckweed	Submergent/Emergent
Flat-top Aster	Emergent
Hardstem Bulrush	Emergent
Long-leaved Pond Weed	Rooted Submerged Aquatic
Pickerelweed	Emergent
Redtop	Perimeter
Sedges	Emergent
Soft-stem Bulrush	Emergent
Smartweed	Emergent
Soft Rush	Emergent
Switchgrass	Perimeter
Sweet Flag	Herbaceous

Herbaceous Plants:

Wild Rice	Emergent
Wool Grass	Emergent

ZONE 4 – Riparian Fringe, Aquatic Bench

Trees and shrubs:

American Elm	Deciduous tree
Arrowwood Viburrium	Deciduous shrub
Bald Cypress	Deciduous tree
Black Ash	Deciduous tree
Black Gum	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Eastern Cottonwood	Deciduous tree
Elderberry	Deciduous shrub
Larch	Coniferous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Shadowbush	Deciduous shrub
Silky Dogwood	Deciduous tree
Slippery Elm	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Sweetgum	Deciduous tree
Winterberry	Deciduous shrub
Witch Hazel	Deciduous shrub

Herbaceous Plants:

Big Bluestem	Perimeter
Birdfoot deervetch	Perimeter
Blue Joint	Emergent
Broomsedge	Perimeter
Cardinal Flower	Perimeter
Fowl Bluegrass	Emergent
Green Bulrush	Emergent
Redtop	Perimeter
Tufted Hairgrass	Perimeter
Smartweed	Emergent
Soft Rush	Emergent
Swamp Aster	Emergent
Water Plantain	Emergent

ZONE 5 – Upland Terraces within Pond / Wetland Systems

Trees and shrubs:

American Elm	Deciduous tree
Bayberry	Deciduous shrub
Black Ash	Deciduous tree
Black Cherry	Deciduous tree
Black Gum	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Eastern Cottonwood	Deciduous tree
Eastern Hemlock	Coniferous tree
Elderberry	Deciduous shrub
Green ash	Deciduous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Shadowbush	Deciduous shrub
Silky Dogwood	Deciduous tree
Slippery Elm	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Sweetgum	Deciduous tree
Winterberry	Deciduous shrub
Witch Hazel	Deciduous shrub

Herbaceous Plants:

Annual Ryegrass	Perimeter
Big Bluestem	Perimeter
Cardinal Flower	Perimeter
Creeping Red Fescue	Perimeter
Redtop	Perimeter
Switchgrass	Perimeter

ZONE 6 – Upland Slopes

Trees and shrubs:

American Elm	Deciduous tree
Bayberry	Deciduous shrub
Black Cherry	Deciduous tree
Eastern Hemlock	Coniferous tree
Eastern Red Cedar	Coniferous tree
Elderberry	Deciduous shrub
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
Shadowbush	Deciduous shrub

Trees and shrubs:	
Sweetgum	Deciduous tree
White Ash	Deciduous tree

Herbaceous Plants:

Birdfoot deervetch	Perimeter
Cardinal Flower	Perimeter
Switchgrass	Perimeter

APPENDIX C
LOW IMPACT DEVELOPMENT RESOURCES

Low Impact Development Resources

A. Low Impact Development Center http://www.lowimpactdevelopment.org/

B. University of New Hampshire Stormwater Center http://www.unh.edu/erg/cstev/

C. Wisconsin Department of Natural Resources http://dnr.wi.gov/

D. Low Impact Development (LID) Urban Design Tools http://www.lid-stormwater.net/index.html

E. The Sustainable Site Initiative http://www.sustainablesites.org/

F. Environmental Protection Agency http://www.epa.gov/nps/lid/

G. Puget Sound Action Team http://www.psp.wa.gov/

H. Center for Watershed Protection http://www.cwp.org/

I. North Carolina State University Stormwater Engineering Group

http://www.bae.ncsu.edu/stormwater/

J. Chesapeake Stormwater Network http://www.chesapeakestormwater.net

APPENDIX D
MAINTENANCE AGREEMENTS FOR STORMWATER SYSTEMS

Note: Stormwater Maintenance Agreement "A" was reproduced from the New York State Stormwater Manual.
Note: Stormwater Maintenance Agreement "B" was reproduced from the Town of Southbury, CT and is for Bioretention systems only.

Stormwater Maintenance Agreement "A"

Whereas, the Municipality of Tolland ("Municipality") and the ____________________________ ("facility owner") want to enter into an agreement to provide for the long term maintenance and continuation of stormwater control/treatment measures approved by the Municipality for the below named project, and

Whereas, the Municipality and the facility owner desire that the stormwater control/treatment measures be built in accordance with the approved project plans and thereafter be maintained, cleaned, repaired, replaced, and continued in perpetuity in order to ensure optimum performance of the stormwater systems. Therefore, the Municipality and the facility owner agree as follows:

1. This agreement binds the Municipality and the facility owner, its successors and assigns, to the maintenance provisions depicted in the approved project plans which are attached as Schedule A of this agreement.

2. The facility owner shall maintain, clean, repair, replace and continue the stormwater control/treatment measures depicted in Schedule A as necessary to ensure optimum performance of the measures to design specifications. The stormwater control/treatment measures shall include, but shall not be limited to, the following: catch basins, mechanical treatment systems, Bioretention facilities, swales, sand or organic filters, infiltration systems, permeable pavement systems, subsurface gravel wetlands, constructed wetlands and ponds.

3. The facility owner shall be responsible for all expenses related to the maintenance of the stormwater control/treatment measures and shall establish a means for the collection and distribution of expenses among parties for any commonly owned facilities.

4. The facility owner shall provide for periodic inspection of the stormwater control/treatment measures on an annual basis, to determine the condition and integrity of the measures. Such inspection shall be performed by a Professional Engineer licensed by the State of Connecticut. The inspecting engineer shall prepare and submit to the Municipality within 30 days of the inspection, a written report of the findings including recommendations for those actions necessary for the continuation of the stormwater control/treatment measures.

5. The facility owner shall not authorize, undertake or permit alteration, abandonment, modification or discontinuation of the stormwater control/treatment measures except in accordance with written approval of the Municipality.

6. The facility owner shall undertake necessary repairs and replacement of the stornwater control/treatment measures at the direction of the Municipality or in accordance with the recommendation of the inspecting engineer.

7. The facility owner shall provide to the Municipality within 30 days of the date of this agreement, a security for the maintenance and continuation of the stormwater control/treatment measures in the form of (a Bond, letter of credit or escrow account).

8. This agreement shall be recorded in the Town Clerks Office, Town of Tolland together with Schedule A.

9. If ever the Municipality determines that the facility owner has failed to construct or maintain the stormwater control/treatment measures in accordance with the project plan or has failed to undertake corrective action specified by the Municipality or by the inspecting engineer, the Municipality is authorized to undertake such steps as reasonably necessary for the preservation, continuation, or maintenance of the stormwater control/treatment measures and affix the expenses thereof as a lien against the property.

10. This agreement is effective ______________________.

Stormwater Maintenance Agreement "B"

Notice of Ongoing Maintenance Obligation
(Name of Subdivision or Property)
(Applicable Lot Numbers)
BIORETENTION MAINTENANCE

KNOW ALL MEN BY THESE PRESENTS:

That ***(name of the legal owner of record)*** with an address of ***(legal address of owner of record)*** pursuant to the approval of the Inland Wetlands & Watercourses Commission and/or the Planning & Zoning Commission of ***(name of project)***, located on ***(street name)*** in Tolland files this Notice of Ongoing Maintenance Obligation (the "Notice") in order to set forth the required maintenance for the Bioretention systems located on lots (numbers of affected lots in development or other reference) of the subdivision (the "Affected Lots"). The Affected lots are described at Schedule A, attached hereto and made a part hereof.

Pursuant to the Approval, the ***(name of legal owner of record)*** files this Notice to give constructive notice to all potential purchasers of approved lots within the Subdivision, of the Town of Tolland's Inland Wetland & Watercourse Commission's and/or Planning & Zoning Commission conditions of approval requiring the ***(name of legal owner of record)*** to propose a maintenance plan for all Bioretention systems. The maintenance plan for the Bioretention systems is attached at Schedule B, attached hereto and made a part hereof.

Upon receipt of this Notice any potential purchaser of one of the lots indicated above should direct any questions about the maintenance plan and rain garden purpose or function to the Tolland Land Use Office.

IN WITNESS WHEREOF, (name of legal owner of record), duly authorized, has hereunto set his hand and seal this ____ day of _________ 2010, as his free act and deed.

____

_________________________________ _________________________________

(name of legal owner of record), duly authorized

STATE OF CONNECTICUT)
) ss: Tolland ***(month)*** _____, ***(year)***
COUNTY OF TOLLAND)

On this the _____ day of ________________, ***(year)***, before me, the undersigned officer, personally appeared (name of legal owner of record) of the State of Connecticut, known to me (or satisfactorily proven) to be the person described in the foregoing instrument, and acknowledged that he, duly authorized, executed the same as his free act and deed in the capacity therein stated and for the purposes therein contained.

In witness whereof I hereunto set my hand.

____

Commissioner of the Superior Court
Notary Public
My commission expires:

SCHEDULE A

LEGAL DESCRIPTION OF AFFECTED LOTS

All those certain pieces or parcels of land designated as ***(Listing of Lot numbers)*** all as shown on a certain map entitled (Name of subdivision Map, Name of Applicant, Street location of property, Map date, Map scale, sheet numbers, if applicable, revision dates as applicable) certified by (Name and license number of land surveyor, license number and Firm Name, if applicable) ", which Map is filed in the Tolland Town Clerk's office in Map Book Volume _____ at Pages _____.

SCHEDULE B

MAINTENANCE PLAN FOR BIORETENTION SYSTEMS

Soil:

Visually inspect soil surface in the month of May and October.

If water appears to be ponding for more than 24 hours, use small claw rake and loosen soil surface in the Bioretention system.

Do not use any mechanical equipment in the Bioretention system as this will compact the soils.

Mulch:

Inspect mulch around plant stems in the Spring

Re-mulch around plant stems only as needed.

Plants:

Immediately after the completion of rain garden construction, water plant material for 14 consecutive days unless there is sufficient natural rainfall.

When trees have taken root, or at least by 6 months, remove stakes and wires.

Once a month during the spring and summer visually inspect vegetation for disease or pest problems.

Twice a year, once between April 15 to May 30 and once between October 1 to November 30, remove and replace all dead and diseased vegetation considered beyond treatment.

Remove accumulated leaves from the Bioretention system in the fall.

During times of extended drought, look for physical features of stress (wilting, yellow, spotted or brown leaves, loss of leaves, etc). Water in the early morning as needed.

Weed as needed. Prune excess growth annually. Remove dead organic matter from the facility.

General:

After large rain events, inspect the rain garden and make sure that drainage paths are clear and that ponded water dissipates over 24-48 hours. It should not provide a breeding ground for mosquitoes. Water must remain stagnant for at least 72 hours after a rainfall event for mosquito larvae to develop.

Professional Resources:

If the Bioretention system has been designed and constructed in accordance with the specifications and standards found in the Town of Tolland Low Impact Development and Stormwater Management Design Manual, it will function appropriately. If the Bioretention system is not functioning properly, the owner should contact the design professional who designed the Bioretention system for assistance in restoring the functionality of the facility.