FISH BAY MANAGEMENT PLAN
for
FISH BAY WATERSHED, ST. JOHN, UNITED STATES VIRGIN ISLANDS

Department of Planning & Natural Resources

2001

Fish Bay Watershed

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The Watershed Planning Committee directed the preparation of this plan. Its members include:

Janice D. Hodge, Chairperson
Dayle Barry
Earl Haase
Rudy O'Reilly
Henry Smith
Edward Towle
Julie Wright

The Watershed Planning Committee was assisted in preparing the plan by The Virgin Islands Nonpoint Source Pollution Control Committee, whose members include:

Dayle Barry, Coordinator, Conservation Data Center
Ralf Boulon, Chief, Resource Management, VI NPS
Olasee Davis, Natural Resources Specialist, UVI/CES
Donna Griffin, Environmental Specialist II, DPNR/F&W
Janice Hodge, CZM Director, DPNR
Carl Howard, Environmental Specialist III, DPNR
William McComb, President, McComb Engineering
Rudy O'Reilly, Soil Conservationist, USDA-NRCS
Leo Preston, Former Coordinator, V.I. RC&D Council
Bill Rohring, NPS Coordinator, DPNR/CZM
Henry Smith, Director, ECC/WRRI
Mayra Suarez-Velez, Marine Advisor, UVI/VIMAS
Syed Syedali, Environmental Engineer, DPNR/EP
Marcia Taylor, Marine Advisor, UVI/VIMAS
Edward Towle, Chairman, Island Resources Foundation
Faye Williams, Administrative Assistant, USDA-NRCS
Julie Wright, Natural Resources & Environment Supervisor, UVI/CES

Technical review and editing was provided by:

Paul Thomas, Former Director, DPNR-CZM
Caroline Rogers, Director, Caribbean Field Station, US Geological Service-BRD
Francis Peltier, ex-Superintendent, National Park Service, St. John

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CONTENTS

LIST OF ACRONYMS

BMP – Best Management Practice
CES – Cooperative Extension Service
CRSP – Comprehensive Road Stabilization Plan
CZM – Coastal Zone Management
DF&W – Division of Fish and Wildlife
DPNR – Department of Planning and Natural Resources
FBMP – Fish Bay Management Plan
GIS – Geographical Information System
IRF – Island Resources Foundation
OSDS – Onsite Sewage Disposal System
TSS – Total Suspended Solids
USDA/NRCS – United States Department of Agriculture/Natural Resource Conservation Service
UVI – University of the Virgin Islands
VIMAS – Virgin Islands Marine Advisory Service
VINP – Virgin Islands National Park
WMP – Wetlands Management Plan

Part 1.
An Introduction to Fish Bay Watershed
St. John, U.S. Virgin Islands

I. The Vision and Goals for the Fish Bay Watershed Management Plan

Fish Bay watershed has many features that make it a special place. It is still relatively unpolluted, it has concerned citizen groups that wish to improve its environment and quality-of-life, and there is general widespread awareness of the environmental problems facing the watershed. These features make this an excellent watershed in which to develop the Territory's model for watershed protection.

The vision driving this management plan is threefold: 1) to reduce the current levels of erosion, sedimentation and other types of nonpoint source pollution caused by prior development, 2) to improve the quality of life for current residents while allowing continued smart growth and development and 3) to preserve the watershed's environment and resources for future generations.

To achieve this vision the Fish Bay Watershed Management Plan promotes the following goals:

1. Reduce current levels of erosion to pre-development levels throughout the watershed.
2. Reduce the amount of sedimentation within Fish Bay to pre-development levels.
3. Prevent future contamination of the watershed from septic systems, common household pollutants, pesticides and other poisons.
4. Improve the quality of life through increasing the educational opportunities and outdoor recreational opportunities available to residents and tourists.

II. A General Perspective on St. John and the Fish Bay Watershed

The Fish Bay watershed is located on St. John, the third largest island of the United States Virgin Islands. Fish Bay is the westernmost bay within the national park boundaries on the southern coast of St. John. Only the eastern half of the bay lies within park boundaries. The watershed, most of which is privately owned, has recently been experiencing extensive home building and associated road construction. Most land use activities consist of excavations for access roads and homesites. In the Fish Bay watershed approximately 16 km./10 mi. of roadways were measured and mapped. Of these, 9 km./5.6 mi., over 56%, were not paved.

The Fish Bay watershed (Fig. 2) is about 6.1 sq. km/3.8 sq. mi., drains a total of 1448 acres and features several diverse terrains. The northern section is a gently sloping upland plateau about 2000 feet wide and 7000 feet in length. The eastern part of the watershed consists principally of a long mountain spur with relatively gentle upper slopes that slant southward from Camelberg Peak Ridge towards the sea. The watershed's southern portion is characterized by steep, rocky terrain, except for some small alluvial fans in the narrow lowland valleys immediately behind Fish Bay. The soils are predominantly Annaberg-Maho Bay Complex, Frederiksdal-Susannaberg Complex, and Victory-Southgate Complex, with the remainder being Southgate-Rock Outcrop Complex, Sandy and Stony Beaches, Cinnamon Bay Gravelly Loam, Cinnamon Bay Loam, Salt Flats - Ponded, Sandy Point and Sugar Beach, and Solitude Gravelly Fine Sandy Loam. Slopes in the Fish Bay watershed tend to be very steep in the lower portions of the catchment, but less extreme in the upper basin areas of Adrian and Susannaberg. The highest point in the watershed is 364 meters/1,194 feet above sea level, and the vegetative cover is primarily moist or dry forest vegetation.

Two major watercourses drain the central uplands into Fish Bay. Battery Gut originates at Herman Farm and Fish Bay Gut begins in L'Esperance. They converge at the northern end of the Fish Bay valley before emptying into a mangrove wetland behind Fish Bay. A shorter gut originates in the hills between Sieben and Mollendal and enters Fish Bay from the east. This drains the southeastern quadrant of the watershed and also empties into the mangrove wetland behind Fish Bay. Small sections of the watershed drain directly to the bay, to mangrove wetlands immediately surrounding the bay, or to intermittent streams that are not tributary to Fish Bay Gut.

Currently, the principal contributor of nonpoint source pollution in the Fish Bay watershed is sediment runoff from unpaved roads and development sites.[1] However, as development and urbanization increases within the watershed, various other pollutants (nutrients, bacteria, pesticides and other poisons, heavy metals, organic matter and trash) will be generated. When stormwater runs off the landscape, it can carry these pollutants with it into the bay. The resulting water quality degradation can cause both immediate and long-term negative impacts on aquatic and terrestrial plant and animal species and their habitat. Eventually, the use of the water resource for swimming, recreation and as a food source can be severely impaired.

III. Threats to the Watershed: A Brief Summary of the Problems

A. Public Perceptions

A public meeting was held on St. John on July 30, 1998. At this meeting, DPNR staff introduced the V.I. Nonpoint Source Pollution Committee, described the draft Fish Bay Management Plan, reviewed the watershed's historical and current conditions and invited the public to express their views and opinions as to what could be done to improve the watershed's environment. Homeowner's concerns focused primarily on paving Marina Drive to reduce dust levels and the options available for raising the necessary funds. However, quality of life issues were also raised as to the merits of both paving Marina Drive and leaving it in its current condition.

Other concerns included the erosion of individual homesites. A final concern was the perceived ineffectiveness of CZM to enforce standards upon all construction sites within the watershed.

Surveys were distributed as an adjunct to this meeting. The results of the survey indicated:

1. The majority of individual homesites have unpaved driveways or parking areas or both.
2. Most individual homesites have either partially or completely landscaped yards.
3. Sediment and/or stormwater from other homesites does have a negative effect on individual homesites.
4. All homesites have cisterns and most homes have septic systems for waste disposal.
5. An awareness of erosion and its negative effects on the environment is widespread.

[1] MacDonald, L. H., D. M. Anderson, and W.E. Dietrich (1997). Paradise threatened: land use and erosion on St. John, US. Virgin Islands. *Env. Mngmnt.* 21(6): 851-863.

In summary, the public meeting and the surveys both indicated that the public considers erosion, stormwater, and dust to be the main problems facing the Fish Bay watershed. These problems not only negatively affect the environment; they also adversely impact the quality of life experienced by area residents. Property owners also expressed concerns regarding a potential increase in traffic through the area and the resulting negative consequences.

B. Technical Perspective

Erosion and sedimentation research has been ongoing in the Fish Bay watershed since the early 1990's. Several reports and papers have been written and their results and recommendations considered. (See Appendix D) The reports have focused upon the requirements of setting up a good field study, estimating the amount of sediment that erodes from steep unpaved roads versus the amount that erodes from individual construction sites, and trying to determine the main cause of increased sedimentation to Fish Bay. The general consensus has been that steep unpaved sections of roadway and unprotected sections of steep cutslopes erode more severely and contribute more sediment to the Fish Bay watershed than do individual construction sites, flat unpaved roads, paved roads, or protected sections of cutslope.

Sedimentation occurs when eroded soil particles suspended in stormwater runoff are deposited onto floodplains or in guts and coastal waters. Suspended sediment increases the turbidity in the receiving waters such as the salt ponds and the bay. The increased turbidity prevents sunlight from reaching the bottom of the bay, thus depriving seagrass beds, other aquatic plants and corals the resources needed for photosynthesis and growth. Once the soil particles settle, they effectively form a blanket over the bottom of the bay. If tides and currents are not sufficiently active, then the blanket of soil can effectively block the sunlight from the seagrass and corals in the bay. While corals can cleanse themselves from some sediment deposition by excreting a mucous that traps the soil particles and then sloughs off, repeated creation of the mucous places the corals under undue environmental stress and leaves them vulnerable to diseases.

Sediment deposition into the Fish Bay ecosystem not only poses a physical threat to the environment through its blanketing action, but it also contributes to the poisoning and invasion of the ecosystems by land-based pollutants and other plants and organisms. Land-based pollutants such as petroleum products often contain numerous chemicals and metals. Heavy metals such as copper, zinc, cadmium and tin are frequently found in waste oil that drips from vehicles onto the land. Once there, the soil particles bind to the heavy metals and carry them into the downstream ecosystems where they are frequently toxic to marine organisms. Copper and tin are especially toxic to marine organisms; the EPA has banned the use of tin in boat bottom paints. Other chemicals such as pesticides and fertilizers also bind to soil particles and are carried into the ecosystem where they are introduced into the food chain. All of these impacts may also cause corals and other marine organisms to be more susceptible to diseases.

Failing septic systems are another nonpoint source pollution problem that can contaminate groundwater or other downslope drinking water supplies such as cracked cisterns, wells or public water lines. The property owner survey indicates that the vast majority of homes rely on septic systems to treat wastewater. St. John's thin, poor quality soils and fractured bedrock cannot accommodate 100% reliance upon traditional septic systems indefinitely into the future. This document addresses failing septic systems in Part 2, section III, Failing OSDS.

Another area for concern is the concomitant increase in noise and air pollution that will accompany any increase in the watershed's population and traffic. The Fish Bay watershed has been under development since the mid-1970s and will continue to develop into the foreseeable future. Studies from the United States have shown that as population densities increase, so do related problems of noise and air pollution. Air pollution increases are also produced by auto emissions and traffic generated dust. While no plan can adequately address all problems at any one time, it is important to list these possible areas of concern.

Part 2.
Best Management Practices and Management Measures

I. Erosion from Common Areas

A. Steep Roads

Rainfall on steep unpaved roads produces the majority of the eroded soil currently impairing the Fish Bay watershed and its interlinked environments. Erosion and sedimentation in these common areas is not only harmful to the watershed's environment, but it is also harmful to the quality of life experienced by the watershed's inhabitants. Repairing damage to vehicles and property and removing excess sediment not only takes a financial toll on people, but also increases the daily stress on individuals. Fortunately, there are many solutions to this problem that is so harmful to both the environment and the public. The following solutions will aid in meeting the first two goals of the Fish Bay Management Plan by reducing the amount of erosion and sedimentation in the watershed.

Of utmost importance is the design and implementation of a storm water drainage and treatment system for the watershed and the paving of the watershed's roads. This plan proposes to have a Comprehensive Road Stabilization Plan (CRSP) designed for all sections of unpaved roadways in the Fish Bay watershed. To control erosion on the steepest, most heavily eroding sections of road, this plan proposes to have roads prioritized and paved in order of priority as soon as funding can be awarded through one or more grants.

As part of CRSP, proper gutters, swales box culverts and other storm drainage devices will be installed. The system will be designed to not only direct the stormwater runoff, but will also be designed to reduce the runoff velocity as much as possible. The system will make use of available terrain features in the design of the storm drainage system and will utilize oil/water separators, sediment traps and other Best Management Practices (BMPs) to reduce the amounts of pollutants entering the lower reaches of the watersheds. The minimum standard that the stormwater runoff system will be designed to is the 50-year, 24-hour storm.

As this will be a long-term project that will be dependent upon the availability of funding, other intermediate measures are required until paving is accomplished throughout the watershed. Details on the following intermediate measures can be found in Appendix C.

One intermediate measure that can significantly slow the rate of erosion is the installation of water bars or cross-drains diagonally across the road. These can be positioned to effectively reduce the amount of erosion off the roadbed. When re-grading is required, the water bar will have to be protected. If it is destroyed by the re-grading project the water bar must be replaced. See Appendix C.

Re-grading of the road surface is also a valuable tool that can be utilized to reduce erosion levels. Proper grading will slope the road so that water quickly drains off the road surface towards the cut bank. To ensure that roads are correctly graded, CRSP requires that all heavy equipment operators must be trained and certified by CZM/CES staff in appropriate grading techniques prior to the start of any road construction. Also, all roads cut after this plan's adoption must be paved, the slopes stabilized, and the introduced stormwater controls integrated into the system developed under the CRSP.

Lastly, but perhaps most importantly, is maintenance. A regular maintenance plan that provides for the routine inspection, maintenance and repair of structures and the removal of debris and accumulated sediment will have a large impact upon the effectiveness of any installed system. Therefore, this plan proposes that a strict maintenance plan be part of CRSP. It is suggested that once an area has been paved or any stormwater control structures have been installed, it will be the responsibility of the respective Homeowners Association, neighborhood association or community group to maintain the paving or structures according to the CRSP maintenance schedule and requirements.

B. Cutslopes

Steep road cutslopes also introduce large amounts of sediment into the Fish Bay watershed. Many unprotected cutslopes not only introduce sediment into the ecosystem, but there are also frequent small landslides that effectively block the runoff that does run between the mountain and the roadbed. These landslides effectively force the water back onto the road surface where it quickly scours new channels that contribute to the problems mentioned above. Cutslopes also "intercept the subsurface water traveling through the soil, rock fractures and old root channels. This converts slow moving subsurface water to fast moving surface flow, and this may further increase the size of peak flows . . . . Outflow from these cut slopes may increase moisture stress on plants below the road and reduce the amount of the time guts flow."[2]

To remedy this problem, this plan proposes that all cutslopes of greater than 50% slope or three feet in height be reduced to a slope of less than 50% or three feet in height and stabilized as described below. As this is part of the common area of the watershed, this problem will also be addressed in the CRSP and will be included in all grant funding requests and proposals. While not meant to be inclusive, the following paragraphs give brief descriptions of methods that can be utilized to effectively control erosion from steep cutslopes. See Appendix C for details on methods of stabilization.

One method that effectively reduces the angle of slope is to simply cut the slope further back into the upslope property. However, even though this method can quickly and efficiently address the problem of steep slopes, it can be also one of the most costly methods described. As reducing the slope through removing land can effectively eliminate the use of some land, the upslope property owner may require compensation. As funds will be limited, unless there is an agreement with an upslope property owner, this method will not be utilized for decreasing the angle of cutslopes. A second consideration is the proper disposal of substantial quantities of fill this method produces.

One very effective method for stabilizing cutslopes is to utilize some form of slope reinforcement. Familiar methods are the use of terraces, retaining walls, either concrete or steel, or gabion baskets.

A third method that has been utilized to control erosion on steep slopes is the use of an artificial mesh, steel or turf reinforcement matting and the introduction of plants to stabilize the slope. This has been effectively used on a $1.3 billion dollar, 16-mile long highway that was recently completed in Hawaii. While Hawaii has substantially more rainfall than Fish Bay, which dramatically improves the effectiveness of plant growth and stabilization, if the proper plants are used and a watering plan established and followed, this method could be very useful here.

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[2] Island Resources Foundation, 1997, p. 5.

Again, a regular maintenance plan that provides for the routine inspection, maintenance and repair of structures and the removal of debris and accumulated sediment will have a large impact upon the effectiveness of any installed system. Therefore, this plan proposes that a strict maintenance plan be part of CRSP. It is suggested that once a cutslope has been stabilized, it will be the responsibility of the respective Homeowners Association, neighborhood association or community group to maintain the stabilization measure according to the CRSP maintenance schedule and requirements.

C. Mangroves and Salt Ponds

These two ecosystems are very beneficial and important for the protection of Fish Bay in particular and the watershed in general. The mangroves and salt ponds not only trap overland flow and provide a place for sediment and other pollutants to settle, they also provide a place for many types of plants, birds and other wildlife to live and feed. The mangrove root system may also be utilized as a nursery for various fish and other sea life. Finally, the mangrove ecosystem protects the shoreline from wave-induced erosion.

Mangroves are sensitive to excessive sedimentation, stagnation and surface water impoundment. If proper assessment and protection of this wetland does not occur, the natural coastal protection and other benefits they provide may disappear. In order to protect these valuable ecosystems, this plan proposes two items. First, that the Virgin Islands Nonpoint Source Pollution Control Committee find funds for the development of a Wetlands Management Plan (WMP). The WMP should provide a comprehensive blueprint for protecting and managing these scarce and valuable resources for the future. Issues that can be addressed in the Wetlands Management Plan include:

- Acquiring the wetlands, the development rights to the wetlands, or converting the wetlands to some sort of park/nature area.
- Change the zoning for the wetland parcels to protect them from development.
- Only allow development (as defined in the CZM Act) within or near the wetlands for scientific or educational purposes.
- Potentially combine all properties that contain wetlands with Fish Bay into one Marine Reserve and Wildlife Sanctuary.

Second, until the Wetlands Management Plan is developed and adopted, this plan proposes that no construction be allowed within 150 feet of the landward edge of any wetlands in the Fish Bay watershed, except for repair and maintenance on development that has already occurred.

II. Erosion from Private/Individual Sites

A. Steep Unpaved Driveways

While shorter in length than the road segments discussed above, steep, unpaved driveways also erode and contribute sediment to the Fish Bay watershed. As these are on private land, it is the responsibility of the individual property owners to remedy this problem.

To control the erosion from unpaved driveways, this plan proposes that homeowners pave or stabilize driveways within 5 years of plan adoption. Any driveways left unpaved after that date will be considered potential point sources of pollution. Once a driveway has been determined to be a point source of sediment that discharges into the common stormwater system, then the homeowner will be fined according to DPNR rules and regulations. See V.I. R. & REGS. tit.12, §184 1976). The driveway may also be fixed, repaired or otherwise brought to the standards set forth in this plan or DPNR rules and regulations, whichever is stricter. The Fish Bay Watershed Authority will be able to repair or upgrade the driveway and all costs and expenses will be assessed against the homeowner. This plan also proposes that all new construction in this watershed must have the driveways paved and all erosion, sediment and stormwater controls must be installed and operating prior to starting construction on any structures or buildings.

As part of driveway protection, proper gutters, box culverts and other storm drainage systems must be installed. The driveway designs must not only direct the stormwater runoff, but must also reduce the runoff velocity as much as possible. The designed system must use the available terrain features and must utilize Best Management Practices (BMPs) to reduce the amounts of pollutants entering the common stormwater runoff system.

Property owners must install velocity dissipaters such as riprap, vegetation or structural devices in any gutter or culvert system. To intercept runoff prior to it's entering a roadway, drains or diverters must be installed at the foot of any driveway that enters the roadway from a higher elevation. The drains or diverters must direct all runoff to the common stormwater runoff system. One intermediate measure that can significantly slow the rate of erosion is the installation of water bars or cross-drains diagonally across the driveway. These can be positioned to reduce the amount of erosion off the driveway. When re-grading is required, the water bar will have to be protected. If any water bar is destroyed by the re-grading project, it must be replaced.

Correctly grading or re-grading the driveway can reduce the amount of erosion that occurs on the driveway. Proper grading will slope the driveway so that water quickly drains off of the driveway surface into the side of the mountain. It is required that all heavy equipment operators be trained by CZM/CES staff in proper grading techniques prior to the start of any construction project.

Lastly, but perhaps most importantly, is maintenance. A regular maintenance plan that provides for routine inspection, maintenance and repair to any structures and the removal of debris and accumulated sediment will have a large impact upon the effectiveness of any installed system. Therefore, this plan requires a maintenance plan be submitted to CZM and the Fish Bay Watershed Authority as part of any driveway design or system and followed.

B. Cutslopes for Driveways and Construction Sites

Steep cutslopes that border driveways and homesites also erode and contribute sediment to the Fish Bay watershed. Again, as these are on private property, it is the responsibility of the individual property owners to remedy this problem. This plan proposes that within 5 years of plan adoption all cutslopes for driveways and construction sites be protected from erosion and stormwater runoff. All plans must be approved by DPNR/CZM. Any cutslopes left unprotected after that date will be considered potential point sources of pollution and can be fined according to DPNR rules and regulations. The cutslope may also be fixed, repaired or otherwise brought to the standards set forth in this plan or DPNR rules and regulations, whichever is stricter. The Fish Bay Watershed Authority will be able to repair or upgrade the driveway and all costs and expenses will be assessed against the homeowner. This plan also proposes that all new construction in this watershed must have all cutslopes protected from erosion and stormwater runoff prior to the issuance of any Certificate of Occupancy by DPNR.

Reducing the angle of the cutslope through cutting the slope further back into the upslope property. This can be one of the quickest ways to address this problem. Unfortunately, reducing the slope through removing land effectively eliminates the use of some land and the larger exposed area may present erosion problems until re-vegetation occurs, thus creating new problems for the property owner.

Another very effective method for reducing erosion is to utilize some form of slope reinforcement. Familiar methods are the use of terraces, retaining walls, either concrete or steel, or gabion baskets. Many private walls utilize native stone and shells and are very aesthetically pleasing.

A third method that has been utilized to control erosion on steep slopes is the use of an artificial matting such as erosion control blankets and turf reinforcement mats combined with the introduction of plants to stabilize the slope. This has been effectively used on a $1.3 billion dollar, 16-mile long highway that was recently completed in Hawaii.

A regular, routine maintenance plan will be necessary for the maintenance and upkeep of all BMPs installed. Failure to routinely maintain the structures could lead to structural failure and the imposition of costly fines if erosion occurs and spreads into the common stormwater drainage system.

C. Improper Site Drainage

A majority of the property owner survey respondents acknowledged that their property was either partially or completely landscaped. Slightly over half of the respondents indicated that stormwater and sedimentation from other sites negatively affects their property. Without knowledge of a particular site it is impossible to maintain that certain practices are or are not effective in controlling a particular lot's runoff. However, with an eye towards increased development and imperviousness, the need to conserve the watershed's resources for future generations, and the goal of reducing runoff to pre-development levels, the plan proposes that individual property owners develop site plans that retain all but the most extreme amounts of rainfall on their individual properties, reduce the amount of runoff to pre-development levels or both.

To achieve this goal the homeowners are encouraged to utilize available information from the Fish Bay Homeowners' Association, The Skytop Homeowners' Association, DPNR/CZM, UVI/CES and the USDA/NRCS on landscaping practices, low impact development and xeriscaping methods. Again, Appendix C has details and information on the following BMPs.

Landscaping property to reduce or eliminate erosion and runoff due to construction should be considered from the very earliest stages of planning the site development. Design factors such as clustering to reduce the area to be cleared and, ultimately, the impervious area, the utilization of natural landscape features to divert runoff from the construction site or to retain stormwater on-site, and the planned retention of stormwater on-site can be important and useful if carefully planned for in the beginning. Permanent landscaping, stormwater and erosion control measures should be installed on each section of property as soon as construction is completed on that section. When developing a landscaping plan, care should be taken to utilize native species to reduce the threats of invasion into the National Park ecosystem.

While the steep slopes predominant throughout the Fish Bay watershed preclude the use of many of the following landscaping and design features, all can be used somewhere within the watershed to reduce or eliminate the runoff from a particular site. When designing any particular BMP, care must be taken to ensure that when combined with the other BMPs little or no runoff will occur during a 25-year, 24-hour storm event. This is a minimum standard; this plan recommends that systems be designed to the higher standard of a 100-year, 24-hour storm. Factors to consider are the depth and infiltration rate of the soil on the site, the slope of the property, the amount of space required for the feature, depth to the water table or bedrock, the proximity of the feature to building foundations, the maximum amount of depth needed for the feature, and the maintenance requirements.[3]

Bioretention utilizes a shallow storage area with a soil bed and plant materials to filter stored runoff. Multiple tiers of bioretention units could be hydrologically linked into terraces and placed in such a fashion that runoff naturally flows into the system. These terraced beds can be landscaped to enhance the aesthetic value of the property.

Dry wells are small pits filled with small gravel or stone that store only a limited amount of runoff from a small area until it can be infiltrated into the surrounding soil. This management practice can be used near small impervious areas that contribute small amounts of runoff, for example patios or decks.

Filter/buffer strips are usually a length of grass of other close-growing vegetation that is planted between a discharge area and a receiving body. These are designed to do one or more of the following: reduce pollutant loads, trap sediment, convert concentrated runoff to sheet flow, provide some infiltration, and disperse stormwater flows over a wider area.

Grassed swales, bioretention swales and wet swales are similar in practice to filter/buffer strips, but have generally been used for larger developments. Swales are vegetated channels that are designed to convey runoff to a desired location. As such they are not explicitly designed to reduce pollutant loads and trap sediment, but they do so to a limited extent.

Stormwater runoff cisterns can be utilized to accept runoff that is not polluted by chemicals or other contaminants. When combined with other practices, the capacity of the cistern can be varied to optimize the reduction of peak runoff and peak discharge volumes. The inlet to the cistern will have to be protected from receiving polluted runoff. However, the gradual discharge of the cistern through an irrigation system or some other designed components will allow some treatment of the water either while in the cistern or through use by the vegetation being irrigated. Care must be taken so no runoff occurs while the irrigation system is being utilized.

Infiltration trenches are stone-filled trenches that are designed to hold runoff until it can be absorbed into the surrounding soil. This is similar to the dry well, but can be used for larger impervious areas. While most areas in the Virgin Islands have soil that is too rocky for these to work effectively, there may be areas within the watershed where this BMP can be used.

[3] Department of Environmental Resources, Prince George's County, Maryland, 2000. *Low-Impact Development Design Strategies*. Prepared for EPA. pp. 4-5.

Silt fences are geotextile fabrics that, when properly installed, prevent large quantities of silt from being deposited in downslope systems. However, these fabrics are not designed to control the smaller sized clay particles that stay suspended for the longest periods of time and cause much of the problem in Fish Bay itself. While effective at reducing the amount of the larger particles that enter downstream ecosystems, this plan proposes that silt fences only be the last BMP of a series of inter-related devices and designs to control the erosion off of a construction site. Silt fences are temporary sediment control devices used during construction; they are not designed to be permanent or to treat concentrated flows such as those found in guts or other channels.

Terraces can be utilized to accept the discharge from the graywater cistern or can be modified to accept flows of water into the system. A similar idea is the constructed wetland system used to treat and dispose the effluent from a septic tank.

Xeriscaping methods use water conservation techniques combined with site-appropriate plants and an efficient watering system to reduce runoff. This system can easily be combined with terraces and gray water irrigation systems.

As with any system, regular maintenance is very important to realize the benefits from any designed system. While many of these BMPs are very low maintenance, maintenance is required. As with any driveway or cutslope system, failure to routinely maintain the structures could lead to structural failure and the imposition of costly fines if erosion occurs and spreads into the common stormwater drainage system or causes damage to downstream properties. Any failing or failed BMPs may be also be fixed, repaired or otherwise brought to the standards set forth in this plan or DPNR, whichever is stricter, by DPNR or the relevant homeowners association and all costs and expenses for the repair or construction will be assessed against the homeowner.

III. Failing Onsite Sewage Disposal Systems (OSDS)

The health of the environment is not the only concern addressed by this plan. This plan also addresses the health of the individuals that reside within the Fish Bay watershed. Failing or failed septic systems can have harmful impacts upon individuals as well as the environment. To avoid problems due to the failure of currently installed septic systems, this plan proposes that all wastewater treatment systems be inspected every five years at a minimum, beginning within one year of this plans' acceptance. Any system found to be discharging effluent that does not meet DPNR standards must be brought into immediate compliance. Failure to do so will result in the individual property owner being fined according to DPNR rules and regulations. The OSDS may also be fixed, repaired or otherwise brought to the standards set forth in this plan or DPNR rules and regulations, whichever is stricter. The relevant homeowners association will be able to repair or upgrade the OSDS and all costs and expenses will be assessed against the homeowner. This plan also proposes that no leach pits, leach fields or other subsurface disposal of effluent be permitted in the Fish Bay watershed. There are several alternative disposal methods that can be utilized to safely dispose of sewage.

Package plants are designed to effectively treat all sewage through one of several different methods. The effluent from the treatment is traditionally discharged through an irrigation system. An architect or engineer will be able to assist in determining a system that will meet your individual needs.

Alternative toilets are designed to contain and treat human waste separately from the rest of the wastewater system. Acceptable alternative toilets are composting or incineration type toilets. Chemical toilets are forbidden for use in this watershed.

Constructed wetlands are impervious trenches that are designed to handle a pre-determined amount of effluent from either a septic tank or package plant. These are similar to terraces in that the trenches are utilized to grow carefully chosen plants that utilize all or almost all the effluent within the trenches. Remaining effluent may then be disposed of in a graywater irrigation system. Appendix C has details of this system.

In the future individual homeowners may be able to connect into the St. John public sewage system. If this does become available, this plan will allow individual property owners to opt into that system, provided that BMPs that provided a dual function of sewage treatment and erosion or stormwater control be maintained for the non-sewage treatment function.

IV. Other Forms of Nonpoint Source Pollution

No plan can address all future problems that can or will arise in a watershed. However, in an effort to focus individual and community awareness upon possible future problems, this plan does note that the following problems have arisen in other areas of the United States as the population of individual watersheds' has grown. Therefore, all individuals and organizations should be aware that this plan may need modification to address the following issues: an increase in noise levels, an increase in air pollution, and an increase in nutrients, toxic household chemicals, pesticides, poisons, waste oils and other types of nonpoint source pollutants being introduced into the watershed.

V. Public Education

Public education is an important component of implementing the Fish Bay Watershed Management Plan. The underlying premise of a public education campaign is that (1) the people who live within or utilize the watershed (i.e., stakeholders) want to protect its unique resources, and (2) when armed with knowledge about how to protect its unique resources, they will eagerly do so.

The goal of public education in the Fish Bay Watershed is to help stakeholders understand how the quality and ecology of this watershed is threatened and what individuals and groups can do to minimize their environmental impacts so that the area can be enjoyed by all well into the future.

Specific objectives of this public education campaign are:

1. DPNR, UVI-CES, UVI-VIMAS and USDA-NRCS will clearly illustrate/demonstrate how the best management practices recommended in this Watershed Plan can help to protect Fish Bay. Small handouts, brochures and other materials will be developed and printed. Training seminars and short courses will be developed and offered to the residents and other users of the Fish Bay watershed.

2. The Homeowners’ Associations will distribute the materials produced in #1 and will encourage all the watershed’s residents to participate in the offered seminars and courses. Their assistance

will be required in installing BMPs in common areas, participating in field days and maintaining the BMPs that are installed in the common areas.

3. Enlist the National Park Service in the campaign by having it provide an area in its Cruz Bay facility where published materials about pollution prevention and management can be displayed for the benefit of staff and the public.

While the scope of public education for the Fish Bay Watershed has been limited to these three objectives at this time, there is no reason that other objectives could not be added in the future as a result of perceived needs.

VI. Implement a Monitoring Program.

As with any large-scale effort, a sediment reduction program should include a monitoring component that provides information and feedback on the success, or lack thereof, of program efforts. For a sediment control program, this should include components to monitor 1) the success of program implementation, 2) the efficacy of BMPs, and 3) the impacts on resources. The first line of defense in erosion and sediment control should be to prevent soil erosion. The effectiveness of various erosion and sediment control measures can be evaluated by monitoring sediment production and the quality of guts or other water bodies adjacent to or near any construction. Measuring the accumulated sediment in detention ponds, settling basins and behind sediment fences is one method of monitoring site sediment production. The delivery of large volumes of sediment to traps and barriers suggests that site erosion control measures are inadequate.

A second measure will be the implementation of a sediment monitoring plan for the salt ponds, mangrove areas and the bay. One proposed monitoring plan will extend current marine studies at Fish Bay and Lameshur Bay, St. John, quantify the distribution and composition of the benthic sediments in both bays and reassess the condition of coral and fish populations in the two bays.

Studies comparing sedimentation rates between Lameshur Bay and Fish Bay have found sediment yields and turbidity to be significantly higher in Fish Bay. In Fish Bay sediment was deposited at the rate of roughly 600 tons/year compared to 100 tons/year for Lameshur Bay. The turbidity levels were also elevated, with a measurement of 1.05 NTUs for Fish Bay versus 0.38 NTUs for Lameshur Bay. (MacDonald, 1997)

Designing and implementing a monitoring program is an interdisciplinary and interagency activity. Technical staff is needed to integrate new monitoring with what is already being done in order to ensure duplicate work is not undertaken. This plan proposes that a water quality monitoring plan be coordinated between the staff, technicians and scientists of DPNR, UVI, the University of Colorado and the National Park Service to evaluate the effectiveness of this plan. Additional data will be collected from both the Fish Bay and the Lameshur Bay watersheds so that any differences between the watersheds can be evaluated. The monitoring plan will be developed and implemented prior to commencing any construction under the CRSP.

Part 3
Timeline and Milestones
For
Implementation of the Fish Bay Management Plan

There are many different activities and responsibilities for everyone if this plan is to be successfully implemented. Adoption of this plan is only the very beginning. This is expected to be a blueprint for all future watershed plans that will be developed, as well as a living document for this watershed and the community that inhabits and utilizes it. Ultimately, it is envisioned that a watershed coordinator or committee will oversee the daily aspects of monitoring the implementation of this plan.

There are three phases to this plan. The first two cover the first five years of the plan's implementation. After that, it is expected that the plan will be updated and modified and phases three and beyond will address future concerns and issues. Many of the activities that are briefly discussed or mentioned in one section are interrelated with other sections. For example, the activities under Public Education will have a direct impact upon the plan's acceptance by the inhabitants of the Fish Bay watershed. Consequently, there is much overlapping of responsibilities among all the stakeholders in the watershed, including the local and federal governments. No one entity assumes total responsibility for the success or failure of this plan in meeting its objectives.

I. PHASE I. YEAR ONE

A. Public Education

Public education is an important component of implementing the Fish Bay Watershed Management Plan. The goal of public education is to help stakeholders understand how the quality and ecology of this watershed is threatened and what each one can do to minimize his or her impact so the area can be enjoyed by all well into the future. The organization, agencies and individuals that will primarily be involved with this aspect of the plan are in Table 1.

TABLE 1. List of Contacts for the Fish Bay Watershed Public Education Campaign

Organization	Position	Name	Address	Phone/fax/e-mail
DPNR/Coastal Zone Management Program	Public Outreach Coordinator	Lillian Moolenaar	C.E. King Airport Terminal Bldg., Fl. 2 St. Thomas, VI 00802	Phone: 340-774-3320 Fax: 340-775-5706 Email: sadie_moo@yahoo.com
UVI/Cooperative Extension Service	Nat. Res. & Environment Supervisor	Julie Wright	#2 John Brewer's Bay St. Thomas, V.I. 00802	Phone: 340-693-1082 Fax: 340-693-1085 Email: jwright@webmail.uvi.edu
UVI/Virgin Islands Marine Advisory Service	Marine Advisor	Mayra Suárez-Vélez	#2 John Brewer's Bay St. Thomas, V.I. 00802	Phone: 340-693-1392 Fax: 340-693-1395 Email: msuarez@uvi.edu
DPNR/Fish and Wildlife Program	Environmental Specialist II	Donna Griffith	6291 Estate Nazareth, 101 St. Thomas, V.I. 00802	Phone: 340-775-6762 Fax: 340-775-3972 Email: Dmarigrif@hotmail.com

VI National Park/Resource Management	Chief	Ralf Boulon	P.O. Box 710 St. John, V.I. 00830	Phone: 340-776-6201 Fax: 340-693-9500 Email: ralf_Boulon@nps.gov
SkyTop Homeowners' Association	President	Brian Bell	P.O. Box 37 Cruz Bay St. John, VI 00831	Phone: 340-779-4619 Fax: Email: bbell@islands.vi
Fish Bay Homeowners' Association	President	Elissa Runyon	P.O. Box 3733 St. Thomas, V.I. 00803	Phone: 340-693-7488 Fax: 340-693-7489 Email: bushwacker@viaccess.net

Under this aspect of the plan, the following activities will take place:

- Meetings will be held with Fish Bay inhabitants to seek input and address any concerns or questions that they may have about the Fish Bay Watershed Management Plan.
- Short booklets will be created on recommended BMPs, alternative onsite sewage disposal systems and the various ecosystems in the Fish Bay watershed.
- These booklets will be distributed, along with this plan, to the various stakeholders in the plan, including all property holders and individuals living within the Fish Bay watershed.

B. Administration

This phase of the plan is very heavily influenced by the need to implement several measures and prepare for the implementation of Phase II. CZM, EP, UVI-CES, USDA-NRCS and NPS all have responsibilities under this section

- An expert, either through USDA-NRCS or through a contract, will design the Comprehensive Road Stabilization Plan. The designer should have experience in watersheds similar to Fish Bay, i.e., steep slopes, fragile ecosystems, high clay content soils, etc., and must have experience in designing systems to offer the most environmental protection and pollution reduction.
- After completion of the Comprehensive Road Stabilization Plan (CRSP), the steepest, most erodible sections of road will be paved. Alternatively, depending upon funding, it may be more beneficial to put a number of smaller BMPs in place to control the erosion of these roads and the sediment produced by them.
- A complete listing of all stakeholders will be developed and distributed.
- The Tier 1/Tier 2 issue will be addressed and resolved.
- Grants will be applied for to implement the CRSP.
- Different agencies will assist stakeholders in finding funding and implementing various BMPs.
- A monitoring plan will be developed for Phase II. This plan will include a map of the area, including monitoring sites and marine communities. The map should be developed in a Geographical Information System (GIS) format.
- The program will be developed to train and certify heavy equipment operators that will be working on Phase II.

C. Enforcement/Permitting

This aspect of Phase I will rely heavily on CZM for actual enforcement. However, all stakeholders will have to be involved for effective enforcement to work. Neighborhood pressure or persuasion is often more effective than government force.

- Strict enforcement of CZM rules and regulations and permit conditions will have to continue.
- Low-impact development will have to be promoted by individual stakeholders, the different neighborhood groups and government agencies. Since the CZM and Building Permits offices have the opportunity to review plans prior to the issuance of any permits, a large amount of responsibility will fall on staff to persuade developers to utilize low-impact development. As one of the goals of this plan, DPNR staff will devise rules and regulations to require low-impact development methods where appropriate.
- Community support is necessary for the enforcement of all natural resource laws.

D. Others/Miscellaneous

The following will be very beneficial in the ultimate success of this plan.

- Homeowners' associations or other neighborhood groups can organize regular cleanups of the neighborhoods and Fish Bay itself. This will provide several benefits, among them the cleaning of litter and debris from the area, the creation of community spirit, and the creation of a tradition of community events.
- The organization and preparation of the Homeowners' associations and other neighborhood organizations to accept responsibility for cleaning, servicing and maintaining the BMPs that will be installed in Phase II.

II. PHASE II. YEARS TWO THROUGH FIVE

A. Public Education

Public education does not stop with the dissemination of the materials developed in Phase I. The following is necessary during this phase of the plan.

- Site visits, continued research and upgrading of all booklets to ensure that they are complete and up-to-date.
- Meetings will still have to be held, possibly at an in-depth level to address detailed questions and concerns of stakeholders.
- Continued distribution of booklets to interested parties and new stakeholders.

B. Administration

During this phase of the plan, the NPS committee will be heavily involved in the following aspects.

- Administering the implementation of the CRSP.

- Administering the implementation of the monitoring plan.
- Holding annual meetings to disseminate information and progress in reaching the FBMP's goals.
- Assistance will be given to help stakeholder organizations find funding to maintain, service and repair the common area BMPs constructed under the CRSP.
- Finding funding to implement the monitoring plans mentioned in this FBMP.
- Assist in the development of the Fish Bay Watershed Authority.

C. Enforcement

Strict enforcement of CZM permit conditions, laws, and rules and regulations will continue, as will the other aspects mentioned in Phase I. The inventory of all sewage treatment systems in the watershed and the upgrading of those that fail to meet DPNR standards will also have to occur.

D. Others/Miscellaneous

There is still a role for other stakeholders to play. The following should be addressed at this time.

- Information will need to be occasionally disseminated to stakeholders and members of community groups, neighborhood organizations and homeowners associations.
- Continued emphasis will have to be placed on low-impact development.
- Regular litter cleanups will have to continue.
- In order to protect the watershed ecosystems and resources of Fish Bay, stakeholders are encouraged to report potential problems.
- Planning for the future evolvement of this plan during Phase III will have to begin.
- Formation of the Fish Bay Watershed Authority will need to occur.

III. PHASE III. YEARS FIVE AND BEYOND

At this time it is envisioned that the plan will be operating under the supervision of a Fish Bay Watershed Authority that will actively meet and have the authority to update, revise and implement this plan. The following will have to occur during this phase if the plan is to continue to be a living document that reflects the cares, concerns and values of the stakeholders in Fish Bay watershed.

- A final report will have to be presented that details the successes and failures of the plan and any ongoing concerns.
- Modification of the plan will be necessary to address any concerns, worries or values that have surfaced during the implementation of the earlier phases of this plan.
- Continued oversight will have to be maintained over any projects that are ongoing, such as the monitoring plan.
- Government and other agencies will have to continue their responsibilities of enforcement of all relevant laws and rules and regulations, and the dissemination of information.

Activities	Time in Months – 12-month time period											
	1	2	3	4	5	6	7	8	9	10	11	12
Phase I - Starts with Plan Adoption												
Education												
Meetings, Seminars & Training	St											
Prepare brochures/booklets			St									
Administration												
Develop Stakeholder List	St				C							
Tier 1/Tier2 Problem Resolved	St											
Design CRSP						St						
CRSP Financing			St									
Develop Monitoring Plan	St					C						
Monitoring Plan Financing			St									
Monitoring Plan Implementation							St					
Heavy Equip. Operator Cert. Prog. Developed and Funded						St						
Demonstration BMP Installation							St					
Annual Meeting w/Stakeholders												
Enforcement/Permitting												
CZM R&Regs & Permit Conditions												
Low-Impact Dev. Encouragement			St									
Build Community Support			St									
Others												
Dissemination to Stakeholders												
Emphasize Low-Impact Dev.												
Bi-Annual Cleanups (Coincide w/Coastweeks)												

Activities	Time in Months – 12-month time frame											
	13	14	15	16	17	18	19	20	21	22	23	24
Phase II – Starts 1 year after plan adopted												
Education												
Meetings, Seminars & Training												
Distribution & Re-printing Material												
Research & Upgrade Materials												
Administration												
Resolve Tier 1/Tier 2 Problem						C						
Design CRSP						C						
CRSP Financing												
Implement CRSP	St											
Monitoring Plan Financing												
Continue Monitoring Plan												
Heavy Equip. Operator Cert. Prog. Developed and Funded						C						
Implement Heavy Equipment Operator Certification Program						St						
Demonstration BMP Installation						C						
Annual Meetings w/Stakeholders												
Enforcement/Permitting												
CZM R&Regs & Permit Conditions												
Low-Impact Dev. Encouragement												
Build Community Support												
Inventory All OSDS						St						
Others												
Watershed Authority Organizes	St											
Dissemination to Stakeholders					St							
Emphasize Low-Impact Dev.					St							
Bi-Annual Cleanups (Coincide w/Coastweeks)												

Activities	Timeline in Months – 12-month time period											
	25	26	27	28	29	30	31	32	33	34	35	36
Phase II – Starts 1 year after plan adopted												
Education												
Seminars & Training												
Distribution & Re-printing Material												
Research & Upgrade Materials						St						C
Administration												
Implement CRSP												
CRSP Financing												
Monitoring Plan Financing												
Continue Monitoring Plan												
Continue Heavy Equipment Operator Certification Program												
Annual Meetings w/Stakeholders												
Enforcement/Permitting												
CZM R&Regs & Permit Conditions												
Low-Impact Dev. Encouragement												
Build Community Support												
Inventory All OSDS												C
Others												
Watershed Authority Organizes												
Dissemination to Stakeholders												
Emphasize Low-Impact Dev.												
Bi-Annual Cleanups (Coincide w/Coastweeks)												

Activities	Timeline in Months – 12-month time period											
	37	38	39	40	41	42	43	44	45	46	47	48
Phase II – Starts 1 year after plan adopted												
Education												
Seminars & Training												
Distribution & Re-printing Material												
Research & Upgrade Materials												
Administration												
Implement CRSP												
CRSP Financing												
Monitoring Plan Financing												
Continue Monitoring Plan												
Continue Heavy Equipment Operator Certification Program												
Annual Meetings w/Stakeholders												
Enforcement/Permitting												
CZM R&Regs & Permit Conditions												
Low-Impact Dev. Encouragement												
Build Community Support												
Repair OSDS	St											
Others												
Watershed Authority Organized	St											
Dissemination to Stakeholders					St							
Emphasize Low-Impact Dev.					St							
Bi-Annual Cleanups (Coincide w/Coastweeks)												
Fish Bay Watershed Management Plan Modification & Acceptance	St											

Activities	Time in Months – 12 month time frame											
	49	50	51	52	53	54	55	56	57	58	59	60
Phase II – Starts 1 year after plan adopted												
Education												
Seminars & Training												C
Distribution & Re-printing Material												C
Administration												
Implement CRSP												C
CRSP Financing												C
Monitoring Plan Financing												C
Continue Monitoring Plan												C
Continue Heavy Equipment Operator Certification Program												C
Annual Meetings w/Stakeholders												
Enforcement/Permitting												
CZM R&Regs & Permit Conditions												C
Low-Impact Dev. Encouragement												C
Build Community Support												C
Repair OSDS												C
Others												
Watershed Authority Organized												C
Dissemination to Stakeholders												C
Emphasize Low-Impact Dev.												C
Bi-Annual Cleanups (Coincide w/Coastweeks)												C
Fish Bay Watershed Management Plan Modification & Acceptance												C

REFERENCES

1. Anderson, D. M., and L. H. MacDonald (1998). “Modelling road surface sediment production using a vector geographic information system”. Earth Surface Processes and Landforms, 23, pp. 95-107

2. Austin, Texas 1991. In: Schueler, T.R. 1994. “Developments in Sand Filter Technology to Improve Stormwater Runoff Quality,” *Watershed Protection*, 1(2): 47-54, Center for Watershed Protection, Silver Spring, Maryland.

3. Empire State, Soil and Water Conservation Society, 1991. “New York Guidelines for Urban Erosion and Sediment Control”, Syracuse, New York.

4. “Environmental Guidelines for Access Roads and Water Crossings”, Ministry of National Resources, Ontario, Canada, 1988.

5. "Environmental Protection Handbook of the Virgin Islands", University of the Virgin Islands/Cooperative Extension Service, 1995.

6. MacDonald, L. H., D. M. Anderson, and W.E. Dietrich (1997). “Paradise threatened: land use and erosion on St. John, US. Virgin Islands”. Environmental Management, 21(6): 851-863.

7. MacDonald, L. H. and C. E. Ramos-Scharron (2000). “St. John Erosion Study: Final Report to the Water Resources Research Institute-Univ. of the Virgin Islands, 1 March 1998 to 31 August 1999”. 27pp.

8. Maryland Department of Environment, Water Management Administration.1994. “1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control”, Annapolis, Maryland.

9. Oertel, Bob. “New Soil Conservation Measures for Fort Indiantown Gap”, Erosion and Sediment Control, May/June 1999.

10. Ohio Department of Natural Resources, 1992. In: “Reducing the Impacts of Stormwater Runoff from Development”, New York State Department of Environmental Conservation, Division of Water, Bureau of Water Quality Management.

11. Schueler, T.R., 1987. “Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs”, Metropolitan Washington Council of Governments, Department of Environmental Programs, Washington, D.C. Publication # 87703.

12. USDA-SCS. 1998. "Standard and Specification for Ponds", U.S. Departments of Agriculture, Soil Conservation Service, Washington, DC.

13. USDA-SCS. "Engineering Field Manual", U.S. Departments of Agriculture, Soil Conservation Service, Washington, DC.

14. USDA-SCS. 1986. "Urban Hydrology for Small Watershed", Technical Release No. 55, U.S. Department of Agriculture, Soil Conservation Service, Washington, DC.

15. U.S. EPA. January 2000."Low-Impact Development Design Strategies: An Integrated Design Approach", U.S. Environmental Protection Agency, Washington, DC. Document # 841-B-00-003.

16. U.S. EPA. 1992. “Stormwater Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices”, U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC. Document # 832-R-92-005.

17. U.S. EPA. September 1986, "Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality", U.S. Environmental Protection Agency, Washington, DC.

GLOSSARY

Bay: An inlet of the sea.

Berm: An earthen mound constructed to direct the flow of runoff around or through a best management practice.

Best Management Practice or BMP: A practice or combination of practices that are determined to be the most effective and practicable means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals.

Best Management Measure: Economically achievable measures to control the addition of pollutants to our coastal waters.

Coastal Zone Management Act: Territorial law that created the Coastal Zone Management Committee and the Division of Coastal Zone Management.

Concentrated flow: Water flow that is not sheet flow. Water flow that has begun to form or run in channels.

Conveyance system: The drainage facilities which collect, contain, and provide for the flow of surface water and urban runoff from the highest points on the land down to a receiving water. Natural elements include swales, guts, streams, and wetlands. Human-made elements include gutters, ditches, pipes, channels and most retention/detention facilities.

Coral: Small animals (polyps) that exist in the shallow waters surrounding the Virgin Islands and other tropical areas. Corals create reefs that provide habitat and food for a wide variety of fish and other marine organisms, protection from large waves and beauty for human visitors.

Debris: Organic material that has accumulated on the ground.

Delivery ratio: A dimensionless ratio of the sediment yield divided by the total potential erosion in a contributing watershed. The sediment yield is the amount of sediment measured in receiving water.

Department of Planning and Natural Resources or DPNR: The territorial government agency that oversees and operates the CZM program. DPNR is responsible for all protecting the territory's natural resources and cultural resources, government planning, issuing and overseeing construction permits, zoning modifications, and operating the territories public libraries and educating the public about energy issues.

Detention basin: Constructed area that is designed to hold an amount of runoff for a specified length of time to allow sediment and other suspended particles to settle out of the water column.

Dissolved oxygen: The concentration of oxygen molecules that are dissolved in water.

Drainage area: Area or district drained.

Drainage channel: Any feature through which water runs in a concentrated flow.

Erodibility: The ease with which materials give way during erosion. It depends on the composition of the geological material and the state of its consolidation. Consolidated rocks have low erodibility; un-vegetated, loose soils (for example, sand) have high erodibility.

Erosion: Detachment of soil particles under the influence of wind and/or water.

Environmental Protection Agency: Federal agency that works to protect the nation's natural resources.

Filter fabric: Material that is designed and constructed to remove particles of sediment from runoff. Can be made of either natural or synthetic materials.

Filter strips: Grassed strips situated along roads or parking areas between an impervious road surface and engineered drainage conveyances such as sewers or ditches.

Floatables: Objects or materials that float on or are suspended in water.

Flow rate: Measure that describes the velocity or quantity of runoff past a particular point over time.

Gabions: Large blocks of wire mesh filled with rocks and are that are manually connected to one another. Usually, they are used to stabilize channels in high erosion zones.

Gleyed: Adjective form of Gley. Gley is a sticky clay soil or soil layer formed under the surface of some waterlogged soils.

Gully: A trench that was worn in the earth by running water and through which water often runs after rains.

Gut or Ghut: Local term for a gully.

Heavy metals: Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Homeowners' Association: [1]An association of people who own homes in a given area, formed for the purpose of improving or maintaining the quality of the area. [2]An association formed by a land developer or the builder of condominiums or planned unit developments to provide management for and maintenance of property in which they own undivided, common interest.[4]

Impervious surface: A hard surface area that either prevents or retards the entry of water into the soil as occurred under natural conditions prior to development. Generally causes water to run off the surface in greater quantities or at an increased flow rate than that found under natural conditions.

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[4]Nolan, Joseph R., and J.M. Nolan-Haley, 1990. Black's Law Dictionary, 6th ed.

Infiltration trench: An excavated trench that is back filled with stone aggregates, gravel, or sand.

Infiltration basin: An impoundment in which incoming runoff is temporarily stored until it gradually infiltrates into the soil surrounding the basin.

Lagoon: A shallow body of water that is near, and may be in contact with, a larger body of water.

Litter or trash: Items and particulates that are deposited in the watershed on street surfaces, on cleared land, or in the bush. Litter can include debris or vegetation residues (leaves, cut grass, etc.) and animal feces, as well as newspapers, plastic bottles, aluminum cans, broken glass, old automobiles or automobile parts, or other discarded or misplaced items.

Nephelometric Turbidity Units (NTUs): Measure of cloudiness in a water column.

Nonpoint source pollution: Pollution caused when water runs over the landscape and becomes contaminated from a variety of sources. Such pollution can consist of pollution off of roadways, trash or litter, sediment, household chemicals such as pesticides, sewage from improperly functioning septic systems and chemicals deposited on the ground from the air. All forms of pollution that are not a point source of pollution.

Ocean: Big, wide deep body of water to the north and east of the U.S. Virgin Islands.

Onsite sewage disposal system (OSDS): Sewage disposal system designed to treat wastewater on a particular site, e.g., septic tanks or package treatment plants.

Pavement: An impervious surface that is constructed of asphalt, concrete or other man-made material.

Point source pollution: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

Pollution: Man-made waste that contaminates the environment.

Pre-construction: The activities involved in a development prior to commencing earthwork or other activities that require a CZM permit.

Post-construction: Any activities that are done to a property after construction has been completed and for which no permits are required.

Retaining wall: Solid structure that is designed and built to hold in place earth. Frequently used to protect steep road cuts or excavations against collapse and erosion.

Retention basin: Constructed area that is designed to hold an amount of runoff for a specified length of time to allow sediment and other suspended particles to settle out of the water column.

Riprap: A layer of man-made, hard, durable material, usually loose rock, stone or concrete blocks, that is used to protect the bank of a gut or a steep road cut against erosion.

Runoff: That part of precipitation or irrigation water that runs off the land into streams, guts or other surface water. It can carry pollutants from the air and land into the receiving waters.

Sediment barrier: A small, temporary structure that is used at various points within and at the periphery of a disturbed area to detain runoff for a short period of time and trap larger sediment particles. Examples include but are not limited to a silt fence and a gravel and earth berm.

Sheet flow: Water flow that is over plane surfaces. Water flow than has not begun to form or run in any channels.

Silt fence: A small, temporary structure made of filter fabric attached to a wire or wood fence that is partially buried. It is used at various points within and at the periphery of a disturbed area to detain runoff for a short period of time and trap larger sediment particles.

Time of concentration: The time for runoff to travel from the hydraulically most distant point of a watershed to a point of interest within the watershed.

Total Suspended Solids: Soil or other and other solid material suspended in stormwater runoff or int he waters of a ghut, pond, bay or other water body.

Trash: See Litter

Turbidity: A cloudy condition in water due to suspended silt or organic matter.

Vegetated swale: An infiltration/filtration method that is used to provide pretreatment before runoff is discharged to other treatment systems.

Watershed: The land area that drains into a receiving waterbody.

Wetland: Area that is inundated or saturated by surface or ground water at a frequency to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Xeriscaping: A horticultural practice that combines water conservation techniques with landscaping; also known as dry landscaping (Clemson University Cooperative Extension Service, 1991).

APPENDIX A
LAND USE AND WATER QUALITY INFORMATION

Land use within the watershed has been and continues to be devoted primarily to residential use. The watershed is primarily zoned R1 – Residential low density with a ½-acre minimum lot size, R2 – Residential low-density with a 10,000 square foot minimum lot size and P – Public/park.

The principal pollutant in the Fish Bay watershed is sediment runoff from unpaved roads and development sites. As development and urbanization increase within the watershed, various other pollutants such as nutrients, bacteria, pesticides, heavy metals, organic matter, and trash will be deposited throughout the watershed. When stormwater runs off the urban landscape, it carries the pollutants with it, into the bay. The resulting degradation of water quality can cause immediate and long-term negative impacts on aquatic and terrestrial plant and animal species and their habitat, as well as limit the use of the water as a resource for swimming, recreation and a food source.

The water quality in Fish Bay is designated class B through tit. 12, §186-1 et seq., VIRR. Class B waters must attain or exceed the following minimum standards:

(a) Best usage of waters: For propagation of desirable species of marine life and for primary contact recreation such as swimming and water skiing.

(b) Quality Criteria:

- (1) Dissolved Oxygen: Not less than 5.5 mg/l from other than natural conditions.
- (2) pH: Normal range of pH must not be extended at any location by more than ± 0.1 pH unit. At no time shall the pH be less than 7.0 or greater than 8.3.
- (3) Temperature: Not to exceed 90º F. at any time, or as a result of waste discharge to be greater than 1.5º F. above natural. Thermal policy section shall also apply.
- (4) Bacteria: Shall not exceed a geometric (log) mean of 70 fecal coliform per 100 ml. by MF or MPN count.
- (5) Dissolved gas: Total dissolved gas pressures shall not exceed 110 percent of existing atmospheric pressure.
- (6) Phosphorus: Phosphorus as total P shall not exceed 50 µg/l in any coastal waters.
- (7) Suspended, colloidal or settleable solids: None from waste water sources, which will cause disposition, or be deleterious for the designated uses.
- (8) Oil and floating substances: No residue attributable to waste water nor visible oil film nor globules of grease.
- (9) Radioactivity:
  - (i) Gross Beta: 1000 picocuries per liter, in the absence of Sr-90 and alpha emitters.
  - (ii) Radium-226: 3 picocuries per liter.
  - (iii) Strontium-90: 10 picocuries per liter.
- (10) Taste and odor producing substances: None in amounts that will interfere with the use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life.
- (11) Color and turbidity: A Secchi disc shall be visible at a minimum depth of one meter.

APPENDIX B
PERMIT REVIEW PROCEDURES

The CZM permit is comprehensive in that it incorporates the requirements of the zoning use permit, earth change permit, shoreline alteration and submerged lands permit. Environmental Assessment Reports (EARs) are required for all water projects, whether major or minor, and for all Major land projects in tier one. All water projects also require a permit from the Army Corps of Engineers. A joint CZM-Army Corps permit process is in place so that both applications can be handled expeditiously.

The following distinguishes Major and Minor Land Permit requirements:

1. Minor Permits are required for subdivisions; construction of one or two single-family residences; construction of a duplex; improvements to an existing structure that costs less than $94,000.00; the development of one or more structures valued in their entirety at less than $136,000.00; any other development, except the extraction of minerals, valued at less than $120,000.00; and the extraction of minerals valued at less than $31,000.00.
2. Major Permits are required for all other development activities.

A. Minor Land Permit Applications

1. Minor Permit Applications are accepted Monday – Friday, 8:00 a.m. to 4:00 p.m.
2. Upon receipt at DPNR, applications are logged and assigned a permit number.
3. Staff Environmental Specialist(s) then review the applications for completeness. DPNR has 15 days to review the application for completeness. If additional information is needed the applicant must be notified within these 15 days. Each time an applicant re-submits an application DPNR has 15 days to review it. An applicant must respond with 60 days, or the application is considered withdrawn. A site inspection is made during this time period.
4. When an application is deemed complete, DPNR notifies all adjacent property owners and interested parties. These people are given 15 days to comment. Anyone that requests a copy of the application must do so in writing. They are given 30 days to comment after it is sent to them.
5. After review, the reviewer sends the application to the Director of CZM with his/her recommendation and conditions.
6. After further review, the Director sends the application, with his/her recommendation and conditions to the Commissioner for signature.
7. The applicant must notify DPNR when construction commences. Routine monitoring of the project then continues through completion.
8. NOTE: If the project includes water activities, it is sent to the Governor and the Legislature after the Commissioner's signature of approval.

B. Major Land Permit Applications

1. Applications are accepted within the first five (5) working days of each month. Applicants may request a pre-application meeting with the Review Team, where they may present their proposed project. In these meetings the Team discusses the application review process and gives general guidelines to the applicant as to what will be expected in the application when it is submitted.
2. Upon submission of the application, the "package" (Environmental Assessment Report [EAR] and drawings) is distributed to the Major Permit Review Team. This team consists of

individuals with varying areas of expertise. They are given 10 working days to review the package. DPNR has 15 days from the day of submittal to respond to the applicant.

3. Upon receipt of comments from the review team, a "completeness" or "incomplete with list of deficiencies" letter is sent to the applicant.
4. If the application is deemed incomplete the applicant is given time to submit additional information. DPNR then has another 15 days to review it. This continues until the application is deemed complete.
5. If the application is deemed complete, the applicant is required to submit twenty additional copies that are distributed to the reviewing agencies (e.g., Department of Public Works, Water and Power Authority/Environment Division). DPNR has 30 days within which to respond to the applicant. A public hearing is then scheduled and a public notice is prepared for publication in the newspaper. A public hearing must be scheduled within 60 days of the determination of completeness. All adjacent property owners and other interested parties are notified and are given 10 days to submit any comments prior to the public hearing.
6. A "Preliminary Staff Findings and Analysis" of the project is prepared for the CZM Committee for the island on which the project is to be constructed. This is sent to the applicant at least seven days before the public hearing.
7. The public has seven days after the public hearing to submit any additional comments. After this, a "Staff Findings/Analysis and Recommendation" is prepared and sent to the CZM Committee. The CZM Director's and review team's recommendations are distributed in-house for review after which it is sent to the Committee members. The Analysis and Recommendation is sent to the Committee members at least seven days before the Executive Committee Meeting.
8. An Executive Committee meeting is scheduled so the Committee can make its decision to either approve or deny granting a permit for the proposed project. An Executive Meeting must be scheduled within 30 days after the public hearing.
9. If the project is approved, the Major Permit is prepared and sent for the applicant's and Committee Chairman's signature. If the project involves activities in the water, it is also sent to the Governor for his approval and to the Legislature for ratification. If the project is denied, the applicant may re-submit after 120 days.
10. Prior to commencing construction, the Permittee must notify DPNR when construction will begin. Staff will then monitor the project through completion. Upon completion of construction, the Permittee must apply for a Certificate of Occupancy (CO). DPNR will make a final inspection and, if all conditions of the approved permit are met, issue a Certificate of Occupancy.

NOTE: If the project involves water activities, the applicant must submit a completed joint application and an additional EAR and drawings. This package is sent to the Army Corps of Engineering for review and issuance of their permit. The Corps will not issue a permit until DPNR issues its permit. When appropriate, the Corps and DPNR will conduct joint public hearings.

Permit fees are based on an established fee schedule and are paid at the time of application submittal.

C. Earth Change Permits (Tier II)

Whereas the Coastal Zone Management Act provides the legislation for development in the coastal zone (Tier 1), development in Tier II is enforced through the Environmental Protection Law. To address local concerns that development is not uniformly enforced and to ensure that the entire watershed comes under the same rules and regulations, the Earth Change Permit applications will not be accepted for development. CZM application procedures and rules and regulations will be enforced throughout the entire watershed.

D. Subdivisions

Approval is required by DPNR for any proposed subdivision. Subdivision means the division of a parcel of land into four or more lots or parcels for the purpose of transfer of ownership or building development, or, if a new street is involved, any division of a parcel of land.

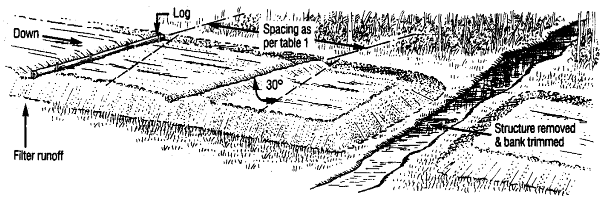
1. Upon filing an application with the Planning Director for approval of a preliminary plat or general subdivision plan, the applicant must submit to the Planning Director sufficient plans, data and other information so that DPNR can determine the extent and scope of the project. Within 30 days from the submission of the plan, the Planning Director must approve or disapprove the plan and notify the applicant of the decision.
2. In the event of approval of a preliminary plat or general subdivision plan, the final plat must be submitted to the Planning Director within the time period prescribed by the Planning Director. The final plat must conform substantially to the general subdivision plan. However, if requested in writing by the applicant, it may cover only that portion of the approved preliminary plat which is propose to be recorded and developed at the time. Such portion must conform to all the requirements of the subdivision law.
3. Applications for plan approval must be submitted to the Planning Director in writing.
4. Seven copies of the final plat and other exhibits required for approval must be submitted to the Director of Planning within six months after approval of the preliminary plat, otherwise the approval will become null and void. An extension of time may be applied for and granted by the Planning Director.
5. The Planning Director must confer with the Department of Public Works regarding the connection of utilities and other engineering aspects of the final plat.
6. In the Fish Bay watershed a Coastal Zone Permit must be obtained prior to subdivision approval. Upon approval of the subdivision, a Road and Driveway Permit must be obtained from the Department of Public Works.
7. Within 30 days of submission of the final plat, the Planning Director must approve or disapprove the plat and notify the applicant. In case the plat is disapproved, the Planning Director must notify the applicant of the reasons for disapproval.
8. Upon disapproval of a preliminary plat, general subdivision plan, or final plat, the applicant may request a hearing before the Board of Land Use Appeals.

APPENDIX C
BEST MANAGEMENT PRACTICES

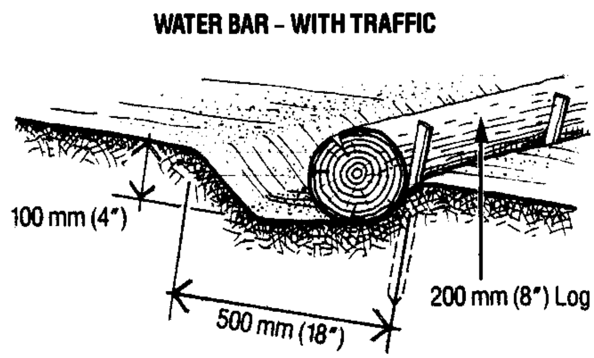
Roads and Driveways

Cross-drains or Water bars

These are shallow ditches that are placed diagonally across a road surface to direct runoff towards the side of the road. The exact distance between cross-drains or water bars has to take into consideration the soil's erodibility, the slope of the road and the expected rainfall. The lower lip of the water bar is reinforced and raised slightly so it is not washed out and eroded by traffic utilizing the road. See attached figure.



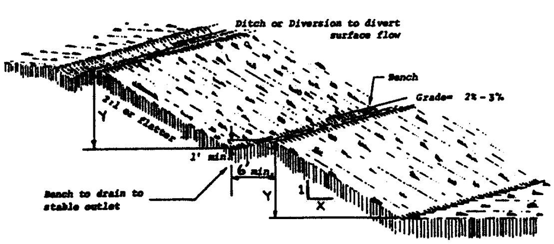
Ministry of Natural Resources, 1988



Ministry of Natural Resources, 1988

Proper Grading/Re-grading

A land grading plan should be established before any work is begun. This should avoid extreme grade modification through utilizing existing topography and desirable natural features to reduce and control the increased runoff that will occur. Some methods of land grading include diverting surface flow away from disturbed soils, serrated cutslopes, and surface roughening.



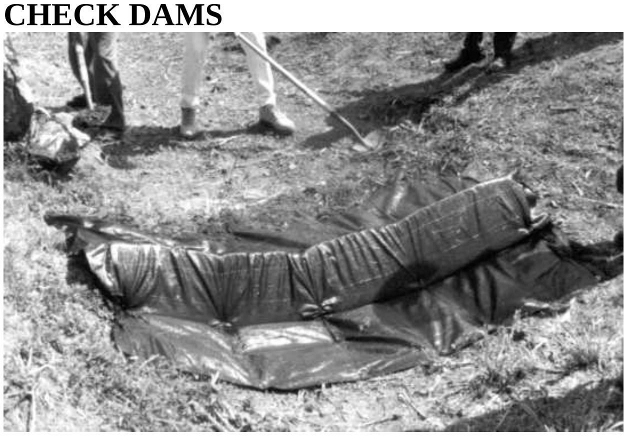
Empire State Chapter, Soil and Water Conservation Society, 1991.

Velocity Dissipaters

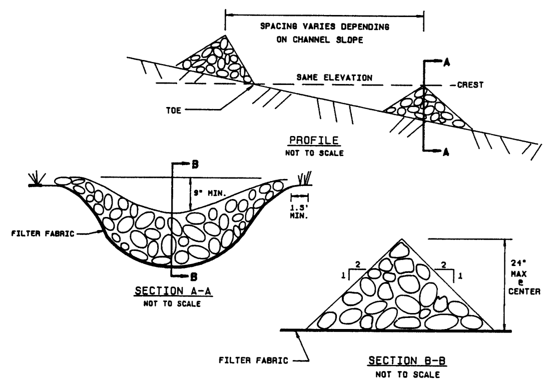
Velocity dissipaters are simply structures that are designed and placed to reduce the velocity of water as it flows downhill. Small check dams, rocks embedded in concrete to roughen the bottom of a gutter, the natural rocky bottom of our guts are all examples of velocity dissipaters. Other velocity dissipaters are rip-rap at the in-flow and outfall of pipes, culverts, and other stormwater structures and around bridges. The application of mulch and matting, and the natural litter and debris on the forest floor are also types of velocity dissipaters. There are a wide variety of materials from which to choose when designing a stormwater system. Factors to consider include the slope of the area, the erodibility of the soils, the exposure of the soils to sun, wind and rainfall, and the amount and type of runoff expected.

Usually the establishment of good vegetative cover is an important first step in reducing the velocity of water. Plant root systems help to anchor the soil, while the leaves, stems and associated litter help to break up and reduce the effects of raindrops hitting the soil. However, there are areas where plants cannot grow. In these situations it rip-rap, small check dams in ditches or rocks embedded in concrete gutters may be necessary to break up the flow of water down the side of the driveway or road. Rip-rap is useful in areas where the slope is not greater than 2:1. Rip-rap should extend higher than the high water level expected for a flood.

CHECK DAMS

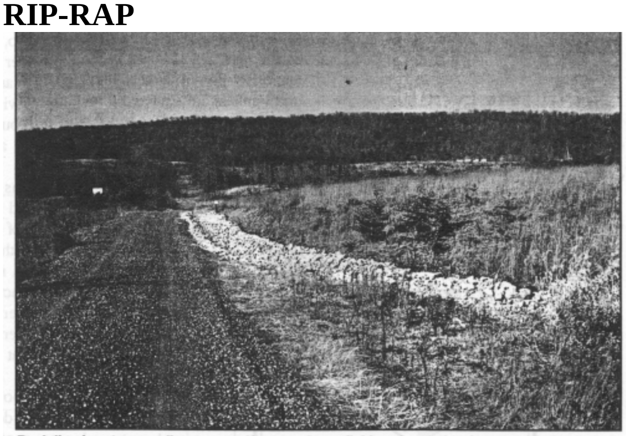


Photograph by: Dale Morton, UVI-CES



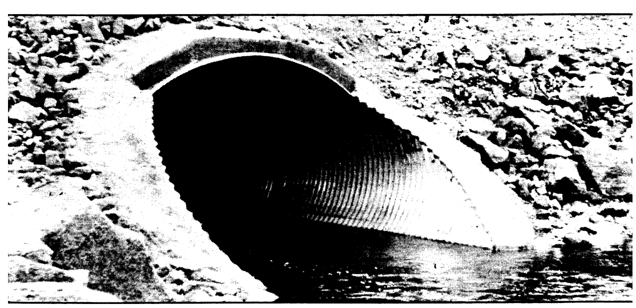
Empire State Chapter, Soil and Water Conservation Society, 1991.

RIP-RAP

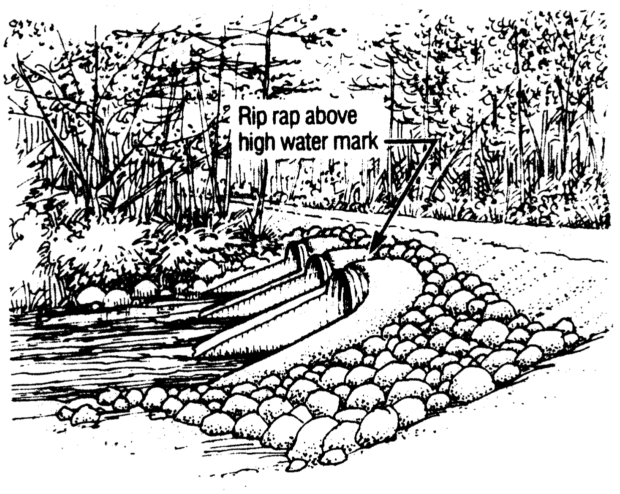


Rock-lined waterway diverts runoff water from field and empties into a rock-lined ditch along the roadway. This arrangement keeps runoff water from causing erosion on the road itself.

Erosion and Sediment Control, May/June 1999.

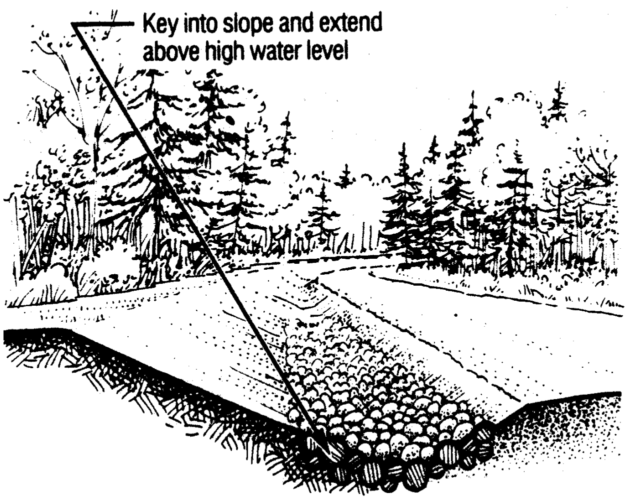


Ministry of Natural Resources, 1988



**RIP RAP AT CULVERT INLET IS USED
TO PROTECT FILL SLOPES FROM EROSION**

Ministry of Natural Resources, 1988



RIP RAP DITCH LINING

Ministry of Natural Resources, 1988

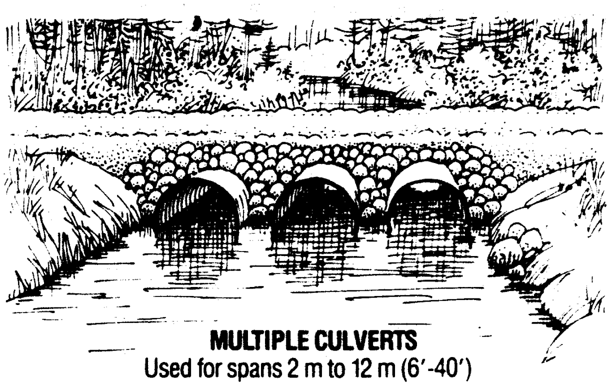
Photograph by: Bill Rohring, DPNR-CZM

Photograph by: Bill Rohring, DPNR-CZM

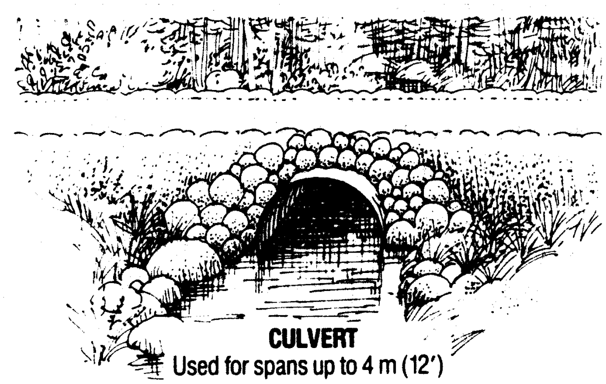
Gutters/Culverts

Installation of gutters or culverts should be completed prior to grading and paving. Gutters should be sized to handle the runoff from the area, both current and expected due to future growth patterns.

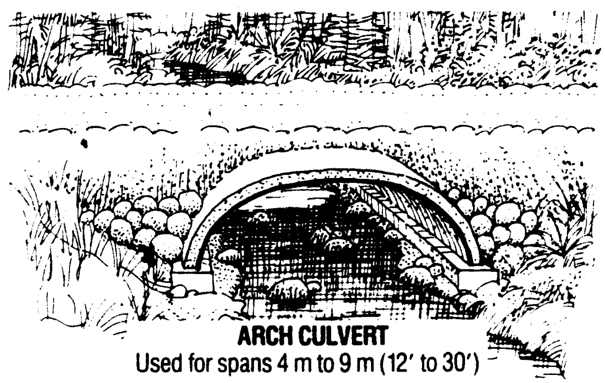
Culverts may be necessary if a road or driveway crosses a natural runoff feature such as a gut or small drainage path. If the gut is too large, a small bridge may have to be engineered and installed. If culverts are suitable for the gut or drainage path, then the structure must be able to support the loads it will be asked to carry and must be large enough to handle all runoff from the area it drains. It is wise to engineer in extra capacity in case uphill changes increase the amount of runoff that may enter the culvert or gutter. The property owner will have to be aware of many variables when designing the culverts such as the opening size, the type of bottom in the culvert - a smooth concrete bottom may increase runoff velocity much more than the natural bed, thus requiring velocity dissipaters to be installed downstream, the style of opening, the life of the culvert versus the life of any alternatives and the cost of the culvert for installation, maintenance and repair.



Ministry of Natural Resources, 1988



Ministry of Natural Resources, 1988



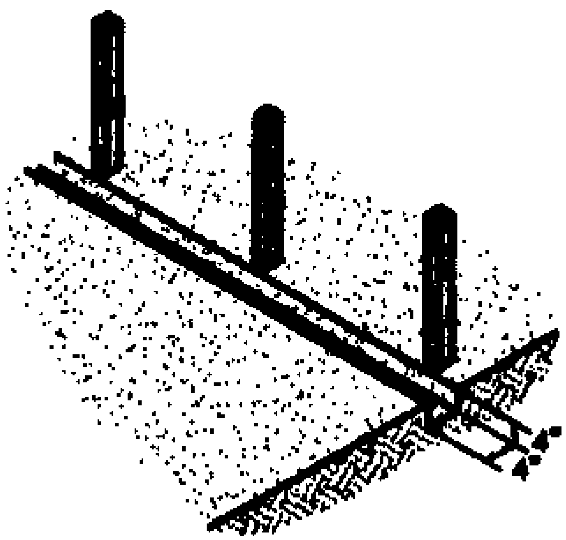
Ministry of Natural Resources, 1988

Sediment Traps

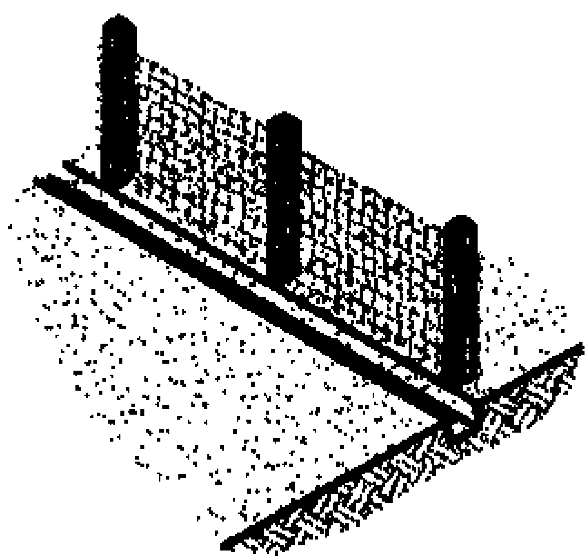
Sediment traps are designed to trap sediment through impounding sediment-laden water for a pre-determined period of time and allowing the suspended soil to settle out or be filtered out. Silt fences, various types of detention ponds, and specially designed structures are examples of sediment traps. Sediment traps and velocity dissipaters, even though designed for different purposes actually overlap in that each function to slow water velocity. However, velocity dissipaters are generally utilized prior to sediment traps so the velocity of the sediment-laden water does not blow out or overwhelm the sediment trap. All sediment traps need regular maintenance and must have the trapped sediment removed and properly disposed of on a routine basis. As sediment removal and disposal can be time consuming and expensive, this plan encourages property owners, designers, architects and engineers to keep runoff to a minimum by retaining water onsite, thereby limiting the need for sediment traps.

Silt fences should be utilized during the cutting and grading of roads and driveways. Proper installation of the silt fence proceeds as follows:

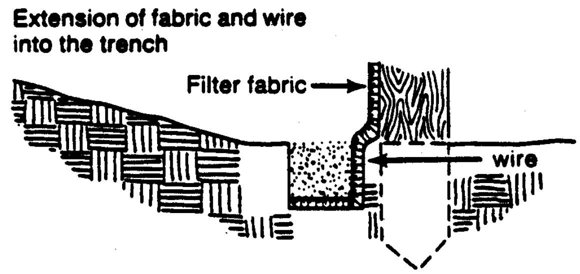
1. Installation should occur prior to disturbing any soil.
2. The fence should be placed across the bottom of the slope, perpendicular to the direction of flow, at a uniform elevation and at the outer boundary of the work area.
3. Steel posts should be used, along with wire fencing as reinforcement for the filter fabric.
4. A trench should be dug at the base of the wire fencing and the filter fabric should then extend into the trench. The trench should be backfilled and compacted once the filter fabric has been placed in the trench.



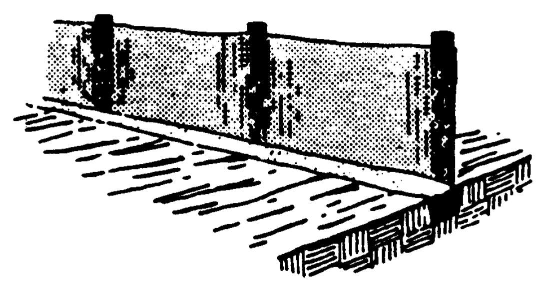
Set posts, excavate a 4" by 4" trench upslope and along the line of posts.



Attach wire fencing to the posts.



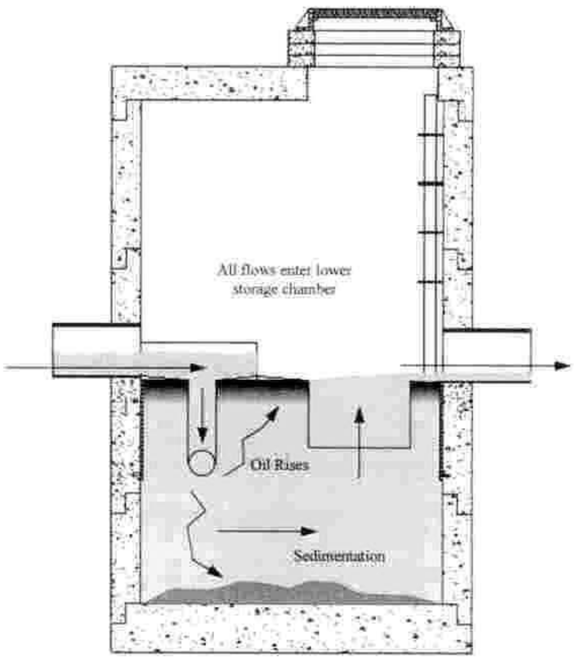
Attach the filter fabric to the wire fencing and extend it into the trench. U.S. EPA, 1992



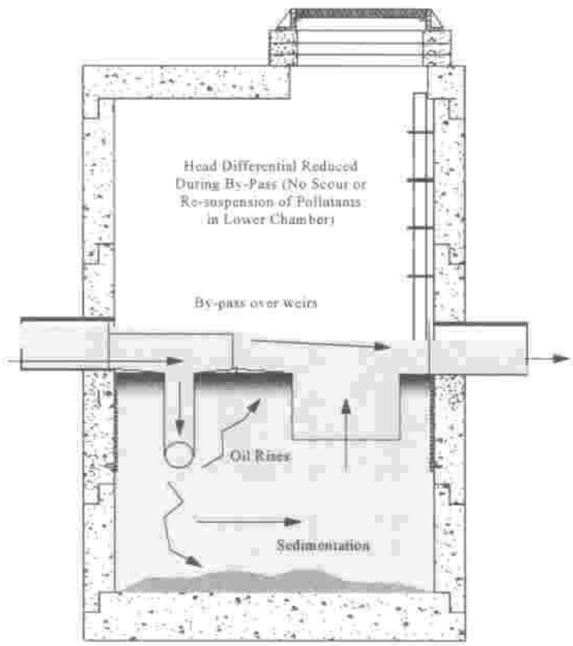
Backfill and compact the excavated soil.

Detention ponds are described in a later section of this Appendix.

Specially designed structures can be purchased to trap sediment. These are various manufacturers of these. A good architect and engineer can assist with choosing an appropriately sized and designed sediment trap. These should not be placed in a natural watercourse. Several of these can be utilized for a large drainage area, either in series or with separate traps utilized for separate drainage areas. Outlets must always be protected against erosion, especially in the case of overflow or an extremely high rainfall event.

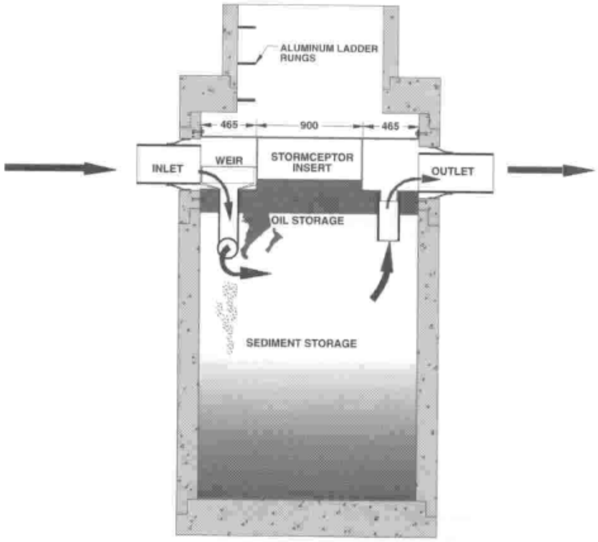


Storm*ceptor* Operation During Normal Flow Conditions
Storm*ceptor*® Technical Manual, 6/97

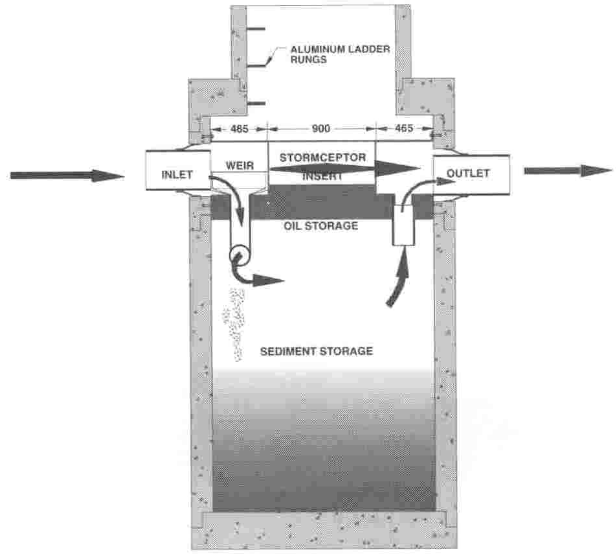


Storm*ceptor* Operation During High Flow Conditions
Storm*ceptor*® Technical Manual, 6/97

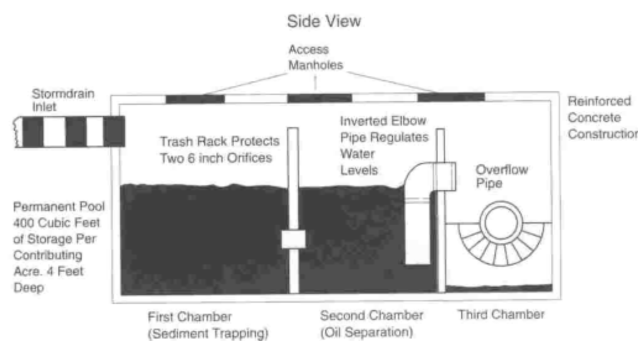
Oil/Water separators are specially designed structures that are utilized to separate oil and other floatable pollutants from water prior to its discharge into downstream receiving bodies. Frequently these structures are designed for the dual purpose of removing sediment and oil from runoff. Again, these structures require routine maintenance to prevent failure and concentrated flows of pollutants into downstream ecosystems. This plan encourages property owners, designers, architects and engineers to deep runoff to a minimum by retaining water onsite and reducing the possibility of oil pollution to a minimum, thereby limiting the need for these structures.



Storm*ceptor*® Study Manual



Storm*ceptor*® Study Manual

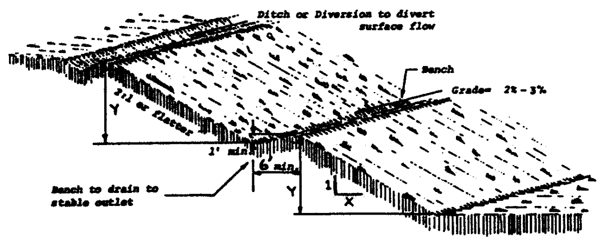


Schueler, 1987.

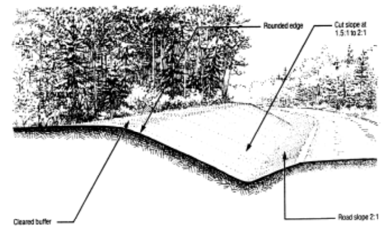
Steep Cutslopes

Reduce angle of cutslope

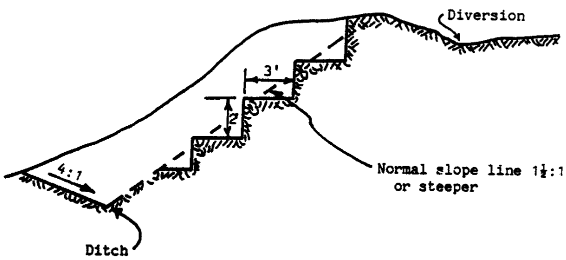
Reducing the angle of the cutslope allows for reduced erosion of the soil due to increased stability of soil structure. Two methods are available to reduce the angle of the slope, by adding more fill or by removing more soil. Adding more fill is not practical for most of the Fish Bay watershed. (I'm not sure about up at the head of the watershed.) Therefore, in most situations the only method available to reduce the angle of the cutslope will be the removal of more soil. This can be difficult as mentioned previously. However, if an individual property owner wishes to reduce runoff by utilizing this method, this plan recommends that the cutslope be reduced to an angle less than 2:1 (or over 6 feet horizontal distance for every 3 foot increase in height). As this exposes large amounts of bare soil, the property owner will have to take extra precautions to ensure erosion does not occur until the ground is heavily re-vegetated or otherwise stabilized. Another requirement will be the proper disposal of the large amounts of fill this method produces.



Empire State Chapter, Soil and Water Conservation Society, 1991.



Ministry of Natural Resources, 1988



Empire State Chapter, Soil and Water Conservation Society, 1991.

Retaining Walls

Retaining walls are frequently used in the Virgin Islands to protect the cutslope from erosion and landslide. They can be constructed of steel, concrete or a combination of the two. An example of a steel retaining wall is on Centerline Road, St. John on the way from Cruz Bay to Coral Bay. Like all structures, these must be designed to withstand the forces that will be exerted against them. Weep holes are necessary so too much hydrologic pressure does not build up behind the retaining wall and damage it. Other concerns that an engineer should address are the foundation bearing capacity, slippage or sliding of slopes and overturning. There are many examples that can be seen by just driving around the island. Many people utilize native stone and shell in the walls for decorative purposes.


Photograph by: Dale Morton, UVI-CES


Photograph by: Dale Morton, UVI-CES

Photograph by: Bill Rohring, DPNR-CZM

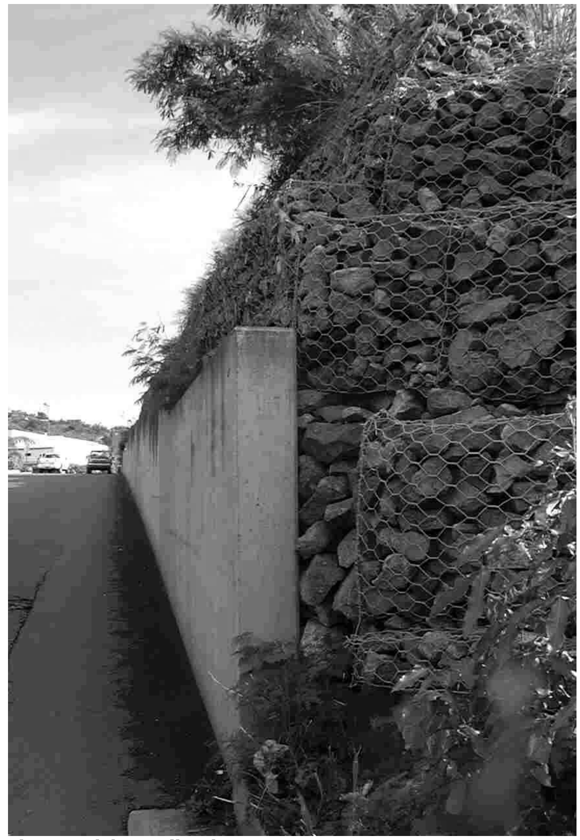
Gabion Baskets

Gabion baskets are wire mesh baskets filled with large rocks that are place against the side of the slope to stabilize it and protect it from erosion. There are several sites on St. John where gabion baskets can be easily viewed from the road**.** The purpose of these is similar to retaining walls.

Photograph by: Bill Rohring, DPNR-CZM

Photograph by: Bill Rohring, DPNR-CZM


Photograph by: Bill Rohring, DPNR-CZM

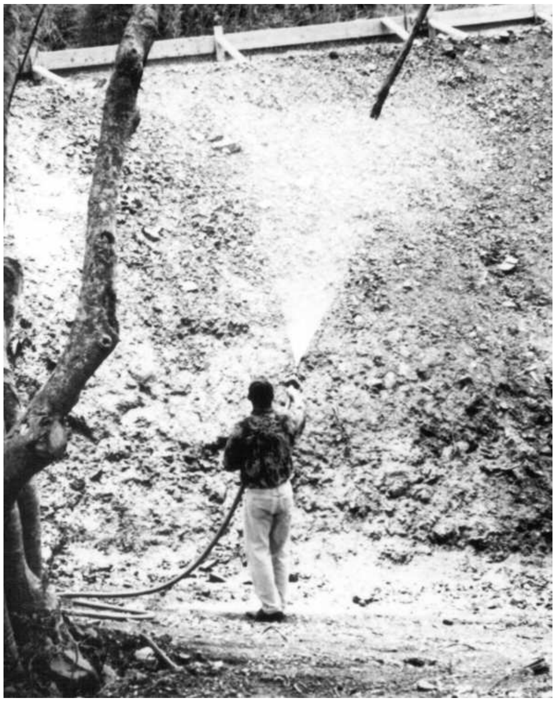

Photograph by: Bill Rohring, DPNR-CZM

Re-seeding/Re-vegetation with mulch or mesh mats

There are several methods of re-vegetating slopes and denuded areas. Hydro-seeding is a method of applying a grass seed, fertilizer and mulch mixture through a low-pressure hydraulic system. This allows for the relatively quick application of a uniform coating over fairly large areas. Unfortunately, the applied mixture can be washed away relatively quickly on steep slopes and cuts. However, with routine watering and minimal care, this method can provide relatively quick re-growth of vegetation.

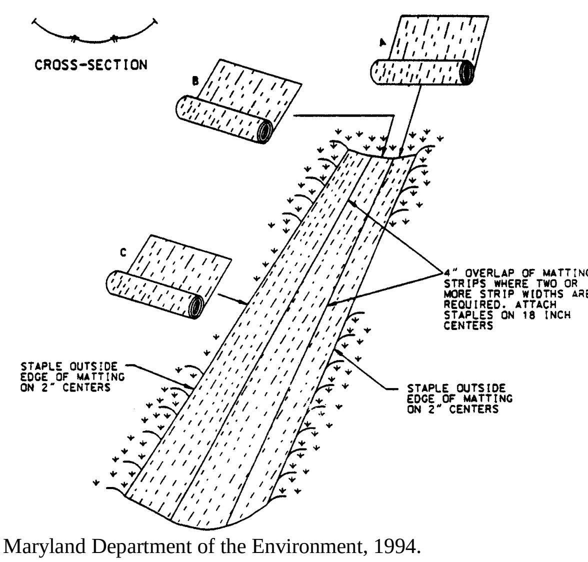

Photograph by: Dale Morton, UVI-CES


Photograph by: Dale Morton, UVI-CES



Photograph by: Julie Wright, UVI-CES

Temporary erosion control mats, when utilized with a re-seeding program, are useful on both flat and moderately steep slopes. These mats must be correctly installed to ensure the usefulness of the product. As these are like shipped in rolls they usually are unrolled into strips that must be overlapped and stapled down to prevent them from being blown away. Even so, high winds can still blow these off of construction sites and hillsides. Generally these mats are constructed by weaving material such as straw or coconut fibers into a thin, loosely woven mat. The mat absorbs the impact of rainfall, thus lessening the erosive impact of rain on bare soil, while the loose weave lets grass or other plants to grow through the mat. The mat also helps to shade the ground, thereby preserving soil moisture and allowing for quicker seed germination and re-growth of vegetation. Lastly, these mats decompose relatively quickly, thus providing nutrients to the soil.



Maryland Department of the Environment, 1994.

Photograph by: Dale Morton, UVI-CES

Photograph by: Dale Morton, UVI-CES

Permanent erosion control mats are useful for protecting the steepest slopes. These are generally formed of some type of synthetic woven mesh. Just like the temporary erosion control mats they must be overlapped and stapled to hillsides. However, unlike the temporary mats, these do not decompose, at least not very quickly, and may, with correct installation, very well be able to withstand higher winds than natural materials. As these do not decompose very readily, they may be preferable when faced with protecting slopes where re-growth will take a relatively long time.

Some factors to consider when using any kind of erosion control methods are the slope of the area to be re-vegetated, the depth, if any, of the soil and the ability of the vegetation to grow under the particular site conditions. For example, a relatively flat area with a soil depth of 12 inches or more that is being re-vegetated during the rainy season will have different requirements than a vertical cutslope with very little soil cover, even if it is the rainy season. In the latter example it may be a year or more before the slope is adequately re-vegetated to protect against most rainfall events.

Construction Sites

During the construction phase of any project there is the increased potential for severe on-site erosion and the deposition of sediment further downslope. Three general methods of control, detention, filtration, and infiltration have been developed to prevent this pollution from occurring. Many times different aspects of these methods are combined into an over-arching plan.

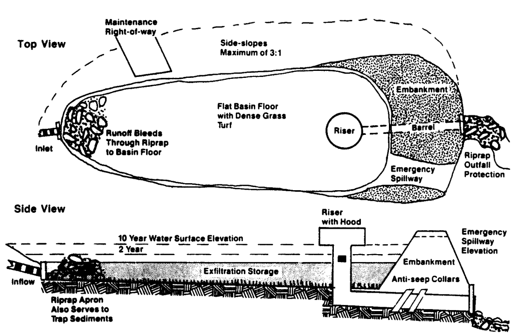
Detention

Methods of detention rely on holding or retaining water for differing lengths of time. Generally the water is released at certain prescribed rates, if it is released at all. Constructed wetlands and retention/detention ponds are the primary practices used under this method. These systems do require maintenance in that excess sediment will have to be removed periodically and plants may have to be pruned, removed or re-planted to maintain the optimum functioning of the system.

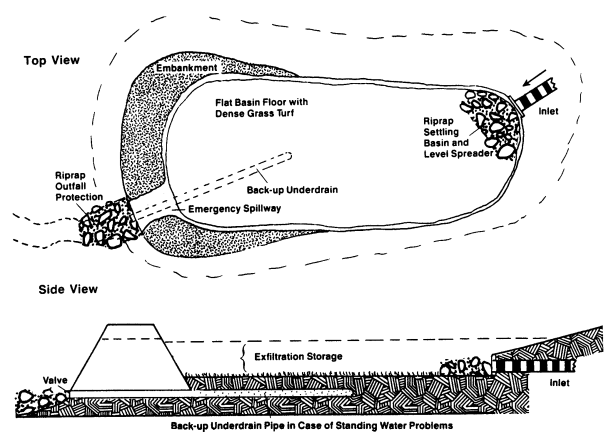
Constructed wetlands can range in size from a small pond or creek that will fit in a single backyard to re-constructed wetlands that cover acres of land. Usually the runoff will flow into one end of the system at much higher rate than it is released. As the water gradually flows through the system sediments and related pollutants are deposited into the wetland. Once deposited, the excess nutrients or other pollutants become are taken up by the wetland plants, broken down by natural soil producing processes, or are bound to the sediment particles that are trapped in the gradually accumulating soil. Disadvantages of these systems are that excess amounts of sediment can overwhelm the system and effectively smother growing plants and excess amounts of water can actually scour through the system, effectively re-suspending and transporting a pulse of pollution further downstream. In this case the constructed wetland becomes a source of pollution.

Retention/Detention Ponds may be used, either singly or with other methods of overland flow to retain, detain and treat the increased and accelerated runoff that the development generates. For these to operate effectively water must be released at a rate and in a manner that approximates the natural flow of the predevelopment site. The following standards must be followed when designing these practices:

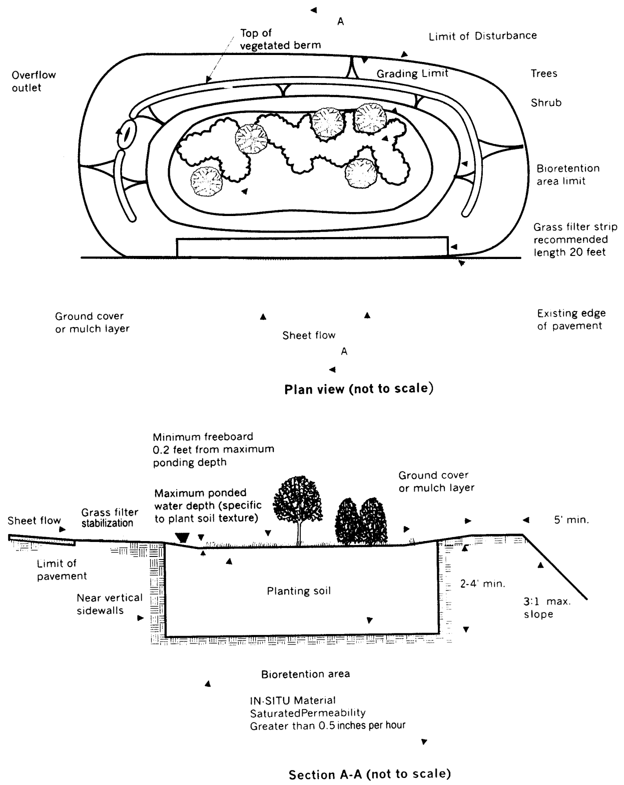
1) Peak flow discharges from 1-year, 2-year and 100-year, 24-hour storms must not be increased by the development or activity.
2) Ponds must not be placed where their use will pose concerns of groundwater contamination through the recharging of pollutants from surface runoff.
3) Detention ponds must have a minimum detention time of 36 hours, a minimum sump depth of 3 feet, and whenever possible utilize permeable sides, bottoms or both to minimize outflows.
4) Outflow must proceed to natural vegetated areas or vegetated swales when discharging near watercourses or wetlands. Areas utilized for sheet flow should have hydrologic and vegetative characteristics to insure that stormwater reaches the watercourse or wetland in a manner that approximates predevelopment conditions.



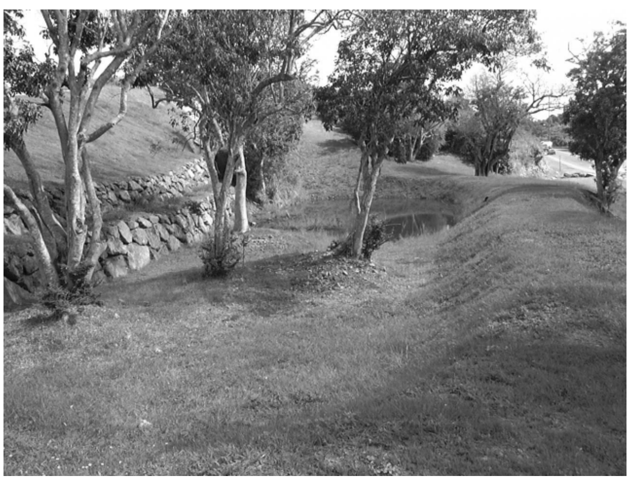
Schueler, 1987.



Schueler, 1987.

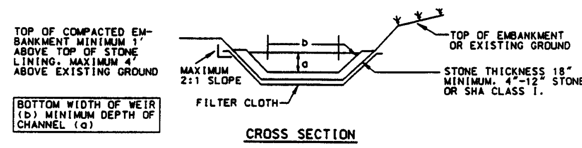


U.S. EPA, 2000

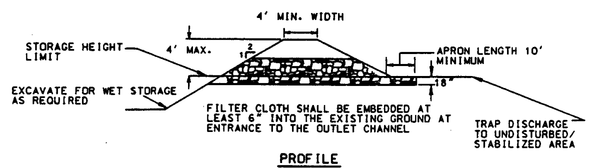


Photograph by: Bill Rohring, DPNR-CZM

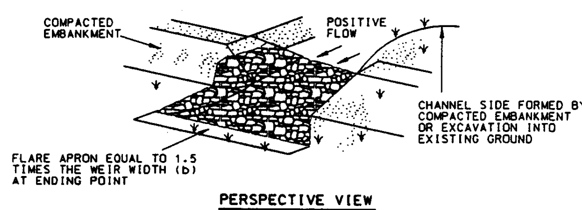
Photograph by: Bill Rohring, DPNR-CZM



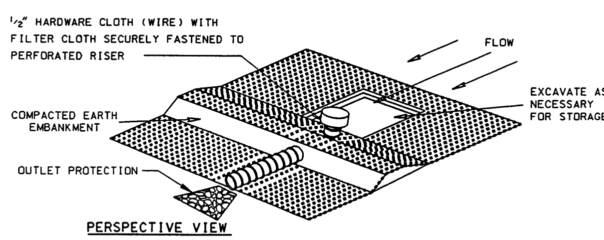
Maryland Dept. of the Environment, 1994



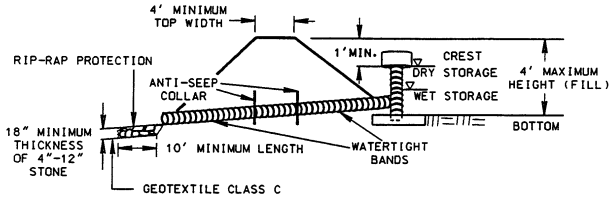
Maryland Dept. of the Environment, 1994



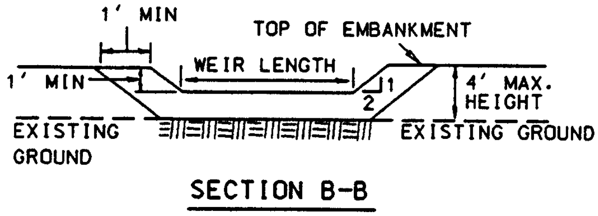
Maryland Dept. of the Environment, 1994



Maryland Dept. of the Environment, 1994



Maryland Dept. of the Environment, 1994



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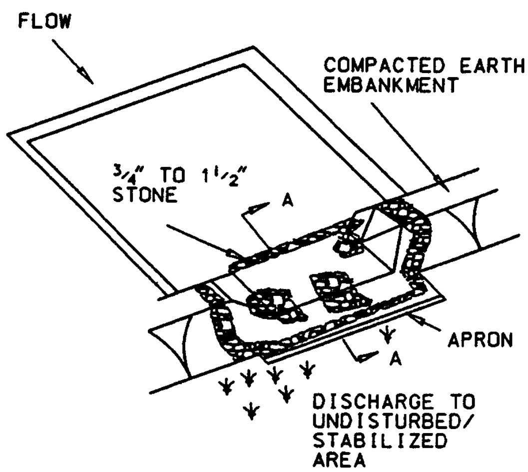
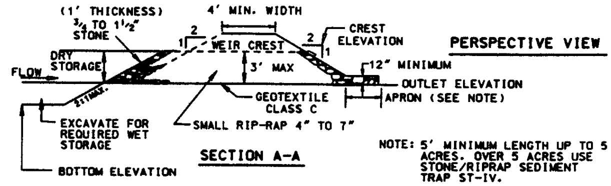
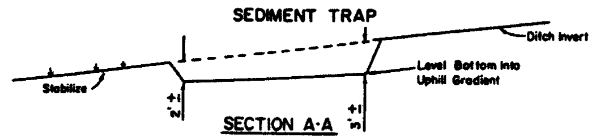


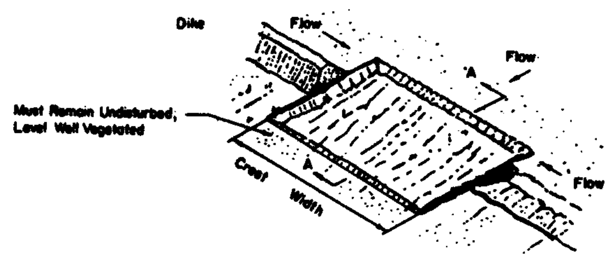
Empire State Chapter, Soil and Water Conservation Society, 1991.



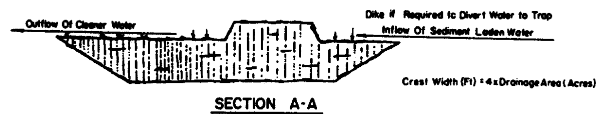
Empire State Chapter, Soil and Water Conservation Society, 1991.



Empire State Chapter, Soil and Water Conservation Society, 1991.



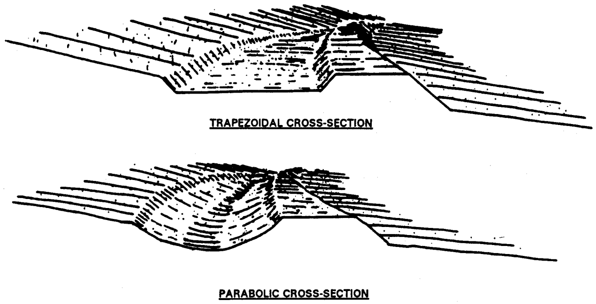
Empire State Chapter, Soil and Water Conservation Society, 1991.



EXCAVATED GRASS OUTLET SEDIMENT TRAP

Empire State Chapter, Soil and Water Conservation Society, 1991.

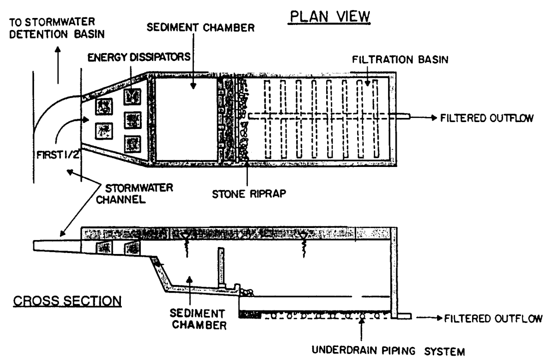
Filtration methods rely on vegetative or other systems to remove sediment and other pollutants from runoff as it gradually flows through the particular system. Grassed swales, vegetated filter strips and sand filters are types of filtration systems. Generally, these systems are used on flat or gently sloping land to control filter runoff from parking lots, roads or driveways or other area that will generate a relatively low volume of low velocity runoff. These systems are generally very good at filtering sediment from runoff prior to its entering other infiltration or detention devices. Again, maintenance is required to prevent the particular system from becoming clogged with sediment. As high velocity runoff will effectively scour away these systems and increase the sediment loads for downstream systems, it is recommended that these be utilized on very shallow slopes where runoff is less than 0.5 ft/sec.



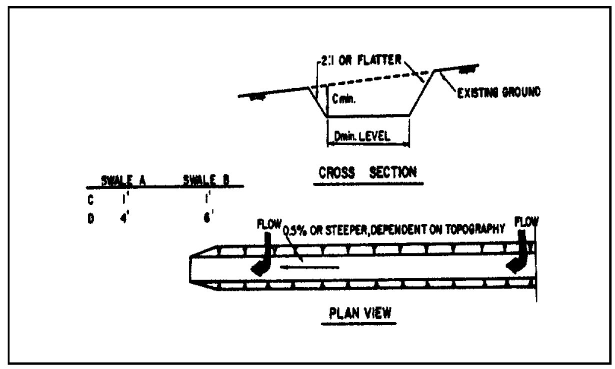
U.S. EPA, 1992.

	Swale A	Swale B
Maximum Drainage Area Contributing Runoff	< 5 Acres	5 - 10 Acres
Bottom Width of Flow Channel	4 feet	6 feet
Depth of Flow Channel	1 foot	1 foot
Side Slopes	2:1 or flatter	2:1 or flatter
Grade	0.5% minimum 20% maximum	0.5% minimum 20% maximum

ADVANTAGES OF DRAINAGE SWALES
• Swale excavation can be easily performed with earth moving equipment.
• Can transport large volumes of runoff.
DISADVANTAGES OF DRAINAGE SWALES
• Stabilization and design costs can make construction expensive.
• Effective use is restricted to areas with relatively flat slopes (< 8% for most designs).



Austin, Texas, 1991.



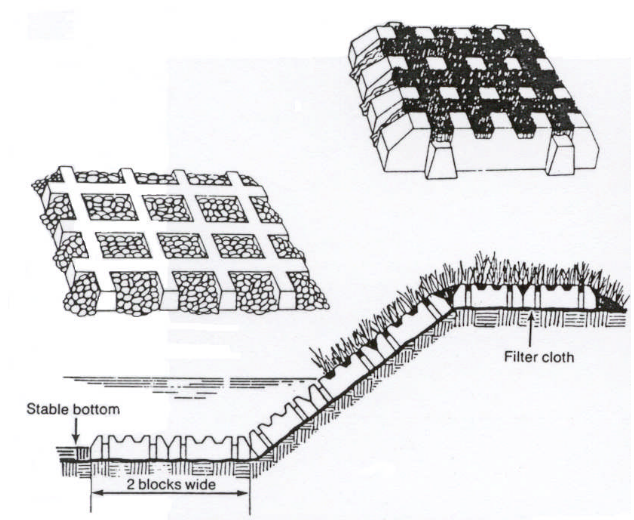
Empire State Chapter, Soil and Water Conservation Society, 1991.

Infiltration relies upon devices that allow the water to filter into the soil rather than becoming runoff. Examples of devices used in this type of system include infiltration trenches and basins and porous pavement. Obviously, the retention pond and, to a lesser extent, the constructed wetland systems described above can allow some water to infiltrate into the ground, however they are principally designed for different purposes. Infiltration devices are designed to contain water until it is either absorbed into the ground, it evaporates, or it overflows the device. For this reason these devices must be designed such that any water that does escape does not contribute to further erosion downstream. Allowing water to overflow via a shallow grassed swale or through sheet flow into a constructed wetland or densely vegetated area is preferable to allowing concentrated flow through an overflow pipe.

Porous pavement allows water to infiltrate onsite, thus reducing the need for other stormwater control devices. However, this system is not suitable for high traffic areas, steep roads or parking areas, or areas with shallow drainage. As such, it is generally better suited to parking areas or driveways for small sites rather than main roads or busy parking lots.

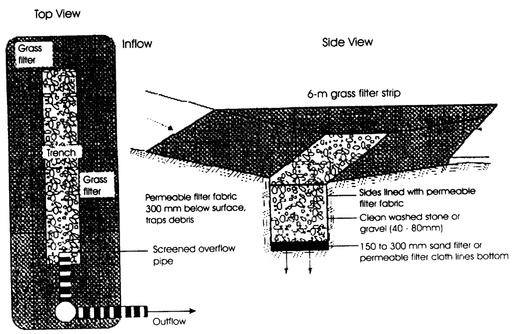
Photograph by: Dale Morton, UVI-CES

Photograph by: Dale Morton, UVI-CES

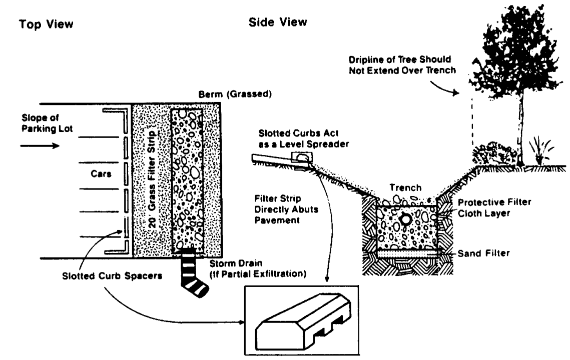


Empire State Chapter, Soil and Water Conservation Society, 1991.

An infiltration trench generally serves a small drainage area and can be placed to easily blend into the surrounding landscape. These trenches are generally several feet deep and filled with gravel. If excess sediment enters the system and clogs the trench then the gravel may have to be periodically removed, cleaned and replaced, or removed, disposed of and replaced. Most sites in the Virgin Islands have soil that is too rocky for these to work effectively, however, there may be areas within the watershed where this BMP can be used.

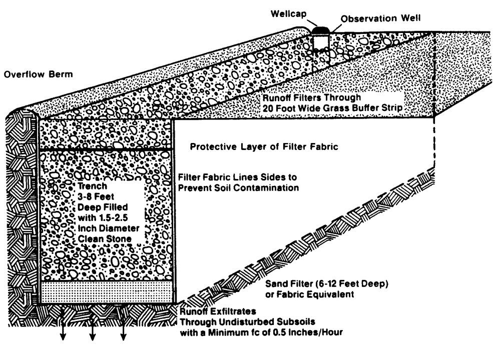


Maryland Dept. of the Environment, 1994

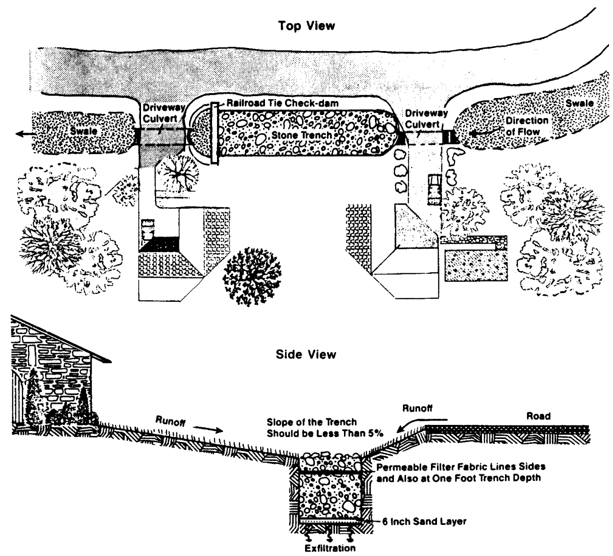


Swale/trench design for a development

Schueler, 1987.



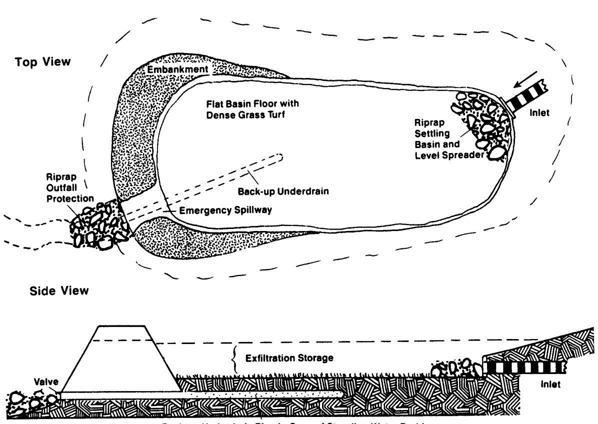
Schueler, 1987.



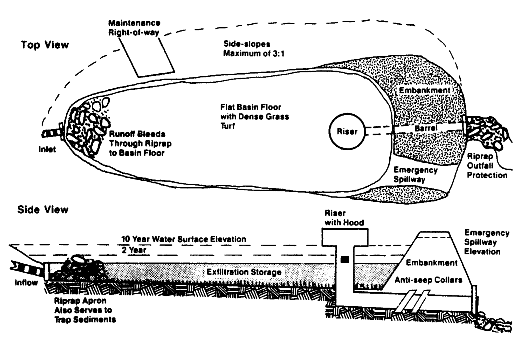
Swale/trench design for a development

Schueler, 1987.

An infiltration basin generally serves a larger area than an infiltration trench. However, if these are not properly maintained they can become stagnant pools of water that provide an excellent place to breed mosquitoes. Rapid clogging can lead to high maintenance costs.

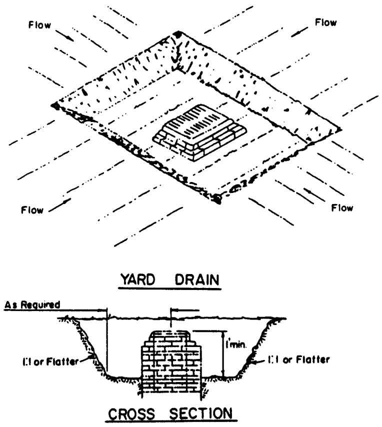


Schueler, 1987.



Schueler, 1987.

Storm Drain Inlet Protection



Empire State Soil and Water Conservation Society, 1991

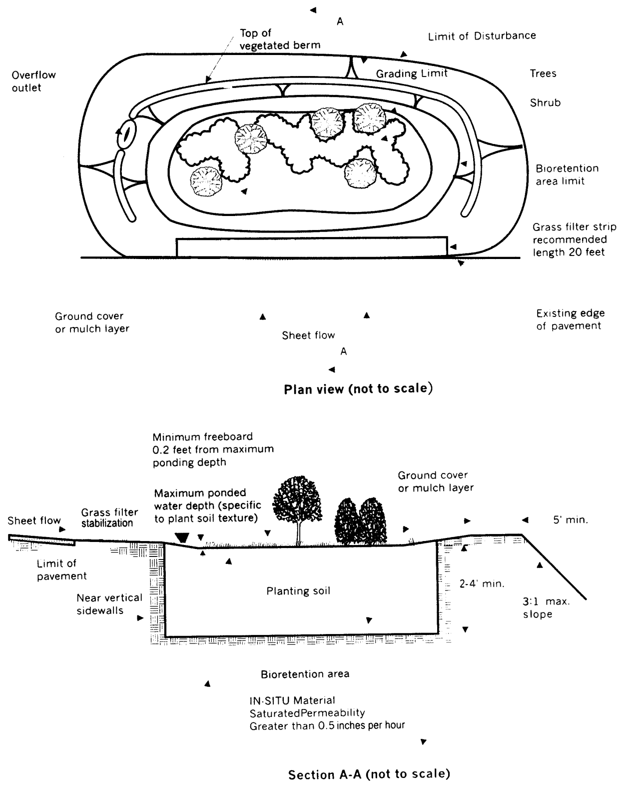
Homesites

This plan encourages all property owners to practice the following methods of low impact development for homesites or other small developments. Low impact development, if properly included and integrated into the earliest design stages, will address: 1) groundwater recharge through infiltration of runoff, 2) the retention or detention of runoff, 3) the settling and trapping of pollutants, and 4) the use of multiple systems or landscaped areas.[5] For more information the EPA publication "Low-Impact Development Design Strategies: An Integrated Design Approach" is highly recommended. This section relies heavily on information adapted from this publication. For all devices mentioned in this section, the plan proposes that the 25-year, 24-hour storm be considered the minimum when calculating rainfall amounts, amount of runoff and retention/detention capabilities of the system.

Bioretention is similar to retention/detention ponds mentioned above. For this practice a relatively small area of land is required, however good drainage and soil infiltration capability is required. A method for adapting this to our terrain could include the use of terraces or constructed wetlands similar to that used in septic systems. For the individual homeowner that may not be familiar with the design of an integrated system for retaining all water onsite, the following are important design considerations.

- A pretreatment area such as a grassed swale or vegetated buffer strip is important if a lot of sediment is expected from a parking area or other disturbed area.
- A retaining area that has a very limited depth, usually 6 inches or less.
- A good ground cover layer of mulch or good topsoil.
- A soil layer 4 feet or more in depth that has good planting characteristics.
- Undisturbed soil that has an infiltration rate of greater than ½ an inch per hour.
- Three or more species of native plants.
- Control of inlets and outlets so flow does not exceed 0.5 feet per second.

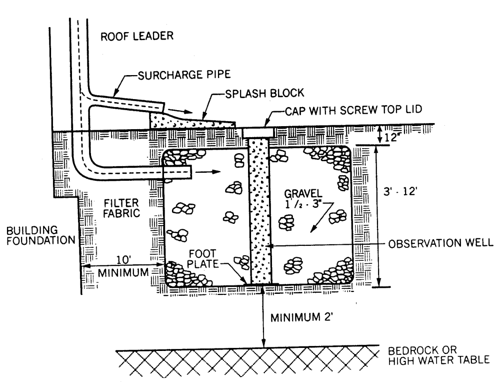
[5] Department of Environmental Resources, Prince George's County, Maryland, 2000. *Low-Impact Development Design Strategies*. Prepared for EPA. p. 4-8.



Maryland Dept. of the Environment, 1994

Dry wells provide good infiltration into surrounding soils provided they are protected from clogging by sediment, grease, oil, organic materials and other settable solids. Design considerations include:

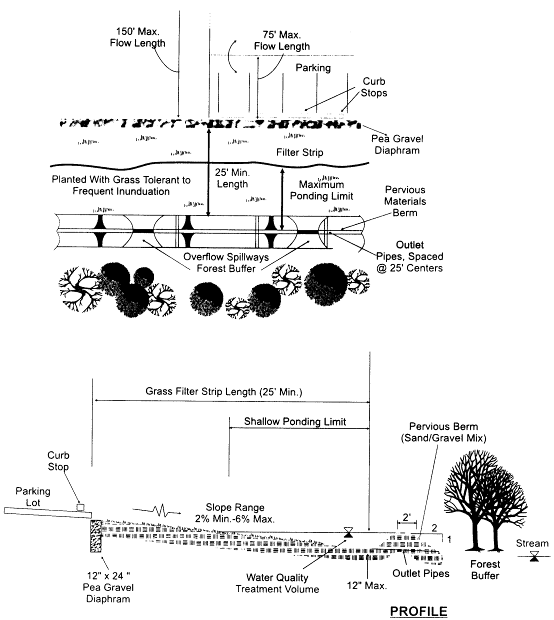
- Soil infiltration rate should be ¼ an inch per hour or more.
- The dry well should empty from full within three days.
- Gravel should be cleaned and washed and between 1.5 – 3 inches in size.
- For storms or flow exceeding design characteristics, the overflow structures must not allow channeling or other erosion to occur.
- Well depth varies from 3 – 12 feet, depending on soil depth and design characteristics.
- Observation/test well required for monitoring, 4" PVC pipe with cap recommended.



Maryland Dept. of the Environment, 1994

Filter strips can be used to protect bioretention devices from sediment clogging. These should not be considered the sole method for treating stormwater, but should be considered one part of the overall design. Design considerations include the following:

- Generally, no more than 150 feet of pervious surface drainage area, or 75 feet of impervious surface drainage area can be accommodated.
- Minimum slope is 1%, maximum is left to designer, but channeling must not occur.
- Length of strip depends upon amount of runoff being treated, but a minimum of 20 feet is recommended.
- Runoff should enter via sheet flow; a level-spreader can be utilized for this if necessary. The outlet should not contribute to channeling.



Maryland Dept. of the Environment, 1994

Level spreaders are devices designed to convert concentrated runoff into sheet flow. An example of a level spreader is shown below. Design considerations include:

- Inlet must not be erodible. Outlet must be level and in stable soil. Permanent matting could be useful in preventing the soil around the outlet lip from eroding.
- A number of small spreaders may be more efficient or workable than one large spreader.
- Sheet flow can be directed towards bioretention, grass swales or other vegetated strips, or heavily vegetated areas.

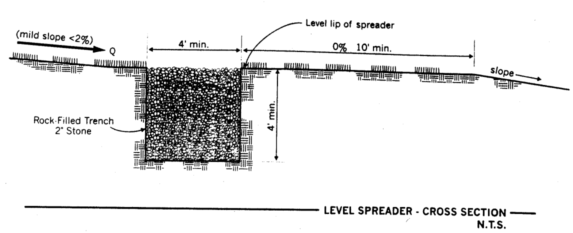
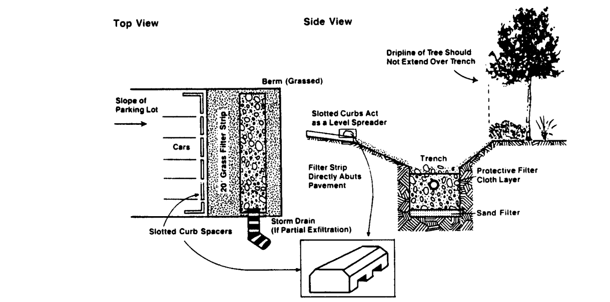
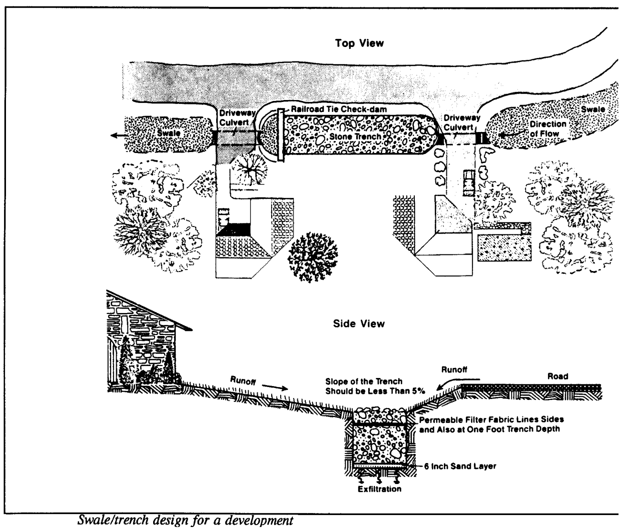


Figure 4-6. Typical rock trench level spreader

Maryland Dept. of the Environment, 1994



Parking lot perimeter trench design



Swale/trench design for a development

Schueler, 1987.

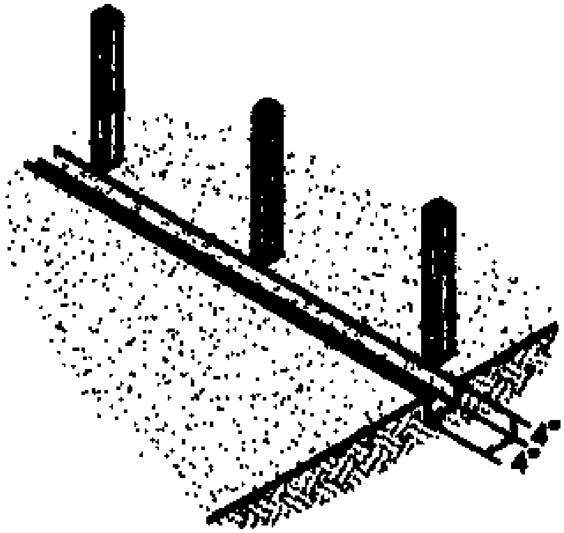
An exceptionally useful idea for V.I. residents is the stormwater cistern. The stormwater runoff cistern should be designed to function as part of the overall stormwater runoff system. The cistern can be designed with extra capacity to accommodate larger flows than those provided by the 25-year, 24-hour storm. Care must be taken when designing a stormwater cistern so that any overflow that does occur will not contribute to scouring. Use of a stormwater cistern is highly recommended on sites that have or receive large amounts of stormwater runoff. A cistern not only provides retention for stormwater runoff, but it can also provide regulated flow to the other stormwater system components, thereby decreasing the possibility of channelization and erosion. These may also be used as a source of irrigation water for gardens and landscaping, as well as an emergency water source. Cisterns must meet all requirements of the V.I. building code.


Photograph by: Bill Rohring, DPNR-CZM
Stormwater Cistern

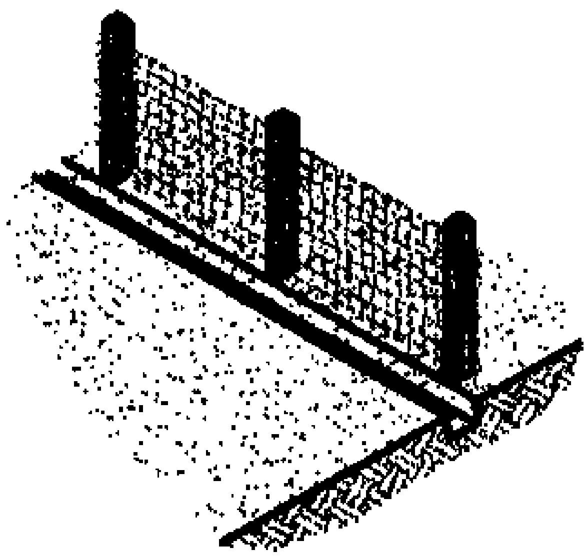

Photograph by: Bill Rohring, DPNR-CZM
Irrigation from stormwater cistern

Silt fences should be constructed in the following fashion:

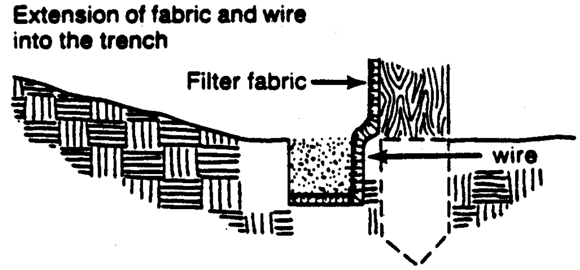
1. Installation should occur prior to disturbing any soil.
2. The fence should be placed across the bottom of the slope, perpendicular to the direction of flow, at a uniform elevation and at the outer boundary of the work area.
3. Steel posts should be used, along with wire fencing as reinforcement for the filter fabric.
4. A trench should be dug at the base of the wire fencing and the filter fabric should then extend into the trench. The trench should be backfilled and compacted once the filter fabric has been placed in the trench.



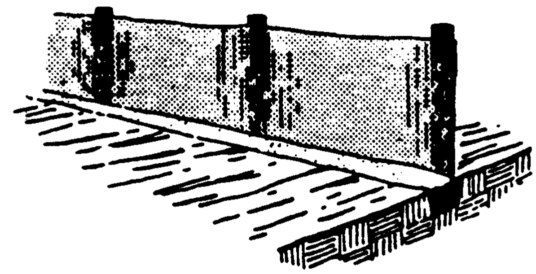
1. Set posts, excavate a 4" by 4" trench upslope and along the line of posts.



2. Attach wire fencing to the posts.



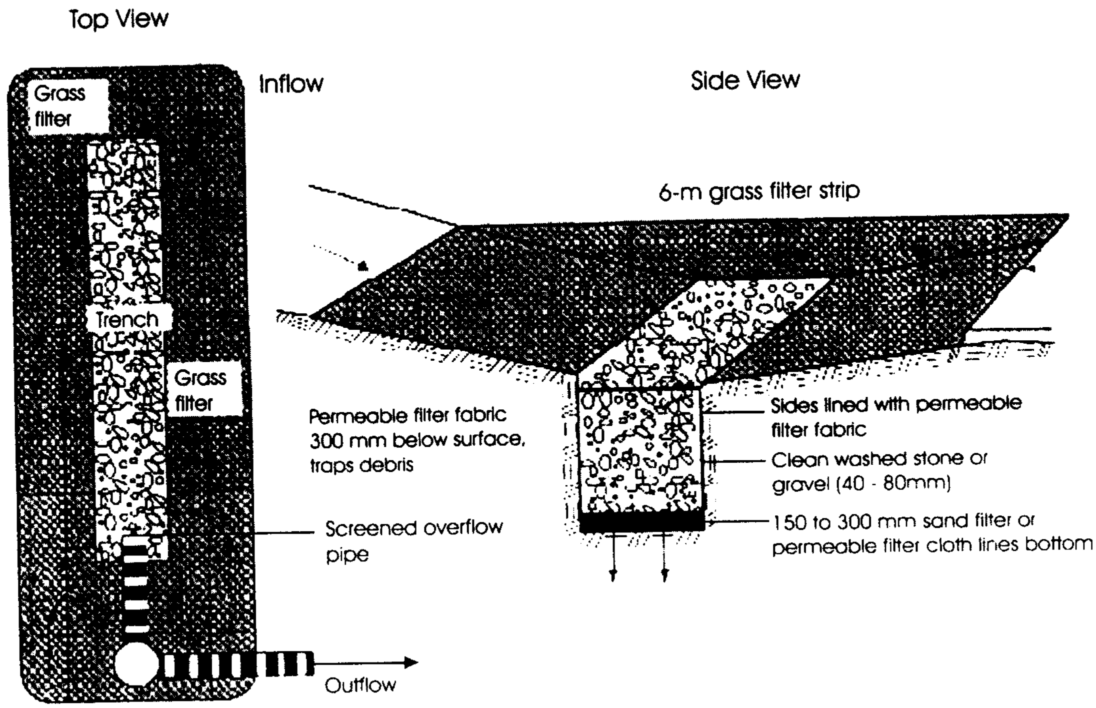
3. Attach the filter fabric to the wire fencing and extend it into the trench.
U.S. EPA, 1992



4. Backfill and compact the excavated soil.

As mentioned earlier, infiltration trenches are similar to dry wells in that their purpose is to store water in a gravel filled trench and let it gradually infiltrate into the surrounding soil. Like dry wells, infiltration strips must be protected from clogging by sediment, grease, oil, organic materials and other settable solids. Design considerations include:

- Soil infiltration rate should be ¼ an inch per hour or more.
- The infiltration trench should empty within three days.
- Gravel should be cleaned and washed and between 1.5 – 3 inches in size.
- For storms or flow exceeding design characteristics, the overflow structures must not allow channeling or other erosion to occur.
- Trench depth varies from 3 – 12 feet, depending on soil depth and design characteristics.
- Observation/test well required for monitoring, 4" PVC pipe with cap recommended


Top View
Grass filter
Inflow
Trench
Grass filter
Screened overflow pipe
Outflow
Side View
6-m grass filter strip
Permeable filter fabric 300 mm below surface, traps debris
Sides lined with permeable filter fabric
Clean washed stone or gravel (40 - 80mm)
150 to 300 mm sand filter or permeable filter cloth lines bottom

U.S. EPA, 2000.

United States Virgin Islands Handbook

On

Alternative Onsite Sewage Disposal Systems –

Constructed Wetlands

Coastal Zone Management
Department of Planning and Natural Resources
Government of the Virgin Islands

Executive Summary

This handbook was developed pursuant to the Virgin Islands Section 6217 Coastal Nonpoint Pollution Control Program. After review of the V.I. Section 6217 Coastal Nonpoint Pollution Control Program the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration recommended, in their findings, that the Virgin Islands "amend its program to include measures for alternative systems in areas unsuitable for conventional systems, appropriate performance standards for the alternative systems, and measures to assure that existing failing systems are repaired or replaced." This handbook, which includes performance standards for alternative onsite sewage disposal systems, is intended to assist the public in designing, installing, maintaining, and operating alternative on-site sewage disposal systems, particularly those systems employing constructed wetlands technology and its variants, in compliance with revisions to Title 12, Virgin Islands Code, Chapter 21 regarding on-site sewage disposal systems.

In addition, this document describes the conditions under which these revisions were necessitated, the applicable policies of the Government of the Virgin Islands and a descriptive comparison of the traditional and alternative systems for on-site sewage disposal.

This handbook was developed in conjunction with rules and regulations that include measures for alternative systems in areas unsuitable for conventional systems.

Table of Contents

INTRODUCTION/BACKGROUND

Nonpoint source pollution, caused by runoff as it moves over and below the ground, has become the most serious cause of impairment of the surface, ground, and near-shore waters of the Virgin Islands. The two greatest problems associated with nonpoint source pollution in the Virgin Islands are sedimentation and bacterial contamination. Sedimentation occurs when eroded soil particles suspended in stormwater runoff are deposited onto floodplains or into guts and coastal waters. Sedimentation on reefs can smother them. Bacterial contamination is caused by failed septic and other sewage systems.

The contribution of failed septic tanks to nonpoint source pollution has prompted DPNR, through its Coastal Nonpoint Pollution Control Program, to develop this handbook and introduce new legislation regarding onsite sewage disposal. Residential sewage disposal, including the installation of septic tanks and disposal fields or seepage pits, is currently governed by Title 19 of the Virgin Island Code. See V.I. R. & REGS. tit. 19, sections 1404-70 to 1404-94). These regulations prescribe the size, dimensions, and locations or residential septic tanks, disposal fields, and seepage pits. They also specify under what conditions disposal fields and seepage pits are unsuitable, as in the case whenever the soil consists of "heavy, tight clay, hardpan, rock, or other impervious formations".

In many areas of the Virgin Islands the soil lacks the necessary two to four feet of pervious soil needed to construct a traditional onsite sewage disposal system (OSDS) comprising a septic tank and a disposal field or seepage pit. Yet these areas may also be so distant from existing public sewer lines as to make connection to the lines prohibitively expensive. As the population and level of development of the Virgin Islands has increased, it has become necessary to revise the regulations regarding onsite sewage disposal to include *alternative* onsite sewage disposal systems. These systems, constructed wetlands and variants thereof, have been successfully implemented in the USVI and elsewhere for the treatment of residential waste.

The impact of the revised regulations allow the use of effective alternatives to traditional septic tanks and public sewer systems while preserving the quality of Virgin Islands waters and reducing the effects of nonpoint source pollution.

Applicable Policies of the Government of the Virgin Islands

The commitment of the Government of the Virgin Islands to preserving the waters of the Virgin Islands is stated in the beginning of the Water Pollution control Act (Title 12, V.I. Code, Chapter 7, Section 181):

> "Whereas the pollution of the waters of the Virgin Islands constitute a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs beneficial uses of water, it is hereby declared to be the public policy of the Virgin Islands to conserve the waters of the Virgin Islands and to protect, maintain, and improve the quality thereof for public and for domestic, recreational, and other beneficial uses; to provide that no waste be discharged into any waters of the Virgin Islands without first receiving the necessary treatment or other corrective action to protect the legitimate beneficial uses of such waters; to provide for the prevention, abatement and control of new or existing water pollution; [and] to authorize the Virgin Islands to implement the provisions of the Federal Water Pollution Control Act . . . .".

Additionally, the Coastal Zone Management Act (Title 12, V.I. Code, Chapter 21, Section 903) provides:

> "(a) The Legislature hereby finds and declares that:
> the coastal zone, and the lands and waters thereof, constitute a distinct and valuable natural resource of vital importance to the people and economy of the Virgin Islands;
> the protection of the natural and scenic resources of the coastal zone is of vital concern to present and future residents of the Virgin Islands
> . . . (4) the shorelines . . . enhance all aspects of the lives of the people of the Virgin Islands;
> . . . (5) to promote the public safety, health and welfare, and to protect public and private property, wildlife, ocean resources and the natural environment, it is necessary to preserve the ecological balance of the coastal zone, and to prevent its deterioration and destruction . . . ."
>
> "(b) The Legislature hereby determines that the basic goals of the Virgin Islands for its coastal resources are to:
> protect, maintain, preserve, and, where feasible, enhance and restore the overall quality of the environment in the coastal zone, the natural and man-made resources therein, and the scenic and historic resources of the coastal zone for the benefit of the residents and visitors of the Virgin Islands;
> . . . (9) maintain or increase coastal water quality through control of erosion, sedimentation, runoff, siltation, and sewage discharge . . . ."

Furthermore, Title 19, Chapter 53 (Sanitation), Sections 1404-72 and 1404-77 of the Virgin Islands Code respectively state:

> “No human excrement or material containing human excrement shall be deposited of in such a manner that it is likely to gain access to any waters except under conditions approved by the Department of Health.”

And,

> “No drainage from a sewage disposal system shall be discharged into a street gutter or onto the surface of the ground. No effluent from any sewage disposal system shall discharge into any tributary of a public water supply.”

Onsite Sewage Disposal Systems

The choice of the appropriate onsite sewage disposal system (OSDS) will depend, in part, upon the conditions at the site. If DPNR deems the site is unsuitable for a traditional system, then an alternative OSDS must be constructed.

Traditional Systems

The current method of choice for onsite disposal of residential sewage in the Virgin Islands consists of a septic tank and either a disposal field or a seepage pit. Household wastes enter the septic tank, where solids settle out to the bottom and scum, consisting primarily of grease and oils, floats to the top. Some breakdown of organic materials by bacteria and other microbes occurs in the septic tank. Liquids typically remain in the septic tank for one to two days, after which they flow either to a subsurface disposal field or a seepage pit. The disposal field consists of at least two rock-filled trenches through which effluent is carried in pervious pipes; the seepage pit is typically a rock-filled hole in the ground. The function of both is to provide soil absorption and filtration of the septic tank effluent. See Figure 1.

Virgin Islands regulations govern the size, dimensions, and location of each component of the system. The required capacity of a residential septic tank depends on the number of bedrooms in the residence, with a minimum capacity of 500 gallons in the case of a residence with not more than two bedrooms. See V.I. R. & REGS, tit. 19, section 1404-84. Septic tanks must be located at least 50 feet away from any source of domestic water supply, at least five feet from dwellings or private property lines and they must be designed to provide access for cleaning and adequate volume for settling and sludge and scum storage. See V.I. R. & REGS, tit. 19, section 1404-83. Septic tanks are to be made of durable materials which will resist corrosion and decay; and they are to be watertight in order to prevent the entrance of surface drainage, groundwater, or rainwater. See V.I. R. & REGS, tit. 19, section 1404-87.

Disposal fields are to consist of at least two trenches not more than 100 feet long. They are to be not less than 18 inches nor greater than 36 inches wide, they are to be between 18 and 36 inches deep, and they are to be spaced between six and nine feet apart (center to center). The disposal field is to be sited at least 50 feet from any domestic water source, 25 feet from any streams and ten feet from dwellings, large trees, and property lines. See V.I. R. & REGS, tit. 19, section 1404-87. The total surface area of the disposal field depends upon the number of bedrooms in the residence it serves and the soil quality and texture; precise specifications can be found in V.I. R. & REGS, tit. 19, sections 1404-87 to 1404-91. In general, the less pervious the underlying soil, the greater the required effective area of the disposal field. In the case of impervious soils, clay, or rock, a disposal field may not be constructed.

Likewise, the size and depth of a seepage pit depends upon the soil quality and the amount of liquids it will be expected to absorb. Unless there is a depth of at least four feet of porous material for each seepage pit constructed, each pit must extend at least 20 feet below the inlet. However, no pit shall extend to the water table. If water is encountered, the bottom the pit must be raised to a height of two feet above the water table with clean coarse sand. See V.I. R. & REGS, tit. 19, section 1404-93. If the soil is of heavy, tight clay, hardpan rock, or other impervious formation, a seepage pit may not be constructed. See V.I. R. & REGS, tit. 19, section 1404-94 [Table IV]. Other specific requirements for the design and construction of a seepage pit are given in See V.I. R. & REGS, tit. 19, sections 1404-91 to 1404-94.

A traditional septic system requires little maintenance other than occasional pumping to remove accumulated sludge. Care should be exercised by users to refrain from disposing of large quantities of harsh household chemicals into the septic system; these will injure or kill the microbes which breakdown the solids in the system, leading to a greater strain on the system and a greater risk of system failure.

Alternative Onsite Sewage Disposal Systems

The Alternative OSDS referred to in this handbook is a constructed wetland or one of its variants. This system mimics the action of a natural wetland, which filters and purifies water before it finally makes it to the sea. Household wastes are initially discharged into a multi-chambered septic tank, as in a traditional system. However, rather than a disposal field or a seepage pit, the septic tank overflow is carried to the constructed wetland, where it undergoes secondary filtration. In the constructed wetland, coarse gravel and plant roots filter the liquids. Additionally, the roots absorb moisture and nutrients while helping to break down waste materials. Plant leaves release water through evapo-transpiration, reducing the liquid load on the system. Effluent, if there is any, may be used in a gray water system.

There are three common approaches used to build a constructed wetland: lined trenches, concrete troughs, and tubs. These three approaches share several important considerations:

Septic Tank

Alternative OSDS must employ a three-chambered septic tank with the same required capacity as the septic tank in a traditional system. See Table 1. The first chamber must occupy 50% of the total volume of the tank. The remaining 50% of the volume is divided equally between the second and third chambers which function as a secondary separator. For traditional systems that are being retrofitted to serve as alternative systems, the original septic tank may be used as the first chamber. A second appropriately sized tank, divided into two equal sections can serve as the required secondary separator. Use of a three-chambered tank improves treatment efficiency by creating conditions more favorable for separation of solids and floatables as the wastewater moves through the system. See Figures 2a and 2b.

The septic tank must be watertight and designed to provide access for cleaning and adequate volume for settling and sludge and scum storage. Connections to the constructed wetland cells should be a minimum of four-inch piping with waterproof seals to prevent leakage. Gravity feed should be employed whenever possible; where it is not possible, a pump should be utilized.

Wetland Cells

The wetland cells may take several different forms. Common forms are concrete troughs, trenches lined with impervious material and plastic tubs. Each cell is filled with gravel and dirt to facilitate secondary treatment of the effluent.

Concrete troughs are particularly well suited for applications where well-structured stabilization of a step slope is desirable. An alternative OSDS using concrete troughs is illustrated in Figure 3.

Excavated trenches with an impervious liner at least 20 mils (0.5 millimeters) thick may be used as wetland cells. A layer of sand should be placed in the trench before installing the liner to protect the liner from being pierced by protruding rocks and other irregular surfaces. Particular care should be taken when placing the gravel and soil in the trenches to avoid piercing the liner. The likelihood of damaging the liner can be reduced by filling the trench with water prior to putting the rock or gravel in place. The presence of water also assists in ensuring that the top of the rock and soil layers is level. Excavated trenches are best use in settings where there is a need for the cells to follow the natural contour of the site.

Tubs such as those made for use in watering cattle may be used as wetland cells when connected end-to-end. This configuration facilitates easy expansion of the wetland system and also installation of the system on step grades, confined and irregularly shaped spaces. Care should be taken to have progressive cells in the connected series lower than the previous cells in order to avoid upstream cells overfilling before effluent moves completely through the system.

The following should be considered for all configurations of wetland cells:

Location: Wetland cells should not be located where they will be subjected to flooding from stormwater runoff, nor should they be placed where surface drainage from the cells can reach any domestic water supply.

Grading: The site should be graded to direct surface runoff away from the alternative OSDS and, if necessary, to facilitate gravity flow through the system.

Setback Requirements: There are no setback requirements for the watertight wetland cells.

Cell Volume Requirements: The total volume in cubic feet of the wetland cells should provide at least 0.75 cubic feet for each gallon of the septic tank's capacity. It is recommended that the width of each cell be at least two feet.

Cell Walls: The walls of all wetland cells must be impervious. The thickness of the liners should be increased as the likelihood of damage increases. This might be due, for example, to rocky surrounding soils, sharp edges on the gravel or other adverse conditions.

Material in Cells: Cells should be at least 24 inches deep. The bottom layer of material should be no closer than 8 inches to the top of the cell. It should consist of clean, washed rock or gravel from 1 inch to 3 inches in diameter. This layer should be covered by a pervious fabric separator on which 6 inches of topsoil or washed pea gravel (1/2 to 1 inch in diameter) is placed. See Figure 4.

Outlets: Cell outlets must be placed such that the level of liquid in the cells rises, at a maximum, to the pervious fabric separator, or 8 inches from the top of the cell.

Plants: When choosing plants the function of the system and the surrounding ecosystem should be taken into account. For example, ornamental plants from a different region of the world could cause problems if they escape into an ecosystem that does not have efficient controls on their growth. Plants with high water uptakes such as canna lily, ginger lily, ornamental ginger, heliconia, bird of paradise, elephant ear, dieffenbachia, and cattails are best suited for use in the wetland cells. See Appendix A.

Allow sufficient time and take other measures such as fertilizing and irrigating to ensure the plants are well-established prior to operation of the OSDS. Proper spacing and density should be allowed to provide for maximum liquid uptake by the plants and to lessen overcrowding.

Maintenance: Constructed wetlands may be kept in proper working condition with very little maintenance. The vegetation planted in the cells requires no more care than it would elsewhere. The plants should be kept healthy and sufficient in number so they can provide adequate transpiration and filtration. The plants will be affected by drought, particularly if there are extended periods of low flow through the wetland cells. Occasionally, the plants may require additional watering and pruning. Dead plants should be removed and replaced as necessary.

The use of harsh household chemicals, especially cleaning agents, should be avoided whenever possible, as they are harmful to the plants upon which the effectiveness of the system depends. Many natural substitutes for harsh synthetic chemicals are available. Information about such substitutes can be obtained through DPNR or the University of the Virgin Islands' Cooperative Extension Service.

As with any wastewater treatment system, introduction of non-biodegradable materials should be avoided. This would include plastics, wood, metals, cloth and other materials that would not readily decay.

Cleaning: Like a traditional system, the alternative OSDS will require occasional cleaning. The septic tank will require periodic pumping (every 3 to 4 years) to remove sludge. This would principally accumulate in the first of the three chambers. Conceivably, sludge can gradually build up in the wetland cells, compromising their effectiveness. This is highly unlikely though, due to the additional settling opportunities provided by the second and third chamber in the septic tank. When sludge has accumulated in the wetland cells, the soil and gravel media will have to be removed, replaced and the wetland cells will have to be re-vegetated. How frequently this will have to occur will depend upon the volume and characteristics of the waste treated by the system.

Comparison of Systems

A tabular comparison of traditional and alternative OSDS is provided in Table 2.

Permits Required for Alternative OSDS

Anyone who plans, constructs, installs, extends, alters, repairs, operates or maintains an alternative OSDS must do so in accordance with a permit issued by the Department of Natural Resources. This includes homeowners who wish to build, repair, or replace an OSDS; engineers and architects who plan and design onsite systems; building and plumbing contractors who would construct, install, or maintain them; and others who are involved with OSDS in any of the above capacities.

Anyone proposing to develop land for building construction that will utilize an OSDS must first obtain an overall site evaluation to determine the suitability of the location for onsite sewage disposal before permission will be granted to develop the property. If it is determined that the site is unsuitable for a septic tank and disposal field or seepage system, then an alternative OSDS shall be required.

In order for DPNR to issue a permit to construct or install an alternative OSDS, the following items must be submitted for review:

1. A completed alternative OSDS application;
2. Planning materials which consist of;
    a. An overall site plan;
    b. A 100-year flood plain map;
    c. A soil survey;
    d. The location of water wells;
    e. A complete report detailing the types of onsite facilities or systems to be considered and their compatibility with area-wide drainage and groundwater; and
    f. An onsite drainage plan.

The application for is available from DPNR. A sample of the form is presented in Appendix B. The planning materials must be assembled with the assistance of a licensed engineer or architect, and the property owner must submit them. In addition, if a single onsite system is to be used for more than a single owner dwelling, then the rules and regulations concerning cluster systems must be followed.

The Department of Planning and Natural Resources will respond to a completed application, including planning materials and payment of appropriate fees, within thirty (30) days.

Summary and Conclusion

The policy of the Government of the Virgin Islands and the Department of Planning and Natural Resources is to protect and preserve the waters of the Virgin Islands from pollution and to assist the residents of the Virgin Islands in obtaining safe and adequate sewage disposal facilities. In an effort to reduce nonpoint source pollution from failed septic systems and to provide a mechanism for ensuring the adequate treatment of domestic wastes where traditional systems are unsuitable and access to public sewers is impracticable, the Water Pollution Control Rules of the Virgin Islands have been revised to encompass the construction and operation of alternative OSDS which effectively treat domestic wastes. These systems may be constructed where the two-to-four feet of pervious soil necessary for traditional systems is unavailable, where the topography is too steep, or the site is otherwise unsuitable for traditional systems.

These alternative systems use the same principle to cleans wastewater as wetlands: water is filtered by rocks, absorbed by the roots of wetland plants, and released through the leaves into the atmosphere while bacteria ant other microbes associated with root systems break down and utilized the organic solids. These systems are appropriate for the Virgin Islands, where such constructed wetlands can operate year-round, unaffected by the climatic extremes that occur in the mainland United States.

The design, construction and operation of these systems will be permitted by the Department of Planning and Natural Resources. Persons involved in the design, construction, extension, repair, operation, or maintenance of these systems must do so in accordance with the guidelines set forth in this handbook and any issued permit.

Alternative OSDS provide residents of the Virgin Islands added flexibility in meeting the challenge of protecting and preserving our greatest natural resource, the waters of the Virgin Islands. These systems allow homes to be sited on properties that might otherwise not be useable for residences.

Table 1

Minimum Capacities for Septic Tanks

Number of Bedrooms	**Minimum Liquid Capacity of Septic Tank in Gallons***
2 or less	500
3	600
4	750
5	900
6	1100
7	1300
8	1500
10	2000

* Note: Increase minimum liquid capacity by 50% when household garbage grinder discharges into the OSDS. *(From: Title 19, V.I. Rules and Regulations, Chapter 53, Section 1404 – 84)*

Table 2

Comparison of Traditional and Alternative OSDS

	Traditional OSDS	**Alternative OSDS**
Oversight	Dept. of Health	DPNR
Site Requirements	No access to public sewer, large area of flat or gently sloping ground with four feet drainage between bottom and water table.	No access to public sewer.
Setback Requirements		
Septic Tank	50’ from domestic water supply. 25’ from streams 10’ from dwellings, large trees and property lines	50’ from domestic water supply. 25’ from streams 10’ from dwellings, large trees and property lines
Seepage Pits/Leach Fields and Wetland Cells	100’ from domestic water supply. 10 feet from lot lines.	No setback requirements for CZM, Zoning Code setback requirements must be met.
Advantages	Well-established practice, low cost.	Self-contained system; provides effective treatment in a compact area. Performance does not depend upon topography or soil characteristics. No setback requirements for CZM.
Disadvantages	Not suitable for all areas.	Less well known.
Limitations	Disposal of harsh household chemicals should be minimized.	Disposal of harsh household chemicals should be minimized.
Maintenance	Occasional sludge removal.	Occasional sludge removal.
Costs	Variable.	Variable, typically 10% to 30% greater than traditional systems.

Figure 1. Traditional OSDS

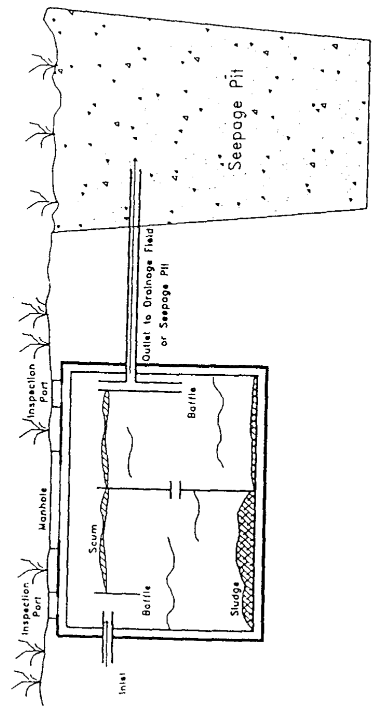


Figure 2a. Typical Retrofitted OSDS (Plan View)

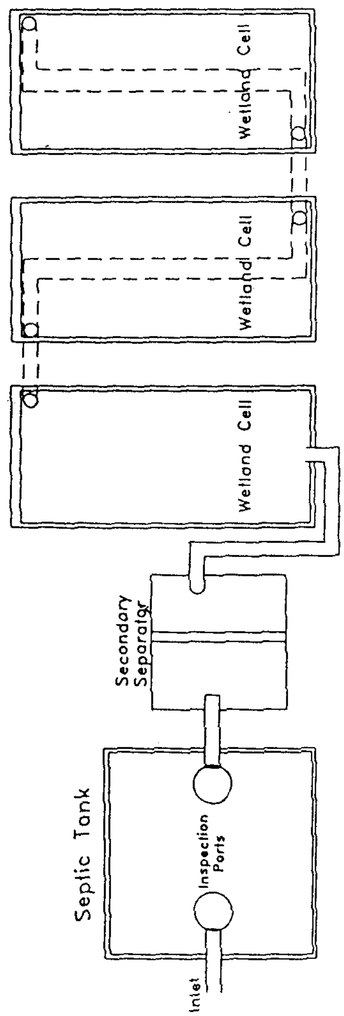


Figure 2b. Typical Retrofitted OSDS (Cross Section)

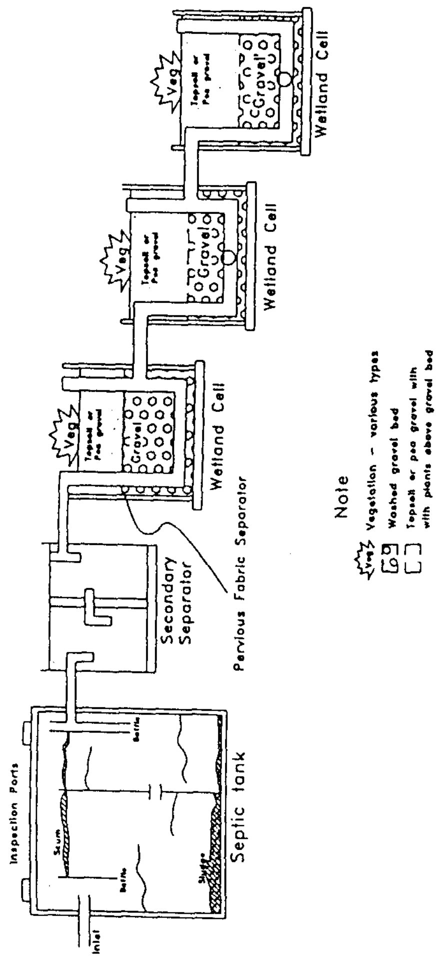


Figure 3. Alternative OSDS

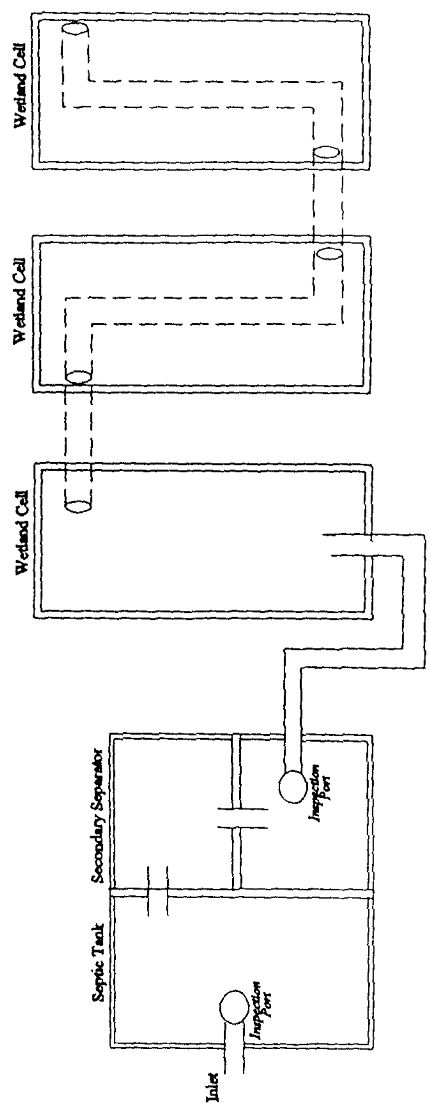
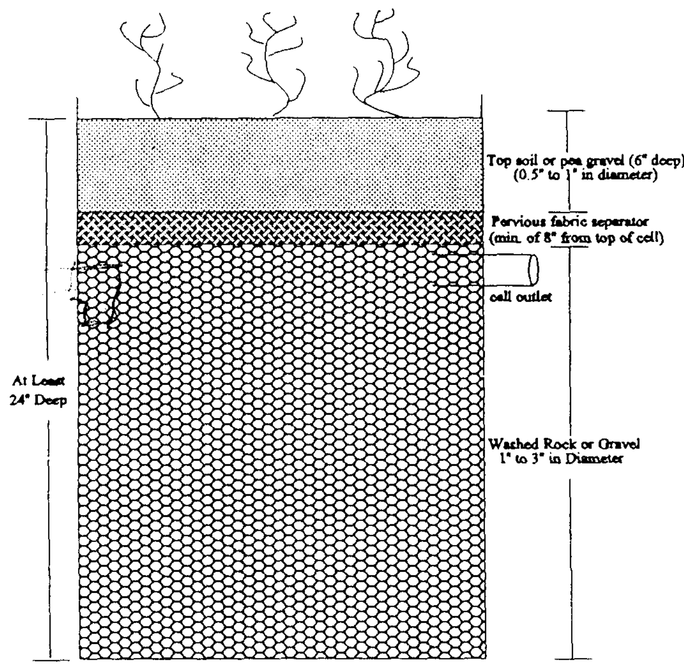


Figure 4. Placement of Material in Cells



Appendix A

Guide to Plants That Can Be Used in Constructed Wetlands *

Common reed: ***Phragmites australis***

Giant bulrush: ***Scirpus validus***

Elephant ear: ***Colocasis esculenta***

Arrowhead: ***Sagittaria lancifolia***

Prairie cordgrass: ***Spartina pectinata***

Canna lily: ***Canna flaccida***

Bird of Paradise:

Cattail:

Ginger Lily:

Heliconia:

Dumbcane:

Water hyacinth:

Banana:

* Information obtained from D. Surrency, *Evaluation of Aquatic Plants for Constructed Wetlands*, CRC Press, Inc. 1993 and *Guidelines for Establishing Aquatic Plants in Constructed Wetlands,* USDA, NRCS, 1996.

Appendix B

Sample Application Form

APPENDIX D
SCIENTIFIC REPORTS

Anderson, Donald M., and L.H. MacDonald. 1997. Modeling road surface sediment production using a vector geographic information system. *Earth Surface Processes and Landforms* 23:95-107. (missing p. 106, will try to get it)

Island Resources Foundation. 1997. Operational Report: Erosion and Sedimentation Impacts on St. John. pp. 6.

MacDonald, Lee H., D.M. Anderson, and W.E. Dietrich. 1997. Paradise Threatened: Land Use and Erosion on St. John, U.S. Virgin Islands. *Environmental Management* 21(6):851-863.

MacDonald, Lee H., and R. Sampson. 1997. Erosion and Sedimentation Impacts Project St. John, U.S. Virgin Islands, Technical Supplement #1 Methodology: Inventory and Monitoring Issues. Island Resources Foundation and the V.I. Resource Management Cooperative. pp. 3.

Sampson, Rob. 1998. Virgin Islands Watershed Erosion and Sediment Reduction: Status Report on Continuing Investigations at Fish Bay and Other Watersheds on St. John. *Natural Resources Conservation Service, Colorado State University*. pp. 18.

Sampson, Rob. 1997. Erosion and Sedimentation Impacts Project St. John, U.S. Virgin Islands, Technical Supplement #2 Predicting Erosion and Sedimentation Impacts Due to Land Use Change on St. John. Island Resources Foundation and the V.I. Resource Management Cooperative. pp. 4.

Sampson, Rob. 1997. Precipitation, Runoff and Sediment Yield on St. John – A Review of the Data. Virgin Islands Resource Management Cooperative. pp.5.

APPENDIX E

GUIDELINES AND PERFORMANCE STANDARDS
FOR CONTROL OF
EROSION, SEDIMENTATION
AND
STORMWATER RUNOFF

I. Guidelines and Performance Standards for the Control of Erosion and Sedimentation

A. Erosion and Sedimentation Control

1. Erosion and sediment control refers to the prevention, control and management of soil loss due to wind and water.
2. It shall be the policy of DPNR to prevent adverse environmental impacts to the Fish Bay watershed, including secondary and cumulative as well as direct impacts, due to erosion, soil loss, and sedimentation. Proper erosion and sediment control practices are required within the Fish Bay watershed for the following activities:
    a) New residential development.
    b) All construction activities.
    c) All roadway construction and upgrading projects.
    d) Any other activity within the watershed that involves any maintenance, alteration, use or improvement to any existing stormwater management structure that changes or affects the quality, rate, volume, or location of surface water discharge.

B. Guidelines for the Erosion and Sediment Control Plan

An Erosion and Sediment Control Plan must be submitted to DPNR for approval prior to undertaking any activity listed above. It must include the following:

1. A site plan showing the grades, elevations and contours of the land prior to disturbance and the proposed grades, elevations, and contours to be created.
2. The location and description of existing natural and manmade features on the property where the work is to be performed.
3. The location and description of existing natural and manmade features on land of adjacent owners that is within 150 feet of the property line, or which may be adversely affected by the proposed development.
4. A soil survey or soils engineering report that includes data regarding the nature, distribution, and strength of existing soils, conclusions and recommendations concerning the adequacy of the site to be developed and an analysis of the best use potential of the soils and the hydrologic group classification. The soils map and use potentials analysis prepared by the US Natural Resource Conservation Services, 1995 ed., should be used as the basis for the analysis. This information is also available from UVI/CES. The soil investigation and subsequent report should be completed and presented by a professional engineer registered in the Virgin Islands.
5. The location and description of all proposed changes on the site.
6. A phased schedule for the installation or application of planned erosion controls, both temporary and permanent, as they relate to the project's progress. Include the total soil surface which will be disturbed during each phase and the estimated start and completion dates for each phase.

7. A slope stabilization and re-vegetation plan with:
   a) a complete description of the existing vegetation and the vegetation to be removed;
   b) the method of disposal of removed vegetation;
   c) the vegetation to be planted, native plant species must be used;
   e) the slope stabilization measures to be installed; and
   f) an analysis of the environmental effects of such operations on slope stability, soil erosion and runoff quality.
8. An operation and maintenance plan for all erosion and sediment control practices to be implemented.
9. Soil erosion calculations estimating pre-construction erosion and post-construction erosion.
10. Calculations of the total amount of stormwater runoff entering the property for 25-year, 24-hour storms. Pre-development and post-construction calculations of stormwater runoff that is generated onsite must also be included.

C. Performance Standards for Erosion and Sediment Control Plans

An Erosion and Sediment Control Plan must demonstrate that the proposed development or activity has been planned and designed and will be constructed and maintained to meet the following standards:

1. Development will minimize adverse effects upon the natural or existing topography and soil conditions. The potential for erosion must be minimized and sediment, to the extent practicable, must be retained on-site during and after construction.
2. Grading and the cutting and stripping of vegetation are kept to the minimal necessary for construction. Where possible, site-clearing operations must be confined to vegetation only, with minimal soil disturbance.
3. Areas that are particularly susceptible to erosion and sediment loss are avoided or minimally converted.
4. Temporary seeding, mulching or other suitable stabilization methods must protect areas exposed during construction. Natural vegetation must be retained and protected to the extent practicable.
5. Tree roots will not be suffocated from improper placement or storage of soil or other materials.
6. Phased construction of land must be in increments that allow for completion of development during a single phase. Control measures must be in effect prior to commencement of each phase of construction.
7. The generation, application and migration of toxic substances must be minimized. Proper storage and disposal of toxic materials must be maintained at all times.
8. Use diversions to prevent runoff from off-site areas from flowing across disturbed areas. Contain runoff flowing across the site on-site. All measures to retain runoff on-site must be installed and operating prior to grading or filling.
9. Sediment traps must be large enough to allow sediments to settle out of the stormwater of a 25-year, 24-hour storm. They must have a capacity to store the collected sediment until removal and must outlet onto stabilized areas.
10. Minimal storage capacity of sediment basins is 3600 cubic feet per acre of on-site drainage area contributing stormwater.
11. Natural drainage features and vegetation must be minimally disturbed, if at all.
12. Surface waters must be protected and if practicable improved.
13. Protect the beneficial functioning of wetlands.

II. Guidelines and Performance Standards for the Control of Stormwater Runoff

A. Stormwater Management

1. Stormwater management refers to a system of vegetative and structural measures that:
   a) Control the increased volume and rate of surface runoff caused by man-made changes to the land, and
   b) reduce or eliminate pollutants that are carried by the surface runoff.
2. It shall be the policy of DPNR to prevent adverse environmental impacts to the Fish Bay watershed, including secondary and cumulative as well as direct impacts, due to improper stormwater management. Proper stormwater control practices are required within the Fish Bay watershed for the following activities:
   a) New residential development.
   b) All construction activities.
   c) All roadway construction and upgrading projects.
   d) Any other activity within the watershed that involves any maintenance, alteration, use or improvement to any existing stormwater management structure that changes or affects the quality, rate, volume, or location of surface water discharge.

B. Guidelines for the Stormwater Management Plan

A Stormwater Management Plan must be submitted to DPNR for review in the early stages of planning. It must include the following:

1. Sufficient information for DPNR to evaluate the environmental characteristics of the affected areas, the potential and predicted impacts of the proposed activity on Fish Bay and its ecosystems, and the effectiveness and acceptability of those measures proposed.
2. The stormwater management plan must contain all supporting documents, including but not limited to, any maps, charts, graphs, tables, photographs, narrative descriptions and explanations, citations to supporting references, and reports that are necessary to explain the information required by this section.
3. The site's existing environmental and hydrologic conditions and the environmental and hydrologic conditions of receiving waters and wetlands must be described in detail. The following must be included:
   a) The direction, flow rate, and volume of surface runoff under existing conditions, post-construction conditions, and, to the extent practicable, pre-development conditions. The required information must be based upon 25-year, 24-hour storms.
   b) The location of areas on the site where stormwater collects or percolates into the ground.
   c) A description of all surface watercourses, waterbodies and wetlands on or entering the site, adjacent to the site, or into which stormwater flows.
   d) The depth to seasonal groundwater levels, and the approximate direction and rate of flow with any seasonal fluctuations.
   e) The site's location of the in relation to the watershed's 100-year flood zone.
   f) The site's principal vegetation types.
   g) A topographic map of the site with full contour detail at 5-foot intervals. Areas of steep slopes (over 10%) must be highlighted.
   h) A soil survey or soils engineering report that includes data regarding the nature, distribution, and strength of existing soils, conclusions and recommendations concerning the adequacy of the site to be developed and an analysis of the best use potential of the soils and the hydrologic group classification. The soils map and use potentials analysis prepared by the US Natural Resource Conservation Services, 1995 ed., should be used as

the basis for the analysis. This information is also available from UVI/CES. The soil investigation and subsequent report should be completed and presented by a professional engineer registered in the Virgin Islands.

4. All proposed site alterations must be described in detail and include:
   a) Any changes in topography, described in full contour details at 5-foot intervals.
   b) Areas where vegetation will be cleared or otherwise altered.
   c) Areas that will be covered with an impervious surface and a description of the surfacing material.
   d) The proposed development layout with:
      i) The site arrangement with the location of structures, roadways, parking areas, sewage disposal facilities, and undisturbed lands.
      ii) All drainage systems to be provided, including the location and design of roadway and individual lot sub-drains; full drainage calculations must be included, with 25-year, 24-hour storms used as the basis of the design.
5. All predicted impacts of the proposed development on the existing conditions noted above must be described in detail and include:
   a) Any changes in water quality.
   b) Any changes in groundwater levels.
   c) Any changes in the incidence and duration of flooding on the site.
   d) Any adverse impacts on wetlands.
   e) Any impacts on vegetation.
6. All components of any drainage system and any measures for the detention, retention, or infiltration of water, or for the protection of water quality must be described in detail and include:
   a) The channel, direction, volume, rate of flow (in cubic feet/second) and the quality of the stormwater that will be conveyed from the site, with a comparison to existing conditions, and to the extent practicable, predevelopment conditions.
   b) Detention and retention areas or devices with:
      i) Plans for the discharge of contained waters, with the time to draw down from full conditions and a description of outlet structures.
      ii) A maintenance plan with schedule, outline of responsible parties and copies of all pertinent agreements that are or will be executed to insure proper maintenance.
      iii) An evaluation of the pollutant removal efficiency of all devices or areas under existing conditions.
   c) Site locations to be used or reserved for percolation with the depth to seasonal groundwater table and a predicted impact upon the groundwater quality included.
   d) Areas to be utilized for overland flow, the hydrologic soil type(s) of such areas, the vegetation present and the soil's susceptibility to erosion.
   e) Any other information that the developer or DPNR believes is necessary for an evaluation of the development.

C. Performance Standards for Stormwater Management Plans

The Stormwater Management Plan must demonstrate that the proposed activity or development has been planned and designed and will be constructed and maintained to meet each of the following minimum standards.

1. After development, runoff from the site will approximate the total suspended solid loadings, rate of flow, volume and timing of runoff that would have occurred following the same rainfall conditions under, to the extent practicable, pre-development conditions.
2. The natural hydrodynamic characteristics of the watershed are maintained.
3. The quality of surface and ground waters are protected or improved.
4. Groundwater levels are protected.
5. The beneficial functions of wetlands as areas for the natural storage of floodwaters, chemical reduction, pollutant assimilation and a wildlife and fisheries habitat are preserved.
6. There will be no increase in flooding or damage from the improper location or design of structures.
7. Alterations to natural drainage features, the flora and fauna, and adverse impacts to fish and wildlife habitat are minimized.
8. Natural watercourses must not be altered in any way, including but not limited to dredging, clearing of vegetation, stabilization, deepening or widening. To preserve the natural hydrodynamics of any watercourse and to prevent siltation or other pollution, water must be retained or detained onsite before it enters any natural watercourse.
9. Runoff must be routed through vegetated swales or other structural and nonstructural systems that are designed to increase the time of concentration, decrease velocity, increase infiltration, allow suspended solids to settle, and remove pollutants. Overland flow and re-infiltration techniques are preferred for the treatment of runoff.
10. Intermittent watercourses such as swales must be vegetated.
11. The amount of impervious surface is limited.
12. The first one-inch of runoff from impervious surfaces such as rooftops and paved areas must be retained, treated and re-infiltrated onsite.
13. Runoff from parking areas and roads must be treated to remove oil and sediment.
14. The discharge of runoff directly into Fish Bay or its tributaries is prohibited. Enlarging the volume, increasing the velocity, or further degrading the quality of existing discharges is prohibited.
15. Drainage facilities and vegetated buffer zones are utilized as open space and conservation areas.
16. Salt water intrusion is prevented or reversed.

APPENDIX F

RESOURCE AGENCIES

DPNR/Division of Coastal Zone Management – regulates development and promotes the conservation of coastal areas designated within the tier 1 coastal zone boundaries as defined in the Virgin Islands Coastal Zone Management Act (VICZMA). The VICZMA sets forth the program's policies regarding development, public access and other land use issues. All development within the coastal zone requires a permit from CZM to ensure compliance with the goals and policies of the VICZMA. The Nonpoint Source Pollution Program provides information on ways to reduce human activity induced pollution of our coastal waters.
(St. Thomas: 340-774-3320) (St. Croix: 340-773-3450)

DPNR/Comprehensive and Coastal Zone Planning – has many materials and other resources including: infrared aerial photographs of significant natural areas, topographic aerial photographs, official zoning maps, general planning maps, estate boundary maps, city limit boundaries, flood hazard boundary map, flood insurance rate maps, the general physical plan for infrastructure, harbors/ports, highways/roads, land use elements and planning districts, and Virgin Islands beaches map. Staff handles zoning and long-term planning issues.
(St. Thomas: 340-774-3320) (St. Croix: 340-773-3450)

DPNR/Division of Environmental Protection – enforces the policies of the Clean Water Act. Any development that will result in discharges to the waters of the Virgin Islands must secure a TPDES permit to ensure that discharges are within the water quality standards set forth for designated water uses. Through the ambient monitoring program, the division monitors coastal waters for compliance with permit conditions. The 305(b) report provides information on the territory's water quality.
(St. Thomas: 340-777-4577) (St. Croix: 340-773-0565)

DPNR/Division of Fish & Wildlife – is the territorial counterpart to the federal Fish and Wildlife Service. The division serves to protect, maintain and enhance the territory's numerous fish, plant and wildlife species. Fish & Wildlife administers the VI Endangered Species Act, which lists the territory's species that are threatened or endangered with extinction. The division is involved in research, surveys and the management of fisheries and wildlife. Reviews environmental assessments for development impacts and provides technical assistance on environmental issues.
(St. Thomas: 340-775-6762) (St. Croix: 340-772-1955)

DPNR/Zoning and Subdivision – regulates the subdivision of land and provides for the orderly development of prospective street systems.
(St. Thomas: 340-774-3320) (St. Croix: 340-778-2994)

Island Resources Foundation – (St. Thomas: 340-775-6225) (Tortola: 284-494-2723)

USDA/Natural Resource Conservation Services – assists landowners with farm subsidy and erosion control program. Provides leadership and administers federal programs to help people conserve, improve and sustain natural resources and the environment. Has many materials including: an atlas of groundwater resources in the VI, draft U.S. Dept. of the Interior, Fish and Wildlife Service, National

Wetlands Inventory Maps, Soils Maps, pond locations, areas of intensive farming, names and acreages of watersheds in the territory, 1984 aerial photography, topographic maps from the USGS.
(St. Croix: 340-692-9662)

UVI/Cooperative Extension Service – is the public education and outreach arm of the University. CES programs include Natural Resources and Agriculture. It conducts farm, home, and site visits; seminars, workshops, short courses, field tours, and presentations. The Soil Diagnostics Lab provides physical and chemical analyses of soil samples free of charge. Technical assistance re: Erosion and Sediment Control plans and permit and plan review is provided. CES also maintains a Diagnostic Herbarium database and identification cards for endangered plant and animal species. Other materials include the current soil survey, educational materials and informational and resource catalogs. The St. Croix office maintains a Diagnostic Herbarium, a lab for insect and disease pest identification, a large database on information resources from ecology to cultural resources, the Agricultural Experiment Station and a Bio-Technology Lab.
(St. Thomas 340-693-1080) (St. Croix: 340-692-4080)

UVI/Conservation Data Center – compiles, analyzes, and disseminates bio-diversity, natural resources, geographic, and socio-economic data. The CDC provides GIS analysis as well as detailed and reliable maps. CDC is building a Biological and Conservation Database System to store and process detailed data on the Territory's plant and animal species.
(St. Thomas: 340-693-1030)

UVI/VIMAS – is the community education, information and outreach branch of the University of Puerto Rico's Sea Grant College Program. It serves the V.I. through UVI's Center for Marine and Environmental Studies. VIMAS provides information and programs on marine-related issues and environmental topics. Marine environmental impact mitigation and marina/shoreline development practices information is also available.
(St. Thomas: 340-693-693-1392) (St. Croix: 340-778-1112)

Virgin Islands National Park Service/Resources Management – is the division of the V.I. National Park responsible for management and preservation of natural and cultural resources occurring on park lands. The park is also very concerned with impacts to park resources that originate on adjacent lands as well as the health and protection of adjacent natural resources. The park provides residents and visitors with information on protecting and preserving natural and cultural resources.
(St. John: 340-776-6201 x224)

APPENDIX G:

PLANTS TO USE SPECIFICALLY IN THE FISH BAY WATERSHED

Clearing land of established vegetation for construction and roadside grading operations exposes soil to erosive forces. Exposed soils on steep slopes are especially vulnerable. Replanting disturbed areas with new vegetation and installation of protective matting can mitigate some of the negative effects.

Selecting the most appropriate plants to use for re-vegetation can be difficult. There are a great variety of plants to choose from and some types may be more successful than others protecting the soil from erosion. It should be noted, however, that establishment of any plant depends on any number of site-specific circumstances—success is not guaranteed.

Nevertheless, it is the policy of DPNR, the Cooperative Extension Service (CES) at UVI, and other agencies and organizations to promote the use of native plants over introduced species. This policy is especially important on St. John near the Virgin Islands National Park because introduced plant species (i.e., exotics), which are often used to landscape around residences, can escape into wild areas and out compete native plants. It is strongly recommended that plant species chosen for landscaping should be consistent with the vegetative community within which the property is located.

UVI- CES has identified several native plants that have potential as cultivated ground covers that can be used to protect disturbed soils on shallow, moderate, and even some steep slopes. Ground covers, however, will not prevent landslides on steep slopes. CES used specific criteria for making their selections: low maintenance, ease of propagation, rapid and complete coverage, attractive appearance, durability and resistance to disease, drought, and insects. Once established, selected native plants may be especially adapted to the harsh climatic conditions, soils types, degraded soils, and rocky and steep slopes found throughout the Fish Bay Watershed. The following table presents a list of these natives.

Plants that are useful for erosion control in the U.S. Virgin Islands (adapted from materials from Cooperative Extension at the University of the Virgin Islands and Caribbean Area Grasses Identification Field Guide, 1994, USDA-SCS)

Common Name	Scientific Name	Description	Erosive Situation Where Most Effective	Availability
GROUND COVER				
Inch plant	*Callisia repens*	Adaptable to dry and moist areas. Withstands drought and full sun. Forms low, dense mat-like cover even over rough surfaces. Attractive bright green foliage has a lush and delicate appearance; remains quite showy even during dry periods. Grows well on steep slopes. Extremely easy to propagate and rapid growth rate.	**Exposed soils on varied slopes** May provide excellent, rapid cover of exposed soil to prevent sheet and rill erosion on moderate to shallow slopes. Because root system is shallow, cannot prevent failure of steep slopes and is not recommended for swales designed to carry high flows.	Stock plants may be collected from roadsides and where plants have become established in road edge gutters (swales). Plants (hanging baskets) also may be obtained from local nurseries.
Spider lily	*Hymenocallis caribaea*	Adaptable to dry and moist areas. Very drought tolerant. Consistently showy foliage, even under drought conditions. Attractive large flowers (intermittent). Easy to establish; requires minimal or no maintenance. Moderate growth rate.	**Exposed soils along the border of paved areas. Varied slopes.** May be most useful for stabilizing border areas of varied slopes (from shallow to steep) along driveways, roadways, patios, and walkways. Is not recommended for swales designed to carry high flows.	Plants may be obtained from local nurseries. May be difficult to obtain enough stock plants to cover a large area at one time.
Wild Wedelia	*Wedelia calycina var. parviflora*	Adaptable to dry and moist areas. Shrubby, branching herb. Dense bushy appearance. Attractive daisy-like yellow flowers continuous throughout the year. Once established, requires little to no maintenance. Moderate growth rate.	**Exposed soils along the border of paved areas. Varied slopes.** May be most useful for stabilizing border areas of varied slopes (from shallow to steep) along driveways, roadways, patios, and walkways. Is not recommended for swales designed to carry high flows.	Stock plants may be collected along roadsides. May be difficult to obtain enough stock plants to cover a large area at one time. Establishing plants may be more labor intensive because plants will probably need to be started in pots and transplanted.
Wedelia or creeping daisy	*Wedelia trilobata*	Adaptable to moist and dry areas. Busy appearance. Attractive daisy-like flowers. Requires low maintenance; although susceptible to fungus disorders during the cool season. Rapid growth rate.	**Exposed soils on varied slopes in open spaces.** Is not recommended for swales designed to carry high flows.	Stock may be available along roadsides and from nurseries.
Talinum	*Talinum triangulare*	Adaptable to dry and moist areas and very drought-tolerant. Native bushy and ornamental succulent herb. Small pink and yellow flowers bloom throughout the year. Can be planted with lower ground cover, such as inch plant, to add color and variety. Grows easily from cuttings or tiny seeds. Requires little maintenance, but plants can be pruned back periodically to maintain maximum bushiness.	**Exposed soils on medium slopes.** May be most useful for stabilizing border areas of varied slopes (from shallow to steep) along driveways, roadways, patios, and walkways. Is not recommended for swales designed to carry high flows.	Stock may be available along roadsides and from nurseries.

GRASSES				
St. Augustine grass	*Stenotaphrum secundatum*	Creeping perennial with flat stolons, long internodes and short leafy branches. Grows in neutral and alkaline soils; common in limestone and sandy soils. Tolerates shade.	**Exposed soils on shallow to medium slopes.** Useful for erosion control along roadsides, in a vegetated buffer zone, or in grassed swales.	
Carpet grass	*Axonopus compressus*	Nearly glabrous perennial; long leafy stolons with short broad blakds, hairy in the borders; flowering culms ascending. Grows in moist grassland, partial shade, acid soils. Lower to higher elevations.	**Exposed soils on shallow to medium slopes.** Useful for erosion control along roadsides, in a vegetated buffer zone, or in grassed swales.	
Bahia grass	*Paspalum notatum*	Short stout woody rhizomes. Grows in moderate acid to neutral soils on open grounds and pastures as turf.	**Exposed soils on shallow to medium slopes.** Useful for erosion control along roadsides, in a vegetated buffer zone, or in grassed swales.	
Alexander grass	*Brachiaria subquadripara*	Annual, flowering branches ascending from a creeping base; stolons up to 1 meter long in humid and shady areas. Grows in arid and semiarid, slightly acid to alkaline soils.	**Exposed soils on shallow to medium slopes**. Useful for erosion control along roadsides or in a vegetated buffer zone.	
Dropseed, smutgrass	*Sporobolus indicus*	Culms tufted, erect, 60 to 100 centimeters tall, with numerous leafy shoots at base. Smooth leaves. Grows in a variety of soils in grasslands and along roadsides.	**Exposed soils on shallow to medium slopes**. Useful for erosion control along roadsides or in a vegetated buffer zone.	
Beachgrass	*Sporobolus virginicus*	Perennial, stoloniferous and rhizomatous; culms 15 to 70 centimeters tall; sheaths overlapping; blades firm. Grows in sandy, saline soils in dunes and along beaches.	May be useful along roads at the lowest end the watershed, near Fish Bay.	
Vetiver grass		Non-invasive, forms a nice living terrace.		