

# Hope and Carton Hill Road Management Plan

## January 2013

Horsley Witten Group

Saint Croix Environmental Association

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

# Table of Contents




*Acknowledgements*

*In addition to local residents that brought specific drainage problems to our attention, we would like to recognize the following Hope and Carton Hill Homeowners Association (HOA) representatives for their extensive contribution to this planning effort: Zandy Hillis-Starr, Rick Starr, Raymond Berkley, Debbie Cullen, and Josh Tate. Julie Wright (USDA) and Carol Cramer-Burke (SEA) also provided coordination and technical assistance.*

# 1.0 INTRODUCTION

This management plan presents road stabilization opportunities identified by the Horsley Witten Group (HW), St. Croix Environmental Association (SEA), USDA Natural Resources Conservation Service (NRCS), and local residents, for reducing erosion and sediment loading from the Hope and Carton Hill Neighborhood, located on St. Croix, USVI (Figure 1). This assessment project was funded by the NRCS Conservation Technical Assistance Program (CTAP).

The Hope and Carton Hill Neighborhood was identified as a chronic source of sediment to Solitude Bay and was listed as one of the priority sites for restoration in the 2011 STXEEMP Watershed Plan. The specific action from the Watershed Plan is as follows:

***Unpaved Roads Action 4:*** *Complete master drainage plan for Hope and Carton neighborhood to identify drainage improvements and potential stormwater retrofits, as well as a routine maintenance plan for the homeowners association (HOA) and Department of Public Works (DPW).*

## 1.1 Purpose

The purpose of this plan is to: 1) reduce long-term road maintenance requirements; 2) manage uncontrolled stormwater runoff in the neighborhood; 3) provide a plan for pursuing funding; and 4) provide examples of how homeowners associations (HOAs) can better manage dirt roads in the USVI. This project was not intended to provide detailed engineering designs for construction.

## 1.2 Summary of Major Findings

The major findings of this plan are listed below and described in greater detail throughout this document.

- The Hope and Carton Hill Neighborhood was subdivided and the road network was constructed without any consideration for drainage issues. In fact, portions of the road and a number of individual lots are located within the guts. The current road issues and associated water quality impacts to Solitude Bay are likely to be exacerbated as remaining lots are developed. Currently, 2/3 of the lots are undeveloped.
- The roads are private and have been maintained without a comprehensive drainage plan.
- Structural drainage improvements are needed, ranging from simple surface features to large-scale storage facilities. Some of the recommended projects will require land acquisition/easements.
- Non-structural improvements are also recommended, including HOA tasks such as educating existing/future homeowners about drainage and water quality issues, providing information on steps that they should take on their own properties to reduce the impacts, and creating incentives for homeowners to manage/disconnect runoff from their driveways.
- Permitting agencies need to be proactive about restricting further development in the guts in this neighborhood. This will include identifying the undeveloped lots located in a gut and informing owners of development restrictions and/or acquisition/easement opportunities.

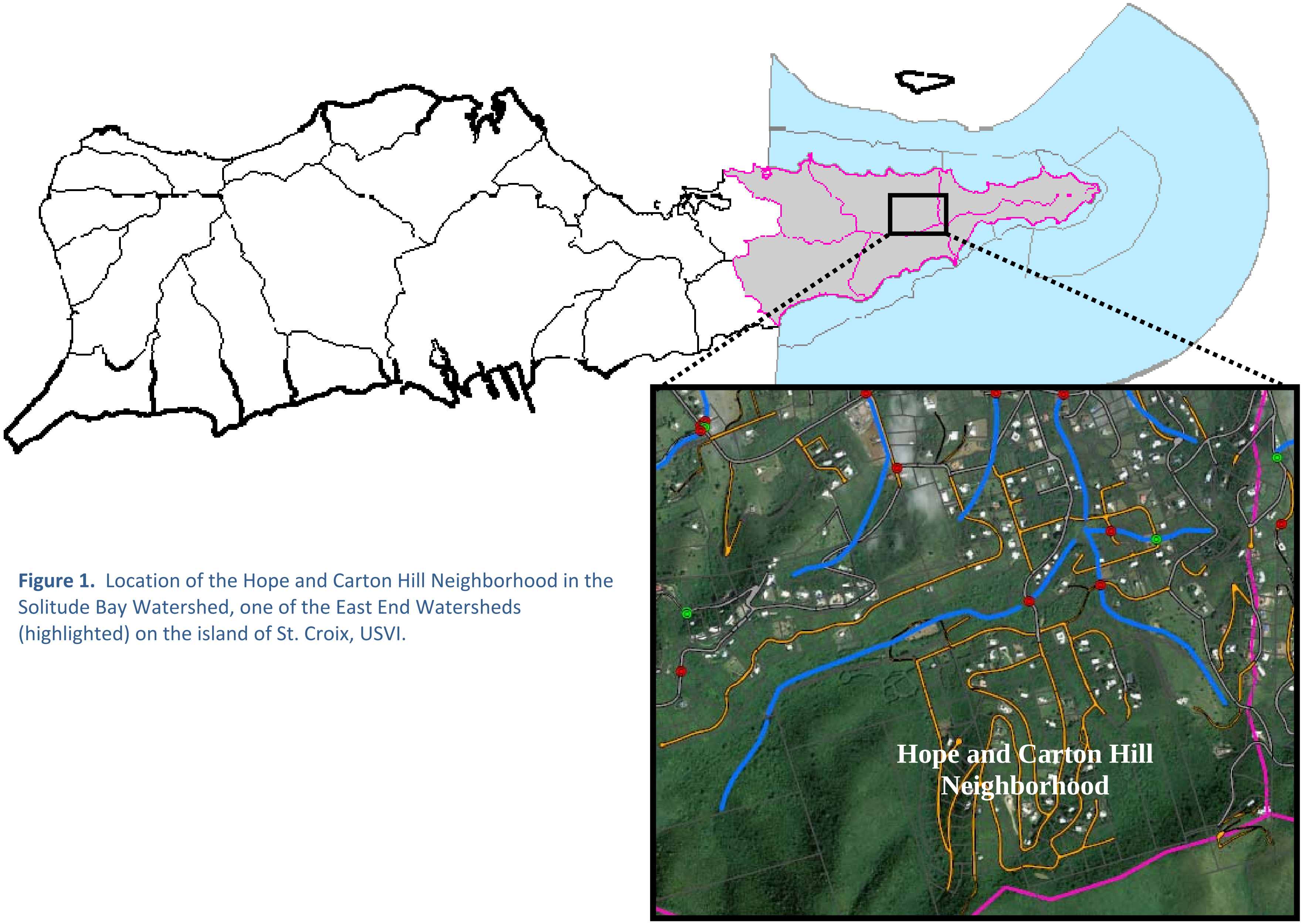



**Figure 1.** Location of the Hope and Carton Hill Neighborhood in the Solitude Bay Watershed, one of the East End Watersheds (highlighted) on the island of St. Croix, USVI.

## 1.3 Project Description

Approximately 4.5 miles in length, the mostly unpaved road network provides access to approximately 50 homes on a steep mountain slope in the upper portion of Solitude Bay Watershed. The roads include Pony Club Trail, Hawks Nest Trail, Coral Reef Trail, Ginger Thomas Trail, Divi-Divi Trail, Yellow Cliff Trail, and Hibiscus Circle. With the exception of the neighborhood entrance and a few isolated sections, this road network has extensive ruts, exposed bedrock, and pot holes. Runoff from the road network discharges into a gut at the neighborhood entrance. Sediment plumes have been observed discharging from this gut into Solitude Bay during rain events, impacting the St. Croix East End Marine Park (STXEEMP) (Figure 2).

**Figure 2.** Sediment plume discharge into Solitude Bay, St. Croix, USVI (photo on right) from sources such as the Hope and Carton Hill road network (photo on left) after Hurricane Omar in 2008.

*Photos courtesy of Zandy Hillis-Starr*

## 1.4 Methodology

A survey of the neighborhood was produced by Antillean Engineers in September 2011 as a reference base map. This ground survey included static GPS data collection to determine horizontal and vertical datum (NAD83 PR/VI 5200); boundary corners where available; partial topographic data in critical areas (e.g., Pony Club); driveways, edge of road and centerline at road breaks; and USACE photogrammetry overlay onto CAD drawing. HW staff used this information and existing mapping data from the watershed plan project to create detailed field maps of the neighborhood.

In March 2012, HW conducted a site assessment of the Hope and Carton Hill road network with some of the residents (Figure 3). During the assessment, HW identified drainage flow paths and potential opportunities for stormwater management and road stabilization projects, as well as possible areas for implementation of a rain garden demonstration project. In addition, HW conducted two stakeholder meetings (in March and October) with representatives of the local Homeowners Association (HOA), as well as with interested residents, to discuss specific problem locations and restoration ideas (Figure 3). This road management plan was developed from both field findings and stakeholder input.

**Figure 3.** Initial site assessment (left) and neighborhood meeting at the Cotton Valley Fire Station (right), both conducted in March 2012.

## 2.0 EXISTING CONDITIONS

A key component to any management plan is an understanding of the existing conditions. This section describes the existing conditions on both the watershed and neighborhood scales, which were determined from the STXEEMP Watershed Plan (HW, 2011), field visits, and input from local residents.

### 2.1 Watershed Context

The Solitude Bay Watershed is 2.6 square miles, with 153 acres of impervious cover (9%). Impervious cover typically consists of man-made surfaces that prevent rainfall from infiltrating into the ground, such as rooftops, paved and unpaved roads, driveways, and parking lots. Unpaved roads not only prevent infiltration; they also can be eroded by fast-moving runoff, becoming a source of sediment to downstream waterbodies. The Watershed Plan identified eroding unpaved roads as the most significant source of sediment loading to Solitude Bay, followed by eroding guts.

The main gut crosses the neighborhood entrance via a 30-inch corrugated metal culvert shown in Figure 4. Based on GIS mapping, the drainage area to that point is 441 acres, with 4.1 miles of gut. The existing culvert does not have the capacity to handle all of the runoff and has created a large (20 ft wide x 50 ft long x 15 ft deep) scour hole on the downstream end. Downstream from the gut crossing is an in-line pond that has a total drainage area of 560 acres, with a total of 5 miles of gut draining to it. This pond provides storage to help mitigate flooding and trap sediment, as well as potential wildlife habitat. It currently has no formal outlet and has been separated from the historical gut channel by a small residential road. As a result, this pond now overflows onto the main road (Cotton Valley Road) during large storm events, resulting in flooding near the Fire Station.

**Figure 4.** Large scour hole in the main gut, downstream of the 30-inch culvert under Pony Club Trail at entrance of Hope and Carton Hill (left). Further downstream, a large pond provides storage and habitat in the gut (right).

## 2.2 Hope and Carton Hill

The Hope and Carton Hill Neighborhood is approximately 200 acres or about 12% of the Solitude Bay Watershed. The neighborhood was subdivided and developed in the 1960s (registered in 1963; OLG# 1341) when little consideration for drainage was required (Figures 5 and 6). Parts of the road network and significant portions of "buildable" lots were located within or near existing guts, while no areas were designated for safe drainage conveyance and management. As a result, the road beds themselves have become de facto guts as topography has been altered over the years. This is clearly illustrated in Attachment A, the Existing Conditions Map. More than two thirds (2/3) of the lots remain undeveloped today; if more houses and driveways are constructed in the neighborhood, the drainage issues and sediment loading to Solitude Bay may be greatly exacerbated. The 4.3 miles of mostly unpaved road in the neighborhood comprise over a third of all unpaved roads in the watershed and create roughly 13.5 acres of impervious cover. Driveways add an additional 3.8 acres or 22% of the total impervious cover (17.3 acres) contributing to the erosion problems in the road network.

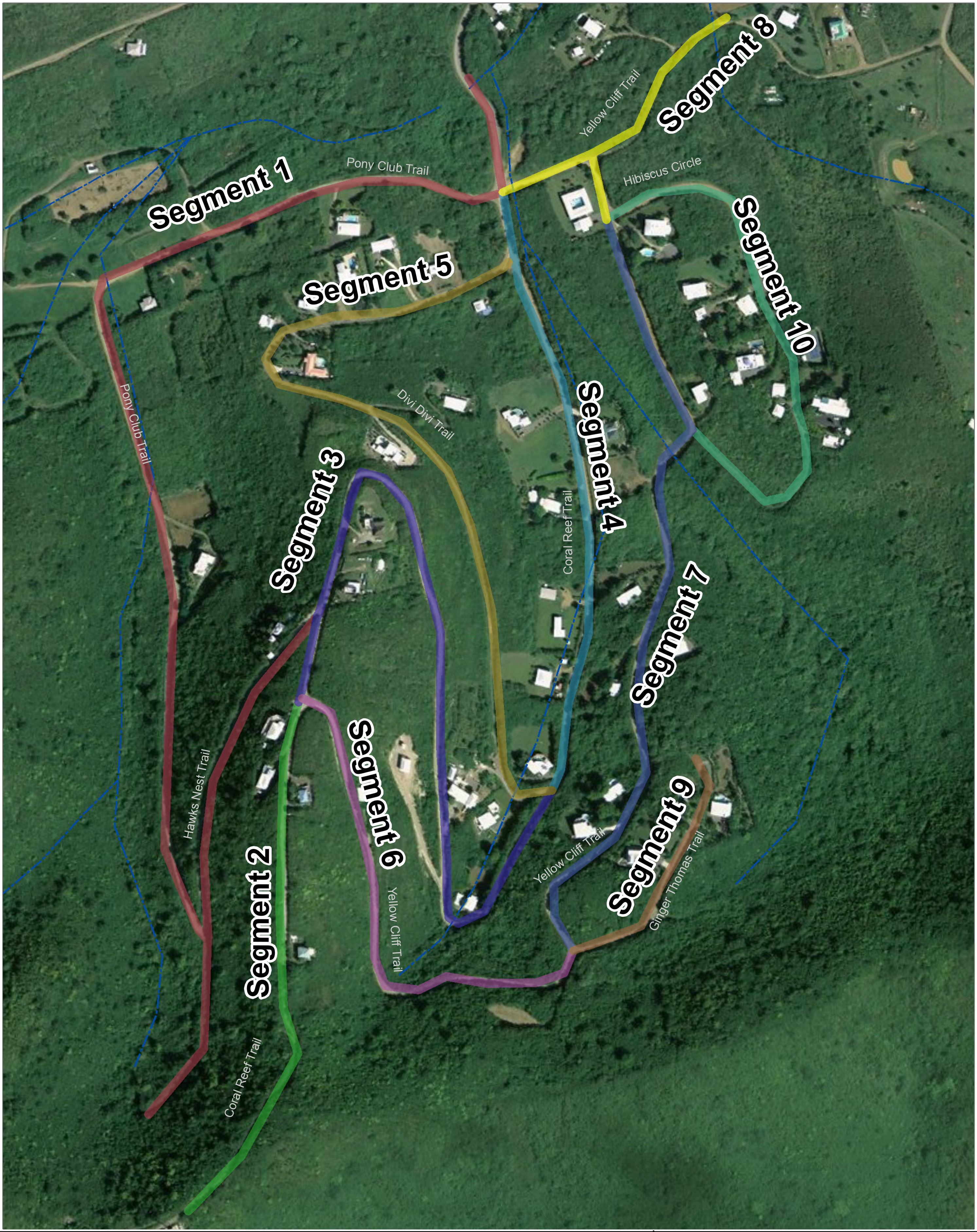
**Figure 5**. While the Hope and Carton Hill neighborhood is not densely developed and is well-vegetated, poor planning and lack of consideration for drainage and stormwater management has led to it being one of the leading sources of sediment in the Solitude Bay Watershed.

**Figure 6.** Horses are currently kept in pastures directly in the gut (left), and a small pond that had existed near the entrance to the neighborhood has recently been filled (right).

Over the years, various attempts have been made to improve the condition of the roads. Homeowners have paved their driveways and certain sections of road to try to stabilize the surface, and shallow paved swales were installed as an attempt to direct runoff. The contractor hired by the HOA for road maintenance has tried to redistribute sediment that collects at the bottom of the neighborhood back up on the higher roads where the surface has been eroded down to bedrock. In addition, the contractor has used machinery to create drainage paths at specific locations to alleviate flooding (see Existing Conditions Map). While these efforts were done with the goal of improving conditions, they were not coordinated and did not consider the road network as a whole; and as a result, in some cases, they have actually added to the problems. For example, erosion is worse at the downstream edge of a paved section or along undermined swales that were not sized appropriately, and grading techniques have created earthen berms that keep erosive flows on the road and have actually pushed sediment into guts (Figure 7). This plan is meant to help the HOA view the road network as a whole, understanding drainage areas and flow paths, so that projects can be designed to address the root of the problem rather than the symptoms.

**Figure 7.** Roads in the Hope and Carton Hill Neighborhood are unpaved and very steep (left). Runoff from this road bypasses and undermines the paved swale (right).

The Hope and Carton Hill road network has been divided into 10 segments to help explain conditions (Figure 8). Table 1 gives a summary of the segments, and detailed descriptions are provided below.




*Legend*

Guts

N

400 Feet

Hope and Carton Hill
Road Management Plan
**Road Segments**

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

Date: 1/3/2013

Figure 8

Path: H:\Projects\2011\11103 St.Croix WS Eng Design\GIS\Maps\130103_RoadSegments_11103.mxd

**Table 1**. Summary of Road Segments

| Segment Number | Segment Name | Length (miles) | # of Homes | % of Road Network Length | Proposed Project Stations (See Section 4) |
|---|---|---|---|---|---|
| 1 | Pony Club Trail/Hawks Nest Trail | 1.07 | 4 | 24.5% | 1, 2, 3, 4, 5, 21 |
| 2 | Coral Reef Trail from Cell Tower Road to Upper Yellow Cliff Trail | 0.33 | 4 | 7.6% | 6 |
| 3 | Coral Reef Trail from Upper Yellow Cliff Trail to Upper Divi-Divi Trail | 0.54 | 7 | 12.4% | 7, 8, 9 |
| 4 | Coral Reef Trail from Upper Divi-Divi Trail to Pony Club Trail | 0.37 | 6 | 8.5% | 10, 19 |
| 5 | Divi-Divi Trail | 0.52 | 10 | 11.9% | 8, 11, 12, 13, 14, 15 |
| 6 | Yellow Cliff Trail from Coral Reef Trail to Ginger Thomas Trail | 0.31 | 1 | 7.1% | 16, 17 |
| 7 | Yellow Cliff Trail from Ginger Thomas Trail to Hibiscus Circle | 0.49 | 6 | 11.2% | 18, 19 |
| 8 | Yellow Cliff Trail from Hibiscus Circle to Mongoose Cut | 0.22 | 1 | 5.1% | 20, 21 |
| 9 | Ginger Thomas Trail | 0.16 | 4 | 3.7% | 22, 23 |
| 10 | Hibiscus Circle | 0.35 | 7 | 8.0% | 24, 25 |
| | **Totals** | **4.36** | **50** | **100.0%** | |

*Segment 1: Pony Club Trail/Hawks Nest Trail*

Segment 1 starts at the gut crossing near the main entrance to the neighborhood and climbs to almost the highest point in the neighborhood. The first portion of Pony Club Trail is quite flat with some areas where runoff ponds on the road. This northern section of land between the road and the gut is public land that the local pony club is allowed to use for their horses (Figure 9). As Pony Club Trail turns uphill to the south, drainage issues become evident as the road has been graded towards the inside slope (inslope) creating a severely eroded ditch (Figure 9). About halfway up Pony Club Trail, there is an 18-inch corrugated metal culvert under a driveway; this culvert is damaged and undersized. Further uphill, Pony Club Trail intersects with Hawks Nest Trail, which becomes the main road, while Pony Club Trail continues straight and becomes a dead-end road. In total, over a mile of road contributes to the drainage problems along this segment.

**Figure 9.** Pony Club Trail is very steep with an extremely eroding ditch on the inside (eastern) slope (left). The flat area between Pony Club Trail and the gut is currently used as a practice corral for the pony club (right).

*Segment 2: Coral Reef Trail from Cell Tower Road to Upper Yellow Cliff Trail*

Segment 2 is the stretch of Coral Reef Trail that starts at the intersection with the upper portion of Yellow Cliff Trail and continues to the top of the cell tower road at the highest point in Solitude Bay Watershed (Figure 10). This road segment runs along a ridge where flow could be directed to either side. The homeowner at the base of the cell tower road reports flooding and sedimentation due to uncontrolled runoff from that steep road. To mitigate flooding, the homeowner has tried to create drainage paths to direct runoff down the ridge to the west by excavating through the roadside berm in several locations. The northern stretch of this segment flows into Segment 6.

**Figure 10.** Coral Reef Trail in this area runs along the top of a ridge (left); this photo is looking down the extremely steep, eroded cell tower road (right).

*Segment 3: Coral Reef Trail from Upper Yellow Cliff Trail to Upper Divi-Divi Trail*

This section of Coral Reef Trail is extremely steep and is graded such that road runoff collects along the inslope, creating an eroded ditch along the whole segment (over 0.5 mile). There are two clogged/damaged 18-inch culverts under driveways along the upper portion of this segment (Figure 11). The roadside ditch along the last portion of this segment (near upper Divi-

Divi Trail) is actually the gut for a drainage area of almost 30 acres, receiving all of the runoff from Segment 6 (Figure 12).

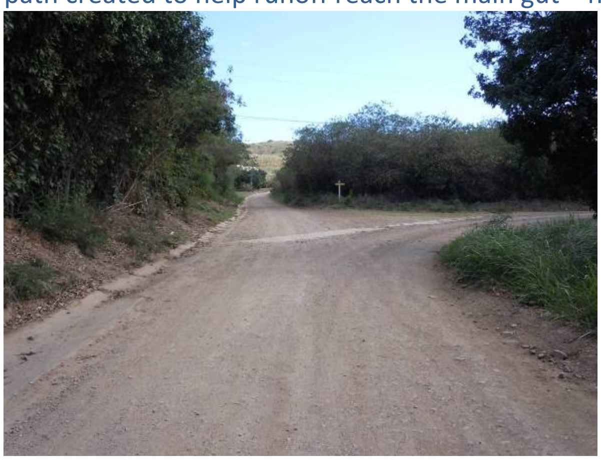
**Figure 11.** Coral Reef Trail in this area is very steep (left) with damaged/clogged driveway culverts (right).

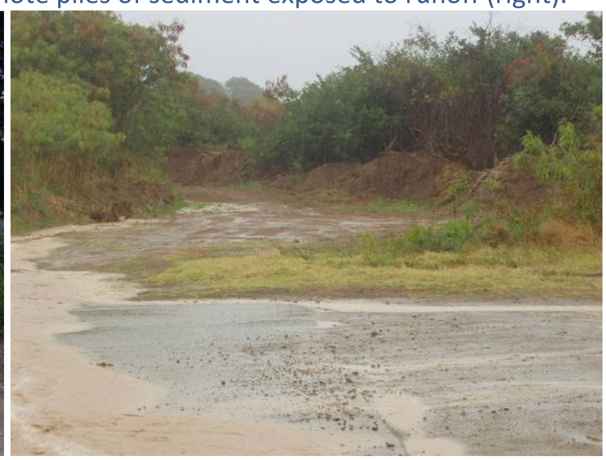
**Figure 12.** In some areas, the road has been graded down to the bedrock (left) with an eroding ditch on one side and earthen berm on the other (right).

*Segment 4: Coral Reef Trail from Upper Divi-Divi Trail to Pony Club Trail*
The ditch alongside this stretch of Coral Reef Trail continues to serve as the gut (Figure 13); at lower (northern) end of Segment 4, the gut receives drainage from 130 acres. This portion of Coral Reef Trail is significantly flatter. There is a partially collapsed 18-inch driveway culvert, as well as several sections of shallow, undermined paved swales, along this segment (Figure 13). The maintenance contractor has created a large drainage path at the downstream end of this segment (near the neighborhood entrance), pushing sediment and debris into the main gut (Figure 14).

**Figure 13.** Damaged driveway culvert (left) and the eroding ditch serving as the gut (right).

**Figure 14.** Shallow, paved swales at the downgradient end of Segment 4 (left), and a manmade drainage path created to help runoff reach the main gut – note piles of sediment exposed to runoff (right).





*Segment 5: Divi-Divi Trail*

Divi-Divi Trail starts and ends on Segment 4, Coral Reef Trail. The first portion of the road (nearest the neighborhood entrance) climbs steadily uphill to the west, with an eroding paved swale on the south side of the road. The upper, steepest portion of this stretch was paved with asphalt at some point, which is now broken up and creating more drainage issues along the edges (Figure 15). The road then takes a sharp curve back towards the east, where there is another stretch of broken asphalt. A low point in the road coincides with two driveways (for Lots 46 and 60). The road continues on to the south where there is a long stretch (~1,000 ft) where runoff ponds along the inslope due to flatter slopes, rather than eroding a ditch. The road surface in this area even has some grass cover (Figure 15).

**Figure 15.** Broken asphalt along Divi-Divi Trail (left), and a grassy section of the road where the slope is flatter, little erosion has occurred, and some evidence of ponding was observed (right).


*Segment 6: Yellow Cliff Trail from Coral Reef Trail to Ginger Thomas Trail*

Segment 6 starts at the end of Segment 2 and ends at the confluence of Segments 7 and 9. This upper portion of Yellow Cliff Trail is extremely steep, with an eroded roadside ditch on the inslope (Figure 16). The whole segment (0.3 miles) drains to a 24-inch ductile iron culvert under the road, which also carries flow from the gut. This culvert was clogged on the upgradient end, with a deep scour hole on the downgradient end (Figure 17).

**Figure 16.** Yellow Cliff Trail is steep with an eroding ditch on the inslope.


**Figure 17.** The upgradient end of the culvert is clogged with sediment, severely reducing its capacity (left), and the downgradient end has created a large scour hole on a steep slope (right).


*Segment 7: Yellow Cliff Trail from Ginger Thomas Trail to Hibiscus Circle*

This segment of Yellow Cliff Trail is mostly steep with an eroding ditch along one side except for two areas: a flat area near a gut crossing (it flows over the road, i.e., no culvert), and one near Hibiscus Circle, where the road experiences some ponding (Figures 18, 19, and 20). Along the steep portion, a section of asphalt was installed in the road, with an adjacent concrete swale directing flow off the road into a manmade drainage path. The gut that crosses this segment has a drainage area of 70 acres at this location, most of which is currently undeveloped. There are two 24-inch driveway culverts in need of repair.

**Figure 18.** Looking uphill and downhill along the steep portion of this segment; the eroding ditch on the inslope is evident.

**Figure 19.** Clogged and damaged 24-inch corrugated metal culvert that carries runoff from the south portion of Hibiscus Circle across to the gut.

**Figure 20.** The gut flows over Yellow Cliff Trail at this location (left); the maintenance contractor has cleared the private lot in this area in an attempt to better accommodate gut flows to prevent flooding of the road (right).  Flow arrows shown in blue.


*Segment 8:  Yellow Cliff Trail from Hibiscus Circle to Mongoose Cut*

Yellow Cliff Trail continues on past the intersection with Hibiscus Circle, where there are three connected sections of paved swale for runoff (Figure 21).  The road then forms a "T," with a short section going west toward the neighborhood entrance, and the other section heading east/northeast towards a gut crossing.  This gut flows under the road via two 24-inch corrugated metal culverts that are in relatively good condition with little blockage and only slight scouring at the downstream end.  The upstream end is a depression that dries out in the dry season.  While these culverts are not currently a significant problem, issues could arise if the upstream watershed (60 acres with very little development) becomes more developed.  This gut flows into the large pond discussed in Section 2.1.

**Figure 21.** Shallow, paved swales at intersection with Hibiscus Circle (left), and the eroded ditch along the corner where Yellow Cliff heads to the northeast (right).


**Figure 22.** Portion of road that crosses the gut to the northeast (left), and the two 24-inch corrugated metal culverts at the gut crossing (right).

*Segment 9: Ginger Thomas Trail*

Ginger Thomas Trail is a short stretch of road (less than 0.2 miles) at the southeast corner of the neighborhood. Drainage from this segment flows to two locations: (1) to a low point where a future spur road has been laid out (Figure 23); and (2) to a low point at the end of the road to the north where the lot lines show a future cul-de-sac may be developed (Figure 24). Both of these locations eventually drain to the gut that crosses Yellow Cliff Trail at Segment 7. No severe erosion was identified along Ginger Thomas Trail.

**Figure 23.** The first low point along Ginger Thomas Trail is shown here looking downhill to the southwest (left); the same stretch of road, but looking uphill to the northeast (right).

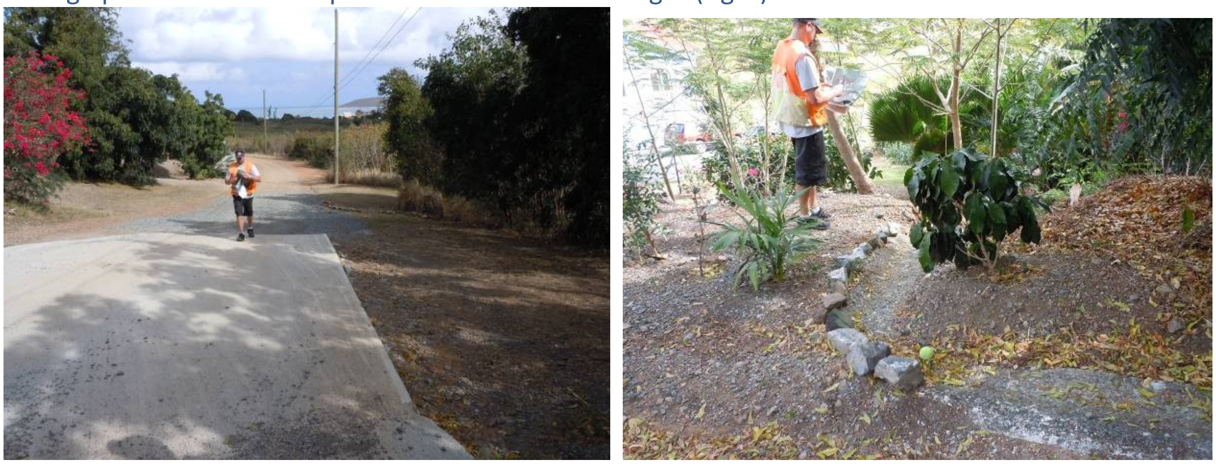
**Figure 24.** Runoff from the last portion of Ginger Thomas Trail flows to the western side of the road (left), towards the flat turnaround area where there were some signs of ponding (right).

*Segment 10: Hibiscus Circle*

The final segment evaluated in the Hope and Carton Hill Neighborhood Assessment is actually in Yellow Cliff Estate. Hibiscus Circle is immediately adjacent to Hope and Carton Hill to the east. It is accessed from Yellow Cliff Trail, and while the road layout makes a complete circle, driving is blocked along the south portion of the circle where the road surface becomes mostly grass instead of gravel. Near the entrance to the circle, the road is very wide (over 30 feet) and relatively flat. Evidence of ponding along the outer (northern) edge of the road was observed (Figure 25). As the road heads south, it climbs in elevation. A paved intersection has been installed at the entrance to a driveway; the section of dirt road at the downhill edge of this pavement has become eroded. Nearby, homeowners have attempted to redirect runoff off the road using various rock and paved channels to carry stormwater to the eastern gut, which crosses Yellow Cliff Trail at Segment 8 (Figure 26).

**Figure 25.** The entrance to Hibiscus Circle is wide and mostly flat, with some evidence of ponding along the outer edge.

**Figure 26.** Some erosion is occuring at the edge of the paved intersection (left), and a manmade drainage path created to help runoff reach the eastern gut (right).



## 3.0 ROAD STABILIZATION AND STORMWATER MANAGEMENT TECHNIQUES

This section defines and describes the various structures and practices that are recommended in Section 4.0 for improving drainage and reducing sediment loads from the Hope and Carton Hill road network. Example photos and typical design details are provided below to better illustrate these techniques; however, these will need to be adapted for Hope and Carton Hill as implementation moves forward.

### 3.1 Road Drainage Structures

Unpaved road surfaces are subject to erosion and deterioration at a much faster rate than paved roads. If roads are intended to remain unpaved permanently, then it is important to incorporate design features that reduce the length of time stormwater is in contact with the road surface (i.e., get water off the road surface at frequent intervals before it concentrates and becomes erosive). There are a number of structures that can be used to manage drainage on unpaved roads that have evolved from efforts to stabilize logging roads and trails including: waterbars, dips, deflectors, cross drains, and culverts (Figure 27). More information on many of these practices can be found at [www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/Chap_4.pdf](www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/Chap_4.pdf).

**Figure 27.** Waterbars (top left), open top culverts (top right), and dips (bottom left) installed by Coral Bay Community Council can have different design variations, but serve to divert surface flows off the road before erosion occurs. Deflectors (bottom right) are an alternative design (USDA). These practices should be spaced according to road slope, discharge to stabilized outlet, and be routinely maintained in order to function properly.

*Waterbars*
Waterbars are narrow berm and swale structures angled across roads like a speed bump to divert water off the road surface into vegetated areas or roadside ditches (Figures 28 and 29). Waterbars are often constructed from compacted earth, logs, concrete, or other materials. Because of the installation lessons learned in Coral Bay and the steepness of roads in Hope and Carton Hill, we recommend using concrete.

Waterbars should follow the following design criteria:

- Excavate trench at 30-45 degree angle across the road surface. Steeper grades with more surface flow should be closer to 45 degrees. All of the recommended waterbars for Hope and Carton Hill divert surface runoff towards an inside ditch.
- If using logs, bury logs 2/3 of their diameter on downhill side of trench. Consider using rock to help anchor.
- Top of berm should be 12 inches higher than bottom of trench. To make a water bar easier to drive over, widen it by increasing the distance between the bottom of the dip and the top of the berm, maintaining the correct height.
- Pitch the waterbar so that the outlet end is at least 3 inches lower than the upper end (~3% slope). The improper angling and pitch can reduce self-cleaning of sediment accumulated in the swale portion of the waterbar.
- Extend waterbars beyond both travel edges of road to prevent water from flowing around ends.
- Direct diverted water into a stable, vegetated area, rock pad, or ditch. Do not discharge onto erodible soils or fill slopes without outfall protection (rock piles, logs, etc.).
- Space water bars according to the road grade (Table 2). If spaced too far apart, concentrated water flow and road surface erosion can occur between waterbars.

**Table 2**. Recommended Spacing of Waterbars, Dips, and Cross Drains

| Road Grade | Spacing (ft) | | |
|---|---|---|---|
| | Waterbars | Dips | Cross Drains |
| 2% | 250 | 300 | 135 |
| 5% | 135 | 180 | 100 |
| 10% | 80 | 140 | 80 |
| 15% | 60 | Do not use | 60 |
| 20% | 45 | | 45 |
| 25% | 40 | | 30 |
| Source: HI DOT (2008) and UVICES (2003) | | | |

The incorporation of a waterbar at the interface of paved and non-paved road sections can help prevent erosion (Figure 29). Primary maintenance includes removing sediment that has deposited at the waterbar outlet feature. It is particularly important to remove sediment that has collected behind checkdams, in ditches, and in culverts as part of regular road maintenance activities.

**Figure 28.** Earthen-berm waterbar from Minnesota Extension Service (left); waterbars divert surface flows and are not intended to intercept roadside ditches (right: Source British Columbia, 2001); and one of a number of alternative concrete waterbar designs by Coral Bay Community Council.

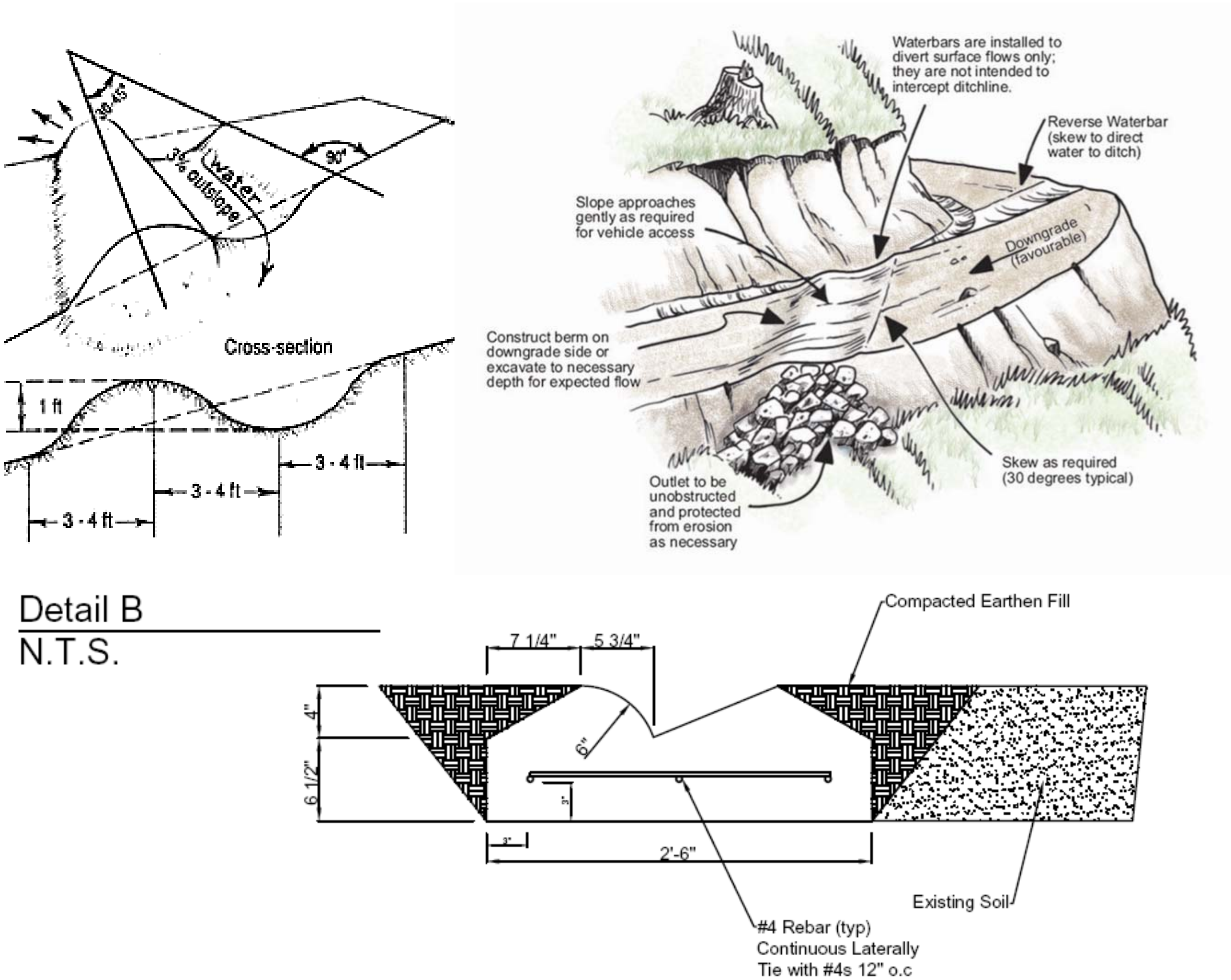


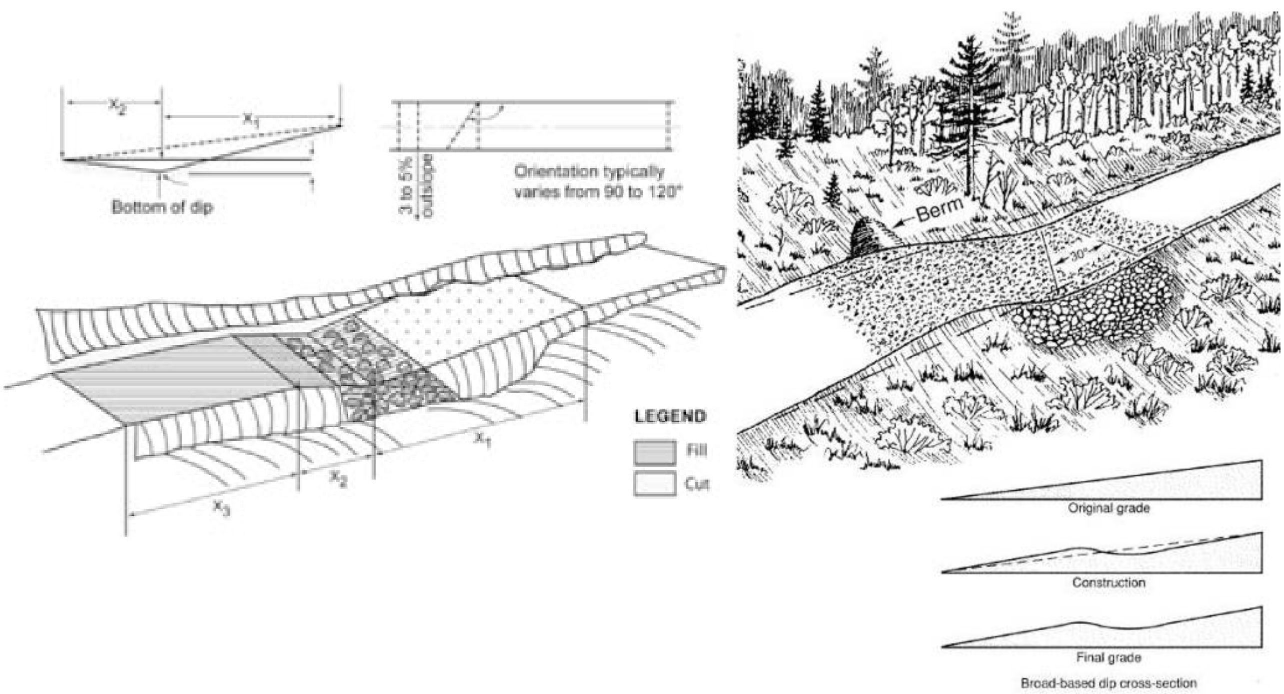

**Figure 29**. Proper angling and pitch of waterbar will help keep sediment from accumulating in swale

*Dips*

Broad dips are commonly used as an alternative to waterbars. They are easier to drive over and can convey water from the road surface as well as from roadside ditches. They are fairly common on flatter, paved roads in the USVI, but have also been used in unpaved situations (Figure 30). They can be constructed from concrete or stone and should be spaced according to slope (see Table 2). The broad dip and outlet pad help to maintain sheet flow (rather than concentrated) discharge. In unpaved situations, it is important to incorporate a sediment trap or other feature at the outlet location to collect sediment. This must be maintained on a routine basis.

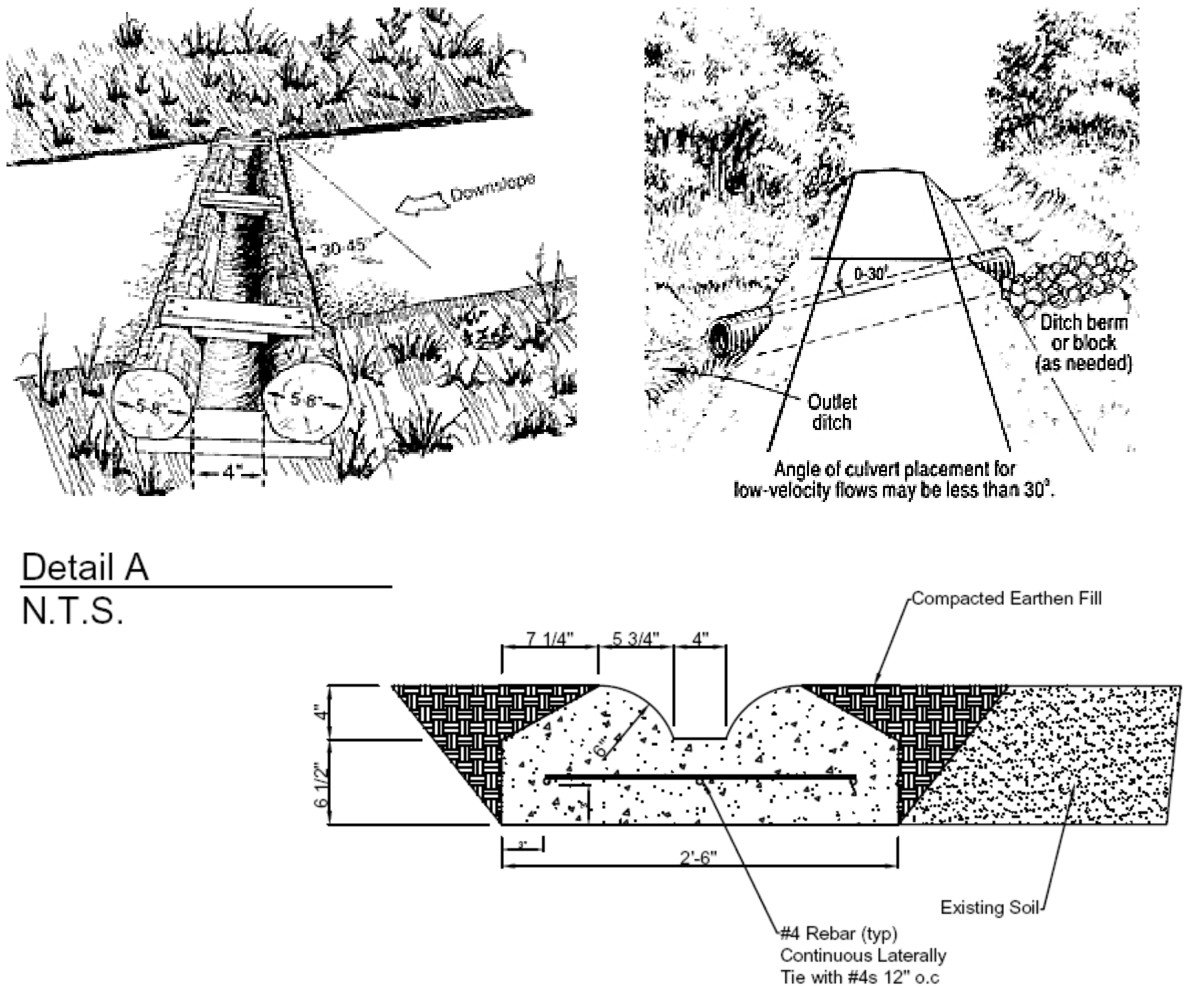
**Figure 30.** Dip constructed on an unpaved road (left) and one used on a paved road (right) in Coral Bay as an alternative to convey flow from both the road surface and from the inslope ditch to outslope.

**Figure 31.** Dip schematic for unpaved roads (USDA, 2006 and Wisconsin Dept. of Natural Resources).



*Cross-drains and Culverts*
In some instances (e.g. steep sections, intersections, or high volume locations), it is necessary to move concentrated flow across a road from an inside ditch or drain inlet. There are a number of piped or open-top culvert designs that have been used in the USVI (Figures 32 and 33). Open-top culverts can be used to divert water off a road surface while allowing for drainage across it. They are most frequently built from telephone poles or other type of timber, but can also be made from concrete.

**Figure 32.** Open-top culvert (left) and piped culvert (right, MN Extension Service) and design alternative for a concrete open-top culvert by Coral Bay Community Council (bottom).




When constructing an open-top culvert, be sure to:

- Make the trench opening at least 6 inches deep and wide enough to be easily cleaned. The width of a shovel is convenient.
- Install the trench at an angle similar to waterbars—30-45 degrees. Do not turn the water more than 45 degrees.
- Use spacers between the side boards to keep them in place and stabilize the structure.

- Remove roadside berms or other obstacles that might block water moving from the outlet. Water should flow into stable vegetation, rock area, or conveyance ditch away from the road.
- Use water bar spacing when the main purpose is to divert water off a traffic surface. Follow broad-based dip and cross-drain culvert spacing if cross-drainage is the main goal (see Table 2).

Like waterbars, the open-top culverts are relatively inexpensive and can be installed with hand tools on site. They permit easy movement of vehicles, but require frequent maintenance to keep them in good working order. Clean soil, rock, and other debris frequently from open-top culverts to prevent clogging. Consider locating open-top culverts below a series of waterbars or below paved sections to help prevent sediment from clogging trenches.

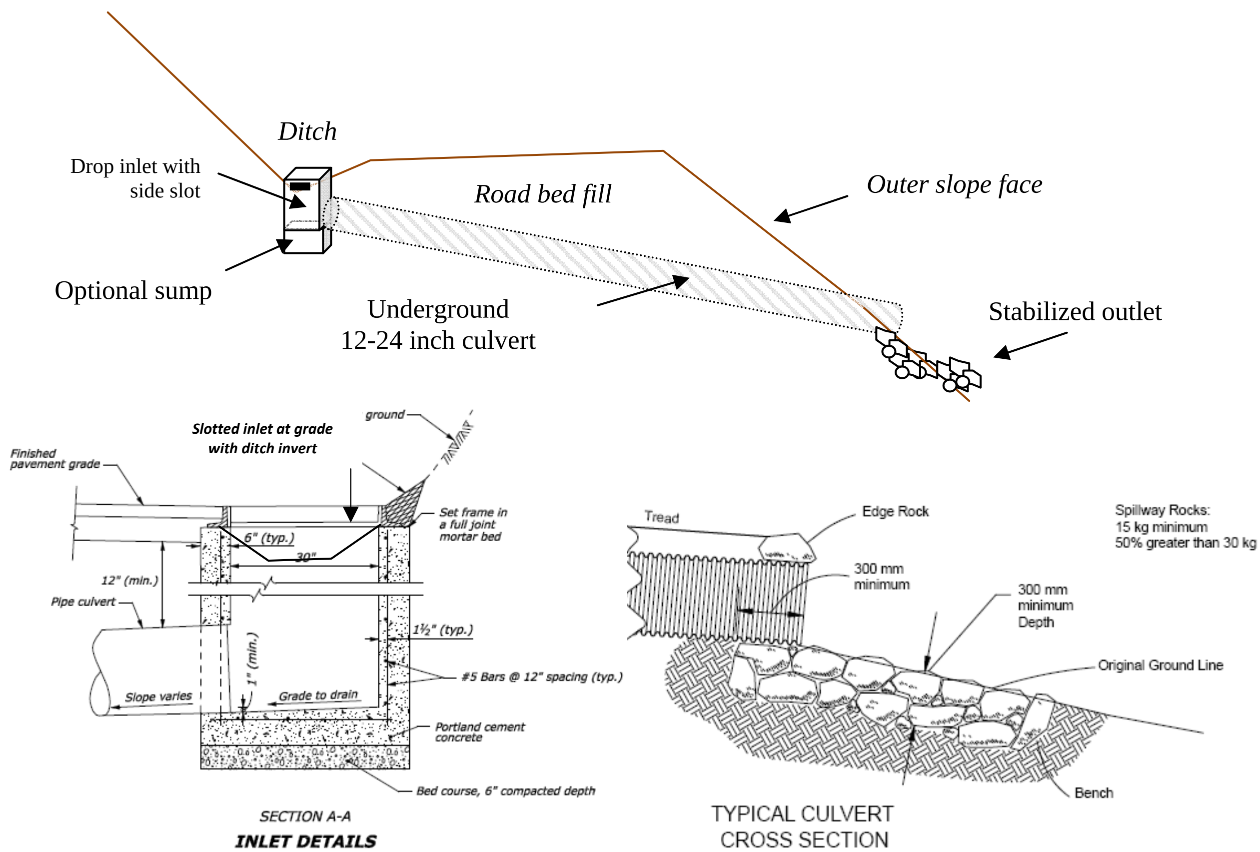
**Figure 33.** Open top-culverts have to be designed for maintenance access. The spacing should be wide enough to fit a narrow shovel. Top left and right photos here show clogged practices with reduced functionality. The grated cross-drain (bottom left) works on paved surfaces, and the grate can be lifted for easy cleaning. Be sure to provide outlet protection (bottom right) and remove deposited sediment on a regular basis.

### *Drop Inlets*

In some locations in Hope and Carton Hill, we recommend installing a drop inlet structure and a 12-24 inch culvert to collect and convey runoff from the roadside swale across the road to discharge at a stable outlet on the outsloping road face (Figure 34). An optional sump can be included in the box structure to help trap sediment. Consideration needs to be given to the size and shape of the inlet (open slot on the side or grated) to prevent debris (mostly rocks) from entering system. Ditches may also need to be excavated to accommodate structures, or to create a sediment/debris trap just uphill of the inlet. It is important to be sure the outlet is stabilized.

**Figure 34.** A drop inlet and culvert installed as a road improvement project in Coral Bay (Source CBCC).

**Figure 35.** Representative road cross section (above), typical inlet (bottom left), and stabilized outlet (bottom right). The inlets should have slots or the frame/grate set at grade with ditch inverts.



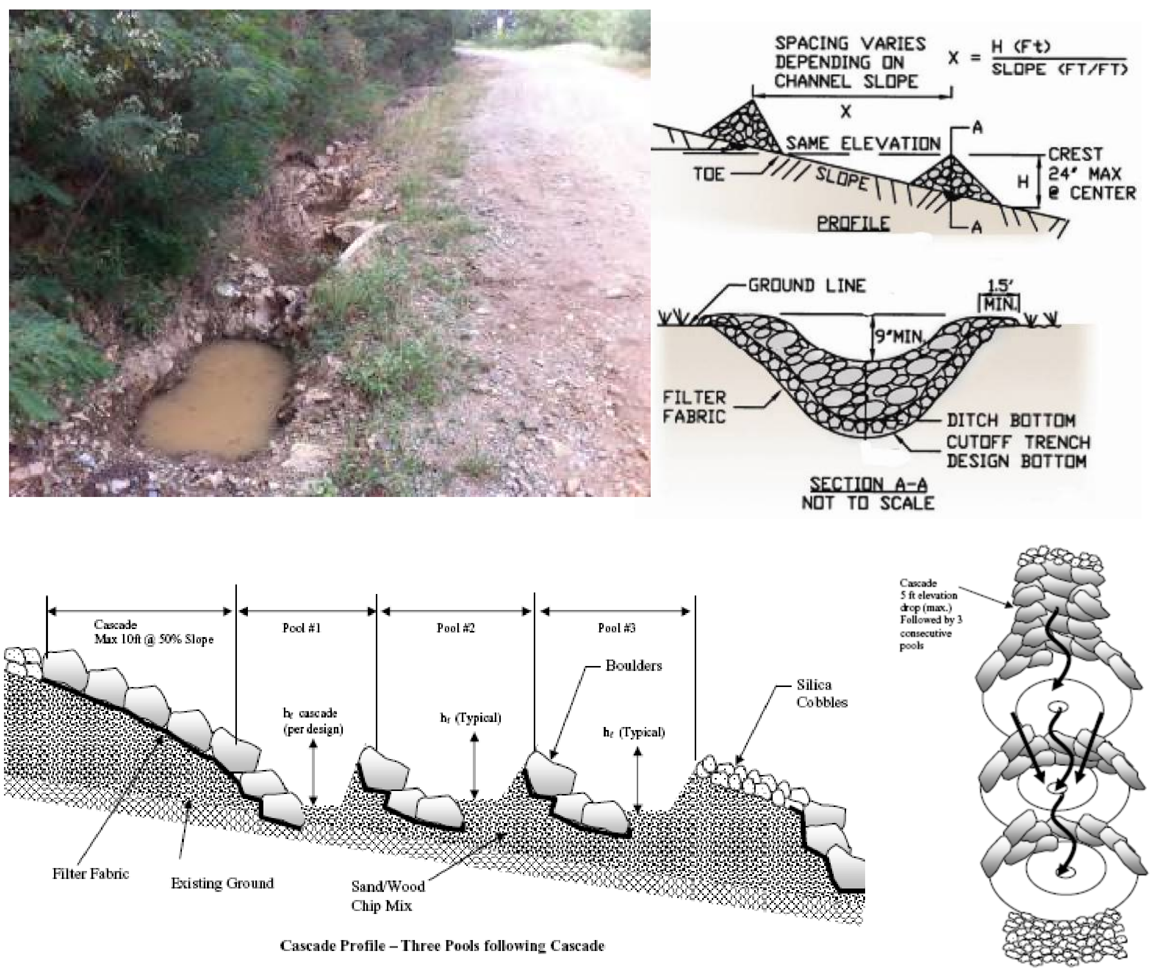
## 3.2 Stormwater Storage and Volume Reduction Practices

There are a number of stormwater practices recommended for Hope and Carton Hill that can provide storage, water quality improvement, and/or overall volume reduction. These include use of checkdams and step pools in roadside ditches to trap sediments in addition to their primary purpose of reducing velocities. More traditional stormwater storage/ treatment practices such as constructed wetlands, bioretention, and rain gardens combine vegetative treatment and, in some cases, infiltrative capabilities to reduce the overall impacts (both water quality and quantity impacts) from the Hope and Carton Hill road network.

*Checkdams and Step-Pools in Roadside Ditches*

We have recommended two alternative approaches to reduce ditch erosion, dissipate runoff energy, and potentially trap sediment in steep ditch sections (Figure 36). In flatter road sections, the installation of rock check dams can be used to pool runoff and trap sediment. In steeper areas, we recommend excavating cascading step pools.

**Figure 36.** Step pools installed in roadside ditch in Coral Bay (left, Source CBCC); typical cross-section and profile of rock check dam (right, NY ESC Manual); and representative design for cascading step pool from Anne Arundel County, MD (bottom left and right).



Check dam installation criteria include:

- Maximum drainage area above the check dam shall not exceed two (2) acres.
- Height not greater than 2 feet. Center shall be maintained 9 inches lower than abutments at natural ground elevation.
- Side slopes shall be 2:1 or flatter.
- Use a well-graded stone matrix 2 to 9 inches in size.
- The overflow of the check dams should be stabilized to resist erosion.
- Check dams should be anchored in the channel by a cutoff trench 1.5 ft wide and 0.5 ft deep and lined with filter fabric to prevent soil migration.
- Space check dams in the channel so that the crest of the downstream dam is at the elevation of the toe of the upstream dam. See Table 3 for general guidance.

**Table 3**. Standard Stone Check Dam Spacing

*(Maryland Department of the Environment, 1994).*

| Slope | Spacing (feet) |
|---|---|
| 2% or less | 80 |
| 2.1% to 4% | 40 |
| 4.1% to 7% | 25 |
| 7.1% to 10% | 15 |
| over 10% | use lined waterway design |

Additional design guidance for step pools can be found from Anne Arundel County, MD at http://www.aacounty.org/DPW/Watershed/StepPoolStormConveyance.cfm.

Check dams and step pools should be inspected after each runoff event. Correct all damage immediately. If significant erosion has occurred between structures, a liner of stone or other suitable material should be installed in that portion of the channel. Remove sediment accumulated behind dams and in pools as needed to allow channel to drain. Replace stones as needed to maintain the design cross-section of the structures.

*Bioretention, Rain Gardens, and Vegetated Swales*

Bioretention areas and rain gardens work as filters with amended soils and vegetation that can handle inundation during storm events as well as long periods of dry conditions. Rain gardens are just simpler versions of bioretention systems as they tend to have simple inlets and outlets with no underlying infrastructure. Rain gardens are perfect practices for homeowners to implement in their own yards and are recommended for wide-scale implementation in Hope and Carton Hill to reduce runoff contributions from driveways. Figure 37 shows a typical-cross section of a raingarden. Figure 38 shows a variation of the bioretention, which is a stepped stormwater conveyance system, as well as a photograph of a linear bioretention, also called a bioswale. Consideration should be given to the appropriate vegetation and media mixtures used to ensure they are available and appropriate (native) to USVI setting.

**Figure 37.** Schematics of a rain garden/with no underdrain (top, from University of Florida Extension Service factsheet) and a bioretention facility (bottom, from Horsley Witten Group).

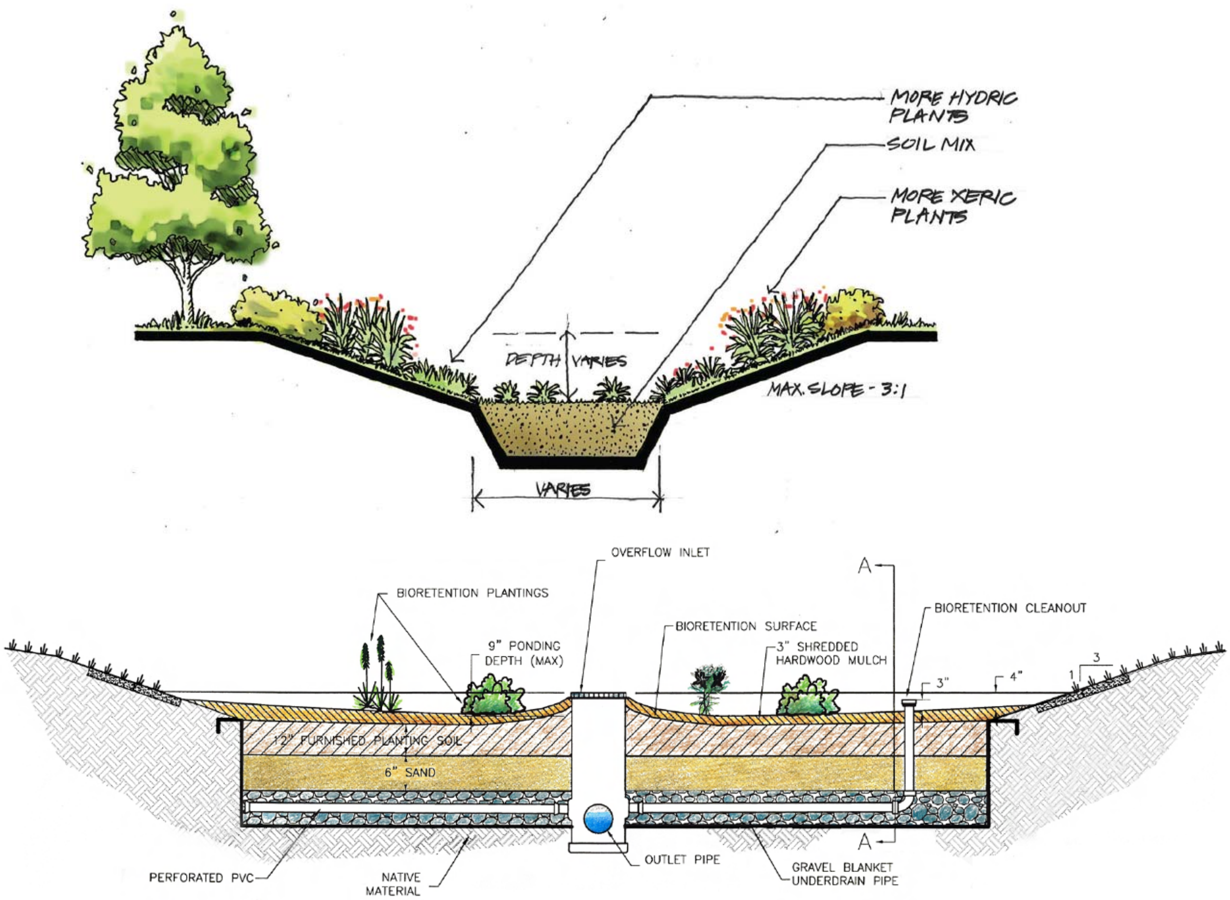



**Figure 38.** Photos showing stepped conveyance systems in channel from Anne Arundel County, MD (two photos on left), and a linear bioretention facility along a residential street in Seattle, WA (on right)

*Ponds and Constructed Wetlands*
There are a few areas where a facility such as a pond or constructed wetland is recommended to manage and treat large amounts of runoff before being discharged to a gut or downstream waterbody. These facilities can be very effective for managing large drainage areas and are proposed in areas where there is a lot of space available. The specific type of practice selected will depend largely on depth to groundwater and the infiltration capacity of soils. If a permanent pool is likely, then a vegetated practice is more desirable than a wet pond, for example. Unlike traditional detention ponds, vegetated facilities with variations in depths can provide wildlife habitat, reduced mosquito risk, and increased aesthetics. Constructed stormwater wetlands mimic natural wetlands with hydrologic regime and plant species. If infiltration is practical, then an infiltration basin design may be a preferred approach. Figure 39 shows an example of a similar retrofits recently installed in Coral Bay to manage runoff.

**Figure 39.** Wet vegetated pond retrofit in Coral Bay that manages runoff from Kingshill Road. Sediment accumulation is evident in the paved flume from the road leading to the practice (Top). The facility is being monitored to determine how much sediment is collected. Infiltration/sediment basin constructed in Carolina drainage in Coral Bay (Bottom, photos courtesy of CBCC).

## 3.3 Grading and Maintenance Techniques

Unpaved roads require a long-term commitment to maintenance and regrading. Better road design (i.e., breaking up drainage and preventing erosive concentrations of flow) can increase the longevity of the road surface, reduce maintenance costs, and ultimately, improve water quality. A full evaluation of the procedures used to grade roads in Hope and Carton Hill was not conducted as part of this work; however, the following techniques for future grading are recommended:

- All surface reshaping efforts should begin with a determination of road crown or cross-slope elevations and a delineation of roadside ditches in order to maintain proper drainage function during re-grading. It is not evident from observations of the Hope and Carton Hill road network that a clear grading plan has been followed in many of the road sections.
- Do not build berms where ditches used to be.
- A big part of road maintenance should include the removal of sediment that has built up in ditches, culverts, and inlets. Consider cleaning infrastructure just before re-grading. Re-establish rock check dams and earthen waterbars (if any) immediately after grading.
- Grading sequencing will include a number of steps and multiple passes in order to properly prepare the road surface and to mix, spread, and compact recovered material.
- Scrapping and cutting should be done to the bottom elevation of potholes, rills, and washboards to prepare the surface for accepting new material and delay the re-formation of holes.
- Over time, materials move from the center of the road surface outward towards shoulders and ditches (where crowned). This material needs to be moved back towards the center of the road during re-grading. Recover enough fine aggregate particles to replace fine particles lost to erosion, dust, and traffic action. Evenly blending cut or removed material is critical. If the large segregated aggregate is brought back to the center of the road without re-establishing a proper mixture of coarse and fine material, the road will unravel very quickly, generating dust and potholes.
- Organic material in ditches should not be mixed back into the road surface; however, sediment and small aggregate collected in the ditches can be reincorporated if well mixed.
- Do not deposit excess sediment into or near the gut. If the road surface is properly prepared, material mixed, and compacted under moist conditions, this material should be adequate to rebuild the roads.

Maintenance of roads and drainage infrastructure will require the proper grading equipment, as well as shovels, picks, and rakes for sediment removal and material spreading. Since the Hope and Carton Hill road network is private, it is important that operators are well trained, that they understand the drainage implications of their work, and that frequent inspection and oversight is provided.

### 3.4 Cost Estimates

Tables 4 and 5 are excerpts from summary reports (CBCC, 2012) showing the unit costs for a number of recent road improvement and stormwater retrofit projects on St. John constructed by the Coral Bay Community Council using a NOAA grant. The full summary report and individual project reports can be found at www.coralbaycommunitycouncil.org/VIRC-and-D.htm.

While construction costs may be different in St. Croix, these tables provide relative and reasonable construction cost estimates that can be used for implementation planning for many of the projects identified for Hope and Carton Hill.

**Table 4.** Construction Costs for Road Improvement Projects in Coral Bay (excerpt from CBCC, 2012).

| Activity | Unit | Cost Range[1] |
|---|---|---|
| Cross-Road Concrete Swale | Each | $3,500-$14,000 |
| Culvert installation – simple HDPE to Aluminum Pipe Arch | Each | $5,000-$35,000 |
| Excavation | Linear Foot | $4-$65 |
| Paving - various | Square Foot | $12-$20 |
| Paving – roadway | Linear Foot (various widths) | $113-$216 |
| Paving – curb, gutter, drainage channel | Linear Foot (various widths) | $12-$90 |
| Retaining Wall – boulder wall and gabion basket | Linear Foot | $130-$297 |
| Rock Weir | Each | $3,400-$14,500 |
| Step Pool and Check Dam | Each | $360-$2,000 |
| Trench Drain | Each | $45,000 |
| Waterbar | Each | $2,000-$2,500 |

[1]The range of costs is often dependent upon square footage/linear footage of each activity and location (some areas required longer travel times; therefore, material costs were higher). Culvert costs were dependent upon the type of culvert installed and the need for inlets/outlets.

**Table 5**. Construction Costs for two Storage Facilities in Coral Bay (excerpt from CBCC, 2012)*

| 6-4 Carolina Sediment Detention Basin Work | |
|---|---|
| *Description* | *Total Cost* |
| Construct BMP Entrances | $9,500 |
| Install Erosion Control Measures | $1,200 |
| Install Rock Weir | $14,500 |
| Clear & Grub Specified Areas | $1,150 |
| Excavate and Construct Primary Sediment Basin | $28,500 |
| Clear, Grub, & Excavate Future Sediment Basin Expansion Area | $13,600 |
| Cleanup & Seed All Disturbed Areas | $2,800 |
| Install Gauge | $250 |
| *Total 6-4 Carolina Work Cost* | $71,500 |
| | |
| **King's Hill Road/Gerda Marsh Road Intersection Bioretention Pond Work** | |
| *Description* | *Total Cost* |
| General conditions, water labors, insurance, and subcontractors. | $8,750 |
| Install rock construction entrance and material lay down area. Clear access area towards the geotextile sediment trap, install sediment trap. | $5,740 |
| Clear and grub site, install erosion control blanket, seeding and maintenance, watering and reseeding, temporary fencing and brush berm installation, and final grading. | $18,400 |
| Excavate pond area. Install and fill gabion baskets. | $33,416 |
| *Total King's Hill Road Work Cost* | $66,306 |

*The Carolina Sediment Basin is approximately 0.28 acres. The Kings Hill road facility is a 6-foot deep pond with a bottom area of 3,800 $ft^2$ and a top area of 7,400 $ft^2$.

The 400 square foot demonstration rain garden installation in Hope and Carton Hill in October 2012 cost approximately $3,500.

## 4.0 POTENTIAL RESTORATION OPPORTUNITIES

Restoration opportunities were broken into three categories: Structural projects in the Hope and Carton Hill Neighborhood, important projects in the surrounding watershed, and recommendations for the HOA. These are described in the sections below.

### 4.1 Structural Improvements in the Hope and Carton Hill Neighborhood

*Road Improvement and Stormwater Management Sites*

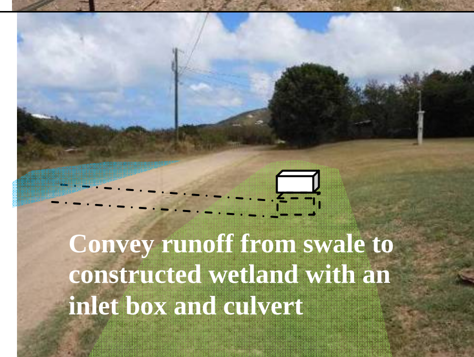
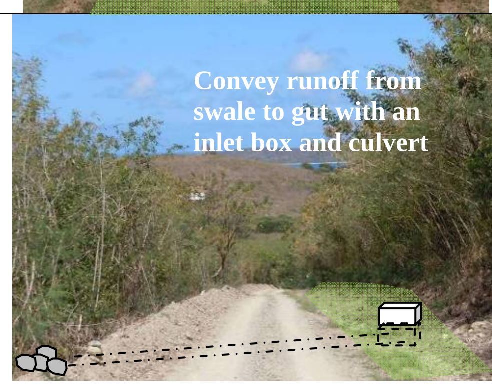
Given the steepness of the road grade, narrowness of the road right-of-way, and limited financial resources for paving, the overall strategy to reduce erosion in the Hope and Carton Hill Neighborhood is to:

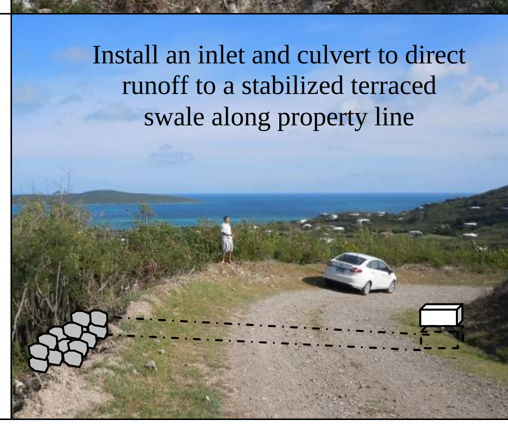
(1) Reduce the amount of time stormwater runoff is in contact with the road surface;
(2) Reduce the total distance runoff travels along the road surface;
(3) Increase the number of discharge points along the road, considering location of downhill residences and drainage patterns;
(4) Stabilize ditches and other conveyance structures to slow runoff velocities through energy dissipation and trap sediment;
(5) Pave or otherwise reinforce areas highly susceptible to erosion and heavy tire action (such as bends and gut crossings);
(6) Minimize the import/use of gravel on the road; and
(7) Identify priority maintenance locations and practices for residents.

To meet these objectives, structural and non-structural practices were identified at over 25 stations along the road network. The Proposed Conditions Map (Attachment B) shows the approximate location of each of the practices proposed. Station numbering was arbitrarily assigned based on the field assessment, though the sequence primarily starts at the entrance of the neighborhood and progresses somewhat in a counter-clockwise direction, following road segment numbering. Multiple stabilization practices that are linked were assigned to each station. Table 6 provides a summary description of the type of stabilization practices recommended at each station and includes site photos to illustrate the concepts.

**Table 6.** Summary of Hope and Carton Hill Neighborhood Road Stabilization/Improvement Opportunities

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 1 – Pony Club Trail Gut Crossing | 1 | • **Replace undersized culvert** with one or more culverts to ensure safe passage of gut flow without overtopping the roadway during the 25-year storm.<br>• **Stabilize** and restore the downstream scour hole with rock and vegetation to reduce erosion.<br>• Reduce/eliminate the practice of pushing sediment from the roadway into the gut in this location. |  |

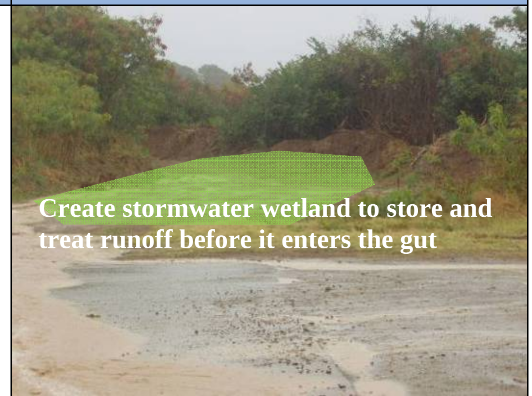
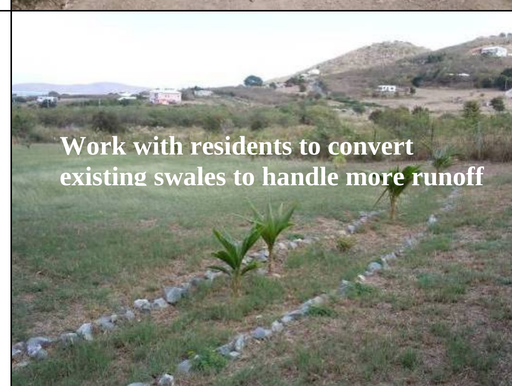
| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 2 – Lower Pony Club Trail | 1 | • Utilize right-of-way for large **vegetated swale** for both storage and conveyance to the gut.<br>• Use appropriately spaced **waterbars** to ensure drainage along this portion of Pony Club Trail reaches the swale. |  |
| 3 – Pony Club Gut Restor-ation | 1 | • **Move Pony Club activities** out of the gut to reduce erosion and water quality impacts (e.g., bacteria and nutrients), as well as to reduce safety concerns during large storms. Upland property appears to be available further to the west.<br>• **Restore gut capacity and vegetation**. |  |
| 4 – Pony Club Trail Swale and SW Storage | 1 | • Construct large, vegetated **swale** along Pony Club Trail, ending near the existing ponding area at the sharp corner near the Pony Club. Stabilize with check dams.<br>• Install **inlet box/pipe structure** to collect and carry flows from inside swale to discharge into a large shallow, **constructed wetland** where the practice corral is currently located. |  |
| 5 – Upper Pony Club Trail | 1 | • Create a **stabilized swale** with step pools along the inslope.<br>• Install **inlet box/pipe structures** to convey runoff to outlets in stormwater (sw) easements created along property lines; design outlet for energy dissipation and flow distribution across forested slope.<br>• The lots to the west are laid out along a gut. These parcels should be preserved if possible; if not, development should occur in a way that preserves the capacity of the gut. |  |

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 6 – Cell Tower Road | 2 | • Install **waterbars/water trenches** all along the cell tower road to direct runoff into the surrounding vegetation rather than let it concentrate on the road and cause downstream flooding and sediment problems. |  |
| 7 – Upper Coral Reef Trail Step Pools | 3 | • Replace the existing damaged 18-inch corrugated metal driveway culverts with larger (at least 24-inch pipe), sturdier pipe with riprap on the downstream ends to prevent/reduce scour.<br>• Install six (6) **waterbars** to divert runoff into an enlarged **swale** along the inside of road. Use four (4) in the upper 200 feet of this section of Coral Reef Trail (which has a 20% slope) and two (2) more in the lower 200 feet (which has a slope of 10%). Consider water "trenches" for the four upper waterbars given steeper slope.<br>• Create **step pools** to slow flow and trap sediment. |   |
| 8 – Upper Coral Reef Trail Terraced Swale | 3/5 | • Install **inlet box/pipe structure** to collect and carry flows from inside ditch to discharge into a stabilized **terraced swale** down the outer slope along the property line. Need to establish a sw easement here.<br>• Size the pipe for 25-year storm event.<br>• Requires installation and maintenance of upslope controls at Station 7. |   |

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 9 – Middle Coral Reef Trail | 3 | • Enlarge and stabilize existing swale on inslope of road.<br>• Install **waterbars/trenches** to deflect runoff into inside swale.<br>• Install **check dam(s)** in swale to create step-pools to help reduce velocity and trap sediment. |  |
| 10 – Lower Coral Reef Trail | 4 | • Enlarge and stabilize the existing drainage **swale** with vegetation and check dams where needed. This swale needs to have enough capacity to safely carry the gut flow.<br>• Remove the undermined paved swale were necessary. |  |
| 11 – Lower Divi-Divi Swale | 5 | • Currently, broken asphalt and concrete swales are exacerbating erosion issues on Divi-Divi. Remove both.<br>• Create **stabilized swale** with checkdams on south side of road, using **waterbars** to direct runoff into the swale. If asphalt is not removed, ensure that a waterbar is placed directly downgradient of the asphalt. |  |
| 12 – Divi-Divi Rain Garden | 5 | • Install a **rain garden** at 53 Hope and Carton to manage runoff from the driveway and to serve as a demonstration project.<br>• Use a speed bump to direct runoff into the garden via a stone-lined swale. Place stones at the outlet for stabilized discharge back to the road during large storm events. |   |

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 13 – Divi-Divi Waterbar | 5 | • Install a **waterbar** at the base of the existing concrete swale to direct runoff down the forested slope. Ensure flow is dissipated non-erosively down slope using stone and/or a level spreader.<br>• Evaluate broken asphalt just upgradient of this location; remove if necessary. |  |
| 14 – Divi-Divi SW Storage Practice | 5 | • Use **paved dip** to convey runoff from Station 8 across Divi-Divi Trail into a large **stormwater storage basin** in Lot 47. This lot would need to be preserved for stormwater purposes.<br>• Discharge any overflows via a stormwater easement along the property line between Lots 49 and 50 to the swale at Station 11. |  |
| 15 – Divi-Divi Bioswale | 5 | • Create a **vegetated swale** to reduce the existing ponding that occurs on this flatter stretch of road.<br>• Direct any overflows along a stormwater easement to the swale created for Station 10. This runoff can be conveyed either by open channel or pipe, depending on site conditions at the time of construction. |  |
| 16 – Upper Yellow Cliff Trail | 6 | • Enlarge and stabilize the existing eroding **swale** using vegetation and check dams to slow runoff and reduce erosion.<br>• Use **waterbars** to direct runoff into the swale every 80 feet based on the existing roadway slope of ~10%. |  |

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 17 – Yellow Cliff Culvert | 6 | • **Replace damaged culvert** and construct stabilized inlet that is easy to maintain and will prevent clogging.<br>• Construct a stabilized, **terraced swale** at the culvert outlet. This culvert discharges through Lot 105; this lot should be preserved for stormwater management. |  |
| 18 – Yellow Cliff Swale | 7 | • **Enlarge and stabilize existing swale** using check dams to slow the runoff.<br>• Use **waterbars/trenches** to direct road runoff into the swale.<br>• Remove broken asphalt patch and concrete swale where undermined.<br>• As the swale approaches the gut crossing (see Station 19), ensure that enough storage is provided for sediment removal. |  |
| 19 – Yellow Cliff Gut Restor-ation | 7/4 | • Construct a **paved dip** in the road where the gut crosses Yellow Cliff Trail.<br>• **Restore** cleared gut area, ensuring sufficient capacity.<br>• Create stormwater storage areas on either side of restored gut for easy maintenance.<br>• The lots located in the gut both upstream and downstream from this crossing should be preserved such that development never compromises the gut capacity. |  |
| 20 – Lower Yellow Cliff Trail | 8 | • **Enlarge and stabilize existing drainage swales**, increasing their capacity and reducing erosive potential by using check dams and vegetation. |  |

| Station | Associated Road Segment(s) | Description | Site Photo |
|---|---|---|---|
| 21 – Neighbor-hood entrance | 8/1 | • Create a large **constructed stormwater wetland** with a sediment forebay for easy maintenance. This stormwater storage practice will slow and treat the runoff before it flows into the gut.<br>• Note: If other, upstream stations are not constructed first, this storage facility should be sized to, at a minimum, safely convey the runoff from the full 130-acre drainage area.<br>• Ownership needs to be confirmed, and the land preserved if possible. |   |
| 22, 23 – Ginger Thomas Trail | 9 | • Create small stormwater storage practices, such as **bioretention areas**, in the road layout. Consideration would need to be given to any future development plans/expansion of existing roadways. |   |
| 24 – Hibiscus Circle 1 | 10 | • **Convert swales** built by residents into larger, vegetated bioswales that can handle more flow. Install **waterbars** to ensure road drainage reaches swale. Need to establish a sw easement here. |   |
| 25 – Hibiscus Circle 2 | 10 | • Convert a portion of this wide road into a vegetated **bioswale** (2-3 feet deep, 8-10 feet wide) to reduce erosion and ponding issues. Use check dams where needed.<br>• Use **waterbars** where necessary to direct road runoff into swale. Specifically, install a waterbar at the downstream edge of the paved intersection.<br>• Discharge any overflows into the eastern gut via a stabilized channel in a **stormwater easement** between Lots 24 and 25. |   |

◄▪▪▪ indicates direction of runoff; ⟵ is a waterbar with arrow showing direction of flow;
-·-·- is location of underground pipe; (blue oval) represents a step pool; (green oval) is a vegetated swale or storage practice

### 4.2 Projects in Surrounding Watershed

While the Hope and Carton Hill neighborhood was the focus of this assessment, we have the following recommended action items for the downstream gut and pond as well to improve conditions in the Solitude Bay Watershed:

- Ensure that the pond lot is never developed. Restore the area, removing sediment that has built up over the years from Hope and Carton Hill Neighborhood.
- Reconnect the pond with the downstream gut to prevent flooding on Cotton Valley Road. This will take coordination with downstream homeowners who have built in and around this gut. Stabilization efforts should be made to ensure that redirecting flow does not cause additional erosion and sediment transport from these areas. Undersized and failing culverts will need to be replaced (Figure 43). These two 24-inch ductile iron pipes carry flow underneath a partially paved road. These pipes have corroded and deformed over time and have become clogged with sediment and vegetation, and a scour hole has formed downstream. The road in this area is deteriorating, creating a sediment source to the gut.

**Figure 43.** Gut downstream from large pond with two damaged/clogged culverts (left); the deteriorating road at the gut crossing (right).

### 4.3 Recommendations for Homeowners Association

There are several non-structural actions that the HOA can take that will improve the conditions in the neighborhood, both before and after the recommended structural projects have been implemented. These actions have been grouped into road maintenance and driveway disconnection.

*Road Maintenance*
Road maintenance is a vital part of any road management plan. Once some of the structural recommendations are implemented, it will be important that the maintenance contractor understand what was built and what the overall intent of this plan is so that practices will be

effective. For example, if a bioretention system is constructed at Station 23, the contractor needs to understand that sediment should not be pushed into that feature.

The recommendations were proposed to get runoff off the roads before it can concentrate and create erosive flows. As a result, the long-term maintenance should be greatly reduced. In addition, the type of maintenance will be different. Instead of grading and creating flow paths, the maintenance will be more focused on removing any sediment build up in swales or step pools or ensuring that debris is not clogging waterbars, inlet boxes, or culverts.

Finally, homeowners need to be aware of their driveway culverts. Many were observed to be damaged, clogged, or greatly undersized. These culverts are an important part of the roadway drainage system and need to be large enough, in good repair, and have stabilized inlets and outlets so that they do not become part of the sediment source.

*Driveway Disconnection*
Since driveways account for approximately 20% of the total road network, they have the potential to contribute a significant amount of surface runoff to the road system. Driveway disconnection involves methods to keep driveway runoff from flowing onto the roads and adding to the drainage issues. To encourage this, the HOA should consider creating a formal driveway disconnection program that provides incentives to existing and future homeowners to disconnect their driveway runoff. Disconnection can be done in different ways, such as re-directing runoff to rain gardens, other stable vegetated areas, or into surface or subsurface infiltration systems. Under this program, the HOA could distribute educational materials (see Attachment C), provide technical design and permitting assistance, and reward participants with a reduction in annual HOA fees. Owners of undeveloped lots should be encouraged to integrate driveway disconnection into any future plans.

Station 12 is a demonstration project that was constructed with volunteer help in late October 2012. The demonstration project involved the creation of a small residential rain garden in an existing grassed area adjacent to a driveway (see Figures 40, 41, and 42 below and the site plan in Attachment C) at 53 Hope and Carton. The purpose was to minimize surface runoff from the property onto the adjacent road and to serve as an example for other residents of the Hope and Carton Hill neighborhood and beyond. This is a great example of what homeowners should consider for their own driveway runoff.

**Figure 40.** Initial rain garden concept (left) and finished rain garden (right), constructed as a part of a volunteer work day in October 2012.


**Figure 41.** Before the rain garden was constructed (left) and immediately after planting (right).

**Figure 42.** The homeowners and volunteers celebrate after a long, hot morning of rewarding work.

## 5.0 IMPLEMENTATION PRIORITIES AND NEXT STEPS

Many of the projects identified above are recommended for immediate implementation to minimize further erosion and downstream flooding and water quality issues. It should also be noted that some of the projects should be paired with installation at uphill/downhill projects. To help with this, most practices linked to others are grouped into a station. However, there are some locations where drainage from one station will have a direct impact on another station. The following sections help identify an implementation strategy based on priority and constraints, as well as identify the key next steps.

### 5.1 Implementation Priorities

Based on these considerations, we offer the following recommendations for determining implementation priorities and sequencing:

1. The most cost-effective recommendations to implement as soon as possible are Stations 3, 4, and 5. The drainage issues along Pony Club Trail are severe, and there are no developed lots between the road and the adjacent gut to the west, which could pose complications for implementation. In addition, the land along the gut and at the Pony Club is public land, which may make easements and collaboration more feasible here.

2. Stations 7, 9, 10, 11, 16, 18 represent controlling runoff from very steep, eroding road sections by constructing stabilized swales/step pools with waterbars. These are very important projects to manage the most erosive flows in the neighborhood (other than Pony Club Trail). In general, we recommend the installation of waterbars from the top of the road working downhill. However, the installation of waterbars and step pools/check dams associated with the downstream edge of paved sections should be done early.

3. Stations 2, 15, 20, 24, and 25 are relatively easy swale projects that can be constructed in the existing road right-of-way without extensive step-pools/checkdams.

4. Stations 6 and 13 are relatively straightforward, inexpensive waterbar projects that should be easy to implement.

5. Stations 1, 17, 19, and 21 recommend fixes for severe sediment loading issues. However, land ownership/land procurement could be an issue in these locations, which would make implementation more difficult.

6. Stations 22 and 23 are great opportunities, but do not solve severe drainage problems or reduce a large quantity of sediment; thus, they have a lower priority. These will become more important if additional development occurs in this area.

7. Stations 8 and 14 are in the "nice-to-have" category but may be difficult to construct due to slopes and property issues. These are lower priority projects.

8. Station 12 has already been constructed.

The information included in this management plan should be used to prepare grant applications to move forward with engineering design and hydrologic/hydraulic modeling as necessary. All designs should assume full build-out conditions to ensure sufficient capacity as future development occurs.

### 5.2 Next Steps

The following next steps are recommended for the HOA and other watershed partners to move forward with implementation:

1. Meet with DPW to review this plan, coordinate efforts related to the culvert replacement/gut stabilization project on Pony Club Trail (Station 1), and discuss alternatives to improve road grading practices by independent operators.

2. Investigate land acquisition/easement options for priority structural drainage projects proposed on private parcels.

3. Proactively raise awareness with the permitting agencies and the owners of the many undeveloped lots that are located in a gut on the implications of the development restrictions in these areas.

4. Identify grant funding for implementation of the structural recommendations.

5. Initiate a driveway disconnection program to educate existing homeowners and help them design and permit rain gardens or other disconnection practices. In addition, work with new home builders at the building permit stage to incorporate disconnection techniques.

## REFERENCES

Anne Arundel County, MD. 2011. Design Guidelines for Step Pool Storm Conveyance. Available at: http://www.aacounty.org/DPW/Watershed/StepPoolStormConveyance.cfm

British Columbia Ministry of Forests. 2001. Best Management Practices Handbook: Hillslope Restoration in British Columbia. Available at: tp://ftp.for.gov.bc.ca/DSC/external/!publish/Contract Opportunities/114 Misery Creek/Appendix IX (Hillslope Restoration BMP).pdf

Coral Bay Community Council (CBCC). 2012. NOAA ARRA USVI Watershed Stabilization Project. Coral Bay Watershed Management Project – Calabash Boom Drainage Improvements. Available at: http://www.coralbaycommunitycouncil.org/Virc-and-D.htm

Hawaii Department of Transportation. 2008. Construction Best Management Practices Field Manual. Available at: http://www.coralreef.gov/transportation/constructionmanual_022708.pdf

Horsley Witten Group. 2011. St. Croix East End Watersheds Existing Conditions Report. Prepared for St. Croix East End Marine Park. Available at http://www.horsleywitten.com/stx-east-end-watersheds/pubs/final/01_Intro_110719.pdf

Horsley Witten Group. 2011. St. Croix East End Watershed Management Plan. Prepared for the St. Croix East End Marine Park. Available at http://www.horsleywitten.com/stx-east-end-watersheds/pubs/final/111114_FinalSTXEEMPWatershedPlan.pdf

Maryland Department of the Environment. 1994. Maryland Specifications for Erosion and Sediment Control: Section B-Grade Stabilization. Available at: http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SoilErosionandSedimentControl/Pages/programs/waterprograms/sedimentandstormwater/erosionsedimentcontrol/standards.aspx

New York State Department of Environmental Conservation. 2005. New York State Standards and Specifications for Erosion and Sediment Control. Available at: http://www.dec.ny.gov/chemical/29066.html

University of Minnesota Extension Service. 2002. Earth-berm Waterbars. Available at: http://www.extension.umn.edu/distribution/naturalresources/DD6972.html.

University of Minnesota Extension Service. 2002. Open-top Culverts. Available at: http://mn4h.net/distribution/naturalresources/DD6976.html

USDA Forest Service. 2006. Chapter 4: Road and Trail Treatments in Burned Area Emergency Response Treatments Catalog. Available at: http://www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/Chap_4.pdf

University of Florida. 2008. Florida Field Guide to Low Impact Development: Bioretention Basins and Rain Gardens. Available at: http://buildgreen.ufl.edu/Fact_sheet_Bioretention_Basins_Rain_Gardens.pdf

University of the Virgin Islands Cooperative Extension Service (UVICES). 2002. Virgin Islands Environmental Protection Handbook.

# ATTACHMENT A: EXISTING CONDITIONS MAP

# ATTACHMENT B: PROPOSED CONDITIONS MAP

# ATTACHMENT C: RAIN GARDEN INFORMATION

- USVI Rain Garden Fact Sheets
- Hope and Carton Hill Demonstration Project: Handout on Rain Garden Plants
- Hope and Carton Hill Demonstration Project: Permit Application and Site Plan