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MEMORANDUM

TO: Danielle Lucid, NOAA and Sharon Coldren, Coral Bay Community Council

FROM: Anne Kitchell and Rich Claytor, P.E., Horsley Witten Group

DATE: November 11, 2009

RE: Summary of Calabash Boom Road Improvements Options

Purpose

This memorandum presents road stabilization opportunities identified on August 25, 2009 by the Horsley Witten Group (HW), Coral Bay Community Council (CBCC), and the NOAA Coral Program for reducing erosion and sediment loading from the unpaved portions of Calabash Boom Rd., located on St. John, USVI (Figure 1). Calabash Boom Rd. was identified as a chronic source of sediment to Coral Bay and was listed as one of the priority sites for restoration in the 2008 Coral Bay Watershed Management Plan. Approximately 1.3 miles in length, Calabash Boom Rd. and its associated side roads provide access to 25-30 homes on a steep mountain slope adjacent to/above the Calabash Boom/Reliance development site. With the exception of the first 400 feet at the entrance and Andy's Way, this road has an unpaved surface with extensive ruts, rocks, and pot holes. The grade is consistently steep and there are four major (unpaved) switchbacks.

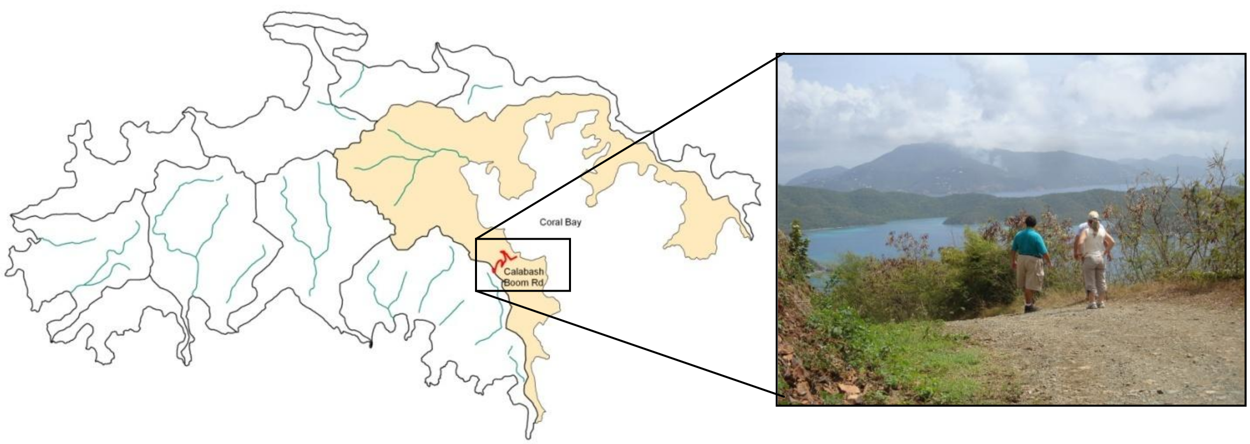


Figure 1. Location of Calabash Boom Rd. (in red) in the Coral Bay Watershed (highlighted) on the island of St. John, USVI.

DPW has listed Calabash Boom Rd. as a priority for maintenance and eventual paving, however lack of adequate resources have prevented paving to date except for the road entrance. DPW re-graded the entire road in 2006, which according to local residents, resulted in the redirection of stormwater runoff from the primary drainage gut into an adjacent gut by Shipwreck Landing. Since then, sediment plumes have been observed discharging from this gut into Coral Bay during frequent rain events impacting fringing reefs (Figure 2).

Figure 2. Sediment plume discharge into Coral Bay, St. John, USVI (photo on left) from Shipwreck gut (photo on right) after a typical morning rain shower.

At the request of CBCC and through funding by the NOAA Coral Program, HW conducted a site assessment of approximately 1.1 miles including all of the main Calabash Boom Rd. and three road spurs, two of which were private. We met with residents and developed preliminary concepts for stabilization/improvement projects at over 30 specific locations along the road. The purpose of this effort was not to develop detailed engineering designs or survey work; rather it was to meet NOAA's and CBCC's objective to kick start implementation of priority restoration projects recommended in the 2008 Coral Bay Watershed Management Plan and to stop a chronic source of sediment loading to the Bay.

Funding to design and construct some of these road improvement projects has been secured under a joint federal stimulus funding request by CBCC, USVI Department of Public Works, and the USVI Department of Planning and Natural Resources.

Road Stabilization Opportunities

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 on Calabash Boom Rd. 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 areas highly susceptible to erosion and heavy tire action (such as bends);

(6) Minimize the import/use of gravel on the road; and
(7) Identify priority maintenance locations and practices for residents and DPW.

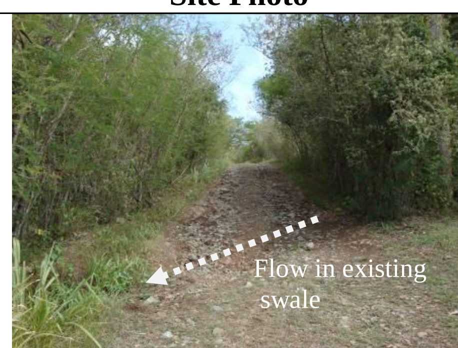
To meet these objectives, the following structural and non-structural practices were identified at over 30 locations along the road:

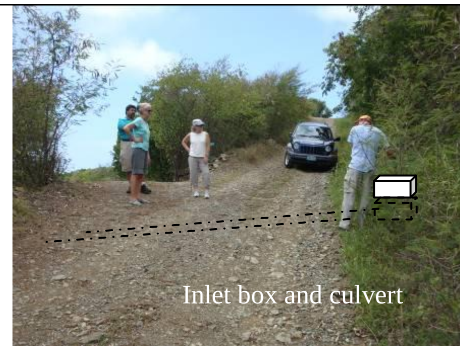
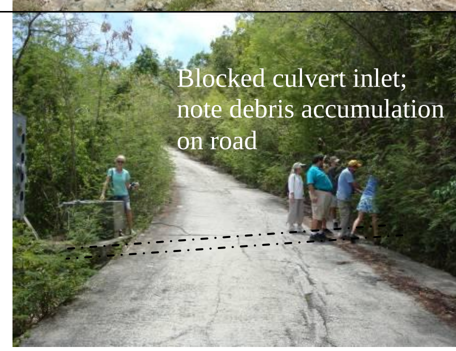
- Waterbars/trenches (at 19 locations)
- Step pool/checks in roadside ditch (3)
- Concrete pad at curves (2)
- Inlet box/culvert replacement and/or flow splitter (3)
- Culvert cleanout and maintenance (2)
- Ditch enhancement and/or maintenance (3)
- Bioretention/step pool channel (1)

Figure 3 shows the approximate location of each of the practices listed above, which are assigned to 15 stations. Station numbering was arbitrarily assigned based on the field assessment and meeting schedule, though the sequence primarily starts at the top of the watershed and progresses down slope towards the road entrance. Multiple stabilization practices that are linked were assigned to each station.

Table 1 provides a summary description of the type of stabilization practices recommended at each station and include site photos to illustrate the concepts. More detail on design, installation, and maintenance considerations for the various practices is included in next section of this report.

Table 1. Summary of Calabash Boom Rd. Stabilization/Improvement Opportunities

Station	Description	Site Photo
1	• Adjust the watershed boundary to include house and road switchback in the drainage area to Coral Bay. Revised boundary shown in Figure 2. • Install single **waterbar** and/or **maintain swale** across road at upper most point of Calabash Boom Rd. to divert flow from upper portion of road (private).	
2	• Install series of (3) **waterbars** between bend at top of road and Villa Ventosa driveway to direct runoff into inside face. • Consider using telephone poles to create waterbars, since poles are currently being removed/replaced • Consider a water “trench” for the two lower waterbars given steeper slope.	

Station	Description	Site Photo
3	• Install **inlet box/pipe structure** and culvert to collect and carry flows from inside ditch to discharge onto vegetated outer slope. • Use a 36-inch diameter pipe to handle 1 inch rainfall. • ~$25k or more for materials and installation/excavation. • Requires installation and maintenance of upslope controls at Station 2.	
4	• Install new **inlet box** and **culvert** above driveway to reduce flow entering existing ditch culvert (downhill on road spur) and to convey flow to outer slope. • Stabilize discharge point/ step pool down slope; design for energy dissipation and flow distribution across forested slope (similar to concrete step pools at Elliott Hooper's-Station 7).	
5, 6	• Andy's Way is a paved, private road off of Calabash Boom Rd. • Two **blocked culverts** (across from electric transformer boxes) to be cleared and maintained by residents and/or homeowners association with shovels when debris accumulation becomes visible on road. • At second bend, **stabilize eroded bank** below discharge location using stepped riprap down slope.	
7	• Between Andy's Way and Baldwin's Driveway, install a series of **waterbars** (minimum of three) to direct flows to inside ditch. Currently most water isn't getting into ditch, which is causing more road erosion. • Replace undersized **culvert** (ex. 12-inch under Baldwin's driveway) with larger diameter pipe to allow more flow in inside ditch to be conveyed into existing 24-inch CMP that discharges behind E.Hooper's residence via stepped, concrete pools. • An adaptation of this outlet design could be used at other discharge locations (e.g., Stations 3, 4, 6, and 11), which would require scheduled removal of accumulated sediment. • **Pave** road switchback**,** starting above Baldwin's driveway. Grade/use **concrete swale** to divert runoff across road surface into an inside ditch.	

<table>
<tr><th>Station</th><th>Description</th><th>Site Photo</th></tr>
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- Private Road/Driveway (Antoinette's property).
- Recent work by homeowner to repair 24-inch culvert and convey runoff across driveway and through property.
- **Maintain swale** on driveway at private residence to prevent backup and overflow of offsite drainage into patio/driveway areas

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- Install one (1) **waterbar/trench** starting below the rocky outcrop downhill of telephone pole. Deflect runoff into inside ditch.
- Install **check dam(s)** in ditch to create small step-pool to help reduce velocity and trap sediment. Maintenance critical to ensure step pool(s) does not push water back into the road.
- Linked to paving Station 7 bend.

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- Install two (2) **waterbars** above driveway to divert runoff into inside of road.
- Excavate four **(4) step pools** along inside shoulder to help trap sediment and reduce runoff velocities.
- Existing rock outcrops on inside ditch are relatively soft, making excavation of pools/sediment traps at this location ideal.

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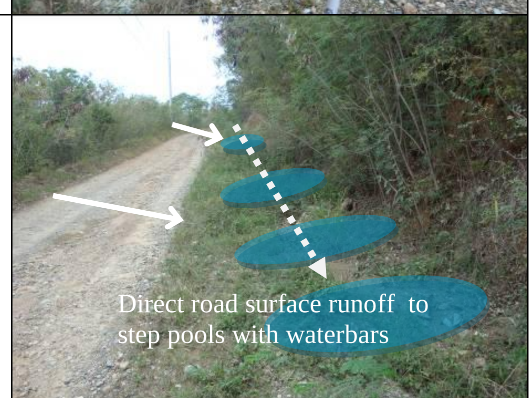
- Install four (4) **waterbars** to divert runoff into inside of road.
- Install **flow splitter** with small step pool/trap at a location just uphill of the existing telephone pole with "PLZ SLO" sign. Smaller storm flows can be taken across the road in a culvert to stabile discharge outlet into existing gut, remaining flow directed into inside ditch (minor excavation to increase capacity).
- Excavate/install 3-5 **step pools** to slow flow and trap sediment.

</td><td>
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Station	Description	Site Photo
12	• Currently, curve shows evidence of significant erosion via presence of large ruts and pot holes. • **Pave** (concrete pad) switchback at Bonnie's. Extend concrete downhill to where road flattens out. • Divert flow around turn and into inside face with **concrete swale**. • May need to excavate ditch; routine maintenance at this location will be required.	
13	• Install minimum of five (5) strategically placed **waterbars** along this stretch to direct flow towards inside channel • Ditch maintenance will be required • Volume along this inside ditch is increased due to the addition of runoff from an uphill diversion at Station 11 that discharges at the location pictured here. Rock, erosion control matting, or other stabilization practice should be used to stabilize bank and plunge pool area within ditch.	
14	• Section of unpaved road adjacent to paved entrance section to Calabash Boom Rd. • Install two (2) waterbars uphill and downhill of the existing driveway. • This may involve the installation of a culvert below the existing driveway shown here, or repaving the driveway entrance to include a concrete swale to safely convey concentrated flow across driveway. • Flow from here flows towards to Station 15.	
15	• Convert ½ of closed road to a linear bioretention facility with 6-7 step pools (2-3 feet deep, 8-10 feet wide) and channel. • Note: Drainage from Station 5 comes down to top of bend, and flows down to stormwater pond at Reliance Housing. • This is not a high priority project, but could serve as a demonstration site sponsored by CBCC, the developers of the Reliance Housing site, and Calabash Boom residents.	
◄▪▪▪ 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 bioretention facility		

Legend

- Watershed boundary (rev)
- 100-ft contours
- 10-ft contours
- (1) Station ID

Practice Type

- waterbar/trench
- single waterbar
- inlet and culvert
- culvert repair/maintenance
- road ditch maintenance
- swale maintenance
- outfall stabilization
- step pools/check dams
- concrete pad

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Feet
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Calabash Boom Road
Drainage Improvements
Coral Bay, St. John, USVI

10/31/09
S:\9039 NOAA Coral Reef Program\GIS\USVI

Figure 3

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Road Stabilization Practices

More detailed information on the various types of recommended practices is provided below.

Waterbars
Waterbars are narrow ridges (angled speed bumps) and small trench built across roads to divert water off of road surface into vegetated areas or roadside ditches before it causes erosion. Waterbars can be constructed from earthen, logs, rock, or other materials such as rubber conveyor belts (Figure 4). Because of the difficulty in procuring materials on the island and the steepness of Calabash Boom Rd. (greater than 10-20% justifies not using earthen-berms), we recommend using logs (telephone poles) that are currently being replaced, or other similar recyclable timber alternative.

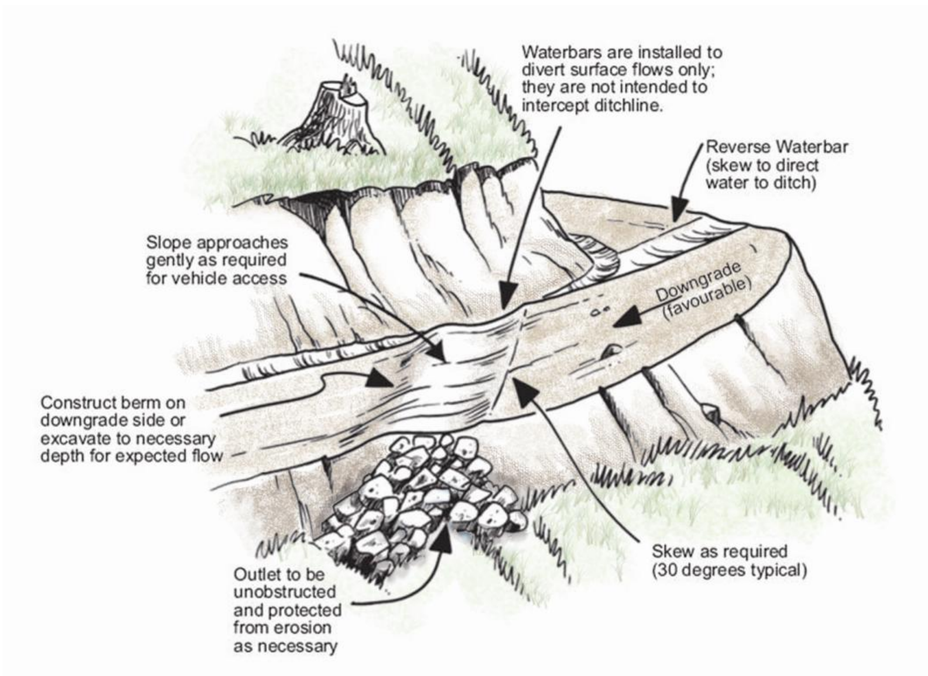

Figure 4. Waterbars divert surface flows and are not intended to intercept roadside ditches (Source British Columbia, 2001).

Waterbars should follow the following design criteria (see Figure 5):

- 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 Calabash Boom Rd. divert surface runoff towards and inside ditch.
- 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 of waterbar is such that outlet end is at least 3 inches lower than the upper end (~3% slope).

- Extend waterbars beyond both travel edges of road to prevent water from flowing around ends.
- Direct diverted water into a stable, vegetated area or ditch. Do not discharge cross drains, culverts, water bars, dips, and other drainage structures onto erodible soils or fill slopes without outfall protection (rock piles, logs, etc.).
- Space earth-berm water bars according to the road grade (Table 2).

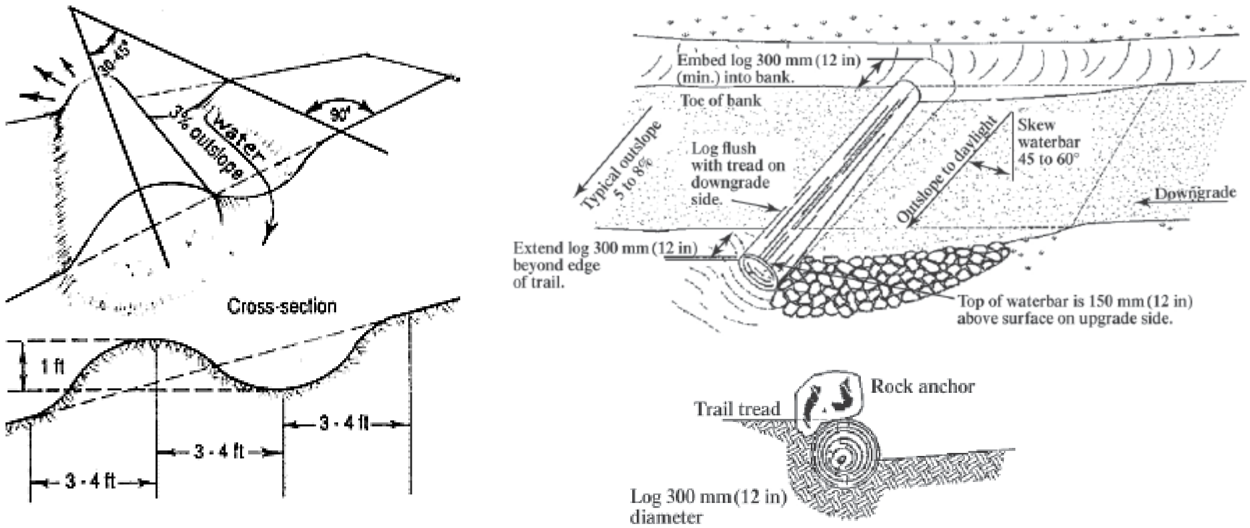

Figure 5. Earthen-berm waterbar from MN Extension Service(left); log waterbar from USGS(right). We do not recommend the top of the log being left flush with downhill surface or skewing waterbar at an angle greater than 45 degrees. Note: Our applications for Calabash Boom Rd. are for diverting flow to the inside ditch, these diagrams show diversion to outs

Waterbars can be difficult to drive over if installed incorrectly or not maintained properly. They can also be difficult to maintain. Dips are commonly used as an alternative to waterbars since they are easier to drive over and are fairly common on flatter, paved roads in the USVI (Figure 6). These are fairly common on the paved roads in the USVI. We are not proposing those here, since the Calabash Boom Rd. is steeper than recommended for dip applications.

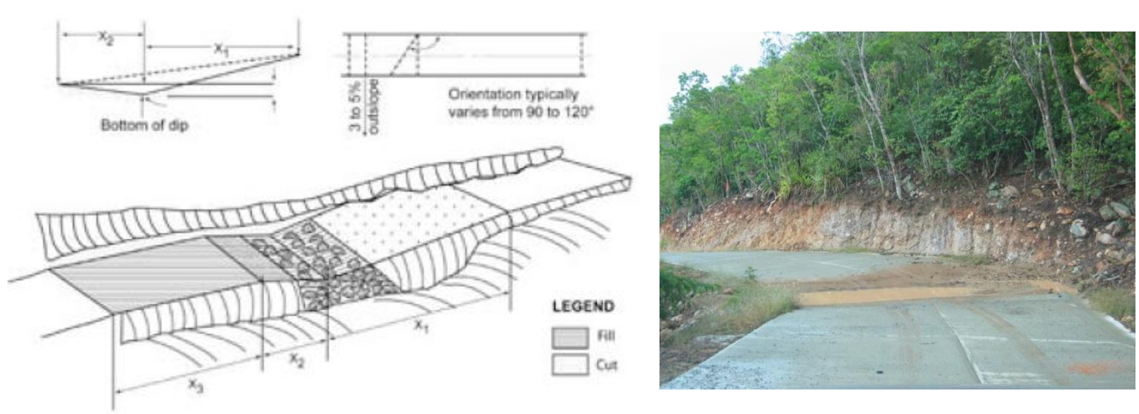

Figure 6. Dip schematic for unpaved road (left) and one used on a paved road (right) as an alternative to convey flow from surface and from inslope ditch to outslope.

Water Trenches (*aka* Open-Top Culverts)
In very steep situations, we recommend adapting waterbar design to include a double row of logs with a trench in between (Figure 7). Potential locations where the water trench vs. single waterbar might be recommended are shown in Figure 3. Water trenches are actually open-top culverts used to divert water off a road surface while allowing for drainage across it. They are most frequently built from logs or other type of timber, as well as concrete or steel. Telephone poles will work here as well.

When constructing a water trench:

- Make the trench between the logs 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.
- Nail spacers between the side boards or logs 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 a stable, vegetated 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 (Table 2).

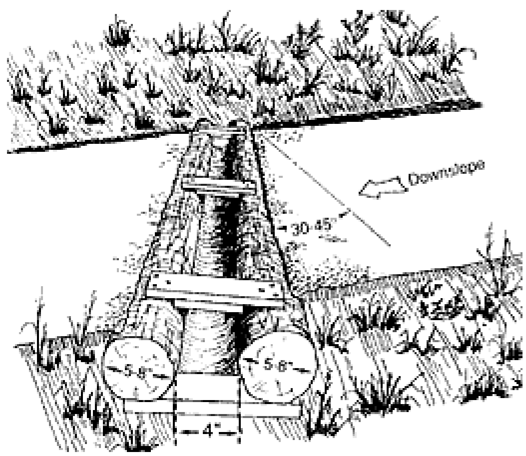

Figure 7. Water trench or open top culvert (MN Extension Service).

Like waterbars, the open-top culverts are inexpensive. They can be built from logs and lumber and installed with hand tools on site. T hey permit easy movement of all 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 water trenches below a series of water bars or below paved sections to help prevent sediment from clogging trench.

Table 2. Recommended Spacing of Waterbars 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 DFW (2003) and VICES (2003); Coeur d'Alene RMP/EIS (2006)			

Additional information on waterbars and open top culverts from the MN Extension Service at http://www.extension.umn.edu/distribution/naturalresources/DD6972.html and http://mn4h.net/distribution/naturalresources/DD6976.html. More detail pertaining specifically to log waterbar schematics and installation details can be found at http://www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/Chap_4.pdf, and http://www.pcta.org/help/volunteer/trail_skills_college_curriculum/pdf/203%20Correcting%20Drainage%20with%20Log%20Waterbars.pdf.

Inlet Box and Culvert

In some locations along Calabash Boom Rd. (Stations 3,4, and 12), we recommend installing a drop inlet structure and a 12-24 inch CMP culvert to collect and convey runoff from the roadside ditch across the road to discharge at a stable outlet on the out sloping road face (Figure 8). 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 grated inlet 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 grate. It is important to be sure the outlet is stabilized. More information on culverts can be found at http://www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/Chap_4.pdf.

Step pool/checks in roadside ditch

We have recommended two alternative approaches to reduce ditch erosion, dissipate runoff energy, and potentially trap sediment in steep ditch sections. In flatter road sections, the installation of rock check dams can be used to pool runoff and trap sediment (Figure 9). In steeper areas, we recommend excavating cascading step pools (Figure 10).

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.

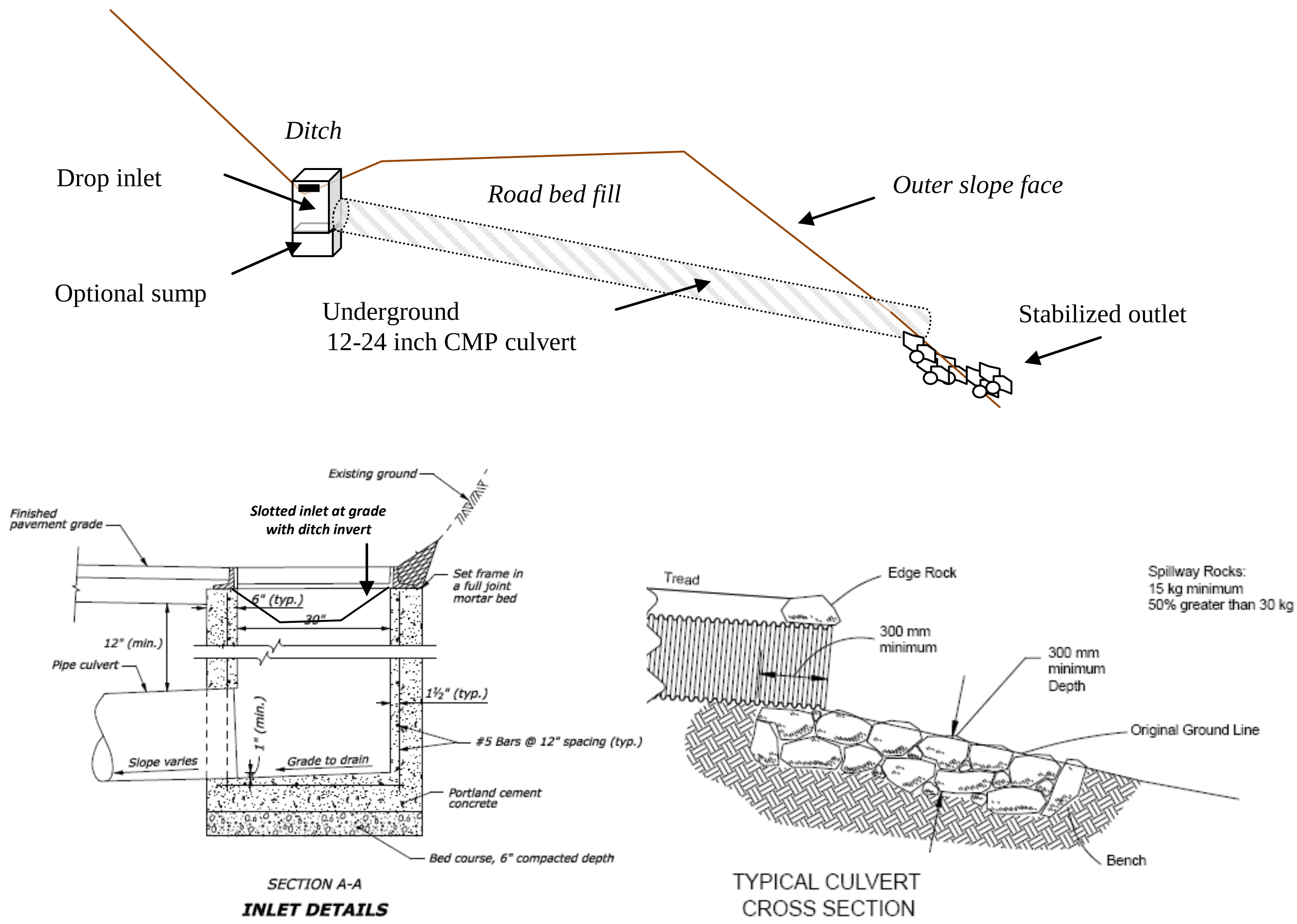

Figure 8. Representative road cross section (above), typical inlet (bottom left) and stabilized outlet (bottom right). The inlets should have slots at grade with ditch inverts.

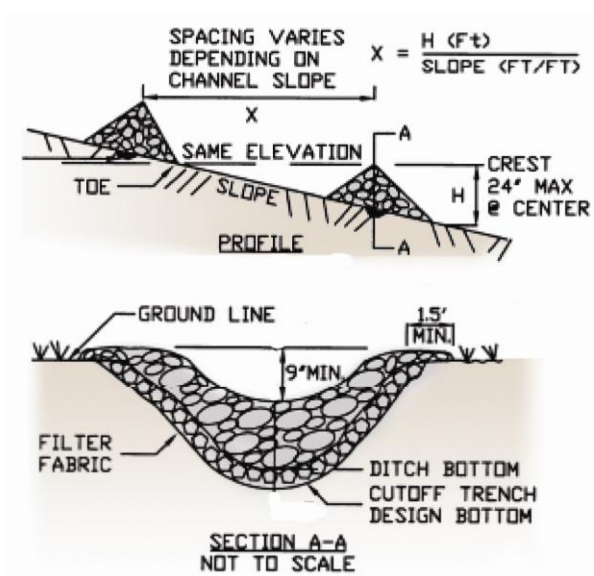

Figure 9. Typical cross section of and profile for rock check dam (NY ESC Manual).

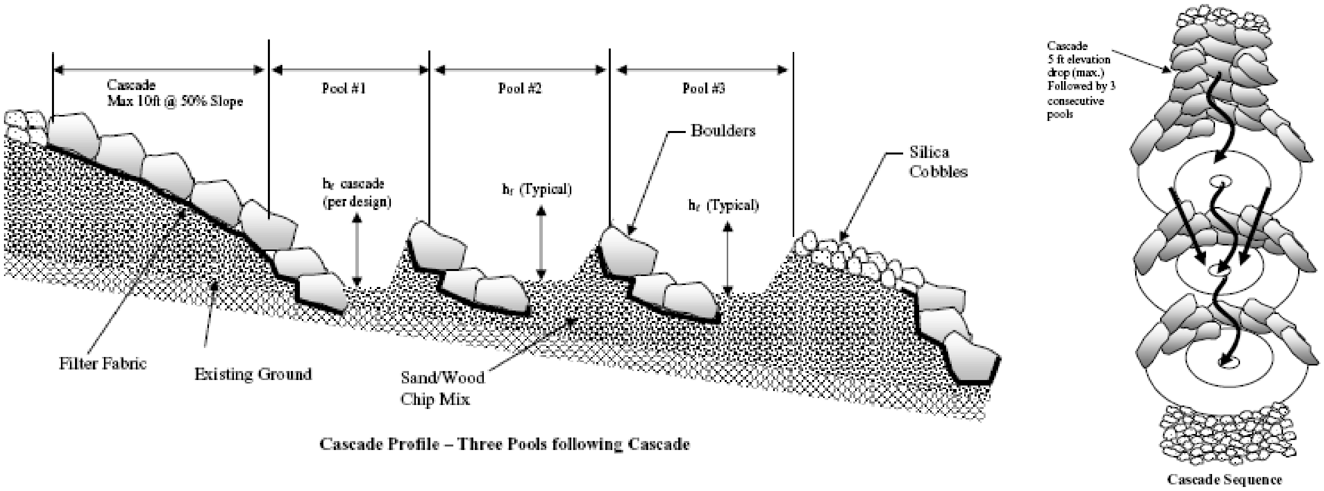

Figure 10. Representative design guidelines for cascading step pool design from Anne Arundel County, MD.

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/Step%20Pool%20Storm%20Conveyance%20Guidelines.pdf.

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 and Stormwater Conveyance.

Consider including a demonstration project at (Station 15) that combines the vegetative and infiltrative treatment capabilities of bioretention facilities with those of the step pool/conveyance systems described above. Figure 11 shows a typical cross section of a bioretention facility. Figure 12 shows a photograph of a stepped stormwater conveyance system and a bioretention. Consideration should be given to the appropriate vegetation and media mixtures used to ensure they are available and appropriate (native) to USVI setting.

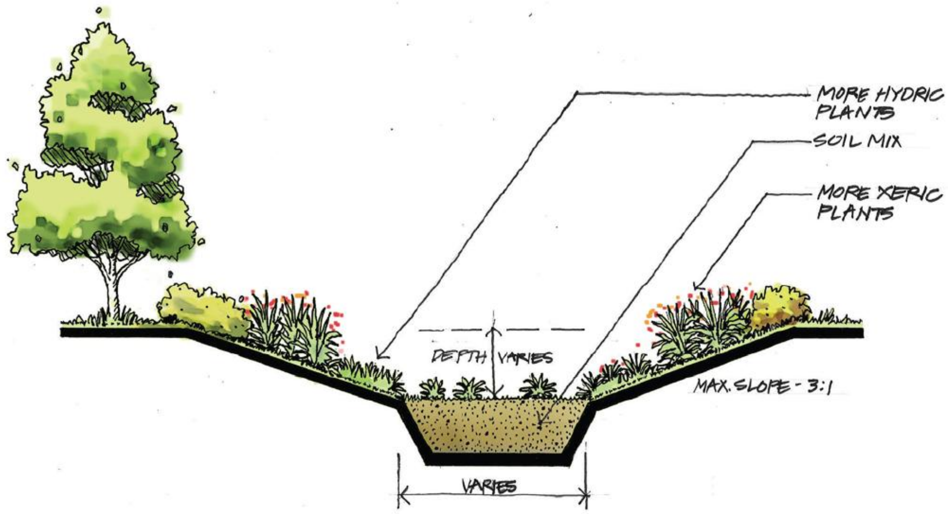

Figure 11. Schematic of a rain garden/bioretention facility with no underdrain (from University of Florida Extension Service factsheet).

Figure 12. 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)

Implementation Considerations

Paving the road completely would most likely result in the greatest reductions in sediment loading to Coral Bay. Estimates for paving the road range from $1.5-$3 million according to estimates derived by the CBCC. Most of the projects identified here are recommended for immediate implementation to minimize further erosion and resident complaints, regardless of road paving schedule. Early implementation is particularly important given obligations under the awarded federal stimulus funding grant, and the timely replacement of telephone poles along the road (i.e., free supplies). 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.

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

1. Clean out roadside ditches and replace/repair existing blocked culverts. As an incentive to road improvement projects, the local homeowners association and DPW should reach agreement on a maintenance plan for existing and proposed culverts. Ditch excavation at Stations 9, 10, and 11 to create step pools/checks may also be done at this time to take advantage of equipment on site.

2. Pave switchback and replace culverts at Stations 7 and 12. These switchbacks are the steepest and most highly erodible sections of the road.

3. Take advantage of the concurrent telephone replacement activities. 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 paved switchbacks should be done early.

4. Inlet boxes/culverts to divert flows from roadside ditches to stabile discharges at Stations 3, 4, and 11 should be installed before additional flow is directed into the ditches by uphill waterbars (Stations 2 and portions of Station 10 and 11).

5. The ditch along Station 13 will receive more flow once the diversion at Station 11 is completed and maintenance will be required.

6. The bioretention at Station 15 is a relatively low priority, but the potential to showcase a demonstration site for stormwater and private/public sector coordination may override other sequencing factors. Drainage at this point is directed into the stormwater pond at the Reliance Housing Site.

7. Individual homeowners at Station 8 will need to address swale maintenance.