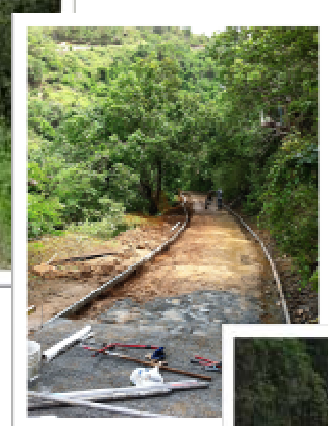
NOAA ARRA USVI Watershed Stabilization Project

Coral Bay Watershed Management Project – Hansen Bay Drainage Improvements



National Oceanic and Atmospheric Administration
Virgin Islands Resource Conservation & Development Council
Coral Bay Community Council

Patricia Reed
Environmental Projects Manager
Coral Bay Community Council

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This report described the projects undertaken in one of six subwatersheds in Coral Bay, St. John, USVI with $1.5 million in National Oceanic and Atmospheric Administration (NOAA) Funding through the American Recovery and Reinvestment Act of 2009 (ARRA). These funds are part of the $2.7 million USVI Watershed Stabilization Project funds awarded to the Virgin Islands Resource Conservation & Development Council, Inc. (V.I. RC&D). The U.S. Environmental Protection Agency (EPA) provided $300,000 in funding to the Coral Bay Community Council (CBCC) under its Community Action for a Renewed Environment (CARE) program to provide the stormwater engineering expertise to provide the design portion of these projects and staff the CBCC Coral Bay Watershed Management Project. Local homeowners associations, the Virgin Islands government, and community volunteers have also provided more than $400,000 in resources and worked cooperatively to achieve the project objective of reducing the stormwater sediment plumes entering Coral Bay, thereby improving water quality, ecological health, and stormwater management while minimizing future negative impacts associated with roadways and new construction.

There are nine reports in this series, describing the complete NOAA ARRA USVI Watershed Stabilization Project:

- Coral Bay Watershed Management Project – Johnny Horn Trail Drainage Improvements
- Coral Bay Watershed Management Project – Hansen Bay Drainage Improvements
- Coral Bay Watershed Management Project – Lower Bordeaux Drainage Improvements
- Coral Bay Watershed Management Project – John’s Folly Drainage Improvements
- Coral Bay Watershed Management Project – Calabash Boom Drainage Improvements
- Coral Bay Watershed Management Project – Carolina Valley Drainage Improvements
- Fish Bay, St. John Drainage Improvements
- East End Bay, St. Croix Erosion Repairs, Trail Construction, and Drainage Improvements
- NOAA ARRA USVI Watershed Stabilization Project Summary Report

Acknowledgements

Based on work by Joseph Mina, P.E., Christopher Laude, P.E., Blake Parker, and Sharon Coldren.

Photos provided by the Coral Bay Community Council.

Overall project management was provided by the Virgin Islands Resource & Development Council and its Board of Directors listed below:

President - Diane Capehart
Vice President - Olasee Davis
Secretary - Marcia Taylor
Treasurer - Dee Osinski (first year)/Olasee Davis
At Large member - Paul Devine

Work would not have been possible without the contributed countless volunteer hours, including the project's Principal Investigator Marcia Taylor who put a substantial amount of volunteer time into this project.

Work in Coral Bay would not have been possible without the Coral Bay Community Council, Inc., a 501(c)(3) organization, its volunteer Board members and many community volunteers. President and Executive Director, Sharon Coldren, spent three years as a volunteer working almost fulltime to implement this project.

Project management and project completion were facilitated by the technical expertise and project management skills of NOAA's Restoration Center, specifically staff members Daphne MacFarlan and Julia Royster.

Executive Summary

The Hansen Bay Watershed contains two residential subdivisions that share an entrance road at the end of Route 10. Stormwater runoff has been carrying sediment from unpaved sections of this road into Hansen Bay, threatening coral reef habitat (Photo 1). This problem was exacerbated by unpaved road sections that received runoff from the paved uphill road sections. **This project paved dirt sections and re-routed water off paved sections into ghuts; thereby decreasing erosion and reducing sediment loads entering Hansen Bay.**

Photo 1: Plume into Hansen Bay prior to drainage improvements.

In order to accomplish this goal, it was initially proposed to do a combination of waterbars, sediment traps, and online and offline bio-filtration and bio-infiltration areas, and/or paving roads, if partner funds were available, as described in the 2009 National Oceanic and Atmospheric Administration (NOAA) American Recovery and Reinvestment Act (ARRA) Coral Bay Workplan. Further discussion with local Homeowners Associations (HOAs) and their willingness to contribute funds to the project allowed paving to be the preferred option. Ultimately, five road segments (identified according to topography and site visit observations; see Section 5.1 for a description) were reviewed and four were paved by the project. The project also included a swale with riprap outfall to replace a rusted-out culvert and other minor project improvements such as pullouts as discussed in Table 4 under the Additional Hansen Bay Work header. Figure 1 shows the pre-existing and new stormwater structures, and other watershed features. The net effects are:

1) No more road erosion since it has been paved;
2) Proper flow of runoff during rainfall events by replacing a rusted culvert with a swale reducing additional unpaved road erosion and damage; and,
3) Reduced sediment-laden water reaching Hansen Bay based on observations of East End residents.

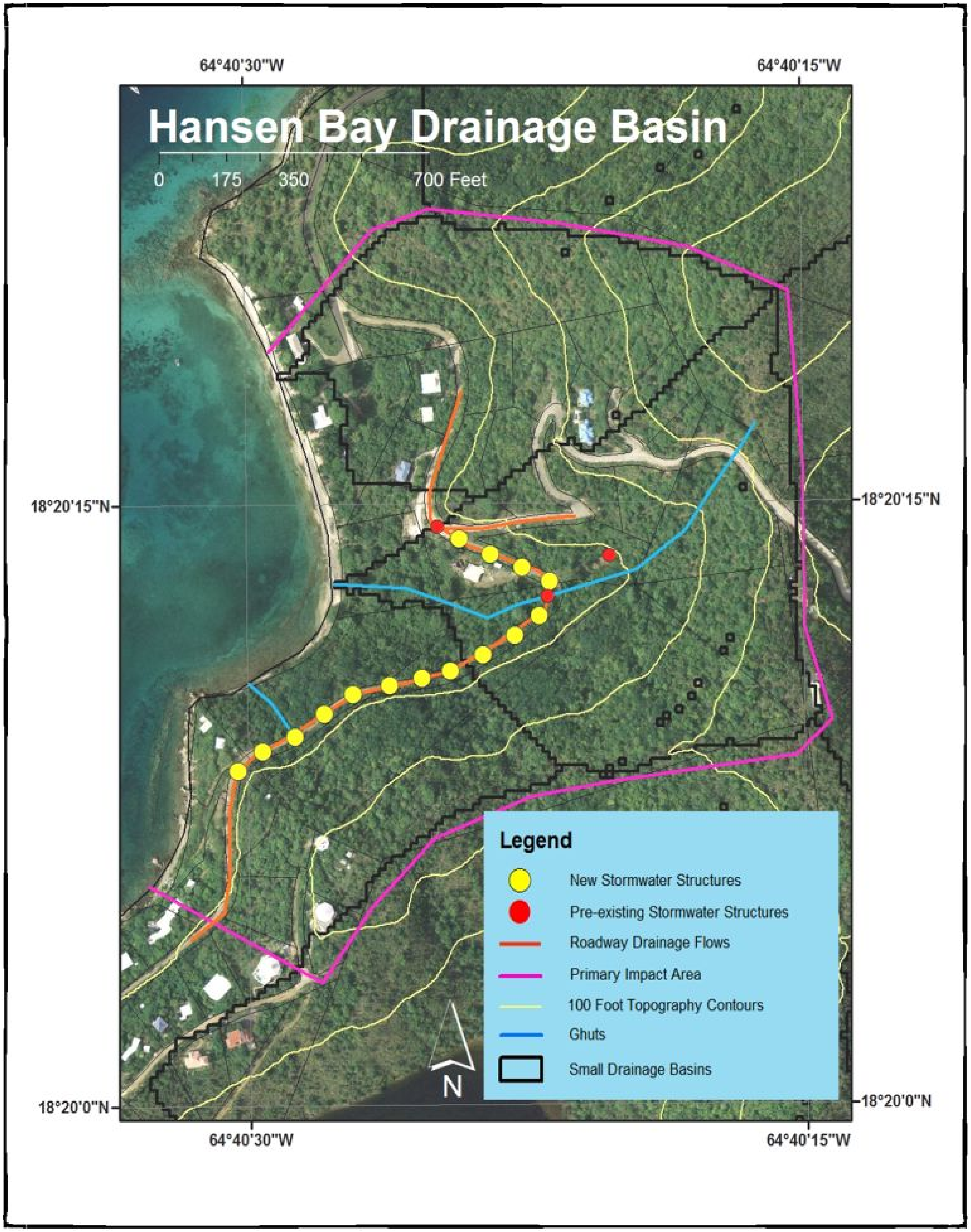

Figure 1: Hansen Bay Drainage Basin and Watershed Features

1. Watershed Description

The approximately 100-acre Hansen Bay Watershed starts at the top of Nancy and Blackrock Hills (523 and 499 feet, respectively), and drains along Frog Hollow and several other short, minor ghuts into Hansen Bay. The watershed is characterized by steep slopes with highly erodible soils. A single public road, Route 10, services the East End of St. John. Hansen Bay is a residential subdivision off the end of Route 10. An adjoining residential subdivision, Privateer Bay, shares an entrance road with, and responsibility for, portions of the Hansen Bay subdivision road. The road itself was originally created using an excavator with later paving along some sections of the unpaved road. Over 50 year-round residents use the road for access. Both subdivisions have mandatory homeowners associations.

The unpaved portion of the road is on both sides of a tight turn framing Frog Hollow Ghut. To channel the stormwater collected by the tributary area surrounding the ghut, the Privateer Bay HOA constructed an uphill retention pond over 10 years ago to collect water and sediment from an upper paved road. This water then drained through a 16-inch diameter concrete culvert under the road prior to emptying into the natural ghut on the downhill side a couple hundred feet upstream of the ocean.

2. Problem Statement

Steep slopes and erodible soils characterize the topography of St. John. Subdivision roads are typically created using large excavators that dig from the uphill or cut-side of the road and dump loose soil on the downhill or fill-side of the road. This particular construction technique produces unstable slopes on the cut-side of the road and loose, highly erodible downhill slopes on the fill-side. More often than not, little thought is put into stormwater management, with few, if any means provided to get water off the road. Road grading generally directs the water to the uphill side in an erosive channel – which overflows into the roadway when debris fills the channel and further erodes the road, as does vehicle traffic.

Photo 2: Hansen Bay unpaved road (Segment 5).

In the Privateer Bay/Hansen Bay subdivision area, a total of 1,475 linear feet (LF) of unpaved roadway (Photos 2 & 3) provided access to and through these subdivision properties. This road incurred direct drainage from an uphill paved section that sent erosion-inducing flows from a concrete roadside drainage channel right onto the dirt road section. The grade on the unpaved roadway was not steep but the road was upland from a steep shoreline (2:1 slope) and just 100 feet away from the waters of Round Bay (the larger bay including Hansen Bay) with significant coral patch reefs and other habitats that needed protection from runoff and sediment discharged from these roads.

Photo 3: Hansen Bay unpaved road (Segment 5).

Additionally, existing drainage structures at two points along the road needed repair/replacement. For instance at Frog Hollow Ghut, the drainage inlet was blocked with rock and sediment, and had no outlet protection. During heavy rains, runoff would run onto the road causing additional erosion. At another ghut location, the bottom of the existing galvanized corrugated metal pipe was corroded through in numerous places and the inlet was partially blocked as well, forcing heavy stormwater flows to run on to the road causing additional erosion and sediment transport.

3. Background and Project Planning

Research has shown that as development increased in Coral Bay so has sedimentation of the bay, thereby threatening the health of the bay and its marine habitats (Devine et al. 2003). In order to reduce this threat, the partner agencies, the Coral Bay Community Council (CBCC), NOAA, the Virgin Islands Department of Planning and Natural Resources (DPNR), the U.S. Environmental Protection Agency (EPA), and the Virgin Islands Resource Conservation and Development Council (V.I. RC&D), have aggressively spent the last five years planning and implementing actions to reduce sediment loads in Coral Bay.

Starting in 2007, NOAA funded the Coral Bay Watershed Management Plan (WMP) as a DPNR pilot watershed plan to provide a demonstration site for the whole U.S. Virgin Islands. Upon publication of the WMP in 2008, CBCC applied for a $300,000 EPA Community for a Renewed Environment (CARE) grant, and received it in early 2009 to begin implementation of the WMP as part of the overall Coral Bay Watershed Management Project. The primary goal of the EPA CARE grant was to implement *WMP Recommendation #1 – Provide direct, on-site technical assistance to watershed residents, businesses, developers, and others implementing watershed recommendations.* To help with this recommendation the WMP discussed five actions, two of which CBCC implemented as part of the EPA CARE grant:

- *Near-Term Action 1.1: Use EPA CARE grant as seed money to support a 1-2 year, full-time hydrologist/watershed manager for Coral Bay.*

- *Near-Term Action 1.4: DPNR and CBCC should consider providing resources needed to support new personnel (i.e. GIS, office basics, vehicle, etc.).*

In spring 2009, working through a local nonprofit partner, V.I. RC&D, CBCC secured $1.5 million of NOAA ARRA grant funds. CBCC and V.I. RC&D used these funds to implement actions proposed in the NOAA ARRA Coral Bay Workplan prepared for the grant application, based on the expertise provided by the newly hired CBCC Stormwater Engineer (see Section 4.1). These NOAA ARRA funds allowed for the restoration of natural drainage functions and paving of roads in six subwatersheds in Coral Bay in order to eliminate or reduce the sediment-laden stormwater runoff plumes entering the bay. These projects also implemented portions of *WMP Recommendation #3 - Evaluate and repair erosion and drainage problems that are threatening property, damaging infrastructure, or delivering excessive sediment loads to Coral Bay*. CBCC's website contains a Project Overview of the USVI Watershed Stabilization Project in Coral Bay and a description of the Coral Bay Watershed Management Project.

In the NOAA ARRA Coral Bay Workplan, CBCC developed a list of watershed stabilization techniques appropriate for the Coral Bay environment (see Appendix A) and directly aimed at reducing sediment plumes to the bay. These were used to formulate the following goals for the Hansen Bay Project:

1. Slow water velocities (Strategy 2);
2. Reduce erosion and improve sediment control from dirt roads (Strategy 4);
3. Reduce sediment entering Hansen Bay (Strategy 1-4); and,
4. Repair existing stormwater devices (Strategy 4).

4. Project Implementation

4.1 Project Design

CBCC hired Joseph Mina, P.E. as its Stormwater Engineer in 2009 using the EPA CARE grant funds to provide design expertise and recommendations. Initially, he wrote a series of engineering design memos based on field conditions to help identify the key best management practices (BMPs) for local implementation. He also contributed significantly to writing the NOAA ARRA Coral Bay Workplan and prioritizing the detailed projects in it. The EPA CARE grant funded the engineering design phase, with the NOAA ARRA funding taking over for the field engineering and inspection, permitting, construction bidding, and field construction phases. V.I. RC&D was directly responsible for the construction phases of the Coral Bay NOAA ARRA projects. For personal reasons, Mr. Mina had to leave CBCC's employment in June 2010 and CBCC hired Christopher Laude, P.E. to complete the design phase and implement the NOAA ARRA BMP projects over the following year.

4.2 BMP Selection Process

In the NOAA ARRA Coral Bay Workplan, Mr. Mina initially proposed installation of a combination of waterbars, sediment traps, and online and offline bio-filtration and bio-infiltration areas to provide drainage from the run-off from paved roads. Additionally, CBCC would consider splitting paving costs with HOAs if they made funds available. Mr. Mina's work focused on five subareas and two drainage structures (see Table 1 below for a detailed description) identified based on topography and observations made during site visits, including discussions with residents and members of the Privateer and Hansen Bay HOAs. In 2010, Mr. Mina conducted a study, including flow calculations, of the drainage areas. Based on the results of the study, he developed design recommendations for roadway and drainage improvements. CBCC shared this work with the HOA boards in writing and via a conference call. Discussions included prioritizing each road segment based on erosion control needs and HOA preferences (see Table 1 descriptions).

Table 1: Pre-existing Hansen Bay Drainage Structure and Road Segment Descriptions

Location Name	Description	Prioritization
Frog Hollow Drainage Structure	An existing reinforced approx. 30-inch concrete pipe under the roadway between Segments 2 & 3 with a concrete headwall & swale at the upstream end of the pipe and no outlet structure.	This drainage structure was in good condition; although some of the entry pathways needed modification; therefore, it was a low project priority.
Segment 1	An approximately 290-foot dirt road section from the intersection of Route 10 and proceeding uphill to the first paved section.	This area was a high neighborhood priority for paving based on the usage of this segment by all of the residents in both subdivisions. However, the potential for sediment-laden runoff in this area was less than other segments, so this segment had the lowest project priority.
Segment 2	An approximately 300-foot dirt road section at the turn-off towards the Hansen Bay subdivision, off the concrete roadway. This section extends from the existing concrete to the existing drainage structure at Frog Hollow.	This section was the highest project priority for paving, as the roadway was in extremely poor condition, and, given road erosion evidence, contributes significantly to the problems in Hansen Bay. Project priority was to pave this section first.
Segment 3	An approximately 530-foot dirt road section from the low point in the road at the Frog Hollow existing stormwater structure up to the high point.	This section was a medium project priority for paving, since it is one of the longer segments and sediment discharge is most prominent downstream of the outlet of the existing structure at Frog Hollow Ghut.
Segment 4	An approximately 260-foot dirt road section from the high point at the end of Segment #3 to the existing small diameter pipe at the next low point in the road.	This section was the lowest project priority for paving, as it was shorter and in good condition, and there was a significant vegetative buffer from where it exits the road to where it enters Hansen Bay.
Segment 5	An approximately 500-foot dirt road section from the low point at the end of Segment#4 to the existing concrete portion of the road in the Hansen Bay subdivision. In addition, there is a galvanized and poor conditioned, 12-inch diameter corrugated metal pipe under the roadway between Segments 4 & 5 that clogs and overtops the road causing damage.	This section was a high priority for paving, since it was a longer section, and there was some evidence of road rutting and other road erosion. The culvert was a high project priority for replacement. A swale was recommended.

CBCC and the HOAs reached an agreement early on to jointly fund the more expensive design option that included paving the road. This allowed the residents to gain a paved road surface, as well as a long term stormwater management solution. With this verbal agreement, Mr. Mina completed detailed designs for the paving and CBCC sought permissions (and additional funds) from adjacent landowners not in the associations. These landowners provided permission but not more funding. CBCC sought and received a road maintenance permission letter from DPNR in June 2010. Mr. Laude, CBCC's second Stormwater Engineer, supervised the construction, and made minor field changes, working with the contractors. Tables 2 & 3 show the transition from actions proposed in the NOAA ARRA Coral Bay Workplan to the implemented actions, including dates for proposal, dates for construction, and any additional comments necessary. Engineering design documents have been included in Appendix A.

Table 2: Proposed Actions (June 2009)

Location	Proposed Action	Status	Comments
To be determined	Waterbars, Sediment Traps, Bio-filtration Areas	Cancelled/Upgraded	Superseded by larger paving initiative since partner funds were available.
Segment 1-5	Pave Road Sections	Constructed (Segments 2-5)	Partner funds were available.

Table 3: Implemented Actions (Designed September/October 2010)

Location	Implemented Action	Status	Comments
Segments 2-5	Paving and roadside finishing and seeding	Constructed (September/October 2010)	
Segment 5	Roadside drainage channel	Constructed (September/October 2010)	
Segment 4/5	Swale across road	Constructed (September/October 2010)	The swale was more cost-effective than installing another culvert; outlet water velocities with a swale were lower than with a culvert, thus reducing the potential for downstream erosion; and, maintenance requirements, efforts, and costs are lower with a swale because potential for clogging and overtopping are greatly reduced.
Segment 4/5	Swale riprap/A-Jack® Outfall	Constructed (September/October 2010)	
Segments 3-5	Create four paved, traffic pullouts, banked to keep storm run-off on paved surface. Seed and hand finish.	Constructed (August 2011)	
Segments 2-5	Hand finish, seed, and plant 200 feet of roadside area.	Constructed (August 2011)	

4.3 Problems Encountered/Overcome

This project was a straight-forward paving project, and did not have any notable problems. The key issue was soliciting and receiving the partner HOA funds, to assure the whole project was done. This did not prove difficult.

4.4 Project Costs & Construction

After taking into consideration site conditions, BMP costs, and available project funds, the final BMPs implemented included paving four road segments, installation of a swale, and riprap outfall for a total cost of $166,181 with $94,106 coming from V.I. RC&D NOAA ARRA funds and the rest from the HOAs. Table 4 below details project costs for both the implemented BMPs and the additional follow-up work. The sections below the table provide a more detailed description of paving, swale installation, and pull out installation. Appendix A has detailed design drawings.

Table 4: Hansen Bay Project Costs					
Segment	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
2-4	Grading, paving, backfill, and installation of erosion control blanket.	LF	1090' x 9'	$107.00	$116,155
5	Grading, paving, backfill, and installation of erosion control blanket from low point at the cross-road swale – including installation of this swale – upwards to the existing concrete portion of the Hansen Bay subdivision road.	LF	244' x 9'; 3' swale	$144.00	$35,180
5	Installation of riprap or A-Jack® (provided by CBCC) under cross-road swale.	Each	1	--	$3,500
				Total BMP Cost	$154,835
Additional Hansen Bay Work					
Item #	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Cost**
1	Create four paved, 8' x 20', traffic pullouts; banked to keep storm run-off on paved surface. Seed and hand finish.	Each	1	$11,346	$11,346
				Total Additional Work Cost	$11,346

Because this private road is subject to an Easement Agreement among area landowners, including the Privateer Bay and Hansen Bay HOAs, the two associations cooperated with CBCC and V.I. RC&D by providing significant construction funds. The HOAs provided these funds with the understanding that they were providing money to help pave areas for which there would not have been sufficient funds for paving under the NOAA ARRA grant. CBCC had noted the HOAs' willingness to share in the costs in the original grant application as some of the contributed local components. The Privateer Bay HOA agreed to contribute the cost of paving Segment 2. The Hansen Bay HOA agreed to supply funds for helping to pave Segments 3-5. Table 5 details these contributions.

The HOAs also funded additional stormwater management improvements and continuing maintenance. The Privateer Homeowners Association cleaned out the sediment basin and culvert at Frog Hollow in 2010 and prepared it for the anticipated increased flow from the paved road sections. They also installed a riprap dissipater below the culvert, on the Stormwater Engineer's recommendation. The Hansen Bay Homeowners Association took on responsibility for roadside maintenance of the new road paving area and did prep work for the traffic turnouts.

Table 5: Total Funding Sources & Amounts for Hansen Bay Implementation	
Source	**Amount**
Privateer Bay HOA - Segment 2	$32,075
Hansen Bay HOA - Segment 5 and parts of 4 & 3	$40,000
NOAA ARRA / V.I. RC&D	$94,106
Total Funds	$166,181
HOAs performed <u>additional</u> small projects after completion to enhance the project: $16,000 estimated value	

Roadway Paving

Roadway paving, although not typically considered a stormwater BMP, is frequently used in the Virgin Islands to control erosion off dirt roads. The contractor conducted the following tasks associated with paving along all road segments. The contractor also used a method of continuous paving, seldom used in the VI that reduced time and labor costs. Photos 4-9 show construction of the various road segments. Figure 2 provides a typical design detail of the paving.

1. Regrading and smoothing roadway to prepare base for concrete paving providing a minimum ½-inch per foot cross-slope.
2. Installation of 4-foot wide erosion control fabric strips along concrete pavement, by placing one edge of erosion control fabric underneath the pavement and pinning the other edge to the cut-side of the road.
3. Installation of a 9-foot wide travel lane with 6 inch paving reinforced with 6” x 6” x ¼” welded wire fabric set about 3 inches above grade (see Figure 2 for detailed drawing).
4. Removal of forms upon completion of paving and grading all areas to bring them flush with the concrete edge.
5. Stabilization of graded areas with erosion control blanket if directed by the inspector and seeding the areas with Bermuda grass (98% purity) at 20 pounds per acre (or approved equivalent).

Roadside Drainage

Where possible, engineers design roadside drainage to funnel water to constructed drainage structures. Segments 2, 3, and 4 only received road runoff from their respective areas. Because of this, the Stormwater Engineer did not include roadside ditches or curb and gutter for these segments. Instead, the Stormwater Engineer designed the road pavement to slope towards the inside (cut-side) of the road at a minimum of one inch in four feet. To protect the road edge, the contractor installed erosion control blanket between the pavement and the cut-side of the road.

Segment 5 receives runoff from a steeply sloped, existing paved road section. The Stormwater Engineer designed and constructed a paved roadside ditch to accommodate the design flow rate of 13.5 cubic feet per second (Figure 2 typical design detail). The space between the edge of pavement and the cut-side of the road was backfilled with rocky material and seeded.

Cross-Road Swale

Stormwater managers typically use swales to convey runoff in a desired direction. For instance, “cross-road” swales are used to channel runoff from one side of the road to the other into appropriate drainages. Concrete swales are used at sites where additional stabilization is necessary, such as a roadway. For the Hansen Bay Project, the contractor installed a reinforced concrete swale across the road at the low point between Segments 4 & 5 replacing a galvanized culvert in poor condition. The Stormwater Engineer designed the swale as a 5-foot bottom width with 10:1 side slopes, and 6 inches deep for a total width of 15 feet for the dip (Figure 2). Then the contractor graded the existing dirt roadside channel to direct flows into the swale. Finally, the contractor directed flows from the Segment 5 concrete channel into the swale.

Photo 4: Segment 2 paving.

Photo 5: Segment 5 erosion control fabric & roadside drainage channel.

Photo 6: Segment 5 grading.

Photo 7: Segment 5 concrete reinforcement.

Photo 8: Segment 5 paving.

Photo 9: Segment 5 paving.

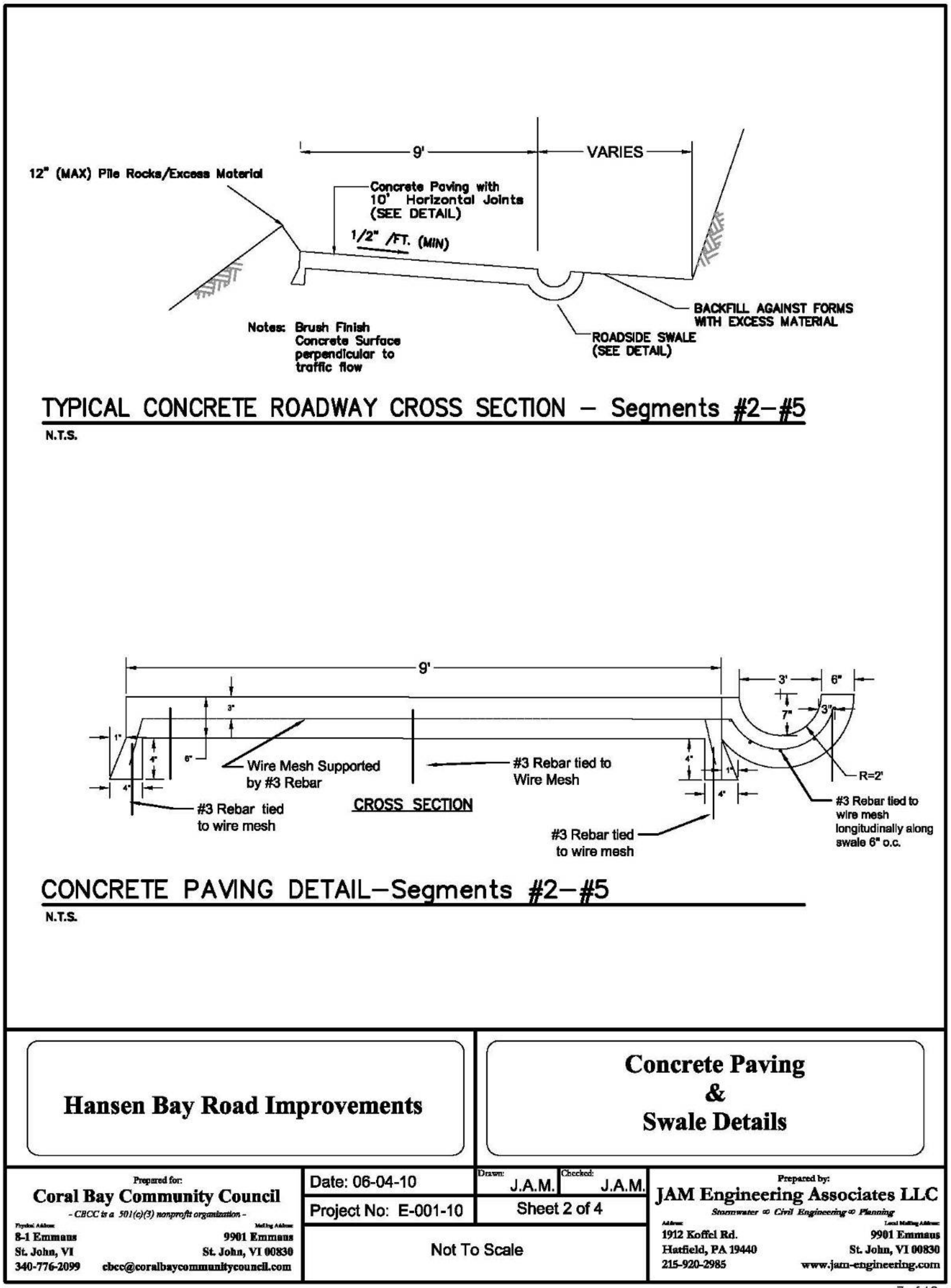

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Figure 2: Segments #2-#5 Paving Detail and Segment #5 Swale Detail

Frog Hollow Drainage Structure Improvements

Photo 10: Frog Hollow Ghut riprap energy dissipater installed by Privateer Bay HOA below Segments #2 and #3.

Rock and soil clogged the existing drainage structure at Frog Hollow. Site conditions suggested the majority of that material came from road drainage. During project planning, the residents requested a new, larger culvert beneath the road. However, the anticipated cost of the new culvert and headwalls would have required a reduction in the length of pavement. The engineer's opinion was that the culvert size was sufficient, as long as it was properly maintained to avoid blockages. Since it was likely that most of the material blocking the culvert came from road drainage, the residents elected to clean it instead of replacing it, and to install a riprap energy dissipater at the discharge (see Photo 10), at their expense. The engineer and the contractor made some modifications onsite to the headwalls and entry channels to improve waterflows to the ghut and culvert and off the road surface (an existing problem).

Pullouts

After the contractor completed paving in October 2010, the Hansen Bay subdivision residents requested the construction of pullouts to allow two cars to pass on the narrow, 9-foot wide roadway. In August 2011, the contractor constructed four pullouts using 4-inch concrete.

4.5 Achieved Results

Since project completion, the area has received at least six moderate rainfall events, including Tropical Storm Irene in August 2011. East End residents have not reported any indications of further sediment plumes in Hansen Bay after these rainfall events. For a total project cost of $166,181 (including $72,000 in contributions from the HOAs), CBCC was able to stabilize the roadway and reconstruct a drainage structure; thus, reducing sediment discharged into the bay. Photographs 11-16 below depict the completed paved road that will decrease the potential for erosion thereby reducing sediment reaching Hansen Bay. Attachment A includes the interpretive poster to highlight these achievements.

5. Sediment Reduction Monitoring

Researchers did not undertake monitoring efforts in this remote area. However, East End residents have not noticed any plumes since October 2010 when the contractor completed the initial paving work.

6. Lessons Learned

HOAs will step forward with significant dollars if they can respond to an engineering plan that incorporates their perceived concerns (and has their input).

Photo 11: Completed Segment 2.

Photo 12: Completed Segment 3.

Photo 13: Completed Segment 4.

Photo 14: Completed Segment 5.

Photo 15: Swale adjoining Segment 5, performing during construction phase.

Photo 16: Completed swale outfall adjoining Segment 5.

Grading and paving should have an exaggerated slope toward the desired drainage path so that water in microburst storm conditions flows correctly, even around corners. (Microbursts are extremely heavy short rain events that may last only five minutes and cover less than one-quarter square mile in area, but may drop over an inch of water in this time, thus often overwhelming normal drainage structures. They are hard to measure accurately, but are a very normal component of local weather.)

The grass seed (Bermuda) that the contractor planted on the roadside next to the paving sprouted and grew in over 90 percent of the construction area and survived through the long dry season on East End. The stormwater engineer and Dr. Gary Ray, the local biologist specializing in native species, agreed that the experimentation and use of Bermuda grass in these disturbed earth roadside areas was a valuable strategy here, given local conditions. No available local species was known to reproduce quickly in disturbed poor quality soil, especially on drivable roadside shoulders. Bermuda grass is an introduced species, although not considered invasive, and might be superseded in the future, if an effective and easy to establish native grass is identified for roadside stabilization. This is especially important as a strategy on one-lane roads where traffic will occasionally need to drive on the roadside.

Since this was one of the first projects that underwent construction, CBCC held back $10,000 (approx 15% of budget) and did not include it in the original budget. This left a cushion of funds for retrofits or fixing minor problems on this project, or possible shortfalls in other projects. This helped ensure priority items could be funded. One year later, the money held in reserve was spent on this project area to put in concrete traffic pullouts in several places including two that were also shown to need armoring to avoid possible heavy storm overflow and erosion. CBCC also used the reserved money to fill in grass seeding in one 200-foot area where the grass had not established well.

7. Next Steps

From a public policy perspective, this area is "complete," with local HOAs taking full responsibility for monitoring, maintenance, future improvements, and being on the lookout for problems in adjacent areas. The Privateer HOA will need to continue maintenance of the Frog Hollow drainage system by emptying the sediment basin and clearing the culvert as necessary.

In addition, the HOAs may pool funds to pave the last portion of the common road entrance (Segment 1). The HOAs need to remain diligent about the water drainage implications of individual home and driveway construction by their members and others in the area.

8. References

Devine, B., Brooks, G., and R. Nemeth. 2003. Coral Bay Sediment Deposition and Reef Assessment Study. *State of the Bay, Final Project Report, Executive Summary*. Submitted to VI DPNR Division of Environmental Protection MOA #NPS-01801.

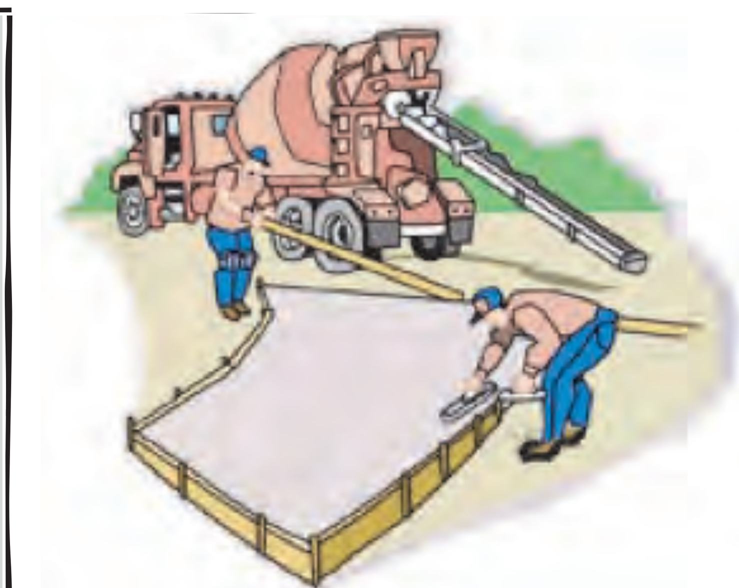
Attachment A: Watershed Poster

HANSEN BAY ROAD

What Is Happening Here?

The Hansen Bay Road improvement project is an excellent example of how the community can work together in partnership to solve local stormwater management issues. Funding by two Homeowners' Associations and NOAA covered the paving of a 1440 foot section of dirt road, including installing concrete swales, and erosion control landscaping. This dirt road has high erosion rates and sediment transport via drainage from paved roads at higher elevations that flows directly into pristine Hansen Bay. Decreasing the amount of time and distance water has in contact with the unpaved section greatly reduces sediment in the bay.

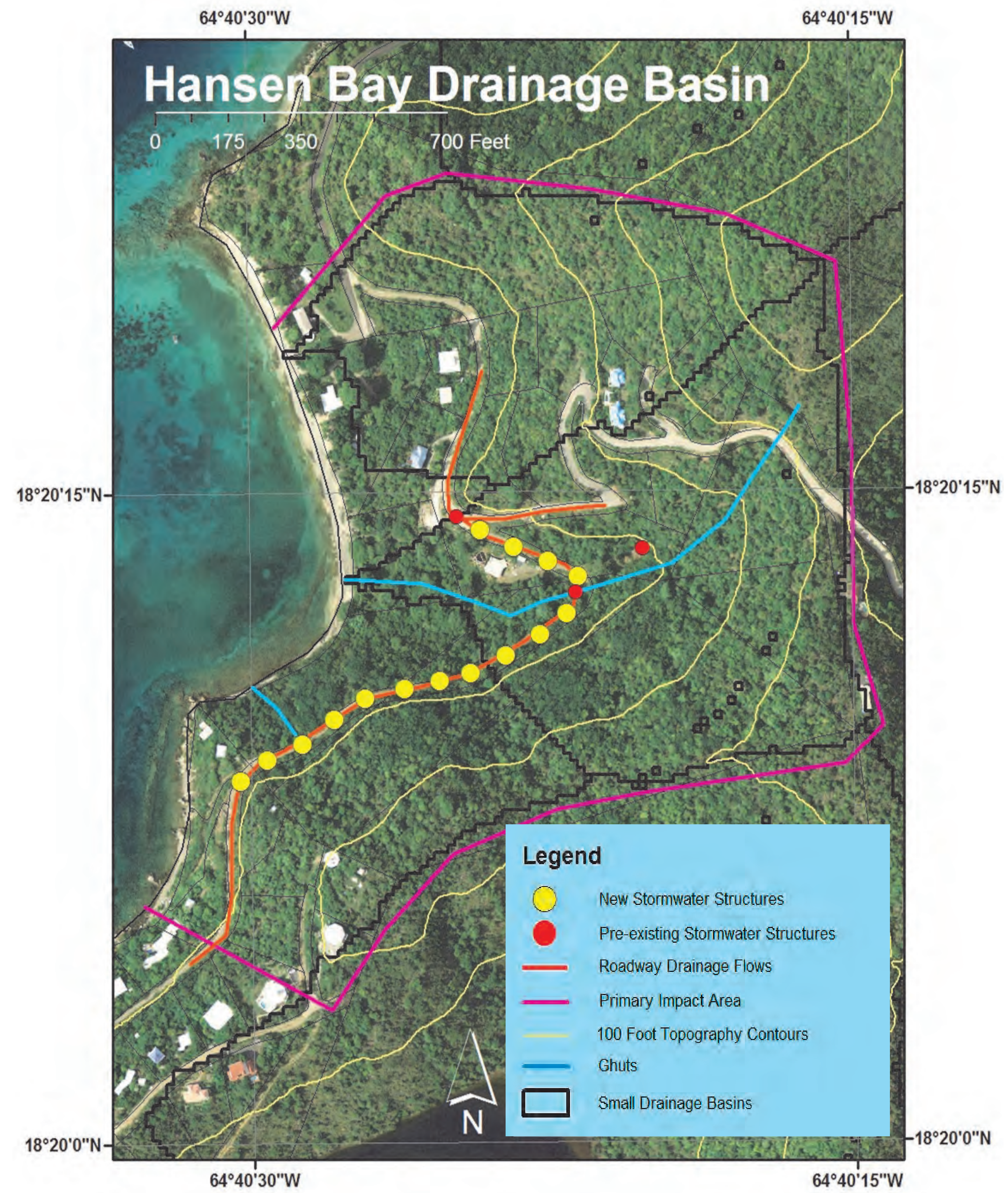
Roadway Paving



Source: GMA / Roadworx Public Works Company

Before

In Construction



Hansen Bay Watershed

Drainage from the Hansen Bay watershed has a significant negative impact on the reefs and sedimentation of Hansen Bay and Round Bay. The drainage of the watershed flows along paved roads at higher elevations down onto dirt roads, where it gathers sediment before flowing directly into the ocean. This map shows the Hansen Bay area, sub-basins, natural drainage flow, pre-existing and new drainage structures. It also shows the old (red) and natural (blue) water routes.

After

Homeowners' Associations

Thank you to these HOA's for providing funding to help complete this project:

Estate Hansen Bay Homeowners' Association

Privateer Bay Homeowners' Association

And all Volunteers!

Site Locations

Watershed scale Geographic Information System (GIS) planning tools targeted water quality monitoring research that helped in selecting the priority sites for these sediment reduction projects. Follow-up terrestrial and marine sediment monitoring will quantify and demonstrate the success in reducing sediment pollution reaching the bay.

What YOU Can Do!

- ⇒ Vegetate bare slopes with native plants
- ⇒ Minimize use of pesticides & fertilizers
- ⇒ Clean up driveways, roadsides and gutters
- ⇒ Use cut brush to create berms on steep slopes
- ⇒ Eliminate muddy run-off water
- ⇒ Never dump anything down storm culverts or ghuts
- ⇒ Properly dispose of oils, paints and chemicals
- ⇒ Do not disturb ghuts for 30 feet from center of ghut
- ⇒ Preserve all trees
- ⇒ Pump and inspect your septic tank regularly
- ⇒ Notify DPNR if you notice a problem
- ⇒ DPNR permits are needed for using backhoes & trackhoes
- ⇒ Educate each other
- ⇒ Participate in community projects!

Protecting Coastal & Coral Reef Habitats by Reducing Erosion & Sedimentation

This project is one of 18 implemented in the Coral Bay watershed with $1.5 million in National Oceanic and Atmospheric Administration funding under the American Recovery and Reinvestment Act of 2009, as part of the $2.7 million USVI Coastal Habitat Restoration through Watershed Stabilization project to reduce sediment loading rates into the coastal waters of three USVI watersheds: Coral Bay and Fish Bay on St. John and East End Bay on St. Croix. The U.S. Environmental Protection Agency has provided funding to the Coral Bay Community Council under its Community Action for a Renewed Environment (CARE) program to support this work. Local homeowners associations, the Virgin Islands Government and community volunteers have also provided resources and worked cooperatively to achieve the project objective of reducing the stormwater sediment plumes entering beautiful blue Coral Bay. These projects are also part of implementing the Coral Bay Watershed Management Plan through public-private partnerships to improve water quality, ecological health, and stormwater management while minimizing future impacts associated with watershed development.

Thanks to our lead partners!

Coral Bay Community Council (CBCC)
Virgin Islands Resources Conservation & Development Council (VIRC&D)
National Oceanic and Atmospheric Administration (NOAA)
US Environmental Protection Agency (EPA)
Virgin Islands Dept. of Planning and Natural Resources (DPNR)
Virgin Islands Dept. of Public Works (DPW)
Community volunteers and Homeowners' Associations

For More Information Please Contact:
Coral Bay Community Council
(340) 776-2099
www.coralbaycommunitycouncil.org

Appendix A: Engineering Designs & Drawings

CORAL BAY COMMUNITY COUNCIL, INC.
Mailing: 9901 Estate Emmaus, St. John, VI 00830
Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands
E-mail: coralbaycommunitycouncil@hotmail.com Phone/Fax: 340-776-2099

Coral Bay Projects Design Guidance

Strategies Appropriate for Coral Bay Environment

By: Joseph Mina, P.E.

1. Many natural drainage flows have been disturbed by construction and other man-made activities. A primary method of addressing water quality exiting the watershed into the bay will be to restore natural drainage flow patterns to the greatest extent possible both in intermittent drainage swales and ghuts and restoring sheet flow over steep slopes where possible. This will be accomplished primarily by:

    a. Redirecting drainage from channels and redirecting the large areas of upslope water intercepted along many roads and construction sites and distribute that water using level spreaders, bioretention/infiltration devices and/or rock aprons or similar means to recreate the natural sheet flow, reduce velocity and improved percolation into soil.

        i. Regrade roadbeds to direct flows to appropriate outflow devices where feasible, and add additional paving or permanent structures as appropriate to make preferred patterns of flow permanent.

        ii. Add shallow vegetated swales, and detention areas with rocks and naturalized vegetation where possible to reduce velocity and promote infiltration.

        iii. Install trench drains across driveways and roads into rain gardens, infiltration trenches, localized water collection systems for irrigation, or other appropriate devices.

    b. Eliminate deep excavated unlined ditches which are common to many of the dirt roads in order to slow velocities and reduce amount of sediment produced by erosion. Check dams, bioretention swales, and underground stone trenches with perforated pipe will be installed where appropriate.

    c. Reduce the length water travels in roadside swales by directing flow from roadways into devices often. Preferably at each switchback at a minimum by incorporating drywells, rain gardens and infiltration chambers using locally available materials and native species.

2. Retain and slow down water that reaches valley floor in larger scale regional detention/retention basins with Best Management Practices installed including forebays, infiltration cells and bioretention pond areas:

    a. Devices will utilize native plantings and species where possible and available to mimic local Caribbean seasonal flow dry ghut conditions to promote both stormwater quality and to provide wildlife and riparian habitat restoration.

    b. Sediment deposition retention area, cleaned regularly, with reuse of sediment material as gravel, topsoil, building sand, etc.

3. Provide “Last Chance” effort to reduce sediment entering sea at ends of ghuts and drainage ways immediately adjacent to where the flows enter the ocean.

a. Install devices just upstream of exit to the ocean from ghuts including:

i. Combination of weirs, pre-manufactured sediment retention chambers and/or small bioretention areas with local rock rip-rap aprons and multi-step natural rock retention step pools.

ii. Baffles and check dams where ghut is large enough.

iii. Construct and maintain natural “Caribbean Berm” (usually created by wave action and sand deposition) where water enters ocean in each area to provide natural sediment protection. Protection against mosquitoes and parasites in sitting water with guppies)

b. Slow, redirect and/or restore gut flow within 300 yards of ocean by installing the following where appropriate and feasible:

i. Re-vegetate gut outflow areas.

ii. Rock weirs, ghut slope and embankment protection including erosion control blankets, concrete cable mats or other manufactured devices to reduce erosion.

c. Install in-line biofiltration areas and flow spreading devices to slow velocities and provide opportunities for sediment to drop out and naturalized vegetation to reduce pollutant loading in the runoff.

4. Correction of failed devices, culverts, water routing by installing any appropriate Best Management Practices to attempt to solve some past poor choices of storm water management, or areas where no thought was given to management.

June 2009

CORAL BAY COMMUNITY COUNCIL, INC.

Mailing: 9901 Estate Emmaus, St. John, VI 00830 E-mail: coralbaycommunitycouncil@hotmail.com
Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands Phone/Fax: 340-776-2099

Engineering Design Recommendation Memo

From: Joseph A. Mina, P.E. **Date:** May 11, 2010

Subject Property: Hansen Bay Dirt Road Drainage Improvements

Specific Issue: Recommendations for Roadway Improvements

Project No: E-1 Hansen Bay Watershed

Attachments: Site Location & Drainage Area Map
A-Jacks Product Specifications
Typical Waterbar Details

A design and study of the drainage areas contributing to each of the road segments identified for a drainage improvements and erosion protection was undertaken, and the following designs are recommended. A drainage study of the indicated drainage areas was performed based on the Rational Method using a Time of Concentration of 5 mins. Based on these flows, calculations were performed to properly size and recommend improvements to the roadway with the overriding design consideration being the improvement of water quality in Hansen Bay per the CARE Grant objectives. Refer to Roadway Improvement Location &Drainage Area Plan dated March 16, 2010 for drainage areas contributing, and locations for each of the structures.

Drainage Study

The site was divided into two specific areas of interest.

Point of Interest ("POI") A currently has an existing small diameter pipe (approximately 12") under the roadway. Two separate areas (A1 & A2) flow to this site via roadside swales on either uphill side of the low point in the road.

Point of Interest ("POI") B currently has an existing pipe (approximately 30") under the roadway with a concrete headwall & swale creating the inflow to the pipe. Two separate areas (B1 & B3) flow to this site via roadside swales on either uphill side of the low point in the road, and one area (B-2) flows to the site via a natural ghut and directly to the concrete headwall structure, bypassing the roadside swales and going directly into the pipe.

Flow calculations were performed using the Rational Method, and a Time of Concentration of 5 mins. due to the small areas and steep slopes in the watershed. Flows for each storm were taken from NOAA Atlas-14 data for the Virgin Islands, specifically the eastern side of St. John. A 'C' value of 0.4 was assumed since most of the watershed is wooded with steep slopes, with a relatively small amount of houses and other improvements.

The following table is a summary of the flows calculated:

		Rational Method Individual Peak Flows For Each Subwatershed (cfs)				
		2-yr	10-yr	25-yr	50-yr	100-yr
		Intensity (in/hr)				
	Area (acres)	5.18	7.27	8.4	9.25	10.1
A1	0.38	0.79	1.11	1.28	1.41	1.54
A2	3.57	7.40	10.38	12.00	13.21	14.42
B1	0.72	1.49	2.09	2.42	2.66	2.91
B2	0.51	1.06	1.48	1.71	1.89	2.06
B3	3.95	8.18	11.49	13.27	14.62	15.96

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				Rational Method Cumulative Peak Flows at Each Point (cfs)				
				2-yr	10-yr	25-yr	50-yr	100-yr
				Intensity (in/hr)				
	Area (acres)	Cumulative Sub-watersheds	Flows To	5.18	7.27	8.4	9.25	10.1
POI A	3.95	A1,A2		8.18	11.49	13.27	14.62	15.96
A1	0.38	A1	POI A	0.79	1.11	1.28	1.41	1.54
A2	3.57	A1	POI A	7.40	10.38	12.00	13.21	14.42
POI B	4.52	B1-B3		17.55	24.63	28.46	31.34	34.22
B1	0.72	B1	B3		1.49	2.09	2.42	2.66
B2	0.51	B1-B3	B3	17.55	24.63	28.46	31.34	34.22
B3	3.95	B3	POI B	8.18	11.49	13.27	14.62	15.96

ROADWAY IMPROVEMENTS

The road is divided up into 5 segments, for ease of reference, and to categorize the importance of performing the required improvements on these areas. The segments are as follows:

Segment#1 – Approximately 290’ dirt road section from the intersection of Rt. 10 and proceeding up the hill to the paved section in front of Sloop Jones’ house. Based on the usage of this segment by all of the residents in Hansen Bay Subdivision and Privateer Bay Subdivision, while this area has a high local priority for paving, the potential for sediment laden runoff in this area is smaller compared to the other segments, so as part of the EPA CARE activities, this segment has the lowest priority and should be done only if funding allows. Paving should be at a minimum width of approximately 14’ (as site conditions allow).

Segment#2 - Approximately 300’ dirt road section at the turn-off towards the Hansen Bay subdivision, off of the concrete roadway. This section goes from the existing concrete to the existing drainage structure at the low point. This section has a highest priority for paving, as the roadway is in extremely poor condition, and the slope of this section, as well as the existing amount of erosion evidence, indicates that this portion contributes significantly to the problems in the bay. This section should be paved first as part of the NOAA Funding. Paving should be at a minimum width of approximately 10’ (as site conditions allow).

Segment#3 - Approximately 530’ dirt road section from the low point in the road where the existing structure is to the high point. This section has a medium priority for paving, since it is one of the longer segments, and the evidence of sediment is most prominent downstream of the outlet of the existing structure. Paving should be at a minimum width of approximately 10’ (as site conditions allow) with dirt pull-off areas where the roadway has enough width to allow passing to occur. .

Segment#4 - Approximately 260’ dirt road section from the high point at the end of segment #3 to the existing small diameter pipe at the low point in the road. This section is the lowest priority for paving, as it is shorter and in fairly good condition, and there is a significant

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vegetative buffer from where it exits the road to where it enters the bay. Paving should be at a minimum width of approximately 10' (as site conditions allow) with dirt pull-off areas where the roadway has enough width to allow passing to occur.

Segment#5 - Approximately 500' dirt road section from the low point at the end of Segment#4 to the existing concrete portion of the road in the Hansen Bay Subdivision. This section has a high priority for paving, since it is a longer section, and there is some evidence of erosion in this segment. This segment should be the second section considered for paving under the NOAA grant. Paving should be at a minimum width of approximately 10' (as site conditions allow) with dirt pull-off areas where the roadway has enough width to allow passing to occur.

For all concrete road sections, the concrete shall be brush finished with the brush strokes directing the flow into the appropriate drainage channel. Asphalt Paving may be substituted for concrete if it is feasible and available at the time of construction.

Roadside Drainage

Segment#1 – Based on the topography, and existing road grading, it is recommended that no roadside ditches be used in this segment. This area should have a road that slopes towards the DOWNHILL side of the road at a minimum of 2% to avoid concentrating the water in a channel. Currently, runoff from this area flows to Rt. 10 and down into the same area it would get to via the hillside, and using the hillside as a vegetative filter will provide cleansing for the water prior to entering the bay. To protect the downhill side of the road (especially in areas of fill) Rip-Rap Protection and Erosion Control Blankest should be used. A minimum of 5' wide Rip-Rap, and 10' wide Erosion Control Blanket should be considered unless access to the adjacent property is not allowed. Then utilizing A-Jacks or similar product placed at the roadside to dissipate energy would be satisfactory.

Segments#2-5 – Maximum Flow in these ditches will range from 2.7 cfs. to 16cfs. Based on this and sizing for the 25 year storm event, a design flow of 13.5 cfs was used. A concrete roadside channel incorporated into the concrete road section should be installed in these locations. This channel should have a minimum of a 3' top width, be 7" deep and have an arc radius of 2'.

POI A & POI B Improvements

POI A- Based on the flows coming to this point, a concrete swale should replace the existing small diameter pipe. This is to provide ease of maintenance to the homeowners and to keep the existing pipe from clogging and over-topping and creating an issue with roadway damage. The swale will be 5' bottom width with 10:1 side slopes, and 6" deep for a total width of 15' for the dip. This will adequately convey the flows from the larger storms while maintaining the ability for cars to pass with only 3-5 inches in the swale.

POI B - The existing structure at POI B will remain with the intent that the roadside swales from the new paving areas will be directed to discharge into this structure. This may require cutting some of the wall area away on one side of the structure to adequately convey the flows from the road to the pipe.

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Engineering Design Recommendation Memo

Other Improvements –Waterbars & Swale

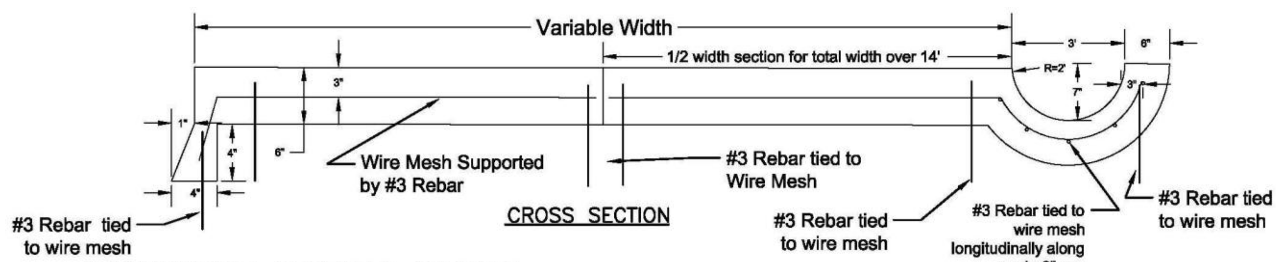
Should the roadway or portions of the roadway not be able to be paved, waterbars should be installed at 50' to 75' intervals, directing the water to the downhill side of the road if possible, and reinforcing the road fill slope with Rip-Rap or A-Jacks. If needed, the waterbars can direct the water into the existing roadside ditches on the uphill side. This will require some excavation of the existing ditches to make them roughly equivalent to the 1' radius concrete ditch recommended. Equivalent size would be a 1' bottom with 2:1 side slopes and a total depth of 1'. The bottoms of the ditches should be lined with rock rip-rap (4"-6" at a depth of 9"-12") if they are not cut into the rock already.

SUMMARY OF DESIGN

Roadways will be paved with varying widths from 10' to 14' with allowances for pull-off areas where the road widens to allow two cars to pass. Segment 1 will have no roadside channel, and roadside channels for segments 2-5 will be used and consist of a 2' radius semi-circular ditch 3' wide at the top, 7" deep and the channel will be in addition to the road width.

At POI A, the roadside ditches will flow to a swale across the road at the low point. This swale will be 5' bottom width with 10:1 side slopes and a minimum of 6" deep for a total width of 15' for the dip. The area downstream of this swale will be reinforced with Rip-Rap and/or A-Jacks.

At POI B, the existing drainage structure will remain, with roadside channels being directed to flow into the pipe under the road at this point.



CONCRETE PAVING DETAIL

N.T.S.

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Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands Phone/Fax: 340-776-2099

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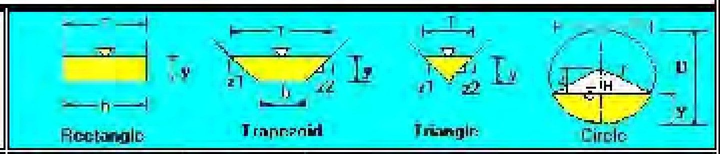
Roadside Channel & Swale Calculations

Open Channel Flow Calculator Page 1 of 1

The open channel flow calculator

Select Channel Type: Circle



Depth from Q | Select unit system: Feet(ft)

Channel slope: .05 ft/ft	Water depth(y): 0.55 ft	Radius (r) 3 ft
Flow velocity 10.649 ft/s	LeftSlope(Z1): Z1/y	RightSlope(Z2): Z2/y
Flow discharge 13.5 ft^3/s	Input n value 0.0155 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 3.69 ft	Flow area 1.29 ft^2	Top width(T) 3.46 ft
Specific energy 2.31 ft	Froude number 3.07	Flow status Supercritical flow
Critical depth 0.96 ft	Critical slope 0.0047 ft/ft	Velocity head 1.76 ft

http://ceserver.lamar.edu/fang/handbook/Channels.html 5/11/2010

Figure 1 Roadside Swale

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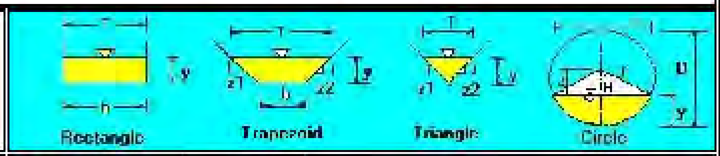
Open Channel Flow Calculator Page 1 of 1

The open channel flow calculator

Select Channel Type: Trapezoid



Depth from Q | Select unit system: Feet(ft)

Channel slope: .02 ft/ft	Water depth(y): 0.35 ft	Bottom width(b) 5 ft
Flow velocity 5.31795 ft/s	LeftSlope(Z1): 10 Z1/y	RightSlope(Z2): 10 Z2/y
Flow discharge 16 ft^3/s	Input n value 0.0155 or select n	
Calculate!	Status: Calculation finished	Reset
Wetted perimeter 12.09 ft	Flow area 3.01 ft^2	Top width(T) 12.06 ft
Specific energy 0.79 ft	Froude number 1.88	Flow status Supercritical flow
Critical depth 0.49 ft	Critical slope 0.0051 ft/ft	Velocity head 0.44 ft

http://ceserver.lamar.edu/fang/handbook/Channels.html 4/8/2010

Figure 2 Swale Across Road at POI A

Mailing: 9901 Estate Emmaus, St. John, VI 00830
E-mail: coralbaycommunitycouncil@hotmail.com
Office: 8-1 Estate Emmaus, Coral Bay, St. John, U.S. Virgin Islands
Phone/Fax: 340-776-2099

ATTACHMENTS

Site Location & Drainage Area Map
A-Jacks Product Specifications
Typical Waterbar Details


East End Road
Route 10
SEGMENT #1
150 75 0 150 300
Feet
N
W
E
S
SEGMENT #2
B1
Hansen Bay Road
(Private Road)
POI B *
B2
SEGMENT #4
SEGMENT #3
POI A *
B3
PROPOSED SWALE ACROSS ROAD
1' Deep
5' Wide Bottom@2%Cross-Slope
10:1 Side-Slopes up to roadway.
A1
A2
SEGMENT #5
Prepared for:
Coral Bay Community Council
Prepared by:
Joseph A. Mina, P.E.
Roadway Improvement Location &
Drainage Area Plan
Hansen Bay Road
April 7, 2010
Project No: E-1
Sheet 1 of 1
Drawn by: JAM
Joseph A. Mina, P.E.
No. 1049E

A-JACKS® Concrete Armor Unit Specification: Wave Attack

2 ft & 4 ft A-Jacks Units

PART 1: GENERAL

A. Scope of Work

The Contractor shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of A-JACKS® concrete armor units in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

B. Submittal

The Contractor shall submit to the Engineer test results showing that the A-Jacks or approved armor units meet the required K_d stability coefficient, as utilized in the Hudson stability formula for coastal applications; or meet the required Factor-of-Safety (FOS) Methods for evaluating the hydraulic stability of the chosen armor units for stream bank applications.

PART 2: PRODUCTS

A. General

The geometry of an A-JACKS® concrete armor unit consists of six arms extending from a central hub. A complete unit is made up of two identical halves, with each half consisting of a central core with three legs radiating outward at equal spacing. On each half, two fillets are located between adjacent arms. These fillets provide additional structural strength and aid in the proper placement of the armor units.

When the symmetrical halves are interlocked, the resultant unit will have a geometry which exhibits six equally spaced arms, with each arm spaced at 90 degrees from the four adjacent arms. When placed in the most stable configuration, each unit will rest on three of the six arms.

B. <u>Concrete Armor Units</u>

1. Scope

1.1 This specification covers concrete armor units for erosion control used for coastal applications (shoreline, breakwaters, jetties, and other harbor structures), along with toe-protection and slope protection for inland applications.

2. Materials

The 2 ft. (AJ-24) A-Jacks units and 4 ft (AJ-48) A-Jacks units will be produced on a pre-determined concrete block machine.

2.1 Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

2.1.1 Portland Cements - Specification C 150, for Portland Cement.

2.1.2 Blended Cements - Specification C 595, for Blended Hydraulic Cements.

2.1.3 Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

2.1.4 Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.

2.2 Aggregates shall conform to the following ASTM specifications, except that grading requirements shall not necessarily apply:

2.2.1 Normal Weight - Specification C 33, for Concrete Aggregates.

2.3 A joint compound such as 4000 psi grout or segmental retaining wall (SRW) adhesive to join two halves of AJ-48 units is required. Armortec can offer suggestions as to the proper compound for use on each project. The grout will be applied by using a trowel**.** The SRW adhesive will be applied by tube caulk. **AJ-24 units do not require joint compound.**

3. Physical Requirements

3.1 At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1 below.

TABLE 1. PHYSICAL REQUIREMENTS

Compressive Strength Net Area Min. psi (mPa)		Water Absorption Max., lb/ft^3 (kg/m^3)	
Avg. of 3 units	Individual Unit (min. required)	Avg. of 3 units	Individual Unit
4,000 (27.5)	3,500 (24.0)	10 (160)	12 (192)

3.2 Durability. The manufacturer shall satisfy the purchaser by proven field performance that the concrete units have adequate durability even if they are to be subjected to a freeze-thaw environment. If a freeze-thaw test is required, it will tested as stated in ASTM C1262-97.

3.3 Sample and test units in accordance with ASTM Methods C 140, Sampling and Testing Concrete Masonry Units.

4. Visual Inspection

4.1 All units shall be sound and free of defects that would interfere with the proper placing of the unit or impair the strength or permanence of the construction. Minor surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.

4.2 Broken units shall not be repaired or used in the matrix assembly.

5. Sampling and Testing

5.1 The purchaser or his authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery.

6. A. Performance Specifications –Coastal applications

6.1.a. To minimize the time and cost for installation, the armor unit should be able to meet the specified design conditions with the placement of a single layer of armor units.

6.2.a. Armor units should be sized for hydraulic stability under the specified wave conditions. The size and weight of an armor unit that is hydraulically stable for a given design wave condition and structure slope should be estimated using the Hudson formula:

$$W = \frac{(\gamma_{cc} H^3)}{K_D (\gamma_{cc} / \gamma_w - 1)^3 m} \qquad M = \frac{\rho_{cc} H^3}{K_D (\rho_{cc} / \rho_w - 1)^3 m}$$

where:

M = weight of median size armor unit (kg)
W = weight of median size armor unit (lb)
γ_{cc} = armor unit weight (N/m^3 or lb/ft^3)
H = wave height (m or ft)
K_D = armor unit stability coefficient corresponding to "no damage" condition (defined actually as minimum acceptable damage expressed as a percent of armor unit rocking or displacement)
γ_w = unit weight of water
m = structure slope angle

6.2.c Armor units may be user specified utilizing the default values below:

Default Values for Hudson Equation		
Variable	**English Units**	**Metric Units**
Hudson Coefficient	K_D = 20 (Random) K_D = 50 (Uniform)	K_D = 20 (Random) K_D = 50 (Uniform)
Concrete Density	γ_{cc} = 135 lb/ft^3 (dry cast)	ρ_{cc} = 2,165 kg/m^3 (dry cast)
Water Density	γ_w = 64 lb/ft^3 (Seawater) γ_w = 62.4 lb/ft^3 (Freshwater)	ρ_w = 1026 kg/m^3 (Seawater) ρ_w = 1000 kg/m^3(Freshwater)

To reduce the size of the structure, the armor unit should have a minimum K_D value of 20 as defined in the above Hudson formula for the specified structural slope.

7. Expense of Tests

Additional testing, other than that provided by the manufacturer, shall be borne by the purchaser.

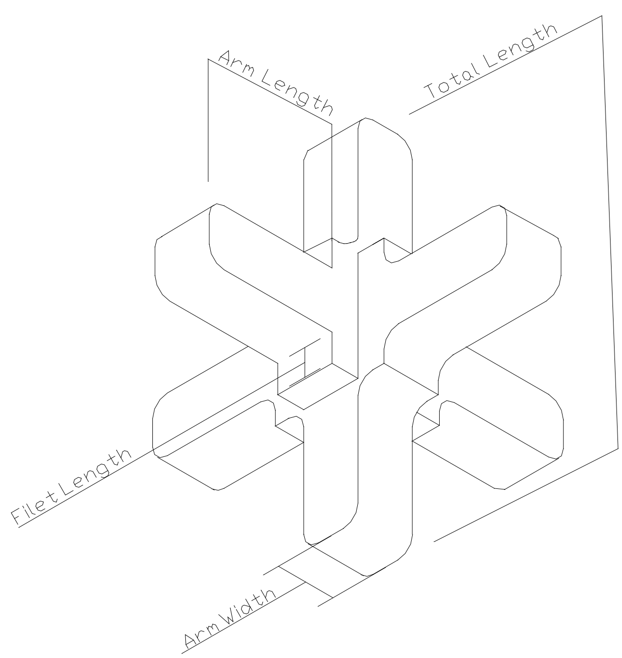
8. Manufacturer

A-JACKS® units are manufactured and sold by:

ARMORTEC (A Contech Company)
9025 Centre Point Drive
Suite 400
West Chester, OH 45069
Phone: 1-513-645-7000
Fax: 1-513-645-7993

The A-JACKS® concrete system shall have the following nominal characteristics:

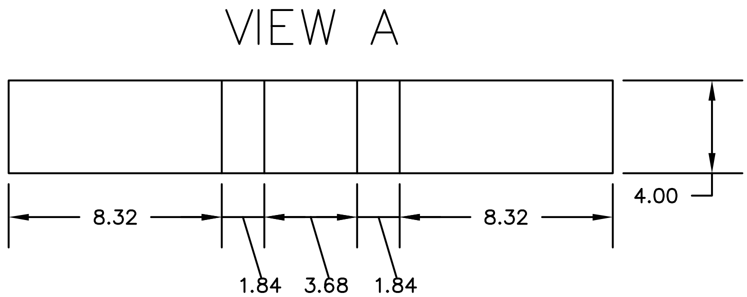
A-JACKS Model	Total Length in (cm)	Arm Length in (cm)	Fillet Length in (cm)	Arm Width in (cm)	Volume ft^3 (m^3)	Weight lbs (kg)
AJ-24	24 (60.96)	4.00 (10.16)	1.84 (4.67)	3.68 (9.35)	.56 (.016)	78 (35)
AJ-48	48 (121.92)	7.36 (18.69)	3.68 (9.34)	7.36 (18.69)	4.49 (.127)	629 (285)

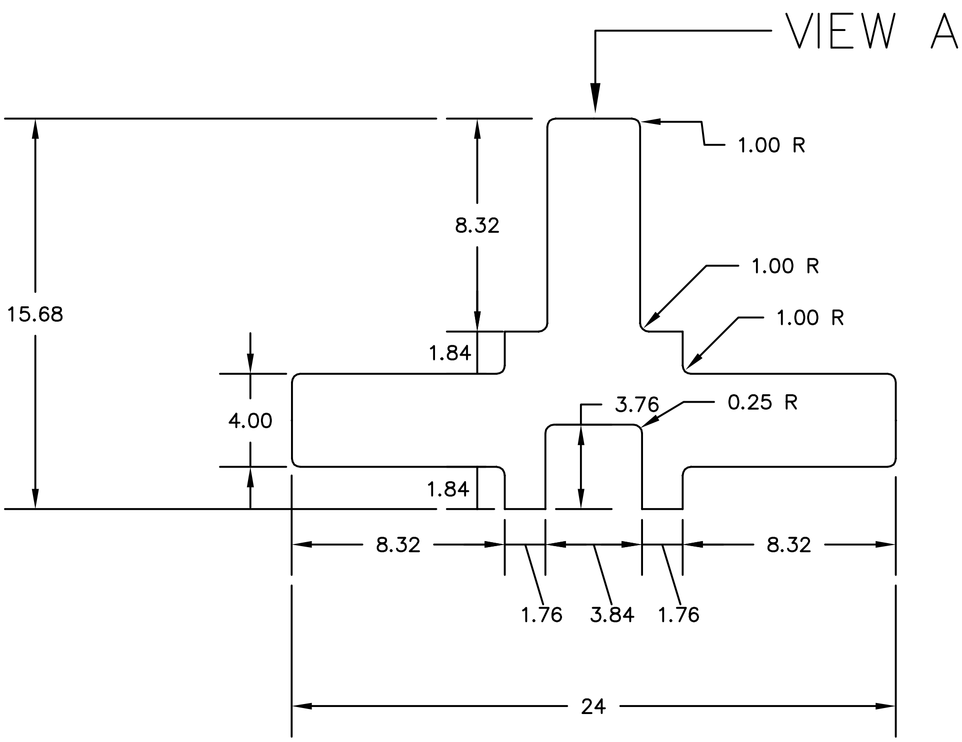


Consultation. The manufacturer of the cellular concrete blocks shall provide design and construction advice during the design and initial installation phases of the project when required.

TABLE 3. STANDARD SIZES OF ARMORFLEX® BLOCKS

CLASS	TYPE	BLOCK WEIGHT		BLOCK SIZE			OPEN AREA %
		Lbs (kg)	**Lbs./Sq.ft. (kg/m^2)**	**Length inches (cm)**	**Width inches (cm)**	**Height inches (cm)**	
30S	Open	31-36 (14-16)	32-37 (152-176)	13.0 (33.0)	11.6 (29.5)	4.75 (12.1)	20
50S	Open	45-52 (20-24)	45-53 (220-254)	13.0 (33.0)	11.6 (29.5)	6.0 (15.2)	20
45S	Closed	39-45 (18-20)	40-45 (191-220)	13.0 (33.0)	11.6 (29.5)	4.75 (12.1)	10
55S	Closed	53-61 (24-28)	54-62 (259-298)	13.0 (33.0)	11.6 (29.5)	6.0 (15.2)	10
40	Open	62-71	35-40	17.4	15.5	4.75	20
50	Open	81-94 (37-43)	46-53 (396-460)	17.4 (44.2)	15.5 (39.4)	6.0 (15.2)	20
70	Open	120-138 (55-63)	68-78 (587-675)	17.4 (44.2)	15.5 (39.4)	9.0 (22.9)	20
45	Closed	78-89	43-50	17.4	15.5	4.75	10
55FT	Closed	94-108 (43-49)	53-61 (460-528)	17.4 (44.2)	15.5 (39.4)	6.0 (15.2)	10
75	Closed	120-138 (55-63)	68-78 (587-675)	17.4 (44.2)	15.5 (39.4)	7.5 (19.1)	10
85	Closed	145-167 (66-76)	82-95 (709-817)	17.4 (44.2)	15.5 (39.4)	9.0 (22.9)	10
40L	Open	95-111 (43-51)	35-41 (303-347)	17.4 (44.2)	23.6 (59.9)	4.75 (12.1)	20
70L	Open	181-211 (82-96)	68-78 (587-675)	17.4 (44.2)	23.6 (59.9)	9.0 (22.9)	20
45L	Closed	113-132 (51-60)	43-50 (382-435)	17.4 (44.2)	23.6 (59.9)	4.75 (12.1)	10
85L	Closed	219-254 (100-116)	82-95 (709-817)	17.4 (44.2)	23.6 (59.9)	9.0 (22.9)	10



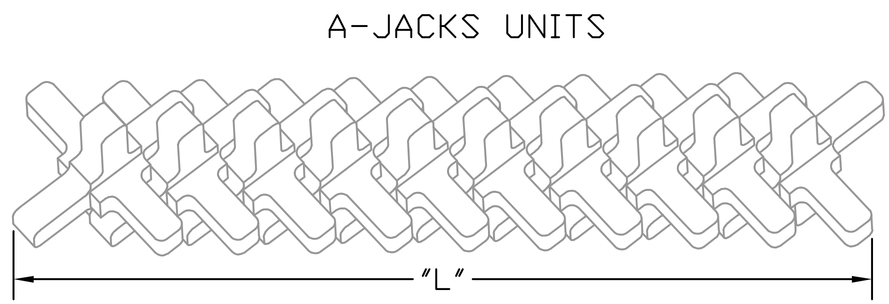


ALL DIMENSIONS IN INCHES

DRAWN BY:	CHECKED BY:	DATE:	SCALE:
KWM	CBK	7/20/07	NTS

24" A-JACKS
STANDARD DETAIL
(Dimensions)

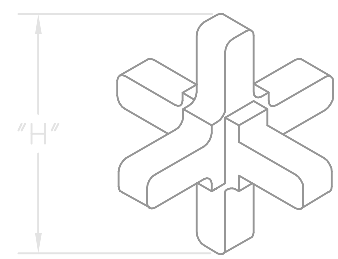
ARMORTEC
Erosion Control Solutions
A CONTECH COMPANY
9025 CENTRE POINTE DR, SUITE 400
WEST CHESTER, OHIO 45069
PH: (513) 645-7000 FAX: (513) 645-7993



A–JACKS PLACEMENT: PROFILE
(NOT TO SCALE)

A–JACKS UNITS: COVERAGE EXAMPLES			
SIZE "H"	"L" LENGTH (ft.)	# OF UNITS	COVERAGE PER UNIT*
24"	15'–0"	15	1'–0"
48"	16'–0"	8	2'–0"
72"	15'–0"	5	3'–0"
96"	16'–0"	4	4'–0"
120"	20'–0"	4	5'–0"

*DEPENDS ON TIGHTNESS OF PLACEMENT

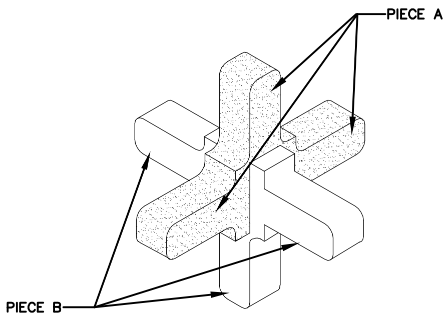


DRAWN BY:	CHECKED BY:	DATE:	SCALE:
KWM	CBK	12/1/08	NTS

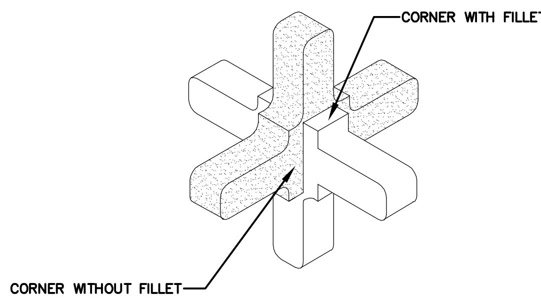
A-JACKS
STANDARD DETAIL
(Installed Dimensions)

ARMORTEC
Erosion Control Solutions
A CONTECH COMPANY
9025 CENTRE POINTE DR, SUITE 400
WEST CHESTER, OHIO 45069
PH: (513) 645-7000 FAX: (513) 645-7993

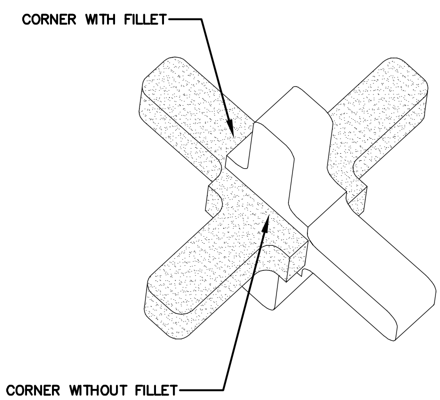
1. IDENTIFY A–Jacks COMPONENTS.



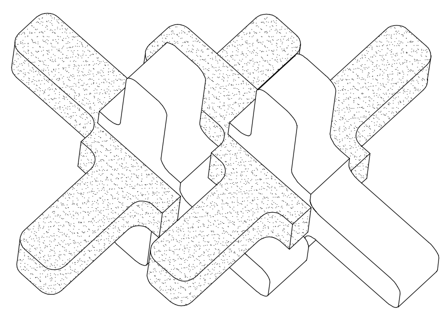
2. IDENTIFY CORNERS WITH AND WITHOUT FILLETS.



3. PROPER ROTATION OF A–Jacks.



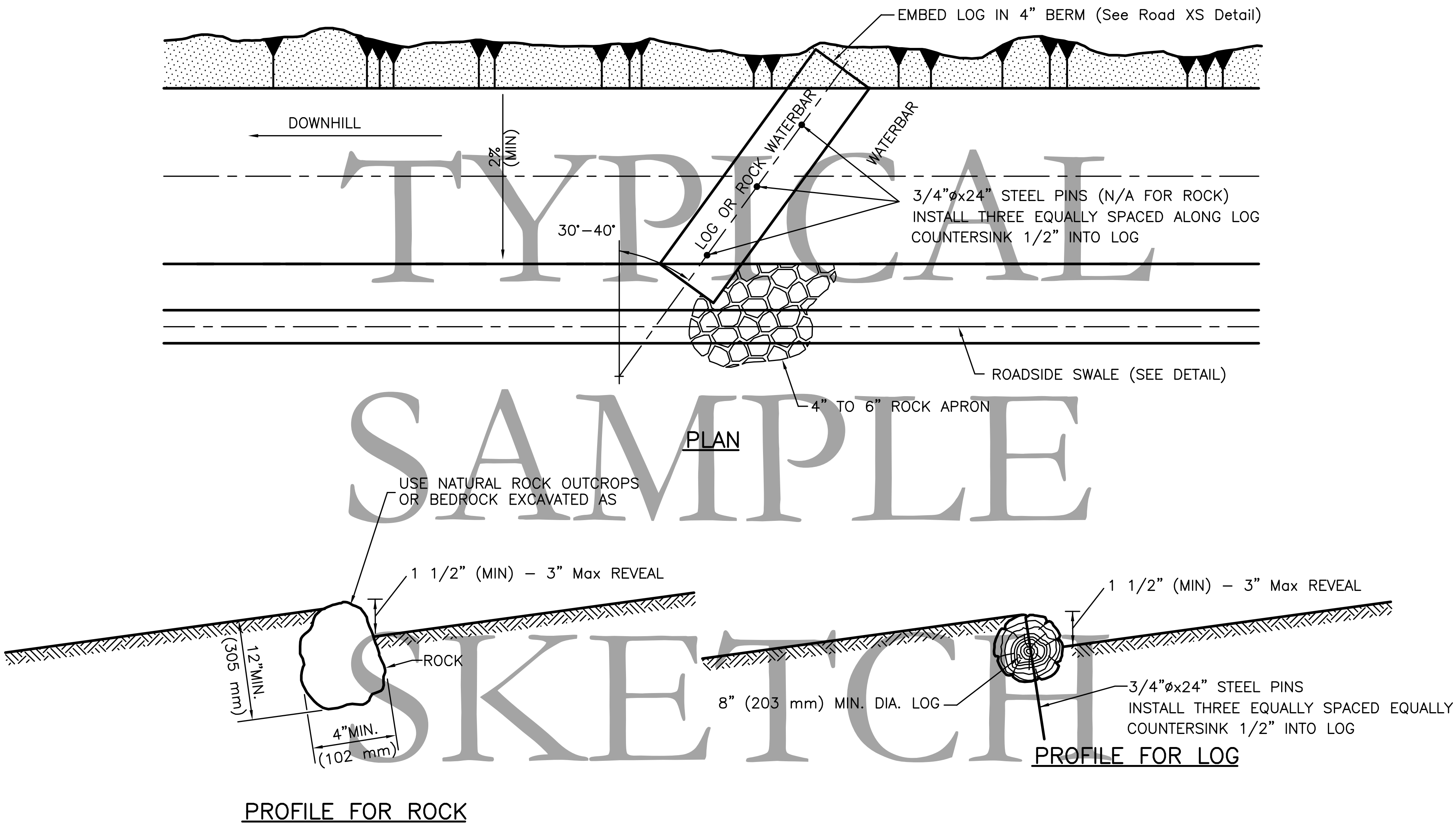
4. ALIGN ALL A–Jacks IN SAME DIRECTION. CORNERS WITHOUT FILLET MUST LINE UP.



DRAWN BY:	CHECKED BY:	DATE:	SCALE:
KWM	CBK	7/21/07	NTS

A-JACKS
STANDARD DETAIL
(Construction)

ARMORTEC
Erosion Control Solutions
A CONTECH COMPANY
9025 CENTRE POINTE DR, SUITE 400
WEST CHESTER, OHIO 45069
PH: (513) 645-7000 FAX: (513) 645-7993



Prepared for:
Coral Bay Community Council
- CBCC is a 501(c)(3) nonprofit organization -

Physical Address: 8-1 Emmaus, St. John, VI, 340-776-2099
Mailing Address: 9901 Emmaus, St. John, VI 00830, cbcc@coralbaycommunitycouncil.com

Date: 03-25-10
Project No: D-001-09
Drawn: J.A.M. Checked: J.A.M.
Sheet 7 of 7

Plan & Profile Views
Waterbar Installation
Calabash Boom Road

Prepared by:
JAM Engineering Associates LLC
Stormwater ∞ Civil Engineering ∞ Planning

Address: 1912 Koffel Rd., Hatfield, PA 19440, 215-920-2985
Local Mailing Address: 9901 Emmaus, St. John, VI 00830, www.jam-engineering.com

Scope of Work & Details

for

Hansen Bay Road
Paving Improvements

PROJECT NO. D-001-10

SITUATE IN

CORAL BAY, ST. JOHN
US VIRGIN ISLANDS

May 5, 2010

PREPARED FOR:

Coral Bay Community Council, Inc.
&
Virgin Islands Resource Conservation and Development Council, Inc.
NOAA-ARRA Grant
9901 Emmaus
St. John, USVI 00830

PREPARED BY:

JAM Engineering Associates LLC
Stormwater ∞ Civil Engineering ∞ Planning
Joseph A. Mina, P.E.

1.0 SCOPE OF WORK

Work shall consist of completing the following tasks in accordance with the locations referenced on a plan titled, "Roadway Improvement Location & Drainage Area Plan, Hansen Bay Road," dated April 7, 2010 and details in this document.

SEGMENT #1

Approximately 300' dirt road section from the intersection of Rt. 10 and proceeding up the hill to the paved section in front of Sloop Jones' house.

1. Regrade and smooth roadway to prepare base for concrete paving. Provide min 1/4" per ft. cross-slope towards the downhill side of the road.. Approximately 300 LF.
2. Paving Work – Install 6" paving reinforced with wire mesh with 14' wide travel lane , installed in two 7' wide sections to maintain traffic flow during construction per detail. Provide cross slope to direct water to downhill side of road. No roadside swale will be constructed in this area. Install 5'wide (min) rip rap apron along downhill slope of paved areas to protect fill slope from runoff as indicated on the detail.
3. Upon completion of paving and removal of forms all areas shall be graded to bring the final grade flush with the edge of concrete. Graded areas shall be stabilized with Erosion Control Blanket (if directed by the inspector) and seeded with Bermuda grass (98% purity) at 20lbs. per acre (or approved equivalent).

SEGMENT #2

Approximately 300' dirt road section at the turn-off towards the Hansen Bay subdivision, off of the concrete roadway to Privateer Bay. This section goes from the existing concrete to the existing drainage structure at the low point.

1. Regrade and smooth roadway to prepare base for concrete paving. Provide min 1/4" per ft. cross-slope. Approximately 300 LF.
2. Paving Work – Install 6" paving reinforced with wire mesh with 9' wide travel lane and 3' wide concrete swale per detail.
3. Direct flows from the roadside swale into the existing drainage structure at the low point marked POI B on the plan. This may require cutting some of the wall away on one side of the drainage structure to adequately convey the flows from the road to the pipe. Any work on the wall will be repaired in a manner consistent with the finish of the existing structure.
4. Upon completion of paving and removal of forms all areas shall be graded to bring the final grade flush with the edge of concrete. Graded areas shall be stabilized with Erosion Control Blanket (if directed by the inspector) and seeded with Bermuda grass (98% purity) at 20lbs. per acre (or approved equivalent).

SEGMENT #3 & 4

Approximately 800' dirt road section from the low point in the road marked POI B to the low point in the road marked POI A on the plan.

1. Regrade and smooth roadway to prepare base for concrete paving. Provide min 1/4" per ft. cross-slope. Approximately 800 LF.
2. Paving Work – Install 6" paving reinforced with wire mesh with 9' wide travel lane and 3' wide concrete swale per detail.
3. Upon completion of paving and removal of forms all areas shall be graded to bring the final grade flush with the edge of concrete. Graded areas shall be stabilized with Erosion Control Blanket (if directed by the inspector) and seeded with Bermuda grass (98% purity) at 20lbs. per acre (or approved equivalent).

SEGMENT #3 & 4 – ALTERNATE

1. Regrade and smooth roadway to prepare base for concrete paving. Provide min 1/4" per ft. cross-slope. Approximately 800 LF. All newly graded road surfaces shall be compacted in accordance with VI DPW specifications
2. Install up to 8 Reinforced Concrete Water Bars at intervals of 100' as directed by the engineer in the field.
3. Direct flows from the existing dirt roadside swale into the existing structure at the low point marked POI B on the plan.
4. All non-traffic areas disturbed shall be protected with Erosion Control Blanket (if directed by the inspector) and seeded with Bermuda grass (98% purity) at 20lbs. per acre.

SEGMENT #5

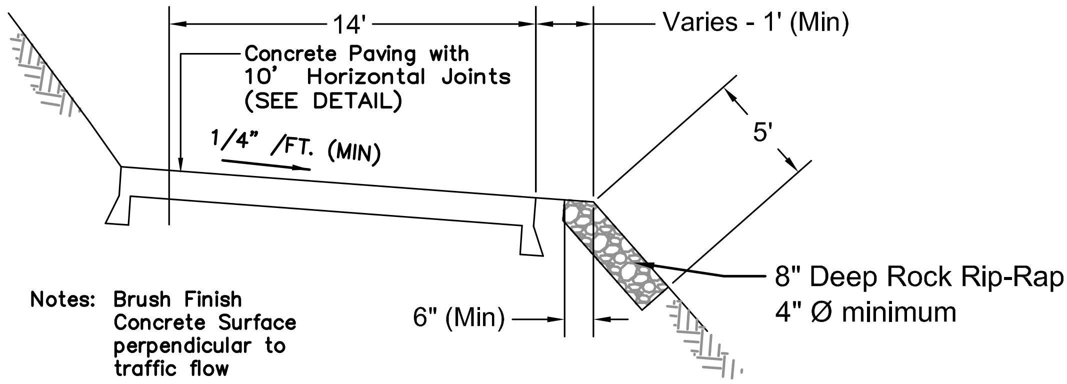
Approximately 500' dirt road section from the low point at the end of Segment#4 to the existing concrete portion of the road in the Hansen Bay Subdivision.

1. Regrade and smooth roadway to prepare base for concrete paving. Provide min 1/4" per ft. cross-slope. Approximately 500 LF. Remove Existing pipe at low point marked POI A on plan, and rough grade area to prepare base for concrete swale.
2. Install Reinforced Concrete Swale across Road at low point per detail. Grade existing dirt roadside channel to direct flows into the swale.
3. Paving Work – Install 6" paving reinforced with wire mesh with 9' wide travel lane and 3' wide concrete swale per detail. Direct flows from concrete channel into swale across road at low point marked POI A on plan by warping the concrete to enter the swale. Convert ¼" per foot road cross slope to match swale at low point within 50' of the swale.
4. Upon completion of paving and removal of forms all areas shall be graded to bring the final grade flush with the edge of concrete. Graded areas shall be stabilized with erosion control blanket and seeded with Bermuda grass (98% purity) at 20lbs. per acre (or approved equivalent).

NOTES AND CONDITIONS

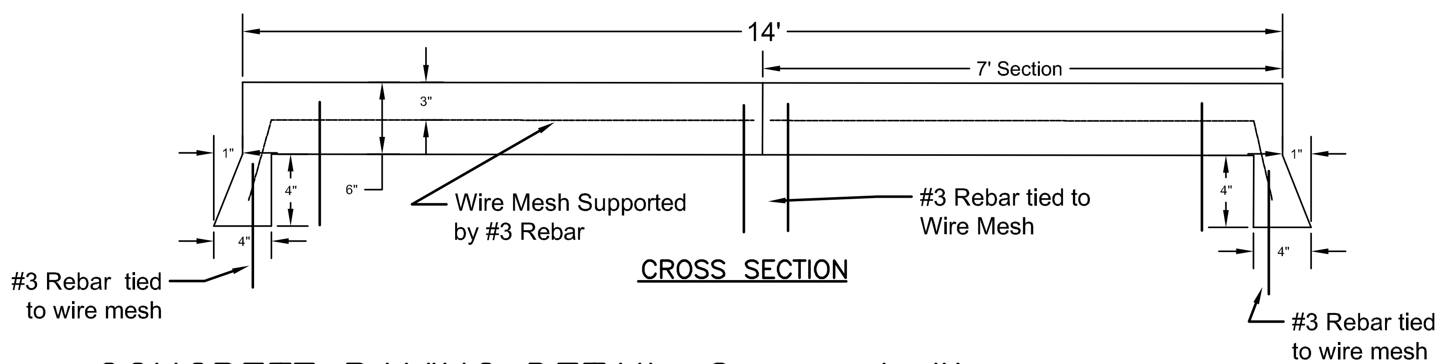
1. All grading and compaction of graded roadways must be performed to appropriate specifications to support concrete paving.
2. Contractors shall provide a cost per linear foot for paving. Actual lengths of paving may be adjusted based on this cost and available funding.
3. Due to the narrow roads, there will be limited access for the residents during construction. All efforts will be made by the contractor to allow residents vehicles to pass, but at a minimum, a schedule of work, including anticipated road closures, will be made available to the residents so they can make alternate plans for access.
4. Excess material excavated shall be used first to fill areas after form removal, and second spread on existing dirt portions of the road to repair minor ruts and erosion damage. All non-traffic areas filled shall be protected with Erosion Control Blanket (if directed by the inspector) and seeded with Bermuda grass (98% purity) at 20lbs. per acre. All fill placed on road surfaces shall be compacted in accordance with VI DPW specifications.
5. During grading & excavation work, sufficient water will be kept onsite to ensure that exposed soil and road surfaces can be sprayed down to control dust.
6. All workmanship shall comply with VI DPW specifications and FP-2006 specifications.
7. Erosion Control Matting & anchors to be provided by VIRC&D. All other materials and supplies including but not limited to additional fill required to adequately grade after concrete form removal, concrete, and other materials are to be provided by the contractor.
8. All grading and excavation included on this job shall include all rock and ledge removal necessary to install items as specified. No additional fees shall be charged for rock work.
9. Contractor shall be responsible for installing up to four sign posts consisting of a 4" x 4" post set 2' into the ground and extending 6' above grade at locations to be determined upon the start of construction. Signs will be provided by VIRCD and mounted on the signpost by the contractor.
10. Contractor may sequence activities as needed with the approval of the VIRC&D Inspector with the exception that the concrete paving shall be installed only after all other heavy excavation is completed on the roadway to avoid heavy equipment travel over newly poured concrete.
11. Contractor may make recommendations to modify this scope to reduce costs or avoid cost overages if conditions or information surfaces that warrant adjustments during bidding or in the field. Any changes to this scope must be approved by the CBCC Stormwater Engineer. Any cost savings generated in this manner will be passed on to the VIRC&D by a reduction in the contracted amount equal to the saving.
12. BUY AMERICAN CLAUSE: Contractors are hereby notified that they are encouraged, to the greatest extent practicable, to purchase American-made equipment and products with funding provided under this award.
13. Contractor must have a VI business license to do the type of work that is being performed.
14. Contractor must have a DUNS number.
15. All workers on the projects must legally be able to work in the VI.
16. Notify Project manager, CBCC and all abutters at least 24 hours prior to beginning work.
17. Contractor must conduct a weekly safety meeting for all on site personnel
18. Provide $ 1 million liability insurance with CBCC and VIRC&D as named insured.
19. Comply with all Federal and VI, DPW and DPNR regulations and requirements.

2.0 PLANS & DETAILS



TYPICAL CONCRETE ROADWAY CROSS SECTION – Segment #1

N.T.S.



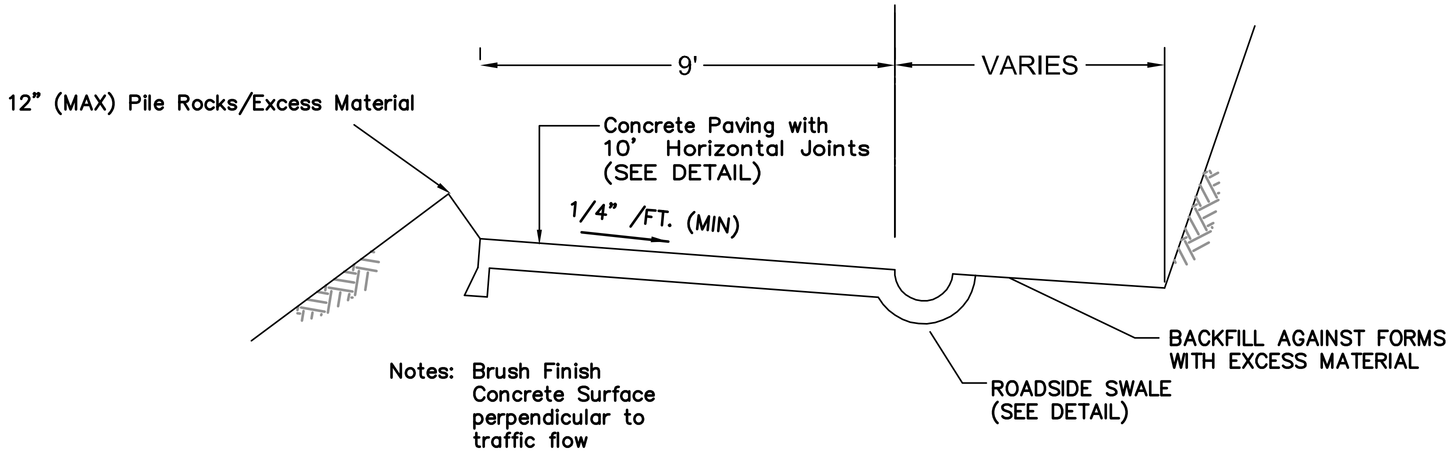
CONCRETE PAVING DETAIL–Segment #1

N.T.S.

Hansen Bay Road Improvements

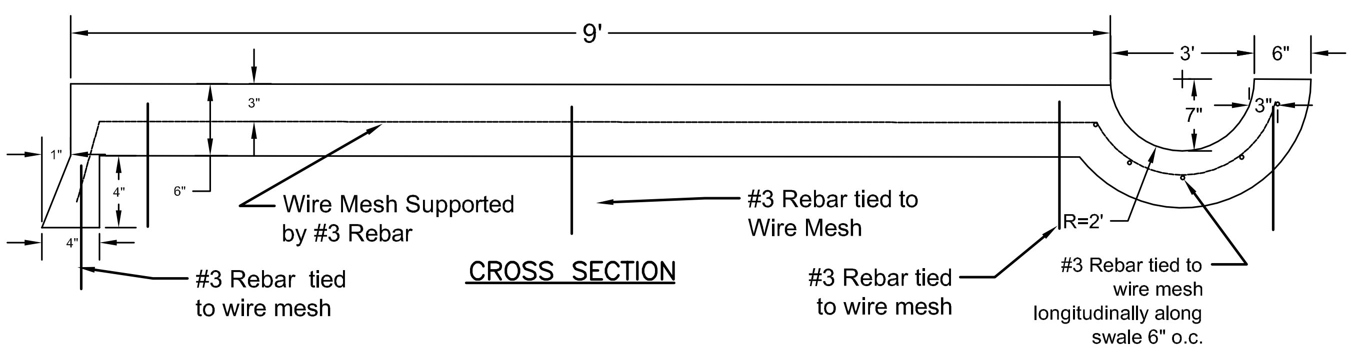
Concrete Paving & Swale Details

Prepared for: **Coral Bay Community Council** - *CBCC is a 501(c)(3) nonprofit organization* - Physical Address: **8-1 Emmaus St. John, VI 340-776-2099** Mailing Address: **9901 Emmaus St. John, VI 00830 cbcc@coralbaycommunitycouncil.com**	Date: 05-4-10	Drawn: J.A.M.	Checked: J.A.M.
	Project No: E-001-10	Sheet 1 of 4	
	Not To Scale		
Prepared by: **JAM Engineering Associates LLC** *Stormwater ∞ Civil Engineering ∞ Planning* Address: **1912 Koffel Rd. Hatfield, PA 19440 215-920-2985** Local Mailing Address: **9901 Emmaus St. John, VI 00830 www.jam-engineering.com**			



TYPICAL CONCRETE ROADWAY CROSS SECTION – Segments #2–#5

N.T.S.



CONCRETE PAVING DETAIL–Segments #2–#5

N.T.S.

Hansen Bay Road Improvements

Concrete Paving
&
Swale Details

Prepared for:
Coral Bay Community Council
- CBCC is a 501(c)(3) nonprofit organization -

Physical Address:
8-1 Emmaus
St. John, VI
340-776-2099

Mailing Address:
9901 Emmaus
St. John, VI 00830
cbcc@coralbaycommunitycouncil.com

Date: 05-11-10		Drawn: J.A.M.	Checked: J.A.M.
Project No: E-001-10		Sheet 2 of 4	
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Prepared by:
JAM Engineering Associates LLC
Stormwater ∞ Civil Engineering ∞ Planning

Address:
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Hatfield, PA 19440
215-920-2985

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St. John, VI 00830
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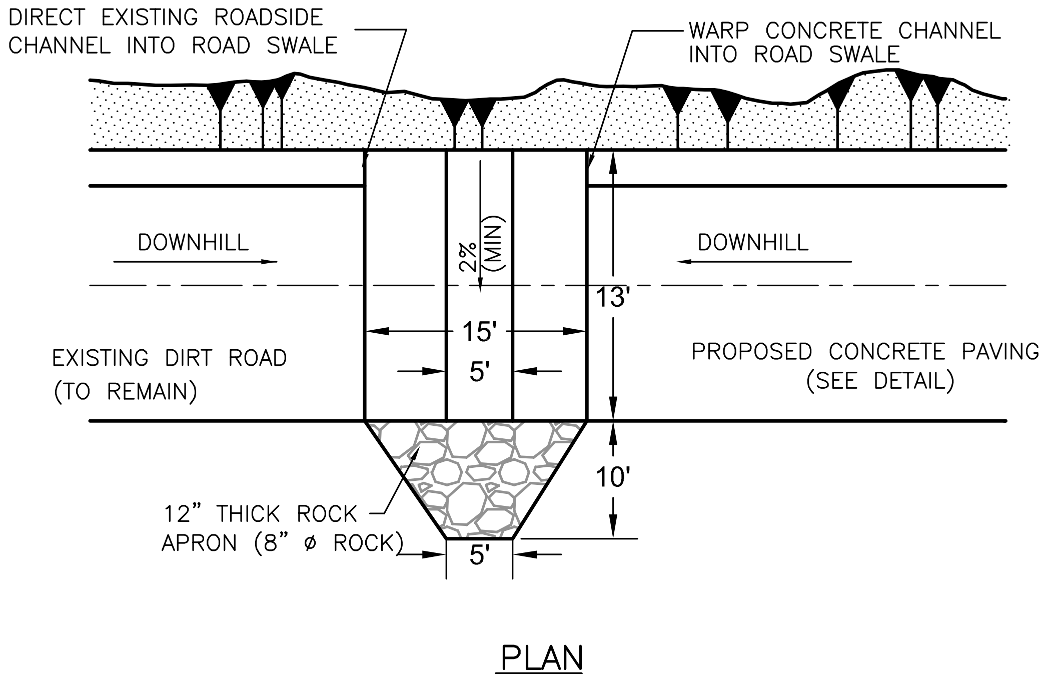
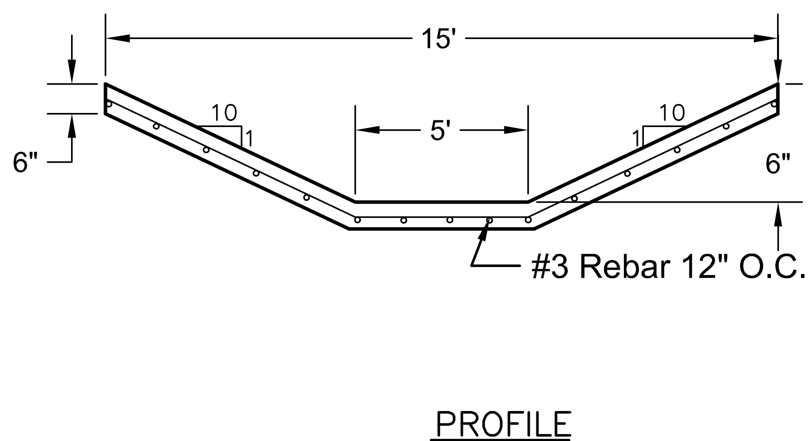




SWALE ACROSS ROAD DETAIL

N.T.S.

Hansen Bay Road Improvements	**Concrete Swale Across Road at POI A Details**

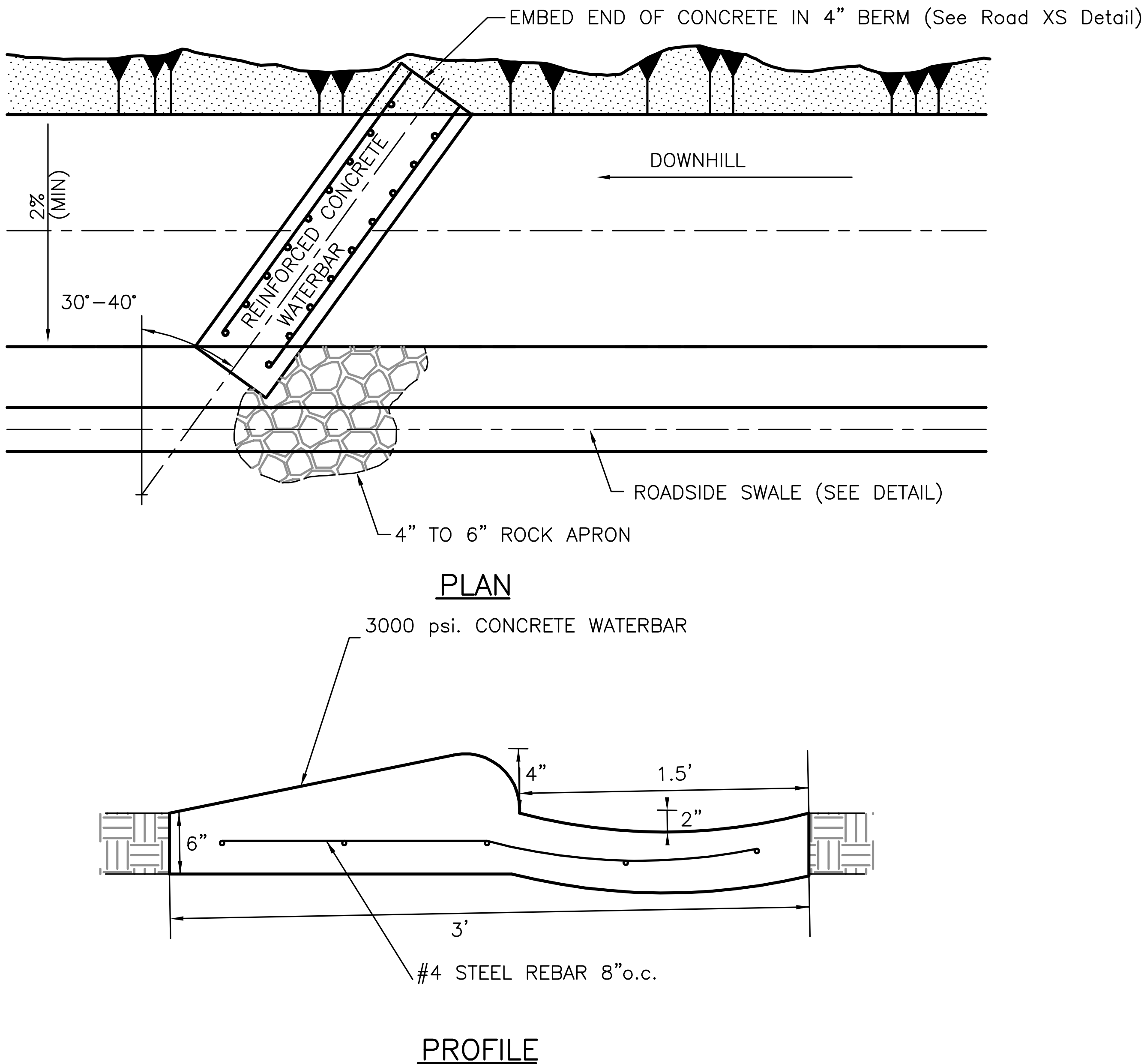
Prepared for:
Coral Bay Community Council
- CBCC is a 501(c)(3) nonprofit organization -

Physical Address:	Mailing Address:
8-1 Emmaus	**9901 Emmaus**
St. John, VI	**St. John, VI 00830**
340-776-2099	**cbcc@coralbaycommunitycouncil.com**

Date: 05-4-10	Drawn: J.A.M.	Checked: J.A.M.
Project No: E-001-10	Sheet 3 of 4	
Not To Scale		

Prepared by:
JAM Engineering Associates LLC
Stormwater ∞ Civil Engineering ∞ Planning

Address:	Local Mailing Address:
1912 Koffel Rd.	**9901 Emmaus**
Hatfield, PA 19440	**St. John, VI 00830**
215-920-2985	**www.jam-engineering.com**



REINFORCED CONCRETE WATERBAR DETAIL

N.T.S.

Hansen Bay Road Improvements	**Reinforced Concrete Waterbar Detail**

Prepared for: **Coral Bay Community Council** - CBCC is a 501(c)(3) nonprofit organization - Physical Address: **8-1 Emmaus St. John, VI 340-776-2099** Mailing Address: **9901 Emmaus St. John, VI 00830 cbcc@coralbaycommunitycouncil.com**	Date: 05-4-10	Drawn: J.A.M.	Checked: J.A.M.
	Project No: E-001-10	Sheet 4 of 4	
	Not To Scale		Prepared by: **JAM Engineering Associates LLC** *Stormwater ∞ Civil Engineering ∞ Planning* Address: **1912 Koffel Rd. Hatfield, PA 19440 215-920-2985** Local Mailing Address: **9901 Emmaus St. John, VI 00830 www.jam-engineering.com**

Erosion Control Blanket and TRM Installation Guide

General

Site Preparation (Channel and Slope) – Grade the surface of installation areas so that the ground is smooth and compact. When seeding prior to installation, prepare for seeding by loosening the top 2″ to 3″ of soil. All gullies, rills, and any other distrubed areas must be fine graded prior to installation. Spread seed before or after mat installation as directed. (**Important:** Remove all large rocks, dirt clods, stumps, roots, grass clumps, trash, and other obstructions from the soil surface to allow for intimate contact between the soil surface and the mat.)

Slopes

1. Anchor blankets 2′ to 3′ over the top of slope as in Fig. 1 or Fig. 2. Pin the mat at 1′ intervals along the anchor trench bottom.
2. Walking backward down the slope, allow the blanket to unroll slowly; ideally the blanket roll will rest against your shin as you walk. Place blankets loosely but without slack. The blanket must be in intimate contact with the soil to perform properly.
3. Staple blanket according to recommended staple pattern for specific product and slope. *(See staple pattern guide)*
4. Overlap blanket edges (side-to-side) approximately 3″ and staple according to Fig. 3. *Note: install blankets so edge overlaps are shingled away from prevailing winds.*
5. Overlap blanket ends 6″ (15 cm), with upper blanket over lower blanket, and staple at 1′ intervals (see Fig. 4 and Fig. 4A) across the width of the blanket.
6. Cut excess blanket with scissors and anchor at end of slope.
7. If installation plan specifies "check slot(s)", see Fig. 5.

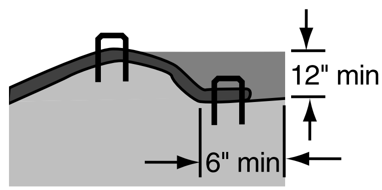


Fig 1

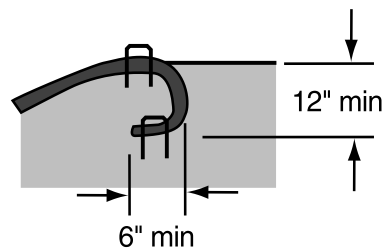


Fig 2

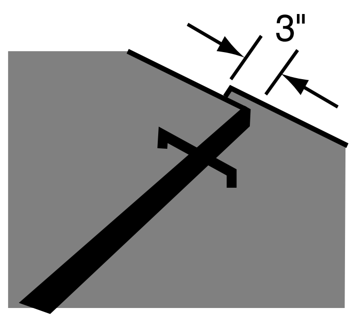


Fig 3

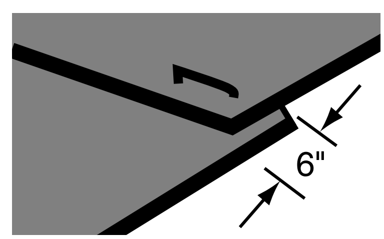


Fig 4

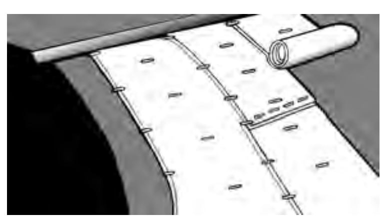


Fig 4A

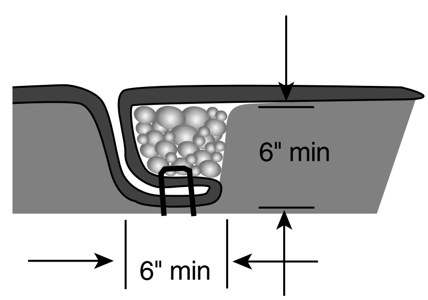
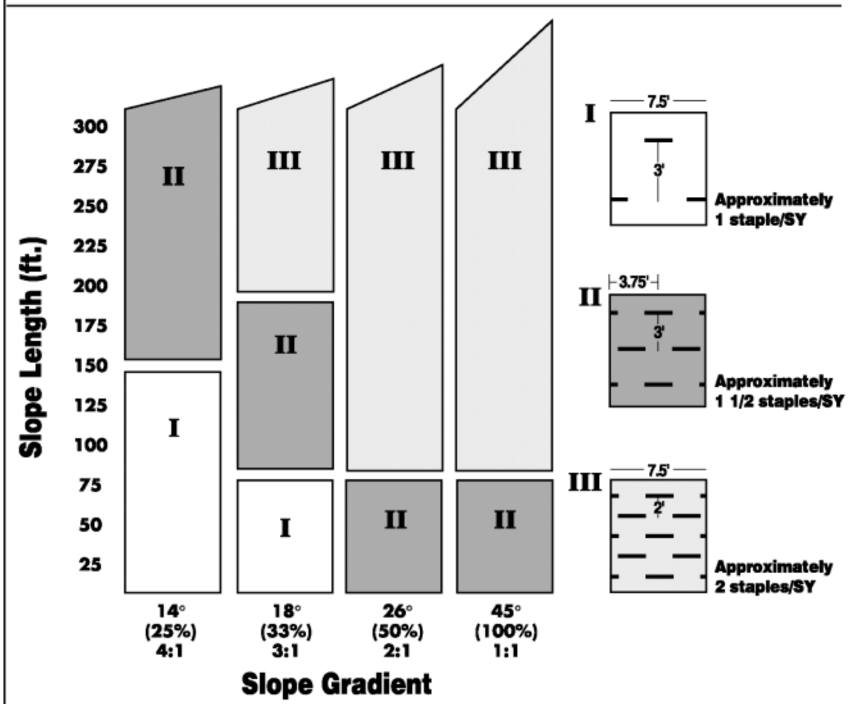


Fig 5

Channels

1. Excavate terminal trenches (minimum 12″ deep and 6″ wide) across the channel bottom at the upper and lower end of the lined channel sections. See Fig. 1.
2. Excavate longitudinal trenches (minimum 6″ deep by 6″ wide) along the channel edges (above the water line) in which to bury the outside blanket edges. See Fig. 2 Fig. or 3.
3. Place the first blanket at the downstream (D/S) end of the channel. Place the end of the blanket in the terminal trench and pin it at 1′ intervals across the blanket width in the bottom of the trench.
4. Once pinned and backfilled, the blanket is deployed by wrapping over the top of the trench and unrolling upstream (U/S). If the channel is wider than the provided rolls, place the ends of the adjacent rolls in the terminal trench, overlapping the adjacent rolls 3″ to 6″. Pin at 1′ intervals, backfill, and compact.
5. Unroll the blanket proceeding U/S and install check slots (minimum 6″ deep by 6″ wide) across the width of the channel on 30′ intervals. See Fig. 4.
6. To join roll ends within the channel bottom, excavate a check slot (minimum 6″ deep and 6″ wide) and place the end of the D/S blanket in the bottom of the check slot. Place the end of the U/S blanket over the D/S blanket and staple at 1′ intervals across the width of the blankets in the bottom of the check slot. Once pinned and backfilled, the U/S blanket is deployed by wrapping over the top of the trench and unrolling upstream (U/S). See Fig. 5.
7. For side channel slopes, intermittent check slots should be installed across the width of the channel at 30′ intervals and at the beginning and end of the channel. The top edge of the furthest side blanket should be placed in an anchor trench running longitudinal to the channel. See Fig. 2 or Fig. 3.
8. Ends of rolls on the side slopes should be lapped 10″ and shingled to the water flow. Pin using 3 rows of staple, with the rows spaced at 4″ and staggered, and staples at 1′ intervals across the roll width. See Fig. 6 and Fig. 6A.

CONTECH Staple Pattern Application Guideline[2]



1. Use 2 staples per square yard as a minimum staple pattern (see staple pattern III) for channel installations.
2. This table should be used as a general guideline, not as a design chart, and is not a guarantee of product performance. Actual blanket performance will vary widely due to extreme and diverse environmental factors. Contact your local CONTECH Sales Engineer for additional guidance.

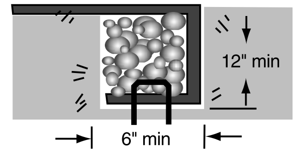


Fig 1

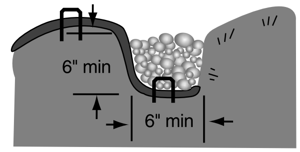


Fig 2

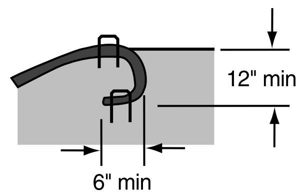


Fig 3

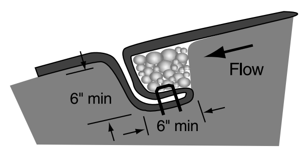


Fig 4

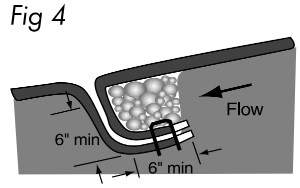


Fig 5

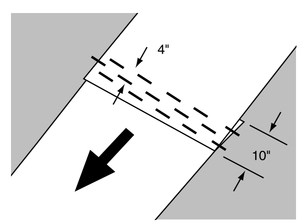


Fig 6

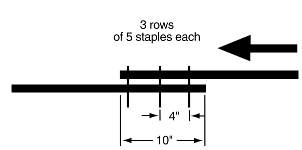


Fig 6A


East End Road
Route 10
SEGMENT #1
150 75 0 150 300
Feet
N
W
E
S
SEGMENT #2
B1
Hansen Bay Road
(Private Road)
POI B *
B2
SEGMENT #4
SEGMENT #3
POI A *
B3
PROPOSED SWALE ACROSS ROAD
1' Deep
5' Wide Bottom@2%Cross-Slope
10:1 Side-Slopes up to roadway.
A1
A2
SEGMENT #5
Prepared for:
Coral Bay Community Council
Prepared by:
Joseph A. Mina, P.E.
Roadway Improvement Location &
Drainage Area Plan
Hansen Bay Road
April 7, 2010
Project No: E-1
Sheet 1 of 1
Drawn by: JAM
Joseph A. Mina, P.E.
No. 1049E
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