# GUIDANCE FOR REDUCING THE IMPACT OF DIRT ROADS ON CULEBRA REEFS

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# Management Practices for Dirt Roads

The goal of this short document is to recommend general standards for dirt road construction, maintenance and retrofitting in Culebra, P.R. to minimize their impact on the nearshore marine environment. Also, this guide will provide the tools to minimize any additional construction and long-term maintenance costs. Dirt roads and bare soils transport sediments at a rate of 10 to 1000 times the natural transport rate from undisturbed hillslopes and forested areas (Ramos-Scharrón and MacDonald, 2007). Once transported to the coast, sediment can reduce the quality and abundance of coral reef and sea grass habitats important for marine turtles, juvenile fish and shellfish (Figures 1 and 2). In adopting this guidance an individual or corporation is helping protect the nearshore ecosystems, reducing their own long-term maintenance costs and helping protect Culebra's natural beauty, economy and ecosystems for future generations.

This document is intended to be a living document and refined as practices are improved and more detailed specifications developed; it is not intended to be used as an engineering guide for road building as this subject matter is handled more thoroughly but with less focus on green infrastructure by other resources including FAO (1998). This document is more about how to minimize sediment transport from areas with dirt

First, a few general principles should be kept in mind:

- **Water flowing on your road will destroy it, sending turbid runoff to coastal waters -** attempt to manage the water by having it shed from the road and safely conveyed across it
- **Minimize the overall footprint of dirt roads-** keep road widths to a minimum needed to convey expected road usage
- **Minimize the creation of additional bare and disturbed soil** in maintenance and construction activities
- **Use concrete in high use areas and on very steep slopes** to minimize sediment transport
- **Use sediment and erosion control practices in construction projects-** including practices such as silt fence and silt traps

roads. When larger drainage areas and stream and channel crossings come into play particularly with new construction; we recommend consulting with a firm and contractors experienced in watershed engineering/ hydrology and construction. However, the vast majority of unpaved road building, management and maintenance are in small drainages, subdivision roads, driveways, road extensions and already built dirt roads particularly in areas such as Culebra (Figure 3).

**Figure 1.** Coral reef impacted by heavy sedimentation. Photo Credit: Dan Derret

**Figure 2.**Healthy Coral Reef in Culebra. Photo Credit CESAM: Alfredo Montanez

## Document Organization

This document begins with a summary of a series of practices for reducing flow and erosion from dirt roads including: 1) Diversion Practices and 2) Flow and Erosion Reduction Practices. The document next reviews several dirt road management scenarios including road grading and ditching scenarios; 3) Example Management Scenarios for

Dirt Roads**.** The scenarios are intended to help establish a practical set of recommendations for sites but each site will have its own unique characteristics. Finally the document provides some guidance for maintenance (4) General Recommendations for the Maintenance of Dirt Roads; in order to provide tips for effective operation and maintenance of practices. Finally, though not comprehensive, a number of design specifications from other successful projects are contained in Appendix I.

**Figure 3.** Existing dirt roads layer for Culebra (Sturm, Viqueira and Meyer, 2014)

# 1- Diversion Practices

Diversion practices are used to remove water from a road surface as flow on a road surface can destroy the integrity of the road – especially an unpaved road.

There are a number of effective practices and designs for removing water from road surfaces – here we discuss a few that are commonly used.

## Concrete or Earthen Water Bar

A concrete or earthen water bar is a type of diversion practice meant to take water off a road in small increments – these can be constructed from concrete or earthen materials on roads that have less usage. Generally they should be constructed at a 30-degree angle and should be sloped 1 to 5% to promote drainage and reduce clogging. There are a number of designs for these types of structures and Figure 4 shows an example under construction.


**Figure 4.** Example of a concrete or earthen water bar under construction in Culebra (based on NYSF, 2011)

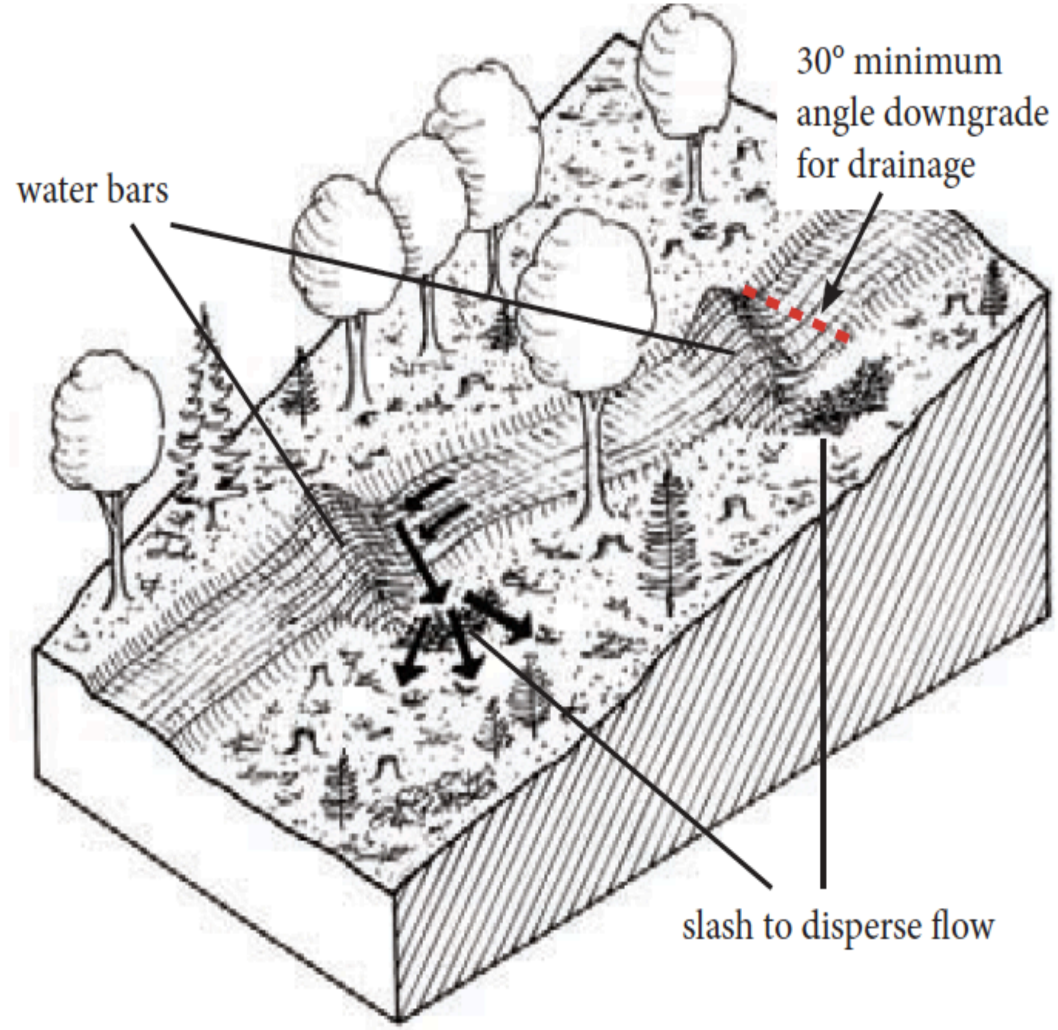


**Figure 5.** Illustration of Water Bars (NYSF, 2011)

### Rolling Dips

Rolling dips are another tool used to push water off a road surface. Due to their width, rolling dips are generally used up to a 15% slope. Figure 6 shows a cross-sectional view of a rolling dip. Rolling dips should be made of less erosive soils (clays and gravels) and compacted to help minimize erosion. Water conveyance from the rolling dips can be conveyed to a vetiver or rip-rap outlet (see further info in this document). They do not need to be angled like a water bar.

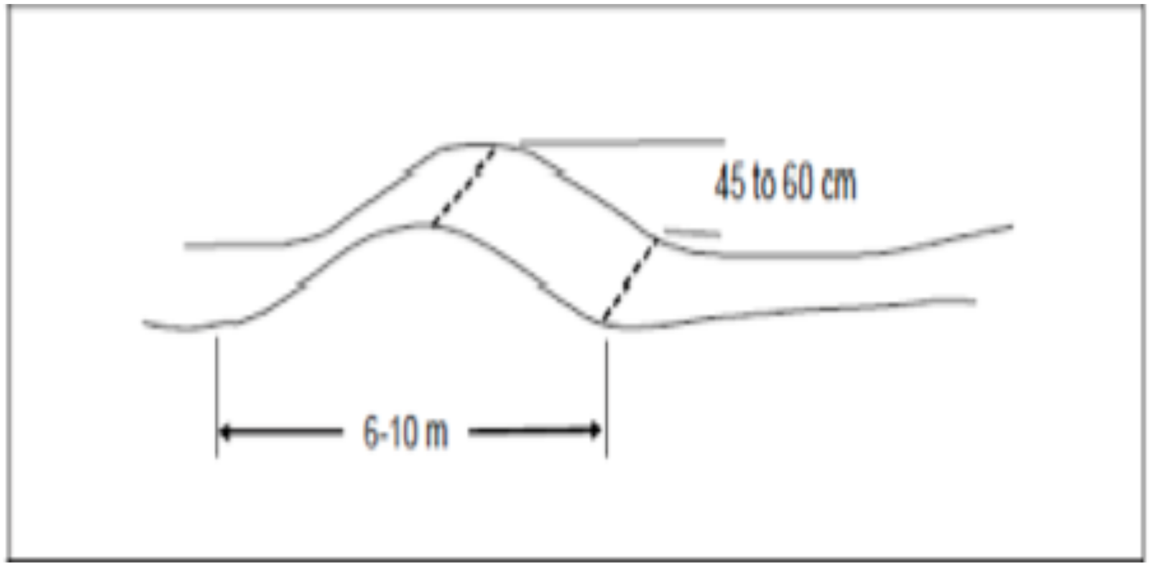


**Figure 6.** Cross Sectional view of a rolling dip (QDERM,2010a)

## 2- Flow and Erosion Reduction Practices

Flow and erosion reduction practices slow down flow and help trap sediment. The practices also serve to better distribute and decentralize flow so that it is less erosive and flows more as sheet flow to the next practice, vegetated area or downstream channel.

### Vetiver or Rock Check Dams

Vetiver and rock check dams are used to attenuate the flow of water in road side ditches they help to reduce erosive velocities and trap sediment (Figure 7). The challenge with stone check dams is that they are harder to maintain as sediment can often become trapped within the stones themselves. Vetiver can accommodate sediment deposition better than stone as it continues to grow even as sediment is deposited behind it. Another option where there is limited subsoil is to accentuate the deposition of soil with rock check dams and plant vetiver in front of the check dam. Ultimately the vetiver will become a living check dam.

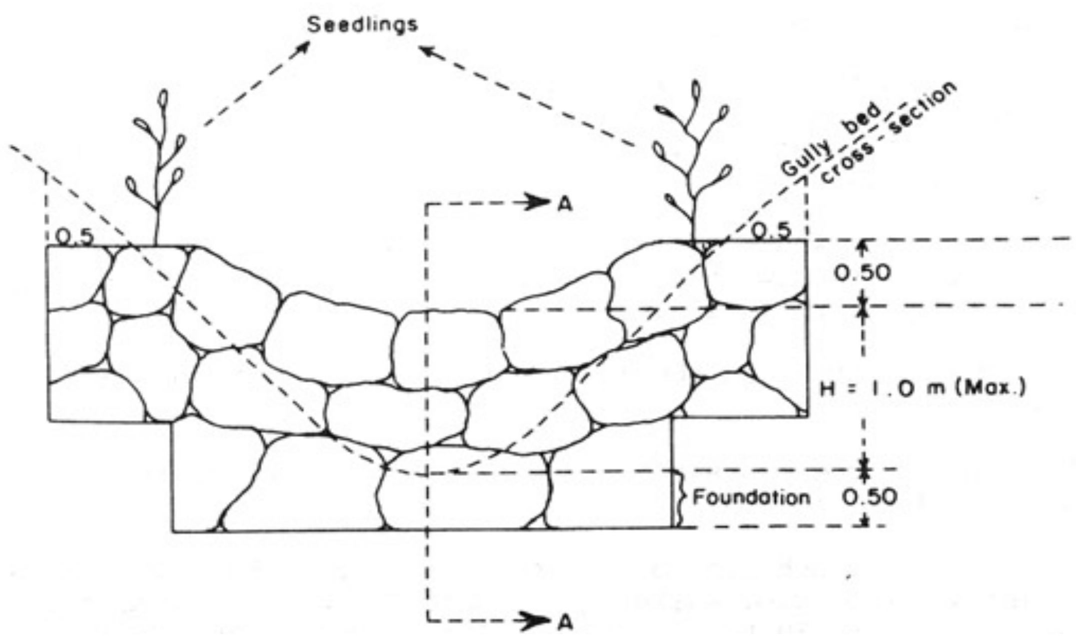



**Figure 7.** Vetiver checkdam (above); and stone check dam (below) (FAO, 1998)

## Vetiver Outlets

Vetiver outlets are constructed to reduce flow velocities, trap sediment and promote infiltration (as vetiver roots grow up to 3 meters deep in the soil and penetrate poor soils). Where shade is present and could impact the growth of vetiver plants, tree limbs should be pruned to allow for vetiver to be established strongly. Figure 8 shows an example of a vetiver outlet. A similar structure can be made solely from vetiver particularly if more mature plants are used. The structures should be concave in order to provide space for the runoff and attenuation.

**Figure 8.** Vetiver outlet (rip rap aids to reduce flow velocities as do the vetiver plants as they mature) (Vetiver outlet for the Mosquito Bay Project in Vieques)

## Rip Rap Outlets

Rip rap outlets are created to reduce velocities and spread out flow in vegetated areas or into a stream channel. This practice should be used combined with diversion practices, road crossing practices and any time concentrated flow is going to be outlet to a vegetated area or channel. The schematic in Figure 9 shows the plan view and cross-sectional view of the practice.

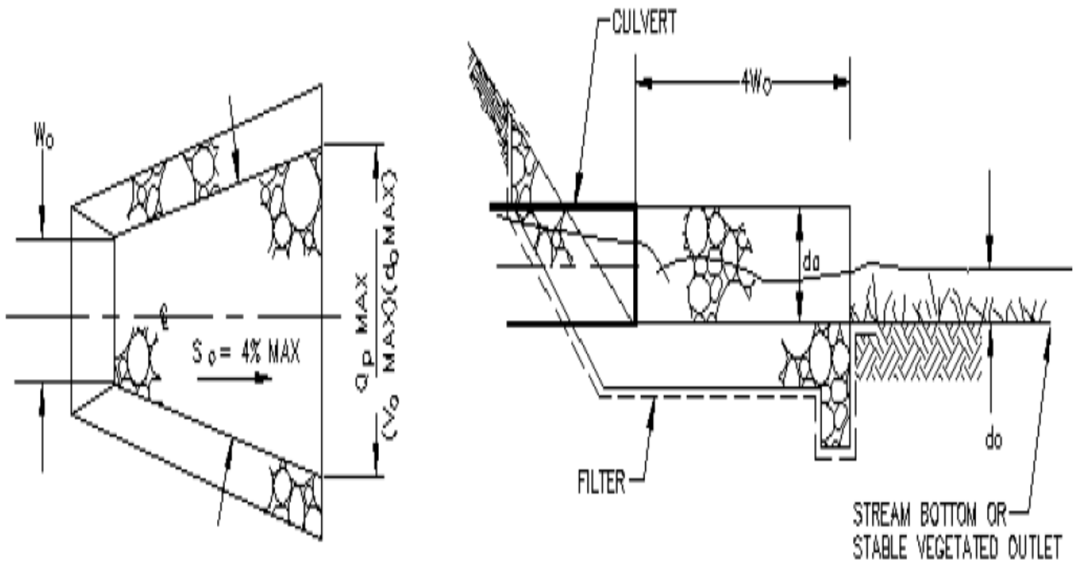


**Figure 9.** A rip-rap outlet structure acts to reduce flow velocity when outlet to a stream or vegetated area

## Bare Soil Stabilization

Bare soil stabilization should be considered after clearing and grading and after road maintenance activities. Examples include planting bahia, rye or bermuda seeds. Straw or another cover should be placed over the seeding to help preserve moisture and daily watering is recommended especially for the first several weeks to promote reestablishment of vegetation. Hydroseeding is another option but can be expensive for small areas due to mobilization costs.

# 3- Example Management Scenarios for Dirt Roads

### Scenario #1: Road runs uphill or downhill

Scenario #1 (Figure 10 adapted from QDERM, 2010a) is where the road is running in the same direction as flow – the road is going uphill or downhill – depending on your perspective. Flow will move down the road as well as across the road where the road bisects flow paths. The goal is to remove water from the road frequently and distribute that flow back to natural vegetation in a non-erosive manner and provide outlet for the water where it will not simply gather and re-cross the road (see Figure 11). Water diversions (including rolling dips, earthen or concrete water bars can be installed at the frequency proposed in Table 1 – from roughly 9 meter separation at 30% slopes to 70 meter spacing at 2% slopes.

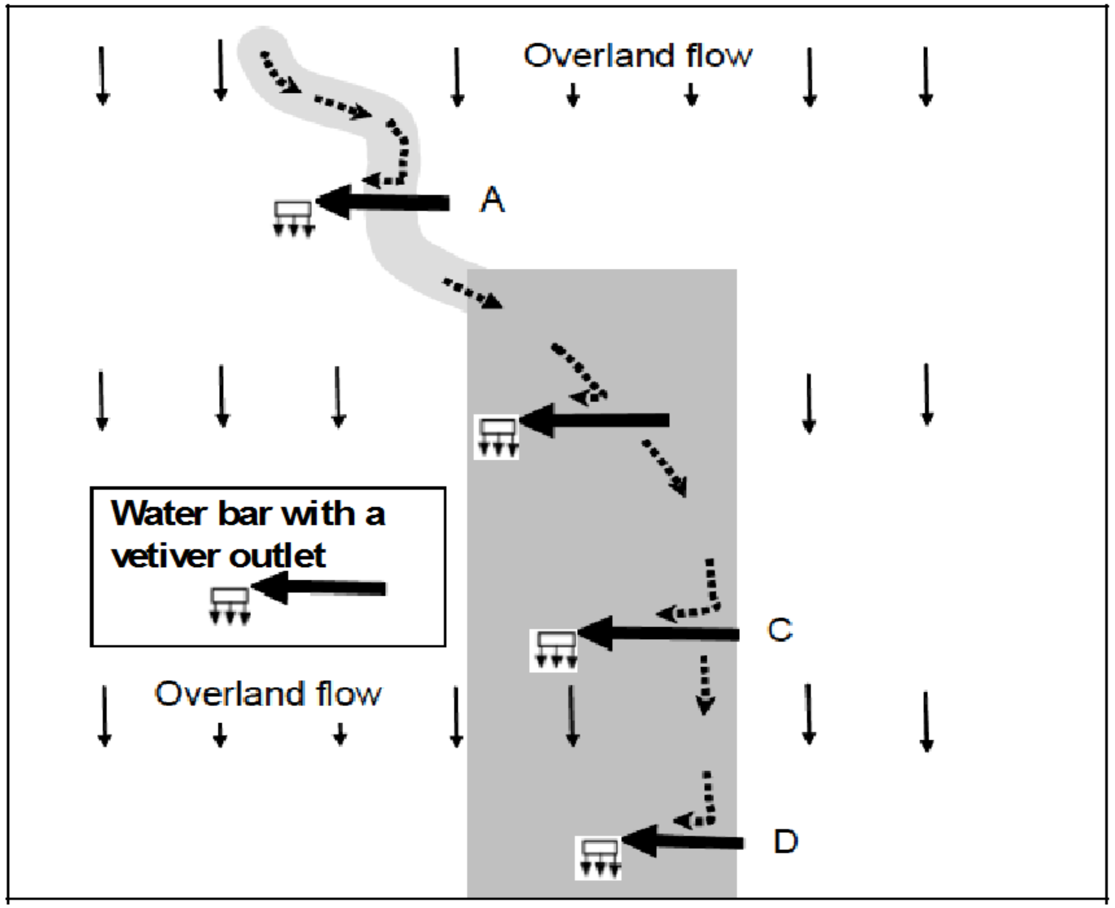


**Figure 10.** Using diversions (concrete or earthen water bar or rolling dip) to convey flow off and across the road surface—vetiver outlets are used to convey the flow back to the land and minimize erosion (QDERM, 2010a)

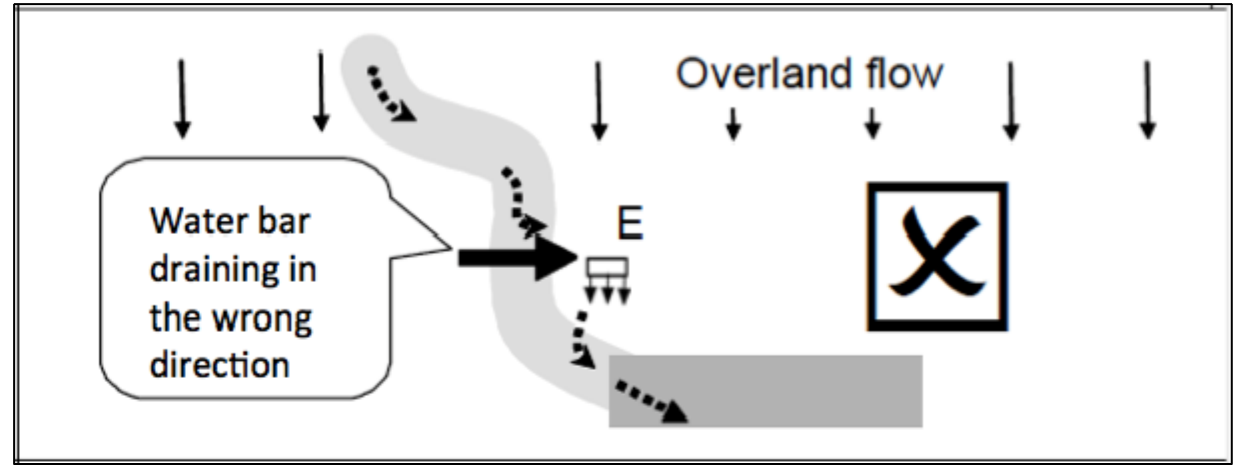


**Figure 11.** Incorrect drainage using water bar and vetiver outlet – flow returns to road surface (QDERM, 2010a)

Table 1. Spacing of water bars on dirt roads based on Slope (NYSF, 2001)

| Slope (%) | Spacing (ft) | Spacing (m) |
|---|---|---|
| 2% | 250 | 75 |
| 5% | 135 | 40 |
| 10% | 80 | 25 |
| 15% | 60 | 20 |
| 20% | 45 | 14 |
| 25% | 30 | 9 |
| 30% | 30 | 9 |

*>30% Slope consider using two track concrete or narrow concrete surface or realigning road*

## Scenario #2: Road runs across a slope

Scenario #2 is where the road runs across a slope and roughly perpendicular to the flow (Figure 12). In this scenario, the road is intercepting overland flow as well as flow generating from the road surface itself – again the goal is to get water off the road quickly via diversions (as in Table 1) and also to convey the overland flow safely across the road safely. Water can be conveyed safely across the road in a culvert or concrete swale or in the case of when the road is near the top of a hill the road can be sloped to allow water to sheet flow across it or into the water bars and vetiver outlets or stone rip rap outlets (see practices). Flow should be outlet to a natural channel or vetiver outlet after velocity dissipation. In this scenario water is also conveyed along the front edge of the road non-erosively with vetiver or riprap check dams.

In this scenario, three options exist for the road surfacing (Figure 13 and 14); 1) a convex road to shed water to both sides (optimal), a road which sheds slightly to the downhill side (can be problematic if the surface when wet is slippery); 3) road sloped toward the inside of the road (less optimal -generates roughly twice the runoff from the road surface).

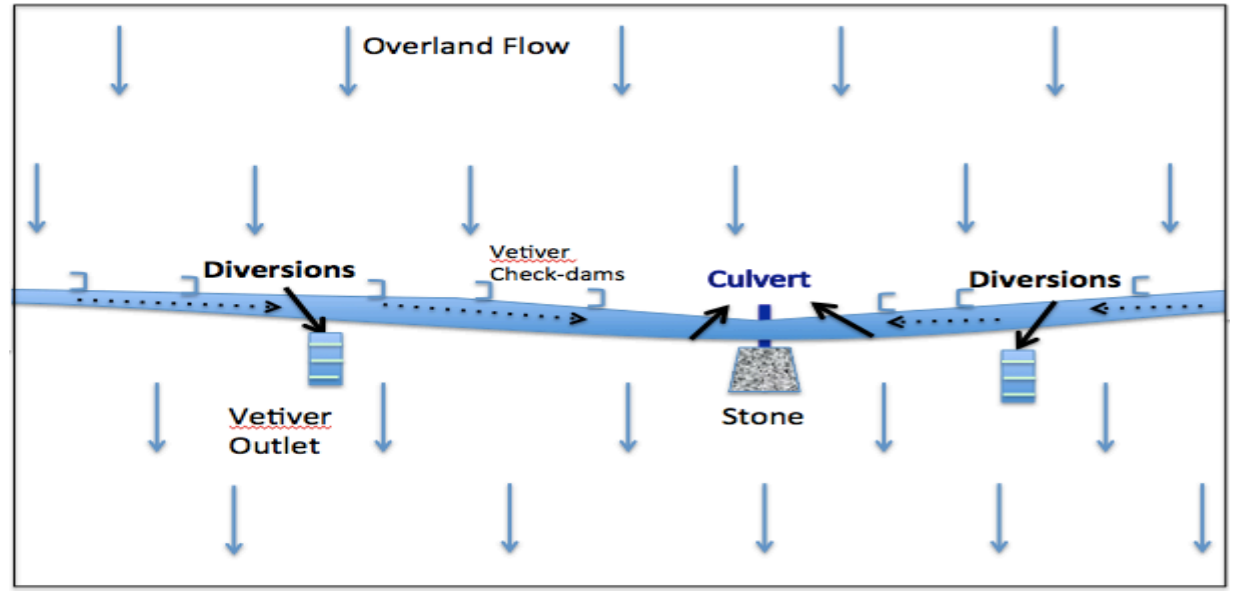


**Figure 12.** Road running across a slope with a natural drainage – In this case – diversions are used as well as a culvert with a rip rap outlet pad to reduce erosion (**Note**- two diversions are used at the bottom of the hill in order to contain runoff which could create headcutting into the road section)

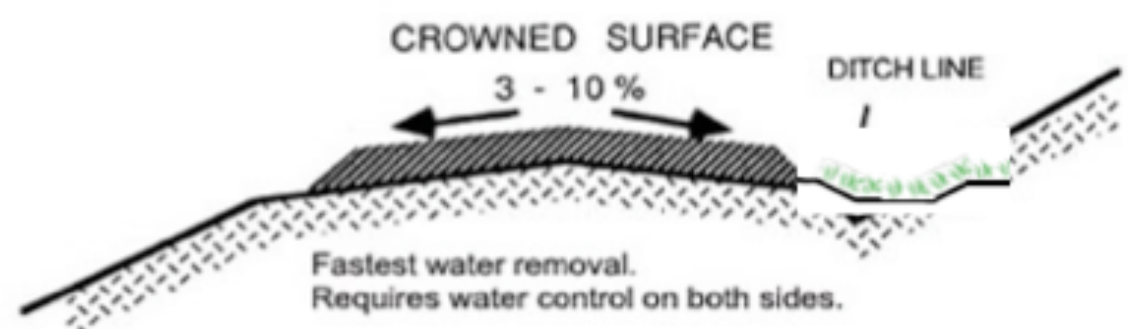


**Figure 13:** *Option 1*: Road is Crowned – channel is grassed with vetiver check dams (Schematic adapted from FAO, 1998)

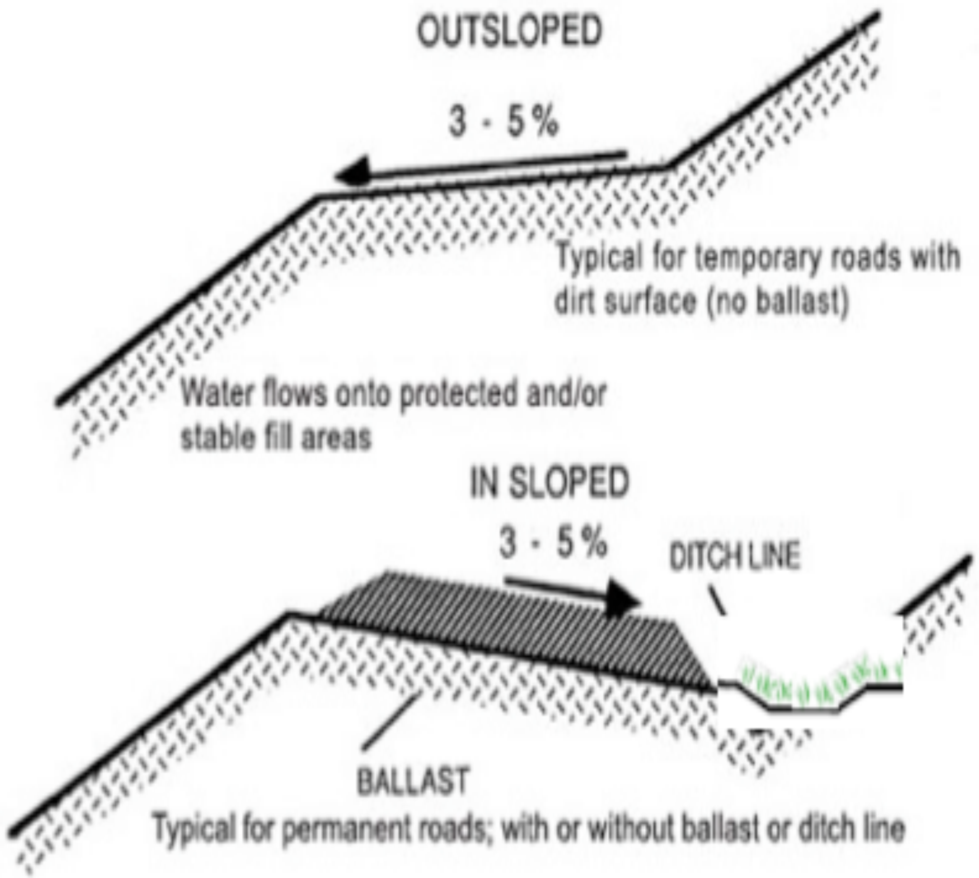


**Figure 14:** *Option 2 and 3*: Road slopes to the outside; or inside and channel is grassed with vetiver check dams (note ditches should be u shaped where possible) (Schematic adapted from FAO, 1998)

# 4- General Recommendations for the Maintenance of Dirt Roads

Maintenance is one of the most important aspects of dirt road management but is often not practiced frequently enough. Proper maintenance is critical to minimize damage to dirt roads, minimize long-term costs and to prevent the loss of sediment to the nearshore habitats including coral reefs and sea grasses.

## Goals of Maintenance

1- Minimize flow on the roads, distribute runoff in as small and discrete amounts as possible;

2- Distribute flow to areas of natural vegetation and areas with flat or lower slope;

3- Minimize exposure and disruption of bare soils to avoid conveying flow on bare soils or recently exposed soils.

## Frequency

- Maintenance/ Maintenance Assessment should occur with trained person 3 times per year (2X rainy season) July or August, October 15th, and one time in the dry season March 15th.
- Assessment to be performed and work conducted with the supervision of the trained assessor.

- Where practical, especially when practices have been built correctly -- hand labor should be used over machinery as large machinery creates additional impact by dislodging sediment.

## Maintenance of Various Practices

- **Vetiver or Stone Check Dams** -- when half full of sediment need to be cleaned out -- consists of 1) scooping dirt from in front of them 2) scooping out the rock with deposited sediment 3) putting in fresh stone or just replacing the stones after removing the sediment
- **Cross Drains** -- ensure conveyance across the road is clear and functioning
- **Rock Outlet Protection** -- adequate coverage of rock below pipe or other outlet -- check for downstream erosion below the protection
- **Minimize exposure** of new bare soil as much as possible consider seeding and watering for stabilization (techniques are referenced earlier in the document)

# Appendix I: Example Specifications

The intention is to provide specific details and specification examples where available and as a result it is not complete as generally these modifications and practices are often implemented informally and not through a series of specifications.

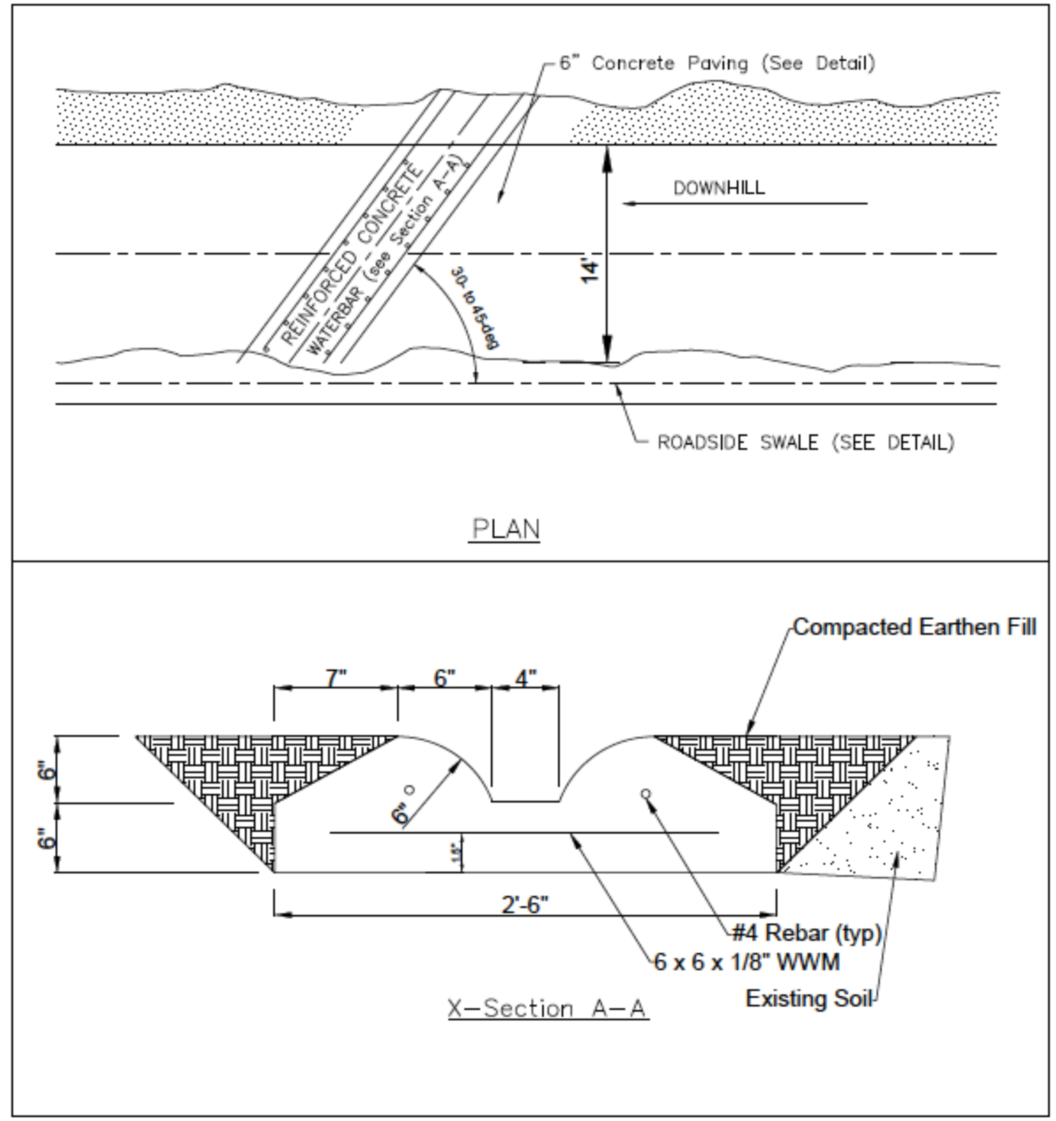


**Figure 12.** Concrete Swale (Coral Bay Community Council)

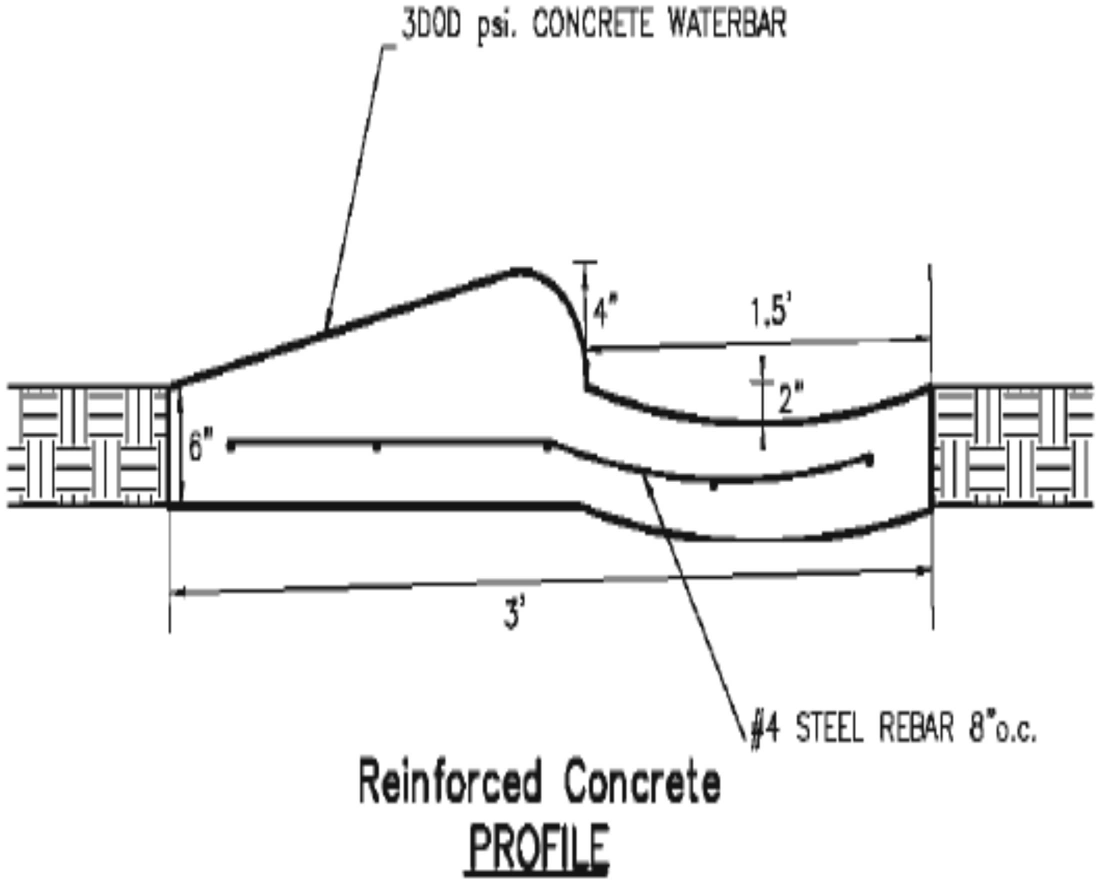


**Figure 13.** Concrete swale (for when drainage channels begin above the elevation of the road and must cross it perpendicularly)

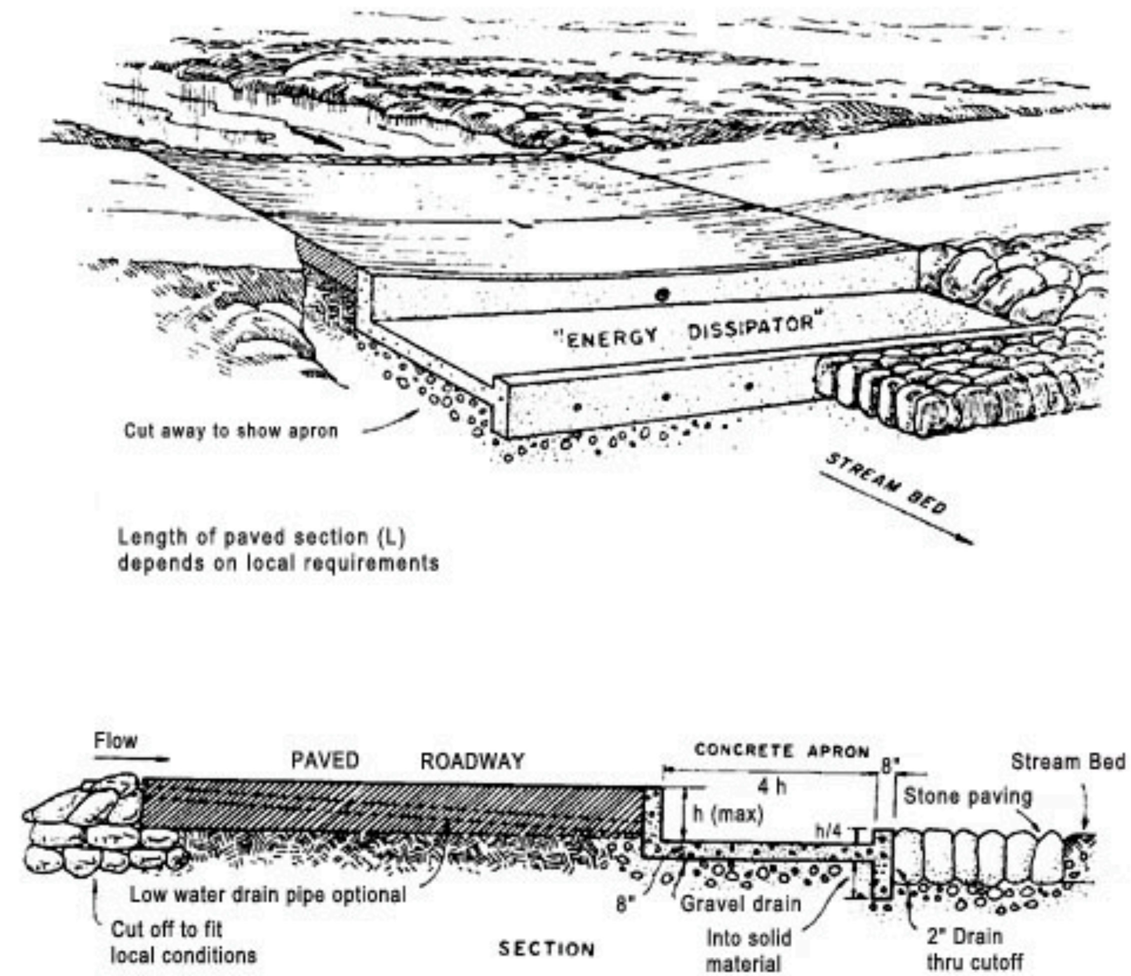


**Figure 14.** Concrete swale for where there is already intermittent concentrated channel above a road and flow is primarily during wet weather (FAO, 1998)

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