US Fish and Wildlife-Caribbean Region
Final Project Report

Project Name: **Erosion Control Strategy for the Fish Bay Watershed**

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1) SUMMARY

This project relied on the results of a Geographical Information System tool (STJ-EROS) to develop and implement an erosion control strategy in the 6.0 km^2 Fish Bay Watershed in St. John, USVI. The objective of the project was to improve the condition of the nearby Fish Bay coral reefs and sea grass beds by reducing sediment loads through the application of erosion control Best Management Practices (BMPs) on the Fish Bay watershed. Through a still continuing information dissemination campaign we are encouraging the development of similar strategies elsewhere in St. John, the US Virgin Islands Territory, and throughout the rest of the Caribbean Region.

2) INTRODUCTION

The main goal of this project was to improve the condition of coral reefs and seagrass beds in Fish Bay by reducing sediment loads through the application of erosion control Best Management Practices (BMP) on the Fish Bay watershed. The fast pace of land development observed throughout the U.S. Virgin Islands Territory over the past several decades has resulted in increased sediment yield rates into coastal waters and this has had detrimental effects on the quality of its marine resources (MacDonald et al., 1997; Jeffreys et al., 2005). Fish Bay (FB) on the southern portions of St. John exemplifies the type of impact that high rates of unchecked land-based erosion may have on marine habitats. The poor quality of the marine environment in FB is in sharp contrast to other nearby bays along the southern shores of St. John that receive discharge from less developed watersheds. Experts agree that increased erosion associated to the unpaved road network and land development occurring on the FB watershed is responsible for its deteriorated condition (Anderson and MacDonald, 1998; Nemeth et al., 2001; Ramos-Scharrón and MacDonald, 2007a).

The poor water quality conditions in FB are currently controlled by a number of factors. First, it is important to recognize the fast pace of development that the FB watershed has experienced over the last three decades. The sediment being delivered by the Main Fish Bay Gut over a long time period has created a depositional delta that extends seaward towards the deeper sections of Fish Bay. Studies conducted in the 1980's showed that the deposits on the bay bottom in close proximity to the gut outlet contained up to 55% of terrigenous material, and this was in sharp contrast to bays receiving drainage from less impacted watersheds such as Reef Bay and Hawksnest Bay where surface sediments generally contained less than 10-15% of terrigenous material (Hubbard, 1987). The settled sediment ranged in texture from coarse sands close to the Main Fish Bay Gut outlet to very fine sand on the deeper central portion of the bay. This sediment is believed to be commonly re-incorporated into the water column during high wave energy periods and is responsible for the poor water quality of Fish Bay during dry conditions.

Secondly, the Fish Bay basin contains different types of active sources that contribute sediment into the marine environment. Of special interest for the purposes of this project are those sources associated to anthropogenic activities. Among the types of land use practices that are considered to be important sediment sources in the Fish Bay basin are land clearing and vegetation removal associated to home construction, a rock crushing and construction material storage site on the upper portions of the Fish Bay basin, and activities associated to road construction and maintenance. Even though our watershed analyses and erosion control strategy focused on the unpaved road network, we recognize the potential importance of the other two land use activities in delivering sediment into Fish Bay. While an individual homesite-development might not appear to contribute large quantities of sediment, its importance for basin-scale sediment yields should not be ignored given that this type of activity has occurred over several decades and is still continuously occurring within the Fish Bay basin.

Previous research on St. John has shown that unpaved roads may erode up to 10,000 times faster than erosion rates on undisturbed hillslopes, and that they are currently a dominant source of the terrestrial sediment entering Fish Bay (Ramos-Scharrón and MacDonald, 2005, 2007b). STJ-EROS results showed that sediment pollution from unpaved roads in Fish Bay is truly a non-point source problem in that significant portions of the sediment that reaches the marine environment originate from various road segments located throughout the entire watershed.

The specific objectives of the study were to:

a) Conduct a GIS sediment budget analysis to identify the most important sediment sources within the Fish Bay watershed;

b) Develop, implement, and evaluate the effectiveness of sediment control BMPs in Fish Bay by collaborating with community members, land managers, and local experts; and

c) Promote the use of similar BMPs in other priority sites in Fish Bay and elsewhere in the USVI by conducting an aggressive dissemination strategy that includes both promotion of the goals of sediment control and demonstration of the value of using these GIS planning models to achieve the highest impacts at least cost.

3) EROSION ASSESSMENT OF THE FISH BAY WATERSHED

BRIEF INTRODUCTION TO THE STJ-EROS GIS ANALYTICAL MODEL

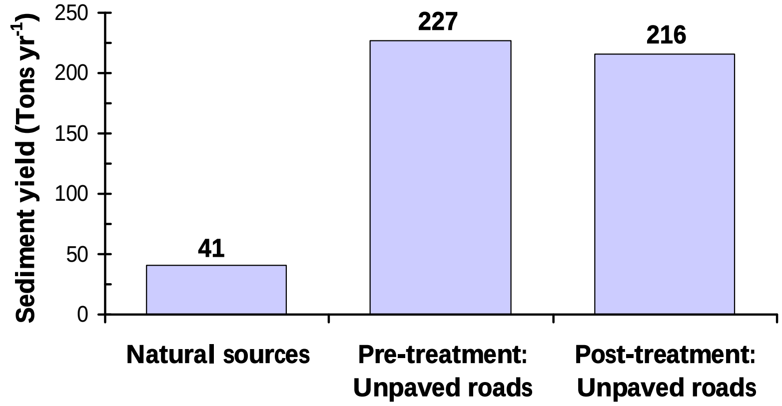
STJ-EROS is a Geographical Information System model that uses empirical sediment production functions and sediment delivery ratios to quantify watershed-scale sediment yields (Ramos-Scharrón, 2004; Ramos-Scharrón and MacDonald, 2007a). The program consists of six input routines and five routines to calculate sediment production and delivery. The input routines have interfaces that allow the user to adjust the key variables that control sediment production and delivery. The other five routines use pre-set erosion rate constants, user-defined variables, and values from nine data layers to calculate watershed-scale sediment yields from unpaved road travelways, road cutslopes, streambanks, treethrow, and undisturbed hillslopes. STJ-EROS estimates sediment production rates from each of these five landscape units using empirical equations that were developed from data collected in St. John between 1998 and 2000 (Ramos-Scharrón, 2004). In STJ-EROS, the estimated rate at which terrestrial sediment is transferred to coastal waters is controlled by user-defined sediment delivery ratios (SDRs), where SDR is the ratio of sediment delivery to the gross erosion in the basin. In STJ-EROS the program allows users to choose SDR values ranging from 50% to 100% for areas with a high sediment delivery potential. These are areas that drain directly to the sea without an intervening coastal wetland or salt pond. SDRs for areas draining into coastal wetlands are assumed to range from 0% to 50%, and these catchments are defined as having a moderate potential for sediment delivery. Catchments that drain to a wetland or pond without any surface pathway to the marine environment are assumed to have a SDR of zero.

MODEL RESULTS

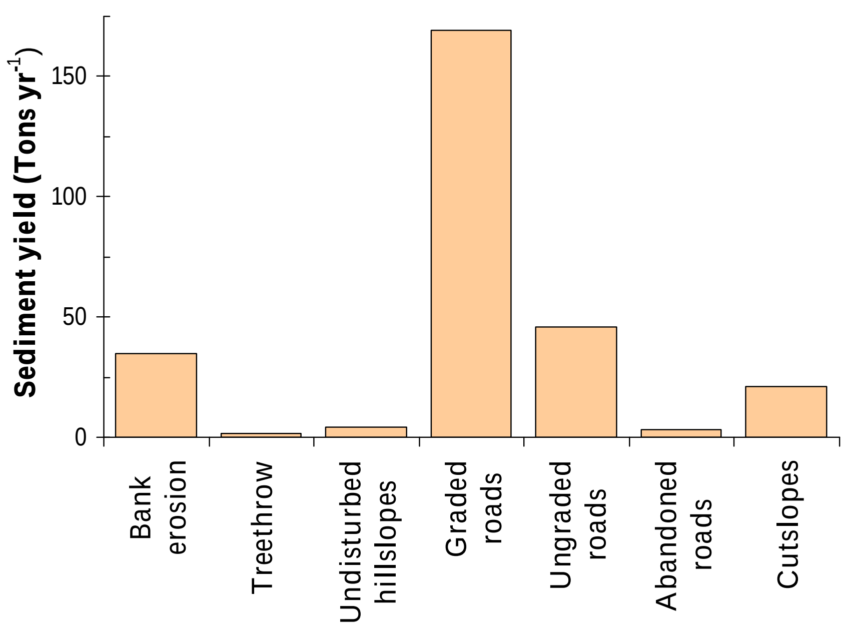
STJ-EROS was applied to the Fish Bay Watershed using an updated geo-database developed during the initial phases of this project. Model application assumed an average rainfall rate of 115 cm and SDR values of 25% and 75% for moderate and high sediment delivery potential areas, respectively. STJ-EROS estimated that current (2006) sediment yields into Fish Bay are 268 tons per year, and this is about seven times higher than background rates (Ramos-Scharrón and MacDonald, 2007a). Out of this total yield, unpaved roads appear to contribute about 227 tons yr^{-1} or almost 85% of all sediment reaching Fish Bay. The 2006 estimates are similar to those estimated for 1999 (275 tons per year). Actions taken by the local government and the Fish Bay Homeowners Association to control erosion had induced a 45 ton per year drop in sediment loads, but the recent proliferation of new roads have maintained sediment loading levels similar to those in 1999.

Only 11% of the roads in the Fish Bay watershed accounted for 60% of the total sediment yield. Most of these roads drain directly into Main Fish Bay Gut in the lower portion of the basin, or to the Battery Gut tributary in the upper portion of the basin. Streambanks and cutslopes are each responsible for roughly 10% of the annual sediment yield, while surface erosion from undisturbed areas, treethrow, and erosion from abandoned road surfaces each represent only 1% of the estimated sediment yield.

Graphical Displays of STJ-EROS Results

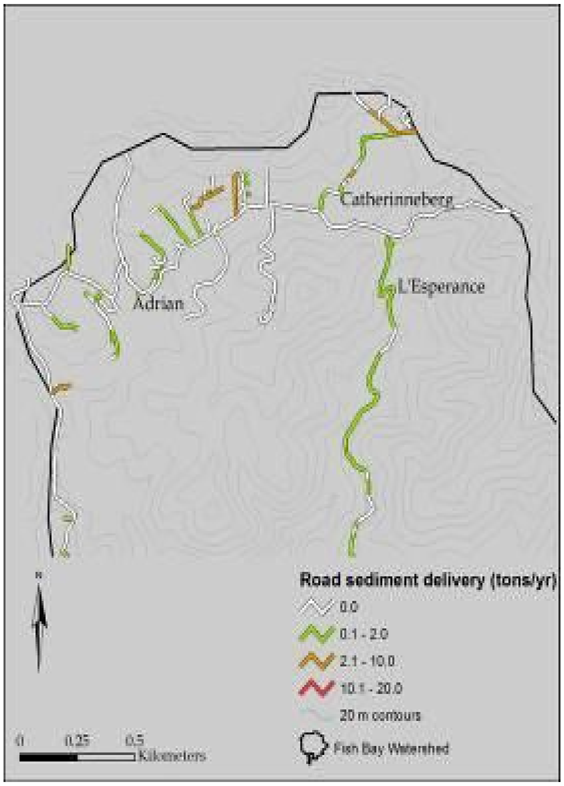


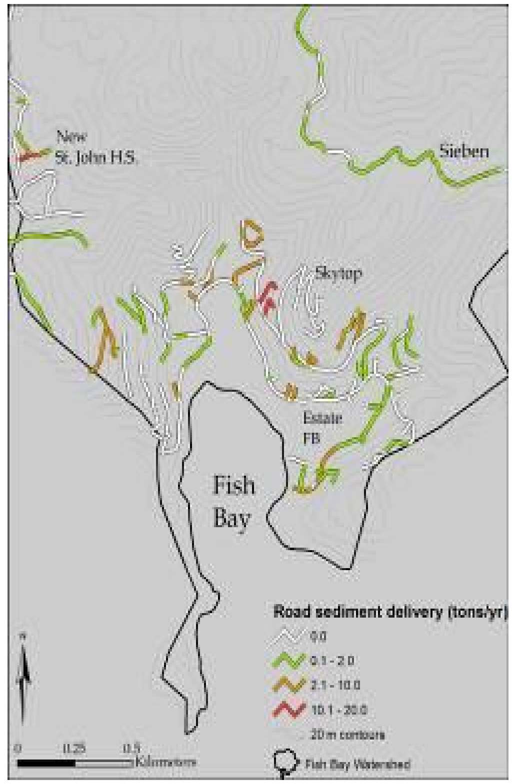
STJ-EROS estimated that the sediment loading rate into Fish Bay averaged about 268 tons of sediment per year before the implementation of the BMP's. Approximately 85% (227 tons yr^{-1}) of this sediment originated from the unpaved roads within the watershed. BMP implementation reduced sediment yields by 11 tons yr^{-1}.



Pre-BMP Implementation: *Recently graded roads (i.e., last graded or constructed within the last two years) are the single most important source of sediment within Fish Bay as they contribute about 60% of the estimated sediment yield or 169 tons yr^{-1}. Bank erosion represents the most important natural contributor of sediment into Fish Bay, contributing 35 tons of sediment every year.*

Pre-BMP Implementation: Fish Bay Watershed-STJEROS Map Results





These two maps represent some of the graphical outputs of STJ-EROS representing conditions existing prior to the installation of BMPs. The 4.2 km of unpaved roads in the upper FB Watershed (map shown on left) are responsible for about 41 tons of sediment that enter FB on an average year, and this is about 15% of the total sediment loading rate. The upper FB Watershed currently does not have any road segments producing sediment at rates exceeding 10 tons yr^{-1} (shown in red). Road segments producing sediment at rates ranging between 2-10 tons yr^{-1} (shown in orange) total 0.78 km and contribute about 19.5 tons of sediment every year, or 7% of the watershed sediment yield. Some of these road segments were the target of our erosion control methods. The 8.6 km of unpaved roads in the lower FB Watershed (map shown on right) contribute on average about 180 tons of sediment per year, and this is about 64% of the total estimated sediment delivery to FB. Road segments eroding at rates exceeding 10 tons yr^{-1} (shown in red) total 0.3 km in length and contribute 43 tons yr^{-1}, or 15% of the sediment reaching FB. Road segments producing sediment at rates ranging between 2-10 tons yr^{-1} (shown in orange) total 2.1 km and contribute 106 tons of sediment per year, or 38% of the watershed sediment yield. Some of these road segments eventually became the target of our erosion control methods.

PICTURES OF THE FISH BAY WATERSHED TAKEN SEPTEMBER 2006

Carlos Ramos-Scharrón prepares a sketch map of a road segment on the Upper Fish Bay basin (left). Kevel Lindsay observes the damage done on an unpaved road segment by erosion (right).

Road segment on Catherineberg Estate which eventually became a site for erosion control implementation (left). Jean-Pierre Bacle observes a steep, recently-constructed, unpaved driveway on Estate Fish Bay (right).

4) FINAL EROSION CONTROL PLAN

Erosion control practices were applied to 0.66 km of unpaved roads. Choice of the specific sites and BMPs used were based on our own expertise, consultations with representatives of the homeowner associations and the contractor, and the funds available. The chosen road segments were estimated to contribute about 16 tons of sediment to Fish Bay annually. Most BMPs applied to these road segments were meant to improve road drainage along roads. Improved drainage is expected to induce a reduction in sediment production rates by decreasing the shear stresses applied by flowing water over unsurfaced roads. In a similar study on the Maho Bay area of St. John, similar BMP's resulted in a reduction of sediment production rates to about a third of pre-treatment levels (Ramos-Scharrón, 2007). Assuming that the BMP's applied in Fish Bay had a similar effect in reducing road erosion rates we initially estimated that BMP application would result in a drop of about 11 tons of sediment to Fish Bay (pre-treatment: 16 tons yr^{-1}; Post-treatment: 5 tons yr^{-1}), so that post-treatment watershed-scale sediment yields would be reduced to 216 tons yr^{-1}. Our monitoring efforts were designed to verify this estimate.

Maps and brief descriptions of the BMPs applied to the four road segments are shown below.

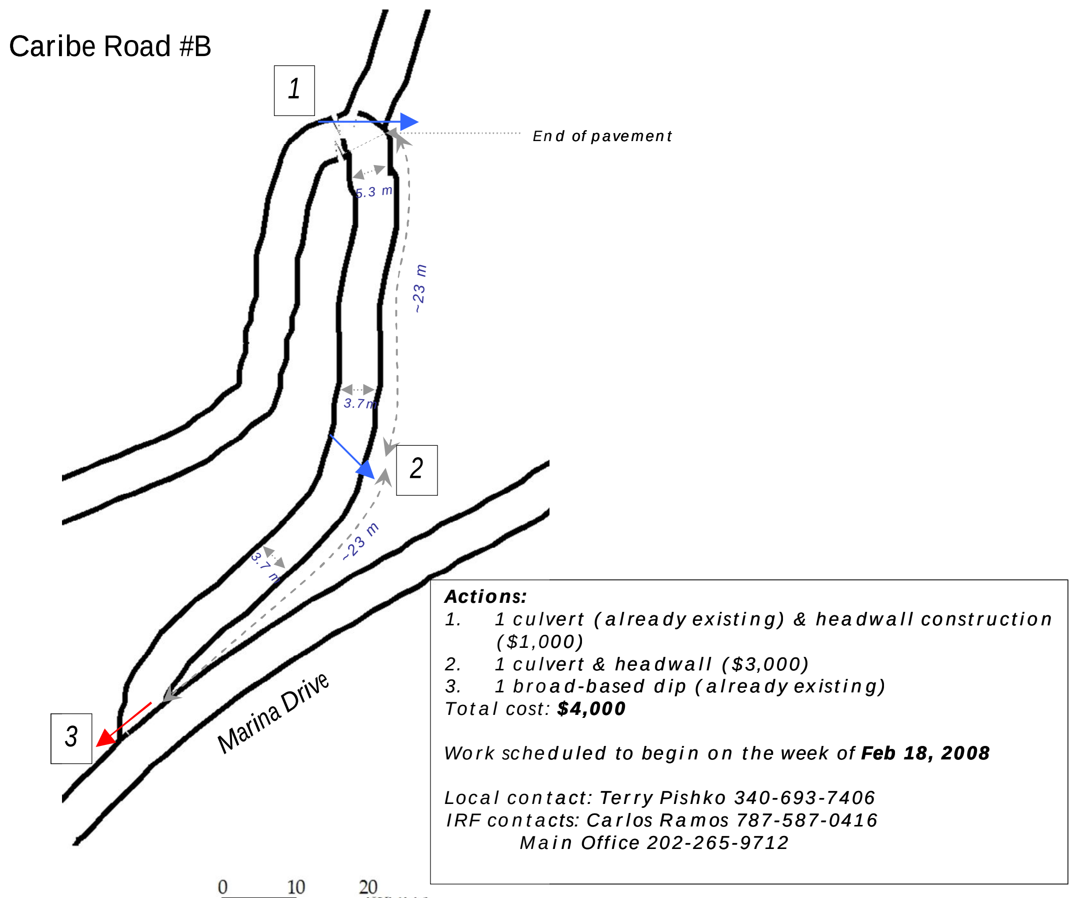
Meetings with members of the Fish Bay community.

Kevel Lindsay and Carlos Ramos discuss details of the erosion control plan with Terry and Chuck Pishko, president and road committee head for the Estate Fish Bay HO Association.

The IRF team discusses the Fish Bay erosion control plan with Bill Osbourne and Joel Black from the Catherineberg HO Association.

Caribe Road

Erosion control at this site concentrated on protecting the lowermost road section of Caribe road where it joins with Marina Drive (Between points 2 and 3 in sketch map below). This lowermost section showed heavy damage by erosion due to its steepness and to the large amount of runoff coming from the top sections. This road segment was also targeted because runoff and sediment produced from it has a high chance of becoming connected to the Main Fish Bay Gut, which lies roughly ten meters from Marina Drive. There were no appropriate locations to install erosion control measures right on this road section and we lacked the funds to provide pavement cover, therefore we opted to improve conditions by disconnecting this section by improving road drainage. We identified two opportunities to divert runoff at points 1 and 2 in the drawing below. Point 1 already had a culvert that was meant to collect runoff from the upper road sections, but the culvert entrance was clogged. Our actions included opening of the culvert entrance and building of a cemented ditch and headwall to promote runoff capture. At point 2, along a flat section of Caribe Road, we installed a new culvert with a headwall to further improve road drainage.



ROAD WORK ALONG CARIBE ROAD- ESTATE FISH BAY

New headwall on pre-existing culvert at Caribe Road (Point 1 in map).

New culverts installed at Caribe Road (Point 1 in map on the left; Point 2 on the right).

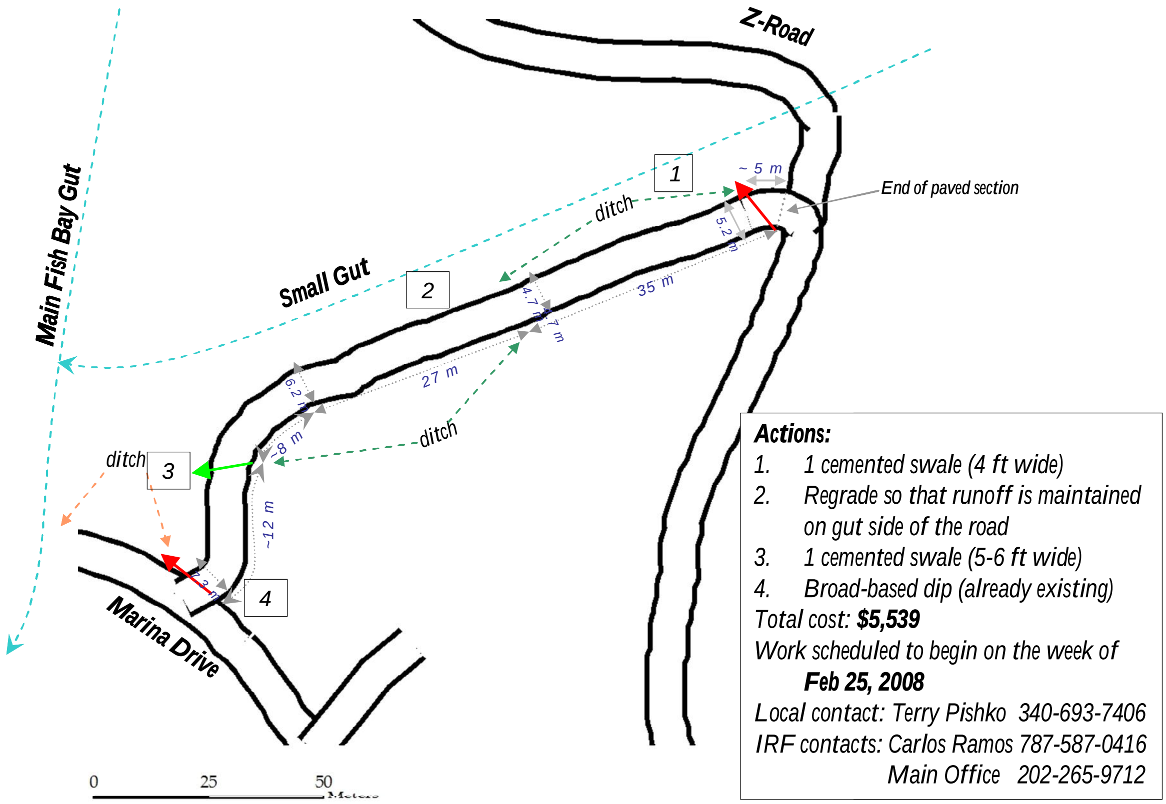
 

New headwall & culvert installed at Caribe Road (Point 2 in map).

Cocoloba Trail

Actions taken along Cocoloba Trail were meant to protect the section of road that joins Marina Drive. This road was a main concern with regards to erosion due to its length, moderate steepness, and because it drains directly into the Main Fish Bay Gut. This road receives a moderate traffic rate (~50-60 vehicles per day measured in 1998; Ramos-Scharrón and MacDonald, 2005) and therefore required installation of traffic-resistant runoff control measures. Two locations were carefully chosen along the road segment to divert runoff using cemented swales. At point 1 the intention was to divert runoff coming from the upper sections of Cocoloba from continuing along this road segment and forcing it into the Small Gut. At point 2 we also diverted runoff into the Small Gut with a swale.

Cocoloba Trail #1



COCOLOBA TRAIL- ESTATE FISH BAY

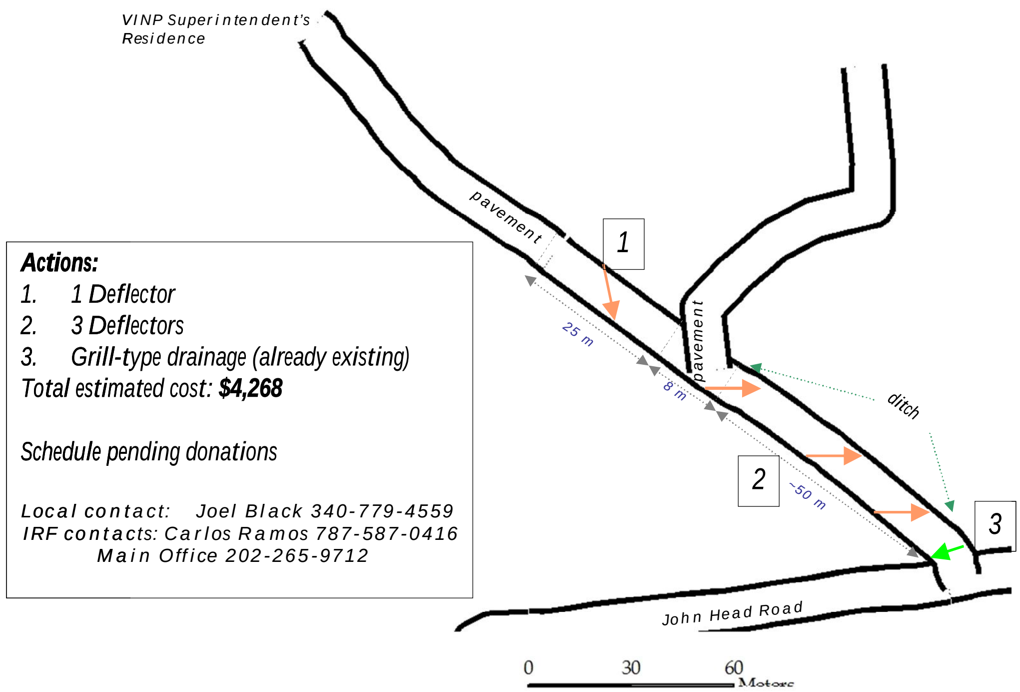
New cemented swale on Cocoloba Trail at Point 1 in map. Swale diverts upslope runoff from flowing over the lowermost sections of Cocoloba Trail.

New cemented swale along Cocoloba Trail at Point 2 in map.

John Head- Flamboyant Road

Erosion control measures at this road segment consisted in the installation of deflectors. This road segment receives very little traffic (~5 vehicles per day during most of the year) and our intention was to test a different type of road drainage control method. Deflectors are made of pieces of skidboard rubber that are vertically-installed and set on trenches dug out of the road surface. The deflectors were meant to force drainage into the inside section of the road where a ditch was intended to be dug out. This ditch was never dug by the contractor. By splitting the road segments into shorter sections we intended to reduce the erosive power of runoff from eroding the road surface. A combination of problems made this method ineffective. First, the rubber material quickly broke down after several weeks. This could have been caused by an already deteriorated condition of the material and by improper installation by the contractor which failed to install them following guidelines provided to them which included the use of wood planks to help stabilize the rubber in a vertical position. The contractor's failure to dig a new ditch also create problems as this allowed the runoff on the inside parts of the road to overflow onto the road surface and continue to erode. Due to its high cost and propensity to breakdown, we do not recommend the use of this method as an erosion control strategy.

John Head at Catherineberg # A

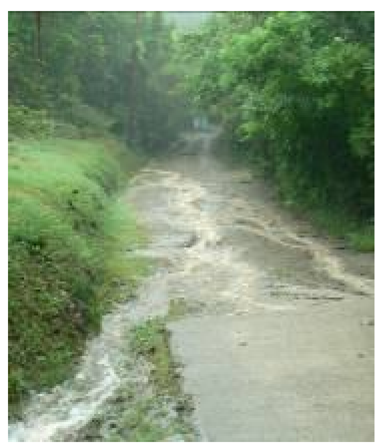


Road work along Flamboyant Road- Estate Catherineberg

Deflectors along Flamboyant Road (Point 2 in map).

Deflector along Flamboyant Road (Point 1 in map).

Deflectors during an intense rain event in October 2008. Pictures show that the deflectors were unable to maintain runoff on the inside portions of the road due to runoff overflow and the lack of a new deep ditch.

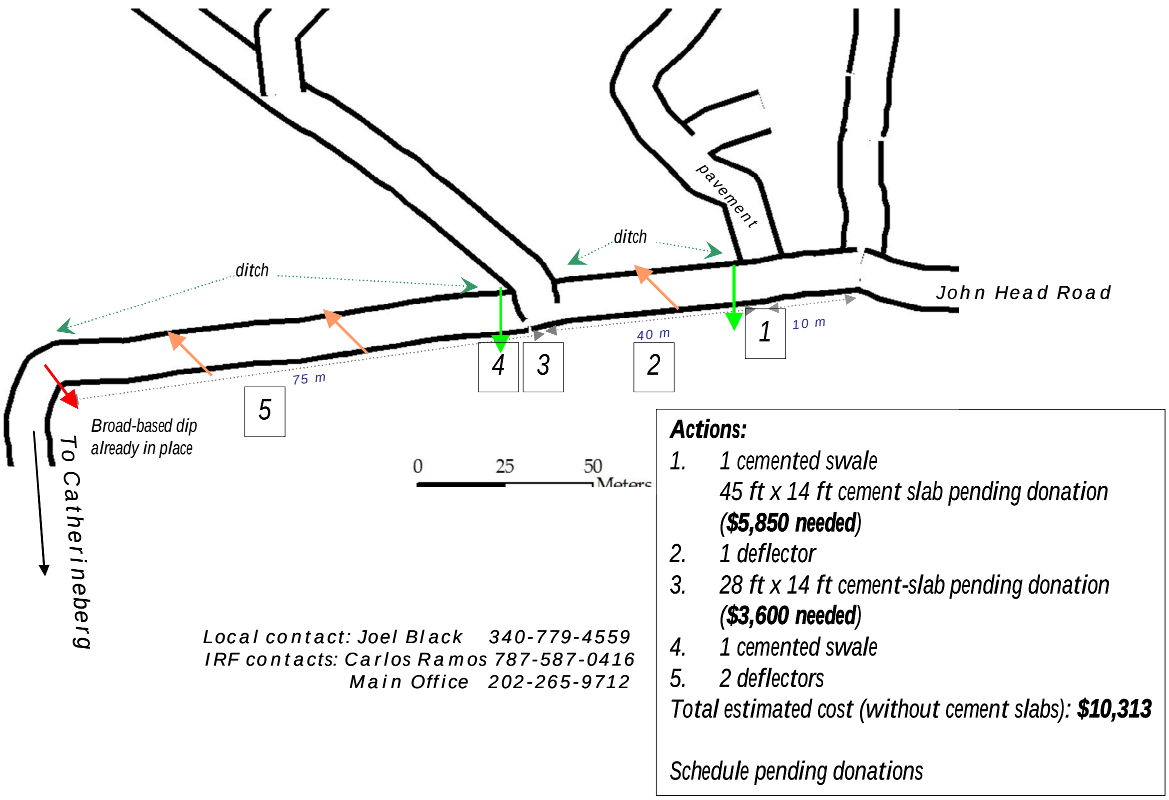


Deflectors during intense rainfall event in October 2008. Picture to the left is a close-up of runoff overtopping the deflector. Picture to the right shows runoff continuing to flow on the road surface instead of the intended purpose to maintain in on the inside ditch.

John Head at Catherineberg-Main Road

A number of road improvements were implemented along the main sections of John Head Road at Catherineberg. The intention of our actions was to protect the road surface by improving road drainage. This section of John Head Road intercepted runoff originating from various driveways and side roads (including Flamboyant Road).The lack of proper runoff control allowed all of the runoff produced from John Head and some of the runoff contributed from other upslope road segments to flow along its surface and induce erosion. Rills were a common feature observed along this road. At point one a combination of a cemented slab and swale were built. This not only provided the road surface with a protective cement cover, but also protected downslope areas by diverting runoff into the sideslope. At point 2 a deflector was installed to attempt to maintain runoff from running on top of the road surface. As in Flamboyant Road, this deflector proved ineffective due to breakdown and the lack of an inside ditch. At points 3 and 4, we also installed a cemented slab-swale combo to protect the road surface and to divert runoff. A cemented swale was already in-place at this location, but it was in very bad condition and therefore did not collect all of the runoff that it was intended to collect. At point 5, two deflectors were installed and these also broke down.

John Head at Catherineberg #B & C (bottom & top respectively)



ROAD WORK ALONG MAIN JOHN HEAD ROAD- ESTATE CATHERINEBERG

Deflectors along John Head Road.

Cemented swale along JH Rd (construction phase).

Cemented swale & pre-existing cattle-guard drain along John Head Road (construction phase).

Cement slab and cemented swale along John Head Road (construction phase).

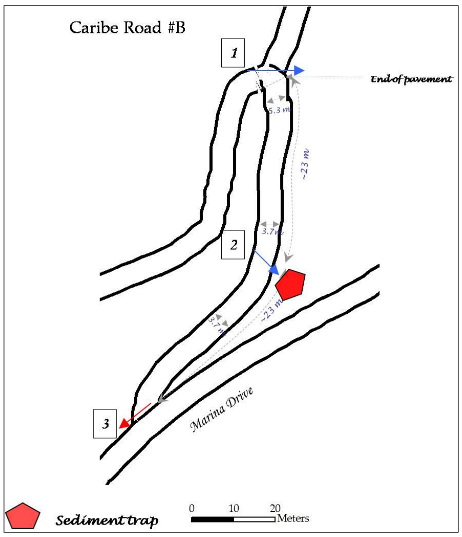
ROAD WORK ALONG FLAMBOYANT AND JOHN HEAD ROADS- ESTATE CATHERINEBERG

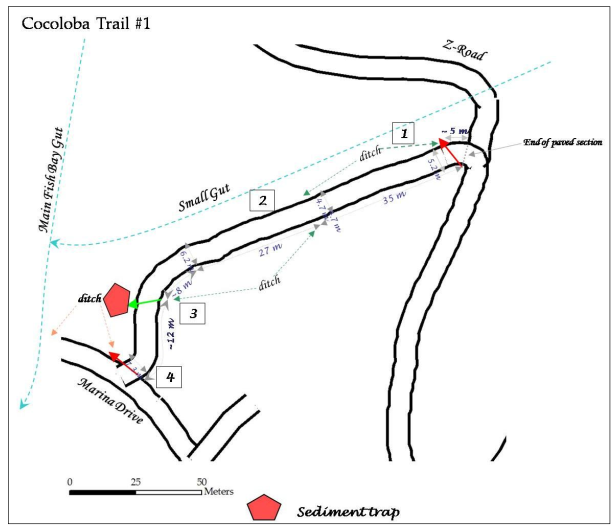
Cement slab and cemented swale at the bottom of a paved driveway along John Head Road (left). Dr. Ramos-Scharrón and volunteers help clean out a clogged runoff drainage structure (right).

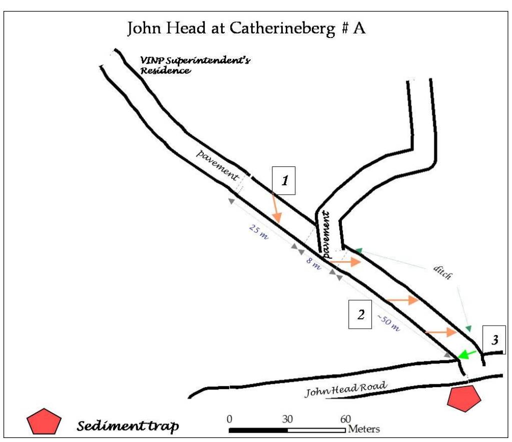
Cemented swales at Points 1 (left) and 3-4 (right) in map during an extreme rainfall event in October 2008. Notice on the picture to the right that some runoff is overtopping the swale and inducing runoff concentration and erosion on the lower portions of the road.

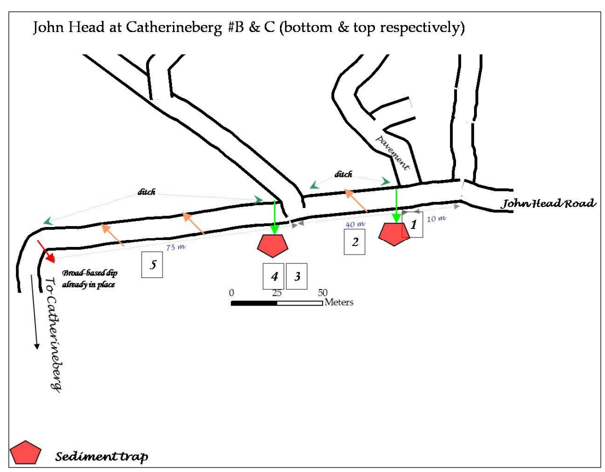
5) MONITORING EROSION

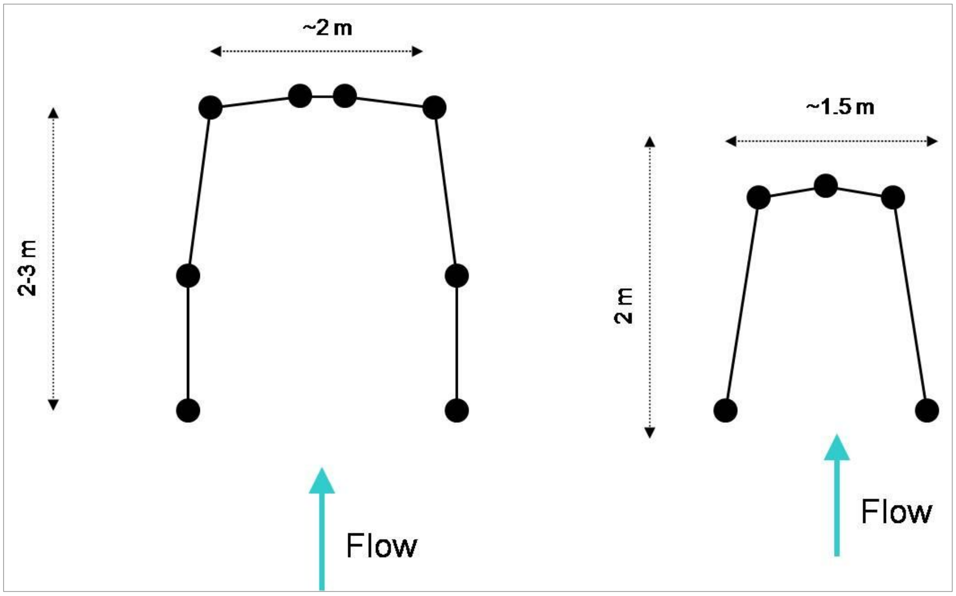
Sediment production from four road segments that were targeted by our BMP implementation efforts was measured using the sediment trap method. Not all road segments benefiting from our erosion control methods were monitored due to lack of appropriate locations to set the sediment traps. The specific location and sketch diagrams of the installed sediment traps are shown in the following maps.











Sketch diagrams of sediment trap layout (top view).

Sediment production rates from the four selected sites were measured between 3 May 2008 and 9 September 2008 with sediment traps. Due to budget limitations just one measurement was collected for each individual trap. Sediment production rates were measured by weighing the mass of material collected in each trap following standard methods (Robichaud and Brown, 2002). Traps were placed immediately below a point of concentrated road drainage. The sediment fences consisted of filter fabric attached to approximately 1 m long pieces of rebar hammered vertically into the ground. This created a sediment trap about 50 cm high, and the remaining fabric was placed flat on the ground to serve as an apron and a base for removing the accumulated sediment. The leading edge was secured to the ground surface with rocks or u-shaped pieces of rebar to prevent underflow. The tight weave of the filter fabric did not readily allow water to flow through it, so the sediment fences acted more like a dam than a filter. The material was shoveled into buckets and weighed with a radial scale to the nearest 0.2 kg. One or two well-mixed samples of 1-4 kg were collected and placed in watertight bags for moisture content estimation. Daily rainfall totals were measured by local residents (Osbourne Family at Catherineberg; Rock-Runyon Family at Estate Fish Bay) with non-recording gages with a resolution of a tenth of an inch.

The dimensions, characteristics, and estimated sediment production rates for each of the four road segments are shown in Table 1. Sediment production estimates are based on an empirical road erosion model developed from a previous study conducted in St. John (Ramos-Scharrón, 2004). The model is based on an annual rainfall rate, frequency of grading and on what is called the area-slope factor (A*S).

A*S incorporates the effects of road slope and road drainage patterns in a single factor used that is commonly used as a surrogate for the erosive capacity of flowing water (Anderson and MacDonald, 1998; Ramos-Scharrón, 2007). The basic principle of this model is that erosion increases with increasing slope and increasing distance between road drainage structures as, over long periods, these two factors control the amount and velocity of runoff flowing over a road segment. Therefore, by decreasing the distance between road drainage structures our erosion control efforts were intended to reduce A*S and thus erosion rates.

Estimated erosion rates for the four road segments ranged between 0.005 and 0.16 kg m^{-2} per cm of rainfall. The monitored Caribe Road segment had the lowest estimated erosion rate, while the main segment of John Head road had the highest estimated rate. Between 12 and almost 1400 kg of dry sediment were collected in individual traps during the monitoring period. A total of 76.2 cm of rainfall were recorded during this time.

When normalized by road surface area and rainfall the measured sediment totals translate into erosion rates ranging between 0.001 and 0.066 kg m^{-2} cm^{-1}. All road segments had measured values that were lower than the estimated (Table 1 and charts shown below). Measured values were between 7 and 65% of those estimated and the total reduction in sediment contribution resulting from the efforts equals close to 20 tons per year. The greatest reduction in erosion rates occurred along main John Head Road and Cocoloba Trail as the cemented swales appear to have resulted in an effective strategy to divert runoff from the road surface. Measured rates on Caribe Road were about a third of those estimated. We believe that the relatively diminished impact of our efforts is due to two factors. First, erosion rates on this road segments were expected to be low and the measured sediment only totaled 12 kg and therefore data from this site is likely to be very sensitive to small changes in erosion rates measured using the sediment trap method. Second, the main objective of BMP implementation on Caribe Road was to protect the lowermost road section which could not be monitored due to the lack of a proper location to set up a sediment trap. Measured rates along Flamboyant Road were 65% of the estimated, making this the road segment where our erosion control efforts had the least effect among the four monitored sites. This was expected given that the runoff control method (i.e., deflectors) failed due to tearing and displacement of the rubber material by traffic activity.

MONITORING EFFORTS

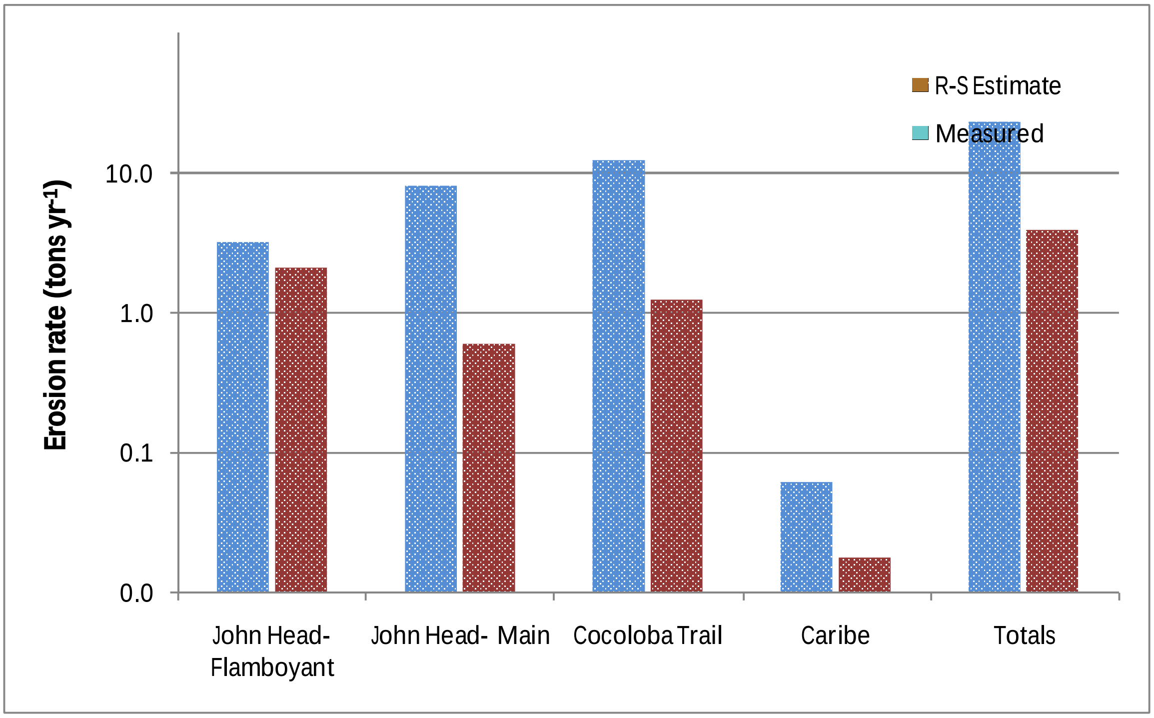
Rain gauge used to measure daily rainfall at Fish Bay. Recently installed sediment trap at Caribe Road.

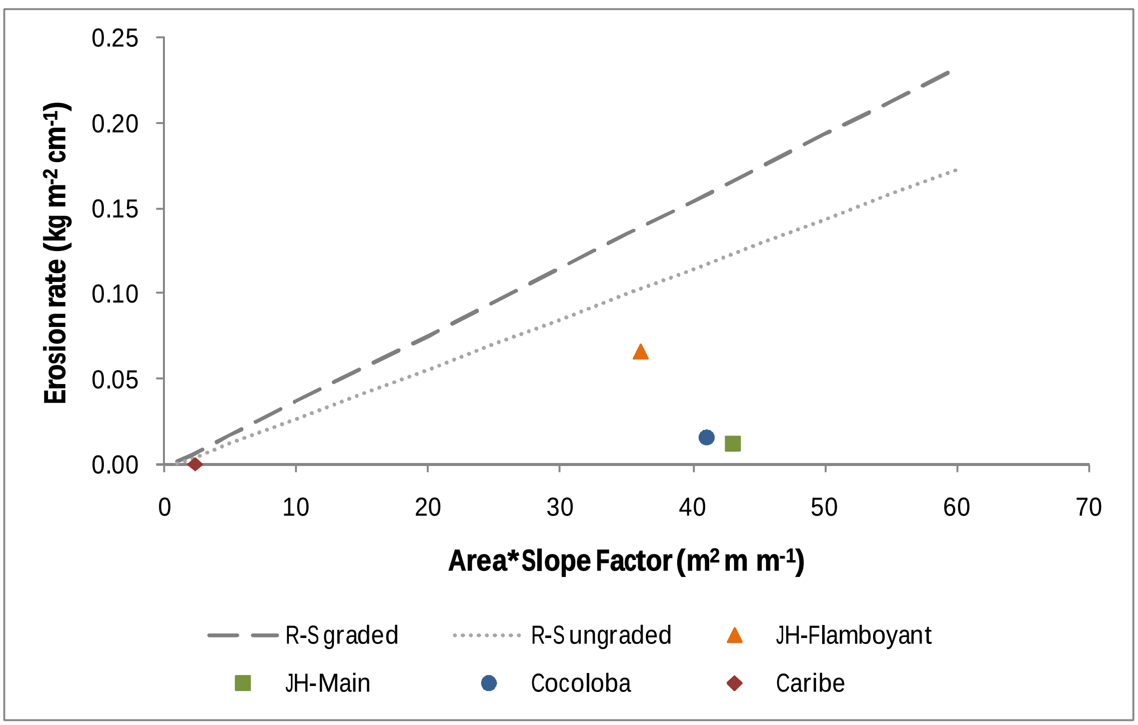
Sediment traps at Cocoloba Trail and John Head Road.

Tables 1a and 1b. Characteristics, erosion rates, and effectiveness of BMP implementation results of the four monitored road segments.

Road segment	Area (m^2)	Slope (%)	A*S value (m^2 m m^{-1})	Grading type	Estimated erosion rate (kg m^{-2} cm^{-1})	Estimated erosion rate (t yr^{-1})
John Head- Flamboyant	275	13%	36	Ungraded	0.102	3.2
John Head- Main	425	10%	43	Graded	0.164	8.0
Cocoloba Trail	680	6%	41	Graded	0.157	12.3
Caribe	113	2%	2.3	Ungraded	0.005	0.062
Totals	***1493***					***23.6***

Road segment	Total sediment in trap (kg)	Dry weight (kg)	Observed erosion rate (kg m^{-2} cm^{-1})	Observed erosion rate (t yr^{-1})	Percent measured relative to estimated	Net reduction (t yr^{-1})
John Head- Flamboyant	1725	1380	0.066	2.1	65%	1.1
John Head- Main	497	398	0.012	0.6	7%	7.4
Cocoloba Trail	1157	810	0.016	1.2	10%	11.1
Caribe	14.5	12	0.001	0.018	28%	0.04
Totals	***3,394***	***2,599***		***3.9***		***19.7***


R-S Estimate
Measured
Erosion rate (tons yr-1)
10.0
1.0
0.1
0.0
John Head-Flamboyant
John Head- Main
Cocoloba Trail
Caribe
Totals


Erosion rate (kg m-2 cm-1)
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
Area*Slope Factor (m2 m m-1)
R-S graded
R-S ungraded
JH-Flamboyant
JH-Main
Cocoloba
Caribe

6) POST-PROJECT OUTCOMES

IRF is committed to continue working with the Estate Fish Bay and Catherineberg Estate HO Associations, and the VI National Park in developing erosion control strategies within the Fish Bay Watershed and elsewhere in St. John. IRF staff is also in continuous communication with the Coral Bay Community Council who is currently working in implementing BMPs in watersheds draining into Coral Bay on the eastern portions of St. John.

Dr. Ramos-Scharrón is currently working on a pair of projects that are working on improving the flexibility and applicability of the STJ-EROS model. One of those projects has been funded by the University of Puerto Rico Caribbean Coral Reef Institute and is being conducted on the Southwestern portions of Puerto Rico (La Parguera). Field data has been collected to improve the erosion prediction capabilities of STJ-EROS, and updates on the model algorithms are currently being made. One such update is to develop STJ-EROS as an ArcTool within the ArcGIS software. This would improve its transferability to other areas as well as improving its user interfaces. Another update of the model involves including construction sites as a sediment source. Currently the model can only include linear features (i.e., roads) as anthropogenic sources of sediment.

Dr. Ramos-Scharrón is also applying STJ-EROS to portions of the islands of Culebra and Vieques (PR) through a project funded by the PR Department of Natural and Environmental Resources. Additional funds have been approved for the implementation of erosion control strategies on Culebra.

IRF will also be the recipient of a research-oriented project funded by the UPR Coral Reef Institute on the Río de Fajardo Watershed on eastern Puerto Rico. The objective of this project is to develop a long-term sediment budget for the watershed (1930's until the present) to estimate sediment yields. Dr. Ramos-Scharrón will be collaborating with Dr. Edwin Hernández (UPR-Río Piedras Coral Reef Research Group) who will be determining long-term coral reef growth rates along a sediment accessibility gradient in the proximity of the Río Fajardo outlet into the sea based on examination of coral cores. The main goal is to determine if there is any temporal and spatial relationship between coral reef growth rates and watershed sediment yields controlled by changes in land use and rainfall patterns.

Dr. Ramos-Scharrón is also providing guidance to Prof. Trent Briggs from San Diego State University who is planning on applying STJ-EROS to develop a sediment budget for areas of Tijuana in México.

7) DISCUSSION & ADAPTIVE MANAGEMENT

This project has lasting implications for watershed management and erosion and sediment control in the Virgin Islands. Building on IRF's 35 years of experience in island systems management and on Dr. Ramos-Scharrón's research work on erosion, the project began as a stand-alone effort. Even though erosion is considered by many one of the most important problems threatening the quality and integrity of the St. Johnian landscape and its surrounding marine environment, no similar large-scale efforts to mitigate its effects had been actively pursued and implemented for about a decade. The objectives of this project went beyond the boundaries of the Fish Bay watershed as the project was designed with the hope that its success would stimulate other similar efforts across St. John and the rest of the V.I. Territory.

Much work is still needed to reduce the adverse impacts of erosion and land-development on the coral reefs of St. John. Our work with this problem, which began decades ago, is not over. It is with much pride on our achievements and sense of commitment that we intend to continue with our work. Direct involvement with the community has helped us in identifying local groups and individuals who are interested in collaborating with us in these efforts. All of our previous work, including this project, is rightly recognized in St. John, the VI Territory, and throughout the Caribbean Region as a success story that many groups would like to emulate. Similar future projects are likely to be developed on Coral Bay and Cinnamon Bay and IRF will likely play a major role in their development and application.

As in most issues related to non-point sources of pollution, mitigating a problem at specific sites will not provide a thorough solution to an environmental problem that originates on many different areas of a watershed. Additional erosion control efforts should also be implemented throughout the entire Fish Bay watershed for such efforts to have a significant impact. Efforts such as the ones conducted as part of this study should be used as examples to promote the application of similar Best Management Practices in other areas of the Fish Bay watershed and throughout St. John.

A total of $24,310 was applied for BMP implementation as part of this project. This resulted in an estimated reduction of at least 19.7 tons of sediment entering Fish Bay annually. Hence, the cost effectiveness of this project was $1,234 per ton of sediment. Therefore, it can be expected that BMP implementation resulting in the reduction of inputs to Fish Bay (and other coastal waters around St. John) by 100 tons is expected to cost approximately $120,000. An approach that combines efforts from HO Associations, the VINP, the VI Government, and private sectors should be able to fund this level of effort. A tool such as STJ-EROS is vital in selecting priority sites where such efforts should be focused.

The $24,310 was applied to 656 m of roads in Fish Bay. The average cost of BMP implementation was $37 per linear meter of road. Reductions in sediment production from unpaved roads can be achieved by the BMPs applied as part of this project without the need to apply more costly alternatives like paving (~$425 per linear meter). The cost-saving alternatives provided by the BMPs used here should encourage its widespread use throughout St. John and elsewhere.

8) DISSEMINATION

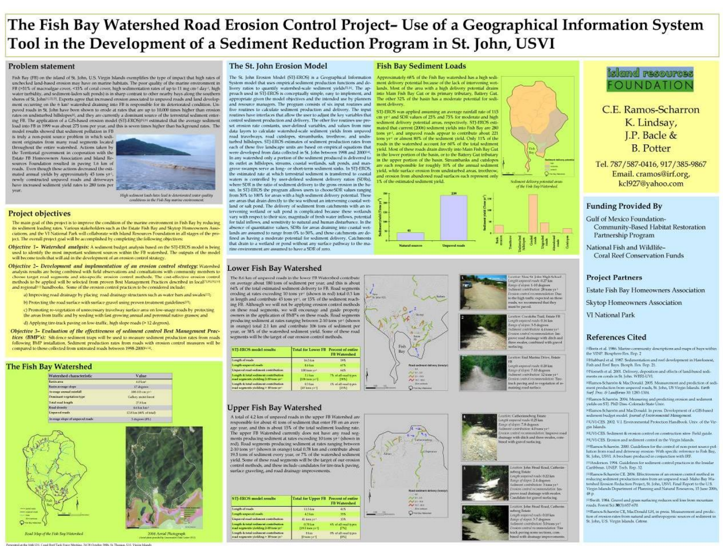
The numerous actions presented in this section describe our dissemination efforts.

October-December 2006

Dr. Ramos-Scharrón was interviewed 2 October 2006 by Andrea Milam, chief editor for a local newspaper, and it resulted in an article published in both the paper and online versions of the Tradewinds newspaper (9-Oct-06).

Preliminary discussions and contacts were made with the community of Catherineberg on the upper portions of the FB Watershed in an effort to encourage the residents to become involved in the project.

IRF presented a poster at the US Coral Reef Task Force Meeting in St. Thomas on 24-28 October 2006. The title of the poster was 'The Fish Bay Watershed Erosion Control Project- Use of a Geographical Information System Tool in the Development of a Sediment Reduction Program in St. John, USVI" (A copy of the poster is shown below).



Following the activities related to the conference, Mr. Lindsay took Dr. Quenton Dokken (Gulf of Mexico Foundation) and Beverly Yoshioka (US Fish & Wildlife Service-Caribbean Coastal Program) on a field trip to Fish Bay. The group was met by several members of the Fish Bay Homeowners Association (Chuck Pishko and Gail Karlsson) who introduce them to the issues confronting the homeowners association and their past and current efforts to mitigate erosion problems.

Ramos-Scharrón met with Beverly Yoshioka in Puerto Rico on November 2006 to discuss the possibility of receiving additional funds from the USFW-Coastal Program for the Fish Bay erosion project. It was agreed that IRF would submit a short proposal requesting funds and that Mrs. Yoshioka would walk it through the internal review process at the USFW. IRF submitted the proposal at the end of December 2006.

January – March 2007

Discussions and contacts were made with the Catherineberg Estate HO Association in an effort to encourage the residents to become involved in the project.

IRF also contacted Mrs. Beverly Yoshioka from the Caribbean Regional Office of the U.S. Fish and Wildlife with regards to this project to follow-up on the proposal. Mrs. Yoshioka reiterated her desire to become a funding partner on IRF's efforts in Fish Bay and indicated that a final decision on the distribution of funds would take place in May 2007.

The IRF team also used the opportunity of their February visit to meet with Ms. Sharon Colden of the Coral Bay Community Association on the eastern end of St. John to explore possible future collaborations and share progress on the Fish Bay project. Coral Bay is St. John's largest watershed and the island's most rapidly developing area. The problems of erosion and declining natural habitats are enormous and IRF has expressed its willingness to share experiences and solutions with the community on completion of the Fish Bay effort.

Dr. Ramos-Scharrón made a presentation on the 1st Coral Reef Symposium sponsored by the Department of Environmental and Natural Resources of Puerto Rico (PR-DNER). As part of this presentation Dr. Ramos-Scharrón showed the audience some of the work that the Island Resources Foundation has been conducting in Fish Bay as part of this project. The presentation encouraged the PR-DNER Coastal Zone Program to fund similar work on the islands of Culebra and Vieques with Dr. Ramos-Scharrón as principal investigator.

April – September 2007

Summer is usually a very slow period in the Virgin Islands when many residents take their vacation off island. No major outreach activities beyond frequent contact with the Homeowners Association and feedback from residents of Fish Bay took place during this period.

October – December 2007

Mr. Kevel Lindsay had the opportunity to attend the Gulf of Mexico Alliance's Florida Caribbean Workshop held from October 24-27, 2007 at the Weedon Island Preserve and Natural History Center, St. Petersburg, Florida. Mr. Lindsay was invited to participate by the Gulf of Mexico Foundation and gave a presentation on the Fish Bay Project and the challenges of habitat restoration efforts in the Caribbean Region.

Dr. Ramos-Scharrón presented some of his work at the 7th Caribbean Island Water Resources Congress held at the University of the Virgin Islands St. Croix campus on 25-26 October 2007. During the presentation Dr. Ramos-Scharrón discussed some of his research on erosion in the Virgin Islands and Puerto Rico and showed how that scientific knowledge was used to mitigate the effects of unpaved roads in Fish Bay. Present at the conference were important figures in the field of water resources including Dr. Matthew Larsen (ex-district chief for the USGS-Caribbean office and current Chief Scientist for the Hydrology section of USGS), Dr. Pedro Díaz (current USGS-Caribbean office district chief), Dr. Henry Smith (Director of the VI-Water Resources Research Institute), and Dr. Rivera Santos (Director of the PR Water Resources and Environmental Research Institute), among many others. Dr. Ramos-Scharrón also took time to chat with Sharon Coldren from the Coral Bay Community Council in St. John to discuss issues related to erosion in the eastern portions of St. John.

January – May 2008

Mrs. Karen Vahling, an undergraduate student from Colorado State University, became involved in the Fish Bay project in March 2008. Among different activities, Mrs. Vahling helped coordinate volunteer efforts to help clean a clogged drain along John Head Road in the Catherinberg Estate area. She also wrote a press release to notify the community on the progress of the Fish Bay road work. The press release was published by the Tradewinds newspaper on April 2008.

In June 2008, Dr. Ramos-Scharrón gave a presentation titled "Science in translation- Application of hydrologic research in the development of erosion control strategies for the US Virgin Islands and Puerto Rico." This presentation was given as part of a series of semi-annual meetings of the Puerto Rico Non-Point Sources of Pollution Inter-agency Committee in San Juan, PR and present were delegates from both Federal (e.g., EPA) and State (e.g., DNER, Environmental Quality Board, Ports Authority, etc.) government agencies. The presentation included a discussion on how empirical field work was used to develop analytical models to assess erosion problems in St. John and Puerto Rico and how those tools were being used to implement erosion control strategies. The Fish Bay project was used as a key example in such efforts.

List of publication and, press releases that resulted from this project.

Although no scientific publications have resulted from this project, the following is a list of references written by Dr. Ramos-Scharrón on erosion issues in the Caribbean during his tenure as Project Manager for this project.

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Press releases and other publications

Tradewinds Newspaper. October 2006.Tons of sediment runoff are reduced through erosion control projects. By Andrea Millam.

Tradewinds Newspaper. April 2008.Community controls erosion at Fish Bay. By Karen Vahling

Environmental Connection Journal. To be submitted late 2008. By: IRF Team.

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Jeffrey CFG et al., 2005. The state of coral reef ecosystems of the U.S. Virgin Islands. pp. 45-90. In: The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005. NOAA Technical Memorandum NOS NCCOS 11.

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Ramos-Scharrón CE, MacDonald LH. 2007a. Development and application of a GIS-based sediment budget model, *Journal of Environmental Management*, **84**: 157-172.

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