Watershed Coordination, Protection, and Restoration to Control Land Based Pollution in Culebra, Puerto Rico FY-2017 FINAL REPORT August 2018





Submitted to: Lisa Vandiver, Ph.D. Marine Habitat Restoration Specialist Earth Resources Technology Contractor

NOAA Restoration Center 2234 South Hobson Avenue Charleston, SC 29405



Anne Kitchell, LEED AP Sr. Environmental Planner Horsley Witten Group 90 Route 6A, Sandwich, MA 02563 Sustainable Environmental Solutions



Submitted By: Roberto A. Viqueira Ríos Executive Director Protectores de Cuencas, Inc. Box 1563 Yauco Puerto Rico 00698

TABLE OF CONTENT

1	PARTNERS AND COLLABORATORS FOR THIS PROJECT
2	SUMMARY4
3	INTRODUCTION
4	FLOATING TREATMENT WETLAND9
5	IMPLEMENTATION PROJECTS
1. 2. 3.	PUNTA SOLDADO10a)BMPs Implemented Prior to Hurricanes10b)Hurricane Damages12c)Repair Efforts14PUERTO DEL MANGLAR15a)BMPs Implemented Prior to Hurricanes15b)Hurricane Damages18c)Repair Efforts20ZONI21a)BMPs Implemented Prior to Hurricanes21b)Hurricane Damages23c)Repair Efforts23c)Repair Efforts23c)Repair Efforts25
6	PROJECT COSTS

Protectores de Cuencas, Inc. Box 1563 Yauco Puerto Rico, 00698 Tel. 787-457-8803 rviqueira@protectoresdecuencasinc.org www.protectoresdecuencas.org



1 PARTNERS AND COLLABORATORS FOR THIS PROJECT



Punta del Viento Estates Homeowner Association (PVEHA)



2 **SUMMARY**

The purpose of this project was to reduce the impact of land-based sources of pollution (LBSP) on coral resources on Culebra, a CRCP priority area and the Caribbean Habitat Focus Area in Puerto Rico. This project furthers implementation of priority restoration objectives of the 2014 Culebra Watershed Management Plan. Protectores de Cuencas, Inc. has implemented green infrastructure practices to intercept stormwater runoff and utilized plants, soils, and natural processes to filter and reduce runoff pollution.

Efforts to support and implement the *Culebra Community Watershed Action Plan for Coral Reefs and Water Quality* has led to unprecedented collaborations between the Municipality of Culebra, the Department of Natural and Environmental Resources (DNER), National Oceanic and Atmospheric Administration (NOAA), the US Fish and Wildlife Service (FWS) through the Partners for Fish and Wildlife Program, local organizations, and the community in general. As part of the funding cycle from NOAA's Coral Reef Conservation Program (CRCP) for Fiscal Year (FY) 2017, and in collaboration with the Horsley Witten Group (HWG) and the USFWS and the DNER, Protectores de Cuencas (PDC) proposed the implementation of wastewater treatment wetlands. Implementation efforts under this project were significantly influenced by the impact of hurricanes Irma and María.

Coordination efforts between the Puerto Rico Aqueduct and Sewer Authority (PRASA) and PDC delayed the implementation process. HWG in collaboration with NOAA and PDC developed a wastewater floating treatment wetland design and drafted a Memorandum of Agreement with PRASA. Hurricanes Irma and María affected all efforts towards the



proposed actions of this project. After the impact of both hurricanes, all local and federal agencies in Puerto Rico focused on recovery efforts.

On September 2018, PDC developed the *Hurricane Impact Assessment on Implemented BMP Projects in Guánica and Culebra Watesheds, Puerto Rico.* This report highlighted the effects of hurricanes Irma and María in nine (9) sites where BMP projects were implemented. Based on that effort, this project implementation efforts where concentrated on recovery actions in three of the affected sites in Culebra, which are: Zoní, Punta Soldado and Puerto del Manglar (Figure 1). Recovery efforts conducted through this project helped the BMPs implemented to be more resilient to future events of similar magnitude. Next steps will include reforestation efforts in all sites.



Figure 1. Project Sites.



3 INTRODUCTION

Increased levels of land-based sediment loads associated with coastal development is one of the most important factors affecting coastal marine ecosystems in Puerto Rico. Puerto Rico coral reefs are among the most threatened marine ecosystems in the Caribbean. The degradation of coastal water quality in Puerto Rico has caused a decline in the population and health of coral reefs. The ability of reefs to survive is gradually being reduced as fine sediment and nutrient discharges from the land to the coastal waters increase. From the stand point of marine ecosystems conservation, degradation of water quality due to dispersed land-based sources of pollution has caused negative and sometimes irreversible damage to the integrity of the coral reef communities, sea grasses, mangroves, and other highly valued coastal ecosystems.

During Fiscal Year 2016, PDC completed BMP implementation efforts for the reduction of high rates of sedimentation and excess nutrients, which are some of the main causes of the degradation of marine ecosystems. This phenomenon is mainly due to the lack of sustainable management from the perspective of integrated watershed management. Erosion and habitat degradation are other serious problems that our wetlands, estuaries, and coastal waters face. The removal of vegetation and land clearing activities for construction without proper erosion and sedimentation control practices impact marine and coastal ecosystems and diminish the attractiveness of coastal areas for recreation and tourism. High sediment loads discharging to marine environments as a result of poorly



maintained dirt roads without the installation of proper management practices is a very common problem in Culebra.

Geospatial Information System models suggest that sediment delivery rates in four general areas of Culebra including Punta Soldado, Bahía Mosquito, Puerto Manglar, and Zoní range between 20 and 120 tons km⁻² yr⁻¹ (tons of sediment divided by km² of land area per year) (Ramos-Scharrón, 2009), and this ranges from about half to up to 10 times higher than those estimated for three comparable watersheds on St. John, USVI. In the case of Puerto del Manglar watershed, a total of 5.8 miles of unpaved roads are calculated with a total delivery of 112 tons of sediment every year into the receiving coastal waters, representing 86% of the entire watershed surface area sediment yield. The data presented by the studies show that sediment pollution from particular road segments outweigh their counterparts in their relative contribution to watershed-scale sediment yields.

Fiscal Year 16 funds had a component of conducting a dirt road assessment of the Island of Culebra. A total of 50 miles of dirt roads were identified in the survey conducted by using GIS tools with the combination of field assessments. From the 50 miles of dirt roads identified, a total of 15 miles have been stabilized or will be stabilized by FY 2018. This represents 30% of all the dirt roads identified.

On September 2017, Puerto Rico experienced extensive ecological damage by hurricanes Irma and María. The force of hurricane winds and storm surge caused serious damage to coastal ecosystems including BMP implemented practices by PDC. All of the projects suffered major erosion due to the rain associated with the hurricanes. During this project PDC directed efforts towards the repair and performance monitoring of BMPs



damaged by hurricanes in Zoni, Punta Soldado and Puerto del Manglar sites. Also, prior both hurricanes, a Floating Treatment Wetland for the Culebra Wastewater Treatment Plant (WWTP) was developed and advanced the permitting process with PRASA. Details on the design are described further in this report.



4 FLOATING TREATMENT WETLAND

In March 2018, water quality samples were collected of effluent from the Culebra WWTP at numerous locations including: the first manhole below the plant's de-chlorination unit; inlet and outlet locations at each of the five treatment ponds; and at downstream locations such as the farm pond and road crossings. Results indicated elevated nitrogen levels within the treatment ponds. A concept design and monitoring plan for Floating Treatment Wetlands was developed by the project team and submitted to PRASA for review and comments on August 8, 2018. Final plans reflecting comments were submitted to PRASA on August 28, 2018 as part of an effort to establish a Memorandum of Agreement (MOA) between PRASA and PDC allowing us to implement the project. As of today, the MOA still has not been signed.

Appendix A includes the conceptual design memorandum describing the design, construction, monitoring, and maintenance components of the project. In addition, an 11x17 design plan and map showing the location of monitoring stations is included.

Appendix B includes the draft Memorandum of Agreement between PRASA and PDC.



5 **IMPLEMENTATION PROJECTS**

Between September and December 2018, PDC repaired several of the project sites on Culebra that were damaged by Hurricanes Irma and María. Below is a detailed description of the damages and repair actions completed at each site.

1. PUNTA SOLDADO

a) BMPs Implemented Prior to Hurricanes

Project implementation in Punta Soldado included the stabilization and conditioning of approximately ½ mile of the main access dirt road and the creation of a permeable parking lot (Figures 2 and 3) that helped to reduce sediment transport to the marine environment of Punta Soldado and Ensenada Malena. A series of 3 sediment trap systems including rain gardens were constructed in the lowest part of the road where there used to be stagnant mud which vehicles crossed creating an ever-increasing sediment and erosion problem. Implementation also included the delimitation of public access and critical habitat areas. PDC restored the coastal beach berm area with native vegetation barriers and delineated



Figure 2. Permeable parking located at Punta Soldado prior to hurricanes Irma and Maria.

public access to the beach. This delineation was conducted by installing treated wooden posts and planting native vegetation. An elevated boardwalk (Figure 4) was constructed for the public



to access the beach without impacting restored vegetation buffers and sand dunes. In order

to restore the coastal vegetated berm and buffer, we re-planted native species to coastal

areas.



Figure 3. Permeable parking located at Punta Soldado prior to hurricanes Irma and Maria.



Figure 4. Public access boardwalk located at Punta Soldado prior to hurricanes Irma and Maria.



b) HURRICANE DAMAGES

During the evaluation process at Punta Soldado, PDC identified that the stabilized dirt road had suffered greatly. The heavy rain and runoff water caused serious erosion on the road. Figure 5 shows the ditches formed by the water flowing over the dirt road. Parts of the stabilized road were clogged with sediment (Figure 6). The restored coastal beach berm area with native vegetation barriers has been overgrown by weeds, limiting the healthy growth of the planted native trees. Wooden posts used for delimitation of public access and critical habitat areas were also damaged and required replacements (Figure 7). The elevated boardwalk constructed showed minimal damages, with some posts needing to be replaced.



Figure 5. Previously stabilized road located at Punta Soldado showing damages following hurricanes Irma and Maria.





Figure 6. Previously stabilized road located at Punta Soldado showing damages following hurricanes Irma and Maria.



Figure 7. Permeable parking area located at Punta Soldado showing damages following hurricanes Irma and Maria.



c) REPAIR EFFORTS

A series of four crossing corrugated pipes were installed to replace the continuous swale and cross runoff from one side of the road to forested areas (Figure 8). On the outfall side, cascade type ripraps with stones and Vetiver grass were installed. Gravel was cleaned from sediment and replaced in clogged areas (Figure 9). Damaged wooden posts were replaced, and the area was cleared out from weeds (Figure 10).



Figure 8. Check dams using crossing pipes and cascade type rip-raps



Figure 9. Unclogged areas from sediment and new gravel installed.





Figure 10. Debris removal.

2. PUERTO DEL MANGLAR

a) BMPs IMPLEMENTED PRIOR TO HURRICANES

Work completed consisted of stabilizing the access road and parking area by regrading and compaction. Sediment control practices included installing silt fences and planting Vetiver grass to redirect runoff to forested areas. A series of swales and check dams were installed to direct part of the runoff from the main access roads to a sediment trap. The parking area and all the road segments that run parallel to the wetland system were then paved with gravel after the installation of geotextile to serve as a filtration system.

The old parking lot that was utilized by visitors was located on the terrestrial maritime zone, and motor vehicles had direct access to the beach area. As part of this project, this area was closed with boulder rocks to ensure soil stabilization and vegetation recovery. The



new parking area was developed using green infrastructure techniques to help with the sediment load reduction process. The parking, as well as all the flat sections of the dirt road, was designed to capture and infiltrate rainwater and runoff from the adjacent hillsides into the subsoil. Parking was also regraded and designed to convey the excess runoff produced in larger storm events into a rain garden system without directly discharging into the mangrove and subsequently into the marine environment.

The salt flat wetland area was restored by removing the piles of sediment that had accumulated from the adjacent road and parking areas. This sediment accumulation was preventing natural hydrological flow patterns of tidal process. After the sediment was removed and natural hydrologic conditions were reestablished, we reforested the area with mangroves and other coastal forest. A wooden boardwalk was constructed to provide pedestrian access while protecting the surrounding restored area. Hydroseeding was used to stabilize remaining bare soil areas of the restored site (See Figures 11 and 12).



Figure 11. Stabilized site at Puerto del Manglar prior to hurricanes Irma and Maria.



August 2018



Figure 12. Stabilized site at Puerto del Manglar prior to hurricanes Irma and Maria.



b) HURRICANE DAMAGES

Puerto del Manglar site suffered structural and vegetative damages. The previously stabilized road was in need of resurfacing and clearing of the accumulated debris. Areas with vegetative cover required replanting of several trees and clearing those that were uprooted by the force of the storms. The affected areas showed signs of water flowing through and accumulating at the dirt road as before instead of being redirected with the help of the green infrastructure constructed by PDC (Figures 13 and 14).



Figure 13. Damages suffered by stabilized site at Puerto del Manglar following hurricanes Irma and Maria.





Figure 14. Damages suffered by stabilized site at Puerto del Manglar following hurricanes Irma and Maria.



c) REPAIR EFFORTS

Steep areas where gravel was installed and washed out were covered with concrete. The whole

area was cleared from debris. Gravel was added to the road and parking areas for better filtration.

PDC also unclogged the swale and cleaned the sediment trap. (Figures 15 and 16).



Figure 15. Steep area covered with concrete and new gravel installed



Figure 16. Steep area with concrete.



3. ZONI

a) **BMPs Implemented Prior to Hurricanes**

Restoration work at this site consisted of diverting runoff water to forested areas in 4 to 6 segmented locations. To stabilize this section of road, we installed dirt swales, thus reducing flow and diverting water to adjoining forested areas. In order to reduce runoff and dissipate its energy, water was conveyed to intercepts at 3 locations on both sides of the road that break up flow paths and reduce concentrated flow of runoff over the parking lot. The excess runoff was forced to a riprap and Vetiver swale built parallel to the south side of the road taking water off the road and ending in a wider concrete bio-filter system with built-in large stones that promote sheet flow towards the sediment trap after passing through several lines of Vetiver grass.

PDC also installed a Rain Garden/Sediment Trap system consisting of three filtration chambers, a Rain garden and a permeable parking system (Figure 17). Water was conveyed to the sediment trap by a concrete swale. The stabilized parking area consisted of approximately 500 m². Parking was constructed with multiple layer base confined with a 1' concrete curb composed of; (1) geo-mebrane support (2) gabion with pebble stones as base, (3) filter fabric, and (4) a Geo-Cell with ¼" gravel infill. A small elevated boardwalk was constructed for the public to access the beach without impacting vegetation and sand dunes (Figure 18). This area was closed to vehicular access by the installing wood poles and it had a defined pedestrian access area to the beach. PDC also re-planted the area with coastal native species. A total of approximately 300 native trees were planted.





Figure 17. Parking area at Zoni prior to hurricanes Irma and Maria.



Figure 18. Elevated boardwalk and area delimitation at Zoni prior to hurricanes Irma and Maria.



b) HURRICANE DAMAGES

Damages encountered following hurricanes Irma and Maria at Zoni were described as mostly vegetative damages with approximately 85% of areas needing recovery, while over one third of the structural components needed repairs. The vegetative buffers were severely affected, allowing sediment to reach the parking lot directly and clogging it. The paved road was severely damaged, and the concrete swale was clogged and needed repairs. Figures 19 and 20.



Figure 19. Paved road in need of repairs following hurricanes Irma and María





Figure 20. Structural and vegetation damages suffered at Zoni parking area following hurricanes Irma and Maria.



c) REPAIR EFFORTS

PDC repaired the swale and built it underground for it to be more resilient to future events of similar magnitude. The dirt road was stabilized, and the paved road was substituted by concrete, which is a more resistant material. The gravel from the parking lot was cleared out from sediment using industrial vacuums and new gravel was installed. Figures 20 to 23.



Figure 20. Removal of sediment in parking lot.



August 2018



Figure 21. Installation of new Geo-Cell



August 2018



Figure 22. Finished parking lot.





Figure 23. Finished paved road substituted by concrete.



6 **PROJECT COSTS**

The work completed in Culebra for FY 2017 was performed for a total combined cost of \$103,906 (Table 1). A total in-kind (non-cash) match of \$120,424 was estimated on this effort from contributing entities including the DNER, PDC, Culebra Municipality and local community volunteers as described in Table 2.

 Table 1. Summarized Global Costs

CATEGORY		COST
Labor and Manpower		\$8,500
Rental Equipment and Materials Transportation		\$7,500
Supplies		\$48,000
Project Management, Coordination, Design and Engineering		\$27,500
Travel (gas, flights, ferry, per diem, etc.)		\$4,906
Monitoring		\$7,500
	TOTAL	\$103,906



August 2018

Table 2. Estimated In-Kind Match Contributions from Project Partners

ENTITY	ACTIVITY	UNITS	COST/UNIT	TOTAL COST
DNER	Lodging for 8 persons at a rate of 1500/Month	12	\$1,502	\$18,024
Culebra Municipality	HD Hammer for Bob Cat at a rate of \$1,450/month	3	\$1,450	\$4,350
Culebra Municipality	Hours labor	40	\$30	\$1,200
Omar Villanueva	Backhoe at a rate of \$400/day	90	\$400	\$36,000
PDC	Dozer at a rate of \$650/day	26	\$650	\$16,900
PDC	Dump truck at a rate of \$450/day	26	\$450	\$11,700
PDC	Small water truck at a rate of \$350/day	10	\$350	\$3,500
PDC	Skid Loader at a rate of \$250/day	7	\$250	\$1,750
PDC	Uncompensated hours at a team mean cost/hour	180	\$75	\$13,500
PDC	Office space and materials at a cost of \$1,500/year	1	\$1,500	\$1,500
PDC	Landscaping Supplies (hand tools, soil enhancements, auger drill, generator, etc.)	120	\$100	\$12,000

TOTAL ESTIMATED \$120,424

