# *Culebra LBSP Best Management Practices Implementation Inventory and Condition Monitoring Work Plan*

Developing a BMP monitoring program to evaluate changes in LBSP stressor in Culebra, Puerto Rico

## 1. Background

This monitoring work plan is a key component of Culebra's LBSP Ridge to Reef Monitoring Program aimed at providing standardized guidelines and methods to monitor changes in land-based pollutant loads, nearshore land-based pollutant exposure, and seagrass habitat responses across the island. These monitoring activities are spatially and temporally coordinated and represent the basis of Culebra's Integrated LBSP Monitoring and Evaluation Framework to successfully evaluate progress toward achieving NOAA's LBSP management goals and outcomes on Culebra.

## 2. Monitoring Objectives

The best management practice (BMP) monitoring is aimed at quantifying sediment load reduction achieved by implementation actions and to evaluate the level of maintenance required over time; and is aligned with the following NOAA LBSP management goals, outcomes, and evaluation questions:

Management Goal:

- By 2025, 100% implementation of NOAA priorities and reduction of sediment from the site.

Management Outcomes:

- Stabilize unpaved roads and bare soils in priority subwatersheds.
- Stabilize and protect the coastal zone in priority locations.

Evaluation Questions:

- What area has been stabilized?
- What percent of the BMPs are functioning as designed?

To achieve this management goal, the following objectives must be fulfilled:

1. Create a spatial inventory of all BMPs installed throughout Culebra to reduce the land-based sources of pollution contributed to the nearshore environment, including stabilized unpaved roads (via sediment traps, cross-drains, check dams, and other actions), floating treatment wetlands, coastal stabilization, and other BMPs.
2. Quantify the condition of unpaved road segments and installed BMPs to inform maintenance schedules and support watershed simulations to model sediment pollutant loads in priority watersheds.
3. Create a tracking tool that will allow for repeating condition assessments over time for both individual BMPs and road segments.

This monitoring data will be utilized to quantify the amount of sediment being captured by installed management practices. These insights will then inform the design and placement of future interventions and justify the funding required to pave roads where significant sediment movement is still observed following road stabilization interventions.

# 3. Monitoring Tasks

## 3.1 BMP Inventory

Road Segment Delineation and Condition Assessment:

Road segments (both stabilized and unstabilized) will be delineated primarily by drainage divides and uniformity of features, and secondarily by landmarks such as major intersections, BMP features, or road barriers. Uninterrupted segments will be delineated by points of high elevation, with the segment start and stop occurring at high points, to capture the entire length of road contributing runoff to a single drainage point. Interrupted road segment ends may be delineated by intersections into another road, dead ends, large BMP, and other unique factors (e.g., funding, maintenance plans, ownership boundaries, etc.) which may not occur at points of high elevation.

There are generally three classes of roads that will be evaluated as part of this monitoring effort:

1. Unstabilized dirt roads
2. Stabilized dirt roads
3. Stabilized paved roads

Unstabilized dirt roads (Figure 1) are those where vegetation has been removed or worn away, directly exposing the soil beneath. These roads contain no drainage control practices to alter the speed or

direction of runoff and are characterized by un-compacted earth. Unstabilized dirt roads often have ruts and potholes which have been worn into the road from vehicles and concentrated flows scouring away the native soil during storm events. During heavy rain events, unpaved dirt roads often produce large quantities of sediment that is swept away in roadway runoff and transported through the watershed to the nearshore environment, causing visible sediment plumes in bays and along the coastline.

Figure 1: Examples of unstabilized dirt roads (Kitchell et al., 2021).

Stabilized dirt roads (Figure 2) are those which have been strategically altered to control the flow path and speed of runoff, using best management practices such as soil compaction and surface grading, installing cross drains, grade breaks, turnouts, and ditches, geosynthetics, and other slope stabilization measures. Stabilized dirt roads have stabilized outfalls and often discharge to forested areas or temporary storage areas to promote infiltration and sediment capture. Well-functioning stabilized unpaved roads convey water off the roadway quickly to prevent it from ponding on the surface, disperse water rather than collect it, maintain proper compaction and road slope across the crown of the road, and have stabilized conveyance ditches and outfalls.


Figure 2: Examples of stabilized dirt roads and best management practices (Kitchell et al., 2021).

Stabilized paved roads (Figure 3) are typically of very steep slope (>20%). These roads have been strategically paved to prevent scour and improve the road's ability to withstand the high velocity runoff caused by their steep nature. Stabilized paved roads still include drainage control measures, such as ditches and cross drains to manage runoff and prevent downhill erosion (Kitchell et al., 2021).

For more detailed explanations of road classifications, performance, and drainage best management practices, please reference the *Unpaved Road Standards for Caribbean and Pacific Islands* by Kitchell et al., 2021.

Figure 3: Examples of stabilized paved roads and best management practices (Kitchell et al., 2021).

Road segments will be remotely delineated using GIS by Project Lead Anne Kitchell. Protectores de Cuencas (PDC) will provide an updated unpaved roads layer that specifies which roads have been stabilized, year and funding source, as well as which road segments are planned for future restoration. The Horsley Witten Group (HWG) will pre-segment the unpaved road layer based on topography (drains to common point), key intersections, BMP locations (like sediment traps), road ownership, or other distinctive features.

Segment nomenclature will start with a two-letter code indicating the watershed in which the segment lies (see Table 1 for list of watersheds and labels). This letter is then followed by a road number indicating the system of road segments. Each segment contained within the same continuous road system will have the same road number. Lastly, the road number is followed by a dash and the segment number. Segment numbers are unique to each segment, and increase in succession until the end of the road system is reached. For example, the road segments in Puerto Del Manglar along the lower road system would be denoted as PM1-1, PM1-2, PM1-3, etc. The segments in the Puerto del Manglar upper road may then be classified as PM2-1, PM2-2, PM2-3, etc.

The HWG will then upload this road segment shapefile to the Culebra Project BMP Field Collection Web Map on ArcGIS FieldMaps (hereafter referred to as the FieldMaps App). These segments will then be ground truthed on Culebra by the PDC staff, the HWG, NOAA, and others. As a result, segment breaks may be field modified and QA/QCed back in the office. This field team will also assess the condition of each road segment using the FieldMaps App, noting attributes such as ditch type, erosion concerns/problems, number of check dams, maintenance recommendations, pitch, surface material, slope, and width of travel lane. Please see the Culebra FieldMap App User Manual for instructions on how to create road segment features in FieldMaps.

Table 1: Watershed label codes for road segment nomenclature.

| Watershed | Code | Watershed | Code |
|---|---|---|---|
| Puerto del Manglar | PM | Molinos | ML |
| Almodovar | AL | Carlos Rosario | CR |
| Manzanilla | MZ | Playa Tamarindo | PT |
| Mosquito | MQ | Bahia Tamarindo | BT |
| Larga | LG | Laguna Cornelio | LC |
| Zoni | ZO | Tamarindo Chico | TC |
| Caranero | CN | Melones | ME |
| Cabra | CA | Bahia Sardinas | BS |
| Cementerio | CM | Culebra | CU |
| San Isidro | SI | Datiles | DA |
| Brava | BR | Cascajo | CJ |
| Resaca | RE | Fulladosa | FD |
| Coronel | CO | Dakiti | DK |
| Aeropuerto | AP | Malena | MA |
| Flamenco | FL | Soldado | SD |
| Peninsula | PN | | |

BMP Location and Condition Assessment:
All other BMPs outside of stabilized roads will be logged by PDC and HWG project support staff in the *Road BMP Maintenance Log* layer of the Culebra Project BMP Field Collection Web Map using the FieldMaps App. BMP type, including sediment traps, road crossings/culverts, pavements, grade breaks, road closures, waterbars, turnouts, slope stabilizations, and terracing, will be indicated, as well as attributes such as dimensions, condition, and a description of actions needed (if any). Please note that individual check dams in ditches will not be mapped rather they are included in the road segment assessment. Condition of the BMP will be graded as one of six conditions, ranging from new, like new, and working, to needs maintenance, needs repair, and needs replacement. Please see the Culebra FieldMap App User Manual for step-by-step instructions on how to create road segment features in FieldMaps. BMP nomenclature will be specified by watershed (using the watershed codes from Table 1) and successive island wide numbers starting at 100.

## 3.2 BMP Maintenance Log

Any maintenance completed, either while assembling the BMP Inventory or from routine BMP cleanouts every 6–8 months, will also be noted as an attribute of the point or line segment to track how frequently each BMP type requires servicing. To add maintenance observations to an existing point, select the existing BMP point or line segment and click a number of times to edit the line segment vertices. Specify

if existing points are to be edited / added by creating a new entry to the maintenance log. Please see the Culebra FieldMap App User Manual for step-by-step instructions on how to create new features in FieldMaps.

The amount of sediment accumulated in each BMP will be logged as a volumetric estimation depending on the maintenance machine/tools used. For example, if a backhoe with a 1 cubic meter bucket is used, then the total number of cubic meters of material removed is logged in the maintenance notes.

- For road segments: the total number of buckets of sediment removed from all the check dams in that segment will be logged in the roads (line) layer.
- For all other BMPs: the total volume of sediment removed is logged in the maintenance notes.

### 3.3 Compile Project Implementation Inventory

The objective of the Project Implementation Inventory is to track the transition of projects from un-implemented to implemented, as well as the total area of projects implemented for federal reporting purposes. Reported metrics include the total area of project footprints (acres) and total length of roads stabilized (miles). After all the completed BMPs and stabilized road segments have been inventoried and verified in the field, the measured dimensions of these BMPs will be used to calculate the total area stabilized as a result of NOAA's LBSP management investments, including road segments, sediment ponds, floating treatment wetlands, coastal stabilization (Tamarindo and Zoni beach projects), and stormwater features. Example metrics may include:

- Create a buffer around each road segment using the measured travel lane to turn the line segment into a polygon.
- Storage capacity of sediment traps based on measured dimensions and estimated sediment accumulation.
- Overlay road segment polygons and BMP polygons to determine total area stabilized.
- Quantify the drainage area of each sediment pond and stabilized road to calculate the total amount of area influenced by implemented BMPs.
- Volume-based measurement of stormwater/sediment managed may be more meaningful metric.
- Acres of road and percent of BMPs by condition and function.

The total length of stabilized roads will be calculated as the sum of all stabilized road segment lengths using GIS.

## 4. Monitoring Location and Frequency

Monitoring will initially be prioritized in the Fulladosa, Culebra/Punta Aloe, and Puerto del Manglar watersheds, as these projects have been completed to date, should not have any major changes in the near future, and are the focus of future watershed modeling efforts. The first year's monitoring effort is expected to be the largest as the BMP inventory, including both road segment delineation and BMP point identification, will need to be intentionally collected. The maintenance log can then be opportunistically collected as deemed appropriate by the Protectores de Cuencas staff, with each installed BMP evaluated between every six to eight months for maintenance. A complete island wide maintenance log should be completed annually.

## 5. Data Management

All data collected via the FieldMaps app will be hosted on the Culebra Project Data Hub by HWG. The HWG will load flat BMP and road inventory spatial layer (time stamped) to the Culebra Project Data Hub and to NCEI on a periodic basis (likely based on end of project call orders). HWG will provide QA/QC on inventory layers and follow NCEI protocols for metadata.

## 6. Estimated Cost

| Category | Item Description | Cost per unit | Unit / days | Per Trip | # Persons | Per Year | Total Annual | Notes |
|---|---|---|---|---|---|---|---|---|
| Staff | Data collection: BMP and road initial inventory. | $20,000.00 | one-time | 1 | 1 | 1 | $20,000.00 | PDC / HWG / NOAA Lead scientist(s) travel to Culebra to complete island wide BMP and road inventory; estimate includes lodging and per diem. |
| Staff | Data collection: hours on Culebra to complete annual inspection. | $35.00 | hour | 120 | 1 | 1 | $4,200.00 | Calculated as 3, 40-hr weeks to complete the island wide BMP and road annual inspection by PDC staff. |
| Staff | Hours on Culebra to complete BMP / road annual maintenance data collection. | $35.00 | hour | 120 | 1 | 1 | $4,200.00 | Calculated as 3, 40-hr weeks to complete the island wide BMP and road annual inspection by PDC staff. |
| Travel | Ferry | $10.00 | roundtrip / person | 1 | 1 | 6 | $60.00 | 6 trips per year. |
| Travel | Lodging | $159.00 | day | 5 | 1 | 6 | $4,770.00 | Until lodging in wet lab is finished, may not need all this lodging. |
| Travel | Car rental | $100.00 | day | 5 | 1 | 6 | $3,000.00 | 6, 1-week trips. |
| Travel | Gas | $6.00 | liter | 20 | 1 | 6 | $720.00 | 6, 1-week trips. |
| Travel | Per diem | $105.00 | day | 5 | 1 | 6 | $3,150.00 | Assuming 5 work days and 2 travel days per trip. |
| Travel | Per diem (travel days) | $78.75 | day | 2 | 1 | 6 | $945.00 | Assuming 5 work days and 2 travel days per trip. |
| Services | Data post processing QA/QC | $40.00 | hour | 100 | 1 | 1 | $4,000.00 | HWG Staff |
| Services | Data posting | $40.00 | hour | 100 | 1 | 1 | $4,000.00 | HWG Staff |
| Services | AGOL Credits | $25.00 | hour | 1 | 1 | 12 | $300.00 | HWG Staff |
| Equipment | Tablet for FieldMaps data collection | $600.00 | one-time | 1 | 1 | 1 | $600.00 | Optional since also can use phone, but preferred. |
| **Total** | | | | | | | **$49,945.00** | |

# 7. References

Kitchell, A., Kuchar, B., & Viqueira Ríos, B. (2021). Unpaved Road Standards for Caribbean and Pacific Islands. Prepared for the NOAA Restoration Center and Coral Reef Conservation Program, 71.