

Climate Technology Centre Network (CTCN) Technical Assistance to the Republic of Mauritius

Identification and characterisation of potential sand
resources for beach rehabilitation

Inception report No.1 20-02-2017, Rev 1. 23-05-2017



Ministry of Social Security, National Solidarity, and
Environment and Sustainable Development (Environment and Sustainable Development
Division) [MSSNSESD]

Inception Report

March 2017

This report has been prepared under the DHI Business Management System certified by Bureau Veritas to comply with ISO 9001 (Quality Management)

ISO 9001
Management System Certification

BUREAU VERITAS
Certification Denmark A/S



Climate Technology Centre Network (CTCN) Technical Assistance to the Republic of Mauritius

Identification and characterisation of potential sand
resources for beach rehabilitation

Inception report No.1 20-02-2017, Rev 1. 23-05-
2017

Prepared for Ministry of Social Security, National
Solidarity, and Environment and
Sustainable Development (Environment and Sustainable
Development Division) [MSSNSESD]

Represented by Permanent Secretary



Project manager	Anders Jensen
Project number	11818880
Approval date	23 May 2017
Revision	Rev. 1
Classification	Restricted

© DHI. All rights reserved. No parts of this document may be reproduced, transmitted or otherwise disseminated in any form or by any means outside the recipient's organisation without the prior written permission of DHI.

CONTENTS

1	Executive Summary	1
2	Introduction and Background	2
3	General Requirements to Sand Mining Areas	3
4	Mauritius Coast and Geology	4
5	Site Inspections.....	5
5.1	Site No 1: The sea east of Bambous Virieux and Pointe du Diable	5
5.2	Site No 2: The coast at Trou aux Biches	6
5.3	Site No 3: Flic-en-Flac and River Noire	6
5.4	Site No 4 : Ile aux Cerfs – Trou d'Eau Douce.....	7
6	Survey Vessel Path Finder and Identification of Laboratory for Testing Sand Size	8
7	Conclusions	8

FIGURES

Figure 3.1	Modern hopper suction dredger with a capacity of 5000 m ³	3
Figure 4.1	Soil map, Department Survey, War Office and Air Ministry 1962	4
Figure 5.1	The sea east of Bambous Virieux and Pointe du Diable	5
Figure 5.2	The coast at Trou aux Biches	6
Figure 5.3	Flic-en-Flac and River Noire	7
Figure 5.4	Ile aux Cerfs – Trou d'Eau Douce	7

ANNEXE A

Grain Size Analysis

1 Executive Summary

The Ministry of Social Security, National Solidarity, and Environment and Sustainable Development Division (Environment and Sustainable Development Division) of the Republic of Mauritius, has requested Climate Technology Centre & Network (CTCN) to provide technical assistance for identification, characterisation and exploitation of potential offshore sand banks and deposits.

Site visit to the most promising areas where marine sand may be found in sufficient quality and quantity was made in the beginning of January 2017. These areas were identified in cooperation with MSSNSESD and MOI. The following has been concluded based on the visit to Mauritius by a coastal expert from DHI, Denmark:

- The quality of sand available offshore. Commonly we refer to offshore as being after the reef) is not suitable for beach nourishment as it is too coarse and sharp grained
- The amount of sand available for mining has not been mapped in this study, but the presence of large coral pieces in all samples taken indicates that the layer of sand is thin
- The only port which can accommodate a sea-going dredger is Port Louis. At all other places, sand will have to be pumped ashore
- The access for dredgers to areas behind the reefs is dangerous so the risk of having a major oil spill is high
- There is plenty of sand of good quality available on land near all beaches.

The site visit and a subsequent study of historical satellite images from 2009 to 2017 available in Google Earth™ indicate that the visited beaches are stable under normal conditions, and only minor maintenance in form of re-locating some minor amounts of sand is necessary.

Should a beach be severely eroded during a cyclone, the sand can be replaced by sand from a land quarry.

Local contractors using local labour force can make the beach nourishment as required, whereas using sea-going dredgers suitable for navigating around Mauritius will involve foreign contractors with specialised crew.

Legislation and regulations in Mauritius may have to be adjusted to allow sand mining on land.

The scheduled seismic survey has no relevance as there are no signs of suitable sand offshore. Instead staff from all stakeholders (MSSNSESD and MOI) should be given a comprehensive course in coastal zone management including numerical modelling.

This report describes the findings from the preparation phase and the visit phase.

2 Introduction and Background

The Ministry of Social Security, National Solidarity, and Environment and Sustainable Development Division (Environment and Sustainable Development Division) has requested Climate Technology Centre & Network (CTCN) to provide technical assistance for identification, characterisation and exploitation of potential offshore sand banks and deposits.

The reason for the request to CTCN by MSSNSESD is that many of the sandy beaches along the coastline of Mauritius seems to be eroding and the erosion problems may accelerate due to the impact of climate change, which will bring increased water levels and more storms in the future.

It is of paramount importance to identify sustainable ways to protect and maintain the beaches as they are important landscape resource, and of great importance for the tourist industry which is a major income for Mauritius.

CTCN has granted funds (suggestion to put technical assistance) to help MSSNSESD to identify, map and characterise potential sand resources, which can be used to mine sand for beach nourishment. DHI was selected to help with this study.

The objectives are to determine if marine sand resources are available in areas, where sand mining is feasible and legal and to perform a geophysical survey in areas, where potential and suitable sand resources might be identified.

DHI in corporation with MSSNSESD and CTCN has prepared a Response Plan RP (Ref. /1/) which outlines the scope and frame of the technical assistance.

This assistance consists of the following sub-activities:

Activity 1.1: Preparations

The consultant's representative, Mr Anders Jensen, prepared for the visit to Mauritius. The preparations included:

- Preparation of discussions to be held with stakeholders to obtain a mutual understanding of coastal hydrodynamics and morphology with special emphasis on the conditions in Mauritius, i.e. generation and characteristics of coral sand beaches and sand deposition areas, equilibrium profile, chronic and acute erosion and requirements to nourishment sand
- Study of existing reports, satellite images and bathymetric maps.

Activity 1.2: One-week visit to Mauritius by coastal expert

Mr Anders Jensen visited Mauritius from the 4th to the 11th January 2017. The visit was hosted by MOESDDBM. The main focus of the visit was discussions with MSSNSESD and relevant stakeholders, a first meeting in the technical committee and site visits.

The following stakeholders were involved:

- MOESDDBM: Responsible for the beaches including maintenance and protection
- Mauritius Oceanography Institute (MOI): Oceanographic and bathymetry data
- Ministry of Housing and Lands Hydrographic Unit: Responsible for bathymetric surveys and operates the survey vessel "Pathfinder"
- Identification of a laboratory capable of carrying out sand size analysis.

A visit to the University of Mauritius, Concrete Technology Laboratory was initially scheduled, but this visit was cancelled due to time constraint.

3 General Requirements to Sand Mining Areas

Mining of sand shall not affect existing beaches. Potential mining areas connected to the existing shore sediment transport should not be considered.

Sand mining should be avoided in protected areas or where it could endanger the existing ecosystem & fishery. Sand for beach nourishment should preferably be located near where sand is needed. If sand is mined by a sea-going vessel, safe access to the mining area is needed and a minimum of 5-6 m water depth is required. Offloading facilities must be established with 5-6 m water depth.

The success of a nourishment scheme depends very much on the grain size of the nourished sand, the so-called borrow material, relative to the grain size of the native sand. The characteristics of the sand determine the overall shape of the coastal profile expressed in the equilibrium profile concept. Furthermore, in nature the hydrodynamic processes tend to sort the sediments in the profile so that the grain size decreases with increasing water depth. If the sand is too coarse, the beach will be narrow and steep, and if it is too fine the beach will be flat and erode fast.

Sand mining is normally done by a hopper suction dredger, see Figure 3.1, which is a special made bulk carrier, where the sand is pumped up from the seabed together with water and the sand-water mixture is separated by sedimentation process in the cargo hold (the hopper) and the surplus water flows back into the sea. The dredger can have a capacity which varies from a few hundred m³ to more than 20,000 m³. The sand is sailed to the end destination in the dredger, where it is offloaded either by a grab in a port or pumped ashore.

The service speed of such a vessel is 8-12 knob.



Figure 3.1 Modern hopper suction dredger with a capacity of 5000 m³

4 Mauritius Coast and Geology

Except for beaches and coral reef formation, the island is entirely of volcanic origin starting 10 million years ago. The latest volcanic activity occurred 20,000 years ago.

The island is partly surrounded by coral reefs, which protect the beaches from ocean waves. The distance between the reef and the beaches is rarely more than 3 km, and the sea between the reef and the beaches is shallow. Inlets (is it reef passes?) connect the ocean with the sea behind the reef. The beaches are separated by rocky headlands, which act as natural breakwaters keeping the individual beaches very stable.

The beach sand is very different from the sand found on the seabed. The sand on the beaches consists of well-rounded and well-sorted particles, whereas the sand on the seabed consists of sharp coral fragments, which have been grinded down by the waves.

Fossil coastlines and fossil coastal plains exist in numerous places on land along the coastline. They were probably deposited during the last interglacial period, where the sea level in the oceans was 6-8 m higher than today. The sand deposited here is of similar quality and grain size as the sand on the beaches. The fossil coastal deposits are shown on the soil map of Mauritius, see Figure 4.1, the yellow signature.

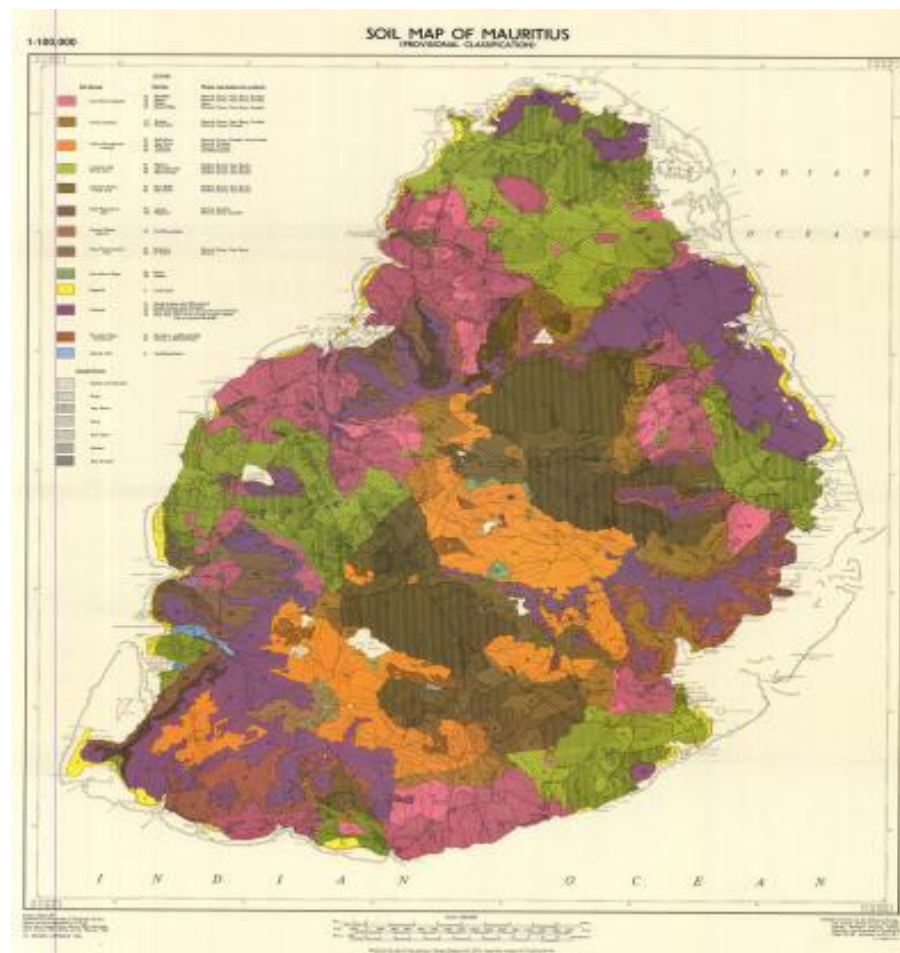


Figure 4.1 Soil map, Department Survey, War Office and Air Ministry 1962

The fossil sand exists all around Mauritius' coastline as can be seen on the figure above (yellow part of the coastal zone).

5 Site Inspections

Site visits to four locations were made during the visit by the coastal expert between the 4th and the 11th January. The four sites were:

1. The sea east of Bambous Vireux, see Figure 5.1
2. The coast at Trou aux Biches; see Figure 5.2
3. The coast at Flic-en-Flac and the mouth of River Noire, see Figure 5.3
4. The island Ile aux Cerfs and the inlet Trou d'Eau Douce, see Figure 5.4

During the site visits, samples of sand were collected from the potential sand mining areas.

The sites 1, 3 and 4 were selected as potential areas for marine sand based on analysis of satellite photos and as per suggestion of JICA study on coastal erosion. Site Nos 2 and 3 were also selected as typical beaches used by tourists and locals and as vulnerable to erosion partly due to the close proximity of building structures. Sediment samples were taken during the site visits using a Van Veen Grab sampler provided by DHI.

5.1 Site No 1: The sea east of Bambous Virieux and Pointe du Diable

Based on analysis of satellite image, Site No 1 in the sea east of Bambous Virieux was the most promising area for finding substantial amounts of marine sand. The area shown on Figure 5.1 was visited using a local coastguard boat. Samples of the seabed were collected from 5-6 m water depth. The samples collected consisted of very coarse coral sand / gravel mixed with coral fragments, see Figure 5.1. This sample was analysed by DHI and the mean grain size was found to be 0.86 mm, see Appendix A-1, which is coarse sand. This material is unfit for beach nourishment as it is far too coarse compared with the sand on the existing beaches, which has a mean grain size of 0.25 mm, see Appendix A-1.

There is no port for offloading a hopper suction dredger so the mined sand will either have to be sailed to Port Louis 57 nm away (5-7 hours sailing each way) or pumped ashore at some place. The access to the sea east of Bambous Virieux is difficult as the inlet through the reef is narrow, un-marked and winding. The risk of accident caused by grounding and subsequent wreckage with damaging oil spill as a consequences is high.

The poor quality of sand in the area combined with the difficult access and lack of a harbour or other supporting facilities makes this site unsuitable as a sand mining area.



Figure 5.1 The sea east of Bambous Virieux and Pointe du Diable

5.2 Site No 2: The coast at Trou aux Biches

The coast at Trou aux Biches is a typical example of beaches used for recreation purpose. The beach is stable, but very narrow due to man-made constructions on the back shore as can be seen on Figure 5.2.

The sand on the beach is regularly cleaned from sea weed by the hotels, and an interview with the staff revealed that sand lost by the cleaning was brought back to the beach.

The beach is vulnerable if a cyclone hits the area as sand from the narrow beach will be washed out into the shallow area between the beach and the reef. The sand will not be lost completely and could be retrieved by simple means (kindly elaborate on same).

North coast Trou aux Biches



Figure 5.2 The coast at Trou aux Biches

5.3 Site No 3: Flic-en-Flac and River Noire

The beach at Flic-en-Flac is also a typical recreational beach. The sand is moving northward by the littoral drift and has formed a wide beach at the northern end. The southern part is narrow and suffers from erosion.

The quality of sand found offshore from the River Noire is poor and consists solely of broken corals. Figure 5.3 clearly shows the difference between the beach sand and the coral sand. The quality of marine sand is too poor to consider it as a resource.

The erosion problem at the southern end of Flic-en-Flac can be solved by manually shifting the sand accumulated at the northern end to the south. This can easily be done with simple tools as the total amount is relatively small, a few hundred m³. Sandbags filled with local beach sand have been placed on parts of the beach to prevent or slower the movement of sand, but these sand bags are now exposed and should be emptied and removed as they have no positive effect.

Flic en Flac – River Noire

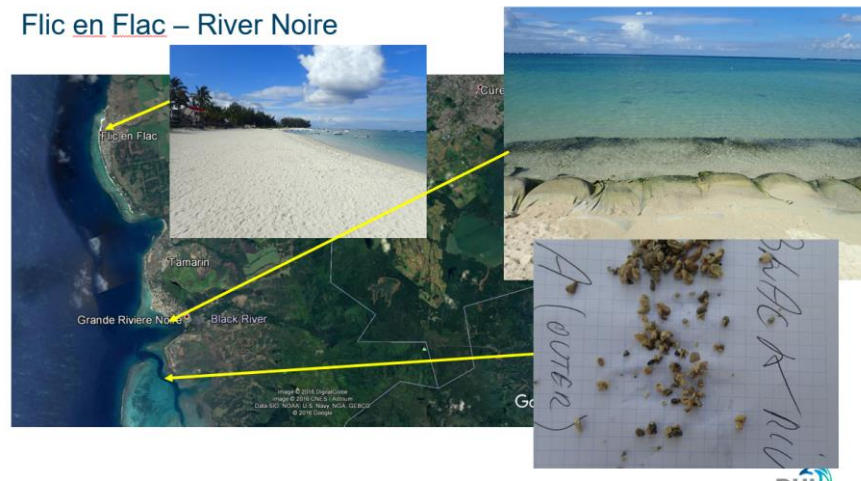


Figure 5.3 Flic-en-Flac and River Noire

5.4 Site No 4 : Ile aux Cerfs – Trou d’Eau Douce

Ile aux Cerfs holds one of the most important recreational complex of beaches and inlets on Mauritius. The beaches are stable, but some sand accumulation takes place in some of the inlets, which hinders traffic with boats. The sand accumulating in the inlets can be removed by a small local available dredger and should be put back on the beaches from where it comes. This can be done by small local available machinery.

As can be seen on Figure 5.4, the sand available at Trou d’Eau Douce is of poor quality compared to the sand on the existing beaches. The access to this potential sand mining area is also dangerous, and there is no port facility available in the area so the sand would have to be pumped ashore.

Ils aux Cerfs – Trou d’Eau Douce



Figure 5.4 Ile aux Cerfs – Trou d’Eau Douce

6 Survey Vessel Path Finder and Identification of Laboratory for Testing Sand Size

The survey vessel belongs to Ministry of Housing and Lands (Hydrographic Office) and is located in Port Louis. The vessel is an excellent survey ship, but it could not operate away from Port Louis for several days in row and not suitable to operate in the shallow lagoons.

The coastguard has patrol boats placed at various coastguard posts around Mauritius. These vessels could be rigged with survey equipment and used for geotechnical survey.

Mauritius Standards Bureau is suitable and capable of making grain size analysis of up to 180 samples from potential sand mining sites.

DHI has submitted standard procedure and a draft subcontractor contract.

7 Conclusions

The quality of sand available offshore at promising sites selected during preparation of the site visit is not suitable for beach nourishment as it is too coarse and sharp grained.

The amount of sand available for mining has not been mapped in this study, but the presence of large coral pieces in all samples taken indicates that the layer of sand is thin.

The only port which can accommodate a sea-going dredger is Port Louis. At all other places, sand will have to be pumped ashore.

The access for dredgers to areas behind the reefs is dangerous so the risk of having a major oil spill is high.

There is plenty of sand of good quality available on land near all beaches. This sand was accumulated during the last interglacial period and the sand areas are also shown on the Soil map, Department Survey, War Office and Air Ministry from 1962 shown here as Fig. 4.1.

The beaches are stable under normal conditions and only minor maintenance in form of re-locating some minor amounts of sand is necessary. Should a beach be severely eroded during a cyclone, the sand can be replaced by sand from a land quarry.

Local contractors using local labour force can make the beach nourishment as required, whereas using sea-going dredgers suitable for navigating around Mauritius will involve foreign contractors with specialised crew.

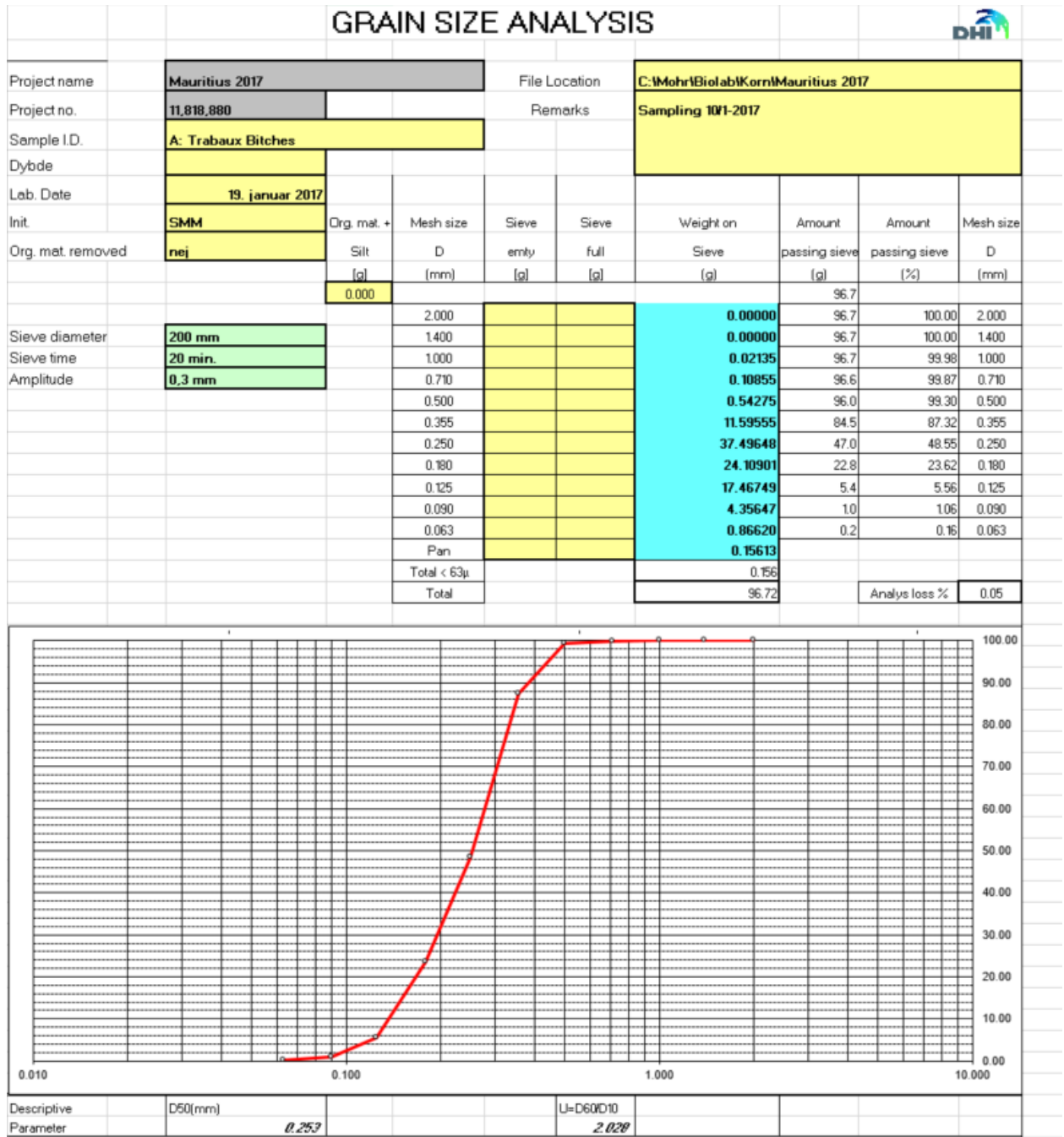
Legislation and regulations in Mauritius may have to be adjusted to allow sand mining on land.

The scheduled seismic survey has no relevance as there are no signs of suitable sand offshore. Instead staff from relevant stakeholders should be given a comprehensive course in coastal zone management including numerical modelling.

ANNEXE A

Grain Size Analysis

A.1 Beach sand from Trou aux Biches



A.2 Coral sand from offshore Pointe du Diable

