3 BASELINE ENVIRONMENT

3.1 Site Location

The site is located at Case Noyale in the district of Black River and along the western coast of Mauritius and is about 120 m long.

The location plan of Case Noyale site is shown in Drawing M190/CN/DD/01 in Appendix C.

3.2 Site Context

3.2.1 General

The project site is situated in the village of Case Noyale along the south-western coast of Mauritius in the district of Black River. The Black River-Savanne Coast Road (B9) runs on the landward side of the site, with a narrow strip of land in between (Figure 3-1).

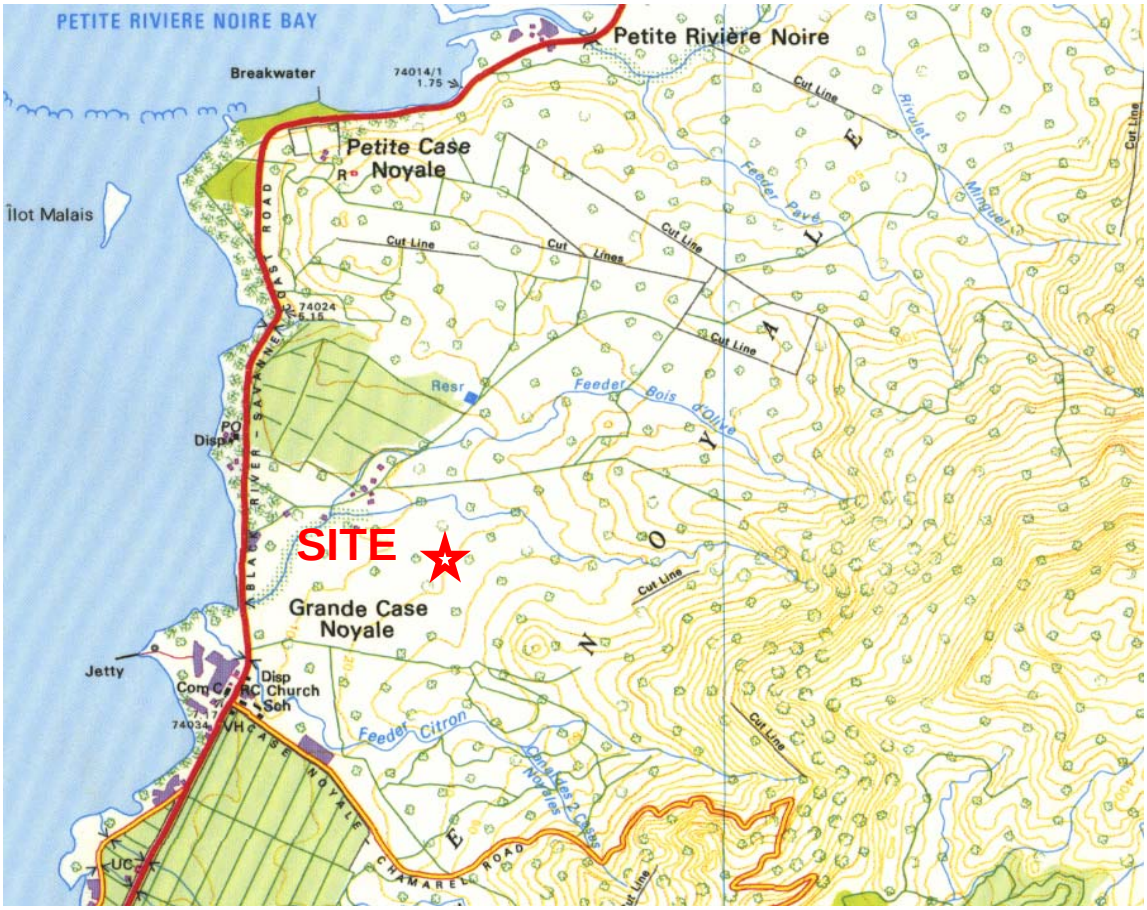


Figure 3-1: Case Noyale Site and Environs

3.2.2 Built Environment

The main built-up area of the village of Case Noyale, which comprises two localities, namely Grande Case Noyale and Petite Case Noyale, is located along B9 Road and runs northwards from the site over a distance of some 800 m. The project site is located in the locality of Grande Case Noyale, where development has taken place along the landward side of B9 Road.

Public service facilities such as the post office and the community health centre are located at the northern extremity of Grande Case Noyale on the seaward side of B9 Road.

The site environs and key features within a 1 km radius are depicted in Drawing M190/CN/EV/01.

3.3 Environmentally Sensitive Areas (ESAs)

3.3.1 General

According to the ESA Report (2009), the following ESAs are located in the site environs:

- Forest systems to the east (Black River Range)
- Feeder Bois d' Olive and Feeder Citron to the south
- Mud flats inshore
- Mangrove patches off the southern and northern tips of the site
- Sea grass in the lagoon area
- Coral reefs to the W and WNW (4.2 km and 1.5 km respectively).

3.3.2 Forest Systems

The entire forest cover of Mauritius amounts to 25% of national land area. Forest with high native species content act as the last repositories of the bulk of remaining endemic plant species in Mauritius which includes a variety of habitat types, including cloud forest, rain forest etc.

The ESA Report states that the remaining high quality forests are almost entirely restricted to the upper hills and peaks of volcanic mountain ranges. It also states in the north, these are restricted to the Port Louis-Moka Range and Gaulettes Serrées region. The bulk of the best preserved forests occurs principally within the Black River Gorges National Park in the south west of the island.

Piton de la Petite Riviere Noire, a mountain in the Black River Range is located at some 1.5 km to the east of the site and will not be influenced by the proposed works.

3.3.3 Watercourses

The site does not contain any watercourses. The nearest natural watercourse, Feeder Bois d' Olive, is located at about 150 m to the south of the site. Feeder Citron is located at some 200 m further south from the first watercourse.

In view of their respective significant distances from the project site, these watercourses will not be impacted by the project.

3.3.4 Tidal Mudflats

The ESA Report mentions the existence of a tidal mudflat along the coastline at Case Noyale.

As per the ESA Report (2009), other than the Rivulet Terre Rouge Estuary Bird Sanctuary, all other tidal mudflats are rated Category II on its role in defining terrestrial-marine ecotone and sediment control. Also, as mentioned in the Biodiversity Survey Report, the proposed woks should have very limited impact on these tidal mudflats during the construction phase.

3.3.5 Mangroves

The project site is nested within two patches of mangroves. Although the ESA Report does not classify Case Noyale as an ESA as far as mangroves is concerned, care has been taken not to damage these patches of mangroves. The Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping has imposed a minimum distance of 5 m to be kept between the mangrove patches and the proposed works. This requirement has been taken into consideration during the design phase of the project.

3.3.6 Sea Grass

According to the ESA Report 2009, the lagoon in the vicinity of the site contains sea grasses. However, the ecological survey carried out by Diospyros Ltd has not revealed the existence of sea grass beds within the study area, which covers some 100 m of the lagoon from the shoreline.

3.3.7 Coral Reef

The nearest coral reef is at some 500 m to the west of the site and as such will not be impacted by the proposed works.

3.4 Physical Site Description

3.4.1 Site Limits

The Case Noyale site is approximately 120 m long. It is bounded towards the north and the south by mangrove patches. B9 Road forms the eastern limit of the site (Figure 3-2**Error! Reference source not found.**).

The location plan of the site is enclosed as drawing M190/CN/DD/01.

3.4.2 Land Use Survey

The site has the following land uses/activities:

- Public road, houses, shops, restaurants and Government offices on the landward side

- Public beach, with benches along the waterfront.

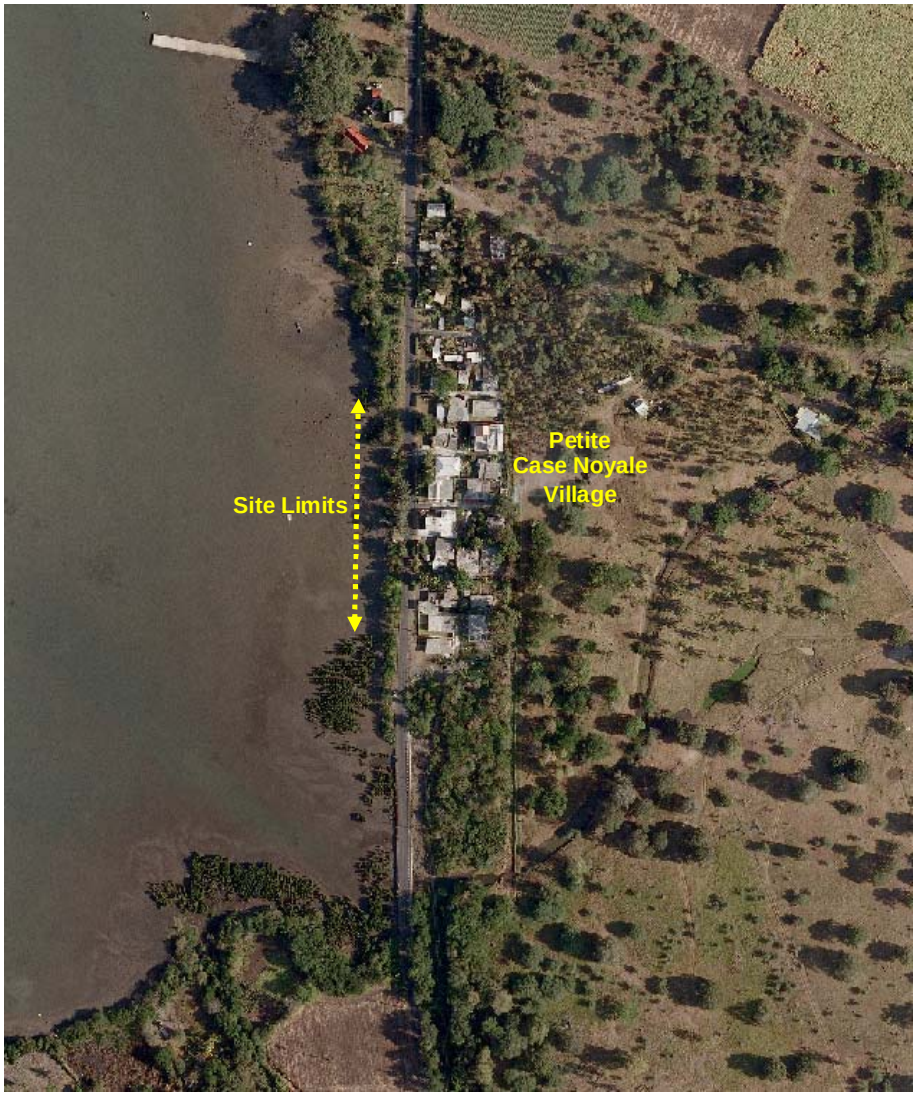


Figure 3-2: Site Limits

3.4.3 Site Topography

The site has been topographically surveyed along the waterfront strip between the landward edge of B9 Road and the High-Water Mark (HWM).

The surveys carried out at this site have also been tied to the Mauritius geodetic network named 'Local Grid Mauritius' (LGM2012), as established by the Ministry of Housing and Lands.

The features surveyed have been mapped as represented in Drawing M190/CN/DD/02.

3.4.4 Lagoon Bathymetry

The lagoon at the site has also been bathymetrically surveyed and mapped up to the -1.0m MSL contour along the site waterfront.

The lagoon is very shallow and the -1.0m MSL seabed contour was found to lie at approx. 400m off the high-water mark.

The seabed contours are shown in Drawing M190/CN/DD/02.

3.4.5 Stormwater Drainage

Storm water from higher grounds at the site drains towards B9 Road and discharges to the sea through one culvert that crosses the coast road off the southern end of the site and thence through a swale to the sea (Figure 3-3).

No storm water discharge outlets were identified within the limits of the site.

The seaward edge of the road is not kerbed and surface run-off from the road surface flows directly into the lagoon.



Figure 3-3: Culvert and Swale

3.4.6 Services/Utilities Infrastructure

Power, potable water and telecommunication networks exist near the site and run under or alongside B9 Road. Water infrastructure is mainly underground.

Power and telecommunication lines are overhead. Some telecommunication cables also run underground along B9 Road. At least three electricity poles have been surveyed at the site. None of the infrastructure elements surveyed at the site will be affected by the works.

3.5 Site Conditions

3.5.1 Waterfront Features

The waterfront is contained between two mangrove clusters at the extremities of the site (Figure 3-4). The shoreline comprises a mix of coralline sandy gravel and shell and is generally of a dark greyish colour.

There is a narrow strip of land with width varying between 5 and 7 m on the seaward side of the Coast Road.



Northern end of site



Southern end of site



View seawards (Ile aux Benitiers in background)



Existing shoreline at low tide (view from S)



South end of site (high tide)



North end (high tide)

Figure 3-4: Site Waterfront

3.5.2 Existing Situation

The fringing reef lies generally about 4.5 km offshore at the site. The beach is exposed to waves from between the SW and W sectors forming over the long fetch from the reef.

Photographs in the Island Wide Survey Report dated April 2014 by MoESD/JICA (Figure 3-5) show the extent of erosion at the lower-lying, southern part of the embankment of the Coast Road. Some concrete blocks and rocks have been laid along the bund.

Figure 3-5 also shows photos of the same Case Noyale stretch in November 2016, which suggests some recovery of the shoreline profile between 2014 and 2016. It is not clear whether this recovery was due to natural causes or human intervention or a combination of the two.

There is sand accretion in the healthy mangrove patch immediately south of the site, which indicates that the mangroves perform a useful protective function.



Erosion in early 2014



Erosion in early 2014



Similar view to South in November 2016



Similar view to North in November 2016

Figure 3-5: Erosion along Site Waterfront

According to information obtained from the Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping, the site at Case Noyale falls within a Marine Protected Area.

There is a fish landing jetty about 350 m north of the site (Figure 3-6). According to information obtained from the Ministry of Ocean Economy, Marine Resources,

Fisheries and Shipping, there are 24 registered fishers at Case Noyale, of which 14 are boat owners. There are 21 registered boats at present.

Whilst fishing boats were seen moored near the fish landing jetty during the site visits and surveys, it appears that boats are not usually moored off the waterfront to be protected under this Project.



Jetty and Landing Station to N of site



Moored fishing boats off jetty

Figure 3-6: Fish Landing Station North of the site

3.5.3 Coast Road (B9 Road)

Drawing M190/CN/PD/03 shows the plan and profile of the Coast Road at the site. The road (Figure 3-7) has a straight alignment parallel to the shoreline over a stretch of about 200m. The level of the seaward edge of the road slopes from +2.87 m MSL off the northern end of the site (Ch 200) to +1.81 m MSL off the southern limit (Ch 0).







Coast Road and verge (view to the South)



Coast Road and verge (view to the North)

Figure 3-7: Coast Road (B9)

Pedestrian facilities exist along the landward side of the coast road only.

3.6 Biodiversity/Ecology

3.6.1 General

An ecological study was carried out at the site during the preliminary design stage of the project for the purpose of providing baseline terrestrial and marine ecological information to allow the successful planning of coastal protection measures in relation to the biodiversity and ecosystems present and their relative sensitivity to impacts.

Considering that the studies were undertaken for EIA purposes, detailed surveys were done.

The surveys and assessment of the coastal and lagoon ecosystems were done in terms of:

- Flora, fauna and ecological compositions, diversity, state of health
- Biotopes, species composition, their relative abundance and state of health
- Ecological sensitivity of the different biotopes
- Geomorphological zonation of the affected lagoon area.

Two patches of mangroves consisting of *Rhizophora mucronata* were identified off the southern and northern tips of the site. A row of trees have been planted along the grass bank next to the road, which comprises 16 No 'coqueluche' *Pongamia pinnata*, 1 No 'tamarind' *Tamarindus indica*, 1 No 'bois noir' *Albizia lebbeck*, 1 No large and multiple-trunk 'lafouche' *Ficus benghalensis*, 1 No 'Sainte Marie' *Thespesia populnea*, and 2 'badamier' *Terminalia catappa*.

The top of the bank was found to be generally overgrown with the grass Chiendent Bourrique *Stenotaphrum dimidiatum*. A small patch of the 'Herbe la Mare' *Paspalum vaginatum* grows at the bottom of the slope near the water's edge. The terrestrial biodiversity at the site, save the mangrove patches, was found to be of low sensitivity to impact that may be caused by the proposed coastal protection works.

The intertidal marine ecosystem at the site, which extends quite far out to about 40 to 50 m, is in a relatively good condition though the species richness and densities are low. It has a medium sensitivity to impacts and coastal protection works should have very limited impact on it during construction and as such should not be significantly impacted by the proposed works.

The Biodiversity Survey Report is enclosed in Appendix B.

3.7 Geomorphology and Sediment Survey

3.7.1 Geology

The geological map of Mauritius (Figure 3-8) indicates that the Case Noyale site was formed from intermediate volcanism of fresh basaltic flows and sedimentary deposits along the coast.

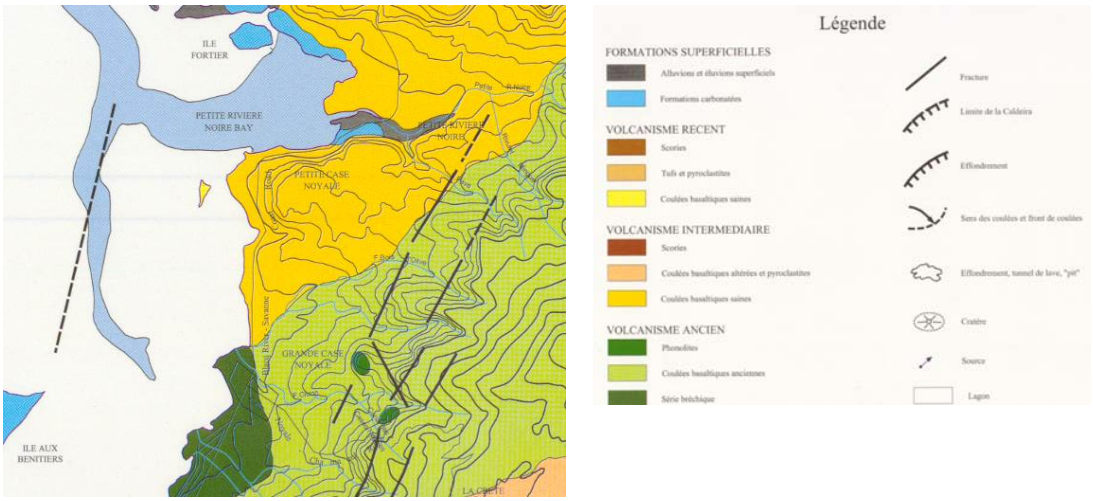


Figure 3-8: Site Geology

The natural strata consist of *Latosolic* Red Prairie Soils – shallow rocky and very rocky and *Regosols* (Coral Sand) that occurs on deep unconsolidated coral around the coast line. Coral sand is a mixture of fragmented corals, shells and sand.

3.7.2 Site Observations

The site topography is generally low-lying alongside the Coast Road. Mangroves are present at the southern and northern extremities of the site. A wide variety of trees such as banyan, *Millettia pinnata* and others exist adjacent to the HWM.

The sediments on site comprise scattered cobbles and gravels spread up to the low water mark (LWM). From visual examination, the soil at the site can be described as grey to dark greyish silty-sand to sandy-silt (muddy in nature up to -1m CD), consisting of fragmented corals, shells and pebbles.

The -1 m CD contour lies 400 m from the HWM.

3.7.3 Sediment Sampling and Test Results

Drawing No M190/CN/PD/03 shows the locations of the collected samples. Sediment sampling was carried out along four profiles at this site at the HWM, Mean Sea Level, Low Water Mark and at -1m CD contour respectively. During the sampling exercise, particle sizes greater than 63mm were discarded.

Sixteen samples were collected and tested for grain size. Dry sieving was carried out in the range of 63 mm to 63-micron particle size. Appendix A contains the detailed test results.

Based on the laboratory test results, the upper stratum at the site comprises greyish to dark greyish sandy gravel to gravelly sand of coralline origin, consisting of fragmented corals, shells and sand. Test results show that the sediment distribution from the coast seaward varies from sandy gravel to gravelly sand (ie, distribution of particles/grains from coarse to fine fraction).

Table 3-1 presents a summary of the soil classification at the site.

Table 3-1: Summary of Soil Classification

Water Mark	Sample Location			
	CN/0	CN/30	CN/60	CN/100
High (H)	Sandy Gravel	Sandy Gravel	Gravelly Sand	Sandy Gravel
Mean (M)	Sandy Gravel	Gravelly Sand	Gravelly Sand	Gravelly Sand
Low (L)	Gravelly Sand	Gravelly Sand	Sandy Gravel	Gravelly Sand
Chart Datum (CD)	Gravelly Sand	Gravelly Sand	Gravelly Sand	Gravelly Sand

3.8 Sediment Transport and Morphology

3.8.1 Sediment Transport and Morphology

A gravelly sand beach runs along the Case Noyale site, which joins a shallow gravel lagoon covered by silt and mud. Approximately 50 to 60 m of beach becomes exposed at low tide and at high tides the water level reaches the steep embankment parallel to the Coastal Road.

A mangrove cluster is present to the south of the site, which was not present historically, shown in the historical aerial image presented in Figure 3-9. Comparing the coastline in Figure 3-9 to the present coastline in Figure 3-10, the growth of the mangroves to the south of the site did not seem to have a significant impact on the morphology of the beach along the site.

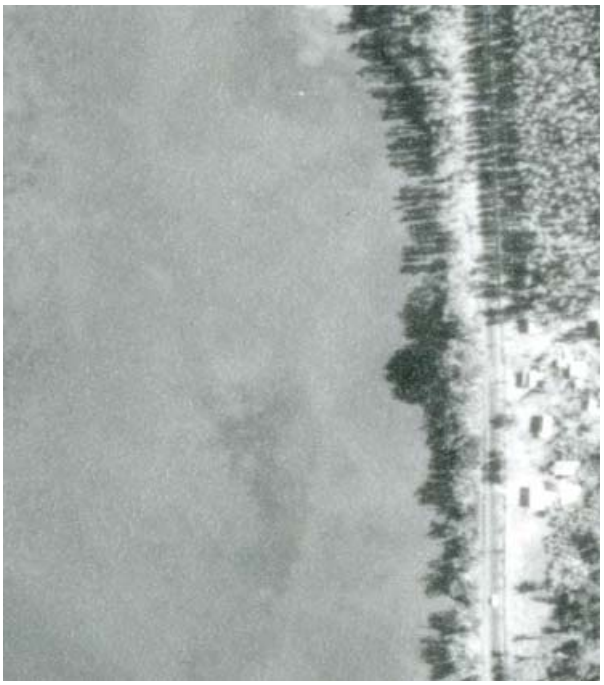


Figure 3-9: Historical aerial image (1975)

The mean wave energy flux directions presented in Figure 3-10 show the mean wave energy is fairly shore normal along the site which significantly limits net longshore

transport under general operational conditions. The wave rose shown in Figure 3-10 shows low wave energy along the Case Noyale site with waves coming from the NW and SW which balance resulting in the shore normal mean wave energy direction.

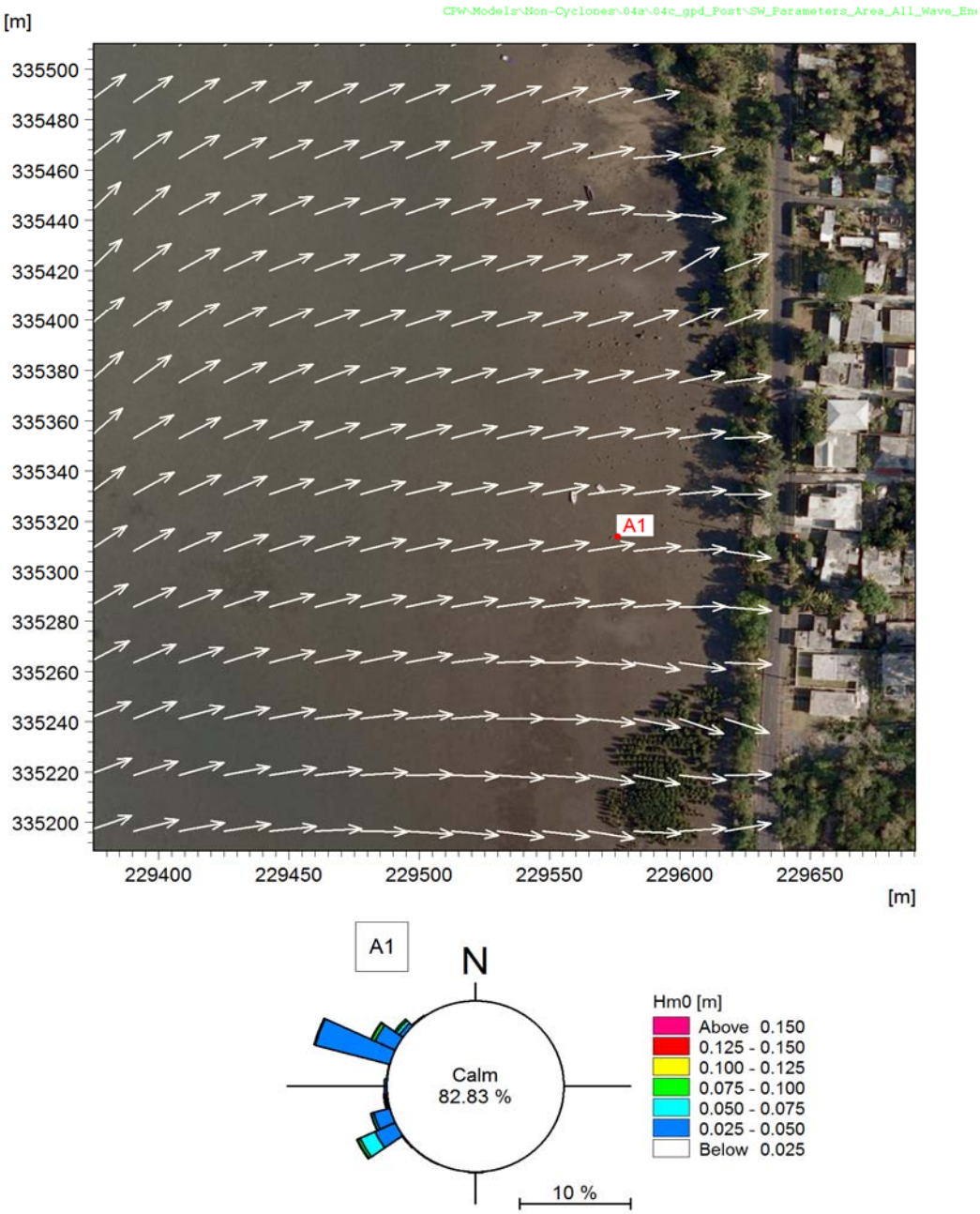


Figure 3-10: Direction of mean wave energy flux (top) and wave rose (bottom)

During low tides, wave energy will be dissipated over the mud flats and not cause significant cross-shore erosion. During high tides it is possible for wave action to attack the steeper embankment and cause cross-shore erosion. An island wide survey report published in April 2014 observed erosion that had occurred along the site causing a steep embankment to erode landwards as shown in Figure 3-11 (MOESD, 2014).



Figure 3-11: Historical imagery of eroded escarpment along site (April, 2014)

This erosion was most likely a result of the historical cyclone Edilson which passed the island of Mauritius in February 2014. The cyclone resulted in westerly winds at the site with wind speeds up to approximately 15 m/s which would have generated local wind waves over the reef flat. Cyclone Edilson that caused the observed erosion generated wind speeds at Mauritius that were between the 1-year and 10-year cyclonic wind speed.

A recent site visit in 2016 revealed that the beach has accreted to its pre-eroded profile. It is not clear whether this accretion is due to natural onshore sediment transport during calm wave periods or due to anthropological intervention.

3.9 Risks and Impacts of Climate Change

Presently the site is quite low-lying with a very narrow coastal buffer. The shallow lagoon, offshore island and mangroves provide a measure of natural protection to this site.

However, should no coastal protection measures be implemented it is expected that the narrow coastal buffer could be eroded after an extreme cyclonic storm event and that the roadway could be compromised. Significant erosion was observed in 2014, which was most likely a result of the historical cyclone Edilson. This highlights the vulnerability of the site.

It is not expected that the coastline would naturally completely recover, but limited recovery has been observed between 2014 and 2016. This may have been the result of the dumping of sediment at this location.

Significant overtopping is expected at the road and flooding of the buildings across the road could occur during a cyclone. The road is also not expected to be safe for use during a storm event.

The extreme still water level for a 100-year cyclone was modelled to be +2.6 m MSL at 2070, which is approximately the height of the current road berm north of the site. Therefore, significant overtopping and inundation would be predicted for a large event couple with SLR.

3.10 Coastal Hydrodynamics – Baseline Modelling

3.10.1 Water Level Analysis

Water level data measured at Port Louis was available from the University of Hawaii Sea Level Center (Caldwell, et al., 2015). The dataset comprises measured water levels for a period of 31.2 years between 1986 and 2017. The vertical datum of the raw dataset is “Tide Staff Zero”, which is 1.321 m below Chart Datum (CD) (Mauritius Meteorological Services, 2016). At Port Louis, Chart Datum is 0.37 m below Land Levelling Datum (LLD), which is also commonly referred to as Mean Sea Level (MSL). The raw measured data is shown relative to MSL in Figure 3-12.

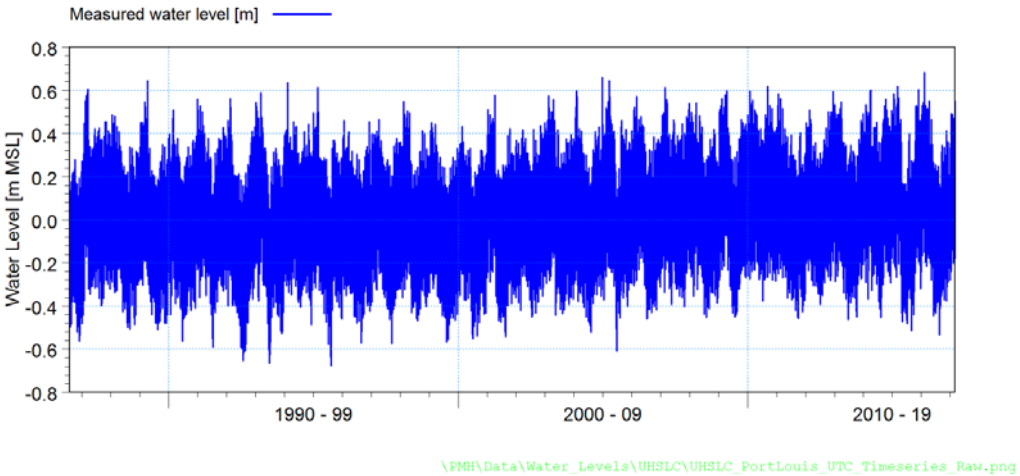


Figure 3-12 Raw water level data measures at Port Louis (Caldwell, et al, 2015), shown relative to Mean Sea Level (MSL)

3.10.2 Tide Levels

The measured water level data presented a notable long-term trend in the mean water level. Prior to conducting a tidal analysis of the measurements, the trend in the long-term data was removed. This was done applying a linearly-varying correction based on a trend line fitted through the data.

The correction was applied such that the mean level of the de-trended dataset is equal to the mean level of the original dataset at 1995, calculated as the average of the period of 1986-2005. This was done in order to have a baseline water level dataset which could be compared against the projections for sea level rise, which use 1995 as a baseline date.

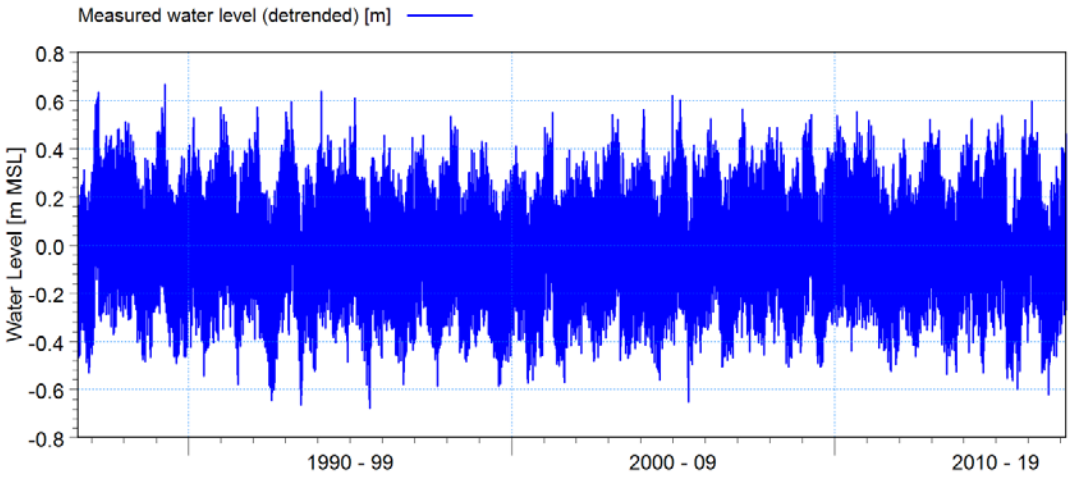


Figure 3-13 Water level data measured at Port Louis (Caldwell, et al., 2015). The data shown was detrended, with a mean level equal to the measured mean level at 1995, calculated as the average over 1986-2005.

A tidal harmonic analysis was carried out on the de-trended dataset, using the Tidal Analysis of Heights Tool in the MIKE 21 Toolbox (DHI, 2016e). The output of the tool is a set of tidal constituents for the site. Using the same tool, the tide at Port Louis was predicted using the constituents obtained from the analysis. The resulting predicted tidal water levels are presented in Table 3-2 relative to MSL and to CD.

Table 3-2 Predicted tidal water levels carried out through analysis of the de-trended water level measurements at Port-Louis. The ML of the de-trended dataset corresponds to the mean level in 1995, calculated as the average over 1986-2005

Tide Level	Predicted from de-trended measurements (m MSL)	Predicted from de-trended measurements (m CD)
Highest Astronomical Tide (HAT)	0.458	0.828
Mean High Water Springs (MHWS)	0.278	0.648
Mean High Water Neaps (MHWN)	0.072	0.442
Mean Level (ML)	0.004	0.374
Mean Low Water Neaps (MLWN)	-0.062	0.308
Mean Low Water Springs (MLWS)	-0.247	0.123
Lowest Astronomical Tide (LAT)	-0.498	-0.128

The maximum measured residual tide is approximately 0.5m. Most of the residuals appear to be associated with cyclones.

3.10.3 Climate Change and Sea Level Rise

The measured tidal data was used to estimate the average sea level rise (SLR) for different time periods. Based on analysis of the Port Louis tidal measurements the following SLR trends have been determined (as shown in Figure 3-14):

- +3.9 mm/yr for 1986 to 2016 (all 30 years)
- -3.2 mm/yr for 1986 to 2000 (first 15 years)
- +6.1 mm/yr for 2001 to 2016 (last 15 years).

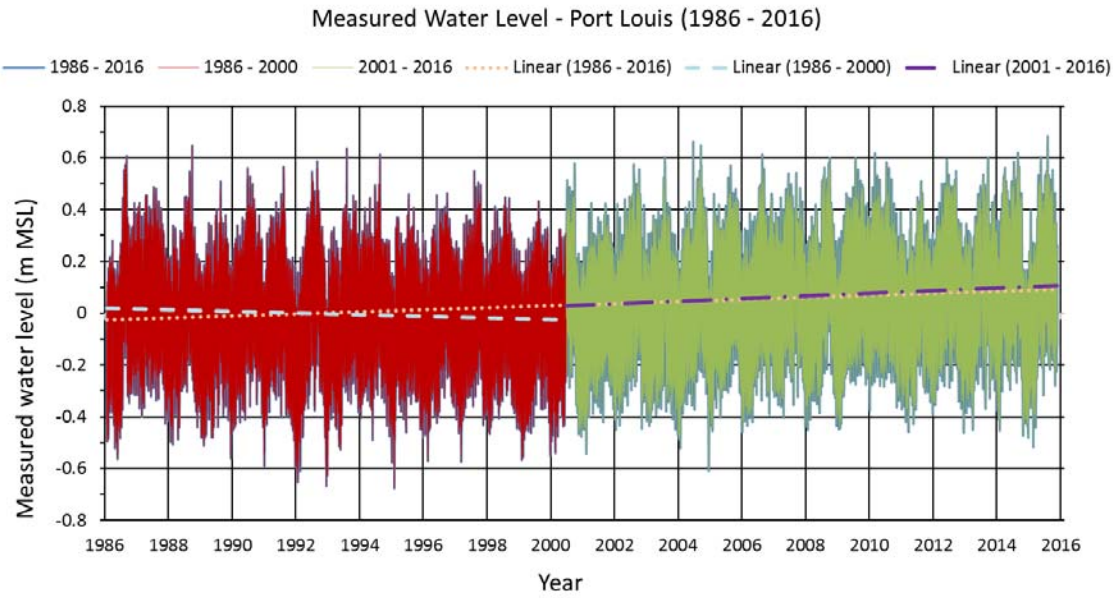


Figure 3-14 Measured Water Level at Port Louis with SLR Trend Lines

The data indicates that some variability is visible in the region's water levels, but in general an increasing trend in the mean water level has been observed.

3.11 Climate

3.11.1 Water Levels

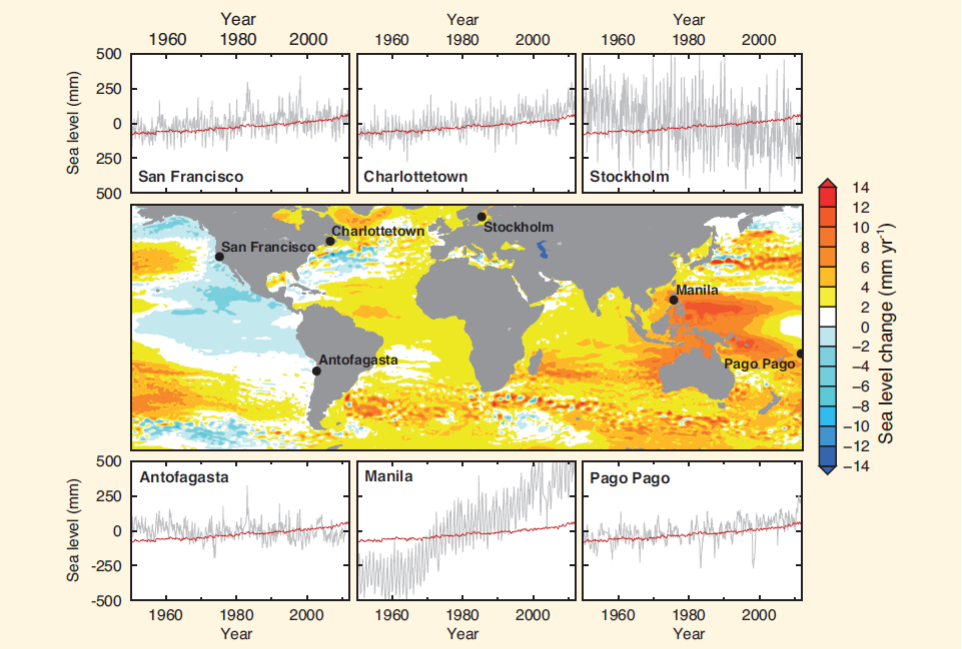
Various literature references were consulted, including the previous project studies. The key findings are summarised below:

- SLR dropped between 1986 and 2000 at Port Louis due to regional water level variability (Church,2006)
- +1.5 mm/yr at Port Louis including measurements in the 1950s and 1960s (Church, 2006)
- +2.1 mm/yr based on tidal data for 2003 to 2013 as sourced by Mauritius Meteorological Services (JICA, 2016)
- The IPCC (2013) estimates an average SLR between 1993-2010 of 3.2 mm/yr (ranging between 2.8 to 3.6 mm)
- +3.9 mm/yr for an analysis of the Port Louis tidal data 1986 to 2013 (JICA, 2016)
- +5.6 mm/yr has been predicted for the period 2003-2012 by the Sea Level Rise centre of the University of Hawaii (Thompson et al, 2016) as referenced by (JICA, 2016)
- +3.9 mm/yr for 1986 to 2016 (all 30 years) based on an analysis of the Port Louis data (discussed in Section 3.10 above)
- -3.2 mm/yr for 1986 to 2000 (first 15 years) based on an analysis of the Port Louis data (discussed in Section 3.10 above)
- +6.1 mm/yr for 2001 to 2016 (last 15 years) based on an analysis of the Port Louis data (discussed in Section 3.10 above)

- Mauritius is situated in a region which experienced ~6 mm/yr SLR in the period between 1993 – 2012, which is above the global average (IPCC, 2013) as shown in Figure 3-15.

Based upon the literature and the measured data for Port Louis, Mauritius appears to be near to the upper limit of the current global SLR observations.

The global mean sea level rise projections (IPCC, 2013) provide a basis for estimating the SLR for different years in the future. The recommended upper limit SLR can be predicted based upon the upper limit of the peer-reviewed climate models (as shown in Figure 3-15). This translates to an SLR of 0.25 m for 2040 and 0.55 m for 2070.



FAQ13.1, Figure 1 | Map of rates of change in sea surface height (geocentric sea level) for the period 1993–2012 from satellite altimetry. Also shown are relative sea level changes (grey lines) from selected tide gauge stations for the period 1950–2012. For comparison, an estimate of global mean sea level change is also shown (red lines) with each tide gauge time series. The relatively large, short-term oscillations in local sea level (grey lines) are due to the natural climate variability described in the main text. For example, the large, regular deviations at Pago Pago are associated with the El Niño-Southern Oscillation.

Figure 3-15 Extract from Chapter 13: Sea level change in the Fifth Assessment Report (IPCC,2013)

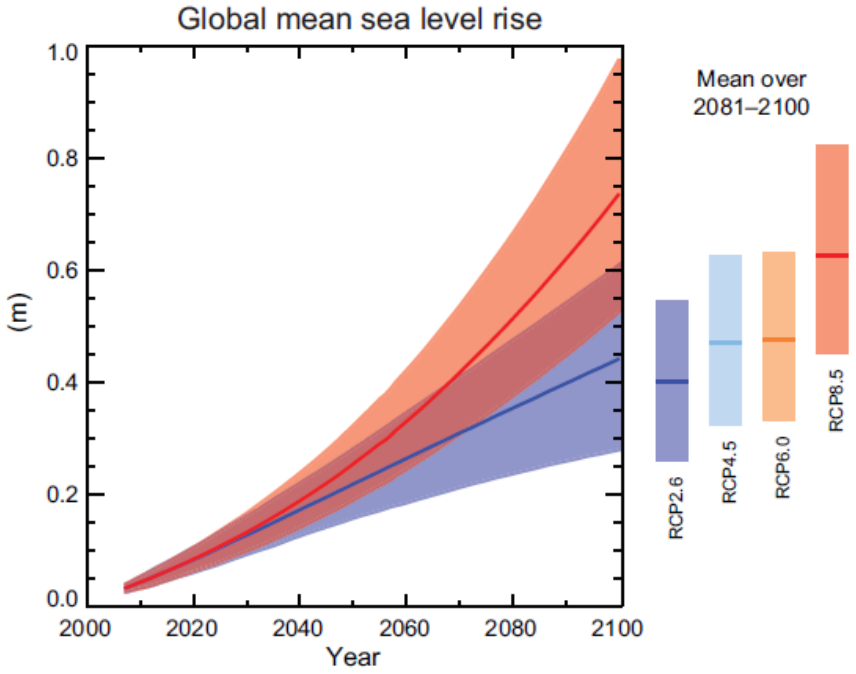


Figure 3-16 SLR projections for this century, showing upper limit values for 2040 and 2070 (IPCC, 2013)

The recommended design SLR for the three different design years are provided in Table 3-3. The recommendation of 0.1 m SLR for 2020 is based upon the actual measured data: an average increase of 3.9 mm/yr increase for 25 years is approximately 100 mm by 2020.

Table 3-3 Applied design SLR for 2020, 2040 and 2070 based on 1995 level

Design Year (yr)	SLR (m)	Average rise from 1995 (mm/yr)
2020	0.10	3.9
2040	0.25	5.6
2070	0.55	7.3

3.11.2 Cyclones

Cyclone track data for this study has been sourced from the International Best Track Archive for Climate Stewardship (IBTrACS) from 1980 to 2015 (NOAA, 2016), as shown in Table 3-4 and Figure 3-17.

Table 3-4 Meteo France La reunion (MFR) storm classification system

Category	10 min average V_{max} (m/s)	10 min average V_{max} (km/h)
Tropical disturbance	<14	<50
Tropical depression	14 – 17	50 – 61
Moderate tropical storm	17 – 24	61 – 86
Severe tropical storm	24 – 32	86 – 115
Tropical cyclone	32 – 46	115 – 166
Intense tropical cyclone	46 – 59	166 – 212
Very intense tropical cyclone	>59	>212

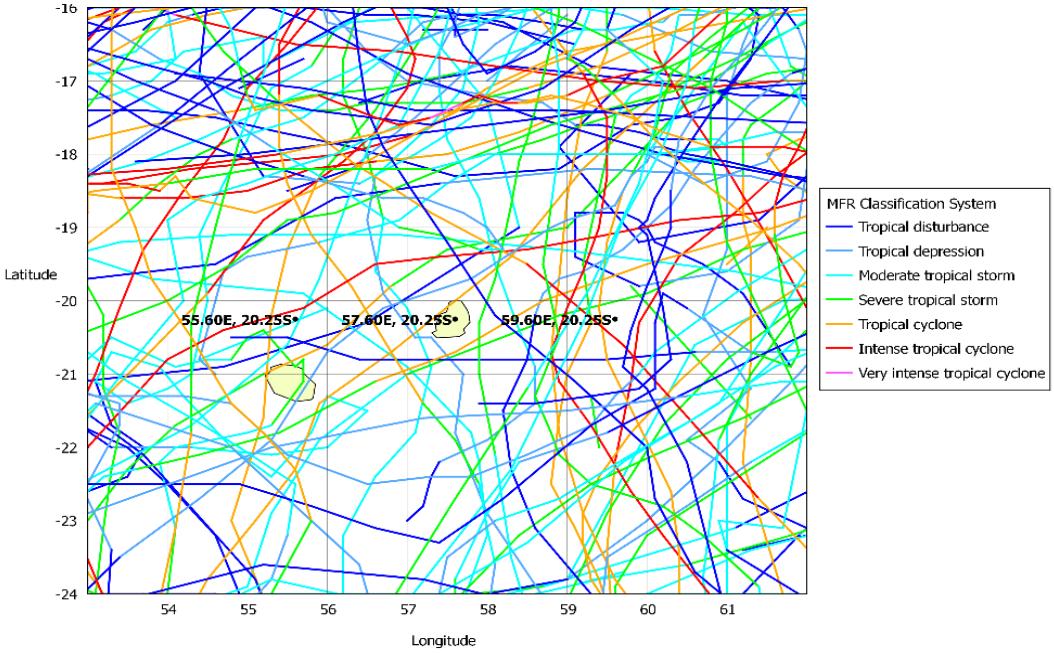


Figure 3-17 MFR best track data for the years 1980 to 2015. Also indicated are the three locations used in the calculation of extreme wind speed.

A parametric wind field model was run to determine time-series of wind speed at any location of interest. The time-series of modelled wind peaks for all available historical tropical cyclone events were extracted at three locations with 2° spacing in longitude for the Mauritius area (Figure 3-17). The resulting time series (Figure 3-18) shows scatter but no clear trend to support an increasing trend in cyclone wind speeds over the last 35 years.

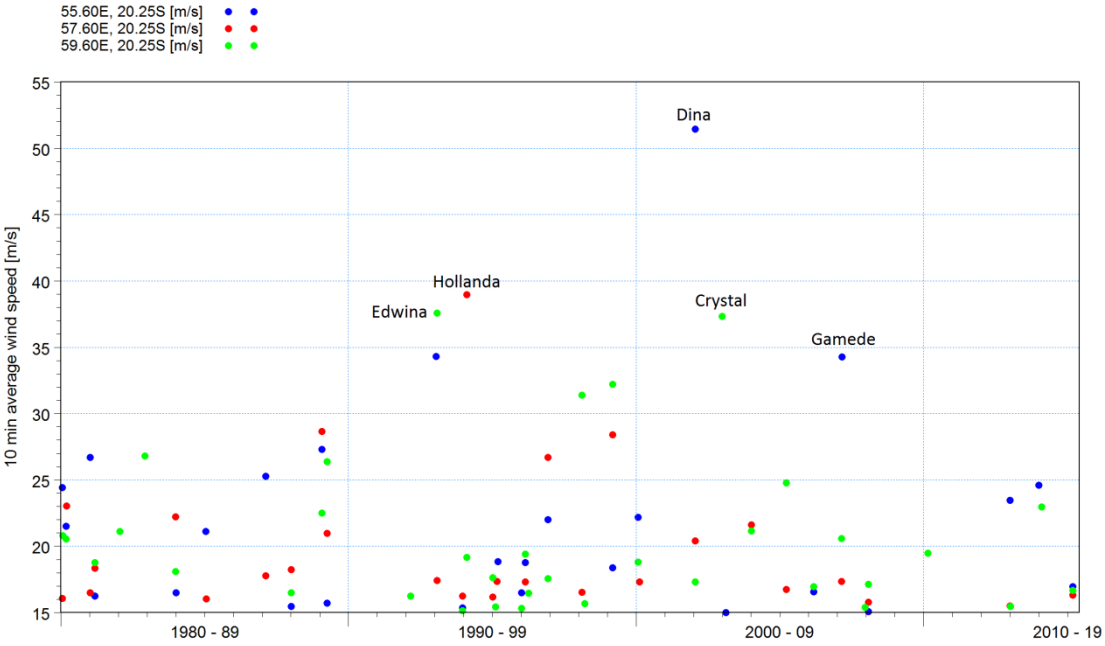


Figure 3-18 Time-series of modelled peak wind speeds for all historical tropical cyclones from 1979 to 2015 at the three locations in Mauritius

Based upon literature, cyclone frequency is expected to decrease or remain unchanged for 21st century (IPCC, 2013). However, on average an increase in cyclone intensity of approximately 10% is predicted for some basins. Additionally, mean cyclonic wind speeds are expected to increase between +2% and +11% (IPCC, 2013), with regional variation likely. There is low confidence in these projections at this stage.

Other sources cite the following findings:

- an increase in the frequency of intense storms in the Mauritius area from 1993 to 2008 (Fairhurst,2011)
- an increase in Category 3 storms and larger after 1997 in the region while no increase in total number of storms (Malan, 2013)
- the frequency and intensity of cyclones indicated overall increased activity during 1980 – 2007 (Mavume, 2009).

The IPCC (2013) predicts a 10% 'best estimate' increase in the lifetime maximum intensity of tropical cyclones for the South Indian Ocean, with a range of 0% to 15%.

Based on the above, the values shown in Table 3-5 have been used in this study.

Table 3-5 Applied increase in cyclone wind speed

Design year (yr)	Change in wind speed (%)
2020	0
2040	+5
2070	+10

3.11.3 Wind

The potential increase in non-cyclonic winds have also been evaluated as this could impact upon the wind and swell wave design conditions, particularly for the operational case.

Various differing predictions for the change in extreme wind speeds have been sourced, i.e. (Young, 2012) estimated the trend in the 100-year wind speeds at 10 m elevation, which resulted in a decadal trend of 3.6 m/s per decade (if based upon a starting point of 44 m/s this results in approximately 8% increase per decade). (Bhaskaran, 2014) reports that an increase in the wind speeds (+3.2 m/s) and corresponding wave heights (+1.52 m in last 21 years) can be seen between the latitudinal belts of 40°S to 55°S (which would result in an increase of 3.5% per decade if 44 m/s was the starting point). A 100-year return wind speed of approximately 44 m/s can be estimated for the Roaring 40's based upon research (Young, 2012).

Tokinaga et al (2011) predicts a trend of less than 0.1 m/s per decade for the average wind which corresponds to approximately 1.4% per decade for an average speed of 7 m/s (as shown in Figure 3-19).

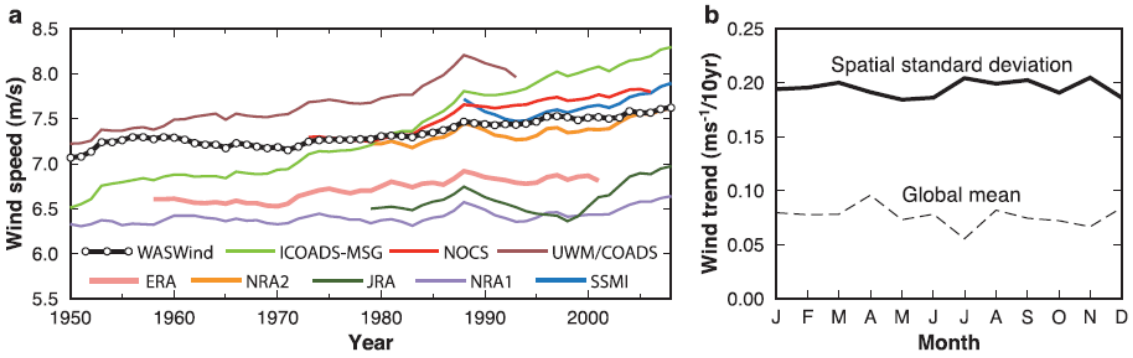


FIG. 14. (a) Time series of globally averaged annual scalar wind speed obtained from nine datasets. Each time series is smoothed with a 5-yr running average. (b) Spatial standard deviation of the scalar wind trend pattern (solid line in m s^{-1} $decade^{-1}$) and the trend of global-mean scalar wind speed (dashed line in m s^{-1} $decade^{-1}$) calculated from WASWind as a function of calendar month.

Figure 3-19 Trends in average wind speed based upon climate change (Tokinaga, 2011)

The IPCC (2013) provided trends in the surface winds speeds (for 10 m elevation) between 1988 and 2010 for various climate models. Most models show an increase in the wind speeds in the area surrounding Mauritius; all show an increasing trend in the roaring 40's, ranging between 0.1 and 0.5 m/s per decade (as shown in Figure 3-19).

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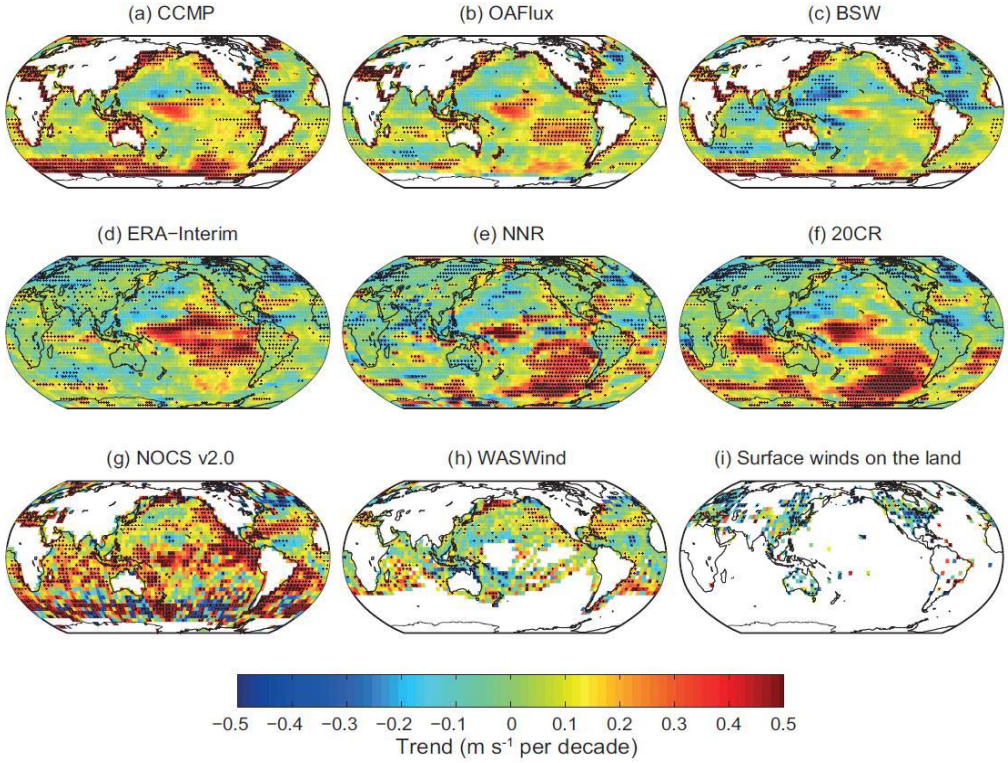

Figure 3-20 Trend in wind speeds per decade for 1998-2010 for different climate models (IPCC, 2013)

This decadal increase translates to between 1% and 5% for an average wind of 10 per decade; or 0.5% and 2.5% for two decades for an average wind of 20 m/s. There is a significant variation in the percentage change for the different models. For this study a decadal increase of 0.4 m/s is applied (for an average wind of 20 m/s); which translates to +5% increase in the wind speed by 2040, double that is applied for 2070.

Table 3-6 Applied increase in wind speed

Design year (yr)	Change in wind speed (%)
2020	0
2040	+5
2070	+10

3.11.4 Waves and Surges

To estimate the expected increase in wind-generated waves resulting from increased wind speeds, the approach detailed in the Coastal Engineering Manual (US Army Corps of Engineers, 2002) was used for fetch and duration limited waves. The expected significant wave height was calculated for different wind speeds, durations and fetches. Wave heights increased more for duration than fetch-limited conditions for the same wind speed increment. Based on these analyses the applied design values are provided in Table 3-7.

Note that when modelling the effect of climate change in this study, these increases in wave heights were only used to increase the waves on the boundary of the regional wave model. When modelling cyclone waves and locally-generated wind-waves, the approach was to adjust the applied wind speed in the model and allow the model to predict the corresponding increase in wave height.

Table 3-7 Applied percentage increase in wave height corresponding to a change in wind speed

Design Year (yr)	Change in Wind Speed (m)	Change in Wave Height (mm/yr)
2020	0	0
2040	+5	+6
2070	+10	+15

3.12 Hydrodynamic Modelling for Case Noyale Site

The results of the hydrodynamic modelling exercise carried out for the project site is detailed in Table 3-8.

Table 3-8: Case Noyale Site - Summary Design Waves and Water Levels

Climate change scenario	Return Period	Tide (incl. residual)* (m MSL)	Wind and wave setup (m)	SLR since 1995 (m)	Design SWL (m MSL)	Sea		Swell	
						Maximum H_{m0} (m)	T_p (s)	Maximum H_{m0} (m)	T_p (s)
2020	1-year	0.36	0.14	0.1	0.60	0.2	1 - 2	0.1	7 - 20
2040		0.36	0.19	0.25	0.80	0.2	1 - 2	0.1	7 - 20
2070		0.36	0.19	0.55	1.10	0.2	1 - 2	0.1	7 - 20
2020	10-year	0.42	1.08	0.1	1.60	0.6	1 - 2	0.3	8 - 12
2040		0.42	1.13	0.25	1.80	0.7	1 - 3	0.4	8 - 12
2070		0.42	1.23	0.55	2.20	0.7	1 - 3	0.5	8 - 12
2020	100-year	0.42	1.58	0.1	2.10	1.1	1 - 3	0.4	8 - 12
2040		0.42	1.63	0.25	2.30	1.2	1 - 3	0.6	8 - 12
2070		0.42	1.63	0.55	2.60	1.3	1 - 3	0.7	8 - 13

*1-year return period values calculated as the 90th percentile of high tide levels (including residuals) for all months over the period of 1986-2016.

*10-year and 100-year return period values calculated as the 90th percentile of high tide levels (including residuals) for cyclone months only (Dec-Apr) over the period of 1986-2016.

***SLR**: Sea Level Rise.

3.13 Historical/Heritage Features

The National Heritage Fund Act quotes four national heritage sites in the district of Black River, namely:

- Batterie de l' Harmonie
- Colonel Draper Tomb (La Mivoie Cemetery)
- La Tour Koenig
- Martello Tower (La Preneuse).

The closest heritage feature, Batterie de l' Harmonie, is located at about 4 km to the north of the project site. The Le Morne Cultural Landscape, which is a UNESCO classified World Heritage Site is at 4 km south of the site.

No features of historical importance are located within the site limits.

3.14 Water Quality

The water quality of the coastal water is given by the Guidelines for coastal Water Quality (Government Notice 620 of 1999).

A water sample was collected for testing to get a better indication of the water quality at the site. The sampling location is shown in Drawing M190/CN/EV/02.

The sample was tested against the requirement of the Guidelines for Coastal Water Quality (Government Notice 620 of 1999) for Category B – Recreation. The test results are presented in Table 3-9.

Table 3-9 Water Quality Test Results at Case Noyale Site

Parameters	Results	Limits Category B Recreation	Units
Temperature	25.1		ºC
Dissolved Oxygen	6.41	>5	mg/l
COD	15	3	mg/l
Cyanide	Not detected	0.01	mg CN^-/l
Nitrate as N	6.5	0.8	mg NO_3-N/l
Oil & Grease	Not detected	Not detectable	mg/l
pH	7.74	7.5-8.5	no units
Phenols	Not detected	0.05	mg/l
Orthophosphate as P	Not detected	0.08	mg PO_4-P/l
Total Suspended Solids (TSS)	4.0	5	mg/l
Arsenic	<0.001	0.05	mg/l
Cadmium	<0.001	0.02	mg/l
Chromium	<0.001	0.05	mg/l
Copper	<0.001	0.05	mg/l
Lead	<0.001	0.05	mg/l
Mercury	<0.000	0.0005	mg/l
Total Coliform	Detected	1000	Verified Coliform/100ml
Faecal Coliform	Detected	200	Verified Faecal Coliform/100ml

It is to be noted that the levels of Chemical Oxygen Demand (COD) and Nitrate as N are above the requirements of the Guidelines for Coastal Water Quality (General Notice No 620 of 1999).

3.15 Landscape and Aesthetics

Landscape and aesthetics cover all aspects of the environment that are considered to be of visual value.

The severely eroded coastline at the site has impacted negatively on the landscape. However, the coastal frontage and the beachfront view are considered to be of significant value, which need to be preserved. Visuals from the site comprise mainly the ocean in the general westerly direction, Ile aux Bénitiers to the SW and the Black River Range including Piton de la Petite Rivière Noire peak to the E.

3.16 Air Quality

The air quality at the site is typical of a low density, residential village along the coastal regions of Mauritius, where main activities are non-industrial hence non-polluting.
The most prominent source of pollution as far as air quality is concerned at the site is emissions from exhausts of vehicles along the coast road.

3.17 Traffic

B9 Road, which runs alongside the site is the only road that links the southern and the northern parts of the island via the west coast. This road starts at Souillac in the south and ends at Grande Riviere Noire. It is a road that is classified under the 'B' roads in the hierarchy of roads in Mauritius hence third in importance from a traffic point of view.

Traffic level along B9 Road at the site can be classified as medium and low during peak and off-peak hours respectively.

The coastal road at the site is also part of public bus routes. Traffic comprises mainly light vehicles, mini buses/coaches that carry tourists and employers of the hotels that are located along the west/southern coast and public buses. Commercial/industrial traffic is quite low.

3.18 Noise

The noise level at the site reflects that of a small coastal village with local traffic being the main noise source.

No other noise-producing activities were identified at the site.

3.19 Socio-economic Activities

3.19.1 Tourist Industry

No such activities have been identified at the site.

3.19.2 Fisheries

According to information obtained from the Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping, the site at Case Noyale falls within a Marine Protected Area as provided for under the Fisheries and Marine Resources Act 1998 and the Fisheries and Marine Resources (Marine Protected Areas) Regulations 2001.

There is a fish landing jetty about 350 m north of the site (Figure 3-6). According to information obtained from the Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping, there are 24 registered fishers at Case Noyale, of which 14 are boat owners. There are 21 registered boats at this site.

3.19.3 Other Activities

The narrow open space at the site waterfront is used by the inhabitants of the village for leisure activities as witnessed by the presence of benches at the site.

3.20 Consultation with Stakeholders

3.20.1 Ministries and Authorities

Consultations were held with the relevant ministries and authorities at inception and preliminary design stages of the project to obtain more information about the site and to have a better appreciation of the functional requirements at this particular site.

The public bodies consulted include:

- Ministry of Housing and Lands
- Ministry of Public Infrastructure
- Ministry of Ocean Economy, Marine Resources, Fisheries and Shipping
- Ministry of Local Government
- Ministry of Tourism
- Mauritius Oceanography Institute
- Forestry Services/Ministry of Agro Industry and Food Security
- National Coast Guard
- Traffic Management and Road Safety Unit
- Road Development Authority
- Central Water Authority
- Beach Authority
- District Council of Black River
- National Heritage Fund
- Mauritius Ports Authority.

Consultation meetings/joint site visits were held on the following dates:

- 26 December 2016
- 20 January 2017
- 24 January 2017.

3.20.2 Public Consultation

During the earlier stages of the project, the Consultant's team had interacted with members of public at the site. These interactions aimed at gathering existing information about the site specificities and were informal.

The MSSESD intends to conduct further consultation with stakeholders including the community at the site at a later stage of the project.