Black Rocks Harbor Saba

Tender Documents - Volume 2 Employer's Requirements
Part 1b: Particular Requirements and Design Criteria

Public Entity of Saba

8 December 2023

Project	Black Rocks Harbor Saba
Client	Public Entity of Saba
Document	Tender Documents - Volume 2 Employer's Requirements Part 1b: Particular Requirements and Design Criteria
Status	Final version 02
Date	8 December 2023
Reference	118421/23-019.705
Project code	118421
Project Leader	A. van den Berg MSc
Project Director	R.W. Bos BSc
Author(s)	A. van den Berg MSc
Checked by	M. Huijsmans BSc
Approved by	A. van den Berg MSc
Paraph	

Address

Witteveen+Bos Raadgevende ingenieurs B.V. | Deventer
Blaak 16
P.O. Box 2397
3000 CJ Rotterdam
The Netherlands
+31 10 244 28 00
www.witteveenbos.com
CoC 38020751

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INTRODUCTION

The purpose of this document is to specify all particular requirements, technical design criteria, design loads and design approaches for all objects to be designed and built.

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GUIDELINES, DOCUMENTS AND DEFINITION DRAWINGS

2.1 Standards, codes and guidelines

The design of all Temporary and Permanent Works shall comply with the latest editions of European specifications, standards, codes of practice, guidance and regulations . A consistent, coherent and compatible set of standards shall be used, appropriate to the form of construction and the environment. Table 2.1 lists design standards/ codes and guidance the Contractor shall at least adhere to.

Equivalent standards, codes of practice, guidance and regulations in another Member State of the European Community or equivalent British Standard or equivalent American Standard may be proposed by the Contractor. In such case the Contractor shall demonstrate to the satisfaction of the Engineer, suitability and equivalence of the substitute codes and standards as well as provide proof of previous successful use.

Table 2.1. References standards, codes and guidelines

Ref.	Standard/code/guideline	Title
[Ref. 1]	NEN-EN 1990	Eurocode 0: Basis of structural design
[Ref. 2]	NEN-EN 1991 (all parts)	Eurocode 1: Actions on structures
[Ref. 3]	NEN-EN 1992 (all parts)	Eurocode 2: Design of concrete structures
[Ref. 4]	NEN-EN 1993 (all parts)	Eurocode 3: Design of steel structures
[Ref. 5]	NEN-EN 1994 (all parts)	Eurocode 4: Design of composite steel and concrete structures
[Ref. 6]	NEN-EN 1995 (all parts)	Eurocode 5: Design of timber structures
[Ref. 7]	NEN-EN 1996 (all parts)	Eurocode 6 - Design of masonry structures
[Ref. 8]	NEN-EN 1997 (all parts)	Eurocode 7: Geotechnical design
[Ref. 9]	NEN-EN 9997-1	Eurocode 7: Geotechnical design of constructions - part 1: General rules
[Ref. 10]	NEN-EN 1998 (all parts)	Eurocode 8: Design of earthquake resistant constructions
[Ref. 11]	NEN-EN 1999 (all parts)	Eurocode 9: Design of aluminium structures
[Ref. 12]	CUR166 6th edition	Sheet pile constructions
[Ref. 13]	CUR211 2nd edition	Quay walls
[Ref. 14]	CIRIA C660	Early age thermal crack control in concrete

Ref.	Standard/code/guideline	Title
[Ref. 15]	CIRIA C674	Use of concrete in maritime engineering
[Ref. 16]	CUR/CIRIA C683	The Rock Manual 2012, The use of rock in hydraulic engineering" (2nd edition), CIRIA C683, London
[Ref. 17]	CIRIA C760	Guidance on embedded retaining wall design
[Ref. 18]	CIRIA C766	Control of cracking caused by restrained deformation in concrete
[Ref. 19]	EurOtop, manual on wave overtopping	EurOtop Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. 2nd edition, 2018.
[Ref. 20]	PIANC	Seismic Design Guidelines for Port Structures
[Ref. 21]	PIANC 2002	Guidelines for the Design of Fender System
[Ref. 22]	PIANC RecCom WG 134	Design and Operational Guidelines for Superyacht Facilities
[Ref. 23]	IAHR Design Manual	Users Guide to Physical Modelling and Experimentation, 2011
[Ref. 24]	NEN-EN 13383-1:2003	Armour stone – Part 1: Specification
[Ref. 25]	NEN-EN 13383-2:2002	Armour stone – Part 2: Test methods
[Ref. 26]	NEN-EN 206-1	Concrete - Part 1: Specification, performance, production and conformity
[Ref. 27]	NEN 8005	Dutch supplement to NEN-EN 206: Concrete - Specification, performance, production and conformity
[Ref. 28]	NEN-EN 13369	Common rules for precast concrete products
[Ref. 29]	NEN-EN 13670	Execution of concrete structures
[Ref. 30]	NEN 8670	Additional regulations to NEN-EN 13670: Execution of concrete structures
[Ref. 31]	NEN-EN 1090 (all parts)	Execution of steel structures and aluminium structures
[Ref. 32]	International Association of Lighthouse Authorities	Aids to Navigation Guide
[Ref. 33]	BS 6349-1-2	Maritime works – Part 1-2: General – Code of practice for assessment of actions

* NEN 9997-1 is a combined document of Eurocode 7 (EN 1997-1), the Dutch National Annex and Dutch complementary rules for application of Eurocode 7.

2.2 Definition drawings

Definition drawings' means drawings which show elements of the scope, standard and design criteria of work as included in the Contract. The Contractor shall read the definition drawings in conjunction with the text in the Employer's Requirements. The Contractor shall comply with the requirements set out in the definition drawings.

To avoid any doubt, any given dimension, coordinate or surface on a definition drawing is a specified requirement, unless noted otherwise. Where a dimension, coordinate or surface is not given, or is referred to as approximate, the dimension shall be determined by the Contractor.

The definition drawings are listed in Table 2.2.

Table 2.2. Definition drawings

Drawing. no	Title
118421-3100	Fort Bay Harbor - Container Yard expansion: revetment and yard
118421-3101	Fort Bay Harbor - Dredging and seabed clearance
118421-3102	Fort Bay Harbor - RoRo quay expansion
118421-3201	Black Rocks package A - Main Breakwater with associated quay wall
118421-3202	Black Rocks package A - Dredging and seabed clearance
118421-3203	Black Rocks package A - Paved connection road and terrain levelling
118421-3204	Black Rocks package A - Storm water drainage hill side
118421-3206	Black Rocks package A - Harbor hardware
118421-3207	Black Rocks package A - Harbor Utilities
118421-3301	Black Rocks package B - Retaining Structures innerside harbor and revetment
118421-3302	Black Rocks package B - Dredging and seabed clearance
118421-3303	Black Rocks package B - Terrain leveling and pavement
118421-3304	Black Rocks package B - Central pier, finger piers and boat ramp
118421-3306	Black Rocks package B - Harbor hardware
118421-3307	Black Rocks package B - Harbor Utilities
118421-3401	General - disposal area and marine park boundary
118421-3402	Site and High risk zone

3

DESIGN LOADS AND DESIGN CRITERIA

3.1 Environmental design conditions

3.1.1 Water levels

Typical water levels are provided in Table 3.1.

Table 3.1 Water levels during frequent and extreme level conditions at the project location

Conditions		Water levels [m +SD]
Frequent water level conditions	Lowest Astronomical Tide (LAT)	-0.18
	Mean Low Water Spring (MLWS)	-0.09
	Saba Datum (SD)	0.00
	Mean Sea Level (MSL)	+0.09
	Mean High Water Spring (MHWS)	+0.24
	Highest Astronomical Tide (HAT)	+0.33
Extreme water level conditions	Design high water level	+1.30
	Design low water level	+0.30

Relative sea level rise in 2075 (approx. 50 years after completion) is expected to be 0.32m +/- 0.17m for IPCC climate scenario SSP2-4.5. No sea level rise has to be taken into account in the design.

3.1.2 Wave conditions

Design daily wave and water level conditions
The design omnidirectional daily wave conditions and associated water levels are presented in Table 3.2.

Table 3.2. Design omnidirectional wave conditions for wave overtopping at the toe of the Main Breakwater

Section	Parameter	Parameter	Condition 1	Condition 2	Condition 3
High Design Water Level	HDWL	mSD	0.13	0.13	0.13
Significant Wave Height	H_{m0}	m	2.00	2.00	1.50
Peak wave period	T_p	s	10	14	6

Hurricane wave and water level conditions

The offshore design wave conditions and associated water levels for hurricane conditions are presented in Table 3.3.

Table 3.3. Offshore design hurricane conditions

Parameter	Abbreviation	Unit	Value
Offshore significant wave height	Hm0	[m]	11.9
Peak wave period	Tp	[s]	13.15
High Design water level	HDWL	[m+SD]	1.3
Low Design water level	LDWL	[m+SD]	0.3
Storm duration	T	[hours]	12

Hurricane conditions are omnidirectional. The most adverse direction shall be considered in the design.

3.1.3 Rainfall / runoff

The design rainfall shall be taken as 180 mm per hour with a duration of 15 minutes.

3.1.4 Geotechnical conditions

The available geological and geotechnical information is provided in Volume 4.

3.1.5 Seismicity

The seismic load is determined based on the peak acceleration of the bedrock (agR) obtained from the Eastern Caribbean Seismic Hazard Map for Mean return Period of 475 years for L2 of the university of west Indies seismic research centre. According to the peak acceleration of the bedrock is agR=0.275g (L2).

3.1.6 Wind conditions

The design wind speed for non-hurricane conditions is 20 m/s and the design wind speed for hurricane conditions is 56 m/s.

3.2 Design lifetime

The design lifetime of all structures shall be 50 years unless otherwise specified in Table 3.4

Table 3.4. Lifetime others than 50 years

Item	lifetime [years]
Aids to navigation	25
Safety items	25
Utilities	25
Boat lifts	25

3.3 Design loads: surface loads, loads from bollards and cleats and wave loads

Surface loads

All structures and areas shall be designed to sustain a characteristic uniform surface load on the entire area between 5 to 20 kN/m^2 depending on the item. During earthquake conditions, a combination factor of 0.3 may be applied on the surface loads since no permanent loads will be present at the quays. Surface loads associated to each structure or area are given in Table 3.5.

Bollard and cleat loads

All structures shall be designed to sustain concentrated horizontal loads from bollards and cleats. During earthquake conditions, these loads do not have to be taken into consideration since it is unlikely that storm conditions (maximum) bollard forces coincide with the occurrence of an earthquake.

Table 3.5 Surface loads applicable on the different structures or areas

Section/area	Surface loads [kN/m^2]
Black Rocks main breakwater and associated quay wall	20
Black Rocks retaining structures innerside harbour	15
Black Rocks emergency roll on-roll of ramp	35
Black Rocks revetment	15
Black Rocks central pier	10
Black Rocks finger piers	5
Black Rocks terraces	20
Black Rocks roads	20
Fort Bay container yard expansion	35
Fort Bay Roll on-roll off ramp expansion	35

Wave loads
Wave loads acting on the main breakwater with the associated quay wall shall be based on physical model tests.

Wave loads for the inner harbor area shall be based on acting wave conditions due to wave transmission and wave penetration.

3.4 Hydraulic design

3.4.1 Wave overtopping requirements

Wave overtopping discharge limits are given in Table 3.6 for each structure element.

Table 3.6. Overtopping requirements

Overtopping limit	Main Breakwater	Revetment at Black Rocks	Terraces
Daily conditions (as defined in Table 3.2)	1 l/s/m	1 l/s/m	1 l/s/m
Hurricane conditions (as defined in Table 3.3)	n/a	10 l/s/m	10 l/s/m

Wave overtopping at the Outer Crestline of all structures shall be verified in accordance with EurOtop II 2018 [Ref. 19]. The wave overtopping at the outer crestline of the main breakwater shall be verified in 2D or 3D physical model tests.

3.4.2 Structural stability

The Main Breakwater and revetments shall be designed to withstand the design (hurricane) events as defined in Table 3.3.

All Structure Sub-components (armour, rear side, toe, scour protection, wave wall, top side etc.) shall be designed to withstand the design (hurricane) events as defined in Table 3.3.

The wave loading and structural stability of the Structure Sub-components shall be verified in 2D or 3D physical model tests.

<u>Armour rock stability</u>

The applicable criteria for armour rock stability are given in Table 3.7.

Table 3.7 Damage criterion armour rock

Structure	Daily conditions (as defined in Table 3.2)	Hurricane conditions (as defined in Table 3.3
breakwater toe structure	no damage criterion	start of damage N_{0d}=0.5
breakwater scour protection	no damage criterion	start of damage N_{0d}=0.5

Structure	Daily conditions (as defined in Table 3.2)	Hurricane conditions (as defined in Table 3.3
Revetment	no damage criterion	intermediate damage (damage number according to Rock Manual [Ref. 16] Table 5.23)

The stability of all armour rock or concrete elements of the Black Rocks main breakwater shall be verified with 2D or 3D physical model tests. Armour rock sizes that are defined in the Definition Drawings can be used without physical model testing, if applied at the defined location and the same configuration (toe height, toe width, slope).

Filter structures
A granular filter structure shall be applied underneath armour rock to prevent washing out of base material. Filter criteria as specified in the Rock Manual [Ref. 16] shall be met between all layers.

3.5 Geotechnical analysis

3.5.1 Design approach

Design approach 3 according to Eurocode 7 is applicable.

3.5.2 Reliability class

The reliability class for the Structures is Reliability Class 2 (RC2) in accordance with NEN-EN 1990.

3.5.3 Seismic

All permanent structures shall be designed to resist seismic events, in accordance with Eurocode 1998. All permanent structures are considered as Eurocode importance class II structures (consequence class CC2), with an importance class factor of γ_l =1.0 for the Ultimate Limit State (near collapse) verifications. According to PIANC [PIANC (2001). *Seismic Design Guidelines for Port Structures*. Report of Working Group No. 34 of the Maritime Navigation Commission. 8th Edition. 8th November 2001.], seismic L2 loads correspond to the Ultimate Limit State with a probability of exceedance of 10 % during the lifespan of the structure. Based on a Design Life of 50 years, seismic L2 loads with a Mean Return Period (MRP) of 475 years shall be taken into account for all permanent structures. This is equivalent to a peak acceleration of the bedrock a_{gR} of 0.275 g. The design ground acceleration a_g corresponding to the factor between the importance class factor and the peak acceleration of the bedrock and is therefore equal to 0.275 g.

3.5.4 Accepted deformations

Maximum deformations should comply with NEN 9997-1. For retaining structures, the horizontal deformation in serviceability limit state should be less than 1/100th of the retaining height. During hurricane conditions, the maximum horizontal displacement is 0.15 m for caissons (including the relaxation effect).

3.5.5 Liquefaction

The design shall be able to withstand loads initiated by earthquakes during the lifespan in line with Eurocode 1998. This includes the evaluation and, if necessary according to Eurocode 1998-5, mitigation of liquefaction of both subsoil and fill material (if fill material is used).

3.5.6 Residual settlement

Residual settlement should be limited to avoid settlement differences on the structures and the surroundings. High amounts of residual settlement might lead to cracks on the structures. Residual settlement is limited to maximum of 10 cm for the design lifetime.

3.6 Structural analysis

The Standards, codes and guidelines as mentioned in section 2.1 are the starting point for the actions, structural analysis, verification of the strength, stability and stiffness and detailing of the construction. The reliability class for the Structures is Reliability Class 2 (RC2) in accordance with NEN-EN 1990.

3.7 Physical model tests

Physical model tests shall be carried out as 2D or 3D tests by an internationally recognized laboratory and in accordance with internationally recognized procedures, see, for example, Users Guide to Physical Modelling and Experimentation of IAHR, 2011 [Ref. 23]. The laboratory, model and test matrix must be approved by the Engineer prior to testing.

The tests shall demonstrate compliance with:
- Damage criteria to armour, toe, scour structure of the main breakwater during design hurricane conditions.
- Wave overtopping criteria of the main breakwater during daily wave conditions.

Determine the following for design purpose:
- The wave transmission over the main breakwater during design hurricane conditions.
- The wave load on the front of the main breakwater during design hurricane conditions.

The scale for the 2D model must be between 1:10 and 1:50.

The model tests for hurricane conditions shall have a consecutive build up with 50 %, 60 %, 80 %, 100 % and 120 % of the design hurricane condition (as defined in Table 3.3). Each condition shall have a duration of at least 1000 waves. The 120 % condition is an overload condition.

If the model is used to determine wave loads on a caisson structure, the duration of the 100% hurricane condition shall be long enough to have at least 1000 waves imping to the model.

The Engineer shall be given at least two weeks' notice prior to any model test and be granted the opportunity to attend should it require.

4

BLACK ROCKS HARBOR NEW BUILD - PACKAGE A

4.1 Main Breakwater with associated quay wall

General
The main breakwater shall protect the harbor area during daily and hurricane hydraulic conditions. The associated quay wall must be suitable for safe berthing and mooring during daily hydraulic conditions.

The main breakwater might be a caisson-type structure, a rubble-mound breakwater with interlocking units, a piled cofferdam, a block wall, etcetera.

The lay-out and location of the main breakwater and associated quay wall shall be in accordance with the definition drawings. The location of quay edge shall be on a straight line between coordinate points B1-B2-B3-B4-B5-B7-B8-B9-B10-B11 as defined in definition drawing 118421-3201.

The works include all associated works such as but not limited to: trenching, soil improvement, crushed granular rock foundation, in-situ casting, placement of caissons or other elements, scour protection, back-filling, leveling, etc.

Quay
At the inner side of the Breakwaters a vertical quay wall shall be provided. The top level and width of the quay at the inner side of the breakwater shall be in accordance with definition drawing 118421-3201. The levels defined are the levels at the quay outer edge. Quay levels across the structure may somewhat vary to ensure surface water run-off.

Design dredge levels are defined on definition drawing 118421-3202. For the stability calculations, a design bed level shall be at least 1m below the design dredge level, to provide margin for over dredging and erosion.

Quay wall structures shall be equipped with a concrete superstructure consisting of a parapet or capping beam and a steel kantenschutz (rounded steel edge profile). The superstructure shall have a vertical front face which shall extent at least 0.5 m below SD to prevent ships getting stuck underneath.

All quay wall structures shall have a concrete finishing.

Scour protection
The seaward side of the Main breakwater shall be installed with an adequate scour protection to prevent erosion that undermines the main breakwater. Use may be made of the in-situ present large boulders. The Contractor shall show that the scour protection is stable during design hurricane conditions in accordance with the requirements in chapter 3.

Foundation layer
A caisson shall be placed on a crushed granular rock foundation layer with a minimum thickness of 0.5 m.

4.2 Dredging and seabed clearance of the harbor basin

The harbor basin shall be suitable for the safe navigation and berthing of the vessels. The harbor basin areas as defined in the definition drawing 118421-3202 shall be dredged and cleared from any obstacle or debris till the required levels as given in Table 4.1.

The dredged materials shall be re-used in the construction of the breakwaters and the land reclamation as much as possible. Dredged materials that cannot be re-used shall be disposed at the designated offshore disposal area as defined in definition drawing 118421-3401. These materials shall be disposed within the contours of this area. Dredged materials to be disposed at the mentioned offshore disposal area shall be in-situ material only, free of contaminations, waste or organic matter. No construction waste shall be disposed offshore.

The slope of the dredged areas shall be stable which shall be confirmed by short and long term stability calculations.

Any existing or new structures adjacent to the dredging areas shall be stable which shall be confirmed by short and long term stability calculations.

Tolerances for dredging is 0 m upward of the dredge design level. Dredging may not be deeper than 0.25 m below dredge design level. A transition slope between area I and area II shall be situated in area I.

Table 4.1 Dredge design levels harbor basin

Area	**Dredge design level** **[SD]**
Area I	-2.75 m a lower level is allowed at the transition between area I and area II
Area II	-5.25 m

4.3 Paved connection road

A paved connection as indicated on the definition drawing 118421-3203 shall be designed and constructed.

The final road shall have a minimum width of 6 m.

The horizontal alignment shall be as outlined on the definition drawings.

The vertical alignment will have an incline of maximum 12 %. One section as defined in definition drawing 118421-3203 is allowed to have an inclination of maximum 20 %.

The road shall have a cross slope of minimal 1% to drain rain water falling on the road. A drainage channel shall be located at one side next to the road. Design rainfall to consider is given in Section 3.1.3. The road itself shall not be the drainage channel.

The utility trench for water, electricity and data shall be designed and constructed by others. The Contractor shall integrate the utility trench in his design. The size of the utility trench is indicated in the definition drawing.

The Contractor shall design and construct retaining walls at the hill side of the road such that the adjacent hill slope is stable and that rocks that are within a distance of 10m from the road will not fall on the road.

A grouted rock wall (typical Saba rock wall) shall be applied. Drainage pipes shall be included. Concrete kerbs will be installed at both sides of the road. The concrete kerb at the lower side of the road shall be supported by a compacted sub-base and a slope protection. The outline dimensions shall be in accordance with the definition drawings.

The Contractor shall install and connect street lighting integrated in the slope protection. The energy supply for the lighting shall be provided by others. The streets lights will be provided by Employer.

Pavement type

The pavement of the road shall consist of:

- Sub-base: typical 0/31.5mm natural rock with thickness of 0.15m. Maximum amount of fines is 10 %. The grading shall be continuous.
- Concrete pavement, with thickness of 0.15 m.
- One steel reinforcement net.

4.4 Terrain levelling and pavement, including construction of terraces on the land slopes

Horizontally levelled terraces shall be designed and constructed. Area and levels in accordance with definition drawings. Different areas are distinguished. One level shall be applied per defined area. The terraces shall be inclined to drain rain water. Design rainfall to consider is given in Section 3.1.3. The levels and inclination of the area's shall be in accordance with Table 4.2.

Retaining walls shall be designed and constructed between the terrace areas and between the terrace areas and the surrounding area. The retaining walls shall be located within the terrace area and shall have a maximum width of 1m.

Paved areas as defined in definition drawing 118421-3203 shall be paved with concrete with the following specifications:

- Sub-base: typical 0/31.5mm natural rock with thickness of 0.15m. Maximum amount of fines is 10 %. The grading shall be continuous.
- Concrete pavement, with thickness of 0.15 m
- One steel reinforcement net.

Excavated materials shall be re-used within the project. Excess of excavated materials may be placed in Area VI. Area VI is a non-paved area that is not part of Black Rocks Harbor Package A. Materials placed in Area VI shall not be erodible during hurricane wave conditions.

Table 4.2 Required levels and maximum inclination terraces, reference is made to definition drawing 118421-3203

Area	level [SD]	Maximum inclination
Area III	+1.2m	2 %
Area II	In accordance with wave overtopping requirement as in section 3.4.1.	2 %
Area I	In accordance with wave overtopping requirement as in section 3.4.1.	2 %
Area VI	maximum of 4mSD	n/a

4.5 Measures Storm water drainage hill side

4.5.1 Flow diversion channel

The Contractor shall design and construct a concrete flow diversion channel on the indicated horizontal location on definition drawing 118421-3204.

The diversion channel shall have a minimum depth of 1m and a minimum width of 4m and shall be resistant for flow velocities in the channel up to 7 m/s. There shall be no discontinuities in the diversion channel. The diversion channel shall have a minimum gradient of 2 %.

At the upstream side the diversion channel shall be wider such that the entire flow from the natural gully will be guided into the diversion channel.

A culvert shall be included under the paved road connection. The culvert shall have sufficient discharge capacity and prevent flooding of the road.

A diffuser shall be installed at the end of the diversion channel to decrease the velocities before entering the sea.

An outlet structure shall be constructed at the downstream side of the diversion channel.

4.5.2 Ditch around terraces

A drainage ditch upstream of the terraces areas Ia, Ib, IIa, and IIb shall be included. The drainage ditch shall collect the water from upstream and use gravity to lead the water around the new harbor area to the sea at the east side of the harbour. The ditch shall have a minimum gradient of 2 %.

4.5.3 Flow retarding dams

Two flow retarding dams shall be included on the location as indicated on definition drawing 118421-3204. The dams shall retard the flow and shall trap large rocks and debris in the flow.

The height of the dams shall be 1.5 m in the center of the natural gully. The dams shall be able to resist a flow velocity of 6 m/s. An adequate scour protection shall be included directly downstream of the dams.

4.6 Drainage Harbor area

Contractor shall ensure adequate drainage of the harbor area's I, II, III and the main breakwater. Design rainfall to consider is given in Section 3.1.3. Rainfall is to be collected in underground drains and discharged to the harbor basin. The drainage shall have a minimum gradient of 2 %. Chambers shall be provided at all outfall locations. The incoming storm water drain shall be fitted with a stainless-steel flap-valve and the outgoing pipe shall be fitted with a stainless-steel penstock.

The drainage will be designed assuming that all areas are paved.

The harbor area will use gravity system as the drainage system.

4.7 Harbor hardware

4.7.1 Bollards and cleats

Bollards and cleats shall be provided in accordance with definition drawing 118421-3206.
- Installation as per manufacturers documentation.

4.7.2 Aids to Navigation

Aids to navigation shall be provided to ensure safe navigation and operations for all vessels during day, night and in periods of reduced visibility.

The aids to navigation shall comply with the standards in 'Aids to Navigation Guide' [Ref. 32].

Aids to navigation shall be provided to operate in non-hurricane wave conditions.

The aids to navigation shall be:
- Available at least 99.0 % of the time.
- Classified as 'important', according to the 'Aids to Navigation Guide'.
- Not interfere with existing aids to navigation.
- Be clearly visible during day, night and in periods of reduced visibility.

The aids to navigation comprise as a minimum:
- Two harbor entrance lights at each side of the harbor entrance.
- Buoy with light to mark channel alignment.

4.7.3 Safety items

The associated quay wall at the main breakwater shall be equipped with adequate safety items:
- Rescue ladders every 40m approximately. Rescue ladders shall be placed in a niche in the concrete superstructure so the front of the ladders shall not protrude.
- Four pillars with life safety buoys and fire extinguisher.

4.8 Utilities

4.8.1 Utility ducts

Contractor shall include utility ducts for future installation of electricity, water and communication cables and pedestals. The size and location of the utility ducts shall be in accordance with definition drawing 118421-3207.

4.8.2 Lighting

Sufficient low-energy led lighting with a minimum level of 50 lux on all marine infrastructural surfaces (e.g., low-level marina type lighting and high-level floodlighting) to be provided to ensure 24/7 safe personnel access to and operation of facilities.

Task specific local lighting shall be included, e.g., at crane operation panel, at service pedestals for bunkering of fuel, for bunkering of water and for discharging of sewage etc.

4.8.3 Water

Two water tanks shall be placed, according to the following specifications
- Both water tanks shall have a capacity of 100 m3.
- The water tanks shall be placed underground within parking area I. The location of parking area I is defined in definition drawing 118421-3203. Parking shall be possible on top of the water tanks. The water tank shall not protrude or hinder parking in any way.
- One tank shall be suitable for gray water and the other tank shall be suitable for water from the RO plant in Fort Bay (Reverse Osmosis).
- A distribution network shall be included that connects the water tanks with the harbor quay walls.

4.9 Environmental mitigation works

The environmental mitigation works include coral relocation and environmental monitoring.

The scope and the requirements of the coral relocation and coral monitoring are listed in Appendix I.

The environmental monitoring shall be in accordance with the permit requirements. See 43860 20231030 Black Rocks Harbor Saba (002), Vergunning op grond van de Wet maritiem beheer BES voor het hebben, aanleggen of doen aanleggen van een bouwwerk in of op de bodem van de territoriale zee van het openbaar lichaam Saba, dd 30/10/2023.

4.10 Fort Bay Harbor upgrade

All items for Fort Bay as described in Chapter 6 are part of Package A.

5

BLACK ROCKS HARBOR NEW BUILD - PACKAGE B

5.1 General

Package B contains all Package A items plus the additional items described in this Chapter.

5.2 Retaining Structures at the innerside of the harbor

Retaining structures shall be designed and constructed at the innerside of the harbor. The retaining structures must be suitable for safe berthing and mooring. The lay-out and location of the retaining structures shall be in accordance with the definition drawings. The location of quay edge shall be on straight lines between coordinate points B10-B13-B12,B11-B12,B14-B15-B16-B17-B18-B19-B20-B21-B22 as defined in definition drawing 118421-3301.

Design dredge levels are defined on definition drawing 118421-3202/3302. For the stability calculations, a design bed level shall be at least 1m below the design dredge level, to provide margin for over dredging and erosion.

Retaining Structures shall be equipped with a concrete superstructure consisting of a parapet or capping beam and a steel kantenschutz (rounded steel edge profile). The superstructure shall have a vertical front face which shall extent at least 0.5 m below SD to prevent ships getting stuck underneath.

Wall sections must be perfectly aligned forming a single plane, with no free spaces between them. No migration of material through the wall shall be possible.

The crest level of the retaining structures shall be 1.2mSD, except the retaining structure between coordinate point B11 and B12 where the crest level shall be 0.75mSD and between coordinate point B14 and B15 where the crest level shall follow the level of the ramp.

5.3 Terrain levelling and pavement, including construction of terraces on the land slopes

Levels and defined areas of package A are partly repeated in this section.

Horizontally levelled terraces shall be designed and constructed. Area and levels in accordance with definition drawings. One level shall be applied per area.

Retaining walls shall be designed and constructed between the terrace areas and between the terrace areas and the surrounding area. The retaining walls shall be located within the terrace area shall have a maximum width of 1 m.

Wall sections must be perfectly aligned forming a single plane, with no free spaces between them. No migration of material through the wall shall be possible.

All areas as defined in definition drawing 118421-3303 will be paved. Pavement specifications as given in Section 4.3.

Table 5.1 Required levels terraces

Area	Level [SD]	Maximum inclination
Area III	+1.2m	2 %
Area IV	+0.75m	2 %
Area V	+1.2m	2 %
Area VI	In accordance with wave overtopping requirement as in section 3.4.1.	2 %

A ramp with a 1:15 slope shall be constructed connecting area V and VI.

5.4 Revetment and Reclamation

Area VI as defined in defined in definition drawing 118421-3303 shall be protected by means of a rubble mound revetment.

The revetment shall lie completely within the area which is defined as revetment on definition drawing 118421-3301.

5.5 Dredging and seabed clearance of the harbor basin

The harbor basin shall be suitable for the safe navigation and berthing of the vessels. The harbor basin areas as defined in the definition drawing 118421-3302 shall be dredged and cleared from any obstacle or debris till the dredge design levels as given in Table 5.2.

The dredged materials shall be re-used in the construction of the Breakwaters and the Land Reclamation as much as possible. Dredged materials that cannot be re-used shall be disposed at the designated offshore disposal area as defined in definition drawing 118421-3401. These materials shall be disposed within the contours of this area. Dredged materials to be disposed at the mentioned offshore disposal area shall be in-situ material only, free of contaminations, waste or organic matter. No construction waste shall be disposed offshore.

The slope of the dredged areas shall be stable which shall be confirmed by short and long term stability calculations.

Any existing or new structures adjacent to the dredging areas shall be stable which shall be confirmed by short and long term stability calculations.

Tolerances for dredging is 0 m upward of the dredge design level. Dredging may not be deeper than 0.25 m below dredge design level. A transition slope between area I and area II shall be situated in area I.

Table 5.2 Dredge Design level harbor basin (only areas that are updated in relation to package A are shown)

Area	Maximum level (top) [SD]
Area I	-2.75m a lower level is allowed at the transition between area I and area II

5.6 Central pier

The central pier shall be designed and constructed as in definition drawing 118421-3304. The following requirements apply:
- The size and alignment in accordance with the definition drawings.
- The width shall be 4 m.
- The crest level shall be 1.2 mSD.
- The structure shall be impermeable: waves shall not propagate through or underneath the structure.
- The superstructure shall be designed such that vessels cannot struck underneath.
- The central pier shall be steel or concrete structures.

5.7 Finger piers

The finger piers shall be designed, constructed and tested in accordance with BS EN 14504, and with the requirements stated below.
- The size and alignment in accordance with definition drawing 118421-3304.
- The crest level shall be 1.0 mSD.
- The superstructure shall be designed such that vessels cannot struck underneath.
- Finger piers shall be designed to minimize finger pier movements for pedestrians in all operational weather conditions.
- The finger piers shall be connected to the central pier or the Retaining Structures.
- The finger piers shall be steel or concrete structures.

5.8 Boat Ramp

A Boat Ramp that facilitates the launching and retrieval of small vessels shall be designed and constructed. The layout, location and the slopes of the ramp are defined in definition drawing 118421-3304.

The boat ramp shall be placed between two retaining walls.

The boat ramp shall be paved with concrete as indicated on the definition drawing. The concrete surface shall have a V-groove finish (or similar), at a suitable angle to the ramp slope to provide sufficient grip and allow drainage of water to the edge.

A curb with a protrusion height of 0.2m and width of 0.2m shall be applied at the open edge side of the boat ramp.

5.9 Drainage harbor area

As for package A. Areas III, IV, V and VI drainage added in package B.

5.10 Harbor hardware: Mooring bollards, cleats, finger piers and boat lifts

Bollards, cleats and boat lift positions and ratings shall be in accordance with definition drawing 118421-3306.

Boat lifts specifications as follows:
- Each boat lift shall have 4 motors, 1.5 HP, 240V/10, 120V/20A.
- There shall be boatlifts with a capacity of 30k (30,000lbs/approx.. 13.6ton), 40k (40,000lbs) and 56k (56,000 lbs). Number and location as on the definition drawing 118421-3306.
- The placement of the motors shall be such that these are storm and hurricane resistant. Motors might be made removable in order to be hurricane proof.
- Each boat lift shall be equipped with a crane mechanism on a steel frame. It should able to lift the boats out of the water.
- Lifting the boat shall be done using nylon slings.

5.11 Utilities

As for package A. Areas III, IV V and VI drainage added in package B. Reference is made to definition drawing 118421-3307.

5.12 Utilities

The utilities (optional item) include the distribution network as per definition drawing 118421-3307 of the harbor for:
- All electricity cables.
- Water lines.
- Data cables.
- Pedestals.
- (Street) lights.

The above items shall be hurricane and storm resistant. The pedestals and street lights might be made removable in order to be hurricane proof.

5.13 Column Jib Crane <<optional item>>

A column jib crane shall be placed on the location as defined on definition drawing 118421-3306.
The column jib crane shall have a capacity of 25 tons at 6m.

The crane shall be hurricane and storm resistant. The crane shall not be removable.

6

FORT BAY HARBOR UPGRADE

6.1 Container yard expansion

The existing container yard shall be expanded.

The location and level of the container yard expansion shall be as identified in definition drawing 118421-3100. A ramp with a 1:15 slope shall be constructed connecting the lower-level existing storage yard with the container yard expansion.

The container yard expansion shall be seamlessly connected to the surrounding areas. A retaining wall shall be included if there is a height difference between the new container yard and the surrounding area.

Pavement shall be suitable for defined surcharge loads.
The level of the platform shall be +4.0mSD at the seaward side of the yard and shall have a 1% slope upwards in the direction of the existing road.

Four reefer plugs shall be installed at the container yard expansion. The reefer plugs shall be suitable for international 20 en 40ft containers. The location of the reefer plugs shall be determined in consultation with the Engineer.

6.2 Revetment for new container yard

The shoreline at the container yard expansion shall be protected against hurricanes/hydraulic conditions. The adjacent existing storage area is protected with Accropodes of 4 m^3 (approx. 10t). The same coastal protection shall be applied at the container yard expansion.

The following requirements apply:
- The location of the crest wall shall be as defined in definition drawing 118421-3100.
- The cross section as given in definition drawing 118421-3100 shall be applicable along the indicated coastline.
- A trench shall be dredged for the construction of the toe. The dredged materials shall be re-used where possible or otherwise be disposed in the disposal area as defined in definition drawing 118421-3401.There shall be a fluid transition between the existing Accropodes and the new Accropodes. There shall be seamless and filter stable transitions between the new and the existing slope structures, which shall be in level with each other without any gaps between the structures.

At the east side the revetment shall tie into the land, such that erosion at the adjacent coastline shall not undermine the container yard expansion.

6.3 Dredging and seabed clearance within the harbor basin

The harbor basin area as defined in the definition drawing 118421-3101 shall be dredged and cleared from all obstacles or debris to a level of -5mSD. The maximum tolerance is +/- 0.1 m.

A 1:2 slope will be created between the -5mSD and the current sea bed level. Parts that are already lower than -5mSD do not have to be filled.

The dredged silt/sand/rock materials shall be disposed in the disposal area as defined in definition drawing 118421-3401.

Sedimentation or spillage is not allowed outside existing harbor basin.

6.4 Roll on-roll off ramp expansion

The existing roll on-roll of ramp shall be widened with 5m in accordance with the definition drawing 118421-3102. The following requirements apply:

- An adequate scour protection shall be included such that there is no erosion due to ship propellor wash that may undermine the structure.
- The top level of the expansion shall have the same level as the existing ramp, i.e. sloping in upward direction starting at the water side.
- One bollard shall be removed as indicated on the definition drawings and the holes shall be filled with a suitable repair mortar.
- Installation of one new bollard on the location as indicated on definition drawing 118421-3102. The bollard will be provided by the Client, but shall be installed by the Contractor. The bollard has the following specifications:
  - Tee type (similar to existing).
  - Minimum capacity of 50 tonnes.
  - Ductile cast steel.
  - Installation and as per manufacturers recommendation.
- D-type fenders shall be installed (as on the existing RoRo). Type 400 x 400mm, length: continuous, or 2 x 1,5m with equal intermediate spacing. Fixing in reinforced deck, as per manufacturers instructions.
- Replacement of the existing Tee bollard on the existing RoRo ramp, as per the details above.
- On the edge of the top deck a kantenschutz (rounded steel edge profile)shall be included.
- Steel rail beams shall be included in the top deck, with same type, length and spacing as for the existing structure.

6.5 Single point mooring facility

A single point mooring facility will accommodate mooring of ships that exceed the length of the existing Fort Bay breakwater. The single point mooring facility shall be placed on the location as defined in definition drawing 118421-3101 and shall have an holding capacity of 100T.

Appendices

APPENDIX: CORAL RELOCATION BLACK ROCKS HARBOR

Scope of Work

Coral relocation Black Rocks Harbor

December 2023

Table of Contents

1 Project Overview

This document describes the coral relocation project, which is part of the scope of the Black Rocks Harbor project Saba.

The *Environmental Impact Assessment (EIA) for the harbor construction at Black Rocks, Saba*[1] by EcoVision N.V. revealed that the proposed Black Rocks Harbor area encompasses several endangered coral species listed in Annex II of the *Protocol for Specially Protected Areas and Wildlife* (SPAW protocol). These species include *Acropora palmata*, *Acropora cervicornis*, *Orbicella annularis*, and *Orbicella faveolata,* see Figure 1.

Besides the coral species being listed in the SPAW protocol, Saba is one of the few places left in the Caribbean that has a high number of Acropora spp colonies in the wild, especially when it comes down to the A. palmata colonies. Therefore, it is of utmost importance that as many fragments of the Acropora species are relocated and treated to have the highest survival rate.

Some of these corals are located within the projected footprint of the new harbor or in the high-risk zone, in which the coral colonies may be impacted by the harbor construction activities. The high-risk zone is projected to have a radius of 100 meters west and 25 meters south and east of the harbor. It has been estimated that about 200 *Acropora spp.* and *Orbicella spp*. colonies in the footprint and high-risk zone must be (partially) relocated.

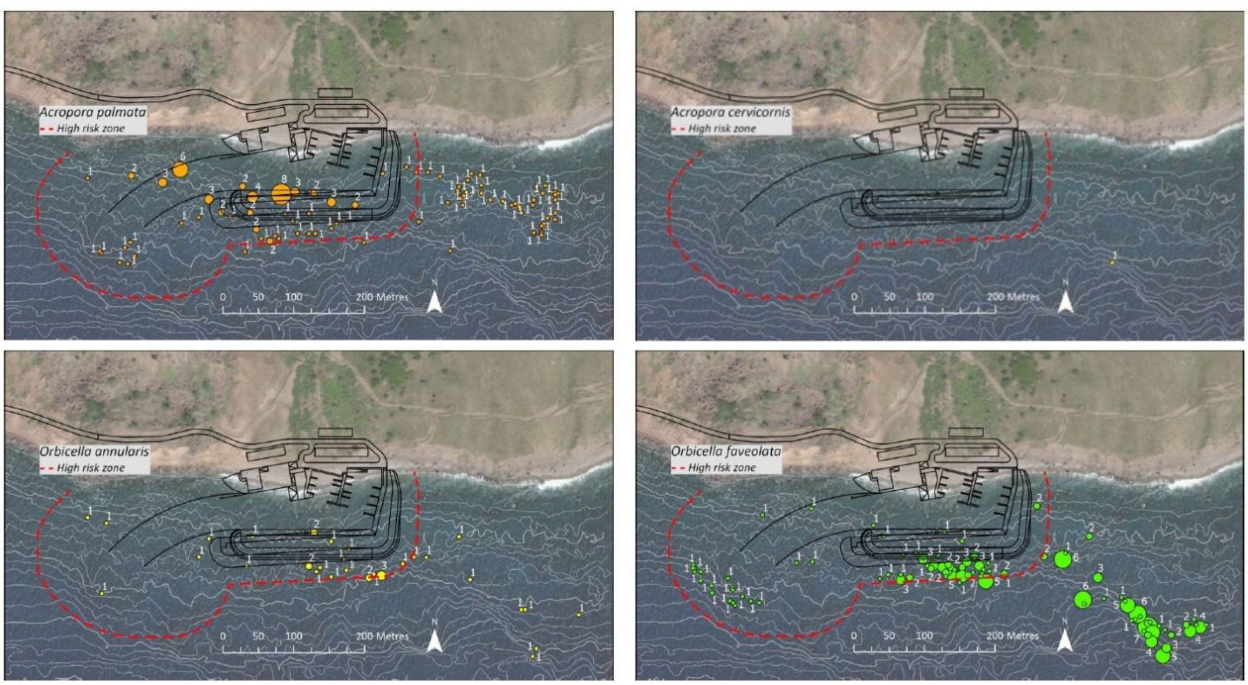

Figure 1 Mapping of the different threatened coral colonies provided by EcoVision. The high-risk zone is demarcated by the red line.

[1] EcoVision N.V. (2022). Environmental Impact Assessment (EIA) for the harbor construction at Black Rocks, Saba.

The significance of these coral species lies in their pivotal role in creating intricate three-dimensional structures, essential for providing habitats to a diverse array of marine species. Unfortunately, the decline of these species in the Caribbean has had a substantial impact on the overall health of coral reefs, making their protection and preservation a matter of utmost importance. In addition to the impacts of global warming, the newly emerged coral disease called Stony Coral Tissue Loss Disease (SCTLD) has severely affected many stony corals, including those found in Saba's coral reefs.

With the Black Rocks Harbor project, it is vital to consider the scale of the project, where a substantial number of coral colonies will be relocated to new locations. The success of this project hinges upon detailed planning, effective implementation and monitoring to ensure the long-term survival and growth of the corals and the surrounding reef system. By integrating passive and active restoration measures, the aim of the Saba Conservation Foundation (SCF), the manager of the Saba National Marine Park (SNMP), is to create a comprehensive approach to coral relocation, restoration, and rehabilitation, contributing to the overall conservation of the existing coral reefs of the Saba National Marine Park. For the Black Rocks Harbor project, the focus of the Contractor will primarily be on active intervention through coral relocation.

In preparation of the relocation of the protected coral colonies from the Black Rocks area, the Saba Conservation Foundation carried out a coral relocation trial[2] early 2021. This experiment included moving small coral colonies (25 x 25 cm) from the Black Rocks area to designated regions within the Saba National Marine Park, where the environmental variables are similar to the Black Rocks area. The relocation trial indicated that the Hole in the Corner location, which is about 2km east of the project side (see Figure 2), exhibited the highest coral survival rate (60-70%), with branching corals thriving on coral nursery trees and encrusting corals flourishing on natural reefs. From this trial it was concluded that Hole in the Corner should be used as outplant area.

1.1 Objectives

While there have been a number of studies that have successfully conducted relocation and restoration at small scales, the Black Rocks Harbor project requires the relocation of a large number of coral colonies at a greater scale. For that, two restoration efforts shall be implemented:

1. **Passive Restoration through conservation and protection:** This involves management actions aimed at improving the environment, reducing overfishing, reduce habitat destruction and pollution, promoting herbivory, and other measures to facilitate the natural recovery of reefs. This is not part of the scope of the Black Rocks relocation project, but will be realized by establishing three new marine reserves within the Saba National Marine Park. The Executive Council of the Public Entity Saba will amend the 'Eilandsbesluit Marien Milieu' accordingly. One of the new reserves is 'Hole in the Corner', which is the outplant area for the coral that will be relocated from the Black Rocks area.

[2] Saba Conservation Foundation. (2021) Coral relocation trial – Progress report.

Designating this area as a marine reserve provides a higher level of legal protection and prohibits overfishing.

2. **Active Restoration through habitat restoration:** This type of restoration entails direct interventions such as coral transplantation, removal of macroalgae, and substrate consolidation. Coral relocation aims to restore damaged or degraded reef habitats by reintroducing corals to areas where they were previously abundant or where reef-building corals have declined. The objective is to rebuild or enhance the ecological structure and function of the reef ecosystem. As part of the scope of the Black Rocks Harbor project the Contractor shall relocate corals from the Black Rocks site for active restoration of the Hole in the Corner site. The relocation of these coral colonies is crucial in mitigating the adverse effects of habitat destruction and impact by the construction of the new harbor and future developments. Through strategic relocation, the project strives to preserve and rehabilitate coral communities, while preserving the ecological health and sustainability of the existing reef system.

By incorporating both passive and active restoration approaches, the project aims to [1] relocate the threatened coral species; [2] enhance survival rate, [3] create a gene bank of the colonies to ensure survivability in the case of a disastrous event, [4] monitor the relocation site and colonies and adjust management decisions where needed to guarantee the highest survivability and preservation of the coral colonies and coral reef ecosystem, which ties into the goals of the Saba Coral Restoration Plan.

1.2 Black Rocks and Relocation Site

1.2.1 Black Rocks

Historically, Acropora spp. have flourished in the vicinity of Black Rocks, extending towards Hole in the Corner. Notably, Acropora species that were previously outplanted by Wageningen Marine Research and Van Hall Larenstein at the Big Rock Dive Site, which is adjacent to Black Rocks, exhibited the highest growth and survival rates when transplanted onto the natural reef.

Analysis of hard coral cover, as reported in the Global Coral Reef Monitoring studies, indicates that the south-east side of the island boasts a higher abundance of hard corals. Furthermore, observations of the current substrate in the area, particularly around the proposed new harbor area, reveal an abundance of Acropora spp. skeletons covering the seabed, suggesting that this area was once densely populated with these corals. Additionally, a significant proportion of the island's Acropora colonies are found in the area, thus making this area and side of the island the most suitable as relocation site. Finally, the area is one of the few sites around Saba that features a bottom type rich in calcium carbonate, ensuring a favorable substrate for coral attachment and growth.

1.2.2 Relocation Site

Compensatory restoration, in other words relocation of corals, will only work if the same conditions and successional/disturbance history exists at the transplant site as at the source site.

If this is the case, then similar coral communities should be present at the transplant site. If a different coral community (or almost no coral) is present at a proposed recipient site, there is probably a good reason for this and efforts to introduce different coral species (that would change the structure and function for the local community) to such a site are likely to fail in the medium to long term.

For the Black Rocks coral relocation the following out-plant locations are defined:

- On a natural or artificial reef in the Hole in the Corner site (outplant site)
- Coral nursery at the Hole in the Corner site (in-situ facility)
- Saba Research Center operated by SCF at Fort Bay Harbor (ex-situ facility)

The selection of the outplant site for the corals originating from Black Rocks is based on the successful results of an outplanting trial (2018) and the relocation trial conducted in 2021. Previous studies on coral outplanting have consistently indicated that the south-east side of the island is the most suitable and favorable location for relocating corals, or to establish a coral nursery. This specific area is situated just west of the dive site known as "Hole in the Corner" within the Saba National Marine Park, see Figure 2.

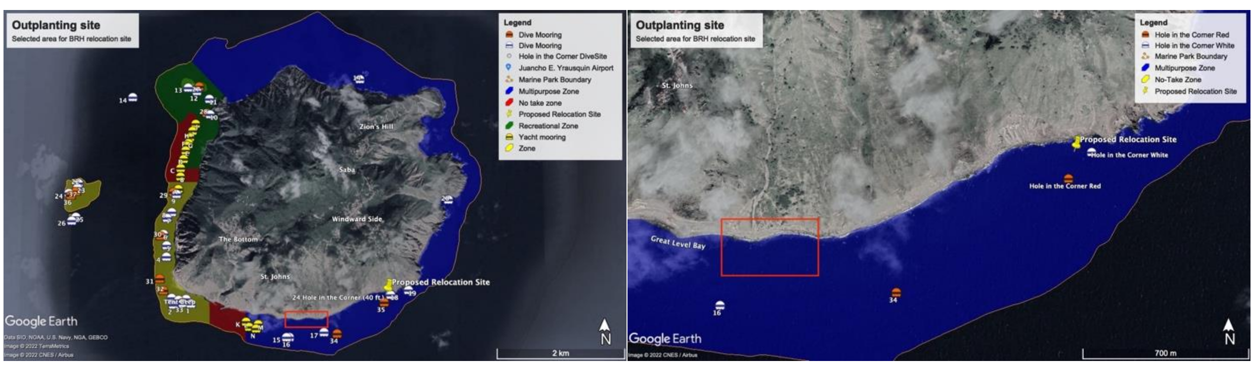

Figure 2 Red box indicates Black Rocks area, outplant area Hole in the Corner is to the east of Black Rocks, and directly west of the 'Hole in the Corner White' dive site marked with the white marker.

Sedimentation movement and deposition have been consistently low in this area, preventing the smothering of recovering or juvenile corals and providing them with an optimal environment for growth and recovery. Furthermore, the relocation site exhibits a high density of Orbicella species, contributing to the overall ecological health and diversity of the area. Finally, Hole in the Corner has shown that, compared to other sites in the marine park, the area has a higher density of herbivorous fish (Homes, 2021), which are detrimental to keep the algae cover low and promote survival and growth of the relocated corals.

2 Scope of Work and deliverables

Below is a description of the Scope of Work and required deliverables related to the coral relocation works. The description specifies which techniques the Contractor shall use and which factors and risks should be taken into account when relocating the corals from the Black Rocks area. The Contractor may propose an alternative approach for (part of) the project, which must be approved by the Engineer and the Saba Conservation Foundation.

2.1 Preparation

2.1.1 Coral Relocation plan

The contractor shall prepare a Coral Relocation Plan for the coral relocation. The plan shall include at least the following: goals, objectives, detailed description of work methods, risk assessment and mitigation measures, monitoring plan, resources, communication plan and a timeline. The timeline shall be integrated with the overall project timeline, showing relevant dependencies. The Public Entity Saba shall include the Contractor's project plan in the 'coral recovery plan'. The coral recovery plan is a requirement of the permit for the construction of Black Rocks Harbor. This coral recovery plan must be approved by Rijkswaterstaat and SCF prior to start of the relocation works. The coral relocation works shall be finalized prior to start of the Black Rocks Harbor construction works.

2.1.2 Demarcation footprint, high-risk zone and outplant location

The high-risk zone is defined as an area 100 meters west and 25 meters south and east of the harbor construction area, see Figure 1. This extent is determined by numerical modelling of sediment dispersion arising from the dredging and backfilling works, taking into account prevailing MetOcean conditions at the site. The area extends further west due to the prevailing westward currents.

The high-risk zone is situated directly outside the harbor footprint. The footprint is defined as the area where the seabed will either be covered by the new harbor structures (breakwater, land reclamation), or removed by dredging (entrance channel and harbor basin).

Depending on the detailed design and site surveys, the Contractor shall confirm the final demarcation of the footprint of the harbor, the high-risk zone and the outplant location. The Contractor shall take high-resolution underwater pictures of the seabed of the footprint, the high-risk zone and outplant location in preparation of the assessment of to be relocated coral colonies and for monitoring purposes. Any proposed changes in the coral relocation scope and plans shall be submitted to the Engineer and SCF for approval.

2.1.3 Assessment of to be relocated colonies

The Contractor shall develop a site overview to assess the distribution of colonies in the footprint of the harbor and in the high-risk zone. This assessment aims to evaluate genetic diversity and determine which colonies are in robust health and suitable for (partial) relocation. The Contractor shall assess colonies of the following coral species:

- Acropora palmata
- Acropora cervicornis

- Orbicella annularis
- Orbicella faveolata
- Dendogyra Cylindrus (not listed in Annex II of the SPAW-protocol, but there are only a few colonies of this species in the Saba National Marine Park)

Based on literature, it is recommended to acquiring at least 35 different colonies that are well-distributed across a reef to maintain the natural genetic variety and ensure sustained adaptive variation. This approach prevents issues like inbreeding and loss of genetic diversity at the relocation site. For the Black Rocks project the basic principle is that the Contractor shall relocate all colonies of protected coral species from the footprint (either in their entirety or fragmented), because there is no chance of survival at the current location.
In the high-risk zone, there may be a higher chance of survival if the colony remains in place instead of being relocated. Therefore, the Contractor shall assess for colonies of protected coral species in the high-risk zone whether they have a higher chance of survival when relocated or when remaining in place. However, the Contractor shall collect fragments of the colonies that remain in place, to ensure the preservation of the genetic diversity.
Colonies displaying signs of illness or bleaching should not be removed and transferred to the relocation site to avoid potential disease spread and elevated mortality risks for both the relocated colony and neighboring colonies. Colonies within the footprint showing signs of bleaching or illness should be relocated to a designated rehabilitation area (to be determined in consultation with SCF) or ex-situ facility, to prevent the potential spread of illness and to improve their chances of survival after the additional stress of post-relocation. Colonies showing signs of bleaching of illness, and which are in high-risk zone outside the footprint, shall be left in place.

2.1.4 Decision whether colony will be sourced as a whole or fragmented

Additionally, a careful evaluation for each colony is essential to decide whether the colonies in the footprint of the harbor and the high-risk area will be sourced as a whole or fragmented to serve as mitigation for collateral damage. This depends on the species, the size and the location of the coral colony.

The Contractor shall follow the below flowchart, Figure 3, to determine which sourcing technique should be used for a colony.

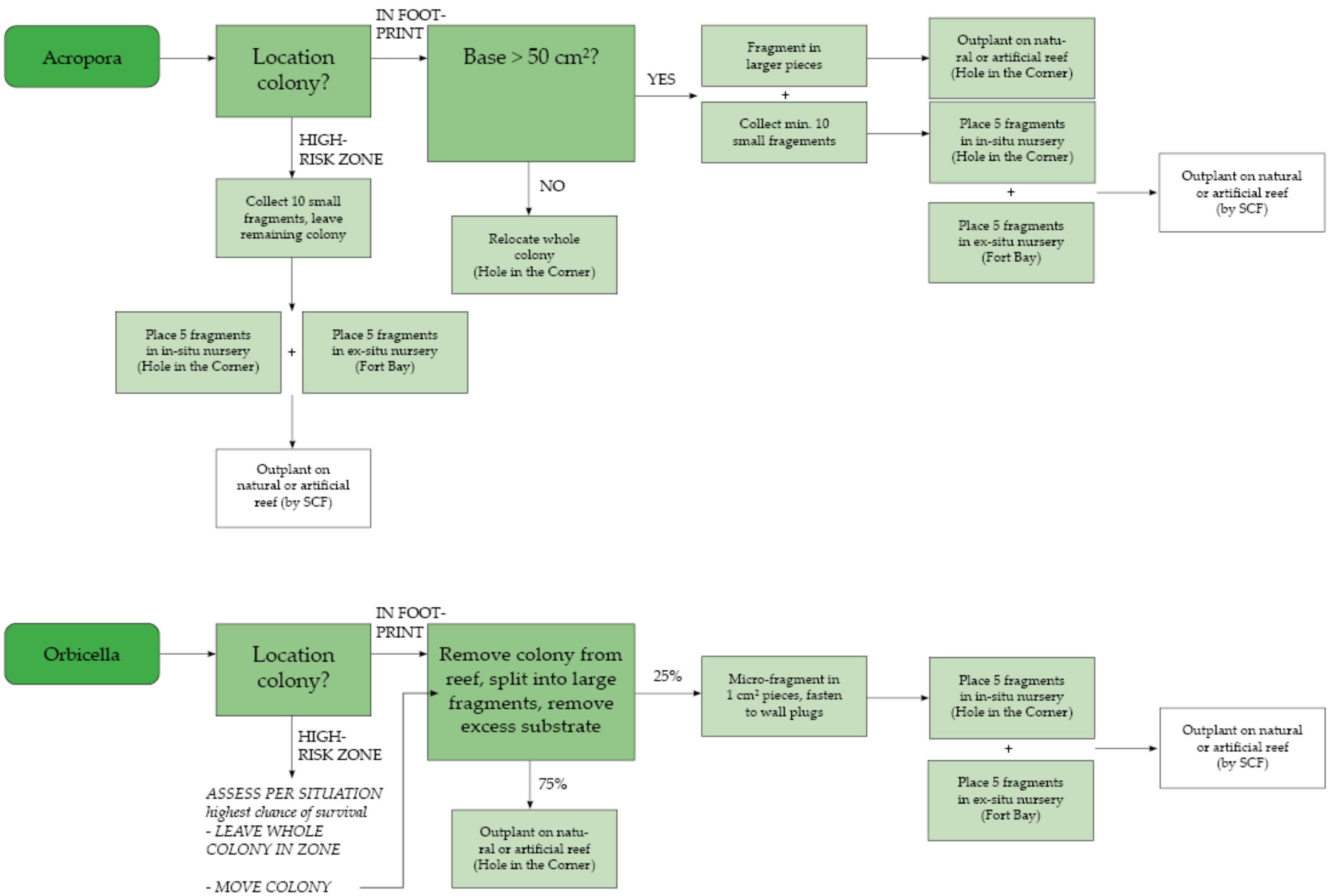

Figure 3 Overview sourcing and outplant techniques

2.1.5 Notification Rijkswaterstaat, Harbor Master and Saba Conservation Foundation

The Contractor shall notify the Engineer, Rijkswaterstaat, the Harbor Master and the Saba Conservation Foundation at least 10 days before the start of coral relocation activities.

2.2 Coral sourcing technique

Various sourcing strategies have been employed for different coral species over the years, and the methods used depend not only on the targeted species but also on the timing of sourcing. Ideally, sourcing should occur during the cold winter months when corals are less stressed from water temperatures and when the corals are less susceptible to disease. Sourcing should be avoided in the main spawning season, which typically occurs in August and September on Saba. Moreover, sourcing activities should not harm the donor region during the sourcing phase, and it is crucial to utilize appropriate methods for each coral species while ensuring that staff involved are well-trained in the process. The Saba Conservation Foundation will supervise the coral sourcing.

2.2.1 Sourcing of Acropora palmata

Figure 4 Nemo power tool

The Contractor shall source colonies of Acropora palmata from the Black Rocks site using the following method. The most effective method for removing complete colonies of *A. palmata* on Saba is using a power tool equipped with a grinder component, such as the NEMO power tool, see Figure 4. Depending on the size of the colony, to ensure minimal damage and facilitate relocation, the colonies should be carefully cut at the base (if smaller than 50 cm^2), as close to the substrate as possible. If the colony is larger than 50 cm^2, than it is advised by CoralVita experts, to fragment the colony in several larger pieces. As a mitigation measure for potential collateral damage, a minimum of ten small fragments should be collected from each colony that will serve as a source of genetic diversity and will be divided and maintained in both ex-situ and in-situ facilities.

2.2.2 Sourcing of Orbicella species

The Contractor shall source colonies of Orbicella species from the Black Rocks site using the following method. *Orbicella* species, being encrusting corals, require a different approach compared to *A. palmata*. Extensive research on coral propagation and restoration of Orbicella spp. have shown that micro-fragmentation is a highly effective method, resulting in significantly higher survival rates and rapid development, up to 6.5 times greater tissue growth than moving whole colonies.

To relocate colonies of *Orbicella* species, the Contractor shall carefully remove them from the reef using an underwater grinder or a hammer and chisel. The colony is then split into multiple large fragments by removing excess substrate underneath, creating a stronger attachment basis for the colony when affixed to the new substrate. This ensures secure attachment even during waves and currents. Similar to *A. palmata*, fragments from the same colony should be placed close to each other to encourage tissue merging over time.

After splitting colonies of Orbicella in large fragments, parts of these fragments should be micro-fragmented into 1 cm^2 pieces using a seawater-cooled diamond saw. These micro-fragments are then affixed to nursery wall plugs or tiles, see Figure 5. This approach facilitates the successful relocation and subsequent growth of Orbicella colonies in the new location as well as creating a genetic pool preservation in ex-situ and in-situ facilities.

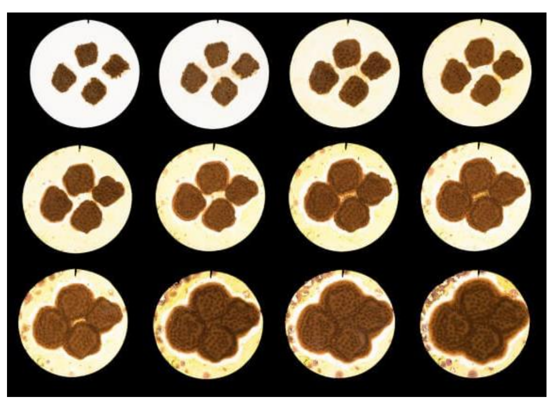

Figure 5 Micro-fragment growth development of Orbicella species

2.3 Transportation

The Contractor shall transport the corals from the Black Rocks area to the relocation site, the in-situ nurseries and the ex-situ facilities using the following methods. Depending on how the coral colonies are sourced based on the colony size, it can be chosen to transport the colonies to the relocation site either in the water or out of the water. Whenever possible, it is highly recommended to transport the corals without removing them from the water. The Saba Conservation Foundation will supervise the transportation.

2.3.1 In the water transportation

When transporting corals underwater, there are multiple methods that can be used. To make transportation from point A to B easier and faster, it is best to have the final location and designated spots marked to indicate where the sourced coral colonies are to be placed. The relocation method for A. palmata colonies varies depending on their size and branching structure. Colonies can be placed in a large tub, crate, or net floating with the help of lift bags. Alternatively, lift bags can be directly attached to the colony using ropes, see Figure 6. When opting for the latter approach, it is crucial to take caution and minimize contact points to prevent additional harm to the coral tissues by shaving, although tissue damage will still occur.

Figure 6 Relocation and reattachment of A. palmata after hurricanes in 2017

If the designated new locations are far from the original site, colonies can be towed behind a small vessel. However, one needs to keep in mind that using this practice will increase the damage to the coral.

2.3.2 Out of the water transportation

To transport sourced coral fragments outside of the water, it is crucial to minimize stress and maintain coral health during the process.

The Contractor shall handle corals with care to avoid any unnecessary damage to the delicate coral tissues. This includes also not overcrowding buckets or crates where fragments will hit each other and cause damage to the tissue. It is important to keep the fragments in fresh sea water at all times to prevent them from drying out. Water from the buckets or crates should be changed every 15 minutes to keep the temperature stable and as near as possible to the temperature from where the colonies originated. Heat stress from the sun can be minimized by placing the buckets in shaded areas or placing a damp cloth over the buckets or crates.

If transporting over longer distances, it is recommended to use coolers or insulated containers to maintain a stable temperature and protect the coral fragments. However, it is recommended to keep the transport time as short as possible. Source sites for coral relocation should ideally be within 30-60 minutes of boat travel, unless specialized facilities like a seawater pump on board, such as the one on the Queen Beatrix II boat operated by SCF, are available to maintain the corals during transportation. Fortunately, the Hole in the Corner relocation site is conveniently located 5-10 minutes by boat from the Black Rocks Harbor area.

2.4 Transplantation

The Contractor shall transplant the coral colonies and fragments using the following methods. Artificial attachment of transplants, with whatever method, should be considered as an interim stabilization measure to give coral time to naturally secure and self-attach itself by growing tissue over the substratum (natural or artificial). Thus, attachment should be made as robust and long-lasting as possible to ensure survival rate over the years. The Saba Conservation Foundation will supervise the transplantation.

2.4.1 Preparing the substrate

The Contractor shall prepare the substrate prior to relocation. Through previous experiments by SCF, coral transplants that have survived over the years were the ones that had the substrate cleaned prior to relocation, pre-drilled holes (with a power tool or auger) and were securely attached to the reef to prevent scouring. A small surface area of 20x20cm that is cleaned prior to transplantation will give coral a chance to grow onto the substrate without having to compete for the substrate with competitors (such as algae). It is essential to remove sponges and other fouling organisms that may hamper the self-attachment and direct contact of coral tissue with the bare substrate. This involves trimming the old substrate from the coral colony that is being transplanted. By doing so, the coral colony can allocate its energy towards growing tissues and self-adherence instead of competing with other organisms on the substrate. To further protect the newly exposed skeleton of the colony and the bare substrate, applying epoxy to the ridge can prevent damage that can be caused by borers or competing organisms.

2.4.2 Stabilization and attachment of fragments

The Contractor shall properly stabilize and attach the relocated colonies and fragments. Coralline algae, sponges, and other encrusting organisms (including corals) can stabilize rubble beds under certain conditions and on the other hand, hurricanes and storms may interrupt the slow process of stabilization. Coral reefs are mosaics of coral, sand, rubble, algal and seagrass habitats. The Contractor shall relocate the corals to substrates that are stable and where transplants will not be threatened by shifting rubble or sand.

The coral transplant will not be able to self-attach if it is subject to any movement (e.g., rocking from side to side as waves pass over). Thus, it is crucial that transplants are securely held in place, with no movement, until they have had time to self-attach. Similarly, where wires, monofilament fishing line or cable-ties are used to attach coral fragments, these can be effective, with coral tissue growing over them and onto the substrate, but only when there is no movement. If the fragments are moved by wave action or currents, then the wires, lines or cable-ties can abrade the coral tissue and either the fragments work loose, or the attachments eventually break. SCF data from 2018 indicated that securely attaching *Acroporid* fragments with fishing line, when tissue is minimally injured encouraged tissue development across the fishing line faster than merely retaining the fragment in place.

When planting coral fragments on a reef, the Contractor shall create small clonal patches. These patches allow adjacent branches to fuse and provide mutual support when they come into contact, promoting long-term stability. This approach contributes to the successful establishment and growth of the transplanted corals, enhancing their resilience and survival on the reef.

2.4.3 Epoxy

The selection of adhesives is influenced by several factors, including their local availability, environmental conditions at the restoration site, the size and shape of the corals, the number of corals to be attached and the available manpower.

Fixing corals directly onto hard substrate using adhesives such as epoxy and cement is a widely adopted method in coral restoration efforts. This technique, while effective, demands considerable labor and preparation before each dive, and will result typically in 20-30 fragments per buddy team per dive.

For attaching small fragments, the HILTI two-part epoxy gun is frequently used on Saba due to its ease of acquisition from local stores. However, it should be noted that this particular epoxy may require up to 48 hours in the water to fully harden and secure the fragments effectively. Despite the time-consuming nature of the process, the use of adhesives remains a crucial method in coral restoration efforts.

2.4.4 Wall Plugs

The Contractor shall fragment some of the coral colonies from the substrate, adhere them to wall plugs, and use the wall plugs to attach the coral fragments. These wall plugs can be conveniently slotted into pre-drilled holes in the selected reefs or on a nursery tree, see Figure 7, or in holding tanks in an ex-situ facility. Wall plugs are readily available for purchase on the island and can be used to securely fasten the coral fragments using epoxy.

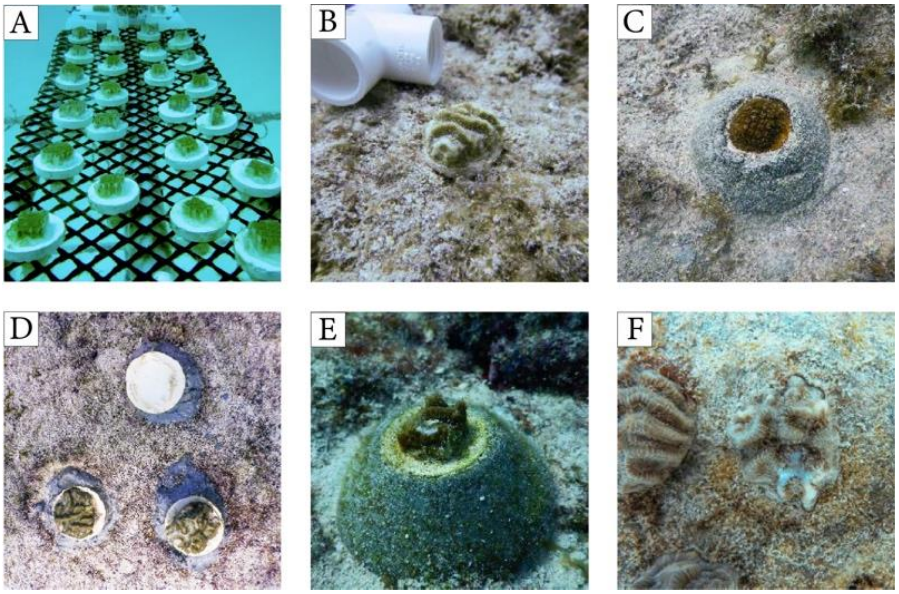

Figure 7 Coral plugs used on natural reef and nursery tree

2.4.5 Coral nursery Hole in the Corner

The Contractor shall create a coral nursery at the Hole in the Corner site for the cultivation of coral fragments from the source colonies in the Black Rocks area. This is referred to as the in-situ nursery. The Contractor shall build and place the nursery trees and/or tables according to SCF's instructions. These nurseries must provide sufficient space for all to be relocated fragments. The Contractor shall place fragments from source colonies in the Black Rocks area in the in-situ nursery. SCF will maintain and monitor the in-situ nursery and use the fragments for coral restoration efforts throughout the Saba National Marine Park.

There are several reasons why a coral nursery is highly recommended to be included in the plan:

- The existing nursery and the nursery trial on Saba have proven to be successful for growing staghorn species, especially within the area of Hole in the Corner. This area has also shown higher survival rate for the encrusting species. Given the biophysical similarities between the Black Rocks area and the relocation area, setting up a nursery in the Hole in the Corner area would be the most appropriate choice.
- Coral fragments can be attached to a nursery (tree) and will have the opportunity to grow and multiply, increasing the number of corals available for outplanting onto degraded reefs.
- Nursery trees allow for the cultivation of multiple coral fragments from different source colonies, contributing to the preservation and enhancement of genetic diversity in restored coral populations.
- Nursery trees allow the coral fragments to be suspended in the water column, elevating the fragments off the seafloor, which protects the corals from certain predators, sedimentation and competitors, which increases their chances of survival and growth.

- It allows researchers to monitor and manage corals more efficiently on health, growth rates and progress.
- Nursery trees offer a lot of flexibility in terms of design and layout, allowing the trees to be adjusted to the needs of different corals and project requirements.
- It offers the option for easy handling since corals do not need to be hammered off the reef, but can be simply clipped off a tree, resulting in less damage to the reef system and the coral itself.
- Nursery trees can be cost-effective since corals are grown in-situ which minimizes infrastructure cost over time.
- Lastly, coral nurseries are a valuable tool for education and public awareness.

2.5 Monitoring and Evaluation

To assess the success of the relocation project, monitoring is essential. The Contractor shall upkeep and monitor the relocated corals at the relocation site weekly throughout the coral relocation works. After completing the relocation, monitoring shall continue on a monthly basis for the duration of the construction of Black Rocks Harbor. After completion of the Black Rocks Harbor project, the contractor shall take high-resolution underwater pictures of the high-risk zone and outplant location to assess the health, growth rate and survival rate of the relocated coral colonies. The contractor will then hand over all monitoring results to the Saba Conservation Foundation.

The relocation site will then be included in the annual surveys that are conducted by SCF island-wide to monitor coral, algae, and herbivores. Monitoring includes assessment of the health, growth rate and survival rate of the relocated corals. Monitoring will provide valuable insights in the methods used for relocation and attachment in the natural habitat and to have better management strategies for relocation of corals. Post-monitoring is particularly critical as it helps identify potential risks, such as high mortality rates due to diseases or bleaching and enables the implementation of adaptive management strategies.

The Saba Conservation Foundation shall monitor the relocated coral fragments in nurseries and the ex-situ facility. This monitoring will be essential to understand the genetic diversity, health differences, disease developments, evaluate the effectiveness of the ex-situ nursery, growth and survival rates.

3 Governance and Stakeholders

The Contractor shall report regularly to the Engineer and the Saba Conservation Foundation. Throughout the preparation and implementation of the coral relocation works, the reporting shall be on a biweekly basis including updates on the progress of works, the coral health and survival rates. After completion of the coral relocation and during the construction works, reporting shall be on a monthly basis following the monthly monitoring. Face-to-face meetings should be conducted frequently to ensure all stakeholders are kept informed and engaged.

Annual reports on coral health will be made publicly available by SCF to provide transparency and share progress with the general public. Data collected during the project should be accessible to all parties, including scientific analyses, and stored in the SCF's database or the Dutch Caribbean Biodiversity Database.

The Contractor, the Marine Park Officer and the Saba Research Center Manager (or SCF's science coordinator) will collaborate closely to coordinate research and monitoring activities within the Saba National Marine Park and the research center's ex-situ facility.

4 Risk Assessment

The Contractor shall consider the main risks of the relocation project and have these addressed beforehand in the Coral Relocation Plan to prevent unexpected outcomes and making the relocation of (highly)endangered corals fail. The Contractor shall conduct a risk analysis and formulate mitigating strategies.