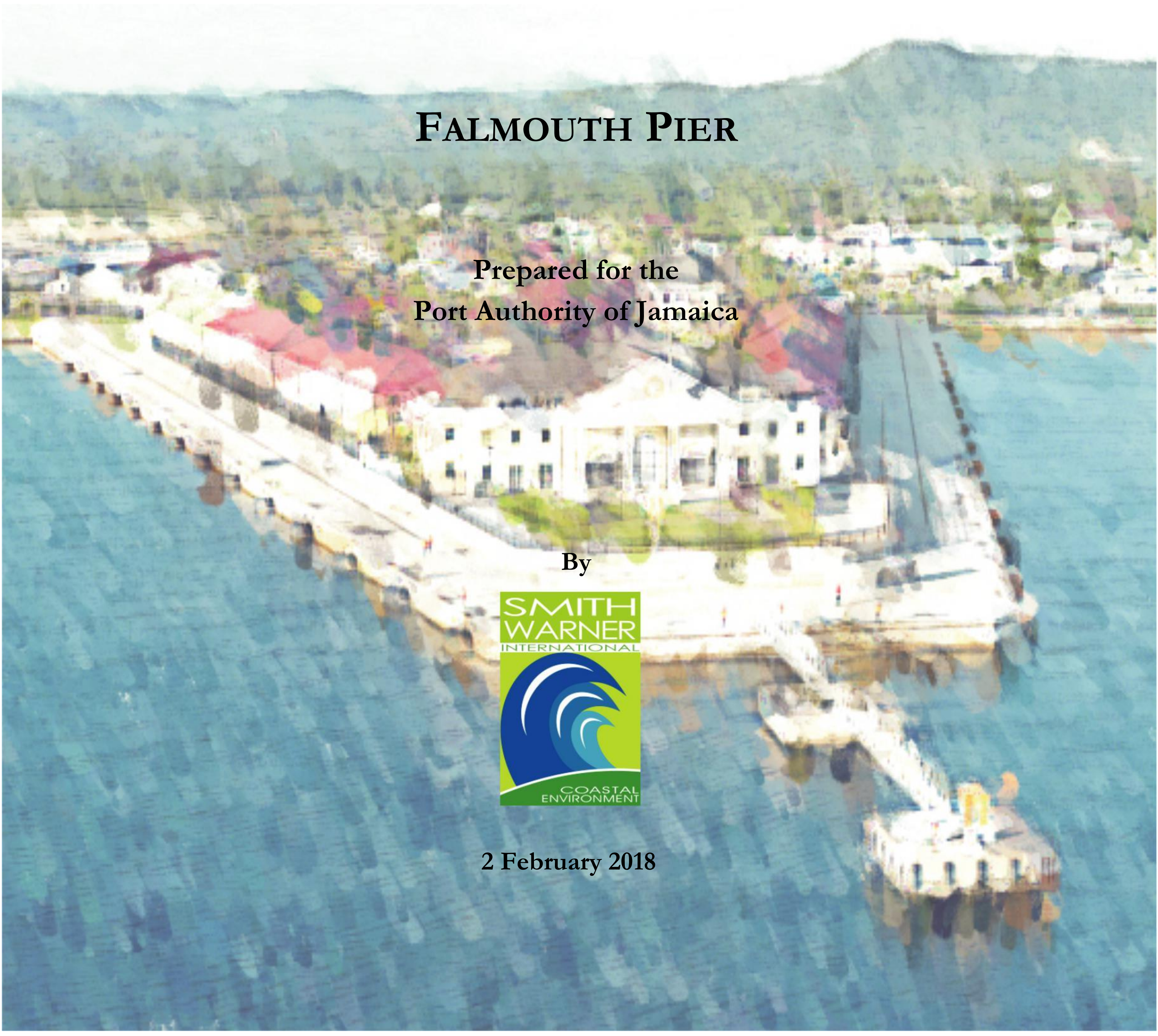
Revised
CORAL RELOCATION PLAN

FOR THE



FALMOUTH PIER

Prepared for the
Port Authority of Jamaica

By

SMITH WARNER INTERNATIONAL
COASTAL ENVIRONMENT

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1 Background

Smith Warner International Limited (SWI) was contracted by the Port Authority of Jamaica (PAJ) to perform an impact analysis on the widening of the berth pocket and a section of the entrance channel of the Falmouth Cruise Ship East Berth. Of concern were the impacts on the surrounding benthos and the marine and coastal processes in the area.

Most of the benthic substrate surveyed within the proposed dredge footprint is secondary in nature as it has been altered from previous activities, presumably capital dredging works between 2009 and 2010. However, sensitive resources, such as hard corals and reef scape, were identified in the surveys within the northern section of the proposed dredge slope. Removal of such corals would result in their death. It was therefore recommended that some minor realignment of the proposed ship channel widening be made.

The proposed realignment is shown in the following Figure 1.1 and shows that:

i. The newly proposed dredged area is wider at the narrowest point of entrance of the existing dredge area, which gives additional space for the vessels to manoeuver;

ii. The shortening of the proposed dredge area along the northern shallow section reduces the overall dredging volume of material to be extracted as well as the turbidity associated with dredging activities in this specific area.

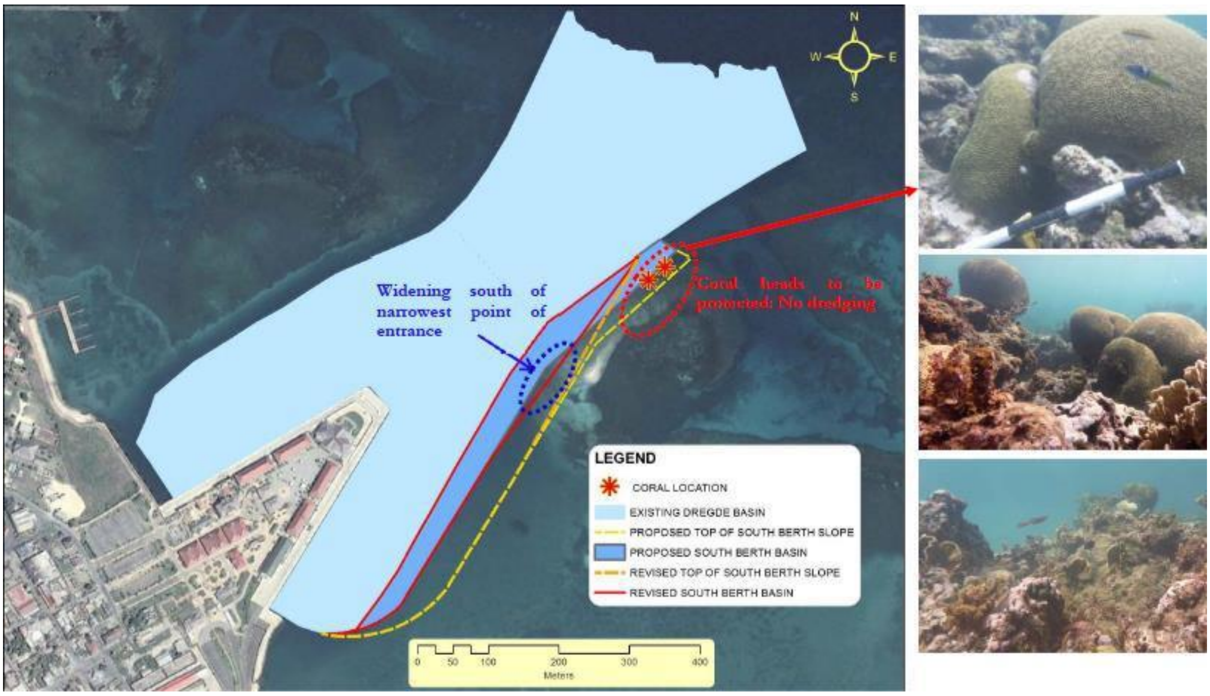

Figure 1.1 Revised ship channel expansion

2 Methodology

Two benthic surveys were conducted at the site. The first rapid benthic survey of the area proposed for ship channel widening was conducted on 13-14 May 2016 and 12 June 2016. Following the survey, the decision was taken to re-align the proposed dredge plan. The details of this report can be found in *Final Report For An Analysis Of Impacts From Dredging At The Falmouth Cruise Ship East Berth* previously submitted to the authority in October 2016. A second survey was conducted on 2-3 November 2017 in order to locate and quantify the corals to be relocated from the new footprint/impact zone, and identify a suitable relocation site.

The site was accessed directly from shore and the survey area demarcated using a hand held Global Positioning System (GPS) instrument and surface marker buoys. The seafloor has a mix of sand, silt, hard pavement and seagrass substrate and the typical marine flora and fauna associated with this type of substrate and wave energy. Corals > 10cm observed were tagged and notation taken of GPS locations of coral clusters.

3 Coral Mapping & Observations

Corals were physically tagged, and a contingency estimate was added to this number to arrive at a total estimated number. The contingency number allowed for the fact that there was poor visibility in sections of the survey, which could have led to an underestimation of gross numbers. The total estimated number of corals was 650. The location of hard corals greater than 10cm within the footprint of the proposed dredging area is illustrated in Figure 3.1. Figure 3.3, Figure 3.3 and Figure 3.4 all show examples of corals located within the footprint that were tagged.

Most of the corals observed were of the following species: *Agaricia agaricites, Diploria clivosa, Porites astreoides, Porites furcata, Siderastrea sideria (*see appendix for estimated abundances of each specie). Many of the corals observed were located in the vicinity of reef substrate on the edge of the previous dredge cut (Figure 3.4). Given the sizes observed (>50% less than 20cm diameter), it is likely that a number of these corals have colonised the area since the completion of the previous dredge works in 2009.

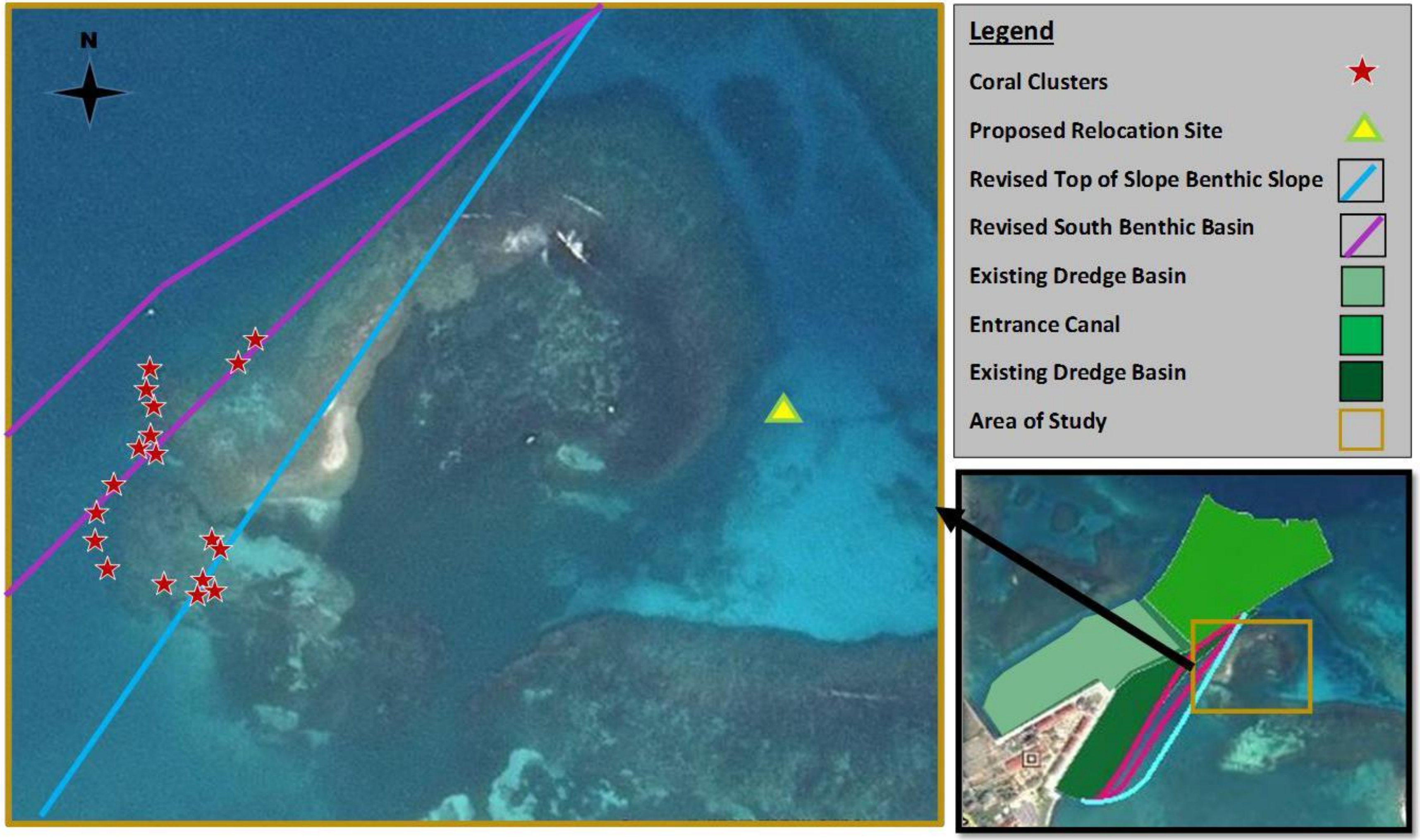

Figure 3.1 Coral relocation site and surveyed coral clusters

Figure 3.2 The largest coral observed during the tagging exercise (estimated to be 55cm)

Figure 3.3 Corals located in the proposed dredge location- most corals observed were <20cm

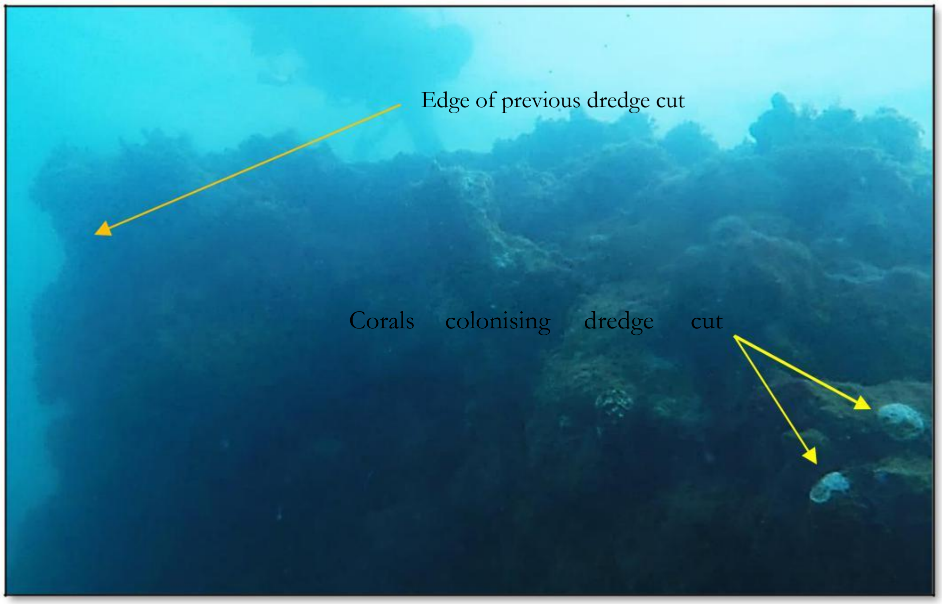

Figure 3.5 Corals located in the proposed dredge location – edge of previous dredge cut

4 Coral Relocation

4.1 Relocation Site

Coral reefs in Jamaica are in serious deterioration, suffering massive, long-term declines in abundance, diversity and habitat structure due to overfishing, natural disasters such as hurricanes, pollution, disease in addition to other anthropogenic and natural causes.

As described above, there are numerous corals within the footprint of the proposed impact area that must be relocated to outside of the project area. For this site, corals will be relocated to the already existing reef. An area adjacent to the coral relocation site from the previous capital dredge work has been identified for use (Figure 3.1). The location has little to no potential impact from existing or expanded cruise pier operations and associated ship channel impacts such a ship grounding, propeller impacts and sedimentation.

The following criteria were used in the assessing the suitability of the proposed recipient site:

- Proximity to project site to facilitate quick replanting to minimize stress on the corals;
- Minimal exposure to strong waves and currents to facilitate efficient replanting and avoid displacement of replanted corals;
- Low turbidity; and existing growth of corals to ensure that conditions are indeed suitable;
- Type of substrate.

The recipient site coordinates (given in UTM, using datum WGS84) are *Easting 220952* and *Northing 2047066* (Figure 4.1).

Figure 4.1 Relocation site

As shown in Figure 4.2, this site is ideal for coral relocation because of similarities in temperature, sunlight penetration, etc. The donor site has a depth range of 1m – 4m and the recipient site has comparable substrate and a depth range of ~ 2m - 4m (Figure 4.2).

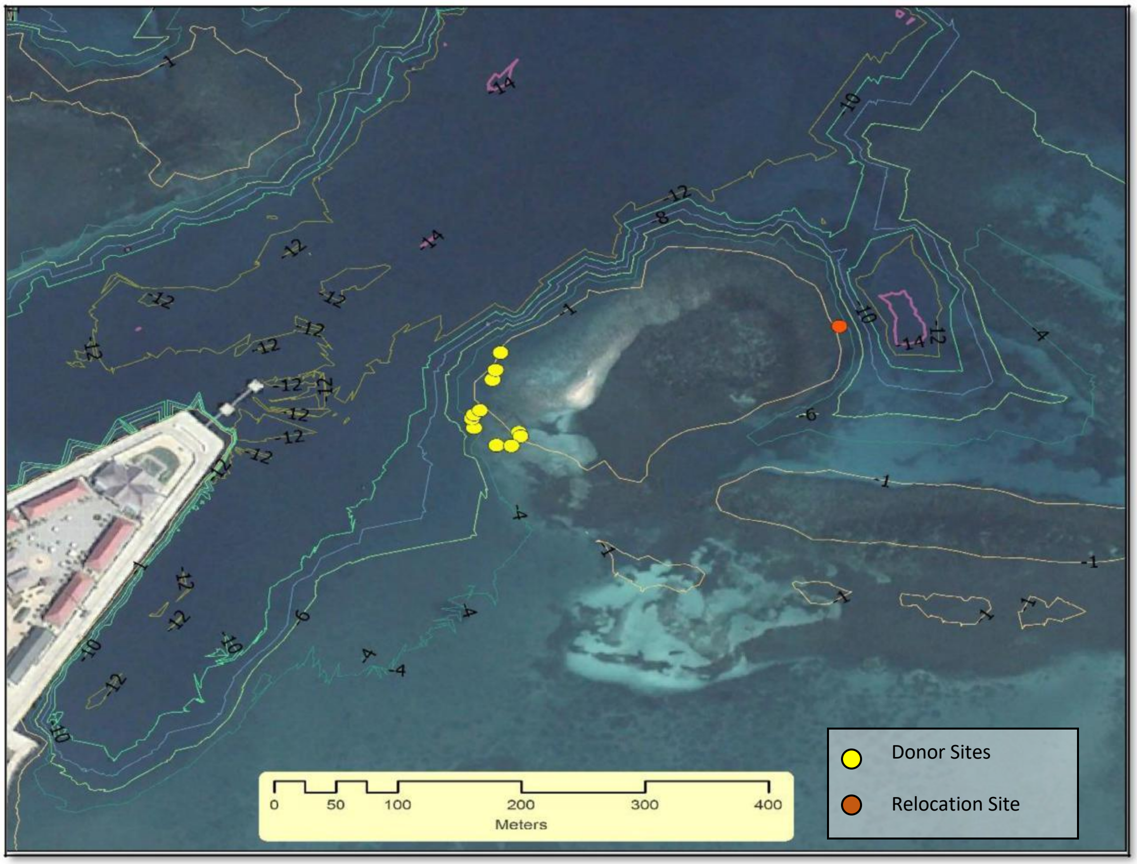

Figure 4.2 Depth profiles of the coral donor site vs the relocation site

4.2 Harvesting and Transporting

Coral larger than 10cm to be relocated will be severed from the base to which it is attached, using hammer and chisels. During the severing process divers will try to avoid touching live surfaces of the corals to prevent damaging or killing the sensitive coral polyps. When possible, the corals will be severed in such a way that they remain attached to their carbonate bases which, in turn, will prevent direct contact of the polyps with the reef cement mixture. Once carefully removed, the coral will be placed in large pervious baskets and guided by the divers to the relocation site. Colonies in the baskets will be arranged to minimize live coral tissue from touching any other surface and no structural elements of the corals will be under pressure. Should any coral colonies be fragmented during the collection phase they shall be cemented to a suitable substrate prior to placement in the recipient site.

4.3 Reseating

At the recipient site the divers will use gloved hands to remove sand particles and loose algae, prior to fitting a semi-cured Portland cement ball to the base of the area of coral to be reattached. The area for reattachment will be determined to get a close fit between the coral base and the area where the cement is to be placed. There will be an approximately 20-30 minute period while the reef cement mixture starts to cure and harden. Corals will therefore have to be placed at the donor site simultaneously with the mixing of the cement on shore. The curing cement will be placed in transparent plastic bags and divers will carefully and slowly remove the balls of cement from the bags to minimize localized sediment dispersal. The reef cement will then be placed on the flush surfaces between the transplanted coral and the block. By gently pressing the coral onto the semi-cured cement, divers will ensure that cement is evenly distributed under the coral colony.

4.4 Removal and Relocation of Other Sensitive Organisms

At the start of each day of operation, any observed sedentary or slow moving marine fauna and/or flora (e.g. *Diadema antillarum*) that require removal and relocating will be done in an approved method, before harvesting commences. These flora and fauna will be placed in a bucket or a basket and immediately moved to areas outside of the harvesting area. The basket will be transported through the water so that the species remain submerged. There will be no holding time, therefore reducing the potential for them to become stressed. If a bucket is used, it will be filled with sea water from the site and the organisms will be submerged in the bucket and immediately relocated to a safer zone.

4.5 Turbidity Control

Turbidity curtains (screens) will be used to minimize leakage of turbid waters to the surrounding environment. Points outside of the turbidity curtain will be monitored to determine if turbidity is escaping and impacting the marine environment outside of the isolated area. The barrier will serve as both demarcations for the areas of replanting as well as containment of any suspended silt in the water column.

4.6 Schedule

Subsequent to receipt of the required permitting from NEPA, the proposed schedule is as follows:

- Day 1 – One day training workshop inclusive of field and lecture sessions for all persons involved in this activity;
- Day 2 to 3 – Preparation of recipient site for coral transplant. Coral removal and transplant;
- Days 4 to 18 – Continued coral removal and transplant.

It should be noted that this schedule is highly weather-dependent and is subject to change.

4.7 Supervising Personnel

The replanting will be carried out under the supervision of Smith Warner International Limited. The management team has carried out similar relocation activity successfully at Palmyra and Trident, and has overseen relocation activities at several other sits including Half Moon, Iberostar and Secrets.

Renée McDonald, who holds an MSc in Marine Environment and Resources will provide oversight of all the relocation activities. She has the relevant experience in marine ecosystems mitigation (restoration, relocation and artificial systems), and environmental monitoring. As part of her duties she will be responsible for quality control in handling the sensitive species being relocated. She will also be responsible for logging and recording relocation activities. Mr. Huon (Dave) Guiness, an experienced SCUBA diver who has worked on other coral relocation projects such as those associated with the construction of the Falmouth pier, will be the lead individual in relocating the corals. Any changes to these project personnel will be submitted to the Agency in writing.

5 Monitoring

5.1 Monitoring Report

A monitoring report will be submitted to NEPA within seven (7) working days of completion of the transplanting period. This will include the following:

- Summary log of the daily transplanting operations. This is to include the location and total number of corals harvested and anchored;
- Dated photographic evidence of all works;
- Sea and weather conditions during transplantation; and
- Any anthropogenic impacts during the transplantation.
- Following completion of relocation, monthly monitoring will be carried out during the period of works. Further monitoring exercises will be carried out as stipulated by the authority.

5.2 Indicators for Marine Monitoring

Water quality monitoring to establish the suitability of proposed seagrass relocation sites has been carried out in the near-shore waters in close proximity to the development site at three sampling stations (origin site and two relocation sites). The water quality indicators being used in the assessment include physical, chemical, and biological measurements. These include turbidity, orthophosphate, nitrate, biological oxygen demand (BOD), pH, dissolved oxygen (DC), salinity and temperature.

Currently no ambient marine water quality standards exist for Jamaica, so a combination of National and International indicator concentrations will be used. The BOD will be compared to data for Jamaica's coastal waters obtained from the National Resources Conservation Authority. Data for orthophosphate, nitrate and pH will be compared to typical offshore water quality of particular areas of the Caribbean Sea around Jamaica, Belize, Bahamas and Barbados. This data was obtained through NEPA and was extracted from the database of the Caribbean Resources Exploration Project, 1990. For further comparison, data for Australian coastal waters will be used for the assessment of turbidity and dissolved oxygen. These indicator concentrations are summarised in Table 5-1 and Table 5-2.

Table 5-1 Typical indicator concentrations in Jamaican and Caribbean offshore waters

Constituent	Concentration mg/L
Orthophosphate	0.001 – 0.055
Nitrate	0.001 – 0.081
pH	8.0 – 8.4
BOD	0.57 – 1.16

Table 5-2 Typical indicator concentrations in Australian (Queensland) waters

Constituent	Concentration
Turbidity	1.0 ntu
Dissolved Oxygen	> 6 mg/L

5.3 Turbidity (Light Penetration)

Inputs from turbid fluvial sources and the resuspension of sediments in shallow coastal waters as a result of wave action can decrease the visible penetration of light into the water column. Turbidity is the result of these suspended sediments and is a relative measure of the clarity of water: the greater the turbidity, the murkier the water.

5.4 Nutrients

The most important nutrients, in terms of water quality, are naturally occurring phosphorus and nitrogen. They can occur in the dissolved (soluble) phase or may be attached to sediments (particulate). Increasing nutrient concentrations are undesirable due to the potential for accelerated growth of aquatic plants, which can create imbalances in the aquatic community, as well as aesthetic issues.

Nitrogen exists in water in inorganic and organic forms and high concentrations can contribute to eutrophication in marine waters. The dissolved species of nitrogen (DIN) include nitrate (NO32-), nitrite (NO2-), ammonium (NH4+) and di-nitrogen gas (N2). These are generally considered to be the bioavailable component of nitrogen within the water column and are a significant source of nitrogen for algal growth. Total dissolved nitrogen (TDN) consists of dissolved inorganic nitrogen (DIN) and dissolved organic nitrogen (DON), and is readily available for plant uptake. Nitrate is the product of aerobic transformation of ammonia and is most commonly used by aquatic plants. Nitrite is usually not present in significant amounts.

Phosphorus is also found in water bodies in dissolved (soluble reactive phosphorus; SRP) and particulate forms. Dissolved phosphorus is readily available for plants, and consists of inorganic orthophosphates (for example, H2PO4-, HPO42-, PO43-) and organic phosphorus-containing compounds (DOP).

5.5 Biochemical Oxygen Demand

The five-day biochemical oxygen demand (BOD5) is a measure of the amount of dissolved oxygen consumed by the decomposition of carbonaceous and nitrogenous matter in water over a five-day period. Matter containing carbon or nitrogen uses dissolved oxygen from the water as it decomposes, which can result in a dissolved oxygen decline.

5.6 Dissolved Oxygen

If the concentration of dissolved oxygen (DO) decreases below the minimum requirements for survival, sustainability of aquatic organisms may be at severe risk. There is natural variation of DO, which results in diurnal and seasonal cycles. Typically, dissolved oxygen concentrations tend to be lowest in the morning, with gradual increases measured throughout the day as a consequence of photosynthesis with a peak occurring in the late evening followed by a decline during the dark hours. There is also a seasonal DO cycle in which concentrations are greater in the colder, winter months and lower in the warmer, summer months, however, this effect is much lower in tropical climates where the surface temperatures of the water show much less temperature fluctuations.

5.7 Seawater Temperature

Water temperature has profound physiological effects on organisms, and if the water temperature goes too far above the tolerance range of an organism, the organisms' ability to survive will be compromised.

5.8 pH

pH is a measure of the hydrogen ion concentration of water and is used to indicate degree of acidity. The pH scale ranges from 0 to 14 standard units (SU). A pH of 7 is considered neutral, with values less than 7 being acidic, and values greater than 7 being basic.

Appendix

Coordinates of clusters of mapped corals

Easting	Northing
220657.4077	2046951
220639.3779	2046968
220637.5052	2046977
220675.4564	2046964
220676.8771	2046960
220669.3434	2046950
220669.3434	2046950
220669.3434	2046950
220669.3434	2046950
220669.3434	2046950
220669.3434	2046950
220639.3565	2046981
220644.1775	2046985
220654.1311	2047016
220656.7007	2047025
220660.7574	2047042

Estimated Coral Abundances

Species	Estimated Abundance
Agaricia agaricites	100
Diploria clivosa	10
Porites Furcata	85
Porites astreoides	170
Montastraea annularis	12
Siderastrea siderea	120
Siderastrea radians	60
Diploria labyrinthiformis	18
Contingency allowance for corals that may have been overlooked due to poor visibility conditions	75

Note: Estimated abundances as shown above, include an extrapolation of species numbers to account for colonies that may have been overlooked within the area of survey.