PROPOSED EXTENSION OF RUNWAY AT NORMAN MANLEY INTERNATIONAL AIRPORT

ADDENDUM
TO
RAPID ECOLOGICAL ASSESSMENT
NOVEMBER 2010

Prepared for:
NMIA Airports Limited
Norman Manley International Airport
Palisadoes
Kingston

By:
Cowell Lyn
ESL Environmental Management Solutions
Smith Warner International

2013 May 01

ADDENDUM – PART 1

CIVIL ENGINEERING DETAILS

FOR

NORMAN MANLEY INTERNATIONAL AIRPORT
500M RUNWAY EXTENSION

COWELL LYN

PROPOSED 500m EXTENSION TO NMIA RUNWAY

ADDENDUM TO REA REPORT SUBMITTED TO NEPA IN FEBRUARY 2011

ADDENDUM PART 1

1. A comprehensive description of all aspects of the project.
2. Drawings and descriptions of the proposed reclamation areas showing methods of hoarding, stabilization and slope protection.
3. Descriptions of the types of equipment and work methods that will be used to carry out the Works.
4. Quantities of fill material required, borrow areas where dredging will be done, and other sources from which fill material will be obtained.

Prepared for

Norman Manley International Airports Limited
Palisadoes, Kingston, JAMAICA, W.I.

Prepared by

Cowell Lyn, PE
Consulting Engineer
15 Gibson Drive, Kingston 6, JAMAICA

April 2013

PROPOSED 500m EXTENSION OF NMIA

ADDENDUM to REA Report submitted to NEPA in Feb. 2011 in support of NMIA applications for Project Permits

PART 1

Contents

PROPOSED 500m EXTENSION OF NMIA RUNWAY

ADDENDUM PART 1 -TO REA REPORT SUBMITTED TO NEPA IN FEBRUARY 2011

1. Introduction

Airports Authority of Jamaica is in the process of implementing some of the preferred options for continuing development of NMIA that were presented in their twenty-year (2002 -2022) Master Plan. This proposed project to extend the length of the existing runway by a further 500m westwards further out into Kingston Harbour has been identified as being one of the most urgently needed up-grading projects if NMIA is to retain its well-established status and viability as one of Jamaica's two economically indispensable international airports.

1.2 The primary purpose of this proposed 500m extension is to improve the safety of operations at the airport by providing RESA's , i.e Runway End Safety Areas. RESAs are areas beyond the ends of a runway that provide margins of safety for *overrunning* (departing) or *undershooting* (arriving) aircraft.

1.3 RESAs are mandatory requirements under the International Civil Aviation Organization (ICAO) standards, the guiding document for Airports worldwide. Jamaica is a signatory to the ICAO conventions and must either make the NMIA facilities compliant with ICAO's recently revised Annex 14 standards, or file a "difference " with ICAO. It is likely that if appropriate RESAs are not installed at NMIA, a penalty will be imposed in regard to the type of aircraft that the runway would be rated capable of accommodating.

1.4 NMIA commissioned preparation of this report to provide supplementary information to the Rapid Ecological Assessment (REA) carried out by Environmental Solutions Limited, that was submitted to NEPA in 2011, in support of NMIA's application for the Permits required for implementation of the project. This ADDENDUM PART 1 is one of three separate addenda commissioned by NMIA in response to the request from NEPA in letter dated February 8, 2013, for some additional information required, in order for the Agency to be able to complete their processing of the NMIA Application.

2. Scope of Works for the Project

The items comprising the scope of works for the 500m runway extension are:

2.1 Reclamation area **A** 500m x 375m (for runway extension)

2.2 Reclamation area **B** -1650m x 15m.(for widening existing runway)

2.3 Reclamation area **C** 145m x 130m.(for aircraft parking & fire rescue station)

2.4 Slope protection for edges of reclaimed areas.

2.5 Compaction of all of the reclaimed areas.

2.6 Construction of new runway and taxiway pavements.

2.7 Relocation of landing approach lights in the sea.

2.8 Construction of new Fire Rescue facilities, including boathouse.

2.9 Relocation of existing north electricity substation to extended tip of runway.

2.10 Construction of new electricity substation near to relocated Fire Rescue

2.11 Modifications to existing aircraft navigation aids

2.12 Extensions of runway and taxiway markings and lights.

2.13 Extension of runway fencing

3. Bathymetry at the project site and the areas to be reclaimed

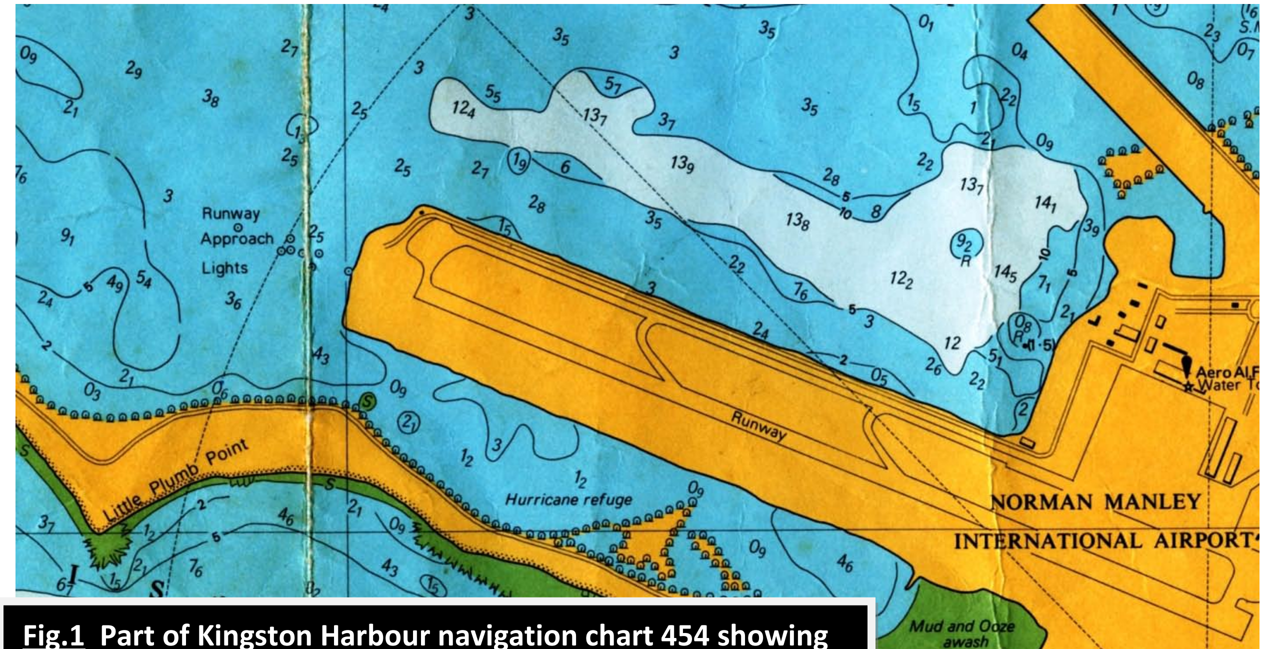


Fig.1 Part of Kingston Harbour navigation chart 454 showing existing seabed soundings (in metres) in the vicinity of NMIA

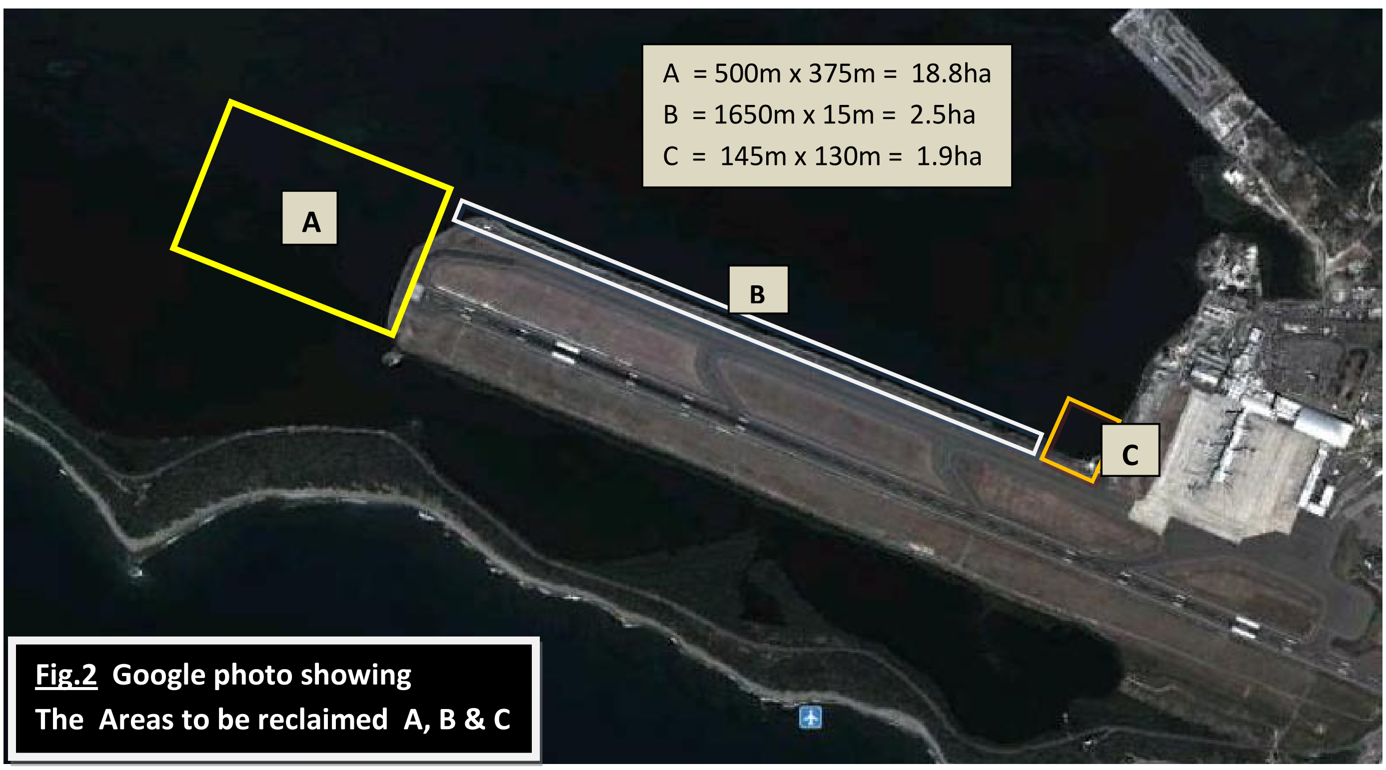


Fig.2 Google photo showing The Areas to be reclaimed A, B & C

Fig. 3 **Photo looking westwards along the north edge of the existing runway.**
This portion of the runway is to be widened by 15m, Reclamation area B in the above Fig.2

Fig. 4 **Photo looking northwards along the western boundary of the NMIA compound.**
Reclamation area C in the above Fig.2

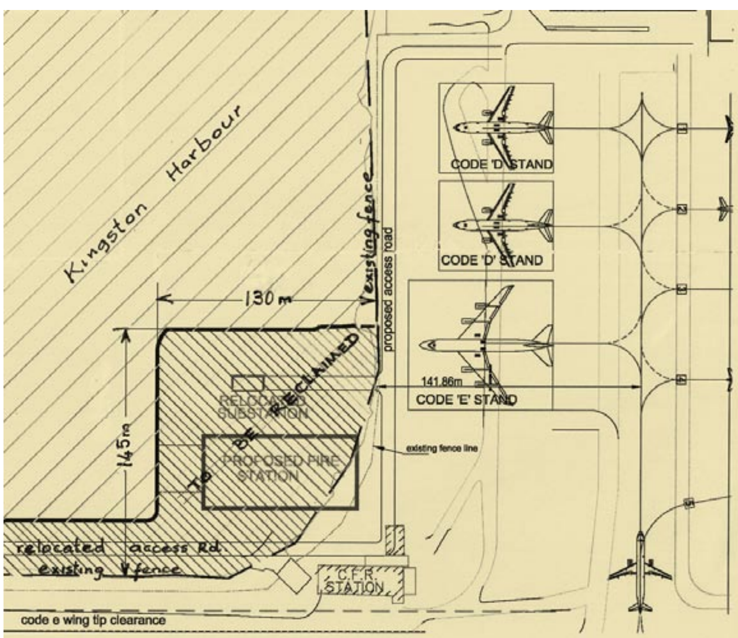


Fig.7 Plan drawing showing dimensions of Reclamation area C

Fig.5 Photo showing eastern frontage of existing Fire Rescue Station at NMIA

Fig.6 Photo showing southern frontage of existing Fire Rescue Station at NMIA

Fig.7 Plan drawing of Reclamation area C 145m x 130m = 1.9ha to accommodate new fire station and electrical sub-station and expansion of aircraft parking apron.

4. **Reclamation methods and equipment.**

The reclamation for creating the required additional lands at NMIA can be accomplished either by Hydraulic Dredging (wet filling), or by Dry Filling:

a). <u>Hydraulic Dredging</u>,
Hydraulic dredging is an efficient engineering method utilizing large, powerful vessels specially equipped for digging into seabed strata and pumping the fluidized material into place for creating new land, or into carrier barges for transportation to disposal sites.

b). <u>Dry Filling</u> i.e., trucking or barging fill material obtained from inland sources (e.g. riverbed shingle or quarried rock) to the project site, tipping it into the sea, and then using heavy equipment (tractors) to spread and compact it into place.

4.1 Hydraulic Dredging.

<u>Fig 8</u> above is a 1955 aerial photo showing a cutter suction dredger (CSD) operating in the Palisadoes wetlands at the start of construction of Palisadoes Airport, which later developed into becoming the present Norman Manly International Airport, NMIA. Over eight million cubic yds of seabed material was dredged to create the 310 acres of new land, using this flat bottom, shallow draught CSD and the "pump ashore " method of reclamation.

Year of construction	1984
Classification	B.V. I 3/3 E Deep Sea
Tonnage	702 GRT
Length overall	66.00 m
Length pontoon	53.40 m
Breadth	12.50 m
Moulded depth	4.50 m
Normal draught	2.40 m
Suction pipe diameter	0.70 m
Discharge pipe diameter	0.70 m
Maximum dredging depth	20.00 m
Minimum dredging depth	4.00 m
Anchoring system	Spud carriage

Fig.9 Photo of CSD *Mercurius*

Typical pontoon shallow draught CSD. Most likely this will be the type of machine that will be used for carrying out pump ashore reclamation for the proposed 500m extension of NMIA runway.

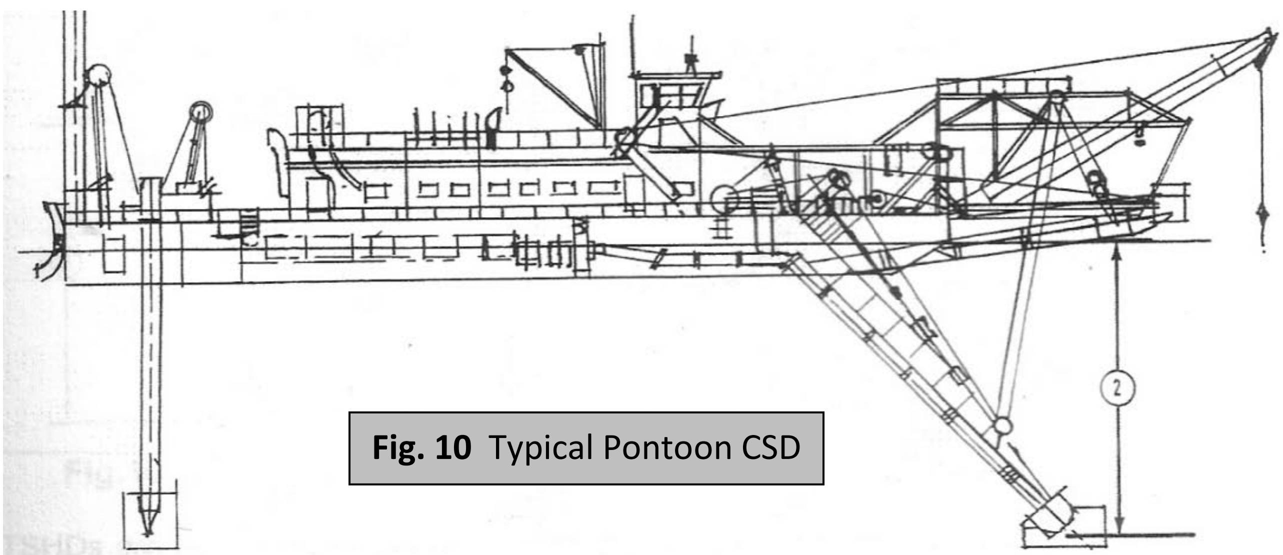


Fig. 10 Typical Pontoon CSD

5. **Disposal of waste material**

It is not anticipated that large volumes of dredged material will be deemed unsuitable for placement as fill in the areas to be reclaimed; but in case any such situation should arise, it should be acceptable for such material to be disposed of by pumping it into the deep borrow pit that remain at site from the 1955 dredging.

Fig. 11 Photo of a split hull barge being towed away from a dredge site carrying dredged material to be disposed of at a remote dump site. Any Contractor engaged for carrying out this proposed NMIA RESA project will very likely come with equipment such as that shown in the above photo to deal with any off-site disposal situations that might arise.

6. Boreholes drilled at site for geotechnical investigations.

The 310 acre NMIA is situated upon reclaimed land that was formed by hydraulic dredging carried out in the Palisadoes wetlands in 1955. Recent soils investigations confirm the availability of adequate volumes of suitable-quality sand and gravel remaining in the seabed just to the north of the proposed 500m runway extension, and therefore this area is very conveniently located to serve as the borrow area from which the necessary fill material can be obtained.

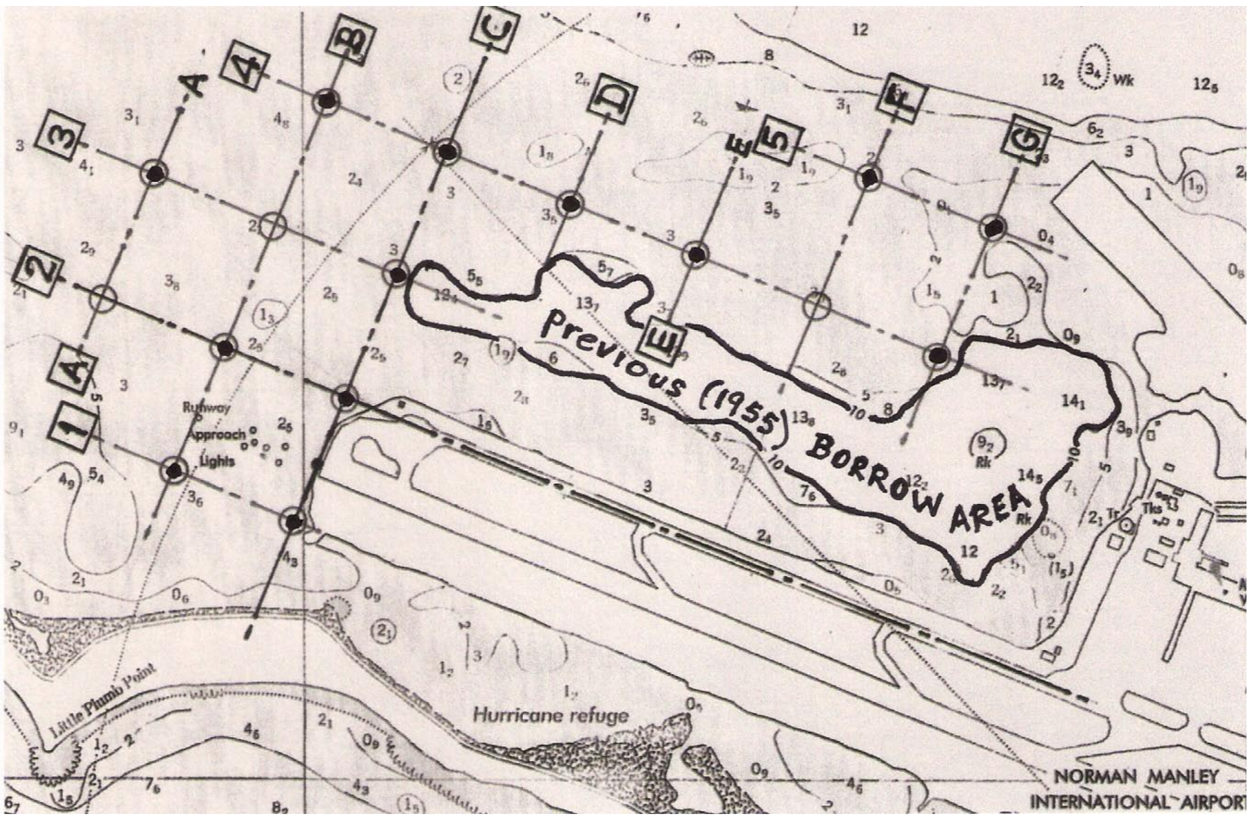
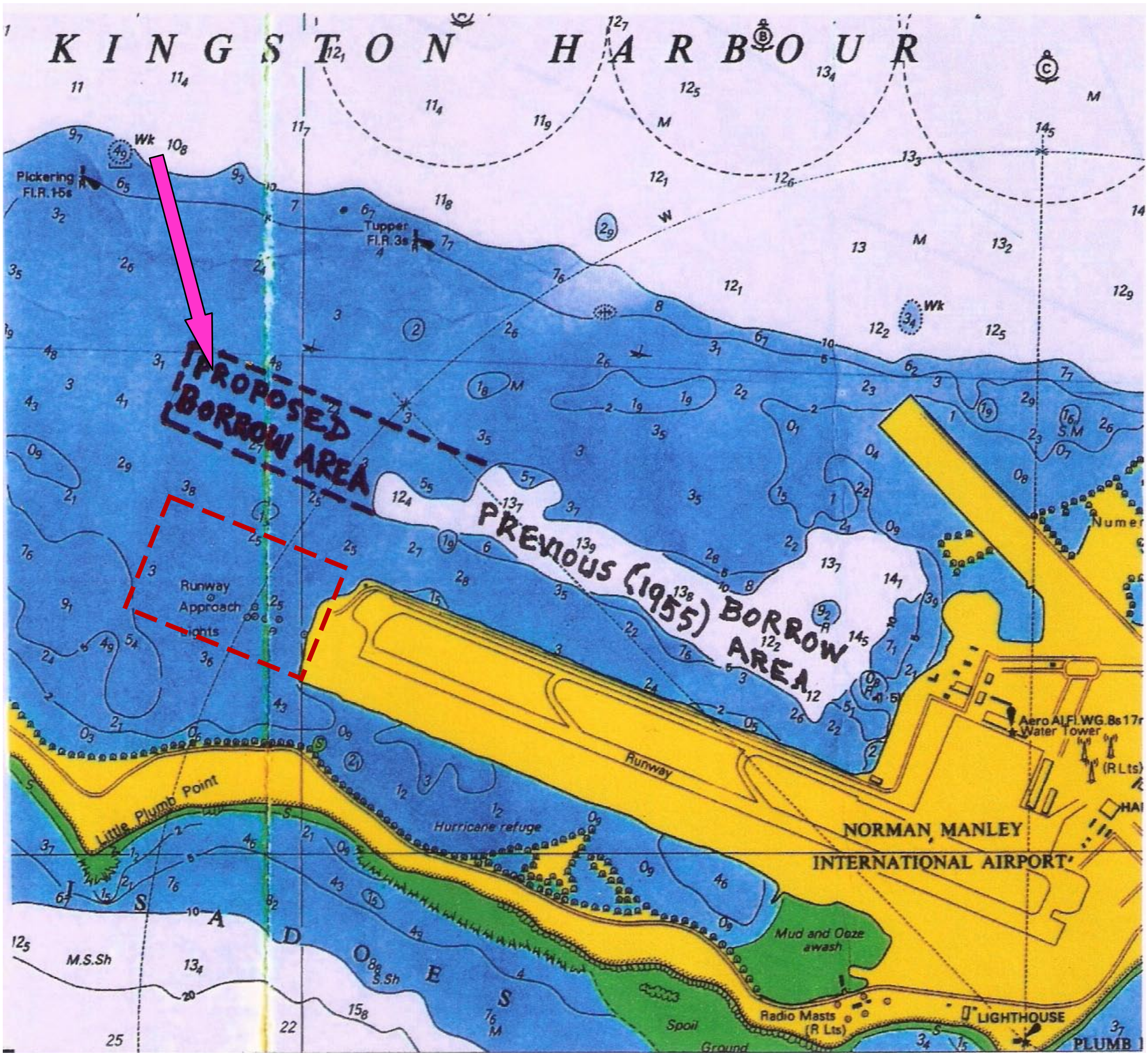


Fig. 12 Showing the layout of boreholes drilled at the project site in 2008

> "*The thirteen (13) boreholes which were advanced were all driven to a maximum depth of 15.69m below mean sea level. The samples which were initially recovered from the boreholes were generally dark grey or black sand accompanied with shell fragments and or a trace of peat. The remaining samples were fairly consistent in their composition in that the dominant material present was sand with sizes ranging from coarse to fine. The sand was often accompanied bya trace of silt and a trace of clay in some instances. Gravel was present in some of the samples recovered however the greatest proportions were present in samples six and seven recovered from borehole 4G.*"
>
> **Geotech Soils Report, Sept. 2008, pg.4**

7. Proposed borrow area for dredging and route of access for the dredger.

Fig. 13 Access route (pink arrow) for CSD to reach to the proposed borrow area.



8. **A convenient source for refuelling dredging equipment**

Aegean Bunkering is an international company that has vessels stationed at Rockfort, approx 2km across the harbour from the NMIA worksite, which will be very conveniently available for refueling the dredging equipment working on this NMIA RESA project.

AEGEAN BUNKERING (JAM) LTD

Address: HARBOUR HEAD PEN
ROCK FORT
KINGSTON 2
JAMAICA, W.I.

Tel: +1 876 938 7752

Fax: +1 876 938 8638

E-mail: operations@aegeanjam.com & agency@aegeanjam.com

In Jamaica, we service our customers in three locations, namely Kingston, Ocho Rios and Montego Bay. Bunker deliveries are conducted in the inner and outer anchorages as well as offshore, by modern supplying vessels, 24 hours a day/7 days a week.

Our local service center, Aegean Bunkering (Jamaica) Ltd, provides technical and logistical support to our operations. Our vessels' pumping capabilities are 300-800 mts/hour. Aegean can supply all grades of marine fuel, from 30 to 380 Cst and MGO. All products supplied in all our bunkering stations meet ISO 8217/2005 standards and are in compliance with Marpol 73/78, Annex VI.

Please note, all vessels calling at Kingston must have a local representative responsible for payment of fees and to communicate with the relevant authorities. Aegean can offer agency services with highly competitive calling cost for supplies in port.

Bunkering Tankers / Current Local Fleet

Ship Name	Bunkering Station	IFO Capacity	MGO Capacity	Pumping Capability	DWT
Kalymnos	Jamaica	5,200 mts	900 mts	700 Mts/h	6.282

CALLING INSTRUCTIONS	
KINGSTON	**Download in PDF form**

AEGEAN BUNKERING (JAM) LTD

Address: HARBOUR HEAD PEN
ROCK FORT
KINGSTON 2
JAMAICA, W.I.

Tel: +1 876 938 7752

Fax: +1 876 938 8638

E-mail: operations@aegeanjam.com & agency@aegeanjam.com

9. Availability of quarried limestone for dry filling.

9.1 There are several licensed limestone quarries in St Thomas that are conveniently located within a twenty-mile radius of NMIA for supplying suitable material for the project; and Consultant is of the view that at the commencement of the reclamation, it will be preferable to use the dry filling method to construct perimeter containment bunding around the main area A for the runway extension, instead of forming the bunds by pumping-in dredged material; because the dry filling method will minimize the possibility of serious negative impacts from dispersion of sediment plumes into the adjacent Port Royal mangroves during the initial filling.

Letter from Shaw's Quarries, one of several nearby companies capable of supplying quarried limestone for dry filling.

Mr. Cowell Lyn
Project Execution Unit
Airports Authority of Jamaica
Norman Manley Intl Airport
Kingston Jamaica

December 23rd 2008

RE: Pro forma Invoice

Dear Sir

Thank you for the opportunity to introduce myself to you as well as supply an attached pro forma invoice.

I am an owner and operator of two medium sized limestone quarries located in Bull Bay, St. Andrew and Lydford, St. Ann.
As a quarry operator and contractor continuously licensed since 1967 I have been affiliated with many civil engineering, infrastructural and development projects across Jamaica. Most members of the Master Builders Association of Jamaica are counted among my repeat customers.

I am pleased to state that I have been specially selected on several occasions over the years to supply hundreds of thousands of cubic metres of aggregate to projects under the aegis of Caribbean Construction, E. Pihl and Sons, Ashtrom, Tank Weld Group, National Works Agency, Airports Authority of Jamaica , The Port Authority of Jamaica and many others.

In addition to initial major works at Gordon Cay for the pier extension, installation of bridges, construction of various roadways and other vital infrastructural works, I have over the years extended the runways at Tinson Pen, Boscobel and Ken Jones Aerodrome. More recently I have worked at Norman Manley International on the Incinerator project as well as the removal of the old Queens Warehouse building, excavations for the new building as well as grading the surrounding area to road level.

I am also pleased to inform you that I have at my disposal one of the larger fleets or earthmoving or digging equipment inclusive of Caterpillar or Komatsu wheeled or crawler type front end loaders, bulldozers and various sizes of excavators.

For your convenience I will send to you by email the test results on our aggregate under consideration.
I cordially invite you to visit my quarry in Bull Bay to verify to your satisfaction the reserve of limestone aggregate available for the project under consideration.
I may be contacted at the numbers listed below as well as by cellular phone at 382-7193.

Respectfully,

Warren Shaw

10. A possible source of river shingle for dry filling.

River shingle from the nearby coastal reaches of Hope River, Cane River, Chalky River, Bull Park, and Yallahs, would also be suitable material for construction of containment bunds for the project.

NATIONAL WORKS AGENCY

140 Maxfield Avenue, Kingston 10, Jamaica Tel: (876) 926-3210-9 · Fax: (876) 926-2572

ANY REPLY OR SUBSEQUENT REFERENCE SHOULD BE ADDRESSED TO THE CHIEF EXECUTIVE OFFICER AND THE FOLLOWING REFERENCE NUMBER QUOTED:-

Ref. No.:

KMR Regional Office
15 Hagley Park Road
Kingston 10
Tel: 926-6499
929-7328, 968-1576
Fax: 929-7327

Central Regional Office
33 Caledonia Road
Mandeville, Manchester
Tel: 962-2258
Fax: 961-6172

Western Regional Office
Flankers Main Road
Flankers, St. James
Tel: 940-7337
940-4466, 979-3166
Fax: 940-7973

North Eastern Regional Office
West Street
Port Antonio
Portland
Tel: 993-2531
Fax: 993-9665

December 4, 2008

Mr. Earl A. Richards
President
Airports Authority of Jamaica
P.O. Box 567
Kingston 10

Dear Mr. Richards:

Further to our discussions on Wednesday November 19, 2008, at a meeting with Airports Authority of Jamaica (AAJ) and the National Works Agency (NWA), we are pleased to inform you that we can undertake the project as summarized below:

To excavate, load and transport river shingle from Yallahs River to Norman Manley International Airport as directed.

	$
70,000M³ or 110,000 tons	
i) Haulage 110,000 tons @ $220.00	24,200,000
ii) Loading 110,000 tons @ $40.00	4,400,000
iii) To stockpile 110,000 tons material on site @$30.00	3,300,000
iv) To provide weighing facility @$3.00 per ton	330,000
Sub- total	32,230,000
NWA's Fees 9.5% of Total	3,061,850
TOTAL	**35,291,850**

We hope the offer is within your budget allocation.

Please do not hesitate to contact us if you need further information or clarification.

Sincerely,

Desrick Litchmore
Project Manager

11 Containment bunding for reclamation.

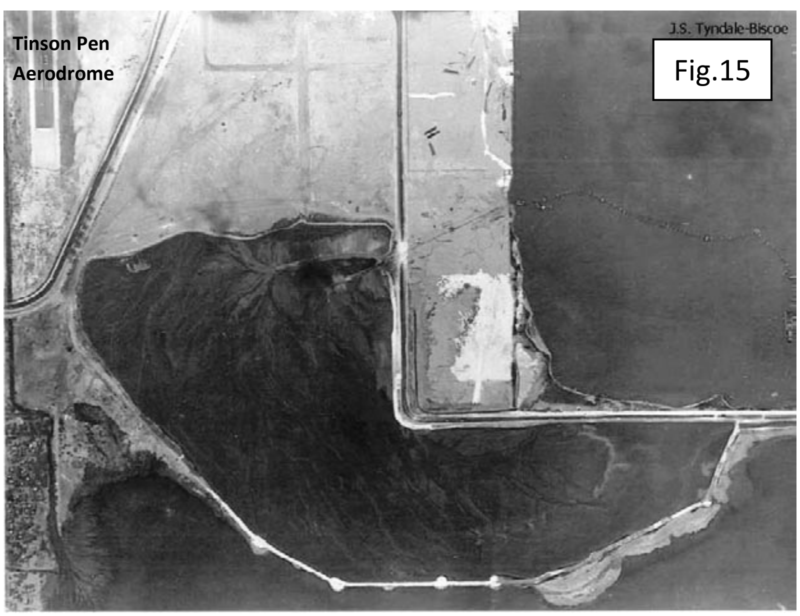


Fig. 14 Containment bunding being constructed in 1967 at Newport West by dry filling with river shingle

Fig.15 Perimeter bunding at Newport west completed by dry filling

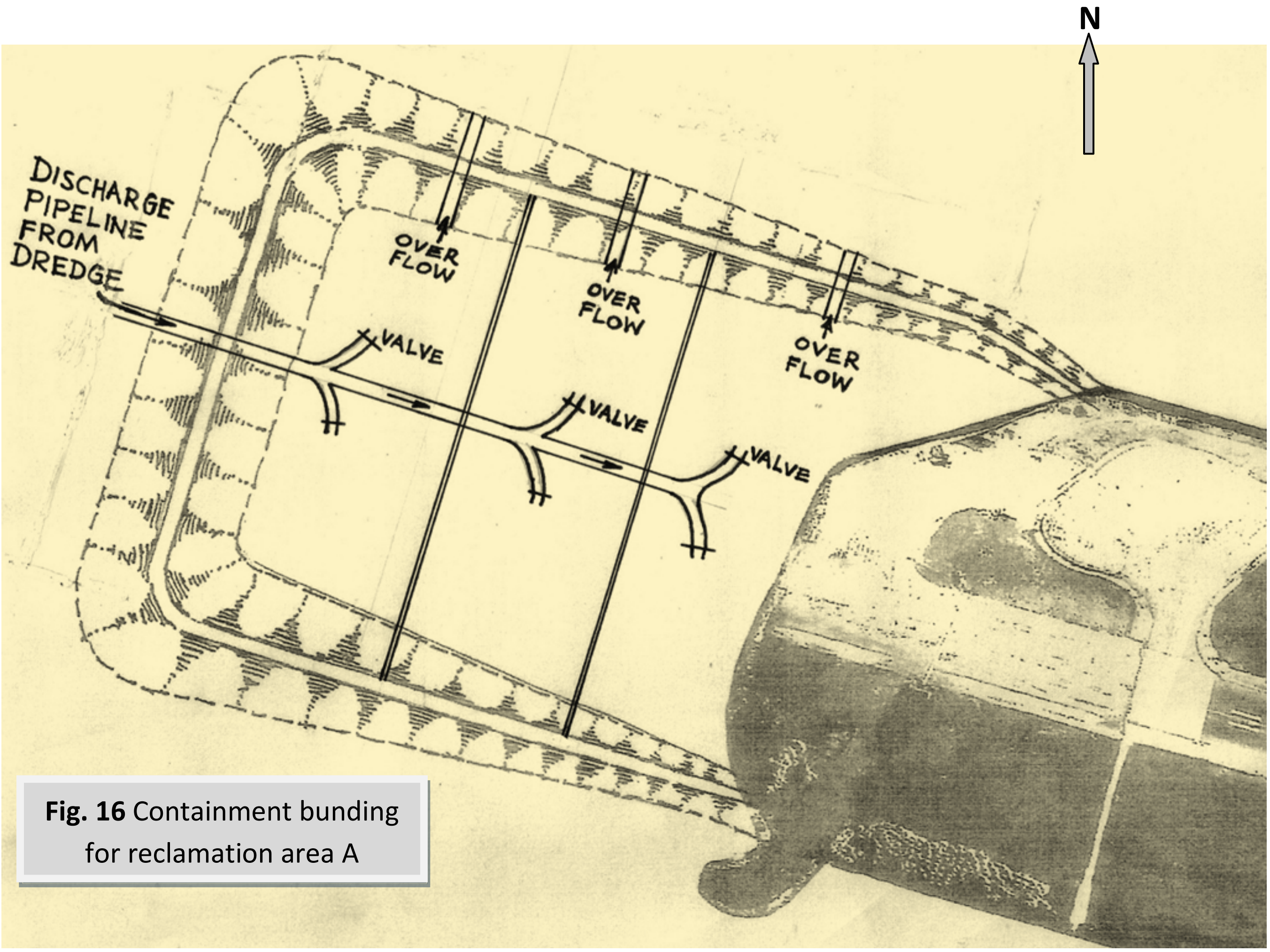


Fig. 16 Containment bunding for reclamation area A

It is envisaged that up-to-date best-practice dredging and reclamation methods will be used for execution of the work of constructing the proposed 500m NMIA runway extension. And so, in order to minimize/avoid dispersion of harmful sediment plumes into environmentally sensitive areas in the vicinity of the work site, such as the Port Royal mangroves, best-practice would call for construction of appropriate perimeter containment bunding, (by dry filling),such as illustrated above, prior to discharging dredged filling into the 18ha reclamation area A. Further enhancement of the effectiveness of protection against environmental damage due to sedimentation can be achieved by providing sluice valves and overflow weirs within the bunded area to control retention and runoff out of the bunded area. Furthermore, depending on wind and water-current conditions it will also be necessary to deploy stretches of silt screens in strategic locations on the work site in order to protect against harmful dispersion of sediment plumes from digging operations of the CSD.

RECLAMATION A

Options	Rough Check (Avg Depth) m^3	Surfer Cal. m^3	Sections Cal. m^3
+3m	1528141.974	1391372.545	1413968.714
+2.66m	1458866.205	1324293.488	1347715.889
+2.33m	1391627.958	1259187.345	1283602.866

RECLAMATION B

Options	Rough Check (Avg Depth) m^3	Surfer Cal. m^3	Sections Cal. m^3
+3m	220463.7032	118082.9166	106751.6388
+2.66m	208931.7556	108519.6283	91788.49338
+2.33m	197738.983	98947.80229	77848.48084

RECLAMATION C

Options	Rough Check (Avg Depth) m^3	Surfer Cal. m^3	Sections Cal. m^3
+3m	100289.445	73566.01569	73676.48291
+2.66m	93469.76274	62082.77051	67085.98737
+2.33m	86850.65937	60945.86538	60899.35521

13. Volumes of fill material required.

13.1 The Volumes of fill that will be required for each of the reclamation areas A,B and C have been computed using three different calculation methods, relative to the proposed net surface dimensions of the reclamation areas, and assuming one to one-and-a-half natural side slopes of the fill. The three different calculation methods used were: 1) **<u>average depth</u>;** 2). **<u>Surfer</u>** (a computer software programme); and 3). **<u>Sections</u>**.(definitive plots of cross sections and longitudinal sections traversed during the hydrographic surveys). Calculations were also done for three different heights of fill surface above mean sea level, viz: +2.33, +2.66 and +3.00. The above approach towards determining volume of fill required for this project was adopted in order to show the sensitivity of the results to the different measurement methods used and heights of fill surface. (Note: the surface height of the existing runway is +2.4m. See Fig. below)

13.2 In light of the above results, for the purposes at hand, it is felt that the total volume of fill required should be taken as (A) 1,347,716m^3; +(B) 91,789m^3; +(C) 67,086m^3;

= **<u>say 1.5 million cubic meters.</u>**

Fig.17 Aerial photo showing the newly completed (August 1959) 1.4 mile long Palisadoes Airport runway

Fig.18 Recent aerial photo showing flourishing growth of mangroves along the south edge of the runway.

13. Slope protection methods and materials.

13.1 The southern edge of the runway is so well-sheltered from wave action that it will not require rock armouring such as can be seen on the existing western and northern edges. It is suggested that instead of rock armouring, mangrove seedlings should be planted along the southern edge of the proposed 500m runway extension to promote fast establishment of a protective mangrove fringe similar to the existing.

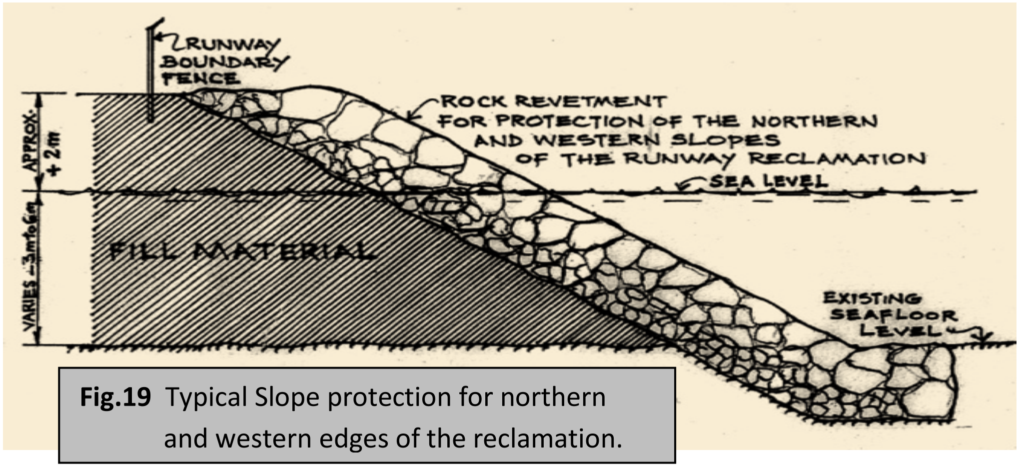


Fig.19 Typical Slope protection for northern and western edges of the reclamation.

Fig.20 Photo looking north along the tip of the runway showing existing slope protection

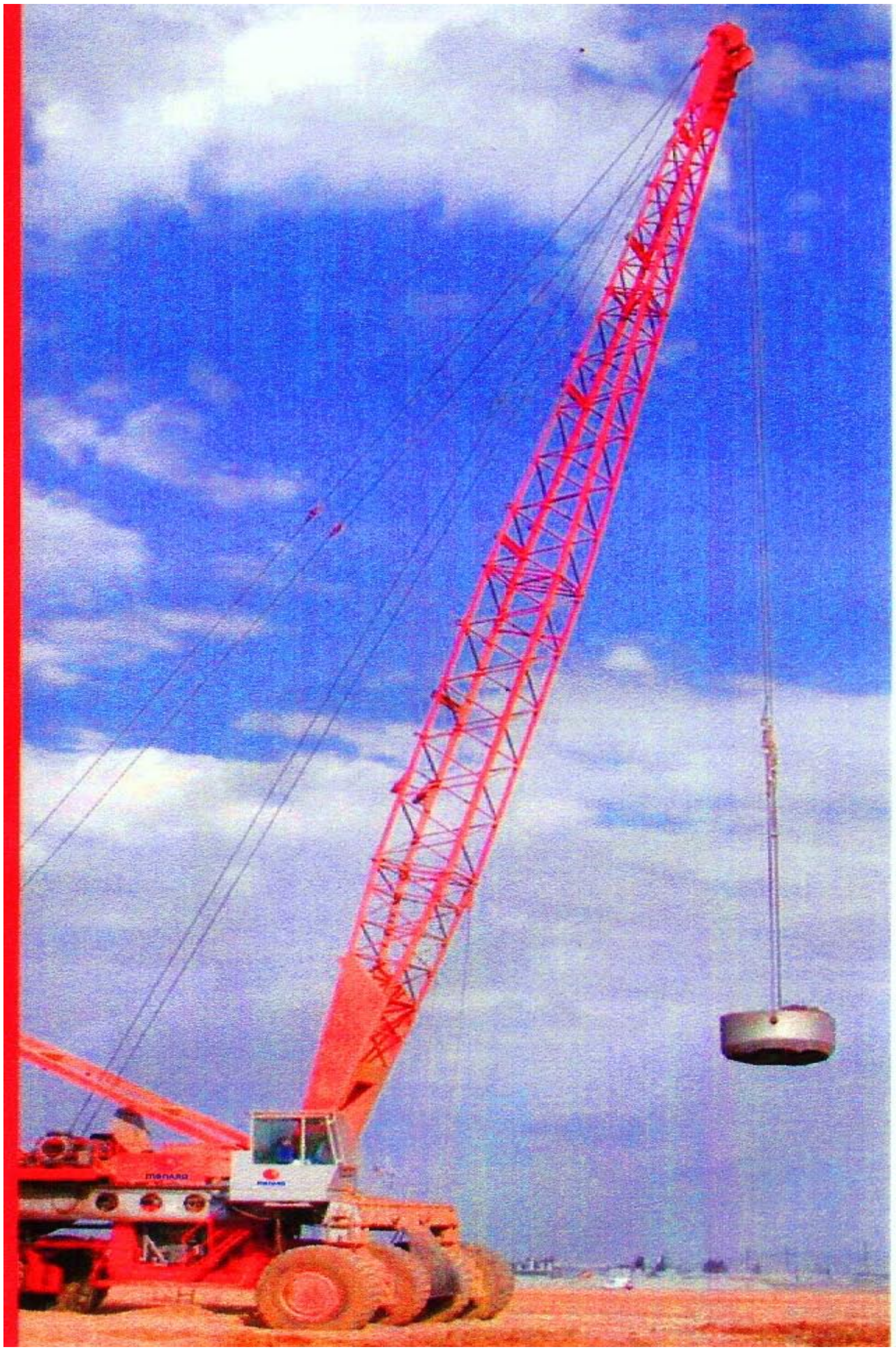
Prior to commencement of filling for reclamation area A, the Works Contractors should be instructed to remove the rock armouring materials from the existing tip of the runway and store them on site for re-installation upon the new extended tip of the runway.

It is estimated that approximately 23,000m^3 of quarried limestone will be needed for slope protection of the reclamation filling to be done for this project.

14. Methods of compaction for the reclamation fill.

Compaction of the reclamation filling can be done by several methods viz: (i) surcharging, (ii) dynamic compaction, or (iii) vibro-compaction.

Fig.21 The surcharge method of compacting newly placed granular reclamation fill
The surcharge method is the least likely to be adopted for this NMIA runway project, because it would require extra fill material to be placed high upon top of the formation level for the runway extension, and left in place over a period of time for actual compaction of the newly placed fill to take place. The height of the surcharge above the existing runway level would likely be deemed unacceptably hazardous for aircraft operations to be ongoing at the airport, while the surcharge was in place.



The Dynamic Compaction Technique achieves deep ground densification using the dynamic effects of high energy impacts resulting from the drop of large pounders. The technique was invented and developed by Mr. Louis MENARD. Since the late 60's, The MENARD company has applied this technique to thousands of sites for very different types of structures and conditions (port and airport platforms, heavy storage, buildings, landfills...).

The basic principle behind the technique consists in the transmission of high energy waves through a compressible soil layer in order to improve at depth its geotechnical properties. Dynamic Compaction is usually associated with an intensive in-situ testing program in order to verify that the required improvement has been achieved.

Dynamic Compaction is applicable in any type of granular soils. This technique is particularly well-adapted to non organic heterogeneous fill, made ground and reclamation areas with variable characteristics, even with the presence of large blocks. Dynamic Compaction is effective in both unsaturated and saturated soils below the water table.

Fig.22 Dynamic compaction of newly placed granular reclamation fill.

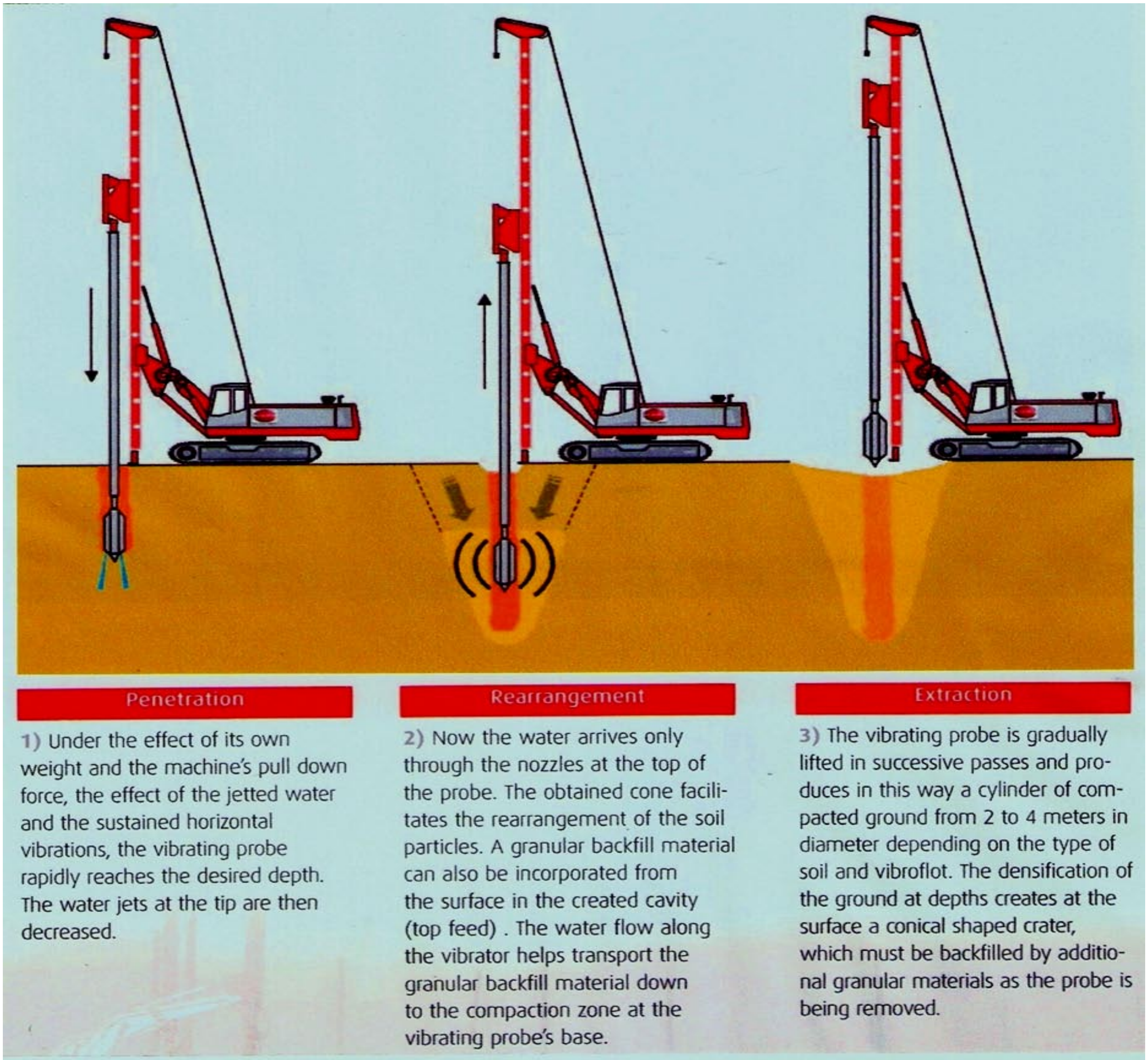


Fig. 23 Vibro-compaction of newly placed granular reclamation fill.

15. Relocation of the existing landing approach lights

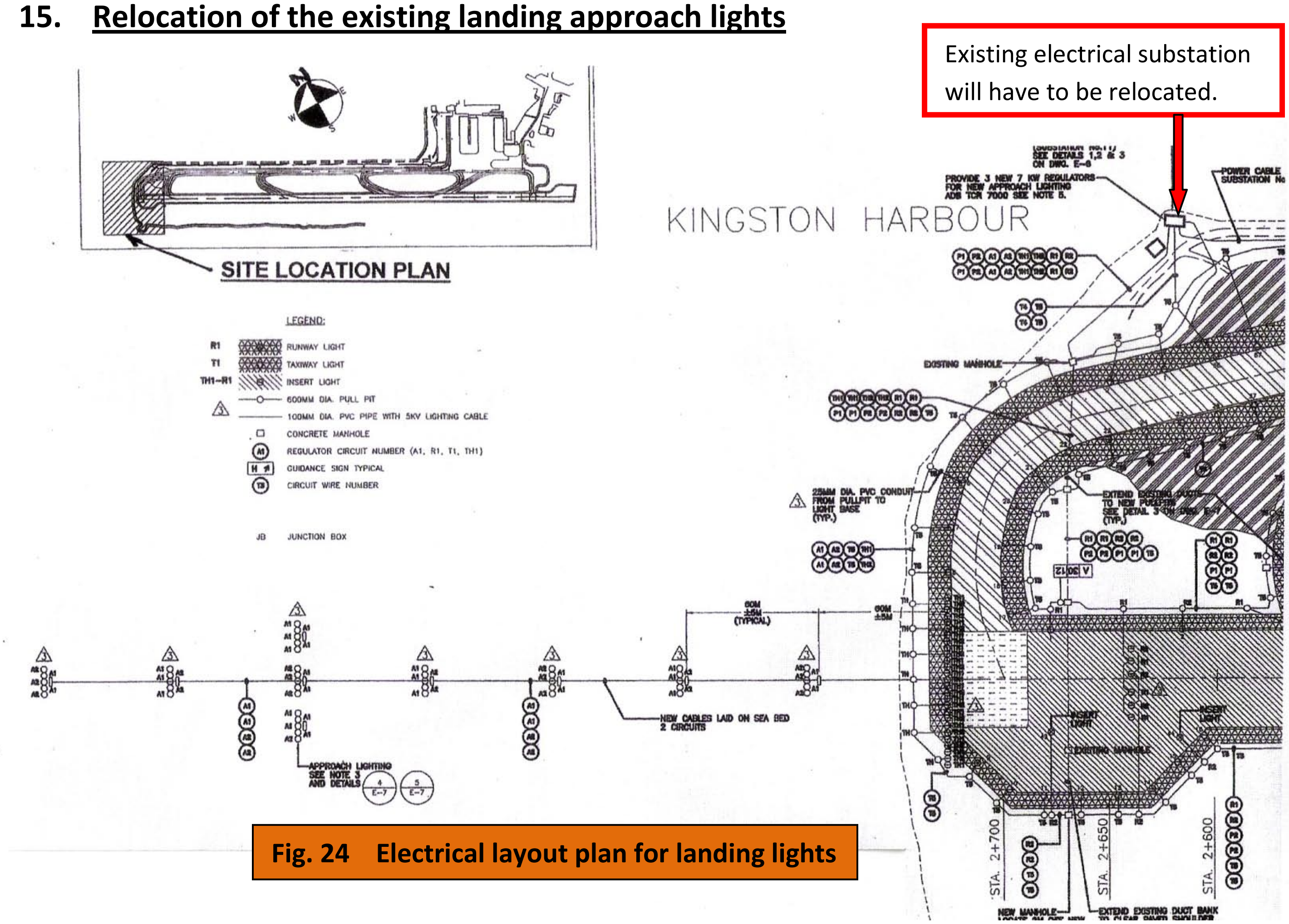


Fig. 24 Electrical layout plan for landing lights

Fig. 25 Landing Lights photo

The existing landing approach lights for runway 12 at NMIA are mounted upon steel frames consisting of horizontal channel sections supported upon H piles driven vertically into the seabed. The clusters of lights are installed in seven rows, spaced approx. 60m apart, in water depths varying from around 2m at the tip of the runway, stretching out for around 400m into the harbour, with the farthest row located in water depth of around 4.5m.

The above system of landing lights will have to be relocated/replicated as part of this proposed 500m runway extension project.

16. Runway and Taxiway Pavements

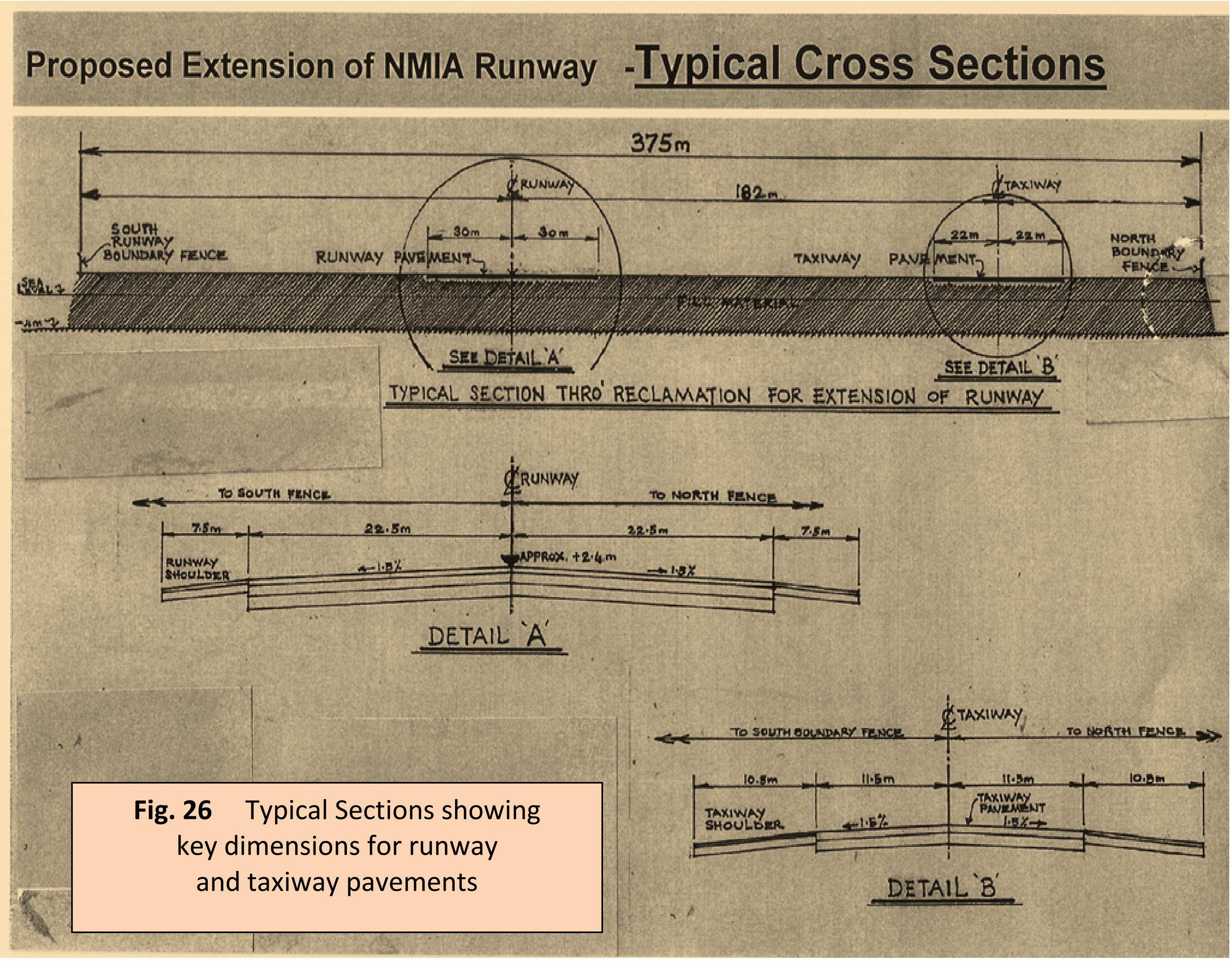


Fig. 26 Typical Sections showing key dimensions for runway and taxiway pavements

It is likely that the runway and taxiway pavements will consist of bases and sub-bases of cement-stabilized marl with layers of hot mix asphaltic concrete surface wearing courses

ADDENDUM – PART 2

ADDITIONAL BENTHIC ASSESSMENT

FOR

NORMAN MANLEY INTERNATIONAL AIRPORT
500M RUNWAY EXTENSION

ESL MANAGEMENT SOUTIONS LIMITED

PART 2

FINAL REPORT: Rapid Ecological Assessment for the Proposed 500 m Runway Extension and Reclamation Works at NMIA

For

Norman Manley International Airports Limited

Submitted: April 24, 2013

DRAFT REPORT

Prepared for:
Norman Manley International Airport Ltd
Palisadoes, Port Royal
Kingston

Prepared by:
Environmental Solutions Ltd.
89 Hope Road
Kingston 6

PROPOSED 500 m EXTENSION TO NMIA RUNWAY
ADDENDUM TO REA REPORT SUBMITTED IN FEBRUARY 2011

PART 2

Terms of Reference for ESL as received from NMIA:

1. Carry out additional benthic assessment to cover all areas that will be impacted by the proposed project, that were not assessed in your recent RAPID ENVIRONMENTAL ASSESSMENT (REA) report.

   Ensure that all areas that might be borrow areas are covered.
   (Check with Lyn to clarify).
   Ensure that the reclamation areas, i.e. areas where fill is to be deposited, are fully investigated.
   Also, the area where the landing approach lights will be re-located is to be fully characterized.

2. Discuss/Comment on all activities and features of the project that will introduce risks or generate impacts (positive or negative) upon the environment, including but not limited to seagrass relocation, wetland modification, sediment transport patterns.

3. Preparation of an OUTLINE MONITORING PLAN

   The Outline Monitoring Plan should include, but not be limited to:

   - Identification of aspects/activities of the project that will be monitored.
   - The specific parameters that will be adopted for the monitoring. Appropriate standards shall be referenced.
   - Specifications for the equipment and methods to be used for the monitoring.
   - Indications of the proposed frequencies of each type of monitoring activity.
   - Contingency proposals for dealing with any significant exceeding of parameters.
   - Identification of appropriate reporting procedures –NMIA to NEPA

4. Attendance at Public Meeting

   - As soon as the above items 1, 2 & 3 are completed, a “Public Meeting” will be convened, for the purpose of giving opportunity to the several key stakeholders who participated in the previous public meeting (April 20th, 2011) and raised concerns regarding certain aspects of the project proposals about which they requested to have further information.
   - Senior personnel from ESL will be required to attend this meeting and give presentation(s) as may be necessary, concerning the particular aspects of the project with which they were personally involved.

CONTENTS

EXECUTIVE SUMMARY

The Norman Manley International Airports Limited proposes to expand the current runway by 500 meters westwards so as to conform to international requirements for Runway End Safety Areas (RESA). The permitting process began in 2011 when a Rapid Ecological Assessment (REA) was completed and submitted to the National Environment and Planning Agency (NEPA). As a part of the permitting requirements a Public Consultation Meeting was also conducted to present the findings of the REA.

Further to the Public Consultation, NEPA has requested additional information about the ecology of the project area, impacts and mitigations, and an outline monitoring plan. This report constitutes Addendum #2 of three Addenda and presents the findings of a REA that was conducted in consideration of the new project footprint.

Project Description

The project will entail the following aspects for RESA compliance:

- Reclamation of area A - 500 m x 375 m (for runway extension)
- Reclamation of area B - 1650 m x 15 m (for widening existing runway)
- Reclamation of area C - 145 m x 130 m (for aircraft parking & fire rescue station)
- Slope protection for edges of reclaimed areas
- Compaction of all of the reclaimed areas
- Construction of new runway and taxiway pavements
- Relocation of landing approach lights in the sea
- Relocation of Fire Rescue facilities, including boathouse
- Relocation of electricity substation presently located at tip of runway
- Construction of new electricity substation near to relocated Fire Rescue facilities
- Modifications to existing aircraft navigation aids
- Extensions of runway and taxiway markings and lights
- Extension of runway fencing

2011 Findings

The 2011 Rapid Ecological Assessment, which was confined to the footprint of the proposed expansion area, revealed the following:

1. The study area adjoins the Port Royal mangroves to the south, a declared RAMSAR Site that have been identified as having important marine and coastal ecological features present within them

2. The seafloor within the Study area is comprised mainly of grey sands of a land-based origin. These sediments appear to be covered with a layer of organic mud towards the southern boundary of the study area.
3. The seafloor and water column appear to be generally benign where marine life is concerned, with the exception of the presence of marine bivalves on or within the seafloor substrates and macroalgae and Sea Urchins towards the northeastern corner of the Study area.
4. No Seagrass beds or other important forms of benthic flora or fauna were observed within the study area. However, hard surfaces present within the study area, specifically, the supports for the approach lights, acted as a point of aggregation for sponges and a limited number of pelagic organisms – specifically the Mangrove Snapper.

2013 Findings

The expanded REA primarily covered the seafloor and water column between both the existing and old runways. In summary, the following conditions were revealed for the study area and its environs:

1. The Study area adjoins the Port Royal mangroves to the south, which have been identified as having important ecological features present within them and elements of this importance were observed during the REA.
2. The seafloor of the study area to the north of the Airport runway was primarily colonized with scattered to dense growths of macroalgae, of which *Halimeda spp*. was the most dominant. *Halimeda* was so prevalent that the surface layers of the seafloor sediments often took on a whitish calcareous look owing to the presence of *Halimeda* fragments covering the grey sands below.
3. The area of seafloor examined (the proposed borrow area and reclamation area along the north of the existing runway) with video techniques revealed a number of benthic mobile organisms, primarily Holothurids (starfish, sea urchins and sea cucumbers).
4. The water in the study area was generally devoid of pelagic fish life, with the exception of the Atlantic Thread Herring, which were fished by artisanal fishermen within the Kingston Harbour.
5. Seagrass resources were observed towards the eastern border of the study area adjoining lands belonging to the Airport.
6. The protective rock armour along the northern extent of the runway appears to act as a reef and nursery for fish resources.
7. Marine water quality of the study area reveals adequate environmental conditions.
8. The study area appears to support fishing efforts from at least two fishing beaches in the Kingston Harbour, with the Atlantic Thread Herring, Snapper and Grunt being the primary fish species targeted. Fishing is most commonly done between the hours of 6 Pm to 6 Am.

Impacts

Construction Impacts

Dredging

Dredging activities were identified as having three categories of impact: 1. Water quality impacts; 2. Species and habitat impacts; and 3. Disposal of dredged material.

1) Water Quality Impacts

With the extent of dredging works proposed for this project it is expected that there will be some impact on the water quality. Any impact to the water quality is a concern both for the flora and fauna supported by the marine environment as well as for the fishery trade of the project area. Dredging activities will chiefly affect water quality in the following ways:

A. Increased Suspended Sediments

Mixing of different soil layers and spillages and leaks from dredge equipment can all increase the suspended solids and turbidity of the marine environment. The locations within the study area other than the borrow location and peripheral areas, particularly the Port Royal mangroves to the south of the study area, seagrass shoals (Mammee and Pelican Shoals) to the west and seagrass bed areas to the east could be put at risk by the movement of suspended solids generated by dredging. The sediments are likely to be distributed:

- At night for the Port Royal mangroves and seagrass beds immediately adjoining the airport, since the prevailing wind/current movement veer towards both areas during this time.
- During the day for the seagrass shoals west of the construction area, since day-time wind influences would then direct turbid waters towards these areas.

Juvenile fish can be damaged if suspended sediments become trapped in their gills. Increased fatalities of young fish have been observed in heavily turbid water. Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites but the sustainability of the fishing trade is dependent on Juvenile fish survival rates.

An increase in turbidity results in a decrease in the depth that light is able to penetrate the water column. Excess and prolonged periods of turbidity can affect sea grasses that are typically found in the project area by temporarily reducing productivity and growth rates.

B. Increased Organic and Nutrient Loading

Dredging or disposal can also increase organic and nutrient loading of the water resulting in the localized removal of oxygen from the surrounding water. Depending on the location and timing of the dredge this may lead to the suffocation of marine animals and plants within the localized area or may deter migratory fish or mammals from passing through.

2) Impact on Species and Habitats

A. Benthic Species

While fish are able to relocate, sessile benthic organisms are likely to be crushed and destroyed by dredging activities. This impact could be significant if appropriate mitigation measures are not implemented.

B. Pelagic Species and Fisheries

There is a potential for negative impacts on fishing activities, both through the restriction of fishing boat traffic by the presence of dredging equipment and also through interference with fish presence by the dredging process. Fishers from the Rae Town and Greenwich Town fishing beaches are most likely to be impacted.

C. Habitats

If the dredge depth is similar to that of the 1955 borrow area, it is likely that there may not be a recovery of the deepened seafloor to its previous habitat where benthic macro-flora and mobile organisms could survive. At a maximum depth of 14 m, there was probably not enough light and too much soft sediments on the seafloor in the 1955 borrow area to support benthic plant or animal life.

3) Disposal of Dredged Material

Dredged material can impact the marine environment based on where and how it is disposed of and is a significant aspect of a project of this nature. The dredged material can have several implications example creating chemical disturbances (depending on its chemical composition), causing habitat alterations due to change in sediment structure and burial and smothering of benthic communities.

Containment Bunding

Containment bunds/berms will need to be constructed to retain dredge materials within the landfilling areas so as to reduce the spread of waterborne sedimentation. The construction of a containment bund/berm is hence a positive aspect to the reclamation works.

Nonetheless, the construction of containment berms/bunds could release sediments into the marine environment. Water contained within the berm, as well as dredge slurry water will ultimately have to be discharged from the contained area back into the marine environment. Sediment plumes can develop if this process is not carefully managed.

Landfilling

The method of Dynamic Compaction (use of dynamic energy generated from the dropping of large heavy weights from a significant height to compact deposited materials) can potentially generate energy waves that would be transmitted through the materials being compacted. These waves could ultimately be transmitted into the adjoining marine environment (water medium) which may cause disturbances to fish life while the activities are underway.

Landfilling along the northern section of the proposed runway was identified as presenting a potentially significant impact to fishery resources currently using that area as shelter and a nursery. In addition, it is anticipated that Seagrass within the area to be land-filled for the new Fire Station will also be directly affected by landfilling.

Approach Light Relocation

The relocation of the approach lights and associated electrical conduits was not viewed as presenting a significant impact on natural resources within the study area. If the approach light system is designed similar to the existing system each light array will be positioned on a framework supported on a single H-piling with a cross sectional dimension of 0.30 m x 0.30 m. This would represent an insignificant area of seafloor disturbance.

Operation Impacts

New Runway End Safety Areas

The RESAs will allow the airport to meet its international requirements and hence fulfill its commitments of maintaining international standards. This is a major positive economic and social impact from a national perspective.

Habitats

Although the rock armour is expected to serve as a habitat over the long term, there is the possibility that the number of target demersal fish will be reduced in the short term.

Fisheries and Fishing Beaches

Positive Impacts:

It is likely that the hard surfaces of the proposed shoreline protection and approach lights will serve as a habitat for marine mobile organisms similar to that currently occupying the existing hard structures within the study area. The stones that currently make up the shoreline protection along the northern face of the runway will be reused after reclamation to encourage re-colonization to a familiar surface. This is anticipated to be a positive long term impact.

Negative Impacts:

Where fishery is concerned there is the possibility that the number of target pelagic and demersal fish caught after the completion of the works will be reduced, owing to the changes that would have occurred in the rock armour protecting the western and northern shores of the runway, impacts related to turbidity and the disruptive presence of the dredge. Unsubstantiated information obtained from representatives of the Rae Town fishing beach indicated that several years passed before stability returned to fishing areas in the Harbour adjoining the areas dredged in 2001-2002 Kingston Harbour dredging exercise.

Mitigation Measures

The following mitigation measures are presented for the project area:

1) In an effort to minimize destruction of sessile benthic organisms, it is recommended that the developer undertakes removal and relocation of these organisms from the seafloor of any proposed borrow areas to pre-selected recipient areas prior to dredging.
2) Removal and replanting of Seagrass resources within the footprint of the land reclamation area. Consideration could be given to the use of the northern sections of the study area for the relocation of important mobile and sessile benthic organisms.
3) The use of silt transport barriers to control sedimentation transport from both the dredging and landfilling areas.
4) The use of materials with a low sediment content for the construction of the bund walls of the reclamation area so as to reduce the introduction of suspended solids into the marine environment.
5) The deployment of submerged artificial habitats along the northern shore of the runway (seaward of the area to be reclaimed) in advance of landfilling operations to provide a location to which fish can "flee" to once landfilling operations commence. Similar considerations could be given to the design of the approach lights that will ultimately have to be relocated, once the runway extension is completed. The developer has indicated that the existing surfaces e.g. the rock armour will be re-used to provide a familiar habitat for the organisms that currently use them as a nursery.
6) The use of shoreline protection materials that can ultimately serve as an aquatic life habitat once marine conditions have naturally stabilized after construction.
7) Design of the shoreline protection along the southern end of the extended runway to facilitate the natural colonization and extended growth of Mangroves currently present along the southern side of the existing runway.
8) The use of landfill compaction methods that will minimize the generation of potentially disturbing ground waves.
9) Undertake compaction and pavement construction processes outside of the rainy seasons as far as possible to minimize suspended materials or hydrocarbons entering the marine environment.

1.0 INTRODUCTION

1.1 Background

Environmental Solutions Limited (ESL) was contracted by the Norman Manley International Airport Limited (NMIAL) to conduct a Rapid Ecological Assessment (REA) for the proposed extension of the runway at the Norman Manley International Airport (NMIA). The project will fulfill international requirements for Runway End Safety Areas (RESA). The REA Report forms Addendum # 2 of three Addenda to be submitted to NEPA for the runway extension project.

NMIA's initial submission of application for permit was submitted in 2011 after a Rapid Ecological Assessment (REA) was completed by ESL and submitted to the National Environment and Planning Agency (NEPA). As a part of the permitting requirements, a Public Consultation Meeting was also conducted to present the findings of the REA. Arising from the proceedings of the Public Consultations additional information was requested for the ecology of the study area, specifically characterization of existing biota in the following areas:

- ✓ The proposed approach light alignment - An approach light layout of length and width dimensions as well as orientation similar to that of the existing lights (approximately 200 m x 10 m) will be implemented.
- ✓ The proposed borrow area – the seafloor immediately to the north of the charted Borrow Area (Kingston Harbour Nautical Chart No. 454), and bound further north by the 10 m depth contour line, represents a potential borrow area for the materials required for the runway expansion.
- ✓ The existing northern edge of the active runway that is to be widened - a 20 m strip of seafloor extending from the western end of existing northern runway shoreline eastwards to the Airport Fire Station and then northwards towards the sewage treatment plant.

2.0 PROJECT DESCRIPTION

Airports Authority of Jamaica is in the process of implementing some of the preferred options that were presented in the 2002 - 2022 Master Plan for continuing development of NMIA. This proposed project to extend the length of the existing runway by a further 500 m westwards (Figure 2.0) into the Kingston Harbour is identified as one of the most urgently needed up-grading projects required for NMIA to retain its well-established status and viability as one of Jamaica's two economically indispensable international airports.

The primary purpose of this proposed 500 m extension is to improve the safety of operations at the airport by providing Runway End Safety Areas (RESA). A RESA is an area beyond the end of a runway that provides a margin of safety for an *overrunning* (departing) or *undershooting* (arriving) aircraft.

The provision of a RESA is a mandatory requirement under the International Civil Aviation Organization (ICAO) standards, the international guiding document for Airports. As Jamaica is a signatory to the ICAO conventions the Government of Jamaica must either make the NMIA facilities compliant with ICAO's recently revised Annex 14 standards, or file a “difference” with ICAO. It is likely that if appropriate RESAs are not installed at NMIA, a penalty will be imposed in regard to the type of aircrafts that the airport’s runway would be rated capable of accommodating.

Addendum #1 provides further details on the construction elements of the project. The scopes of works for the 500 m runway extension are outlined as follows:

1) Reclamation works as follows (Figure 2.0 below):
    - Area A - 500 m x 375 m (for runway extension)
    - Area B - 1650 m x 15 m (for widening existing runway)
    - Area C - 145 m x 130 m (for aircraft parking & fire rescue station)
2) Slope protection for edges of reclaimed areas.
3) Compaction of all of the reclaimed areas.
4) Construction of new runway and taxiway pavements.
5) Relocation of:
    - Landing approach lights in the sea.
    - Fire Rescue facilities, including boathouse.
    - Electricity substation presently located at tip of runway.
6) Construction of new electricity substation near to relocated Fire Rescue
7) Modifications to existing aircraft navigation aids
8) Extension of:
    - Runway and taxiway markings and lights
    - Runway fencing

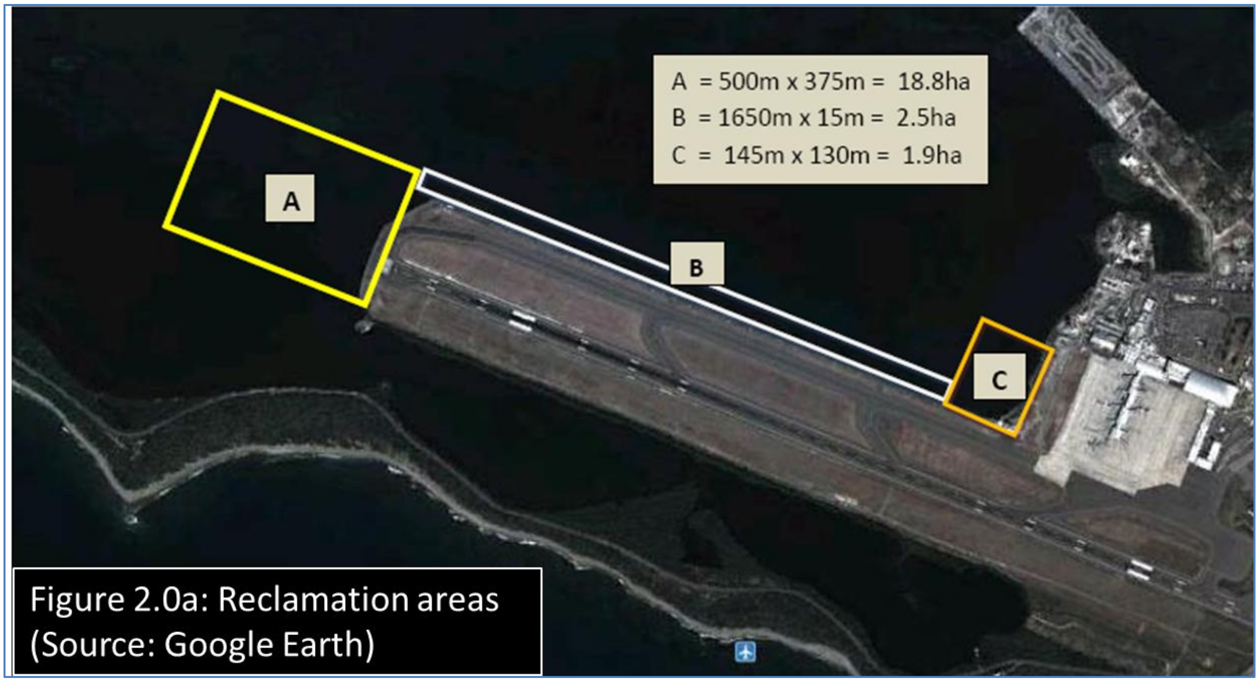


Figure 2.0a: Reclamation areas
(Source: Google Earth)

Figure 2.0a: Project site showing areas to be reclaimed. A - This will be the main area for extension of the runway platform; B - This widening of the existing runway platform will allow for better separation between the centerlines of the runway and the taxiway, which presently is somewhat inadequate; C - This reclamation is needed to provide additional land space for aircraft parking and for relocation and upgrading of the airports fire rescue facilities including boathouse. Space will also be provided here for construction of a new electrical substation.

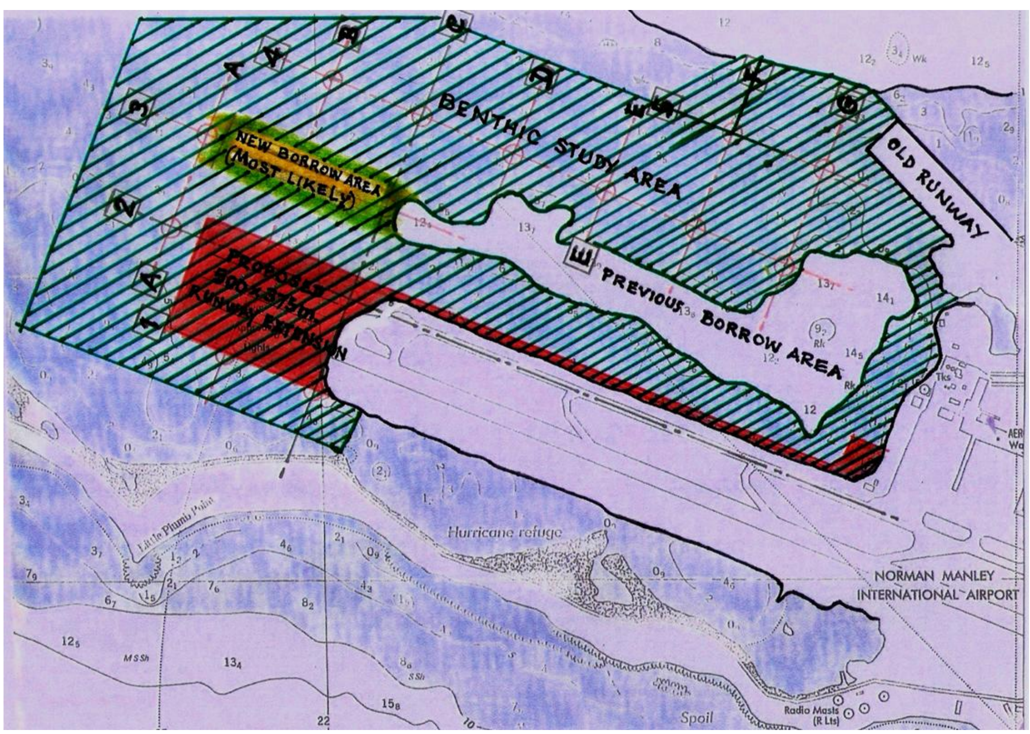


Figure 2.0b: Project site showing the proposed reclamation areas (red), proposed borrow area (green) and the previous (1955) borrow area.

3.0 TERMS OF REFERENCE

The scope of works as presented and discussed with the NMIA for the 2013 REA are outlined as follows:

1. Carry out additional benthic assessment that was not assessed in the 2011 REA report; cover all areas that will be impacted by the proposed project. All areas that might be borrow areas and reclamation areas (i.e. areas where fill is to be deposited) should be fully investigated.
2. Characterize the area where the landing approach lights will be re-located to.
3. Produce maps of the area showing the adjacent mangrove communities
4. Conduct water quality sampling in the study area and analysis of the following water quality parameters:
   - ✓ Dissolved Oxygen
   - ✓ Nitrates
   - ✓ Phosphates
   - ✓ Biochemical Oxygen Demand
   - ✓ Total Suspended Solids
   - ✓ Salinity
   - ✓ Temperature
   - ✓ Faecal Coliforms
   - ✓ Water clarity (Secchi Disk)

5. Discuss/Comment on all activities and features of the project that will introduce risks or generate impacts (positive or negative) upon the environment, including but not limited to seagrass relocation, wetland modification, sediment transport patterns.

6. Prepare an Outline Monitoring Plan that should include, but not be limited to:
   - ✓ Identification of aspects/activities of the project that will be monitored.
   - ✓ The specific parameters that will be adopted for the monitoring. Appropriate standards shall be referenced.
   - ✓ Specifications for the equipment and methods to be used for the monitoring.
   - ✓ Indications of the proposed frequencies of each type of monitoring activity.
   - ✓ Contingency proposals for dealing with any significant exceedance of parameters.
   - ✓ Identification of appropriate reporting procedures – NMIA to NEPA

7. Attend a Public Meeting – Following the completion of the study a “Public Meeting” will be convened, for the purpose of giving opportunity to the several key stakeholders who participated in the previous public meeting (April 20th, 2011).

4.0 APPROACH AND METHODOLOGY

The following methods were used to facilitate the information collection tasks outlined in the REA TORs:

4.1 Air Photo Interpretation and Initial Mapping

The 2002 Google Earth images were the most suited for interpretation and mapping as they show the most detailed illustration of the seafloor conditions compared to the other image dates in the Google Earth archives. Though these images are 11 years dated, they were useful in providing a basis for the understanding of how benthic organisms might be distributed over the study area (Figure 4.1).

Relevant images were inputted into a Geographical Information System[1] and referenced to JAD 2001, a known map projection/coordinate system (http://www.jamaicancaves.org/jad2001.htm). Such referencing would enable measurements and general mapping to be done to support air photo interpretations for the study.

Figure 4.1: Mosaic of 2002 Google Earth images of the study area used for initial assessments

4.2 Field Data Collection

Geotech Exploration Services Ltd was commissioned by AAJ in 2008 to conduct geotechnical assessments of the seabed strata to investigate the ability of suitable material for filling for the proposed runway expansion. A grid pattern of dimensions 300 m x 300 m was used for the collection of substrate data (Figure 4.2a).The spatial

[1] www.mapmakerpro.com

representation of the seafloor surface findings from that study have been used in this current REA to provide a baseline of pre-existing seafloor surface conditions.

The 2008 grid was further subdivided for the present study into a 150 m x 150 m grid layout to facilitate the collection of additional data (Figure 4.2b). The coordinates for the intersection of each grid line were established and converted to Latitude-Longitude coordinates for up-loading into a hand-held GPS for navigation facilitation. All field data collected were referenced to an intersection point between imaginary grid lines established over the study area.

Boat-supported field data were collected within the study area over the period February 27-28 and March 2-3, 2013, with data collection activities commencing at approximately 8:30 am and ending when daytime winds began to increase significantly (usually around 11:00 am).

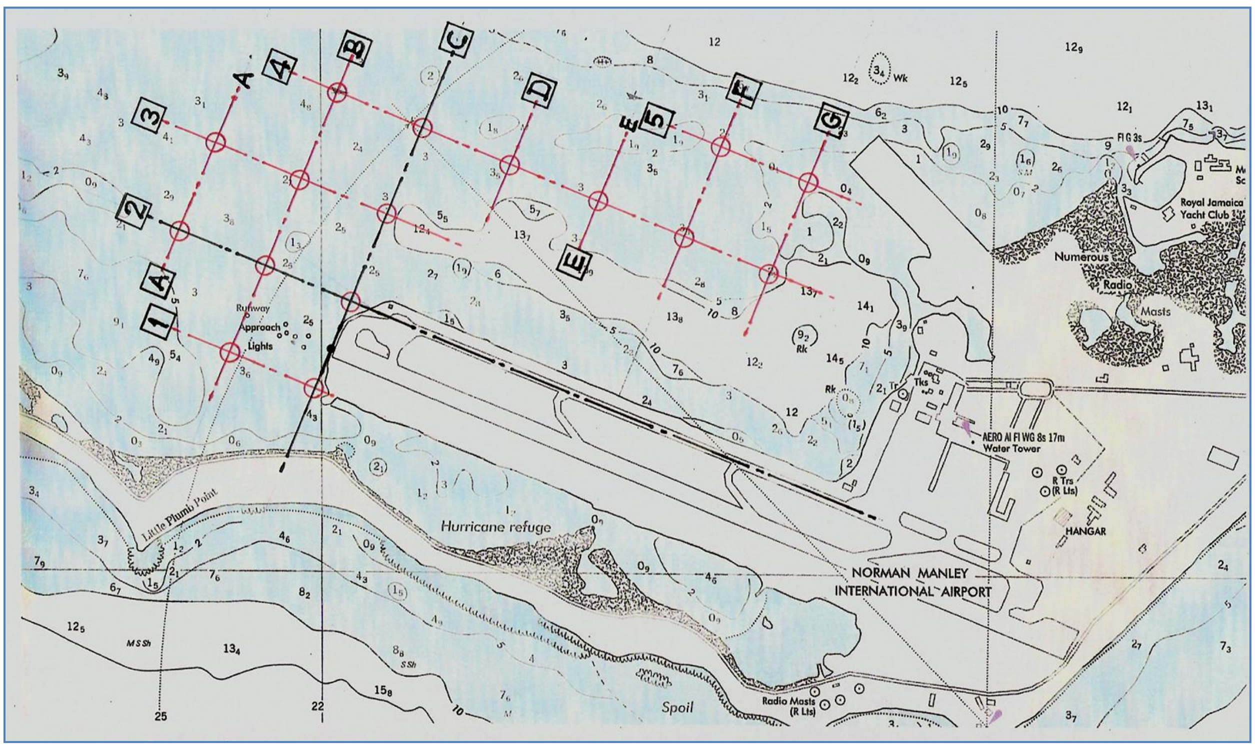


Figure 4.2a: 300 meter x 300 meter grid layout (Source: Geotech Ltd, 2008)

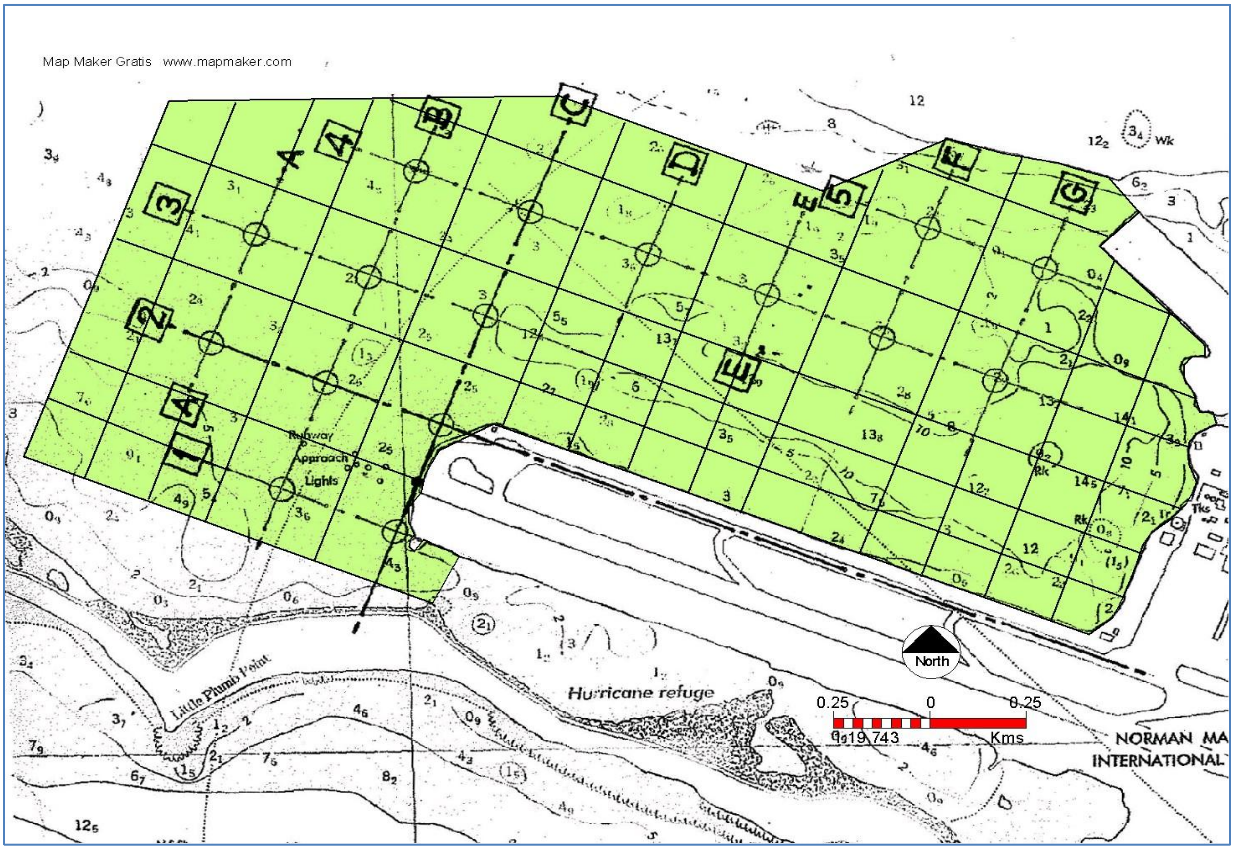


Figure 4.2b: 150 meter x 150 meter grid layout (ESL, 2011)

4.2.1 Benthic Organisms Analysis

Two methods were used for the determination of the nature of benthic organisms within the study area. The first method used was the sampling of seafloor surface substrates with the deployment of a Van Veen grab sampler. The grab sampler was deployed at each of the 150 m x 150 m line intersection points. Following retrieval of the sampler, the top layers of the recovered sediments were examined for the presence of seafloor surface-dwelling flora and fauna.

The second method was the use of underwater video information collected along fifty 20 m tape-defined transects distributed systematically over locations within the study area. These transects were specifically deployed in areas identified by AAJ as being earmarked for particular activities such as dredging/filling (areas marked by broken red lines on Figure 4.2.1). Video information was collected with the use of SCUBA gear and a Sony Mini-DV camera mounted within an Amphibico underwater housing. In both cases, observations were related to positions within the study area so that a spatial representation of those observations could be determined.

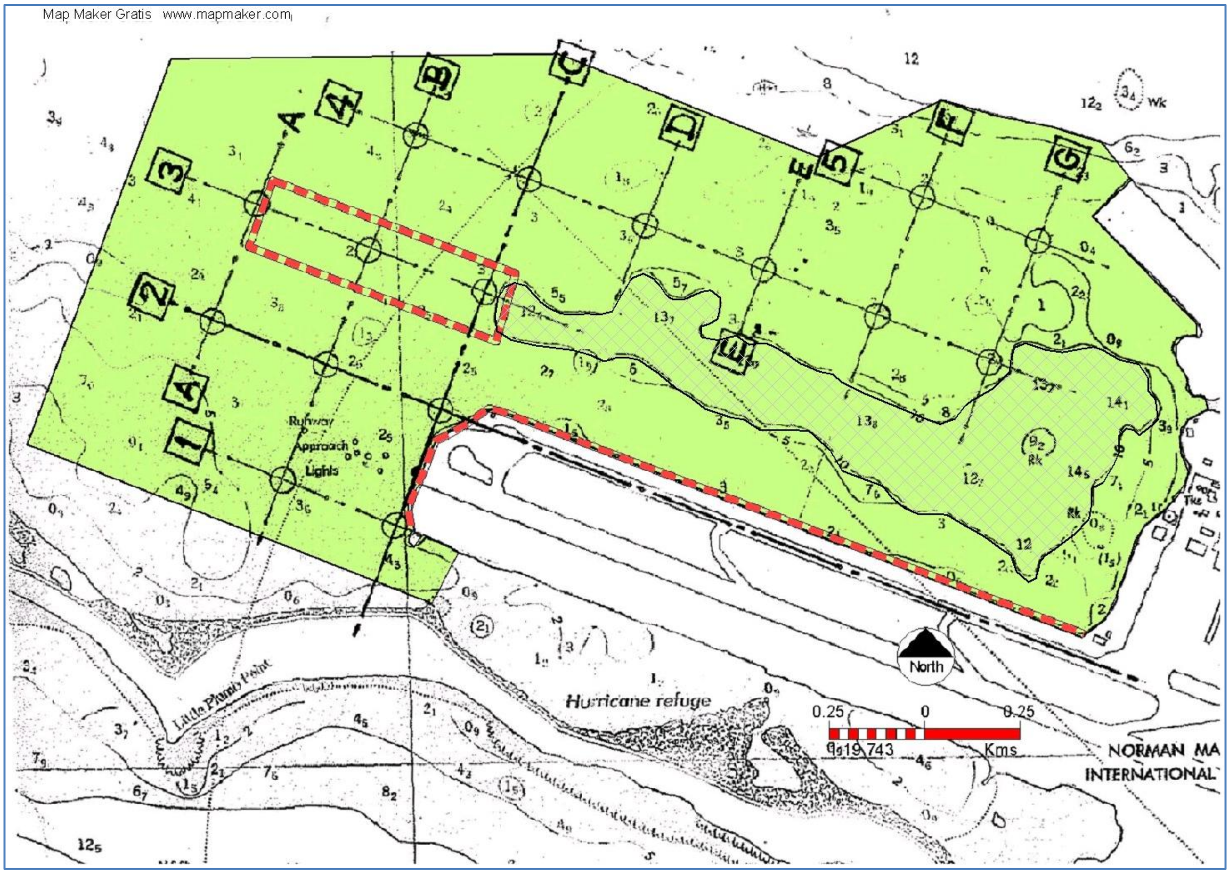


Figure 4.2.1: Location of video collected information in areas earmarked by AAJ for development within the study area (within and along areas marked by broken red lines)

4.2.2 Water Quality Sampling

Water samples were collected at four locations (Figure 4.2.2) within the study area from the surface and at a depth of 1 meter above the seafloor.

The following parameters were analyzed by the ESL Quality and Environmental Health Laboratory:

1. Dissolved Oxygen
2. Nitrates
3. Phosphates
4. Biochemical Oxygen Demand
5. Total Suspended Solids
6. Salinity
7. Temperature
8. Faecal Coliforms

Water clarity measurements were done in-situ using a secchi disc. Detailed methodologies are presented in Appendix 3**.**

The locations of the water sample monitoring sites are listed S1-S4 as defined in Table 4.2.2 and Figure 4.2.2 below and are as follows:

Site Number	Location	
S1	17 56 24.1N	76 48 18.7W
S2	17 56 24.9N	76 47 32.3W
S3	17 56 56.6N	76 47 57.7W
S4	17 56 44.3N	76 47 2.4W

Figure 4.2.2: Water quality sampling sites, March 2013

4.2.3 Supplemental Mapping

All data sets collected in the field were positioned using a Garmin Foretrex 101 Global Positioning System, with positions being obtained in latitude and Longitude. The Latitude and Longitude positions were then converted to Easting and Northing coordinates compatible with the JAD 2001 map reference system used in the GIS and overlaid onto geo-referenced Google Earth images. The following layers were then produced:

1. Spatial distribution of water quality parameters within the study area

2. Spatial distribution of benthic and pelagic marine organisms within and adjoining the study area
3. Spatial distribution of terrestrial flora found adjoining the study area

5.0 THE EXISTING ENVIRONMENT

5.1 Air Photo Interpretation and Initial Mapping

Figure 5.1a below illustrates four main differences based on colour and visible patterns. Area A on Figure 5.1a was reminiscent of sand with scattered patches of what was believed to be a marine plant form. Area B was blue-black in colour and characteristic of deeper water while C was typical of a shallow semi-emergent reef or sand bar feature. Area D showed varying shades of dark green without obvious patterns. This area included the proposed footprint of the runway expansion.

Figure 5.1b spatially defines the four different zones identified on Figure 5.1a above and overlays them on top of depth information (Geotech, 2008). The grey area on Figure 5.1b (Area A on Figure 5.1a) is somewhat deeper than the areas coded with cross hatching (Area D on Figure 5.1a).

Water clarity conditions within the study area at the time of the capture of the 2002 Google Earth images may have allowed the shallower areas to be observable while the deeper areas may have been outside of visual range. The area defined as B in Figure 5.1a and coloured blue on Figure 5.1b was shown on the depth information to be in excess of 10 meters deep and was apparently the area that had been dredged to create the existing runway.

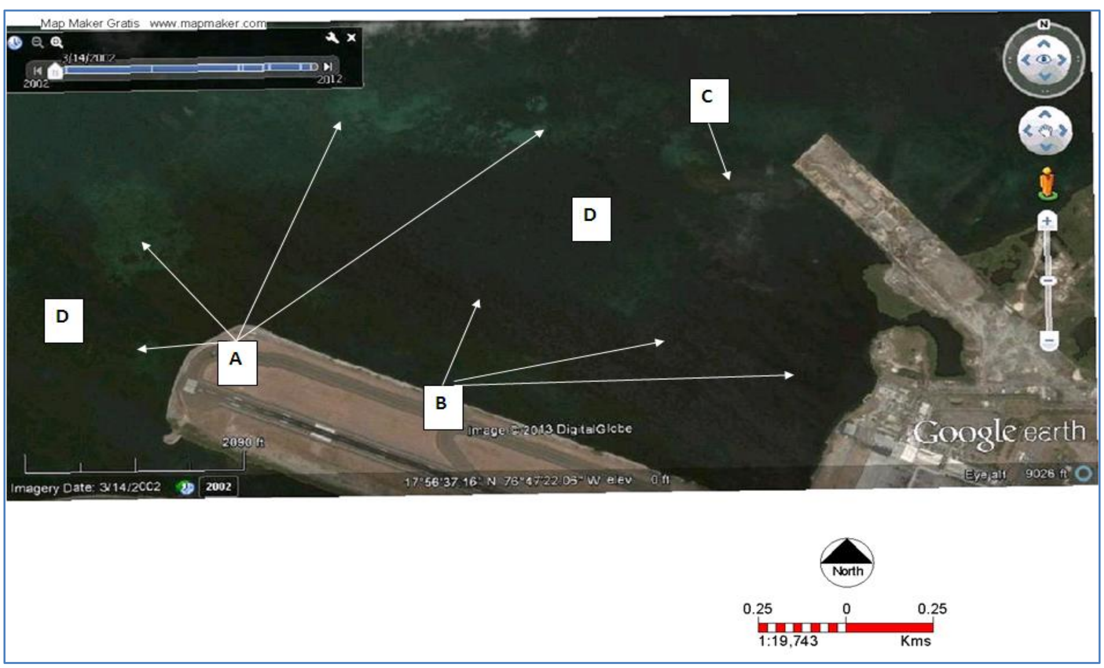


Figure 5.1a: Substrate character interpreted from 2002 Google Earth images – A: Sand and macro-algae, B: Deep water, C: Shallow Reef/Sand Bank, D: Unidentifiable seafloor condition (interpreted as sand and macro-algae from 2011 study).

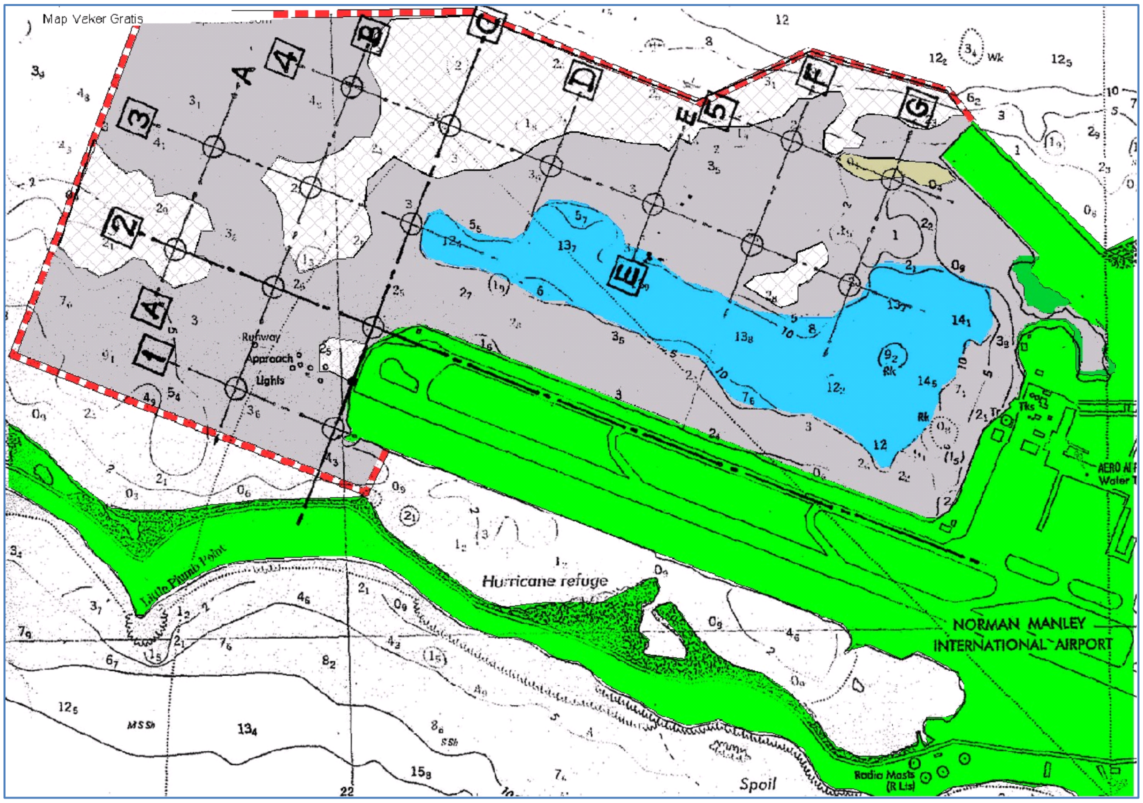


Figure 5.1b: Spatial representation of interpreted seafloor features interpreted from 2002 Google Earth images – Green: Land, Cross Hatching: Shallow Sand with Macro-algae; Grey: Deep Water Possibly Overlain with Macro-algae; Blue: Deep Water.

5.2 Water Quality Analysis

The 2013 water quality monitoring covers the entire project area. As in 2011, both surface and seafloor water samples were collected at each sample station. The 2011 monitoring stations were proximate to the approach lights for the proposed runway.

In both 2011 and 2013, samples showed salinity values typical of tropical marine environments and varied between 30.6 to 35.8 ppt (Table 5.2a and b). All monitoring sites in 2011 and 2013 had BOD values that were marginally in excess of the NRCA Marine Water Quality standards; sample point S4 in 2013 was particularly elevated both at surface and depth.

Particularly high Faecal Coliform counts were obtained for two of three of the surface sample locations examined in 2011, with one marginally high result being observed for one deep sample. On the other hand, all the 2013 sample points, both at the surface and at depth, had Faecal Coliform values below the standard.

The 2013 monitoring points had nitrate values all within the standard. Phosphates in 2013 were lower than those in 2011 with ranges from <0.02-0.04 mg/l and 0.02-0.11 mg/l respectively.

Water clarity readings taken during the 2013 study demonstrated much clearer water conditions than those in 2011, despite the fact that there had been incidences of rainfall and gully flow influence at the site. In 2011, the study area immediately adjoined an area of muddy bottom near mangroves which may have influenced those readings.

Table 5.2a: Water quality data for the 2013 study area, February 2013

Parameter	2013 Samples								NRCA Ambient Water Standard (Marine Water)
	S1 Top	S1 Bottom	S2 Top	S2 Bottom	S3 Top	S3 Bottom	S4 Top	S4 Bottom	
Biochemical Oxygen Demand (mg/L)	2.2	2.0	0.6	0.6	1.7	1.3	3.2	2.4	0.0 - 1.16
Total Suspended Solids (mg/L)	16.9	6.1	<2.5	7.3	5.0	7.9	7.1	6.3	-
Salinity (ppt)	33.8	35.4	35.3	35.6	34.8	35.6	35.6	35.8	-
Nitrate as Nitrogen (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.007 – 0.014
Phosphate (mg/L)	<0.02	0.02	0.02	0.04	<0.02	0.02	0.03	<0.02	-
Phosphate (mgP /L)	<0.0036	0.0036	0.0036	0.0072	<0.0036	0.0036	0.0054	<0.0036	0.001 – 0.003
Faecal Coliform (MPN/100ml)	<1.8	4.5	<1.8	7.8	6.8	<1.8	4.5	1.8	<2 - 13
Dissolved Oxygen (mg/L)	8.57	7.28	8.81	8.81	8.51	7.74	8.00	8.21	-
Temperature (°C)	21.2	21.2	21.1	21.1	21.0	21.1	21.4	20.9	-

Table 5.2b: Water quality data for the 2011 study area, October 2011

Parameters	2011 Samples						NRCA Ambient Water Standard (Marine Water)
	AL-#1S	AL-4S	AL-7S	AL-1D	AL-4D	AL-7D	
Temperature (Celsius)	32.0	32.3	30.5	30.2	29.9	30.1	-
Salinity (ppt)	36.7	33.3	32.5	33.0	30.6	33.8	-
Secchi Depth (m)	1	1	1	1	1	1	-
Biochemical Oxygen Demand (mg/L)	1.0	2.4	1.8	1.2	2.0	1.6	0.0 - 1.16
Total Suspended Solids (mg/L)	7.6	9.0	7.4	9.4	8.6	8.2	-
Nitrate as nitrogen (mg/L)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.007 – 0.014
Phosphate (mg/L)	0.03	0.02	0.03	0.02	0.10	0.11	-
Faecal Coliform (MPN/100mL)	350	33	920	33	22	70	<2 - 13

5.3 Sea Floor Ecology

5.3.1 Sessile Benthic Organisms

A total of 140 grab samples were taken in the study area. These locations are illustrated in Figure 5.3.1a below. The detailed result of each grab sample is presented in Appendix 3.

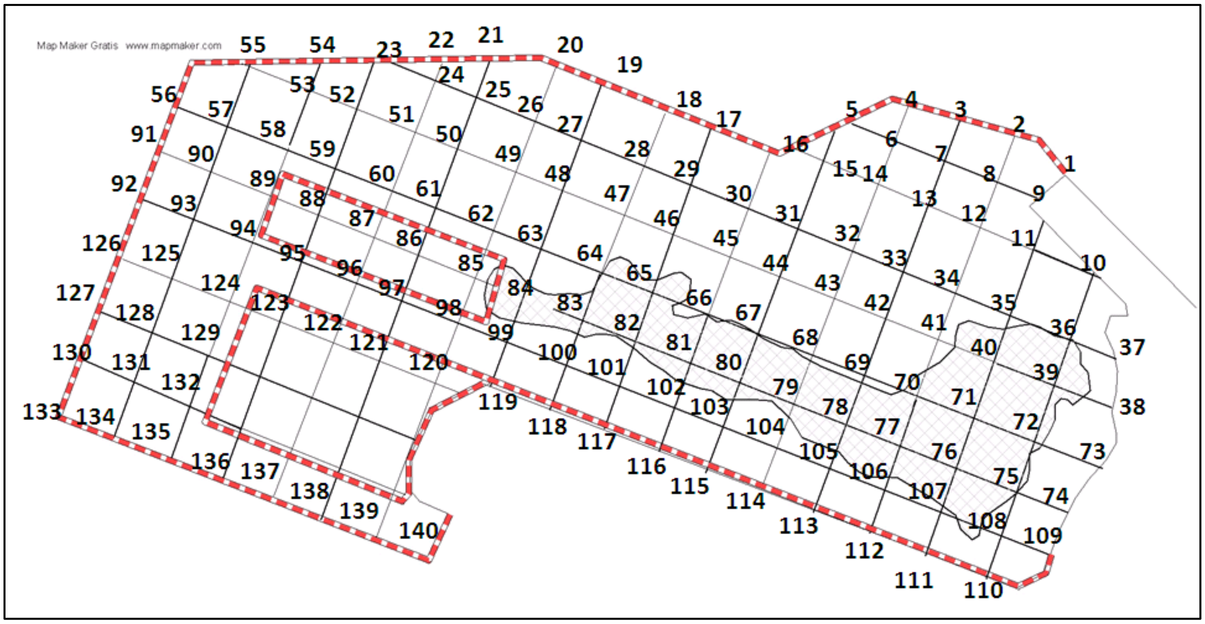


Figure 5.3.1a: Grab sample location codes for NMIA Study Area

Observations made from the analysis of the140 grab samples, compared with air image pattern analysis (interpretations made in section 5.1), has led to the conclusion that the seafloor within the study area is 90% overlain with macro-algae. The three dominant macro-algae species (Plates 5.3.1a-b) observed are:

1. *Halimeda sp*
2. *Caulerpa mexicana*
3. *Caulerpa racemosa*

Of the three, *Halimeda sp.* was, by far, the most dominant macroalga and the most dominant sessile benthic organism observed within the study area. While a detailed quantitative assessment of the distribution and abundance of the algae on the seafloor was not conducted, visually it was determined that the Halimeda species covered 80% or more of the seafloor. The seagrassTurtle Grass (*Thalassia testudinum*) was also observed in the study area, especially in shallower water near the shoreline, as illustrated in Figure 5.3.1b below.

Plate 5.3.1a: Macro-algae species observed within the Study Area: Left: *Halimeda spp;* Right: *Caulerpa mexicana* and *Caulerpa racemosa*

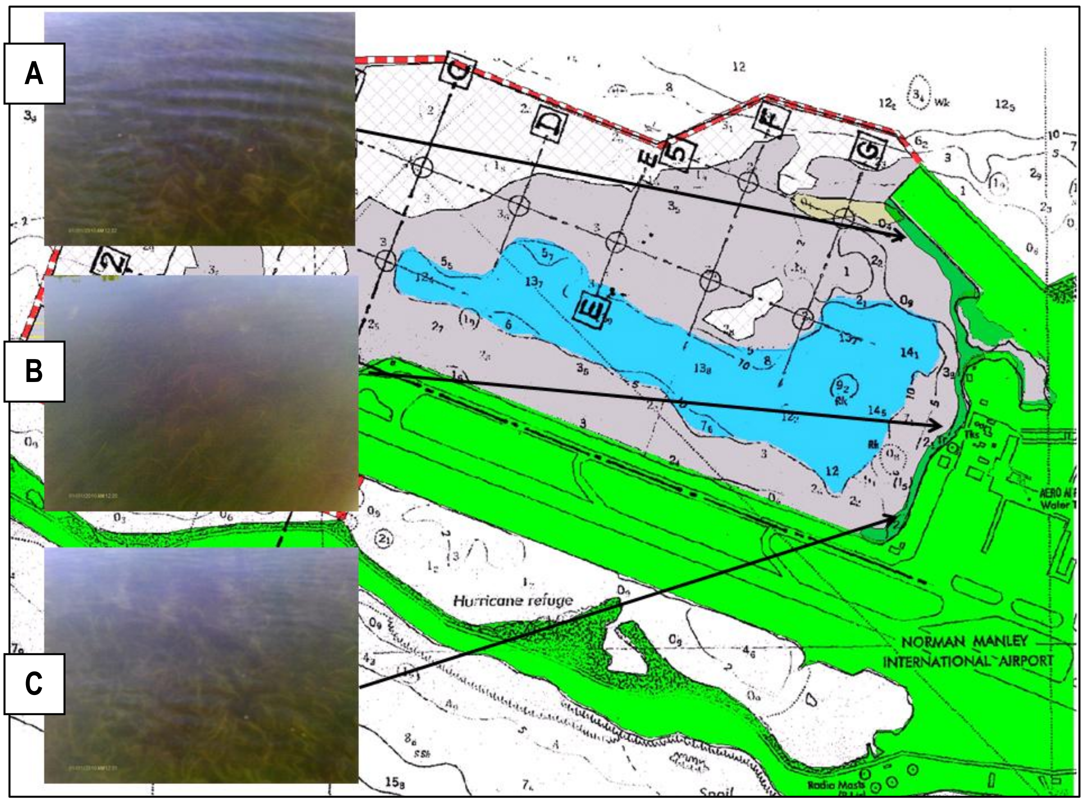


Figure 5.3.1b: Seagrass areas (Dark Green = *Thalassia testudinum* at points A-C) observed within the study area.

5.3.2 Mobile Benthic Organisms

Video transect information collected within the areas defined on Figure 5.3.2 below was analysed to determine the characteristics of the proposed borrow area, the shoreline protection area and the 1955 borrow area.

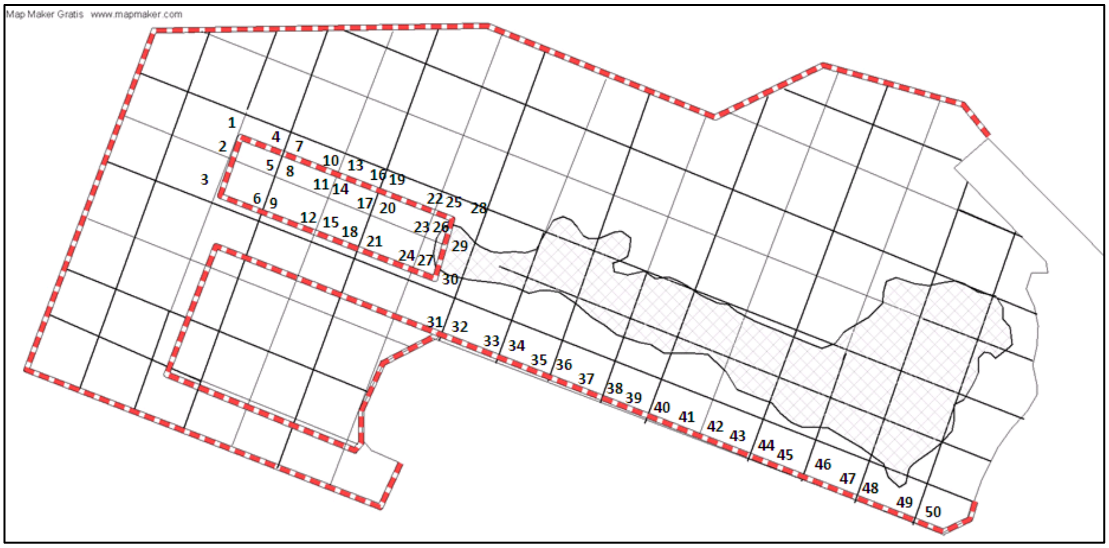


Figure 5.3.1d NMIA Study Area video transect locations

Proposed Borrow Area

In the area defined as the Proposed Borrow Area the total survey area included 30 20 x 1 m transects or an area of approximately 600 square meters. The main mobile benthic species and their remains found in this area included Variegated Sea Urchins, Donkey Dung Sea Cucumber, Common Comet Stars, Whelks and Crown (Swamp) Conchs. The total seafloor area within the proposed borrow area was estimated at 13 hectares or 130,000 square meters. Using simple proportion calculations and assuming that the distribution of benthic organisms observed within the video transects was uniform, the following estimates of total numbers of mobile benthic organisms within the borrow area is outlined below:

No.	Species Name	Common Name	Number of Individuals
1	*Lytechinus variegates*	Variegated (Green) Sea Urchin	2817
2	*Holothuria mexicana*	Donkey Dung Sea Cucumber	1083
3	*Linckia guildingii*	Common Comet Star	650
4	*Cittarium pica*	West Indian Top Shell (Welks)	1300
5	*Melongena corona*	Crown Conch	433

The fragments of four bivalves were visually observed in the top layers of the seafloor sediments. These correspond with examples observed in the 2011 study and are listed below:

1. *Anadara chemnitz*
2. *Martesia sp.*
3. *Brachiodonte sexustus*
4. *Cardita meragracilis*

All benthic fauna observed were associated with sandy substrates inhabited by macroalgae. No demersal or pelagic fish were observed on video; however, schools of Atlantic Thread Herring, locally known as Sprat (*Opsitone maoglinum*) were swimming over the entire study area (including the proposed borrow area). Their popularity in the study area was confirmed by the survey boat Coxswain who fishes in the study area. Also, a number of Spotted Eagle Rays (*Aerobatus narinari*) and numerous Moon Jellyfish (*Aurelia aurtita*) were observed breaching and floating, respectively, on the water surface here and across the study area.

Shoreline Protection Area

A total survey area of twenty 20 x 2 m transects or approximately 400 square meters area was studied along the existing shoreline protection area. The most abundant benthic organism observed within this area was algae, specifically turf algae and *Derbesia sp*. Three examples of the very hardy coral, Lesser Startlet Corals (*Sidasterea radians*) were observed during the evaluations. Each individual was approximately 10 cm in diameter and showed signs of bleaching. This species of coral is known to exist under very stressful environmental conditions and, in the absence of other coral species, is often an indicator of pollution.

The following benthic organisms were observed amongst the shoreline protection rocks adjoining the northern section of the runway:

1. Mangrove Snapper (*Lutjanus griseus)*
2. Sergeant Major (*Abudefduf saxatilis*)
3. Four-eye Butterfly Fish – (*Chaetodon capistratus*)
4. Atlantic Thread Herring – (*Opsitone maoglinum*)
5. Grunt – (*Haemulon sp.*)
6. Variegated Urchin – (*Lytechinus variegates*)
7. The Common Comet Star – (*Linckia guildingii)*
8. The lesser Startlet Coral – (*Sidasterea radians*)

The 1955 Borrow Area

Grab samples taken within the 1955 borrow area revealed muds that were not occupied with marine benthic life. Video transects conducted within the borders of the borrow area confirmed a lack of marine life, both benthic and pelagic.

5.4 Fisheries Evaluation

Interviews conducted with fishing interests at both the Rae Town and Greenwich Farm Fishing Beaches (the closest to the study area and the biggest - respectively - in the Harbour) revealed the following:

1) The study area is routinely fished by fishers from both fishing beaches.
2) Fishers from both fishing beaches recognize the significance of the area as a source of fish, owing to its proximity to the Port Royal Mangroves to its south and the Mammee and Pelican Seagrass shoals to the west. Both locations act as an important nursery area for marine fish within the Harbour.
3) The pelagic Atlantic Thread Herring can be caught at any location throughout the study area. Snapper and Grunt, which are demersal species associated with sheltering underwater structures like reefs, were most often caught near to the runway's shoreline protection structures.
4) The fish species most frequently targeted by fishers (using nets) from both beaches are:
   - ✓ Atlantic Thread Herring
   - ✓ Snapper
   - ✓ Grunt
5) Fishing in this area is typically done between the hours of 6 pm to 6 am, since that is the time of day that these fish types are most commonly active in the area.
6) There were no published quantitative data on the economic value of the area as a fishery zone; however, fisherfolk interviewed, indicated that on average, $20,000.00 to $50,000.00 worth of fish catch can be caught by a single boat crew.
7) Night observations made on March 22, 2013 revealed a minimum of eight fishing boats operating in the area between the hours of 6 pm to 6 am. The fisherman facilitating the observation indicated that more vessels could be in the area, as not all vessels carried lights and hence would not have been visible in the dark.
8) Less than 20 individual fishers fish the shallow areas of the northeastern corner of the study area for small conch, Whelks and Shrimp.

5.5 Protected Areas

The Study area immediately adjoins the Port Royal Mangroves, an area that was designated under the Ramsar Convention (1971) as a Ramsar Site on April 22, 2005. The Information Sheet on Ramsar Wetlands for Port Royal[2] describes the Port Royal mangroves as having significant ecological importance due to fact that:

1. It provides a habitat for several endangered species of fauna, such as the West Indian Crocodile and three species of marine turtles.
2. It contributes to the biodiversity of the area in that it supports a large number of endemic species of marine fauna
3. It acts as a nursery habitat for a number of marine and avi-fauna species and, through this function, supports an important commercial fishery immediately offshore of the location.

[2] http://www.wetlands.org/RSIS/_COP9Directory/Directory/ris/6JM002en.pdf

A technical reference entitled The Biodiversity of Jamaican Mangrove Areas -Volume 7 was used for the observation and identification of species during boat-based surveys conducted immediately adjoining the study area (within the confines of the area defined on Figure 2.0 above). The species identified are outlined below.

Terrestrial Flora:

1. Red Mangroves (*Rhizophora mangle*)
2. Black Mangroves (*Avicennia germinans*)
3. White Mangroves (*Laguncularia racemosa*)
4. Button Mangroves (*Conocarpus erectus*)
5. Seaside Mahoe (*Thespesia populnea*)

Avi-Fauna:

1. Great Blue Heron (*Ardea Herodias*)
2. Brown Pelican (*Pelecanus occidentalis*)
3. Magnificent Frigate Bird (*Fregata sp*.)
4. Cattle Egret (*Bubulcus ibis*)

Terrestrial Fauna:

1. Fiddler Crab (*Uca sp*)
2. Mangrove Tree Crab (*Aratus pisoni*)

An examination of the IUCN's Red List for Threatened Species revealed that none of the species listed as being observed within or peripheral to the study area were classified as being Critically Threatened.

6.0 IMPACT ANALYSIS

6.1 Construction Impacts

6.1.1 Dredging

1) <u>Water Quality Impacts</u>

With the extent of dredging works proposed for this project it is expected that there will be some impact on the water quality. Any impact to the water quality is a concern both for the flora and fauna supported by the marine environment as well as for the fishery trade of the project area. Dredging activities will chiefly affect water quality in the following ways:

C. Increased Suspended Sediments

Mixing of different soil layers and spillages and leaks from dredge equipment can all increase the suspended solids and turbidity of the marine environment. The locations within the study area other than the borrow location and peripheral areas, particularly the Port Royal mangroves to the south of the study area, seagrass shoals (Mammee and Pelican Shoals) to the west and seagrass bed areas to the east could be put at risk by the movement of suspended solids generated by dredging. The sediments are likely to be distributed:

i. At night for the Port Royal mangroves and seagrass beds immediately adjoining the airport, since the prevailing wind/current movement veer towards both areas during this time.
ii. During the day for the seagrass shoals west of the construction area, since day-time wind influences would then direct turbid waters towards these areas.

Juvenile fish can be damaged if suspended sediments become trapped in their gills. Increased fatalities of young fish have been observed in heavily turbid water. Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites but the sustainability of the fishing trade is dependent on Juvenile fish survival rates.

An increase in turbidity results in a decrease in the depth that light is able to penetrate the water column. This can affect sea grasses that are typically found in the project area, by temporarily reducing productivity and growth rates (Parr *et al.,* 1998).

D. Increased Organic and Nutrient Loading

Dredging or disposal can also increase organic and nutrient loading of the water resulting in the localized removal of oxygen from the surrounding water. Depending on the location and timing of the dredge this may lead to the suffocation of marine animals and plants within the localized area or may deter migratory fish or mammals from passing through.

2) <u>Impact on Species and Habitats</u>

A. Benthic Species

While fish are able to relocate, sessile benthic organisms are likely to be crushed and destroyed by dredging activities. This impact could be significant if appropriate mitigation measures are not implemented.

B. Pelagic Species and Fisheries

There is a potential for negative impacts on fishing activities, both through the restriction of fishing boat traffic by the presence of dredging equipment and also through interference with fish presence by the dredging process. Fishers from the Rae Town and Greenwich Town fishing beaches are most likely to be impacted.

C. Habitats

If the dredge depth is similar to that of the 1955 borrow area, it is likely that there may not be a recovery of the deepened seafloor to its previous habitat where benthic macro-flora and mobile organisms could survive. At a maximum depth of 14 m, there was probably not enough light and too much soft sediments on the seafloor in the 1955 borrow area to support benthic plant or animal life.

3) <u>Disposal of Dredged Material</u>

The best method for disposal of dredged material will need to be decided as this material can impact the marine environment based on where and how it is disposed of. This is a significant aspect of the project. The dredged material that will not be used in reclamation is typically disposed of at deep sea which can have several implications from creating chemical disturbances (depending on its chemical composition), causing habitat alterations due to change in sediment structure to burial and smothering of benthic communities.

6.1.2 Containment Bunding

The initial construction of a containment bund/berm (Figure 6.1.2a) to retain dredge materials within the landfilling areas will serve to significantly reduce the spread of waterborne sedimentation, as opposed to no containment being used. The construction of a containment bun/berm is a positive benefit to the reclamation works.

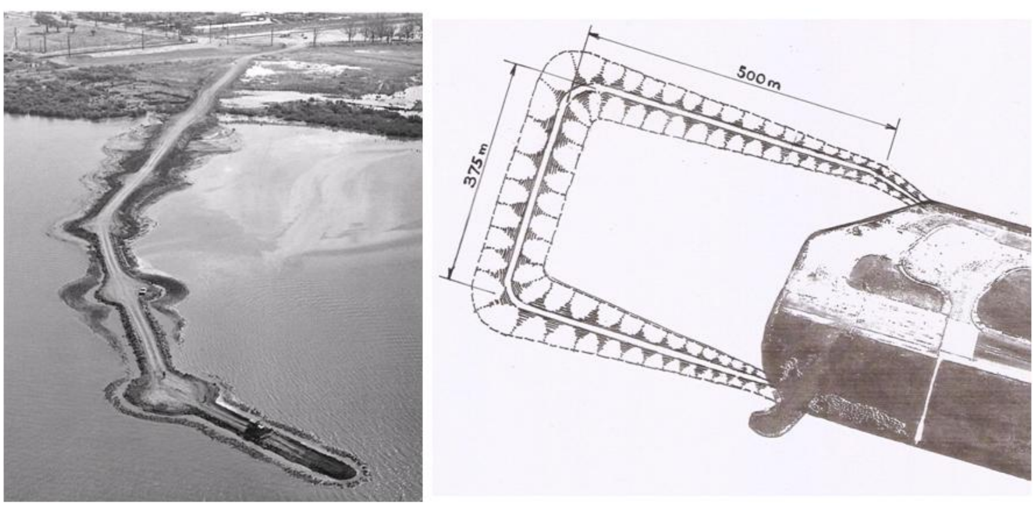


Figure 6.1.2a: Dry-filling method for landfill within the proposed expansion area (photo – construction of Causeway Road).

Nonetheless, the construction of dredge material containment berms/bunds could release sediments into the marine environment. Dredge materials will be pumped into the bermed area using a method similar to that outlined in Figure 6.1.2b below. Water contained within the berm, as well as dredge slurry water will ultimately have to be discharged from the contained area back into the marine environment. If careful management of the slurry water retention time is not done to ensure that settling of suspended solids occurs, a plume of sediment could be discharged from the bunded area (see example illustrated on Figure 6.1.2c below).

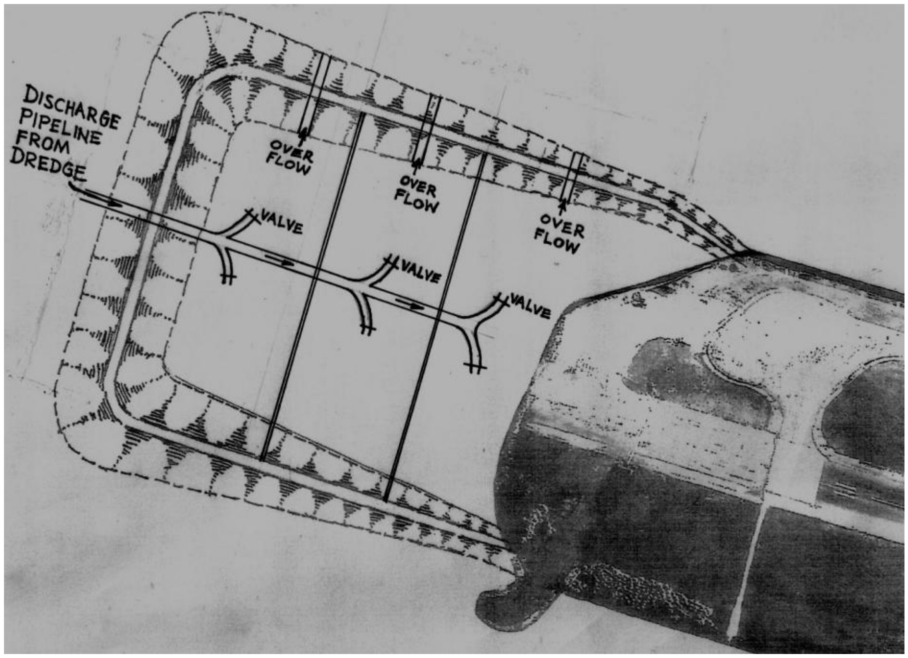


Figure 6.1.2b: Proposed Method of Deposition of Dredge Spoil into the Bunded Area

Figure 6.1.2c: Sediment plume from spoil slurry water discharge from spoil disposal area at Montego Freeport Montego Bay during dredging in 1991

After the landfill materials have been deposited and before the surface is sealed, compacted and rendered impermeable through runway surfacing, there is the potential for the introduction of suspended materials from the landfill surface to the marine environment through rainfall-induced runoff.

6.1.3 Landfilling

The three methods available for the compaction of landfill materials within the reclaimed area are as follows:

1. Surcharging –this involves the placing of additional fill material on top of the required formation level so that the additional material exerts pressure due to its weight. This weight then compacts the filled materials over time.
2. Dynamic Compaction – this involves the use of dynamic energy generated from the dropping of large heavy weights from a significant height to compact deposited materials.
3. Vibro-compaction – this involves the use of a vibrating probe driven into the landfill material to compact a cylinder of soil around the probe.

Of the three methods available for the compaction of landfill materials, Dynamic Compaction and Vibro-compaction appear to be the methods from which a final choice will be made. This is owing to the speed of compaction provided by either method, as well as the fact that surcharging does not require materials in excess of what would be required to fill the area (which would have to be disposed of) and takes a considerable time to ensure stability in settling.

Of the two mechanical compaction methods, dynamic compaction, generate energy waves that would be transmitted through the materials being compacted. These waves could ultimately be transmitted into the adjoining marine environment (water medium) and could cause disturbances to fish life, which may shy away from the area while the activities are underway.

Landfilling along the northern section of the proposed runway was identified as presenting a potentially significant impact to fishery resources currently using that area as shelter and a nursery. In addition, it is anticipated that Seagrass within the area to be land-filled for the new Fire Station (defined under Figure 1B above) will also be directly affected by landfilling.

6.1.4 Approach Light Relocation

Figure 6.1.4: Existing approach light

The relocation of the approach lights and associated electrical conduits was not viewed as presenting a significant impact on natural resources within the study area. If the approach light system is designed similar to the existing system (Figure 6.1.4) each light array will be positioned on a framework supported on a single H-piling with a cross sectional dimension of 0.30 m x 0.30 m. This would represent an insignificant area of seafloor disturbance.

6.1.5 Extended Runway Paving

The processes of landfill compaction and surface sealing through paving will reduce the potential for suspended solids to be introduced into the marine environment through rainwater drained from the extended runway area. However, if there is protracted rainfall during the process of runway paving, hydrocarbons mobilized by rainwater collected on the freshly laid surfaces could be routed to the marine environment.

6.2 Operation Impacts

6.2.1 New Runway End Safety Areas

The RESAs will allow the airport to meet its international requirements and hence fulfill its commitments of maintaining international standards. This is a major positive economic and social impact from a national perspective.

6.2.2 Habitats

After reclamation process is completed, there is the possibility that the number of target demersal fish caught after the completion of the works will be reduced. This is due to the removal of the protective rock armour on the western and northern shores of the runway that currently serve as nursery areas. Extensive search of the literature did not find any information that could give an indication of how long it would take before the newly positioned rock armour would start to re-play the habitat role that the old rock armour provided. The rock armour is expected to serve as a habitat over the long term.

6.2.3 Fisheries and Fishing Beaches

Positive Impacts:

It is likely that the hard surfaces of the proposed shoreline protection and approach lights will serve as a habitat for marine mobile organisms similar to that currently occupying the existing hard structures within the study area. The stones that currently make up the shoreline protection along the northern face of the runway will be reused after reclamation to encourage re-colonization to a familiar surface. This is anticipated to be a positive long term impact.

Negative Impacts:

Additionally, where fishery is concerned there is the possibility that the number of target pelagic and demersal fish caught after the completion of the works will be reduced, owing to the changes that would have occurred in the protective rock armour protecting the western and northern shores of the runway, impacts related to turbidity and the disruptive presence of the dredge. There was no information that could be found that could give an indication as to:

1. How long it would take before the newly positioned shoreline protection would start to re-play the habitat role that the old rock armour provided.

2. How long it would take for fish that had migrated away from the dredging/landfilling disturbance to return to the area after these activities had been completed. Un-substantiated information obtained from representatives of the Rae Town fishing beach indicated that several years passed before stability returned to fishing areas in the Harbour adjoining the areas dredged in 2001-2002 Kingston Harbour dredging exercise.

7.0 MITIGATIONS

The following mitigations are proposed:

1) In an effort to minimize destruction of sessile benthic organisms, it is recommended that the developer undertakes removal and relocation of these organisms from the seafloor of any proposed borrow areas to pre-selected recipient areas prior to dredging.
2) The removal and replanting of Seagrass resources within the footprint of the land reclamation area. (Consideration could be given to the use of the northern sections of the study area for the relocation of important mobile and sessile benthic organisms).
3) The use of silt transport barriers to control sedimentation transport from both the dredging and landfilling areas.
4) The use of materials with a low sediment content for the construction of the bund walls of the reclamation area so as to reduce the introduction of suspended solids into the marine environment.
5) The deployment of submerged artificial habitats along the northern shore of the runway (seaward of the area to be reclaimed) in advance of landfilling operations to provide a location to which fish can "flee" to once landfilling operations commence. Similar considerations could be given to the design of the approach lights that will ultimately have to be relocated, once the runway extension is completed.
6) The re-using of the existing shoreline protection materials that had served as a habit prior to construction to continue this process once marine conditions have naturally stabilized after construction.
7) Further to above, the design of the shoreline protection along the southern end of the extended runway to facilitate the natural colonization and extended growth of Mangroves currently present along the southern side of the existing runway (as illustrated on Figure 7 below).

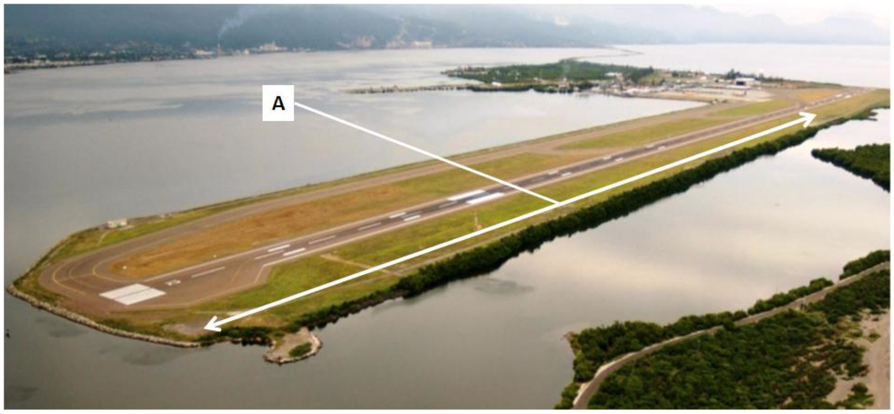


Figure 7.0: Mangrove distribution along southern boundary of existing runway (A)

8) The use of landfill compaction methods that will minimize the generation of potentially disturbing ground waves.
9) Undertake compaction and pavement construction processes outside of the rainy seasons as far as possible to minimize suspended materials or hydrocarbons entering the marine environment.

9.0 OUTLINE MONITORING PLAN

Environmental monitoring of construction activities should be guided by legislation and regulations, permits, licences and approvals, environmental aspects such as erosion and sediment control, deleterious substance control, air, noise and water quality, habitat management, site and habitat restoration and environmental management plans. Effective environmental reporting and diligent professional practice are of essence to the monitoring programme that is implemented at any major construction.

As is typical under the NEPA system, if a permit is granted for the proposed development, a Monitoring Programme will be requested for submission to NEPA for their approval before site preparation and construction activities begin at the project site. The aim of the Monitoring Programme is to ensure the following:

- compliance with relevant legislation
- implementation of the mitigation measures provided in the EIA submitted to the Client and regulatory agencies
- conformance with any General or Specific Conditions as outlined in the permit
- long-term minimization of negative environmental impacts

9.1 Components of the Monitoring Programme

The following sub-sections present the basic requirements of a typical environmental monitoring programme.

9.1.1 Initial Project Team Consultations

Prior to commencement of the project, a meeting should be convened between the developer, their environmental consultants and NEPA representatives to review the monitoring programme in detail and to agree on its purpose, mode of implementation, and the procedures for monitoring and reporting. This meeting should also include a review of the construction schedule and methodologies.

9.1.2 Monitoring Frequency

For the duration of the construction works it is likely that the project site will be inspected once per month for the first six months of the construction phase, then on a quarterly basis for the rest of the project. This has been the typical experience with NEPA permits of this nature. If deemed necessary, this monitoring frequency may be adjusted at any stage by NEPA after consultation with NMIA and their environmental representatives. Monitoring of the operations phase may be done on a bi-monthly basis for the first six months.

9.1.3 Construction Phase Monitoring Tasks

The project areas to be monitored will be determined and specified.

Materials Sourcing and Transport

Objectives:

1. To ensure project does not induce indirect environmental impacts due to illegal quarry operations.
2. To ensure that transport of fill materials does not cause undue spillage or dusting.

Tasks:

- Through Contractor, examine quarry licenses to verify that fill materials are supplied from approved quarries.
- Confirm that material in trucks as they traverse the property is covered with tarpaulin and that tailgates are closed during transport.

Construction Works

Objectives:

1. To maintain sites in tidy manner with adequate sewage and garbage facilities.
2. To ensure that the general construction site works do not exceed air quality standards for respirable particulates or create other environmental problems.

Tasks:

- Inspect construction sites to verify provision and use of garbage receptacles and VIP or chemical toilets for worker use.
- Inspect equipment maintenance yard and ensure that marl base is laid to absorb spilled oil and lubricants.
- Inspect site to ensure that fine construction materials are stored and covered/contained without risk of being washed into the marine environment.
- Inspect site and verify that dust is adequately controlled by wetting.
- Measure noise levels and respirable particulates.

Solid Waste Management

Objective: To ensure that solid waste generated at sites during the construction phases are disposed of in an environmentally acceptable manner.

Tasks:

- Verify use of identified disposal site by contractor.
- Inspect sites to ensure that construction wastes/garbage are not being scattered over the site or deposited in the marine environment.
- Inspect site to ensure provision of adequate numbers of garbage receptacles.

Solid waste management best practices would also apply to all dredging and auxillary vessels used in the process of dredging.

Equipment Management

Objective:

To ensure that heavy equipment usage, refueling and maintenance are all done in an environmentally acceptable manner.

Tasks:

- Verify use of appropriate spill prevention mechanisms for fuel storage and dispensing (this would also apply to the dredge and other auxiliary vessels.
- Verify use of adequately prepared areas for equipment servicing and maintenance.

<u>**Water Quality**</u>

Indicator parameters for nutrients, organics and bacteria would need to be monitored within the study area to control the discharge of sediments and pollutants from construction activities.

Objective:

To determine whether quality of surface waters is being adversely affected by construction activities (at sampling stations selected to reflect water quality at project sites)

Tasks:

1. Measure water quality at specified sites on a monthly basis, prior to and throughout the duration of the construction phases. The parameters to be measured will be as stipulated in the permit granted by NEPA.
2. The determination of the spatial extent of any dredging/landfilling derived turbidity through the use of aerial monitoring techniques.

<u>**Ambient Air Quality**</u>

Landfilling activities will generally produce windblown dust as the site is cleared and exposed surfaces are created on the site. High dust levels can lead to complaints from the airport operations or other stakeholders within the sphere of influence. Air monitoring equipment that measure particulate matter are generally set up to monitor the 24 hour dust levels at the site so the developer will be cognizant that the site may require increased or improved levels and types of mitigations.

<u>**Noise**</u>

Noise monitoring at construction sites is usually done to determine if the construction activities exceed recommended standards beyond the boundaries of the site. In other words environmental monitoring for noise can advise if the activities are nearing nuisance levels and / or whether complaints are valid. The relevant mitigation measures such as screening and servicing of equipment will normally be implemented by the developer upon recommendation.

Habitats and Organisms

The most critical components that will require evaluation over the period of dredging and land reclamation are listed below:

1. The verification of removal of mobile benthic fauna from the borrow area prior to dredging
2. The verification of removal of any important attached benthic fauna from the existing shoreline protection prior to its relocation seaward.
3. The verification of removal of any important benthic flora (seagrasses) from the development footprint
4. The monitoring of rates of success of seagrass replanting

5. The verification of any changes in fish catch over the period (in conjunction with the Fisheries Agency).

REFERENCES

ESL. 2011. Rapid Ecological Assessment of the NMIA 500 m Expansion of the Runway.

Jamaican Caves Organization. Undated. Accessed on March 26, 2013 http://www.jamaicancaves.org/jad2001.htm

Parr, W., Clarke, S.J., van Dijk, P. and Morgan, N. 1998. Turbidity in English and Welsh waters. Report prepared for English Nature, Report no. Co 4301/1., 116 pp. Marlow: Water Research Centre.

Tyler J. 1968. The Secchi Disc. Limnol. Oceanog. **13**: 1-6.

Webber, M. The Biodiversity of Jamaican Mangrove Areas - Mangrove Biotypes VI: Common Fauna.

APPENDIX 1 - PROJECT TEAM

Barry Wade, PhD – Specialist Consultant

Experience:

- Coastal Zone Management
- Pollution Prevention Control
- Ecology
- Institutional Development
- Total Quality Management
- Petroleum Industry Management

Dr. Wade is an environmental scientist experienced in teaching, research, consulting and management. Educated in Jamaica and the USA, he has held senior technical and management appointments in the environmental, energy and financial sectors. He has been Principal Consultant on several infrastructural development projects throughout the Caribbean including airport planning, expansion and rehabilitation, water, wastewater and solid waste management projects, new and upgraded highways, and port expansions.

Dr. Wade has produced several major works including his landmark study on the pollution ecology of Kingston Harbour and has conducted more than fifty environmental impact assessments and audits in Jamaica, the Caribbean and Central America. Dr. Wade has received several national and international honours and awards for his contribution to environmental management in Jamaica.

Dr. Wade is Chairman and Consulting Principal of Environmental Solutions Ltd. and Director of ESL Management Solutions Ltd. He served as a technical strategic support to the project.

Peter Wilson Kelly, M.Phil: Team Marine Ecologist and Technical Diver

Peter Wilson-Kelly has over 20 years professional experience in watershed, coastal zone, and fisheries management, marine environmental science research and remote sensing. His expertise in remote sensing has been expanded to the application of Geographic Information Systems to the analysis and monitoring of environmental change directly associated with human development and to the generation and transfer of information through modeling and multimedia presentation.

Mr.Wilson-Kelly specializes in diving, particularly in the areas of underwater videography/photography, search and recovery and marine ecological assessments. He currently holds the following certifications: PADI SCUBA Diver, PADI Enriched Air (NITROX) Diver, and PADI equipment specialist. He also holds a Jamaica Defence Force equivalent of a US Navy Compressed Air Diver qualification. Mr. Wilson-Kelly was responsible for baseline data collection and analysis.

<u>Kimberly Bryan, MSc: Senior Environmental Analyst</u>

Kimberly Bryan is an environmental professional educated in Jamaica and the UK with over four years' experience. Her specialties include proposal writing as well as establishing budgets and work plans for the conduct and completion of projects; client and agency liaison; analysis of technical information, review of survey plans, engineering designs and environmental data to identify potential constraints to wetlands, watercourses, wildlife and sensitive habitats, and determining appropriate mitigation measures.

Ms. Bryan has comprehensive knowledge of environmental assessment and regulatory processes, environmental permit and approval requirements and processes, environmental monitoring, hazard assessment and mitigation, impact analysis, and environmental planning. She served as the EIA coordinator and was responsible for overall project coordination, analysis of data, and report writing.

APPENDIX 2 – SAMPLING EQUIPMENT, RESULTS CERTIFICATES AND LABORATORY METHODS

Water Clarity Measurements

Secchi Disc readings were determined in accordance to methods outlined by Tyler (1968). A weighted Secchi Disc 30 cm in diameter, affixed to a line marked in meters, was lowered from the side of a boat in the water to the point where the disc was no longer visible. Observations of the disc were made through a view-box placed on the seafloor. The secchi disc was then pulled slowly back towards the surface to a point where the disc could be seen by the observer and then the depth at which observation occurred was recorded.

Secchi Disk used for Water Turbidity Measurements at NMIA

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

a division of

89 Hope Road
Kingston 6, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Attention: Winsome Strachan
Project Coordinator
Airports Authority of Jamaica
Norman Manley International Airport

RESULTS CERTIFICATE
NO.: AAJ/01A/13

Specific Handling: None
Analysis Started: March 11, 2013
Number of samples: 4
Sample Condition on Arrival: Cool
Report Date: March 22, 2013
Analysis completed: March 22, 2013
Sample Type: Marine Water

Sample Submission Date: March 11, 2013

PARAMETER	TEST METHOD	SAMPLE ID				NRCA AMBIENT WATER STANDARD (Marine Water)
		S1 TOP	S1 BOTTOM	S2 TOP	S2 BOTTOM	
Biochemical Oxygen Demand (mg/L)	H-10099 H-8043	2.2	2.0	0.6	0.6	0.0 - 1.16
Total Suspended Solids (mg/L)	SM-2540 D	16.9	6.1	<2.5	7.3	-
Salinity (ppt)	DR	33.8	35.4	35.3	35.6	-
Nitrate as Nitrogen (mg/L)	H-8192	<0.01	<0.01	<0.01	<0.01	0.007 – 0.014
Phosphate (mg/L)	H-8048	<0.02	0.02	0.02	0.04	-
Phosphate (mgP /L)		<0.0036	0.0036	0.0036	0.0072	0.001 – 0.003
Faecal Coliform (MPN/100ml)	SM-9221	<1.8	4.5	<1.8	7.8	<2 - 13
Dissolved Oxygen (mg/L)	DR	8.57	7.28	8.81	8.81	-
Temperature (°C)	DR	21.2	21.2	21.1	21.1	-

KEY:
DR -Direct Readings
H - HACH Water analysis handbook 4th and 7th edition
SM - Standard Method for the examination of water and wastewater 21th edition

Quality Control – Analytical and Field duplicates, standard reference materials.

Prepared by…………………
Abigail McIntosh, Project Officer

Approved by…………………
Rashidah Khan-Haqq, Technical Manager

AAJ Water Samples March 10, 2013

Page 1 of 2

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

a division of

89 Hope Road
Kingston 6, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Attention: Winsome Strachan
Project Coordinator
Airports Authority of Jamaica
Norman Manley International Airport

RESULTS CERTIFICATE
NO.: AAJ/01B/13

Specific Handling: None
Analysis Started: March 11, 2013
Number of samples: 4
Sample Condition on Arrival: Cool
Report Date: March 22, 2013
Analysis completed: March 22, 2013
Sample Type: Marine Water

Sample Submission Date: March 11, 2013

PARAMETER	TEST METHOD	SAMPLE ID				NRCA AMBIENT MARINE WATER STANDARD
		S3 TOP	S3 BOTTOM	S4 TOP	S4 BOTTOM	
Biochemical Oxygen Demand (mg/L)	H-10099 H-8043	1.7	1.3	3.2	2.4	0.0 - 1.16
Total Suspended Solids (mg/L)	SM-2540 D	5.0	7.9	7.1	6.3	-
Salinity (ppt)	DR	34.8	35.6	35.6	35.8	-
Nitrate as Nitrogen (mg/L)	H-8192	<0.01	<0.01	<0.01	<0.01	0.007 – 0.014
Phosphate (mg/L)	H-8048	<0.02	0.02	0.03	<0.02	-
Phosphate (mgP /L)		<0.0036	0.0036	0.0054	<0.0036	0.001 – 0.003
Faecal Coliform (MPN/100ml)	SM-9221	6.8	<1.8	4.5	1.8	<2 - 13
Dissolved Oxygen (mg/L)	DR	8.51	7.74	8.00	8.21	-
Temperature (°C)	DR	21.0	21.1	21.4	20.9	-

KEY:
DR -Direct Readings
H - HACH Water analysis handbook 4th and 7th edition
SM - Standard Method for the examination of water and wastewater 21st edition

Quality Control – Analytical and Field duplicates, standard reference materials.

Prepared by…………………
Abigail McIntosh, Project Officer

Approved by…………………
Rashidah Khan-Haqq, Technical Manager

AAJ Water Samples March 10, 2013

Page 2 of 2

APPENDIX 3 – RESULTS OF GRAB SAMPLES

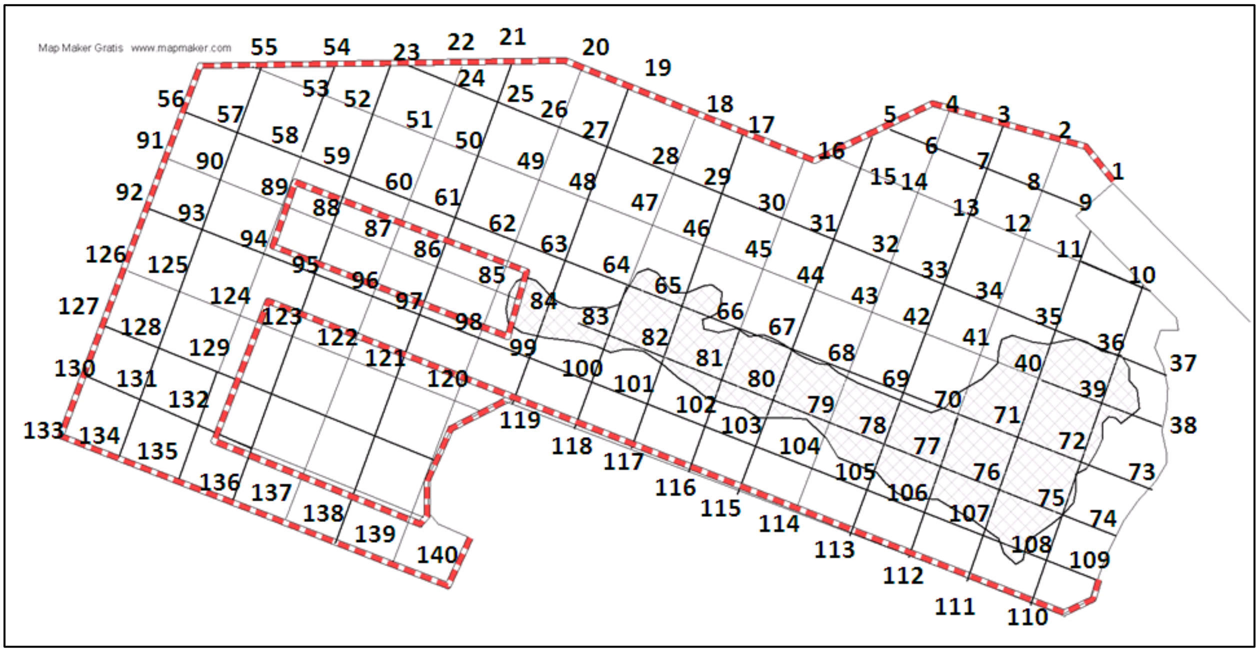


Figure 1: Grab Sample Location Codes for NMIA Study Area, March 2013

Table 1: Grab Sample Character within the NMIA Study Area. Samples coded in order of biota and sediment observation, from water/soil interphase downwards: Biota – Macro-algae [**A**], Seagrass [**S**], Sediment –Halimeda Fragments [**H**], Bivalve Fragments [**B**], Grey Sand [**G**], Mud [**M**])

Location	Character	Location	Character	Location	Character
1	**AG**	15	**AG**	29	**ABG**
2	**BG**	16	**ABG**	30	**AG**
3	**BG**	17	**AG**	31	**AG**
4	**AG**	18	**ABG**	32	**ABG**
5	**AG**	19	**AG**	33	**AG**
6	**AG**	20	**AG**	34	**AG**
7	**SG**	21	**ABG**	35	**ABG**
8	**SG**	22	**AG**	36	**AG**
9	**AG**	23	**AG**	37	**ABG**

Location	Character	Location	Character	Location	Character
10	**AG**	24	**AG**	38	**SBG**
11	**ABG**	25	**ABG**	39	**M**
12	**AG**	26	**AG**	40	**M**
13	**ABG**	27	**AG**	41	**AHG**
14	**AG**	28	**AG**	42	**AHG**
43	**AHBG**	72	**M**	101	**AG**
44	**AHG**	73	**SG**	102	**AG**
45	**AHG**	74	**SG**	103	**AG**
46	**AHG**	75	**M**	014	**AG**
47	**AHG**	76	**M**	105	**AG**
48	**AHG**	77	**M**	106	**AG**
49	**AHG**	78	**M**	107	**M**
50	**AHG**	79	**M**	108	**M**
51	**AHG**	80	**M**	109	**SBG**
52	**AHBG**	81	**M**	110	**SBG**
53	**AHG**	82	**M**	111	**GM**
54	**AHG**	83	**M**	112	**GM**
55	**AHG**	84	**M**	113	**G**
56	**AHBG**	85	**AHG**	114	**GM**
57	**AHG**	86	**AHBG**	115	**G**
58	**AHG**	87	**AHG**	116	**G**
59	**AHG**	88	**AHG**	117	**GM**
60	**AHG**	89	**AHBG**	118	**AG**
61	**AHBG**	90	**AHG**	119	**G**
62	**AHG**	91	**AHBG**	120	**ABG**
63	**AHG**	92	**AHG**	121	**ABG**
64	**BM**	93	**AHG**	122	**AG**
65	**M**	94	**AHG**	123	**BG**

Location	Character	Location	Character	Location	Character
66	**ABM**	95	**AHG**	124	**BG**
67	**ABM**	96	**AHG**	125	**ABG**
68	**GM**	97	**AHG**	126	**BG**
69	**GM**	98	**AHG**	127	**ABG**
70	**GM**	99	**AG**	128	**BG**
71	**M**	100	**AG**	129	**BG**
130	**BG**	134	**M**	138	**M**
131	**BG**	135	**M**	139	**M**
132	**M**	136	**M**	140	**M**
133	**M**	137	**M**		

Addendum –Part 3

HYDRODYNAMIC MODELING

FOR

NORMAN MANLEY INTERNATIONAL AIRPORT
500M RUNWAY EXTENSION

SMITH WARNER INTERNATIONAL

Contents

This report describes the hydrodynamic model investigations currently being undertaken by Smith Warner International Ltd. (SWI) for the proposed 500m extension to the Norman Manley International Airport (NMIA) runway.

1 Hydrographic Survey Results

As stated in the inception report, a bathymetric survey was carried out on March 7th and 8th (2013) with the actual tracklines shown in Figure 1. Figure 2 shows the results of the survey as shaded contour lines. What stands out is the more detailed outline of the dredge borrow zone just north of the NMIA runway. This detailed survey has been combined with the spot depths of the British Admiralty charts contained in MapSource. These data were used in the hydrodynamic model.

Figure 1 Surveyed bathymetric tracklines

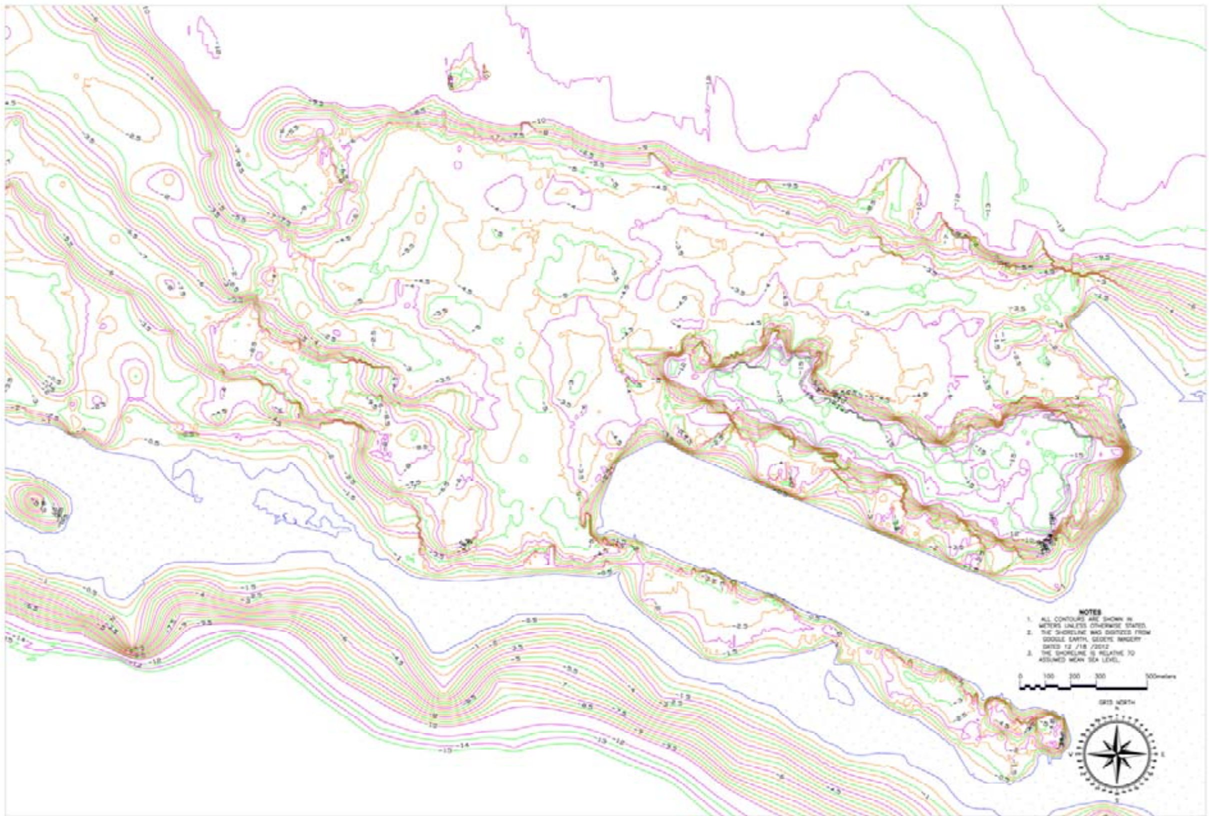


Figure 2 Contour results of the survey

2 Baseline Hydrodynamic Results

2.1 Model Setup

The section describes the hydrodynamic model set-up, calibration and the baseline hydrodynamic conditions of the area of interest.

MIKE 21 (Release 2012) from the Danish Hydraulics Institute was the modeling software used for these investigations. MIKE 21 is the world's leading modeling package for 2D free surface flow, waves, sediment transport, morphology and environmental processes. It is a modular system and for this study the Hydrodynamic (HD), Spectral Wave (SW) and Pollutant Transport (PT) modules were used. A flexible mesh (FM) has been employed, which is based on an unstructured mesh and uses a cell-centred finite volume solution technique. The mesh is based on linear triangular elements. Due to the irregular grid and variable resolution, the FM version is particularly well-suited for modeling large complex areas that, at the same time, require a detailed resolution of specific features, as is the case for NMIA.

The flexible mesh model covers the whole of Kingston Harbour including Hunts Bay as shown in Figure 3. The resolution ranges from cells with a maximum side length of approximately 35m around the proposed runway extension to over 400m over the outer model domain.

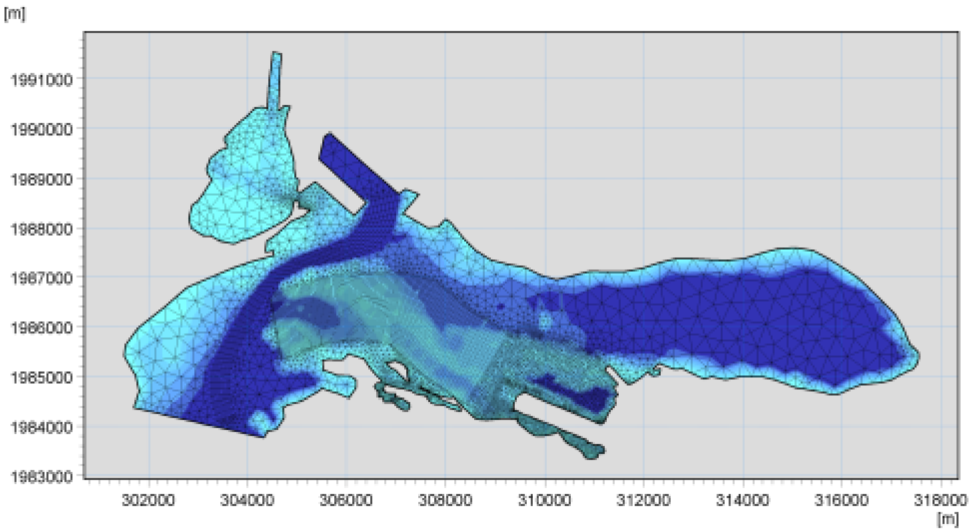
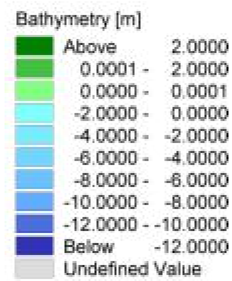


Figure 3 Flexible mesh of Kingston Harbour and Hunt's Bay



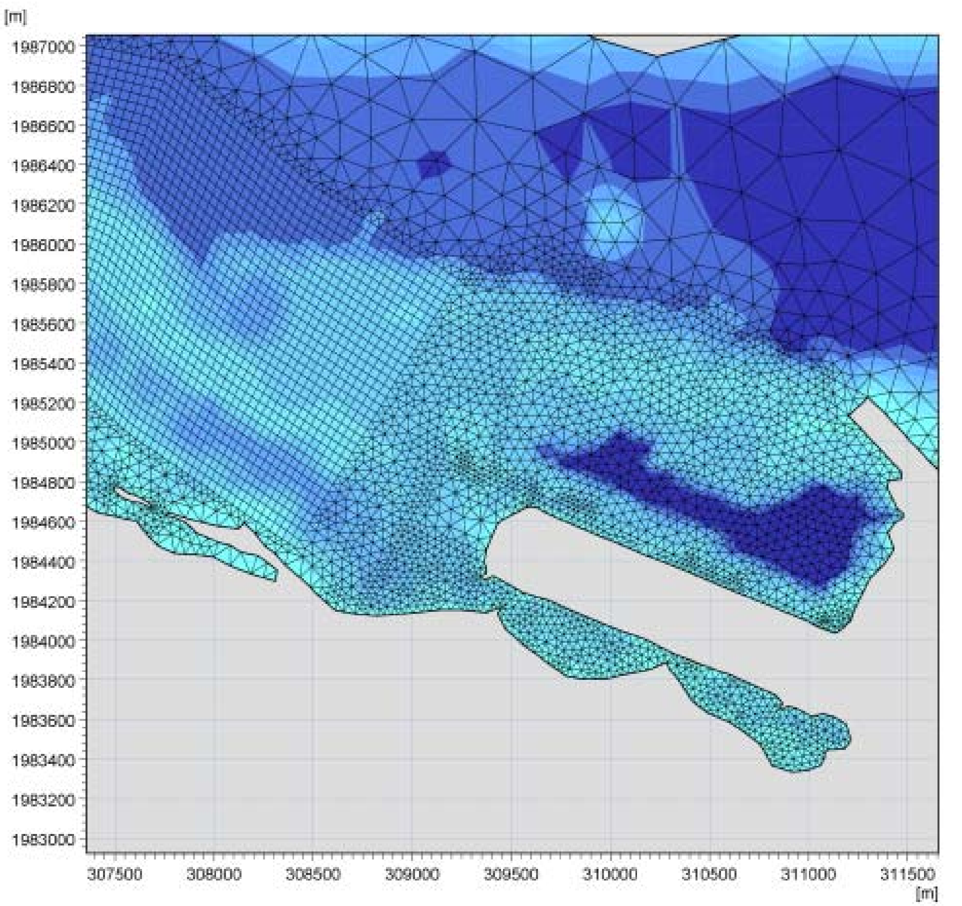


Figure 4 Detail of flexible mesh showing the area of the proposed runway extension and dredge borrow site

2.2 Winds

Wind data was obtained from the Climate Branch Meteorological Service for the data collection period as shown in Figure 5. The majority of winds approached either from the south-west to south-east or from the north to north-west. During the daytime, the wind generally blows from the sea on to shore, and during the night the wind blows from the land to the sea. Most of the daytime wind speeds were above 4 m/s, especially the winds approaching from the south-east.

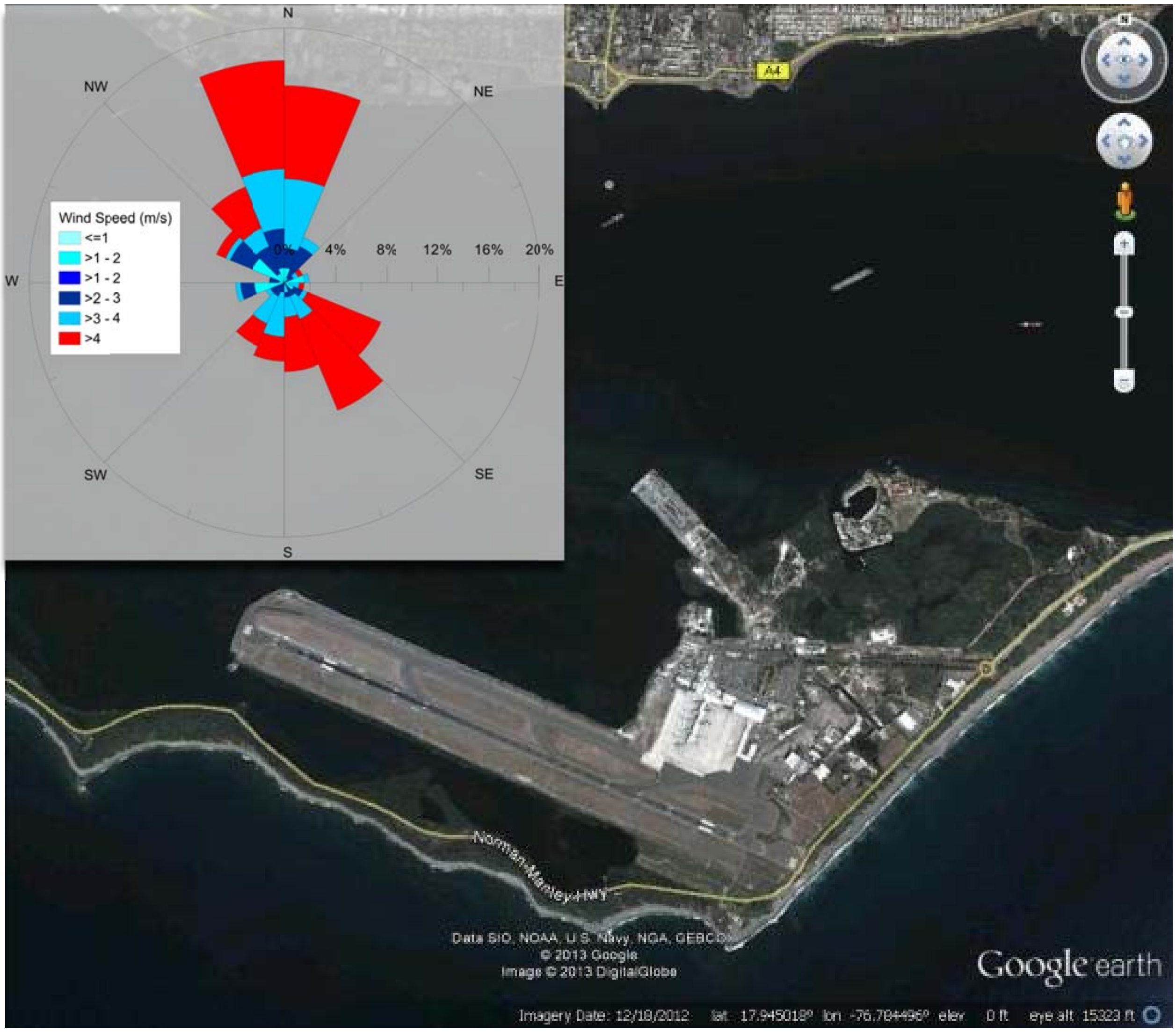


Figure 5 Measured wind at the NMIA from 5-16 March 2013

2.3 Boundary Conditions

As stated in the Inception Report (March 2013) the main boundary input consists of the time-varying tidal heights along the entrance to the Kingston Harbour. The tidal boundary was generated using the DTU2010 global ocean tide model. In addition, to ensure that the predicted tides can be used, the Aquadopp measured tidal heights at its location. An extraction point in the HD model was selected at the location of the Aquadopp current meter and the modeled tidal heights were compared with the measured tidal heights, as shown in Figure 6. The predicted model tides match the measured tide levels reasonably well in terms of both height and phase. The box plot on the right hand side shows the range of tide levels, along with the mean, and 25th and 75th percentiles, which appear quite similar.

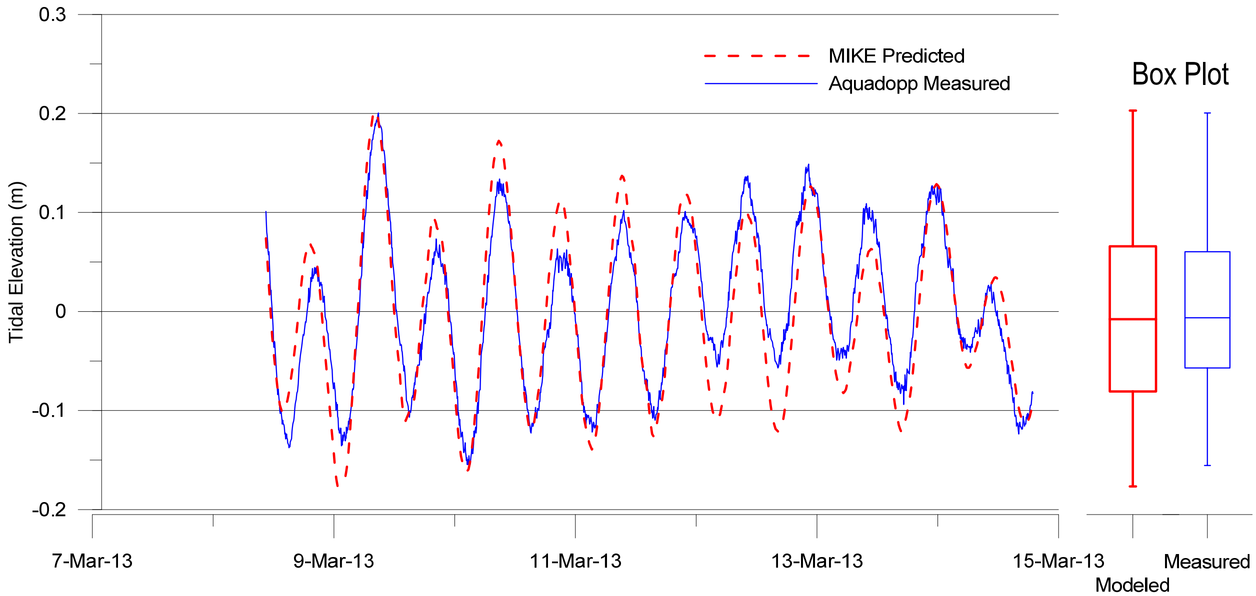


Figure 6 Time series and Box Plot comparison of measured and predicted tides

2.4 Current Comparisons at Aquadopp Locations

It is important that the predicted currents represent the ambient conditions as accurately as possible so that the impacts of the proposed works can be evaluated with minimal uncertainty. By applying the predicted tides at the model boundary, adjusting friction coefficients and including wind forcing using the data measured offshore the NMIA runway, the hydrodynamic model was able to represent the measured current speeds and directions at the instrument location with a reasonable degree of accuracy as shown in Figure 7. This plot depicts the currents as "progressive vectors", which shows a persistent drift to the north-west in both the measured and predicted values. Overall, the drift speeds and directions are similar, with perhaps slightly less scatter in the model values compared to the measured values.

In Figure 8 and Figure 9 the currents have been divided into easting and northing components. It appears that the model does not properly represent the full range of current speeds in the easting direction as shown in the normal distribution (see Figure 8). However, it properly represents the overall trend in the currents fairly well, as can be seen in the average speeds of both the measured and predicted currents of -20.9 mm/s and -17.5 mm/s respectively. Figure 9 shows that the distribution of predicted northing currents matches closely with the measured distribution, with average current speeds of 12.6 mm/s and 9.9 mm/s. Both the predicted easting and northing components match reasonably closely to the average speeds of the measured currents, however, the standard deviation of the measured easting and northing current speed is much larger than the predicted standard deviation, implying that the model does not match the scatter or variability of the currents in both directions.

Figure 10 shows the scatter diagram of the measured and predicted current speed and direction. It shows the model currents moving in a narrower band than the measured currents as shown by the standard deviation in the histogram. The average speed and direction are very similar to the measured data, as shown in the histograms.

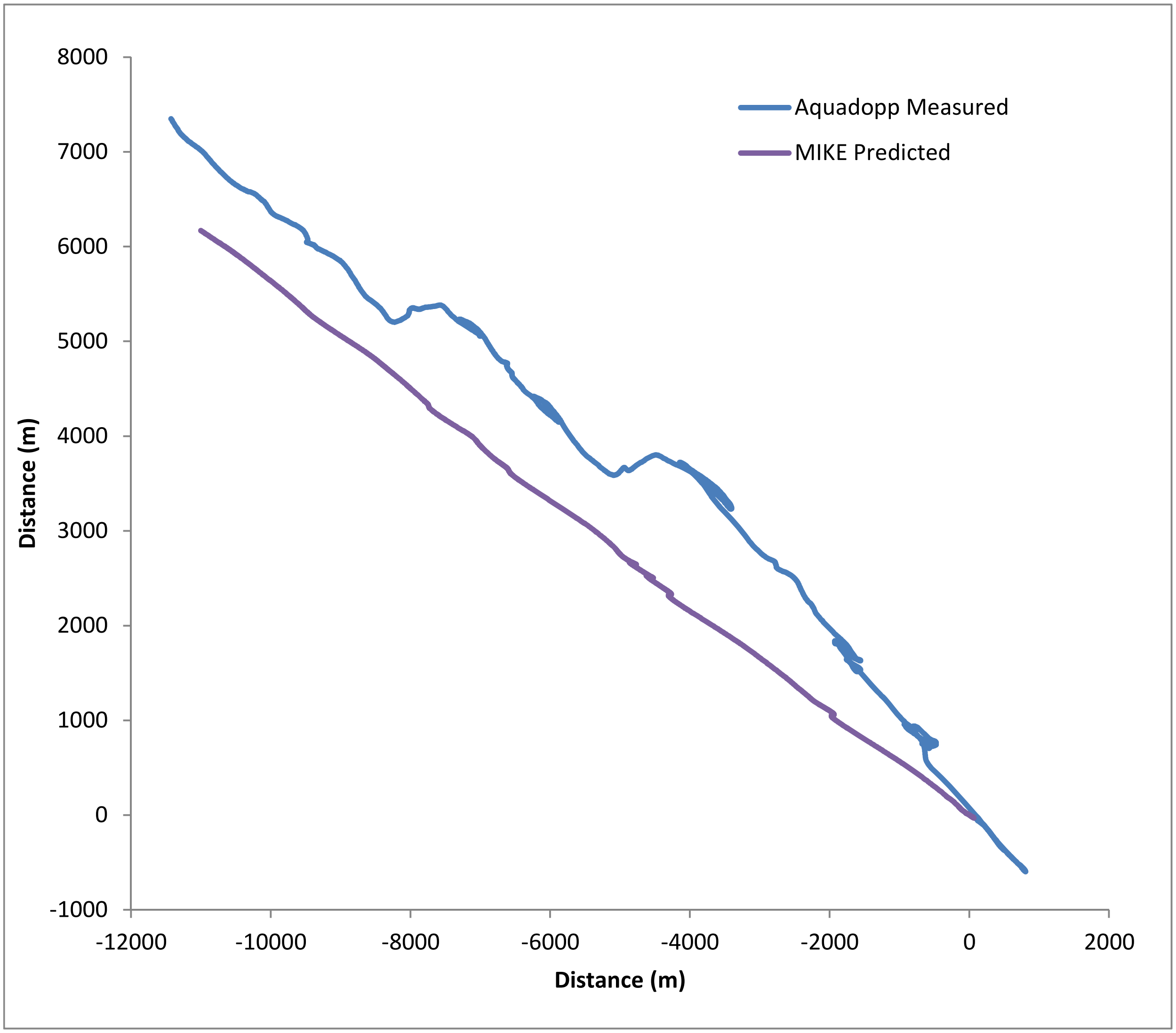


Figure 7 Progressive vector plot diagram comparing measured Aquadopp and MIKE 21 predicted currents

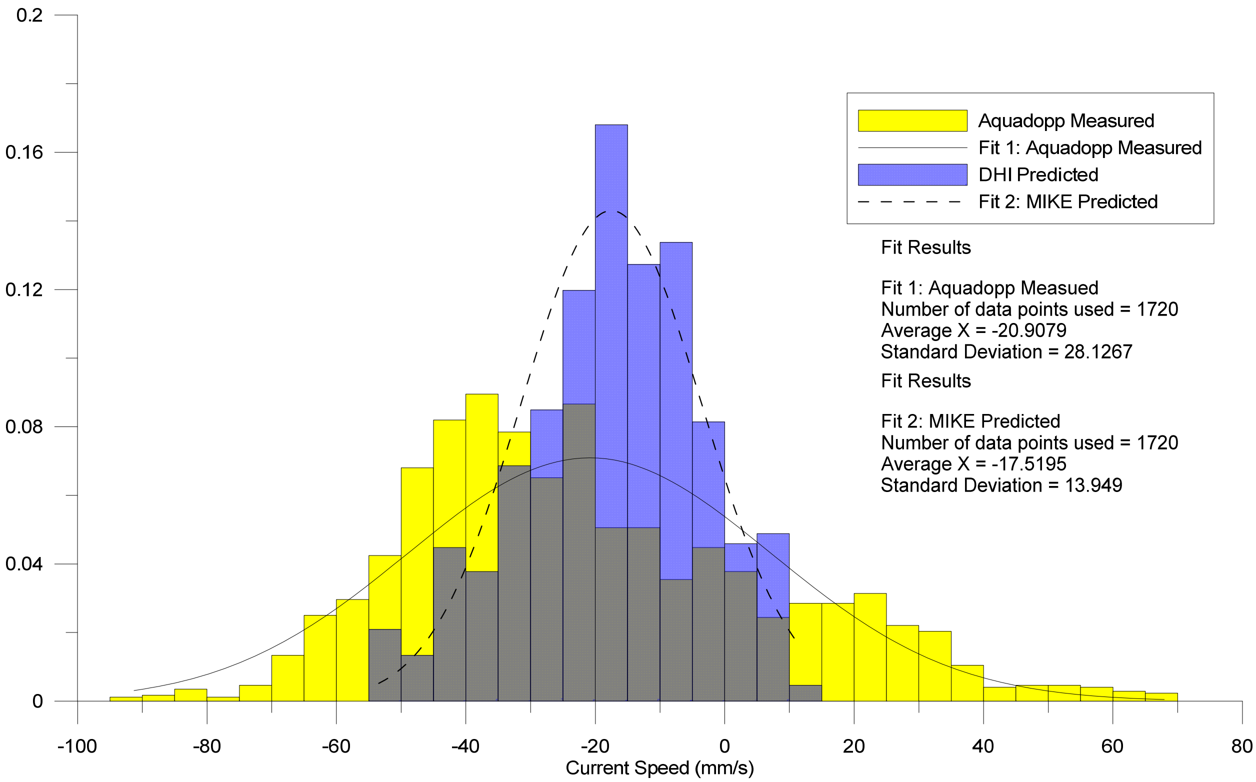


Figure 8 Histogram comparison of Aquadopp measured and MIKE 21 predicted Easting current speeds

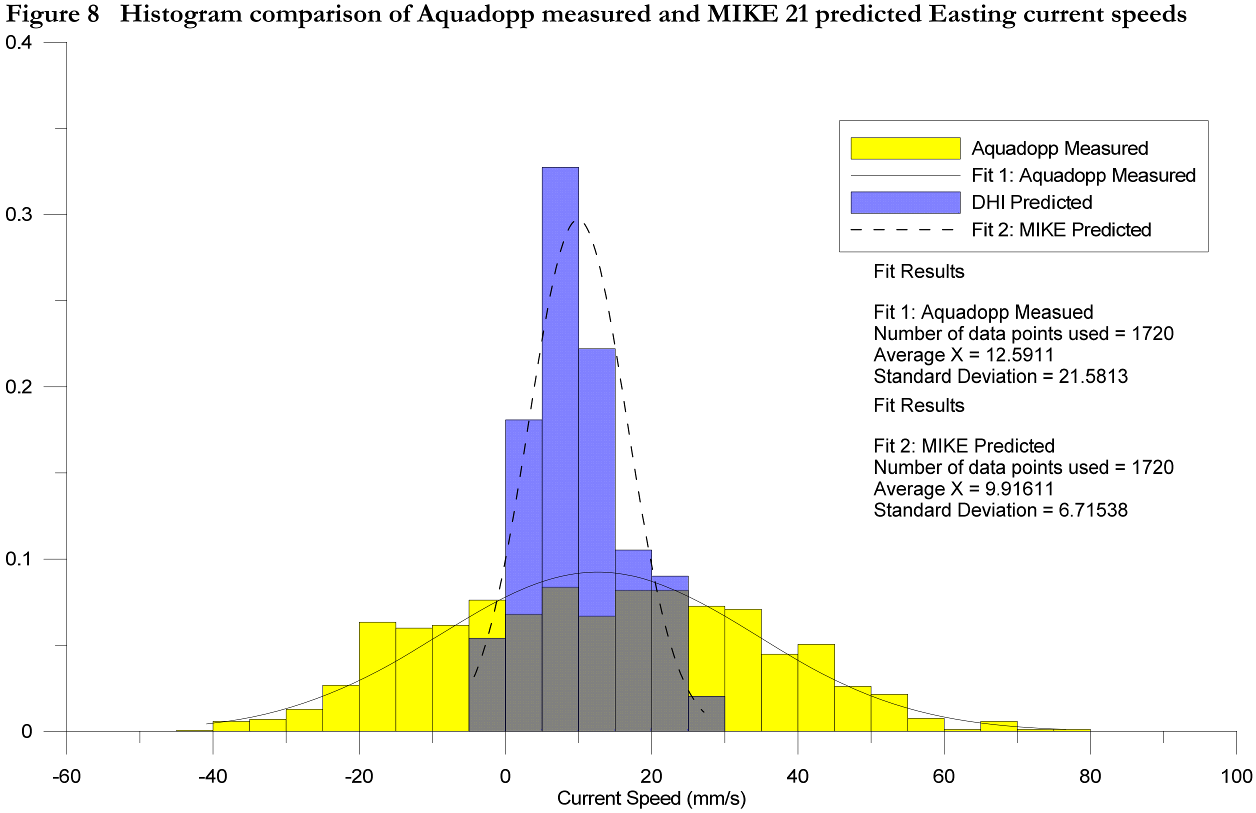


Figure 9 Histogram comparison of Aquadopp measured and MIKE 21 predicted Northing current speeds

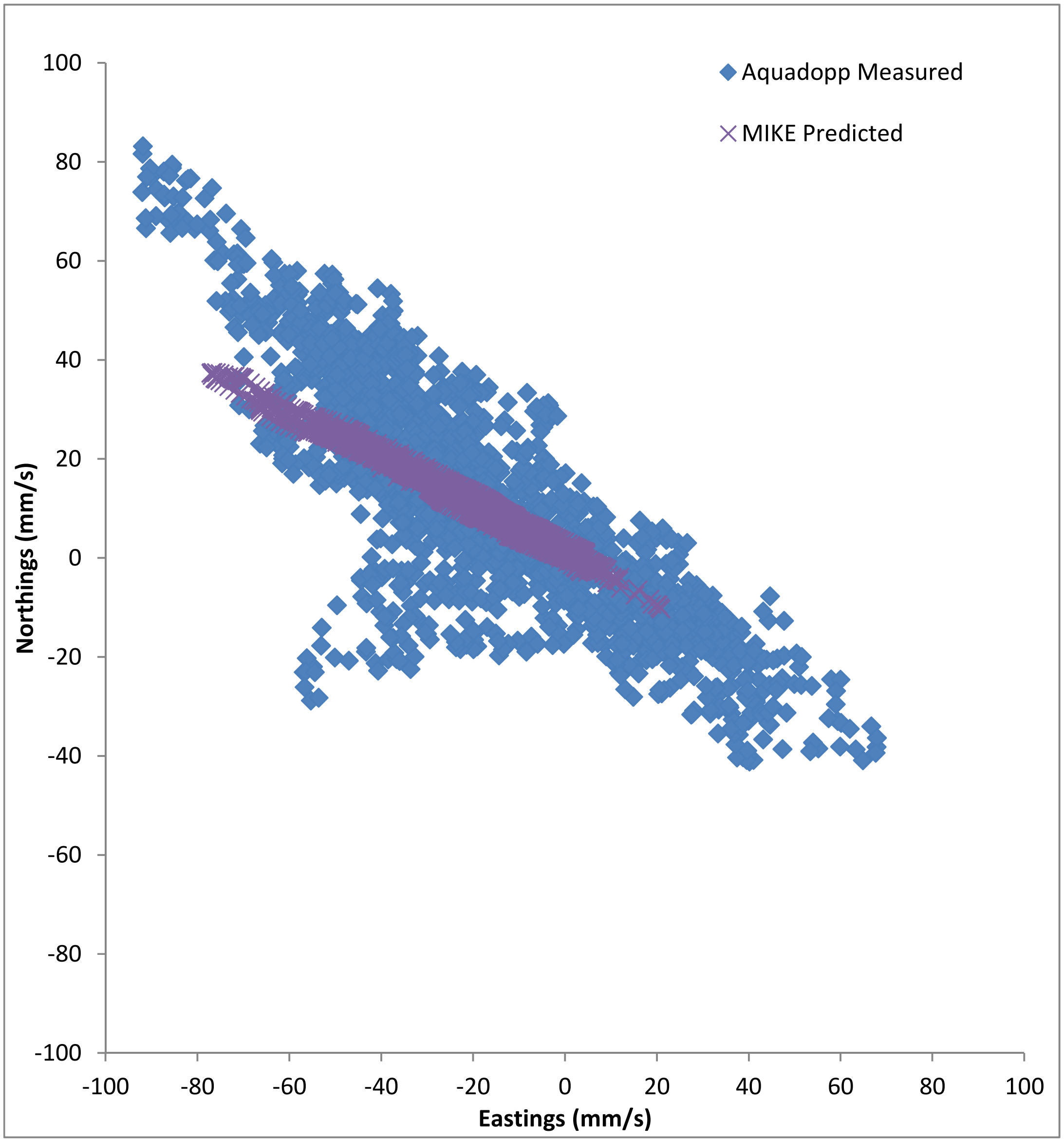


Figure 10 Scatter diagram of measured and predicted currents

2.5 Validation at S4 Current Meter Location

A S4 current meter was obtained from the University of the West Indies Mona and deployed to the west of the proposed runway extension. The instrument was deployed for the same period as the Aquadopp, however, when the instrument was retrieved it was apparent that the data had to be discarded. An analysis revealed that one of the current sensors was malfunctioning and the data could not be used in the model validation.

2.6 Validation at Causeway Bridge

To validate the calibrated model, another dataset of measured currents was used: current measurements recorded 8-23 June 2007 under the causeway bridge as shown in Figure 11. As expected, the measured data shows more scatter than the predicted results, however, the model shows that it is within the range of the measured data as shown in Figure 12.

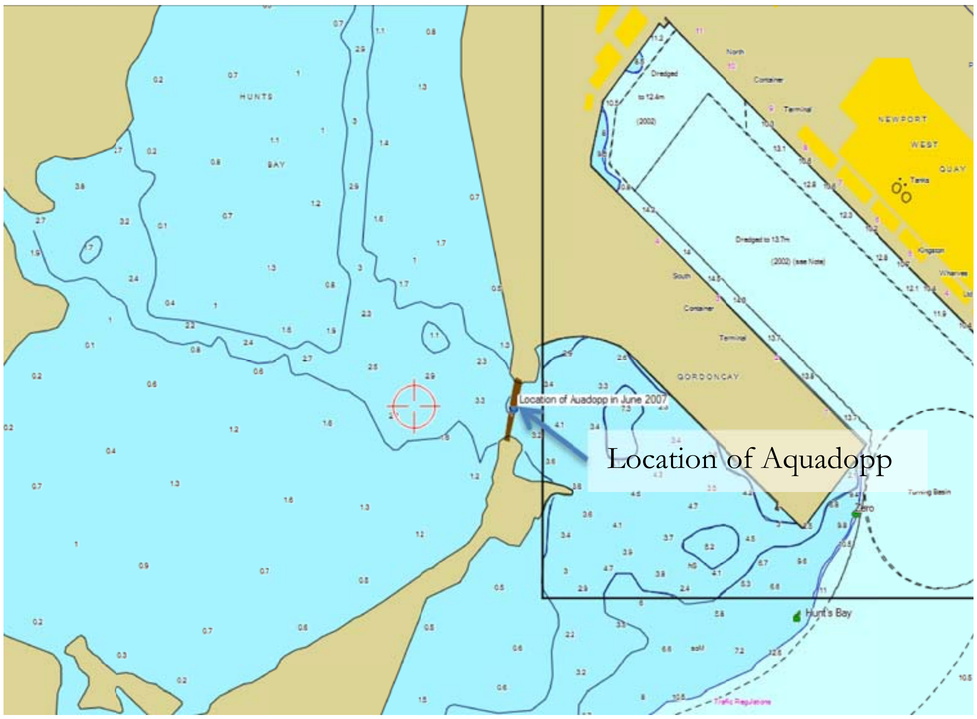


Figure 11 Location of Aquadopp in June 2007

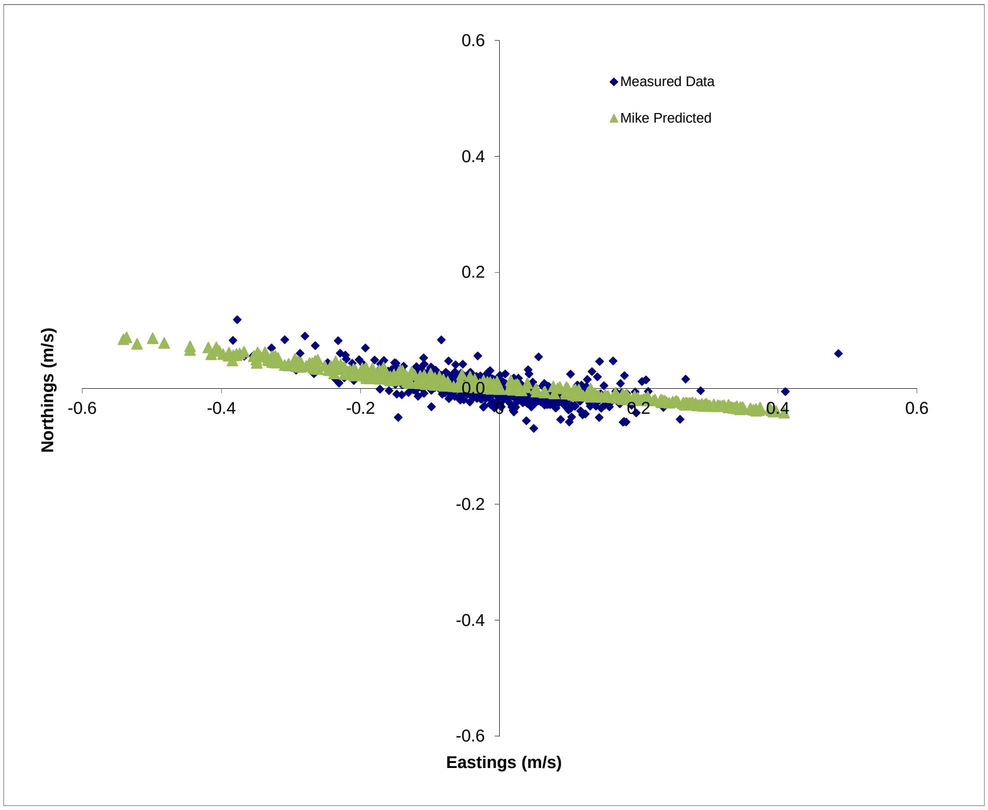


Figure 12 Scatter diagram of measured and predicted current speeds under the causeway bridge

3 Impact Analysis

This section describes the use of the calibrated hydrodynamic model to examine the impacts the proposed works will have on the ambient conditions. The impacts being assessed are as follows:

- 9-day neap tide simulation under ambient conditions using a conservative pollutant tracer with a constant flow input to the model at specific locations.
- 9-day neap tide simulation under proposed conditions with the same conservative pollutant tracer at the same locations.

The purpose of running simulations during the neap tide is based on the assumption that the effects of the proposed runway extension would have the greatest impact when the least amount of water is circulating in and out of the harbour. This would occur during neap tide conditions, when the tidal variations are at their smallest. Figure 14 shows the layout of the proposed expansion of the runway (in green) along with the proposed dredge area (outlined in red).

A total of eight locations were chosen to examine the hydrodynamic impacts on the current speeds due to the proposed runway expansion and dredge location (shown in Figure 14). Locations 1-4 are in a line starting just outside the entrance to the refuge moving in a northerly direction. Locations 5 and 6 are within the refuge area, while 7 and 8 are further away from the project site. Location 2 is located in line with the runway and Location 3 is at the proposed dredge borrow area. It is therefore expected that these two locations should show the largest impact.

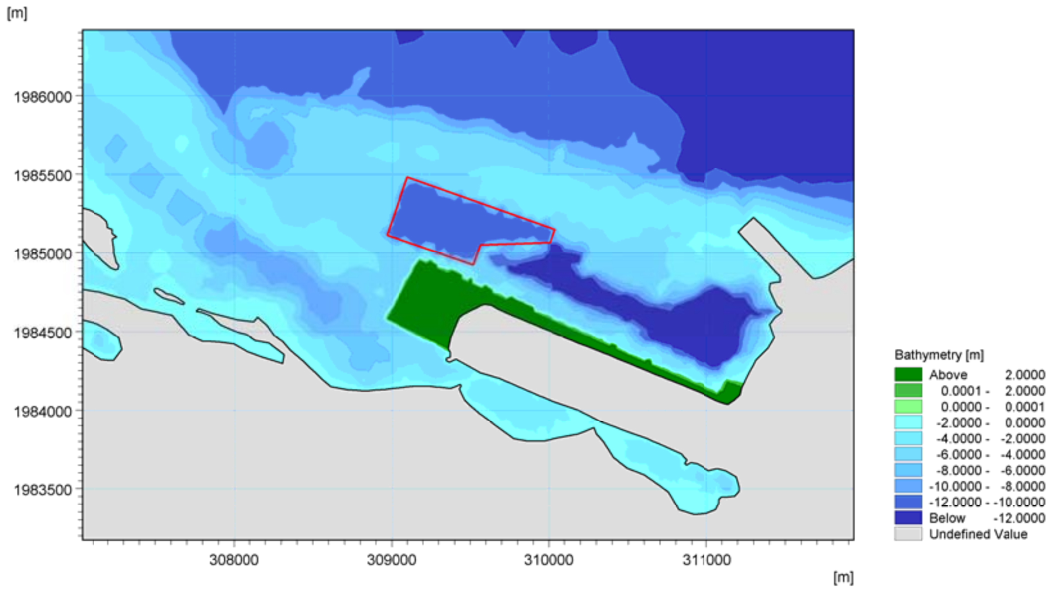


Figure 13 Proposed layout of NMIA expansion and dredge location

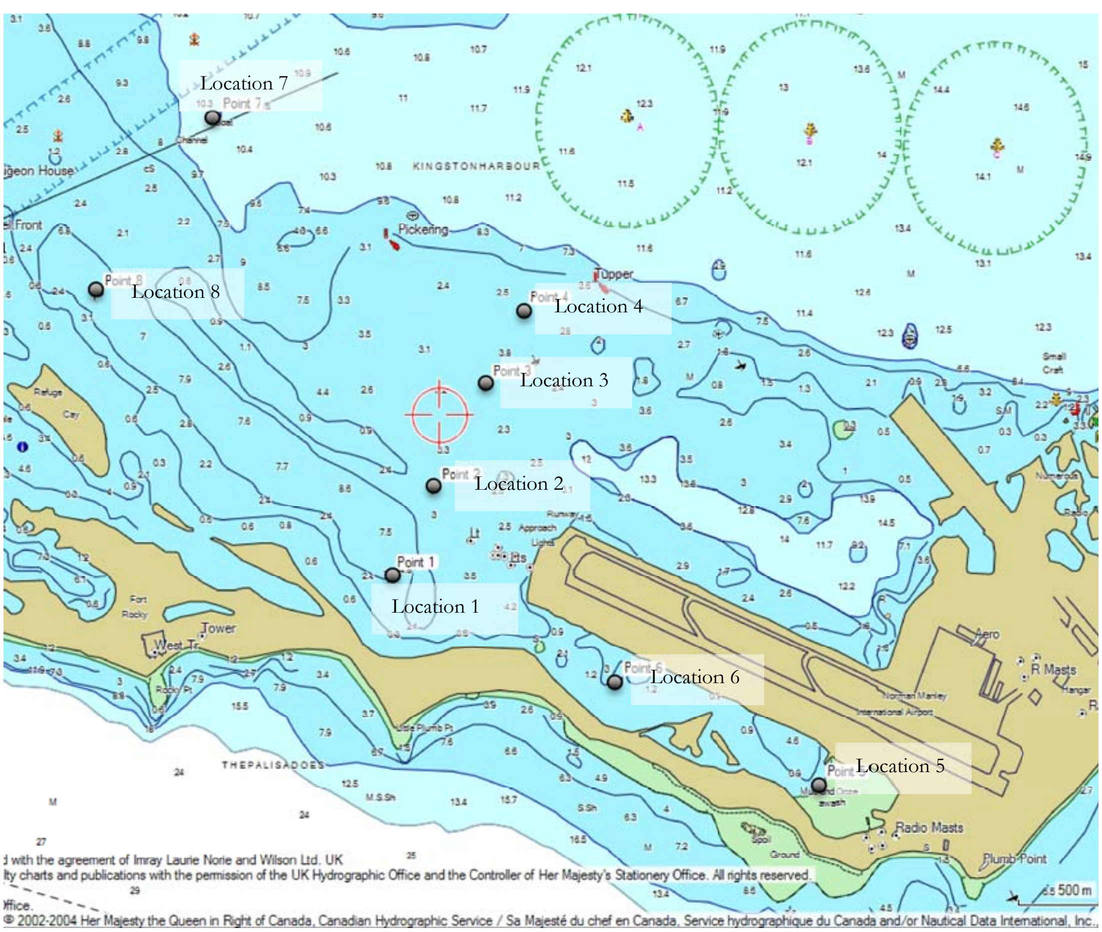


Figure 14 Location of the 8 comparison points

Figure 15 shows the 11 locations where tracers were released into the environment to investigate the visual impact the proposed NMIA expansion would have on the surrounding environment with special regards to the refuge area south of the runway.

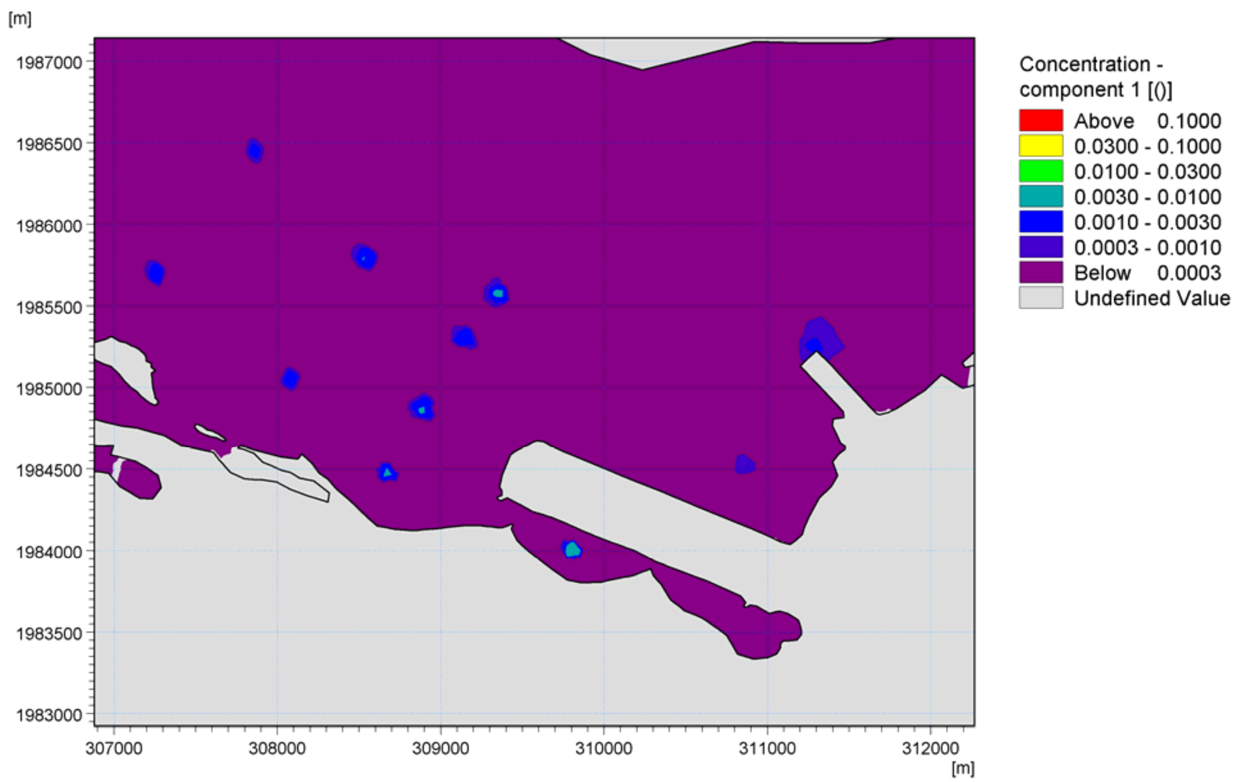


Figure 15 Initial concentration of tracer at 11 locations

3.1 Neap Tidal Conditions

The neap tide simulation period used in the investigation of impacts was from the 30th August 2012 to 9th September 2012 as shown in Figure 16.

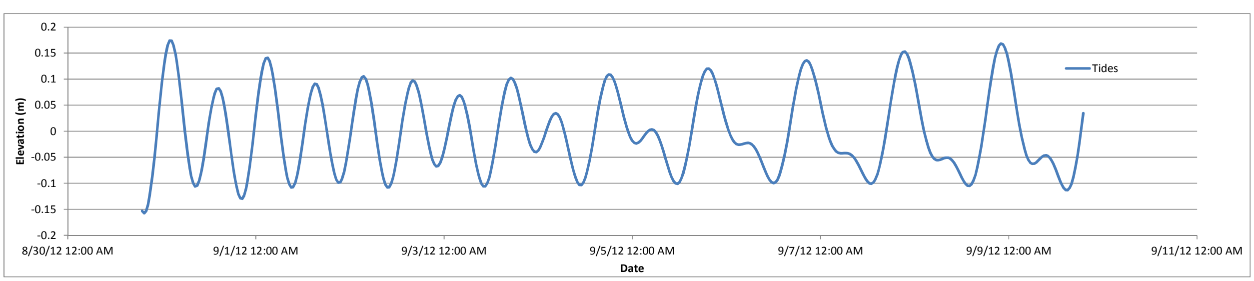


Figure 16 Tides used in impact analysis

Hydrodynamic Comparison

This section describes the predicted impact that the proposed runway extension would have on the current speeds at eight locations near the project site as shown in Figure 14. Figure 17 shows the current speed histogram charts for Locations 1 to 4.

Location 1 shows a slight increase in current speed with the proposed extension and dredged area. This slight increase could be due to the extended runway creating a slight contraction of flow area, which in turn would result in a slight increase in the current speeds at Location 1.

As expected, a noticeable change in current speed is predicted to occur at Location 2, as the runway extension will alter the hydrodynamics within this area due to the runway now being much closer to this comparison point. At Location 2, the extended runway reduces current speeds within this area.

At Location 3, the water depth has increased from an average depth of around 4.5m down to an average depth of 10m due to the volume of material taken from the borrow site to extend the NMIA runway. This is predicted to lead to a decrease in current speeds at this location, as the existing average current speed is 34 mm/s and the proposed speed is 27.6 mm/s, as expected.

Location 4, which is the further away from the proposed changes, shows negligible impacts to the current speeds as shown in Figure 17.

Figure 18 shows the current speed histogram charts for Locations 5 to 8.

At Locations 5 and 6 it is expected that there will be some impacts as the runway has been extended by 500m and could block the circulation in this area. However, the hydrodynamic model shows that this is not actually the case, as both existing and proposed current speeds for Locations 5 and 6 are nearly identical. The reason for this is that current speeds are very low in this area, therefore there is already only a minimal transfer of momentum into the refuge area, especially during a neap tidal cycle such as that being simulated.

Location 7, which is located in a water depth of approximately 10m, also shows negligible change in current speeds between existing and proposed conditions. It can be said with a high degree of certainty that this area will not be impacted by the proposed works.

Location 8, which is directly in line with the runway, shows a slight decrease in the average current speeds, from 28.3 mm/s for the existing conditions to 25.4 mm/s for the proposed conditions. These changes in current speeds, however, should not have a major impact on the surrounding environment.

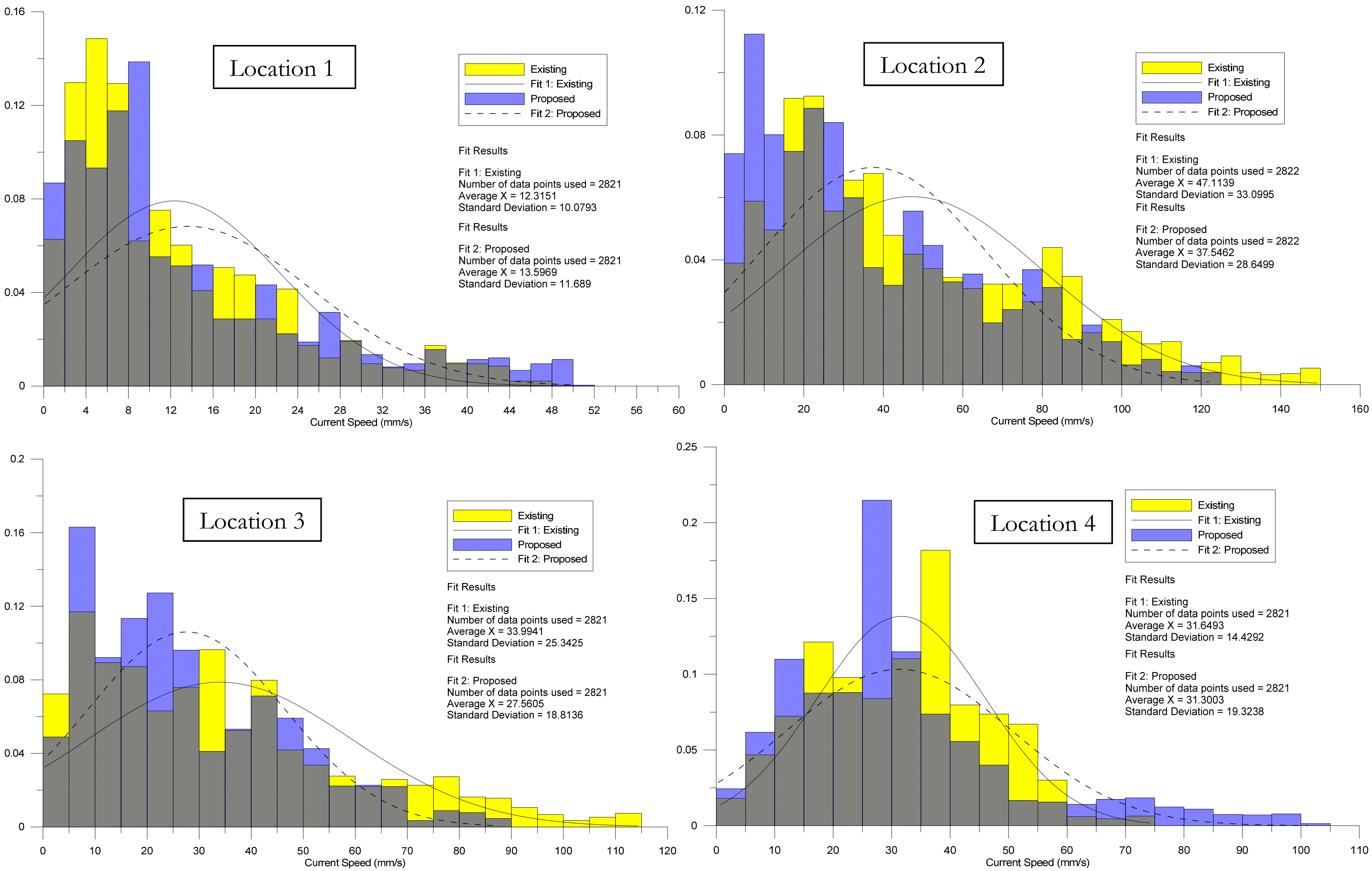


Figure 17 Current speed comparison histograms between existing and proposed at locations 1 to 4

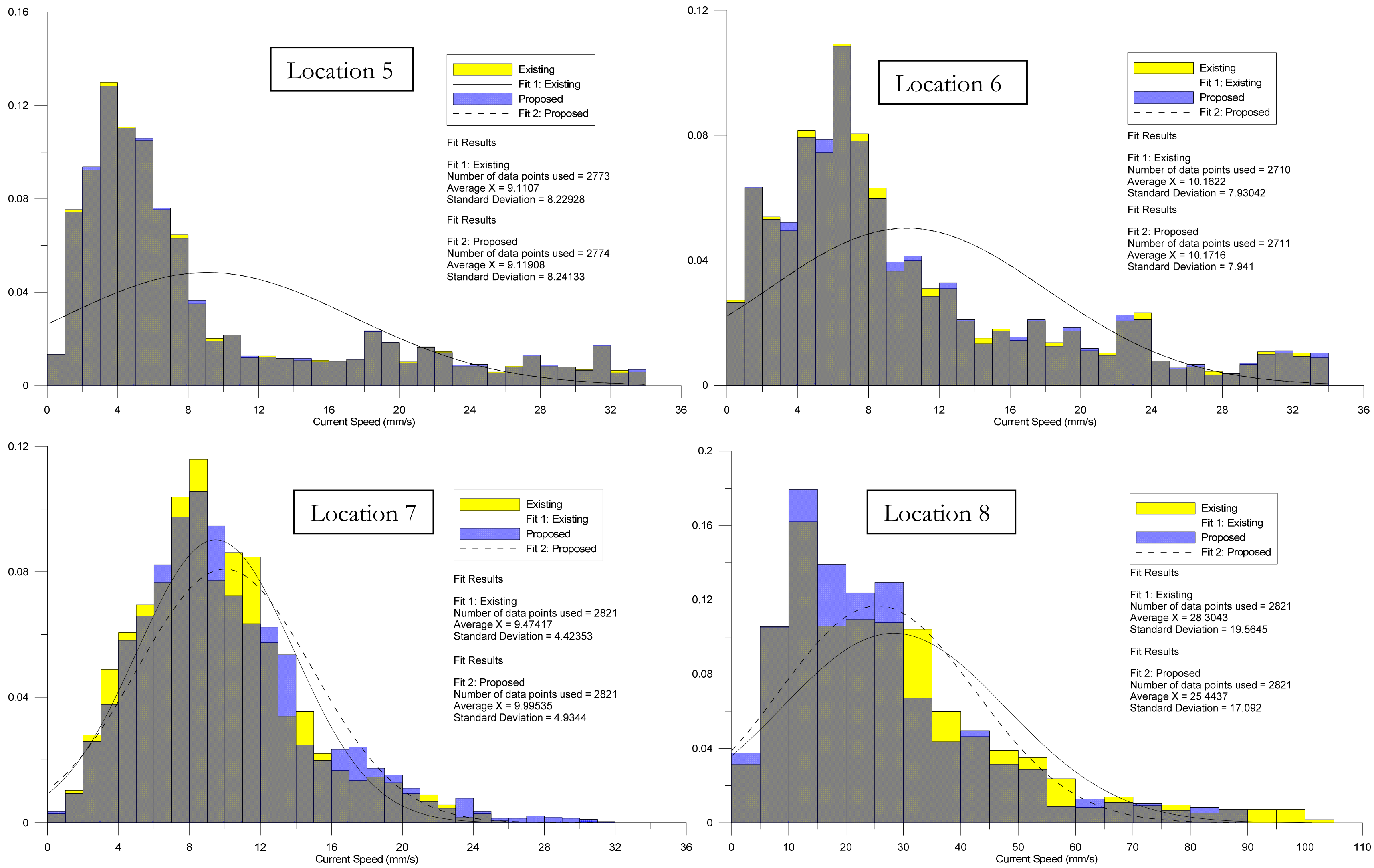


Figure 18 Current speed comparison histogram between existing and proposed at locations 5 to 8

Visual Comparison

This section examines how the proposed runway extension impacts the hydrodynamics over a 9-day neap tide simulation. The purpose is to provide a visual comparison of the existing and proposed conditions over the model domain by using tracers as they spread throughout the Kingston Harbour.

Figure 19 shows the distribution of the tracers after 24 hours of simulation. The model shows higher tracer concentration at the end of the proposed runway compared to existing conditions. With respect to the refuge area, there are no noticeable changes in tracer concentration patterns.

Figure 20 shows the tracer concentrations after three days of simulation. The model shows no noticeable changes in the tracer concentration maps except to the south of the proposed runway expansion where the proposed tracer concentration is higher than the existing condition.

Figure 21 shows that after six days, the proposed tracer concentration is higher than the existing concentration along the southern coast of Kingston Harbour.

Figure 22 shows the results at the end of the 9-day neap tide simulation and the overall noticeable change is limited to an area at the south tip of the proposed runway extension where the concentration is consistently higher. This means the currents within this area are altered in such a way that is somewhat inhibiting the movement of water out of this area compared to the existing conditions. The impacts seem to be limited to the southern shoreline of Kingston Harbour from the tip of the proposed runway to Rosey Hole. There are no other noticeable impacts of the proposed dredge borrow area and runway extension within Kingston Harbour.

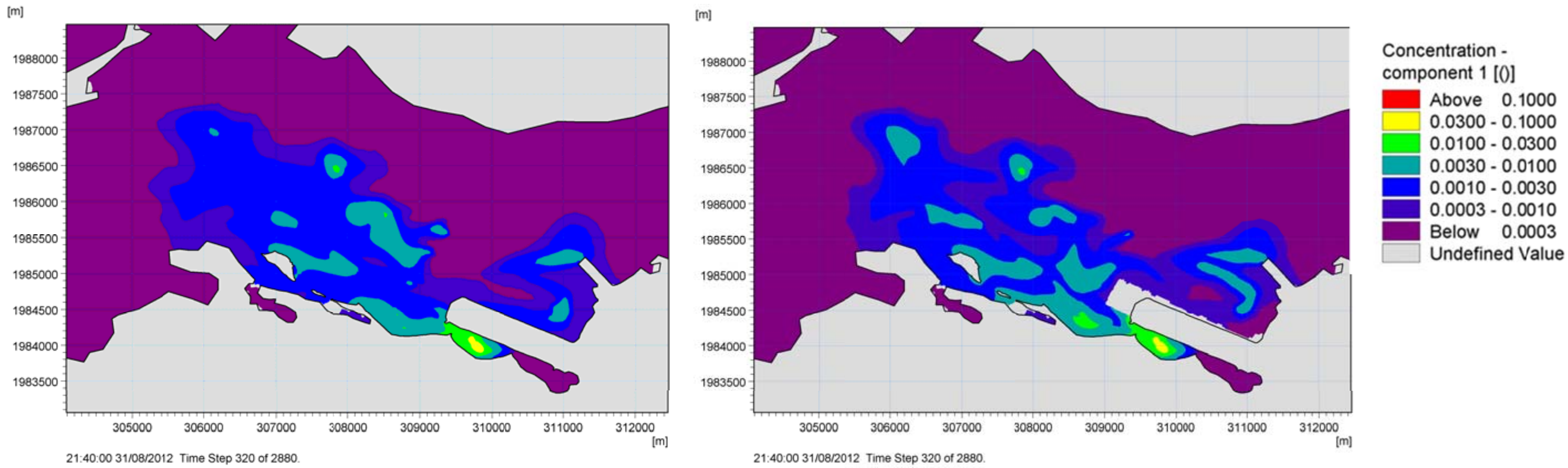


Figure 19 One day after start of neap tide simulation, existing condition on the left and proposed on the right

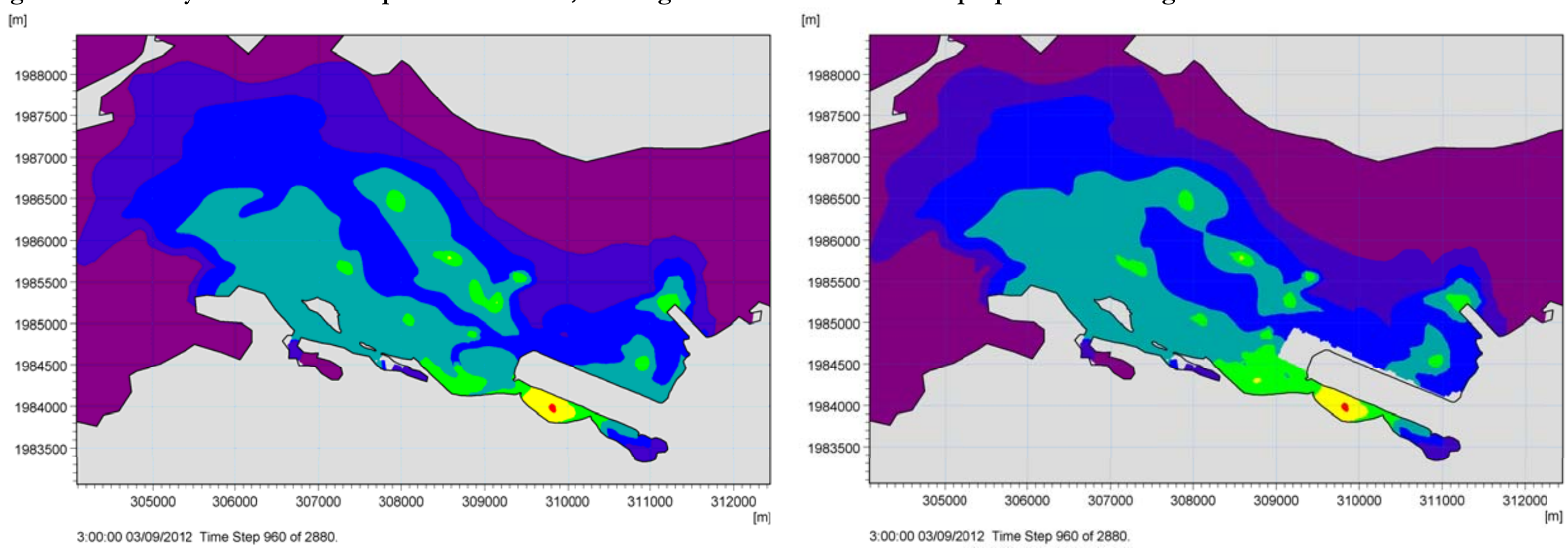


Figure 20 Three days after start of neap tide simulation, existing condition on the left and proposed on the right

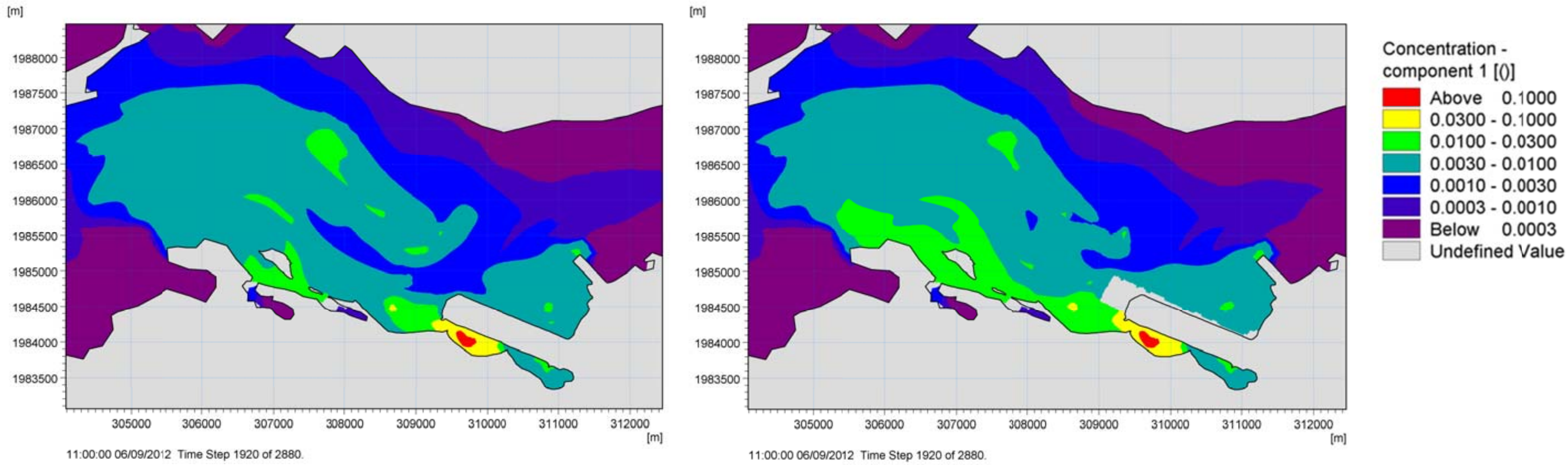


Figure 21 Six days after start of neap tide simulation, existing condition on the left and proposed on the right

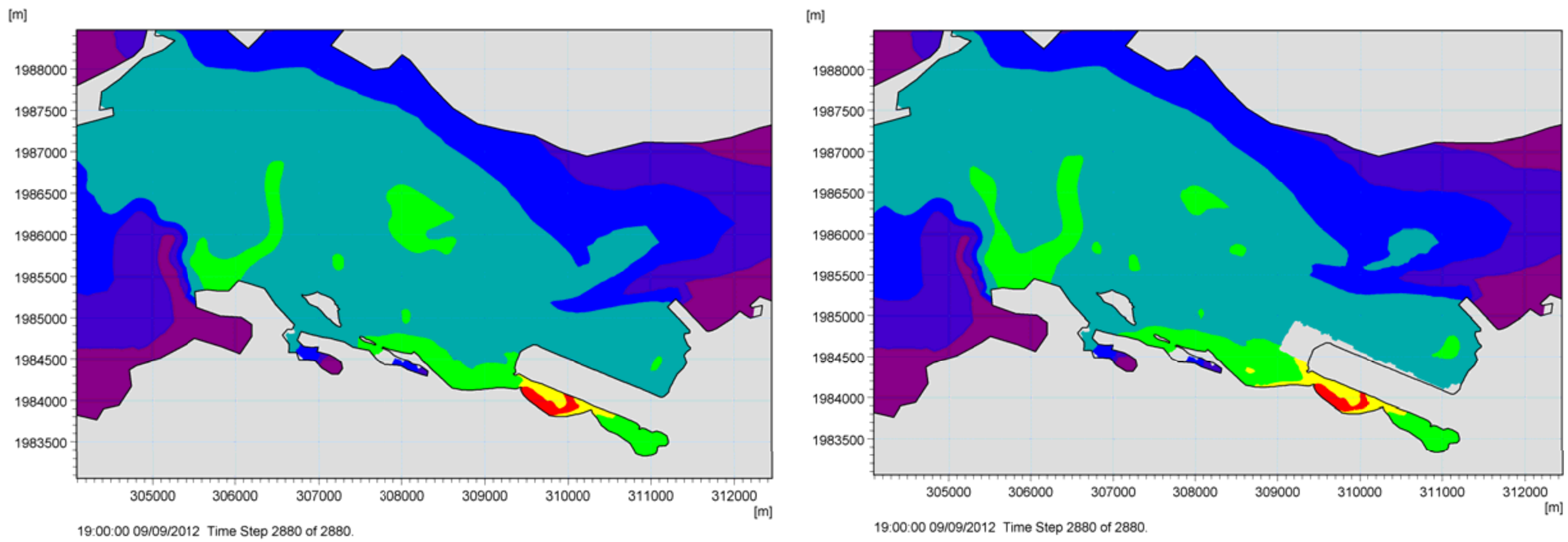


Figure 22 End of 9-day neap tide simulation, existing condition on the left and proposed on the right

3.1 Extreme Analysis

This section compares extreme event-driven impacts for existing and proposed conditions. The impacts were evaluated in terms of changes in the waves, storm surge and bed level change patterns.

Wind Speeds

A previous study carried out by Smith Warner International Limited (SWI) provided extreme wind speeds that are predicted to occur within the Kingston Harbour. A directional analysis was completed such that the wind speeds were filtered into three significant directional bins: north-north-west, north-north-east, and east-north-east. Given the project location relative to the Palisadoes, winds approaching from the other directions will not have a critical effect. The results from the previous study indicate that the highest wind speeds are from the NNE to the ENE sector as shown in Table 1.

Table 1 Results of Statistical Hurricane Analysis

	North-north-west (315 - 360)	North-north-east (0 - 45)	East-north-east (45 - 90)
Return Period (years)	**Wind Speed (m/s)**	**Wind Speed (m/s)**	**Wind Speed (m/s)**
5	7.0	10.7	17.0
10	14.7	20.3	24.5
25	22.6	30.1	32.2
50	**27.7**	**36.5**	**37.2**
100	32.3	42.1	41.6

Water Levels

As with wind speeds, water level rise due to inverse barometric rise (IBR) associated with the eye of a hurricane, global sea level (GSL) rise and high tides were also computed by SWI in previous studies within Kingston Harbour and are shown in Table 2.

Table 2 Computed Water Level Values

Return Period (years)	IBR (m)	GSL (m)	Tide (m- above MSL)	Water Levels (m)
5	0.09	0.0	0.3	0.39
10	0.18	0.125	0.3	0.605
25	0.32	0.125	0.3	0.745
50	0.43	0.25	0.3	0.98
100	0.56	0.25	0.3	1.11
150	0.63	0.25	0.3	1.18
200	0.69	0.50	0.3	1.24

The NMIA runway is located on the lee side of the Palisadoes strip, which is at the south end of Kingston Harbour. The site is protected from hurricane waves approaching from the Caribbean Sea by the sand dunes along the Palisadoes strip. It is, however, vulnerable to waves generated inside the harbour. This modeling exercise is therefore intended to compare both existing and proposed layouts under extreme climate conditions, based on an analysis of the 50-year hurricane event.

Results of Extreme Event Modeling

The proposed runway extension and dredge area do not appear to have any major impacts on bed level changes, storm surges and wave conditions under event-driven scenarios compared to the existing condition, as shown in Figures 23 to 25. The only noticeable impacts occurring are with the wave heights at the northern tip of the extended runway. There is an increase in wave heights within this area and this is due to the proposed dredge area which allows high energy waves to pass over it.

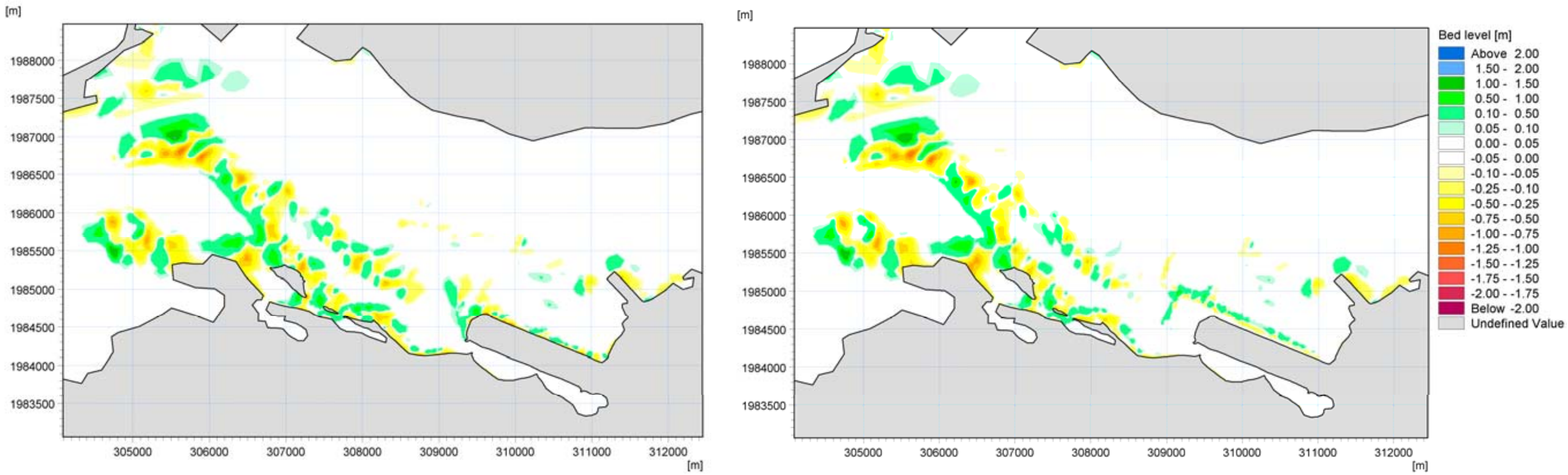


Figure 23 Bed level change from ENE wind direction, existing on the left and proposed on the right

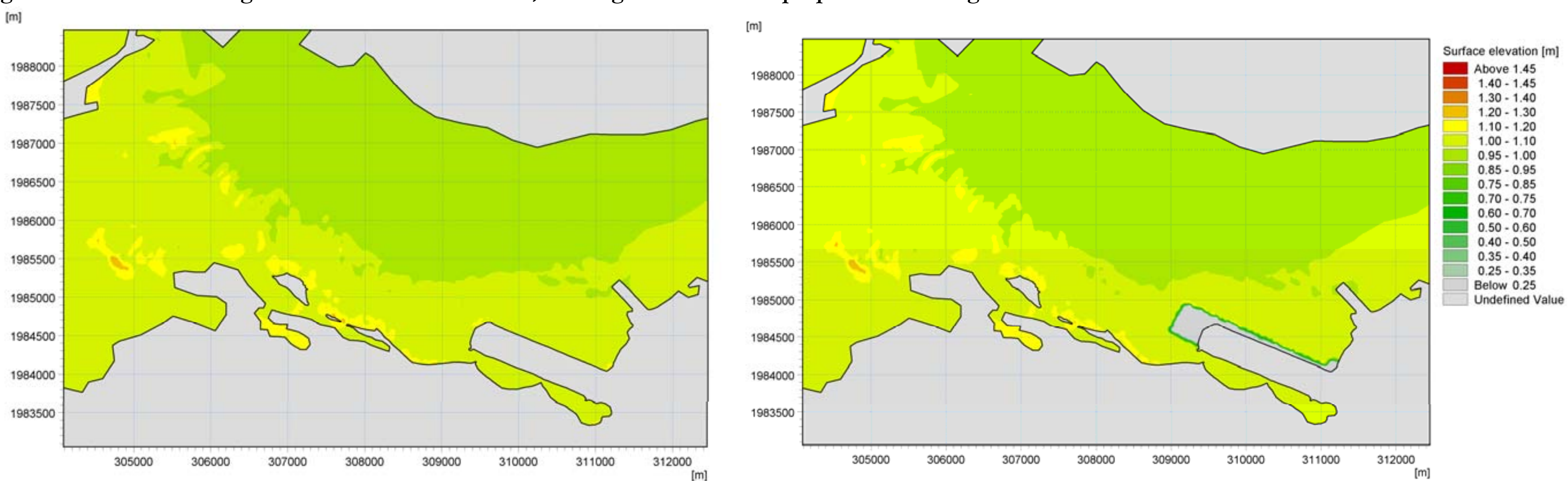


Figure 24 Maximum storm surge comparisons from all three directions, existing on the left and proposed on the right

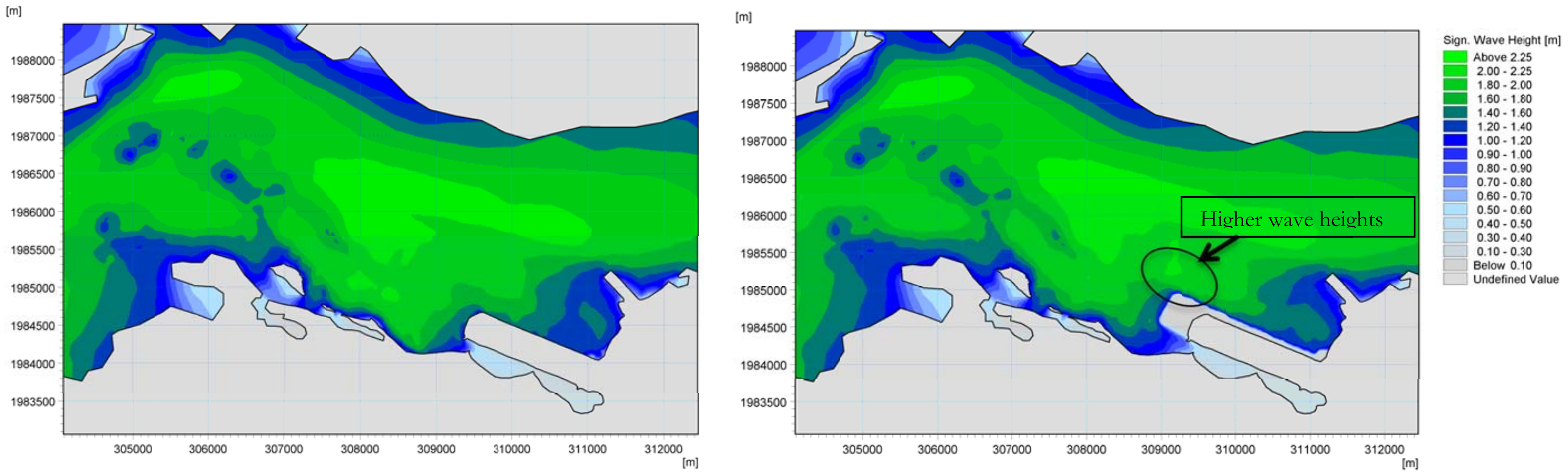


Figure 25 Maximum wave height comparisons from all three directions, existing on the left and proposed on the right

Extreme Flood Modeling

This section examines how the proposed runway extension and dredging would impact extreme flooding within Kingston Harbour. Peak flow rates for the Rio Cobre during the 50-year events were derived by Beckford & Dixon in a previous study within Hunts Bay. Based on the catchment area and the type of rainfall event, the time to peak was of the order of 9-10 hours and the total time for runoff was around two days as shown in Figure 26. A 50-year return period event was also derived for Sandy Gully as shown in Figure 27.

Figures 28 to 31 show the salinity comparison between existing and proposed conditions. The only small difference is at the southern tip of the extended runway where there is an area of slightly higher salinity, only noticeable in Figures 28 and 29.

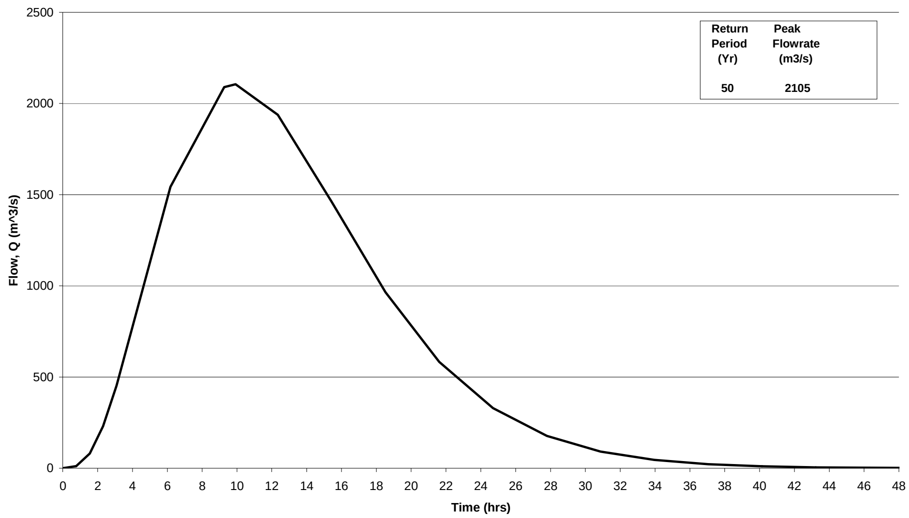


Figure 26 Predicted runoff for the Rio Cobre for a 50 – year rainfall event.

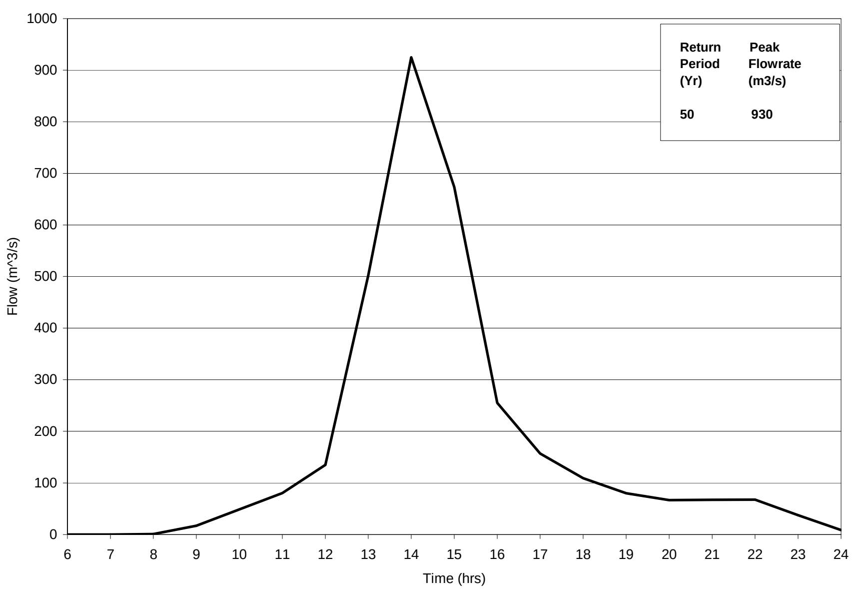


Figure 27 Predicted runoff for Sandy Gully during a 50 - year rainfall event

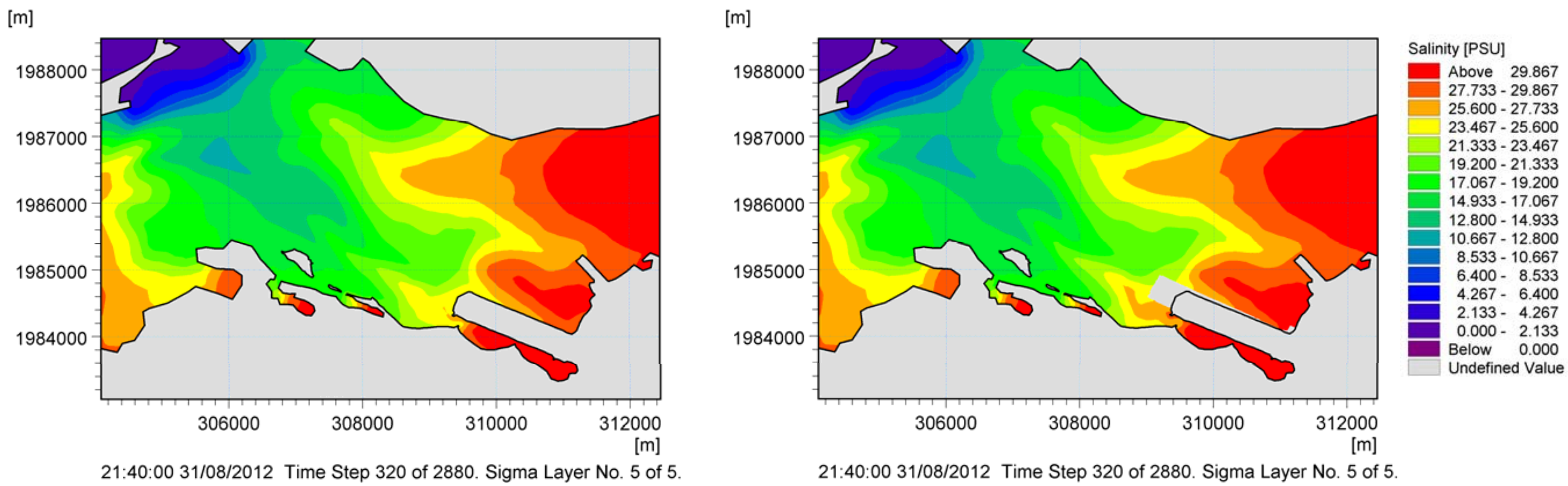


Figure 28 Day 1 of salinity simulation with existing on the left and proposed on the right

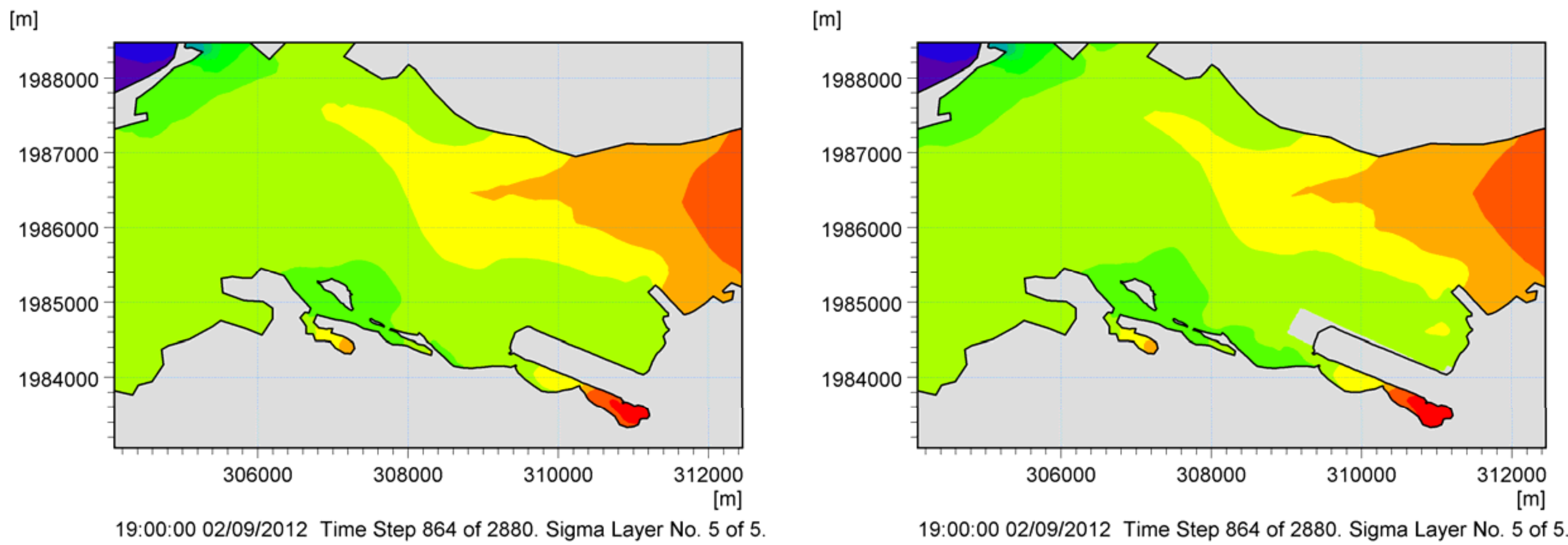


Figure 29 Day 3 of salinity simulation with existing on the left and proposed on the right

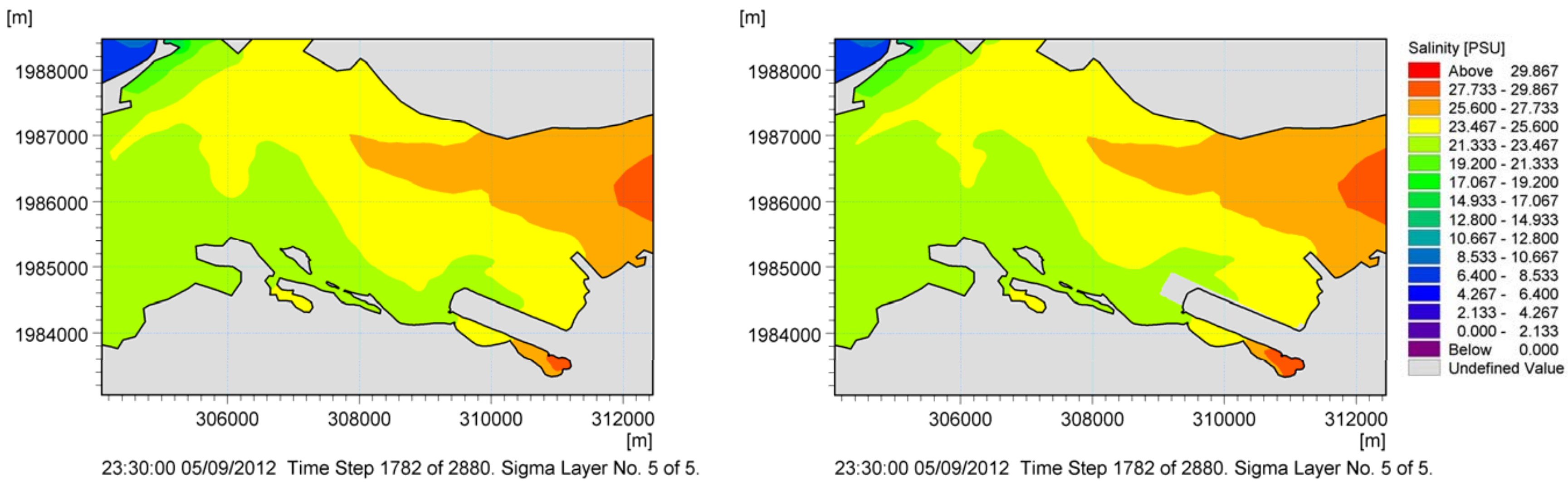


Figure 30 Day 6 of salinity simulation with existing on the left and proposed on the right

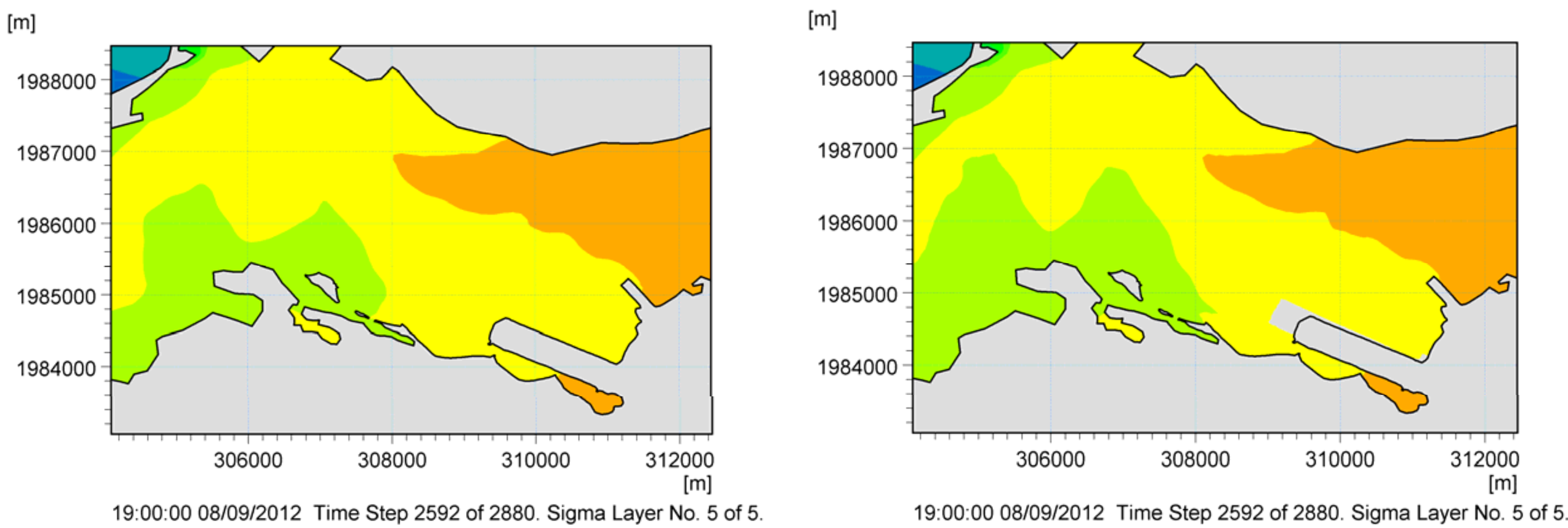


Figure 31 Day 9 of salinity simulation with existing on the left and proposed on the right

3.2 Summary of Impact Analysis

The MIKE 21 HD model was used to examine the impacts that the proposed dredge borrow site and NMIA runway extension would have on the existing coastal environment from the perspective of hydrodynamics and water quality. This section summarizes the results and the impacts under existing and proposed conditions.

- Based on the validation of the hydrodynamic model, it is reliably able to predict mean flow conditions, but appears to underestimate peak velocities. Therefore the model can be considered conservative.
- The model was also validated with previous measured data obtained at the entrance to Hunts Bay. The model showed similar current speeds and directions compared with the measured data.
- Existing conditions were modeled to establish baseline conditions.
- Model results during the 9-day neap tide simulation showed that the current speeds did not vary significantly except at Locations 1, 2 and 3, which are all within close proximity of the proposed runway and dredge borrow area.
- Based on the mean current speeds occurring near the project site, the simulation of sediment transport would have shown little to no change. Tracers were therefore used to obtain a visual impact of how the proposed modifications may impact the ambient surroundings.
- Under extreme hurricane conditions, the model results did not show significant changes to the sediment, storm surge and wave heights.
- Under extreme 50-year flood conditions, the model shows that the difference in the distribution of salinity is minimal and localized.

4 Specific Mitigation Measures

This section describes ways of minimizing any environmental impacts that could occur during construction of the runway and the dredging of the sea bed. The issues of concern relate to the dredge at the borrow site, as well as the dredging or excavation activity itself. The issue related to navigation and the berthing of the dredge is the threat of physical harm and injury arising from collision due to sea accidents. This is discussed further in the following sections below.

4.1 During Dredging

The primary impacts or environmental disturbance would be to the seafloor, the suspension of fine sediments and the re-deposition of coarse fractions. Other possible environmental impacts could be the direct physical destruction of benthic habitat, and attenuation of light, impeding photosynthesis of seagrass, macro-algae and other autotrophs. Mitigation measures are as follows:

- Use of silt curtains at borrow site and ensuring that lower end of silt curtain is resting on the seafloor, and ensuring that top is always above the surface of the sea.

- Monitoring and, where necessary, repairing and/or replacing leaky pipes and faulty couplings of the spoil discharge pipes.
- Decrease time frame over which the dredging operation is to take place, to avoid the daily re-suspension of sediments.
- Ameliorate re-suspension of sediments by confining dredging operations to calmer sea states like in the night when the wind speeds are low within the harbour.

Additional primary impacts could be a decrease in dissolved oxygen and an increase in BOD (biochemical oxygen demand) leading to possible stress and lethal effects on benthic invertebrates and, to a lesser extent, fishes. Completion of dredging operation in as short a time as possible is encouraged.

4.2 Navigation and Berthing of Dredge

Issues include navigational hazards and the threat of injury and possibly death associated with boat and ship traffic. Mitigation measures are as follows:

- Ensure that marker buoys and navigational lights are deployed and activated on the dredge, the sediment curtains and the spoil discharge pipes. Buoys are to be large and brightly coloured, and navigational lights are to be fully operational from 6:00 p.m. to 6:00 a.m. on a daily basis.