Using Dry Ports to Support Nova Scotia's Tidal Energy

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Submitted to: Mr. Rodrigo Menafra

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1 REVISIONS

Number	Date	Description	By	Checked	Approved
Rev 0	June 15/18	Draft report	Hughes Offshore	K. Boudreau S. Murch	J. Hughes
Rev 1	June 21/18	Draft report	Hughes Offshore	K. Boudreau S. Murch	J. Hughes
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Rev 3	Sept 24/18	Final Report	Hughes Offshore	K. Boudreau S. Murch	J. Hughes

TABLE OF CONTENTS

2 DEFINITIONS

Chart Datum	Chart datum is that water level that the sea will seldom fall below it and only rarely will there be less depth available than what is portrayed on the chart.
DP2	Dynamic Positioning Class 2
DWT	Deadweight - tonnes of cargo/consumables able to be carried by a ship
EMEC	European Marine Energy Centre
FEED	Front end engineering design
FORCE	Fundy Ocean Research Center for Energy
FTI	Fundy Tidal Inc
GB	Gravity based
GSINS	Goods and Services Identification Number (Government of Canada)
HW	High Water
LAT	Lowest Astronomical Tide
LCOE	Levelized Cost of Energy
LOA	Length Over All
LW	Low Water
MRE	Marine Renewable Energy
NB	New Brunswick
NM	Nautical Mile (1852m)
NS	Nova Scotia
O&M	Operations and Maintenance
OE	Ocean Energy
OEM	Original Equipment Manufacturer
OERA	Offshore Energy Research Association
OES	Ocean Energy Systems
ORE	Ocean Renewable Energy
OTEC	Ocean Thermal Energy Conversion
ROM	Rough Order of Magnitude
ROV	Remotely Operated Vehicles
SPMT	Self Propelled Modular Transporter
SSB	sub-sea base
t	Metric tonne (1,000kg)
TEC	Tidal energy converter
TISEC	Tidal in-stream energy conversion device
TRL	Technology Readiness Level

3 EXECUTIVE SUMMARY

The Offshore Energy Research Association engaged Hughes Offshore and Shipping Services Inc. for a study of the use of "dry ports" in support of the developing tidal energy industry in the Province (NB: for the purposes of this study, the term "dry port" refers to a port where the harbour bottom is mainly exposed at low tide. It does not refer to the more common use of the term to describe a logistics port inland of a sea port used to increase the logistics capacity of the sea port itself.) (Roso V, 2009)

To date, the tidal industry has deployed large in-stream gravity based tidal device(s) at the Fundy Ocean Research Center for Energy (FORCE) in the Minas Passage. Although the manufacture of the turbines and gravity structures took place in Nova Scotia, the staging area, mobilization, and maintenance works have all been carried out in the New Brunswick port of Saint John. Saint John is an international port with extensive infrastructure and is located 75 nautical miles (NM) from FORCE's tidal testing site in the Minas Passage. The Nova Scotian ports of Parrsboro and Hantsport are located in close proximity to the FORCE site by comparison, being only 5.4 NM and 21.7 NM respectively, from FORCE.

Tidal In-Stream Energy Conversion devices (TISEC's) currently planned to be deployed at FORCE include smaller gravity-based units and moored floating arrays. Developers have indicated that, with the proper infrastructure in place, deployment and (for the longer term) operations and maintenance activities could be carried out from these two Nova Scotia ports.

The study shows, via GAP analysis, that both of the two ports studied presently lack the infrastructure necessary to take fuller advantage of the economic benefits available from the developing tidal energy industry. The single critical gap is the lack of a suitable wharf in either port. The wharf is the interface between the shore side supply chain and the generating power of the tides. Without this interface, the supply chain will develop elsewhere. Tidal development centres in other countries have recognized suitable wharves in close proximity to the tidal sites as the necessary link for development, and have committed significant public funding mechanisms to appropriate wharf construction/upgrades.

Proximity to the FORCE development site offers significant and varied benefits to the tidal energy developers. Marine operations for deployment, operations and maintenance, are cost-for-time operations. Reduced transit times offer cost efficiencies, particularly for repetitive maintenance and inspection operations. The economic impact of unplanned maintenance events can also be reduced with suitable marine assets stationed in and operating from these ports. In order to make this scenario an attractive alternative for vessel owners, operating time and an assurance of sustainable revenue is required.

Conclusions from the study include:

1. The dry ports of Hantsport and Parrsboro can offer economic benefits in terms of reduced operating and/or deployment costs to developers deploying tidal devices in the Minas Passage. These cost reductions could be significant. Cost savings to developers can be realized by operating closer to the deployment site. This enables a reduction in one of the two major project cost components, namely the marine transit costs (see section 8.1).

2. The primary requirement for developers to consider being able to operate from these ports will be the provision of a suitable wharf from which operations can be conducted. This is an essential first step.
3. There is no available data supporting a business case that would make it reasonable to expect stand-alone private investment in new wharves at this pre-commercial stage of the tidal industry in Nova Scotia.
4. Funding assistance for the repair and/or upgrade of the two private wharves (one in Parrsboro, one in Hantsport) should be urgently explored with each respective wharf owner. There is no business case at the current development/pre-commercial stage of the tidal industry for private investment in wharf upgrades. Wharves are essential for any economic activity in the ports studied. It will thus require a model similar to those successfully used globally where government investment in infrastructure upgrades has proven to be the catalyst for further economic activity in this sector.
5. FORCE is the lead agency for tidal energy research in the Minas Passage. This role might be advantageously expanded to managing the operational requirements of developers as they apply to the wharf and potential shared vessel(s), as well as investigating cost sharing or synergies between developers with respect to other assets, resources, equipment, data, and knowledge. FORCE is well positioned to leverage previous investments in order to explore the potential benefits of coordinating developers defined vessel needs (with their own) to meet arising operations, environmental, and maintenance requirements.
6. Engage with other marine based industries to investigate additional uses that could drive parallel economic development in the port.

4 Introduction and Objectives

This study intends to determine the potential economic benefit to industry of using the dry ports of Parrsboro and Hantsport for future Operations and Maintenance activities for tidal developers. Infrastructure deficiencies, if they exist, that would make the ports potentially attractive to developers will be identified. The study intends to indicate both the operational cost differential between Saint John and the studied dry ports, as well as provide indicative estimates of the capital investment that may be required in the two ports to attract the operations and maintenance business of the tidal developers going forward.

The use of dry ports by the marine sector is certainly not intuitive. However, ports that do indeed "dry out" at low tide have been used successfully for commercial activities. The fishing industry in Europe is no stranger to using dry ports, working with the schedule dictated by the tides, and ensuring vessel and wharf designs are suitable.

Ports in the Canadian Arctic experience dry port conditions, Iqaluit being a prime example. Here, the tidal range is not dissimilar to the Bay of Fundy (10-11m range) and access to the port is complicated by a harbour that is dry. As re-supply is essential, innovative thinking has derived working solutions because they offer the most economic benefit. This too, is becoming a shared characteristic of the tidal industry.

FIGURE 1: CARGO DISCHARGING IN IQUALUIT

5 NOVA SCOTIA'S DRY PORTS

Nova Scotia has two ports in the general vicinity of the Minas Passage, namely Parrsboro and Hantsport. Both ports lie within 25 nautical miles (NM) of the Fundy Ocean Research Center for Energy's' (FORCE) tidal test site. Both ports have a previous history of significant commercial activity in the export trade. This activity flourished despite the extreme tidal nature of the ports causing the harbour bottom to "dry" out at low tide.

The port of Hantsport is 21.7 nautical miles from the FORCE site. Hantsport served as the export hub for bulk gypsum shipments by sea up until 2011. Vessels loading from this port at that time were designed to carry up to about fifty thousand tonnes of cargo. The following data provides a comparison between gypsum vessels calling in Hantsport, and a typical heavy lift ship used for transporting large tidal turbines similar to those currently installed at the FORCE facility.

Gypsum vessel

DWT: 52,000 metric tonnes
LOA: 197.10m
Depth: 17.75m
Draft: 9.75m
Beam: 32.20m

Heavy Lift Ship

DWT: 14,800 metric tonnes
LOA: 153.44m
Depth: 11.95m
Draft: 9.10m
Beam: 23.20m

Cargo operations in Hantsport were adapted to the existing tidal conditions, and loading was carried out via two conveyors with a capacity of 10,000 tonnes/hour each. The vessels would arrive in a lightship condition (minimum draft) and load immediately upon arrival, departing on the high tide some 3 to 4 hours later. Bulk gypsum was transported to the facility by rail. Of note: the significant investment in the port infrastructure by United States Gypsum Corporation was made due to the port being close to the mines producing the raw material; challenges faced by marine operations from the port were deemed secondary and managed to the economic benefit of the company.

The port of Parrsboro is the closest port to the FORCE site in the Minas Passage, with a dock to FORCE site distance of 5.4 nautical miles. Though once a busy commercial port with cargos of lumber, pulpwood and coal regularly exported from various wharfs, the port is now serviced by a single remaining wood pile/concrete decked wharf which accommodates a small fishing fleet during the season. Due to its' proximity to the FORCE site, the port of Parrsboro has served as a base for the laying of the FORCE data cable, and more recently as a wharf from which personnel transfers can occur during certain O&M and installation activities, giving operators some options other than beach landings.

5.1 Description

The general layout of the ports of Hantsport and Parrsboro has been well described in previous studies undertaken by the Offshore Energy Research Association of Nova Scotia (OERA). (Allswater , 2016)

5.1.1 Authority

The ownership and governance of the port facilities differs between Hantsport and Parrsboro. This may certainly be relevant for tidal developers as they explore the utility of the two dry ports being studied and is thus worthy of introduction.

The Canada Marine Act **S.C**. 1998, c. 10, (Transport Canada, 2018) defines certain ports in Canada as being public ports, where such ports serve the commercial activities of the port community. The activities in public ports are overseen by Transport Canada through the relevant regional office, irrespective of whether the Government of Canada owns or operates facilities within the port limits. In addition, the Minister may set certain user fees with respect to the port. Under the Public Ports and Public Port Facilities Regulations SOR/2001-154, Hantsport is currently a designated Public Port. The port includes "All the navigable waters, including any foreshore, of the Avon River south of a line drawn between the fog signal at Horton Bluff and Indian Point.". However, it should also be noted that, as of May 9, 2018, Hantsport is listed in Schedule 3 of the Regulations as <u>intended</u> to have its' public port designation repealed once port ownership is transferred "to a person or body by Her Majesty in Right of Canada as represented by the Minister of Transport". Transport Canada confirms that there is no government owned facility in Hantsport, but nonetheless the port operates as a public port, and relevant regulations remain applicable.

Canadian Coast Guard indicates that all floating aids to navigation have been removed from the Avon River and approaches as it is no longer considered a commercial waterway. Surveys of the Avon River have also been discontinued.

The most suitably positioned wharves to support the tidal industry in Hantsport are privately owned by Minas Basin Pulp and Power Company.

The administration and ownership of the port of Parrsboro was handed over from Transport Canada in 2000, under the Port Asset Transfer Program, to the Parrsboro and Area Harbour Commission. The Harbour Commission is a volunteer not-for-profit organization within the Municipality of Cumberland, and exercises local ownership, control, and management of the wharf. The Commission has a 10-member board of directors. With the port administration handed over to the Commission, the regulations governing public ports are no longer applicable. Developers desiring to make use of the port in Parrsboro would liaise directly, and only, with the board of the Commission.

5.1.2 MARINE ACCESS

5.1.2.1 HANTSPORT

(Population 1,560 Statscan 2016 census)

The chart for Hantsport (4140; Edition 2002-11-15) is based upon survey data from 1969 with soundings in feet. The passage from the wharf to the outer bay with good water depth (> 10m at LW) is approximately 7.7 nautical miles. Tidal heights range from chart datum to 14.8m above chart datum.

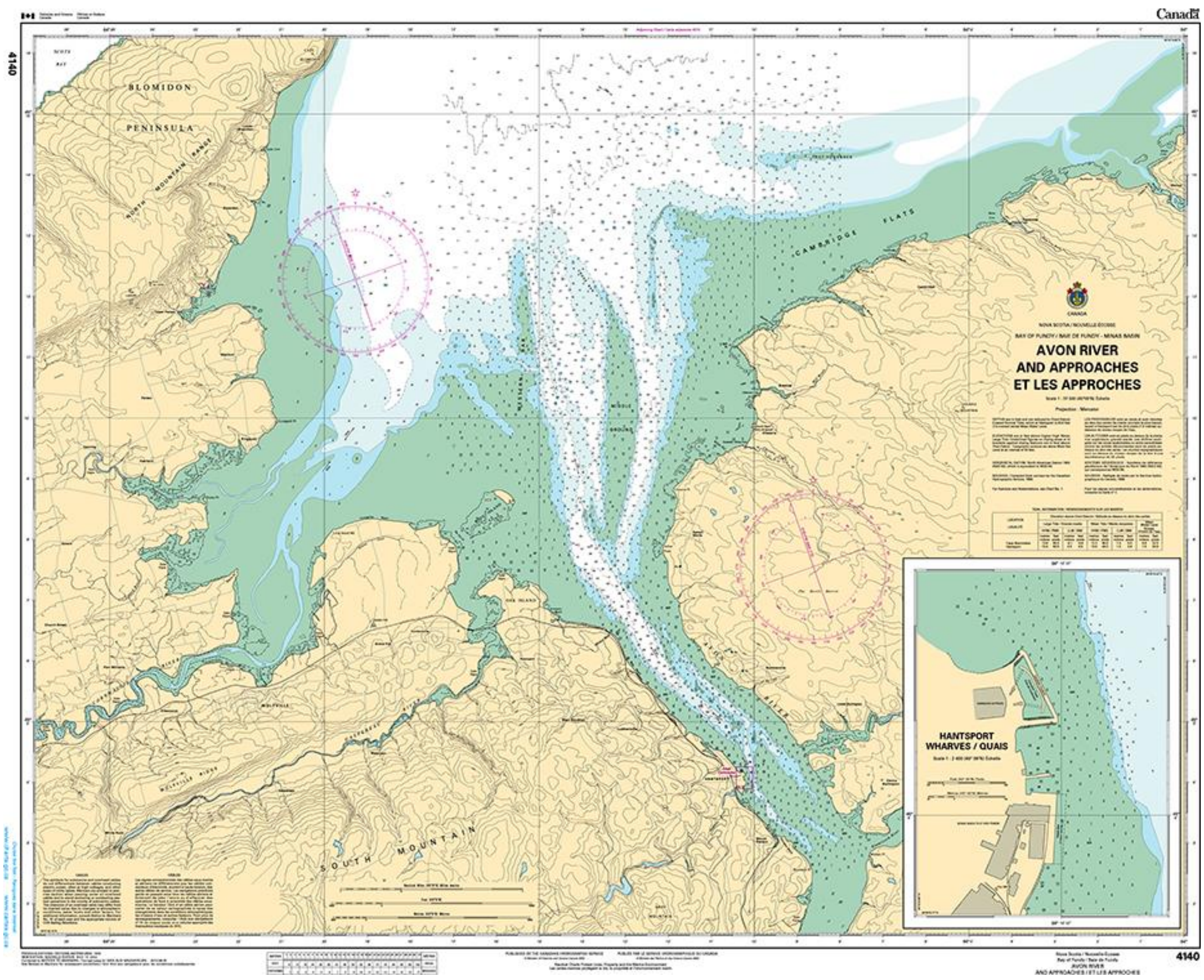

FIGURE 2: CHART OF HANTSPORT & APPROACHES

At low water the wharves of Minas Pulp and Paper and the adjacent US Gypsum facility dry completely, though the depth in the channel some 200m off the face of the wharf remains at or above chart datum. This unique feature may offer tactical benefits to developers through production or operation and maintenance and will be discussed in more detail, herein.

The prevailing winds are south westerly in the summer, and winds from the west and northwest predominate in winter. Fog on the Avon River is uncommon. Due to the freshwater nature of the river, icing is common in the winter. Pilotage on the Avon River is non-compulsory. Local knowledge would be well sought/advised as part of any marine planning for operations from the wharf in Hantsport.

From a marine operations perspective, it is about 2 NM from the wharf to a minimum depth of 10m at LW. By extension and using the vessel details shared earlier in this study, a vessel would need to be moored 2 NM from the wharf to ensure sufficient keel clearance at LW. As the tide will flood at up to 3.5 knots, this means that it can take an hour for a slower tug/barge to make the 10m depth on the flood tide upon departure from the berth. Thus, if the vessel is not able to safely ground out at LW, the time alongside the wharf will be limited by the tidal cycle and must be carefully considered. Depending on the draft of the vessel/barge/unit, time alongside might be a few hours on either side of HW where it can lie alongside the wharf afloat and still be assured of being able to reach safe water.

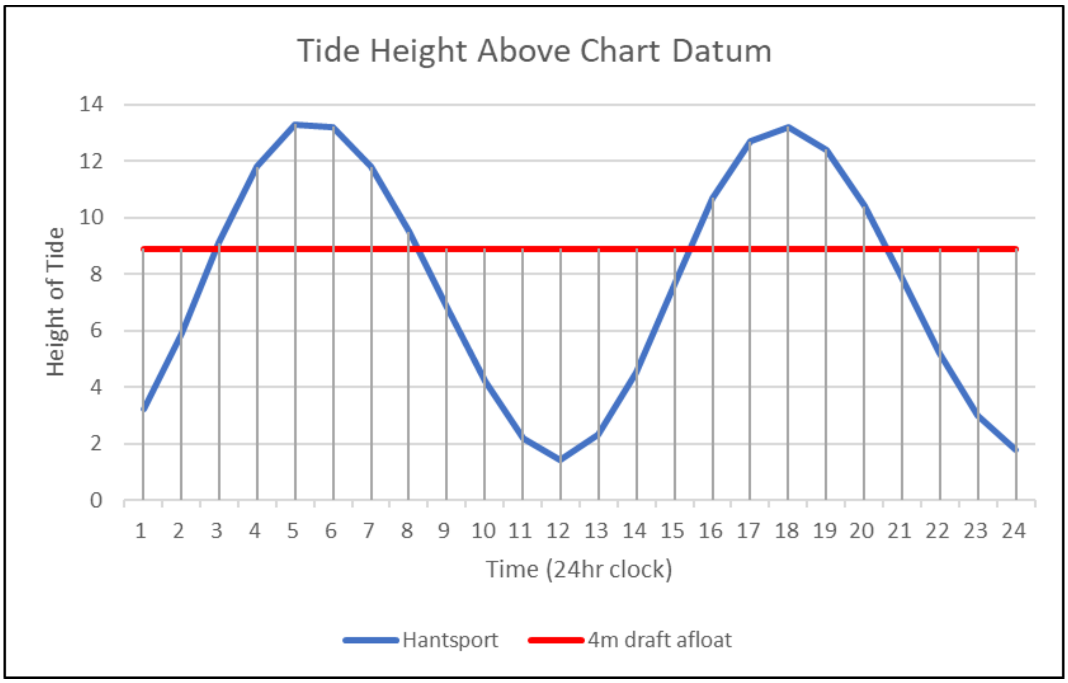

FIGURE 3: WATER DEPTH ALONGSIDE HANTSPORT WHARF

By way of illustration, a barge/vessel requiring 4m of water depth alongside could be berthed safely (on arbitrarily selected date of 1/8/18 ADT) from 1530hrs until 2030hrs, for a time alongside of **5h 00m**. Given the nature of the channel and proximity to the berth, it would be expected that they could be alongside for this period.

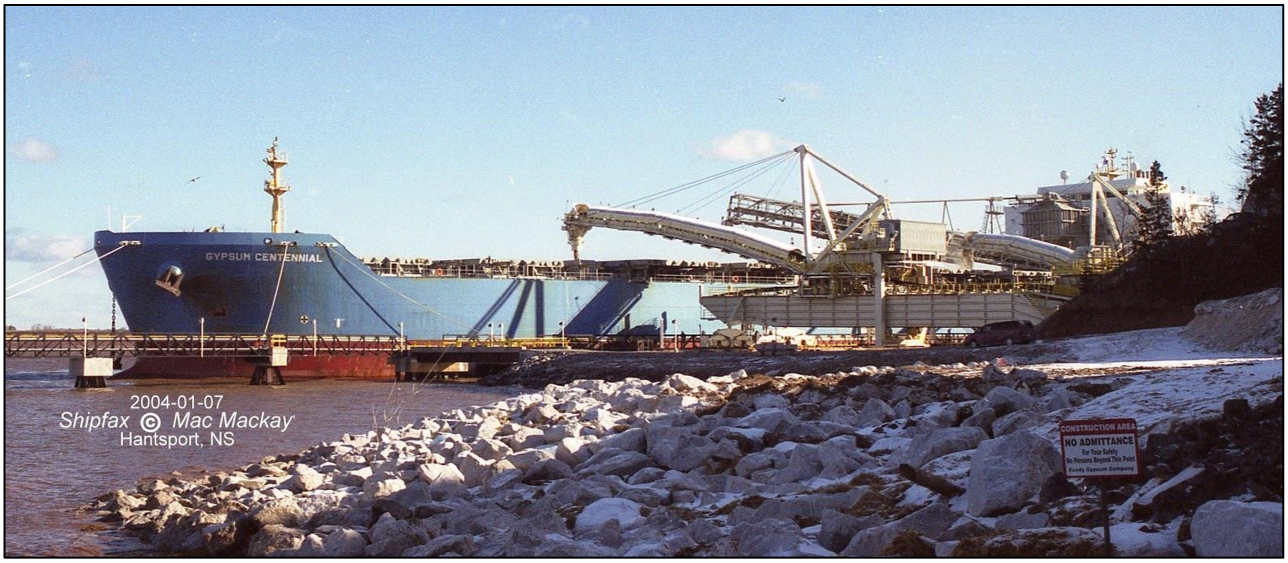

FIGURE 4: BULK CARRIER IN HANTSPORT 2004 (PHOTO CREDIT SHIPFAX / MAC MACKAY)

FIGURE 5: TUG DRIED OUT A/S NORTH END OF MP&P WHARF HANTSPORT (PHOTO CREDIT SHIPFAX / MAC MACKAY)

FIGURE 6: MP&P WHARF SHOWING BED FOR SHIPS TO BOTTOM OUT ON

5.1.2.2 Parrsboro

(Population 1,205 Statscan 2016 census)

The Canadian Hydrographic Services chart for Parrsboro (4399; Edition 2002-08-23) is based upon a 1941 survey with amendments. The passage from the Parrsboro wharf to the outer harbour beyond the area which dries at LW is approximately 1NM, and from the wharf to a chart datum of 30 feet (9m) is 1.9 NM. Tidal heights in the area range from chart datum to 13.5m above chart datum. The difficulty with the entrance and departure from Parrsboro is that the distance from the wharf to chart datum is almost a mile.

FIGURE 7: COASTAL VESSEL AT THE PARRSBORO WHARF (PHOTO CREDIT HARBOUR CPOMMISSION)

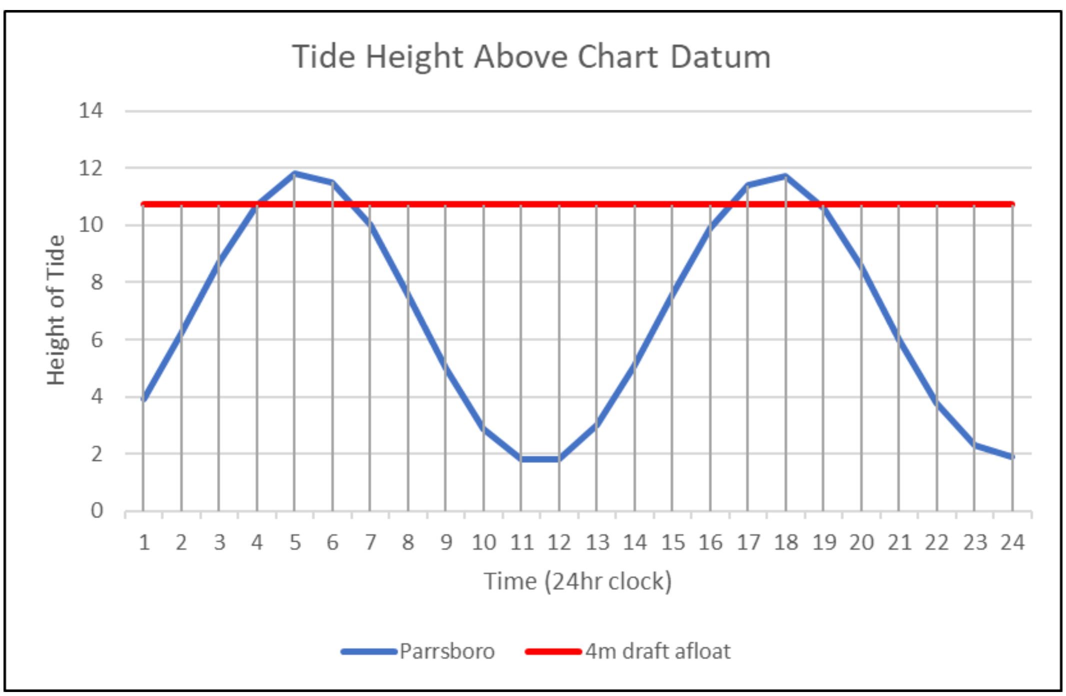

FIGURE 8: WATER DEPTH ALONGSIDE PARRSBORO WHARF

By way of illustration, a barge/vessel requiring 4m of water depth alongside could be berthed safely (on arbitrarily selected date of 1/8/18 ADT) from 1545hrs until 1715hrs, for a time alongside of **1h 30m**. However, given the nature of the harbour approaches, the operator would have to wait until there was 4m of water depth at the bar entering the port. Allowing 15 minutes to transit this area in each direction this reduces the time alongside by approximately 30 minutes, reducing the time alongside (afloat) to **1h 00m**.

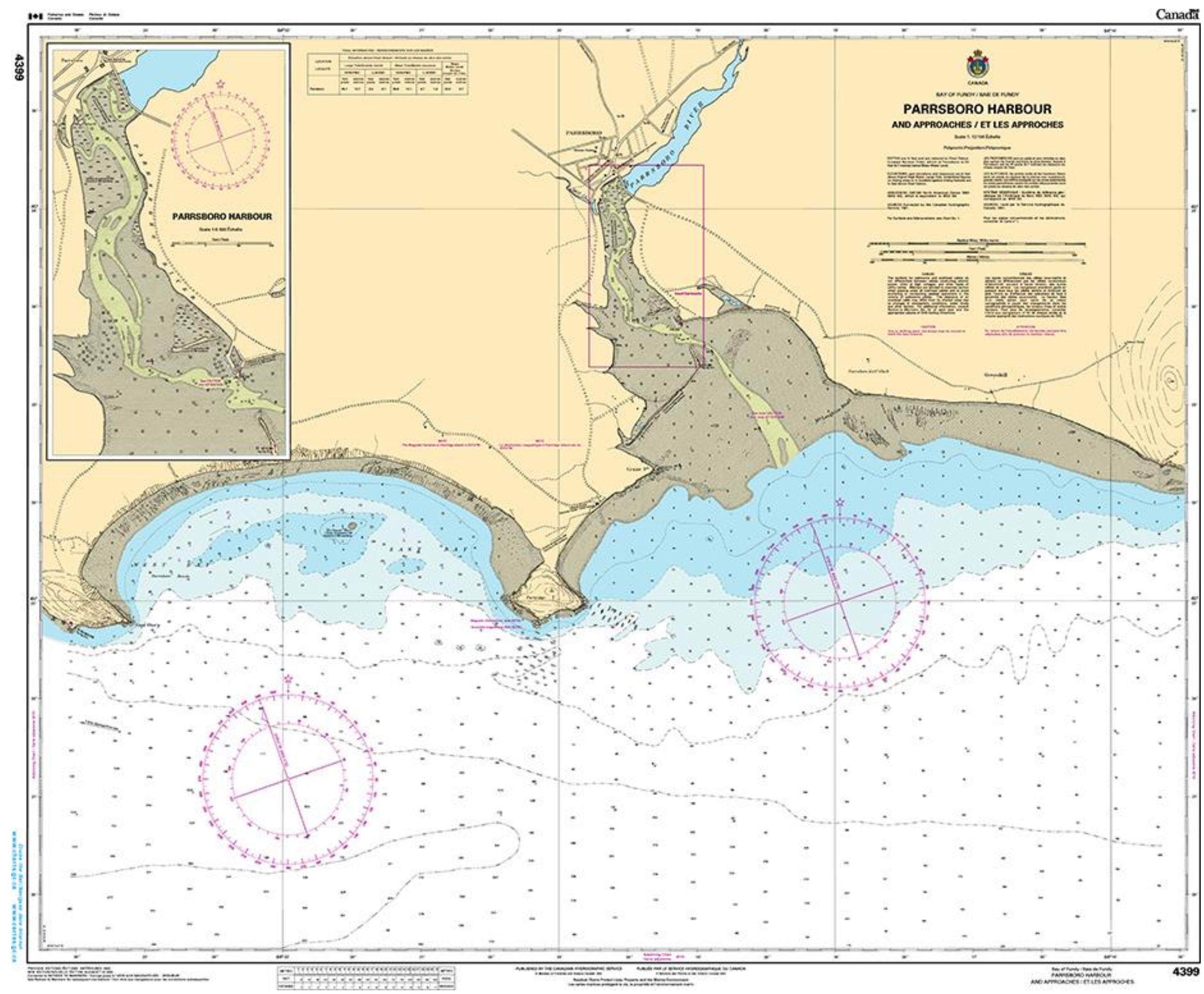

FIGURE 9: CHART OF PARRSBORO & APPROACHES

5.1.3 Road Access

5.1.3.1 Hantsport

The private wharf in Hantsport is accessed via a 100 series highway to a two-lane connector and Route 1 road leading into the town, which then follows a municipal paved road to the secure entrance to the Minas Pulp & Power facility.

From Wharf to:	Distance:	Average Travel Time:
YHZ (Halifax International Airport)	Total Distance: 80.7 km (75.9km on 100 series highway).	49 mins
Burnside Industrial Park	69.6 km	46 mins
Container terminal, Halifax	72.8 km	49 mins
Windsor Industrial Park	12.1 km	11 mins

FIGURE 10: HANTSPORT PROXIMITY TO INDUSTRY

Industrial activity is well supported by the supply chain in both the Valley towns and in Halifax Regional Municipality, all within an hour of the wharf.

5.1.3.2 Parrsboro

The harbour commission wharf in Parrsboro is serviced by a paved municipal road leading through town to Route 2; this two-lane paved route leads to the 100 series highway. Route 2 eastbound is approximately 73 km to intersect with Highway 104; westbound via Springhill, the Highway 104 is approximately 55 km.

From Wharf to:	Distance:	Average Travel Time:
YHZ (Halifax International Airport)	Total Distance: 154km (78.3 km on 100 series highway).	1 hour 44 mins
Burnside Industrial Park	178 km	1h 58 mins
Container terminal, Halifax	183 km	2h 02 mins
Amherst	58.7 km	50 mins
Moncton	121 km	1h 26 mins
Truro	93.3 km	1h 15 mins

FIGURE 11: PARRSBORO PROXIMITY TO INDUSTRY

Industrial activity is well supported by the supply chain between towns in Colchester County and the larger centres of Halifax Regional Municipality, Truro, and also Moncton in New Brunswick.

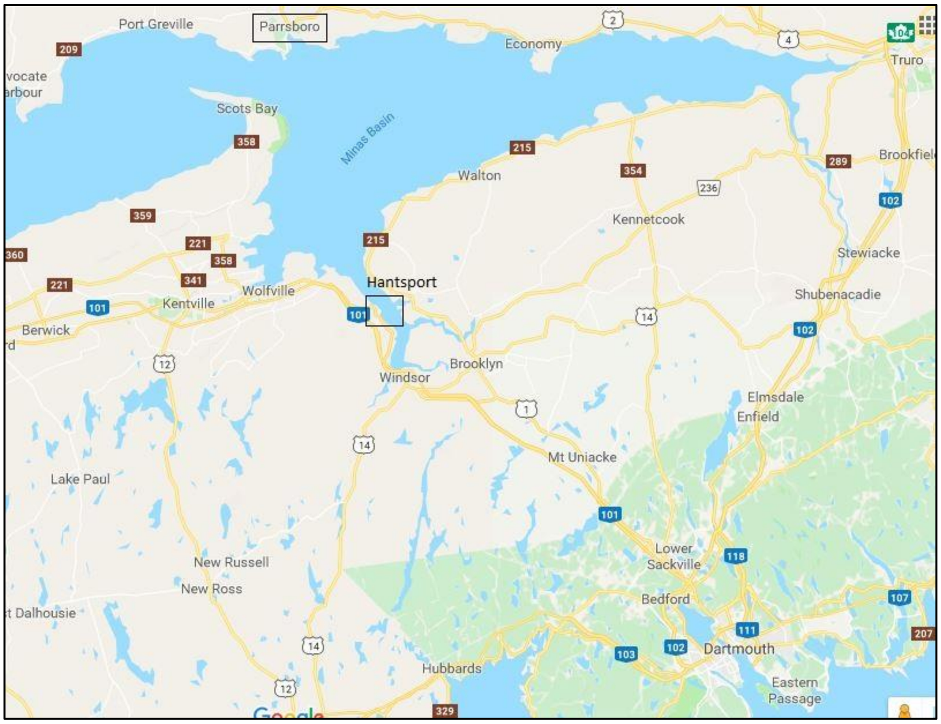

FIGURE 12: MAP OF NS SHOWING PARRSBOR/HANTSPORT/HRM (IMAGE FROM GOOGLE MAPS)

5.1.4 Fixed Assets

5.1.4.1 Hantsport

The existing wharf under consideration is privately owned by Minas Basin Pulp and Power Company Limited. The wharf has 137.15m of frontage on the river and is 17.68m in width parallel to the water. The surface area of the wharf is approximately 2,425m2. The construction dates back to circa 1950 and is wood piles beyond a wooden crib wall approximately 12m in height. The decking on the wharf is a combination of wood and concrete, with wood fendering along the face of the wharf. The wharf has not been used for commercial purposes for some years.

The owners (Minas Basin Pulp and Power) undertook an engineering study of the wharf in 2010 to ascertain the existing condition and potential scope and cost of necessary upgrades to provide an industrial base for marine activities. The wharf structure was deemed of concern when being considered for heavy industrial applications; this will be an important consideration for any developer and will be further discussed herein.

The adjacent industrial property of the former pulp and paper plant is comprised of a number of buildings on the 8.61-acre site. Of significant interest is the opportunity provided by the covered building immediately adjacent to the wharf, as well as the adjoining buildings which housed the plant machinery and processing equipment.

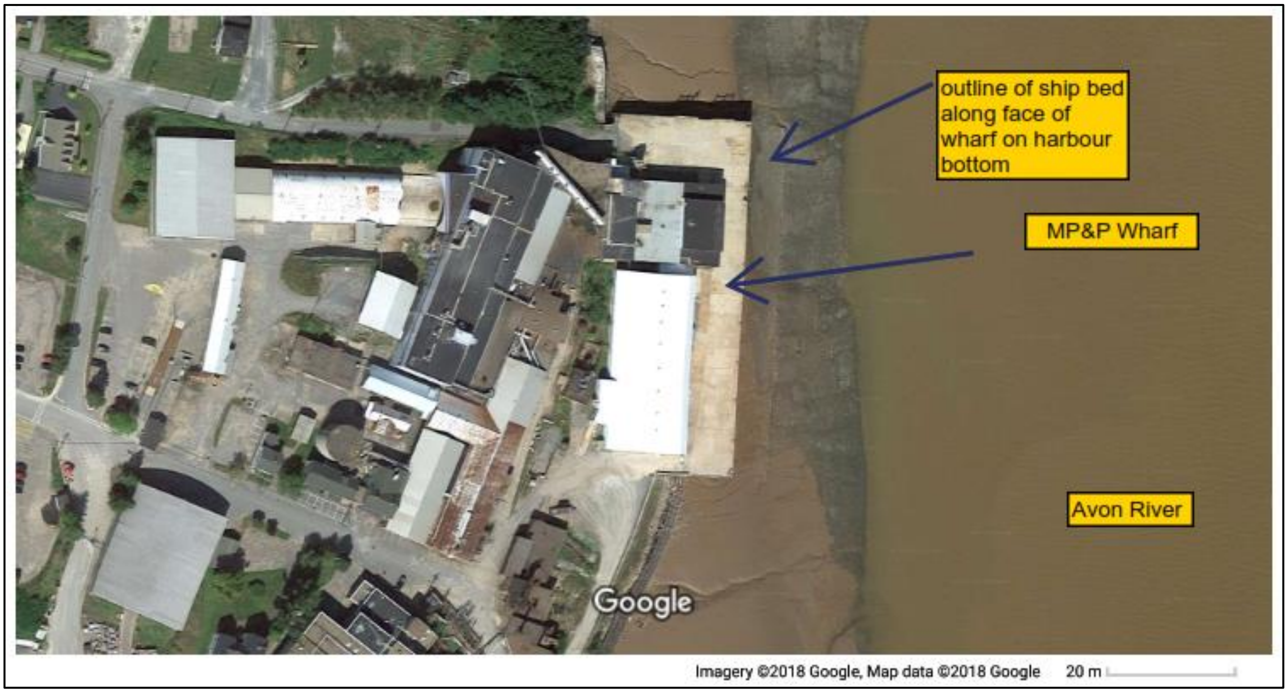

FIGURE 13: MP&P WHARF HANTSPORT (IMAGE FROM GOOGLE)

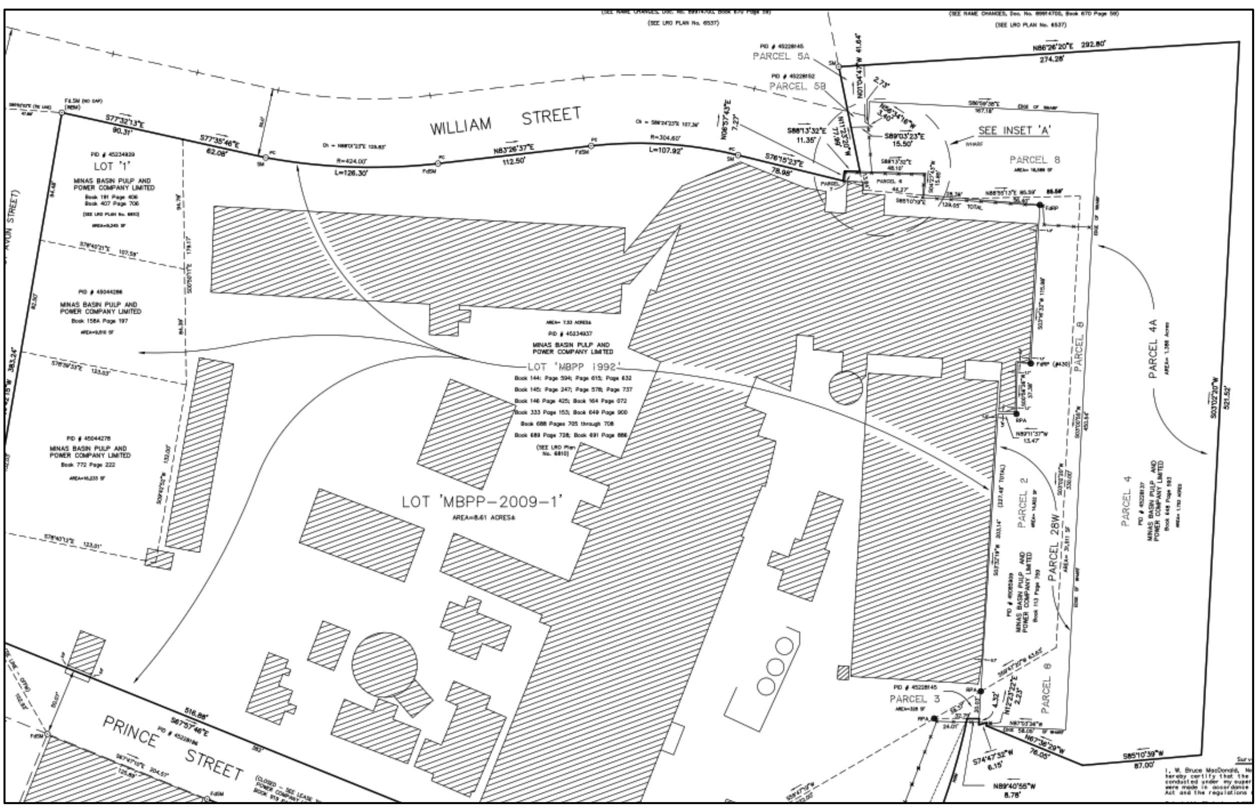

FIGURE 14: EXTRACT FROM MBP&P SURVEY 2010 (WITH PERMISSION)

To the immediate north of the Minas Pulp and Paper Company property lies the privately-owned wharf of US Gypsum Company. This wharf, consisting of concrete dolphin caissons positioned offshore and connected by steel gangways, was used up until 2011 for the loading of bulk carriers of 200m in length and up to 52,000 tonnes DWT.

The wharf has no deck, and thus though suitable for securing of large vessels/units alongside has little application where craneage and laydown areas adjacent to the wharf would be required.

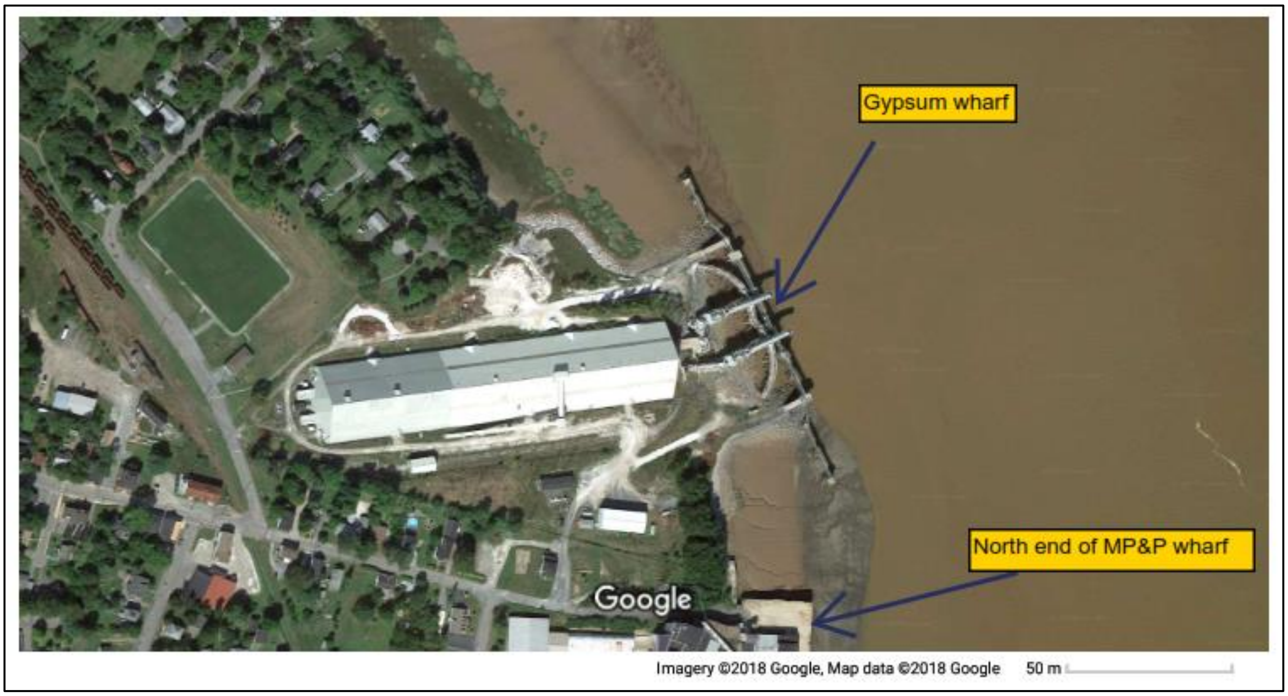

FIGURE 15: US GYPSUM WHARF, HANTSPORT

FIGURE 16: AVON RIVER AND HANTSPORT (IMAGE FROM GOOGLE)

5.1.4.2 Parrsboro

The existing wharf in Parrsboro is generally constructed of wood pile with a concrete/blacktop decking. There is no available load rating capacity for the wharf, but it is sufficient for light commercial vehicles on the full length, and for higher limited loads on the stem (the wharf is "L" shaped, the "stem" connecting the "L" to the shore). The stem itself is a wooden crib, rock filled and decked with concrete. Reported load capacity on the stem is 7 tonne/m2 at the centre, not within 1.5m of the edge (Allswater , 2016). Fuel trucks do currently use the full length of the wharf to service fishing vessels.

The wharf is faced with timber fendering. On the west face of the "L", the harbour bottom is cribbed with timbers (see Figure 17). This enables the local fishing vessels to dry out alongside sitting on their keelsons.

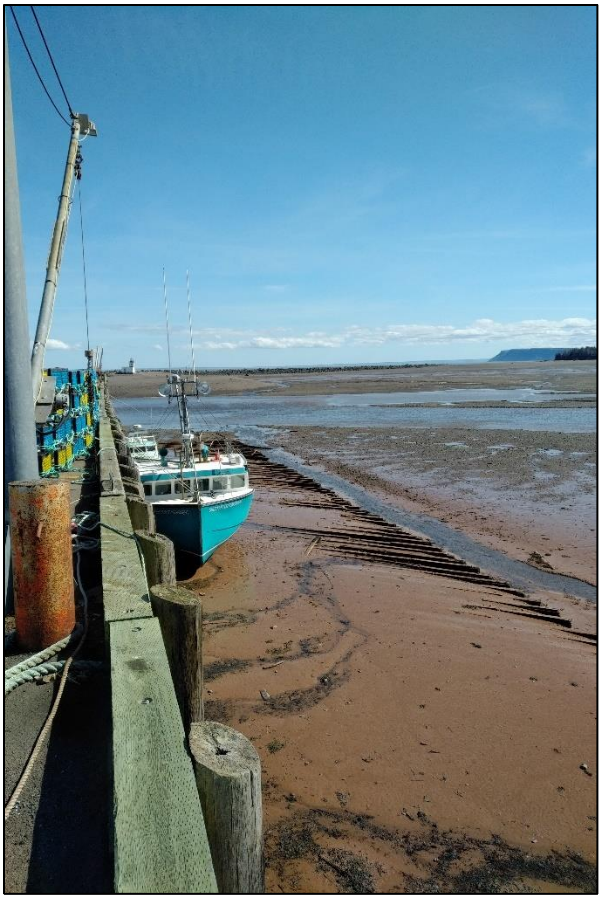

FIGURE 17: PARRSBORO WHARF - WEST FACE & CRIB

FIGURE 18: PARRSBORO WHARF, INSIDE BASIN SHOWING BOAT RAMP

FIGURE 19: PARRSBORO WHARF EAST FACE

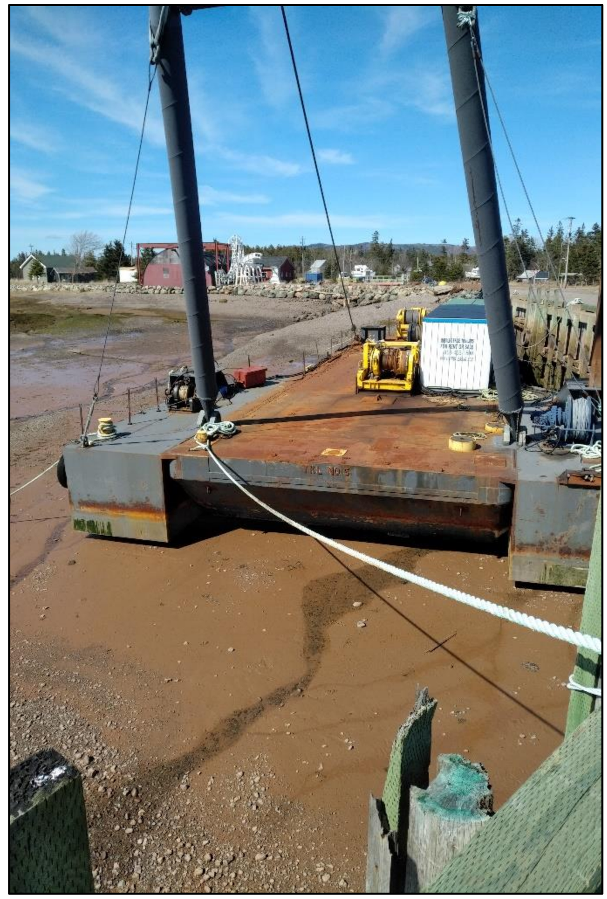

FIGURE 20: PARRSBORO WHARF, NORTH FACE

(During the commercial activity in the port of Parrsboro, there were several such “cribbed” wooden wharves where commercial ships of the day would load timber and coal for export.)

The “L” portion of the wharf is 120m by 16.6m, yielding a deck area of approximately 1,980 m2, with the stem measuring 47m by 10m wide for a deck rea of 470m2. Total deck area is thus 2,450m2.

Immediately adjacent to the wharf, the Parrsboro and Area Harbour Commission has approximately 2 acres of owned land bordered by private residences/plots. This land could be developed or leased.

There is no current engineering survey of the current condition of the wharf in Parrsboro.

The harbour commission has undertaken local dredging in the harbour in both 2011 and again in 2017. Costs for dredging operations have most recently been reported as in the order of two to three dollars per cubic yard of material displaced, with some four thousand cubic yards moved (CAD8,000-12,000).

Parrsboro harbour has a small boat ramp on the east side of the basin inside the wharf. This ramp has been used to launch small boats from trailers during some operations undertaken at the FORCE site.

5.1.5 Summary Table of Port Characteristics

		Hantsport		Parrsboro	
Distances from Support Facilities/Industries	From Wharf to:	Distance:	Travel Time:	Distance:	Travel Time:
	YHZ (Halifax International Airport)	80.7 km	49 mins	154 km	1h 44 mins
	Burnside Industrial Park	69.6 km	46 mins	178 km	1h 58 mins
	Container terminal, Halifax	72.8 km	49 mins	183 km	2h 02 mins
	Windsor Industrial Park	12.1 km	11 mins	NA	NA
	Amherst	NA	NA	58.7 km	50 mins
	Moncton	NA	NA	121 km	1h 26 mins
	Truro	NA	NA	93.3 km	1h 15 mins
Administration	Harbour Authority	Transport Canada		Parrsboro and Area Harbour Commission	
	Wharf Ownership	Minas Basin Pulp and Power Company		Parrsboro and Area Harbour Commission	
Operational Profile of Wharf	Distance from Wharf to FORCE	21.7 nm		5.4 nm	
	Distance from Wharf to sea	7.7nm		1.9 nm	
	Distance from Wharf to channel	200 metres		1.9 nm	
	Distance from wharf to 10m depth	2.0 nm		1.9 nm	
	Time alongside the wharf afloat for 4m draft vessel	5 hours		1 hour	
	Wharf length	137.15 m		120 m	
	Breadth	17.68 m		16.6 m	
	Covered warehouse space	Yes		No	
	Laydown area (outside) potential	Yes		Yes	
	Adjacent Industrial land	8.61 acres		2 acres	
	Current Engineered study/proposal	Yes		No	
	Other prioritized (fishers) wharf users	No		Yes	

FIGURE 21: SUMMARY OF PORT CHARACTERISTICS

5.1.6 Other Considerations

In terms of other port infrastructure available in either of the two ports being studied, there is a scarcity of both fixed and mobile assets in place. Neither port has marine service providers with vessel based there. Fixed cranes are not installed on either wharf; neither port possesses a dry dock or marine repair facility. Hantsport does have abundant covered spaces (former industrial manufacturing) that could be re-purposed. Some overhead gantry cranes exist and may potentially be upgrade and put back in to service.

Services are, however, easily available from outside the port where such services are mobile (i.e. fuel trucks, craneage) and can be mobilized on demand with sufficient notice. Activities related to the FORCE site have made use of such specialized services for marine activities mobilized to the port on as as-required basis.

Proximity to the industrial parks of towns and cities is a consideration, as is the distance from the Halifax International Airport.

6 Developer Preferred Infrastructure

6.1 Current & Past Requirements

Tidal energy developers are undertaking operations in the Minas Passage due to the availability of the FORCE installed sub-sea distribution infrastructure and the availability of the facilities provided for transmission of generated power to the grid in Nova Scotia. This follows the current trend in Europe, where most activity is centered around integrated and developed test sites where public funding support has enabled high capital cost infrastructure to be built out. These sites were chosen primarily because of their dense energy characteristics.

FORCE was similarly developed because of the dense energy resource available at this location. Of the five current berth holders (listed below) with leases at the FORCE site, only Cape Sharp Tidal Ventures has undertaken deployment operations to date.

Berth	Developer	Device Technology
Berth A:	Minas Tidal	TBD
Berth B:	Black Rock Tidal Power (BRTP)	Schottel/PLAT-I moored floater
Berth C:	Atlantic Operations Canada Limited (DP Energy)	Andritz 1500 Gravity Base Turbine
Berth D:	Cape Sharp Tidal Venture (CSTV)	Large Gravity Base Shrouded Turbine
Berth E:	DP Marine Energy (DP)	SRTP2000 moored floater

The original development of the sub-sea cable array at FORCE involved operations with crane lifts in the order of 100 – 150 tonnes from the wharf to barges/marine assets. These lifts were carried out in the port of Saint John, that being the closest port to the FORCE tidal site that had wharves capable of accommodating this need. Engineering studies were nonetheless required prior to permission being granted to conduct operations to confirm that the wharves could take the point loads shown by the lifting plan, and specific cautionary measures were required to spread the load on the wharf deck and monitor the condition of the wharf sub-structure during operations.

Transit times from Saint John to the FORCE site averaged 11 hours (a distance of ~75 NM) for tugs and tugs with flat barges. For the OpenHydro deployment barge with turbine and base ready for deployment the transit was an average of 20 hours.

The first gravity-based turbine connection and deployment operations at the FORCE site required a significant level of port infrastructure; crane lifts ranged from ~ 70 to 450 tonnes at up to 19m outreach, well beyond the design load capability of any wharf structures in the Maritime provinces. The physical size of the Cape Sharp Tidal turbine places it in a separate category when considering possible port structure requirements for O&M, or indeed for future installation and commissioning operations. The highly specialized deployment barge needed for this first installation requires a water depth of approximately 9.5m once loaded with the turbine and gravity base. Due to the lifts involved, marine lifting operations have been conducted by both a heavy lift ship mobilized from Europe and large land-based cranes siting atop bespoke engineered steel pile-based crane pads. Bespoke crane pads for large land-based cranes can be an economical solution to large lifts and of potential interest to developers looking at using dry ports; more on this herein.

The power cable installation operations at FORCE made some use of the Parrsboro wharf facility as a personnel transfer site when the weather precluded safe operations directly at the FORCE beach.

Other successful TISEC (tidal in-stream energy conversion device) deployments to date at European sites of both gravity-based turbines and of the floating or moored type have required wharves capable of handling mobile crane lifts ranging from 20 tonnes up to approximately 150 tonnes. These load ranges are similar to those that were required of the cable laying operations conducted by FORCE, and that would likely be required for any future cable operations.

- ✓ *Tidal device developers have required the capability to lift loads of up to 150 t from wharf to barge/vessel for the majority of deployments to date in other jurisdictions.*
- ✓ *Cape Sharp Tidal turbine and sub-sea base exceeds the above lift requirement by multiple(s)*

Second to the fixed infrastructure requirement of wharves and access, developers require marine infrastructure in way of service vessels for all operations. These needs have been serviced by vessels mobilizing from ports outside of the Minas Passage. There are minimal marine assets based in Nova Scotia in close proximity to FORCE. Typical vessel requirements have included:

Vessel Type	Home Port (typical)	Distance from FORCE
Crew boat	Halifax	By road (160km)
Small Survey vessel	Halifax	305 NM
Utility boat	Halifax	305 NM
Tug	Saint John	74 NM
DP Construction vessel	Halifax	305 NM
DP AHTS	St. John’s	823 NM
DP Construction vessel	Halifax	305 NM
DP AHTS	St. John’s	823 NM

6.2 Future Developer Requirements

Four of the current five berths at the FORCE site have not yet undertaken marine operations for TISEC deployment. There remains an opportunity for Nova Scotia to more fully participate (potentially) in these activities. The scheduling of such activities is described by the Fundy Ocean Research Centre for Energy and the respective developer websites. Activity levels are expected to increase over the next two years. Furthermore, operations and maintenance and activities on installed TISEC’s will be an increasing activity as devices are installed.

The characteristics of the TISEC’s expected to be deployed in the future at the FORCE site at berths which have not seen activity to date are as follows:

Device	Lift Weights	Est. Mobile/Crawler Crane Size Required
OpenHydro/DCNS	Base: 440te; turbine 230te	600 t lifting capacity at 10 m radius
PLAT-I/Schottel	Hull: 100 t; Turbines: 1.5 t	220 t
AR 1500	Base: 150 t; Turbine: 130 t	500 t, 2 of paired (est.)
SRTO2000	Hull: 550te; Turbines: NA (est. 30te)	220 t (estimated for turbine)

Developers coming to Nova Scotia’s FORCE site to deploy and operate TISEC’s will have three distinct operating phases:

1. Power cable preparation and connectivity
2. TISEC deployment
3. Operations and maintenance activities

Each phase of the operation will require port infrastructure to support these activities. Discussions and past operating experience with developers has shown that:

1. Deployment site has been determined by the location of FORCE and the potential energy of the Minas Passage;
2. Cable preparation activities will depend on development plans, but will involve marine cable operations to retrieve/re-configure/re-lay existing power cables and/or new installations
3. Deployment requires wharves structurally capable of supporting crane lifts up to 150 t;
4. Maintenance requirements anticipate retrieving device weights of up to 130 t (in air) and putting them onshore periodically; otherwise maintenance would be at the TISEC deployment site and would require lifting outside the port area only. In all other described maintenance activities, shore side lifting requirements were less than 25 t.

It needs to be recognized that there are two distinct types of TISEC technology planned for deployment at FORCE, namely the gravity base type (seabed installation) and the moored floating platform with turbines deployed near the surface. The services that either of the dry ports might offer is different depending on the requirements dictated by the particular device design.

Gravity based deployments have requirements as outlined above. For the moored floating platforms, the philosophy behind the designs is based upon easy access to the TISEC components from smaller maintenance vessel carrying personnel and tools, and the ability to change out the majority of serviceable components at sea. The key selection criteria for the operating base for this vessel type is proximity to the site.

In addition, the moored platforms offer a very different scenario for the dry ports. In most cases, the turbines are supported on appendages which can be stowed in a “towing” position. The floating platform can then be disconnected from the mooring system and towed fairly easily to sheltered waters or a close port for more extensive maintenance. The draft of the platform in this state varies from a barge type that could dry out satisfactorily, to devices where the towing draft is 6m for the turbine blades. The overall weight of the largest (currently) floating device is given as 550te in air, making drydocking likely more feasible than craneage for work on the hull. It was also noted that the prototype was launched at a shipyard and towed approximately 340 NM from there to the deployment site by a small tug.

Previous studies commissioned by OERA provide detailed requirements for port infrastructure (lay down areas, covered storage areas, wharf areas, and adjacent staging and storage areas) based on current information as of 2016. To date, Nova Scotia has seen the installation and O&M activities related to one model of large gravity-based TISEC. These operations were carried out within the general infrastructure requirements identified in the previous study, with the necessary marine assets being mobilized as required from other ports in both Nova Scotia and New Brunswick.

7 PORT INFRASTRUCTURE GAP ANALYSIS

The World Energy Council, in its' report on World Energy Resources Marine 2016 (World Energy Council, 2016), spoke clearly to the idea that infrastructure capacity could pose a "critical barrier" to the development of tidal energy. Of the identified forms of infrastructure necessary to fuel development, port infrastructure was mentioned as the third priority behind subsea infrastructure (such as at FORCE) and, secondly, grid connectivity and capacity.

Recognizing this requirement, it was noted during this study that some other agencies with administrative responsibility for areas in proximity to turbine developments test sites have implemented plans to ensure that port infrastructure meets the needs of such developments.

One of the noted developments to close this infrastructure gap was the "three port strategy" of the Orkney Islands Council (Orkney Islands Council, 2017) to ensure that ports within the vicinity of the European Marine Energy Centre were provided with support to build the necessary infrastructure. Funding in the order of CAD38M (GBP22M) was provided to improve the wharves and supporting infrastructure at the ports of Stromness, Lyness, and Kirkwall.

The French region of Bretagne, owners of the port of Brest, will also be looking to close the gap by investing some Euro220M to upgrade the port (Marine Energy.biz, 2018) to better accommodate the marine renewables and offshore wind sectors. The additional infrastructure deemed necessary to attract industry includes a new heavy lift wharf and dedicated adjacent laydown area of 400,000 m^2.

Port infrastructure to support the tidal energy sector is a necessary component of any plan to attract further economic activity to the Province of Nova Scotia. In order to better understand the infrastructure needs, one-on-one meetings were held with developers (and potential developers).

It was also noted that trial deployments and device operations have been conducted from the port of Connel (Scotland), a "dry port" where the wharf dries out at LLW. To summarize the discussions;

1. Some participants offered no firm objections to using a dry port, assuming infrastructure was adequate in other respects.
2. All required details on the wharf and lifting capacity and adjacent storage.
3. All commented on suitable vessel types in the immediate area for maintenance and other support activities.
4. Some participants discussed potential for a sheltered harbour where floating TISECs could be taken for maintenance while afloat.

7.1 Hantsport

Pros	Cons
Close proximity to the FORCE site	No usable wharf at present
Significant potential for both covered and open lay down areas (if upgraded)	No marine assets based in the port; need to be mobilized well in advance as available
Outer harbour could provide a sheltered mooring area for floating TISECs and/or maintenance vessels	"dry" area extends somewhat to seaward limiting time alongside
Engineering studies have been carried out on the existing wharves at Minas Pulp and Power	
Significant proximity to industrial bases nearby	
The dry port provides an opportunity to access the underwater hull/components for inspection by both people and equipment.	

FIGURE 22: HANTSPORT PROS/CONS

7.2 Parrsboro

Pro's	Con's
The closest port to the FORCE site	Existing wharf of insufficient size/weight capacity for most purposes other than personnel operations
Has been the base for personnel and operations to date within the surrounding area	No marine assets based in the port; need to be mobilized well in advance as available
The dry port provides an opportunity to access the underwater hull/components for inspection by both people and equipment.	"dry" area extends well to seaward limiting time alongside
	No current engineering study of present wharf
	Covered laydown area would need to be a new development

FIGURE 23: PARRSBORO PROS/CONS

7.3 GAP Identified Infrastructure Requirements

The following table outlines infrastructure gaps that have been identified. The first three items are primary requirements. The remainder enhance the value of the selected O&M site to the tidal developer.

No.	Requirement	Parrsboro	Hantsport	Saint John
1	Wharf with shore-based lift capability to 150 t	No	No	Yes (with engineering support)
2	Adjacent laydown area for maintenance	Available	Available	Yes
3	Covered maintenance/warehousing area	No	Available	Yes
4	Wharf with shore-based lift capability to 450 t	No	No	No
5	Supply of sufficient electrical power to wharf/laydown/warehousing spaces	No	Yes	Yes
6	Supply of fuel to mob wharf (pipeline)	No	No	No
7	Supply of fresh water (pipeline)	No	No	Yes
8	Harbour towage/support	No	No	Yes
9	Boat launching ramp	Yes	No	Yes
10	Marine lift/drydock	No	No	No
11	Diving Services	No	No	Yes

FIGURE 24: INFRASTRUCTURE GAPS

The adjacent laydown/maintenance area must be accessible for the heavy transport of the TISEC components moving to/from the wharf (e.g. SSB and turbine/nacelle components) most likely by Self Propelled Modular Transporter (SPMT). Load requirements will differ depending on the design but planning for the upper range is recommended. Any covered maintenance areas would ideally provide access through doors sized for the largest height/width of TISEC components.

Marine railways have been used extensively in the shipping industry for ship construction and repair. The primary difference between marine railways and wharves is that wharves are static structures, whereas marine railways are dynamic systems and have moving components that require certification and maintenance. Although more cost effective to construct than graving docks (Naval Systems Engineering Command, 1982), thy are “more subject to mishap than other docking facilities”. Although cost effective to build if one was considering alternative docking facilities for ships (i.e. graving docks), they have some limitations when considering them for tidal device operations and maintenance. The design of a particular railway is limited at construction to physical dimensions of length and width. This might exclude certain future designs of TISECs. Railways are also designed to haul a ship from the water on a cradle, carry out maintenance, and then re-launch the ship. There is no option to place components on to a barge, unload them from a ship, or lift components from a device for shore-based maintenance inside a covered area. A secure, safe wharf would still be required for these types of activities. Marine railways would not provide the flexibility of a wharf/mobile crane option.

8 Economic Analysis

The intent of this study is to define potential economic advantages that may be obtainable by conducting tidal energy related activities (particularly O&M activities) in close proximity to the FORCE site. Two foundational assumptions will underpin the analysis as follows;

1. that the developers are prepared to base operations from a dry port;
2. that the infrastructure identified in the preceding GAP analysis has been installed and/or upgraded.

With respect to the first assumption, discussions with the prospective future developers at the FORCE site indicated that working towards deployment from a dry port was currently acceptable with 50% of respondents. The discussions revealed that, given favourable economics, the challenges posed by the port characteristics could be mitigated with proper planning and some ingenuity. This included responses from both gravity-based TISEC installations as well as floating (moored) technologies. These findings align with a survey described in the (Scottish Enterprise and Highlands and Islands Enterprise) National Renewables Infrastructure Plan (Scottish Enterprise and Highlands Islands Enterprise, 2010). Industry was asked to rate the attractiveness of locations for the development of offshore renewables resources. In the study, locations were rated on the following criteria and weighting;

Proximity to the Deployment Site	25%
Site Characteristics	40%
Location Proximal (within 45 min commute) to Labour market catchment	15%
Timescale for Site Development	20%

Within these criteria, only a 10% weighting was given to the assessment of water depth within the site characteristics. Proximity to both the deployment site and labour catchments, and remaining site characteristics are given a weighting of 70%. Fully meeting these criteria for site selection may outweigh issues relating to water depth and make the dry ports a viable alternative.

In order to understand the potential economic benefits of operating from either of the dry ports under consideration, the potential of planned future TISEC deployments at FORCE must also be considered.

8.1 Deployment

The cost associated with the TISEC deployment at a selected tidal site can be considered to fall within three general categories;

1. Preparation of the grid connected cables (or cable laying) and the site for mooring/cables connections and installing base or moorings;

2. Support functions, including fabrication, installation of equipment on barge/vessel, shore-based activities and logistics for mobilization (excludes manufacture, assembly, testing of TISEC components;
3. At sea deployment of the TISEC

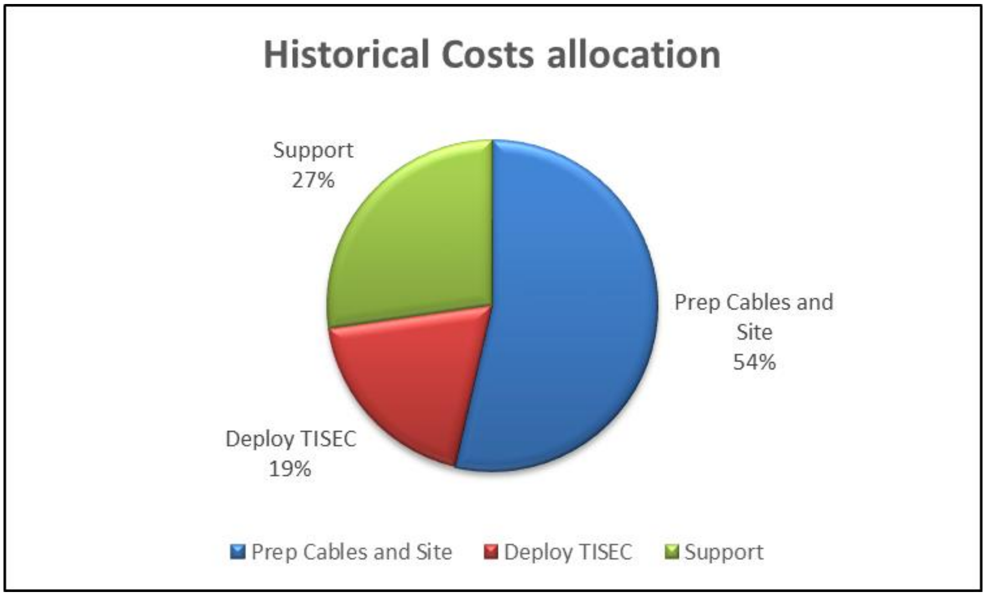

FIGURE 25: DEPLOYMENT COSTS

The conclusion from this review is that typically about 19% of the project cost relates to the deployment at sea of the TISEC. In some instances, the characteristics of the TISEC and deployment apparatus require significant water depth alongside the mobilizing wharf at all states of the tide. Case studies have been undertaken to ascertain if installation barges can "dry out" under certain conditions. The majority of remaining TISEC's planned for deployment at FORCE can be deployed from standard flat barges with a crane or crane equipped work vessels.

Cable preparation and support activities were either shore-based or related to the preparing of the electrical connections and remote/connector ends on the sub-sea power cables at FORCE. The marine component of these activities is very ably carried out from an outfitted barge. Most barges have no difficulty drying out at low tide on suitable ground. Dry ports have the potential, therefore, to capture 81% of forward looking project economic activity if the infrastructure gap is closed. Additionally, discussions with tidal developers suggest that current deployment methods and systems such as bespoke catamaran barges that could "dry-out" provide some optimism for the use of Parrsboro and Hantsport in the future.

Breaking down the costs allocated to marine assets and costs allocated to specific port requirements after the commencement of mobilization, the marine asset costs account for approximately 83% of the capital expenditure. We can also see that within this category, the transit costs for the marine assets (tugs/support vessels) can account for up to 44% of the total. With a daily cost estimated to be in the order of between

CAD45K/day and CAD123K/day depending on the complexity of the marine operation, transit costs are indeed significant.

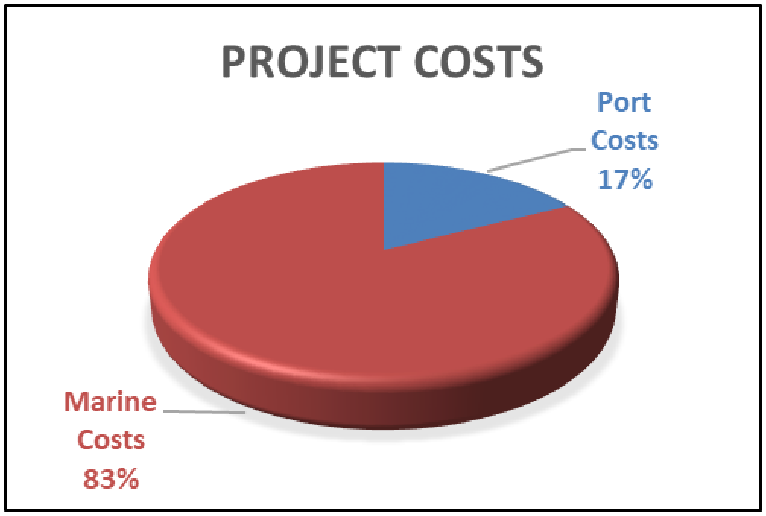

FIGURE 26: TIDAL OPERATIONS

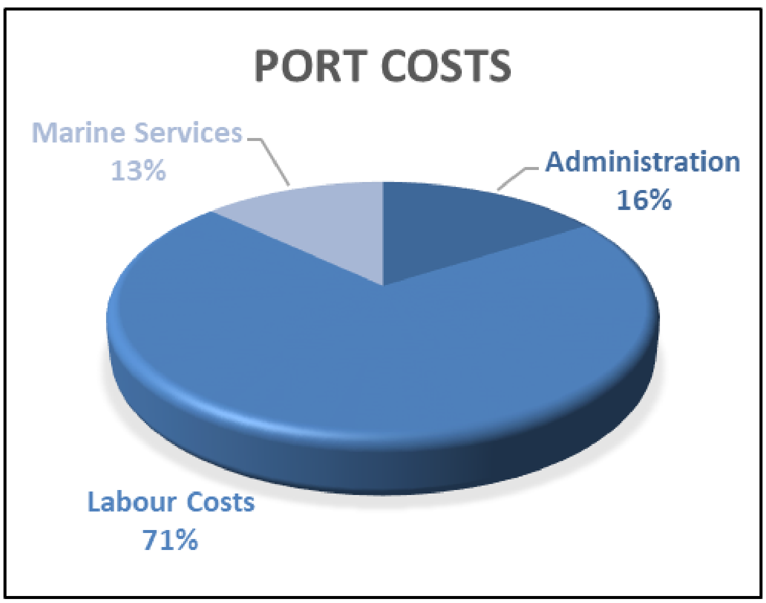

FIGURE 27: PORT COSTS BREAKDOWN

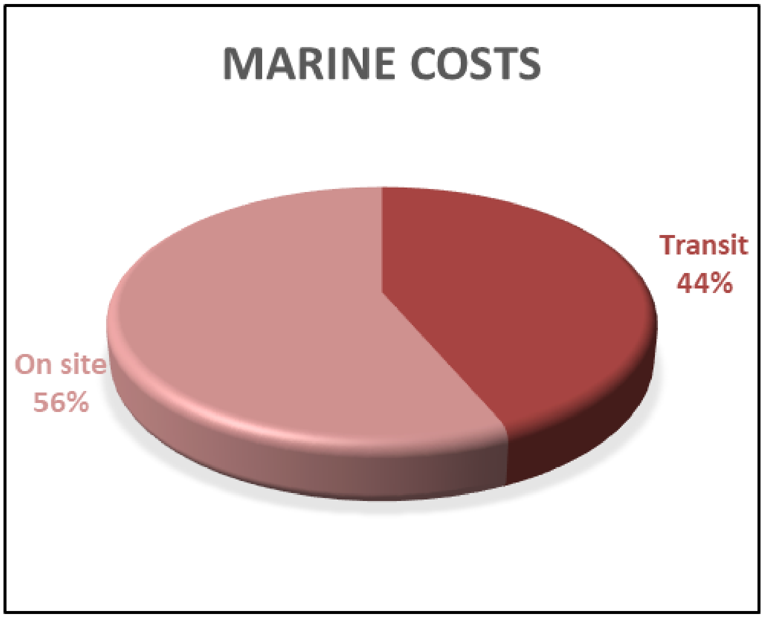

FIGURE 28: MARINE COSTS BREAKDOWN

Within the breakdown of port costs, we also see that the labour component is the largest cost driver where vessel and cargo operations are concerned and furthermore, the most volatile given the complex overtime structure existing in most other ports (excluding Hantsport and Parrsboro).

- ✓ *Proximity to deployment site may offer reductions on transit costs*
- ✓ *Labour costs in larger ports are significant and may provide competitive opportunities to reduce developer costs in smaller ports*

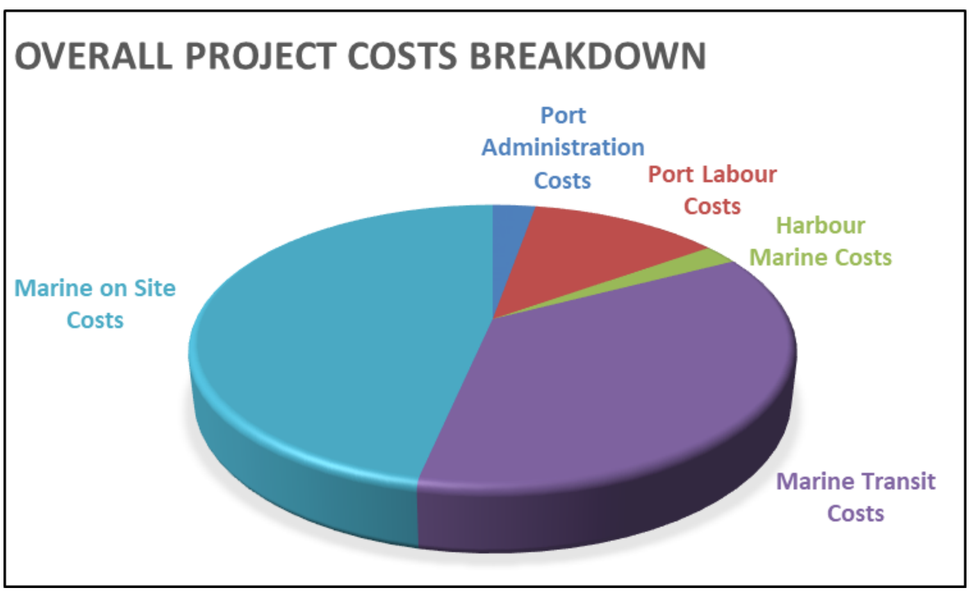

FIGURE 29: OVERALL PROJECT COST BREAKDOWN

8.2 Operations and Maintenance

Operations and maintenance activities mostly occur on a planned maintenance schedule, and also when they are initiated to deal with condition-based maintenance (repairs/failures). The frequency and timing largely depend on the developers planned maintenance cycles for their specific design, and to some degree, provisions for maintenance agreed with Classification Societies and/or insurance providers. The relative frequency of these operations, and the typical requirement to use smaller or less sophisticated vessels, increases the attractiveness of being able to operate from a base in close proximity to the site. The activity can also be forecast in advance; as the number of installed devices increases, the utilization (days/year) of vessels and experienced operating personnel also increases.

Free Flow Energy, Inc. (Free Flow Energy, Inc., 2009) identified prospective technologies to be utilized in planned maintenance of offshore tidal devices likely to include;

- ✓ Acoustic Doppler current profilers (ADCP)
- ✓ Accelerometers and gyros
- ✓ Cathodic protection and corrosion monitoring system
- ✓ Didson sonar
- ✓ Eddy-current testing
- ✓ Geospatial detection
- ✓ Infrared inspection
- ✓ Mid-infrared evanescent wave sensors
- ✓ Physical inspection methods
- ✓ Physical oceanography sensor suites
- ✓ Remote and autonomous underwater vehicles
- ✓ Strain gauges and load cells and pressure gauges/transducers
- ✓ Ultrasonic guided wave technology
- ✓ Ultrasound
- ✓ Wave radar
- ✓ Weather monitoring

Some of these technologies will enable some maintenance/monitoring to be carried out remote from the TISEC site. However, most will require some level of attendance by trained personnel aboard the appropriate vessel type, even if for short duration.

Most of the planned maintenance routines can be carried out from workboat type vessels. One operator indicated that in the initial stages of monitoring a deployed device, regular weekly maintenance visits may be required per installed device. The schedule below is based on published maintenance routines available in European sites where available as part of the licensing regime, and on interviews with developers with deployed devices.

Maintenance Routine (Gravity Based TISEC)	Frequency	Duration (per device)	Vessel Requirement
Turbine inspection	2-5 years	2-3 days	Workboat with ROV
Turbine repair/removal	2-5 years	3-5 days	Moored barge with crane or DP OCV
Turbine support inspection	2-5 years	2-3 days	Workboat with ROV
Environmental monitoring equipment inspection	6 months	1 day	Workboat with ROV
Environmental monitoring equipment replacement	1 year	3-5 days	Workboat, DP OSV, moored barge, ROV
Sub sea cable inspection	2-5 years	4-5 days	Workboat with ROV

Maintenance Routine (Moored floater TISEC)	Frequency	Duration (per device)	Vessel Requirement
Turbine inspection; component inspection	Frequent personnel visits and access to equipment in/on hull	Measured in hours	Personnel transfer/workboat
Turbine repair/removal	1-3 years	3-5 days	Workboat with crane
Environmental monitoring equipment inspection	6 months	1 day	Workboat
Environmental monitoring equipment replacement	1 year	3-5 days	Workboat
Mooring and turret arrangement	Monthly (est)	1 day	Workboat with ROV
Sub sea cable inspection	2-5 years	4-5 days	Workboat with ROV

NB: one developer transferred over 1,000 persons in/onto a floater during a testing phase in 8 months [Scot Renewables Safe Access 2012]

8.3 Economic Opportunities

Cape Sharp Tidal Ventures, the first developer to install a TISEC at the FORCE site in Nova Scotia, spent some CAD33M in the province supporting their project. They manufactured both turbines and sub-sea gravity bases in Nova Scotia. There are currently five additional developers planning deployment projects beginning in 2019. Based on present developments within the industry as they seek improved economics transitioning from a demonstration to a pre-commercial technology, it is most likely that Nova Scotia ports could benefit from component assembly and deployment/O&M marine activities. Steel fabrication of turbine support structures and assembly of mooring systems also presents a real opportunity in Nova Scotia. The manufacture of turbines internationally is typically being consolidated in existing manufacturing centres already in operation where economies of scale can be realized. Some respondents have indicated, however, that assembly of turbine components may be best carried out locally, and, as the industry develops, manufacturing locally may prove cost effective.

The OERA report on *The Value Proposition for Tidal Energy Development in Nova Scotia* (Gardner Penfold Consultants Inc. & Acadian Tidal Energy Institute, 2015)estimated the demonstration phase to include a build out of up to 64MW of installed capacity at supported sites. The determined value proposition put an estimated O&M cost against this phase as an annualized CAD16.92M over the period from 2015 to 2040. On a per MW installed basis this would equate to CAD265K of O&M costs per annum. This report also noted that “The infrastructure needed to support the industry must be designed, planned, funded and built.” Based on these number and the planned 20MW build out at FORCE, one could anticipate O&M spending to reach CAD5.12M per annum by 2020.

The experience in Scotland, particularly, supports the need for such infrastructure to attract activity, with a focus on port infrastructure in particular. The HIE and SE National Renewables Infrastructure Plan Update (Scottish Enterprise and Highlands Islands Enterprise, 2010) confirm that the Marine Energy Group “considers such public intervention is likely to be necessary to provide infrastructure owners with confidence that offshore renewables is a growing source of opportunity. It will also allow the necessary upgrades in ports, harbours, manufacturing and testing facilities to be achieved” (Marine Energy Group, 2012).

The dry ports of Hantsport and Parrsboro could, with the appropriate infrastructure development in place, be well positioned to capitalize on these opportunities.

8.4 Challenges

One of the key strategies for the reduction of infrastructure costs in European tidal development has been the ability to seek synergies with other industries (oil and gas exploration and exploitation, offshore wind development, wave technologies, bunkering). The supply chain in Nova Scotia that supports not only the oil and gas industry, but also onshore wind energy is well developed. Supply industries are typically located close to the population centres, and specifically near Halifax which is also a major seaport. Tidal developers coming to Nova Scotia noted this as a benefit, with an established highway network enabling access to the tertiary industries.

From a marine perspective, this is a more challenging strategy within the Minas Passage due to the distances from centres of other activity. By way of comparison, EMEC sites are a distance of 127NM by sea from the oil and gas hub in Aberdeen, whereas the FORCE site is 305NM from Halifax (more than twice as far) and 823 NM from St. John's. Aberdeen is a key North Sea industrial and marine base supporting the offshore oil and gas industry. The port there saw 4,292 vessel arrivals directly related to offshore oil and gas activity in 2017 (Aberdeen Harbour, 2017). Halifax recorded visits from 210 "other" vessels in the same period only some of which were related to offshore oil and gas (Atlantic Pilotage Authority, 2017). The implication is that the most synergetic (marine) industry is based not only significantly further by sea from the TISEC deployment site, but also has an activity level that is relatively small. From an infrastructure perspective this provides limited opportunities. The weakness on the supply side in the immediate proximity may present some cost challenges to the developers, as does the demand side weakness at the pre-commercial stage of tidal provide a challenge to marine services to locate assets in or close to the dry ports.

The other opportunity for cost efficiencies being exhibited elsewhere is the ability to co-locate with other industries able to benefit from common infrastructure and similar supply chain providers. Further study beyond the dry ports themselves would be needed to determine if other industrial activity might be attracted to the area(s) with improved infrastructure in place to service the marine renewables sector.

8.5 Rough Order of Magnitude Upgrade Costs

8.5.1 Primary requirement - Wharf Upgrade

The cost to upgrade and/or replace the wharves in both Parrsboro and Hantsport was examined. A review of expenditures from the GSINS codes of all such activities in the province provide a base for an estimate (Government of Canada, 2018). In addition, private information was available on a number of projects to compare with. The results of this work give an estimated cost per square meter to upgrade of approximately CAD4000/m^2. However, to provide a suitable wharf for tidal developers it may be possible to strategically upgrade selected portions of the larger wharf in Hantsport to reduce front end capital cost.

In addition, one method that has been used successfully is selectively providing local strengthening on the wharf deck and supporting substructure for designated crane pads. This can allow high point loading where needed in a cost-effective manner.

The strategic estimates are based on the "L" portion of the Parrsboro wharf, and in Hantsport that section of the wharf accessed directly from William Street.

Order of Magnitude Costs			
Full Wharf Upgrade			
	Parrsboro	$	9,800,000
	Hantsport	$	12,576,000
Strategic Wharf Upgrade			
	Parrsboro	$	3,960,000
	Hantsport	$	2,608,000
Wharf Crane Pad		$	350,000

Note: Full Wharf Upgrade costs are based on the surface area of the wharf and the averaged per m2 costs from Appendix B. Private estimates for some re-construction projects have been seen to be significantly less. In addition, the costing details as per Appendix B may include additional works on a per contract basis. Strategic Wharf Upgrade costs are based on providing access to useable wharf for crane lifts. Marginal type wharfs benefit in this manner potentially.

It must be noted that repairing or upgrading wharves to be able to accommodate smaller areas and lifting capacities (through lighter structural reinforcement/construction) might be achieved at a significantly lower cost. Detailed cost benefit analysis versus expected activity from both marine renewables and other industrial activities would need to be considered in capital decisions.

8.5.2 Dredging

Dredging has been carried out in the vicinity of Parrsboro wharf in both 2011 and 2017. Cost for any extensive dredging of the channel in either port is quite difficult to estimate as the mobilization cost for the equipment can be both variable and significant. In addition, the tidal flows make this a relatively short-term benefit without permanent breakwaters engineered to reduce rapid silting. Typical dredging costs can range between a very low CAD2.50/cubic yard to a more normal larger scale project at CAD15-20/cubic yard.

8.5.3 Laydown Area

In 2017 construction costs in Halifax were estimated using the Altus Group Construction Cost Database (Altus Group, 2017) as follows:

Order of Magnitude Costs						
Item	**Cost Range**					**Units**
Warehouse Construction	$	95	-	125		$/ft2
Manufacturing Facility	$	250	-	325		$/ft2
Arterial Roads, 9m width	$	3,700	-	4,400		$/m
Site services	$	116,200	-	185,400		$/acre
Surface parking	$	10				$/ft2

These are construction costs only and do not include other soft costs such as engineering, permitting, legal, taxes, surveys, environmental or soil testing.

Parrsboro has 2-3 acres of land adjacent to the existing wharf that could be developed. This area is essentially undeveloped at present and could be used for laydown or covered warehouse or assembly space.

Hantsport differs in that the property adjoining the wharf operated as a manufacturing facility and has substantial warehouse and other space that could be refurbished/re-purposed. This site covers an industrial area of approximately 8.61 acres and is more easily re-purposed for manufacturing, maintenance, and operational support activities as a result.

8.5.4 Moorings

Hantsport has the potential to benefit from a permanent mooring in the Avon River approximately 2 NM from the wharf seawards. Such a mooring could be used by the floaters potentially as a sheltered harbour within which to carry out periodic maintenance. Additionally, moorings in waters with sufficient depth at LLW to maintain workboats or barges for a period may prove useful. Costing would vary significantly with the type and size of vessel that might make use any installed mooring, and the availability of vessels to do the installation.

9 CONCLUSIONS

The study with current and prospective berth holders/tidal developers at FORCE has clearly indicated a desire to work from ports in close proximity to the site. Economic benefits to developers will result from reduced transit times to the site for both marine operations at seas, as well as mobilising resources from industrial bases in Nova Scotia to the ports. Reduced port operating costs, which are a large portion of the marine installation project costs, can be reduced by working in Nova Scotia from small ports with flexible administration and labour requirements. The real challenge facing developers is not so much the "dry" nature of the ports, but the lack of infrastructure to support operations. Neither port currently has a wharf capable of offering significant support to the industry. The existing wharves are physically incapable of supporting the cranes and loads required. This is **the key requirement** for any port operations in support of marine renewables operations. Without a wharf suitable for servicing planned or anticipated operations in the tidal energy sector, the vision of the dry ports capturing the operations and maintenance activities related to the FORCE site is a non-starter. Marine railways do not offer the flexibility of robust wharves and mobile cranes for marine operations in this sector.

The high capital costs of both subsea cable installations, grid connectivity, and port infrastructure was recognized early on as a significant impediment to the development of marine renewables. This resulted in early stage support in Nova Scotia with public funding, the creation of FORCE, and the development of a world-class testing and research centre for tidal energy. As a result, the barrier to tidal energy development in the province posed by the capital cost of connecting tidal devices to the grid was removed.

Similarly, the need for public support around port development is well studied. Suitable ports and infrastructure are necessary for fostering development in the marine renewables sector. European centres for marine renewables have followed the recommendations of early investigations into the business model with significant capital funding for port infrastructure, and wharves in particular. This has led to the continued development of the industry, with resulting benefits to the local economy.

Wharves, in and of themselves, are not revenue generators. Ports generate the bulk of their revenue from fees associated with the economic activity the wharf or pier enables, namely the moving of goods. Major ports charge a small berthage fee for the use of the wharf that equates to CAD$0.05/gross ton/half day, but a rate per tonne of cargo moved many multiples of the berthage fee (Saint John Port Authority, 2017). A coastal container vessel might pay CAD1K in berthage, but CAD52K for fees associated with the cargo loaded or unloaded. By way of example, the *Scotia Tide* (OpenHydro's installation barge) would pay berthage of CAD129.30 for each full day alongside a wharf. There is little-to-no data to support a business case for building or restoring a private wharf or wharves to support the marine renewables sector where the economic benefits that will flow from this infrastructure via indirect revenue associated are spread across a broad supply chain and tax base.

Outside of the marine tidal industry, there may be some secondary industries that could utilize upgraded port infrastructure in these two dry ports to further their development. Though beyond the scope of this study, industries that might require a base of operations could be:

- Fishing
- Whale watching
- Eco-tours

All stakeholders interviewed in support of this study also identified marine support vessels as an issue, based on their experiences elsewhere. Vessels that have been used at FORCE have been sophisticated DP OSV's, modern tugs, crew boats, work boats, and barges. In other theatres of operation, marine renewables have been able to develop synergies with the marine expertise developed in the oil and gas sectors.

However, in Nova Scotia, there is a market supply problem impacting this arrangement. The potential synergy with the oil and gas sector which has benefited development elsewhere is non-existent due to the lack of a "spot market" made up of vessels awaiting work. Vessel owners make capital investments in a vessel only when there is an assurance of high utilization. The result is a very small number of vessel "idle" and waiting on contracts. As a result, such vessels cannot (typically) be obtained quickly when needed unless operations are planned well in advance. In addition, mobilization times/distances affect all vessel types coming to work in the Minas Passage and further add to supply-driven operating costs.

The oil and gas sectors (both on and offshore) have otherwise enabled a supply chain, however, that does provide many of the skills and expertise needed for tidal energy development. The bulk of this expertise has, naturally, been centered around Halifax as the Nova Scotia port serving the offshore.

Overall marine activity levels in the Minas Passage are negligible, and utilization levels for vessels in the renewables sector is such that there is no commercial incentive for an operator to locate a service vessel at either of the two ports. Being "dry ports" further exacerbates this problem, defining a need for vessels that can operate at reduced draft and periodically "dry out" on the harbour bottom at low tide. As more devices are installed at FORCE, the time required for ongoing planned maintenance as well as the risk-to-project of unscheduled maintenance or repairs will increase. Each developer will have the need of a suitable maintenance vessel for a relatively small number of days per year. Acting individually, each developer will be faced with mobilization/demobilization costs; in addition, rapid access to a vessel when urgently needed to effect repairs will be problematic. As described in the (Scottish Government) Marine Energy Action Plan 2012 "Availability of suitable vessels for deployment and operations and maintenance activities will also be a key consideration for the sector as it develops." (Marine Energy Group, 2012)

Globally, the subsea communications cable industry has experienced similar challenges in the past. Damage to a cable resulting in interrupted communications traffic meant a daily loss of revenues. Cable vessels capable of carrying out repairs were often weeks, if not months away. The solution was the establishment of "station" vessels, whereby many cable owners would collaborate to hire a vessel to remain on station at a strategic port. Whilst standing by on station, the vessel operating cost was shared among the group of owners. When needed, the vessel would leave port to carry out repairs without delay. The full hire would be assumed by the particular cable owner needing the repair from the time the vessel left until it returned to the dock and was back "on station".

One of the stated objectives of FORCE is "*To be a catalyst for the creation of a new marine energy industry in the Province, including the development of value added manufacturing, and development of services for* *the deployment, maintenance, inspection, repair, and decommissioning of tidal energy devices."* Coordination between developers and researchers needs may provide sufficient utilization (working days/annum) for a vessel owner to increase the service offering to the industry. This would reduce project risk and improve the operating expenses of individual developers, and most certainly be a catalyst for the development of services.

9.1 Summary of Conclusions and options

1. The dry ports of Hantsport and Parrsboro can offer economic benefits in terms of reduced operating and/or deployment costs to developers deploying tidal devices in the Minas Passage. These cost reductions could be significant. Cost savings to developers can be realized by operating closer to the deployment site. This enables a reduction in one of the two major project cost components, namely the marine transit costs.
2. The primary requirement for developers to consider being able to operate from these ports will be the provision of a suitable wharf from which operations can be conducted. This is an essential first step.
3. There is no available data supporting a business case that would make it reasonable to expect stand-alone private investment in new wharves at this pre-commercial stage of the tidal industry in Nova Scotia.
4. Funding assistance for the repair and/or upgrade of the two private wharves (one in Parrsboro, one in Hantsport) should be urgently explored with each respective wharf owner. There is no business case at the current development/pre-commercial stage of the tidal industry for private investment in wharf upgrades. Wharves are essential for any economic activity in the ports studied. It will thus require a model similar to those successfully used globally where government investment in infrastructure upgrades has proven to be the catalyst for further economic activity in this sector.
5. As the lead agency for tidal energy research in the Minas Passage, suggest leveraging previous investments and have FORCE explore the potential benefits of coordinating developers defined vessel needs (with their own) to meet arising operations, environmental, and maintenance requirements. This role might be advantageously expanded to managing the operational requirements of developers as they apply to the wharf and potential shared vessel(s), as well as investigating cost sharing or synergies between developers with respect to other assets, resources, equipment, data, and knowledge. This role might be advantageously extended to managing the operational requirements of developers as they apply to the wharf and potential shared vessel(s), and at the same time offer some oversight to the public investment.
6. Engage with other marine based industries investigate additional uses that could drive parallel economic development in the port.

9.1.1 Options

1. Engage with the wharf owners in both dry ports. Consider an updated FEED study from the wharf owners to accurately define the infrastructure costs for upgrading or repairing as required to support the industry.
2. Explore the potential for strategic funding assistance for infrastructure based on the order of magnitude costs in this study, pending further definition of costs as above.
3. Develop a business plan to support such funding.
4. Further define specific vessel requirements most broadly useful to development and research activities.
5. Explore with FORCE management the potential expansion of their support role as suggested in the conclusions.

10 Appendix A: Survey Summary of Comments

During the course of the study developers, prospective developers, suppliers, and marine service companies headquartered in Nova Scotia were contacted and interviewed. Much of the specific details on expected physical port requirements had been extensively covered in two pervious studies. Previous findings were discussed in light of more recent activity in the sector. The focus was on the utilization of dry ports, and of Parrsboro and Hantsport specifically. The table below summarizes responses from the interviews.

	Developers	**Suppliers**
Primary decision-making process for selecting a port for operations and maintenance activities	All recognize the value of being close to the deployment site. Preference would always go to the closest site with acceptable facilities.	Decision by developer usually; proximity to work site
Has a dry port been considered or used for operations?	6/7 interviewed considered dry ports for some activities. Consideration of maintenance activities was varied depending on the device technical requirements.	Considered and used for some functions; time alongside a serious concern for vessels unable to dry out. Ability to get in/out of port combined with daylight working (typically) makes timing critical. Smaller vessels need alternative to leaving vessel unattended alongside.
Operations that could be carried out in a dry port	Responses varied by design of device. All devices that can be deployed from non-custom vessels offered some potential ideas for dry port activity. • Full assembly and deployment; • Sheltered water floating maintenance • Lifting turbines ashore for periodic maintenance in proper facility • Crew transfers • Base for inspection of devices and moorings • Maintenance facility for inventory of parts that	Varied responses; some owners would not want vessel and/or barges drying out. Insurance issues mentioned.

	can be readily moved offshore to site • Proximity minimizes downtime if workable for repair operations	
Comment on size and space requirements needed in the port	During the interviews general re-affirmation of those sizes from previous studies. With some changes in the industry more recently, there was consideration for flexible	NA
Depth requirements; restrictions on being “dry”	As most developers expressed a preference for a turn-key vessel solution, this was not a direct issue. Some floaters could be “dried”, some not. Some subsea structures could be set alongside the wharf and allowed to dry awaiting transport to site.	See above
Transportation routes and costs	Preference to truck components/modules for assembly alongside the wharf prior to deployment.	Utilization levels require vessel to mob/de-mob on a per job basis. Costs for transit factored in to service agreements.
Laydown areas and crane requirements	Device dependent; ranged from 450m2 to 1800m2 covered maintenance area with large “hanger type doors” for maintenance of turbines inside. See also (Allswater , 2016)	Some small lifts for vessel maintenance may be required periodically. No significant weights expected.
Crane and lifting requirements	Device dependent; typical large gravity base lift requires 150 t for installation; this might stretch to 200 t, but for O&M the 150 t is likely a max lift from shore. Turbines requiring specialized deployment barges would require crane pads to lift 320 t currently. Can be achieved with sized crane pads constructed in the wharf and specialized crane mobilized from out of long distance.	See above
Experience with dredging for operational activities	NA	Some experience. Generally felt dredging is a short-term solution (or frequent requirement) unless engineered breakwaters used to

		mitigate silting in. Local experience in both suction and grab dredging from multiple contractors.
Workforce experience in ports; comments on the ports being studied	Typically work carried out by staff or short-term contractors; specialized technical staff from overseas.	No issues raised.
Infrastructure in the port vicinity	Laydown areas for storing/loading and offloading/receiving/preparation essential adjacent to wharf. Otherwise city centres are within reasonable range for supply chain requirements.	Fueling/fresh water supply of some concern. For day boats (no long-term accommodation) local services for accommodation/food etc. can be difficult to arrange.
Future potential in dry port under study	Almost without exception proximity to site was key; a willingness was expressed to innovate solution as long as the basic infrastructure was in place.	NA
Vessel/tug/barge requirements for activities	Requirements range from crew transport to deployment and maintenance requirements. Developers are more used to properly sized workboats being available both fairly close and at short notice. Mobilization time and distance was mentioned as a consideration for costs versus other areas.	NA

11 APPENDIX B: WHARF PROJECT COSTS GOC DATABASE

Recent Comparative Wharf Repair and Replace Projects in Nova Scotia			**Removal**	**New Build**	**Est Cost**
Project Reference	**Project Description**	**Project Cost**	**Est m2**	**Est m2**	**Per m2**
E0225-141517/001/PWA	Wharf Repair and Replace, Pinkney's Point, NS	$ 377,795	468	468	$ 807
EB144-151232/001/PWA	Wharf Removal and New Construction, Caribou Harbour, NS	$ 4,554,086	280	1650	$ 2,760
EB144-151385/001/PWA	Wharf Reconstruction, Sonora Wharf, Guysborough, NS	$ 1,257,780	762	762	$ 1,651
EB144-160283/001/PWA	Wharf and Service Area Construction - Havre Boucher	$ 2,696,963		706	$ 3,820
EB144-162629/001/PWA	Wharf Construction, Newellton, NS	$ 2,270,186	460	460	$ 4,935
EB144-180169/001/PWA	Wharf Construction, New Harbour NS	$ 3,768,690		536	$ 7,031
EB144-180461/001/PWA	Wharf Removal and Re-construction, Port Bickerton, NS	$ 3,340,827	182	392	$ 8,523
		$ 2,609,475	**430**	**711**	**4,218**

Notes:

1. Most projects included some demolition and removal in addition to new construction or repair

2. New construction in several project included significant expansion of the original wharf and/or service area

3.Several projects included some component of associated dredging

4. Several projects included work on associated wharf service area

5. Estimated cost/m2 based on new construction area

12 TABLE OF FIGURES

13 REFERENCES

Aberdeen Harbour. (2017). *Aberdeen Harbour Reports Annual Review 2016/2017*. Retrieved from Aberdeen Harbour: www.aberdeen-harbour.co.uk

Allswater . (2016). *MRE Infrastructure Assessment Update.* Halifax: Offshore Energy Research Association.

Altus Group. (2017). *Canadian Cost Guide 2017*. Retrieved from Altus Group Web site: https://www.altusgroup.com/news_insights/construction-cost-guide-2018

Atlantic Pilotage Authority. (2017). *Atlantic Pilotage Authority | ANNUAL REPORT 2017.* Retrieved from Atlantic Pilotage Authority Web site: https://www.atlanticpilotage.com/wp-content/uploads/2018/05/APA_AR-2017-Eng_Full_web.pdf

Department of Justice. (2018, May 5). *Public Ports and Public Ports Facilities Regulations.* Retrieved from Department of Justice: http://laws-lois.justice.gc.ca

Free Flow Energy, Inc. (2009, March 31). *Assess the Design/Inspection Criteria/Standards for Wave and/or Current Energy Generating Device.* Retrieved from http://large.stanford.edu/courses/2011/ph240/yan1/docs/FinalReport.pdf

Gardner Penfold Consultants Inc. & Acadian Tidal Energy Institute. (2015, April). *Value Proposition for Tidal Energy Development in Nova Scotia.* Retrieved from Offshore Energy Research Association: http://www.oera.ca

Government of Canada. (2018). *Contract History*. Retrieved from Open Government: https://open.canada.ca/data/en/dataset/53753f06-8b28-42d7-89f7-04cd014323b0

Marine Energy Group. (2012, June). *Marine Energy Action Plan.* Retrieved from Scottish Government : http://www.gov.scot/resource/0039/00395516.pdf

Marine Energy.biz. (2018). *Port of Brest steps up for marine renewables*. Retrieved from Marine Energy.biz: https://marineenergy.biz

Naval Systems Engineering Command. (1982). *NAVFAC Design Manual Marine Railways.* Department of the Navy (USA).

Orkney Islands Council. (2017, May). *Sustainable Energy Strategy.* Retrieved from Orkney Islands Council Web site: www.orkney.gov.uk

Roso V, &. W. (2009). Dry Port Concept: -Connecting Seaport with their Hinterland by Rail. *Journal of Transport Geography*, 338-345.

Saint John Port Authority. (2017, January 1). *Saint John Port Corporation*. Retrieved from Saint John Port Corporation: https://www.sjport.com/

Scottish Enterprise and Highlands Islands Enterprise. (2010, September). *National Renewable Infrastructure Plan*. Retrieved from National Renewable Infrastructure Plan: http://national-renewable-infrastructure-plan

Transport Canada. (2018, May 10). *Canada Marine Act.* Retrieved from Department of Justicve: http://laws-lois.justice.gc.ca

World Energy Council. (2016). *World Energy Resources Marine Energy 2016.* Retrieved from World Energy Council website: https://worldenergy.org

14 BIBLIOGRAPHY

ABLE (2013, June). Seaton Port Site Plan. Retrieved May 2018, from http://www.ableuk.com/wp-content/uploads/2016/11/ABLE-Seaton-Port-Site-Plan.pdf

Arctic Council (2012, December). Arctic Transportation Infrastructure: Response Capacity and Sustainable Development. Retrieved May 2018, from https://oaarchive.arctic-council.org/handle/11374/1222

Astariz, S., Iglesias, G., & Vazquez, A. (2015). Evaluation and comparison of the levelized cost of tidal, wave, and offshore wind energy. Journal of Renewable and Sustainable Energy, 1-17. Retrieved May 2018, from https://www.researchgate.net/publication/282579414_Evaluation_and_comparison_of_the_levelized_cost_of_tidal_wave_and_offshore_wind_energy

Canada. Offshore Energy Research Association Halifax Nova Scotia. Gardner Penfold Consultants Inc., & Acadian Tidal Energy Institute (April 2015). Value proposition for tidal energy development in Nova Scotia, Atlantic Canada and Canada. Retrieved May 2018, from http://www.oera.ca/marine-renewable-energy/tidal-research-projects/other-tidal-research/value-proposition-for-tidal-energy-development/

Canada. Department of Justice (2018, May 9). Navigation Marine Act. Retrieved June 2018, from http://laws-lois.justice.gc.ca

Canada. Department of Economic Development and Transportation. Government of Nunavut. (2010). Nunavut: Worley Parsons resources and energy. Iqaluit Port Development. Retrieved May 2018, from http://assembly.nu.ca/library/GNedocs/2010/002717-e.pdf

Canada. Department of Justice. (2018, May 24). Atlantic Pilotage Tariff Regulations, (1996). Retrieved May 2018, from http://laws-lois.justice.gc.ca/eng/regulations/SOR-95-586/index.html

Canada. Transport Canada. (2018, Jan 01). Tariff Notices. Saint John Port Authority. Retrieved May 2018, from https://www.sjport.com/wp-content/uploads/2016/04/Saint-John-Port-Authority-Tariffs-Effective-January-1-2017-English2.pdf

Canada. Department of Justice (2018, May 9), Public Ports and Public Port Facilities Regulations. Retrieved June 2018, from http://laws-lois.justice.gc.ca

Canada. Department of Justice (2018, May 9). Navigation Protection Act. Retrieved June 2018, from http://laws-lois.justice.gc.ca

Destination Scotland – the cruise industry guide (2011). Kirkwall's Halston pier extension project contractor announced [Brochure]. Retrieved May 2018, from http://www.cruisescotland.com/kirkwalls-hatston-pier-extension

Developing Orkney's Ports (2017) Orkney Island Council Harbour Authority Annual Report. Retrieved May 2018, from http://view.publitas.com/k4-graphics/developing-orkneys-ports/

EMEC (2017, September 28). Orkneys sustainable energy strategy unveiled.pdf. Retrieved May 2018, from www.orkney.gov.uk/Service-Directory/S/Sustainable-Energy-Strategy.htm

EMEC (2017). Orkneys 3 Port Strategy. Retrieved May 2018, from www.orkney.gov.uk/Service-Directory/S/Sustainable-Energy-Strategy.htm

EMEC (2012) Experience. Support Services for the Marine Renewables Industry. Retrieved June 2018, from www.emec.org.uk/services

EMEC (2009). Guidelines for Project Development in the Marine Energy Industry. Retrieved May 2018, from http://www.emec.org.uk/guidelines-for-project-development-in-the-marine-energy-industry/

Fundy Engineering & Consulting Ltd (2010, July). Wharf Investigation Minas Basin Pulp and Paper Wharf. Retrieved May 2018, from www.fundyeng.com

Government of Nova Scotia (2009). The State of Nova Scotia Coast Report: Working Waterfronts 5.1. Our coast. Retrieved May 2018, from https://novascotia.ca/coast/state-of-the-coast.asp

Government of Scotland (2018). Scotland Current Marine Renewable Project. Retrieved May 2018, from http://www.gov.scot/Topics/marine/Licensing/marine/scoping

How to Determine the Crane Capacity Index (Nd) Retrieved May 2018, from http://estaeurope.eu/media/files/Section-Cranes/How-to-determine-the-Crane-Capacity-Index.pdf

MacDougall, S. Dr., (2016) Financial evaluation and cost of energy. Acadia Tidal Energy Institute, 1-15. Retrieved May 2018, from http://tidalenergy.acadiau.ca/tl_files/sites/atei/Content/Reports/Module_7_Financial_Evaluation_and_Cost_of_Energy.pdf

Marine Scotland (2015). Pilot Pentland Firth and Orkney Waters marine Spatial Plan. Retrieved May 2018, from http://www.gov.scot/Publications/2016/03/3696

Marine Scotland (2012). Draft Regional Locational Guidance – Tidal Energy in Scottish Waters. Retrieved June 2018, from https://data.marine.gov.scot/dataset/draft-tidal-regional-locational-guidance/resource/79781eec-cc55-47c3-a98a-1d08f53b9f0e

Marine Scotland (2011, March). Blue Seas Green Energy. Retrieved May 2018, from http://www.gov.scot/Topics/marine/marineenergy/wind

Marine Scotland. Tidal Energy in Scotland (2012). Retrieved May 2018, from https://data.marine.gov.scot/dataset/draft-tidal-regional-locational-guidance

MEG (2012, June). Marine Energy Action Plan. Retrieved May 2018, from http://www.gov.scot/Topics/Business-Industry/Energy/MarineAP

Minesto (2016, June). Deep Green Holyhead Deep Project Phase 1. Non-Technical Summary. Retrieved May 2018, from https://tethys.pnnl.gov/sites/default/files/publications/Minesto_Environmental%20Statement.pdf

Morris-Underhill, C., (2018, February 9). Hantsport Railway Article Retrieved May 2018, from http://ns-news.pressreader.com/

MRE (2016, June). Infrastructure Assessment Update. Retrieved May 2018, from http://www.oera.ca/marine-renewable-energy/tidal-research-projects/mre-infrastructure-assessment/

Nova Scotia Marine Renewable Energy Strategy (2012, May). Nova Scotia marine renewable energy strategy. Retrieved May 2018, from http://energy.novascotia.ca/energy

Ocean Energy Europe (2017, March). Ocean Energy Project Spotlight Investing in wave and tidal energy. Retrieved May 2018, from https://www.oceanenergy-europe.eu/wp-content/uploads/2017/06/170228-Ocean-energy-spotlight-final.pdf

Ocean Energy Forum (2016, November). Ocean Energy Strategic Roadmap: Building Ocean Energy for Europe. Retrieved May 2018, from https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/OceanEnergyForum_Roadmap_Online_Version_08Nov2016.pdf

OERA (2011). MRE Infrastructure Assessment Collective Wisdom Solutions. Retrieved May 2018, by https://energy.novascotia.ca/sites/default/files/Marine-Renewable-Energy-Infrastructure-Assessment.pdf

OREG (2011, June). Canada's Marine Renewable Energy Roadmap. Retrieved May 2018, from http://www.policyandinnovationedinburgh.org/canadian-roadmap.html

OES Eion Sweeney (2015, June). The Future of the Ocean Economy, Exploring the Prospects for Emerging Ocean Industries to 2030. Ocean Energy Systems Discussion Paper. Retrieved May 2018, from https://report2016.ocean-energy-systems.org/ongoing-tasks/international-co-operation/

OES (2017) An International Vision for Ocean Energy. Retrieved June 2018, from http://testahemsidaz2.files.wordpress.com/2017/03/oes-international-vision.pdfOREA (2016). MRE Infrastructure Assessment Update. Retrieved May 2018, by http://www.oera.ca/wp-content/uploads/2016/10/MRE-Infrastructure-Update-Final-Report-Public.pdf

Premier Construction Channel Islands Industry News (2013 October). Three Port Strategy: Lyness. Retrieved May, 2018 from http://premierconstructionnews.com/2013/10/02/three-port-strategy-lynessl

Public Service and Public Procurement Canada (2018, May 30) Regional marine industry consultation workshops: Final report 2018. Retrieved June 2018, from http://buyandsell.gc.ca/procurement-data/tender-notice/PW-18-00830335

Roso, Violeta & Woxenius (2009) Dry Port Concept-Connecting Seaports with their Hinterland by Rail. Journal of Transport Geography, 17, 338-345. Retrieved May 2018, from https://www.gu.se/digitalAssets/1344/1344857_2004_iclsp_dalian_wox-ros-lum.pdf

Roso, V. & Lumsden, K (2009). The Dry Port Concept: Moving Seaport Activities Inland? Retrieved May 2018, from http://www.unescap.org/sites/default/files/bulletin78_Article-5.pdf

Scottish Enterprise and Highlands and Islands Enterprise (2010, September). National Renewable Infrastructure Plan. Retrieved May, 2018, from http://national-renewable-infrastructure-plan(1).pdf

Scotland Government. Current Marine Renewable Project. Retrieved June 2018, from https://beta.gov.scot/search/?q=current+marine+renewable+project

SI Ocean (2014, June). Ocean Market Deployment Strategy. Wave and tidal energy market deployment strategy for Europe. Retrieved May 2018, from https://www.oceanenergy-europe.eu/wp-content/uploads/2017/10/SI_Ocean_Market_Deployment_Strategy_-_Web_version.pdfSME (2017, December). Sustainable Marine Energy Inshore Platform – Power's Up. Retrieved May 2018, from https://www.schottel.de/de/news-events/presseinformationen/news-detail/?no_cache=1&tx_ttnews%5Btt_news%5D=490

The Highland Council Planning Environment & Development Committee (2009, September), NIGG development masterplan & accompanying strategic environment. Retrieved June 2018, from http://www.highland.gov.uk/download/meetings/id/18233/ped2009.pdf

US National Geospatial Intelligence Agency (2018). US Sailing Directions Eighteen Ed. Retrieved June 2018, from https://msi.nga.mil/NGAPortal

Wind Europe (2017, November). Offshore wind Energy in the North Sea. Retrieved May 2018, from https://windeurope.org/wp-content/uploads/files/policy/position-papers/WindEurope-Offshore-wind-energy-in-the-north-sea.pdf

World Energy Council (2018), Perspectives on the Grand Energy Transition. World energy issues monitor. Retrieved June 2018, from https://www.worldenergy.org/publications/2018/world-energy-issues-monitor-2018-perspectives-on-the-grand-energy-transition/

World Energy Council (2016), Marine Energy. World energy resources. Retrieved June 2018, from https://www.worldenergy.org/wp-content/uploads/2017/03/WEResources_Marine_2016.pdf