Marine Renewable Energy Infrastructure Assessment

Prepared for

Nova Scotia Department of Energy

Collective Wisdom Solutions
MAKING IDEAS HAPPEN

exp.

Maritime Tidal Energy Corporation

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EXECUTIVE SUMMARY

Background

The Nova Scotia Department of Energy engaged a consulting team - Collective Wisdom Solutions, **exp.** Services Inc. (formerly O'Halloran Campbell Consultants) and Maritime Tidal Energy Corp - to undertake a Marine Renewable Energy Infrastructure Assessment. The purpose was to benchmark the infrastructure within Nova Scotia that could be used to support marine renewable energy development, fabrication, deployment, operation and servicing in order to characterize the Province's current status and to understand potential opportunities. The assessment was also intended to identify infrastructure improvements that would augment the Province's capabilities. It focused primarily on tidal energy, reflecting Nova Scotia's current activity in that field and the unique tidal resource available here, but also covered offshore wind and wave energy generation.

Purpose

Key objectives were:

- Identification of industry requirements for viable marine coastal support facilities and associated infrastructure
- Consolidation of port inventories (i.e. physical assets/wharf facilities, available water depth, tidal conditions, exposure, permissible deck loadings, back-up land, other users / facility availability, transportation infrastructure and support services)
- Identification of likely ports to support tidal energy and offshore wind development projects
- Outlining of practical concepts to enable the target ports to support tidal and wind energy development projects
- Identification of support services enhancements needed to support development
- Benchmark Nova Scotia infrastructure to that of another region (or established area)
- Order of magnitude costs to undertake port and infrastructure improvements to improve the capability of ports and the service sector
- High level assessment of potential benefits and impact of the work (perhaps by drawing upon the experience of another area).

The assessment included reviewing Nova Scotia ports and related infrastructure and services, and identifying marine renewable energy infrastructure requirements, specifically to identify:

- Planned (anticipated next stage) demand for infrastructure to support local marine renewable energy projects and exports
- Infrastructure requirements for development, fabrication, deployment, operation and servicing
- How infrastructure demands vary for smaller [<0.5 megawatts (MW)] to larger [>0.5MW] tidal devices
- How the demands relate to the stage in the project's life cycle (from development through to deployment and servicing).

In summary, the scope of work included a capability inventory, requirements identification, gap analysis, a detailed review of a small number of ports, and researching a comparable region elsewhere with significant development in marine renewable energy to gain ideas and lessons learned. The results will assist the Department to support the current and prospective supply and service community in the successful pursuit of renewable energy opportunities locally and in export markets.

Industry Context

The tidal energy industry is at an early stage of development. The UK, Canada and South Korea are currently the leading countries, having all installed demonstration turbines. The UK and Korea also have plans for commercial arrays in the next few years. There are currently two grid-connected demonstration sites in the world –The European Marine Energy Centre Ltd. (EMEC) in Orkney, Scotland, and Fundy Ocean Research Center for Energy (FORCE) in the Bay of Fundy (whose waters are under the jurisdiction of the Provinces of Nova Scotia and New Brunswick). It is not certain how the technology will evolve; at this stage there is a variety of turbine types and base structures. As the industry matures the technology may converge and this could have a significant impact on shore infrastructure requirements. The report gathers the information available today to best inform planning but it should be recognized that requirements will continue to evolve.

The offshore wind industry is more mature, although in this study no activity was identified in Nova Scotia. A global online database contains over 1000 offshore wind projects in 36 countries, primary markets being China, Denmark, Germany, Netherlands and the UK. Wave energy is at a similar stage of development to tidal energy, and very little activity is under way in Nova Scotia.

Approach

The Project approach consisted of two phases.

Phase 1 was a preliminary review of Nova Scotia ports and related infrastructure to gain an understanding of the current infrastructure and a simultaneous review of marine renewable energy requirements based on a combination of survey research, interviews with organizations and relevant government representatives, and desk research.

Phase 2 was a more in-depth assessment of the capabilities of a limited number of selected ports and associated infrastructure. A gap analysis was done, based on the outcomes of Phase 1 requirements gathering, supplemented by more extensive desk research into infrastructure requirements for marine renewable energy based on the experiences of other comparable jurisdictions with significant development in marine renewable energy, including planned development as applicable, to provide benchmarks and lessons learned. The results were used to develop concept plans for short listed ports along with lessons learned from other jurisdictions and conclusions for Nova Scotia.

Because the industry is at an early stage requirements are not clearly defined; technology is still evolving and it is difficult to predict in which direction requirements may evolve. The infrastructure requirements vary according to technology and for the purposes of analysis were grouped into base cases with similar demands as follows:

- Base Case 1. Large Tidal (>0.5 MW), gravity base, ‘short-term’ and ‘long-term’
- Base Case 2. Large Tidal (>0.5 MW), pin/pile base, ‘short-term’ and ‘long-term’
- Cabling for Base Cases 1& 2: Large Tidal (>0.5 MW); ‘short-term’ and ‘long-term’
- Base Case 3: Small Tidal (<0.5 MW); ‘short-term’ and ‘long-term’
- Base Case 4: Offshore Wind and Wave

For the purposes of analysis for Large Tidal, ‘short-term’ was defined as the period in which up to 64MW of tidal generating capacity is installed at the FORCE site; ‘long-term’ was defined as an additional 30MW of large tidal devices installed. The terms ‘short-term’ (up to 64MW of tidal generating capacity installed) and ‘long-term’ (an additional 30MW of tidal generating capacity installed) are used throughout the report in the context of explaining the thresholds used in the analysis.

The “tipping point” for needing infrastructure for Large Tidal is dependent on a number of factors. There are uncertainties around the “tipping point” at which existing infrastructure will no longer be considered to be cost-effective or infrastructure improvements, including new construction required, as elaborated in the report.

The three tidal base cases cover the following stages of the lifecycle for the ‘short-term’ and long term scenarios: manufacturing, assembly, deployment, O&M and decommissioning. The offshore wind base case covers the same stages of the lifecycle as the three tidal base cases except assembly and deployment are combined. It does not separate ‘short-term’ and ‘long-term’, but addresses requirements for 100 turbines deployed.

In reviewing the findings, it is useful to keep in mind some considerations that are unique to the Nova Scotia context and that impact the overall assessment and requirements.

The Bay of Fundy has the highest tides in the world. There are billions of tonnes of water entering and exiting the bay during each tidal cycle. Tide changes occur on average every six hours and 13 minutes. This is the principal underlying source of the in-stream tidal resource. The tide ranges from 3.5 metres along the southwest shore of Nova Scotia and steadily increases to approximately 16 metres in the Minas Basin.

The high tidal variation introduces major challenges for the construction of wharf facilities. It is not always practical or financially viable to construct wharf structures so that they provide water depth below low tide. In smaller ports it is generally accepted that wharf structures are constructed relatively close to shore and that the port/harbour bottom dries out at low tide (these are referred to as “dry” ports). It is quite common for there to be a grounding bed at some wharf facilities. Tidal variation is one of the most difficult aspects of introducing new infrastructure for marine renewable energy within the Bay of Fundy.

Due to the large size of offshore wind and tidal devices, fully assembled units can only be transported by water to and from the deployment site. The high costs of transportation drive the requirement for final assembly, deployment, operations and maintenance to be conducted at suitable ports that are located as close as possible to the deployment site, while also having access to appropriate services and land transportation. In the case of tidal energy, the development of the industry will necessitate the development and use of infrastructure within a range of 150 kilometres from the deployment site(s) in the Bay of Fundy. Ideally the ports would be even closer – within a range of 50 kilometres – but there are no “wet” ports (with water at the wharf at low tide) within this range of the FORCE site. In the case of offshore wind, suitable ports on the Atlantic coast are needed. These ports are also well located for wave energy, and can be assumed to be more than adequate for the infrastructure needs of wave devices, which are considerably smaller than tidal and wind devices

Infrastructure Requirements for Tidal Energy

Short-Term

For tidal energy, the sense from industry representatives is that currently planned deployment for the 'short-term' can be accommodated from existing facilities such as Halifax, Hantsport (with planned enhancements), Parrsboro or other ports located between Shelburne and Digby. Facilities in Saint John, New Brunswick may also provide support as the industry expands. Some modest enhancements to accommodate mobile crane loadings may be required at one of the ports close to the deployment area for the small tidal devices.

There are uncertainties around the "tipping point" at which existing infrastructure will no longer be considered to be cost-effective, such as the high costs of transporting completed turbine units (including bases) from Halifax to the Minas Passage, the costs of infrastructure improvements and whether any funding assistance might become available to ameliorate them, and the speed of technology evolution and industry development. For the purposes of this study, it is anticipated, based on information from industry, that existing marine and supporting infrastructure is sufficient to support in-stream tidal power development over the 'short-term' and it is not anticipated that infrastructure improvements or new construction (except some planned enhancements at Hantsport and modest improvements at Saulnierville or Meteghan) will be required for the initial 'short-term' phase (to FORCE's four approved berths, up to 64 MW generating capacity, and up to 10MW of small tidal devices).

Long-Term

In order to support the industry beyond the initial 'short-term' (up to 64MW of tidal generating capacity installed), it is clear that deployment facilities along the Bay of Fundy (within 150 km range, as indicated by developers, of Minas Passage for large tidal devices) are necessary. There are two obvious regional ports which are considered suitable for the 'long-term' deployment phase: Saint John and Digby.

The Port of Saint John is a well developed deep water "wet port" (i.e. it has water at low tide) with a mature supply chain capable, for the most part, of supporting in-stream tidal power deployment. However it may not be possible to displace existing and planned industries to allow space for all necessary requirements for fabrication, assembly, erection and load-out and for berthing of support vessels and barges of in-stream tidal power generation.

Digby Harbour has two major wharf facilities, the Fisherman's Spur Wharf and the Ferry Terminal. Although Digby appears to be strategically located, it does not have the wharf structure or back-up land necessary to adequately support in-stream tidal power development. Digby would require a new development if it is to be a primary port for the next phase or 'long-term', the time installed turbine capacity is approaching 64MW. In addition, these facilities are considered unsuitable to support larger in-stream tidal power generation as neither of the existing facilities is compatible with the marine renewable energy needs for the deployment phase. However, based on industry requirements it appears that the Harbour Authorities' planned development will not meet the needs of the larger gravity base tidal devices. It would be considered advantageous to construct a new major wharf facility in Digby Harbour to support larger MRE deployments as Digby will likely be a strategic location in the 'long-term' development of MRE resources. Based on information from the MRE development industry it is reasonable to consider constructing a new marine facility that would accommodate the MRE industry for all cases and through all phases of development, should the tipping point be reached.

Some in-stream tidal power developers, particularly those using pin/pile base structures that can be designed to float, will likely devise schemes to deploy or conduct some operations from dry ports (dry at low tide) i.e. Hantsport or Parrsboro. Ramps or floating dry docks can be constructed to enable these structures to be launched in a similar way to newly-built boats.

It is envisaged that if large tidal turbines or base components were produced for export, they would be shipped from a major port such as Halifax/ Dartmouth with break bulk cargo/ container facilities, and ideally would be manufactured close by. If manufacture were to take place at another location the equipment would be transported by road or rail to the container terminal. Large base structures tend to be assembled (and often fabricated) near the deployment site.

To support small tidal devices in the Digby Neck area, it is expected that several ports will be suitable including Digby, Meteghan, Meteghan River, Saulnierville and Weymouth, which are close to the planned and proposed 'short-term' deployment sites in Grand Passage, Petit Passage and Digby Gut. Fabrication and assembly capabilities also exist near some of these ports. It is also reasonable to expect that Freeport, Westport, Tiverton and East Sandy Cove will potentially provide a support role.

Offshore Wind Infrastructure Requirements

Based on information available, it appears that in order to meet future demands for offshore wind power generation, significant production, assembly and deployment facilities will be required. Major coastal locations for manufacturing facilities will be required, as it is difficult to transport the large offshore wind foundations in any manner other than via water. In light of this preliminary information and assuming that most of the offshore wind power generation activity will occur off the Atlantic coast of Nova Scotia it is feasible that certain Nova Scotia ports could either individually or collaboratively support the industry.

Collectively the facilities at Yarmouth, Shelburne, Halifax/Woodside, Sheet Harbour, Strait of Canso Superport, Sydney/North Sydney and Pictou should be capable of providing the required marine and associated support infrastructure for offshore wind power generation. It is not anticipated that there would be a need for major marine structure upgrades or expansion. However, given that the industry is still in its infancy in Nova Scotia the requirements and physical asset availability should be reassessed at the next stage of activity of this industry.

It is envisaged that exports of offshore wind turbines or base components manufactured in Nova Scotia would be transported by road or rail to a major port with break bulk cargo/ container terminal facilities for shipping. Base structures tend to be assembled (and often fabricated) near the deployment site.

Wave Energy Infrastructure Requirements

The Atlantic ports mentioned as suitable for offshore wind support are also well located for wave energy since the best wave resources are on the Atlantic coast, and can be assumed to be adequate for the infrastructure needs of wave devices, which are considerably smaller than tidal and wind devices.

Vessels

A variety of vessels will be required for tidal energy including dynamic positioning vessels, remotely operated vehicles (ROV's), barges with large cranes capable of lifting up to 400 tonnes, catamaran barges, tugs, and smaller vessels. For offshore wind larger vessels will be needed, possibly jack-up barges and new purpose-built offshore wind installation vessels. Many of these vessels also serve the offshore oil and gas industry and there are risks that vessels may not be available when required if increased demand occurs in more than one of these industries at the same time.

Supply Chain

Expertise exists in Nova Scotia for the fabrication and assembly of tidal and wind base structures. Final assembly in both cases needs to take place at the deployment wharf. For turbine manufacture and a host of other skills and services, Nova Scotia has a considerable ocean-related industry sector, but some gaps and new opportunities have been identified.

Jurisdictional Comparison

Useful lessons can be learned from Scotland (tidal) and Denmark (offshore wind). In Orkney (Scotland), a plan leading to 1 Gigawatt (GW) of marine renewable energy installed by 2020 has been developed that includes: 3-4 expanded/ new ports, 2-3 assembly / maintenance yards, 20-30 maintenance boats, 1-10 large purpose–built vessels, a local workforce of 500-1000, and major electricity grid upgrades.

Conclusions

Infrastructure requirements vary according to the type and size of technology being used, and stage of the lifecycle (manufacture, assembly, deployment, O&M, monitoring). Varying roles can be played by several ports in support of the MRE industry. Technology is still evolving and requirements could change; these conclusions reflect the information currently available.

1. For large in-stream tidal, the primary drivers in the consideration of marine structure development vary.

    - During deployment large in-stream gravity base structures require more robust wharf structures with deeper water than the lighter pin/pile structures. However, industry representatives indicate that wharf facilities preferably should be capable of deploying both large gravity base and the lighter pin/pile base. They also indicate that facilities should preferably be located at a “wet port” (a “wet port” is a port which has water at low tide).

    - Most developers have indicated a “wet port” is considered essential for deployment as well as operation and maintenance. A “wet port” is a critical factor for the ‘long-term’ deployment phase because it is anticipated that deployment will require vessels with drafts in the order of 6 m to 7 m for the gravity base structures and may need relatively deep drafts to accommodate pile driving/drilling templates for the pin/pile structures. The “wet port” will also prove beneficial during the O&M phase. Some developers, however, have stated that it is not necessary to have a “wet port” for most operations. These developers will have to devise schemes to operate from a “dry port” (i.e. Hantsport, Parrsboro). Many developers have also expressed the need for load outs; however the magnitude of load-out capacity varies dramatically between gravity type base and pin/pile base.

    - For large in-stream tidal, consideration should be given to developing a “greenfield” common user wharf facility in the Digby area consisting of a wharf structure capable of withstanding heavy lifts/load-outs, with 8 metres minimum water depth below low tide level, and ample back-up land required to support the broad range of requirements for in-stream tidal power generation beyond the initial 64 MW threshold. The facility should have the ability to be expanded in the future.

- Should the above "greenfield" common user wharf facility be developed, a first step should be to conduct an initial site selection study to identify potential sites in Digby Harbour that are viable locations for a new common user wharf facility and which would be practically and financially viable for development in support of the in-stream tidal power generation industry as a whole. This new common user wharf facility should be capable of accommodating all phases of development and operations and maintenance. The site selection study should focus on "greenfield" but could also examine "brownfield" sites. The preferred site should be capable of providing the key development requirements with an emphasis on wharf length, water depth, accessibility and proximity to a reliable and developed service supply chain and capable of being expanded.

2. For small in-stream tidal, offshore wind and wave energy, based upon the information available, it is considered that existing infrastructure in a variety of ports will be adequate.

3. The tidal energy industry is at an early stage of development, and technology is still evolving in response to early experience in deploying and operating the devices in challenging marine environments. Infrastructure requirements may change as the technology and the industry mature. Therefore, industry requirements should be reassessed in four or five years in order to develop appropriate plans for infrastructure improvements and expansion. While the focus of this study has been on in-stream tidal power generation in the Minas Passage, other sites in the Bay of Fundy could likely be of interest as the industry matures. When the offshore wind and/or wave energy industries develop in Nova Scotia the infrastructure requirements for those industries should be assessed in more detail.

4. For planned developments to move forward in a coordinated manner it will be necessary to orchestrate a number of infrastructure requirements in parallel and respond to the uncertainties inherent in the evolution of an early-stage industry. A blueprint similar to that prepared by Orkney would be useful to articulate and clarify various parallel activities needed to advance development. For example, the Orkney blueprint covers numerous parameters, some directly related to infrastructure, while others address issues that may impact development pace: targets, regulation, policy, capacity, technologies, projects, facilities, grid, harbours, vessels, research, surveys, education, employment, consents, coordination and incidents.

5. Nova Scotia's engagement with the 'Marine Renewable Energy Technology Road Map' may highlight opportunities for linkages between infrastructure requirements needed by the Province for Marine Renewable Energy development and needs for other strategic infrastructure for national security, maritime security and energy security.

6. Nova Scotia's approach to Marine Renewable Energy infrastructure development to date is very similar to that of other jurisdictions that are in similar stages of development and can continue to benefit from the experiences and lessons learned, particularly in terms of technology advancements and related infrastructure requirements.

7. Supply chain development could be fostered in strategic and tactical ways such as:

   - Supplier development information sessions/networking events to make suppliers aware of potential opportunities within marine renewable energy development and also enable them to showcase their relevant expertise and capabilities.

   - Building on previous events and established networks to further inform supply chain considerations and how best to address identified gaps. (For example, Fundy Energy Research Network, Ocean Renewable Energy Group conferences, Commercialization Workshop, NS Tidal Energy Symposium – Getting Power to Market, OEER/ FORCE Research and Development Workshop and university events such as Dalhousie’s Oceans Week)

   - Aligning infrastructure requirements and supply chain requirements to develop the marine renewable energy sector in Nova Scotia with relevant economic development and sector development initiatives to strategic advantage, using the Equimar example, to ensure that relevant linkages are clearly understood and articulated. Related initiatives include: the NS Renewable Electricity Plan; jobsHere – the plan to grow our economy; marine renewable energy legislation; Feed-In Tariffs; OEER/ OETR projects and priorities; plans for ocean sector development and consideration of regional energy partnerships).

   - Collaboration with adjacent jurisdictions to identify shared interests and opportunities.

1.0 INTRODUCTION

1.1 Background

As part of the Environmental Goals and Sustainable Prosperity Act (EGSPA) the Province of Nova Scotia has set a target to reduce greenhouse gas (GHG) emissions by at least 10% from 1990 levels by 2020. Under the Renewable Electricity Plan the Province has set a target to increase electrical energy generation from renewable sources to 25% of the Province's demand by 2015. In keeping with its mandate to manage and promote energy resources in order to achieve optimum economic, social and economic value from the energy sector, the Nova Scotia Department of Energy has developed five strategic goals. The goals most pertinent to this project are secure, competitive and sustainable energy supplies, sustainability from energy resource revenues, and new economic growth and opportunities. Marine renewable energy, in particular in-stream tidal and offshore wind, offers the real possibility of contributing to the achievement of these goals.

Nova Scotia has plentiful offshore wind resources, often close to the electricity grid. Currently there are no offshore wind projects in North America, but it is likely that early projects will develop in Ontario in the Great Lakes, and off the coast of the North Eastern US. Of the top 25 existing offshore wind projects in the world, 21 are in Europe.

On July 12, 2010, Nova Scotia and Maine signed a Memorandum of Understanding (MOU) to cooperate on marine renewable energy generation. The objectives of the MOU are to investigate opportunities and areas for cooperation on furthering offshore wind and tidal energy technology and application, and to cooperate on tidal energy research and development to ensure the maximum contribution to renewable electricity standards for both regions.

According to a 2006 study by the Electrical Power Research Institute in California, Nova Scotia is the best location to develop tidal power in North America. Two sites are expected to have the most potential and include the Minas Passage at 166 MW, and the Minas Channel with 131 MW. The other sites identified in the report include Cumberland Basin, Cobequid Bay, Digby Gut, Petit Passage, Grand Passage, and Great Bras d'Or Channel. Work funded by the Offshore Energy Environmental Research Association (OEER) to refine these estimates is currently under way under the direction of Dr. Richard Karsten (Acadia University). This work has produced revised estimates of 2,500 MW extractable from the Bay of Fundy.

The UK and Canada are emerging as world leaders in exploring the potential for harnessing the energy from tidal currents. The UK has done, and is doing extensive tidal research. They have undertaken several proof-of-concept tidal turbine demonstrations, with several more in the works. They continue to encourage investment. This has led to plans to install 1 GW of tidal power capacity in the UK by 2020. In 2010, Scotland began by leasing undersea real estate to six large consortiums in exchange for the development of a 600 MW tidal capacity by 2020. This will generate considerable economic activity. The capital cost alone is expected to be in the $2 billion range. The UK Marine Renewable Energy - State of the Industry Report (2009), estimates tidal energy could become competitive with current base costs of electricity by the time 2.8 GW have been installed.

In Canada several proof-of-concept demonstrations have been undertaken (British Columbia and Nova Scotia) and several more are planned. Canada's Ocean Renewable Energy Group, an industry organization, has said that Nova Scotia alone could reasonably expect to build a tidal energy capacity of 100 MW by 2020.

The Nova Scotia government has taken a strong lead in shaping and funding the activities needed to create a tidal energy industry in Nova Scotia. Specific steps taken in Nova Scotia include:

- The completion of a Strategic Environmental Assessment focusing on tidal energy development in the Bay of Fundy in 2007;
- The establishment of the Fundy Ocean Research Centre for Energy (FORCE) in 2008; $7million in funding was provided by the Province towards its establishment;
- One turbine was installed at the FORCE site in 2009 and retrieved in 2010; all four berth-holders at FORCE plan to install turbines in 2012/13;
- The allocation of $2 million to the Offshore Energy Environmental Research Association for tidal energy research in 2008; an additional $2 million was allocated in 2011 for additional research;
- The publication of "Toward a Greener Future" Nova Scotia's 2009 Energy Strategy;
- The publication of the Renewable Energy Plan in 2010;
- The publication of the Report on the Stakeholder Consultations Process for a new Renewable Energy Strategy in Nova Scotia in 2010;
- Renewable energy regulations allowing for Feed-In Tariffs and Community Feed-In Tariffs for tidal energy projects in 2010;
- Various studies and workshops to focus on economic implications and infrastructure assessment needs as well as supply chain development related to renewable energy.

1.2 Purpose

The Nova Scotia Department of Energy engaged a consulting team - Collective Wisdom Solutions, **exp.** Services Inc. (formerly O'Halloran Campbell Consultants) and Maritime Tidal Energy Corp - to undertake a Marine Renewable Energy Infrastructure Assessment. The purpose was to benchmark the infrastructure within Nova Scotia that could be used to support marine renewable energy device development, fabrication, deployment, operation and servicing in order to characterize the Province's current status and to understand potential opportunities. The assessment was also intended to identify infrastructure improvements that would augment the Province's capabilities. Key objectives were:

- Identification of industry requirements for viable marine coastal support facilities and associated infrastructure
- Consolidation of port inventories (i.e. physical assets/wharf facilities, available water depth, tidal conditions, exposure, permissible deck loadings, back-up land, other users / facility availability, transportation infrastructure and support services)
- Identification of likely ports to support tidal energy and offshore wind development projects
- Outlining of practical concepts to enable the target ports to support tidal and wind energy development projects
- Identification of support services enhancements needed to support development
- Benchmark Nova Scotia infrastructure to that of another region (or established area)
- Order of magnitude costs to undertake port and infrastructure improvements to improve the capability of ports and the service sector
- High level assessment of potential benefits and impact of the work (perhaps by drawing upon the experience of another area).

The assessment included reviewing Nova Scotia ports and related infrastructure and services, and identifying marine renewable energy infrastructure requirements, specifically to identify:

- Planned (anticipated next stage) demand for infrastructure to support local marine renewable energy projects and exports
- Infrastructure requirements for development, fabrication, deployment, operation and servicing
- How infrastructure demands vary for smaller (<0.5MW) to larger (>0.5MW) tidal devices
- How the demands relate to the stage in the project's life cycle (from development through to deployment and servicing).

In summary, the scope of work included a capability inventory, requirements identification, gap analysis, a detailed review of a small number of ports, and researching a comparable region elsewhere with significant development in marine renewable energy to gain ideas and lessons learned. The results will assist the Department to support the current and prospective supply and service community in the successful pursuit of renewable energy opportunities locally and in export markets. Marine renewable energy for the purpose of this project is defined as tidal, wave and offshore wind energy generation.

2.0 INDUSTRY CONTEXT

2.1 Global State

2.1.1 Tidal Energy – Background and Industry Context

Large Tidal (greater than 0.5 MW)

The tidal energy industry is at an early stage of development. To date the UK has installed two large commercial-sized demonstration tidal turbines (1MW or larger). Marine Current Turbines deployed a 1.2MW turbine in Northern Ireland, and Atlantis Resources, a 1MW turbine in Northern Scotland. Two more 1MW demonstration tidal turbines are planned for installation this year by Hammerfest Strom and Voith. Both will be installed in northern Scotland.

In the next two years the UK plans to install several commercial turbine arrays or farms in the 10MW range – Marine Current Turbines in Wales and Northern Scotland, and Hammerfest Strom in Western Scotland. Plans are also in place to install much larger commercial arrays by 2020 in Northern Ireland and Scotland. Undersea leases have been let in exchange for the developments in excess of 600MW. The main developers behind these plans are Marine Current Turbines, OpenHydro and Hammerfest Strom. They are backed by large, financially sound companies like EDF Group, SSE Renewables (Southern Scottish Energy), and SPR (ScottishPower Renewable) respectively.

The only other countries that have approached this level of tidal energy development activity are Canada and Korea. Korea has shown leadership in tidal development in Asia, and has demonstrated a 1MW turbine and plans to follow up soon with a 90MW commercial project. In Canada, OpenHydro/ Nova Scotia Power has tested a 1MW turbine in the Bay of Fundy.

There are currently two grid-connected demonstration sites – EMEC in Orkney, Scotland, and FORCE in the Bay of Fundy. In the Pentland Firth, (northern Scotland), a strategy and timeline have been developed for tidal and wave energy. In essence, the plans include:

- EMEC wave and tidal sites: there have been 8 technology deployments involving over 50 delivery/ recovery operations
- A target of 1 GW of marine renewable energy generated by 2020
- Ports to be developed include: Stromness harbour, Kirkwall harbour, Hatston, Lyness, Scrabster harbour.

Looking beyond the UK, Canada and Korea, other countries are beginning to realize the potential of generating energy from their tidal resources. The US, France and Australia have early tidal demonstration and commercial projects in process or on the books. China and India are becoming very interested as well. The world is waking up to the great energy possibilities in the oceans.

Leading Tidal Developers – Current and Planned Commercial Turbine Installations Summary

- Four of the world's leading tidal turbine developers have plans to install small commercial arrays in the next two to three years

Marine Current Turbines	Wales	10.5 MW
OpenHydro	France	4-10 MW
Hammerfest Strom	Scotland	10 MW
Verdant Power	United States & Central Canada	6-16 MW
Korea East West Power Co	S. Korea	90MW

- Three of these leading tidal turbine developers have successfully been approved to develop larger commercial arrays to be installed in the next ten years

Marine Current Turbines	Scotland & N Ireland	200 MW
OpenHydro	Channel Island & Scotland	485 MW
Hammerfest Strom	Scotand	95 MW

- In eastern Canada there are plans to install up to 5 MW at the FORCE site in the next two years.

More detail on current and planned developments by leading turbine developers is included in Appendix D.

Small Tidal (less than 0.5 MW)

Small run-of-river devices have been developed and used for a number of years. Several companies are now scaling these up to around 0.5 MW for tidal applications, and modifying them for marine conditions.

These include:

i) Verdant Power
Has demonstrated a 6 turbine array [small 35 kW (kilowatt) units] in the United States between 2006 and 2008. Plans include a 1 MW (30 turbines) installation in the East River in New York City (application for licence submitted December 2010), with a 2 MW – 4 MW expansion to follow, and 5 – 15 MW in the St Lawrence River near Cornwallis, Canada between 2010 – 2012.

ii) New Energy Corp.
Located in Alberta. Is testing a device at Canoe Pass in BC.

iii) Ocean Renewable Power Corp. (ORPC)
Based in Maine, US. Tested a device in 2010 and plans a deployment in Eastport, Maine in 2011.

iv) Fundy Tidal Inc.
Conducted tide tests of a 5 kW New Energy Corp device in 2010. Plans installations of New Energy Corp and ORPC devices in the Bay of Fundy in 2012/13

2.1.2 Offshore Wind – Background and Industry Context

A global online database contains over 1000 offshore wind projects in 36 countries, primary markets being China, Denmark, Germany, Netherlands and the UK. Offshore wind farms off the coast of Europe and the UK have been installed gradually from shallow to deeper waters.

The Danish Experience

Since 1991, Denmark has seen continuous growth in offshore wind. Growth is attributable to the dramatically decreased cost of foundations, thus reducing the total investment required to install 1 MW of wind power offshore in Denmark to around £1.5 million, including grid connection. Among the cited advantages is the fact that Denmark is heavily electricity-network-connected to its immediate neighbours and can buy and sell electricity in times of shortages or surpluses.

The US

The offshore wind industry is in its infancy, and is facing many start-up challenges. In the US, purpose-built portside infrastructure for the offshore wind industry does not currently exist. A comprehensive program of research and testing is underway, involving partnerships with national laboratories, university research centres and industry. A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States was prepared by the US Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Wind and Water Power Program to outline the actions it will pursue to support the development of a world-class offshore wind industry in the United States. The Strategy is intended to guide DOE's efforts through the Offshore Wind Innovation and Demonstration (OSWInD) initiative to promote and accelerate responsible commercial offshore wind development in the US in both federal and state waters. The OSWInD initiative aims to address industry challenges through three primary activities: Energy Resource Planning, Siting and Permitting and Complementary Infrastructure, which will address domestic manufacturing and supply chain development, transmission and interconnection planning, and specialized vessels and other installation, operations and maintenance technology.

The UK

The UK entered the wind industry later than a number of its European neighbours, but is now installing and planning to install large numbers of offshore wind farms. There are plans to install 9,500 turbines in UK waters (in three "Rounds" of site leasing), excluding projects in Scottish and northern Irish territorial waters, where approximately 70 additional installations are planned. It is estimated that by 2020 the average size of a wind turbine will be 6MW. The first phase of the largest offshore wind farm in the world, the London Array, is currently under construction, with investments from European companies DONG Energy and E.ON and Abu Dhabi's Masdar. Actions are planned to increase port capacity in all regions close to wind installation sites to help handle future marine and offshore energy developments. It is considered that investment now will bring long-term benefits to the UK port industry.

Technology development

The primary components of the wind turbine system include the foundation, support structure, a transition piece, the tower, the nacelle, and the rotor blades. The foundation and the support structure can be constructed from a variety of materials including reinforced concrete and steel. The tower is usually made of steel plate rolled into conical subsections welded together. A tower is usually manufactured in 20-30 m long sections, transportation to the site being the limiting factor. The nacelle contains the key electrical components for the turbine including gearbox and generator. The rotor blades are of carbon fibre composites.

Because such factors as weather depth, seabed conditions, wave heights and current velocities and ice climate can vary widely from one site to another, the use of a generic support structure has generally not been feasible, rather being designed for particular site conditions. Typical offshore platforms have a design life of about 20 years. There are about six different types of support structures: gravity structures, monopiles, guyed monopole towers, tripods, braced lattice frames, and floating structures.

Larger turbine systems and greater water depths associated with offshore wind farms are expected to place significant demand on wind turbine support structures and foundations, requiring innovative, cost-effective designs. While most early wind farms are in shallow waters, depths of 30-50m are increasingly common. The combination of increased depth, tower heights and larger rotor blade diameters complicate the process of designing foundations, further complicated by exposure to ocean currents, storm winds and waves, ice and potential impacts of navigational vessels. The requirements for offshore and inshore wind turbines are quite different due to the very different deployment environments such as water depth, wind intensity, distance from shore and weather conditions, needing alternative technology to enable the effective utilization of wind power in all environments, an example being the degree of buoyancy required for the cable.

A large portion of the technology in offshore wind turbines has been developed and tested in the demanding, deepwater offshore environments for the oil and gas industry. Technologies originally developed for deep-water oil and gas extraction (such as for foundation structures and installation methods) can be transferred to offshore wind power applications.

The economics of offshore wind farms are presently less favourable than for onshore wind energy and therefore there is a strong need for significant cost reductions in order to become competitive.

About 70% of the electricity cost of offshore wind farms is determined by the initial investment costs, which mainly consist of the wind turbines, foundations, internal and external grid-connections and installation. The main drivers for cost reduction appear to be design improvements and use of larger wind turbines and the development and high utilization rates of purpose-built installation vessels. Other factors include further development of HVDC converter stations and cables, standardization of turbine and foundation design, and economies of scale for wind turbine production. It is then hoped that the investment costs of offshore wind farms may drop by about 25-39% by 2020. The major stumbling blocks at the moment are the availability of turbines, the dramatically increasing prices of steel and the availability of large scale installation ships especially designed for the purpose.

2.1.3 Wave Energy – Background and Industry Context

The wave energy conversion industry is at an immature stage, with only a few full-scale devices tested from over 100 device developers. Most device developers are based in European countries that have R&D programs in place to support device development activities. The largest number of developers is in the UK, followed by the US, Canada, Denmark, Norway and Ireland, with a small number in many other countries internationally.

The US

There are no full-scale wave (or tidal) power systems in the US; however, there are a few projects in exploratory or development stages. In the US, there are significant funds committed to research ocean energy technologies. Under the Marine Renewable Energy Research and

Development Act of 2007, the US has committed $200M in federal funds through 2012 towards wave energy technology. [1]

For the States of Maine, New Hampshire, Massachusetts, Rhode Island, New York, and New Jersey, the Electric Power Research Institute (EPRI) has estimated that 120 Terawatt hours (TWh) of wave power generation per year is possible, but there are significant political, technological, and financial barriers to overcome in order to attain this potential. The location with the most potential for wave power is the Pacific coast.

The coastal states of California, Washington, and Oregon boast a combined ocean wave energy potential of roughly four times that of the US east coast, and Hawaii and southern Alaska also are seen to have potential. To date only 10 permits have been granted by the Federal Energy Regulatory Commission for wave projects, 8 being in Oregon, the first filed in 1998. Oregon is the wave energy leader on the west coast, aided by the Oregon Wave Energy Trust[2], a non-profit Private-Public Partnership (PPP) funded by the Oregon Innovation Council in 2007, working with stakeholders in an attempt to provide 500MW of installed capacity by 2025 and acts as liaison for stakeholders including researchers, community members, and utilities. While there are many companies developing concepts and patents, very few technologies have undergone long-term testing to demonstrate commercial viability. [3]

Technology development

Different approaches are being pursued and there is currently no consensus on which technical approaches are the most promising ones. Few have tested their device at full-scale in real sea conditions and even fewer are ready for early adoption in commercial development projects; some are missing a comprehensive understanding of design requirements. Most of Canada's wave energy technologies are undergoing conceptual design and part scale test activities.

Characterization of Wave Energy Devices

A recent National Research Council (NRC) report noted that 63 wave energy conversion device developers have been identified worldwide, and these can be characterised as follows: *Point Absorber*- this being the most common, a floating device which absorbs kinetic energy through its movement in the waves; *Attenuator* -floating multiple-segment device arranged and moored in-line with the prime wave direction; *Oscillating Wave Surge Converter:* typically vertical plate which extracts energy from the ocean waves by moving in horizontal direction; *Oscillating Water Column* - a hollow structure that has an open bottom; *Overtopping Device* - typically an enclosed basin into which waves overtop using a ramp. In Canada the point absorber seems to dominate the technology approach being pursued. Some developers are investigating ways of integrating the application of arrays into the design. Details on wage energy developers are available from NRC.

[1] Renewable Energy Opportunities and Competitiveness Study. By SLR for NS Dept. of Energy September 2010
[2] www.oregonwave.org
[3] Marine Renewables Market Study: Wave, Tidal and Offshore Energy Canada and the United States of America Coordinated by Innovation Norway, Toronto, Canada

2.2 National / Provincial Context

Canada has an abundance of "conventional" energy sources (oil, natural gas, hydro-electricity, onshore wind), and has experienced less pressure than the UK and northern Europe to develop marine renewable energy despite also having excellent potential resources of this type. In Nova Scotia and British Columbia marine renewable energy is seen as an attractive opportunity, especially Nova Scotia which is heavily dependent on imported fossil fuels, and has one of the world's best tidal resources in the Bay of Fundy. Nova Scotia leads Canada in developing tidal energy, and along with Scotland currently occupies a leading position globally.

In 2010-11 Natural Resources Canada initiated the development of a Marine Renewable Energy Technology Roadmap, which will cover tidal and wave but not offshore wind (which was included in a previous technology roadmap for onshore and offshore wind development). As of mid-2011 this consultative and strategic process is reaching the concluding stages, and includes the identification of needs and opportunities for Canada. Involvement and participation from Nova Scotia tidal energy players is high. Once the Roadmap has been completed it will facilitate the focussing of national public and private sector resources on the development of marine renewable energy.

FORCE and the European Marine Energy Centre (EMEC) signed a strategic agreement in May 2011. The agreement builds on EMEC and FORCE's existing assets, and will help strengthen both organizations' capacity for research, including:
-- environmental assessment and monitoring
-- turbine and submarine cable deployment, connection, maintenance, and retrieval

The four berth-holders at FORCE plan to deploy demonstration turbines in 2012-13. In order to remain well positioned to seize the opportunities in tidal energy, Canada and Nova Scotia must build experience and foster an environment conducive to early development of commercial arrays. In addition to building up technical and operational experience, a critical factor in determining the speed of development will be financing. Government initiatives to establish the 'rules of the game', develop a commercialization strategy, and incent the early commercial adopters are also key success factors.

Offshore wind, a more mature industry globally, has not begun to develop in Nova Scotia. Nova Scotia has good offshore wind resources, although much of the resource is in deep water. Deep water wind projects are more complex and costly and require different foundation types such as floating foundations and buoyant cables. The establishment of DSTN, a wind turbine and tower manufacturer in Nova Scotia, and the existence of expertise and Atlantic ports active in offshore oil and gas, are important assets upon which to build. Additional assets include environmental expertise and experience in harsh marine environments.

An Inventory of Canada's Marine Renewable Energy Resources by NRC (2006) to quantify and map Canada's renewable marine energy resources due to waves and tidal currents concluded that wave energy off Canada's Pacific and Atlantic coasts is sufficient to justify further research into its development as a source of renewable green energy for the future. The research identified the west coast of British Columbia as having some of the best wave energy potential in the world. Future projects may be constructed along the west coast of Vancouver Island, and along the north coast near the Queen Charlotte Islands.[4] The Grand Banks east of

[4] Ocean Renewable Energy Group (OREG). www.oreg.ca

Newfoundland, SE coast of Newfoundland, and waters near Sable Island and the southern shore of Nova Scotia are also considered optimal deep water sites in terms of annual mean wave power.

There are five Canadian companies pursing wave energy conversion technologies, including the College of the North Atlantic in Newfoundland. Details about these technologies and other descriptive information about the state of the industry used in this report are excerpts from Natural Resources Canada (NRC).[5]

Within Canada the wave industry has not achieved a significant milestone and there is no dedicated large scale open sea demonstration facility. Developers are continuing to further develop, optimize and scale up their technologies. More information on wage energy developers is available from Natural Resources Canada's latest report on the state of technology. [6]

Syncwave Systems Inc. has developed a next-generation wave energy capture technology in British Columbia. SWELS™ technology was invented and laboratory tested with scientists and engineers from the University of Victoria, and a preliminary design executed for the open ocean in collaboration with Marinus Power LLC, of Houston, Texas. SyncWave Power Resonator™ represents a next-generation advance in the global race to commercialize wave energy and is intended to be demonstrated off the west coast of Vancouver Island in 2011.[7]

Pacific Coastal Wave Energy Corporation is partnering with the District of Ucluelet to develop a wave power demonstration facility off the west coast of Vancouver Island. The project will generate up to 4MW of electricity using CETOTM wave technology.

Wave Energy Technologies Inc., based in Toronto, Ontario, with operations in Nova Scotia, has been created and organized to develop, patent, test and commercialize the WET EnGen™ technology.[8] The WET EnGen™ technology converts ocean wave energy into electrical power or pressurized water for reverse osmosis desalination, and can be applied in a wide range of wave climates throughout the world. The Company has completed the concept development and the model testing phases of product development and is preparing for pre-commercial prototype demonstration projects. Preliminary ocean tests of the 20 kW WET EnGen take place in Nova Scotia and some of the project partners / collaborators include the National Research Council of Canada and Dalhousie University.

The College of the North Atlantic[9] in Newfoundland is currently doing a research and development project on Wave Powered Pumping of Seawater for Onshore Use and Electrical Generation in Burin. The project aims at harnessing the ocean wave energy into onshore commercial applications. The project is a collaboration by a team of researchers, managers and financers.

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[5] Review of Marine Energy Technologies and Canada's R&D Capabilities. Prepared for Natural Resources Canada. 2008. http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/marine_energy/publications/review_marine_energy.html

[6] Marine Renewable Energy – Wave, Tidal and Water Current Canadian Technology Status Report. Prepared by Natural Resources Canada**.** 2010 Edition http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/fichier.php/codectec/En/ISBN_M154-40-2010E/CanadianTechnologyDeveloper2010update_eng.pdf

[7] www.syncwavesystems.com

[8] www.waveenergytech.com

[9] www.cna.nl.ca

3.0 APPROACH AND METHODOLOGY

3.1 Approach

The project involved two phases. Phase 1 was a preliminary review of Nova Scotia ports and related infrastructure to gain an understanding of the current infrastructure and a simultaneous review of marine renewable energy requirements based on a combination of survey research, interviews with organizations and relevant government representatives, and desk research. The results of this phase were used to inform the development of base cases of facility requirements to support large-sized and smaller-sized tidal devices, and help to determine the focus and direction of Phase 2.

Phase 2 was a more in-depth assessment of the capabilities of a limited number of selected ports and associated infrastructure. A gap analysis was done, based on the outcomes of Phase 1 requirements gathering, supplemented by more extensive desk research into infrastructure requirements for marine renewable energy based on the experiences of other comparable jurisdictions with significant development in marine renewable energy, including planned development as applicable, to provide benchmarks and lessons learned. The results were used to develop concept plans for short listed ports along with lessons learned from other jurisdictions, conclusions and recommendations for Nova Scotia.

Factors taken into consideration in the research design and focus included:

- Likely areas for tidal energy resource development and for offshore wind development in Nova Scotia based on current insights – including high level differences and similarities in requirements.

- The range of ports to be considered for potential servicing of tidal projects most likely to occur in the coastal areas in the Bay of Fundy and Digby Neck, and around the Southwest coast of Nova Scotia; ports need to be relatively close to deployment sites

- Critical factors that must be available at a target port for it to be considered for further analysis, such as availability of back-up land and staging areas, and ability to load-out large and heavy devices.

- Identification of key players in the tidal and offshore wind energy sector both in research and developed technologies.

- Collection of specific information though separate meetings with key informants related to other aspects of development such as supply chain information and critical factors influencing development.

3.2 Methodology

Key activities included the following:

- Design and development of survey tools – a questionnaire for targeted Nova Scotia and nearby ports; and an interview guide to be used as the basis of telephone interviews with equipment developers and operators, both reviewed in advance by the client.

- Information gathering – since marine renewable energy is at an early stage of development, interviews were considered the most effective way of eliciting requirements from the developers, equipment manufacturers, operators, and other knowledgeable organizations, as well as with government officials, industry associations and other interest groups. A survey of the ports was also conducted.

- Development of base cases for requirements to support different scenarios, taking into consideration various factors including the evolution of various technology options and local partnering. Due to uncertainties about the pace of development it was decided that rather than consider a five-year time horizon for the anticipated demand for infrastructure it was more useful to define the phases of development that would likely require infrastructure improvement. This approach makes the study more flexible and adaptable to changes as the industry advances.

- Capabilities assessment and gap analysis of port infrastructure and supply chain.

- Benchmarking against other world class facilities - by identifying and analyzing comparable jurisdictions with significant development in marine renewable energy, tidal and offshore wind in particular; Internet, literature research, as well as direct contacts with organizations associated with the selected region to determine such things as current and planned infrastructure, sector development history, infrastructure financing, sharing, similarities and differences with Nova Scotia, and lessons learned.

- Concept infrastructure development plan – assessing requirements for development, fabrication, deployment and servicing of tidal and offshore wind projects and comparison to the available facilities at specific ports with a view to determining potential for improvement and/or expansion, “common user” arrangements and other considerations.

To gather information about the present and future demand for infrastructure, interviews were conducted with companies involved in tidal energy in the Bay of Fundy and other key informants and a discussion was held with the board of FORCE. Results were summarized in a detailed spreadsheet. The aggregated summary results are included in the report.

In terms of identifying anticipated demand for infrastructure to support local marine renewable energy projects and exports, 5 years was the starting point but the project scope was redefined to “next stage of activity” in consideration of the current stage of industry development.

It should be noted that the industry is at an early stage and requirements are therefore not clearly defined: technology is still evolving and it is difficult to predict in which direction requirements may evolve. To shed more light on the issue, documents and websites in other jurisdictions were reviewed in order to gather additional information about the industry’s current and predicted demand for infrastructure and supply chain capabilities.

The offshore wind industry is a more mature industry but no current activities in offshore wind in Nova Scotia were uncovered in the course of this study. Documents and websites in other jurisdictions were reviewed in order to gather information about infrastructure and supply chain requirements for this industry. Wave energy technology is at an early stage and little evidence of development in Nova Scotia was uncovered. However offshore wind and wave energy remain on the radar.

An interim working session was held with the Steering Committee at the end of Phase 1 – to review preliminary research findings, identify the preliminary list of ports for further consideration, define the criteria for development of the bases cases, and help to define the scope and focus of Phase 2. There was regular correspondence with the client by telephone and email throughout the project including regular status reports.

The interview guide, lists of contacts and ports questionnaire are included in Appendices A, B, and C respectively.

4.0 ASSESSMENT OF PRESENT AND PLANNED DEMAND FOR INFRASTRUCTURE

This Chapter provides an assessment of present and planned demand for infrastructure for marine renewable energy based on the combined results of interviews and other research. The Chapter consists of:

- A summary of the industry survey findings, presented in two sections: infrastructure requirements and supply chain requirements.
- A summary of findings from a review of documents and websites, presented in three sections: tidal energy, offshore wind and wave.
- Findings from previous studies that give some information about the strengths and gaps in the supply chain for the marine renewable energy sector in Nova Scotia.

In reviewing the findings, it is useful to keep in mind some considerations that are unique to the Nova Scotia context and that impact the overall assessment and requirements.

The Bay of Fundy has the highest tides in the world. There are billions of tonnes of water entering and exiting the bay during each tidal cycle. This change in tide (from low tide to high tide or high tide to low tide) occurs on average every six hours and 13 minutes. This is the principal underlying source of the in-stream tidal resource. The tide ranges from 3.5 metres along the southwest shore of Nova Scotia and steadily increases to approximately 16 metres in the Minas Basin.

The high tidal variation introduces major challenges for the construction of wharf facilities. It is not always practical or financially viable to construct wharf structures so that they provide water depth below low tide. Therefore, in smaller local ports it is generally accepted that wharf structures are constructed relatively close to shore and that the port/harbour bottom dries out. It is quite common for there to be a grounding bed at some wharf facilities. The challenge presented by this tidal variation is one of the most difficult aspects of introducing new infrastructure for marine renewable energy within the Bay of Fundy.

Due to the large size of offshore wind and tidal devices, fully assembled units can only be transported by water to and from the deployment site. The high costs of transportation drive the requirement for final assembly, deployment, operations and maintenance to be conducted at suitable ports that are located as close as possible to the deployment site, while also having access to appropriate services and land transportation.

In the case of tidal energy, the development of the industry will necessitate the development and use of infrastructure within a range of 150 kilometres from the deployment site(s) in the Bay of Fundy. Ideally the ports would be even closer – within a range of 50 kilometres – but there are no “wet” ports within this range of the FORCE site. In the case of offshore wind, suitable ports on the Atlantic coast are needed. These ports are also well located for wave energy, and can be assumed to be more than adequate for the infrastructure needs of wave devices, which are considerably smaller than tidal and wind devices.

4.1 Industry Survey Findings

4.1.1 Infrastructure requirements

The MRE industry is at an early stage, in Nova Scotia and elsewhere, and therefore requirements are not clearly defined. Technology is still evolving and it is difficult to predict in which direction requirements may evolve. Infrastructure requirements vary according to technology and for the purposes of analysis were grouped into base cases with similar demands as follows:

- Base Case 1. Large Tidal (>0.5 MW), gravity base, 'short-term' and 'long-term'
- Base Case 2. Large Tidal (>0.5 MW), pin/pile base, 'short-term' and 'long-term'
- Cabling for Base Cases 1& 2: Large Tidal (>0.5 MW); 'short-term' and 'long-term'
- Base Case 3: Small Tidal (<0.5 MW); 'short-term' and 'long-term'
- Base Case 4: Offshore Wind and Wave

The three tidal base cases cover the following stages of the lifecycle for the 'short-term' and 'long-term' scenarios: manufacturing, assembly, deployment, O&M and decommissioning.

The offshore wind base case covers the same stages of the lifecycle as the three tidal base cases except assembly and deployment are combined. It does not separate 'short-term' and 'long-term', but addresses requirements for 100 turbines deployed. The wave information was derived from a case study covering the same stages of the lifecycle and addressing "full scale deployment" scenarios but with no specification as to the number of devices deployed.

For the purposes of analysis for Large Tidal, "Short term" was defined as the period in which up to 64MW of tidal generating capacity is installed at the FORCE site; "Long term" was defined as an additional 30MW of large tidal devices installed. The terms "Short Term" (up to 64MW of tidal generating capacity installed of tidal generating capacity installed) and "Long Term" (an additional 30MW of tidal generating capacity installed) are used throughout the report in the context of explaining the thresholds used in the report preparation.

Long term (an additional 30MW of large tidal devices installed) would necessitate, in addition to infrastructure improvements or new construction, additional cabling and electrical grid improvements beyond the capabilities of FORCE. (Electrical grid upgrades, identified as a key infrastructure issue, are addressed in other studies and are not covered in this report).

The "tipping point" for needing infrastructure for Large Tidal is dependent on various factors. There are uncertainties around the "tipping point" at which existing infrastructure will no longer be considered to be cost-effective, such as the high costs of transporting fully assembled turbine units including bases from Halifax to the Minas Passage (which would have to be by water), the costs of infrastructure improvements and whether any funding assistance might become available to ameliorate them, and the speed of technology evolution and industry development. For the purposes of this study, it is anticipated, based on information from industry, that existing marine and supporting infrastructure is sufficient to support in-stream tidal power development over the 'short-term' and it is not anticipated that infrastructure improvements or new construction (except some planned enhancements at Hantsport) will be required for this initial 'short-term' phase.

The future, beyond 100MW of large tidal devices installed, is outside the scope of this study except for noting projected requirements from UK studies.

Base Case 1: Large Tidal (>0.5 MW) – Gravity Base; 'short-term' and 'long-term'

Context

- Short term = up to 64MW installed at FORCE
- Long term = an additional 30MW installed
- Future = beyond 100MW installed. Outside scope of this study except for noting projected requirements from UK studies.

1. Size and weight of devices and bases

<u>Gravity bases</u>

Gravity bases for large tidal devices may support 1-3 turbines. Typically they are large steel structures with ballast consisting of steel blocks, poured concrete or concrete blocks. Ballast is inserted either at dockside just before deployment when the base is already on or in the deployment barge or vessel, or inserted once the base has been lowered into its final deployment position.

Dimensions vary, and could increase in future as more turbines are mounted on a single base.
- Width: Tripod 23 meters per side; others range from 13 – 18 m in diameter.
- Height: Maximum 23 metres
- Weight: 500-1300 tonnes (includes turbine unit/s as well as base)

<u>Turbines/ nacelles</u>

Designs and dimensions vary.
Width: 10 – 18 metres diameter
Weight: 200 tonnes approx

2. Critical factors

i) Distance from deployment site

<u>Long term</u>
- For O&M, less than 50 kilometres
- For deployment, a bit further (up to 150 kilometres) is acceptable
- Wet port with year-round accessibility

ii) Vessels and port facilities must be adequate

iii) Electricity grid capacity for the devices to feed generated power into the grid. This will become a critical factor once the capacity at FORCE is fully utilized.

Manufacturing requirements		Assembly requirements	
Short term	**Long term**	**Short term**	**Long term**
Do in NS: Base fabrication, final assembly, hydrographic studies Import: Most turbines (nacelles) imported Requirements: Facilities such as Irving Shipyard Woodside; or Cherubini Metalworks, plus specialized NS sub-contractors.	Do in NS: Would consider turbine manufacture as well as base fabrication; hydrographic studies Location of manufacture - Halifax /other NS location. -For export – Halifax/ Dartmouth for shipping via break bulk cargo/ container terminal facilities. Requirements Facilities such as Irving Shipyard Woodside, or Cherubini Metalworks. (Final assembly & O&M in Bay of Fundy)	Existing Halifax/ Dartmouth facilities & transport are adequate. Heavy and large unloading capacity. Heavy and large truck access. Large fabricated components shipped by container& break bulk (could be Multi Purpose Project Ship)	Location Bay of Fundy location for final assembly. Requirements Heavy lift, gantry crane, Ro Ro capabilities, dock surface with low effect of tidal level; wet dock. 10 ha staging area. Irving Shipyard Woodside would need additional lay-down area. Future For 1 GW of tidal: 3-4 expanded/ new ports 2-3 assembly/ maintenance yards

Deployment requirements – 'short-term'		Deployment requirements – 'long-term'		O&M requirements
Ports	**Vessels & other**	**Ports**	**Vessels/ other**	
Need wet dock. 8- 9 metres depth at low tide. 10 ha staging area beside/ very close to wharf. 500 T + crane Heavy lift transporter (50 T crane specified by another company) Ability to load turbine and base from a wharf to a barge.	Marine barge LxW 60m x 40m. 8m water depth. Wharf face 150 m length. OSV (Offshore Supply Vessel) with 200T crane or dedicated barge. Plus Tugs, ROV, divers, cable laying, trenching, hydrographic survey. DP 3 ships with big cranes (100-200T) that can handle ocean-going & tidal conditions. The OpenHydro Installer, a heavy lift catamaran barge. Size 60-70 x 50 ft. Bay of Fundy port is paramount. Cost of towing from Halifax is prohibitive. Transportation of complete units has to be by water.	Location Bay of Fundy Need wet dock. 9 metres depth. 10 ha staging area beside wharf. 500 T + crane Heavy lift transporter Staging area for 3-5 units (50 T crane specified by another company) Could use marine railway or a concrete ramp.	Same as 'short-term'. Future For 1 GW of tidal: 10 large purpose built vessels, 25 work boats, 1-2 emergency tugs	Same as for assembly & deployment Long term Bay of Fundy base within 50 kilometres of Minas Passage. Facilities similar to Woodside: wet port able to accommodate large vessels at all hours; safety vessels Parrsboro for small unit maintenance? DP 2 or 3 vessels - lift a 100-plus ton nacelle in tidal conditions Staging areas for 3-5 turbines

Base Case 2: Large Tidal (>0.5 MW)–Pin/pile base; 'short-term' and 'long-term'

Context

- Short term = up to 64MW installed at FORCE
- Long term = an additional 30MW installed
- Future = beyond 100MW installed. Outside scope of this study except for noting projected requirements from UK studies.

1. Size and weight of devices and bases

<u>Non-Gravity bases</u>
Bases do not have to be as heavy as gravity bases, as they are attached to the ocean floor with piles and/or pins. This allows more variety of structure and options for bringing turbines to the surface for removal/ replacement during O&M.

Dimensions: Maximum length of steel struts 180 metres; floatable/sinkable pontoon 10m x 70m on which 3 turbines can be mounted; base structure attached to 4 piles on ocean floor.
Weight: Struts, pontoon and 3 turbines approx 500 tonnes.

<u>Turbines</u>
Width: 20 metres diameter (each blade 10 m)
Weight: Struts, pontoon and 3 turbines approx 500 tonnes.

<u>Pile-drilling unit</u>
Dimensions 70m x 70 m (approx)
Weight: Approx 300 tonnes

2. Critical factors

i) Distance from deployment site

<u>Long term</u>

- For O&M, less than 50 kilometres
- For deployment, a bit further (up to 150 kilometres) is acceptable
- Dry port with floating dock at Hantsport is planned; (this is possible due to innovative base design which is floatable with turbines installed on it from port to installation site).

ii) Vessels and port facilities must be adequate.

iii) Electricity grid capacity for the devices to feed generated power into the grid.
This will become a critical factor once the capacity at FORCE is fully utilized.

Note: at the time of this study only one respondent proposed to use a pin/ pile base.

Manufacturing requirements		Assembly requirements	
Short term	**Long term**	**Short term**	**Long term**
Do in NS: Base fabrication, final assembly. Import: Drive train & blades Requirements: Steel fabrication plus specialized NS sub-contractors. Could be done at Hantsport (Minas Basin Pulp & Power plus Fundy Gypsum facilities) or at a NS shipyard and transported by road to final assembly location.	Do in NS: Base fabrication, final assembly; turbine blades (composite) Import: Drive train Requirements: Steel fabrication plus specialized NS sub-contractors. Will be done at Hantsport. (Minas Basin Pulp & Power expanded facility plus possibly Fundy Gypsum facilities). For export: transport by road to Halifax break bulk cargo/ container terminal facilities	Hantsport – own port & assembly facility (500ft dock) with floating dry dock (200ft) plus use of Fundy Gypsum facility for assembly. Rock base laid under dry dock.	Hantsport – own port & assembly facility with floating dry dock will be developed to handle larger volumes; additional land is available; plus possible continued use of Fundy Gypsum facility.

Deployment requirements – 'short-term'		Deployment requirements – 'long-term'		O&M requirements
Ports	**Vessels & other**	**Ports**	**Vessels & other**	
Hantsport for base and turbine deployment from floating dry dock: the assembled turbine & base unit floats. Cranes 50-70 tonnes. Pile-drilling unit requires 8 m water depth; use Halifax/ Dartmouth	Tug to tow assembled unit from dry dock to site. Pile-drilling unit requires special barge similar to OpenHydro catamaran barge with cranes able to lift 200 + tonnes. (min. size 70m x 70m) Tug required to tow barge.	Hantsport for base and turbine deployment: assembled unit floats. Cranes 50-70 tonnes. Pile-drilling unit requires 8 m water depth; Bay of Fundy port needed	Tug to tow assembled unit from dry dock to site. Pile-drilling unit requires special barge similar to OpenHydro catamaran barge with cranes able to lift 200 + tonnes. (min. size 70m x 70m). Tug required to tow barge.	Use Hantsport facility plus Parrsboro. Possible use of Partridge Island as sheltered deeper water location to wait out bad weather. Need to build special supply vessel – tug / barge.

Cabling for Base Cases 1& 2: Large Tidal (>0.5 MW); 'short-term' & 'long-term'

Context

- Short term = up to 64MW installed at FORCE
- Long term = an additional 30MW installed
- Future = beyond 100MW installed. Outside scope of this study except for noting projected requirements from UK studies.

The only deployment issues are installation of the cables to the four berth sites, and the attachment of each berth-holder's turbines (3-5 turbines at each of the four berths) to the cable ends on the ocean floor. Short term: IT International has the contract to source and install the cable. There are challenges to be solved re attachment/ detachment of turbine units to cables.

Manufacturing requirements		Deployment requirements – 'short-term'		Deployment requirements – 'long-term'		O&M requirements
Short term	Long term	Ports	Vessels & other	Ports	Vessels & other	
Cable manufactured in Italy; Connect-ors from Europe (tbd)	Cable manufactured in Italy; Connect-ors from Europe	Cable brought Italy to Halifax (or Saint John) where port facilities are adequate for large ship and unloading. Storage of the cable pre-deployment requires a large, secure facility. Cable brought by barge from Halifax/ Saint John to deployment site. Deployment site likely to be beach in vicinity of shore-based connector to grid – near Parrsboro.	Not sure about vessel yet (generalist or specialist): maybe a shallow draft barge to bring cable from beach to the 4 berth sites.	Similar to 'short-term': additional cables required once FORCE is at capacity. New location(s)/ different deployment site also?	Similar to 'short-term'.	Cables Vessel that can enable retrieval, attachment/ & detachment of cables as different turbines are installed/ decommissioned. Need deep water wet port on Bay of Fundy for vessel. For studies - fishermen who operate from Hall's Harbour and Parrsboro.

Base case 3: Small Tidal (<0.5 MW); 'short-term' and 'long-term'

Context

Within the scope of this study ('short-term' and 'long-term') it is assumed that the total generation capacity to be installed will be 20 MW. Locations currently under consideration are Grand Passage, Petit Passage and Digby Gut. Turbine locations equating to 5MW in each of Grand and Petit Passage have been identified at this stage.

For the purposes of this study, 'short-term' and 'long-term' have been defined as follows.

Short term = up to 10MW installed at Digby Gut, Grand Passage, Petit Passage
Long term = an additional 10MW installed in other locations in Digby County
Future = beyond 20MW installed. Outside scope of this study; potential seen by some for hundreds of turbines in Atlantic region.

1. Size and weight of devices and bases
Bases
Dimensions – different devices
i) (ORPC) 20 m (66 ft) long by 14 m (46 ft) wide by 6 m (20 ft) high.
ii) (NEC) to be decided

Weight:
i) (ORPC) Bottom supports are 40 tonnes
ii) (NEC) to be decided

Turbines/ nacelles
Dimensions – different devices
i) (ORPC) 27 m (90 ft) long by 3 m (10 ft) wide and 3 m (10 ft) tall.
ii) (NEC) Up to 7.4 m diameter

Weight:
Rotor plus turbine 60 tonnes.

2. Critical Factors
- Proximity to site. Distance and time are critical expense factors.
- Capacity and Availability
- Safe Harbour for small and large vessels

<table>
<tr><th colspan="2">Manufacturing requirements</th><th colspan="2">Assembly requirements</th></tr>
<tr><th>Short term</th><th>Long term</th><th>Short term</th><th>Long term</th></tr>
<tr><td>Turbines / nacelles built & assembled in Massachusetts, Maine & Calgary.

<u>In NS</u>
Bases designed/ built in NS (Meteghan, Cornwallis).

Flotation, mooring and anchoring systems designed/ built in NS (Meteghan, Cornwallis).

Large fabricated components via container & break bulk</td><td>Same as ‘short-term’; possibly more items manufactured in NS.</td><td><u>Requirements</u>
-2 acres lay-down area
-Direct access to water
-Ability to load and offload into water
- Crane & wharf infrastructure capable of handling 60+ tonnes.

Access to deep port, assembly and staging facilities by road and sea. The port of Saulnierville and/or the Port of Digby will receive shipments.

Workspace/Warehouse</td><td>8-10 acres lay-down area
-Direct access to water
-Ability to load and offload into water
- Crane & wharf infrastructure capable of handling 60+ tonnes.</td></tr>
</table>

<table>
<tr><th colspan="2">Deployment requirements – ‘short-term’</th><th colspan="2">Deployment requirements – ‘long-term’</th><th rowspan="2">O&M requirements</th></tr>
<tr><th>Ports</th><th>Vessels & other</th><th>Ports</th><th>Vessels & other</th></tr>
<tr><td>- Crane & wharf infrastructure capable of handling 60+ tonnes.
- Water depth 4 m
- Length of wharf face TBD.

Saulnierville, Meteghan and Digby.

Onshore Infrastructure is lacking.
•Require offices, storage, electrical (3-phase), etc.
• Internet connectivity speed is sub-standard</td><td>- Marine barge to be designed & constructed in year ahead.
This may change infrastructure reqs.

- Towing vessel or large fishing boat.

- Tender craft and zodiac

Saulnierville, Meteghan and Digby.</td><td>Same as ‘short-term’ – expansion needed</td><td>Same as ‘short-term’.</td><td>Ports used for O&M Westport, Tiverton and Digby.

•Standard wharf and port infrastructure for anchoring of service vessel
• Standard wharf winch and crane equipment.
• Surface and subsurface vessels and capabilities for onsite & subsurface maintenance.
•Larger overhauls and repairs at assembly & manufacturing facilities in Meteghan.</td></tr>
</table>

Base case 4: Offshore Wind

Context

Information was largely obtained from documents and websites – UK and US sources. Typically, assembly and deployment would take place at the same site, because the towers and turbines are so large. All offshore wind foundations are very large and once produced can only be transported by water. Deployment would ideally be located near the installation site to avoid lengthy and costly transportation of assembled wind towers by sea. Typically, ports are selected for projects around two years before wind farm installation starts. Foundation manufacturing facilities can be set up relatively quickly. For the purposes of this study, the focus is on the requirements for 100 offshore wind turbines installed.

1. Size and weight of devices and bases

Bases

Dimensions
Shallow water bases: Whether steel monopiles, concrete gravity bases, or jacket or tripod structures, all offshore wind foundations are very large.

Deep water floating platforms may be used. One such is shaped like a tall cylinder anchored to the bottom, and containing ballast at one end and flotation at the other that keep it vertical and stable.

Weight:
Deep water floating platform bases – over 5,000 tons.

Turbines/ nacelles

Dimensions
Blades vary from 110 feet (33 m) up to 60 m + for a 5-MW turbine. May become larger for offshore wind projects.

Weight:
Nacelles 50-70 tons; can be 90+ tons

2. Power cables

Can weigh approximately 1 ton per 10 metres. For deepwater floating platform bases, cables may require controlled buoyancy to accommodate movement and weight load, and be suspended in mid-water.

Manufacturing requirements	Assembly and Deployment requirements for 100 turbines		O&M requirements	Transport reqs
	Ports	Vessels & other		
Location DSTN (Trenton) Halifax has what is needed for shipping and receiving; may not be cost-competitive. For export: transport by road to suitable break bulk cargo / container terminal. Blades and foundations for large turbines are manufactured on waterside locations and loaded directly on to delivery vessels to the construction port. Due to the cost of land transport, new tower manufacturing facilities also tend now to have coastal locations.	Typical requirements for a construction base with the capacity to handle 100 turbines a year: • At least 80,000 m^2 (8 hectares) suitable for lay down and pre assembly of product; • 200–300 m length of quayside with high load bearing capacity and adjacent access; • Water access to accommodate vessels up to 140m length, 45m beam and 6m draft with no tidal or other access restrictions; • Overhead clearance to sea of 100m minimum (to allow vertical shipment of towers); and • Sites with greater weather restrictions on construction may require an additional lay-down area, up to 300,000 m^2 (30 hectares). Other requirements relating to cranes and load bearing points are relatively easily achieved through local engineering works. Ideally, sites should have good land-side transportation access to facilitate their use also in transportation for onshore wind farm construction.	- Jack up barges for installation. - Barges to transport wind towers and blades to site. - In some cases, mono-piles are floated to site. - Ships with rotating cranes are used when more manoeuvrability is needed. - If assembly is located at a distance from installation site, the crane jack-up barge used for installation lifts needs to be self-powered and able to travel relatively fast. - Ideal offshore wind installation vessels: • Able to raise 500 tonnes up to 90m (above fulcrum) at radii of 35m • Ample deck space. • Various types of work spaces. • Able to withstand different wave types at greater depths than most jack up barges. - Cable laying and grid connection.	Grid connection Modified offshore service vessels	All offshore wind foundations are very large and once produced can only be transported by water. Land (road & rail) transportation challenges: -Height, weight, width, and length limitations -The growing size and weight of wind turbine blades, towers and nacelles, -The limited number of truck trailers and rail cars capable of transporting turbine components

4.1.2 Supply Chain Requirements

Supply Chain requirements cover the following stages of the lifecycle: Manufacturing, Assembly, Deployment, O&M and Decommissioning.

In this requirements analysis the Base Cases and 'short-term' and 'long-term' scenarios are not separated out, due to the lack of a sufficient level of detailed information at this stage.

Requirements for Large Tidal and Small Tidal are based on a combination of interview research and literature research findings.

Requirements for Offshore Wind are based primarily on literature research findings.

Large Tidal (>0.5 MW) – Short and Long Term

Manufacturing/fabrication capabilities expected from local companies
▪ Bases: require a fairly simple manufacturing process and there is suitable local (Nova Scotia) expertise. Cherubini Metal Works has already made the steel base structure for one turbine. ▪ Turbines: the capabilities required depend on the design. Some will be imported; at least one could quite easily be manufactured here with existing local expertise. ▪ Most respondents will seek to use local suppliers, and will only look outside the Province if necessary. They are optimistic NS has what is required.

On-Site Assembly and Deployment Requirements

Deployment vessels – size, capabilities	Specific services, marine technology and supporting equipment that could be provided by local suppliers	HR & skills requirements for development and deployment
▪ Dynamic positioning (DP) class 2 or 3 vessels needed. ▪ There are DP 3 ships locally; the ones needed for tidal installation also need big cranes on them. ▪ Struts with cross bracing need a barge or vessel. ▪ Cranes on barge able to lift 200-plus tonnes. ▪ Barge with crane – can put up to a 400 tonne crane on a barge. Higher than that is a problem. ▪ Special supply vessel – tug. ▪ For installation of the cable at test site – it is not yet clear whether a generalist vessel or a specialized vessel is needed.	▪ Storage of the cable – requires a large, secure facility – the cable is huge, contains a lot of copper and is therefore quite valuable. ▪ Need a solution to enable ability to terminate, connect and disconnect the cables. Splicing takes 40 hours; unless some kind of plug could be developed. This is a unique challenge – almost all previous sub-sea cables (for other uses) come out on shore at each end or are permanently connected. The need to disconnect one turbine at the end of a demonstration period, and connect a new, different one, is unique to test and demonstration facilities. ▪ Opportunity for Canada around deployment and operation in harsh climates.	▪ Need some locals who know the tides on these vessels. ▪ At deployment site – inspection, welders, shop yard for manufacturing ▪ Structural welding ▪ Specific skills for "fibre" welding, filler, fibreglass welding. There are local suppliers recognized for their fibre skills ▪ Electrical skills – magnetic generators, rare earth minerals – needed at the manufacturing facility

Operations requirements

Management, Monitoring, Security, Technology, Equipment
▪ Monitoring devices – these are very specific to the technology that is deployed ▪ Monitoring and environmental studies ▪ Current instrumentation does not survive very well in the Minas Passage. Need testing and monitoring equipment that can operate in the turbulent and rugged conditions of the Minas Passage. This is a unique requirement. Most equipment is designed for calmer, non-turbulent water with low tidal flow and lack of sediment. E.g. acoustic doppler technology does not operate well in water with great turbulence and a lot of sediment (like Minas Passage).

Maintenance

Ocean and port-side maintenance: repair, replacement of components or devices; surface and subsurface vessels and capabilities	HR and skills requirements
▪ Will need similar vessels for O&M as for deployment. ▪ Need to be able to lift a 100-plus ton nascelle in tidal conditions. ▪ For maintenance, need same capabilities, skills as in Irving ship-yard. ▪ Possible floating maintenance structure in middle of Bay of Fundy, as near as possible to deployment site: while not a consideration at this time due to its being a challenging environment, may be considered in future when there are hundreds of turbines in the water. ▪ Facilities required depend on the technology and deployment – not yet determined ▪ In the case of a cable break and need to bring a number of turbines to the surface and in for repair, have to have equivalent facilities at O&M port as for deployment ▪ How to get turbines up and in to maintenance base for repair is a question that has not yet been answered. ▪ For cable repair :need a vessel and a technician available	▪ HR - Crew for 100 devices – if there were a floating maintenance platform there may be 50 people on site going back and forth from the platform to the staging area in one tidal cycle. The maintenance platform would have to be designed to accommodate that. ▪ Monitoring devices – very specific to the technology that is put in (designed specific to the conditions of the Minas Passage - current instrumentation does not survive very well there)

Decommissioning

Surface, subsurface, disposal and other requirements – equipment, labour, skills, facilities
▪ Same requirements as for maintenance and deployment. ▪ If pile structure, attached to seabed, is used – it would be more challenging to remove; these requirements were not articulated in this study. ▪ Subsea cables would likely not come back up (will become buried in some spots).

Public Safety and Emergency Response

Storm damage, navigational hazards, environmental protection - requirements for equipment, expertise, training
▪ Work is to be done to develop full plan specific to Nova Scotia projects and site-specific needs.

Case Study – Supply Chain

The following information was provided by Nova Scotia Power Inc. (NSPI) from its experience in the Bay of Fundy and is used with permission. It is the only information available that is based upon actual experience of deploying a turbine in the Bay of Fundy and is presented as a specific example rather than being merged in with the other information gathered.

Summary of Solicited Services for In-Stream Tidal Deployment

Types of services, materials and skill sets that were solicited outside of the berth holder (Nova Scotia Power Inc.) and technology developer's (OpenHydro's) organization during the fabrication, deployment and recovery of the OpenHydro In-Stream Tidal Turbine in the FORCE site in the Bay of Fundy. The information is divided into three sections: Design, Fabrication, Deployment and Recovery.

DESIGN

Research Support

- Collection of bathymetry data to aid in selecting the most ideal location for assembly deployment
- Collection of Acoustic Doppler Current Profiler (ADCP) measurements at the deployment location so that design of the assembly could be optimized
- Analysis of the weather patterns in the area and the tidal profile so that the design could be optimized
- Collection and evaluation of acoustic data to quantify the acoustic signature of the area before and after deployment

Engineering Consultants

- Assistance in the preparation of applications for funding support
- Assistance in evaluation of possible technologies for deployment

Marine Architect

- Evaluation of the subsea base design
- Provided logistical support during final design, testing and deployment
- Informed on Nova Scotia marine safety and standards requirements

FABRICATION

Steel Fabrication

- Fabrication of the subsea base in Nova Scotia (closer to the deployment location than the technology developer's shop in Ireland)
- Inspection of the subsea base during fabrication

Concrete supplier

- Ballasting the subsea base for stable deployment in the Bay of Fundy

Cranes

- Lifting the various components into place and allow for assembly
- Lifting the assembly into the OpenHydro Installer barge (the "barge") for testing and deployment

Diving Services

- Assistance with removal of subsea base ballast fill pipes

Insurance

- Protection of the owner from accidental damage to the components during fabrication and assembly

Instrumentation

- Provision of communication with the assembly during deployment
- Recording of forces experienced on the assembly and other data to further understand conditions in the Bay of Fundy and optimize the design

Marine Consultant

- Inspection of the barge and associated equipment for compliance with regulations
- Provision of warranty surveyor services and preparation of tow certificate
- Evaluation and summary of available underwater electronic data collection and communication technologies

Research Support

- Assessment of seabed conditions to aid in design of sea trials / testing of assembly

DEPLOYMENT AND RECOVERY

Marine Consultants

- Review and valuate the OpenHydro Installer barge (the “barge”)
- Assist in identification of permitting requirements

Customs Broker

- Assistance in movement of materials from the UK to Nova Scotia as required
- Guidance in obtaining proper permits for temporary use of the OpenHydro Installer barge

Personal Protective Equipment

- Ensuring personnel involved with deployment and recovery operations had all available precautions in place to ensure their safety

Radios

- Ensuring efficient and effective communication between all parties involved in deployment and recovery operations

Fishing boats

- Accompaniment for the barge and tugboats during deployment and recovery operations to carry additional personnel that could not be on the tugboats
- Providing quick response in case of emergency.

Tugboats

- Towing the OpenHydro Installer barge (the “barge”) through a test program prior to initiating deployment activities in the Bay of Fundy
- Towing the barge and tidal assembly into place for deployment, and again the barge into place for recovery of the assembly.

Research Support

- Monitoring the movement of lobster during deployment for indication of change from normal behaviour
- Viewing the turbine in operation using side scan SONAR
- Viewing the turbine in operation using a camera on a tether
- Study of the anticipated wind and sea state during expected recovery window

- Monitoring biomass (schools of fish) and their movements in the upper Bay of Fundy through echo sounding and netting
- Monitoring bird and mammal behaviour in the area of the turbine for changes
- Passive monitoring of acoustic noise from marine mammals and determine if they are affected or at risk from the turbine.
- Exploring fish monitoring technologies at the turbine site (e.g. 2-D and 3-D sonar), and follow fishing patterns at shoreline herring weirs in the area.
- Identification of acoustic signatures to each turbine and determine the effects locally. Determination of deployment effects scour on benthic habitat

Insurance

- Protection of the owner from accidental damage to the components during deployment and recovery operations

Public Relations

- Provision of professional media coverage of milestone events such as assembly and deployment

Cranes

- Lifting for dismantling of the assembly to allow for evaluation of performance

Diving Services

- Observation of the subsea base to evaluate biological growth and overall condition

Looking forward, there are a number of services and technologies that may be valuable for further deployments of in-stream tidal turbines in the Bay of Fundy.

- Dynamic Positioning (DP) Vessel – This type of vessel was not required for the deployment or recovery of the OpenHydro turbine. However, this type of vessel may be valuable for the deployment of other technologies, or larger turbines as they approach commercialization. In addition, cable repairs or cable splicing for any reason “on sea” may require a constant position which may be facilitated by this type of vessel.

- Remote-Operated Vehicle (ROV) – ROVs were not used in the deployment or monitoring of the OpenHydro turbine. However, all technology developers recognize the benefit of using an ROV to monitor deployment, perform visual surveys of the cable or turbine, and complete work under water. It is unknown if ROVs are available which can be manipulated accurately in the Bay of Fundy.

- Core sampling – Core sampling was not performed when evaluating the deployment site for the OpenHydro turbine. Accurate characterization of the floor of the Bay of Fundy, particularly at the engineered deployment site, may be valuable information for technology developers. The ability to do this type of work in a cost effective manner in the Bay of Fundy is unknown.

- Piling etc. – Some technology developers may be planning to anchor their turbines directly to the floor of the Bay of Fundy (vs. the subsea base used by OpenHydro). This may also prove to be a challenge in the Bay of Fundy.

Small Tidal (<0.5 MW) – Short and Long Term

Manufacturing/fabrication capabilities expected from local companies
▪ Fundy Tidal Inc. has strategic partnerships with Clare Machine Works Ltd. of Meteghan Centre, Nova Scotia for local services and support including manufacturing of system components, flotation equipment and mooring expertise. ▪ FTI, NEC and Clare Machine Works of Meteghan have signed a development agreement to provide marinized systems including the design of new flotation systems and mooring design to withstand the both extreme currents and wave conditions found in Grand Passage. ▪ A 25kW unit will be prepared by CMW and Bear River Plastics of Cornwallis for deployment in 2011. This team will also prototype and develop a custom solution for the 250kW device. Local service providers and FTI staff will be trained for subsequent deployments ▪ Estimated 80% of locally contracted goods and services ▪ Research partnerships have been formed with Acadia and Dalhousie University to profile and model the region; made within the region wherever possible. ▪ Manufacturing/fabrication capabilities expected from local companies: o Engineering and materials for ocean environments and forces o Large laydown area o Direct access to water o Service, Supply and Repair o High Safety Standards o Familiarity with generators and turbines an asset o Ability to load and offload into water

Deployment vessels – size, capabilities	Specific services, marine technology and supporting equipment that could be provided by local suppliers	HR & skills requirements for development and deployment
▪ 60 tonnes is current requirement for cranes. ▪ Final specifications for vessels not yet determined. ▪ Towing Vessel for barge with appropriate draw (Maximum of 4 metres currently anticipated). ▪ Routine and annual maintenance of bottom mounted devices will require detaching the rotor and generator from the bottom support structure and bringing it to the surface for onsite maintenance. The design and nature of this vessel is yet to be determined.	▪ Relationships with the following local businesses in place for delivery of manufacturing, assembly and deployment. ▪ Clare Machine Works Ltd.- Meteghan Centre ▪ Bear River Plastics- Cornwallis Industrial Park ▪ Comeau Marine Rail- Meteghan ▪ Other specific services, marine technology and supporting equipment that could be provided by local suppliers: o Marine Observation	▪ Skipper and Crew for main vessel ▪ Tender Craft and Crew ▪ Dive Team ▪ Mooring & Anchoring/Aquaculture Industry Experience ▪ Electrical Engineering ▪ Cabling & Interconnection ▪ Mechanical Engineering ▪ Systems Engineering ▪ Marine Health & Safety ▪ Training/Certification

Deployment vessels – size, capabilities	Specific services, marine technology and supporting equipment that could be provided by local suppliers	HR & skills requirements for development and deployment
▪ Deployment vessels required: ▪ Tender craft and zodiac ▪ Barge & tow or large fishing boat ▪ Design of custom deployment vessels will be a future consideration	○ Geotechnical Survey ○ Bathymetry and Benthic Surveys ▪ Metals, anchoring, cables etc. (readily available through existing supply chain in region.)	▪ Journeyman machinists ▪ Certified welders (CWB Class 47.1) ▪ Power Engineers ▪ Systems Engineers ▪ Fabricators

Operations requirements

Specific services, technology and supporting equipment that could be provided by local suppliers	HR and skills requirements for operations
▪ Marine Observers ▪ Computing Systems ▪ Navigation Systems and Data ▪ GIS services	▪ Marine Engineer Class 4 or higher ▪ Mechanical Technician ▪ Operation of vessel ▪ Health & Safety/Emergency Response ▪ Environmental Monitoring ▪ Data Acquisition ▪ Power Engineer Class 1 and Class 4

Maintenance

Ocean and port-side maintenance: repair, replacement of components or devices; surface and subsurface vessels and capabilities	Other specific services, marine technology, equipment that could be provided by local suppliers	HR and skills requirements
▪ General Maintenance (surface and subsurface work) will be performed onsite ▪ Annual scheduled maintenance for antifouling, lubrication and physical inspection will occur onsite. ▪ Larger overhauls and repairs, scheduled and unscheduled, done at the assembly and manufacturing facilities across St. Mary's Bay in Meteghan. ▪ It is expected that every 5-6 years the entire unit will be returned to manufacturing and service hub for overhaul.	▪ Salvage ▪ Dock and Wharf additions or renovations ▪ Security	▪ Marine Engineer Class 4 or higher ▪ Welding and Machining ▪ Mechanical Technician ▪ Operation of vessel ▪ Health & Safety/Emergency Response ▪ Environmental Monitoring ▪ Data Acquisition

Decommissioning

Surface, subsurface, disposal and other requirements – equipment, labour, skills, facilities	Other specific services, technology, equipment that could be provided by local suppliers	HR and skills requirements
▪ Mirror equipment, skills and services and facilities used in deployment.	▪ Unknown at this point	▪ Unknown at this point

Public Safety and Emergency Response

- Extensive Health and Safety Procedures and Standard Operating Procedures must be developed
- Training and presentation materials required for development
- Regular first aid, WIMS, first responder training for relevant personnel
- Small runway for airlift requirements

Offshore Wind

General Supply Chain Considerations
▪ Factors that would influence the establishment of a supply chain: ○ A key influence on the suppliers' decision to locate in a given jurisdiction is market access to the end-user for their products or services ○ Suppliers are attracted to jurisdictions with robust local markets for their product, including government support for their status as preferred suppliers for firms and developers who plan to implement projects in the Province, as well as a commitment to developing and maintaining new and existing infrastructure that supports access to other large markets. ○ A stable policy climate that is unlikely to fluctuate according to political whim also encourages manufacturing investment, as do a skilled labour force and a favourable tax regime.
Manufacturing/fabrication capabilities expected from local companies
▪ World-class engineering and design ▪ A manufacturer of turbine internals ▪ A ready source of resins and composites ▪ Engineering services, environmental, legal, construction ▪ Overlap with other forms of marine energy ▪ Similar HR skills to those used in oil and gas industry

4.2 Findings from the document review

This section is divided into three parts: tidal, offshore wind and wave.

4.2.1 Tidal Energy

A. REQUIREMENTS

1. Ports infrastructure requirements

A Sustainable Energy Strategy for Orkney' (Orkney Islands Council, December 2009) indicates that Orkney / Pentland Firth has the potential to develop more than 1 GW of power by 2020.

Infrastructure and other developments required in the region to deliver this are outlined in the table below.

Additional information about ports requirements is included in the Case Study: Lyness, Orkney Islands, Scotland, in the Jurisdictional Comparison, Chapter 8.

Orkney/Pentland Firth - Infrastructure / Developments Required to Deliver 1 GW of Marine Renewable Energy		
Item	**Quantity**	**Year**
▪ Operations control centre	1	2012
▪ Prototype/demonstration devices	50	Now - 2014
▪ Expanded/new ports	3-4	Now - 2014
▪ Assembly/maintenance yards	2-3	Now - 2014
▪ Work boats	20-30	Now - 2015
▪ Large purpose built vessels	1-10	Now - 2015
▪ Local workforce	500-1000	Now - 2015
▪ New houses	300-600	Now - 2015
▪ Expanded and new offices	50	2012 - 2015
▪ Emergency tugs	1-2	2014
▪ Sub stations (off/onshore)	10-20	2014/15
▪ New 132kv connections	50-150 km	2014/15
▪ Connecting cables	1000	2014-2019
▪ Commercial energy devices	1100-1200	2015-2020
▪ Converter stations	2-3	2016/17
▪ HVDC grid connection	2	2016/17
▪ Co-gen/ storage	1-2 schemes	2016/17

2. Vessels requirements by stage of industry development

The following table indicates vessel requirements in broad terms as the number of installed devices increases based on the EquiMar Project.[10]

Table 4. Evolution of Marine energy converters and vessels with increasing array scale

Array type	Number of devices	Vessels
Demonstrator	≈10	Existing vessels used. Constraint and conflicts with other industries tolerated
Small	10-50	Device and vessel modifications as industry expands. Potential conflict of use with other industries such as offshore wind/ oil & gas unless new vessels are constructed.
Medium	50-200	Increase in conventional craft as industry grows. Emergence of dedicated vessels for marine energy industry or even particular devices
Large	>200	Dedicate service industry and/or array operators with specialist deployment vessels

Source: Equimar **"Pre-deployment and operational actions associated with marine energy arrays**".
http://www.equimar.org/equimar-project-deliverables.html

[10] EquiMar involved about 60 scientists, developers, engineers and conservationists from 11 European countries working together to find ways to measure and compare the dozens of tidal and wave energy devices, proposed locations and management systems currently competing for funds, so governments can invest in the best ones and get marine energy on tap fast. The team has delivered a suite of “high level” protocols – general principles to allow fair comparison of marine energy converters testing and evaluation procedures.

Issues and requirements pertaining to vessel assembly and deployment based on stage of industry development are shown below.

<100MW installed	100MW – 1000MW installed
▪ Quantity, availability and functionality of existing vessels for deployment of marine energy converters. ▪ Existing industries (especially oil and gas) can afford to pay premium rates for vessel contracts. Vessels are often designed with these industries' requirements not marine energy. ▪ Solutions: Device developers need to evolve devices to require less-specialist vessels or to develop their own vessels/components to expedite deployment. ▪ Deployment vessel cost will be a large factor in estimating overall cost.	▪ Vessel construction takes time so supply side must be confident that marine energy industry will provide good investment if they expand their range of services. ▪ A high-level review strategy of existing and predicted deployments with possible conflicts/restrictions should be conducted with key stakeholders. ▪ Orkney: ○ 1 GW of marine renewable capacity the region will require the following: ○ -10 large purpose built vessels ○ -20-30 work boats - 1-2 emergency tugs

Vessel characteristics

Offshore supply vessels with dynamic positioning systems will be required to allow the vessel to remain on station within a close tolerance for support during turbine installation, commissioning, and for inspection and maintenance.

<u>Jack-up barges</u>
Key performance parameters of such vessels are:

- Lifting water depth typically 40m, although some vessels can operate in deeper water (up to 70m but costs may be prohibitive).
- Maximum payload dependent upon size; smaller barges may not be able to lift heavy first generation devices.
- Maximum wave height 23m; maximum tidal current 1.5 - 1.75m/s are typical maximum values.
- Maximum wind speed 1520m/s (5472 kph).
- With longer legs maximum working tidal currents are likely to be lower due to larger effect of vortex induced vibrations on the circular legs.

<u>Crane barges</u>
Crane barges are barge vessels with the ability to lift heavy loads from deck.

- Mooring is usually through multipoint anchors (up to 8) and the barge deck areas are often large (up to 100m x 100m) in order to accommodate heavy lift cranes.
- Lift capacity generally decreases with height; upper limit values range around 8000t lift capacity and lift heights up to 80m above deck level.

- The largest vessels are used for offshore oil and gas platform installation and O&M and their specifications easily accommodate the present wave and tidal energy devices on the market.
- Crane barges are nearly always equipped with manoeuvring thrusters but are rarely self propelled.
- In this case a tug or similar towing vessels will need to be utilised to travel to site.
- Transit times should be adjusted for the towed load in question.
- As with jack-up vessels measures to increase the operational metocean conditions of crane barges would benefit the marine energy sector.

Tugs

Tugs are principally used for towing such things as crane barges and pontoons.

- They can also be equipped to perform additional functions such as installation of sea bed anchors and moorings.
- Tugs can be employed to tow devices directly to site if they are buoyant and have appropriately designed harness systems.
- Examples would include floating wave energy converters and potentially second generation tidal devices designed to be ballasted down at site to their appropriate position in the water column.

3. Roads/ rail

Land transportation requirements are much less of an issue for tidal than for offshore wind, as tidal turbines and bases are physically smaller in size.

- Rail and highways are considered adequate to transport components.
- Final assembly needs to take place at a port-side facility.

4. Electricity grid

Onshore electrical grid

- Grid ‘queues’ have existed in most European countries at some time. Solutions are strategic planning involving electrical grid and marine energy stakeholders to identify and address bottlenecks and restrictions for deployment.

In the case of Nova Scotia, common user equipment to allow transmission of energy generated from each of the turbines at FORCE to the Nova Scotia Power grid will generally consist of underwater cables, onshore transformers, substation, protection and control equipment, pole line and conductors, access roads, site development, and any associated buildings.

Offshore electrical installation

- Specific challenges include cable laying in high currents (tidal), heavy sea states, and interconnection of devices within an array.
- Technical issues are likely to increase with the scale of array deployment.

B. SUPPLY CHAIN (Large Tidal)

The following is a summary of supply chain requirements have been previously identified for Large Tidal development.

Supply Chain Requirements for Large Tidal	
R&D	Engineering needs identified for Bay of Fundy tidal installations include: ▪ cable connectors ▪ drilling bore holes ▪ fixing structures to the seafloor ▪ umbilicals, and ▪ technology transfer from the offshore petroleum industry[11]. OEER has identified research priorities in physics, sediments, ecology and environmental effects monitoring and is funding research projects to address some of them. Metocean data capture will require a system of scientific buoys and surveys.
Assembly/ deployment	Turbine installation will require offshore heavy lift capability, seabed excavation, and foundation preparation which may require pile driving and pouring or placing seabed foundations.
Other lifecycle phases	Ongoing environmental permitting requires subsea surveys, onshore surveys, marine species impact assessments, and other specialized services, all of which are available in Nova Scotia. Design services for onshore and offshore installations are also available locally.
HR	Orkney: 1 GW of marine renewable capacity the region will require the following: 500-1500 persons (local workforce) ***Occupations, Skills in the Wind, Wave and Tidal Sectors*** From Marine Energy (Wave and Tidal) and Offshore Wind Skills Analysis – for South West England Aug 2010 by EMB. ***Skills*** Control systems and design; construction/cabling; rotor hub/gear boxes /gears/ bearings; foundations planning and development; installation/operations; steel tower erection; onsite assembly; operations ***Occupations*** Electrical and electronic engineers; civil engineers; mechanical engineers; structural engineers; installation engineers; environmental specialists; health and safety specialists; construction project managers; fabrication engineers; service engineers; wind turbine operators; offshore operation specialists

[11] *Report of the OEER/FORCE Tidal Energy Workshop* (Nova Scotia, October 2010)

4.2.2 Offshore Wind

A. REQUIREMENTS

1. Ports infrastructure requirements

Assembly/ deployment	The most commonly used installation process to date involves delivery of towers, blades and nacelles to a construction port close to the wind farm. At the construction port they are pre-assembled ready for transportation by jack-up barge to the wind farm site. Typical requirements for a construction base with the capacity to handle 100 turbines a year are: ▪ At least 80,000 m^2 (8 hectares) suitable for lay down and pre assembly of product; ▪ 200–300 m length of quayside with high load bearing capacity and adjacent access; ▪ Water access to accommodate vessels up to 140m length, 45m beam and 6m draft with no tidal or other access restrictions; ▪ Overhead clearance to sea of 100m minimum (to allow vertical shipment of towers); ▪ Sites with greater weather restrictions on construction may require an additional lay-down area, up to 300,000 m^2 (30 hectares). Other requirements relating to cranes and load bearing points are relatively easily achieved through local engineering works. Ideally, sites should have good land-side transportation access to facilitate their use also in transportation for onshore wind farm construction. Whether steel monopiles, concrete gravity bases, or jacket or tripod structures, all offshore wind foundations are very large and once produced can only be transported by water. Compared with set-up times relating to other elements of the value chain, foundation manufacturing facilities can be set up relatively quickly.
O&M	As an example, for 1GW offshore wind farm – The London Array (Thames Estuary, UK): The purpose-built operations and maintenance facility will accommodate up to 90 staff and six maintenance vessels. It will include computerised monitoring and control facilities, a workshop, offices and storage facilities. A pontoon and fuel pumping facility are also being built.

2. Vessels requirements by stage of industry development

Issues and requirements pertaining to vessel assembly and deployment based on stage of industry development are shown below.

<100MW	100MW – 1000MW
As offshore wind projects begin construction in the US, the limited number of vessels and crews for this work will become an issue. With current technology, cost-effective installation of offshore wind turbines requires specialized vessels. These vessels do not currently exist in the U.S Jack up barges are used to install wind turbines. Barges are used to transport wind towers and blades to site. In some cases, mono-piles are floated to site. Ships with rotating cranes are used when more manoeuvrability is needed. If a distant port is being used for pre-assembly of turbines (i.e. a port local to turbine production), the crane jack-up barge used for installation lifts needs to be self-powered and able to travel relatively fast. If the port is local, then the crane jack-up barge need not be self-powered. Modified offshore service vessels are used for service and maintenance	A new ship type has evolved, the Wind Tower Installation Ship (WTIS), a hybrid integrating elements of an oceangoing heavy lift jack-up vessel with passenger accommodations, since wind tower installation crews are not considered ships' crews. Requirements for WTIS are: self-propelled to ensure mobility, equipped with DP2 or DP3 to ascertain accurate positioning for jacking at water depths up to 60m and open sea conditions, designed for continuous operation under extreme conditions, equipped with legs able to absorb stresses produced by different wave characteristics, equipped with cranes able to heave loads up to 500 tonnes at heights 90m above fulcrum and radii of 35 m, capable of absorbing stresses and vibrations produced by wind forces on handing loads at such heights. Designed to provide ample deck space for heave and oversized cargos and equipment, often for multiple unites installation to avoid logistical lading processes and designed to accommodate installation and engineering crew and respective workspaces.

3. Transportation (Roads/ rail)

Transportation to the site is a limiting factor, due to the very large size of wind turbine blades, towers and bases.

For example, in the US, the (onshore) wind energy industry is said to have contributed to transportation and logistics challenges facing manufacturers and developers. It is also creating business opportunities for those with expertise in these areas, including logistics providers, truck trailer and rail car manufacturers, railroads and train crews, trucking companies and drivers, port operators, and barge and ocean vessel owners and crews, among others.

A single turbine can require up to eight hauls (one nacelle, one hub, three blades and three tower sections). For an entire project of 150 MW (MW), transportation requirements have been as much as 689 truckloads, 140 railcars, and eight ships to the United States.

4. Electricity grid

The main components of a typical offshore wind farm include several wind turbines connected by a series of cables to an offshore transformer station, which is connected by an underwater cable to an onshore transformer station linked to the existing power grid.

For example, the first phase of the London Array in the UK consists of: an offshore area of 100km2; 175 wind turbines; 2 offshore substations; nearly 450km of offshore cabling; 1 onshore substation; and will generate 630MW of electricity, enough to power around 480,000 homes a year, at a cost of €2.2 billion to build and install.

In the US, with current technology, cost-effective installation of offshore wind turbines requires robust undersea electricity transmission lines, and grid interconnections. This infrastructure does not currently exist in the US

B. SUPPLY CHAIN

For the London Array – a supply chain event attracted the following sectors seeking opportunities: construction specialists, marine consultancies, security services, equipment providers, hotels and B&Bs, engineering companies and recruitment consultants.

Manufacture, Assembly/ deployment	A tower is usually manufactured in 20-30 m long sections. Site preparation and placement usually typically involves dredging and other preparation. Underwater power transmissions cables are deployed by hydroplowing, whereby the cables are buried several feet beneath the ocean floor. Extensive studies including seabed mapping are required to determine the optimal route. The overall manufacturing process requires a high level of quality control. London Array Phase 1 (175 turbines; 640MW) Principal contractors / suppliers: In 2009, contracts totalling almost €2bn were agreed with a number of European suppliers to provide the core components and expertise needed. Very few of these suppliers were UK companies.
O&M	Maintenance needs to consider joint fatigue, corrosion protection, scour potential, marine growth.

4.2.3 Wave Energy

REQUIREMENTS

No current or planned commercial activities related to wave energy were uncovered in Nova Scotia during the course of the research. Therefore, to provide insights into possible future infrastructure requirements, the following Case Study is provided.

Case Study – Wave

This Case Study is based on a Wave Energy Infrastructure Assessment in Oregon Prepared for the Oregon Wave Energy Trust by Advanced Research Corporation, December 2009.[12] The infrastructure assessment included four Scenarios: Test Center; Offshore; Nearshore; and Onshore Breakwater. For the purpose of this Case Study, the latter Scenario is excluded for brevity and considering that Nova Scotia's wave resource is predominantly offshore. The full report is available at the link cited in the footnote.

Deployment Considerations

Wave power conversion devices need to be designed and optimized for the deployment location. A device optimized for North Atlantic conditions may not perform well in Pacific wave conditions unless its size, shape, and mass parameters are optimized for the particular wave conditions. Devices can be located either onshore, nearshore, or offshore. Deployment location has critical impacts on foundation design, available resource, and environmental impacts. Water depth is a key driver in foundation design. Typically, devices designed for near-shore and shoreline locations are fixed to the seabed or the shoreline. As water depth increases, devices are increasingly self-referenced (Multiple structures moving relative to each other and extracting energy from the relative motion between individual bodies). These devices are typically catenary moored, allowing for flexibility in deployment locations and water depth. Typical installation depths for deep-water devices are in the range of 40m – 100m.

The mooring arrangement is largely a function of water depth. Deep water are typically self referenced and slack moored, while near-shore and shoreline devices are fixed to the seabed or existing civil structure such as a harbor wall. For large scale commercialization, they will need to be deployed offshore in deep water to tap into the most energetic wave climate as well as minimize shoreline impacts. Most offshore, deep-water devices are catenary moored and not seabed referenced. Reliability, maintainability, and redundancy are considered to be of paramount importance to be competitive. New developments in single point moorings and synthetic fiber ropes could lead to such cost-reductions. Other areas of note are quick connect/disconnect systems, mooring line dynamic for multiple devices, and studies of different mooring systems, mooring line fatigue, and riser cable dynamic / integration with mooring system. Industry specific tuning and control systems are also requirements.

Operational Considerations

The ability to remotely diagnose problems and monitor status is important to reduce intervention cycles and associated cost. The device needs to be instrumented properly and be connected via a wireless link and/or fiber optic cable to a command center on shore. Device access is considered crucial to carry out maintenance and repair. A device may be inaccessible during

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[12] Oregon Wave Energy Trust (December 2009) Wave Energy Infrastructure Assessment in Oregon. Available: http://www.oregonwave.org/wp-content/uploads/Wave-Energy-Infrastructure-Assessment-FinalReport-web.pdf

high seas, because personnel can no longer be safely transferred to the device. Maximizing this accessibility has a critical impact on overall device availability and therefore on the technology's competitiveness.

The operational strategy under which a device is operated has a key impact on port-side infrastructure requirements. Two main strategies are being pursued by different manufacturers. The first allows devices to be quickly disconnected from their mooring system to carry out all operational activities at the pier side; the second relies on carrying out maintenance and repair at sea. In the second case, oftentimes entire subsystems are swapped out as modules to minimize the time spent offshore. Many devices are being designed in places where a strong offshore oil and gas sector is present such as in the UK and Ireland. As a result, the devices are designed with availability of the sophisticated equipment of the offshore oil and gas sector and deep water ports in mind. In future deployment locations may require operating out of small ports with minimal infrastructure and small vessels.

Device Fabrication / Materials

There are many similarities between wave and tidal power systems in terms of device Fabrication / Materials, offshore operations and electrical collector systems. Both are typically built from steel and concrete, materials used extensively by the offshore industry. The knowledge and experience for the design and construction of these devices is available through engineering consultants and well suited for technology transfer.

Electrical Collector System

Since wave (and tidal) power systems are arranged in arrays of devices deployed at sea, an electrical collector system needs to connect the individual devices to a common device interconnection point. Individual devices will also need to be isolated and disconnected from the electrical network to allow the device to be retrieved for O&M considerations. While there is a significant body of knowledge on subsea cables, there are three areas of concern: Electrical quick connect/disconnect system; reliability of flexible riser cables; and device isolation from the collector network using subsea circuit breakers. Solutions within the offshore oil and gas industry are considered cost prohibitive for the use in wave and tidal power. Manufacturers are expecting related industries to develop cost-effective solutions.

SCENARIOS

Developer needs in manufacturing, deployment, or operations and maintenance are best characterized by their distance from the coast and their stage of development, whether in a pre-commercial phase or fully operational. To accommodate varying infrastructure requirements from wave energy developers and to protect the proprietary information obtained from interviews with wave energy developers, infrastructure needs are grouped into four scenarios:

- test center scenario
- full-scale deployment offshore scenario
- full-scale deployment nearshore scenario
- full-scale onshore breakwater scenario.

The test center scenario is included because of its difference in infrastructure needs from the three operational scenarios. A table illustrating the unique infrastructure needs of each of the scenarios is provided to highlight the commonality and differences between the scenarios. The material was largely obtained from interviews with numerous wave energy developers. Summary findings are presented in the table below.

	Test Center	Offshore	Nearshore	Onshore Breakwater
Manufacturing	Manufacturer's input in component design. Steel and small scale composite	High volume output of large devices. Steel, large composite, and concrete	High volume output of large devices. Steel and large composite	On-site concrete manufacturing of large structures and modules. Concrete
Transportation	Truck, rail, standard barge	Truck, rail, custom barge	Barge, truck, rail	Truck for parts, rail for cement and gravel. Local site manufacturing
Assembly	Common site, not large	Dedicated land for assembly and deployment	Dedicated land for assembly and deployment	Land at the deployment for assembly and construction
Deployment	Device towed to site. Adaptable and knowledgeable workforce.	Device towed to site. Adaptable and knowledgeable workforce.	Device towed to site or deployed by jack up barge	Caisson towed to site or deployed off of beach
Operations & Maintenance	Provided by developer	Local workforce and service vessels. Dedicated site for onshore maintenance of devices	Local workforce and service vessels. Dedicated site for onshore maintenance of devices	Local workforce. On-site maintenance or possible onshore maintenance
Retrieval	Frequent—at end of device test period	Infrequent retrieval for maintenance	Infrequent retrieval for maintenance	At end of life
Emergency Services	Single device salvage or retrieval	Large array of devices salvage or retrieval	Multiple device salvage	N/A

Test Center Scenario

In Oregon, the Northwest National Marine Renewable Energy Center (NNMREC) provides developers test facilities to prove their devices to US regulators, potential financiers, and ocean-use stakeholders. NNMREC plans to develop a mobile test facility near Newport, Oregon that will allow developers to bring their device to the designated test berth site or the test berth could be towed to the developer's site. Bringing the device to the test berth site will reduce some of the risks associated with permitting by providing a common site to deploy that was agreed upon by stakeholders. The currently envisioned testing scenario is that the test berth and the device under test would have separate mooring systems independently deployed by NNMREC and the device developer, respectively. Through services provided by the Hatfield Marine Science Center, developers will be able to arrange for transparent environmental assessment capabilities providing third-party validations of the effects from wave energy devices.

Manufacturing

Developers favour Oregon as the site for manufacturing the larger components, such as spars or concrete forms, while importing the specialized components containing proprietary technology. Developers of devices in their early stages of development seek companies that can manufacture small quantity lots and are willing to interact with developers to suggest necessary modification and adapt to design changes as they occur. Many of the early devices are being constructed out of steel to provide more flexibility for modifications and changes to the design. For the later demonstration tests, fewer design changes will be necessary. However, manufacturing companies that are willing to work with small numbers of devices is still necessary. Some developers are leaning towards cheaper construction materials such as fiber-reinforced plastics (FRPs) and structural concrete to lower production costs.

Transportation

Depending on location of manufacture it may be necessary to move large sections to the assembly and deployment sites, each designed to fit on standard flatbed trailers or railroad cars. Shipment via truck for smaller devices and sections is preferred due to costs and schedule flexibility. Projects requiring lots of material, such as large piping, favour rail; extremely large devices would probably use of barges to transport devices and large components from manufacturing facilities to deployment facilities. Final assembly occurs at the manufacturing facility, where access to large cranes and complex equipment may be easier and cheaper.

Assembly

Areas to assemble and deploy test devices are needed on a short-term basis, such as days or weeks. For test center projects, buying or leasing the necessary land for assembly may not be feasible for most developers. Such areas should be provided by the test facility or existing nearby ports or industry.

Deployment

Standard barges outfitted with hoists and winches and towed by coastal tugs will perform deployment of devices directly into coastal waters. Since demonstration devices or arrays are of limited scope, custom vessels or barges are not economically viable, and not expected to be used. For early testing, devices would be deployed for short periods of time, weeks or months. For demonstration phases the devices would remain deployed for much longer periods, such as seasons or years, reducing the standby need for deployment capabilities.

Operations & Maintenance

Developers will provide monitoring of their own device performance, while the test facility will provide environmental and power monitoring. Developers expressed interest in third party organizations to perform assessments, like environmental impact studies that could be used for later commercial deployments. For early short-term testing, maintenance would not be a large requirement and would be handled by the developer. In the demonstration phases, developers will need skilled personnel to inspect the devices, perform preventative and corrective maintenance, as needed. Waterfront space and manufacturing or repair capability will likely be required for modifications, and repairs to test devices as designs evolve through the testing phase. Some of these tasks may be handled at sea, in which case sea-going equipment and skilled labor will be required. For devices more mature, requirements will lessen, although unexpected events may rekindle the need. Arranging and providing these services will be the responsibility of the developer and likely not provided by the test center.

Device Retrieval

For early testing, device retrieval would be a frequent occurrence as developers install and remove devices in the test center as they work kinks out of the devices and their mooring systems. As testing moves into demonstration phases, retrieval would become less frequent. On the other hand, the sizes and quantities to remove would most likely increase, as the devices move from small-scale prototypes to full-scale devices, and are incorporated into larger arrays of multiple devices. Salvage of devices is a possibility due to the uncertainty of the technology and the complexity of the devices. Retrieval will also include removal of all anchoring and mooring components of the test device. If the test berth is no longer needed in that area then it will also include the removal of its anchoring and mooring components as well.

Emergency and other Abnormal Situations

Emergency situations involving offshore devices include: device breaking loose from mooring and drifting into surf and onto beach; fisherman or boaters entering the operational, anchoring, and mooring area of the wave energy device and becoming entangled in the anchors or mooring lines Large sea mammal venturing into the operational, anchoring, and mooring area of the wave energy device and becoming injured by the devices or mooring lines; fisherman losing gear into the operational, anchoring, and mooring area of the wave energy device (not life threatening); wave energy device sinking to the bottom Emergency services: US Coast Guard rescue services for people in peril; Oregon Department of Fish and Wildlife; salvage companies; divers: required for removal of sunken devices from the seafloor. Operating depths will depend on the device tested.

Offshore Scenario

The offshore environment is characterized by depths of 30m or more, up to 100m and may have sandy or rocky bottoms. The deployment zones range from 1 km to 5 km offshore. Devices are moored in place using either conventional drag-embedment or dead-weight anchors in multipoint mooring configurations. Electrical power is generated at the device and transmitted to shore by cables across on the ocean bottom. Types of offshore wave energy devices include attenuators, point absorbers, and floating oscillating water column.

Manufacturing

Offshore devices range from several tonnes to over a thousand tonnes, with typical weights of a few hundred tonnes. The material of choice for prototype devices has been steel. The material is strong, easy to modify and can be fabricated by a wide range of companies. In future, other materials are being considered to help reduce full-scale production costs and corrosion in salt water. Some developers are considering composite materials (FRPs) while others are considering structural concrete. Wave energy developers of offshore devices plan to manufacture their devices in pieces, with separation between the mechanical and the electrical components. Respondents stated a need for local mechanical engineering and fabrication. According to many developers, manufacturing of the electrical and proprietary components will take place outside of Oregon with the components shipped in. Other services needed during the manufacturing process include corrosion protection, integration of various subsystems and intellectual property sensitive parts, as well as ballasting in the form of sand or concrete. Manufacturing materials: steel fabrication, composites including fiber-reinforced plastics (FRP), structural concrete.

Transportation

Developers are designing their devices for easy transportation by truck or rail, meaning that the size of the devices will conform to the standard transportation platforms. If these sizes are too constraining shipment is via custom barge. In this case final assembly usually takes place on the barge and removes the need for an assembly area near the deployment site. With many of the smaller devices, components will be manufactured at large manufacturing centers and shipped to the assembly site on the coast.

Assembly

Offshore developers need assembly areas that provide sufficient area over the term of the assembly and launch, and are located close to water. Moving the device from the land to the water can either be accomplished via crane from a strong dock or bulkhead or, in the case of large devices, via a marine railway. Very large devices will be built in a dry dock or on a custom barge that is also used to transport the device to the final site and deploy it. The typical assembly area will resemble a large building construction site. There will be a need for an office building, staging and storage of parts and equipment, utility hook ups, and even covered work areas for some devices. The assembly site will need a dock or mooring for final checkout of the device once the device is in the water. Developers will either lease or purchase the land. Term of deployment: days or weeks for single demonstration units to year round for full-scale deployments.

Deployment

Deployment involves transporting the devices from the land base or assembly area to the deployment site, which is located one to five km offshore. Deployment includes inserting the devices into the water, orienting them correctly, and installing and attaching mooring systems. There are two ways devices are transported to site. One way is to tow them out to the site. Typically this involves orienting the spar horizontal in the water with a flotation collar used to hold the bottom end at water line. The device is then towed out to sea by means of a tugboat. With attenuators, the rotation is not necessary, as the draft of the device does not present the same issue in shallow harbors. Alternatively, the device is placed on a specially fitted barge or vessel and take it out to sea. The vessel must be outfitted with winches and cranes or be able to partially submerge for deploying the device into the water.

Deployment vessels:

- Coastal tugboat – to tow either the device or barge
- Anchor handling tug – to deploy the anchors and mooring system
- Cable deployment vessel – to install the power cable coming ashore and burry where necessary
- Custom barge – designed to haul and deploy wave energy devices
- Dive support vessel – to support divers to assemble and hook up the mooring system
- Survey vessel – to map out and determine bottom composition and topography
- Divers: depths from 30m to 100m, requiring dry suits, mixed gas air, dual decompression chambers on surface

Operations & Maintenance

Few developers had a detailed understanding of the processes and workforce requirements for the operations and maintenance functions, and in some cases, had given no consideration to O&M processes or needs. Nonetheless, an understanding of the attributes of offshore wave energy devices provides a general understanding of the maintenance needs. In one sense, offshore devices are akin to medium scale ocean going vessels. Devices range in diameter from 6 to 20 meters and in mass from 100 to 2,000 tonne. Operations involve monitoring power levels, the health of the wave energy devices, and in some cases providing control functions.

Developers indicated staffing needs from no onsite personnel (autonomous operation) to 10 or more personnel available to support power monitoring and management. In most cases, developers are planning for remote monitoring of the wave energy devices using a combination of wireless and internet connectivity. Maintenance requirements include a need for personnel skilled in mechanical and electrical equipment maintenance, replacement, and repair. Depending on the power take off mechanism used, the devices could have any combination of pumps, generators, pistons, and hydraulic systems housed in a climate controlled environment. The workforce will need to be able to provide their services at sea in less than optimal conditions as well as dockside. The number of personnel required can range from only one to a dozen or more workers on staff, depending on the complexity and size of the system.

Maintenance activities are heavily dependent on the types of device employed and the features developers have designed into their systems to minimize system maintenance. Maintenance functions include inspecting units (opening up of hatches and examining for leakage, rust, and other damage), performing preventative maintenance at sea (opening up of hatches and performing basic maintenance duties), replacing failed components on the wave energy devices at sea (opening up hatches and replacing failed components), and retrieval of wave energy devices for shore-based maintenance. In some cases storage and work areas are required near to the dock where devices will be returned for maintenance. Much of the maintenance activities are expected to be scheduled in the summer season, but a limited amount of work (inspections, emergency maintenance) will occur in the harsh winter months.

Device Retrieval

Periodic device recovery is expected to occur infrequently, on the order of every two to five years, and will involve scraping, repainting, maintenance and repair before being redeployed. If it is an end-of-life removal, retrieval will include removal of all anchoring and mooring components as well. Retrieval is performed for depot level maintenance or at end of life, which could occur at any time throughout the system lifespan. The process includes deactivation of the device, disconnection of the device from the grid, disconnection from the mooring systems, return to shore, and transfer to the maintenance yard for decommissioning.

Return of the device to shore is implemented either by hoisting the device onto a transportation vessel that returns the device to shore or towing the device to the shore. Smaller devices are expected to be towed back to shore with large devices (that require deep drafts) to be placed on semi-submergible barges. Since the depth of point absorber devices range from 25 to 50 meters, towed devices will have to be rotated into the horizontal position in order to enter the harbor.

Workforce requirements: certified able-bodied seamen; required to operate the recovery vessels and retrieve the wave energy devices.
Divers: required for removal of mooring components on some devices; operating in depths from 10m to 50m (possibly deeper).

Emergency and other Abnormal Situations

Emergency situations involving offshore devices include:

- Device breaking loose from mooring and drifting into surf and onto beach
- Fisherman or boaters entering the operational, anchoring, and mooring area of the wave energy device and becoming entangled in the mooring lines
- Large sea mammal venturing into the operational, anchoring, and mooring area of the wave energy device and becoming injured by the devices or mooring lines
- Fisherman losing gear into the area of the wave energy device (not life threatening)
- Wave energy device sinking to the bottom

Emergency services: US Coast Guard rescue services for people in peril; Oregon Department of Fish and Wildlife; salvage companies
Divers: required for removal of sunken device from seafloor; operating in depths from 30m to 100+m, requiring dry suits, mixed gas air, dual decompression chambers onboard.

4.3 Nova Scotia Supply Chain Capabilities and Gaps

This section includes summary information about the Nova Scotia supply chain gleaned from a review of previous studies.

As noted in section 4.1.2 above, NSPI indicated that all the services they solicited for the deployment and retrieval of the tidal turbine in the Bay of Fundy were obtained within Nova Scotia. An earlier report commissioned by the Nova Department of Energy [13] indicated that Nova Scotia companies are capable of supplying the bulk of the onshore and offshore construction and installation services, as well as inspection and maintenance services, notable exceptions being:

- offshore heavy lift capability, which is highly specialized, and vessels with this capability are usually booked many months in advance - even if such a vessel was based in Nova Scotia, there would be no guarantee of its availability;
- offshore supply vessels with the capability to service a tidal energy project which, while based in Nova Scotia, may not be available when needed by the project developers, due to ongoing commitments to the offshore oil and gas industry in this region.

This report lists supply chain activities, related to and wind / or tidal energy projects and comments on gaps and challenges in Nova Scotia, as summarized in Table 4.3.1 below.

Table 4.3.1 - Supply chain activities - Gaps and/or Challenges in NS

Supply chain activities wind / or tidal energy projects	Gaps and/or Challenges in NS
▪ Financing	▪ Data and analysis that major banks would need in order to even consider a financing possibility. ▪ Venture capital
▪ Design and Project Management ▪ Turbine foundations ▪ Electrical and control systems ▪ Civil works ▪ Mechanical systems	▪ It is not always easy to know where to go to obtain services of a qualified engineering consultant in the field of renewable energy
▪ Transportation ▪ Components arriving in the Province by sea or rail will require transport by truck to the site. ▪ Local transport companies need to be able to provide the correct equipment to safely and efficiently transport these components to site ▪ Some sub components will need to be transported from shops where they are semi-	▪ Many components are imported from Europe, USA, and elsewhere, and reported that transportation costs are quite steep, and add considerably to the cost of the equipment. ▪ Specialized equipment for highway transport of oversized components, such as wind turbine tower sections or blades, is not common in Nova Scotia.

[13] Assessment of Current and Proposed Renewable Energy Projects in Nova Scotia with a Focus on Wind Power and In-Stream Tidal, and the Identification of Opportunities for Local Companies in the Services and Supply Chains of these Projects Prepared by CBCL. Prepared for: Nova Scotia Department of Energy 2008.

Supply chain activities wind / or tidal energy projects	Gaps and/or Challenges in NS
assembled, to the wind farm / or site for final assembly and erection.	
▪ Installation	▪ As turbines become increasingly larger, local equipment suppliers will be required to invest in larger, higher capacity cranes in order to meet the erection requirements. If the market for this equipment is not seen to be large or 'long-term', it may be difficult for local companies to justify this level of investment if other needs for such large cranes are not apparent.
▪ Balance-of-Plant Construction	▪ Lack of qualified contractors specializing in overhead power line and substation construction
▪ Fabrication	▪ Lack of local capability, the manufacture of the following equipment poses challenges for local companies unless they are willing to make major investments: o Electrical generators - no local expertise or facilities o Gearboxes - technology does not exist in Nova Scotia for manufacture and fabrication of gearboxes o Bearings - lack of technology base locally o Turbine hydraulic systems - no interest by manufacturers to bring this skill to small local markets o Turbine yaw drives - this is considered a highly competitive capability, and the critical mass necessary for a manufacturer to invest locally in yaw drive fabrication is in the range of about 600 MW annually.

A review of other previous studies yielded the additional insights about the Nova Scotia supply chain as summarized below.

Table 4.3.2 is illustrative of Nova Scotia capabilities in relevant areas of specialization based on a representative sample of companies from earlier research. The number of companies shown in each category in this table is intended only to illustrate the range of capabilities and the clusters of capability based on the survey capture; it is not the actual total number of companies in the Province.

The report noted that many companies not included in these categories, from the environmental, engineering, marine supply and numerous other sectors, can play a role in the renewable (onshore and offshore) sector.

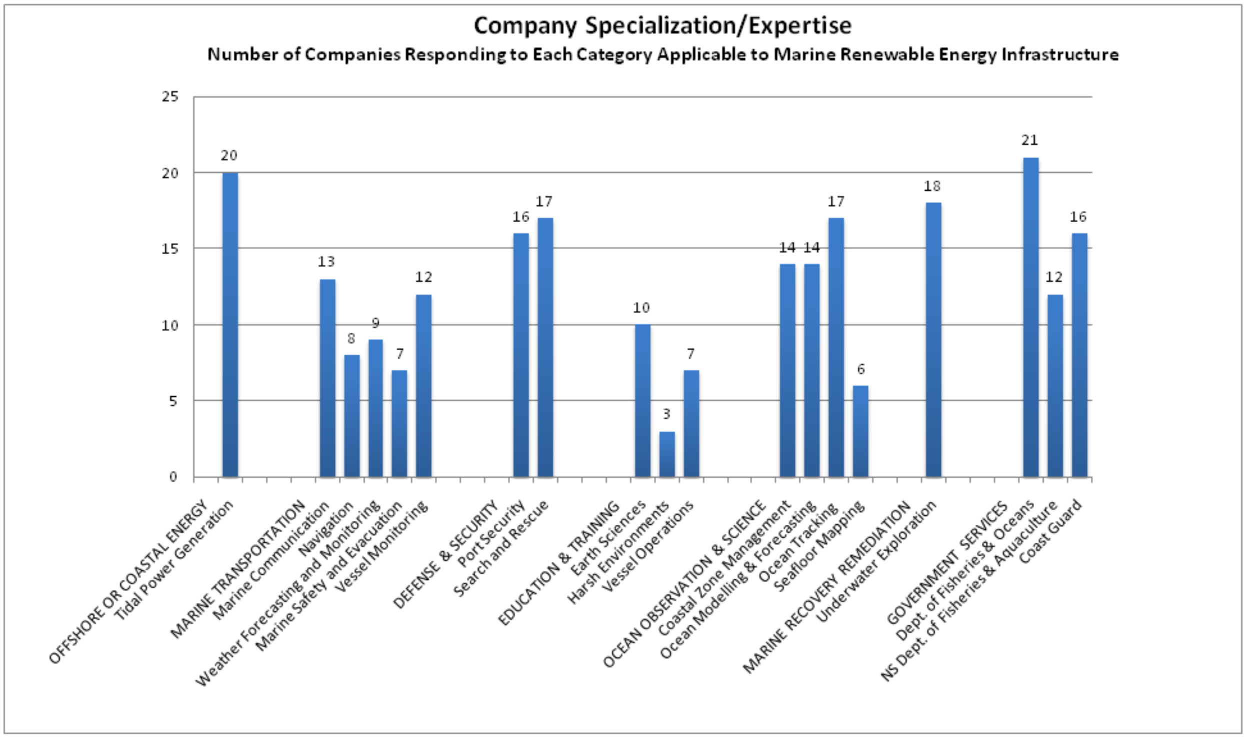
Table 4.3.2 - NS Manufacturers, Operators, Specialized Subcontractors

NAICS Codes	2007 NAICS Definition*	Number of Companies (fabricators, manufacturers and suppliers)				
		Larger Tidal	Smaller Tidal	Offshore Wind	Small Hydro	Total
2211	Electric Power Generation, Transmission and Distribution		1			1
3353	Electrical Equipment Manufacturing			1		1
3359	Other Electrical Equipment and Component Manufacturing			2		2
5416	Management, Scientific and Technical Consulting Services			2		2
5419	Other Professional, Scientific and Technical Services			1		1
326130	Laminated Plastic Plate, Sheet and Shape Manufacturing		1			1
331513	Steel Foundries (except Investment)	1	1			2
331528	Other Nonferrous Foundries (except Die-Casting)		2			2
332111	Iron and Steel Forging	1				1
332312	Fabricated Structural Metal Manufacturing	11	13	1	1	26
332313	Plate Work Manufacturing	1	1		1	3
332319	Other Plate Work and Fabricated Structural Product Manufacturing (CAN)	1	1			2
332420	Metal Tank (Heavy Gauge) Manufacturing	1	1		1	3
332431	Metal Can Manufacturing (US)	1	1		1	3
332710	Machine Shops	4	6			10
332721	Precision Turned Product Manufacturing		1			1
333310	Commercial and Service Industry Machinery Manufacturing (CAN)			1		1
333920	Material Handling Equipment Manufacturing (MEX)			1		1
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing			1		1
334290	Other Communications Equipment Manufacturing			1		1
334511	Navigational and Guidance Instruments Manufacturing**			2		2
334512	Measuring, Medical and Controlling Devices Manufacturing			1		1
335920	Communication and Energy Wire and Cable Manufacturing			1		1
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	2	2			4
336611	Ship Building and Repairing**			2		2
336612	Boat Building**	1	2			3
339999	All Other Miscellaneous Manufacturing	2	2			4
541330	Engineering Services			1		1
541360	Geophysical Surveying and Mapping Services		1	2		3
541370	Surveying and Mapping (except Geophysical) Services			2		2
541510	Computer Systems Design and Related Services (MEX)			2		2
541620	Environmental Consulting Services	1		1	1	3
541690	Other Scientific and Technical Consulting Services			1		1
541710	Research and Development in the Physical, Engineering and Life Sciences (CAN)			2		2
561990	All Other Support Services			1		1
611690	All Other Schools and Instruction (CAN)			1		1
	Totals	**27**	**36**	**30**	**5**	**98**

Note: The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies (Canada and US) in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the business economy.
*Statistics Canada NAICS 2007 definitions used unless cited otherwise. Sources: Statistics Canada: NAICS 2007 http://www.statcan.gc.ca/subjects-sujets/standard-norme/naics-scian/2007/list-liste-eng.htm
** US Census Bureau: NAICS 2007 http://www.census.gov/cgi-bin/sssd/naics/naicsrch
Source: Derived from: Renewable Energy Opportunities and Competitiveness Study. Prepared by SLR for NS Dept. of Energy September 2010

Table 4.3.3 below, from a different study of Nova Scotia's ocean technologies sector, illustrates company's self-declared areas of specialization/expertise based on a sample of 80 respondents to a survey.

Table 4.3.3 - NS Company Specialization / Expertise



Source: Statistics selected from: Nova Scotia Ocean Technology Sector Analysis. CFN Consultants (Atlantic) Inc. and Partner International. The Atlantic Canada Opportunities Agency. March 17, 2011

Below is a summary of Nova Scotia marine renewable energy (MRE) research and development activity based on other recent research.

Table 4.3.4 - NS MRE R&D Activity

FOCUS	DESCRIPTION	PARTNERS
ACADIA		
Tidal (OEER Project Involvement)	Acadia researchers are participating in areas of tidal power potential, 3-D acoustic tracking of fish, ice and debris. Acadian Center for Estuarine Research (ACER)	Department of Fisheries and Oceans, Triton Consulting, Ocean Tracking Network
DALHOUSIE		
Wind	Turbine blade and tower manufacturing plant design	DSTN (1), NSERC
Wind	Development of a cluster of excellence focussed on wind and tidal turbine manufacturing	Dalhousie, NSCC, DSME, and others
Small Wind	Small wind designs, electrical systems	
Tidal	Above research in wind turbine blades will incorporate tidal turbine design	DSTN (1)
Tidal	Working to bring together Canadian networks for technical aspects of tidal energy R&D. Many institutions, including the Canadian Marine Energy Research Network (C-MER). Working on three different scales: 25 kW, Briar Island NS; 250 kW, Canoe Pass, BC, and; larger 1 to 2 MW, Bay of Fundy, NS	
Tidal (OEER project involvement)		Martec, Fisheries and Oceans, East Carolina University
Marine Energy	Working to develop, and incorporate a non-profit organization, for a new Marine Institute to be housed at Dalhousie, and serving as an umbrella for other marine projects such as C-MER (Canadian Marine Energy Research Network). Varied roles, one being to assist technical firms in development	Bringing together the GSC, NRCan, Fisheries and Oceans, Environment (2)
Marine Energy	MOU with the Marine Renewable Energy Consortium based in Massachusetts.	MREC
ST. FRANCIS XAVIER		
Wind	Identifying the potential for geothermal and wind energy in Atlantic Canada	Universidad Complutense de Madrid, Universidad de Murcia, Spain, and Stantec Ltd
Wind/Tidal	Hydrofoil blade design for wind and potentially tidal turbines	NSCC
Tidal	Research in biofilms and coatings to reduce or eliminate marine biofouling on underwater structures. Research would have application to tidal turbines.	Rolls Royce/ODIM Brooke Ocean
ST. MARY'S		
Tidal (OEER project involvement)	Effects of energy extraction on sediment dynamics	

Source: Nova Scotia Department of Energy, *Renewable Energy Opportunities and Competitiveness Study.* Prepared by SLR for NS Dept. of Energy September 2010 and updated with Notes 1 and 2.

(1) Formerly DSME.
(2) The Halifax Marine Research Institute (HMRI) was launched in June 2011. The HMRI brings together partners from industry, government and the post-secondary education system, and is designed to increase the scale, quality, internationalization and impact of marine research in the region. Dalhousie has taken a leadership role in establishing the HMRI, and is one of its founding members.

5.0 SURVEY OF NOVA SCOTIA PORTS

5.1 Preliminary Target Ports

The infrastructure survey of Nova Scotia ports began with the identification of a number of "Preliminary Target Ports" deemed as possible facilities which could potentially support marine renewable energy. These ports were selected, based on local knowledge, at the very early stages of the study because the port facility requirements were not yet known as the requirements of the Marine Renewable Energy (MRE) developers had not been determined at the start-up of the study. Therefore, an overview screening of a number of Nova Scotia Ports was undertaken using Fisheries and Oceans Canada's List of Nova Scotia Harbour Authorities (Appendix E). The initial screening considered various wharf facility features such as size, suitability for large scale fabrication, load-out capability and availability of adjacent back-up land.

During the initial screening process, ports all across Nova Scotia and as well as Saint John New Brunswick were considered as the importance of proximity from the port to the resource location was unknown at the early stage of the study. The issue of proximity from the resources location was also part of the scope of the study.

Approximately 40 ports were identified in the "Preliminary List of Target Ports". These are presented in Table 5.1 and are shown on Figure 5.1. This list was reviewed with the Study Steering Committee and was reduced to the "Preliminary Shortlist of Target Ports", presented in Table 5.2, which was intended to focus on in-stream tidal power generation in the Bay of Fundy area (as well as a smaller focus on the other 3 base cases presented in Chapter 4).

Table 5.1 - Preliminary List of Target Ports

1. Saint John
2. Digby
3. Hantsport
4. Parrsboro
5. Meteghan
6. Saulnierville*
7. Weymouth*
8. Freeport*
9. Westport*
10. Tiverton*
11. East Sandy Cove*
12. Yarmouth
13. Wedgeport
14. Lower West Pubnico
15. Clark's Harbour
16. Shelburne
17. Lockeport
18. Riverport
19. Lunenburg
20. Fox Point
21. Sambro
22. Halifax/Dartmouth
23. Cherubini
24. Eastern Passage
25. Port Bickerton
26. Sheet Harbour
27. Guysborough
28. Mulgrave
29. Auld's Cove
30. L'Ardoise
31. Louisbourg
32. Glace Bay
33. Sydney
34. North Sydney
35. Alder Point
36. Bay St. Lawrence
37. Cheticamp
38. Havre Boucher
39. Pomquet
40. Cribbon's Point
41. Arisaig
42. Caribou
43. Pictou
44. Pugwash

Note: The ports listed in Tables 5.1, 5.2 and 5.3 are arranged in no specific order; however, they are generally grouped according to regional ports, those located around the Minas Basin, those located near St. Mary's Bay and finally counterclockwise around the Province.

Table 5.2 - Preliminary Shortlisted Target Ports

1. Saint John
    a. Long Wharf
    b. Lower Cove
    c. Rodney Terminal
    d. Navy Island
2. Digby
    a. Digby Fisherman's Wharf
    b. Bay Ferries Ltd.
3. Hantsport
4. Parrsboro
5. Meteghan
6. Saulnierville*
7. Weymouth*
8. Freeport*
9. Westport*
10. Tiverton*
11. East Sandy Cove*
12. Yarmouth
13. Shelburne
14. Lockport
15. Lunenburg
16. Halifax/Dartmouth
17. Cherubini
18. Eastern Passage
19. Sheet Harbour
20. Guysborough
21. Mulgrave
22. Sydney
23. North Sydney
24. Cheticamp
25. Pictou

* Note: Selected smaller ports were included subsequent to the selection of the Preliminary List of Target Ports due to their proximity to the development site and because of the likelihood that they may be strategically situated to provide a level of support (i.e. a vessel berth in the event that other facilities are fully occupied or emergency berth.)

The locations of the Preliminary Shortlisted Ports are shown on Figure 5.2.

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Figure 5.1

New Brunswick
Prince Edward Island
Gulf of St. Lawrence
Northumberland Strait
Bay of Fundy
Atlantic Ocean
Cape Breton Island
Gulf of Maine
NOVA SCOTIA
Service Nova Scotia and Municipal Relations
Nova Scotia

Figure 5.2

5.2 Questionnaire/Selected Results

A questionnaire was prepared and sent to key Preliminary Shortlisted Target Ports for completion. A sample questionnaire is included in Appendix C.

The results of the questionnaire responses were summarized in a detailed spreadsheet which is considered confidential as it may contain information which the Port Authorities deem sensitive and aught not be released to the public. Some of the key inputs from the questionnaire responses were:

- Port location
- Wharf type
- Water depth below Low Normal Tide (LNT)
- Tidal variation
- Type of deck
- Support structure
- Current condition of wharf structure
- Land area abutting wharf structure
- Lay-down area available
- Opportunity to expand
- Capacity to accommodate oversize transportable loads
- Current general usage of the wharf facilities
- Restrictions on times when the existing wharf facilities can be used
- Ability to displace existing users

Key data is incorporated in this report and is included in the table below:

Table 5.3 - Selected Responses: Preliminary Short List of Target Ports

The Preliminary "Shortlisted Target Ports" were considered for a "Gap Analysis and Infrastructure Assessment" to determine their suitability to support firstly in-stream tidal power over the 'short-term' and 'long-term', which is the primary focus of this study, and secondly offshore wind and wave power generation. The "Gap Analysis and Infrastructure Assessment" is presented in Chapter 6.

Table 5.3

Selected Responses- Preliminary Shortlist of Target Ports

Port / Location	Wharf Type	Wharf Length (ft)	Wharf Width (ft)	Water Depth (ft below LNT)	Tidal Variation	Type of Deck	Support Structure	Condition of Wharf Structure	Amount of Land Abutting Wharf Structure	Laydown Area Available	Opportunity to Expand Laydown Area?	Capacity to Accommodate Oversize or Transportable Loads	General Usage of Wharf	Are there Times when There is no Spare Berth Space/Back-up Space	Can Existing Users be Displaced?
1a. Long Wharf	Slip and Marginal berths	Slip 617; Marginal 935	--	Marginal 30; slip not usable	28	Concrete & Asphalt	Concrete Crib	Overall the wharf is in good condition	19.6 acres	19.6 acres depending on the time of year	Yes	Very Flexible in this regard, specific details can be provided	Cruise, bulk	No	No current leases in this area
1b. Lower Cove	Marginal	738	--	34	28	Concrete crib	Concrete	Structure is approx. 30 years old, requires a bit of work	18.2 acres	18.2 acres	Yes	Very Flexible in this regard, specific details can be provided	Project cargo, bulk and break bulk	Nothing that causes a problem	No current leases in this area
1c. Rodney Container Ter.	Slip and Marginal berths	Slip 954; Marginal 1210	Slip 110; Marginal 110	40	28	Concrete deck	Concrete piles	In good condition	31.3 acres	Several acres	Yes	Very Flexible in this regard, specific details can be provided	Container handling, bulk and break bulk	Yes, weekly container ship loading	No, however ship coordination could be easily accomplished.
1d. Navy Island	Pier 1: Slip Berth / Pier 2 & 3 Slip Berth-Finger Pier	1A/B 1248; 2B 623; 3A/B 1023	1A/B 75; 2B 147; 3A/B 147	34	28	Concrete & Asphalt	Concrete Cribs and Arch Wave	Overall the wharf is in good condition	34.5 acres	Almost none	Yes	Very Flexible in this regard, specific details can be provided	Bulk and break bulk and containers	No	No current leases in this area
2a. Digby Fishermen's Wharf	Marginal, spur, spur ext., 2 ells, 11 floating docks	1230*	45	15	30	Precast concrete	prestressed concrete bearing piles	See attached facilities description	See development plan for property boundary	Existing parking lot	Yes, see Phase I&II	Yes up to 70 ton via loading ramp	Commercial traffic tractor trailers, autos, etc.	Could be anytime - big push or logs, fish trucks, drop trailers, etc.	No
2b. Bay Ferries Ltd.	Closed Face	600	30	15	28	concrete/ asphalt	concrete/ steel	Good	608 acres	2 acres	Not likely	Yes up to 70 ton via loading ramp	Commercial traffic tractor trailers, autos, etc.	Could be anytime - big push or logs, fish trucks, drop trailers, etc.	No
3. Hantsport	Marginal	449	62	0	42	Concrete	Timber	GOod	7 acres- on industrial land and in use	3 acres within 1 km of wharf	Yes through purchase of adjacent land	No Capacity for heavy loads at this time- wharf is upgradable	No current marine usage- occasional fishing boat	No	Current use is industrial. This can be modified to accommodate other uses for the wharf.
4. Parrsboro	EII	396	65	0	38-45	Reinforced Concrete	Timber	Good Repairs in 2010-2011	3 acres	3-5 acres	Yes	Any load on the stem- varies on the Ell	Fishing and Pleasure Craft	Fisheries move for larger vessels	Yes
5. Meteghan	Ell	1351	30.6-51	11	18-20	Concrete	Timber crib	Stem is older but solid.	Next to none	-	Very Little	Limited	Fishing vessels	From Nov-June during the lobster season, spare berthage is a problem	No
6. Saulnierville	Marginal	465	--	5	18-20	Concrete	Concrete	The wharf is in fairly good condition	None	May be acquired from Comeau's Seafood		-	45-50 ft lobster boats and 45-65 ft draggers	Possible	No
7. Weymouth															
8. Freeport															
9. Westport															
10. Tiverton															
11. Sandy Cove															
12. Yarmouth	Marginal and T	152.4 / 121		2.8 / 5.1		Asphalt	Timber	Reasonable good shape does require some work on support cross members on Old Gov. Wharf	-	-	Yes	-	Mostly commercial fishing, i.e. lobster, groundfish	During the first month of lobster fishing port facility is nearly full capacity	Not at this time.
13.. Shelburne	Finger	2500		30 low tide	6	Concrete	Timber/Concrete	Mostly new	-	325,000ft2	Yes	120 ton	Ship repair	No	No
14. Lockport															
15. Lunenburg															
16. Halifax/Dartmouth	Finger and Marginal (see brochure)			30 - 55	6	Asphalt/ Concrete	Timber and Concrete crib	Good	Varies	Varies	Possibly	Good	Project cargo (tar sands equip), general breakbulk and container	Several competing stevedore firms - usually some space available	Possibly - alternative facilities could be available
16a. Irving Shipbuilding															
16b. Woodside		750		30	6	concrete	Timber and Concrete	Good	193,000 ft2 of fabrication&storage	146,395 ft2	Yes	2800 ton on laydown and 4500 ton roll out	Rig/ship repair	Yes, no backup	At present, yes
17. Cherubini Metal Works	SSP	295	160	18	unknown	Gravel	Sheet pile with steel tie-ins	Excellent	None	50,000 sqft	Yes	No restrictions on heavy or oversized loads	Load out of fabricated materials and steel structures	No	N/A
18. Eastern Passage															
19. Sheet Harbour	T	500	120	34	4	Concrete	Concrete	Good	12 acre Laydown area	38 acres	if adjacent lands are purchased	per case basis	Resources, break-bulk, off-shore material, project	No	This would not be an issue.
20. Guysborough															
20a. Goldboro Isaacs Harbour	Marginal	200	161	16	5.5	Main Circular Pilings backfilled		Main Wharf is excellent	Not applicable	None	Yes	Highway Limits	Fishing and recreational	No	Yes
21. Mulgrave SCSCL	Marginal	1400*	min. 150	33	6	Concrete/ Asphalt	Concrete caissons/SSP	North Berth - good con. 1984 South Berth - excellent. Const. 2003	4 acres	4 acres	Yes, 3 km from wharf	All transportable loads permitted on NS Highways	Breakbulk, bulk cargoes and marine construction	Cargo coordination required, but scheduling normally manageable	With notice, can coordinate new activity with existing users.
22. Sydney		900	300	39	3'-4.5'	Concrete	Concrete caissons	Excellent - built 1997	Several Thousand acres within Port	None	Yes, within port area	Concrete heavy lift pad-wharf face 100'	Cruise terminal-tanker discharge to pipeline	Cruise season (Apr-Oct) - other terminals within Port available	No
23. North Sydney															
24. Cheticamp															
25. Pictou Marine Terminal	Finger	600	100	24.6	4 to 6	Concrete	Timber	Presently under Study by Eagle Beach. Report due in April	4 acres, 2 of which are leased to AECON-Fabco	Included in 8a	Yes, see 7b	up to 70 MT's	Kraft paper, pulp wood, fish feed, gravel, supplies inbound for Aecon-Fabco, modular homes	Can handle 2 vessels at once. Generally ample capacity.	Opportunity to increase capacity.

6.0 GAP ANALYSIS AND INFRASTRUCTURE ANALYSIS

6.1 Overall Objective of the Gap Analysis

This chapter presents the results of the overview assessment of the Preliminary Shortlisted Target Ports. The ports were evaluated to determine, at a very preliminary level, their suitability to support Marine Renewable Energy (MRE) resources for:

i. Large in-stream tidal power generation for large tidal gravity base (over both 'short-term' and 'long-term')
ii. Large in-stream tidal power generation for large tidal pin/pile base (over both 'short-term' and 'long-term')
iii. Small Tidal
iv. Offshore wind power generation

The overall focus of the study and gap analysis was in-stream tidal power generation within the Minas Passage and Digby Neck areas. The assessment compared the fundamental marine structure requirements for the four base cases:

i. Base Case 1: Large In-Stream Tidal (gravity base) > 0.5 MW
ii. Base Case 2: Large In-Stream Tidal (pin/pile base) >0.5 MW
iii. Base Case 3: Small Tidal <0.5 MW
iv. Base Case 4: Offshore Wind and Wave

The matter of offshore wind and wave power generation is presented briefly in section 6.8.

6.2 Short Term Marine Structure Requirements for In-Stream Tidal Power

As mentioned in Chapter 5, a questionnaire was sent to the Shortlisted Target Ports to gather information about their current marine and support facilities. Also, interviews were conducted with developers in the industry. The results of the developer interviews and questionnaires illustrate that the port-related requirements of MRE are not well established across the industry.

For tidal energy, the sense from industry representatives is that currently planned deployment for the 'short-term' (to FORCE's four approved berths, up to 64 MW generating capacity and up to 10 MW of small tidal devices) can be accommodated from existing facilities such as Halifax, Hantsport (with some planned enhancements), Parrsboro or other ports located between Shelburne and Digby. Facilities in Saint John, N.B. may also provide support as the industry expands. There are uncertainties around the "tipping point" at which existing infrastructure will no longer be considered to be cost effective. Factors such as the cost of transporting completed turbine bases from the Port of Halifax to the Minas Passage, the cost of infrastructure improvements and whether any funding assistance might be available to ameliorate them, and the speed of technology evolution and industry development will all play a role in determining this "tipping point". For the purpose of this study, it is anticipated based on information from the industry, that existing marine and supporting infrastructure is sufficient to support in-stream tidal power development over the 'short-term' and it is not anticipated infrastructure improvements or new construction (except some planned enhancements at Hantsport) will be required for the 'short-term' phase.

The period of initial industry expansion is anticipated to occur over the length of time it takes for the full generating capacity of the four berths to be built-out. This time-frame is highly dependent on external factors, as mentioned above, but provides a “planning horizon” for the initial development phase, or ‘short-term’ phase, of marine infrastructure.

Therefore, it is anticipated, based on information from industry, that existing marine and supporting infrastructure is sufficient to support in-stream tidal power development over the ‘short-term’ and it is not anticipated that infrastructure improvements or new construction will be required for the ‘short-term’ phase.

6.3 Longer Term In-Stream Tidal Development Requirements

The developer interviews and questionnaires indicate that the industry can, in the ‘short-term’, deploy from current available marine facilities in Nova Scotia and New Brunswick. However as industry requirements change from the ‘short-term’ to the long-term deployment phase (beyond the 64 MW, four berth stage) marine facility requirements will also change and should become better defined.

One key factor affecting the requirements for marine facility development is the prohibitively high cost of towing large fabrications from Halifax. Although the industry has indicated their recognition of the high cost of towing from Halifax during the ‘short-term’ phase of development, the industry cannot tolerate the high cost of deployment from Halifax over the longer term. The industry believes that deployment over the longer term will require major marine infrastructure in the Bay of Fundy.

However, there is very limited information available on facility requirements for the range of in-stream tidal power generation equipment. The information obtained from the developers was assembled, coupled with some desk research, and jurisdictional comparisons, and common sense considerations in order to establish very conceptual marine structure requirements. These requirements will be fundamentally dictated by the “phase” of the project beyond the ‘short-term’. At this time, two distinct phases of the project have been identified:

1. ***Long Term Deployment Phase:*** considered to be the time when the FORCE berths are fully developed and there will be large scale commercial developments.

2. ***Operation and Maintenance (O&M) Phase:*** will commence after deployment and will extend over the life of the development.

Base Case 1 (Large In-Stream Tidal – Gravity Base) – Facility Requirements based on Assumed Criteria
Long Term Deployment Phase (Conceptual)

Number of Berths…………………………………………………………	Two
Length Overall…..…………………………………………………………	200 m-220 m ± initial phase Additional 110 m in future expansion
Water Depth………………………………………………………………	8 m – 9 m
Assumed Vessel Size……………………………………………………	75m - 85 m ± length 15 m - 20 m ± beam (i.e. barge or supply vessel) 5 m - 6m ± draft
(note: sizes based on information from Secunda's website)	
Back Up Land/Staging Area……………………………………………..	10 ha
Crane Capacity..	500 tonne
Buildings………………………………………………….....................	TBD*
Facility Location……………………………………………....................	Within 150 km of deployment site
Electricity Grid..	Suitability TBD

*Note: The requirements for building structures for manufacturing, assembly and warehousing are not known at this time although it is known that some buildings will be needed. Building requirements will have to be determined in the future when the developers have decided what is needed for their specific devices.

Base Case 2 (Large In-Stream Tidal - Pin/Pile Base) Facility Requirements based on Assumed Criteria
Long Term Deployment Phase (Conceptual)

Number of Berths…………………………………………………………	One to Two
Length Overall…..………………………………………………………..	150 m ±
Water Depth………………………………………………………………	4 m preferred* (dry port acceptable to some) 8 m for pile driving unit
Back Up Land/Staging Area……………………………………………..	TBD
Crane Capacity...	70 tonnes
Facility Location……………………………………………..................	Within 50 km preferred (up to 150 km acceptable for deployment)

* Note: Pile Driving Template requirements differ from deployment requirements and may require up to 8 m water depth.

Base Case 3 (Small Tidal)
Facility Requirements based on Assumed Criteria
Long Term Deployment Phase (Conceptual)

Number of Berths………………………………………………………	One to Two
Length Overall…..………………………………………....................	100 m-150 m ± (assumed)
Water Depth………………………………………………...................	4 m
Back Up Land/Staging Area………………………………...................	4 - 5 ha
Crane Capacity..	60+ tonne
Facility Location………………………………………….....................	In and around St. Mary's Bay and Digby*

* Note: Small in-stream tidal is assumed to be located in Grand Passage, Petit Passage or Digby Gut.

Base Case 4 Offshore Wind
Facility Requirements based on Assumed Criteria
Long Term Deployment Phase (Conceptual)

Number of Berths……………………………………………..................	One to Two
Length Overall…..………………………………………....................	200 m -300 m ±
Assumed Vessel Size...	140 m length, 45 m width, 6 m draft
Water Depth………………………………………………...................	6 m
Overhead Clearance...	100 m
Back Up Land/Staging Area………………………………..	8 ha
Facility Location……………………………………………...	TBD

Operation and Maintenance (O&M) Phase (Conceptual) - All Scenarios

Number of Berths…………………………………………	Four - Six
Water Depth………………………………………………	4 m min preferred
Facility Location………………………………………..	Within 50 km

It is clear that during deployment large in-stream gravity base structures require more robust wharf structures with deeper water than the lighter pin/pile structures. However, key industry representatives indicate that wharf facilities preferably should be capable of deploying both large gravity base and the lighter pin/pile base. They also indicate that facilities should preferably be located at a "wet port" (a "wet port" is a port which has water at low tide).

Most developers have indicated a "wet port" is considered essential for deployment as well as operation and maintenance. A "wet port" is a critical factor for the 'long-term' deployment phase because it is anticipated that deployment will require vessels with drafts in the order of 6 m to 7 m for the gravity base structures and may need relatively deep drafts to accommodate pile driving/drilling templates for the pin/pile structures. The "wet port" will also prove beneficial during the O&M phase. It is desirable for the "wet port" to be located within 50 km of the Minas Passage. Unfortunately there are no "wet ports" within the 50 km radius of Minas Passage. Some developers, however, have stated that it is not necessary to have a "wet port". These developers will have to devise schemes to operate from a “dry port” (i.e. Hantsport, Parrsboro) (a “dry port” does not have water at low tide- i.e. it dries out).

Many developers have also expressed the need for load outs, however; the magnitude of load-out capacity varies dramatically between gravity type base and pin/pile base.

The above factors will be primary drivers in the consideration of marine structure development.

Based on the requirements of the industry, it is clear that ports located around the Minas Basin and Bay of Fundy will be necessary to support the industry over the ‘long-term’ (i.e. beyond the initial four berths). The developers have indicated that they will require marine facilities on the Minas Basin or Bay of Fundy for both the ‘long-term’ deployment (i.e. beyond the 64 MW) and for the on-going operations and maintenance.

The ports that are viewed as being reasonably well situated to support in-stream tidal power generation are presented in Table 6.1 below:

Table 6.1 - List of Preferred Target Ports

1. Saint John
2. Digby
3. Parrsboro
4. Hantsport
5. Meteghan
6. Saulnierville
7. Weymouth*
8. Freeport*
9. Westport*
10. Tiverton*
11. East Sandy Cove*

* Note 1: Selected smaller ports were included subsequent to the selection of the Shortlisted Target Ports due to their proximity to the development site and because of the likelihood that they may be strategically situated to provide a secondary level of support (i.e. a vessel berth in the event that other facilities are fully occupied or emergency berth.)

**Note 2: The ports listed in Table 6.1 are arranged in no specific order; however, they are generally grouped according to regional ports, those located around the Minas Passage and those located near St. Mary’s Bay.

Table 6.2 lists the Preferred Target Ports organized by their proximity to Minas Passage.

Table 6.2 Target Ports by Location

Within 10 km	1. Parrsboro
Within 50 km	1. Hantsport
Within 100 km	1. N/A
Within 150 km	1. Digby 2. Saint John

Many of the ports found on the list of Preferred Target Ports (Table 6.1) are located outside a 150 km radius from the Minas Basin/Passage and these include:

Meteghan
Saulnierville
Weymouth
Freeport
Westport
Tiverton
East Sandy Cove

The proximity of the Preferred Target Ports to Minas Passage is indicated on Figure 6.1.

Several of the Nova Scotia Ports can be categorized as local community/fishing wharfs. These ports include:

Parrsboro	Freeport
Meteghan	Westport
Saulnierville	Tiverton
Weymouth	East Sandy Cove

It is not expected that these ports will support the deeper draft vessels nor will they support large cranes (larger than 35 T) for equipment load out. Also, the marine facilities at Hantsport are essentially privately owned by Minas Basin Pulp and Power (MBP&P) and are not conducive for accommodating larger, deeper draft vessels at all times and would not likely be suitable for large cranes (larger than 50-60 T).

Digby, a larger regional port, has accommodated various larger vessels and a wide range of commodity/cargo shipments. The port is primarily home to the Digby Scallop Fleet, and it understood that the Scallop Fleet cannot be displaced. The Digby Fisherman's Spur Wharf is not well suited to large, heavy lifts or load outs and there is insufficient suitable back-up land.

Although one key fundamental requirement of the MRE industry is proximity to the Minas Passage, many other factors play a role and no single Nova Scotia port can truly accommodate the broad industry requirements.

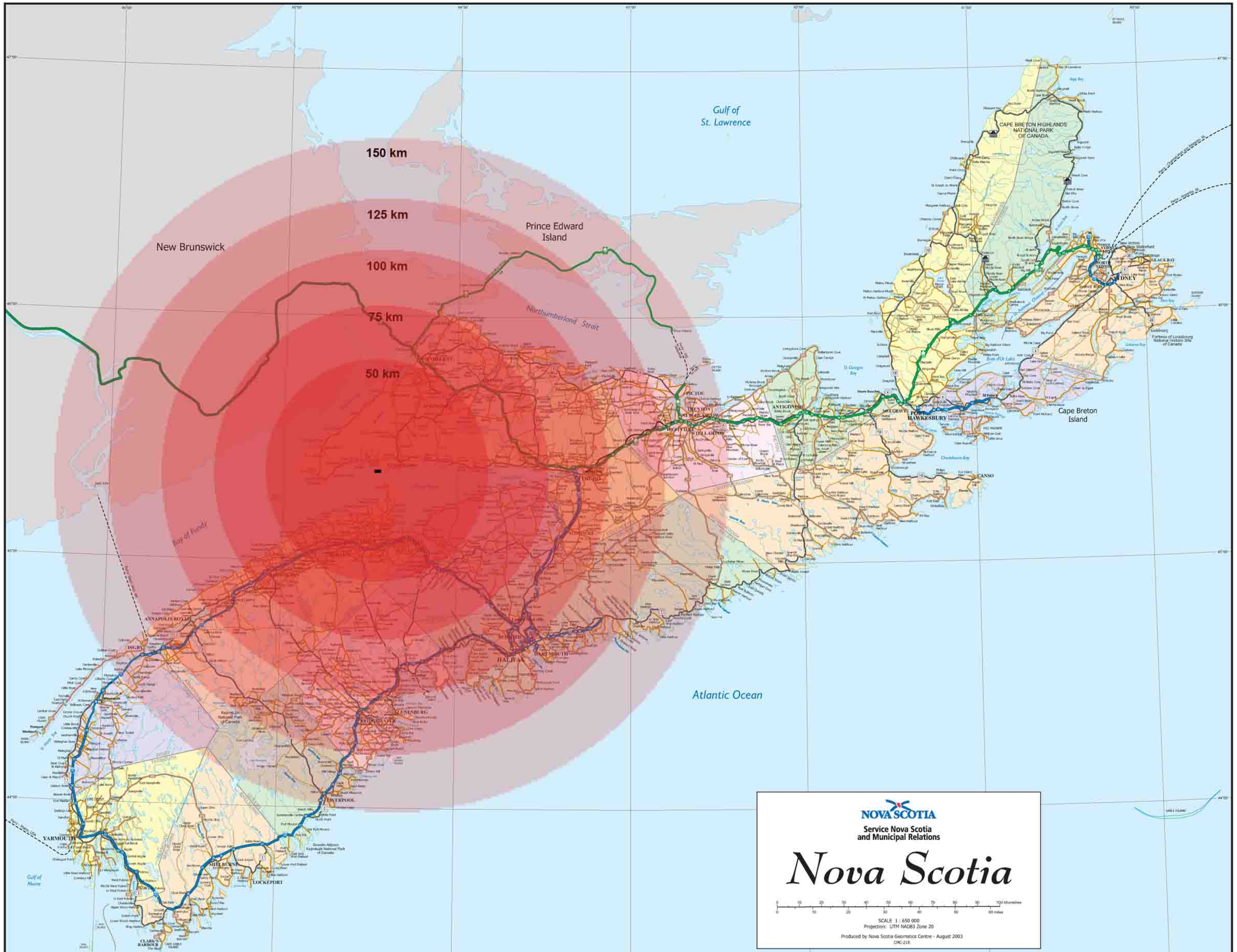

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Figure 6.1

6.4 Long Term - Base Case 1 (Large In-Stream Tidal Gravity Base Structures)

There are two strategically located regional ports within a 150 km radius of the Minas Basin which have significant facilities to support MRE development, specifically the deployment phase.

Firstly, the Port of Saint John is located approximately 150 km from the Minas Basin. The port has several existing deep water berths, including Long Wharf, Navy Island, Rodney Terminal and Lower Cove (see Figure 6.2.). The availability of the facilities as dedicated deployment sites would have to be investigated further well in advance of the start-up of the deployment phase to determine whether facilities could be dedicated for in-stream tidal power generation and to ensure that there are no competing interests from container shipping, general cargo shipping and cruise ship traffic. There are many services at Saint John including on-site rail lines and an airport is located within 20 km. Marine supply/support services, industrial parks, warehousing, metal fabrication, CNC machining, marine supply/installation vessels, heavy industrial fabrication, and educational/training facilities are all located within 15 km of the port. Heavy equipment rental is available within 7 km of the port and 3-phase industrial/manufacturing power is available on site.

Additionally, nearby Irving Equipment offers world class equipment and transporter rentals and Fleetway offers specialty/custom steel fabrication, lathes, plate rolling, steel and aluminum welding, machining, CNC, horizontal and vertical boring machines, heated paint shop with wheelabrator, pump and compressor sales and services, non-destructive testing, and infrared thermography. Clearly, there is a well established, sophisticated service supply chain in and around the Port of Saint John.

The Port of Digby is also located approximately 150 km from Minas Basin and is strategically located as well as being a regional Nova Scotia port (see Figure 6.3). The port is the home of the Digby Scallop Fleet which berths behind the Fisherman's Spur Wharf. The Princess of Acadia Ferry also berths in Digby and travels regularly between Digby and Saint John, N.B.

Digby is also home to many support services. There is a small airport located within 10 km of Digby; however, the site does not have rail line access. The closest rail line is over 150 km from the site; however, developers have not indicated that rail service is a critical criterion for manufacturing, assembly, deployment or operations and maintenance procedures. Industrial parks and CNC machining are both within 10 km of the port and warehousing is available within 20 km. Marine supply/support services as well as 3-Phase Industrial/Manufacturing Power are found within 1 km of the site. Marine supply/installation vessels, metal fabrication, as well as heavy industrial fabrication are located within 50 km of the facilities and metal and heavy industrial fabrication may be located as close as 1 km from the site. The site does not have heavy equipment rental (approximately 100 km from the site) located nearby.

Although Digby appears to be strategically located, it does not have the wharf structure or back-up land necessary to adequately support in-stream tidal power development. The scallop fleet cannot be displaced and the existing Fisherman's Spur Wharf is not suitable to accommodate the wide range of physical requirements. Also, the land adjacent to the Fisherman's Spur Wharf, which the Digby Harbour Authority is planning to develop, is too small and constrained to meet the back up land requirements for MRE developments. A new development in Digby should be considered if it is to be a primary port the MRE industry for the 'long-term' phase.

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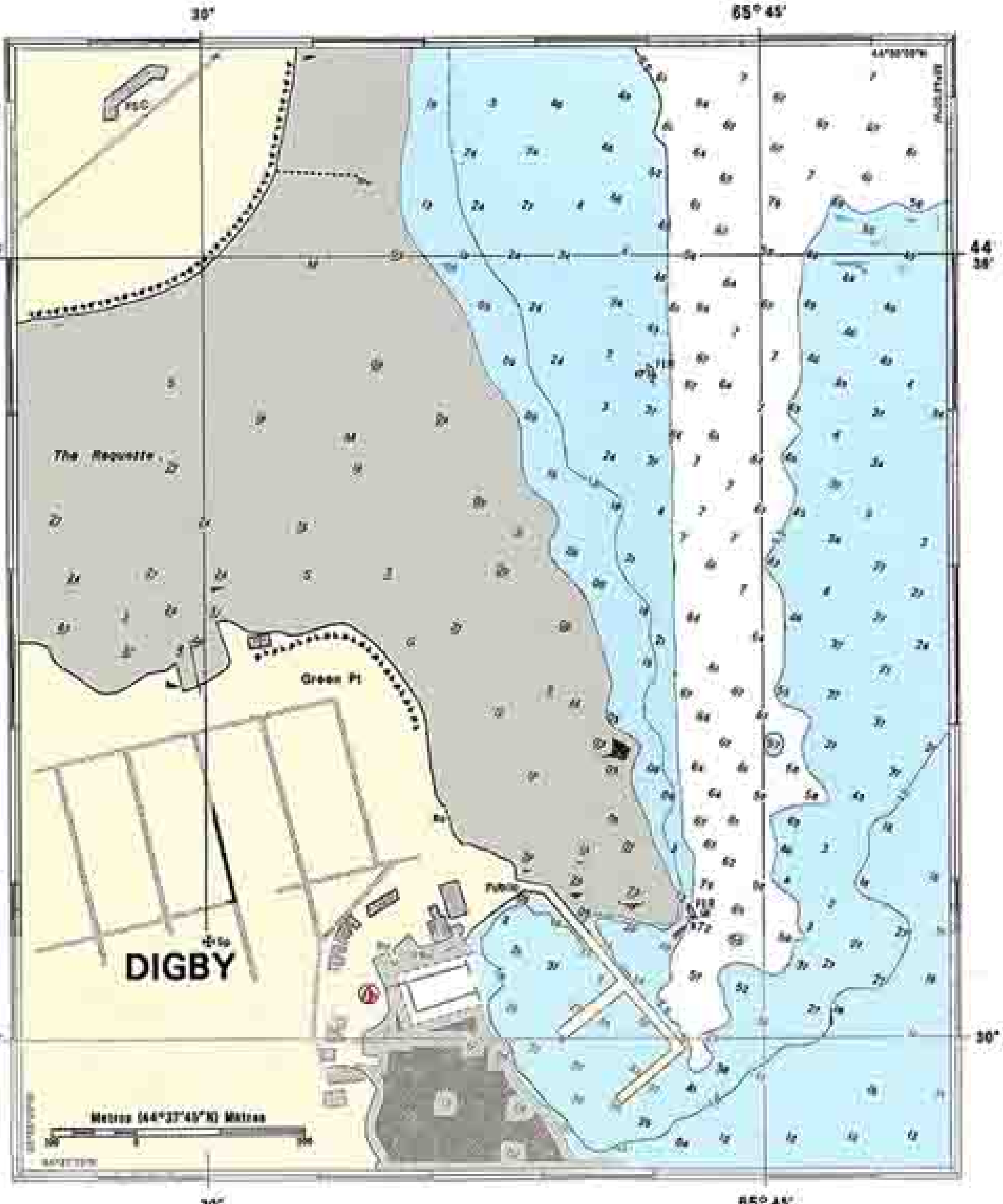
Figure 6.2-
Saint John, N.B.



Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4396)

exp.

Figure 6.3- Digby

6.5 Long Term – Base Case 2 (Large In-Stream Tidal Pin/Pile Base Structures)

The development industry is mixed on the marine facility requirements for this Base Case 2. It would appear, based on the results of the industry interviews that the overriding preference of the majority of developers is to have support from a "wet port" with a minimum 4 m water depth below low normal tide (LNT). It is however clear that a "dry port" in close proximity such as Hantsport and Parrsboro could meet some developers' basic needs. In this case it is highly possible that Hantsport could be a primary "dry port" with Parrsboro, another "dry port", playing a secondary or supporting role.

Some in-stream tidal power developers using lighter pin/pile bases will likely devise schemes to deploy or conduct some operations from "dry ports" (i.e. Hantsport or Parrsboro). In addition to their relatively light weight, another key feature of the pin/pile base structure is they can be designed to float and can be towed to the installation site. It may also be possible to construct ramps or marine railways, along with floating dry docks or barges to launch the bases and generating units.

Although a "dry port", Hantsport has an existing marginal wharf structure approximately 140 m long and 20 m wide. This is viewed as adequate to facilitate unit assembly and deployment with some wharf structure upgrades and strengthening and with a dry dock/barge and grounding bed to accommodate the dry dock/barge when it is at the berth at low tide. There is good road and rail access within 1 km of the site although some roadway and rail upgrades may be required.

Hantsport is also located in the Minas Basin and is therefore strategically located for the in-stream tidal resource at Minas Passage. It is also situated 65 km from Halifax, positioning Hantsport close to the steady and reliable supply chain provided in Halifax. For these reasons, Hantsport could be viewed as a "primary" port for Base Case 2.

Parrsboro, although located closest to Minas Passage, has a limited labour force and limited supply chain (based on anecdotal evidence and supported by the questionnaire response). Also, it is located approximately two and a half hours from Halifax. However, the port can provide secondary support if facilities elsewhere are fully occupied. It is expected that some wharf repairs and upgrades will be required, however the extent is not known and would have to be determined through an engineering investigation.

Although there are few "dry ports" within a 50 km radius of the Minas Channel, the industry will have to assess the practicality and financial viability of using a local "dry port" versus a "wet port" for deployment. Having said this, it is fully expected that "dry ports" will have a role to play in this emerging industry.

Based on the preference of many developers for a "wet port", it would be considered preferable at this time to consider a Greenfield Common User Wharf Facility at Digby. Developers, however, would have to prepare their own business case on the matter of deploying from a "dry port" versus a "wet port".

6.6 Long Term – Base Case 3 (Small Tidal)

There is little information available on the physical requirements for marine facilities for small in-stream tidal devices. It is expected however, that there are several ports that will be suitable to support this niche industry expected to occur in the Digby Neck area. The ports could include:

Digby
Meteghan
Meteghan River
Saulnierville
Weymouth

It is reasonable to expect that Freeport, Westport, Tiverton and East Sandy Cove could potentially provide a role to small tidal power devices in the Digby Neck area, although as they are remote communities, it would likely be a support role.

6.7 In-Stream Tidal O&M Phase

The physical requirements to support larger in-stream gravity base devices during the O&M phase would be similar to those required during the deployment phase. The Port of Saint John and a possible new major marine facility in Digby could provide support for vessels requiring up to 8 m to 9 m of water depth. Other ports around the Bay of Fundy could provide support for smaller vessels and lighter components.

The physical requirements to support the O&M phase of the lighter pin/pile base in-stream devices are much less robust than those needed for deployment and this could open opportunities for some of the smaller local ports. Table 6.3 lists the ports which could potentially be used during the O&M phase.

Table 6.3 - Potential O&M Phase Ports (Pin/Pile Base and <0.5 MW)

Port	Role	Water Depth at LNT
Digby	Primary	4.5 m
Saint John	Primary	Between 9 m and 12 m
Hantsport	Primary	Dry
Parrsboro	Secondary	Dry
Meteghan	Secondary	3.5 m
Saulnierville	Secondary	1.5 m
Weymouth	Secondary	2 m
Freeport	Support	4m
Westport	Support	3 m
Tiverton	Support	7 m
East Sandy Cove	Support	3 m

Note: The ports listed in Table 6.3 are arranged in no specific order; however, they are generally grouped according to regional ports, those located around the Minas Basin, and those located near St. Mary’s Bay.

Hantsport and Parrsboro are strategically located (see Figure 6.4); however, as shown on Figures 6.5 and 6.6 both ports are “dry ports”. This will present some operational challenges and will require working with the tides to facilitate O&M processes as well as environmental/biological monitoring activities. For reasons stated earlier in Section 6.5, Hantsport could provide primary support to the industry while Parrsboro could be available to provide secondary support when the primary marine facilities are fully occupied. Also, Digby and Saint John are considered of primary importance because they have significant wharf structures and are “wet ports” which would be capable of supporting large vessels and barges required during the O&M phase.

Other ports which are either located greater distances from Minas Passage but have reasonable access to a supply chain are considered to be available to provide a secondary level of support. Such ports include Meteghan, Saulnierville and Weymouth. Ports which are located greater distances from Minas Passage and are considered geographically remote would be available to provide a support role if necessary. Ports which may provide a support role include Freeport, Westport, Tiverton and East Sandy Cove.

There are several ports on St. Mary’s Bay that will be reasonably positioned to provide support (See Figure 6.7) such as Meteghan, Saulnierville, and Weymouth to name a few.

Meteghan wharf provides 410 m berth with 3.5 m of water depth below low normal tide (LNT) (see Figure 6.8).

Saulnierville wharf provides 140 m berth with 1.5 m of water depth below LNT (see Figure 6.9).

Weymouth wharf provides 85 m berth with 2 m of water depth below LNT (see Figure 6.10).

Other facilities could provide a support function such as East Sandy Cove which provides 110 m berth and is located within a 175 km radius from Minas Channel.

Facilities in Grand Passage and Petit Passage may also be suitable to support smaller in-stream tidal power generation in the Digby Neck area although these ports are somewhat remote. It is likely these ports would be support facilities working collaboratively with more major marine facilities and support services in Digby and the St. Mary’s Bay area (i.e. Meteghan/Meteghan River, Saulnierville, Weymouth).

Additionally, the above referenced ports, particularly the “wet ports” will be well positioned in the future when in-stream tidal power generation expands from the current focus study area to other areas in the Bay of Fundy.

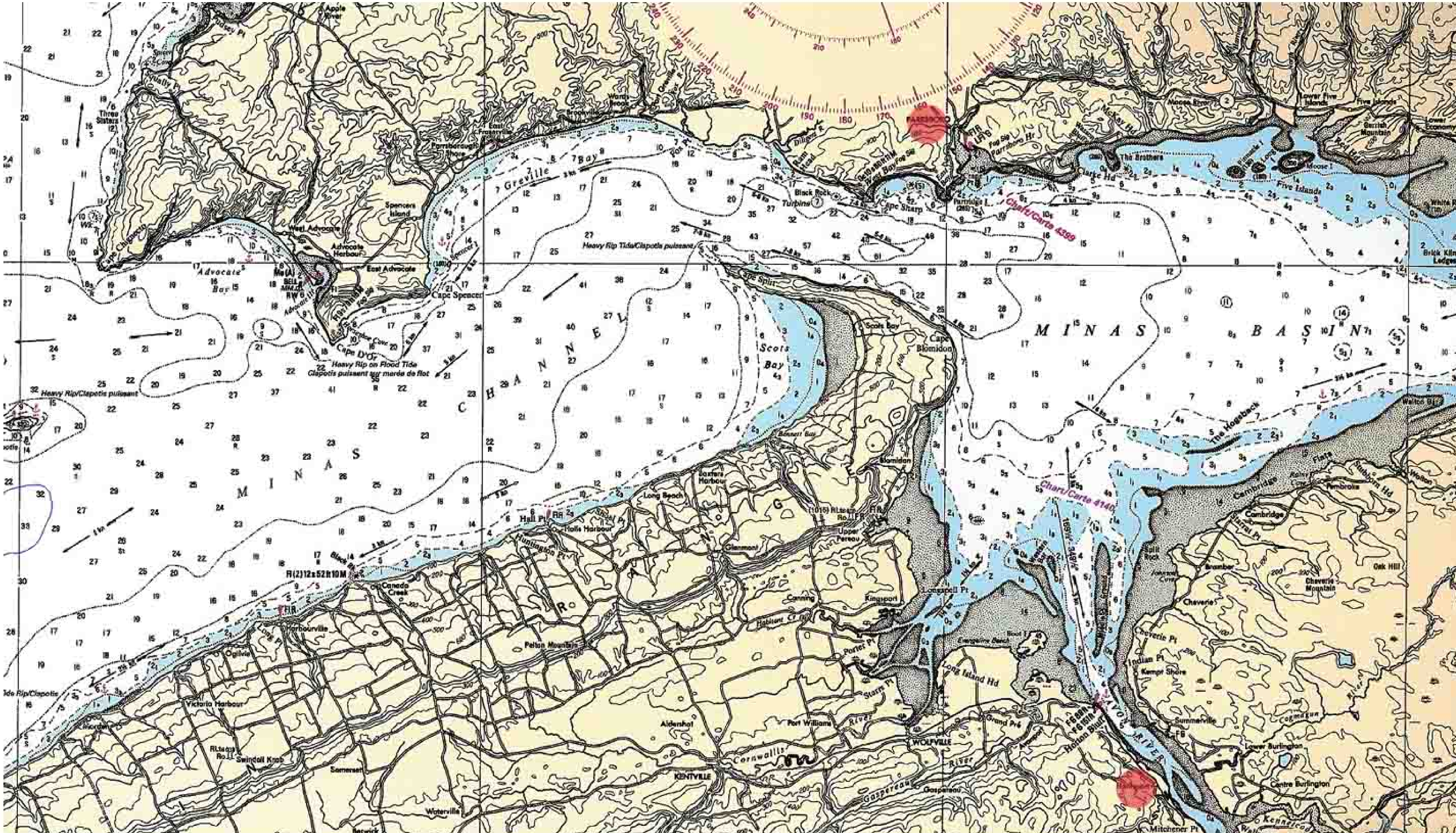


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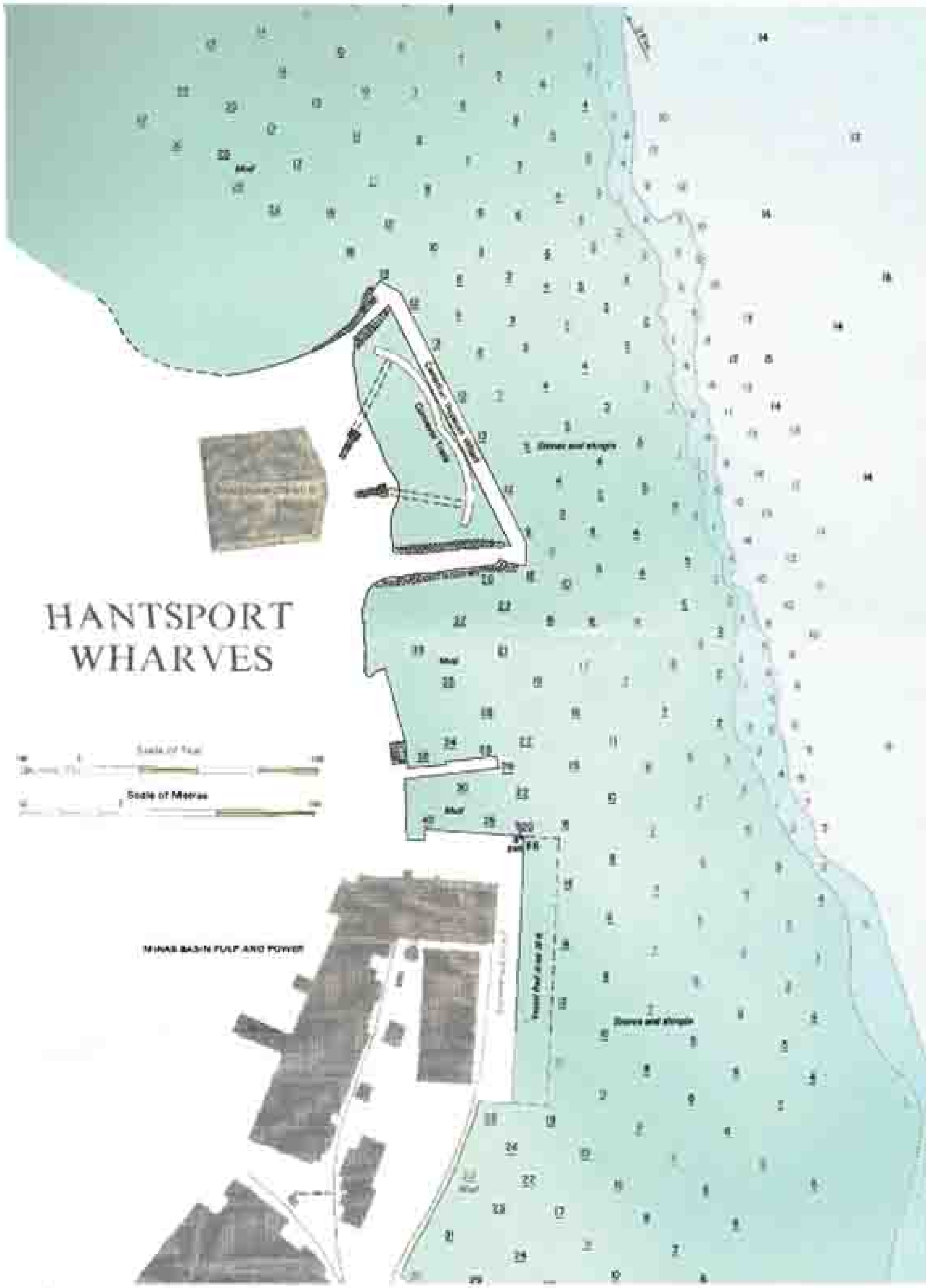
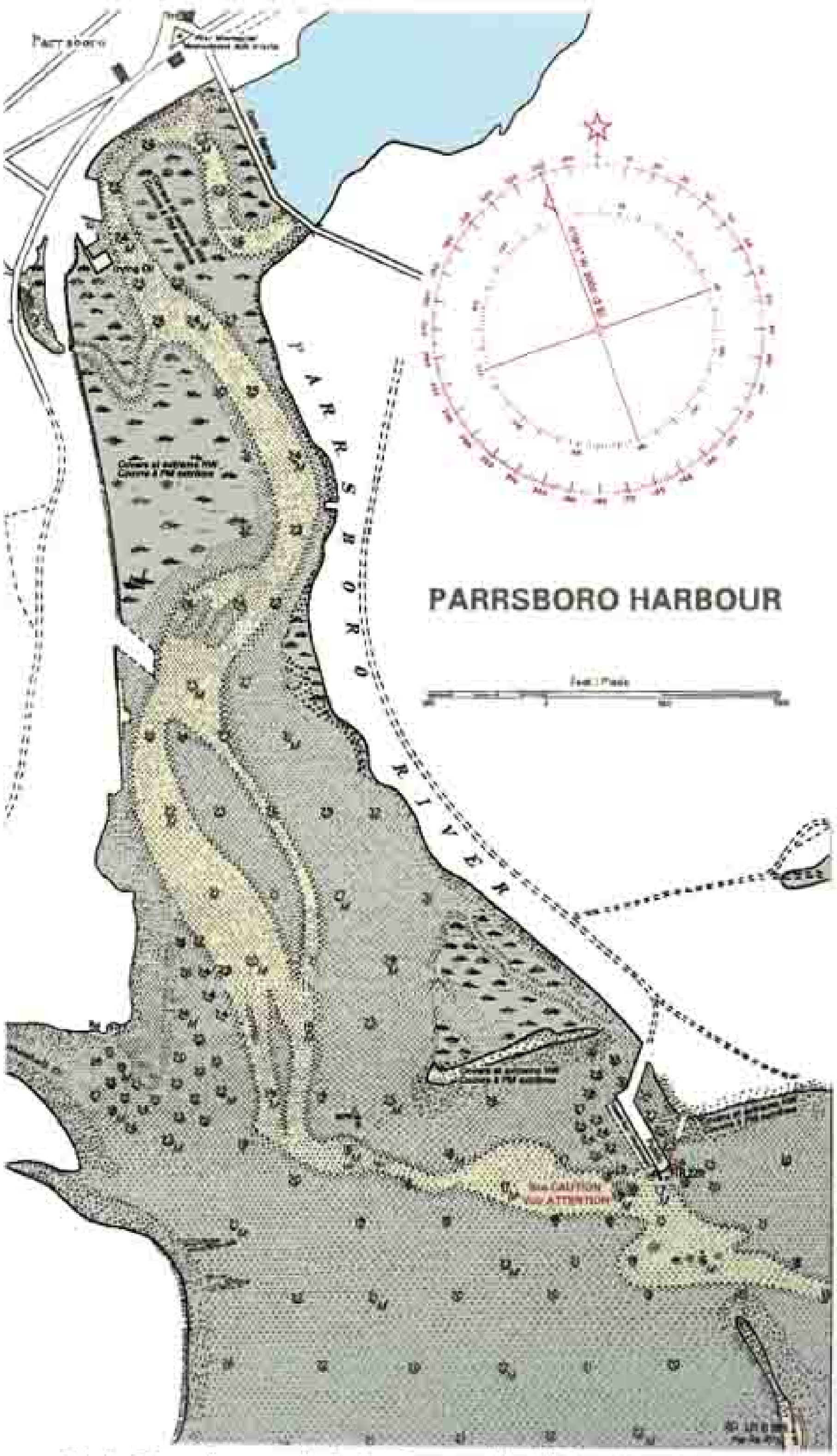
Figure 6.4-
Minas Passage



Note: Soundings are in feet referenced to LNT
(Information scanned from CHS Hydrographic Chart 4140)

Figure 6.5- Hantsport



Note: Soundings are in feet referenced to LNT
(Information scanned from CHS Hydrographic Chart 4399)

Figure 6.6- Parrsboro

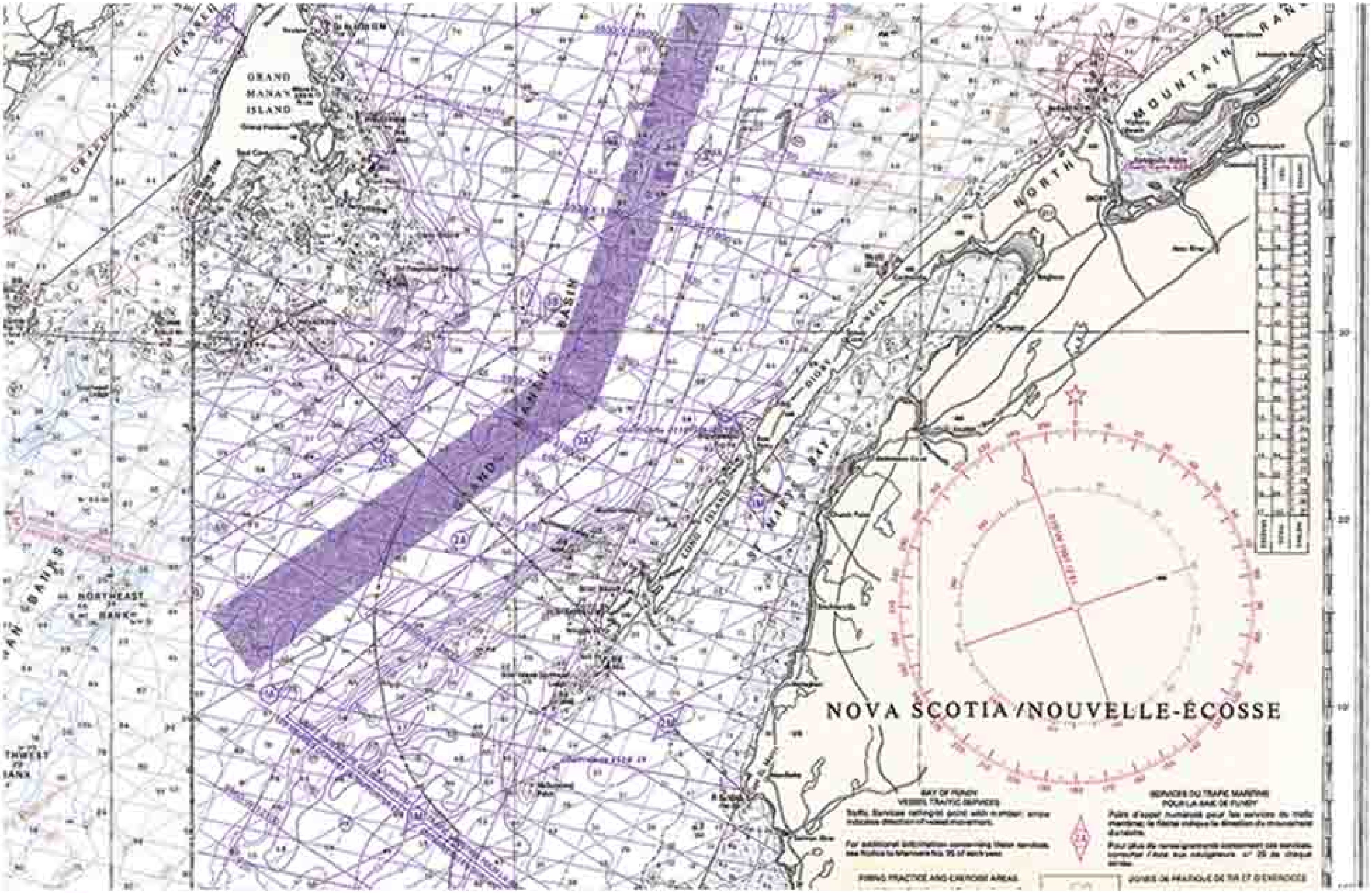
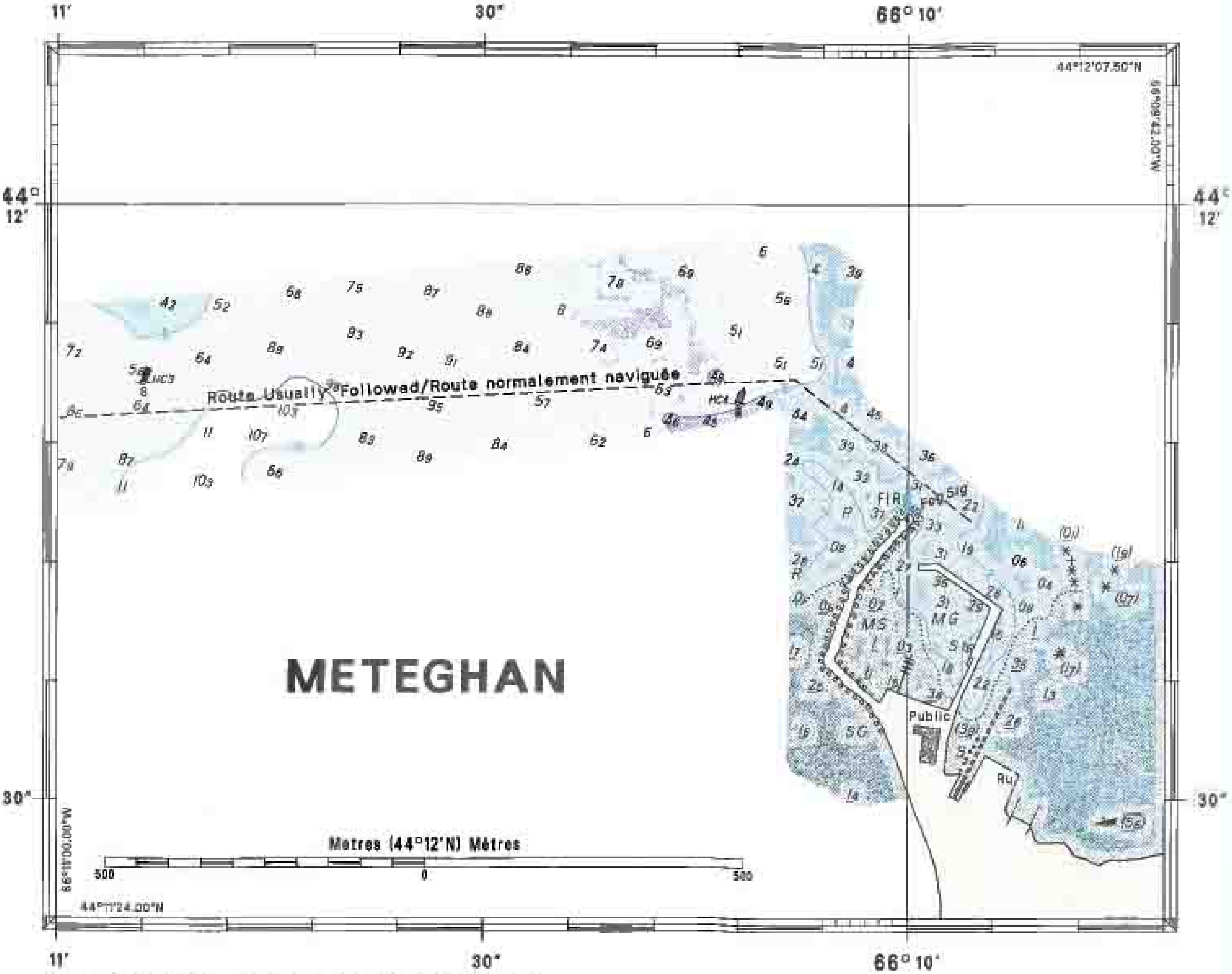
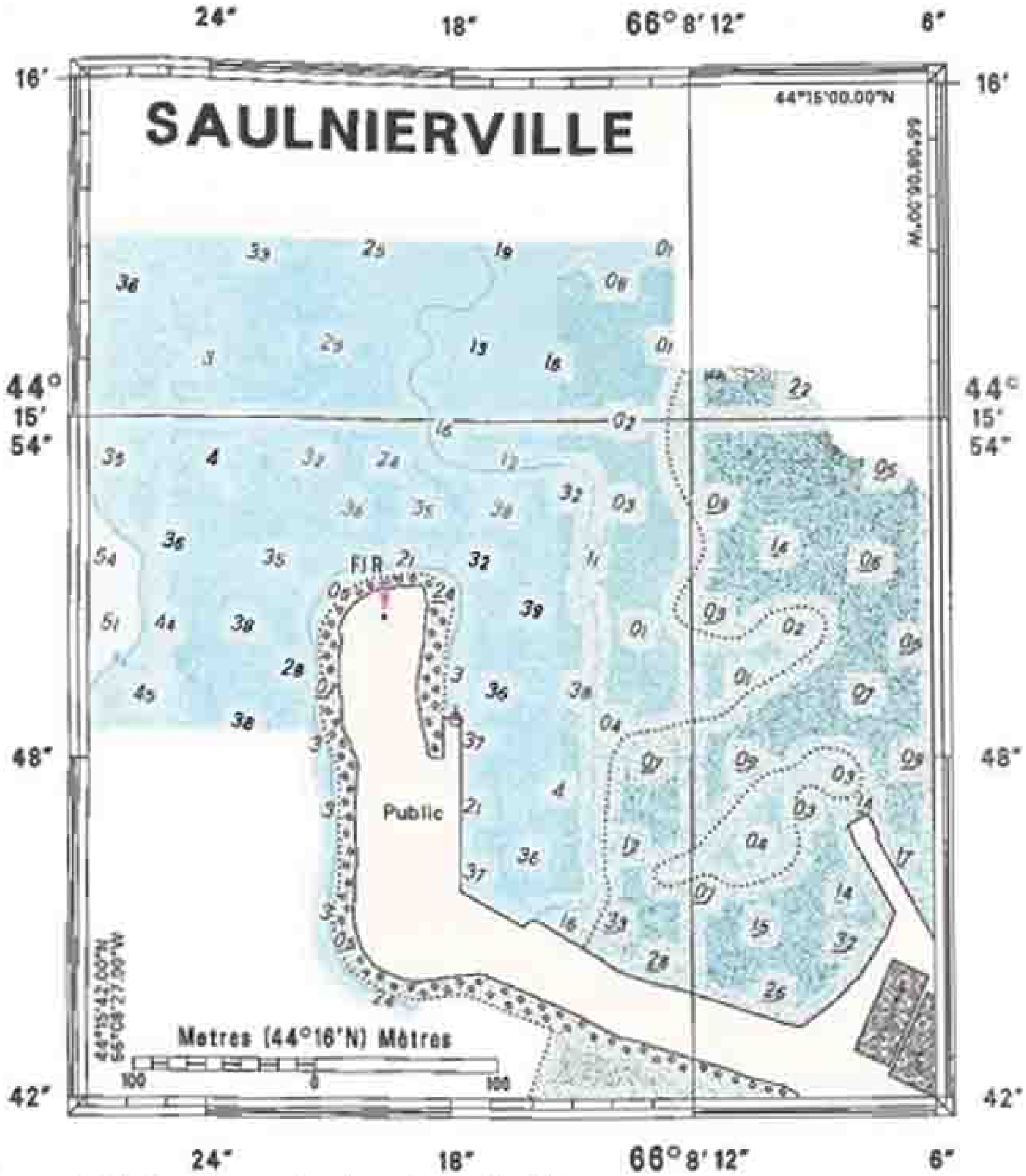


Figure 6.7-
St. Mary's Bay



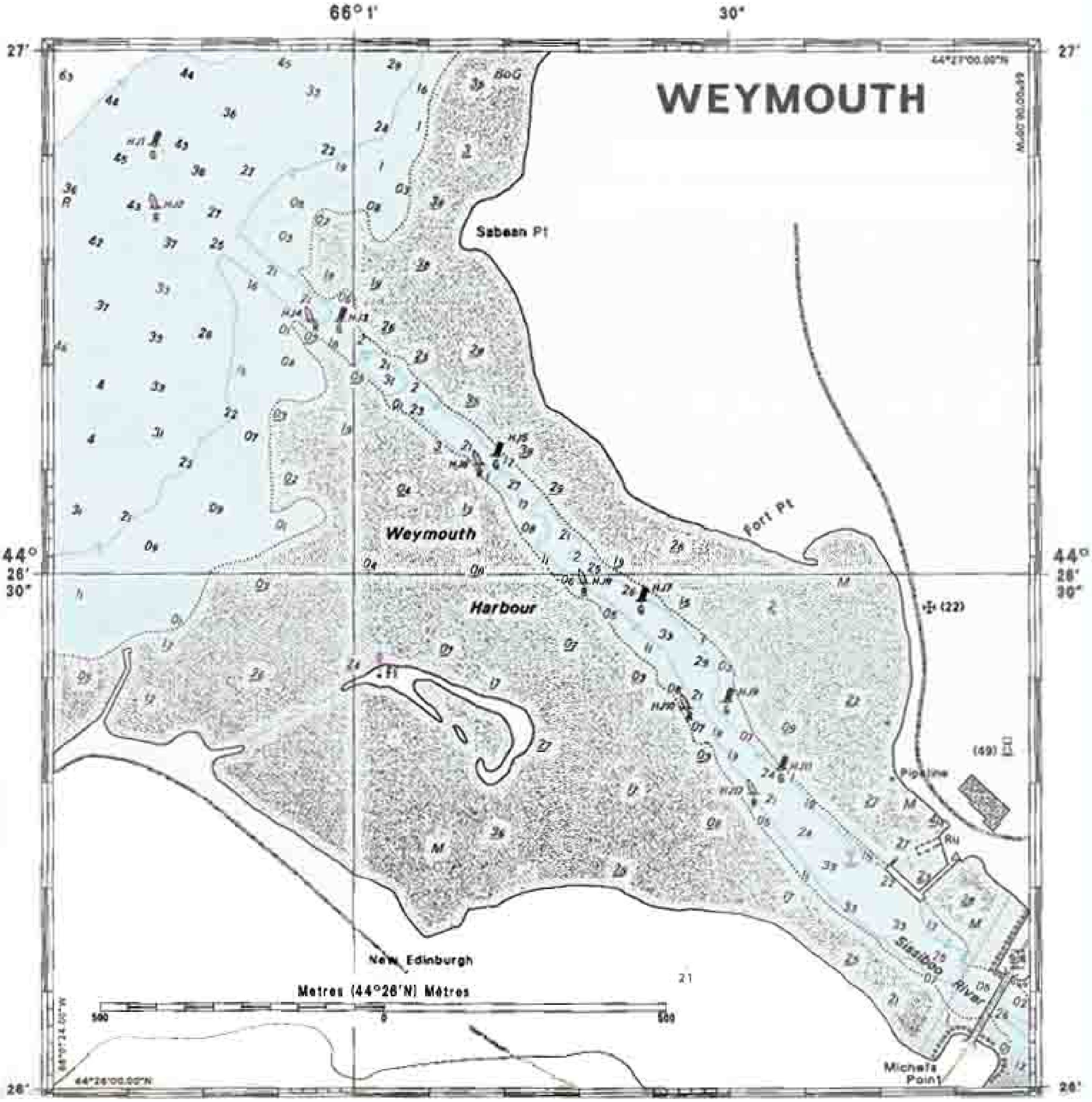
Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.8- Meteghan



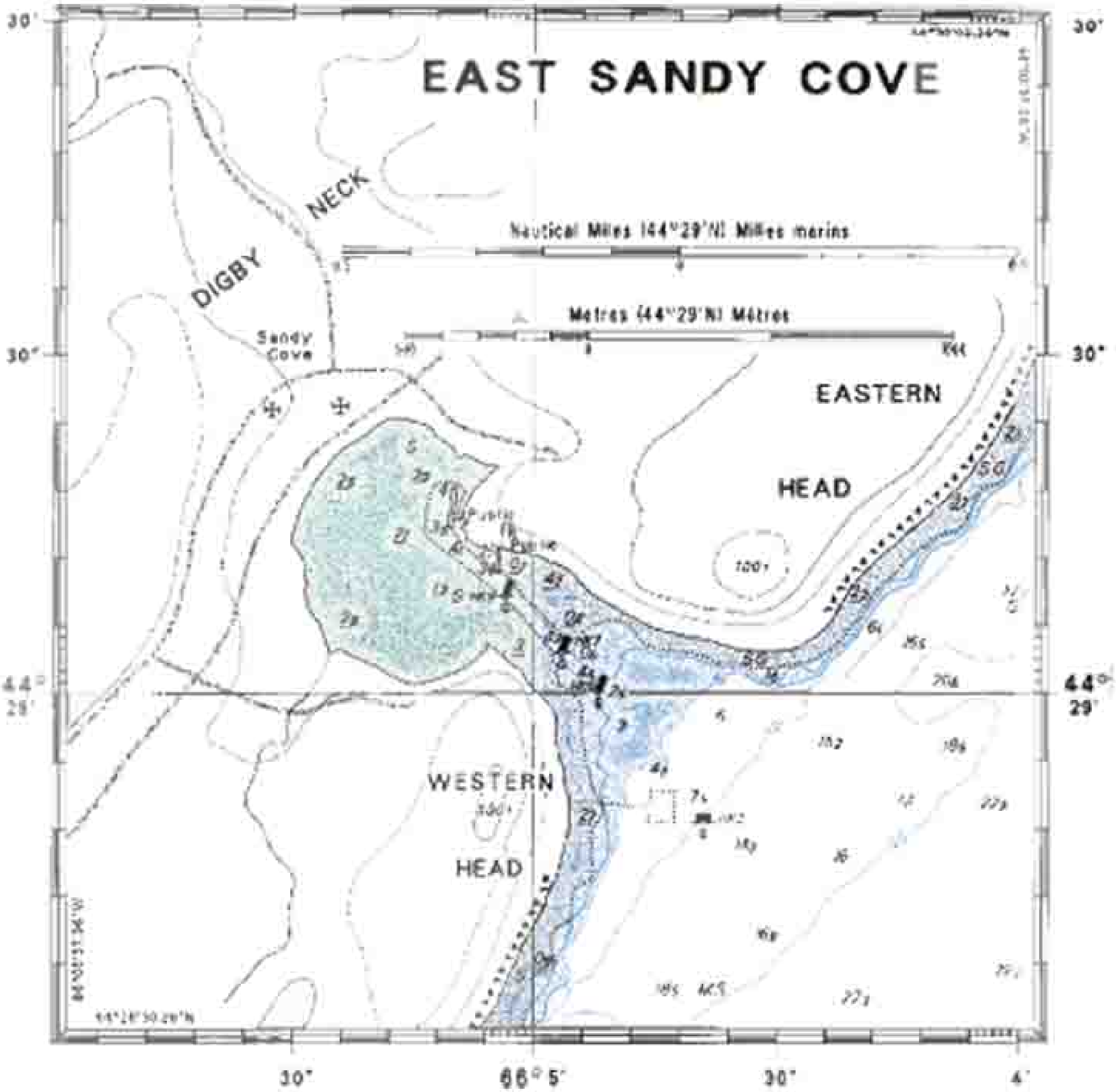
Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.9- Saulnierville



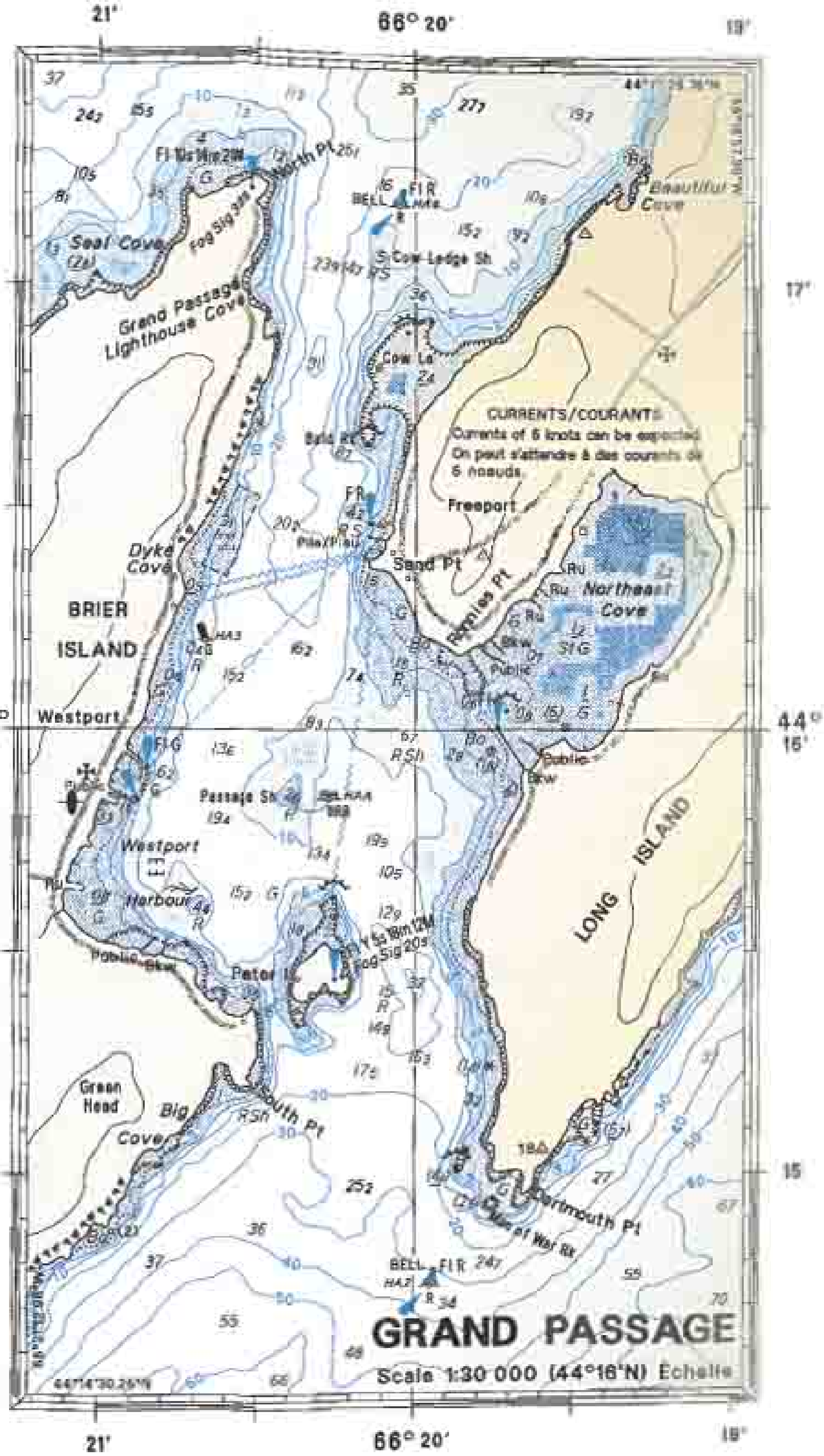
Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.10- Weymouth



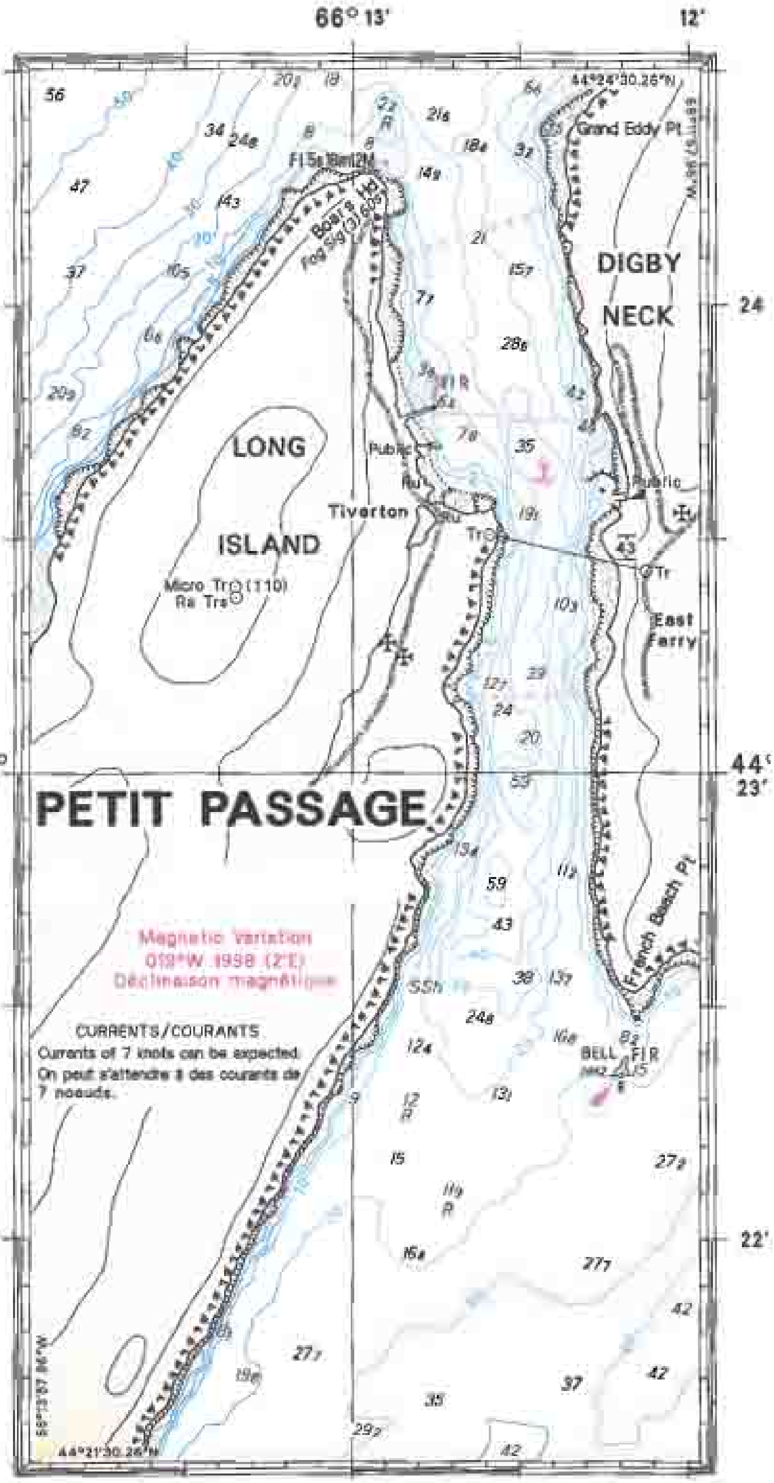
Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.11-
East Sandy Cove



Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.12- Grand Passage



Note: Soundings are in metres referenced to LNT
(Information scanned from CHS Hydrographic Chart 4118)

Figure 6.13- Petit Passage

6.8 Long Term - Base Case 4 (Offshore Wind and Wave)

As noted previously, the primary focus of this study was in-stream tidal power generation. However, this section provides a preliminary look into the possible physical requirements necessary to support offshore wind and wave power generation.

Based on available information, it appears that to meet future demands for offshore wind and wave power generation significant production, assembly and deployment facilities will be required. It is expected major coastal locations for manufacturing facilities will be required, as it is difficult to transport the large offshore wind foundations in any manner other than via water.

Typical Requirements for a Construction Base with the Capacity to Handle 100 Turbines a Year:

Lay Down and Pre-Assembly Area* …………………………….	8 ha
Length of Quayside ………………………………………………	200 m – 300 m ±
Water Depth………………………………………………………..	7 m
Vessel Size…………………………………………………………	140 m length 45 m beam 6 m draft
Overhead Clearance to Sea…………………………………….	100 m (min)
Crane Jack Up Barge/ Heavy Lift Equipment ………………..	Yes

*Note: On sites with greater weather restrictions on construction, an additional lay down and pre-assembly area of up to 30 ha may be required.

In addition to the above listed criteria, sites should have good land-side transportation access to aid with onshore wind farm construction. Also, any requirements relating to cranes or load bearing points could be achieved through local engineering works.

Although the industry requirements for support of offshore wave power generation are not well defined it is anticipated, at this early stage of industry development, that the needs will be similar to those of the offshore wind industry. It is also anticipated that the resource location will be the Atlantic Coast of Nova Scotia.

In light of this preliminary information and considering that most of the offshore wind and wave power generation activity will occur off the Atlantic Coast of Nova Scotia it is feasible that certain Nova Scotia ports could either individually or collaboratively support the industry. Table 6.4 outlines potential facilities for offshore wind power generation.

Table 6.4 - Potential Facilities Capable of Supporting Offshore Wind and Wave Power Generation

Yarmouth
Shelburne
Halifax/Woodside
Sheet Harbour
Strait of Canso Superport
Sydney/North Sydney
Pictou

Note: The ports listed in Table 6.4 are arranged in no specific order, however, generally they start at the southern tip of Nova Scotia and travel counterclockwise around the Province.

Collectively these facilities should be capable of providing the required marine and associated support infrastructure for offshore wind and wave power generation. It is not anticipated that there would be a need for major marine structure upgrades or expansion.

However, given that the industry is still in its infancy the requirements and physical asset availability should be reassessed within the next five to ten years. If the industry develops to the point where exports are to other areas such as the North-eastern United States or other global markets are expected ports such as Halifax, which has a well developed container and break bulk cargo facility, may then play an important role.

7.0 CONCEPT DEVELOPMENT PLANS

7.1 Overview

This chapter presents the Concept Development Plans for marine infrastructure based on the understanding of requirements from MRE resource developers. The plan is based on the results of the Gap Analysis and Infrastructure Analysis presented in Chapter 6.

Concept Development Plans are provided for the following base cases:

- i. Base Case 1: Large Tidal (gravity base) > 0.5 MW
- ii. Base Case 2: Large Tidal (pin/pile base) >0.5 MW
- iii. Base Case 3: Small Tidal <0.5 MW
- iv. Base Case 4: Offshore Wind

The following sections outline comments on the Concept Development Plans.

7.2 Short Term In-Stream Tidal- Base Case 1 and 2 (Large In-Stream Tidal Structures)

It is expected that development of in-stream tidal power generation, up to the initial 64 MW generating capacity, can be accommodated from existing facilities including Halifax, Hantsport and others between Shelburne and Digby. Saint John, N.B. may also have a role to play in the development. It is not anticipated that infrastructure improvements or new construction will be required for the ‘short-term’ phase. However, there may be some cases where wharf repairs are needed to address deferred maintenance, such as Hantsport, but these matters are considered to be beyond the scope of the study.

7.3 Long Term - Base Case 1 (Large In-Stream Tidal Gravity Base Structures)

In order to support the industry beyond they initial 64 MW development, it is clear that deployment facilities along the Bay of Fundy (within 150 km of Minas Passage) are necessary. There are two obvious existing regional ports, located within 150 km of Minas Basin, which are considered suitable for the ‘long-term’ deployment phase:

1. Saint John
2. Digby

The Port of Saint John is a well developed deep water “wet port” with a mature supply chain capable, for the most part, of supporting in-stream tidal power deployment. There are several wharf facilities, including Long Wharf, Navy Island, Rodney Terminal, and Lower Cove, which may be available to support the longer term deployment phase. However, some of these facilities also support container handling and cruise ship traffic. It may not be possible to displace these existing industries to allow space for all necessary requirements for fabrication, assembly, erection, load-out and for berthing of support vessels and barges of in-stream tidal power generation.

If there were interest in supporting MRE operations from Saint John in the future, the availability of wharf facilities in Saint John should be reassessed to determine whether they can dedicate the necessary space to major fabrication, assembly, erection and load-out in order to support deployment of larger gravity base in-stream tidal generation equipment from the port.

The second strategically located regional port is Digby Harbour which is located about 150 km from Minas Basin. Digby has two major wharf facilities, the Fisherman's Spur Wharf and the Ferry Terminal. Currently, these facilities are considered unsuitable to support larger in-stream tidal power generation deployment as neither of the existing facilities is compatible with accommodating the needs of the MRE industry over the deployment phase. Additionally, even if it were possible to displace the Scallop Fleet, the Fisherman's Spur Wharf is not considered suitable for heavy lifting, load-out and it has insufficient back-up land to support MRE.

It is known that the Digby Harbour Authority has a master plan for expansion of their facilities at the Fisherman's Spur Wharf. However, based on industry requirements, it appears that the Harbour Authorities' planned development which is understood to consist of the installation of new breakwaters (to allow for the opportunity to develop additional land) as well as some dredging will not meet the needs of the larger gravity base MRE resource development. Therefore, if the "tipping point" of large tidal device deployment is reached, and the MRE industry's requirements remain broadly similar to those currently expressed, it would be considered advantageous, and likely necessary, to construct a new major wharf facility in Digby Harbour to support larger MRE deployments as Digby will likely be a strategic location in the 'long-term' development of MRE resources. Based on information from the MRE development industry it is reasonable to consider constructing a new marine facility that would accommodate the MRE industry for all cases and through all phases of development.

Preliminary conceptual development information for a similar development was obtained from Orkney in Scotland. Orkney has grown from about 15 MW installed generation capacity in 2000 to more than 45 MW in 2010. 'A Sustainable Energy Strategy for Orkney' (Orkney Islands Council, December 2009) indicates that Orkney has the potential to develop more than 1 GW of power by 2020. Orkney would appear to be a reasonable comparative jurisdiction for MRE development. It is interesting to note that there has been over £ 200 million in investment in Orkney. In order to support MRE expansion, Orkney has determined that there will be a need for extensive harbour facilities as well as three to four expanded/new port facilities and the possible development of a floating service.

For Nova Scotia MRE resource development, it is anticipated that a new Common User Facility with ample back-up land would be desired. This facility must have the ability to expand to at least twice the size of the initial development. Considering information gathered to date and applying some judgment, it is expected that a facility similar in concept to the one shown on Figure 7.1 and Figure 7.2 could be required in the port of Digby.

Suggested Initial Development

- Two berths
- 200 m – 220 m length overall (L.O.A.)
- 500 T lift capacity
- Load-out capability
- 8 - 9 m water depth alongside
- 100 m overhead clearance
- 10 ha back-up land

Figure 7.1-
Marine Structure Concept, Initial Phase

Figure 7.2-
Marine Structure Concept, Initial Phase

Although a location has not been identified within the port, it may be possible to locate the common user facility on a Greenfield site north of the Ferry Terminal. Planning for a possibly major wharf facility with ample back-up land would provide a dedicated facility. A major facility in Digby would also be beneficial when deployment activities reach the point where more than two or three vessel berths are required. Therefore, it is anticipated that development of a Common User Facility in Digby is likely to be warranted in the future. The fundamental requirements for this marine facility have been outlined above.

The order of magnitude cost for the initial development phase is expected to be in the $25-30 million range ($2011). Costs should be reassessed when an appropriate site has been identified.

7.4 Long Term – Base Case 2 (Large In-Stream Tidal Pin/Pile Base Structures)

The development of larger pin/pile base supporting structures will likely require support from a “wet port” such as a Greenfield Common User Facility in Digby, or possibly the Digby Fisherman’s Spur Wharf or Saint John to accommodate larger vessels and barges used to deploy equipment such as pile driving templates which will likely be required to install piles. Many ports such as Hantsport and Parrsboro appear to be strategically located for the deployment of pin/pile base structures; however, they are “dry ports”. As previously stated, a “wet port” is likely required for some of the deployment operations.

Based on a quick review of the hydrographic chart for Hantsport it appears that there would be upwards of 12 m of dredge depth necessary to provide the desired 4m water depth below low normal tide (LNT). This is not considered practical and it is fully expected that maintenance dredging would be required. Additionally, it would not be possible to dredge to the required depth adjacent to the existing wharf face as it is possible the dredging could undermine the existing structure. After a similar review of the hydrographic chart of Parrsboro, it appears there would be upwards of 14 m of dredge depth required to provide the desired 4 m water depth. As with Hantsport, this is not considered practical.

Unfortunately, it is not considered practical or economically viable at this stage to dredge either Hantsport or Parrsboro to provide the desired 4 m minimum water depth at the existing wharf faces. Having said this, there could be some components deployed from some of the nearby “dry ports”. It is fully expected that some developers will have facilities strategically located within 50 km of Minas Passage and will devise methods to deploy and operate from a “dry port”. If deemed economically advantageous to operate from a “dry port” the developers will have to design methods and operating procedures to effectively use the available “dry ports” without dredging and with existing wharf infrastructure. Any facilities, such as launching ramps, marine railways, dry docks or barges would be considered a “manufacturer’s/developer’s” project specific requirement, not an industry-wide requirement, and are considered to be beyond the scope of this study.

It would appear that the Digby Fisherman’s Spur Wharf would meet the general requirements for the deployment of pin/pile base devices. Some strengthening of the wharf deck may be required but a detailed structural engineering investigation would have to be conducted to determine the extent of the physical works. A new Greenfield Common User Facility would also be advantageous for the deployment of the barges and pile driving templates as the common user wharf would be suitable and available to all developers.

7.5 Long Term – Base Case 3 (Small Tidal)

To support smaller in-stream tidal power generation a “wet port” with a supply chain capable of supporting the marine industry will be required. The port should also be located near Grand Passage, Petit Passage and Digby Gut.

It is expected that facilities in Digby, either at the Fisherman’s Spur Wharf or a newly developed Common User Facility, Meteghan, Meteghan River, and Saulnierville will be well positioned to support the industry. Little to no infrastructure improvements should be expected.

7.6 In-Stream Tidal O&M Phase

During the O&M phase it will be imperative that some wharf and support facilities be located within 50 km of Minas Passage. At first glance, Hantsport and Parrsboro seem to be logical choices for O&M phase ports. Although they are strategically located, Hantsport and Parrsboro are “dry ports”. It is not considered practical or feasible to effectively dredge at Hantsport. Similarly it is not viable to dredge at Parrsboro. If deemed economically advantageous to operate the O&M phase from a “dry port”, the developers will have to devise methods and operating procedures to effectively use the available “dry ports” during the O&M phase.

7.7 Long Term – Base Case 4 (Offshore Wind and Wave)

The fundamental requirements for the support of offshore wind power generation include a major wharf facility with ample back-up land which must be located within a reasonable distance from the resource.

It is expected that existing marine facilities along the Atlantic Coast could provide suitable wharf facilities.

The facilities which show the most potential include:

1. Yarmouth
2. Shelburne
3. Halifax/Woodside
4. Sheet Harbour
5. Strait of Canso
6. Sydney/North Sydney
7. Pictou

Note: The ports listed in the above table are arranged in no specific order, however, generally they start at the southern tip of the Province and travel counterclockwise around the Province.

At this stage it is not anticipated that there will be any need for infrastructure improvements. This is due to the amount of already developed marine facilities providing a broad coverage of the Atlantic Coast. It is expected that infrastructure needs for offshore wave power generation will be accommodated by the same facilities available to support offshore wind power generation.

7.8 Submarine Cable Installation

It is anticipated that major wharf facilities, such as those that exist at the outer face (exposed face) of the Digby Fisherman's Spur Wharf or at Saint John, will be required to accommodate ocean going cable laying vessels.

7.9 Concluding Remarks

In conclusion, consideration should be given to constructing a new Common User Facility near Digby, as Digby is a strategically located "wet port" with much potential as a primary port for in-stream tidal power generation during both the deployment phase as well as the O&M phase. Digby is well positioned to support smaller in-stream tidal power installations in the Digby Neck area. Digby quite conceivably could become an even more important port if other areas of the Bay of Fundy, beyond the Minas Passage, are developed.

Also, if developers deem it viable to operate an O&M phase port or a deployment phase port from a "dry port", it will be necessary for developers to devise methods and operating procedures to effectively use the available "dry ports".

Additionally, it is anticipated that some wharf structure upgrades and strengthening will be required to accommodate mobile crane loadings. The extent of upgrades and associated costs are not known and could only be determined after a detailed structural engineering inspection and investigation. It can be expected that some level of upgrades and strengthening will be required at Digby, Meteghan, Saulnierville, Weymouth, Hantsport and Parrsboro.

It must be recognized that the concept plans presented are based on very initial information. The MRE industry is very much in its infancy in the Bay of Fundy and it is highly recommended that industry requirements be reassessed in four or five years with appropriate plans for infrastructure improvements and expansion.

It should also be noted that the focus of this study has been on in-stream tidal power generation in the Minas Passage; however, other sites in the Bay of Fundy could likely be of interest as the industry matures.

8.0 JURISDICTIONAL COMPARISON

8.1 Case Study: Esbjerg, Denmark

Port of Esbjerg. Source: Northern Maritime Corridor Project Summary Report 2005-2008 Activities, Results and Impacts

Background

Denmark has a long history of offshore oil and gas, being the first country to find and produce oil from the North Sea and a net exporter of crude oil, the only oil exporting nation in the EU. While most electricity is produced from coal, Denmark is also a long time leader in wind energy - wind turbines produce 16–19% of electricity demand. Denmark has been leading in offshore wind since the early 90's when Vindeby Offshore Wind Farm was constructed. Since then, more than 400 offshore wind turbines have been erected in Danish waters. The Danish offshore wind industry has developed steadily. Today almost half of the wind turbines around the world are produced by Danish manufacturers (such as Vestas and Siemens Wind Power) along with many component suppliers. A recent World Wildlife Federation report (May 2011) cites Denmark as a world leader in terms of clean-tech investment as a percentage of gross domestic product, spending $9.4 billion a year on renewable energy and energy efficiency, about 3.1 percent of GDP. Denmark is connected by transmission lines to other European countries, as well as by its other transportation infrastructure. The oil and gas industry as well as a large part of the offshore wind industry is located in Esbjerg, in the southern part of Denmark.

Location

The Port of Esbjerg is the international port of Western Denmark. It is situated on the North Sea, facing the UK, Norway, and the Faroe Islands, Iceland and Greenland as well as the Western part of continental Europe. Esbjerg is the natural Danish port to the North Sea; the Port's hinterland connections also put it within reach of Sweden and the Baltic countries (latitude 55° 28' N and longitude 8° 26'E). Esbjerg is the fifth largest city in Denmark, with a population of about 115,000.

History

Esbjerg is the main centre for Denmark's offshore activity, fuelled by the establishment of numerous offshore oil and gas companies during the1980's after Denmark commenced extracting oil and gas from the North Sea around 1972. Prior to that Esbjerg was once Denmark's biggest fishing harbour. The Port of Esbjerg has evolved into a dynamic hub for cargo flows between the Nordic countries, the Baltic area and Europe, and is Denmark's number one Ro-Ro port. The Port's excellent infrastructure and local business community have reportedly helped to position Esbjerg as one of the world's leading ports for the provision of offshore services and support, and recently the offshore wind farm industry in the North Sea. After many years of development Esbjerg also services offshore wind farms in other European nations most notably England. Esbjerg is considered a leader in the field of energy with 80% of the Danish offshore industry based there, increasingly focused toward offshore wind power.

Approximately 270 companies are linked to the port and in turn over 7,000 people are employed at these port-linked companies. During the past several years, the City of Esbjerg and the port have increased their connections to the rest of Denmark with the development of rail and motorways direct to the port area. The last stretch of motorway, the E20, to be completed in 2014 will enable vehicles to drive directly into the port area. The port area covers over 3.5 million m2 of land and with an extensive infrastructure for both Ro-Ro and Lo-Lo, the port's strategy is to focus on intermodal transport solutions. In 2009, the port was reportedly one of the best performing ports in Denmark with an after tax profit of about €7 million.

Esbjerg region was strengthened in 2003 when Offshore Center Danmark was established as the official national competence and innovation center for the Danish offshore industry. Partly funded by the government, the centre aims to develop new knowledge and to bring the industry together. Through its work, Offshore Center Danmark seeks to benefit from more than three decades experience of offshore oil/gas companies for the new area of offshore wind energy.[14]

Current initiatives are aimed at developing Port of Esbjerg into a multimodal transport centre making it an ideal short sea shipping alternative to road transport on Europe's congested and expensive highways.

Port Characteristics

Esbjerg is Denmark's largest port in terms of sq.m[15]

Description / Land Available	Infrastructure /Capabilities
▪ Total land area = 3,487,685 m2 ▪ Rented areas=1,570,450 m2 ▪ Developed areas = 365,499 m2 ▪ Infrastructure=1,137,965 m2 ▪ areas used by the Port itself= 36,858 m2 ▪ Non-developed areas = 376,913 m2	▪ Cranes, Quays, activities, facilities, etc: ▪ Cranes with lifting capacity up to 467 tons ▪ Total of 10km quay length ▪ Depth at quay between 3.9m and 11.5m ▪ A total of 10 km of quays: ▪ Fishing Harbour - 4.5 km of quays water / depths ranging from 4.4 m to 7.5 m M.L.W.S.* ▪ Traffic Harbour - 5.5 km of quays water / depths ranging from 4.4 m to 11.5 m M.L.W.S.* *Mean Low Water Springs

[14] http://www.offshorecenter.dk/
[15] http://www.portesbjerg.dk/en/infrastructure--facilities.aspx

Role in Marine Renewable Energy

Esbjerg gained experience with offshore wind farms when the Horns Rev Offshore Wind Farm, the first wind farm built in the open waters of the North Sea, and biggest cluster of offshore wind turbines, was erected on the Danish west coast close to Esbjerg harbour in 2002. Horns Rev was a demonstration project. Two utility companies were required by state decree to jointly build the wind farm, Elsam - Denmark's largest heat and power producer - as a production company, was requested to build the offshore wind farm and the internal offshore network, while Eltra - a Danish a transmission company - was requested to build the offshore platform and the transmission grid.

A Case Study on the project noted that one of the greatest challenges experienced in the first project was harbour logistics. The harbour space ordered by the turbine manufacturer was far too small for the assembly volume. The harbour area was used for assembly and preparation for shipment of towers, nacelles and rotor blades – as well as a harbour quay for loading the components onto the transport ships at the same time. It was originally planned to prepare four turbines at the same time and ship them together. Due to the bottleneck in the harbour logistics, however, only two turbines were shipped at a time. From the view of A2SEA, the offshore transport and installation services provider, the most important lesson was in the underestimation of the onshore harbour logistics. An area of 5,000 m² was planned for turbine installation. After installation commenced, it became apparent that a drastic enlargement was required: at least additional 10,000 m², and preferably 20,000 m².

One of the major lessons cited recognition that harbour logistics should be planned and be fully contracted in all details far in advance of the installation. Another lesson was that for a harbour like Esbjerg, the work and assignments connected to an offshore wind farm project was at that time seen as unique business, and as long as only a limited number of turbine installations is expected for a harbour, the wind farm installation is a secondary-priority business compared to long-term activities such as container shipping and other continuous naval business.[16]

In 2004 Esbjerg served as the base city when the 80 nacelles were demounted and brought onshore for maintenance, and has continued to service this industry. According to one industry report, today the harbour of Esbjerg is the only Danish North Sea port which meets the European Wind Association (EWEA) infrastructure requirements for harbours which aim to play a decisive role in the installation of offshore renewable energy, and has development plan covering the period up to 2015 for further improvements to solidify its position.[17]

Plans / Expansion of Port

Between 2011 and 2013 the Port of Esbjerg is investing 500 million DKK (95,915,000 CAD) in new facilities comprising 650,000 m^2 land area and 1km of quays in response to increasing demand for facilities for both shipping and energy purposes – the latter in response to the North Sea offshore wind market which is expected to boom in the coming years, and England, Germany and the Netherlands have also launched ambitious offshore wind development programs. Existing facilities will be expanded through construction of a new port section - "East Port". The expansion will be based on the multi-purpose concept allowing hinterland and quays to be as flexible as possible and enabling the port to respond to changes in the demand for capacity, access roads and infrastructure in general.

[16] Case Study: European Offshore Wind Farms. A Survey for the Analysis of the Experiences and Lessons Learnt by Developers of Offshore Wind Farms.
[17] Summary: From Assembly to Action. Recommendations for Development of a Green Offshore Energy in Denmark. http://dl.dropbox.com/u/17198035/Website/Investeringsstrategi/Investeringsstrategi%20-%20Summary%20UK.pdf

The multi-purpose concept is considered to have been essential to the positive development of the port's business, and the port will apply the concept in the future. Competitive tendering within the EU will take place in spring 2011. The vision is to become a leading port from Scandinavia to the rest of Europe. Esbjerg plans to increase the number of short sea routes to other European ports in order to shift cargo from road to sea and reduce pollution. Port investment is also supported by extension of the Danish highway E20 into the port area to be completed by the end of 2012.Building on its increasingly expanding role in handling other commodities and goods, the port is positioning itself to be a major facilitator to the windmill industry, with the export of windmill blades and turbines.

Planned activities to address some of the current challenges the port faces include:

- building of a 360m multipurpose quay
- dredging of a 200m wide and 10.5 m deep channel
- a new multimodal terminal
- extension of the existing Ro-Ro terminal - a Ro-Ro floating ramp will give the port direct highway access and a new Ro-Ro jetty to relieve current congestion.
- railway by-pass
- traffic monitoring and streamlining administration

Port officials are prioritizing intermodal transport within its business plans and strategies. The port has employed a person with expertise in intermodal transport and who works closely with firms at the port and other organisations doing business at the port. Making more space available for new and expanding businesses are catering to the booming offshore industry, which is playing an increasing role in Esbjerg's plans. The port's master plan from 2004 sees the port area increase by about 25% in the coming years. The port has three special cranes for handling windmill blades and a new wharf will be used exclusively by the wind energy sector. Over 50% of the windmills produced in Denmark are shipped out via the port. Officials hope that the fast developing wind energy sector holds much promise for the port and region of Esbjerg. The port is also home to a central command post for Vattenfall's over 600 windmills out at sea. This new centre opened up in late 2009 and monitors all windmill activities, including at Horns Rev 1 & 2, the world's largest offshore windmill parks.[18]

The Port of Esbjerg will also work to expand rail services to the port and it has already been given funding clearance by the Danish government with commitment of approximately €13 million (100 million Danish kroner) based on a self-financing of about €30 million. Rail services will allow the port to expand its hinterland connections, such as linking up with Denmark's only rail terminal, Taulov Transport Center, located 60 km east of the port.

Investment / Financing

Since 2002 the Port of Esbjerg has received funding under the Northern Maritime Corridor (NMC) Project. NMC is an Interreg IIIB financed project, Interreg being a large community initiative to stimulate interregional cooperation in the European Union, started in 1989, financed under the European Regional Development Fund (ERDF). ERDF was established by an Act of European Parliament with the objective of addressing the gap between developed and lagging regions, and contributes towards the financing of: investment for creating sustainable jobs; investment in infrastructure; measures to support regional and local development, including support and services for businesses, in particular small and medium-sized enterprises (SMEs); and technical assistance. [19]

[18] Ibid. Development of the Hub Concept.
[19] http://ec.europa.eu/regional_policy/funds/feder/index_en.htm

The ERDF funded NMC project is part of a much larger concept of "Motorways of the Sea" (MoS) developed by the EU with the main objective of shifting cargo from road to sea as part of an intermodal transport chain to provide "efficient, safe and sustainable transportation, connecting coastal areas and enhancing regional development in the North Sea region and the northern periphery area". MoS is intended to respond to the challenges that Europe faces in coping with the steadily increasing traffic. Freight transport on roads is increasing more than any other mode of transport, which for long haulage transport is not environmentally friendly or sustainable. To support the MoS concept funds are made available to develop services and infrastructure. The MoS objective is to improve the sea services to peripheral areas in Europe, with Norway and Scotland considered the peripheral. The current programme, Interreg IV, covers the period 2007–2013. *"The core approach has been to cooperate with the private sector, to assist and to give a "push" to the private sector actors to implement new services".*

The scope of work has included funding for studies to provide an overview of port facilities and hinterland connections in the partner regions. These include pilot cargo surveys, port scenarios and framework conditions which have been studied to guide partners in further SSS initiatives, market communication and new services, technological development and ICT Tools to improve intermodal transport, and introduction of new services, including various specialized intermodal services. Other initiatives have focused on ICT to simplify communication and security in the intermodal transport chain, including Radio Frequency Identification (RFID), networking between Russian and European private and public entities related to petroleum development in the Barents Sea and transport in that connection.

A working group comprising shipping companies, forwarders, ports and public authorities has been established for the purpose of cooperating and coordinating their services to be more regular and frequent, and other pilots are underway to test aspects of the intermodal transport chain from the Continent to external regions, including Russia and Amsterdam. [20] MoS is exploring the concept of clusters in economic development strategies with the aim of improving hub and hinterland connections, communication, coordination, services, efficiency and management in relation to ports. The StratMoS project is a part of the North Sea Interreg IVB programme (January 2008 to March 2011) with partners from Norway, Belgium, Denmark, Germany, UK and The Netherlands, and in cooperation with partners from North-west Russia. The aim is to strengthen the role of ports and hinterland facilities in transport chains, including the primary and secondary hubs and the logistics facilities, ports, dry ports, transport infrastructure, premised on the concept that clustering can benefit transport and logistics supply chains and improve economic development in the overall North Sea Region.[21]

Private Sector

DONG Energy, one of the leading energy groups in Northern Europe, headquartered in Denmark, has been a source of private financing. Research and development has taken place between DONG Energy and Danish and foreign universities. A new RADAR and communication technologies have been developed as a result of offshore wind development in Esbjerg. DONG Energy claims that one in ten inhabitants of Esbjerg are now directly or indirectly involved in the offshore wind industry. DONG Energy expresses that partial credit for

[20] Northern Maritime Corridor II. Project Summary Report 2005-2008. Activities, Results and Impacts.
[21] Development of the Hub concept. A Study of Clusters and MoS ports. StratMoS WP C. The North Sea Programme. May 2010.

the success of projects like the Horns Rev 2 offshore wind farm must be given to the many local partners, suppliers and skilled workers from Esbjerg.[22]

Community

A critical part of financing of wind energy in Denmark has come from the general public. Wind energy production in Denmark started as a grass roots movement and is now considered a concern of the general public in Denmark. This has been made possible though a few innovative regulations. The general public of Denmark is allowed to purchase shares in wind farms near their homes. As well, subsidies exist to help local owners of turbines to fund preliminary appraisals for future projects. The regulations guarantee the local communities a say in the planning process, which in turn increases the social acceptability of wind farms. An example of this was the involvement of the Esbjerg fishing fleet, which was able to select a location for the wind farm that did not interfere with fishing and were able to negotiate compensation of 1.3 million dollars.

National Government Involvement

One cited factor in the success of the offshore wind industry in Denmark is that project management has been streamlined. The Danish Energy Agency has created a single body representing the various ministries involved and the national grid connector. The body is in charge of selecting wind farm locations, coordinating research and issuing calls for tenders. Furthermore, the national transmission system operator (Energinet) is obligated to connect any project approved by this body.

Comparison to Nova Scotia

Nova Scotia and Denmark share a comparable maritime history, are located on major international shipping routes, share a history of oil and gas exploration, development and exporting, and a similar mix of energy resources, which in addition to petroleum, also include electricity generated from coal, and more recently renewable energy. Denmark has successfully leveraged its oil and gas expertise to become a world leader in wind energy. Its infrastructure has evolved from fishing ports into a complex inter-modal transportation hub that supports oil and gas development and exporting, as well as renewable wind energy production and exporting.

Lessons Learned

Lessons learned and infrastructure-related considerations relevant for Nova Scotia's growth strategy:

- Oil and gas expertise, infrastructure and supporting services can be used to successfully transition into other industry with similar requirements
- Non-renewable and renewable energy create synergy that can be leveraged to mutual advantage – in terms of critical mass, similar requirements, infrastructure and support services

[22] DONG Energy. Retrieved June 3 2011 .http://www.dongenergy.com/en/business%20activities/renewables/pages/investment_in_wind_power.aspx

- Considerable infrastructure investment is required to develop a world-class, export oriented industry
- The financial support of national governments plays a large role due to the size of required investment
- Working cooperatively with other jurisdictions, and industry stakeholders who have a vested interest can accelerate development to mutual benefit
- Community involvement and buy-in is achievable through thoughtful, strategic planning and incentives
- The nature of the renewable industry, and the types of skills required over the life-cycle, are well suited to rural areas and maritime environments making it attractive as an economic development and job creation strategy in these areas
- The logistical complexity of specific infrastructure projects should not be underestimated, requiring application of industry knowledge, experience and best practices.

Note: In addition to those cited above other information sources used for the Case Study are included in the References section of the report.

8.2 Case Study: Lyness, Orkney Islands, Scotland

Port of Lyness before development.
Source: Orkney Island Council Marine Services (2011a) Marine Renewable Energy Strategy

Background

Pentland Firth is a marine body of water with the capacity to produce enormous amounts of electricity. In close proximity to Pentland Firth are the Orkney Islands to the north, and the county of Caithness on the mainland to the south. Both areas have ports that are quickly undergoing development to support the marine renewable energy industry. The current plan is that by 2020 there will a 'farm' of marine renewable devices embedded in and around the waters of the Pentland Firth between Caithness and Orkney sufficient to generate 1GW of electricity, enough to power 420,000 homes. The intention is to provide a marine renewable development base and to meet the industry needs and to form a 'centre of excellence' for the Marine Renewable Energy Industry in Scotland.[23]

[23] Orkney Island Council Marine Services (2011a) Marine renewable Energy Strategy, Website: http://www.orkneyharbours.com/marine_renewable_energy.asp

The marine renewable energy industry currently employs 200 people in Orkney, and this figure is expected to increase dramatically as more leasing rounds for marine renewable sites are completed.

The marine renewable energy industry in the Pentland Firth region is taking a cluster approach to port infrastructure premised on the view that the cluster approach can be a lower cost option than some single site options in other competing regions. The cluster approach is seen as an attractive alternative to investing in one single site at significant cost. Although the supply chain is not physically on one site, sea connections mean that moving elements between sites and assembly installation locations is practical.

The Port of Lyness is being developed as a critical port in a port cluster approach in the Orkney Islands. Orkney Island ports that will play a role in conjunction with Lyness are the ports of Kirkwall Harbour, Hatston Pier (Kirkwall), Stromness Harbour and St Margaret's Hope. Ports in Caithness that are important to mention are Scrabster Harbour, Wick Harbour and Gills Bay. This approach is in keeping with the National Renewables Infrastructure Plan Stage 2[24]. The purpose of the National Renewables Infrastructure Plan is to support the development of a globally competitive offshore renewables industry from design through manufacturing, to pioneering new approaches to installation and operations and maintenance. Scotland's key strengths are considered to be: companies with expertise and skills in subsea engineering and installation from experience of working in the North sea and globally; innovative research and development; a skills development infrastructure that can quickly grow the skilled workforce needed to serve this industry; and existing port and harbour infrastructure that could be used and a port industry keen to engage with the renewables sector.

The Scottish Government's Renewables Action Plan (2009) instigated development of an investment plan to support infrastructure for the emerging offshore wind, wave and tidal energy industries, with government taking an active leadership role in building a Scotland-wide proposal to capitalize on perceived opportunities in offshore renewables for a range of organisations including project developers, utilities, supply chain firms and port and harbour asset owners.

Location

The Port of Lyness is located in close proximity to the town of Lyness, population 272, and is located on the eastern side of the Orkney Island of Hoy (Latitude 58° 50.0' N and Longitude 003° 11.0' W). The port of Lyness is strategically located for accessing The Crown Estate lease sites in Orkney Waters and the Pentland Firth as well as the test sites at EMEC.

[24] National Renewables Infrastructure Plan Stage 2 Report. Report from Scottish Enterprise and Highlands and Islands Enterprise. July 2010

The Port of Lyness is owned by Orkney Islands Council Marine Services. The Port was originally built as a naval base during World War 1 and closed in 1957. The Port has 130 square kilometres of deep water, and sheltered anchorage. Before port development for marine renewable energy began, the port consisted of 313m of quay length and some small buildings.

Port Characteristics

Description / Land Available	Infrastructure /Capabilities
▪ Land designated for marine renewable support= 141,640 m² ▪ Hard standing on quayside=4000m^2 ▪ Additional space available= 35,000m^2 ▪ Sheltered harbour= 130 sq km	▪ Cranes= Large crane truck ▪ Depth at quay= 5-9m ▪ A total of 313m quay length
Source: http://www.sdi.co.uk/~/media/SDI/Files/documents/energy/Brochures/Northern%20Marine%20Energy%20Cluster%20-%20Development%20Sites.ashx	

Role in Marine Renewable Energy

Due to its ideal location, the Port of Lyness is being developed as a designated marine renewable area and being refurbished as a centre for the assembly, storage and servicing of marine renewable energy devices. Research and development as well as deployment of these devices will also take place at Lyness.

Port of Lyness concept drawing
Source: Energy of Orkney

Lyness has now refurbished the port as a centre for the assembly, storage, servicing, deployment, research and development of marine renewable energy devices. An increase in activity over the summer and fall of 2011 is expected as developers use the facilities to install marine renewable energy devices. The developers planning to install devices at Lyness are Aquamarine Power, Pelamis Wave Power and Wello Oy.

The Furgo Seacore jack-up barge Excalibur alongside the Lyness Wharf.

Planned Expansion / Refurbishment

The refurbishment at the port of Lyness will be complete in two phases. The £3 million ($4,765,300 CND) phase one of the refurbishment was completed in May 2011. The second phase of refurbishment will provide steel-framed buildings, secure compounds office and communication facilities as the site and the industry develop. Pelamis Wave Power have already set up a base (900m^2).

Private Sector

Private sector bodies are expected to have a key role to play in developing detailed investment proposals for site developments. Scotland's public sector economic development bodies are proactively working with the private sector to accelerate progress. It is expected that finance for port infrastructure development would be raised principally by private companies either on a corporate or project basis. An example of this is the base (900m^2) at the port of Lyness set up by Pelamis Wave Power.

Public financing

Public sector financing is also expected to play an important role. The Government of Scotland has been directly financing some of the developers making use of the port of Lyness. A £3.15 million ($4,998,150 CND) grant was awarded to Aquamarine Power to support demonstration of Aquamarine's Oyster 3 project at the European Marine Energy Centre in Orkney. Furthermore the Orkney Island Council approved £3 million ($4,765,300 CND) funding for the refurbishment of the port of Lyness (National Renewables Infrastructure Plan Stage 2 Report.)

Some other public financing approaches have been outlined by the Scottish Enterprise and Highlands and Islands Enterprise. These include:

- Joint Venture – this could either be for a specific site or building, or a more broadly structured joint approach where there is a sharing of risk and return agreed.
- Public Financed Loan – provision of finance as a repayable loan on agreed commercial terms.

- Equity Investment – the public sector may become an equity investor on a commercial basis in an asset owner enabling investment to take place.

- Direct Investment – in some instances there might be value in a direct public sector investment that would require ownership of the asset in question. The public sector would then manage the asset in a manner that complies with state aid requirements.

- Regional Selective Assistance – available in certain locations and may support the investment required.

The Saltire Prize is £10 million to be awarded by the Government of Scotland to the team that can demonstrate in Scottish waters, a commercially viable wave or tidal stream energy technology that achieves the greatest volume of electrical output over the set minimum hurdle of 100GWh over a continuous two year period using only the power of the sea.

Plans / Expansion Port

Orkney plans to reach 1 GW capacity by 2020. The infrastructure requirements for the region have been assessed as described in the Table below.

Orkney Requirements to reach 1 GW capacity by 2020.		
Item	**Quantity**	**Time**
Operations control centre	1	1100-1200
Prototype/demon. Devices	50	Now-2014
Expanded/new ports	3-4	Now-2014
Assembly/maintenance yards	2-3	Now-2014
Work boats	20-30	Now-2015
Large purpose built vessels	10	Now-2015
Local workforce	500-1000	Now -2015
New houses	300-600	Now-2015
Expanded and new offices	50	2012-2015
Emergency tugs	1-2	2014
Sub stations (off/onshore)	10-20	2014/15
New 132kv connections	50-150 km	2014/15
Connecting cables	1000	2014-2019
Commercial energy devices	1100-1200	2015-2020
Converter stations	2-3	2016/17
HVDC grid connection	2	2016/17
Co-gen/ storage 1-2 schemes	2	016/17
Source: Energy of Orkney		

The Development timescale currently employed in Scotland to reach the goal of 1GW capacity by 2020 is as follows:

- Strategic planning 1 yrs (2011)
- Site planning & permitting 2 yrs(2011-12)
- Infrastructure design and construction 3 years (2012-14)
- Installation over 5 years (2015-20)

- Total programme 9 years
- Success will require more than £5billion investment

Source: Energy of Orkney[25]

Comparison to Nova Scotia

Similarities to Nova Scotia include being located in a region with much room for economic development. Furthermore before development for marine renewable energy the port was small with little infrastructure in place. This is similar to a port such as Digby, N.S. which currently lacks infrastructure to support marine renewable energy.

Note: In addition to those cited above other information sources used for the Case Study are included in the References section of the report.

[25] **Energy of Orkney (2011)** Two decades to change the world; A host community's perspective, Available: http://www.all-energy.com/userfiles/file/gareth-davies-190511.pdf Last Accessed 15 June 2011

9.0 CONCLUSIONS

Infrastructure requirements vary according to the type and size of technology being used, and stage of the lifecycle (manufacture, assembly, deployment, O&M, monitoring). Varying roles can be played by several ports in support of the MRE industry. Technology is still evolving and requirements could change; these conclusions reflect the information currently available.

1. For large in-stream tidal, the primary drivers in the consideration of marine structure development include the following. During deployment large in-stream gravity base structures require more robust wharf structures with deeper water than the lighter pin/pile structures. However, key industry representatives indicate that wharf facilities preferably should be capable of deploying both large gravity base and the lighter pin/pile base. They also indicate that facilities should preferably be located at a “wet port” (a “wet port” is a port which has water at low tide).

   Most developers have indicated a “wet port” is considered essential for deployment as well as operation and maintenance. A “wet port” is a critical factor for the ‘long-term’ deployment phase because it is anticipated that deployment will require vessels with drafts in the order of 6 m to 7 m for the gravity base structures and may need relatively deep drafts to accommodate pile driving/drilling templates for the pin/pile structures. The “wet port” will also prove beneficial during the O&M phase. Some developers, however, have stated that it is not necessary to have a “wet port” for most operations. These developers will have to devise schemes to operate from a “dry port” (i.e. Hantsport, Parrsboro). Many developers have also expressed the need for load outs; however the magnitude of load-out capacity varies dramatically between gravity type base and pin/pile base.

   For large in-stream tidal, consideration should be given to developing a “greenfield” common user wharf facility in the Digby area consisting of a wharf structure capable of withstanding heavy lifts/load-outs, with 8 metres minimum water depth below low tide level, and ample back-up land required to support the broad range of requirements for in-stream tidal power generation beyond the initial 64 MW threshold. The facility should have the ability to be expanded in the future.

   Should the above “greenfield” common user wharf facility be developed, a first step should be to conduct an initial site selection study to identify potential sites in Digby Harbour that are viable locations for a new common user wharf facility and which would be practically and financially viable for development in support of the in-stream tidal power generation industry as a whole. This new common user wharf facility should be capable of accommodating all phases of development and operations and maintenance. The site selection study should focus on “greenfield” but could also examine “brownfield” sites. The preferred site should be capable of providing the key development requirements with an emphasis on wharf length, water depth, accessibility and proximity to a reliable and developed service supply chain and capable of being expanded.

2. For small in-stream tidal, offshore wind and wave energy, based upon the information available, it is considered that existing infrastructure in a variety of ports will be adequate.

3. The tidal energy industry is at an early stage of development, and technology is still evolving in response to early experience in deploying and operating the devices in challenging marine environments. Infrastructure requirements may change as the technology and the industry mature. Therefore, industry requirements should be reassessed in four or five years in order to develop appropriate plans for infrastructure improvements and expansion. While the focus of this study has been on in-stream tidal power generation in the Minas Passage, other sites in the Bay of Fundy could likely be of interest as the industry matures. When the offshore wind and/or wave energy industries develop in Nova Scotia the infrastructure requirements for those industries should be assessed in more detail.

4. For planned developments to move forward in a coordinated manner it will be necessary to orchestrate a number of infrastructure requirements in parallel and respond to the uncertainties inherent in the evolution of an early-stage industry. A blueprint similar to that prepared by Orkney would be useful to articulate and clarify the various parallel activities needed to advance development. For example, the Orkney blueprint covers numerous parameters, some directly related to infrastructure, while others address issues that have an impact on the pace of development: targets, regulation, policy, capacity, technologies, projects, facilities, grid, harbours, vessels, research, surveys, education, employment, consents, coordination and incidents.

5. Nova Scotia's engagement with the 'Marine Renewable Energy Technology Road Map' may highlight opportunities for linkages between infrastructure requirements needed by the Province for Marine Renewable Energy development and needs for other strategic infrastructure for national security, maritime security and energy security.

6. Nova Scotia's approach to Marine Renewable Energy infrastructure development to date is very similar to that of other jurisdictions that are in similar stages of development and can continue to benefit from the experiences and lessons learned, particularly in terms of technology advancements and related infrastructure requirements.

7. Supply chain development could be fostered in strategic and tactical ways such as:

   - Supplier development information sessions/networking events to make suppliers aware of potential opportunities within marine renewable energy development and also enable them to showcase their relevant expertise and capabilities.

   - Building on previous events and established networks to further inform supply chain considerations and how best to address identified gaps. (For example, Fundy Energy Research Network, Ocean Renewable Energy Group conferences, Commercialization Workshop, NS Tidal Energy Symposium – Getting Power to Market, OEER/ FORCE Research and Development Workshop and university events such as Dalhousie's Oceans Week).

   - Aligning infrastructure requirements and supply chain requirements to develop the marine renewable energy sector in Nova Scotia with relevant economic development and sector development initiatives to strategic advantage, using the Equimar example, to ensure that relevant linkages are clearly understood and articulated. Related initiatives include: the NS Renewable Electricity Plan; jobsHere – the plan to grow our economy; marine renewable energy legislation; Feed-In Tariffs; OEER/

OETR projects and priorities; plans for ocean sector development and consideration of regional energy partnerships).

- Collaboration with adjacent jurisdictions to identify shared interests and opportunities.

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Appendix A—Interview Guide

Requirements Analysis - Interview Guide

Marine Renewable Energy Type

□ Tidal Turbines □ Offshore Wind Equipment □Wave Energy Equipment

2. Information categories covered in this questionnaire

a) Manufacturing/ fabrication
b) Assembly & deployment
c) Operations
d) Maintenance
e) Salvage/Removal
f) Emergency Response

A. Preliminary assessment:

1. What is the stage of development of your renewable energy device/ equipment (proof of concept/ small scale test installation/ full size installation/ commercial generation)?
2. What deployments/ installations do you currently have? Location(s)?
3. What plans do you have for activity/ deployment in Nova Scotia?
4. Have you researched Nova Scotian capabilities and infrastructure to fit your requirements for development/ deployment in NS?
5. What lessons have you learned from previous deployments that should be applied in Nova Scotia development/ deployment?

B. General description and characteristics of equipment

6. Characteristics of equipment: physical, materials, components
   E.g. turbine technology, construction and base structure
7. State of technology
   E.g.; innovative, mature, leading
8. Size and generating capacity
   i) e.g. tidal devices - mid-size (up to 0.5 MW); or large (greater than 0.5 MW)
   i) Weight & physical size of device and base structure

C. **Manufacturing/ Fabrication**

9. Where are you currently manufacturing?
10. What are the manufacturing /fabrication processes for your system?
11. What are the main considerations impacting the location of this work (NS vs. other location)? e.g.; transportation, skills, technology, cost of services, financial incentive
12. Do you anticipate major fabrication or assembly in NS?
    i) Do you anticipate a need to "load out" heavy machinery? Over a wharf to a barge?
13. If you plan to manufacture in NS, what manufacturing/fabrication capabilities would you be expecting from local companies?
14. What special requirements do you have in manufacturing/fabrication?
    i) Do you require a staging area/back-up area adjacent to a wharf face? If so, approximately how large?
    ii) Do you require special equipment such as small mobile cranes (35-50 T); large cranes (say up to 200 – 300 T); heavy lift transporters?
    iii) Do you require a wharf deck specifically suited to accommodate heavy load-outs?
    iv) Do you require a marine barge for load-out and equipment deployment? If so, what size? What minimum draft would be required at the wharf face?
    v) Does tidal variation have an impact on your deployment procedures? What impact would a 5-6 ft tidal variation have? What impact would a 28-30 ft tidal variation have?
    vi) Do you require any special equipment such as "offshore" heavy lift barges?

15. What transportation requirements will you have for your operations in NS? E.g. air, road, sea, proximity to installation site
    - i) What is the requirement for proximity of the installation site to major modes of transportation?
    - ii) Would equipment/components normally be shipped (say from Europe) and then transfer to truck or rail mode upon arrival in N.S.?
    - iii) Do you anticipate large fabricated components being shipped by container? Or break bulk?

D. On-Site Assembly and Deployment Requirements

16. Transportation to assembly site and to deployment sites
17. Onsite assembly
    - i) How much back-up land (or staging area) do you require for manufacture/fabrication/assembly?
    - ii) Is it a requirement that the back-up land (or staging area) be immediately adjacent a suitable wharf/marine load-out face?

18. Electrical grid connection
19. Deployment vessels required – size, capabilities
20. Other specific services, marine technology and supporting equipment that could be provided by local suppliers
21. Port characteristics required for development, assembly, deployment/installation
    - i) What minimum length of wharf face for berthing of vessels or barge?
    - ii) What minimum water depth below low tide?
    - iii) What requirements for port side crane? Size ranges required?
    - iv) What minimum wharf deck permissible loading? Standard highway truck? Heavy lift crane? Special heavy lift transporter?
    - v) Any special services requirements such as high voltage power? Potable water?

22. HR & skills requirements for development and deployment

E. Operations requirements

23. Management, Monitoring, Security, Technology, Equipment
24. Other specific services, technology and supporting equipment that could be provided by local suppliers
25. Port characteristics required for operations
26. HR and skills requirements for operations

F. Maintenance

27. Ocean and port-side maintenance: repair, replacement of components or devices; surface and subsurface vessels and capabilities
28. Other specific services, marine technology, equipment that could be provided by local suppliers
29. Port characteristics required for maintenance
30. HR and skills requirements for maintenance

G. Decommissioning

31. Surface, subsurface, disposal and other requirements – equipment, labour, skills, facilities
32. Other specific services, technology, equipment that could be provided by local suppliers
33. HR and skills requirements

H. Public Safety and Emergency Response

34. Storm damage, navigational hazards, environmental protection - requirements for equipment, expertise, training

I. Key issues, sum up

35. What are the most crucial factors you need to consider for infrastructure – e.g. time, risk, distance from deployment site by sea/ land, year-round accessibility (ice, storms)

36. What lessons have you learned from deployment elsewhere that should be considered in Nova Scotia as MRE develops here?

J. **General Considerations**

37. Procurement Practices: estimated percentage of contracted goods and services
38. Issues and risks associated with each phase of the project
39. Identify importance of locality for each required product or service
40. Identify importance of time-sensitivity for each required product or service

Appendix B—List of Contacts

The following marine renewable energy organizations were interviewed.

Alstom

Atlantis Resources Corporation

DSTN (DSME Trenton)

European Marine Energy Centre (EMEC)

Fundy Ocean Research Centre for Energy (FORCE)

Fundy Tidal Inc.

Irving Shipbuilding

Lockheed Martin Canada

Maine Wind and Ocean Energy Initiative

Minas Basin Pulp & Power

Mojo Maritime

Nova Scotia Power Inc.

Ocean Renewable Energy Group (OREG)

Ocean Renewable Power Corporation

Senergy

Verdant Power Inc.

Appendix C—Ports Questionnaire

IMPORTANT
PLEASE COMPLETE AND RETURN BY MAY 16, 2011 TO:
e-mail: admin@ohcc.ns.ca
fax: 1-902-429-5457

Marine Renewable Energy Infrastructure Questionnaire

1. Facility Name: ______________________________

2. Location: ______________________________

3. Questionnaire Completed by: ______________________________
   name

   ______________ ______________
   telephone email

4. Description of facility:
   a. Wharf type: ______________________________
      (Finger, Marginal, Ell, T, other)
   b. Plan of facility attached: yes ☐ no ☐
   c. Wharf size: length: __________(ft) width: __________(ft)
   d. Available water depth: ______________(ft below LNT)
   e. Tidal variation: ______________(ft)
   f. Typical maximum vessel which can be reasonably accommodated:
      Length overall: ______________(ft) Draft: ______________(ft)
   g. Road access: Excellent? Good? Poor? ______________________
   h. Any constraints for oversize transportable loads from road or rail? __________
   i. Is there an existing crane in the port/on the wharf? If so, what capacity? ______________________ If not where is the nearest mobile crane? ______________________ What capacity? ______________________
   j. Is the wharf facility suitable for load-out or launching of equipment. Please explain.
      ____

5. Harbour features
   a. Is the harbour and marine facility well sheltered against wind/waves
      yes ☐ no ☐
   b. Is the port operational all year long?
      ____
   c. Describe constraints due to; ice, wind, wave, current, water depth, sediment deposition, etc.
      ____
      ____

d. Any history of maintenance dredging:

____

____

e. Is there an opportunity to expand existing wharf and back-up area:

____

____

f. Any known environmental contamination? Spills?

____

____

6. Type of wharf construction (please describe, drawings and photos would be helpful)
   a. Type of deck (e.g. timber, concrete, etc): ______________________
   b. Support structure (e.g. timber, concrete, etc): ______________________
   c. Permissible deck load: ______________________(psf)
   d. Permissible vehicle gross weight: ______________________ (lb)
   e. Max. permissible axle load: ______________________ (lb)
   f. Is structure capable of supporting heavy equipment or large cranes?
      yes ☐ no ☐

7. Wharf Condition:
   a. Describe condition of wharf structure:

   ____

   ____

   b. Are there any major repairs or deferred maintenance required?

   ____

   ____

   ____

   c. Are there any planned port upgrades or upgrades to your facility within the next 5 years?

   ____

   ____

   ____

   d. Is there land available nearby that might be acquired for expansion if needed?

   ____

   ____

   ____

8. Back-up Land
   a. How much land does the "Authority" have abutting the wharf structure:

   ____

   b. How much lay-down area is available for general fabrication/assembly:

   ____

c. Is there an opportunity to expand the lay-down area if that was desired:

____

____

d. What is the general topography of the back-up lands (e.g. Flat, gentle slope, steep)

____

9. Please describe the proximity of your wharf facility to the following:
   a. Major 100 series highways: ______________ (km)
   b. Rail lines: ______________ (km)
   c. Airport / heliports ______________ (km)
   d. Marine supply / support services: ______________ (km)
   e. Industrial parks: ______________ (km)
   f. Warehousing: ______________ (km)
   g. Metal fabrication: ______________ (km)
   h. CNC Machining: ______________ (km)
   i. Specialty suppliers such as:
      1. Marine supply/installation vessels: ______________ (km)
      2. Heavy industrial fabrication ______________ (km)
      3. Heavy equipment rental (e.g. cranes, etc.) ______________ (km)
   j. 3-Phase industrial/manufacturing power ______________ (km)
   k. Educational/training facilities ______________ (km)
   l. Please describe educational facility: ______________

10. Please describe the capacity of your wharf facility to accommodate:
   a. Oversize or heavy transportable loads:

   ____

   ____

11. Wharf Activities/facility usage/availability
   a. Please describe usage by vessels at the wharf e.g. What is the general usage?

   ____

   b. Are there any competing interests or are there times of the year when there is no spare berth space or spare back-up space? Please explain.

   ____

   ____

12. Other comments:

a. Are there any aspects of your harbour, wharf facility or back-up land that you believe would lend itself to development as a major base for renewable offshore energy development?

____

____

b. Please describe availability of skilled labour/trades people (e.g. stevedores, crane operators, welders, fitters, machinists, high voltage electricians, etc.)

____

____

c. Comments on Port/Wharf readiness. Is the wharf available for use or up-gradable?

____

____

d. Can existing users be displaced?

____

____

Appendix D— Leading Turbine Developers – Current and Planned Installations

Bold Italics = Commercial Plans

Leading Tidal Developer	**Current installed capacity**	**Date installed**	**Planned installed capacity**	**Location**	**Planned install dates**
MCT	1.2 MW	2008		Ireland	
			1.5 MW	Canada	2012 demo
			8 MW	***Scotland***	***2014***
With RWE			***10.5 MW***	***Wales***	***2012-13***
With EDF Group			***95 MW***	***Scotland***	***2017-20***
With ESP Int'l			***100MW***	***N. Ireland***	
OpenHydro	250 kW	2006		Scotland	
	1 MW *	2009		Canada	
			285 MW	***Channel Is.***	***2010 Start***
			4-10 MW	***France***	***2011***
With SSE Renewables			***200 MW***	***Scotland***	***By 2020***
Hammerfest Strom	300 kW	2003		Norway	
			1 MW	Scotland	2011 demo
			10 MW	***Scotland***	***2013***
With Scottish Power Renewables			***95 MW***	***Scotland***	***By 2020***
Verdant Power	35 kW x 6	2006-8		USA	
			1 MW	***USA***	***2010-2012***
			2-4 MW	***USA***	***TBD***
			5-15 M	***Canada***	***2010-2012***
Atlantis Resources	150 kW	2008		Australia	
	1MW	2010		Scotland	
With Irving Shipbuilding & Lockheed Martin			1 MW	Canada	2012
With MayGen			***400MW***	***Scotland***	***By 2020***
Voith Hydro	110kW	2010		Korea	
			1MW	Scotland	2011 Demo
SSE Renewables			***200 MW***	***Scotland***	***By 2020***
Korea East West Power Co.			***90MW***	***S. Korea***	***2013***

* Now removed

Appendix E—List of Harbour Authorities

Fisheries and Oceans Canada Pêches et Océans Canada Canada

Harbour Authorities – Nova Scotia

A

Abbots Harbour (Harbour Authority of), NS	
MIDDLE WEST PUBNICO BOX 145 NS B0W 2M0	**Managed Harbour(s):** • Abbotts Harbour

Advocate (Harbour Authority of), NS	
ADVOCATE HARBOUR P. O. BOX 46 NS B0M 1A0	**Managed Harbour(s):** • Advocate

Alder Point (Harbour Authority of), NS	
ALDER POINT 908 ALDER POINT ROAD NS B1Y 1B2 **Phone:** (902) 736-9128	**Managed Harbour(s):** • Alder Point

Arisaig (Harbour Authority of), NS	
ANTIGONISH COUNTY P.O. Box 10 137 Arisaig Point Road NS B2G 2L1	**Managed Harbour(s):** • Arisaig

Aulds Cove (Harbour Authority of), NS	
R.R. # 2 HAVRE BOUCHER P.O. Box 103 NS B0H 1P0 **Email:** cdeagle@ns.sympatico.ca	**Managed Harbour(s):** • Aulds Cove

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B

Bailey's Brook (Harbour Authority of), NS	
PICTOU COUNTY P.O Box 81 MERIGOMISH NS B0K 1G0	**Managed Harbour(s):** • Baileys Brook (Lismore)

Ballantyne's Cove (Harbour Authority of), NS	
ANTIGONISH P. O. BOX 1063 NS B2G 2S3 **Phone:** (902)863-8162 OFFICE	**Managed Harbour(s):** • Ballantynes Cove (McNair's Cove)

Barrios Beach (Harbour Authority of), NS	
ANTIGONISH COUNTY P.O. Box 130 Monastery NS B0H 1W0	**Managed Harbour(s):** • Barrios Beach (Tracadie)

Battery Point (Victoria Beach) (Harbour Authority of), NS	
GRANVILLE FERRY R. R. #2 NS B0S 1K0 **Phone:** (902) 532-5297	**Managed Harbour(s):** • Battery Point (Victoria Beach)

Bay St. Lawrence (Harbour Authority of), NS	
VICTORIA COUNTY P.O. BOX 71 ST. MARGARET'S VILLAGE NS B0C 1R0 **Phone:** (902) 383-2000	**Managed Harbour(s):** • Bay St. Lawrence

Bayfield (Harbour Authority of), NS	
ANTIGONISH COUNTY P.O. BOX 34 HEATHERTON NS B0H 1R0 **Email:** bayfieldha@hotmail.com **Web:** www.bayfieldns.com	**Managed Harbour(s):** • Bayfield (Pomquet Point)

Bayport (Harbour Authority of), NS	
LUNENBURG COUNTY R. R. #1, ROSE BAY NS B0J 2X0 **Phone:** (902) 634-3570	**Managed Harbour(s):** • Bayport

Bayshore Harbour Authority (Parker's Cove), NS	
PARKER'S COVE RR#3 GRANVILLE FERRY NS B0S 1K0	**Managed Harbour(s):** • Parkers Cove

Bear Point (Harbour Authority of), NS	
BEAR POINT c/o Troy Goodwin R.R. #1 NS B0W 3B0	**Managed Harbour(s):** • Bear Point

Big Bras d'Or (Harbour Authority of), NS	
BIG BRAS D'OR 1825 B OLD ROUTE 5 NS B1X 1A7	**Managed Harbour(s):** • Big Bras d'Or

Big Tancook Island (Harbour Authority of), NS	
LUNENBURG COUNTY P. O. BOX 38 BIG TANCOOK ISLAND NS B0J 3G0	**Managed Harbour(s):** • Big Tancook Island

Blandford (Harbour Authority of), NS	
LUNENBURG COUNTY 110 Upper Blandford Road R.R. #1 Hubbards NS B0J 1T0 **Phone:** (902) 673-3270	**Managed Harbour(s):** • Blandford (Shoal Cove)

Brooklyn (Harbour Authority of), NS	
QUEENS COUNTY R. R. #1 BROOKLYN NS B0J 1H0	**Managed Harbour(s):** • Brooklyn-Fishermen's Wharf / Skidway

Bush Island (Harbour Authority of), NS	
QUEENS COUNTY P. O. BOX 80 MILL VILLAGE NS B0J 2H0 **Phone:** (902) 677-2491	**Managed Harbour(s):** • Bush Island

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Camp Cove (Harbour Authority of), NS	
YARMOUTH COUNTY BOX 91 PUBNICO NS B0W 2W0 **Phone:** (902) 643-2425	**Managed Harbour(s):** • Camp Cove (Lower Argyle)

Canso Harbour Authority, NS	
CANSO P. O. BOX 207 NS B0H 1H0 **Phone:** (902) 366-2172	**Managed Harbour(s):** • Canso

Cape John (Harbour Authority of), NS	
PICTOU COUNTY P.O. BOX 143 RIVER JOHN NS B0K 1N0 **Email:** haocj@live.ca	**Managed Harbour(s):** • Cape John

Cape Sable Island (Harbour Authority of), NS	
Clark's Harbour P. O. Box 89 NS B0W 1P0	**Managed Harbour(s):** • Clark's Harbour • Cripple Creek • Newellton • South Side • Stoney Island • Swims Point

Cape St. Mary (Harbour Authority of), NS	
METEGHAN	**Managed Harbour(s):**

P. O. BOX 435 NS B0W 2J0 **Phone:** (902) 645-3151 **Email:** haom@ns.aliantzinc.ca	• Cape St.Marys

Caribou (Harbour Authority of), NS	
PICTOU P. O. BOX 569 NS B0K 1H0	**Managed Harbour(s):** • Caribou (Little Caribou Entrance) • Caribou Ferry - Fishermen's Facilities

Carters Point (Harbour Authority of), NS	
RR # 2 TANGIER 15958 # 7 HIGHWAY NS B0J 3H0	**Managed Harbour(s):** • Carters Point (Murphy Cove)

Centreville (Trout Cove) (Harbour Authority of), NS	
DIGBY COUNTY #8841, R. R. #4 Waterford NS B0V 1A0	**Managed Harbour(s):** • Centreville (Trout Cove)

Chebogue (Harbour Authority of), NS	
YARMOUTH RR#2, BOX 3808E NS B5A 4A6	**Managed Harbour(s):** • Chebogue (Town Point Hill)

Chegoggin Point (Harbour Authority of), NS	
YARMOUTH R. R. #3, P. O. BOX 3420 NS B5A 4A7 **Phone:** (902) 742-2516	**Managed Harbour(s):** • Chegoggin (Pembroke Dyke Channel) • Chegoggin Point

Cheticamp (Harbour Authority of), NS	
INVERNESS COUNTY PO BOX 178 CHETICAMP NS B0E 1H0 **Phone:** (902)224-3009 OFFICE **Email:** info@hacheticamp.ca **Web:** http://www.hacheticamp.ca/	**Managed Harbour(s):** • Cheticamp - Town Wharf • Cheticamp (la Digue) • Cheticamp Point

Coopers Point (Harbour Authority of), NS	
TANGIER 22 WALSH ROAD R. R. #1 NS B0J 3H0	**Managed Harbour(s):** • Coopers Point

Cribbons Point (Harbour Authority of), NS	
ANTIGONISH P. O. BOX 998 NS B2G 2S3 **Phone:** (902)863-3907 OFFICE **Email:** cribbonspoint@ns.aliantzinc.ca	**Managed Harbour(s):** • Cribbons Point

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Delaps Cove (Harbour Authority of), NS	
ANNAPOLIS COUNTY R. R. #3 GRANVILLE FERRY NS B0S 1K0 **Phone:** (902) 532-5636	**Managed Harbour(s):** • Delaps Cove

Dennis Point (Harbour Authority of), NS	
YARMOUTH COUNTY PO BOX 261 LOWER WEST PUBNICO NS B0W 2C0 **Phone:** (902) 762-3001	**Managed Harbour(s):** • Dennis Point (Lower West Pubnico)

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East and West Dover (Harbour Authority of), NS	
HALIFAX COUNTY 128 BERRINGER ROAD WEST DOVER NS B3Z 3T5	**Managed Harbour(s):** • East Dover • West Dover

East Chezzetcook (Harbour Authority of), NS	
HALIFAX REG. MUNICIPALITY 1530 LOWER EAST CHEZZETCOOK EAST CHEZZETCOOK NS B0J 1N0	**Managed Harbour(s):** • East Chezzetcook

East Ferry (Harbour Authority of), NS	
DIGBY c/o DIANE THERIAULT R. R. #4 NS B0V 1A0	**Managed Harbour(s):** • East Ferry

East Side Port l'Hebert (Harbour Authority of), NS	
PORT JOLI R. R. #1 C/O PHILIP MACDONALD NS B0T 1S0	**Managed Harbour(s):** • East Side Port l'Hebert

Eastern Passage (Harbour Authority of), NS	
EASTERN PASSAGE P.O. BOX 487 NS B3G 1M7	**Managed Harbour(s):** • Eastern Passage

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Feltzen South (Harbour Authority of), NS	
LUNENBURG COUNTY R.R. #1 ROSE BAY NS B0J 2X0 **Phone:** (902) 766-4071	**Managed Harbour(s):** • Feltzen South

Finlay Point (Harbour Authority of), NS	
MABOU, INVERNESS COUNTY P.O. Box 202 MABOU NS B0E 1X0 **Phone:** (902) 945-2860 **Email:** haoffp@hotmail.com	**Managed Harbour(s):** • Finlay Point

Fishermens Reserve - Three Fathom Harbour (Harbour Authority of), NS	
WEST CHEZZETCOOK R. R. #2, BOX 4 NS B0J 1N0	**Managed Harbour(s):** • Three Fathom Harbour

Fox Point (Harbour Authority of), NS	
LUNENBURG COUNTY RR #2, HUBBARDS 510 HIGHWAY 329 NS B0J 1T0 **Phone:** (902) 857-9403	**Managed Harbour(s):** • Fox Point

Freeport (Harbour Authority of), NS	
DIGBY COUNTY FREEPORT NS B0V 1B0 **Phone:** (902) 839-2103 **Email:** freeportwhale@gmail.com	**Managed Harbour(s):** • Freeport (South Cove) • Freeport-Fish Point Wharf

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Glace Bay (Harbour Authority of), NS	
GLACE BAY P. O. BOX 556 NS B1A 5V1 **Phone:** (902) 849-5701	**Managed Harbour(s):** • Glace Bay

Grand Etang (Harbour Authority of), NS	
GRAND ETANG P. O. BOX 162 NS B0E 1L0 **Phone:** (902)224-1349 **Email:** hage1952@hotmail.com	**Managed Harbour(s):** • Grand Etang

Gunning Cove (Harbour Authority of), NS	
PORT LATOUR 2C BOX 12 NS B0W 2T0	**Managed Harbour(s):** • Gunning Cove

Phone: (902) 875-1113 **Email:** haofgc@ns.sympatico.ca	

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Hall's Harbour N.S. (Harbour Authority of), NS	
HALL'S HARBOUR C/O HALL'S HARBOUR CAPSITE 3586, HIGHWAY 359 NS B0P 1J0 **Phone:** (902) 678-0320	**Managed Harbour(s):** • Halls Harbour

Hampton (Harbour Authority of), NS	
ANNAPOLIS COUNTY R. R. #3, GRANVILLE FERRY NS B0S 1K0	**Managed Harbour(s):** • Hampton

Havre Boucher (Harbour Authority of), NS	
ANTIGONISH COUNTY GENERAL DELIVERY HAVRE BOUCHER NS B0H 1P0	**Managed Harbour(s):** • Havre Boucher

Hunts Point (Harbour Authority of), NS	
LIVERPOOL PO BOX 1426 C/O KEVIN HUSKINS NS B0T 1K0 **Phone:** (902) 227-7053	**Managed Harbour(s):** • Hunts Point

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Indian Point (Harbour Authority of), NS	
LUNENBURG COUNTY R. R. #3 MAHONE BAY	**Managed Harbour(s):** • Indian Point

NS B0J 2E0 **Phone:** (902) 624-9155	

Ingomar (Harbour Authority of), NS	
SHELBURNE COUNTY RR# 3 C/O SHELLEY HIPSON NS B0T 1H0 **Email:** sea.scape@ns.sympatico.ca	**Managed Harbour(s):** • Ingomar (Black Point)

Inverness (Harbour Authority of), NS	
INVERNESS COUNTY PO BOX 757 NS B0E 1N0	**Managed Harbour(s):** • Inverness (McIsaac Pond)

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Jones Harbour (Harbour Authority of), NS	
QUEEN'S COUNTY C/O: W. BROWN SITE 2, COMPARTMENT 9 R. R. #1, GREENFIELD NS B0T 1E0	**Managed Harbour(s):** • Jones Harbour

Judique Baxter's (Harbour Authority of), NS	
INVERNESS COUNTY P.O BOX 17 JUDIQUE NS B0E 1P0 **Phone:** (902)787-2031 OFFICE **Email:** judiquebaxtersharbourauthority@hotmail.com	**Managed Harbour(s):** • Judique (Baxters Cove)

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Larry's River (Harbour Authority of), NS	
LARRY'S RIVER	**Managed Harbour(s):**

GENERAL DELIVERY NS B0H 1T0 **Phone:** (902) 525-2106	• Larrys River

Ledge Harbour (Harbour Authority of), NS

YARMOUTH COUNTY BOX 145 MIDDLE WEST PUBNICO NS B0W 2M0	**Managed Harbour(s):** • Ledge Harbour

Liscomb/Little Liscomb (Harbour Authority of), NS

LISCOMB RR#1, 45 MAILMAN BRANCH ROAD NS B0J 2A0	**Managed Harbour(s):** • Little Liscomb

Little Dover (Harbour Authority of), NS

LITTLE DOVER 803 MAIN STREET NS B0H 1V0 **Phone:** (902) 366-2434	**Managed Harbour(s):** • Dover (Little Dover)

Little Harbour - Richmond County (l'Ardoise) (Harbour Authority of), NS

ST. PETER'S RR# 3 SITE 3, COMP 4 NS B0E 3B0 **Phone:** (902) 587-2202	**Managed Harbour(s):** • Little Harbour (l'Ardoise)

Little Harbour (Halifax County) (Harbour Authority of), NS

LAKE CHARLOTTE P. O. BOX 3 NS B0J 1Y0	**Managed Harbour(s):** • Little Harbour (Halifax County)

Little Harbour (Shelburne Co.) (Harbour Authority of), NS

SHELBURNE C/O BORDEN WILLIAMS RR 2 SITE 2, COMPARTMENT 17 NS B0T 1W0	**Managed Harbour(s):** • Little Harbour (Shelburne County)

Little River - Victoria Co. (Harbour Authority of), NS

	Managed Harbour(s):

BADDECK P. O. BOX 596 NS B0E 1B0	• Little River (Victoria County)

Little River (Digby County) (Harbour Authority of), NS	
DIGBY COUNTY LITTLE RIVER NS B0V 1C0 **Phone:** (902) 834-2620	**Managed Harbour(s):** • Little River (Digby County)

Little River Harbour (Harbour Authority of), NS	
ARCADIA R. R. #1, BOX 2381 NS B0W 1B0	**Managed Harbour(s):** • Little River Harbour

Livingstones Cove (Harbour Authority of), NS	
LIVINGSTONE'S COVE R.R. #3 NS B2G 2L1	**Managed Harbour(s):** • Livingstone Cove

Lockeport (Harbour Authority of), NS	
LOCKEPORT P. O. BOX 435 NS B0T 1L0	**Managed Harbour(s):** • Lockeport

Louisbourg (Harbour Authority of), NS	
LOUISBOURG 7495 MAIN STREET NS B1C 1H6	**Managed Harbour(s):** • Louisbourg

Lower East Pubnico (Harbour Authority of), NS	
YARMOUTH COUNTY P. O. BOX 10 LOWER EAST PUBNICO NS B0W 2A0	**Managed Harbour(s):** • Lower East Pubnico

Lower Jordan Bay (Harbour Authority of), NS	
SHELBURNE COUNTY C/O RAYMOND HOPKINS R. R. #2, 3964 SANDY POINT RD NS B0T 1W0	**Managed Harbour(s):** • Lower Jordan Bay

Lower Sandy Point (Harbour Authority of), NS	
SHELBURNE R. R. #3 C/O SHELLY HIPSON NS B0T 1W0 **Email:** sea.scape@ns.sympatico.ca	**Managed Harbour(s):** • Lower Sandy Point

Lunenburg (Harbour Authority of), NS	
LUNENBURG P.O BOX 1649 NS B0J 2C0 **Phone:** (902) 634-3470	**Managed Harbour(s):** • Lunenburg - Fishermen's Wharf • Lunenburg - Railway Wharf

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Mabou Harbour (Harbour Authority of), NS	
MABOU 823 MABOU HARBOUR ROAD R. R. #3 NS B0E 1X0	**Managed Harbour(s):** • Mabou Harbour

Main-A-Dieu (Harbour Authority of), NS	
MAIN-A-DIEU 2461 MAIN-A-DIEU ROAD NS B1C 1X2 **Phone:** (902) 733-3238	**Managed Harbour(s):** • Main-à-Dieu

Malagash (Harbour Authority of), NS	
CUMBERLAND COUNTY P.O. BOX 271 WALLACE NS B0K 1Y0	**Managed Harbour(s):** • Malagash

Margaree Harbour (Harbour Authority of), NS	
INVERNESS COUNTY GENERAL DELIVERY BELLE COTE NS B0E 1C0	**Managed Harbour(s):** • Margaree Harbour (Belle Côte)

Phone: (902) 235-2608	

Marie Joseph (Harbour Authority of), NS	
MARIE JOSEPH P. O. BOX 4 NS B0J 2G0	**Managed Harbour(s):** • Marie Joseph

Maryville (Harbour Authority of), NS	
INVERNESS COUNTY P.O. BOX 123 PORT HOOD NS B0E 2W0	**Managed Harbour(s):** • Little Judique Ponds

Meteghan (Harbour Authority of), NS	
DIGBY COUNTY BOX 105 METEGHAN NS B0W 2J0 **Phone:** (902) 645-3151	**Managed Harbour(s):** • Meteghan

Mill Cove (Harbour Authority of), NS	
LUNENBURG COUNTY 1290 Highway 329 R.R. # 1 HUBBARDS NS B0J 1T0 **Phone:** (902) 857-3170	**Managed Harbour(s):** • Mill Cove

Moose Harbour (Harbour Authority of), NS	
LIVERPOOL P. O. BOX 1724 C/O PETER STEWART NS B0T 1K0	**Managed Harbour(s):** • Moose Harbour

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New Harbour (Harbour Authority of), NS	
LARRY'S RIVER R. R. #1 NS B0H 1T0	**Managed Harbour(s):** • New Harbour

Phone: (902) 387-2152	(Guysborough County)

New Waterford (Harbour Authority of), NS	
NEW WATERFORD 207 CURRAN STREET NS B1H 5V9 **Phone:** (902) 371-0982	**Managed Harbour(s):** • New Waterford

North Sydney Ballast Grounds (Harbour Authority of), NS	
SYDNEY MINES P. O. BOX 175 NS B1V 2Y4 **Phone:** (902) 736-1580	**Managed Harbour(s):** • North Sydney-Ballast Grounds

North Victoria Six Ports Harbour Authority, NS	
NEIL'S HARBOUR P. O. BOX 21 NS B0C 1N0 **Phone:** (902) 336-2235 **Email:** nvspha@ns.aliantzinc.ca	**Managed Harbour(s):** • Dingwall • Ingonish (MacLeods Point) • Ingonish Beach • Ingonish Ferry (South Ingonish) • Neils Harbour • New Haven • White Point

North West Cove (Harbour Authority of), NS	
LUNENBURG COUNTY 2522 Highway 329 South R.R. # 1 HUBBARDS NS B0J 1T0 **Phone:** (902) 228-2967	**Managed Harbour(s):** • Northwest Cove

Northport (Harbour Authority of), NS	
NORTHPORT R. R. #1 NS B0L 1E0 **Email:** hanorthport@live.ca	**Managed Harbour(s):** • Northport

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Owls Head Harbour Authority, NS

LAKE CHARLOTTE R. R. #1 NS B0J 1Y0	**Managed Harbour(s):** • Owls Head

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Peggys Cove (Harbour Authority of), NS

PEGGYS COVE 178 PEGGYS COVE ROAD NS B3Z 3S5 **Phone:** (902) 823-2561	**Managed Harbour(s):** • Peggys Cove

Pereau (Delhaven)/Kingsport (Harbour Authority of), NS

CANNING P. O. BOX 112 NS BOP 1H0	**Managed Harbour(s):** • Pereaux (Delhaven)

Petit de Grat (Administration Portuaire de), NS

PETIT DE GRAT C.P. 310 3435 RUE PRINCIPALE NS B0E 2L0 **Phone:** (902) 623-1670 **Email:** harbourmanager@yahoo.ca	**Managed Harbour(s):** • Petit-de-Grat

Pictou Island (Harbour Authority of), NS

PICTOU ISLAND PICTOU ISLAND NS B0K 1J0	**Managed Harbour(s):** • Pictou Island

Pictou Landing (Harbour Authority of), NS

TRENTON SITE 3, BOX 11, R. R. #2 NS BOK 1X0 **Phone:** (902)754-4275 (CELL) **Email:** haopl@auracom.com **Web:** http://www.auracom.com/haopl/index.html	**Managed Harbour(s):** • Pictou Landing

Pinkney's Point (Harbour Authority of), NS	
YARMOUTH COUNTY BOX 1290, RR#1 ARCADIA NS B0W 1B0 **Phone:** (506) 742-1110	**Managed Harbour(s):** • Pinkneys Point

Pleasant Bay (Harbour Authority of), NS	
CHETICAMP P. O. BOX 1272 NS B0E 1H0 **Email:** harbourauthorityofpbay@gmail.com	**Managed Harbour(s):** • Pleasant Bay

Point Aconi (Harbour Authority of), NS	
RR# 2 BRAS D'OR 71 SPRUCE MEADOW DRIVE NS B1Y 1W7	**Managed Harbour(s):** • Point Aconi (McCreadyville)

Port Bickerton (Harbour Authority of), NS	
BICKERTON WEST P. O. BOX 123 NS B0J 1A0	**Managed Harbour(s):** • Port Bickerton East • Port Bickerton West

Port Hood (Harbour Authority of), NS	
PORT HOOD PO BOX 193 NS B0E 2W0 **Phone:** (902)787-2058 OFFICE	**Managed Harbour(s):** • Murphys Pond

Port la Tour (Harbour Authority of), NS	
PORT LA TOUR 2C BOX 12 ATTN: RICHARD NICKERSON NS B0W 2T0 **Email:** haofpl@ns.sympatico.ca	**Managed Harbour(s):** • Port la Tour • Smithsville • Upper Port la Tour

Port Maitland (Harbour Authority of), NS	
PORT MAITLAND BOX 631 NS B0W 2V0 **Phone:** (902) 649-2882	**Managed Harbour(s):** • Port Maitland

Port Medway (Harbour Authority of), NS	
QUEENS CO. P.O. Box 32 PORT MEDWAY NS B0J 2T0 **Phone:** (902) 354-2125	**Managed Harbour(s):** • Port Medway

Port Morien (Harbour Authority of), NS	
PORT MORIEN 11 BREAKWATER STREET NS B1B 1Y5	**Managed Harbour(s):** • Port Morien

Port Mouton (Harbour Authority of), NS	
PORT MOUTON P. O. BOX 16 NS B0T 1T0 **Phone:** (902) 683-2428	**Managed Harbour(s):** • Central Port Mouton - Fishermen's Wharf • Port Mouton

Pugwash (Harbour Authority of), NS	
PUGWASH 20 Brickyard Road P.O. Box 329 NS B0K 1L0	**Managed Harbour(s):** • Pugwash

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Queensport (Harbour Authority of), NS	
HALIFAX 289 FERGUSONS COVE ROAD NS B3V 1L7 **Phone:** (902) 475-0123	**Managed Harbour(s):** • Queensport

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Riverport (Kraut Point) (Harbour Authority of), NS	

LUNENBURG COUNTY PO BOX 40 RIVERPORT NS B0J 2W0 **Phone:** (902) 766-0228	**Managed Harbour(s):** • Kraut Point (Riverport)

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Sambro (Harbour Authority of), NS	
WILLIAMSWOOD 17 STEVEN MURPHY DRIVE NS B3V 1C5	**Managed Harbour(s):** • Sambro

Sandford (Harbour Authority of), NS	
YARMOUTH BOX 1699, R.R. #5 NS B5A 4A9	**Managed Harbour(s):** • Sandford

Sandy Cove East (Harbour Authority of), NS	
DIGBY COUNTY R. R. #1 SANDY COVE NS B0V 1E0	**Managed Harbour(s):** • Sandy Cove East

Saulnierville Harbour Authority, NS	
SAULNIERVILLE C/O NOEL DESPRES P. O. BOX 39 NS B0W 2Z0 **Phone:** (902) 769-2101	**Managed Harbour(s):** • Saulnierville

Scot's Bay (Harbour Authority of), NS	
KINGS COUNTY RR# 3, CANNING NS B0P 1H0 **Email:** f.huntley@ns.sympatico.ca	**Managed Harbour(s):** • Scots Bay (Little Cove)

Shad Bay (Harbour Authority of), NS	
HALIFAX COUNTY	**Managed Harbour(s):**

3962 PROSPECT ROAD SHAD BAY NS B3T 2B8 **Phone:** (902) 852-3733	• Shad Bay

Shag Harbour (Harbour Authority of), NS

SHAG HARBOUR BOX 171 NS B0W 3B0 **Phone:** (902) 723-2526	**Managed Harbour(s):** • Shag Harbour • Shag Harbour (Prospect Point)

Skinner's Cove (Harbour Authority of), NS

PICTOU COUNTY P.O. BOX 155 RIVER JOHN NS B0K 1N0 **Email:** hasc@live.ca	**Managed Harbour(s):** • Skinners Cove

Sluice Point (Harbour Authority of), NS

YARMOUTH COUNTY RR# 2, TUSKET BOX 130A NS B0W 3M0 **Phone:** (902) 648-2549	**Managed Harbour(s):** • Sluice Point

Sonora (Harbour Authority of), NS

RR# 1 SONORA 2130 SONORA ROAD NS B0J 3C0	**Managed Harbour(s):** • Sonora

South Bar Fishermen's Harbour Authority, NS

SYDNEY 2194 hIGHWAY 28 NS B1N-3H7 **Phone:** (902) 564-4327	**Managed Harbour(s):** • South Bar

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Terence Bay/Lower Prospect (Harbour Authority of), NS

HALIFAX COUNTY 95 SANDY COVE ROAD TERENCE BAY NS B3T 1Y4	**Managed Harbour(s):** • Lower Prospect • Terence Bay

Tiverton (Harbour Authority of), NS

DIGBY COUNTY TIVERTON NS B0V 1G0	**Managed Harbour(s):** • Tiverton -Fishermen's Wharf

Toney River (Harbour Authority of), NS

TATAMAGOUCHE P.O. BOX 157 NS B0K 1V0	**Managed Harbour(s):** • Toney River

Two Islands (Harbour Authority of), NS

TUSKET BOX 252A, R. R. #2 NS B0W 3M0	**Managed Harbour(s):** • Morris Island • Surettes Island (the Tittle)

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United Communities (Harbour Authority of), NS

QUEENS COUNTY P. O. BOX 80 MILL VILLAGE NS B0J 2H0 **Phone:** (902) 677-2491	**Managed Harbour(s):** • Little Harbour (Cherry Hill) • Voglers Cove West

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Wallace (Harbour Authority of), NS

WALLACE P. O. BOX 147 NS B0K 1Y0	**Managed Harbour(s):**

	• Wallace

Wedgeport Harbour Authority, NS	
YARMOUTH COUNTY PO Box 131 WEDGEPORT NS B0W 3P0 **Phone:** (902) 663-4666	**Managed Harbour(s):** • Lower Wedgeport -Tuna Wharf • Wedge Point (Wedgeport)

West Berlin (Harbour Authority of), NS	
QUEENS COUNTY R. R. #1 BROOKLYN NS B0J 1H0 **Phone:** (902) 354-4745	**Managed Harbour(s):** • West Berlin

West Green Harbour (Harbour Authority of), NS	
SHELBURNE COUNTY C/O THOMAS MACKAY RR #1, LOCKEPORT NS B0T 1L0 **Phone:** (902) 656-2018	**Managed Harbour(s):** • West Green Harbour

West Head (Harbour Authority of), NS	
CLARK'S HARBOUR P. O. BOX 45 NS B0W 1P0 **Phone:** (902) 745-3134	**Managed Harbour(s):** • West Head

West Quoddy (Harbour Authority of), NS	
PORT DUFFERIN R.R. #1 NS B0J 2R0	**Managed Harbour(s):** • Gammons Creek (John Voglers Shore)

Westport Harbour Authority, NS	
WESTPORT P. O. B0X 1247 NS B0V 1H0	**Managed Harbour(s):** • Westport (Irishtown) • Westport -Ferry Wharf

Whale Cove (Harbour Authority of), NS	
SANDY COVE R.R. #1 NS B0V 1E0	**Managed Harbour(s):**

Phone: (902) 834-2777	• Whale Cove

Whitehead Harbour Authority, NS	
GUYSBOROUGH COUNTY R.R. #2 WHITEHEAD NS B0H 1T0 **Phone:** (902) 358-2502	**Managed Harbour(s):** • Upper Whitehead

Woods Harbour (Harbour Authority of), NS	
SHELBURNE COUNTY P. O. BOX 39 WOODS HARBOUR NS B0W 2E0 **Phone:** (902) 723-0110	**Managed Harbour(s):** • Falls Point • Forbes Point • Lower Woods Harbour

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Y

Yarmouth Bar (Harbour Authority of), NS	
YARMOUTH P. O. BOX 6560, R.R. #3 NS B5A 4A7	**Managed Harbour(s):** • Yarmouth Bar

Date Modified: 2011-06-14

Abbotts Harbour, NS

Managed by:
Abbots Harbour (Harbour Authority of)

Locate on map

Target **no**

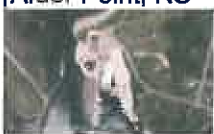
Advocate, NS

Managed by:
Advocate (Harbour Authority of)

Locate on map

Target **no**

Alder Point, NS



Managed by:
Alder Point (Harbour Authority of)

Locate on map

Target **yes**

Arisaig, NS

Managed by:
Arisaig (Harbour Authority of)

Locate on map

Target **yes**

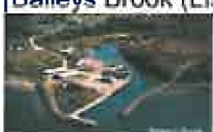
Aulds Cove, NS

Managed by:
Aulds Cove (Harbour Authority of)

Locate on map

Target **yes**

Baileys Brook (Lismore), NS



Managed by:
Bailey's Brook (Harbour Authority of)

Locate on map

Target **no**

Ballantynes Cove (McNair's Cove), NS

Managed by:
Ballantyne's Cove (Harbour Authority of)

Locate on map

Target **yes**

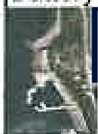
Barrios Beach (Tracadie), NS

Managed by:
Barrios Beach (Harbour Authority of)

Locate on map

Target no

Battery Point (Victoria Beach), NS



Managed by:
Battery Point (Victoria Beach) (Harbour

Locate on map

Target no

Bay St. Lawrence, NS

Managed by:
Bay St. Lawrence (Harbour Authority of)

Locate on map

Target yes

Bayfield (Pomquet Point), NS

Managed by:
Bayfield (Harbour Authority of)

Locate on map

Target yes

Bayport, NS

Managed by:
Bayport (Harbour Authority of)

Locate on map

Target no

Bear Point, NS

Managed by:
Bear Point (Harbour Authority of)

Locate on map

Target yes

Big Bras d'Or, NS

No photo

Managed by:
Big Bras d'Or (Harbour Authority of)

Locate on map

Target no

Big Tancook Island, NS	
	**Managed by:** Big Tancook Island (Harbour Authority of) Locate on map

Target no

Blandford (Shoal Cove), NS	
	**Managed by:** Blandford (Harbour Authority of) Locate on map

Target no

Brooklyn-Fishermen's Wharf / Skidway, NS	
	**Managed by:** Brooklyn (Harbour Authority of) Locate on map

Target no

Bush Island, NS	
	**Managed by:** Bush Island (Harbour Authority of) Locate on map

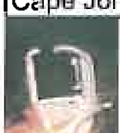
Target no

Camp Cove (Lower Argyle), NS	
	**Managed by:** Camp Cove (Harbour Authority of) Locate on map

Target no

Canso, NS	
	**Managed by:** Canso Harbour Authority Locate on map

Target no

Cape John, NS	
	**Managed by:** Cape John (Harbour Authority of) Locate on map

Target no

Cape St.Marys, NS

Managed by:
Cape St. Mary (Harbour Authority of)

Locate on map

Target no

Caribou (Little Caribou Entrance), NS

Managed by:
Caribou (Harbour Authority of)

Locate on map

Target no

Caribou Ferry - Fishermen's Facilities, NS

Managed by:
Caribou (Harbour Authority of)

Locate on map

Target yes

Carters Point (Murphy Cove), NS

Managed by:
Carters Point (Harbour Authority of)

Locate on map

Target no

Central Port Mouton - Fishermen's Wharf, NS

Managed by:
Port Mouton (Harbour Authority of)

Locate on map

Target no

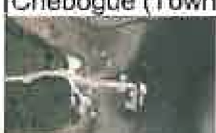
Centreville (Trout Cove), NS

Managed by:
Centreville (Trout Cove) (Harbour Authority of)

Locate on map

Target no

Chebogue (Town Point Hill), NS



Managed by:
Chebogue (Harbour Authority of)

Locate on map

Target no

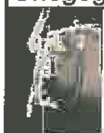
Chegoggin (Pembroke Dyke Channel), NS

Managed by:
Chegoggin Point (Harbour Authority of)

Locate on map

Target no

Chegoggin Point, NS

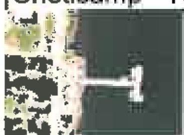


Managed by:
Chegoggin Point (Harbour Authority of)

Locate on map

Target no

Cheticamp - Town Wharf, NS

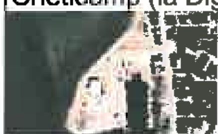


Managed by:
Cheticamp (Harbour Authority of)

Locate on map

Target yes

Cheticamp (la Digue), NS



Managed by:
Cheticamp (Harbour Authority of)

Locate on map

Target no

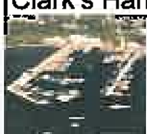
Cheticamp Point, NS

Managed by:
Cheticamp (Harbour Authority of)

Locate on map

Target no

Clark's Harbour, NS



Managed by:
Clarks Harbour (Harbour Authority of)

Locate on map

Target yes

Coopers Point, NS

Managed by:
Coopers Point (Harbour Authority of)

Locate on map

Target no

Cribbons Point, NS

Managed by:
Cribbons Point (Harbour Authority of)

Locate on map

Target

Cripple Creek, NS

Managed by:
Cripple Creek (Harbour Authority of)

Locate on map

Target **no**

Delaps Cove, NS

Managed by:
Delaps Cove (Harbour Authority of)

Locate on map

Target **no**

Dennis Point (Lower West Pubnico), NS

Managed by:
Dennis Point (Harbour Authority of)

Locate on map

Target **yes**

Dingwall, NS

Managed by:
North Victoria Six Ports Harbour Authority

Locate on map

Target **no**

Dover (Little Dover), NS

Managed by:
Little Dover (Harbour Authority of)

Locate on map

Target **no**

East Chezzetcook, NS

Managed by:
East Chezzetcook (Harbour Authority of)

Locate on map

Target **no**

East Dover, NS

Managed by:
East and West Dover (Harbour Authority of)

Locate on map

Target no

East Ferry, NS

No photo

Managed by:
East Ferry (Harbour Authority of)

Locate on map

Target no

East Side Port l'Hebert, NS

Managed by:
East Side Port l'Hebert (Harbour Authority of)

Locate on map

Target no

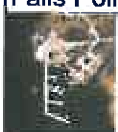
Eastern Passage, NS

Managed by:
Eastern Passage (Harbour Authority of)

Locate on map

Target no

Falls Point, NS



Managed by:
Woods Harbour (Harbour Authority of)

Locate on map

Target no

Feltzen South, NS

Managed by:
Feltzen South (Harbour Authority of)

Locate on map

Target no

Finlay Point, NS

Managed by:
Finlay Point (Harbour Authority of)

Locate on map

Target yes

Forbes Point, NS

Managed by:
Woods Harbour (Harbour Authority of)

Locate on map

Target no

Fox Point, NS

Managed by:
Fox Point (Harbour Authority of)

Locate on map

Target yes

Freeport (South Cove), NS

Managed by:
Freeport (Harbour Authority of)

Locate on map

Target no

Freeport-Fish Point Wharf, NS

Managed by:
Freeport (Harbour Authority of)

Locate on map

Target yes

Gammons Creek (John Voglers Shore), NS

Managed by:
West Quoddy (Harbour Authority of)

noLocate on map

Target no

Glace Bay, NS

Managed by:
Glace Bay (Harbour Authority of)

Locate on map

Target yes

Grand Etang, NS

Managed by:
Grand Etang (Harbour Authority of)

Locate on map

Target no

Gunning Cove, NS

Managed by:
Gunning Cove (Harbour Authority of)

Locate on map

Target no

Halls Harbour, NS

Managed by:
Hall's Harbour N.S. (Harbour Authority of)

Locate on map

Target no

Hampton, NS

Managed by:
Hampton (Harbour Authority of)

Locate on map

Target no

Havre Boucher, NS

Managed by:
Havre Boucher (Harbour Authority of)

Locate on map

Target yes

Hunts Point, NS

Managed by:
Hunts Point (Harbour Authority of)

Locate on map

Target no

Indian Point, NS

Managed by:
Indian Point (Harbour Authority of)

Locate on map

Target no

Ingomar (Black Point), NS

Managed by:
Ingomar (Harbour Authority of)

Locate on map

Target no

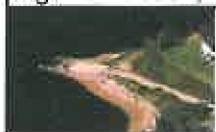
Ingonish (MacLeods Point), NS

Managed by:
North Victoria Six Ports Harbour Authority

Locate on map

Target **no**

Ingonish Beach, NS



Managed by:
North Victoria Six Ports Harbour Authority

Locate on map

Target **no**

Ingonish Ferry (South Ingonish), NS

Managed by:
North Victoria Six Ports Harbour Authority

Locate on map

Target **no**

Inverness (McIsaac Pond), NS

Managed by:
Inverness (Harbour Authority of)

Locate on map

Target **no**

Managed by:
Jones Harbour (Harbour Authority of)

Locate on map

Target **no**

Judique (Baxters Cove), NS

Managed by:
Judique Baxter's (Harbour Authority of)

Locate on map

Target **no**

Managed by:
Riverport (Kraut Point) (Harbour Authority of)

Locate on map

Target **no**

Larrys River, NS

Managed by:
Larry's River (Harbour Authority of)

Locate on mapyes

Target no

Ledge Harbour, NS

Managed by:
Ledge Harbour (Harbour Authority of)

Locate on map

Target no

Little Harbour (Cherry Hill), NS

Managed by:
United Communities (Harbour Authority of)

Locate on map

Target no

Little Harbour (Halifax County), NS

Managed by:
Little Harbour (Halifax County) (Harbour

Locate on map

Target no

Little Harbour (l'Ardoise), NS

Managed by:
Little Harbour - Richmond County (l'Ardoise)

Locate on map

Target yes

Little Harbour (Shelburne County), NS

Managed by:
Little Harbour (Shelburne Co.) (Harbour

Locate on map

Target no

Little Judique Ponds, NS

Managed by:
Maryville (Harbour Authority of)

Locate on map

Target no

Little Liscomb, NS

Managed by:
Liscomb/Little Liscomb (Harbour Authority of)

Locate on map

Target **no**

Little River (Digby County), NS

Managed by:
Little River (Digby County) (Harbour Authority

Locate on map

Target **no**

Little River (Victoria County), NS

Managed by:
Little River - Victoria Co. (Harbour Authority of)

Locate on map

Target **no**

Little River Harbour, NS

Managed by:
Little River Harbour (Harbour Authority of)

Locate on map

Target **no**

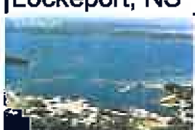
Livingstone Cove, NS

Managed by:
Livingstones Cove (Harbour Authority of)

Locate on map

Target **no**

Lockeport, NS



Managed by:
Lockeport (Harbour Authority of)

Locate on map

Target **yes**

Louisbourg, NS

Managed by:
Louisbourg (Harbour Authority of)

Locate on map

Target **yes**

Lower East Pubnico, NS	
No photo	**Managed by:** Lower East Pubnico (Harbour Authority of) noLocate on map

Target no

Lower Jordan Bay, NS	
	**Managed by:** Lower Jordan Bay (Harbour Authority of) Locate on map

Target no

Lower Prospect, NS	
No photo	**Managed by:** Terence Bay/Lower Prospect (Harbour Locate on map

Target no

Lower Sandy Point, NS	
	**Managed by:** Lower Sandy Point (Harbour Authority of) Locate on map

Target yes

Lower Wedgeport -Tuna Wharf, NS	
	**Managed by:** Wedgeport Harbour Authority Locate on map

Target no

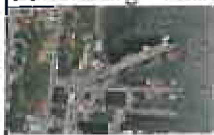
Lower Woods Harbour, NS	
	**Managed by:** Woods Harbour (Harbour Authority of) Locate on map

Target no

Lunenburg - Fishermen's Wharf, NS	
	**Managed by:** Lunenburg (Harbour Authority of) Locate on map

Target yes

Lunenburg - Railway Wharf, NS



Managed by:
Lunenburg (Harbour Authority of)

Locate on map

Target **yes**

Mabou Harbour, NS

Managed by:
Mabou Harbour (Harbour Authority of)

Locate on map

Target **no**

Main-à-Dieu, NS

No photo

Managed by:
Main-A-Dieu (Harbour Authority of)

Locate on map

Target **no**

Malagash, NS

Managed by:
Malagash (Harbour Authority of)

Locate on map

Target **no**

Margaree Harbour (Belle Côte), NS

Managed by:
Margaree Harbour (Harbour Authority of)

Locate on map

Target **no**

Marie Joseph, NS

Managed by:
Marie Joseph (Harbour Authority of)

Locate on map

Target **no**

Meteghan, NS

Managed by:
Meteghan (Harbour Authority of)

Locate on map

Target **yes**

Mill Cove, NS	
No photo	**Managed by:** Mill Cove (Harbour Authority of) Locate on map

Target **no**

Moose Harbour, NS	
No photo	**Managed by:** Moose Harbour (Harbour Authority of) Locate on map

Target **no**

Morris Island, NS	
	**Managed by:** Two Islands (Harbour Authority of) Locate on map

Target **no**

Murphys Pond, NS	
	**Managed by:** Port Hood (Harbour Authority of) Locate on map

Target **no**

Neils Harbour, NS	
	**Managed by:** North Victoria Six Ports Harbour Authority Locate on map

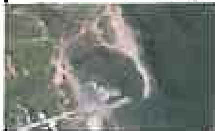
Target **no**

New Harbour (Guysborough County), NS	
No photo	**Managed by:** New Harbour (Harbour Authority of) Locate on map

Target **no**

New Haven, NS	
	**Managed by:** North Victoria Six Ports Harbour Authority Locate on map

Target **no**

New Waterford, NS		
	**Managed by:** New Waterford (Harbour Authority of) Locate on map	**Target** no

Newellton, NS		
	**Managed by:** Newellton (Harbour Authority of) Locate on map	**Target** no

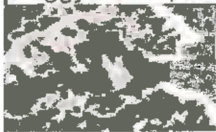
North Sydney-Ballast Grounds, NS		
No photo	**Managed by:** North Sydney Ballast Grounds (Harbour Locate on map	**Target** no

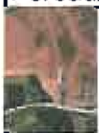
Northport, NS		
	**Managed by:** Northport (Harbour Authority of) Locate on map	**Target** no

Northwest Cove, NS		
	**Managed by:** North West Cove (Harbour Authority of) Locate on map	**Target** no

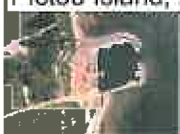
	**Managed by:** Owls Head Harbour Authority Locate on map	**Target** no

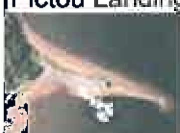
Parkers Cove, NS		
	**Managed by:** Bayshore Harbour Authority (Parker's Cove) Locate on map	**Target** no

Peggys Cove, NS			
	**Managed by:** Peggys Cove (Harbour Authority of) Locate on map	**Target**	**no**

Pereaux (Delhaven), NS			
	**Managed by:** Pereau (Delhaven)/Kingsport (Harbour Locate on map	**Target**	**no**

Petit-de-Grat, NS			
	**Managed by:** Petit de Grat (Administration Portuaire de) Locate on map	**Target**	**no**

Pictou Island, NS			
	**Managed by:** Pictou Island (Harbour Authority of) Locate on map	**Target**	**no**

Pictou Landing, NS			
	**Managed by:** Pictou Landing (Harbour Authority of) Locate on map	**Target**	**no**

Pinkneys Point, NS			
No photo	**Managed by:** Pinkney's Point (Harbour Authority of) Locate on map	**Target**	**no**

Pleasant Bay, NS			
	**Managed by:** Pleasant Bay (Harbour Authority of) Locate on map	**Target**	**no**

Point Aconi (McCreadyville), NS

Managed by:
Point Aconi (Harbour Authority of)

Locate on map

Target **no**

Port Bickerton East, NS

Managed by:
Port Bickerton (Harbour Authority of)

Locate on map

Target **no**

Port Bickerton West, NS

Managed by:
Port Bickerton (Harbour Authority of)

Locate on map

Target **yes**

Port la Tour, NS

Managed by:
Port la Tour (Harbour Authority of)

Locate on map

Target **no**

Port Maitland, NS

Managed by:
Port Maitland (Harbour Authority of)

Locate on map

Target **no**

Port Medway, NS

Managed by:
Port Medway (Harbour Authority of)

Locate on map

Target **no**

Port Morien, NS

Managed by:
Port Morien (Harbour Authority of)

Locate on map

Target **no**

Port Mouton, NS

Managed by:
Port Mouton (Harbour Authority of)

Locate on map

Target **no**

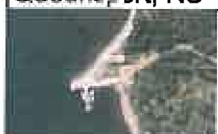
Pugwash, NS

Managed by:
Pugwash (Harbour Authority of)

Locate on map

Target **yes**

Queensport, NS



Managed by:
Queensport (Harbour Authority of)

Locate on map

Target **no**

Sambro, NS

Managed by:
Sambro (Harbour Authority of)

Locate on map

Target **yes**

Sandford, NS

Managed by:
Sandford (Harbour Authority of)

Locate on map

Target **no**

Sandy Cove East, NS

Managed by:
Sandy Cove East (Harbour Authority of)

Locate on map

Target **yes**

Saulnierville, NS

Managed by:
Saulnierville Harbour Authority

Locate on map

Target **yes**

Scots Bay (Little Cove), NS

Managed by:
Scot's Bay (Harbour Authority of)

Locate on map

Target no

Shad Bay, NS

Managed by:
Shad Bay (Harbour Authority of)

Locate on map

Target no

Shag Harbour, NS

Managed by:
Shag Harbour (Harbour Authority of)

Locate on map

Target yes

Shag Harbour (Prospect Point), NS

Managed by:
Shag Harbour (Harbour Authority of)

Locate on map

Target yes

Skinners Cove, NS

Managed by:
Skinner's Cove (Harbour Authority of)

Locate on map

Target no

Sluice Point, NS

Managed by:
Sluice Point (Harbour Authority of)

Locate on map

Target no

Smithsville, NS

Managed by:
Port la Tour (Harbour Authority of)

Locate on map

Target no

Sonora, NS		
	**Managed by:** Sonora (Harbour Authority of) Locate on map	**Target** no

South Bar, NS		
	**Managed by:** South Bar Fishermen's Harbour Authority Locate on map	**Target** no

South Side, NS		
	**Managed by:** South Side (Harbour Authority of) Locate on map	**Target** yes

Stoney Island, NS		
	**Managed by:** Stoney Island (Harbour Authority of) Locate on map	**Target** yes

Surettes Island (the Tittle), NS		
	**Managed by:** Two Islands (Harbour Authority of) Locate on map	**Target** no

Swims Point, NS		
	**Managed by:** Clarks Harbour (Harbour Authority of) Locate on map	**Target** yes

Terence Bay, NS		
	**Managed by:** Terence Bay/Lower Prospect (Harbour Locate on map	**Target** no

Three Fathom Harbour, NS

Managed by:
Fishermens Reserve - Three Fathom Harbour

Locate on map

Target no

Tiverton -Fishermen's Wharf, NS

Managed by:
Tiverton (Harbour Authority of)

Locate on map

Target no

Toney River, NS

Managed by:
Toney River (Harbour Authority of)

Locate on map

Target no

Upper Port la Tour, NS

Managed by:
Port la Tour (Harbour Authority of)

Locate on map

Target no

Upper Whitehead, NS

Managed by:
Whitehead Harbour Authority

Locate on map

Target no

Voglers Cove West, NS

Managed by:
United Communities (Harbour Authority of)

noLocate on map

Target no

Wallace, NS

Managed by:
Wallace (Harbour Authority of)

Locate on map

Target no

Wedge Point (Wedgeport), NS

Managed by:
Wedgeport Harbour Authority

Locate on map

Target yes

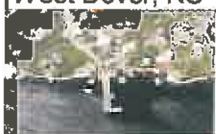
West Berlin, NS

Managed by:
West Berlin (Harbour Authority of)

Locate on map

Target no

West Dover, NS



Managed by:
East and West Dover (Harbour Authority of)

Locate on map

Target no

West Green Harbour, NS

Managed by:
West Green Harbour (Harbour Authority of)

Locate on map

Target no

West Head, NS

Managed by:
West Head (Harbour Authority of)

Locate on map

Target yes

Westport (Irishtown), NS

No photo

Managed by:
Westport Harbour Authority

Locate on map

Target no

Westport -Ferry Wharf, NS

Managed by:
Westport Harbour Authority

Locate on map

Target no

Whale Cove, NS	
	**Managed by:** Whale Cove (Harbour Authority of) Locate on map

Target no

White Point, NS	
	**Managed by:** North Victoria Six Ports Harbour Authority Locate on map

Target no

Yarmouth Bar, NS	
No photo	**Managed by:** Yarmouth Bar (Harbour Authority of) Locate on map

Target no