APPENDIX 1

ATTACHMENT A-1

Harbor Plan Sections Relating to Navigational Dredging Projects

Identification of Individual Properties

At a minimum, the project stakeholders whose mission includes Harbor maintenance, have identified the commercial properties that are in specific need of dredging and should fall under the SER process umbrella. It is anticipated that, at a minimum, all commercial properties will be conducted under the auspices of the SER Process. As part of the Harbor Master Plan update process, stakeholders and users of the Harbor were interviewed to determine infrastructure maintenance and redevelopment nees for the next 5-15 years. The list of dredge projects anticipated over that time frame was distilled by property and lot number of the watersheet adjacent user.

The projects associated with the New Bedford/Fairhaven Harbor Dredge Program are listed on **Table A-4** and the general dredge areas for the program are depicted on **Figure A-4.**

TABLE A-4: Proposed Navigational and Maintenance Dredging Projects

City/ Town	Plot/ Lot	Current Owner	Address	Description	Estimated Volume
NB	N/A	N/A	NB/Fairhaven Harbor	Channels, Turning Basins, Anchorages, Fairways	850000
	N/A	N/A	USEPA	Material From Upper Harbor	300000
NB	N/A	N/A	Harbor North of Route 6 Bridge	DMMP Area	Storage (2,000,000 yards)
NB	60-19	Mitchell Mark S "Trustee"	83 Popes Island	Whaling City Marina	15,000
NB	60-12	Popes Island Harbor Development Corp.	173 Popes Island	Niemic Marine	15000
NB	60-18	Popes Island Harbor Development Corp.	243 Popes Island	Gear Locker Marina	5000
NB	60-11	BLF Realty Trust	226 Popes Island	The Olde New Bedford Yacht Club/Captain Leroy's	3000
NB	60-2	City of New Bedford Marine Park	102 Popes Island	Pope's Island Marina	17000
NB	60-1	Maritime Terminal, Inc.	NS Fish Island	Bridge Terminal/ NORPEL	5000
NB	60-23	M A T Marine Inc.	Fish Island	Empty Lot/For Sale	3000
NB	60-4	Fish Island Nominee Trust	SS Fish Island	AGM Marine Contractors, Inc.	15000
NB	N/A	City of New Bedford	Gifford Street	Gifford Street Boat Ramp	100000
NB	31-263	Shuster, Richard A	4 Wright Street	Shuster Corporation	5000
NB	31-254	R P C Realty LLC	6 Hassey Street	Eastern Fisheries	5000
NB	31-252	Maritime Realty, Inc.	16 Hassey Street	Northern Wind, Inc.	5000
NB	31-251	Tichon Seafood Corp.	8 Hassey Street	Bergies Seafood, Inc.	2500

NB	37-304	D Fillet Inc.	38 Hassey Street	Tempest Fisheries, Inc.	2500
NB	37-329	Pier Side Realty, LLC	50 Hassey Street	Whaling City Seafood Display Auction	5000
NB	37-305	Port Side Realty, LLC	62 Hassey Street	Whaling City Seafood Display Auction	5000
NB	37-303	South Terminal Leasing	7 Conway Street	Tichon Seafood Corporation	10000
NB	42-268	Trio Algarvio, Inc.	26 Green & Wood Pier	MASC Fabricating & Welding, Inc.	7500
NB	42-260	W Trading, Inc.	25 Green & Wood Pier	MASC Fabricating & Welding, Inc.	7500
NB	42-160	Sprague Massachusetts Properties, LLC	1 Pine Street	Sprague Energy	20000
NB	42-84	Commonwealth Electric Co C/O Property Tax Department	180 Macarthur Drive	NSTAR	10000
NB	47-181	Commonwealth Electric Co C/O Property Tax Department	180 Macarthur Drive	NSTAR	10000
NB	47-212	City of New Bedford	Leonard's Wharf	Leonard's Wharf	10000
NB	47-180	City of New Bedford Harbor Development Commission	Homers Wharf	Homer's Wharf	10000
NB	47-204, 47-179, 47-225	City of New Bedford	ES Macarthur Drive	Coal Pocket Pier and Steamship Pier	18000
NB	47-203, 53-217	Commonwealth of Massachusetts State Pier	ES Macarthur Drive	State Pier	24000
NB	53-120, 53-253, 53-254	City of New Bedford	51 Macarthur Drive	Fisherman's Wharf and Tonneson Park	5000
NB	53-34	Co-Op Wharf Realty Trust	101 Co-Op Wharf	Global Fuels Marine, Inc.	5000
NB	53-116	155 Front Street Realty Corporation	248 Macarthur Drive	Crystal Ice	2500
NB	53-241	178 Front Street Corporation	252 Macarthur Drive	Crystal Ice	2500
NB	53-42, 59-173, 59-217	Maritime Terminal, Inc.	276 Macarthur Drive	Maritime Terminal, Inc.	5000

NB	59-41, 66-134	American Seafoods International, LLC	40 Herman Melville Blvd	American Pride Seafoods (American Seafoods Group, Southern Pride Catfish and Frionor)	10000
NB	66-165	New Bedford Land Company, Inc.	Herman Melville Blvd.	Mass Tow Boat	7000
NB	66-128, 66-147	M A E Realty, LLC	SS Antonio L Costa Blvd.	Eastern Fisheries	10000
NB	66-125	Sea Watch International, LTD	15 Antonio L Costa Blvd.	Sea Watch International	2000
NB	72-284	U S EPA c/o Harbor Development	NS Hervey Tichon Ave.	US EPA Dewatering Facility	5000
NB	72-248	Marine Hydraulics	256 Herman Melville Ave.	Marine Hydraulics, Inc.	7500
NB	72-292	Cook, Robert C.	286 Herman Melville Ave.	New Bedford Welding Supply	5000
NB	72-297	Dolinsky, Marvin L.	300 Herman Melville Ave.	ABCO Electric, Task International	5000
NB	72-299	Acushnet River Shipyard, Inc.	302 Herman Melville Ave.	Evergreen Sheet Metal/Acushnet River Shipyard, Inc.	7500
NB	72-293	City of New Bedford Harbor Development Commission	352 Herman Melville Ave.	Tisbury Towing/ Packer Marine	10000
NB	79-5	PAL Realty, LLC	10 N Front Street	Former MacLean's Seafood	20000
NB	79-2	Revere Copper Products	26 N Front Street	Revere Copper Products	10000
NB	79-4	Revere Copper Products	24 N Front Street	Revere Copper Products	10000
NB	79-1	B S Realty Limited Partnership	94 Kilburn Street	Old Mill Building (Various Occupants) – Boat Ramp	6000
NB	86-3	North Wharf Trust	2 Washburn Street	Kyler's Catch Seafood Market	10000
NB	86-25	City of New Bedford	ES Washburn Street	Right of Way	5000
NB	86-20	North Wharf Trust	Washburn Street	No Occupants/Old Piers	5000
NB	93-265	USA c/o Army Corps of Engineers	Sawyer Street	Vacant	5000
NB	93-263	Aprak Realty Trust	Sawyer Street	Abandoned Building/ Under Demolition	5000
NB	93-265	USA c/o Army Corps of Engineers	Sawyer Street	Vacant	5000

NB	93-120	City of New Bedford Park Dept	103 Sawyer Street	USEPA De-Sanding Facility	5000
NB	N/A	N/A	Harbor North of Coggeshall Street Bridge	Future Rowing Course	110,000
F	05-015, 05-016, 03-001, 03-001A,	Rodman Candle Works Realty, LLC	38-48 Fort Street	Fairhaven Shipyard	40000
F	07-014	Wood's Hole Martha's Vineyard Steamship Authority	2 Water Street	Steamship Authority	40000
F	07-012, 07-013	Kelley South, LLC	4 Water Street	Warren Alexander Property	2500
F	07-011	Kelley South, LLC	7 Union Wharf	DN Kelley and Son	2500
F	07-009	Town of Fairhaven	2 Union Wharf	Union Wharf	15000
F	07-001	Kelley Dock & Marine Co, Inc.	24 Water Street	D N Kelley and Son	20000
F	09-002A	E&W Properties, LLC	42 Water Street	Harbor Hydraulics + Machine	5000
F	09-002	Olde North Wharf	4 Washington Street	Olde North Wharf/ Harbor Blue Seafood	5000
F	09-001, 09-116A	L&L Realty Co., Inc.	50 Middle Street	Linberg Marine	20000
F	11-012	Town of Fairhaven	Pease Park	Pease Park Boat Ramp	10000
F	11-008, 11-009. 11-010	Acushnet River Safe Boating Club	80-82 Middle Street	Acushnet River Safe Boating Club – Coast Guard Auxiliary	20000
F	12-016A, 12-016, 12-017. 12-018. 12-019. 12-020, 12-020A, 12-020B, 12-021, 12-022, 12-023, 12-024	Sky View Lines, LLC/Town of Fairhaven	110 Middle Street	Harbor front Center (Former Holiday Inn Express and Marina)	20000
F	13-066	Jerco, LLC	2 Elm Avenue	Cozy Cove Marina	4000
F	17-016	Two River Ave, LLC	2 River Avenue	Moby Dick Marina	10000
	17-001			Residence/Business Docks	4000
				Total:	**1998000**

Figure 6.1 Harbor Bathymetry

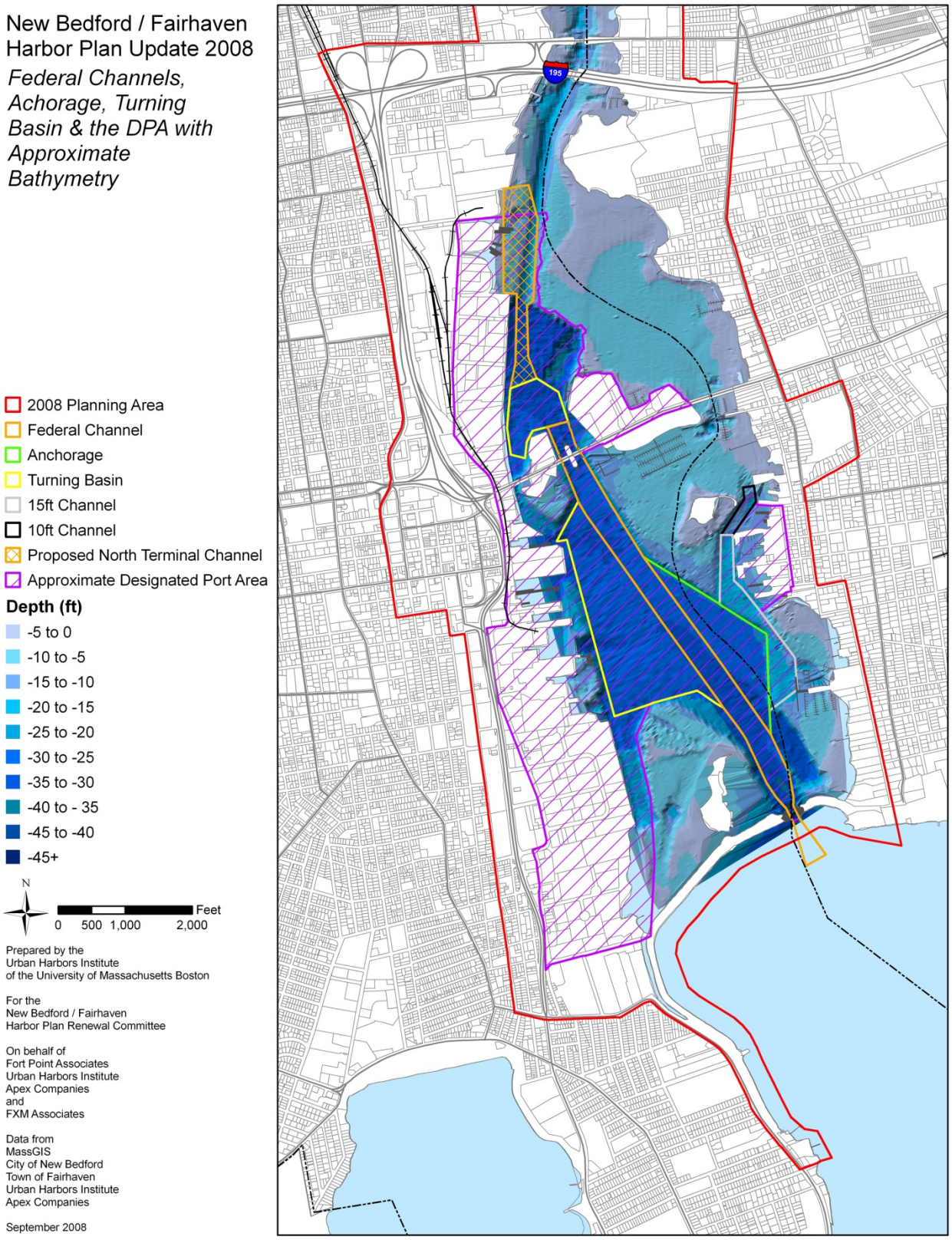
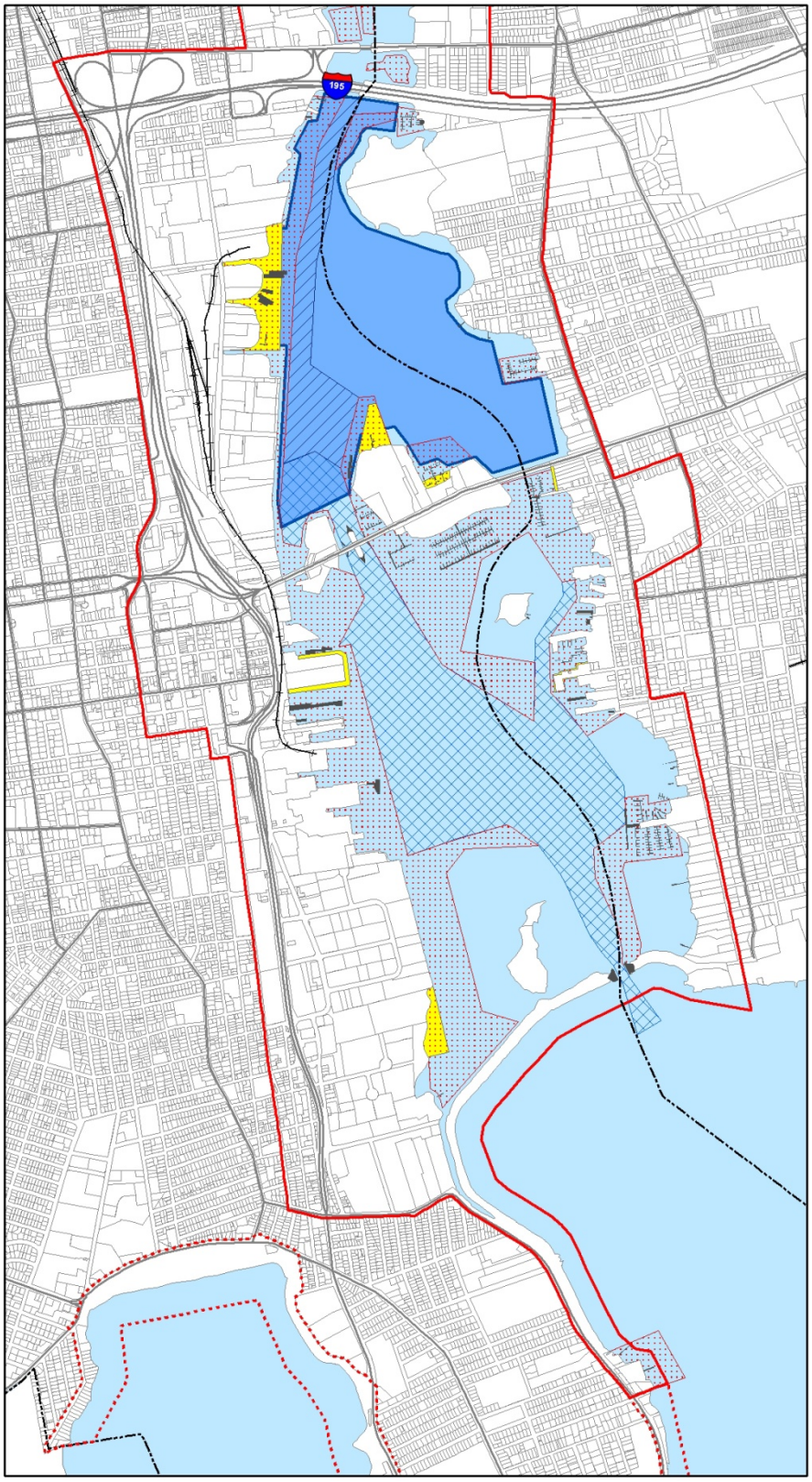


Figure 6.2 Dredging Projects

New Bedford / Fairhaven Harbor Plan Update 2008

Potential Waterfront Development Shoreline Facilities (WDSFs) and Dredge Areas



Secondary Planning Area
2008 Planning Area
TOWNS_POLY
Potential Dredge Area*
State/Other Channel
Army Corps Dredge Project Areas
Potential WDSFs
Boundary for CAD Cells (2008)

* Based on individual properties scheduled for dredging

N

0 500 1,000 2,000 Feet

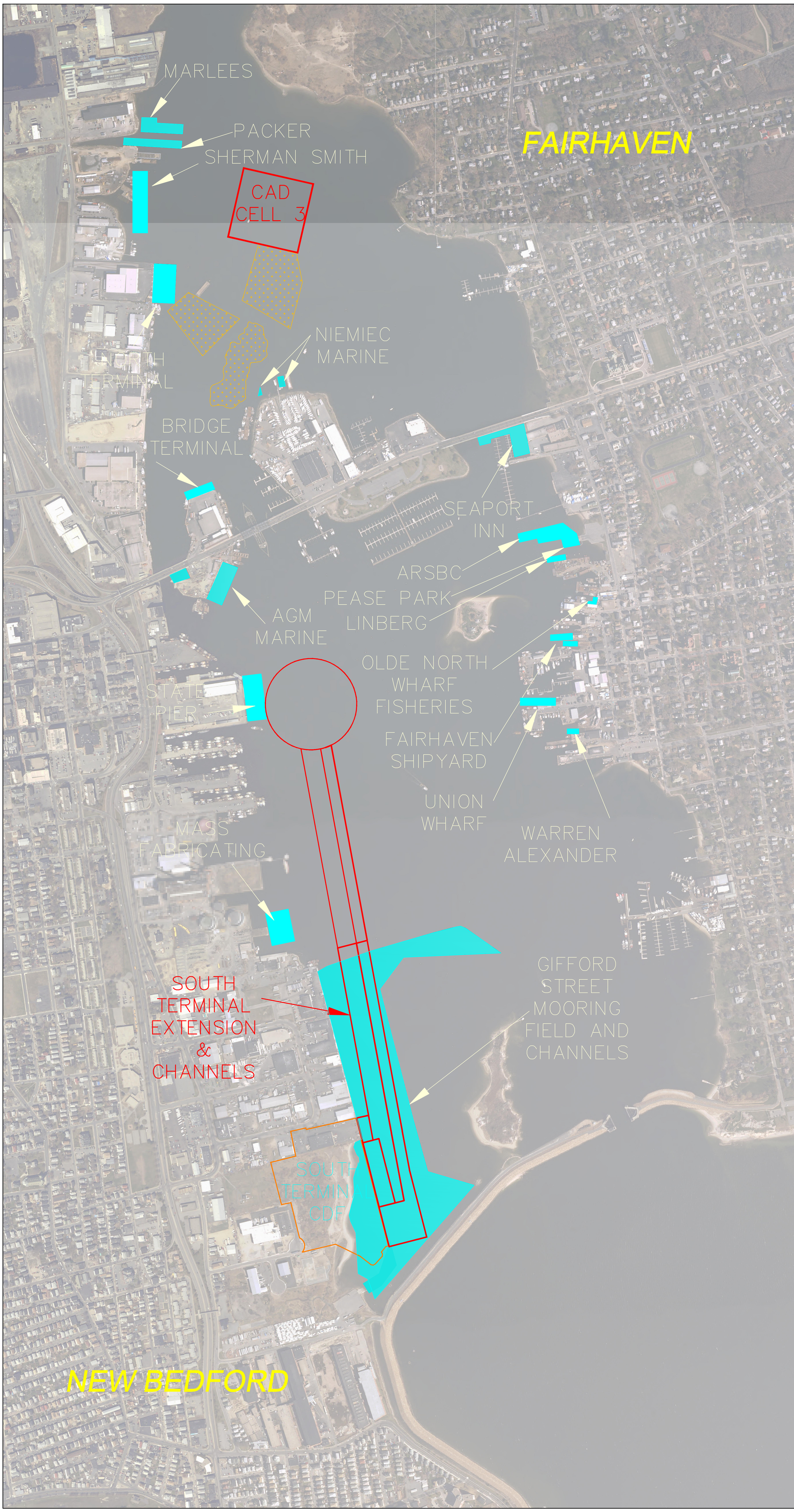
Prepared by the
Urban Harbors Institute
of the University of Massachusetts Boston

For the
New Bedford / Fairhaven
Harbor Plan Renewal Committee

On behalf of
Fort Point Associates
Urban Harbors Institute
Apex Companies
and
FXM Associates

Data from
MassGIS
City of New Bedford
Town of Fairhaven
Urban Harbors Institute
Apex Companies

December 2009



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REVISIONS

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HARBOR DEVELOPMENT COMMISSION · 41°38'N 70°56'W · NEW BEDFORD, MA

KEY:

- OTHER PHASE 4 AREAS
- CAD #3 PROPOSED
- CAD CELLS EXISTING
- GIFFORD STREET AREA (PHASE 4 DREDGING)
- SOUTH TERMINAL EXTENSION DREDGE AREA

PREPARED FOR:

THE NEW BEDFORD HARBOR DEVELOPMENT COMMISSION AND THE TOWN OF FAIRHAVEN, MASSACHUSETTS

DRAWING TITLE:

NEW BEDFORD/FAIRHAVEN PHASE IV DREDGE AREAS AND SOUTH TERMINAL AREAS

Scale: 1"=400'

0 200 400 800 1200

Date	9/23/10	Drawing No.
Proj. Mgr.		L-1
Design		
Check	CM	
Drawn	GCD	
Job. No.	6615	
Last Rev.	9/23/10	

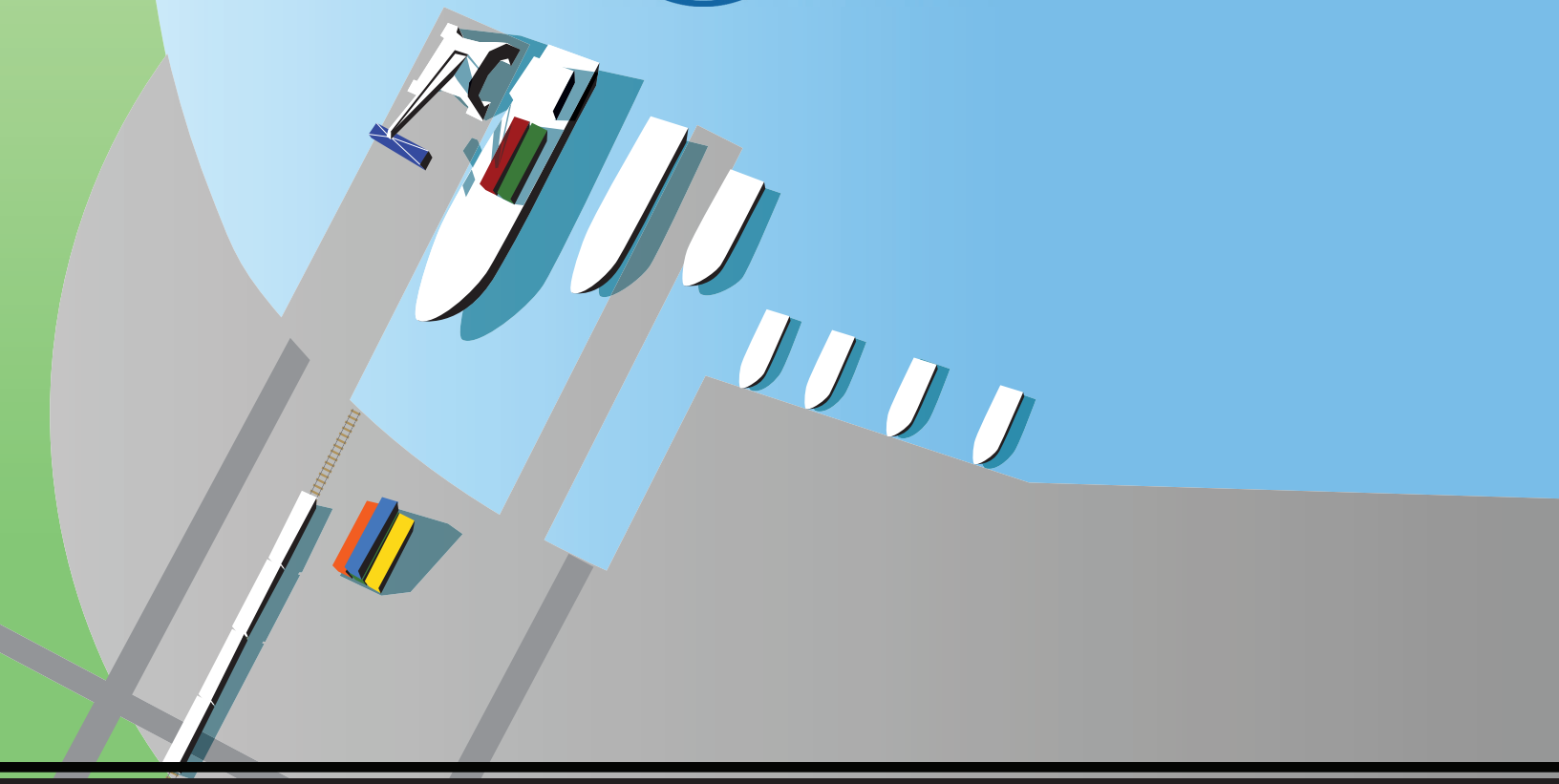
APPENDIX 2

FEBRUARY 2010

Port and Infrastructure Analysis for Offshore Wind Energy Development

PREPARED FOR

MASSACHUSETTS CLEAN ENERGY CENTER



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Port and Infrastructure Analysis for Offshore Wind Energy Development

Prepared by:

TETRA TECH EC, INC.

and

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FXM Associates

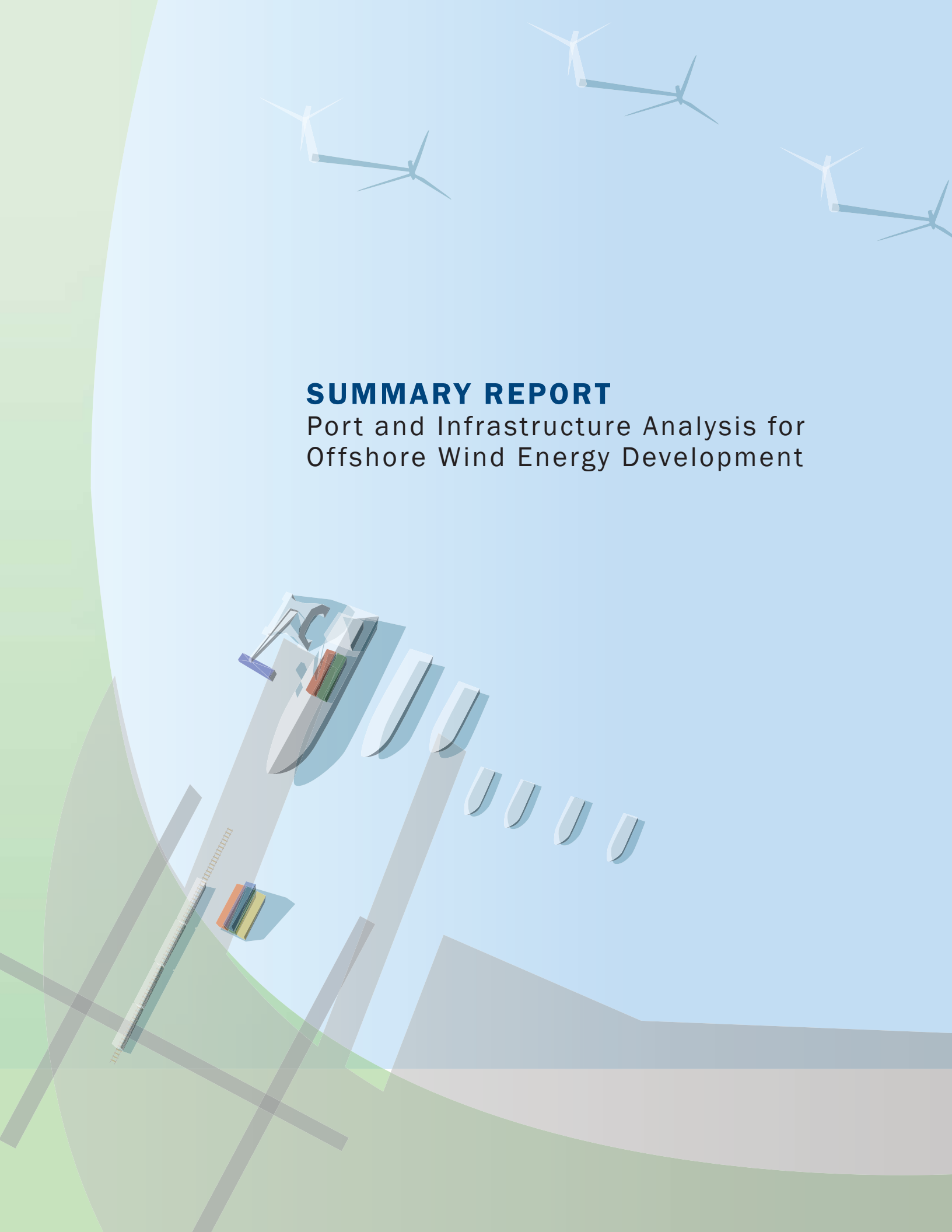
The Glosten Associates

MARPRO Associates International

February 2010

SUMMARY REPORT

Port and Infrastructure Analysis for Offshore Wind Energy Development



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ACRONYMS AND ABBREVIATIONS

DPAs	Designated Port Areas
EPA	Environmental Protection Agency
EWEA	European Wind Energy Association
FAA	Federal Aviation Administration
GDP	Gross Domestic Product
HDC	Harbor Development Commission
hp	horsepower
IBEW	International Brotherhood of Electrical Workers
LNG	liquid natural gas
MCEC	Massachusetts Clean Energy Center
MCZM	Massachusetts Coastal Zone Management
MDEP	Massachusetts Department of Environmental Protection
MDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MIT	Massachusetts Institute of Technology
MREC	Marine Renewable Energy Center
mt	metric ton
MW	Megawatts
nm	nautical miles
NPDES	National Pollutant Discharge Elimination System
OCS	the Outer Continental Shelf
OMP	Ocean Management Plan
psf	per square foot
ROWEI	Representative Offshore Wind Energy Installation
USACE	U.S. Army Corps of Engineers
WHOI	Woods Hole Oceanographic Institute

1 Introduction

1.1 Background

In the context of a widespread interest in reversing the climate effects of fossil fuels and federal and state incentive programs that promote growth in the use of renewables for electricity generation, the overall goal of this report ("Summary Report" or "report") is to identify port facilities in Massachusetts that have the ability to support offshore renewable energy development. This report also seeks to explore the feasibility and economic development potential, as well as the economic impacts, of planned and potential port and landside facilities at short-listed Massachusetts ports. For this first-of-its-kind study of port infrastructure to support offshore wind, the Massachusetts Clean Energy Center (MCEC) contracted with Tetra Tech EC, Inc. and a team of specialized professionals (collectively "the Team") to conduct this study and issue a report on the findings.

As stated in the Request for Proposals solicitation for this study "Offshore wind energy is the most viable option available for developing utility-scale renewable energy electric generating facilities to the densely populated states along the Eastern seaboard in the near term." Marine-based wind energy generation has the advantage as a renewable energy source because it is closer to commercial deployment than other marine-based renewable energy generation approaches, such as tidal and wave technology. Furthermore, the large scale of equipment and components required for wind generation (i.e. the blades, foundations and towers) means that if a port can physically support offshore wind generation it most likely will meet the requirements for other marine based renewable energy technologies. Therefore, this study focused primarily on how Massachusetts ports can meet the requirements of commercial scale offshore wind energy generation projects.

This Summary Report has been distilled from the more detailed report ("Final Report"). The Final Report provides the approach, analysis, and recommendations that resulted in the identification of potentially appropriate port facilities in New Bedford and Boston, Massachusetts, which were subsequently evaluated in more depth. It also addresses the high level engineering requirements, associated costs, and economic impacts of the proposed port improvements at the two short-listed ports. The Final Report provides the key findings of our study and recommendations to the MCEC of the most effective investment in port facilities to support offshore wind energy generation construction, operation, and maintenance.

1.2 Context

The Northeast Atlantic coastal waters, particularly those off Massachusetts, provide a combination of relatively shallow waters, favorable wind conditions, and proximity to population centers that makes this area uniquely attractive for offshore wind energy development. Those Massachusetts ports possessing the facilities, land area, and navigational characteristics necessary for the assembly and transport of wind turbine components, and for long-term operation and maintenance needs of offshore wind farms, are well-positioned to serve the emerging demands of the offshore wind energy industry.

In April 2009 the U.S. Department of the Interior Minerals Management Service issued final regulations on "Renewable Energy and Alternative Uses of Existing Facilities on the Outer Continental Shelf (Final Rule)," establishing a process for leasing submerged lands for renewable energy projects on the Outer Continental Shelf (OCS). The Final Rule outlines the requirements for limited (short-term – for testing and characterizing) and commercial (long-term – for power generation) leases and the bidding and regulatory procedures a wind developer must follow to obtain rights to a wind farm development site on the OCS.

Additionally, the Massachusetts Ocean Management Plan (OMP) was released on January 4, 2010 by the Commonwealth's Executive Office of Energy and Environmental Affairs (EOEEA OMP 2010). The OMP establishes new protections for environmental resources, and sets parameters for the development of community-scale and commercial-scale offshore wind energy as well as other infrastructure in State waters. The OMP designates which areas are prohibited from use and which may be used for wind energy farms and other renewable energy facilities. This new regulatory framework indicates interest in and expectation for future offshore development. Two renewable energy areas were identified based on the presence of suitable wind resource, water depth, and the absence of conflict with other uses or sensitive resources. These areas are located approximately one mile offshore in the vicinity of the southern end of the Elizabeth Islands and southwest of Nomans Land Island. These areas could accommodate approximately 150 3.6 megawatts (MW) turbines at full build-out (OMP pp 4-1). The Team recognized the potential for these sites to be developed for offshore wind energy and the implications for port and infrastructure to support offshore wind farms. Massachusetts ports with the potential to satisfy the infrastructure requirements of the offshore wind energy industry are well-positioned to support construction, as well as operation and maintenance in these areas.

Developers have yet to construct any offshore wind generation facilities in U.S. waters (to date only meteorological towers to test wind characteristics). In turn, U.S. port facilities have yet to stage construction for any offshore wind farms. Other than the import of landside wind farm components, East Coast ports have no experience in handling, storing or assembling the offshore wind generation components. Therefore, the current experience of European ports servicing offshore wind facilities and U.S. Gulf of Mexico ports staging construction for the offshore petroleum industry have formed the basis of the Team's analysis of the port infrastructure needed to support the East Coast offshore wind industry. The combination of the trend toward production of much larger components (such as blades with lengths approaching 90 meters) and the expectation that stateside developers intend to skip pilot scale offshore facilities (which would present learning opportunities) in favor of full-scale production projects, complicates the Commonwealth's preparation for this new industry. Also, the physical constraints in and around Massachusetts ports suggest that its ability to cost effectively stage such offshore construction will take both physical improvements and creative problem solving.

The focus of this port infrastructure analysis is to specifically determine:

- The required characteristics of a port facility to be considered an appropriate staging point for construction of offshore wind generation facilities;
- The difference between traditional port facility features and those required for delivery, storage, handling and deployment of large offshore wind farm components;
- The harborside (navigational) and landside (port facility) needs of purpose-built installation and component delivery vessels (now and in the future);
- Port facilities in the Commonwealth of Massachusetts that could be upgraded or expanded to be considered appropriate staging points;
- The costs for required upgrades or expansions at short-listed ports; and
- The ability of facility improvements to attract wind farm developers and government investment and to ensure a return on investment to the Commonwealth.

Construction staging depends on a number of variables, including number of turbines in a given development scenario, size and weight of the component pieces, schedule of material needs and their point of origination. Other factors include the degree of assembly prior to transport to the development site and the specialty equipment needed for final installation.

The following section provides an overview of offshore wind turbine components as an introduction, since each component has handling and care characteristics that need to be considered. The subsequent analysis characterizes navigation and port infrastructure requirements and identifies Massachusetts ports for further evaluation of the costs and economic impacts and benefits to upgrade port facilities to required standards.

2 Assessment of Offshore Wind Energy Port Infrastructure Needs

This section provides a description of wind farm components and the issues affecting their delivery and deployment and explains how other marine industries offer insight into navigational and port requirements for offshore wind deployment.

2.1 Wind Farm Components

Offshore wind turbine components include the turbine, tower, transition piece, and foundation (see Figure 1). The turbine consists of the nacelle, rotor (with blades) and hub. Most current large-scale turbines use a three-bladed rotor connected through the drive train to the generator, which is housed in the nacelle. Offshore wind turbines are typically larger than 2 MW in generation capacity because of the higher return on the construction investment in terms of power and revenue generation. In this analysis, the Team considered 3 MW or 3.6 MW turbines, as these are the current generation of turbines being installed. For the purposes of this study, a minimum offshore wind turbine array was assumed to consist of ten turbines. Based upon discussions with current and future developers, larger wind farm arrays would include from 60 to 150 turbines.

Various foundation structures can be used, depending on seabed geology, wind/wave conditions and water depth at the site. Four standard types of offshore foundation structures exist and are described below (see Figure 2).

- Monopile
- Gravity-Based
- Multi-Leg or Jacket
- Floating

Monopile and gravity foundations are commonly used in shallow and transitional water depths up to 90 feet. Multi-leg configurations with broader bases such as tripods, jackets, and suction bucket support structures are used for water depths of 180 feet or greater. Floating turbines may also become feasible long-term options for deep water (beyond 180 ft depth). These structures would be secured to the ocean floor via catenary guy wires, mooring lines, or tension legs, which in turn would be fastened to anchors or gravity-based platforms, according to a publication released by the U.S. Offshore Wind Collaborative in 2009.

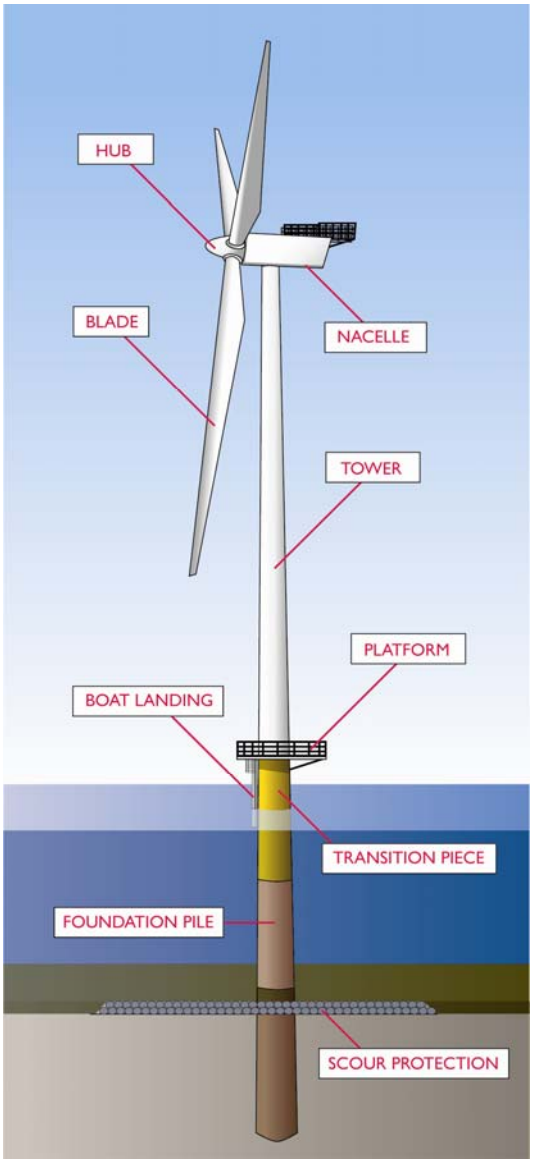

Figure 1 Primary Components of an Offshore Wind Turbine

Figure 2 shows five basic types of foundations. The illustration is not comprehensive as other pile type foundations exist. General depth ranges are shown in feet.

Dimensions of turbine components vary from make, model, and power rating. As stated above, most of the planned commercial-scale generation projects for the Northeast Atlantic coast expect to use turbines in the 3MW to 3.6MW range. Table 1 below provides an example of the magnitude of component dimensions.

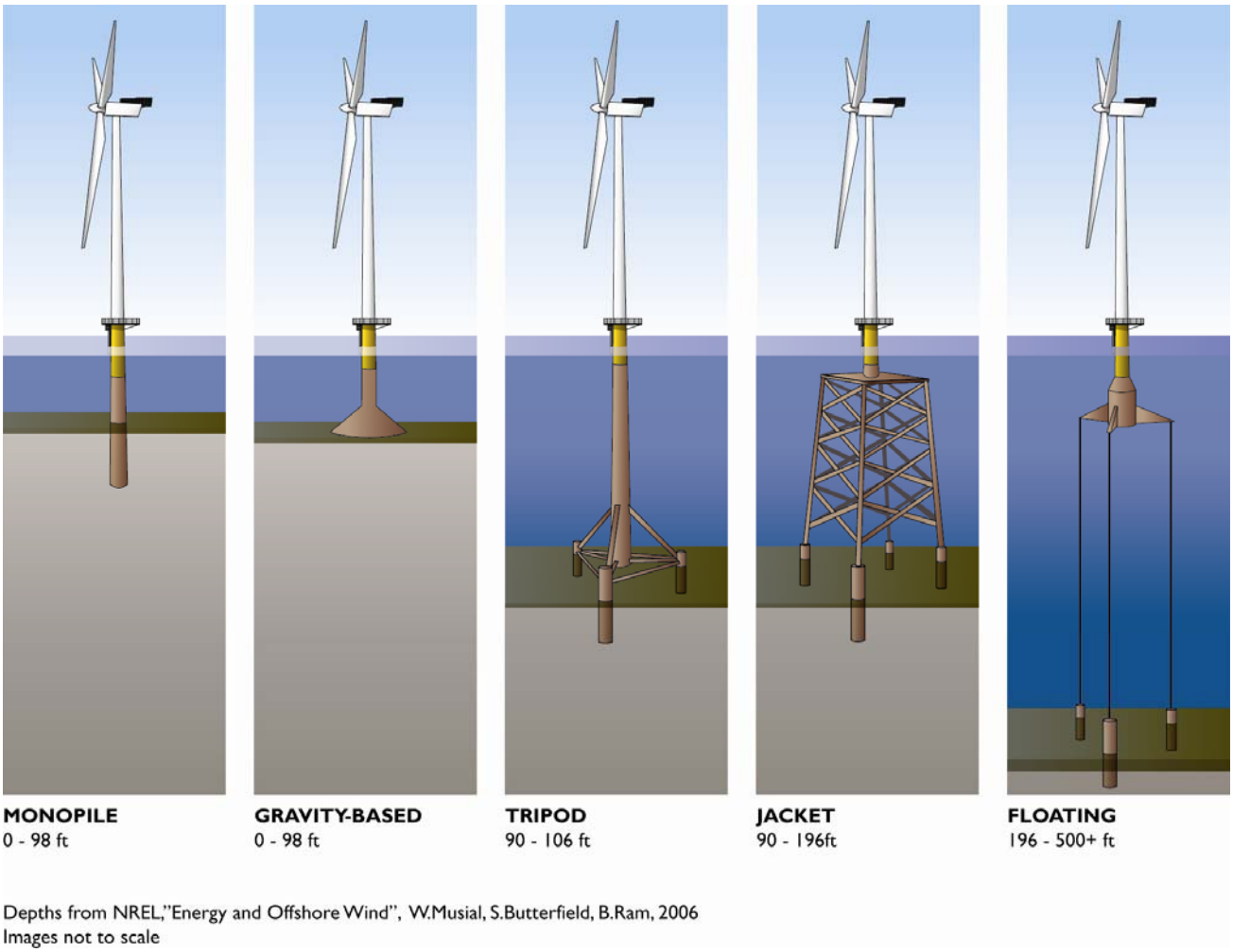

Figure 2 Types of Foundation for Offshore Wind Turbines

Table 1 Dimensions of Turbine Components (Technical data for Vestas V112-3.0 MW)

	Dimensions			
Turbine Component	**Weight**	**Length**	**Height**	**Width/Diameter**
Monopile foundation	165 to 231 US ton (for 90 to 130 ft long monopile) 551 US tons (for 197 ft long monopile)	Varying 90 to 130 ft to up to 197 ft	N/A	D: 16.75 ft / 18 ft)
Transition piece	187 US tons	56 ft per unit	N/A	D: 13.8 ft
Nacelle (incl. hub)	138 to 165 US tons	46 ft	10.8 ft	w: 12.8 ft
One Blade	14 to < 20 US tons	179 ft	N/A	Max. w: 13.8 ft
Tower Section	Approximately 77 US tons	106.6 ft	197 ft assembled	d: 13 ft to 15 ft

(Source: Vestas 2008)

2.2 Wind Turbine Component Delivery and Deployment

Currently, very few offshore wind turbine components suitable for commercial-scale offshore wind farms are being manufactured in the U.S. that are of the size appropriate for a wind farm with 60 to 150 turbines. Manufacturers will have little incentive to set up large scale offshore wind component manufacturing operations in the United States until developers are ready to purchase components at a rate that makes the investment in a manufacturing facility financially attractive (based on Team discussions with manufacturers). Therefore the Team's analysis assumes that most, if not all turbine component pieces for the planned offshore wind farms would be manufactured and shipped from European facilities.

Foundations and transition pieces tend to be manufactured and delivered separately from the turbines, although there may be some manufacturing capacity overlap with towers. Currently, no operational rolled steel manufacturing facilities on the East Coast have been identified at a scale suitable for a large offshore wind farms. Like turbine manufacturers, foundation suppliers lack the incentive to set up an East Coast production facility, and therefore it is likely that foundation components would be shipped ready to be assembled on large barges from the Gulf of Mexico, Europe or Malaysia. Rail and truck delivery options are limited to aggregate for scour protection, or sectional pieces such as iron bars or flat sheets of steel for use in the foundations or transition pieces. Fully assembled foundations have dimensions which preclude shipping by rail or truck.

Developers do not necessarily have to stage foundations for offshore deployment out of the same port staging the turbine construction. The convenience of utilizing a common port facility generally would not outweigh the cost savings associated with improved logistics, less assembly, and minimizing storage space and handling needs. Barges also may be used for foundation storage in certain circumstances. Foundations can be delivered and stored on barges fully assembled and then tugged out to the installation site with less handling.

Turbine components may be transported from the staging port to the installation site in various stages of assembly (see Figures 3, 4, and 5 below). *Vessel Requirements for Offshore Wind Farm Construction and Maintenance* (The Glosten Associates 2009), which is Appendix A of the Final Report, provides more details on these transport options. The options range between offshore on-site assembly and installation at the wind farm site, and turbine assembly in the controlled environment of the staging port, with the fully assembled turbines transported to the installation site in an upright position. Assembly at the offshore installation site lessens the risk

associated with fully assembled turbine transport, but entails risks associated with turbine assembly in the marine environment.

Turbine manufacturers and contractors experienced in European wind farm construction prefer specialized purpose-built vessels for turbine installation. Purpose-built vessels are not currently available in the U.S. and are not expected to be available for use in the U.S. in time for the initial construction of commercial-scale wind generation facilities on the East Coast. Construction costs for these vessels range from $40 million ($40M) to $80M for tugged vessels and $150M to $250M for self-propelled vessels (The Glosten Associates 2009). Similar to potential investment in manufacturing facilities, the incentive to build a purpose-built installation vessel will depend on actual demand and potential return on such investment. Existing U.S. built jack-up vessels are less than optimal for offshore wind turbine installation, but probably can be used for the initial deployments for East Coast offshore wind construction. However, the use of these existing vessels involves more risk and would require more installation time than purpose-built vessels. Rental rates for installation vessels are high and developers will attempt to maximize the utilization of the vessels when they have them. This factor, along with the ever present possibility of weather and seasonal delays, indicates that the staging port must be available 24 hours per day and 7 days per week. Both the availability of wind turbine components and delivery and construction vessels are critical elements of the offshore wind energy supply chain.

Future Trends

Proposed offshore wind projects in Europe and North America for 2015 are forecasted to reach 40 GW, of which the United States is expected to undertake projects totaling more than 2 GW (Infocast, U.S. Offshore Wind Report 2009, p. 6). The European Wind Energy Association (EWEA) has set a target for 2020 of 40 GW of offshore wind capacity. European offshore demand for 2010 is forecasted to reach 10 GW. This implies a European need for 30 GW or more over a 5-year span, which cannot be supported by current manufacturing capacity (EWEA, Oceans of Opportunity 2009, p. 44). However, the offshore wind industry will need to deploy upwards of 10,000 structures by 2020 to meet the minimum forecasted European demand. The current offshore manufacturing industry cannot deliver this number of structures due to insufficient capacity (EWEA, Oceans of Opportunity 2009, p. 49). Significant additional manufacturing facilities and related industrial capacity are needed to meet the forecasted European and North American demand.

2.3 Similar Offshore Activities

Offshore wind generation as a new marine industry on the U.S. East Coast will be added to a region that has historically been heavily dependant on maritime industry and commerce. As a new industry, however, offshore wind will require specialized equipment, services and labor not currently operating out of any U.S. ports. Understanding what will be needed to support both short-term construction activities and long-term operational and maintenance activities involves both learning from recent construction of European offshore wind projects, as well as identifying how similar services and activities already associated with existing marine industries here in the U.S are currently performed. There are a number of marine industries, each with its own port requirements, currently operating in the waters offshore of the U. S., including, but not limited to, petroleum extraction, liquid natural gas (LNG) ports, commercial shipping, and commercial fishing. The Final Report describes these existing U.S. marine industries in more detail and discusses potential similarities with the offshore wind industry.

Each marine industry is specialized, requiring differing shore-side support as well as equipment for conducting offshore operations. However, understanding the needs of these industries can help to identify the port-related requirements for offshore wind development and the potential utilization of the available marine equipment and facilities along the U.S. East Coast. In many ways, wind turbine foundations (and approach to installation) are comparable to offshore petroleum structures. Commercial fishing operation requirements are very comparable to offshore wind construction and operational needs. However, offshore wind generation support needs are much smaller in scale than the warehousing and wharf frontage needed for commercial shipping. Port and support vessel requirements for maintenance of offshore wind farms are similar to those for commercial fishing, offshore LNG ports, and petroleum platforms. Offshore wind turbine foundation technology has been developed based on structural foundations already in use in petroleum extraction, primarily the use of piles and jackets. As with wind turbine foundations, the foundation types for petroleum platforms vary greatly with water depth. Deep water technologies such as semi-submersible and floating platform equipment are being explored for the offshore wind industry as well as deep water LNG ports. Anchor systems similar to those used for petroleum and LNG ports could be modified for use as wind turbine foundations, anchoring floating turbine structures in deep water locations.

Petroleum extraction platforms are currently assembled using specialized heavy lift vessels. Vessels currently in the fleet (including jack-up cranes, tow boats, and large barges) have the potential to be modified for use as construction platforms for wind turbines. While such modifications can be made to existing vessels, the specialized construction techniques and heavy lift needs of offshore wind turbine construction may make the modification option expensive and potentially risky. The option of applying modified existing equipment may also be limited to smaller construction projects in near-shore environments. Purpose-built construction vessels for offshore wind turbine construction most likely, in the long run, would be more cost effective, less risky, and flexible in terms of operational capabilities. An offshore wind farm, once constructed, will need operational support in the form of routine maintenance. Maintenance vessels used during wind farm operations would likely be similar in size to those currently in use to support offshore LNG ports and petroleum extraction operations. Berthing space for support vessels will be vital for port facilities, as well as yard and warehousing space for components and other maintenance supplies.

3 Industry Overview

3.1 Development of Port Criteria

To determine the port-facility/land-based requirements for both the installation and long-term servicing of planned offshore wind projects, the Team:

- Held discussions with offshore developers and compiled relevant data;
- Conducted research and compiled data on manufacturer requirements;
- Determined key harborside and landside port parameters;
- Developed a list of evaluation criteria for harbors and port facilities; and
- Identified the most highly desirable characteristics of port facilities.

The following sections of this Summary Report describe some of the specific areas of analysis listed above.

3.2 Discussions with Developers

The Team identified and contacted several prospective U.S. East Coast offshore wind farm developers with the goal of compiling a detailed understanding of the requirements necessary to successfully support the construction, operation and maintenance of a commercial-scale offshore wind farm. The Team intended to use this developer input to identify an objective set of weighted criteria with which to compare and evaluate Massachusetts port facilities. Many developers have yet to specify or disclose in detail the key parameters and characteristics that were sought for this purpose; however, developers did identify and explain many aspects of the most important parameters, which helped the Team establish the basic port criteria. The Team's discussions with developers did provide a better understanding of offshore wind farm components and the logistics of importing, storing, assembling, scheduling, and deploying wind turbines and foundations to installation sites.

Some developers have already initiated permitting or applied for lease blocks for several wind generation sites along the East Coast. From the available information on these projects, the Team determined that port infrastructure must support projects of varying scale ranging from 60 to 150 turbines. These proposed projects formed the starting point for the Team's analysis of port requirements. Table 2 below provides a quick view of these proposed projects based on available public information. Projects are listed by developer with particulars such as location, water depth, generating capacity, number of turbines, and distance from shore. Because these projects are in various stages of development, not all information on every project is publicly available.

As the developer's needs were analyzed, the Team found that Massachusetts ports had clear, distinguishable differences relative to the offshore wind development requirements.

Table 2 Planned Offshore Wind Projects

Developer/Project	Project Location	Water Depth at Proposed Location	Project Generating Capacity	Number of Turbines (Scale)	Foundation Type	Estimated Cost of Construction	Port Staging Area
Cape Wind Associates							
Cape Wind	4.5 NM (5.2 miles) from coast of Cape Cod, MA, 7.8 NM (9 miles) from Martha's Vineyard, 12 NM (13.8 miles) from coast of Nantucket Island	3.7 m (12 ft) MLLW (mean low low water) minimum depth	468 MW	130 (3.6 MW per turbine)	Monopile	$700 million	Quonset Davisville Port and Commerce Park, Quonset, Rhode Island
NRG Bluewater Wind							
Bluewater Delaware	11.3 to 19.1 NM (13 to 22 mi) east of Rehoboth Beach, DE (wind park); 14.3 NM (16.5 mi) due east Rehoboth Beach (met tower)	12.2m to 18.3m (40 to 60 feet)	200 to 450 MW	Up to 150	Monopile	$800 million	Port of Wilmington, Delaware; Delaware Bay Launch in Milford Delaware for crew boat and small cargo barge launch
Bluewater New Jersey	14 NM (16 mi) southeast of Atlantic City, NJ	21.3m to 30.5m (70 to 100 feet)	350 MW	116	Monopile	$1.4 billion	Port of Wilmington, Delaware; Delaware Bay Launch in Milford Delaware for crew boat and small cargo barge launch
Deepwater Wind							
Garden State Offshore Energy (Deepwater with PSEG Renewables)	13.6 NM (15.6 mi) from shore, 17.4 NM (20 mi) due east of Avalon, NJ	24.4m to 27.4m (80 to 90 feet)	350 MW	96	Jacket	$1 billion	Atlantic City, New Jersey
Deepwater Wind Rhode Island	2.6 NM (3 miles) off Block Island, RI for Phase 1; Phase 2 located 13 to 17.4 NM (15 to 20 mi) off RI coast (location TBD upon completion of RI Ocean Special Area Management Plan in 2010	'deeper' waters	20 MW (Phase I) 400 MW (Phase II)	Phase 1: 8 turbines Phase 2: 106 turbines	Jacket	$1 billion	Quonset, Rhode Island

Table 2 Planned Offshore Wind Projects

Developer/Project	Project Location	Water Depth at Proposed Location	Project Generating Capacity	Number of Turbines (Scale)	Foundation Type	Estimated Cost of Construction	Port Staging Area
Fisherman's Energy							
Fisherman's Energy of New Jersey Project	Phase 1: 2.6 NM (3 miles) off the coast of Atlantic City Phase 2: 6.1 NM (7 miles) off the coast	18.3m to 21.3m (60 to 70 feet)	Total: 350 MW Phase 1: 20MW Phase 2: 330 MW	Total: 74 Phase 1: 8 turbines Phase 2: 66 turbines	Monopile	$100 million for Phase 1 $1 to 1.5 billion for Phase II	Dorchester, Atlantic City, and or Cape May, New Jersey
Fisherman's Energy of Rhode Island Independence 1 Project	2.6 NM (3 miles) south off the southern coast of Block Island, RI	20 m to 30 m (65.6 to 98.4 feet)	400 MW	80	TBD	$1.25 to $1.5 billion	TBD

3.3 Key Parameters: Conditions at Ports and Wind Farm Locations

Wave height, water depth and wind speed impose limitations on at-sea construction operations. The Team studied sea states, wind conditions, and water depths at a number of proposed wind farm sites along the U.S. East Coast, as well as transit distances between proposed wind farm sites and potential staging ports.

The base line transit routes for cargo in the region track around the east end of Cape Cod and the primary alternative route is via the Cape Cod Canal (MARPRO Associates International 2009). Air draft (i.e., the free space above the water line below an overhead obstruction) in the Cape Cod Canal is limited to approximately 135 feet. Vessels or barges transporting 5 MW turbines in the "bunny ear" configuration (especially the "fore-aft" configuration – See Figures 3 and 4) most likely cannot transit the Cape Cod Canal. Alternative turbine load-out configurations (e.g., the "star" configuration – See Figure 5) and/or smaller turbines (e.g., 3.6 MW turbines) in the "bunny ear" configuration probably could utilize the Cape Cod Canal.

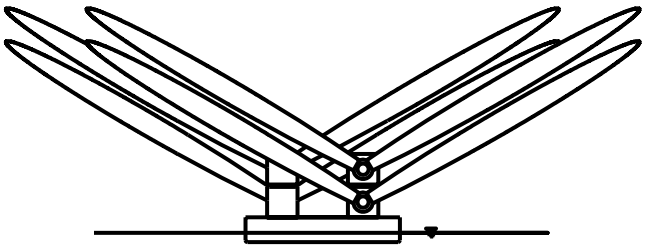

Figure 3 Bunny Ear Configuration (Lateral) – End view looking forward

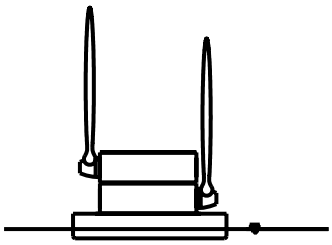

Figure 4 Bunny Ear Configuration (Fore-Aft) – End view looking forward

Figure 5 Star Configuration – End view looking forward
(Source of Figures 3-5: The Glosten Associates 2009)

3.4 Key Parameters: Vessel Constraints and Requirements

Characteristics of Available Vessels

The following sections discuss the basic characteristics, capabilities, limitations, and general availability of vessels that are currently available for use in the construction and maintenance of offshore wind farms. *Vessel Requirements for Offshore Wind Farm Construction and Maintenance* (The Glosten Associates 2009), which is Appendix A of the Final Report, provides further details.

Turbine Import/Delivery Vessels

The turbines used for the first round of U.S. offshore wind farms likely will be imported from Europe. Turbines are generally shipped in pieces (tower sections, nacelle, hub, individual blades) from the point of origin directly to the project site aboard open hatch cargo vessels.

Foundation Delivery and Installation Vessels

Foundations can be installed using either jack-up crane vessels or floating derrick barges. Jack-up crane vessels are described further below. Large floating derrick barges are in service on all three major U.S. coastlines and could be mobilized to serve the U.S. East Coast offshore wind energy market. Depending on the type of foundation being used (i.e., monopile, gravity-base, jacket, or tripod), a derrick barge could transport foundations between the staging port and the wind farm site on its own deck, or foundations could be transported using a separate barge.

Wind Turbine Installation Vessels

European offshore wind turbines have been installed using a variety of specialized equipment, which generally falls into one of three categories:

- Leg-Stabilized jack-up crane ships ("partial jack-ups");
- Jack-up crane barges; and
- Jack-up crane ships.

For all three vessel types, the limiting wind speed for at-sea crane operations is approximately 15 to 20 knots. For the leg-stabilized vessels, the limiting sea state for crane operations is approximately 1.7-foot seas, as the vessel's hull remains submerged and is subject to wave-induced motion. For the jack-up barges and ships, the process of jacking up and down is limited to approximately 5-foot seas. The crane can be operated in higher sea states once the vessel is jacked-up. Future wind turbine installation vessels are expected to focus on improving construction efficiency through faster transit speeds, larger payload capacity, and ability to erect turbines in higher wind speeds and larger sea states.

Maintenance Vessels

Regular, planned maintenance of offshore turbines requires personnel access to the wind farm facilities. Maintenance personnel are typically shuttled to the turbines by a crew boat or by helicopter. Major maintenance or repair of offshore wind turbines may require mobilization of a wind turbine installation vessel to reverse some or all of the installation process.

Vessel Requirements for Deployment and Maintenance

Understanding the marine vessel requirements for deploying and maintaining offshore wind farms along the U.S. East Coast is critical in the overall evaluation of ports' suitability as staging areas for offshore wind farm development. Vessel requirements are governed primarily by the following:

- Physical conditions in which vessels must operate at offshore wind farm sites;
- Size and weight of turbines being transported and installed; and
- Methodology for transporting and installing turbines.

The Team evaluated physical conditions, including wind speeds, wave regime, and water depth at proposed offshore wind farm installation sites along the U.S. East coast, as well as navigational constraints in and near existing Massachusetts port facilities. The Team reviewed demonstrated methodologies for transporting and installing offshore wind turbines.

Installation and Transport Vessel Requirements

For purposes of this study, it was assumed that the installation vessels discussed below would be subject to the Jones Act, which requires vessels engaged in the transport of passengers or cargo between U.S. places to be built and flagged in the United States, and owned and crewed by U.S. citizens.

The key dimensions of the turbine installation and turbine transport vessels are beam, length, draft, and vertical clearance (a.k.a. "air draft"). The beam of installation and transport vessels is largely dictated by vessel stability requirements during transit and, when applicable, the stability requirements and structural strength while elevated on legs (i.e., "jacked up"). The length of the vessel depends on functional and cargo requirements and structural considerations. The vessel's draft, or the required clearance between the waterline and sea bed, is dependant on the hull form and total weight, including cargo. Vertical clearance is dictated by three factors: length of legs (for a jackup barge or vessel), pre-assembly methodology, and crane height in the stowed position.

Figures 6 and 7 show a fully loaded 400-ft x 100-ft (length x beam) barge with jackup legs in transit and after installation configurations, respectively. Turbine tower sections are typically transported in the vertical orientation, with maximum height approximately even with the top of the blades in the bunny ear configuration.

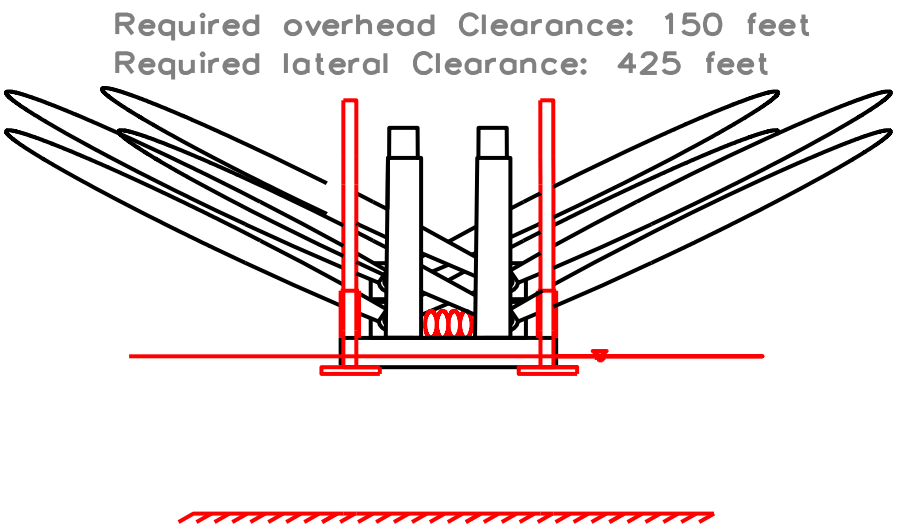

Figure 6 Loaded Barge in Transit

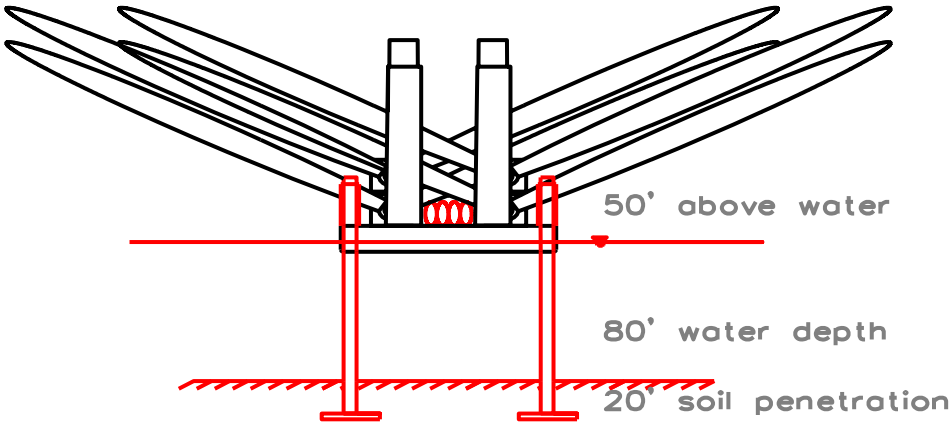

Figure 7 Barge on Site with Legs Down
(Source for Figures 6 and 7: The Glosten Associates 2009)

The required overhead clearance is approximately 150 ft. The star (Figure 5) and lateral bunny ear (Figure 3) configurations require a lateral clearance of approximately 425 ft. The lateral clearance for the fore-aft bunny ear (Figure 4) configuration is dictated by the barge or vessel beam, which is typically on the order of 100 to 125 ft. In the near future, it is expected that specialized installation vessels will transport multiple pre-assembled turbines on tower sections out to the installation sites, requiring overhead clearances in excess of 300 ft.

The principal dimensions and draft characteristics (navigational and air) of a typical installation or transport vessel are presented in Table 3.

Table 3 Principal Dimensions for Turbine Installation or Transport Vessels
(Source: The Glosten Associates 2009)

Length Overall	90 – 140 m (300' – 450')
Beam	30 – 40 m (100' to 130')
Navigation Draft	3.6 – 4.9 m (12' to 16')
Air Draft (legs in up position)	varies, approximately 46 m (150')
Air Draft (tower sections, bunny ears)	46 m (150')
Air Draft (crane in stowed position)	varies

Section 4.4.1 of the Final Report provides additional details of the principal dimensions of wind turbine installation vessels/barges and import vessels.

Tugboat and Auxiliary Vessels

Self-propelled wind turbine installation vessels likely will not require tug assistance, as they would be able to move and position themselves using their own propulsion and dynamic-positioning systems. Barges, on the other hand, would require at least one tug of approximately 4,000 to 5,000 horsepower (hp). In addition, a smaller tug of around 1,000 hp may be needed to help position the vessel for jacking operations. Additional necessary vessels include high-speed crew boats during wind farm construction and several auxiliary vessels to complete the marine fleet. These types of vessels are all readily available for hire throughout the Northeast U.S.

3.5 Key Parameters: Navigational Access and Transit Distances

The required navigational clearances for vessels involved in the construction and maintenance of offshore wind farms were presented. The key considerations for navigational access are:

- Vessel draft compared to navigable water depth;
- Vessel beam (including overhanging cargo) compared to channel width; and
- Vessel air draft compared to overhead clearance restrictions (bridges and aerial cables).

Table 4 summarizes the navigational restrictions associated with selected Massachusetts ports. Further details are given in *Vessel Requirements for Offshore Wind Farm Construction and Maintenance* (The Glosten Associates 2009), which is Appendix A of the Final Report.

Table 4 Summary of Navigational Constraints at Selected Massachusetts Ports

Staging Port	Potential Obstructions	Lateral Clearance	Overhead Clearance	Controlling Water Depth	Feasible Turbine Load-Out Configurations	Jack-Up Feasible?
New Bedford	Hurricane Barrier	45 m (150')	No Constraints	6.7-9.1 m (22'-30')	all	yes
Gloucester	water depth, channel width	61 m (200')	No Constraints	4.9-5.8 m (16'–19')	fore-aft bunny ear	Marginal (water depth)
Fall River	Mt. Hope Bridge	122 m (400')	41 m (135')	12.2 m (40')	star	Marginal (air draft)
Charlestown / East Boston (inner harbor)	Logan Airport	over 150 m (500')	Report air draft to airport traffic control	12.2 m (40')	all	yes

Table 4 Summary of Navigational Constraints at Selected Massachusetts Ports (continued)

Staging Port	Potential Obstructions	Lateral Clearance	Overhead Clearance	Controlling Water Depth	Feasible Turbine Load-Out Configurations	Jack-Up Feasible?
Mystic River	Tobin Memorial Bridge	over 150 m (500')	41 m (135')	7.6-10.7 m (25-35')	star	Marginal (air draft)
Chelsea River (West of Chelsea St. Bridge)	Andrew McArdle Bridge	53 m (175')	No Constraints	8.8-12.2 m (29-40')	fore-aft bunny ear	yes
Chelsea River (East of Chelsea St. Bridge)	Chelsea St. Bridge	28 m (93')	25 m (83')	8.8-12.2 m (29-40')	rotor disassembled	no

In selecting a support facility, distance to the wind farm must be considered in term of cost and effect on risk. Distance impacts fuel consumption, insurance and schedule costs. When turbine components are in transit from the staging port to the installation site, they are more vulnerable to risks associated with weather events and the ocean environment. The cost differential between a distant state-of-the-art facility and a closer facility with less than optimal component handling ability must be carefully evaluated. Table 5 provides transit distances to staging port locations from the Massachusetts OMP Wind Energy Areas located near the southern end of the Elizabeth Island and southwest of Nomans Land Island.

Table 5 Distances to Staging Port Locations from the OMP Wind Energy Areas

Staging Location	Primary Route Distance [nautical miles]	Alternate Route* Distance [nautical miles]
Boston, MA	260	100
Gloucester, MA	235	100
New Bedford, MA	35	n/a
Fall River, MA	50	n/a
Portland, ME	290	175
Quonset/Davisville, RI	40	n/a

* Alternative route is via the Cape Cod Canal

Staging Through-put Estimates

The Team examined the expected level of activity at a port serving as a staging area for offshore wind farm development and estimated the construction time for wind farm construction. Multiple wind farm construction scenarios were considered in order to develop upper and lower bounds of expected port activity. For this analysis the primary metric of port activity is the number of wind turbines deployed per month, which is referred to as "through-put."

The results of the desk top time line modeling of three different staging scenarios for New Bedford, MA were as follows:

- The time line modeling of the Baseline scenario for turbine staging and installation yielded an expected through-put of 15-18 turbines per month for 6-9 months.
- The time line modeling of the Optimistic scenario for turbine staging and installation yielded an expected through-put of 16-22 turbines per month for 12-15 months.

- The time line modeling of the Aggressive scenario for turbine staging and installation yielded an expected through-put of 15-20 turbines per month for 12-15 months and thereafter an expected through-put of 21-25 turbines per month for an additional 8-10 months.

Additional wind farm construction scenarios were evaluated to develop a better estimate of the potential ranges of through-put that may be required at regional staging ports. Each scenario was defined by a vessel type, a transit distance and a length of the construction season. The results of these multiple modeling runs are summarized in Table 6.

Table 6 Expected Through-Put at Staging Port, for Various Construction Scenarios

Transit Distance (staging port to wind farm site *)	Existing Vessels **		Future Vessels ***	
	Summer	Winter	Summer	Winter
50 nautical miles	20-22 turbines/month	16-18 turbines/month	30 turbines/month	30 turbines/month
150 nautical miles	18-20 turbines/month	15-17 turbines/month	21-25 turbines/month	21-25 turbines/month
250 nautical miles	15-17 turbines/month	12-15 turbines/month	16-20 turbines/month	16-20 turbines/month

Notes:
* The transit distance from New Bedford to the Cape Wind site is approximately 60 nautical miles (nm). The transit distance from Boston to Cape Wind is approximately 130 nm. The transit distance from New Bedford to the Deepwater sites near Delaware Bay is approximately 260 nm.
** Existing Vessels means jack-up vessels or barges with slewing cranes, typical of present European offshore wind farm construction practice.
*** Future Vessels means vessels or barges that transport and install fully assembled turbines.

(Source: The Glosten Associates 2009)

The through-put estimates are for turbine installation only. Foundation installation is typically completed in advance of turbine installation and can utilize a wider range of vessels and staging ports than turbine installation. For U.S. offshore wind farms, foundation installation can be completed using existing equipment, which is currently available.

Using a through-put of 18 to 22 turbines per month (based on the results of the time line modeling discussed above), the turbine manufacturer would want 20 nacelles stored at the staging port in advance of assembly and deployment. As workers assemble the turbines in preparation for loading onto the installation vessel, and bad weather hits the installation site, the assembled turbines would have to be stored at the port. Unassembled turbine components would continue to arrive from the manufacturer and require additional storage space for 20 more turbines. Throughput requirements translate into the laydown requirements discussed in Section 3.6 and may require multiple port facilities to support a given offshore wind development.

3.6 Key Parameters: Staging Port Facility Requirements

One developer we interviewed provided a description of the ideal port facility to support offshore wind; a port would have a 1000-ton crane on rolling tracks, which would carry components from a delivery vessel to a storage location; sufficient linear footage to efficiently load/unload one vessel at a time, with a preference for multiple deepwater berths to unload several vessels simultaneously; a secondary 80-ft berth; and about 200 acres for assembly and storage.

While no existing Massachusetts port facility has an assembly and staging area this large, the existing Commonwealth facilities could be repaired, upgraded, or expanded to provide sufficient area to meet the other requirements for staging offshore wind farm construction. If it is necessary to provide a larger area at these existing facilities, then a combination of properties at these marine parks, a combination of ports, or barge storage would have the ability to provide additional space.

Physical Considerations for Staging Turbines

There are a few minimum physical port characteristics that are necessary to stage offshore wind farm development. Based on a review of various European projects and available information from manufacturers, as well as discussions with potential U.S. offshore wind developers, the desirable (minimum) characteristics include:

1. Minimum 24-ft depth of water at low tide;
2. Minimum 450-ft berth;
3. Minimum horizontal channel clearance to harbor of 130 ft;
4. No restriction or air draft limitation on vertical clearance (in anticipation of a future need to transport fully assembled turbines to the installation site); and
5. Minimal distance in open water to project site (see Table 5 above).

Harborside

Water depth requirements relate directly to the vessel type, draft and function. The minimum water depth at mean low water applies to both the navigation channel and the berth. The deepest draft vessel used for transporting offshore wind components sets the navigation channel depth criteria. The vessel length of the largest expected vessel establishes the berth length. With visits from import vessels and transport/installation vessels overlapping, multiple berths or longer berths become more desirable.

Horizontal channel clearance not only depends on vessel beam, but also on component overhang during transport to the installation site. Unobstructed vertical clearance is highly recommended because of likely deployment methods in the future. Turbine manufacturers expect 197 foot-tall tower sections to be transported to the installation site in the upright position. If the turbines are fully assembled for transport, then the nacelle and blade would add significantly to this height. Furthermore, various installation tasks require jack up vessels (for stability at the site), the retracted legs of which would be in the 'up' position. There may be methods to work around vertical obstructions, such as placing a connector pin in the legs or utilizing a hydraulic leg that compresses within itself; however, these methods could add significant expense and complication. The salient point, however, is that vertical obstructions will limit assembly, transport, and vessel options. Further detail on vessel drafts and obstruction clearances can be found in Appendix A of the Final Report.

Landside

The port facility must have adequate laydown space for delivery, storage and assembly of turbine components. Among developers, manufacturers, and European staging facilities the estimated area varied widely, but a minimum of 10 acres was required with a 15- to 25-acre area desirable. If all components of a large development (110 turbines) were to be fully stored on land prior to installation, including both assembly and foundation

components, the area required would be about 200 acres. In general, the logistics of manufacturing, assembly, and installation would not require all elements to be on the ground at one time.

To maximize the use of construction equipment, vessels and crews, turbine suppliers require storage based on two factors: (1) having a supply of turbine components ready for assembly and deployment; and (2) having an additional area ready for instances where weather precludes deployment to the installation site while import vessels continue to deliver components to the staging port. While turbine assembly continues, the newly arrived unassembled turbine components need storage. Based on a manufacturer's recommendations, and assuming storage of 20 or more turbines at any one time, the minimum space needed in this scenario is about 8.5 acres.

An additional accommodation for interior storage and/or fabrication space is necessary at the port facility. Developers, contractors and manufacturers also have a strong preference for office space on site. Worker accommodations at the staging port or on a 'hotel' ship at the installation site did not emerge as a major factor in port selection decisions. Construction workers at the installation site would travel on fast crew transport vessels from the construction site to various landing points.

Based on the weight of many of the components, the lay down space may require very high load bearing ground or deck capacity. Using a simple "footprint" analysis, these loads can reach well over 2,000 pounds per square foot (psf). As with many of the facility needs, the deck/ground capacity issue can be accommodated by using certain types of equipment or by placing "load spreading" mats or slabs. Various cranes and other types of material handling equipment will be needed, but it is anticipated that the fabrication or erection contractor would provide these items. Table 7 summarizes the key crane requirements for two representative turbines (a Siemens 3.6 MW Offshore Turbine and a REPower 5 MW Offshore Turbine) and typical monopile components. Load capacity was not used as a criterion to short list the ports, but rather was an issue further analyzed in the engineering review of the shortlisted facilities.

Table 7 Crane Requirements for 3.6 MW and 5 MW Turbines and Associated Monopile Foundations
(Source: The Glosten Associates 2009)

	Siemens 3.6 MW	REPower 5 MW	Monopiles
Max Pick Weight*	Nacelle: 125 mt (138 tons)	Nacelle: 290 mt (320 tons)	180 – 455 mt (200 – 500 tons)
Max Pick Height**	80 m (260 ')	85 – 95 m (280'-310')	Less than 30 m (100')

* 1 ton = 2000 pounds = 0.908 metric ton (mt);
** height above calm sea surface

As noise levels at operating landside facilities must comply with applicable regulatory limits, this factor was not viewed as a discriminator for short-listing ports.

Physical Considerations for Staging Foundation Transport

Harborside criteria established for turbine transport do not apply to foundations, which can be transported flat on barges. Barge transport of foundations would not have the same height, draft or clearance requirements as that for turbine transport; however, the foundation installation vessel may have similar characteristics as the turbine installation vessel. If the foundation installation jack-up vessel is at the construction site and barges are used to transport foundations to the site, then there would be more options for the staging facility. Port facilities with insufficient navigation access for turbine staging potentially could stage foundation deployment.

The staging requirements for foundations depend upon the stage of assembly phase upon arrival and the size and type of foundation. The size of the foundation depends on the size of the assembled turbine and tower, transition piece and blades and the maximum wind load imposed on them, as well as the geotechnical conditions and water depth at the installation site. The staging facility will need landside areas for loading and unloading, storage, and potentially for assembly of foundations components. Fully assembled foundations require a storage area. This area needs to be larger if foundation assembly is required. Shipping unassembled steel bars maximizes cargo space, which would lower shipping costs by reducing the number of shipments. However, the shipping of unassembled foundations or foundation parts would involve the labor cost associated with bar welding. In this case, foundation staging becomes a financial decision.

Manufacturing and Assembly Requirements

Monopile foundation manufacturing utilizes a series of specialized machines not currently available on the East Coast of the U. S. The industry views this potential market as lucrative enough to consider opening facilities in anticipation of offshore wind energy development. However, the investment risk remains similar to that of turbine and purpose-built vessel construction. Until the demand is sufficient for a profitable return on investment, monopiles for East Coast offshore wind farms will have to be manufactured elsewhere. However, a phased approach can reduce the initial investment risk. Monopile pieces can be shipped to a staging port as ‘cans’, or basically smaller sections of rolled steel. At the staging port the ‘cans’ would be welded together to form the monopiles.

3.7 Key Parameters: Rail and Highway Access

The ability to move component parts via rail is determined by rail corridor track curvatures, component weights, and loaded height on the rail car. In general, the weight and length of the proposed units can be handled by the nationwide system. Components can be designed to be transported on the national rail system. They can be broken down to insure they do not exceed rail system limitations on weight or clearance.

Overweight and large roadway shipment units are limited by State permitting requirements. Infrastructure is also considered in permit approvals including limitations from overhead utilities, road lighting, road curvatures and intersections.

Highway and rail delivery modes appear unlikely options for turbine or foundation delivery to port facilities. However, highway and rail access is desirable for delivery of related products such as aggregate for scour protection and component pieces.

4 Evaluation Criteria

The information presented in Section 3 above was reviewed to identify a broad set of direct requirements and highly desirable characteristics of port facilities relative to supporting offshore wind farm construction and operation. These requirements and characteristics were distilled down into a smaller set of criteria to be used more efficiently in the comparative evaluation of the candidate ports. In the distillation process, the Team distinguished a "hard" physical requirement that must be met from a "soft" requirement that reflects preferences and advantages that are more subjective to the developer. Two sets of "hard" requirements were identified for comparing the ports: (1) those related to harbor access (referred to as the 1st Tier Criteria) and (2) those required to meet specific developer and turbine supplier needs (referred to as the 2nd Tier Criteria). Also, a set of "soft" criteria was developed that is somewhat more subjective, but nevertheless allows ports to be distinguished from one another.

4.1 1st Tier Hard Criteria

The 1st Tier Hard Criteria identified relative to harbor access were:

- Sheltered harbor;
- Unobstructed vertical (overhead) clearance (e.g. no bridges);
- Minimum horizontal clearance greater than approximately 130 feet;
- Minimum low tide navigational channel depth of 24 feet; and
- 24 hour/day and 7 days/week operational availability; and
- Exclusive use of the staging facility.

Physical parameters for marine vessels to access a harbor emerge as critical criteria, while rail and trucking access were believed to be present or easily attainable at the set of ports being compared. Staging ports need to accommodate vessels shipping and handling the large components used for commercial scale wind farms. The greatest vessel draft (depth) establishes the criteria for the shipping or navigation channel depth. The widest vessel beam (width) along with the method of component transport, which may involve overhang, establishes horizontal clearances. Along with vessel height, the options for method of transport also contribute to vertical clearance criteria. The potential for bad weather interruptions and the need to maximize labor and equipment availability makes a sheltered harbor an essential criterion.

Implications of the cost of contractor mobilization, vessel and equipment usage combined with weather and seasonal limitations on the construction window result in developers and turbine suppliers requiring a port facility that allows operations 24 hours a day, seven days a week. Given that optimal operations would entail moving large components around the clock, the staging port must also provide exclusive use of the staging facility.

4.2 2nd Tier Hard Criteria

The 2nd Tier Hard Criteria identified relative to the port facilities were:

- Minimum berth length of approximately 450 feet;
- Minimum berth water depth of 24 feet;
- Lay down storage and assembly area larger than 10 acres;
- Proximity to likely offshore wind farm site.

Water depth at the berth must be sufficient to accommodate industry vessel drafts or must be attainable through routine dredging. Additionally, vessel length and the number of vessels operating simultaneously establish the parameters needed for length of the berth. The size of the backland area landside of the bulkhead for storage and assembly of the turbine components and the ability to handle the loads of the components and construction equipment are significant criteria. Proximity of the port to the construction site can affect operational logistics, risks, and costs. The distance from a port facility to wind farm sites, therefore, has significance, but becomes secondary to the parameters discussed above.

4.3 Soft Criteria

Soft criteria parameters, as noted above, are other port area attributes that may attract developers to consider one port over another. The Soft Criteria identified were:

- Workforce availability;
- Education and training facilities;
- Political climate/community acceptance; and
- Regulatory considerations.

The location of education or training facilities and work force availability, including various skilled labor trades, as well as political climate and potential regulatory requirements, are factors that could influence port selection.

4.4 Screening and Short-Listing the Ports

The larger set of ports considered in this study were analyzed using these criteria. Those that did not meet minimum thresholds were eliminated from further consideration by the Team. Section 5 provides an overview of Massachusetts ports that could support staging and installation of offshore wind farms, as well as other regional ports that could meet the assembly, construction, and/or servicing needs of the offshore wind industry. Section 6 describes the process that resulted in the two short-listed ports, the South Terminal in the Port of New Bedford Renewable Energy Marine Park and Dry Dock #4 in the Port of Boston Marine Industrial Park.

5 Inventory of Massachusetts Ports

5.1 Overview of Massachusetts Port Facilities and Characteristics

Our initial inventory of port facilities in Massachusetts is based on: (1) an assessment of each of the state's 11 Designated Port Areas (DPAs) and (2) a review of other properties or areas in other states currently used for industrial maritime activities. DPAs in Massachusetts include Gloucester Inner Harbor, Beverly Harbor, Salem Harbor, Lynn, Mystic River, East Boston, Chelsea Creek, South Boston, Weymouth Fore River, New Bedford-Fairhaven, and Mount Hope Bay. *Comparison of Selected Northeast Ports for Potential Handling of Wind Power Offshore Energy Installations* (MARPRO Associates International 2009) and *Road and Rail Access Ports of Massachusetts* (MARPRO Associates International 2009), Appendices F and G in the Final Report, provide more detail on these ports and modes of transportation to and from the ports.

Massachusetts has a number of ports that, because of their existing or proposed marine terminals, geographic location and surrounding market area, already have substantive marine activity including a wide range of freight activity. In addition to the ports discussed below, the Team contacted the municipalities of Beverly, Chelsea, Lynn, Everett, Somerset, Weymouth, and Falmouth to obtain information about their port facilities; those ports were removed from further consideration based on navigational and/or landside constraints. All of the ports in Massachusetts have some rail access; however, waterfront access to particular facilities varies in each area. No ports in Massachusetts have access to second generation rail with vertical clearances over 19 feet. From north to south, brief summaries of these six remaining Massachusetts candidate ports and their potential to stage a Representative Offshore Wind Energy Installation (ROWEI) 130-turbine wind farm follow:

Gloucester has sufficient land area for a new marine facility, a readily available skilled work force, and rail access. However, water depth and lateral clearance are the most significant constraints for the inner harbor at the Port of Gloucester and the rail service is limited to commuter rail. Turbine installation vessels should be able to navigate the Port of Gloucester, but turbine import vessels most likely would not be able to call at this port.

Salem has limited potential for substantial expanded marine industrial activities, with limited access by road and rail. The port's only deepwater commercial terminal is situated at the head of the harbor; however, the terminal is primarily used to supply the needs of the Salem Power Plant. There is also very little area outside of Salem Terminal where large vessels could handle offshore wind turbine or foundation components. The immediate area in and around the waterfront is congested and has poor capacity for high volume roadway traffic flow.

Boston is the largest and most prominent freight port in the Commonwealth. It has the most diversified port mix and handles the largest volume of containers in New England and the second largest amount of petroleum cargo. However, direct rail connections to the waterfront need improvements. The Boston Redevelopment Authority has 'shovel ready' plans to expand the existing rail from the Boston Marine Industrial Park to the North Jetty and to Dry Dock #4. Roadways are congested and direct street connections between the terminal and highway connectors are a weak link in the landside transportation connection. There are areas within the Port that might be available to support offshore wind deployment, but issues of height due to FAA requirements associated with Logan Airport must be considered.

Fore River (Ship Yard) has served as the Central Receiving Point for new car delivery to local dealerships. The site, which features rail and roadway access, is currently undergoing an initial planning process to determine all

potential uses for the site including marine-related, residential, retail, office, and entertainment. The entrance to the Shipyard is restricted by the Fore River Bridge which has a 175 ft vertical clearance and a 175 ft horizontal clearance.

Fall River (Mount Hope Bay) is an active niche port serving several international markets. The port has the potential for industrial expansion at the State Pier, which has available storage and land area for operations but already is used for both industrial and tourism based activities. The State Pier can only handle small cargo ships and most of the critical infrastructure in the port is aging and in need of considerable repairs and improvements. Vertical clearance is the most significant navigational constraint for the Port of Fall River. The Braga Bridge and Mt. Hope Bridge each impose a height restriction of 135 feet. The port has good highway access and a rail corridor which requires additional infrastructure improvements.

New Bedford is an active freight seaport and a major logistical connection for agricultural products entering the New England market. Highway connections are good; the port would benefit from expanded and improved rail connections to meet freight needs. A request for TIGER Grant money was submitted to extend the rail line to the State Pier, but further rail extension to the proposed South Terminal expansion area is unrealistic. The port has sufficient deep water access for the size and type of vessel common to most break bulk and project cargo and has property available for expansion.

The Final Report contains more detailed data on each port, including location, facilities, harbor profile, advantages, disadvantages, and potential.

Other East Coast ports, including Portland Harbor (Maine), Portsmouth Harbor (New Hampshire), the Port of Providence (Rhode Island), the Port of Davisville (Rhode Island), New Haven Harbor (Connecticut), the Port of New York and New Jersey, the Port of Philadelphia (Pennsylvania), the Port of Baltimore (Maryland), the Port of Wilmington (Delaware), and the Port of Virginia, were evaluated to assess their suitability to support offshore wind projects. The Final Report describes these port facilities in more detail.

5.2 U.S. East and Gulf Coast Shipyard Construction and Repair Capacity

Declining domestic demand has reduced the number of available U.S. shipyards for new construction or repair of large vessels. In addition, existing shipyards' inability to comply with recent regulations, such as the "Jones Act," which requires vessels in domestic service or operating in domestic waters to be built and serviced in U.S. yards, has resulted in a decrease in yards available for new large vessel construction or repair. This is particularly evident in the Northeast U.S., including New England, where the ability to handle large tonnage vessels, such as deep water cargo ships, tankers, and specialty vessels for offshore delivery and support, has dramatically decreased in the past few decades. In other parts of the world, new shipyard capacity has replaced capacity lost in the U.S. However, in spite of the fact that the number of shipyards in the U.S. that handle large tonnage vessels has declined, the number of smaller yards has remained stable.

Specialty wind farm vessels have unique construction and servicing requirements. Smaller service vessels, including offshore supply vessels, tugs and barges, can be readily adapted to service offshore wind farm equipment. Installation and service vessels operating within the territorial waters of the U.S. most likely would be subject to the Jones Act, but import/delivery vessels could be foreign flagged if their operation is limited to equipment delivery at a single U.S. port. *US East and Gulf Coast Shipyard Construction and Repair Capacity and*

Availability Offshore Wind Turbine Delivery and Service Vessels (MARPRO Associates International 2009) provides detailed information on construction capacity and repair capacity at U.S. shipyards

Construction Demand and Capacity

In recent years, the U.S. small vessel construction industry has demonstrated growth. Stricter regulations and replacement requirements have increased demand for new small vessel construction, with the tug and barge industry emerging as the largest demand market. Tug and barge construction is of particular importance as the servicing and installation of offshore wind turbines may well be handled by tugs and barges in large part because of their lower operational costs.

Tank barge construction has had a major impact on shipyard capacity and delivery times. There are some new shipyards emerging to meet this demand for tank barges, and the major yards are ramping up production capabilities in anticipation of more tank barge orders. Increasing demand for tank barge construction is using up ship construction capacity in the yards where offshore specialty vessel construction could take place.

Shipyard Availability

The number of shipyards that have current capacity for large specialty vessel construction is limited within the U.S. Of the 350 active vessel construction companies in the U.S., only 52 have a history of significant vessel construction on the Atlantic and Gulf Coasts. A limited number are capable of handling large specialty vessels due to size limitations, but a number of them could handle smaller specialty vessels. The Final Report provides a list of the yards that can build offshore wind-related vessels on the Atlantic and Gulf Coasts.

Vessel Repair Capacity

In the Northeast, many of the yards have compressed operations due to increasing environmental concerns and gentrification of industrial areas. A number of yards confine activities to repair only and have refocused their efforts on small craft such as ferries, yachts and similar commercial watercraft. In the Gulf of Mexico, a number of the yards still have not fully restored operations to pre-Katrina levels primarily due to a shortage of qualified personnel and infrastructure that yards have chosen not to replace. Nevertheless, the Gulf of Mexico region still has the highest percentage of multi-purpose construction and repair yards in the country. Orders for vessels are averaging a 6 to 12 months delay to begin construction; however, there are several smaller yards in the Northeast and the Gulf that have no backlogs and can manage new vessel orders. Very few of these shipyards have multiple vessel capacity, and backlogs do not extend beyond 2011. Most of the shipyards on the Atlantic Coast that build vessels also have repair capacity; however, there is limited repair capacity in New England.

Shipyard Construction and Repair Capacity on the Atlantic Coast

Large vessel construction and small vessel construction most likely would be handled by different shipyards. Yard capacity varies from region to region. The industry can meet the demand for a phased-in cycle of new vessels on a limited basis up to approximately three units per year using multiple yards in various regions of the U.S. New England has new construction capability limited to smaller vessels, but has adequate repair capability for smaller vessels and some capacity for larger vessels. A developer should anticipate an 18-month lead time for design, contracting, construction and delivery of small vessels and up to 24 months for larger vessels. These projections along with the restrictions of the Jones Act will dictate time lines associated with the earliest offshore projects.

6 Short-Listing Ports for Further Evaluation

Based on the evaluation criteria developed for this report and further analysis, the Team concluded that the ports of New Bedford and Boston have the greatest potential to support the assembly and installation phases of planned and prospective offshore wind energy projects.

Of the Massachusetts ports described in Section 5 above, six ports (located in DPAs) were selected for further consideration. The Massachusetts Port Criteria Evaluation Matrix (see Table 8) clearly demonstrates how these six Massachusetts ports compare against each other with respect to the established "hard" criteria. Application of the identified "soft" criteria was reserved for only the short-listed ports.

Table 8 Massachusetts Port Criteria Analysis Matrix

PARAMETERS		PORTS					
Criteria	Recommended Values/Ranges	Boston	New Bedford	Fall River	Gloucester	Salem	Fore River
First Tier Harbor Navigational Access							
Protected Harbor	Sheltered from Weather Conditions	Yes	Yes	Yes	Yes	Yes	Yes
Shipping Vessel Channel Depth	Minimum 7.3 m (24')	12.2 – 13.7 m (40' - 45')	9.1 m (30')	10.7 m (40')	4.9 – 5.8 m (16' - 19')	9.4 m (31')	9.8 m (32')
Overhead Clearance	No Vertical Obstruction (NVO)	NVO, but FAA approval required	NVO	41 m (135')	NVO	NVO	53.3 m (175')
Horizontal Clearance	40 m (130') (beam plus overhang)	131 m (430')	45.7 m (150')	122 m (400')	61 m (200')	85.3 m (280')	53.3 m (175')
24/7 Operational Ability	24/7 operations	Yes	Yes	Yes	No	Yes	Yes
Exclusive Use of Port Facility	Ability to Offer Exclusive Use	Yes	Yes	No	No	No	Yes
Comments				Mt Hope Bridge height restriction	Navigational constraints	Salem DPA in full use by power plant	Fore River Bridge height restriction
Second Tier Port Facilities							
Berth Length	Minimum 138 m (450')	549 m (1,800')	488 m (1,600')	189 m (620')	427 m (1,400')	177 m (580')	244 m (800')
Shipping Vessel Water Depth	Minimum 7.3 m (24')	12.2 – 13.7 m (40' - 45')	9.1 m (30')	10.7 m (40')	4.9 – 5.8 m (16' - 19')	9.4 m (31')	9.8 m (32')
Total Wharf and Yard Upland Area	4.0 ha (10 ac)	5.7 – 6.9 ha (14-17 ac)	4.0+ ha (10+ ac)	2.8 ha (7.0 ac)	3.2 ha (7.8 ac)	NA	44.9 ha (111 ac)
Rail Access	Rail Access	Limited	Limited	Yes	Yes	No	Yes
Highway Access	Highway Access	Yes	Yes	Yes	Yes	No	No
Comments				State Pier can only accommodate small cargo vessels.	Limited adaptable area	Insufficient work area; additional focus on tourism	Multiple berths/ rough estimate; plans for mixed-use waterfront development

Legend NVO = No vertical obstruction
= Criteria not met
NA = Not available for ROWEI staging

6.1 Evaluation of Massachusetts Ports against Hard Criteria

Protected Harbor: All of the six Massachusetts ports are in protected harbors. The hurricane barrier in New Bedford adds an additional layer of protection for portside operations during inclement weather.

Shipping Channel Depth and Overhead Clearance: Navigational access to Fall River and Fore River is constrained by the overhead height restrictions of existing bridges, and the Port of Gloucester does not meet the minimum shipping channel depth of 24 feet (indicated by the shaded cells in Table 8). On the other hand, the shipping channels of New Bedford and Boston Harbors meet the minimum depth criterion. Both New Bedford and Boston Harbor have unobstructed overhead clearance. There are no vertical obstructions, such as bridges and/or power lines, which would prohibit offshore wind component delivery and installation vessels, including jack-up vessels, from accessing either harbor. However, FAA approval may be required in Boston Harbor because of the harbor's proximity to Logan International Airport.

Horizontal Clearance: None of the selected ports are restricted by horizontal (lateral) clearances less than 130 feet. The minimum horizontal clearance criterion eliminated facilities in New Bedford upstream of the New Bedford-Fairhaven Bridge (92 feet of lateral clearance). However, the South Terminal at New Bedford Harbor is downstream of the New Bedford-Fairhaven Bridge and upstream of the Hurricane Barrier.

24/7 Operational Ability and Exclusive Use of Port Facility: All ports being evaluated, with the exception of the Port of Gloucester, can operate round the clock and all year. The Ports of Gloucester and Salem also did not have the ability to offer exclusive use of their facilities.

Berth Length and Shipping Vessel Water Depth: The established berth length and channel and portside depth criteria reflect minimum requirements for accommodating berthing operations. The Port of Gloucester failed to meet the depth criterion. All other ports had sufficient length and depth.

Total Wharf and Yard Upland Area: Landside (upland) port facilities provide storage, staging and assembly work areas to facilitate offshore wind farm installation. The Team determined that given sufficient land area, storage, assembly, and load bearing issues could be addressed with improvements to the port. Neither Fall River, Gloucester, or Salem has sufficient adaptable space for the work area required to support offshore wind farm staging.

Rail Access: None of the Massachusetts ports evaluated for this study has second generation rail access. Existing rail lines could be used primarily for delivery of aggregate and related products rather than turbine or foundation components. Whereas Fall River, Gloucester, and Fore River have existing freight rail lines to the waterfront, Boston and New Bedford currently have limited rail access, and Salem has none. Boston and New Bedford submitted TIGER applications for rail extensions; however, the New Bedford rail line will connect the existing tracks to the State Pier, but not the South Terminal.

Highway Access: Road connections are important for transport of ancillary material and equipment, as well as personnel. Neither Salem Harbor nor the Fore River Shipyard has sufficient highway access due to roadway congestion. There is no highway access within the City of Salem; the nearest highway access to Route 128 is along Route 114 in neighboring Peabody. Fore River's access to the interstate highway network is via Route 3, a limited-access roadway that is about two miles away from the Shipyard.

Based on the hard criteria established in Section 4 and displayed in Table 8 above, the ports of Fall River, Gloucester, Salem, and Fore River fell short of the minimum requirements for navigational access and port infrastructure to support offshore wind development activities. The ports of New Bedford and Boston emerged as the two short-listed ports.

6.2 Engineering Cost Analysis of Port Upgrades for Short-Listed Ports

New Bedford Harbor

The project team identified two possible locations in New Bedford Harbor that could reasonably meet the established criteria, the South Terminal area and the State Pier facility. However, both facilities failed to meet all of the criteria and demonstrated deficiencies in their current physical condition. Cost estimates for facility improvements were provided by Childs Engineering Corporation.

South Terminal

The City of New Bedford has identified the expansion of the South Terminal as a major priority. The City applied for a TIGER grant to support its proposed plan to expand the berth by approximately 800 ft and dredge a 30-ft deep channel from the main channel to the new berth. The new facility would have significant backland load bearing capacity. There are between 14 and 20 acres of land adjacent to the berth. The cost of the new bulkhead and dredging is estimated to be approximately $20 million (see the cost analysis conducted for this study, which resulted in a comparable estimate), in the Final Report. Additional improvements, including paving, utilities and site equipment (such as a large crane), could add an additional $15 million and would provide a “future” life as a general cargo or container handling facility.

State Pier

The State Pier is constructed with a solid fill core surrounded by a marginal wharf. This construction is typical of many old New England ports. The wharf structure is in poor condition according to recent inspections and must be replaced or modified. The rebuild options include a repair/replace in kind, which would result in a reasonably low deck capacity. The preferred alternative would replace the wharf structure with solid fill behind a new bulkhead. A recent study suggested rebuild costs could be from about $12.1 million to more than $52 million. The immediate backland is about 7 to 8 acres, which does not meet the landside criterion. This lack of space would probably result in material rehandling costs, which would not occur on a larger site. The State Pier would best be described as a short-term, but an immediately available site. This solution also anticipates that no repairs would be performed and a larger land-based unloading crane would be employed inshore of the wharf structure.

The Team believes the preferred option for New Bedford is the South Terminal. The site is the most ideal in terms of meeting the port criteria established by the Team. The expansion cost is similar to the repair cost for the State Pier. However, the South Terminal has significantly more laydown area, which offsets any potential cost savings from the State Pier repair/rebuild.

Boston Harbor

The project Team identified three possible locations in Boston Harbor that reasonably meet the criteria. These include the North Jetty, Dry Dock #4 in the Boston Marine Industrial Park, and the former Coastal Oil site adjacent to Conley Terminal on the Reserved Channel. None of these facilities meet all of the defined criteria and each has

deficiencies in their current physical conditions. . Cost estimates for facility improvements were provided by Childs Engineering Corporation.

North Jetty

The North Jetty is constructed with a solid fill core supported by a steel sheet pile bulkhead fronted by a marginal wharf. The marginal wharf is comprised of steel h-piles supporting a reinforced concrete super structure. The wharf structure is in poor condition and must be replaced or rebuilt to be a viable staging port. The immediate backland is about 7 to 8 acres, with an additional 10 or more acres immediately adjacent. A 1996 design suggested rebuild costs (in 2010 dollars) would be about $15 million.

The City included the North Jetty rebuild in its application for a TIGER grant. Although the rebuild will correct current deficiencies, it will still leave the wharf with a deck capacity of 600 lb/ft^2, which is insufficient for unit loading under certain situations.

Dry Dock #4

The existing Dry Dock is in very poor condition but could be rebuilt to provide a two sided solid fill pier with almost 1800 feet of berthing. The Dry Dock would be filled with gravel and new steel sheet piling would be installed around the deteriorated bulkheads. The estimated cost to rebuild the site is approximately $20 million. This site would provide nominal laydown space, but the solid fill pier has very high ground capacity and the berth has “bonus” length. Although the site does not have covered space, there are such structures and warehouses in the Boston Marine Industrial Park.

Dry Dock #4 could accommodate the staging of offshore development with improvements at a reasonable cost. However, from a planning perspective, there are potential permitting issues associated with these improvements due to Dry Dock #4’s proximity to Logan Airport. Tall equipment, such as cranes, likely will require approvals from the FAA. Furthermore, the potential wind farm locations are much closer to New Bedford Harbor than Boston Harbor.

Coastal Oil Site

The Massachusetts Port Authority owns the former Coastal Oil terminal in South Boston. The site is approximately 35 acres and has a former oil tanker berth with a water depth in excess of 34 ft. The facility would require a new steel sheet pile bulkhead to be adequate for laydown. It also would need re-grading and paving to “cap” any environmental issues. The estimated cost for the repairs is approximately $20 million. The site does not have any covered space, and there is no covered space on the immediately adjacent parcel.

The Team believes the preferred option for Boston is Dry Dock #4, which meets most of the established criteria. The rebuild cost is similar to the cost of repairs for the North Jetty; however, Dry Dock #4 has significantly more berthing space, which offsets any potential repair/rebuild cost savings.

6.3 Soft Criteria

The Team examined education and training needs required to support the offshore wind energy industry in Massachusetts. We conducted interviews with various educational and training institutions to ascertain the status of programs designed specifically for the offshore wind industry.

More effective state support for renewable energy has encouraged investment in workforce training at many levels. The Massachusetts Maritime Academy is nationally known for its mariner training programs, and a regional Marine Renewable Energy Center (MREC) at the University of Massachusetts/ Dartmouth joins the resources of some of the region's leading academic institutions, community colleges, and trade unions to coordinate and plan appropriate training for this emerging industry. Several public and private academic institutions, including the Amherst and Dartmouth campuses of the University of Massachusetts system, Harvard, the Massachusetts Institute of Technology (MIT), the Massachusetts Maritime Academy, and the Woods Hole Oceanographic Institute (WHOI), have examined and will continue to explore numerous issues related to offshore renewable energy generation, including energy production, facility design, transmission issues, and maritime training.

Understanding that the ocean energy industry is evolving within the U.S. and specifically New England, MREC joined forces with Cape Wind, Resolute Marine Energy, Ocean Renewable Power Company, Local 56 Pile Drivers Union, the Massachusetts Maritime Academy, the New Bedford Department of Workforce Development, and the community college system to form the Ocean Energy Training Task Force. The Task Force meets regularly to identify issues and to discuss how best to meet the needs of offshore energy developers, and draws on the expertise of each of its members. Significant education and training programs related to offshore renewable energy are being developed, and some are currently being offered.

Massachusetts trade unions have been very active in identifying offshore energy construction needs and developing appropriate training courses. For example, Local 56 of the Massachusetts Pile Drivers is a statewide organization that has been at the forefront of training workers for offshore energy. Similarly, the International Brotherhood of Electrical Workers ("IBEW") Local 103 has demonstrated its leadership in support and training for the renewable energy industry through the erection of a publicly visible 100kW wind turbine and the installation of a 5.4kW solar roof at its headquarters and Apprentice Training Facility in Dorchester.

With the state aggressively supporting the development of offshore wind energy through policy initiatives, expertise, and financial support, and with academic institutions and trade unions actively developing and improving training opportunities, Massachusetts is well situated to respond to a wide variety of technologies used to harness renewable energy in offshore waters. Perhaps more relevant, Massachusetts is in a unique position to successfully meet the needs of the offshore wind energy industry because of its broad geographic coverage, extensive research facilities, in-depth industry expertise, and a trained, flexible work force.

Soft criteria also include regulatory considerations. Port facility upgrades may require Massachusetts environmental review if the project meets or exceeds certain thresholds established by the Massachusetts Environmental Policy Act (MEPA). A variety of federal, state and local permits also may be required, including, but not limited to:

- U.S. Army Corps of Engineers (USACE) Section 10 permit for structures in navigable waters,
- USACE Section 404 permit for discharge of dredged or fill materials into waters of the U.S.,
- Federal Aviation Administration (FAA) Determination of No Hazard,
- Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) permit,

- EPA Air Emission permit,
- Massachusetts Coastal Zone Management (MCZM) Consistency Determination,
- Massachusetts Department of Environmental Protection (MDEP) Water Quality Certificate,
- MDEP Chapter 91 License for work in, under, or over flowed or filled tidelands,
- Massachusetts Department of Transportation (MDOT) Oversize/overweight vehicle permit,
- Conservation Commission Order of Conditions for alteration of "any bank, fresh water wetland, coastal wetland, beach, dune, flat, marsh, meadow, or swamp bordering on the ocean or on any estuary (a broad mouth of a river into which the tide flows.), creek, river, stream, pond, or lake, or any land under said waters or any land subject to tidal action, coastal storm flowage, or flooding," and
- Local zoning, building or utility permits.

7 Economic and Tax Effects of Construction and Operating Expenditures

Based on the criteria and cost analysis presented above, the South Terminal in the Port of New Bedford Renewable Energy Marine Park (Figure 8) and Dry Dock #4 in the Port of Boston Marine Industrial Park (Figure 9) were selected for further evaluation and discussion. More detailed information about how the team arrived at this conclusion can be found in *Economic Effects of Offshore Wind Energy and Related Construction and Operating Expenditures* (FXM Associates 2009), which is Appendix J of the Final Report.

Figure 8 New Bedford Harbor

Figure 9 Boston Harbor

This section summarizes the economic and fiscal effects of construction and operation of these ports to support a ROWEI 130-turbine wind farm.

Construction and Operating Periods- Economic Effects

The measures of economic effects are:

- Output – which comprises business sales less the costs of materials and equipment produced outside Massachusetts;
- Employment – the full-time equivalent jobs expected to be held by Massachusetts residents;
- Income – the payroll and self-employment earnings of households; and
- GDP (Gross Domestic Product) – which measures the value added to the Massachusetts economy in terms of labor and proprietors' income, corporate profits, dividends, interest, rent and taxes.

Expenditures for the assembly and installation of the ROWEI are estimated to increase business output by more than $457 million in Massachusetts over the anticipated three-year projected period of construction, provide over 1700 person years of employment, and generate nearly $163 million in household income statewide. Construction of the Port of Boston Dry Dock #4 facility is expected to increase business output by nearly $19 million, provide over 100 person years of employment and $9.1 million of additional household income in Suffolk County. Construction of the South Terminal project in New Bedford Harbor is estimated to expand business output by more than $44 million, provide nearly 400 person years of employment, and $19.2 million of additional household income in Bristol County over its estimated 2-year construction period.

Each year following completion of the ROWEI, expenditures for servicing and maintaining the wind turbines is estimated to expand business output in Massachusetts by $27.5 million, provide 110 permanent jobs, and generate $6.8 million in household income annually. New Bedford South Terminal port facility operations, specifically the handling, storage, and transshipment of prospective new container, break bulk, and bulk cargoes, are estimated to expand business output in Bristol County by $15.6 million, provide over 130 permanent jobs, and generate $5.9 million in additional household income each year.

Construction and Operating Periods- Fiscal Effects

The total direct, indirect, and induced tax effects correspond to the economic effects discussed above. Local taxes include property and excise taxes paid to municipalities by workers in the jobs generated by construction and operating period employment effects, as well as property and other local taxes paid by the companies employing those individuals. State taxes include income and sales taxes paid by individuals as well as payroll, income, and other taxes paid by the companies that employ those individuals.

During the assembly and installation phase of the ROWEI nearly $9 million in taxes to municipalities throughout Massachusetts are estimated to be attributable to the direct, indirect and induced economic effects discussed above over the projected 3-year construction period of the ROWEI. More than $10 million in taxes paid to the Commonwealth of Massachusetts over this 3- year period would be attributable to the economic effects of construction, and almost $46 million in federal taxes would be stimulated by the construction period economic effects. Some additional local, state, and federal taxes would be generated by activity at the staging ports. Servicing and maintaining the exemplified offshore wind energy project would generate an annually recurring amount of $390,000 in municipal tax receipts throughout Massachusetts, $433,000 in state taxes annually, and $2.2 million in new federal taxes each year.

As can be seen from these projections, the economic and fiscal effects of port development and use are roughly comparable for both ports. Therefore, the selection of one port over the other is more likely to be determined by the balancing of the soft criteria.

8 Summary and Recommendation

In Massachusetts there are no port facilities ready for turnkey support of offshore wind energy facility development at this point in time. However, the opportunity to attract offshore wind deployment exists if appropriate investment in relevant port upgrades is made. The Team performed a side-by-side comparison of the two short-listed ports and has concluded that the expansion of the South Terminal in the Port of New Bedford represents the best opportunity for a Massachusetts port facility to accommodate assembly and installation of offshore wind energy projects. Table 9 summarizes the comparison between Dry Dock #4 at the Port of Boston and the South Terminal at the Port of New Bedford relative to the hard and soft evaluation criteria developed for this study.

Table 9 Comparison of the Two Short-Listed Ports

	Port of Boston Dry Dock #4	New Bedford Harbor South Terminal	Comments
1st TIER HARD CRITERIA			
Protected Harbor	●	●	Both ports are acceptable.
Shipping Channel Depth	●	●	Both ports are acceptable.
Overhead Clearance	●	●	Both ports are acceptable.
Horizontal Clearance	●	●	Both ports are acceptable.
24/7 Operational Ability	●	●	Both ports are acceptable.
Exclusive Use of Port Facility	●	●	Both ports are acceptable.
2nd TIER HARD CRITERIA			
Berth Length	●	●	Both ports are acceptable.
Shipping Vessel Water Depth	●	●	Both ports are acceptable.
Total Wharf and Yard Upland Area	●	●	Both ports are acceptable.
Rail Access	●	⊙	BRA has a design to expand rail access to Dry Dock #4. New Bedford submitted TIGER application to extend rail line to State Pier, but not to South Terminal.
Highway Access	⊙	●	Despite adequate highway access to port area, the Boston Haul Road currently has vertical/ horizontal limitations; however, a new freight roadway system is planned.
Proximity to Construction Site	⊙	●	South Terminal is closer to the planned offshore sites than Dry Dock #4 (as of January 2010).
SOFT CRITERIA			
Workforce Availability	●	●	
Education and Training Facilities	⊙	⊙	In U.S., education and training programs are now being developed for nascent offshore renewable energy industry. Given extensive research facilities, in-depth industry expertise, and trained, flexible work force, Massachusetts will be able to successfully meet education and training needs.

Table 9 Comparison of the Two Short-Listed Ports (continued)

	Port of Boston Dry Dock #4	New Bedford Harbor South Terminal	Comments
Political Climate/Community Acceptance	⦿	●	New Bedford has a Green Port initiative in place, has done study on South Terminal development, has submitted various proposals for infrastructure grants, and has the goal of strengthening its economy by focusing on renewable energy such as offshore wind. The BRA has emphasized a commitment to sustainability but may not be focused on the seaport. Dry Dock #4 currently has a tenant.
Regulatory Considerations	⦿	●	Required permits could include, but are not limited to: MEPA review; CZM Consistency Certification; USACE Section 404 and 10 Permits, FAA approval; Chapter 91 License/Permit; Water Quality Certification; NPDES Permit; Order of Conditions. Certain circumstances at each port may eliminate or reduce regulatory process. FAA approval at Dry Dock #4 may be problematic.

LEGEND:
- ● Acceptable / Most Supportive of offshore wind farm development
- ⦿ Qualified Acceptability / Degree of Supportiveness of offshore wind farm development
- ○ Unacceptable / Not Supportive of offshore wind farm development

With specifically targeted upgrades, both Dry Dock #4 and the South Terminal would have acceptable harbor access and the navigational parameters needed to accommodate wind turbine delivery and installation vessels (1st Tier Hard Criteria), and both ports are capable of accommodating the assembly and installation of offshore wind turbines and foundations (2nd Tier Hard Criteria). An exception at the present time may be Rail and Highway Access; however, it is unlikely that rail and highway delivery would be used for large offshore wind generation components due to weight and dimensional constraints. Based on available public information as of January 2010 regarding proposed offshore wind farm sites, the South Terminal at New Bedford Harbor is closer to these potential installation sites than is Dry Dock #4 at the Port of Boston.

With regard to soft criteria, the City of New Bedford is moving ahead with its goal of strengthening its economy by focusing on supporting the renewable energy industry at the Port of New Bedford. In Boston, the BRA has demonstrated its commitment to environmental sustainability by launching a pilot program to help small businesses improve their energy efficiency and sustainability practices. However, this initiative is not focused specifically on the seaport.

Another soft criterion, Regulatory Considerations, involves the environmental review and permitting processes that may be required for the port projects. Work in and around Massachusetts waters may require state environmental review, if one or more MEPA review thresholds is met or exceeded. Installing and operating an offshore wind farm also will require obtaining a number of federal, state, and local permits. MEPA review of a major port improvements project could take between six months and one year, depending on the type of MEPA review triggered and the amount and intensity of political and community support for the project. Permitting such

a project may require a similar amount of time, depending on (among other factors) the complexities of the project, the number and length of public comment periods, and the duration of mitigation negotiations that must be conducted between the project proponent and the regulatory agencies.

Since some of the environmental impacts of the South Terminal site have already been assessed by the Commonwealth as part of the Superfund cleanup response for the site, MEPA review of the South Terminal expansion may be streamlined or limited. The permits required for this project are contingent on its projected impacts on regulated resources. The dredging component of the port expansion project may be covered under the State Enhanced Remedy CAD Cell Dredge Disposal Approval for the cleanup. However, other permits/approvals may still be required.

If the required upgrades to Dry Dock #4 at the Port of Boston can be defined as maintenance activities authorized under existing permits, the regulatory process may be circumvented or limited. Nevertheless, because of its proximity to Logan International Airport, obtaining FAA approval of crane heights at Dry Dock #4 could prove to be a lengthy process. The level of MEPA review required for the Dry Dock #4 improvements also would depend on which thresholds were exceeded, if any. Other permits/approvals may be required.

Determining the permits applicable to either project was not within the scope of this report. Additional research would be required to verify which, if any, permits would be needed. If support of renewable energy and immediate job creation are important political objectives in the Commonwealth, it would follow that the port project with the shortest regulatory track and the greatest political and community support would emerge as the best project to meet those objectives.

Based on this comprehensive side-by-side comparison, the Team has concluded that the expansion of the South Terminal at the Port of New Bedford represents the best opportunity for a Massachusetts port facility to accommodate assembly and installation of offshore wind energy projects. In addition, the new facility will provide sufficient economic and fiscal benefits to Bristol County and the Commonwealth of Massachusetts to make the investment attractive and worthwhile. This recommendation does not preclude and should not discourage possible future upgrades to Dry Dock #4 at the Port of Boston to service the offshore wind industry as the level of offshore construction activities increases and other roles become available. However, at this time, the political support, advanced planning effort, proximity to offshore sites, and absence of FAA obstacles have led the Team to recommend the South Terminal expansion.

9 Path Forward – Preliminary South Terminal Business Plan

As a follow-up to the recommendation presented above, the Team prepared portions of a preliminary business plan for an offshore wind deployment/multi-use cargo facility at the South Terminal at the Port of New Bedford (see *Port of New Bedford South Terminal Business Plan* [FXM Associates 2009], which is Appendix K of the Final Report). Specific objectives of this effort were to (1) identify potential cargoes and revenues for the South Terminal facility, in addition to those associated with a ROWEI; (2) identify an appropriate governance model for multi-use terminal ownership and management; and (3) prepare a preliminary terminal business plan with operating pro forma. In addition to the economic and tax effects discussed in Section 7 above, the Team made the following findings:

- A new multi-use cargo facility at the South Terminal site represents the best option in the Port of New Bedford for servicing offshore wind energy development projects during the assembly and installation phases;
- A new multi-use port facility at the South Terminal can capture container, break bulk, and bulk cargoes not now handled in New Bedford or other Massachusetts ports and can generate income for the Harbor Development Commission (HDC) with or without offshore wind energy development projects;
- The optimal model for governance of a new facility at the South Terminal would be ownership by the New Bedford HDC, which would lease offshore wind energy staging and other cargo handling, storage, and related facility operations to a qualified private operator.
- Capital costs for a new multi-use port facility at the South Terminal are estimated to total about $44 million (in 2009 dollars). Approximately $32 million of this total investment is for land acquisition, bulkhead construction and dredging, buildings and site improvements to support offshore wind energy installation projects, with an additional $5 million in capital expenditures ($37 million total) functionally necessary to attract and support new bulk, break bulk, and container cargoes;
- Average net operating income to the HDC from the fully-developed South Terminal port facility would total about $1.2 million per year during a projected 3-year ROWEI and about $622,000 per year with full cargo operations. Potential operating revenues and costs are shown in Table 10; and
- The South Terminal can cover all of its operating expenses during the ROWEI use of the facility and annually thereafter based on non-ROWEI cargo operations. Approximately $12 million of the capital costs for the new facility can be supported by annual net operating income combined with income from the 3-year ROWEI use of the facility. This leaves $32 million of debt that would require financing from other sources.

These components of a “path forward” relative to the development of an expanded multi-use cargo facility at the South Terminal address the key findings of a preliminary business plan for port expansion. This study demonstrated that the South Terminal at the Port of New Bedford meets the necessary requirements and possesses a number of the advantageous characteristics needed to successfully support a developing offshore commercial wind farm. The study also identified some areas where this port could make modifications and improvements to its harbor or wharf facilities that would further enhance the port’s ability

to support offshore wind energy. The path forward would continue the process outlined here, more fully develop the elements that were addressed in this study, and consider other important aspects of the port's development that were not considered to be critical to the scope of this study.

Table 10 South Terminal Operating Income and Expenses

SOUTH TERMINAL OPERATING INCOME & EXPENSES	Offshore Wind Installation	Non-Offshore Wind Cargoes
Average Year Annual Operating Income		
Offshore Wind Energy Development (ROWEI)	$ 1,500,000	
Container Service		$ 280,000
Break Bulk Program		$ 240,000
Bulk Cargo		$ 432,500
Total Non-ROWEI Cargo		$ 952,500
Average Year Annual Operating Expenses		
HDC Personnel (contract/lessee management)	$ 140,000	$ 140,000
HDC Capital/maintenance reserve at 20% income	$ 190,500	$ 190,500
Average Year Annual Expenses	$ 330,500	$ 330,500
Average Year NET Operating Income		
Offshore Wind Energy Development (ROWEI)	$ 1,169,500	
Total Non-ROWEI Cargo		$ 622,000

Source: FXM Associates, RECON™ Input Output Model

Section 9 of the Final Report provides details of the Team's findings as a result of our preliminary business plan for a multi-use cargo facility at the South Terminal at the Port of New Bedford.

These components of a "path forward" relative to the development of an expanded multi-use cargo facility at the South Terminal address only a few of the key elements of a comprehensive, fully developed business plan for port expansion. Additional information relative to these components can be found in the Final Report and a number of its appendices. This study demonstrated that the South Terminal at the Port of New Bedford meets the necessary requirements and possesses a number of the advantageous characteristics needed to successfully support a developing offshore commercial wind farm. The study also identified some areas where this port could make modifications and improvements to its harbor or wharf facilities that would further enhance the port's ability to support offshore wind energy. The path forward would continue the process outlined here, more fully develop the elements that were addressed in this study, and consider other important aspects of the port's development that were not considered to be critical to the scope of this study.

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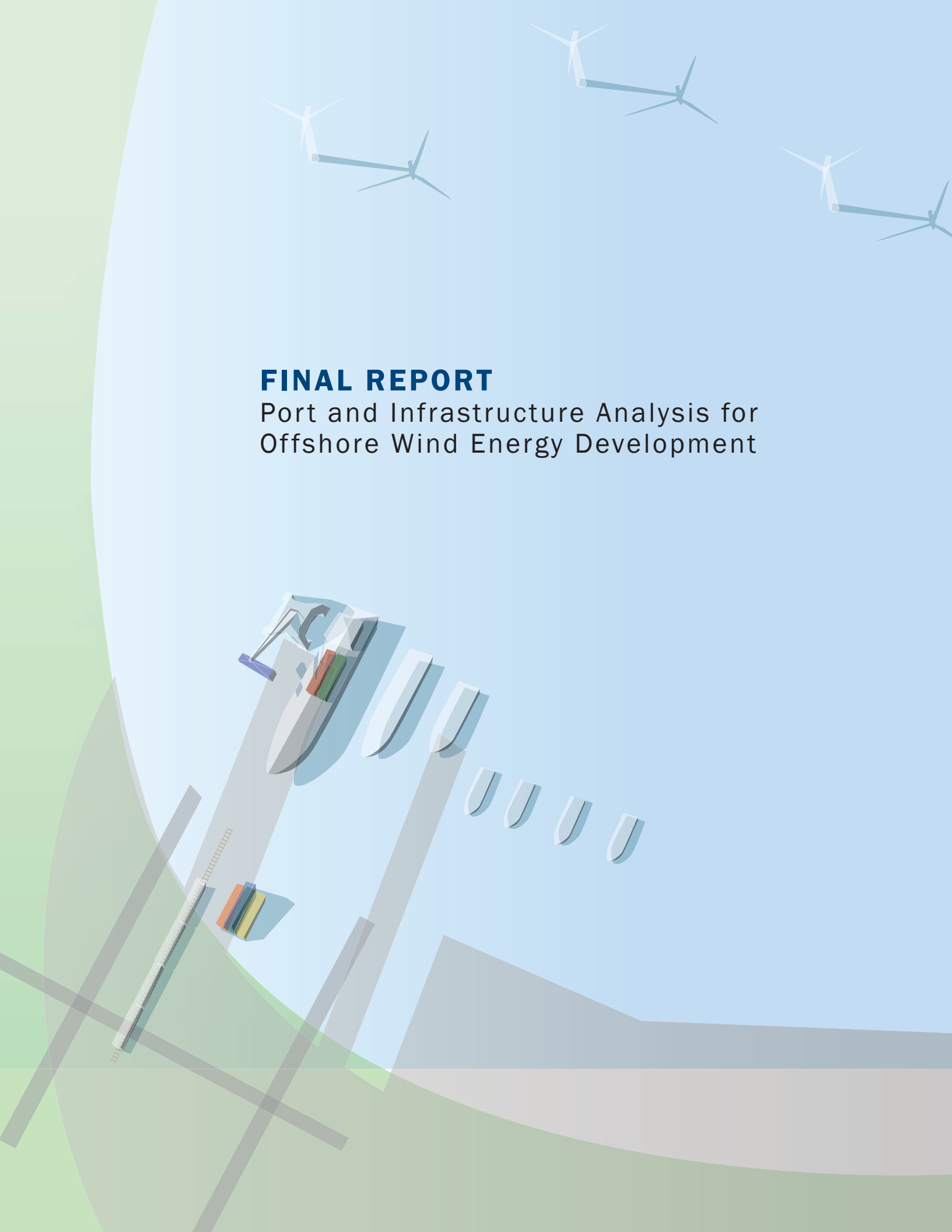
FINAL REPORT

Port and Infrastructure Analysis for Offshore Wind Energy Development



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ACRONYMS AND ABBREVIATIONS

ABS	American Bureau of Shipping
ATR	above the rail
BRA	Boston Redevelopment Authority
DP	dynamic-positioning
DPA	Designated Port Area
Dry Dock #4	Boston Port Facility
EOEEA	Energy and Environmental Affairs
EEZ	Exclusive Economic Zone
EMEC	European Marine Energy Center
EPA	Environmental Protection Agency
EWEA	European Wind Energy Association
FAA	Federal Aviation Administration
GDP	Gross Domestic Product
GW	gigawatt
HDC	Harbor Development Commission
hp	horsepower
H_S	wave height
Hz	hertz
IBEW	International Brotherhood of Electrical Workers
km	kilometers
KTH	KTH Royal Institute of Technology (Sweden)
kV	kilovolt
kW	kilowatt
LNB	Lighted Whistle Buoy N
LNG	liquified natural gas
LOA	length overall
M	million
MassDEP	Massachusetts Department of Environmental Protection
Massport	Massachusetts Port Authority
MBTA	Massachusetts Bay Transportation Authority
MBTA	Massachusetts Bay Transportation Authority
MCEC	Mass Clean Energy Center
MCZM	Massachusetts Coastal Zone Management
MDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MIT	Massachusetts Institute of Technology
MLW	mean low water
MMA	Massachusetts Maritime Academy
MMS	Minerals Management Service
MREC	Marine Renewable Energy Center
MRET	Massachusetts Renewable Energy Trust
mt	metric tons
MTC	Massachusetts Technology Collaborative
MW	megawatt

NaREC	New and Renewable Energy Center
NEG	Northeast Gateway
NOREIZ	National Offshore Renewable Energy Innovation Zone
NPDES	National Pollutant Discharge Elimination System
nm	Nautical mile
O&M	Operation and Maintenance
OCS	Outer Continental Shelf
OMP	Ocean Management Plan
OSHA	Occupational Safety and Hazards Administration
OSV	offshore support vessel
P&W	Providence & Worcester
PCB	polychlorinated biphenyls
psf	pounds/square foot
QDC	Quonset Development Corporation
RFI	Requests for Information
RFP	Request for Proposal
ROWEI	Representative Offshore Wind Energy Installation
RWU	Roger Williams University
SMAST	School for Marine Science and Technology
TEU	twenty-foot equivalent units
TIGER	Transportation Investment Generating Economic Recovery
TIVs	turbine installation vessels
U.S.	United States
UMaine	University of Maine
UMass/Dartmouth	University of Massachusetts/Dartmouth
UNH	University of New Hampshire
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
V AC	volts alternating current
V_W	average wind speed
WHOI	Woods Hole Oceanographic Institution
WTTC	Wind Technology Testing Center

1.0 INTRODUCTION

In January, 2009, the Massachusetts Clean Energy Center (MCEC)[1] acting in concert with Massachusetts Renewable Energy Trust (MRET) issued a Request for Proposals for Port and Support Infrastructure Analysis for Offshore Energy Development No. 2009-IId-01 ("RFP"). This RFP outlined the context for this study, stating "Offshore wind energy is the most viable option available for developing utility-scale renewable energy electric generating facilities to the densely populated states along the Eastern seaboard in the near term." In the context of a widespread, growing interest in reversing the climate effects of fossil fuels and federal and state incentive policies and programs that promote growth in the use of renewables for electricity generation, the overall goal of this study is to identify port facilities in Massachusetts that have the ability to support offshore renewable energy development. This study also seeks to explore the feasibility and economic development potential, as well as the economic impacts, of planned and potential port and landside facilities at short-listed Massachusetts ports.

For this first-of-its-kind study of infrastructure to support offshore wind, the MCEC contracted with Tetra Tech EC, Inc. and a team of specialized professionals (collectively "the Team") to analyze the ability of Massachusetts port facilities to support the anticipated development of commercial scale offshore wind generation facilities along the northeast Atlantic coast. This study provides the results of the Team's efforts to analyze and integrate information from current industry participants, such as potential developers and turbine manufacturers, with information from ongoing European offshore energy developments (see Figure 1-1) to characterize the parameters of ports and associated facilities. These parameters for existing ports and facilities in Massachusetts were then compared to determine which facilities may best be able to support commercial offshore wind development and what specific improvements may be required to better support offshore wind and other marine energy projects. This report presents the approach, analysis, and findings of the study that resulted in the identification of two Massachusetts port facilities, which were subsequently evaluated in more depth. This report further provides the MCEC with recommendations for direct port investment in support of offshore wind energy generation.

Marine-based wind energy generation has the advantage as a renewable energy source because it is closer to commercial deployment than other marine-based renewable energy generation approaches, such as tidal and wave technology. Furthermore, the large scale of equipment and components required for wind generation (i.e. the blades, foundations and towers) means that if a port could physically support offshore wind generation it also would likely meet the requirements for other offshore renewable energy technologies. Therefore, this study focused primarily on how Massachusetts ports can meet the requirements of offshore wind energy generation projects. The needs related to transmission line construction and interconnection to the power grid are outside the scope of this report. Integrating power from offshore wind generation into the Massachusetts power transmission system raises other issues of concern in terms of who should invest in such construction and how the costs of such investments might be allocated. A separate report administered by MCEC analyzes the issues related to offshore wind power transmission investment. *The 2009 Summary Report - Strategic*

[1] The RFPs for both studies were originally advertised and the selection process administered by the Massachusetts Technology Collaborative (MTC), MTC subsequently transferred staff and the project to the MCEC.

Options for Investments in Transmission in Support of Offshore Wind Development in Massachusetts provides an analysis of the transmission investment issues (The Analysis Group, Inc. et al. 2009).

Figure 1-1 Installed Nysted Windfarm
(Source: A2Sea)

The focus of this analysis was to specifically determine:

- The required characteristics of a port facility to be considered an appropriate staging point for construction of offshore wind generation facilities;
- The primary differences between traditional port facility features and those required for delivery, storage, handling and deployment of very large wind farm components;
- The potential impacts to ports resulting from purpose-built installation and component delivery vessels (now and in the future);
- The set of port facilities in the Commonwealth of Massachusetts that could be upgraded or expanded to be considered relevant staging points;
- The estimated costs for required upgrades or expansions at the ports that are the leading candidates for supporting offshore wind development; and
- The ability of facility improvements to attract wind farm developers, government investment, and ensure an appropriate return on investment.

2.0 BACKGROUND AND CONTEXT

The Northeast Atlantic coastal waters, including those off Massachusetts, are a national focus of the offshore wind industry. This interest is based primarily on the relatively shallow water of the continental shelf, favorable wind characteristics, and relative proximity to large electrical load centers. Those Massachusetts ports possessing the facilities, land area, and navigational characteristics necessary for the assembly and transport of wind turbine components, and for long-term operation and maintenance needs, are well-positioned to serve the emerging demands of the offshore wind energy industry.

In April 2009 the United States (U.S.) Department of the Interior, Minerals Management Service (MMS) issued final regulations on "Renewable Energy and Alternative Uses of Existing Facilities on the Outer Continental Shelf (Final Rule)," establishing a process for leasing submerged lands for renewable energy projects on the Outer Continental Shelf (OCS). The Final Rule outlines the requirements for limited (short-term – for testing and characterizing) and commercial (long-term – for power generation) leases and the bidding and regulatory procedures a wind developer must follow to obtain rights to a wind farm development site on the OCS. Current and future activities of potential developers of offshore wind generation facilities and MMS's Final Rule provide a context within which to evaluate offshore wind energy development in waters off the Massachusetts Coast and along the Atlantic Seaboard.

The Massachusetts Ocean Management Plan (OMP) was released on January 4, 2010 by the Commonwealth's Executive Office of Energy and Environmental Affairs (EEA OMP 2009). The OMP establishes new protections for environmental resources and sets parameters for the development of community-scale and commercial-scale offshore wind energy and other infrastructure in Commonwealth waters.

OMP identifies and designates areas such as:

- Prohibited Areas;
- Renewable Energy Areas; and
- Multi-Use Areas.

Offshore Wind Energy Areas identified in the OMP are specifically designated for commercial wind energy facilities, which are defined as eleven or more turbines. This designation recognizes the need to provide opportunity for renewable energy generation at a meaningful scale while being cognizant of potential environmental impacts. Two Offshore Wind Energy Areas were identified in the OMP based on the presence of suitable wind resource and water depth and the absence of conflict with other uses or sensitive resources. These areas are located approximately one nautical mile offshore in the vicinity of the southern end of the Elizabeth Islands and southwest of Nomans Land Island (located just southwest of Martha's Vineyard) (see Figure 2-1). These areas could accommodate approximately 150 3.6 MW turbines at full build-out (EOEEA OMP pp 2-2). Commercial scale wind farms are restricted to the Wind Energy Areas.

This study considered the OMP Offshore Wind Energy Areas as possible offshore wind construction sites. Distances to the these sites (measured in nautical miles) were calculated from the ports of Gloucester, Salem, Boston, Fore River, Fall River, and New Bedford, MA, and from Portland, ME, Quonset/Davisville, RI, Philadelphia, PA, New York, NY, and Norfolk, VA.

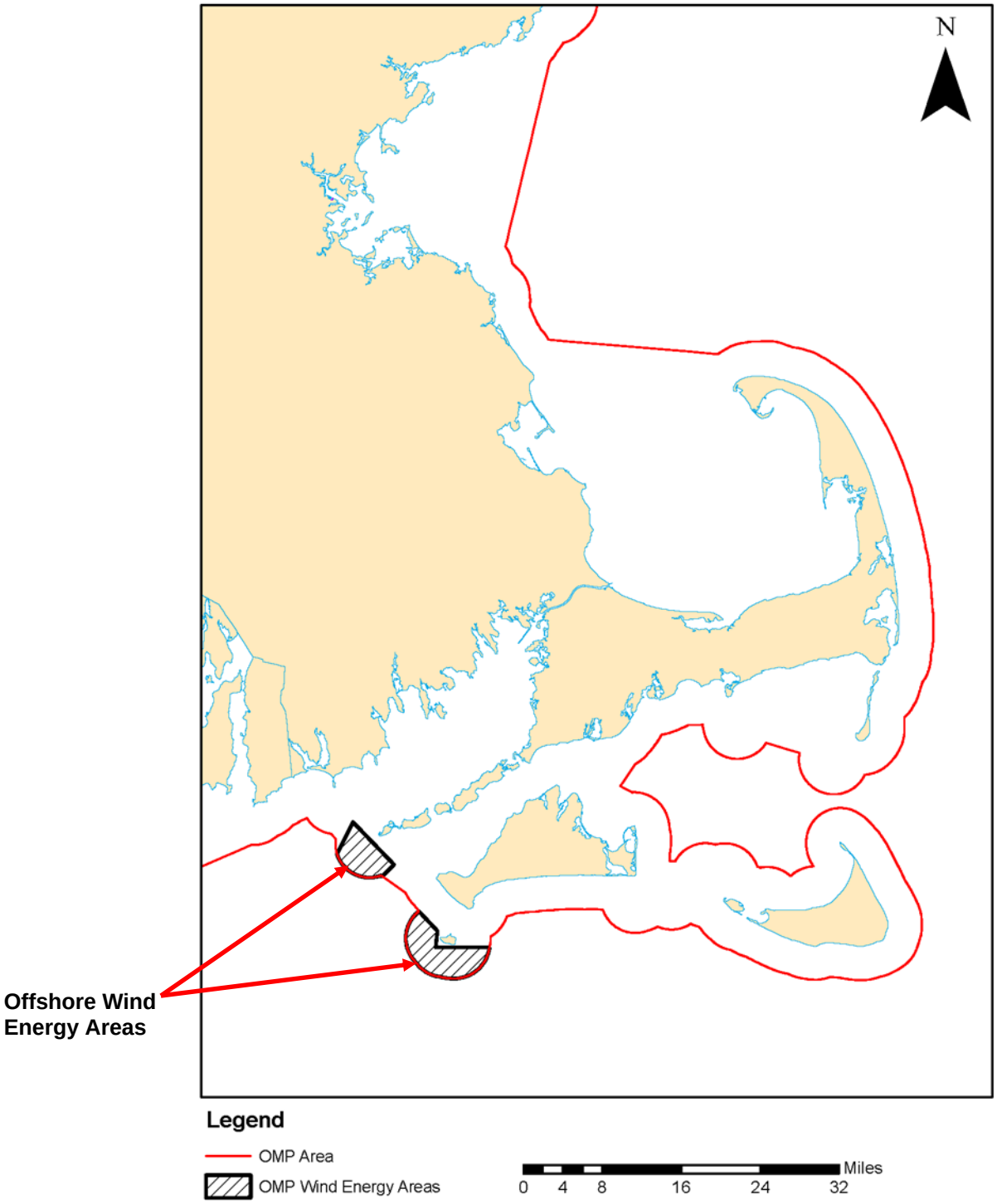


Figure 2-1 Massachusetts Ocean Management Plan Offshore Wind Energy Areas
(Source: Based on EOEEA OMP, 2009)

The Team recognized the potential for these sites to be developed for offshore wind energy and the implications of that development on the demand for port and offshore support infrastructure. Massachusetts ports with the potential to satisfy the infrastructure requirements of the offshore wind energy industry would be well-positioned to support construction in the Offshore Wind Energy Areas.

Developers have yet to construct any offshore wind commercial generation facilities in U.S. waters (so far only meteorological towers have been constructed to test wind characteristics). As such, U.S. port facilities have yet to stage construction for any offshore wind farms. Other than the import of landside wind farm components, East Coast ports have no experience in handling, storing or assembling offshore wind generation components. Therefore, the experience gained at European ports that are servicing offshore wind facilities and at the U.S. Gulf of Mexico ports staging construction for the offshore petroleum industry have formed the basis of the Team's analysis of the port infrastructure needed to support the East Coast offshore wind industry. The combination of massive turbine component sizes, the trend toward production of much larger components (such as blades with lengths approaching 90 meters), and the expectation that stateside developers intend to skip pilot scale offshore facilities (which would present learning opportunities) in favor of full-scale production projects, complicates the Commonwealth's preparation for this new industry. The physical constraints in and around Massachusetts ports also suggest that their ability to cost-effectively stage such offshore construction will take both physical improvements and attentive problem solving.

The Team's approach to addressing these questions and specific needs of the industry involved a sequential approach that considered:

- Assessment of Offshore Wind Energy Port Infrastructure Needs – Section 3.0 of this study provides an overview of the current industry, site conditions along the eastern U.S. coastline, and vessel characteristics and constraints for transport, installation and maintenance of offshore wind farms.
- Evaluation Criteria – Section 4.0 describes the "hard" and "soft" criteria that were used to evaluate specific port facilities. These criteria include port utilization, staging requirements, navigational access, distance to the installation site, and rail/highway access for component delivery to port facilities.
- Inventory of Port Facilities in the Commonwealth of Massachusetts – Section 5.0 outlines the general characteristics of six port facilities, along with their navigational constraints and rail and highway access. This section also provides the distance from each port to a Representative Offshore Wind Energy Installation (ROWEI) 130-turbine wind farm.
- Short-listing of Ports for Further Evaluation – Section 6.0 considers the information developed in the needs assessment and the port inventory against the evaluation criteria to short-list two ports for further consideration. Section 6.0 also includes an engineering cost analysis of port upgrades, along with a description of educational, training and research organizations that will support offshore wind energy activities in the Commonwealth of Massachusetts.
- Economic and Tax Effects of Construction and Operating Expenditures – Section 7 provides an analysis of the estimated costs for required upgrades at the two short-listed

ports, in addition to the economic and tax effects of these activities on the Commonwealth.

- Summary and Recommendation – Section 8.0 contains a summary of the Team's findings, along with a final comparison of the two short-listed port facilities to the evaluation criteria developed for this study.
- Path Forward – Section 9.0 contains a preliminary high-level business plan for the recommended port and suggests a path forward that would consider other important aspects of the port's development that were not within the scope of this study.
- References cited in this report are listed in Section 10.0.

3.0 ASSESSMENT OF OFFSHORE WIND ENERGY PORT INFRASTRUCTURE NEEDS

Any port to be used to support offshore wind energy development must be capable of meeting a number of physical and operational requirements relating to navigation, scale of operations, physical space, ancillary support facilities, and other considerations. This section reviews a number of the key features and characteristics of commercial offshore wind farm development to provide a basis for identifying port criteria that would be either required or highly desirable for supporting that development.

3.1 Introduction to Offshore Wind Energy and Similar Offshore Activities

This section provides a description of wind farm components and the issues affecting their delivery and deployment, explains how other offshore industries offer insight into navigational and port requirements for offshore wind development, discusses proposed offshore wind projects and site conditions at these locations, provides an overview of currently available vessels, and discusses the constraints and requirements of installation, import and auxiliary vessels for the offshore wind industry.

3.1.1 Wind Farm Components

A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations. The "farm windmill" that is still seen in many rural areas of the United States is a wind-powered water pumper, but it can also be used for many other purposes (e.g., grinding grain, sawing). If this mechanical energy is converted into electricity, the machine is called a wind turbine. Wind electric turbines generate electricity for homes and businesses and for sale to utilities. Wind turbines, including offshore wind turbines, primarily consist of a rotor (with blades on a hub), a nacelle, tower, foundation and associated electronic equipment (see Figure 3-1). Most turbines use a three-bladed rotor that is connected through the drive train to the electrical generator that is housed in the nacelle. Offshore wind turbines are typically designed to also have extra space within the nacelle to allow access for maintenance. The associated electronic controls for the system are housed in the nacelle and in land-based control buildings. The cylindrical, self-supporting, tubular tower supports the turbine rotor and nacelle

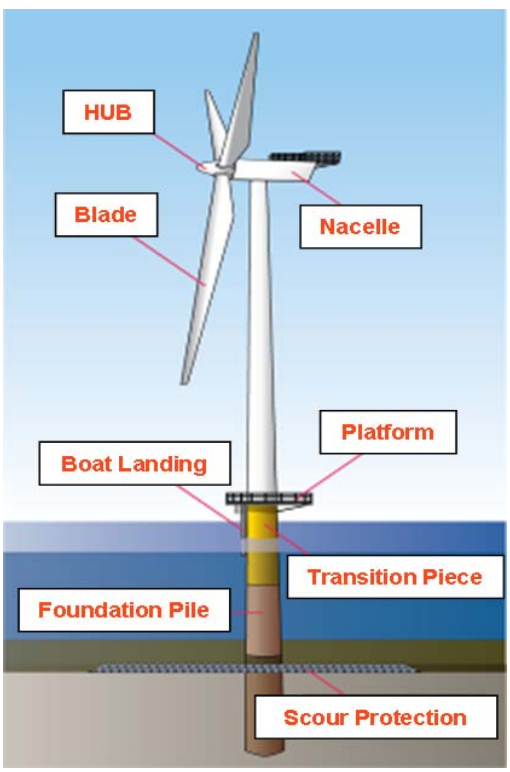


Figure 3-1 Primary Components of an Offshore Wind Turbine

and provides a sheltered interior for the cables, controls and access way to the nacelle for maintenance and repairs. Cabling, transformers, interconnect equipment, meteorological tower(s) and a substation are the major components of any wind turbine system.

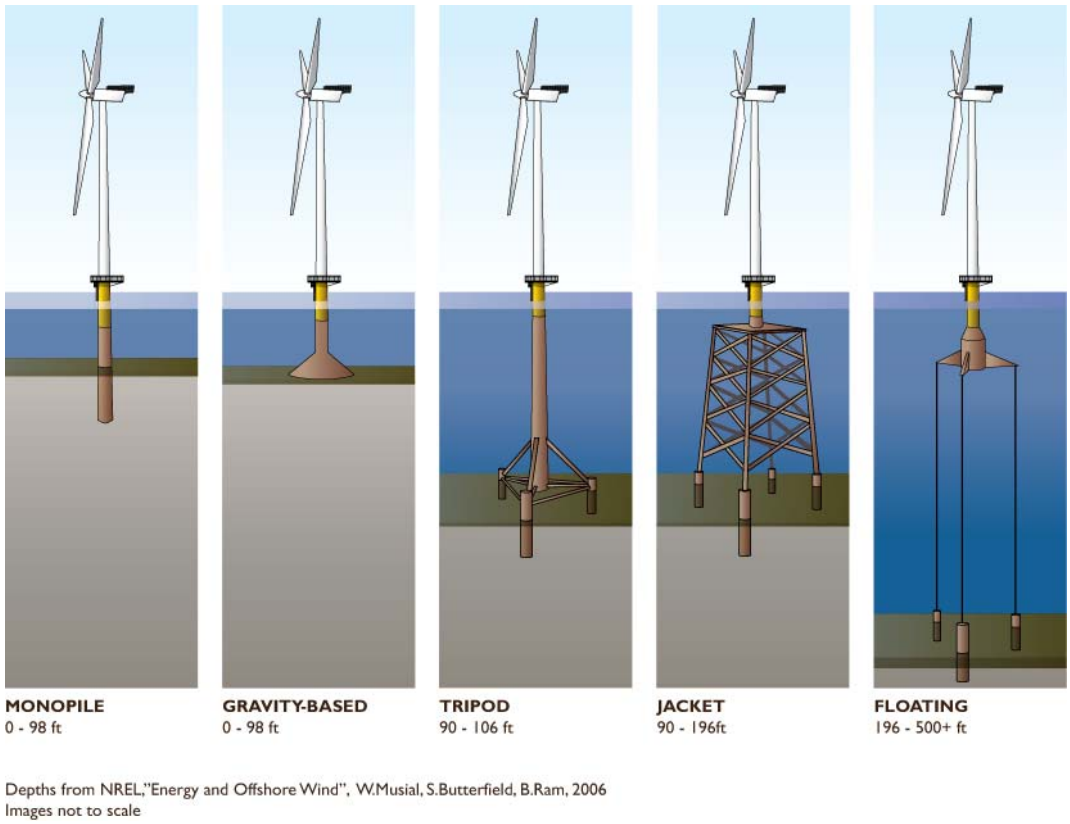


Figure 3-2 Types of Foundation for Offshore Wind Turbines

Offshore wind turbines are typically larger than 2 MW in generation capacity. In this analysis, the Team primarily considered 3 MW or 3.6 MW turbines, as these are typical of the sizes currently being deployed. Examples of current wind turbines in this range are the Siemens SWT-3.6-107 turbine or the Vestas V112- 3MW turbine. Next generation wind turbines for offshore deployment are expected to be 5 MW and greater in generation capacity. For the purposes of this study, a minimum offshore wind turbine array was assumed to consist of ten turbines. Based upon discussions with current and future developers, larger wind farm arrays would include from 60 to 150 turbines.

Various foundation structures can be used depending on the seabed geology, the wind/wave conditions, and water depth at the site. Four standard types of offshore foundations currently exist (see Figure 3-2):

- Monopile;
- Gravity-Based;
- Multi-Leg – Tripod or Jacket; and
- Floating.

Offshore wind turbine foundation technology is being developed from the structural foundations already in use in the offshore petroleum extraction industry, mainly from the use of piles and jackets. Foundation types for wind turbines, like those for petroleum extraction platforms, vary with water depth. Deep water technologies, such as semi-submersible and floating platform technologies, are being explored for the offshore wind industry. However, there are differences between stabilization requirements of petroleum extraction platforms and wind turbine towers. The torque of the rotating blades of the wind turbine adds stresses to the structure that makes stabilization of the towers more difficult. The State of Maine is currently exploring the use of floating turbine technology, specifically because of the deep water environment found in the Gulf of Maine (University of Maine 2009). The technology used for floating and anchored structures has also been modified for new applications such as deep water Liquified Natural Gas (LNG) ports. Anchor systems used for petroleum and LNG ports could also be adapted for wind turbine applications to anchor structures at deep water locations.

Monopiles and gravity-based foundations are commonly used in shallow and transitional water with water depths up to 30 m (approximately 100 feet). Monopile foundations are already heavily used for offshore wind in Europe. Multi-pile configurations with broader bases (such as tripods, jackets, mono-towers and suction bucket support structures) are used where the water depth is 30 to 60 m (approximately 100 to 200 feet). Floating turbines may also become feasible long-term options for deep water installations greater than 60 m (200 feet) deep. These floating turbine structures would be secured to the ocean floor via guy wires, mooring lines, or taut tension legs, which in turn would be fastened to anchors or gravity-based platforms (U.S. Offshore Wind Collaborative 2009, p. 23). Most of the developers that were interviewed for this study indicated they plan to use monopiles for their currently proposed offshore wind farms. Deepwater Wind expects to use monopiles for its proposed Block Island project and jacket foundations for its deeper water Delaware project (Tetra Tech 2009b).

3.1.2 Wind Turbine Component Delivery and Deployment

Port infrastructure needs must consider the logistics of wind turbine component delivery and the sequencing of installation and construction. Currently, very few offshore wind turbine components are manufactured in the United States that are large enough to be suitable for a commercial offshore wind farm. Manufacturers such as Siemens, Vestas, REPower, Clipper Windpower, General Electric, Northern Power Systems, and Multibrid currently have little incentive to set up large scale offshore wind component manufacturing operations for offshore wind development in the United States until developers are ready to place orders and purchase components at a rate that makes the investment in a manufacturing facility financially attractive (based on Team discussions with manufacturers). Vestas has been manufacturing turbine components in the United States for a couple of years and Siemens and General Electric (among other manufacturers) are currently developing domestic manufacturing facilities for wind turbine towers and nacelles in the United States. Some of these new facilities are expected to become operational in 2010. However, these facilities will likely focus on landside wind turbines in the short term. Therefore, this analysis assumes that almost all turbine component pieces for offshore wind farms in the near future would be delivered from Europe.

Suppliers are expected to ship turbines from European manufacturing facilities to the United States in pieces (e.g., the tower sections, nacelle, hub, individual blades) aboard crane-equipped, open hatch cargo vessels. These vessels can accommodate from four to eight

nacelles, hubs and blades depending on the size of the vessel. As discussed below, the draft and beam of these vessels (referred to as either “import” or “delivery” vessels) must be accommodated by the port of delivery (see Appendix A, Vessel Requirements for Offshore Wind Farm Construction and Maintenance). Component pieces will be offloaded upon delivery and placed in a storage area. Onshore assembly of the wind turbine parts makes use of land-based cranes. Turbine towers have their own storage requirements, including specific brackets. Components assembled in the storage areas require relocation to the quayside via onshore cranes before being loaded onto the installation vessels. Smaller wind turbine component pieces and scour protection aggregate could be transported to the onshore staging port by existing rail or truck.

Foundations and transition pieces tend to be manufactured and delivered separately from the turbines, although there may be some manufacturing overlap with towers. Currently, no operational rolled steel manufacturing facilities on the East Coast have been identified that operate at a scale suitable for manufacturing the towers and structural components of a large offshore wind farm. Since there is still no firm demand for the number and size of monopiles necessary to construct a 60 to 150 turbine wind farm, foundation suppliers also currently lack an incentive to set up an East Coast production facility.

Existing domestic and foreign suppliers may deliver foundations fully assembled or ready for assembly. These sections or components would be shipped in on large barges from the Gulf of Mexico, Europe, or Malaysia. A potential scenario for monopiles delivery would include shipping ‘cans’ or small sections of rolled steel from Europe or Malaysia by barge for welding and assembly at the staging port. Similarly, jacket piles could be shipped as unassembled bars from the Gulf of Mexico to the staging port to save cargo space and be welded together there. Depending on the type and point of origin, foundation component delivery to the staging port may also be performed using more traditional means such as barges, rail, or truck. Rail and truck options are limited to bulk concrete components, or sectional pieces such as iron bars or flat sheets of steel. Fully assembled foundations have dimensions that preclude their delivery by rail and truck.

Developers do not necessarily have to stage foundations for offshore deployment out of the same port that is staging the turbine construction. The value of the convenience of utilizing a common port or port facility generally would not outweigh the cost savings associated with improved logistics, less assembly, and minimizing storage space and handling needs. Barges may also be used conveniently for foundation storage in certain situations. Foundations can be delivered and/or stored on barges fully assembled, then tugged out to the installation site with less handling.

Ample storage at the staging port is needed to support routine logistical inventories. For example, Vestas stated that it would generally require 20 turbines to be assembled ahead of time before transport to the installation site (Tetra Tech EC 2009-2010a). Weather conditions at the installation site, including wind and wave action, can disrupt deployment and installation activity. This possibility translates into a need for increased landside storage capacity to accommodate a backlog of turbine and foundation component deliveries.

3.1.3 General Sequence of Offshore Construction and Installation Activities

The sequence of offshore wind turbine construction begins with the installation of foundations. Foundations can be delivered from the staging port by either a standard barge or on the installation vessel. A jack-up barge with a crane creates a stable work platform for the placement. Traditionally, these vessels have been used in the U.S. marine construction industry in contrast to the specialized vessels that are generally preferred by European offshore wind developers for turbine installation. The foundation installation methodology depends on the foundation type. Each type of foundation requires tailored installation procedures and equipment. A monopile foundation, for example, would require pile drivers (see Figure 3-3). After foundation installation, the transition piece gets attached to the top of the foundation, creating a level connection surface for the towers. See Appendix A for details of other installation types.

Figure 3-3 Monopile Being Driven In with a Menck Hammer
(Source: Courtesy of A2Sea)

As previously noted, turbine components may be transported from the staging port to the installation site in various stages of assembly. Appendix A provides more details of these transport options. In general, options are defined by the capabilities of the particular installation vessel, preferences of the manufacturer for sub-assembly configurations, and site-specific navigation constraints. On-site assembly cuts down on transport risk, but entails other risks associated with assembly in the marine environment. Similarly, assembly in the controlled environment of the staging port results in more difficult and risky transport, but less risk at the installation site. Turbine manufacturers and contractors with experience in European wind farm construction prefer to use specialized vessels for turbine installation. Installation vessels need to be stabilized (i.e., with jack-up

legs) and have a crane or cranes able to lift a 3 MW or 3.6 MW nacelle (which weighs approximately 135 to 185 metric tons (mt) (approximately 150 to 200 tons)) into place so that the blades can be attached. Delivering and installing fully assembled turbines on towers requires greater lifting capabilities of up to 275 mt (approximately 300 tons). It should be noted that a 5 MW nacelle, which may be employed in future systems, weighs 360 to 390 mt (approximately 400 to 430 tons).

The unassembled deployed wind turbine components are then assembled at the offshore site. The foundations are installed first, followed by the transition piece, the tower, the hub, and the nacelle. Next the blades are attached to the hub and the assembled rotor is hoisted and attached to the nacelle. However, as was noted, the turbine components also can be transported partially or fully assembled to the site.

Purpose-built vessels (vessels designed specifically for the offshore wind industry) for wind turbine installation are not currently available in the United States. Additionally, it is not expected that a U.S. purpose-built vessel will exist in time for the initial construction of utility scale wind generation facilities on the East Coast. Construction costs for these vessels range from $40 million ($40M) to $80M for tugged vessels and $150M to $250M for self-propelled vessels (see Appendix A). Like other offshore wind turbine components, the incentive to build a purpose-built installation vessel will depend on the amount of actual demand for their use and the potential return on such investment. Existing U.S. built jack-up vessels were built for the oil and gas industry and are less than optimal for offshore wind turbine installation, but they could be used for the initial deployments for East Coast offshore wind construction. However, the use of these existing vessels involves more risk and would require more installation time than purpose-built vessels. Rental rates for installation vessels are high and developers will attempt to maximize the utilization of the vessels when leased. This factor, along with the ever present possibility of weather and seasonal delays, indicates that the staging port must be available 24 hours per day and 7 days per week. Both the availability of wind turbine components and delivery and construction vessels are critical elements of the offshore wind energy supply chain.

3.1.4 Forecasts and Future Trends in Offshore Wind Energy Affecting Port Requirements

Proposed offshore wind projects in Europe and North America for 2015 are forecasted to reach 40 gigawatt (GW), of which the United States is expected to undertake projects totaling more than 2 GW (Infocast, U.S. Offshore Wind Report 2009, p. 6). The European Wind Energy Association (EWEA) has set a target for 2020 of 40 GW of offshore wind capacity. European offshore demand for 2010 is forecasted to reach 10 GW. This implies a European need for 30 GW or more over a 5-year span, which cannot be supported by current manufacturing capacity (EWEA, Oceans of Opportunity 2009, p. 44). However, the offshore wind industry will need to deploy upwards of 10,000 structures by 2020 to meet the minimum forecasted European demand. The current offshore manufacturing industry cannot deliver this number of structures due to insufficient capacity. (EWEA, Oceans of Opportunity 2009, p. 49). Additional manufacturing facilities and related industrial capacity are needed to meet the forecasted European and North American demand.

Offshore development costs depend significantly on the price of the substructures. For example, foundations represent 25 percent and 34 percent of total investment costs for 5 MW and 2 MW

systems installed in 25 m of water, respectively (Papalexandrou 2008, Economic analysis of offshore wind farms, KTH Royal Institute of Technology [Sweden] (KTH) School of Energy and Environment, in partnership with Ecofys). The economics of offshore wind development tend to favor larger machines (potentially in the range of 5 MW to 10 MW in the future, with less emphasis on design features (such as aesthetics and sound emission level) than for onshore wind turbines (EWEA, Oceans of Opportunity 2009, p. 44). Current technology suggests that increases in turbine power rating are commensurate with incremental increases in turbine size.

3.1.5 Similar Offshore Activities

Offshore wind generation is a new marine industry on the Eastern Seaboard and will be added into a region that has historically been heavily dependent on maritime industry and commerce. As a new industry, however, offshore wind will require specialized equipment, services and labor not currently available in any U.S. ports. Understanding what will be needed to support both short-term construction and long-term operational and maintenance activities involves learning from the recent experience of European offshore wind projects, as well as identifying similar services and activities already associated with existing marine industries here in the United States.

There are a number of marine industries currently in operation in the waters offshore of the United States, each with its own specialized port requirements. These industries include, but are not limited to, petroleum extraction, LNG off loading or storage, commercial shipping, and commercial fishing. Each marine industry is specialized, requiring differing shore-side support as well as different configurations for the appropriate offshore environment. However, comparing and contrasting the needs of these industries with European experience can increase our understanding of the port-related requirements for offshore wind development and the potential utilization of the available marine industrial capabilities in the US. For instance, wind turbine foundations are comparable to offshore petroleum structures. Shore-side infrastructure for construction and maintenance of offshore wind farms is similar to that needed for commercial shipping and large-scale commercial fishing operations. Additionally, port requirements for maintenance and support of offshore wind farms would be similar to those for offshore LNG ports and petroleum platforms.

3.1.5.1 Offshore Energy Industry in the US

Petroleum Extraction

Petroleum extraction is well established in the United States, especially in the Gulf of Mexico. There is a broad range of off shore platform designs, and their structural design has evolved over time. In general, the petroleum extraction platforms in the Gulf of Mexico are designed for water depths of 60 to 190 m (approximately 200 to 600 feet) (MMS 2009). However, platforms in deeper water up to 2,450 m (approximately 8,000 feet) also exist (MMS 2009). These deep water platforms are built using pre-fabricated modules. The super-structure is pre-assembled on land and transported to the field site for final assembly. These structures are comprised of different modules, typically partitioned into crew housing and process or control functions. Petroleum platforms are often built in clusters, centered on a developed well. Assembly is intensive due to the multiple connections required between modules, clustered platforms, and the well. Steel construction is preferred for the platform superstructure while concrete is limited to the platform foundations. Shallow foundations are commonly constructed using piles that

anchor the superstructure or jack-up platforms on the seabed. Deeper platforms require semi-submersible elements or floating devices anchored to the seabed to fix the position of the platform. Platform assembly is generally accomplished using specialty vessels, including jack-up cranes, tow boats, and large barges. Special heavy lift vessels are needed to transport the large assemblies, such as the pre-fabricated modules. Jack-up cranes or crane vessels lift the pre-fabricated modules into place. Platform modules are purposefully designed to have a minimum number of tie-ins to minimize field assembly efforts.

Large ports play an important role in the operation and maintenance of these petroleum extraction platforms. Major petroleum companies with a number of offshore platforms maintain permanent access to their own shore-side terminals that are capable of berthing vessels from 90 to over 185 m (approximately 300 to over 600 feet) in length with drafts that can exceed 11 m (36 feet). The accessibility and use of onshore facilities is critical to supporting petroleum extraction. Considering the premium that is placed on the space available on offshore platforms, activities aboard are typically minimized to assure operational efficiency and safety. All other materials are supplied from storage facilities at nearby ports, ready to be shipped out when and as needed. Because of this, ports receiving and delivering large petroleum extraction components and platform modules require large areas for yard storage, large dock heavy lift capability, and berthing for other construction and maintenance vessels. These requirements are similar to those for supporting offshore wind development on a commercial scale.

LNG Ports

The importation of LNG into U.S. markets has recently begun to favor fixed locations in deepwater offshore locations. These deepwater ports offer easy access, improved safety and reduced visibility to coastal residents. Deepwater LNG ports typically consist of re-gasification equipment, LNG vessel anchorage, and pipeline delivery systems to shore-based storage and distribution pipelines. Many technologies have been proposed for re-gasification, including barged equipment, modified petroleum platforms, island structures, and underwater riser assemblies. Northeast Gateway (NEG) Deepwater LNG Port is currently operating off the Massachusetts coast. Another similar deepwater LNG port facility is being planned in the area by Neptune LNG. Both of these facilities are located approximately 8.7 nm (10 miles) due east of Boston. The technology used for the NEG port is an underwater riser assembly that acts as anchorage and gas delivery system to a sub-sea delivery pipeline. Two such riser assemblies were constructed, and are anchored in place much like anchored floating petroleum platforms. Construction of the NEG Port required a large 110 m (approximately 350 foot) pipeline lay barge for offshore pipeline construction, anchoring vessels, and diver support vessels. Crew vessels provided provisions, material and transit for the 150 to 300 person crew throughout the construction operations. Specialized 275 m (900 feet) long LNG re-gasification vessels moor to the riser/mooring assembly during gas delivery operation. Support and security vessels for the NEG Port are based out of Boston, and are deployed to provide safety and security. Shore-based facilities are minimal for operation of the NEG Deepwater Port. However, construction of the deepwater port required layout, staging areas, and crew deployment from multiple ports.

3.1.5.2 Commercial Shipping

Commercial shipping requires large, mobile vessels exporting and importing bulk cargo to ports throughout the world. Vessels range from under 215 to over 300 m (approximately 700 to over

1,000 feet) in length. Ports that receive and deliver cargo require large areas for yard storage and wharf frontage. Vessels calling on commercial shipping ports must also be able of pass under vertical obstructions such as bridges. In the United States, vertical obstructions are typically standardized by the U.S. Coast Guard (USCG) to maintain a minimum clearance of approximately 41 m (135 feet) (Coast Pilot specification).

Commercial shipping ports such as Boston require distribution and warehousing facilities for the handling of roughly 1.2 million mt (1.3M tons) of general cargo, 1.4 million mt (1.5M tons) of non-fuels bulk cargo, and 11.6 million mt (12.8M tons) of bulk fuel cargo per year (Massachusetts Port Authority 2009). The Port of New York and New Jersey handles 5.3 million loaded and unloaded twenty-foot equivalent units (TEUs) per year (Port Authority of New York and New Jersey 2009). Trucking and rail access facilitate shipment of cargo over land. The Port of New York and New Jersey also boasts 54 container cranes that can handle all types of cargo, 135 to 320 mt (approximately 150 to 350 ton) capacity cranes, and the largest heavy-lift crane on the East Coast (an approximately 900 mt (1,000 ton) rated-capacity Chesapeake 1000). Donjon Marine Co. Inc. cranes have handled large bulk cargo including 365 mt (400 ton) General Electric Co. and Siemens generator units that were transported to the port via oceangoing vessels (Port Authority of New York and New Jersey 2009).

3.1.5.3 Commercial Fishing Factory Vessels

Commercial fishing is conducted by vessels ranging from very small, 1 or 2 man crew ships to large factory vessels. Shore-based support for these operations varies widely considering the large diversity of vessel types. Large factory vessels have similar shore-side requirements as commercial shipping. Consequently, commercial fishing operation requirements are very comparable to offshore wind operational and maintenance needs. However, offshore wind generation support needs are much smaller in scale than the warehousing and wharf frontage needed for commercial shipping. Frozen fish products also require freezer containment for offloaded cargo. In Rhode Island, Seafreeze Ltd. utilizes berthing space for two 45 m (approximately 150 feet) processing vessels, warehousing cold storage capacity of approximately 10.4 million kg (23 million pounds), offloading cranes, and truck and rail access (Seafreeze Ltd. 2009).

3.1.5.4 Submarine Transmission Cables

Additionally, technologies and construction techniques used for submarine pipeline installation may have similarities, in terms of lay-down area and construction vessel size, to those needed for high-capacity submarine transmission cable installation required for the offshore wind industry.

3.1.5.5 Implications

Offshore wind power generation will require specialized labor and equipment for construction and operation. Specialized training will be required to successfully construct and operate safely and efficiently in the marine environment. The basic skill-set exists, to a certain extent, within the maritime industry and Merchant Marine. Local universities (including the Massachusetts Maritime Academy) and labor unions could modify existing training courses to create and maintain a qualified labor force specifically geared to service a growing offshore wind industry. But establishing programs in anticipation of the offshore wind industry is unlikely.

Petroleum extraction platforms are currently assembled using specialized heavy lift vessels. Similar vessels will be required for the construction of wind turbines. Vessels currently in the fleet (including jack-up cranes, tow boats, and large barges) have the potential to be modified for use as construction platforms for wind turbines (especially for initial installations). While such modifications can be made to existing vessels, the specialized construction techniques and heavy lift needs of offshore wind turbine construction may make the modification option expensive and potentially risky as compared to purpose-built vessels. The option of applying modified existing equipment may also be limited to smaller construction projects in near-shore environments. Purpose-built construction vessels for offshore wind turbine construction would most likely, be more cost effective, less risky, and flexible in terms of operational capabilities.

As with petroleum extraction, commercial shipping and factory fishing port facilities, offshore wind construction lay down and port requirements are fairly significant. To support the offshore wind industry, significant lay down areas will be required for the assembly and storage of large wind turbine components. It is estimated based on discussions with major offshore wind turbine manufacturers in Europe that a minimum of 8.1 hectares (approximately 20 acres) would be needed for assembly and storage of these components assuming component delivery is scheduled so that the portside assembly area only needs capacity for a fraction of the total wind farm components at any given time (based on interviews with developers). Large-capacity cranes will also be needed to move turbine components such as nacelles and tower pieces. Yard and wharf facilities will need to be sufficiently large to store, move and assemble turbine components with weights up to approximately 290 mt (320 tons). The large vessels needed for receiving and delivering such components require navigation channels of particular depth and clearance (both horizontal and vertical) to allow passage through/beneath obstructions such as bridges. Recent developments in offshore wind turbine size, coupled with evolving construction and component delivery techniques, may exceed the current 41 m (135 feet) vertical clearance of local, large fixed bridges.

An offshore wind farm, once constructed, will need routine maintenance and occasional component replacement, including major components such as a blade or nacelle. Maintenance vessels used during wind farm operations would be similar in size to those currently in use to support offshore LNG ports and petroleum extraction operations and, on rare occasion, would require the same or similar vessels to those used during construction for major maintenance. Berthing space for support vessels would be vital for these port facilities, as well as sufficient yard and warehousing space for components and other maintenance supplies and activities. The NEG Deepwater LNG Port operating off the coast of Massachusetts currently utilizes a 33 to 49 m (approximately 110 to 160 feet) long offshore support vessel (OSV) that makes roughly 65 round trips to the port site each year (U.S. Coast Guard 2006). For comparison, Cape Wind estimates that three maintenance vessels will be required each day, 252 days per year, for routine maintenance, resulting in an estimated 756 vessel trips per year. Commercial shipping and fishing vessel activity is similarly constant with vessels arriving and departing port facilities on a daily basis. Vessel activity during offshore wind project construction also would be constant, but short in duration during the one to two year long construction phase of a project (depending upon the size of the wind farm). Larger vessel activity would drop off considerably during operation and maintenance of offshore wind projects. However, major repair work would likely require a large vessel like the ones used during wind park construction. Vessels currently in the fleet, including jack-up cranes, tow boats, and large barges, can be modified for use as

construction/maintenance platforms. However, the availability of purpose-built construction vessels would be the preferred option in the long run.

3.2 Industry Overview

3.2.1 Development of the Port Criteria

To determine the port facility/land-based requirements for offshore wind development, the Team interviewed developers, obtained turbine manufacturer information, and had discussions with consultants with offshore wind farm construction experience in Europe. Through this information gathering, the Team identified:

- specific port- and land-based needs related to vessel requirements;
- component, materials and equipment storage and assembly requirements;
- preliminary estimates of potential through-put of wind turbines (e.g., the number of wind turbines deployed); and
- skilled labor needs and trades requirements.

The Team identified “hard” and “soft” criteria based on the stated requirements (see Section 4.0). These criteria were used to create a Criteria Evaluation Matrix as a tool for comparing and ranking Massachusetts port facilities (see Section 6.0) on the ability to serve as offshore wind construction and deployment ports.

3.2.2 Interviews with Developers

The Team contacted most of the current and prospective offshore wind farm developers on the East Coast to gain a deeper understanding of the requirements for supporting the construction, operation and maintenance of a utility scale offshore wind farm. The Team intended to use this developer input to identify an objective set of weighted criteria with which to compare and evaluate Massachusetts port facilities. However, many developers have yet to specify or disclose in detail the key parameters and characteristics of the port and other supply chain requirements. While cognizant of the need to solve logistical issues, negotiations between developers and various manufacturers and material suppliers are ongoing. Actual component manufacturing sites and delivery methods will be determined on a project- and item-specific basis. As a result, many of the detailed questions contained in the customized developer questionnaires were left unanswered (see Appendix B for the questionnaire). However, developers did identify and explain many aspects of the most important parameters that helped the Team establish the basic criteria. Developers identified general port staging needs against the characteristics of which current ports could be compared and ranked. Developers also were questioned about what would make one port more attractive than another. Cost control and risk avoidance emerged as key factors.

The Team’s interviews with developers provided insight into the principal issues concerning commercial offshore wind energy development off the Northeast Atlantic Coast. These insights provided a better understanding of wind farm components and the associated logistics of importing, storing, assembling and deployment to and installation at the project site. Table 3-1 below provides a quick summary of these proposed projects based on available public information. Projects are listed by developer with project particulars such as location, water depth, generating capacity, number of turbines, and distance from shore. Because these

projects are in various stages of development, not all information on every project is publicly available.

As the developer's needs were analyzed, the Team found that Massachusetts ports had clear, distinguishable differences relative to offshore wind development requirements, and that the ports could be compared in a straightforward manner relative to these parameters. Development of a more complex framework for the evaluation that made use of multi-variable, weighted criteria was unnecessary.

Table 3-1
Planned Offshore Wind Projects

Developer/ Project	Project Location	Water Depth at Proposed Location	Project Generating Capacity	Number of Turbines (Scale)	Foundation Type	Estimated Cost of Construction	Port Staging Area
Cape Wind Associates							
Cape Wind	4.5 NM (5.2 miles) from coast of Cape Cod, MA, 7.8 NM (9 miles) from Martha's Vineyard, 12 NM (13.8 miles) from coast of Nantucket Island	3.7 m (12 ft) MLLW (mean low low water) minimum depth	468 MW	130 (3.6 MW per turbine)	Monopile	$700 million	Quonset Davisville Port and Commerce Park, Quonset, Rhode Island
NRG Bluewater Wind							
Bluewater Delaware	11.3 to 19.1 NM (13 to 22 mi) east of Rehoboth Beach, DE (wind park); 14.3 NM (16.5 mi) due east Rehoboth Beach (met tower)	12.2m to 18.3m (40 to 60 feet)	200 to 450 MW	Up to 150	Monopile	$800 million	Port of Wilmington, Delaware; Delaware Bay Launch in Milford Delaware for crew boat and small cargo barge launch
Bluewater New Jersey	14 NM (16 mi) southeast of Atlantic City, NJ	21.3m to 30.5m (70 to 100 feet)	350 MW	116	Monopile	$1.4 billion	Port of Wilmington, Delaware; Delaware Bay Launch in Milford Delaware for crew boat and small cargo barge launch
Deepwater Wind							
Garden State Offshore Energy (Deepwater with PSEG Renewables)	13.6 NM (15.6 mi) from shore, 17.4 NM (20 mi) due east of Avalon, NJ	24.4m to 27.4m (80 to 90 feet)	350 MW	96	Jacket	$1 billion	Atlantic City, New Jersey

Developer/ Project	Project Location	Water Depth at Proposed Location	Project Generating Capacity	Number of Turbines (Scale)	Foundation Type	Estimated Cost of Construction	Port Staging Area
Deepwater Wind Rhode Island	2.6 NM (3 miles) off Block Island, RI for Phase 1; Phase 2 located 13 to 17.4 NM (15 to 20 mi) off RI coast (location TBD upon completion of RI Ocean Special Area Management Plan in 2010	'deeper' waters	20 MW (Phase I) 400 MW (Phase II)	Phase 1: 8 turbines Phase 2: 106 turbines	Jacket	$1 billion	Quonset, Rhode Island
Fisherman's Energy							
Fisherman's Energy of New Jersey Project	Phase 1: 2.6 NM (3 miles) off the coast of Atlantic City Phase 2: 6.1 NM (7 miles) off the coast	18.3m to 21.3m (60 to 70 feet)	Total: 350 MW Phase 1: 20MW Phase 2: 330 MW	Total: 74 Phase 1: 8 turbines Phase 2: 66 turbines	Monopile	$100 million for Phase 1 $1 to 1.5 billion for Phase II	Dorchester, Atlantic City, and or Cape May, New Jersey
Fisherman's Energy of Rhode Island Indepen-dence 1 Project	2.6 NM (3 miles) south off the southern coast of Block Island, RI	20 m to 30 m (65.6 to 98.4 feet)	400 MW	80	TBD	$1.25 to $1.5 billion	TBD

3.2.3 Conditions at Ports and Wind Farm Locations

Wave height, water depth and wind speed impose limitations on at-sea construction operations. The following subsections describe sea states, wind conditions, and water depths at a number of proposed wind farm sites along the U.S. East Coast. Transit distances[2] between proposed wind farm sites and potential staging ports also are evaluated.

Sea states are typically characterized by the significant wave height (H_S), which is the average of the largest one-third of the observed waves. H_S correlates very well to the sea state as observed by mariners. Wind is characterized by the 10-minute average wind speed (V_W).

The base line transit routes for cargo in the region track around the east end of Cape Cod. The primary alternative route is via the Cape Cod Canal (see Appendix C). Air draft (i.e., the free space above the water line below an overhead obstruction) in the Cape Cod Canal is limited to approximately 41 m (135 feet). In practice, this means vessels or barges transporting 5 MW turbines in the "bunny ear" configuration (especially the "fore-aft" configuration – see Figures 3-4 and 3-5) probably cannot expect to transit the Cape Cod Canal. Alternative turbine load-out

[2] Transit distances are in nautical miles and are based on typical shipping routes.

configurations (e.g., the “star” configuration – see Figure 3-6) and/or smaller turbines (e.g., 3.6 MW turbines) in the “bunny ear” configuration could probably utilize the Cape Cod Canal.

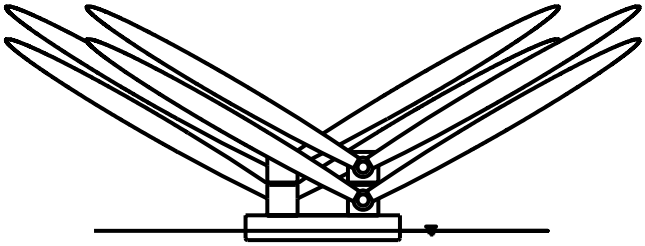


Figure 3-4 Bunny Ear Configuration (Lateral) – End view looking forward
(Source: The Glosten Associates 2009)

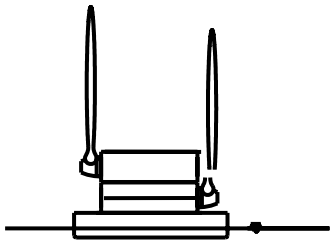


Figure 3-5 Bunny Ear Configuration (Fore-Aft) – End view looking forward
(Source: The Glosten Associates 2009)

Figure 3-6 Star Configuration – End view looking forward
(Source: The Glosten Associates 2009)

3.2.3.1 Nantucket Sound

Cape Wind Associates has proposed a project for Horseshoe Shoal in Nantucket Sound. The location for that project is shown below in Figure 3-7. The distances from the proposed project site to the potential staging port locations are listed below in Table 3-2.

Water depths in the proposed project area are approximately 3.6 to 18 m (approximately 12 to 60 feet). Information on wave heights and wind speeds is limited for this area. According to the Coast Pilot, during the winter (November-February), wave heights of 3.7 m (approximately 12 feet) can be expected 5 percent to 15 percent of the time. During the summer, wind speed rarely exceeds 15 knots, and wave heights are 1 m (approximately 3.2 feet) or less 98 percent of the time. Additionally, in the summer (May-July), thick fog frequently forms, which could complicate installation operations.

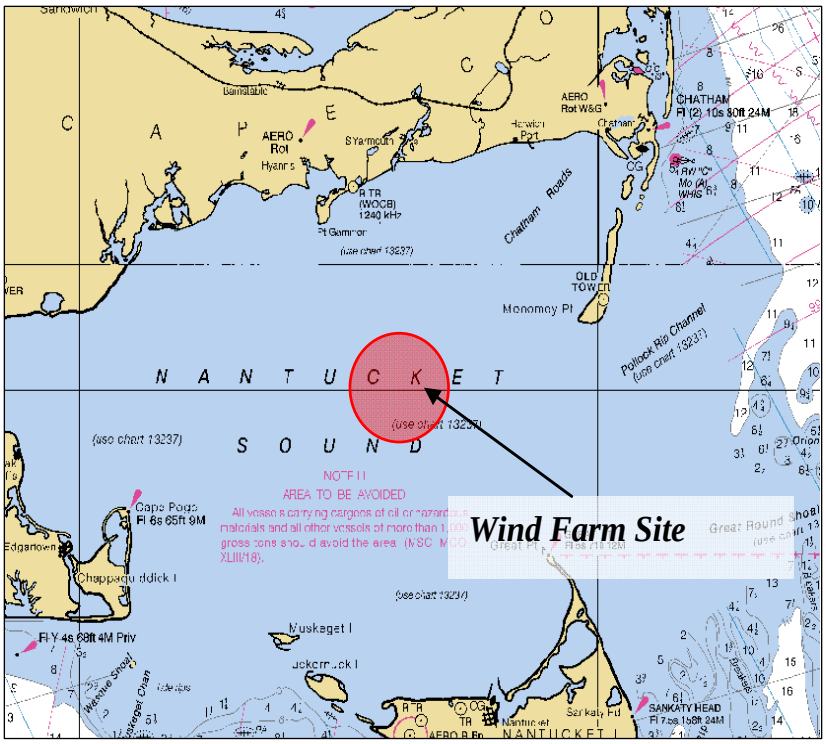


Figure 3-7 Cape Wind Proposed Horseshoe Shoal Site
(Source: The Glosten Associates 2009)

Table 3-2
Distances to Staging Port Locations from the Proposed Cape Wind Site
(Source: The Glosten Associates 2009)

Staging Location	Primary Route Distance [nautical miles]	Alternate Route* Distance [nautical miles]
Boston, MA	130	130
Gloucester, MA	105	130
New Bedford, MA	45	n/a
Fall River, MA	75	n/a
Portland, ME	160	200
Quonset/Davisville, RI	70	n/a

* Alternative route is via the Cape Cod Canal.

3.2.3.2 Rhode Island

Deepwater Wind, in collaboration with First Wind (a Massachusetts-based wind developer), is planning two projects off the Rhode Island coast. The first is a small-scale project, located three nautical miles off Block Island. The second is planned for a utility-scale project, located approximately 12 to 18 nm (15 to 20 miles) off the coast of Rhode Island[3]. This area is shown below in Figure 3-8. The distances from the sites to the potential staging port locations are listed

[3] The precise location of the second Deepwater Wind site will be established based of the results on the forthcoming Ocean Spatial Area Management Plan, which is expected to be completed in 2010.

in Table 3-3. Water depths are approximately 30 to 40 m (100 to 130 feet) at the proposed Rhode Island site. However, due to the large regional area being considered for the wind farm sites, water depths vary widely. Climatology for the general region is presented in numerical and graphical forms in Figure 3-9 and Table 3-4.

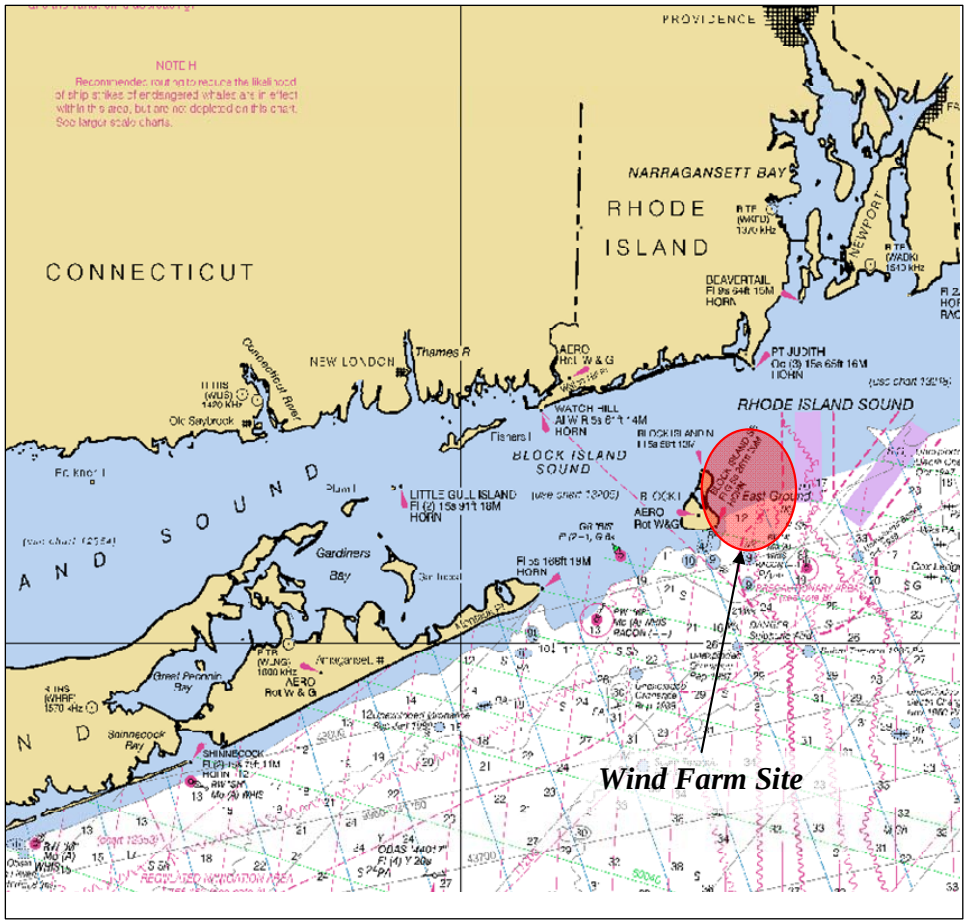
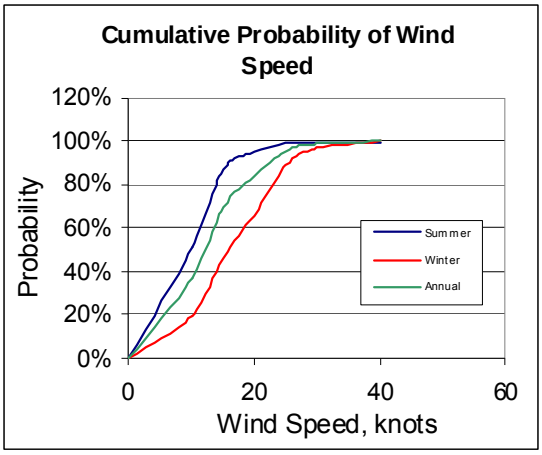


Figure 3-8 Deepwater Wind Proposed Rhode Island Site
(Source: The Glosten Associates 2009)

Table 3-3
Distances to Staging Port Locations from the Proposed Deepwater Site

Staging Location	Primary Route Distance [nautical miles]	Alternate Route* Distance [nautical miles]
Boston, MA	295	120
Gloucester, MA	270	120
New Bedford, MA	50	n/a
Fall River, MA	45	n/a
Portland, ME	325	190
Quonset/Davisville, RI	35	n/a

* Alternative route is via the Cape Cod Canal.



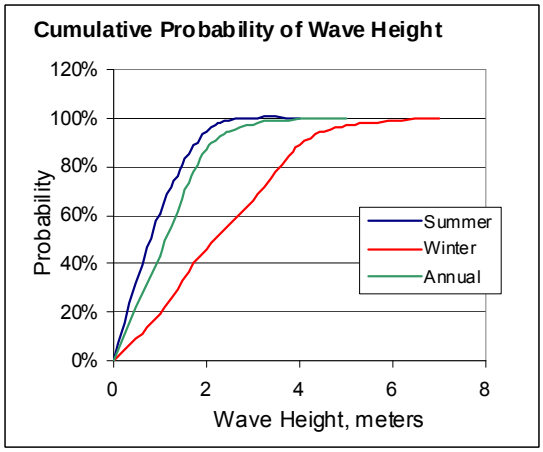


Figure 3-9 Cumulative Probability Graphs of Wind Speed and Wave Height for Coastal Rhode Island

(Source: The Glosten Associates 2009)

Table 3-4
Rhode Island Climatology Data
(Source: The Glosten Associates 2009)

Description	Annual	Winter (January)	Summer (August)
Probability {$H_S \leq 1$ meters}	43.5%	28.5%	60.3%
Probability { $H_S \leq 2$ meters}	86.7%	78.2%	94.3%
Probability { $H_S \leq 3$ meters}	97.2%	95.2%	99.8%
Probability { $H_S \leq 4$ meters}	99.4%	98.7%	99.9%
Probability {$V_W \leq 15$ knots}	36.9%	18.2%	52.6%
Probability {$V_W \leq 20$ knots}	69.3%	45.9%	87.5%
Probability {$V_W \leq 25$ knots}	83.9%	65.9%	95.9%
Probability {$V_W \leq 30$ knots}	95.6%	89.4%	99.8%

3.2.3.3 Delaware Bay

Bluewater Wind and Deepwater Wind have each proposed wind farm sites in the Delaware Bay and in the southern New Jersey coastal area, which are shown below in Figure 3-10. The distances from the sites to the potential staging port locations are listed below in Table 3-5. Water depth in the northwest field varies widely from 9 to 24 m (approximately 30 to 80 feet), and from to 12 to 21 m (approximately 40 to 70 feet) in the southeast field. Climatology for the general region is presented in numerical and graphical forms in Table 3-6 and Figure 3-11.

3.2.3.4 Other Areas

The Massachusetts OMP identified additional areas that could be suitable for commercial wind energy production. The two designated Wind Energy Areas are located near the southern end of the Elizabeth Islands and southwest of Nomans Land Island. Wind and wave conditions at

these sites are similar to the Rhode Island sites. Transit distances between these sites and potential staging areas are shown in Table 3-7.

Massachusetts, as well as other states on the Atlantic Seaboard, is working with the U.S. Interior Department, MMS to develop Requests for Information (RFIs) for potential wind projects in federal waters off their respective coasts.

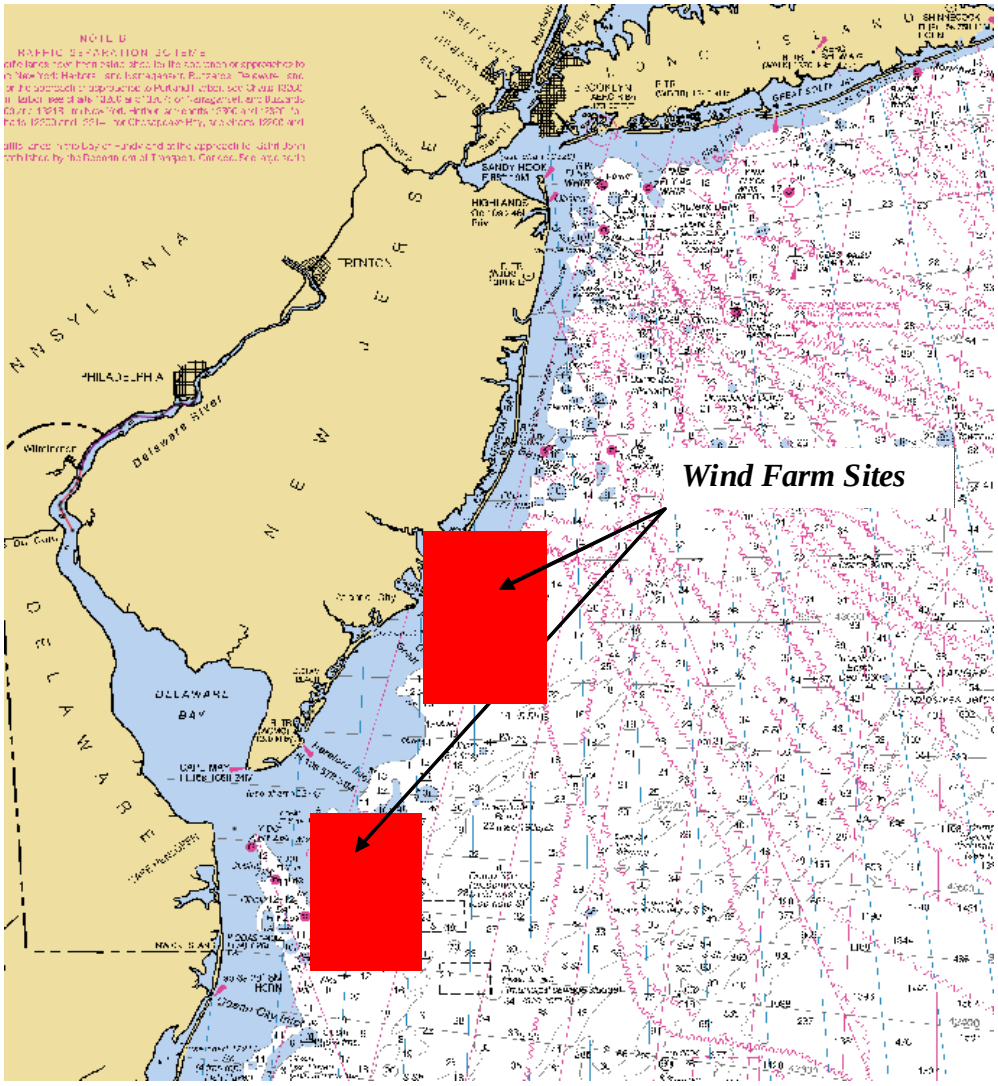


Figure 3-10 Bluewater Wind and Deepwater Wind Proposed Sites
(Source: The Glosten Associates 2009)

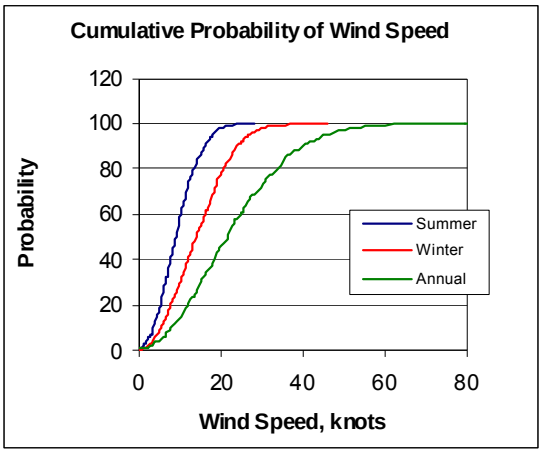
Table 3-5
Distances to Port Staging Locations from the Proposed Bluewater/Deepwater Sites

Staging Location	Primary Route Distance [nautical miles]	Alternate Route* Distance [nautical miles]
Boston, MA	470	330
Gloucester, MA	445	330
New Bedford, MA	260	n/a
Fall River, MA	250	n/a
Portland, ME	500	400
Quonset/Davisville, RI	280	n/a

* Alternative route is via the Cape Cod Canal.

Table 3-6
Delaware/New Jersey Climatology Data
(Source: The Glosten Associates 2009)

Description	Annual	Winter (January)	Summer (August)
Probability {$H_S \leq 1$ meters}	66.8%	53.3%	79.4%
Probability { $H_S \leq 2$ meters}	93.4%	88.8%	96.8%
Probability { $H_S \leq 3$ meters}	98.3%	96.7%	98.9%
Probability { $H_S \leq 4$ meters}	99.6%	98.7%	99.9%
Probability {$V_W \leq 15$ knots}	32.1%	21.8%	43.5%
Probability { $V_W \leq 20$ knots}	48.8%	36.6%	61.7%
Probability { $V_W \leq 25$ knots}	60.8%	47.4%	74.4%
Probability { $V_W \leq 30$ knots}	75.5%	61.3%	86.9%



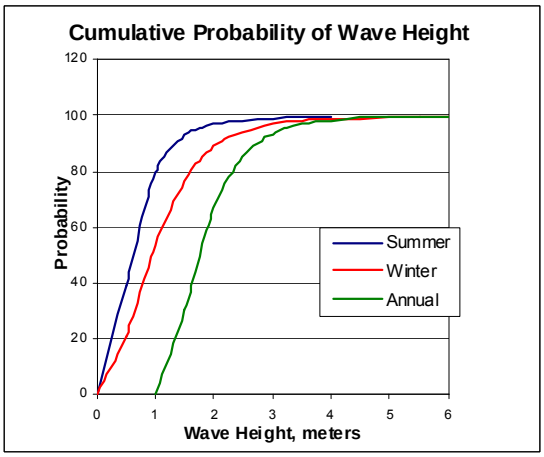


Figure 3-11 Cumulative Probability Graphs of Wind Speed and Wave Height for the Delaware/New Jersey Area
(Source: The Glosten Associates 2009)

Table 3-7
Distances to Staging Port Locations from the OMP Designated Sites
(Near the Elizabeth Islands and Nomans Land Island)

Staging Location	Primary Route Distance [nautical miles]	Alternate Route* Distance [nautical miles]
Boston, MA	260	100
Gloucester, MA	235	100
New Bedford, MA	35	n/a
Fall River, MA	50	n/a
Portland, ME	290	175
Quonset/Davisville, RI	40	n/a

* Alternative route is via the Cape Cod Canal.

3.3 Characteristics of Available Vessels

This section describes the marine vessels that are currently available for use in the construction and maintenance of offshore wind farms. Different vessels are required for the following specific activities:

1. Delivery of turbine components (e.g., tower sections, nacelles, blades) to the staging port;
2. Foundation delivery and installation;
3. Turbine erection;
4. Regular maintenance and personnel transport; and
5. Major maintenance.

The following subsections discuss the basic characteristics, capabilities, limitations, and general availability of the various types of vessels (see Appendix D, Potential Wind Turbine Delivery Vessels, for more details).

3.3.1 Turbine Import/Delivery Vessels

The turbines used for the first round of U.S. offshore wind farms will likely be imported from Europe. Turbines are generally shipped in pieces (e.g., tower sections, nacelle, hub, individual blades) from the point of origin directly to the project site aboard open hatch cargo vessels. Table 3-8 summarizes the principal dimensions of turbine import vessels. An example of this vessel type is shown in Figure 3-12 (Section 3 of Appendix A provides further details).

Table 3-8
Principal Dimensions for Turbine Import Vessels
(Source: The Glosten Associates 2009)

Length Overall	98 to 143 m (330’ to 470’)
Beam	20 to 23 m (66’ to 75’)
Design Draft	6.7 to 9.8 m (22’ to 32’)

Figure 3-12 BBC KONAN In Transit With Turbine Components (Nacelles Stowed Below Deck)
(Source: BBC KONAN)

3.3.2 Foundation Delivery and Installation Vessels

Foundations can be installed using either jack-up crane vessels or floating derrick barges. Jack-up crane vessels are described further below. Large floating derrick barges (as shown in Figure 3-13) are in service on all three major U.S. coastlines and could be mobilized to serve the U.S. East Coast offshore wind energy market.

Depending on the type of foundation being used (i.e., monopile, gravity-base, jacket, or tripod), a derrick barge could transport foundations between the staging port and the wind farm site on its own deck, or foundations could be transported using a separate barge. Floating derrick barges can lift up to 900 mt (approximately 1,000 tons), but a more common lifting capacity is 455 mt (500 tons) or less. Floating derrick barges could be used to install wind turbine foundations in up to 1.5 m (5 feet) seas, with a wind speed limit of around 20 to 30 knots.

Figure 3-13 Self-Propelled Crane Barge with 250 Ton Lifting Capacity
(Source: Marine Transportation Consultants http://www.tug-barge.com/p297.htm)

3.3.3 Wind Turbine Installation Vessels

European offshore wind turbines have been installed using a variety of specialized equipment, which generally falls into one of three categories:

- Leg-Stabilized jack-up crane ships ("partial jack-ups") (see Figure 3-14 for an example);
- Jack-up crane barges (see Figure 3-15 for an example); and
- Jack-up crane ships (see Figure 3-16 for an example).

Figure 3-14 Leg-Stabilized Crane Ship
(Source: A2Sea)

Figure 3-15 Jack-Up Crane Barge
(Source: A2Sea)

Figure 3-16 Jack-Up Crane
(Source: Offshore MPI)

For all three vessel types, the limiting wind speed for at-sea crane operations is approximately 15 to 20 knots. For the leg-stabilized vessels, the limiting sea state for crane operations is approximately 0.5 m (approximately 1.7 feet) seas, as the vessel's hull remains submerged and is subject to wave-induced motion. For the jack-up barges and ships (see Figure 3-17), the process of jacking up and down is limited to approximately 1.5 m (5 feet) seas. The crane can be operated in higher sea states once the vessel is jacked-up.

Figure 3-17 The Dixie Class Lift Boat Represents a Near-Term Option for U.S. Offshore Wind Turbine Installation
(Source: Superior Energy Services, Inc.)

The typical dimensions of wind turbine installation vessels are presented in Table 3-9. Further details are provided in Appendix A.

Table 3-9
Principal Dimensions for Turbine Installation Vessels
(Source: The Glosten Associates 2009)

Length Overall	91 to 137 m (300' to 450')
Beam	30 to 40 m (100' to 130')
Navigation Draft	3.7 to 4.9 m (12' to 16')
Air Draft (legs in up position)	varies, approximately 46 m (150')

No purpose-built wind turbine installation vessels exist that are compliant with U.S. coastwise trade laws (i.e., "Jones Act"). These laws require vessels to be U.S.-built, U.S.-owned, and U.S.-operated. A small number of Jones Act-compliant vessels that are currently operating in the Gulf of Mexico could be used to construct the first-generation U.S. offshore wind farms. These vessels lack the efficiency associated with purpose-built wind turbine installation vessels, such as the ability to transport multiple sets of turbine components and the ability to rapidly jack-up, pre-load the legs, erect the turbines, and jack-down. In order to economically and efficiently achieve GW-scale deployment of offshore wind in the United States, a fleet of purpose-built, Jones Act-compliant vessels will be needed. The industry recognizes this fact and is taking steps to develop the vessel infrastructure. NRG Bluewater Wind, for example, has teamed with the Aker Philadelphia shipyard to develop three purpose-built wind turbine installation vessels. (Bluewater Wind 2009b).

Future wind turbine installation vessels are expected to focus on improving construction efficiency through faster transit speeds, larger payload capacity, and ability to erect turbines in higher wind speeds and larger sea states. Some firms are developing designs that accommodate the transport and installation of fully assembled turbines (see Figure 3-18).

Figure 3-18 Glosten Turbine Installation Vessel Concept
(Source: The Glosten Associates 2009)

3.3.4 Maintenance Vessels

Regular, planned maintenance of offshore turbines requires personnel access to the wind farm facilities. Maintenance personnel for existing offshore wind farms are typically shuttled to the turbines by a crew boat or by helicopter. Specialized crew boats have been developed in Europe to increase the weather window during which maintenance personnel can safely access turbines.

Major maintenance or serial defects in turbines may require mobilization of a wind turbine installation vessel to reverse some or all of the installation process. There is an industry trend to develop maintenance-specific jack-up vessels that have highly capable cranes and limited cargo capacity but relatively slower transit speed. (Gusto MSC 2009).

3.4 Overview of Vessel Constraints and Requirements

The following sections evaluate the marine vessel requirements for deploying and maintaining offshore wind farms along the U.S. East Coast. Understanding the characteristics of these vessels is critical in the overall evaluation of a port's suitability as a staging area for offshore wind farm deployment and maintenance.

Vessel requirements are governed primarily by the following:

- Physical conditions at offshore wind farm sites (i.e., conditions in which vessels must operate);
- Navigational constraints in port and along transit route to the wind farm site;
- Size and weight of turbines being transported and installed; and
- Methodology for transporting and installing turbines.

The Team evaluated the physical conditions (e.g., wind speeds, wave regime and water depth) at proposed offshore wind farm sites along the U.S. East Coast. Navigational constraints in and near the Ports of New Bedford, Boston, Gloucester, and Fall River, MA also were evaluated. The physical properties of large offshore wind turbines (i.e., 3 MW to 5 MW) were reviewed, along with the demonstrated methodologies for transporting and installing these turbines.

The principal dimensions of wind turbine installation vessels/barges and import vessels are summarized below, as are the navigational constraints for all the analyzed ports. Appendix A discusses much of the information that is summarized in this section.

3.4.1 Installation and Transport Vessel Requirements

3.4.1.1 Flag and Class

The Merchant Marine Act of 1920, commonly known as the “Jones Act”, requires vessels engaged in the transport of passengers or cargo between U.S. places to be built and flagged in the United States, and owned and crewed by U.S. citizens. It was assumed for this study that the vessels discussed in this section would be subject to the Jones Act, as bottom-fixed foundations within the U.S. Exclusive Economic Zone (EEZ) are considered U.S. places. Vessels discussed in Appendix A, which are used to transport turbine components from overseas to a U.S. staging port, are not subject to the Jones Act. Therefore, the discussion of

turbine installation vessels provided below relates to purpose-built vessels currently operating in the North Atlantic.

Commercial vessels are typically certified by a classification society. The purpose of classing a vessel is to demonstrate compliance with an independent, accepted standard for vessel design, operation, inspection, and maintenance. Several options are available for classing the installation and transport vessels for offshore wind development. Existing European vessels are classed by Det Norske Veritas as "Self-Elevating Units," or by Germanischer Lloyd as "Special Type Offshore Unit – Surface Unit with Stabilizing Legs." Additionally, the American Bureau of Shipping (ABS) Rules for Mobile Offshore Units also are an appropriate classification avenue for installation vessels (see Appendix A and associated references).

3.4.1.2 Principal Dimensions

The key dimensions of a turbine installation and turbine transport vessel are beam, length, draft, and overhead clearance (a.k.a. "air draft"). The following summaries were extracted from Appendix A.

The beam (width) of the installation and transport vessels is largely dictated by the vessel's stability requirements during transit and, if applicable, the stability requirements and structural strength while elevated on legs (i.e., during "jack-up"). Pre-assembled tower components have a relatively high center of gravity, which increases the vessel stability requirements and, consequently, the required vessel beam. Typical European installation vessels, such as SEA JACK and RESOLUTION have a beam in the range of 30 to 40 meters (approximately 100 to 130 feet).

The length of the vessel is dictated by functional and cargo requirements and structural considerations. Typical European turbine installation vessels and barges have an overall length of 90 to 140 meters (approximately 295 to 460 feet).

The vessel's draft, or the required clearance between the waterline and sea bed, is dictated by the hull form and total weight, including the transported cargo. Wind turbine installation vessels and barges tend to have full hull forms with large beam and length. As such, the load-out of these vessels is typically governed more by space requirements than cargo weight. These factors lead to relatively shallow draft requirements. Typical European installation vessels have a draft in the range of 3.5 to 5 meters (approximately 11 to 16 feet).

Overhead clearance, or "air draft", is dictated by three factors: length of legs (for a jack-up barge or vessel), pre-assembly methodology, and crane height in stowed position. The methods of turbine component pre-assembly and transport can vary from project to project. The three most common methods for transporting pre-assembled components from the staging area to the wind farm site were illustrated in Figures 3-4 through 3-6: (1) the bunny ear configuration (lateral); (2) the bunny ear configuration (fore-aft); and (3) the star configuration. For purposes of context, the barge in Figures 3-4 through 3-6 and in the next few figures was drawn to have a beam (width) of approximately 30 m (approximately 100 feet) and an overall length of 122 m (approximately 400 feet). The nacelle and blade dimensions represented are based on a REPower 5 MW turbine (reflecting future equipment sizes). Figures 3-19 and 3-20 show a fully loaded barge with jack-up legs in the transit and jacked-up positions, respectively. Turbine tower sections are typically transported in the vertical orientation, with the maximum height

approximately even with the top of the blades in the bunny ear configuration. The legs of a jack-up vessel that is intended to operate in 25 m (approximately 80 feet) of water require an overhead clearance of about 45 m (approximately 150 feet) when the legs are in the up position4. If the barge is required to jack-up in water depths greater than about 45 m, then the leg towers will dictate the overhead clearance requirement. As shown in Figures 3-19 and 3-20, the required overhead clearance is approximately 45 m (150 feet). The star configuration (Figure 3-6) has the lowest overhead clearance requirement, except when transported aboard a jack-up vessel. Overall crane heights vary, but can be approximately as high off the deck in the stowed position as the tower sections. To navigate beneath bridges, the legs can be temporarily lowered if the channel depth is adequate.

The star and lateral bunny ear configurations require a lateral clearance of approximately 130 m (approximately 425 feet) for the 5 MW system components. The lateral clearance for the fore-aft bunny ear configuration is dictated by the barge or vessel beam, which is typically on the order of 30 to 38 m (approximately 100 to 125 feet).

Wind turbines are relatively lightweight for their size. Consequently, cargo vessels that carry turbine components are generally space-limited, rather than weight-limited. This means that these vessels can operate at a light draft of 9 m (approximately 30 feet) or less, even though the design draft may be greater. Table 3-10 presents the principal vessel dimensions for some specific existing turbine import vessels.

The principal dimensions and draft characteristics (navigational and air) of a typical installation or transport vessel are presented in Table 3-11.

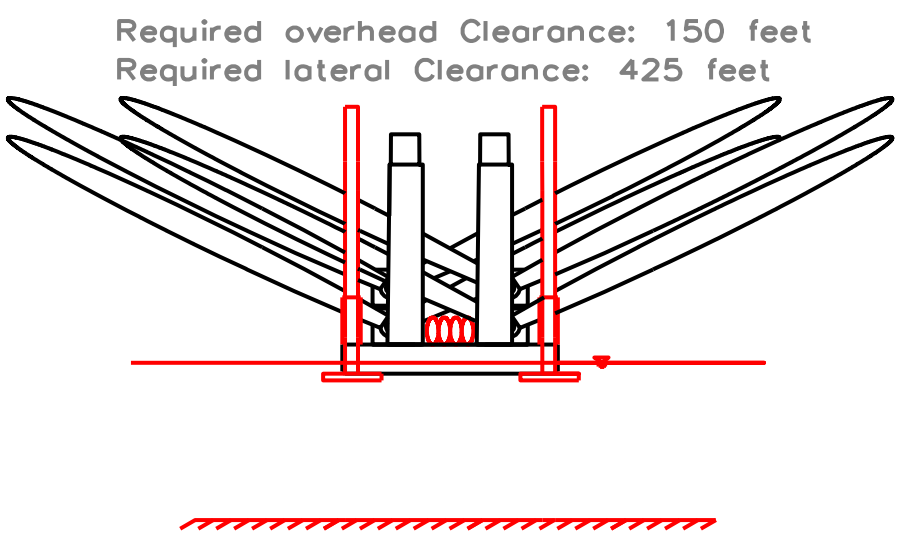


Figure 3-19 Loaded Barge in Transit
(Source: The Glosten Associates 2009)

[4] In general, the legs must be about 20 m (approximately 70 feet) longer than the operating water depth to account for soil penetration and the length of the legs inside the hull and jack house.

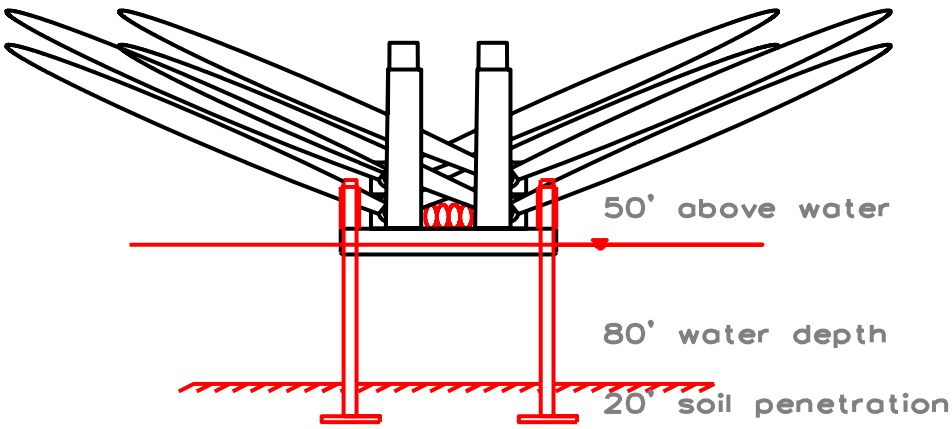


Figure 3-20 Barge Onsite with Legs Down
(Source: The Glosten Associates 2009)

Table 3-10
Principal Dimensions of Specific Turbine Import Vessels
(Source: The Glosten Associates 2009)

Vessel Name	Length Overall	Beam	Design Draft
BBC ELBE	143 m (470')	23 m (74.8')	9.7 m (31.8')
BBC KONAN	127 m (416')	21 m (68.2')	6.7 m (21.8')
Beluga F-Series	138 m (453')	21 m (68.9')	8.0 m (26.2')
Clipper MARINER	101 m (331')	20 m (66.3')	8.2 m (26.9')

Table 3-11
Typical Dimensions of Turbine Installation or Transport Vessels
(Source: The Glosten Associates 2009)

Length Overall	90 – 140 m (300' – 450')
Beam	30 – 40 m (100' to 130')
Navigation Draft	3.6 – 4.9 m (12' to 16')
Air Draft (legs in up position)	varies, approximately 46 m (150')
Air Draft (tower sections, bunny ears)	46 m (150')
Air Draft (crane in stowed position)	varies

3.4.1.3 Propulsion

Self-propelled ships and non-self-propelled barges have both been used successfully to install offshore wind farms in Europe. A self-propelled vessel with a dynamic-positioning system can cost three to five times as much as a barge with the same crane capacity and jacking system. However, a self-propelled vessel can achieve higher transit speeds than a towed barge and can work independently (i.e., without tug boats). It is currently unclear whether the U.S. market will prefer self-propelled ships or barges.

3.4.1.4 Crane Requirements

The key factors that dictate crane requirements for an installation and transport vessel are the:

- Maximum weight to be lifted (i.e., the "pick weight");
- Maximum height to be achieved above sea surface (i.e., "pick height"); and
- Required spatial clearance for objects being lifted.

The first U.S. offshore wind farms will likely use 2.5 MW to 3.6 MW wind turbines, with 5 MW turbines becoming commercially available within the next two years. Maximum pick weight and pick height generally increase with increasing turbine power rating. Table 3-12 summarizes the key crane requirements for two representative turbines (a Siemens 3.6 MW Offshore Turbine and a REPower 5 MW Offshore Turbine) and typical monopile components.

Table 3-12
Crane Requirements for 3.6 MW and 5 MW Turbines and Associated Monopile Foundations
(Source: The Glosten Associates 2009)

	Siemens 3.6 MW	REPower 5 MW	Monopiles
Max Pick Weight*	Nacelle: 125 mt (138 tons)	Nacelle: 290 mt (320 tons)	180 – 455 mt (200 – 500 tons)
Max Pick Height**	80 m (260 ')	85 – 95 m (280'-310')	Less than 30 m (100')

* 1 ton = 2000 pounds = 0.908 metric ton (mt)
** height above calm sea surface

Installation techniques vary for monopiles. A crane can lift the monopile or the monopile can be "tipped up" from the horizontal to the vertical position. Monopiles are often installed with a vibratory hammer, which itself can weigh up to 275 mt (approximately 300 tons) and must be lifted by the crane.

3.4.1.5 Jacking System Requirements

The current trend in turbine installation vessels is toward those vessels with a four-leg configuration. In contrast, the oil and gas industry typically uses three-leg jack-ups. The reason for using four legs is to reduce the time required to pre-load the legs (i.e., to test the soil on the sea bottom). A three-legged rig requires sea water ballasting to achieve pre-load position. With four legs, pre-loading can be achieved by lifting one leg at a time, thereby transferring loads to the other legs. A fourth leg also provides redundancy in the event of a leg failure.

3.4.1.6 Limiting Weather Conditions for Pile Driving and Crane Operation

The limiting sea state for monopile installation depends on the equipment used, but tends to be more sensitive to sea conditions than wind conditions. A robust monopile installation vessel can work in up to 2 to 3 m (6 to 10 feet) seas and wind speeds of up to 20-25 knots at the vessel deck level.[5]

[5] Wind speed increases as height above sea level increases. For example, a 20 knot wind at the deck could be a 24 knot wind at the height of the nacelle, as per DNV RP-C205 "Environmental Loads", Section 2.3.2.12.

Existing turbine installation vessels can operate their cranes in wind speeds of up to 15 knots at the deck level (approximately 23 knots at the crane tip) and can jack-up and down in seas as high as 1.5 to 3 m (5 to 10 feet).

3.4.1.7 Requirements for Accommodations

Installation vessels work around the clock when the weather permits, so personnel accommodations are needed aboard the vessel. Turbine installation vessels generally require accommodations for approximately 16 persons. The vessel/barge crew includes a master, an engineer, four to six mates or deck hands, and two stewards. The wind farm owner often requires accommodations for two to five representatives. This brings the total minimum complement of individuals on board to 30 to 35 persons. Many installation vessels in Europe have accommodations for 40 to 70 persons, and some planned new-build vessels are being designed to accommodate up to 200 persons.

3.4.1.8 Power Requirements

The primary systems that require power on a wind turbine installation vessel are the crane and the jacking system (see Appendix A). Since they do not operate simultaneously, a single power plant can be used for both systems. Cranes capable of lifting turbine components require up to 1,500 kilowatt (kW) (approximately 2,000 horsepower [hp]) power supply. This amount of power is generally also sufficient for a jacking system that meets the lifting capacity and jacking speed requirements for a vessel carrying three to four complete sets of turbine components. Heavier vessels with larger jacking systems will require more installed power, perhaps 3,000 to 4,000 kW (approximately 4,000 hp to 5,500 hp).

To achieve even heel and trim prior to jacking operations, the installation vessel must have a relatively robust ballasting system. A total pump capacity of 300 to 600 tons of water per hour (approximately 72,000 to 144,000 gallons of water per hour) would probably be needed, which would require up to 150 kW (approximately 200 hp) of supplied power.

A self-propelled installation vessel will require a separate power plant that can provide 3,000 to 5,200 kW (approximately 4,000 hp to 7,000 hp) of power to the propulsion system. This power plant can also be used to power a dynamic-positioning (DP) system or to power the crane, but is unlikely to suffice for simultaneous operation of the DP system and the jacking system.

Power generation also is required for “hotel loads”, deck lighting, and emergency systems. Existing vessels have installed auxiliary power of roughly 110 kW (approximately 150 hp) for these purposes.

3.4.1.9 Deck Load Requirements

Existing turbine installation vessels have deck capacities in the range of 1.5 to 20 tons/meter^2 (approximately 300 to 4,100 pounds/square foot (psf)). A 272 mt (approximately 300 ton) nacelle with a footprint of 17 m by 4 m (approximately 56 feet by 13 feet) requires a deck capacity of roughly 4.5 tons/meter^2 (925 psf). Typical ocean class deck cargo barges have a deck capacity of 10 tons/meter^2 (approximately 2,050 psf).

3.4.1.10 Safety Equipment

Marine installation vessels also must be equipped with life saving equipment (including life boats), a fire protection system, and pollution prevention equipment. These requirements would not be unique to turbine installation vessels.

3.4.1.11 Requirements Associated with Alternative and Future Vessel Uses

It is possible that a purpose-built wind turbine installation vessel could be employed in other services, such as general marine construction (e.g., harbors, wharfs, piers, bridges) or offshore oil and gas. In both of these industries, there currently exists a wide range of vessel types and capabilities in response to a diverse set of needs. A wind turbine installation vessel would be a highly capable marine construction vessel. For the oil and gas industry, a wind turbine installation vessel would fall in the middle of the "capability spectrum" (e.g., being able to out-perform smaller work boats, but being incapable of performing the most challenging operations). The economic viability of using a purpose-built wind turbine installation vessel in other industries is difficult to predict, since the market forces that generally drive charter rates are highly volatile and industry specific.

3.4.1.12 Parametric Cost Estimate

The capital cost for a new-build jack-up crane barge ranges from $40M to $80M (see Appendix A). New-build self-propelled jack-up crane vessels have been reported to cost between $150M and $250M. However, new-build cost estimates are few and difficult to verify. For perspective, a simple deck cargo barge 90 m (approximately 300 feet) in length x 27 m (approximately 90 feet) beam can cost up to $20M. A mid- to large-sized, state-of-the-art, ice-breaking arctic research vessel with several specialized onboard systems can cost between $100M and $150M.

3.4.2 Tugboat and Auxiliary Vessel Requirements

3.4.2.1 Tug Boat Requirements

Self-propelled wind turbine installation vessels will likely not require tug assistance, as they would be able to move and position themselves using their own propulsion and dynamic-positioning systems. Barges, on the other hand, would require at least one tug of 3,000 to 3,750 kW (approximately 4,000 to 5,000 hp) (see Appendix A). In addition, a smaller tug of around 745 kW (1,000 hp) may be needed to help position the vessel for jacking operations. If a feeder (shuttle) barge is used to transport turbine components from the port staging area to the wind farm site, a 1,500 to 3,750 kW (approximately 2,000 to 5,000 hp) tug would be required to tow and position the barge. These types of tugs are readily available for hire along the entire Northeast coast and should not be a limiting factor.

3.4.2.2 Crew Boat Requirements

For ongoing maintenance, a high-speed crew boat is an essential component of marine logistics. High-speed crew boats, capable of carrying 15 to 20 passengers, are required during wind farm construction. At the peak of construction activity, two boats may be required. Once again, this service is readily available along the entire East Coast and should not be a limiting factor. In Europe, special vessels and foundation boarding arrangements have been developed solely for accessing turbines in rough sea conditions.

3.4.2.3 Other Auxiliary Vessel Requirements

Several auxiliary vessels, which are readily available for hire, are needed to round out the marine fleet for the complex task of building an offshore wind farm. These auxiliary vessels include:

- dredging equipment;
- cable laying vessels;
- survey vessels; and
- rock laying vessels (to provide scour protection around turbine foundations).

Once again, these vessels are readily available along the entire East Coast and should not be a limiting factor.

3.5 Navigational Access and Transit Distances

The required navigational clearances for vessels involved in the construction and maintenance of offshore wind farms were evaluated. The key considerations for navigational access are:

- Vessel draft compared to navigable water depth;
- Vessel beam (including overhanging cargo) compared to channel width; and
- Vessel air draft compared to overhead clearance restrictions (e.g., bridges and aerial cables).

Turbine installation vessels govern the air draft and channel width requirements. Turbine import vessels govern the draft requirements (e.g., navigable water depth). Tables 3-10 and Table 3-11 summarized required vessel clearances for turbine import vessels and turbine installation vessels, respectively. Table 3-13 summarizes the navigational restrictions associated with selected Massachusetts ports. Further details are given in Appendix A.

Table 3-13
Summary of Navigational Constraints at Selected Massachusetts Ports

Staging Port	Potential Obstructions	Lateral Clearance	Overhead Clearance	Controlling Water Depth	Feasible Turbine Load-Out Configurations	Jack-Up Feasible?
New Bedford	Hurricane Barrier	45 m (150')	No Constraints	6.7-9.1 m (22'-30')	all	yes
Gloucester	water depth, channel width	61 m (200')	No Constraints	4.9-5.8 m (16'–19')	fore-aft bunny ear	Marginal (water depth)
Fall River	Mt. Hope Bridge	122 m (400')	41 m (135')	12.2 m (40')	star	Marginal (air draft)
South Boston	Logan Airport	over 150 m (500')	Report air draft to airport traffic control	12.2 m (40')	all	yes
Charlestown / East Boston (inner harbor)	Logan Airport	over 150 m (500')		12.2 m (40')	all	yes
Mystic River	Tobin Memorial Bridge	over 150 m (500')	41 m (135')	7.6-10.7 m (25-35')	star	Marginal (air draft)

Staging Port	Potential Obstructions	Lateral Clearance	Overhead Clearance	Controlling Water Depth	Feasible Turbine Load-Out Configurations	Jack-Up Feasible?
Chelsea River (West of Chelsea St. Bridge)	Andrew McArdle Bridge	53 m (175')	No Constraints	8.8-12.2 m (29-40')	fore-aft bunny ear	yes
Chelsea River (East of Chelsea St. Bridge)	Chelsea St. Bridge	28 m (93')	25 m (83')	8.8-12.2 m (29-40')	rotor disassembled	no

Transit distances from potential New England staging ports to the proposed or possible offshore wind farm sites are included in Table 3-14.

Table 3-14
Distances from Regional Ports to Proposed Wind Farms

Staging Location	Ports	Distance (nautical miles)	Alternative Route A [Around Nantucket Island] Distance (nautical miles)	Alternative Route B [Through the Cape Cod Canal] Distance (nautical miles)
Delaware Bay (Deepwater)	Boston, MA	470		330
	Gloucester, MA	445		330
	New Bedford, MA	260		Not Applicable
	Portland, ME	500		400
	Fall River, MA	250		Not Applicable
	Quonset/Davisville, RI	280		Not Applicable
Block Island (Deepwater/Northwind)	Boston, MA	295		120
	Gloucester, MA	270		120
	New Bedford, MA	50		Not Applicable
	Portland, ME	325		190
	Fall River, MA	45		Not Applicable
	Quonset/Davisville, RI	35		Not Applicable
Nantucket Sound (Cape Wind)	Boston, MA	130	270	130
	Gloucester, MA	105	240	120
	New Bedford, MA	60	n/a	Not Applicable
	Portland, ME	160	295	200
	Fall River, MA	75	Not Applicable	Not Applicable
	Quonset/Davisville, RI	70	Not Applicable	Not Applicable
MA OMP Wind Sites (Nomans Land Island)	Boston, MA	260		100
	Gloucester, MA	235		100
	New Bedford, MA	35		Not Applicable
	Portland, ME	290		175
	Fall River, MA	50		Not Applicable
	Quonset/Davisville, RI	40		Not Applicable

3.6 Staging Port Through-Put Estimates

This section examines the expected level of activity at a port serving as a staging area for offshore wind farm development. Multiple wind farm construction scenarios were considered in order to develop upper and lower bounds of expected port activity. For this analysis the primary metric of port activity is the number of wind turbines deployed per month, which is referred to as "through-put."

A desktop tool for estimating the construction time line for an offshore wind farm was applied. This time line tool considers numerous parameters representing vessel characteristics, climatology, at-sea construction capabilities, and other project considerations. Using this tool, the expected through-put of wind turbines at a staging port was estimated for a range of wind farm construction scenarios. Each scenario was defined by vessel type, transit distance, and the length of the construction season. The methodology and analysis are detailed below.

Table 3-15
Excerpt from Time Line Model Illustrating the Typical Work Breakdown Structure
(Source: The Glosten Associates 2009)

Cycle Start Time	**10/14/12 20:22**
Cycle #	1
Supply Chain Delay at Staging Area [hours]	0.0
Load Vessel [hours]	24.0
VESSEL LOADED	**3/25/13 18:21**
Vessel Transit to Wind Farm Site [hours]	25.0
Weather Availability for Jacking Up	86%
Jack Up [hours] (includes weahter delay)	9.3
Weather Availability for Installation	61%
Installation of Monopile/Turbines [hours] (includes weather delays)	88.5
Jack Down [hours] (includes weather delays)	4.6
INSTALLATION COMPLETE	**3/31/13 1:48**
Vessel Transit to Staging Area [hours]	25.0
VESSEL ARRIVES AT STAGING AREA	**4/1/13 2:48**
Turbines Installed (total)	3
Cycle Start Time	**4/1/13 2:48**
Cycle #	2
Supply Chain Delay at Staging Area [hours]	0.0
Load Vessel [hours]	24.0
VESSEL LOADED	**4/2/13 2:48**
Vessel Transit to Wind Farm Site [hours]	25.0
Weather Availability for Jacking Up	93%
Jack Up [hours] (includes weahter delay)	8.6
Weather Availability for Installation	72%
Installation of Monopile/Turbines [hours] (includes weather delays)	74.6
Jack Down [hours] (includes weather delays)	4.3
INSTALLATION COMPLETE	**4/6/13 19:16**
Vessel Transit to Staging Area [hours]	25.0
VESSEL ARRIVES AT STAGING AREA	**4/7/13 20:16**
Turbines Installed (total)	6

3.6.1 Methodology and Assumptions

The desktop time line model breaks down the overall wind farm construction process into discrete tasks, assigns a time requirement to each task, and builds a sequential time line for the principal activities. Some tasks have a limiting weather criterion, such as maximum wind speed for conducting crane operations. The time line model cross-references each weather-dependent task with site-specific monthly climatology data to determine whether that task is subject to weather delay.

The work breakdown model is illustrated by the excerpt presented in Table 3-15.

The following is a list of the assumptions that were used in the time line modeling:

1. Study considers turbine construction only. Foundation installation is accomplished independently and with different marine equipment.
2. One installation vessel is utilized at a time.
3. Foundation construction does not delay turbine installation.
4. Operations (and delays) at the staging area do not delay turbine construction. In other words, the turbine installation vessels (TIVs) do not "wait" for the staging area operations.
5. Staging area has 24-hour / 365-day operation.
6. Existing Vessels are capable of transporting 3 turbines.
7. Future Vessels are capable of transporting 5 turbines.
8. Installation vessels are capable of 6-10 knots transit speed.
9. Limiting wind speed for Existing Vessels is 15 knots.
10. Limiting wind speed for Future Vessels is 25 knots.
11. Limiting wave height for jack-up operations (all vessels) is 2.0 m.
12. For Existing Vessels, time to erect one turbine is 12 hours, once on-site and vessel is jacked-up (excluding weather delays).
13. For Future Vessels, time to erect one turbine is 8 hours, once on-site and jacked-up (excluding weather delays).
14. Wind and wave conditions based on U.S. East Coast from Delaware Bay to Cape Cod.

3.6.2 Analysis

The potential utilization of a single port for three different staging scenarios was modeled for this analysis. These scenarios, which all assumed New Bedford, MA as the staging port, were:

- Baseline - The Baseline scenario was defined as:
  - One offshore wind farm project staged out of New Bedford, MA, using Existing Vessel type.
  - Number of turbines: 130
  - Transit distance from staging area to wind farm site: 50 nautical miles
- Optimistic - The Optimistic scenario was defined as:
  - Two projects staged out of New Bedford, MA, using Existing Vessel type.

- Projects are sequential in time (not concurrent).
- Number of turbines for Project 1: 130
- Number of turbines for Project 2: 100
- Transit distance from staging area to wind farm for Project 1: 50 nm
- Transit distance from staging area to wind farm for Project 2: 50 nm

- Aggressive - The Aggressive scenario was defined as:
  - Three projects staged out of New Bedford, MA, using combination of Existing and Future Vessel types.
  - Projects are sequential in time (not concurrent).
  - Projects 1 and 2 use conventional vessel type.
  - Project 3 uses future vessel type.
  - Number of turbines for Project 1: 130
  - Number of turbines for Project 2: 100
  - Number of turbines for Project 3: 200
  - Transit distance from staging area to wind farm for Project 1: 50 nm
  - Transit distance from staging area to wind farm for Project 2: 50 nm
  - Transit distance from staging area to wind farm for Project 3: 150 nm

These scenarios are based on development plans discussed during interviews with project developers in July and August of 2009.

3.6.3 Results

The results of the desk top time line modeling of these scenarios for New Bedford, MA were as follows:

- The time line modeling of the Baseline scenario for turbine staging and installation yielded an expected through-put of 15-18 turbines per month for 6-9 months.
- The time line modeling of the Optimistic scenario for turbine staging and installation yielded an expected through-put of 16-22 turbines per month for 12-15 months.
- The time line modeling of the Aggressive scenario for turbine staging and installation yielded an expected through-put of 15-20 turbines per month for 12-15 months; Thereafter, a through-put of 21-25 turbines per month was expected for an additional 8-10 months.

Additional wind farm construction scenarios were evaluated to develop a better estimate of the potential ranges of through-put that may be required at regional staging ports. Each scenario was defined by a vessel type, a transit distance and a length of the construction season. The results of these multiple modeling runs are summarized in Table 3-16.

Table 3-16
Expected Through-Put at Staging Port for Various Construction Scenarios
(Source: The Glosten Associates 2009)

Transit Distance (staging port to wind farm site*)	Existing Vessels**		'Future' Vessels***	
	Summer	Winter	Summer	Winter
50 nautical miles	20-22 turbines/month	16-18 turbines/month	30 turbines/month	30 turbines/month
150 nautical miles	18-20 turbines/month	15-17 turbines/month	21-25 turbines/month	21-25 turbines/month
250 nautical miles	15-17 turbines/month	12-15 turbines/month	16-20 turbines/month	16-20 turbines/month

Notes:
* The transit distance from New Bedford to the Cape Wind site is approximately 60 nm. The transit distance from Boston to Cape Wind is approximately 130 nm. The transit distance from New Bedford to the Deepwater sites near Delaware Bay is approximately 260 nm.
** Existing Vessels means jack-up vessels or barges with slewing cranes, typical of present European offshore wind farm construction practice.
*** Future Vessels means vessels or barges that transport and install fully assembled turbines.

It should be noted that the above through-put estimates are for turbine installation only. Foundation installation is typically completed in advance of turbine installation and can utilize a wider range of vessels and staging ports than turbine installation. For U.S. offshore wind farms, foundation installation can be completed using existing equipment.

3.6.4 Near-Term and Long-Term Demands on Staging Port Support Infrastructure

In the near term (i.e., now through year 2013), a port supporting offshore wind farm development is expected to handle approximately 18 to 22 turbines per month. This estimate assumes that projects are within 150 nautical miles (i.e., a transit distance) of the staging area and that construction operations will take place during spring, summer and fall using conventional methods (see Appendix A). Based on the above turbine through-put estimates, the near-term demand for support infrastructure at an offshore wind farm staging port is approximately as follows:

- 40-90 annual port calls (for cargo vessels delivering components);
- 70-90 annual port calls (for wind turbine installation vessel); and
- 54,500-81,700 mt (approximately 60,000-80,000 tons) of cargo loaded and discharged annually.

These near-term estimates assume:

- 18-22 turbines deployed per month for 12 months;
- cargo vessels deliver 3-5 turbines per port call;
- installation vessel loads 3 turbines per port call; and
- total turbine weight is 272 mt (approximately 300 tons).

Looking ahead to year 2014 and beyond, a port activity level as high as 30 turbines per month may be expected assuming an increase in vessel capabilities compared to the present technology. Based on the above turbine through-put estimates, the long-term demand for support infrastructure at an offshore wind farm staging port is approximately as follows:

- 90-120 annual port calls (for cargo vessels delivering components);
- 120 annual port calls (for wind turbine installation vessel); and
- 99,900-227,000 mt (approximately 110,000-250,000 tons) of cargo loaded and discharged annually.

These long-term estimates assume:

- 30 turbines deployed per month for 12 months;
- cargo vessels deliver 3-5 turbines per port call;
- installation vessel loads 3 turbines per port call; and
- total turbine weight is 272-635 mt (approximately 300-700 tons).

3.7 Staging Port Support Facility Requirements

One developer that was interviewed provided a description of the "ideal" port facility to support offshore wind. In their view, the port would have: a 910 mt (approximately 1,000 ton) crane on rolling tracks that would carry components from a delivery vessel to a storage location; enough linear water front footage or berthing to efficiently load/unload one vessel (with a preference for multiple deepwater berths to potentially unload several vessels concurrently); and about 80 hectares (approximately 200 acres) for assembly and storage.

While no existing Massachusetts port facility has an assembly and staging area this large, the existing Commonwealth facilities could be repaired, upgraded, or expanded to provide sufficient area to meet the other requirements for staging offshore wind farm construction. If it is necessary to provide a larger area at these existing facilities, then a combination of properties at these marine parks or a combination of ports would have the ability to provide additional space. If the berthing area is sufficient, moored barges also could be used for storage.

3.7.1 Physical Considerations Relative to Staging Turbines

There are a few minimum physical port characteristics that are necessary to stage offshore wind farm development. Based on a review of various European projects and available manufacturers, as well as discussions with potential U.S. offshore wind developers, the minimum desirable characteristics include:

1. 7.3 m (approximately 24 feet) depth of water at low tide;
2. minimum 137 m (approximately 450 feet) berth;
3. minimum channel clearance to harbor of 40 m (approximately 150 feet);
4. no restriction or air draft limitation on vertical clearance (in anticipation of a future need to transport fully assembled turbines to the installation site); and
5. relatively short distance in open water to project site.

3.7.1.1 Harborside Area

The harborside characteristics of a staging port facility present the most pertinent information to determine whether a port is worthy of consideration for wind farm construction staging. Water depth criteria directly dictate options with respect to the vessel type, draft and function. Tidal fluctuations change the water depth twice a day. Therefore, the minimum water depth at low tide is the appropriate characteristic to consider with respect to the navigation channel and berth.

The deepest draft vessel used for transporting offshore wind components sets the navigation depth criteria. Horizontal channel clearance not only depends on vessel beam, but also on component overhang during transport to the installation site. An unobstructed vertical clearance is highly recommended. Turbine manufacturers expect 60 m (approximately 197 feet) tall tower sections to be transported to the installation site in the upright position. If the turbines are fully assembled for transport, then the nacelle and blade would add significantly to this height. Furthermore, various installation tasks require jack-up vessels, the retracted legs of which would be in the 'up' position. The Philadelphia Regional Port Authority has submitted a Transportation Investment Generating Economic Recovery (TIGER) application to build a purpose-built wind turbine installation vessel; the jack-up legs are 75 m (approximately 246 feet) long. However, there may be methods for working around vertical obstructions, such as placing a connector pin in the legs or utilizing a hydraulic leg that compresses within itself. The salient point, however, is that vertical obstructions can limit the range of acceptable assembly, transport, and vessel options.

With visits from import vessels and transport or installation vessels overlapping, multiple berths or longer berths become more desirable. The required length of berthing at a staging port is linked to the size of the project and the delivery schedule for its components. If the project is "fast track", the actual amount of material at the staging site might be small in comparison to what is there for a "normal" project. The material would arrive as soon as complete, rather than being stored at the manufacturer's facility, and would be shipped in the most cost-efficient manner in a vessel filled to capacity. The larger berth would also allow for delivery vessels to operate concurrently with the jack-up or other purpose vessels at the dock.

3.7.1.2 Landside or Lay Down Area

The landside or lay down area required for a project is also tied to the project size. More turbine units will require more space. One of the ways that a lack of space at a given site has been addressed in the past is to use alternate sites for different functions. The needs of the foundation contractor may be different from those of the turbine assembly contractor. One approach would be to stage these two functions from different sites. Although the port criteria for turbine assembly may be slightly different from those for foundation assembly, since there is some overlap in the type of vessels used for these different functions, in general, the same or similar staging criteria can be applied to both.

The interviews with developers indicated that the lay down area is seen as one of the most important logistical elements for a staging port facility. It is crucial to have sufficient space to efficiently store and assemble turbine or foundation components. The developers that were interviewed provided the information contained in Table 3-17 regarding indoor/outdoor storage requirements:

Table 3-17
Indoor/Outdoor Storage Requirements
(Source: Developer interviews)

Landside Requirements / Staging Area	4 to 10 hectares (approximately 10 to 25 acres) (Bluewater, Cape Wind)
Quayside Area	150 to 300 m (approximately 500 ft to 1,000 ft) (Cape Wind)
Inside Storage Area	Approximately 465 m^2 (5,000 sq. ft.) (Cape Wind) to up to 929 m^2 (10,000 sq. ft.) (Bluewater Wind with regard to European Experience)
Accommodation Area (e.g., for offices and dormitories for workers)	Approximately 1,400 m^2 (15,000 sq. ft.) (Deepwater)

3.7.1.3 Onshore Construction Area

Developer needs for onshore construction include space for delivery, storage and assembly of turbine components. The estimates obtained for the amount of onshore construction area needed varied widely among the developers, manufacturers and representatives of European staging facilities, but a minimum of 4 hectares (approximately 10 acres) was indicated to be required with 6 to 10 hectares (approximately 15 to 25 acres) of available space being more desirable. If a large development (e.g., 110 turbines) were to be fully accommodated on land, including both assembly and foundation components, the area required would be about 80 hectares (roughly 200 acres). However, the logistics of manufacture, assembly and installation would never require all units to be co-located on the ground at one time.

To maximize the use of construction equipment, vessels and crews, turbine suppliers require storage based on two factors: (1) having a supply of turbine components ready for assembly and deployment; and (2) having an additional area ready for instances where weather precludes deployment to the installation site while import vessels continue to deliver components to the staging port. While turbine assembly continues, the newly arrived unassembled turbine components would need to be stored. Based on manufacturer's recommendations, and assuming storage of 20 or more turbines, the minimum space needed in this scenario is about 3.4 hectares (approximately 8.5 acres). One of the foundation manufacturers suggested that lay down (not manufacturing) might require 1.5 to 2.0 hectares (approximately 4 to 5 acres). Another manufacturer suggested that each turbine (and its components, except foundation) would require about 6,500 sf, which would require an additional 1.2 hectares (approximately 3 acres). The pre-assembly area based on one manufacturer's recommendation would be 200 m x 50 m or 1.0 hectare (or 650' x 165' or 2.5 acres). This suggests that, without foundations, the minimum space needed is about 8.5 acres. Additional area (possibly 0.4 to 3.2 hectares [1 to 8 acres]) would also be needed for parking, field trailers, traffic lanes, and other support functions.

If a through-put of 18 to 22 turbines per month would be deployed to the installation site (based on the results of the time line modeling discussed above), the turbine manufacturer would want 20 nacelles stored at the staging port in advance of assembly and deployment. As workers assemble the turbines in preparation for loading onto the installation vessel, and bad weather hits the installation site, the assembled turbines would have to be stored at the port.

Unassembled turbine components would continue to arrive from the manufacturer and require additional storage space for 20 more turbines.

The preferences for features outlined below for the onshore construction area are based on an offshore wind farm consisting of 30 to 60 turbines and describe a port staging area for wind turbines only. The following information was drawn from one manufacturer's specifications (Vestas Offshore A/S 2008). There may be engineering solutions that could provide alternative arrangements to meet the parameters discussed below.

General

Total onshore area	4.5 to 7 hectares (10 to 17 acres)
Variation factors	Shape of area, Number of turbines, Delivery sequence of turbines
Pier length	Minimum 150 m (495'), preferably 200 m 650') or more
Water depth at pier	Minimum 6.0 m (20')
Assembly area	Pier Length and 40 m (130') behind pier

Details

Electrical

Electrical power supply should be 3 x 400 volts alternating current (V AC) (60 hertz [Hz]) and at least 200 amp capacity. Major power consumers would be offices, welding and machining, and air compressors. It is preferred that the entire site be fully illuminated to facilitate safe night work.

Area Details

Assembly Area	0.5 – 1.0 hectares (1.5-2.5 acres)		
Storage Area	3.5 – 5.0 hectares (9-12.5 acres)	400 m^2 (4,300 ft^2) sheltered with a minimum clear height of 3.5 m (12 ft)	100 m^2 (1,100 ft^2) secured and dry
Access, Office, Parking	0.5 – 1.0 hectares (1.5-2.5 acres)	About 200 m^2 (2,200 ft^2) office and social area.	For minimum 20 persons
Total Site Area	4.5 – 7.0 hectares (11-17.5 acres)		

The area should be enclosed by fencing with a guard or some type of security system. Water supply for fire fighting and general consumption should be available, as well as a wastewater system. A suitable drainage system should be installed that meets all regulatory requirements for stormwater discharge effluent limits.

Onshore Handling Equipment

The following equipment most likely would be necessary for offloading, assembling, and deploying offshore wind turbines:

1	Large crawler crane (DEMAG CC2800 or similar with 78 m boom length), approximately 2,500 tm as 250 mt at 10 m radius
1	Medium crawler crane (Liebherr LR1400 or similar with 42 m boom length), 600 to 800 tm capacity
1	Truck mounted crane, 150 tm capacity
1	Cherry picker (telescopic personnel lift for min 2 persons)
1	Forklift (3 mt (3.5 ton) capacity)
1	Terrain moving telescopic forklift (3 mt (3.5 ton) capacity)
1	Terrain moving telescopic forklift with turntable (3 mt (3.5 ton) capacity)
1	Terrain moving transport vehicle (2-3 persons and minor parts and equipment)
1	Triple axel trailer (suitable for blade transport) moveable with crane truck or similar
1	Self propelled low loader (suitable for tower transport, 150 – 200 mt (165-220 ton) capacity)

3.7.1.4 Inside Storage / Assembly Space

Some interior storage and/or fabrication space is required for most projects. Developers, contractors and manufacturers also have a strong preference for onsite office space. Again, estimates of this requirement varied significantly among those interviewed. While some suggested 464 m^2 (approximately 5,000 square feet) would be adequate for interior storage, assembly and office space, a minimum of 930 m^2 (approximately 10,000 square feet) with appropriate access characteristics was the consensus. Facilities for worker accommodations at the staging location or on a 'hotel' ship at the installation site have been used for some offshore wind farm constructions overseas. One developer suggested an accommodation area of 1,400 m^2 (approximately 15,000 square feet) for office space and worker dormitories. The amount of available inside storage or assembly space did not emerge as a major factor in staging facility selection decisions. None of the Massachusetts Designated Port Areas (DPAs) has such a convenient facility. At this stage of planning, most of the developers had given little thought to such needs. Nevertheless, the DPAs in Massachusetts do have nearby accommodations. Construction workers at the offshore installation site would expect to work in shifts for a 24-hour operation. Crews can travel back and forth on fast transport vessels from the construction site to various points on land, thereby eliminating the need for on-site accommodations (Vestas 2008).

3.7.1.5 Load Capacity

Based on the weight of many of the components, the lay down space may require very high capacity ground or deck. Using a simple "footprint" analysis, these loads can reach over 9.8 mt/m^2 (approximately 2,000 psf). As with many of the facility needs, the deck/ground capacity issue can be accommodated by using certain types of equipment or by placing "load spreading" mats or slabs. Various cranes and other types of material handling equipment will be needed, but it is anticipated that the fabrication or erection contractor would provide these items.

The need for high ground or deck capacity suggests that perhaps a solid fill backland is more appropriate than an open pier type structure, which provides an opportunity for the contractor to establish high load zones as necessary in its lay down configuration. Open pier structures require high capacity piles relatively closely spaced. Historically general cargo and container terminal wharves and piers have load capacities of approximately 2.9 metric tons/m^2

(approximately 600 psf, with the exception being 4.9 mt/m^2 (approximately 1,000 psf) at some terminals. From a cost standpoint, this is often impractical for pile supported structures. Solid fill structures, once out of the active earth zone, can easily have 9.8 metric tons/m^2 (approximately 2,000 psf) load capacity. Load capacity was not used as a criterion to short-list the ports, but rather was a consideration that was further analyzed in the engineering review of the short-listed facilities.

3.7.2 Physical Considerations Relative to Staging Foundations

Some of the harborside restrictions set out for turbine transport may not apply to foundations, because foundations are less delicate and can be transported flat on barges. Barge transport of foundations would not entail the same height, draft or clearance requirements as turbine transport. However the foundation installation vessel may have similar characteristics as the turbine installation vessel. If the foundation installation jack-up vessel was at the construction site and barges were used to transport foundations to the site, then there would be more options for the staging facility. Facilities that are not suitable to stage turbine construction/installation because they are upstream of a bridge with a 41 m (approximately 135') clearance height or require 7.3 m (24') draft or other restrictions could possibly stage foundation deployment.

The review of the currently planned projects indicated that roughly 744 or more turbines would be deployed off the Northeast Coast of the United States (Delaware to Massachusetts). The planned projects examined would create a combined need for 544 monopile foundations and 200 jacket foundations. Monopile foundations are basically large diameter rolled steel piles. Monopiles are comprised of rolled steel plate (3.8 to 12.7 cm (1.5 to 5 inches) thick) components between 2.1 and 5.5 m (approximately 7 feet and 18 feet) in diameter, and often fabricated in 4.5 to 4.6 m (15' to 16') long sections. Jacket foundations are lattices of steel members. Both types of foundations require a transition piece which is also a rolled steel pipe section, with additional add-ons such as electric cable tubes, climbing ladders, platforms and docking areas. Tower sections are also rolled steel. These tend to be supplied by the turbine manufacturers along with the other turbine components.

The staging requirements for foundations depend upon the stage of assembly as they arrive and the size and type of foundation. The size of the foundation depends on the size of the assembled turbine with tower, transition and blades and the maximum wind load imposed on them, as well as the geotechnical conditions at the installation site. The staging facility will need landside areas for loading and unloading, storage, and potentially for assembly of foundations components

Partially assembled foundations would still likely arrive at a Massachusetts facility by vessel. Steel sections for jacket assembly might come from the Gulf of Mexico or overseas. Shipping the steel sections allows for maximizing cargo space and minimizes shipping costs relative to transporting a fully assembled jacket foundation. A factor in selecting a shipping method is the difference between the shipping cost and the labor cost of field welding the bars together. The selection also may depend on the availability of a skilled labor force of welders at the assembly location.

3.7.2.1 Manufacturing and Assembly Requirements

Monopile manufacturing utilizes a series of specialized machines. Modern versions of this equipment are not currently available on the East Coast of the United States. The industry views the potential market as lucrative enough to consider opening facilities in anticipation of offshore wind energy development. However, the investment risk remains similar to that felt by turbine manufacturers and the purpose-built vessel industry. Until a demand for product emerges sufficient to project a profitable return on investment, monopiles for East Coast offshore wind farms will probably come from elsewhere. The difference here is that a piecemeal approach can reduce the initial investment risk. Initial wind farm construction will probably see monopile pieces shipped to a staging facility as 'cans', or basically smaller sections of rolled steel. At the staging location the 'cans' would be welded together to form the pile sections appropriate for the installation.

One European steel fabrication firm expects that a functional facility would need roughly 16,900 m^2 (approximately 182,000 ft^2) of production floor. The facility would require high capacity floors and fabrication cranes with 136-182 mt (150 - 200 ton) capacity, rail access, and water access. Like the foundation assembly facility, the required water depth for a foundation staging facility would likely be less than is required for a turbine staging facility.

3.7.2.2 Storage Requirements

The storage requirements for foundations are more flexible than the turbines since they are less sensitive structures. The foundation elements will be exposed to the harsh marine environment during their life, and are designed to be exposed to these harsh conditions. If there is a backlog of deployment causing foundation storage to overlap significantly with turbine component storage, then the required storage area could increase by 2 to 4 hectares (approximately 5 to 10 acres). Potentially, barges also could provide additional storage in a sheltered bay or harbor area.

3.8 Rail and Road Access

Issues of port access for the large offshore wind generation components being delivered via rail and highway are unique for each port. There is the potential for delivery of components from domestic North American suppliers, such as those located in the State of Colorado. Height, width, curve radius, and weight limitations associated with rail or roadways are potential constraints. Turbine pieces could potentially be transported by component or sections (including tower sections, wind blades, and nacelles). Turbine sections and wind blades would be transported horizontally and nacelles vertically on transport units, at least for current wind turbines being deployed. This will become less viable as the larger, next generation offshore wind turbines become available.

Shipment specifications (dimensions and weights) for typical offshore nacelle components are presented in Table 3-18.

Table 3-18
Dimensions and Weights of Turbine Components
Technical Data for Vestas V112-3.0 MW
(Source: Vestas 2009a)

Turbine Component	Dimensions			
	Weight	Length	Height	Width/Diameter
Monopile Foundation	150 to 210 mt (165 to 231 ton) for 28 to 40 m (92' to 132') long monopile 500 mt (551 ton) for 60 m (200') long monopile	Varying 28 - 40 m (92' to 131') up to 60 m (197')	N/A	d: 5 m to 5.5 m (16.75' to 18')
Transition Piece	170 mt (187 ton)	17 m (56') per unit	N/A	d: 4.2 m (13.8')
Nacelle (including hub)	125 - 150 mt (138 to 165 ton)	14 m (46')	3.3 m (10.8')	w: 3.9 m (12.8')
One Blade	12.5 to 18 mt (13.77 to <20 ton)	54.6 m (179')	N/A	Max. w: 4.2 m (13.8')
Tower Section	Approximately 70 mt (77.16 ton)	32.5 m (106.6')	N/A	d: 4.2 m to 4.5 m (13.7' to 14.76')

N/A = Not applicable

3.8.1 Overview of Rail

In general, the weight and length proposed for the units (excluding blades) can be handled by rail in the nationwide system depending on how finite certain components can be broken down. There are various routes throughout the United States that can be employed for shipments of oversized shipments. Main line route movement is easier to address than final delivery by rail to the various ports. In Massachusetts, delivery to central distribution points would include Beacon Park Yard in Allston (which is operated by CSX) or Ayer (which is operated by Pan Am Railways in conjunction with Norfolk Southern). From this point, equipment would travel on secondary routes to each of the port areas. There are differences in right of ways, bridge clearances and secondary access corridors for rail lines throughout the United States and in the region. It can be assumed that if the rail link between the manufacturer and a main line rail corridor can handle the equipment that the main line corridor can move the equipment anywhere in the country. For the most part, if there are any unique choke points, there are sufficient other corridors available to handle the move. All of the ports in Massachusetts have rail access. However, direct waterfront access varies by area.

The ability to move component parts via rail is determined by rail corridor track curvatures, component weights, and loaded height on the rail car.

Curvature: The lines to port facilities vary in terms of curvature, so specific routing and the need for single overhang vs. double overhang vs. bolster load loadings must be considered to address any length issues associated with the specific equipment being shipped. Overhang is simply the extension beyond the limits of the rail car either at one end or both. The overhang depends upon the length of the item carried and where the center of gravity is for the load.

Weight: In general, a weight of 81.7 mt (90 tons) can be loaded onto a standard rail car. Heavier loads would require either special equipment that is available in various configurations (including a bolster load and are able to carry up to about 363 mt (400 tons)). The bolster is the part of a railroad car body underneath that connects the truck's pivot to the body (see

Figure 3-21). The bolster also includes and refers to the cross members which provide the frame for the rail trucks which is the piece between the side frames. The bolster load is the maximum weight that the bolster frame and truck assembly can support. Boston and New Bedford's rail network would support standardized loads up to the limits indicated for the rail system. New Bedford track conditions are, in general, not as good as in Boston.

Figure 3-21 Rail Trucks
(Source: MARPRO Associates International 2009)

Height: Heights limitations are very route specific. Overall first generation clearances for container doublestack cargo movement are 5.8 m (19 feet) "above the rail" (ATR). Second generation clearances are approximately 6.8 m (22' 6") ATR. In most cases, Massachusetts rail lines to ports average 5.2 m (17 feet) ATR.

In general, components can be designed to be transported on the national rail system (see Figure 3-22). They can be broken down to insure they do not exceed rail system limitations on weight or clearance. It can be clearly seen in Figure 3-22 that component heights, when loaded on rail equipment, generally average a similar height to standard rail box cars.

Figure 3-22 Broken Down Wind Components on Rail Cars
(Source: MARPRO Associates International 2009)

3.8.2 Overview of Road Transport Requirements

Overweight and large shipment units are limited to State permitting requirements. These requirements allow an excess of 1,240 kg (88,000 pounds) only on roadways either specially designated for such shipments or with the use of specialized equipment such as tri-axle trailers. Shipments are generally limited to a maximum of 1,410 kg (100,000 pounds) and are often only permitted during certain time periods (such as off-peak or overnight periods). Infrastructure is also considered in permitting applications including limitations from overhead utilities, road lighting, road curvatures and intersections.

3.9 Implications of Distance

Developers identified cost as a critical consideration. Under the precept of “time equals money”, schedule generally has a strong impact on project cost. The distance between a staging port and the installation site affects costs both in terms of fuel schedule. Distance also has an effect on controlling the risk of damage or loss during transport. When expensive turbine components are in transit from the staging port to the installation site they are more vulnerable to ocean and weather effects and motion accidents than when they are being managed from a vessel stabilized by jack-up legs. The proximity of the staging port to the installation site, therefore, is a factor in reducing risks and costs and risk.

In terms of component delivery to the staging port, distance also is an important factor, but not typically an overriding factor for the project. Required components and raw materials for a project may come from Europe, Colorado, or Brazil. One manufacturer that was interviewed advised that industry on the Gulf Coast is already set up to manufacture the steel pieces needed for jacket piles. This manufacturer expects to barge the fabricated pieces to a location closer to the installation site for assembly. He believes that manufacturing and shipping is more cost-effective than setting up a manufacturing facility in the region. However, at the same time, the manufacturer wants an assembly location relatively close to the fabrication site so that he does not have to “ship air” (i.e., the spaces between the framework members).

4.0 EVALUATION CRITERIA

The information presented earlier in this report was developed to identify a broad set of direct requirements and highly desirable characteristics of port facilities relative to supporting offshore wind farm construction and operation. In this section, the broad list of considerations is analyzed and further distilled down to a smaller set of criteria that can be used to effectively and adequately differentiate the identified Massachusetts port facilities from each other based on their potential to support offshore wind energy development.

4.1 Summary of Requirements and Desirable Characteristics

Previous sections of this report have discussed the multiple roles a port plays in staging the construction and maintaining the operation of an offshore wind farm. Particular features and characteristics of the port either enhance the port's ability to perform these roles or represent obstacles to providing those services and supporting those functions. The direct requirements and highly desirable characteristics of port facilities were identified through interviews with developers and wind turbine manufactures and then compiled and evaluated. To facilitate review, these requirements and characteristics were grouped into five general categories:

- Aspects associated with the wharf and yard portions of the port;
- Aspects associated with the berthing facilities of the port;
- Aspects associated with navigation into and out of the port;
- Aspects associated with the geographic location of the port relative to potential projects; and
- Aspects and characteristics of the region in the vicinity of the port.

Table 4-1 lists these grouped requirements and characteristics.

Table 4-1
Groupings of Port Characteristics

Aspects of the Port	Requirement or Characteristic
Wharf and Yard	• Has available inside storage capacity • Has sufficient lay down area for required storage and assembly • Would be able to expand the scale of operations • Has adequate rail or road access • Has previously staged offshore projects or development • Has ready access for and experience with large tugs and support vessels
Berthing Facilities	• Has sufficient berth (length and depth) • Already has large cranes of sufficient size and type • Has piers with high load carrying capacities • Has capacity to handle hundreds of additional port calls/year
Navigation	• Has operations 24 hours/day and 365 days/year • Is in a sheltered harbor • Has no restrictive lateral clearance constraints • Has no restrictive air draft constraints • Has sufficient draft at low tide • Has a short route to open water

Aspects of the Port	Requirement or Characteristic
Geographic Location	• Is located proximate to related marine infrastructure and equipment • Is as close as possible to component manufacturers • Is not subject to excessive extreme weather that can adversely affect operations • Is as close as possible to proposed project sites (including MA OMP Wind Energy Areas)
Region in the Vicinity of the Port	• Has accommodations for workers and visitors • Has, or can quickly develop, a trained work force • Has access to a sufficient workforce • Development is welcomed by the community • Development is welcomed by regulators • Development will contribute to economic growth

First, it should be noted that not all of these collected requirements and characteristics were identified to be equally as critical to a port's ability to successfully support offshore wind farm development. Some are "must have" physical requirements, while others represent desirable characteristics that potentially could be worked around provided other features are present and compensate for their absence. Second, a few of the listed characteristics are complementary and linked. For example, ports with ready access to large tugs and support vessels would almost certainly be located proximate to other related marine infrastructure and equipment. As such, the presence of one generally ensures the presence of the other. Third, some characteristics would be shared by any larger port or any port in the Eastern U.S. For example, all port locations in the region have accessible accommodations for workers and visitors and have access to a sufficient work force. Therefore, these characteristics would not enable one to meaningfully discriminate between the ports being comparatively evaluated.

In consideration of these factors, the requirements and characteristics were distilled down into a smaller set of critical criteria appropriate for the comparative evaluation of the ports. The distillation process was conducted so that all of the considerations that were identified as critical or important were preserved as "hard" requirements, as distinguished from softer trade-off characteristics. The criteria that were developed are presented in the next section.

4.2 Criteria Development

Upon further consideration of the requirements and characteristics identified above, two sets of "hard" requirements were identified for comparing the ports: (1) those related to harbor access (referred to as the 1st Tier Criteria) and (2) those related to the port facilities' attributes needed to meet specific developer and turbine supplier needs (referred to as the 2nd Tier Criteria). In addition, a set of "soft" criteria was developed that is somewhat more subjective but nevertheless allows ports to be distinguished from one another relative to supporting offshore wind farm development. Soft criteria attributes may attract developers to consider one port over another, and the absence of these criteria is likely to have financial consequences to port projects.

4.2.1 1st Tier Hard Criteria Relating to Harbor Access

The 1st Tier Hard Criteria identified relative to harbor access were:

- Sheltered harbor (protected from bad weather by means of a barrier);
- Unobstructed vertical (overhead) clearance;
- Minimum horizontal clearance greater than 40 m (approximately 150 feet);
- Minimum low tide navigational channel depth of 7.3 m (24 feet);
- 24/ hour/day and 7 days/week operational availability; and
- Exclusive use of the staging facility.

Ensuring port access as dictated by developer and turbine supplier needs is essential. Hard criteria related to the logistics of the origin of the turbine components and their method of delivery to the staging port and the installation (construction) site are crucial. Possible delivery modes include seafaring vessels, rail, and trucking (see Section 3). Physical parameters for marine vessels to access a harbor emerge as critical criteria, while rail and trucking access were believed to be present or more easily attainable at the set of ports being compared. Staging ports need to accommodate vessels shipping and handling the large components used for commercial scale wind farms. The greatest vessel draft (depth) establishes the criteria for the shipping or navigation channel depth. The widest vessel beam (width) along with the method of component transport, which may involve overhang, establishes horizontal clearances. Along with vessel height, the options for method of transport also contribute to vertical clearance criteria. The potential for bad weather interruptions and the need to maximize labor and equipment availability makes a sheltered harbor an essential criterion, especially for the barges that are adapted as near-term delivery and installation vessels.

Implications of the cost of contractor mobilization, vessel and equipment utilization combined with weather and seasonal limitations on the construction window result in developers and turbine suppliers requiring a port facility that allows operations 24 hours a day, seven days a week. Given that optimal operations would entail moving large components around the clock, the staging port must also provide exclusive use of the staging facility.

A systematic evaluation of these 1st tier hard criteria will address the navigational considerations identified in Table 4-1.

4.2.2 2nd Tier Hard Criteria Relating to Port Facilities

The 2nd Tier Hard Criteria identified relative to the port facilities were:

- Minimum berth length of 138 m (approximately 450 feet);
- Minimum berth water depth of 7.3 m (24 feet);
- Lay down storage and assembly backland area larger than 4 hectares (10 acres); and
- Proximity to likely offshore wind farm site.

These 2nd tier criteria establish port facility attributes that would accommodate industry vessels. Primarily, these 2nd tier hard criteria must include the water depth at and overall length of the facility berth. Water depth must be sufficient to accommodate industry vessel drafts or must be attainable through routine dredging. Additionally, vessel length and the number of vessels operating simultaneously establish the parameters needed for length of the berth.

The size of the backland area landside of the bulkhead for storage and assembly of the turbine components and the ability to handle the loads of components and construction equipment are significant criteria. The requirements of foundation storage and assembly can increase the area requirements, but foundations do not necessarily need to be staged from the same port or have the same delivery vessel-related restrictions. Port proximity to the construction site can affect operational logistics, risks, and significantly costs. The distance from a port facility to potential wind farm sites, therefore, has significance but becomes secondary to the parameters discussed above. If a maximum distance is established to screen ports, it may follow, however, that closer ports have limitations that could have a persuasive effect on logistics, risks, or costs, thereby making more distant ports the more viable option. This has recently been true for the U.K. where deployment operations have been staged out of Denmark in some cases.

A systematic evaluation of these 2nd tier hard criteria will address the wharf and yard and berthing facility considerations identified in Table 4-1.

4.2.3 Soft Criteria

Soft criteria parameters, as noted above, are other port area attributes that may attract developers to consider one port over another. The Soft Criteria identified were:

- Workforce availability;
- Education and training facilities;
- Political climate/community acceptance; and
- Regulatory considerations.

The location of education or training facilities and work force availability, including various skilled labor trades, could be an important factor in port selection. Soft criteria are discussed in more detail in Section 6.4. European offshore wind developers have reported shortages among skilled workers in related trades. Massachusetts ports have ready access to considerable education and training resources that are geared to offshore and underwater construction, seamanship, and technical trades and services. Taking into consideration the nine-plus years' approval process of the Cape Wind project, which was greatly affected by opposition to the project, political climate and community acceptance of a large scale industrial operation to support potentially controversial projects also must be evaluated.

A systematic evaluation of these soft criteria will address the aspects of the region in the vicinity of the port identified in Table 4-1.

4.2.4 Screening and Short-Listing the Ports

The set of ports considered in this study were analyzed using these criteria. Those ports that did not meet minimum thresholds were eliminated from further consideration by the Team. Section 5 provides an overview of Massachusetts ports that could support staging and installation of offshore wind farms, as well as other regional ports that could meet the assembly, construction, and/or servicing needs of the offshore wind industry.

Section 6 describes the process that resulted in the two short-listed ports - the potential South Terminal area in the Port of New Bedford Renewable Energy Marine Park and the existing Dry Dock #4 in the Port of Boston Marine Industrial Park.

5.0 INVENTORY OF PORTS

The following sections provide an overview and general description of Massachusetts ports, as well as regional ports that could support offshore wind development activities. This section also provides an overview of the capability of East Coast and Gulf Coast shipyards to construct new vessels, modify existing vessels, provide support vessels, and provide repair services.

5.1 Profiles of Port Facilities in Massachusetts

The Commonwealth of Massachusetts has a varied mix of marine activities in its five key port areas, with connections to both international and domestic markets. Primarily, these ports serve as transition points where cargo moves to and from marine modes including ship and barge to land-based modes, in particular truck or rail. Appendices F and G provide more detail on these ports and modes of transportation.

Massachusetts has a number of ports that, because of their existing or proposed marine terminals, geographic location, proximity to regional commercial activity, and access to land-based transport to more distant inland markets, already have substantial marine activity including a wide range of freight activity. The Commonwealth has one major tonnage and diversified seaport and five smaller niche ports that operate within the marine network. The major Commonwealth seaport is Boston, and the five niche ports include Gloucester, Salem, the Fore River Shipyard, Fall River, and New Bedford. From north to south, profiles of these Massachusetts ports and their potential for expanded marine industrial activity are presented below.

5.1.1 Gloucester, Massachusetts

Background

The Port of Gloucester is located on Cape Ann and is approximately 22.6 nm (26 miles) north of Boston. Cape Ann is located adjacent to the main shipping routes between Southern and Northern New England. The port is historically known for its fishing industry. See Appendix E for the extent of the Gloucester Designated Port Area (DPA).

Gloucester still has a large fishing industry and the potential to develop an all water ferry connection to the Province of Nova Scotia in Canada. The port has some land area available to develop a new marine facility for commercial activities. It has a readily available skilled work force and diverse marine service sector. It also has a rail line that would provide access to the national rail system, and the Route 128 corridor provides excellent highway connections to the New England highway network.

Facilities

The primary marine industrial facilities in the port are within the Industrial Port (see Figure 5-1). The principal businesses are fishing, fish processing, recreational boating, marine repair and supply, and a fledgling cruise ship business. The Industrial Port has become the city's primary marine industrial area with 98% of the land and pile-supported area within this district dedicated to industrial and accessory-to-industrial uses. It has recently experienced several significant changes, including the opening of the Gloucester Seafood Display Auction, modernization of Americold's and Gorton's waterfront infrastructure, and significant expansion of facilities on the

State Fish Pier. Most recently, the development of the Gloucester Marine Terminal at Rowe Square offers important new opportunities for the port (Garcia et al. 2009). The Gloucester Marine Terminal, the cruise ship facility, is accessed via the North Channel of Gloucester Inner Harbor and can accommodate vessels up to 152.4 m (500 feet) in length and drawing up to 5.5 m (18 feet). The facility is owned by the City of Gloucester and is limited to tourism activities. Larger vessels up to 244 m (800 feet) in length and drawing up to 7.9 m (26 feet) can be accommodated inside the breakwater at Gloucester Harbor.

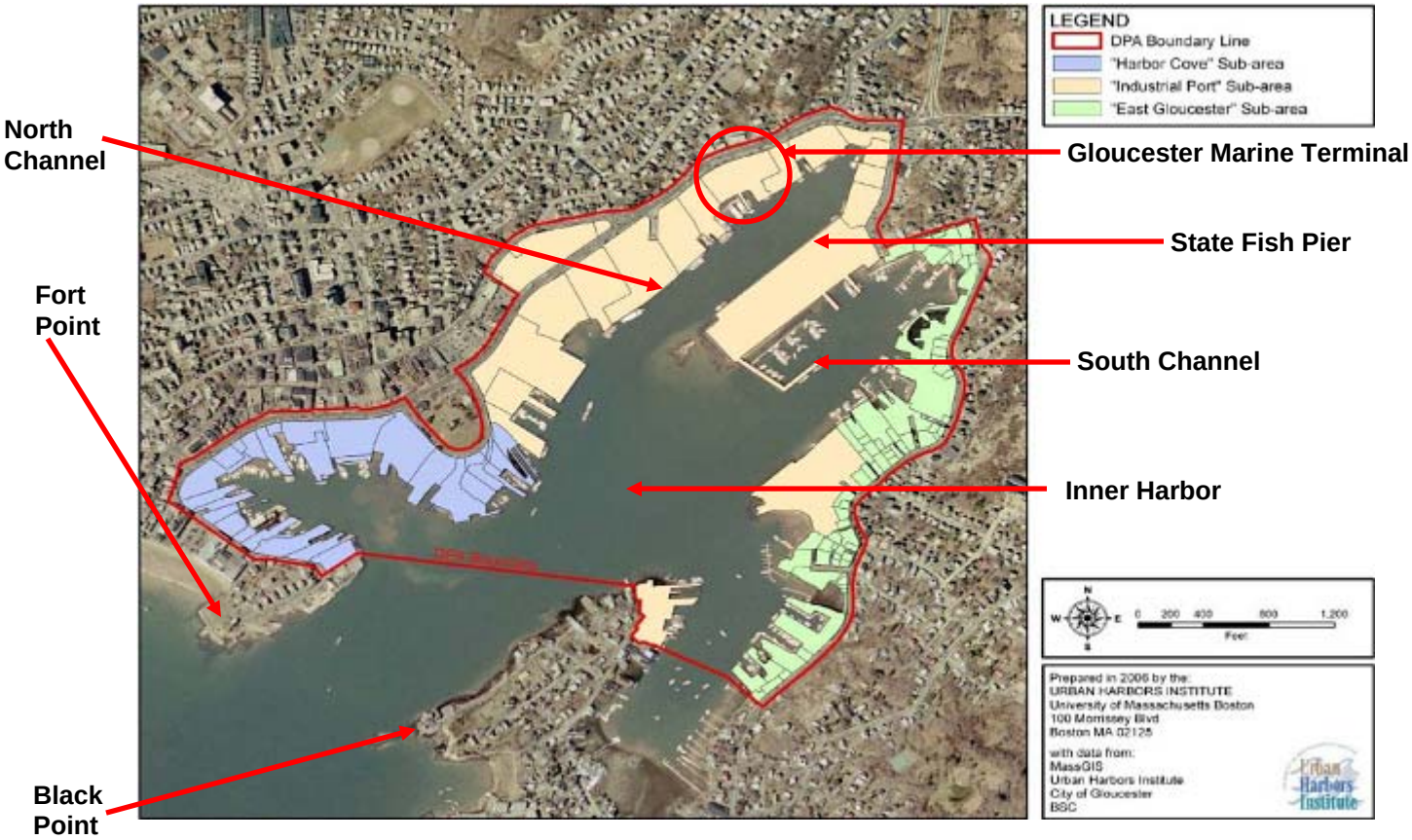


Figure 5-1 Layout of the Inner Harbor at the Port of Gloucester
(Source: City of Gloucester Harbor Plan and Designated Port Area Master Plan 2009)

The largest facility is the State Pier, which is dedicated to fishing activities. The 3.1 hectares (7.8 acre) facility has a 410 m^2 (approximately 4,400 sf) wharf with 425 m (approximately 1,400 feet) of berthing with depths of between 5.2 and 6.1 m (17 and 20 feet) at mean low water (MLW). A dredged channel of 6.1 m (20 feet) at MLW provides access to the pier.

There are several buildings that support the fishing industry onsite, and a number of businesses that support marine activities, including several small boat marinas. There are also a number of repair yards and associated businesses. There is little capability at existing facilities for ROWEI staging.

Harbor Profile

Gloucester Harbor is a well protected harbor with an easily navigable entrance and broad inner harbor located on the south shore of Cape Ann. The entrance to the port is close to the pilot station located in Massachusetts Bay.

The outer harbor has a protective breakwater that extends from the east side of the harbor entrance at Easter Point. Primary access is on the western side of the harbor entrance. The harbor becomes progressively shallower from about 5.5 to 15.8 m (18 to 52 feet) outside the entrance to 7.6 to 9.1 m (25 to 30 feet) within the harbor to less than 4.5 to 7.3 m (15 to 24 feet) in the inner reaches. The channel entrance is approximately 365 m (approximately 1,200 feet) wide with depths of 11.6 to 14.3 m (38 to 47 feet) into the outer harbor.

Tidal range is about 2.65 m (approximately 8.7 feet) average, and currents within the harbor are nominal. Parts of the harbor entrance are difficult to traverse due to breaking waves in severe weather and a number of shoals and submerged obstacles. There is a dredged anchorage for vessels with up to 4.9 m (16 feet) of draft about 275 m (approximately 900 feet) southwest of the State Fish Pier.

The inner harbor is defined by a line between Fort Point and Black Point. The approaches to the inner harbor have water depths ranging from 6.7 to over 12.2 m (22 feet to over 40 feet). Water depths range from 4.72 to 5.8 m (15.5 to 19 feet) in the inner harbor. The lateral clearance is approximately 61 to 76 m (approximately 200 to 250 feet). Gloucester harbor has inner areas known as the Western Harbor (which is closest to the town center) and Southeast Harbor (which is closest to the entrance) (see Figure 5-2). Shoreline areas in the Western Harbor and Southeast Harbor have very shallow water depths. There are shallow channel (6.1 m (20 feet) at MLW) accesses to the State Fish Pier, Gloucester Marine Terminal and East Gloucester.

Advantages

The port is well sheltered and has support mechanisms in place for commercial and industrial activities. No overhead clearance constraints were identified in the approaches to the Port of Gloucester. The port has both rail and highway access which supports the traffic associated with the fish processing industry. There is a waterfront commercial roadway connecting to Route 128.

Disadvantages

Water depth and lateral clearance are the most significant constraints for the inner harbor at the Port of Gloucester (see Figure 5-2). The harbor entrance is narrow and deep, but becomes shallow quickly. There is little deep water access to shore areas for large vessels, but access is suitable for barges Turbine installation vessels should be able to navigate the Port of Gloucester, but turbine import vessels most likely would not be able to call at this port. The lateral clearance limits turbine load-outs in the fore-aft bunny ear configuration. The immediate area in and around the shoreline is congested and has mixed traffic flow. Although there is rail service to the City, it is limited at this time to commuter rail.

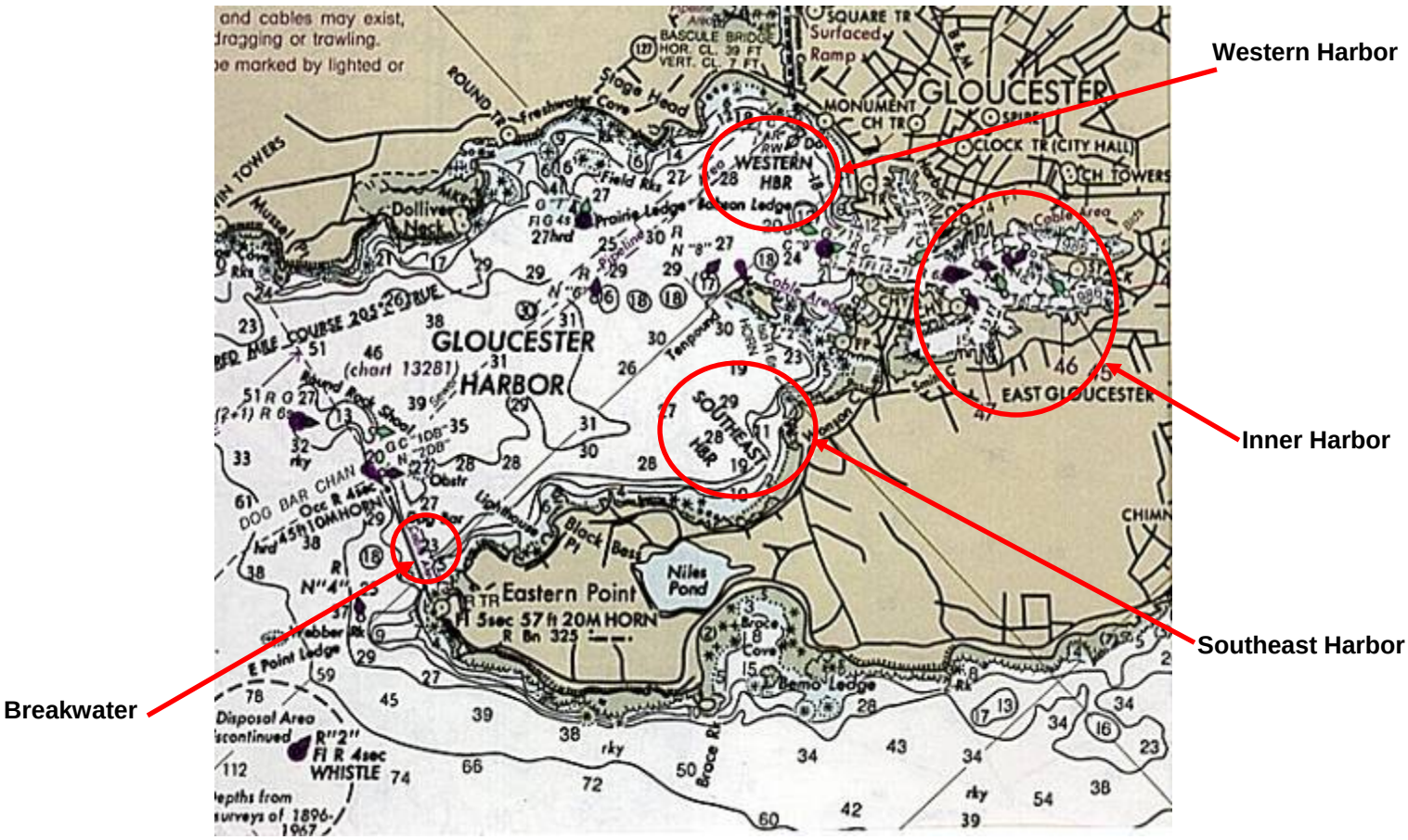


Figure 5-2 Gloucester Harbor and Shoreline Areas
(Source: MARPRO Associates International 2009)

Potential

There are limited areas for industrial growth adaptable to ROWEI staging. It is unlikely that a suitable location within the port of sufficient size could be identified to handle processing and assembly. To take advantage of existing water depth, highway connections and other access issues, any facility should be located on the west side of the harbor.

5.1.2 Salem, Massachusetts

Background

The Port of Salem is located 9.6 nm (11 miles) southwest of Cape Ann and is approximately 10.4 nm (12 miles) northeast of Boston. It is a small harbor, part of an irregular indentation in the shoreline of Massachusetts Bay (see Figure 5-3). The watershed area also includes Manchester, Beverly and Marblehead Harbors. The port is primarily known for its recreational and yachting industry. It also has a deepwater oil facility and commuter passenger service connecting to Boston. See Appendix E for the extent of the Salem DPA.

Figure 5-3 Aerial View of Salem Harbor
(Source: MARPRO Associates International 2009)

Facilities

The principle deepwater facility in Salem Harbor, Salem Terminal, is located at the head of the harbor. The facility handles petroleum for the 27 hectares (approximately 67 acre) New England Power Company plant owned by Dominion Energy. In addition, Key Span Energy operates the adjacent 6 hectares (15 acre) support facility for an offshore liquefied natural gas handling platform. The port has a 0.8 hectares (approximately 2 acre) commuter ferry facility with connecting service to Boston. There are several fishing and recreational boat slips in the harbor, and the National Park Service has a 244 m (800 foot) berth that is used for historic vessels.

The port has fuel, water, provisions, and general marine services available, including several small machine shops that mostly service smaller craft. There are no dry-dock or shipyard facilities in the port for large commercial craft.

Salem has limited potential for substantial expanded marine industrial activities. The Salem Waterfront is shallow and has poor road connections to the waterfront. The port already provides supplemental marine support for the expanding petroleum and gas network in New England. The port's only deepwater commercial terminal is situated at the head of the harbor, and there are several former rail rights-of-way that connect to inland points. The expansion of pipeline connections from the terminal into the gas and petroleum network was first identified in the study conducted in 1994 by the Governor's Commission on Commonwealth Port

Development (MARPRO Associates International 2009). While the terminal is primarily used to supply the needs of the Salem Power Plant, it has the capacity to handle additional marine operations, including ROWEI staging. The port, however, does not have enough of a transportation network to meet a wide range of industrial needs, which would require adequate waterfront property, deep water access, unencumbered road access, and direct highway and rail connections. It does have the potential for other water based activities not dependant on road or rail connectivity.

Harbor Profile

Salem Harbor is a well protected harbor with three main channels that serve the watershed area. The Salem Channel, which is 9.4 m (approximately 31 feet) deep, is the primary access channel for deep draft vessels and passes through Salem Sound for approximately 3 nm (see Figure 5-4). The channel connects to a turning basin at the west side of the harbor at the Salem Terminal Wharf. The turning basin has a controlling depth of 8.2 m (approximately 27 feet). The harbor also has a special anchorage area. The harbor extends to the Salem Waterfront where the National Park Service's recreational and fishing piers and ferry terminal are located. Depth in most cases at the Salem Waterfront is less than 5.5 to 6.1 m (18 to 20 feet).

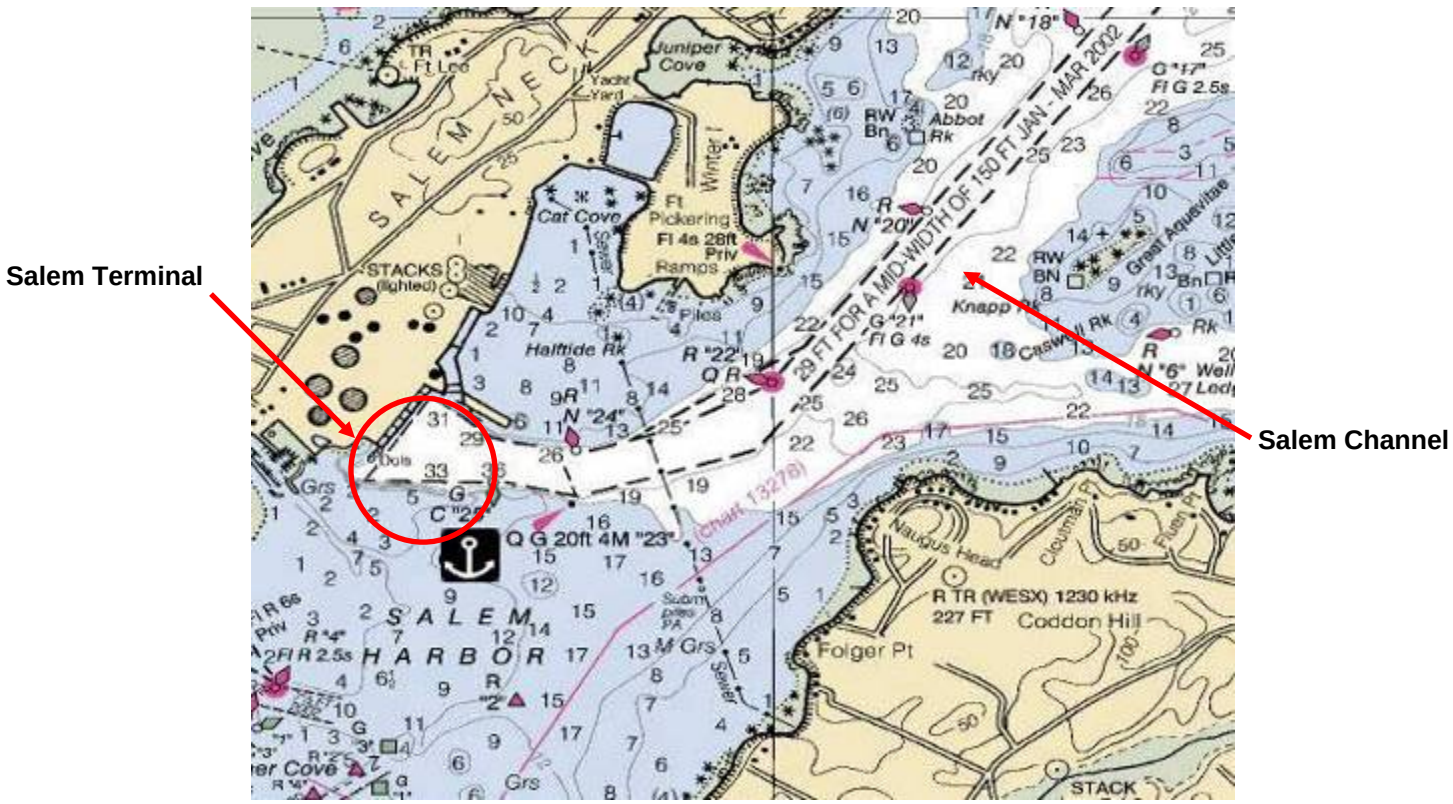


Figure 5-4 Salem Harbor and Shoreline Areas
(Source: MARPRO Associates International 2009)

The overall range of the tide in the harbor is between 2.6 and 2.75 m (8.5 and 9 feet). Within the harbor the current has minimal velocity. There is ice buildup at the head of the harbor during

very cold winter months, mostly in January and February. Tug services are available out of Boston, and Salem is a U.S. Customs Port of Entry.

Advantages

The port is well sheltered and has some commercial vessel activity. The Salem Terminal site is underutilized and may be adaptable for some ROWEI staging activities. No overhead or lateral clearance constraints were identified in the approaches to the Port of Salem.

Disadvantages

The community is a popular tourist destination, and the surrounding waterfront communities have significant recreational vessel activities that have hindered industrial waterfront development. A potential focus of Salem Harbor is developing the emerging pocket cruise ship industry.

Water depth is a constraint. There is little deep water access to shore areas near the center of the waterfront. There is also very little area outside of Salem Terminal where large vessels can handle ROWEI components. The immediate area in and around the waterfront is congested, has poor capacity for high volume traffic flow, and does not have adequate and acceptable truck access. Although there is rail service to the City of Salem, it is limited at this time to commuter rail. The rail does not extend to the harbor areas, but there are former rail rights of way that connect to the harbor area. There is little space around the harbor for the development of additional freight activities other than what is currently handled at Salem Terminal.

Potential

The main area for commercial growth lies with the tourism-based cruise business. The community is well known and has good growth opportunity in marine based tourism activities. There is limited capacity for ROWEI staging or fabrication.

5.1.3 Boston, Massachusetts

Background

The Port of Boston is located north of Cape Cod and is adjacent to the main shipping routes between Southern and Northern New England. Within New England, the Port of Boston is the second largest tonnage port (after the Port of Portland, Maine,) the largest container port, the largest international passenger port and the largest oil port in Massachusetts. The port is historically known for its diverse maritime mix. The port has two shipyard facilities, hosts several commuter ferry operations, marine research activities, marinas, and the largest U.S. Coast Guard facility in New England (see Figure 5-5). While in recent years some segments of the port's activities have declined, notably fishing, the Port of Boston remains the largest of the Commonwealth's five major seaports. See Appendix E for the extent of the Boston DPA.

Boston is the largest and most prominent freight port in the Commonwealth. It has the most diversified port mix and handles the largest volume of containers in New England and the second largest amount of petroleum cargo. The port mix includes containers, general cargo, automobiles, scrap metal, road salt, project cargo, refined petroleum products, liquefied natural gas, international port of call and homeport cruise passengers, and domestic commuter and outer harbor ferry operations. Including liquid bulk cargo, the Port of Boston handled over

13.6 million mt (approximately 15 million tons) of cargo in 2007. Only the Port of Portland handled more, approximately 22.7 million mt (25 million tons) of cargo, mostly crude oil bound for Canada. Of the Port of Boston's total tonnage, 1.54 million mt (1.7 million tons) were containerized cargo representing 216,434 intermodal shipping container TEUs. With 4 container cranes, the annual port throughput averages 5,288 containers per hectare (2,140 containers per acre). The port hosted over 1,000 vessel calls in 2007.

Figure 5-5 Aerial View of Boston Harbor
(Source: http://www.mappingboston.org/html/map20-a.htm)

Boston has some critical key advantages and some distinct disadvantages for potential growth (see Figure 5-6). The port is situated within one of New England's largest market areas for products and commodities, and there is a significant amount of related port business, a wide range of diversity in the port operational mix, and a strong commitment to expanding activities. The port also has numerous terminals, deep water access, full marine services, and a large and skilled work force. The port has enhanced the economies of scale at its two major freight

terminals, Conley and Moran Terminals, by consolidating container operations at Conley Terminal in South Boston, nearest the open seas and deep water areas, and shifting auto import and processing operations to Moran Terminal in Charlestown. This has resulted in lower overall operating costs and has enhanced the Moran Terminal operating authority's ability to attract and retain auto carrier and processing services. This trade suits the terminal's draft limitations and longer port transit.

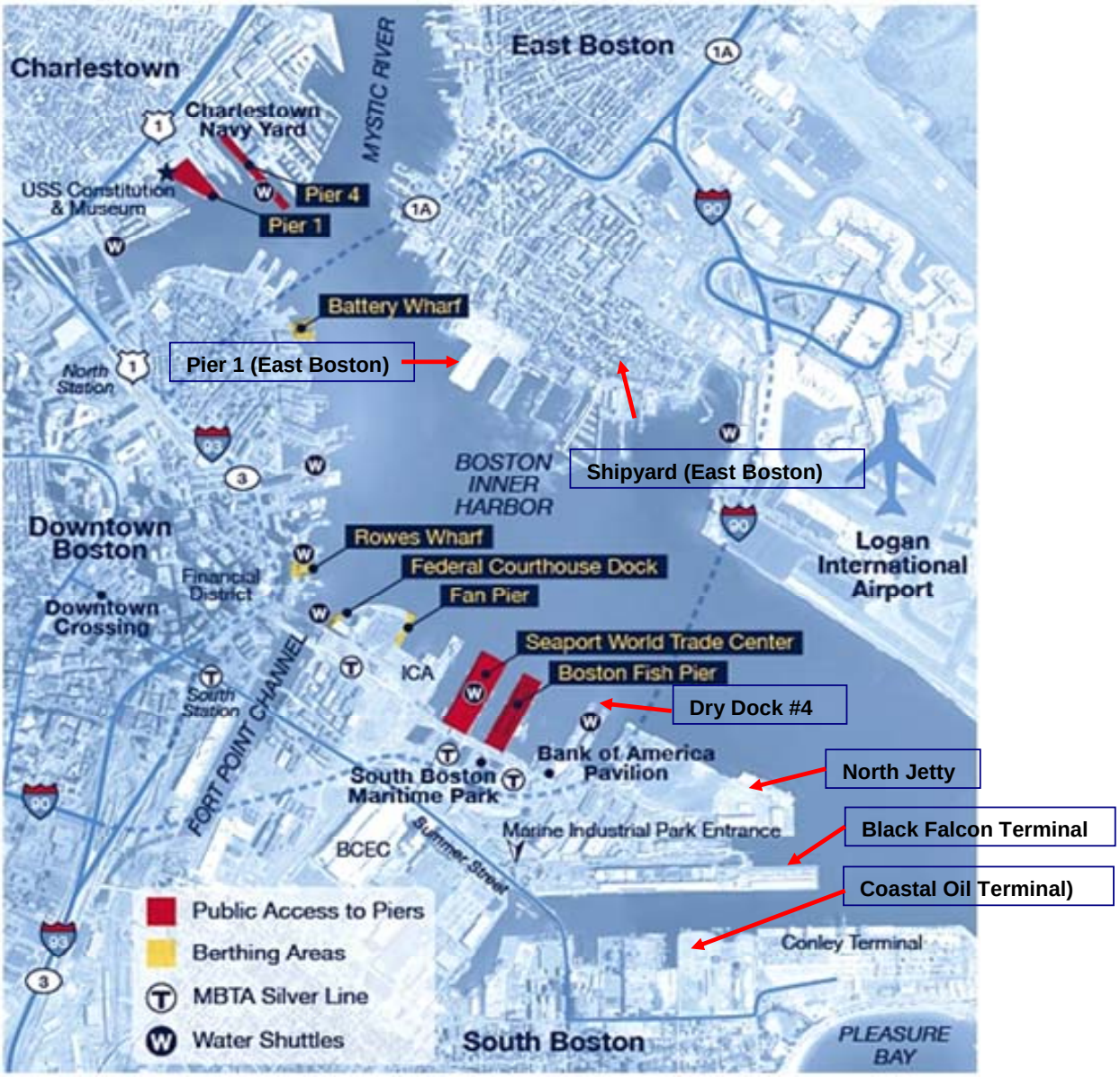


Figure 5-6 Massport Facilities
(Source: http://www.massport.com/business/pic/c_haarborwide.pdf)

Boston has been limited in its ability to take full advantage of significant industrial growth. A series of development projects has gentrified port areas, which has created choke points for the marine terminals. South Boston, for example, had been developed by the railroads for the

handling of freight at numerous piers, but most of the original infrastructure has been replaced by new and non-related commercial and residential development. The result is that most of the rail infrastructure has been removed and direct rail connections to the waterfront are gone. Roadways are congested and direct street connections between the terminal and highway connectors are inefficient. The nearest major rail terminal is located at Allston Yard, some 14 miles from the port, which would make transport and transfer of turbine components or ancillary material expensive.

Facilities

The public marine passenger and cargo facilities in the Port of Boston are managed by the Massachusetts Port Authority (Massport). Massport is an independent public authority that develops, promotes and manages Massachusetts' airports, seaport and transportation infrastructure. Massport owns, operates and leases approximately 202 hectares (500 acres) of property in Charlestown, East Boston, and South Boston. Most of the properties are located within the Commonwealth's regulated DPAs, which are restricted to maritime industrial activities. These facilities include the Boston Autoport located at the combined Mystic River Piers and Moran Terminal in Charlestown and East Boston Pier 1 and adjacent properties in East Boston. Massport also owns the Paul W. Conley Container Terminal, the Black Falcon International Cruiseport, the North Jetty cargo facility, and the Boston Fish Pier all located in South Boston.

The 41 hectares (101 acre) Paul W. Conley Container Terminal South Boston is the largest marine facility in the harbor and is utilized for cargo container operations. The facility has 610 m (approximately 2,000 linear feet) of berthing with depths of between 12.2 and 13.7 m (40 and 45 feet). The terminal is equipped with four, low profile gantry cranes capable of 30 moves an hour, and the terminal can handle vessels up to an average of 5,000 TEUs, considered mid-size in the current vessel market. The container terminal handled nearly 220,000 TEUs in 2007, up 10% from 2006. The North Jetty is located on the waterfront in the Marine Industrial Park next to the Black Falcon Cruise Terminal. It offers 245 m (approximately 800 feet) of berthing space with a depth of 12.2 m (40 feet) at MLW (Massport website accessed February 2010). The North Jetty facility in South Boston is underutilized and adaptable to ROWEI assembly.

Boston Autoport in Charlestown is primarily used for automobile import, processing and distribution and has capacity for approximately 50,000 cars per year. It is also the location for the Wind Technology Testing Center (WTTC), a joint project with the U.S. Department of Energy to build a large wind turbine blade testing facility. There is some covered storage for high-value automobiles on site in the former Mystic Pier transit shed. The property encompasses approximately 20.2 hectares (50 acres) of land, not all of which is actively utilized and is consequently potentially suitable for ROWEI staging. The facility is also equipped with a shore-side gantry crane. The Boston Autoport is upstream of the Tobin Bridge and, therefore, is subject to vertical navigational constraints.

Another Massport facility in Charlestown is the former Revere Sugar site, now known as the Medford Street Terminal, which comprises approximately 5.7 hectares (14 acres) of waterfront industrial property with deepwater access. The Medford Street Terminal is being utilized for some storage and has good potential for ROWEI assembly. This terminal is upstream of the Tobin Bridge, which imposes a vertical constraint of approximately 41 m (135 feet). This

restriction makes navigation marginal for jack up vessels and limits turbine load-outs in the star configuration.

The East Boston Shipyard is located on Marginal Street in East Boston between Piers Park and the site of the former Navy Fuel Pier. The shipyard is the only ship repair facility in Boston Harbor equipped to serve mid-sized commercial vessels. Features include: 3.6 hectares (9 acres) of backland, including 4 piers and approximately 8.1 hectares (20 acres) of water sheet, 18,580 m^2 (200,000 square feet) of commercial office and industrial building area in 12 structures, and 762 m (approximately 2,500 linear feet) of commercial berthing space (Massport website accessed February 2010).

Moran Terminal has rail access through Sullivan Square, and Massport owns the freight rail line from Sullivan Square into the Terminal. Conley Terminal does not have rail access and there are no identified plans for extending rail service into the facility. There is a proposed rail line connection that would provide access from the North Jetty for bulk, project and other cargos. Most of the roadway system in and around Massport's South Boston and Charlestown facilities is heavy weight rated for handling oversized loads up to 45.4 mt (approximately 100,000 pounds or 50 tons). The port has handled a number of project cargos using specialized tri-axle road trailers and has received State permits for transportation out of the terminal areas. Massport and the Boston Redevelopment Authority, which would have a approximately 15.25 m (50 foot) wide right-of-way and would eliminate some potential limitations with local utility infrastructure for very large component pieces. The roadway would provide better and unencumbered access to the Central Artery/Tunnel connections in South Boston. Massport also has proposed the extension of Cypher Street and the reconstruction of E Street as part of the freight roadway system with adequate turning curvatures and heavyweight access up to State authorized permit levels.

Harbor Profile

Boston Harbor is the largest physical harbor in New England and is well protected with a wide and easily navigable entrance and large inner harbor with deep water access. The entrance to the harbor has numerous shoals and islands. There are two dredged channels and two traffic separation schemes which define the approaches to and into the harbor for deep draft vessels. The entrance is well marked by navigational aids, and the entrance to the port is close to the pilot station located in Massachusetts Bay.

Boston's Main Ship Channel extends from the harbor entrance to the mouths of the Mystic and Chelsea Rivers and to the Charlestown Bridge on the Charles River. The Federal project channel depth is 12.2 m (40 feet) deep from the harbor entrance to the mouth of the Mystic River and is 10.6 m (35 feet) in areas near the south side of the harbor to just seaward the location of the Third Harbor. The Boston Harbor Deep Draft Navigation Improvement Project proposes to deepen the existing channel (USACE 2008). There are several deep draft ship anchorages in the harbor with the anchorage on the north side of President Roads used most frequently for ships and barges. Tidal range is around 2.75 to 2.9 m (9 to 9.5 feet) with two highs and two lows per day. Harbor currents are generally less than 1 knot.

Table 5-1 below summarizes the navigational constraints in the Port of Boston and their operational implications. This report focuses on the port facilities in South Boston, Charlestown, and East Boston discussed above. Other facilities on the Chelsea River currently are not

considered feasible for ROWEI staging due to lateral and overhead restrictions, which are shown in Table 5-1, and are not discussed further.

Table 5-1
Summary of Navigational Constraints in Boston

Staging Port	Potential Obstructions	Lateral Clearance	Overhead Clearance	Controlling Water Depth	Feasible Turbine Load-Outs	Jack-Up Feasible ?
South Boston (all ports)	Logan Airport	over 152 m (500')	report air draft to airport traffic control	12.2 m (40')	all	yes
Charlestown / East Boston (inner harbor ports)	Logan Airport	over 152 m (500')		12.2 m (40')	all	yes
Medford Street Terminal and Mystic River	Tobin Memorial Bridge	over 152 m (500')	41 m (135')	7.6 – 10.7 m (25'-35')	star	marginal
Chelsea River (west of Chelsea St. Bridge)	Andrew McArdle Bridge	53.3 m (175')	none	8.8 – 12.2 m (29'-40')	fore-aft bunny ear	yes
Chelsea River (east of Chelsea St. Bridge)	Chelsea St. Bridge	28.3 m (93')	25.3 m (83')	8.8 – 12.2 m (29'-40')	rotor disassembled	no

Advantages

The port is well sheltered and has significant support mechanisms in place for commercial vessel activity and ROWEI assembly. There are numerous roadway connections to most of the main marine terminals which are heavily used. The port is the largest support center for marine activities in New England with a diversified mix of services and associated businesses.

Disadvantages

Boston is a typical metropolitan port, with gentrification pressures and limited ability to expand marine activities. The Port of Boston is affected by air traffic at Logan Airport. While maritime operations are not restricted, according to the Coast Pilot®[6], all vessels with air draft greater than approximately 25.9 m (85 feet) must advise air traffic control of their presence (U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Ocean Service 2009). South Boston facilities do not have significant navigational constraints. All turbine load-out configurations (i.e., bunny ear fore-aft, bunny ear lateral, and star) can be accommodated. Jack-up vessels can navigate between these ports and the sea. Long-term staging operations in South Boston should be evaluated in the context of the vertical limitations due to proximity to Logan airport and related FAA regulations.

While there are numerous road connections to terminals, many are congested and pass through residential areas creating potential conflicts with pedestrian and automobile traffic. Rail connectivity is very limited in several areas including South Boston, Charlestown and East

[6] The United States Coast Pilot® consists of a series of nautical books that cover a variety of information important to navigators of coastal and intracoastal waters and the Great Lakes. Coast Pilot 1 covers the coasts of Maine, New Hampshire, and part of Massachusetts, from West Quoddy Head in Maine to Provincetown in Massachusetts. Major ports are at Portsmouth, NH and Boston, MA.

Boston. Boston's container and auto terminals have no direct access to the nation's doublestack (Gen2) rail network. Boston is considered to be a high cost port due to existing labor agreements and work rules, expensive infrastructure and limited volume capacity. The marine terminals, particularly Conley Terminal, have limited area to expand their property boundaries, which would affect utilization for other activities. Vessel access to the inner harbor, specifically, Charlestown and Chelsea Creek is draft and length limited.

Potential

There is adjacent property that can be purchased and added to the existing terminal footprints to allow for expanded yard area allowing for dedicated ROWEI processing. Roadway connections to the terminals in most cases also need to be improved to provide appropriate capability.

Boston's industrial marine growth is tied to three major areas to expand marine activities. These include:

- Expansion of terminal size;
- Improvement of roadway connections to main highways that avoid the inner city roadways; and
- Creation of a better connection to the national rail network.

5.1.4 Fore River Shipyard

Background

Fore River Shipyard is less than 10 miles south of Boston. This approximately 45 hectares (111 acre) site is situated partially in both Quincy (2/3) and Braintree (1/3) (see Figure 5-7). Fore River Shipyard was once a prominent shipyard in the United States, producing ships for World War II (WWII), peaking with approximately 50,000 employees during this time. In the 1970s, the 1,200 ton "Goliath" crane (since removed in 2008) was built specifically to place aluminum spheres (pressure vessels) on the LNG vessels constructed there. Recently, Fore River Shipyard has served as the Central Receiving Point for new car delivery to local dealerships. See Appendix E for the extent of the Fore River (Weymouth, Quincy and Braintree) DPA.

The site is currently undergoing an initial planning process to determine potential new uses for the site, including marine-related, residential, retail, office, and entertainment. Current planning goals are to create a mixed-use, working waterfront development at the site. At this time, the Shipyard is actively seeking industrial tenants for both indoor and outdoor space. The Fore River which flows directly into Boston Harbor has recently been dredged by the Army Corps of Engineers, and can accept "Panamax" class vessels (i.e., vessels of a maximum size to fit through the existing Panama Canal).

Figure 5-7 Aerial View of Fore River Shipyard
(Source: Google Earth, Fore River Shipyard, 2010)

Facilities

The site is currently owned by Daniel Quirk, a local auto dealer, and is used as the Central Receiving Point for new car delivery. The port area also contains a ferry terminal for commuter boats to Boston and Hull that is run by Harbor Express for the Massachusetts Bay Transportation Authority (MBTA). The yard also is used by Jay Cashman, Inc., for heavy construction and marine equipment services, the Massachusetts Water Resources Authority, as a sewage sludge heat-drying and pelletizing facility, and by the Fore River Transportation Corporation for short line freight rail service to CSXT South Braintree (discussion with Daniel Quirk).

The site currently features rail and roadway access, a 41,800 m^2 (450,000 square foot) open floor building, a 9,290 m^2 (100,000 square foot) open floor building, and additional buildings for a total of 55,740 m^2 (600,000 square feet). The site also includes a 11,150 m^2 (120,000 square foot) Wet Basin with a current 6.1 m (20 foot) draft that can be dredged to deeper than 9.1 m (approximately 30 feet).

Shipyard Profile

The Shipyard is located in a well protected area with adequate draft to accept “Panamax” class vessels. The entrance to the Shipyard is narrow, restricted by the Fore River Bridge, which currently has a 53.3 m (175 foot) vertical clearance and a 53.3 m (175 foot) horizontal

clearance. This bridge is a temporary lift bridge and plans are not yet finalized as to whether the replacement bridge will be a lift style or bascule style drawbridge. North and East of the bridge, the approach channel ranges from 41 to 183 m (136 feet to 600 feet) wide and is approximately 9.75 m (32 feet) deep. South of the bridge, the channel opens to 122 m (400 feet) wide. Channel depth is 9.75 m (32 feet). Tidal range is around 3 to 3.1 m (9.8 to 10.2 feet).

Advantages

The port is well sheltered and has significant support mechanisms in place for commercial vessel activity. There are numerous roadway connections and an active railroad line.

Disadvantages

The entrance to the Shipyard is laterally and vertically constrained by the Fore River Bridge. Additionally, the site is currently undergoing an initial planning process to determine new potential uses for the site, including marine-related, residential, retail, office, and entertainment. Currently, the site is serving as the Central Receiving Point for new car delivery to local Quirk car dealerships. Much of the infrastructure is significantly aged.

Potential

New bridge design for the Fore River Bridge is yet to be finalized. Additionally, improvements could include the following:

- Improvement of roadway connections to main highways that avoid the inner city roadways;
- Creation of a better connection to the national rail network; and
- Facilities to support secondary functions associated with offshore wind deployments.

5.1.5 Fall River, Massachusetts

Background

The Port of Fall River is located at the mouth of the Taunton River at the head of Mount Hope Bay, at the northeast side of Narragansett Bay, near the Massachusetts-Rhode Island border. The port is approximately 18 nm from the south entrance of Narragansett Bay, which flows into Rhode Island Sound, 17 nm west of the Cape Cod Canal and approximately 90 nm south of Boston. It is geographically located about 74 kilometers (km) (46 miles) south of Boston, 26 km (16 miles) southeast of Providence, RI and 19 km (12 miles) west of New Bedford. The port is historically known for its manufacturing and distribution and has developed an active break-bulk trade. Cargo operations have included handling mostly break-bulk cargoes such as bananas, wallboard, heavy equipment, automobiles, wood pulp, chemicals, newspaper and seafood. See Appendix E for the extent of the Mount Hope Bay (Fall River and Somerset) DPA.

The Port encompasses the waterfronts of Fall River and Tiverton, Rhode Island on the east side of the Taunton River and the waterfront of Somerset, MA on the west side of the river. The port has good highway access and is served by U.S. Route 6, Routes 24, 79 and 138 and Interstate 195 that connects to Providence, RI with Cape Cod. There are rail freight activities through CSX connecting to several industrial sites in Fall River. In addition to freight activities, there are

several cruise ship visits each year and a number of recreational vessels activities supported by marina facilities at several locations.

Fall River is also an active niche port serving several international markets. The area is ringed with liquid bulk terminals and has the potential for expanded industrial activities at the State Pier. The State Pier has available storage and land area for operations but is used for both industrial and tourism based activities. One way of enhancing Fall River's ability to handle more marine industrial operations is to remove tourism-based activities from the State Pier. The port has good highway access and a rail corridor that requires additional infrastructure improvements.

Facilities

The port has a number of active private facilities and one principal public facility (see Figure 5-8). The Borden and Remington Corporation Wharf is 116 m (380 feet) long with a water depth of 8.5 m (28 feet) alongside. The pier is currently used for handling of latex and caustic soda, is owned by the Tillotson Co., and is operated by the Borden and Remington Corp.

The primary marine facility for the City of Fall River is the State Pier and is located on the site of the former Fall River Line Pier, which was a major steamship operator in New England. The State-owned general marine terminal provides two deep-water berths, a 120 m (398 foot) berth with a depth of 4.5 to 10.7 m (15 to 35 feet) alongside, and a 189 m (620 foot) berth with a 10.7 m (35 foot) water depth alongside. There is also a 7,900 m^2 (85,000 sf) terminal and roll-on/roll-off facility, as well as 2.8 hectares (7 acres) of open storage yards. The terminal is equipped with an approximately 24 m (80 foot) roll-on/roll-off ramp and a 45 mt (50 ton) truck scale. There are three rail spurs, which provide direct on-dock rail connections, but only one is currently operable. The State Pier handles break-bulk and containers. This cargo comes primarily from the Cape Verde Islands, and vehicles and equipment from Angola. The port also handles frozen fish, totaling approximately 680 mt (750 tons) per year, from a fish processing vessel as well as petroleum products at several private terminals. The State Pier represents the best alternative for ROWEI staging.

Just north of the State Pier is the *USS MASSACHUSETTS* Battleship Memorial where a number of former naval vessels are berthed. The Memorial is an active museum that is open to the public and cannot be utilized for marine industrial activities. Two miles above the State Pier is the former Shell Oil Company Wharf that has a 213 m (700 foot) berth with a 9.1 m (30 foot) water depth alongside. Shell Oil discontinued the petroleum products operations in the 1990s, and it is now owned by Fall River Marine, LLC. This site, which is the proposed location of the Weaver's Cove LNG Terminal, could be adaptable for ROWEI staging if it is abandoned by Weaver's Cove. The Mt. Hope, Braga and Brightman Street bridges would impose navigational restrictions. The Mt. Hope and Braga bridges each have a 41.1 m (135-foot) vertical clearance and a 121.9 m (400-foot) horizontal clearance. The Old Brightman Street Bridge has a 29.9 m (98-foot) horizontal clearance but no vertical restriction, and the New Brightman Street Bridge has a 18.3 m (60-foot) vertical and 61 m (200-foot) horizontal clearance.

On the west side of the Taunton River is the Brayton Point Station Dock which has a 310 m (1,017 foot) berth with a 10.6 m (34 foot) water depth alongside. The facility is designed to handle fuel oil and coal and is owned by New England Power Company. Montaup Electric

Company owns and operates a wharf with a 197 m (645 foot) berth and an alongside depth of 10.6 m (34 feet). The facility is designed for handling fuel oil and coal.

The rail line that serves New Bedford also serves Fall River and extends to the State Pier facility in the harbor. Wind turbine components could be delivered to Fall River via road or rail as long as they do not exceed dimension and weight limitations.

Harbor Profile

The main access to the Port of Fall River is from the shipping lanes of the Atlantic Ocean, into Narragansett Bay, through Mount Hope Bay, and down the Taunton River. The harbor is a medium deep-water harbor with a 10.7 m (35 foot) deep federal channel through Mount Hope Bay to about 0.9 nm (approximately 1 mile) above the Brightman Street Bridge (See Figure 5-8). There are additional deep dredged channels near the north Tiverton waterfront with between 6.1 and 10.1 m (20 and 33 feet) of water depth. The harbor has no designated anchorages.

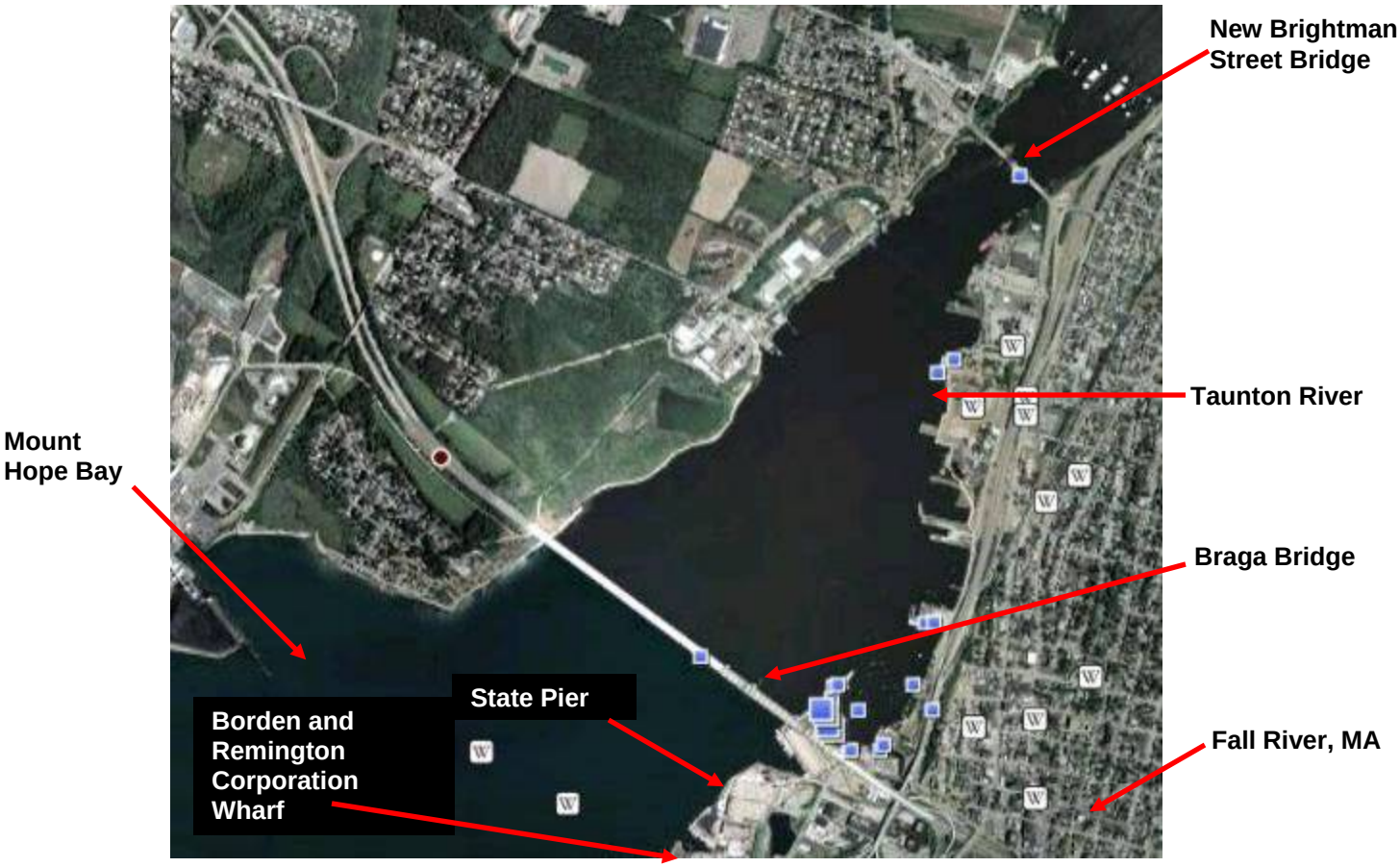


Figure 5-8 Aerial View of Fall River Harbor
(Source: Google Earth, Fall River, MA, 2010)

There are two bridges which cross the Taunton River. They include a fixed bridge at the State Pier with an air draft clearance of approximately 41 m (135 feet). The second bridge is a bascule style bridge with a 18.3 m (60 foot) clearance about 1.1 nm (approximately 1.3 miles)

the bascule style New Brightman Street Bridge with a 18.3 m (60 foot) clearance about 1.1 nm (approximately 1.3 miles) above the fixed bridge. There are additional bridges upstream on the Taunton River but outside of the deepwater port.

Tidal currents are generally not a problem for navigation. The mean range of the tide is around 1.4 m (4.5 feet). Pilotage is compulsory for foreign and U.S. vessels under register of 356 mt (392 tons) or more. Pilotage is provided by Northeast Marine Pilots. The Port has U.S. Customs port of entry capability through New Bedford. Tug services are available in the port from Providence, RI. There are some repair services but no dry-docking capability. There are two small shipyards in the port on the west side of the harbor that provide skilled workforce capability for wind projects.

Advantages

The port is well protected and has support mechanisms in place for commercial vessel activity, including ROWEI assembly and staging. There is cargo storage and handling capacity that can be utilized for fabrication, and the area is supported by good road and reasonable rail access. The port has a roll-on/roll-off facility at the State Pier, which can be used for handling wheel-based industrial components. There is also capacity at some of the private terminals for new industrial development. Water depth is not a significant constraint for Fall River, as dredged channels have water depth in excess of 9.1 m (30 feet). The lateral clearance at the Braga and Mt. Hope Bridges is 122 m (400 feet).

Disadvantages

Vertical clearance is the most significant navigational constraint for the Port of Fall River with respect to deployment configurations for offshore wind turbines and assemblies. The Braga Bridge and Mt. Hope Bridge each impose a height restriction of approximately 41 m (135 feet). This restriction makes navigation marginal for jack-up vessels and limits turbine load-outs in the star configuration. Vessel draft is limited to a 10.7 m (35 foot) overall depth that restricts large vessel access. The State Pier can only handle small cargo ships. The warehouse space at the terminal is unheated and provides only temporary storage, but does provide weather protection for project assembly. Most of the critical infrastructure in the port is aging and in need of repairs and improvements.

The port's commercial and industrial expansion is also hindered by gentrification and a focus on tourism-based activities on the Fall River waterfront. There have been a number of proposals for expanded industrial development, including a proposal for developing an LNG import facility that has been met with significant local opposition.

Potential

There are several main areas for industrial growth well suited to ROWEI staging. Its proximity to the major shipping route near the Cape Cod Canal places the Port of Fall River in a position to facilitate ROWEI staging using smaller ships and barges.

One of the most significant opportunities is the stalled construction of a LNG facility in the port. If not completed, this could potentially provide a parcel of available land for ROWEI staging. However, the Mt. Hope, Braga, and New Brightman Street Bridges, all seaward of the LNG

terminal, have vertical and horizontal clearance restrictions that could preclude certain turbine import and installation vessels and load-out configurations.

Required Improvements

The State Pier requires additional investment to bring it up to industry standards for expanded cargo handling, and there are several other facilities that require infrastructure improvements, including bulkheads, piers and wharves. The site needs to be expanded, and there is an unused salt storage area near the State Pier that could be annexed to create increased capacity. The rail line needs to be restored in some areas and the trackage improved to accommodate increased cargo shipments. An estimated $15 million is required for State Pier improvements (MARPRO Associates International 2009).

5.1.6 New Bedford, Massachusetts

Background

The Port of New Bedford is located on the northwestern side of Buzzard's Bay and is approximately 83 miles south of Boston. The port, encompassing the City of New Bedford and the Town of Fairhaven (see Figure 5-9), is historically known for its fishing industry connections but has developed a significant break-bulk trade. The harbor, considered to be small geographically, is located at the mouth of the Acushnet River, and has direct access into Buzzards Bay, Vineyard Sound and the Atlantic Ocean. The harbor entrance is approximately 10 nm from the beginning of the south entrance of the Cape Cod Canal. See Appendix E for the extent of the New Bedford - Fairhaven DPA.

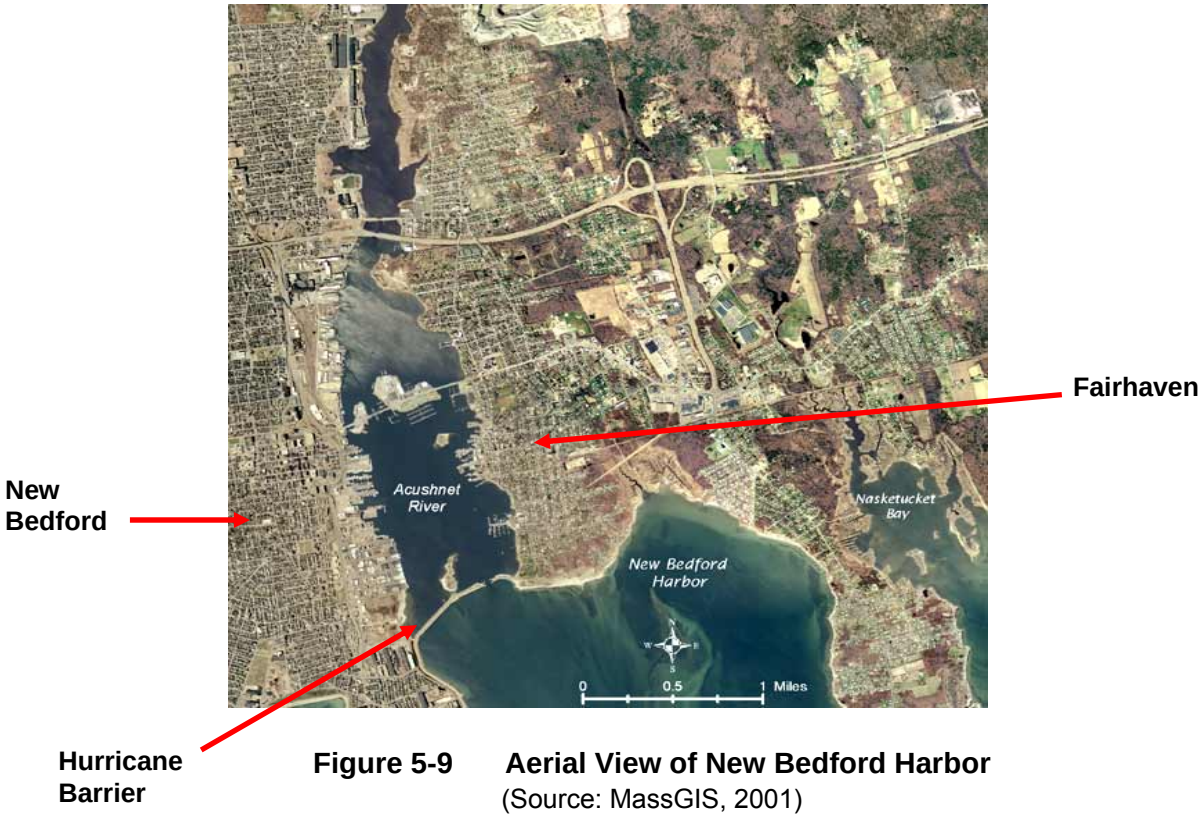


Figure 5-9 Aerial View of New Bedford Harbor
(Source: MassGIS, 2001)

The Port of New Bedford is a deepwater port and is one of the nation's major fishing ports. The fishing fleet includes more than 500 vessels operating out of the port. The Port of New Bedford also supports a diverse market of cargo transport. Barge operations move aggregate and break-bulk cargo to the Islands of Martha's Vineyard and Nantucket. Shipments of break-bulk cargo consisting primarily of house goods are exported to Cape Verde and Angola. The Port of New Bedford has the largest throughput tonnage of break-bulk perishable commodities in New England.

The port hosts reefer (refrigerated) vessels that handle fresh fruit and fresh and frozen fish. The labor force consists of approximately 30 International Longshoreman's Association personnel for vessel operations and 20 Teamsters for warehouse operations. The port currently handles around 25 freighters per year (MARPRO Associates International 2009).

New Bedford is already an active freight seaport and is a major logistical connection for agricultural products entering the New England market. Highway connections are good, and the port could benefit from expanded and improved rail connections to meet freight needs. New Bedford is a small niche port that can continue to expand activities with some infrastructure improvements and investment. It has sufficient deep water access for the size and type of vessel common to most break-bulk and project cargo and has available property for expansion.

Facilities

The New Bedford waterfront has a number of large and small piers and wharves that are primarily used by the commercial cargo and fishing industry (see Figure 5-10). Most facilities have good highway connections as well as rail connections. Harbor regulations and berthing limits, except berthing for private terminals, are enforced by the Harbor Development Commission (HDC) and the Port Maritime Security Unit.

New Bedford South Terminal Wharf has a 488 m (approximately 1,600 foot) berth with 9.1 m (30 feet) of water depth and serves as the major off-loading center for fish product. The wharf has 7,080 m^3 (250,000 cubic feet) of refrigerated storage on site and handles primarily seafood. The southernmost portion of the facility has the potential to build out a 122 m (400 foot) solid fill bulkhead. The site currently has 4.0 hectares (approximately 10 acres) of backland.

Sprague Terminal just North of South Terminal has a 225 m (740 foot) berth with an 8.2 m (27 foot) water depth alongside. The pier primarily handles petroleum products, but was originally part of the operations of a defunct electric power plant (the building is still standing on site.)

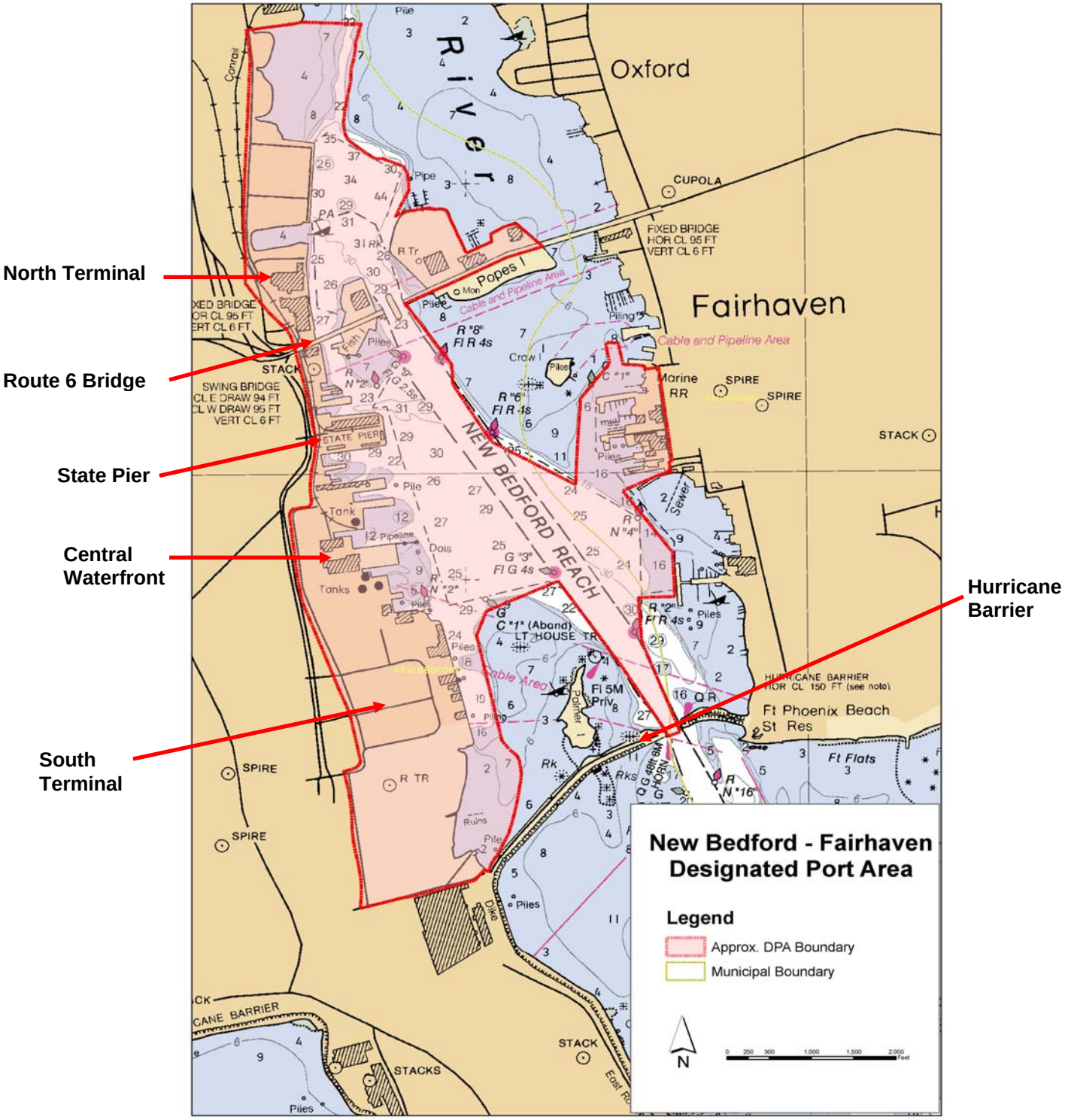


Figure 5-10 Navagational Map of New Bedford Harbor

The State Pier Terminal at the center of the Inner Harbor has three berths measuring 137 m (450 feet), 183 m (600 feet), and 236 m (775 feet) with a 9.1 m (30 foot) water depth alongside. There are 11,610 m^2 (125,000 square feet) of covered storage for general cargo. The facility can support freighter service and store over 135 containers. American Cruise Lines operates out of the facility with a minimum of 20 ports of call on an annual basis and up to 89 passengers per trip. Ferry services also operate out of the State Pier, including passenger and cargo service to Cuttyhunk Island and passenger service to Martha's Vineyard. Ferry service brings over 115,000 passengers through the port annually. The Quick Start Ferry facility on the State Pier allows intermodal transfers of waterborne freight and freight carried by truck and rail. This terminal features an 8.2 m (27 foot) pier depth, roll on/roll off capability, offsite cold storage, and easy access to the interstate highway system. The ramp is approximately 30.5 m (100 feet) long and 5.5 m (18 feet) wide and will hold up to 182 mt (approximately 200 tons). The State Pier requires a significant amount of investment to bring it up to industry standards for cargo handling (see Section 7).

Above the Route 6 Bridge are the Maritime Terminal, Bridge Terminal and North Terminal. The Maritime Terminal Wharf, operated by Maritime Terminal International, has a 183 m (600 foot) berth with a 9.5 m (31 foot) water depth alongside. The facility has 84,960 m^3 (3 million cubic feet) of refrigerated storage and is one of the largest U.S. Department of Agriculture-approved cold treatment centers on the East Coast for use with controlled imported agricultural products. The terminal receives approximately 25 vessels a year, each carrying between 1,362 and 3,630 mt (1,500 and 4,000 tons) of fish or, approximately 1,816 to 2,723 mt (2,000 to 3,000 tons) of fruit.

The Bridge Terminal Wharf, on the northeast side of the harbor, is 137 m (450 feet) long with a 8.5 m (28 foot) water depth alongside. The wharf has a 14,160 m^3 (500,000 cubic foot) refrigerator warehouse and handles frozen and chilled food products. The facility is owned and operated by Bridge Terminal Inc.

American Pride Seafood is a private facility operating out of the North Terminal and one of the world's leading seafood product processors. The bulkhead supporting this operation is 177 m (580 feet) long with a 7.6 m (25 foot) water depth alongside. The facility has 5,890 m^2 (63,400 square feet) of refrigerated warehouse space, 5,342 m^2 (57,500 square feet) of freezer space and 3,224 m^2 (34,700 square feet) of covered warehouse space.

Within the New Bedford North Terminal Wharf are commercial properties managed by the HDC. These properties cover 10.1 hectares (approximately 25 acres) of land. Tenants include the seafood processors Eastern Fisheries and Seawatch International, barge operators, ship repair facilities, and other maritime service businesses. A 0.8 hectares (2 acre) terminal site is proposed to come on-line over the next 5 years. This facility is currently operated by the EPA as part of the superfund clean-up will revert back to the City of New Bedford in the next few years. The facility has rail connections that lead directly to the water's edge.

The port is considered a full service port with associated maritime industries include vessel maintenance and repair conducted at dockside or at repair facilities in New Bedford or in Fairhaven. The port has two moderate size shipyards, and equipment and provisions to support commercial and recreational vessels.

New Bedford is served by a rail line operated by CSX. Roadway bridge constraints prohibit doublestack (Gen2) access to the port. However, this is not a problem limited to New Bedford. An application has been submitted for TIGER Grant money to extend the rail line to the State Pier, but further extension to the proposed South Terminal Development site is unrealistic. The port has handled overweight and oversized project cargo in the range of 45.4 mt (approximately 50 tons) out of the northern part of the harbor. Wind farm components could be moved by road into New Bedford as long as the loaded units do not exceed permit requirements for oversized loads, including weight and overall dimensions. The highway system accessing New Bedford conforms to federal standards that allow a minimum vertical clearance under overhead structures of 4.88 m (16 feet) in rural areas and 4.27 m (14 feet) in urban areas. Routes into New Bedford include US I-195 and Route 18 which connects the west and south port areas to the main highways system.

The Port of New Bedford is considered a moderately deep-water port with overall depths of 9.1 m (30 feet). The harbor is protected by a hurricane barrier (see Figures 5-9 and 5-10) that is constructed across the harbor entrance and is equipped with an opening that can be closed during hurricane conditions and severe coastal storms. The port is considered a harbor of refuge for vessels in the region.

The harbor approach is characterized by a number of ledges and shoals. The approach channel allows for safe navigation and avoids most of the obstructions. The hurricane barrier entrance is 45.7 m (approximately 150 feet) wide and opens up to a 107 m (350 foot) wide channel, at a depth of 9.1 m (30 feet), extending to a turning basin approximately 305 m (1,000 feet) above the New Bedford-Fairhaven Bridge. The range of the tide is 1.1 to 1.2 m (3.5 to 4.0 feet), and harbor currents are overall considered weak. Maximum ebb and flood tide currents are under an average of 2.5 knots.

There are vessel limitations due to the hurricane barrier and the Route 6 highway bridge in the Inner Harbor (see Figure 5-10). The hurricane barrier opening width is 45.7 m (approximately 150 feet) and the Route 6 New Bedford–Fairhaven Bridge is 28.0 m (approximately 92 feet) wide. All vessel transit to and from northern portion of the harbor (upstream of the Route 6 Bridge) is subject to daylight only restrictions for vessels with overall length above 121 m (400 feet) and/or beam above 18 m (59 feet) and to wind velocity restrictions

Advantages

The port is well protected by the hurricane barrier and has support mechanisms in place for commercial and industrial vessel activity, including ROWEI staging. The port is has good road and rail access, and adaptable warehouse capacity is significant. The port has several opportunities for expansion to accommodate ROWEI assembly.

The harbor is challenged by a significant pollution problem due to local industries which up until the 1970s discharged wastes containing polychlorinated biphenyls (PCBs) and toxic metals into New Bedford Harbor. There are high levels of contamination throughout the waters and sediments of the harbor that extend into Buzzards Bay. This contamination led to New Bedford Harbor being designated as a Superfund Site. Since 2004 the EPA has been dredging to remove the PCBs in contaminated sediments. The EPA is expected to explore new technologies (confined aquatic disposal) that will reduce the demand for land-side facilities. This

could accelerate the process of bringing the terminal facility under City control and opening other waterfront parcels up for development.

As a result of the contamination, no maintenance dredging has occurred for over 50 years. The port faced the loss of waterfront business unless maintenance dredging could be implemented. In 2005, the first navigational maintenance dredging was conducted restoring portions of the harbor to useable depths. This has allowed business to increase and larger commercial vessels to return to the harbor.

The navigational draft within the Port of New Bedford is sufficient for turbine installation and import vessels. As turbine components are relatively lightweight for their size, import vessels are space-limited, rather than weight-limited. As such, they would be able to enter New Bedford Harbor with a draft of less than 9.1 m (30 feet). No overhead clearance constraints were identified in the approaches to the Port of New Bedford.

Disadvantages

While advantageous to port safety, the hurricane barrier however is a significant navigational constraint for the southern section (i.e., seaward of the swing bridge) of the Port of New Bedford (see Figure 5-10). The lateral (horizontal) clearance is 45.7 m (150 feet), which restricts turbine load-outs in the fore-aft bunny ear configuration. The Route 6 New Bedford–Fairhaven Bridge has a lateral clearance of 28 m (92 feet), which makes turbine transport above (i.e., upstream of) the swing bridge marginal. The Route 6 Bridge not only imposes lateral constraints for vessels transiting to and from the northern section of the harbor but also is outmoded and causes delays in travel time. The turning basin can only handle small cargo ships.

Potential

There are several port areas adaptable for marine terminal expansion capable of supporting ROWEI staging. The State Pier requires a significant amount of investment to bring it up to industry standards for cargo handling. However, there are several other facilities, including the South Terminal that could accommodate ROWEI staging with infrastructure improvements. The rail corridor needs to be extended and trackage improved to accommodate increased and oversized shipments. Commuter rail improvements are being planned, and the engineering of the commuter rail should include upgrades for freight transport. Development and of staging areas for trucks is also critical for increased activity in the port.

The South Terminal is convenient to the mouth of the harbor. Expansion of, and repairs to, the South Terminal would create a multi-use manufacturing and shipping facilitate suitable for ROWEI staging. Dredging along the bulkhead, improvements to the pier structure, and an extension of the existing bulkhead would allow for larger deeper-draft vessel berthing and expanded use of the South Terminal facility.

The North Terminal can be improved for handling of ROWEI fabrication and staging. Terminal facilities should be equipped with a versatile mobile harbor crane and ground support equipment. This equipment can be used for both cargo handling and wind farm components. Additional dredging to provide better access to all deepwater berths could be completed, and the turning basin could be lengthened to accommodate longer, higher tonnage cargo vessels. Improvements to the Route 6 Bridge are critical to the passage of vessels to North Terminal and maximizing vessel access.

5.2 Profiles of East Coast Ports Outside of Massachusetts

The other East Coast ports that were evaluated in this study are described briefly below.

5.2.1 Portland, Maine

Portland Harbor, at the western end of Casco Bay, is the most important port on the coast of Maine (see Figure 5-11). The ice-free harbor offers secure anchorage to deep draft vessels in all weather. The harbor is home to significant domestic and foreign commerce in petroleum products, paper, wood pulp, scrap metal, coal, salt and containerized goods. It is also the Atlantic terminus pipeline for shipments of crude oil to Montreal and Ontario. In 1998, Portland became the largest port in the Northeast based on throughput tonnages.

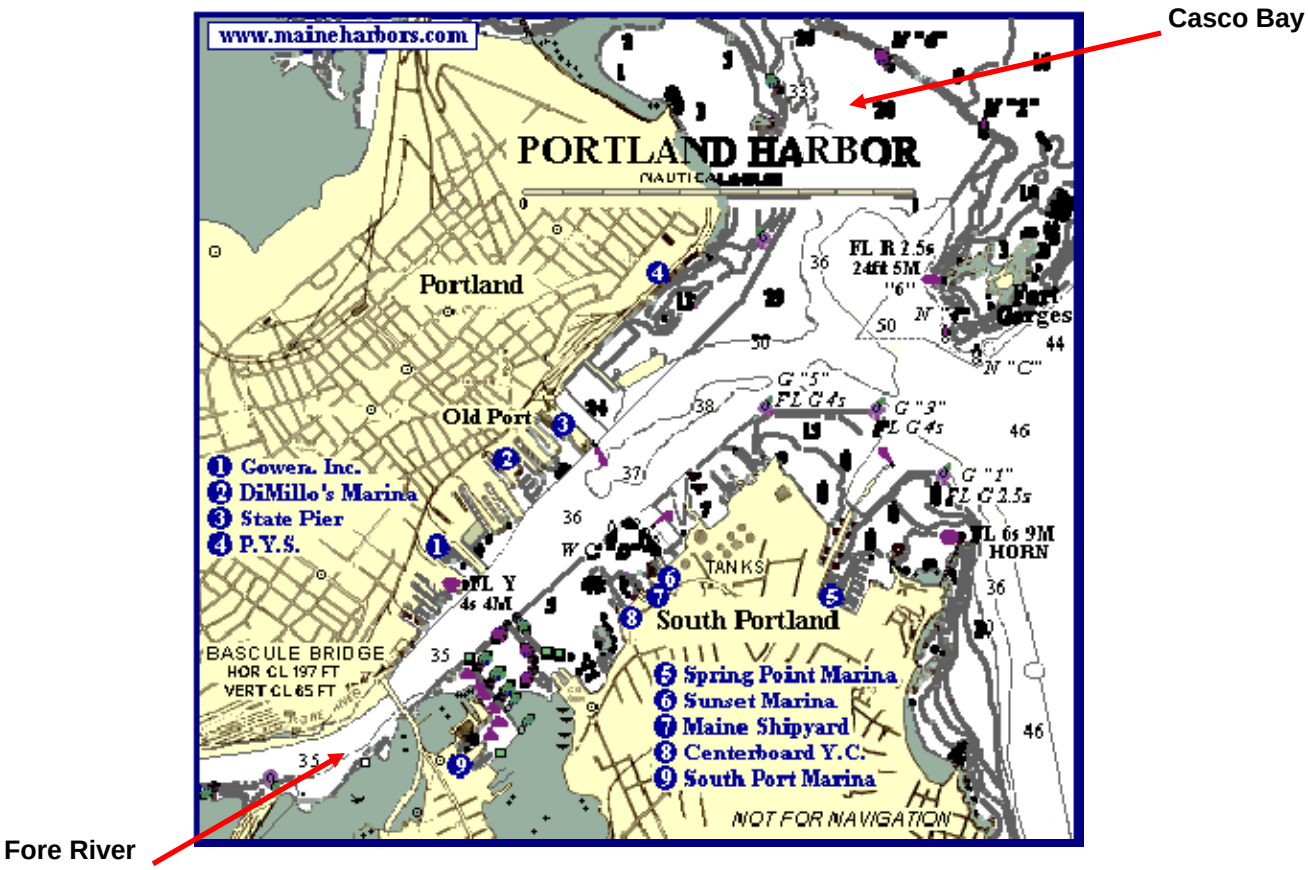


Figure 5-11 Portland Harbor and Shoreline Areas
(Source: www.maineharbors.com)

Portland is served by Pan Am Railways and the St. Lawrence and Atlantic Railroad, connecting the Port to a national network that also reaches into Canada. Passenger and freight ferries serve the nearby islands. Three scheduled airlines operate from the airport, and charter and air taxi service is available. Numerous truck lines serve the greater Portland area with interstate and intrastate service.

Although Portland is equipped to handle above-water hull and engine repairs of deep-draft vessels, major repairs to large vessels are typically made in Boston or, to a lesser extent, in

Bath. Deepwater facilities at Portland include seven petroleum terminals, one general cargo terminal, and one international ferry terminal. All have highway connections and most have railroad connections.

The channel from the sea to Fort Gorges has a depth of 13.7 m (45 feet), continuing at 10.7 m (35 feet) in the Inner Harbor and Fore River to a turning basin seaward of the railroad/highway bridge. The harbor includes two well-protected deepwater anchorages. Casco Bay Bridge, approximately 1.3 nm (approximately 1.5 miles) above the entrance to the Fore River, has a bascule span with a clearance of approximately 16.7 m (55 feet).

5.2.2 Portsmouth, New Hampshire

Portsmouth Harbor, located approximately 3 nm inland of the mouth of the Piscataqua River, is the only harbor of refuge for deep-draft vessels between Portland, ME and Gloucester, MA (see Figure 5-12). The harbor has sufficient depth to accommodate large deep-draft ships and is open throughout the year. The north side of the river, on Seavey Island in Kittery, ME, is occupied by the U.S. Navy and the Portsmouth Naval Shipyard. Foreign trade includes petroleum products, gypsum, frozen fish, fish products, and salt. Oil shipments in tankers drawing as much as 10.7 m (35 feet) arrive frequently in the fall, winter, and spring. The Division of Ports and Harbors of the Pease Development Aurhority oversees the maintenance, development and use of the port.

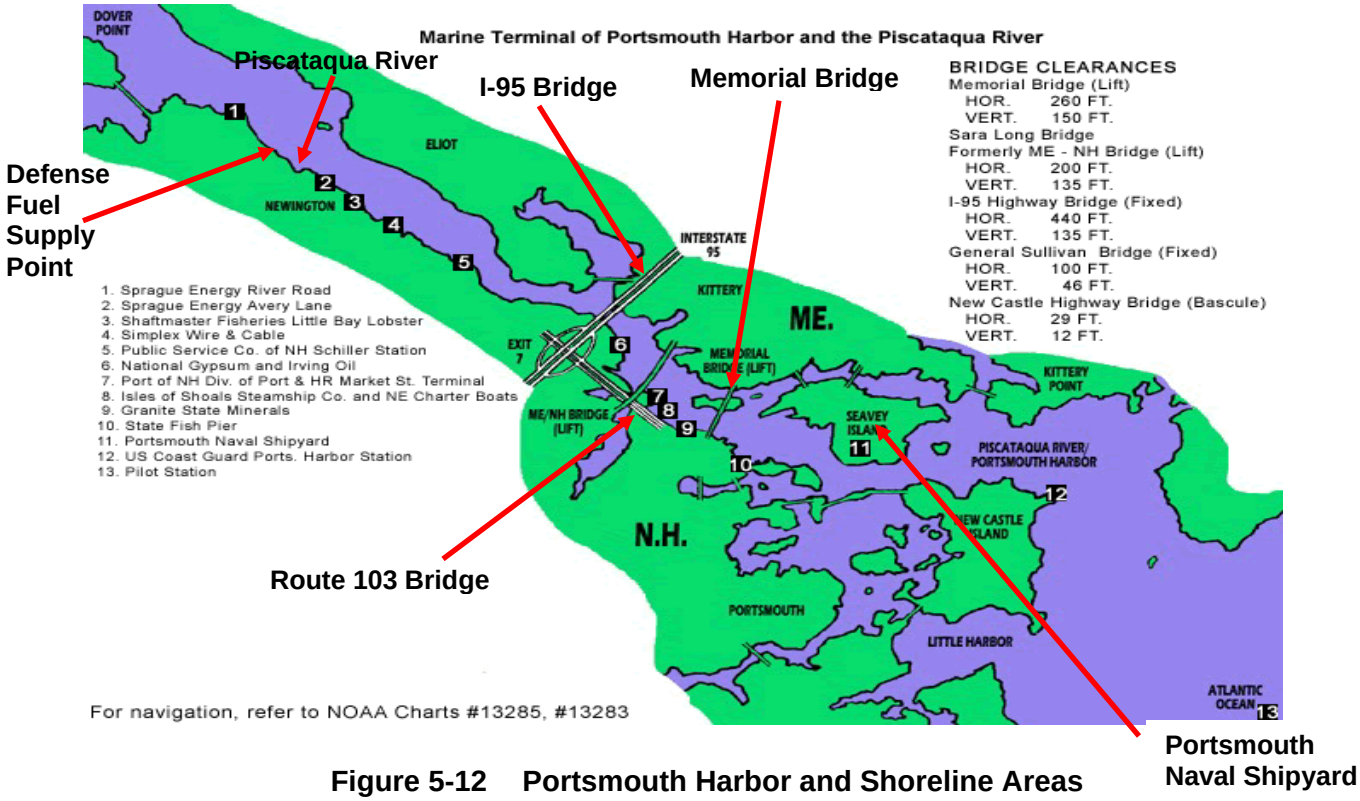


Figure 5-12 Portsmouth Harbor and Shoreline Areas

The port is served by a freight branch of the Boston and Maine Railroad, local and interstate highways, and is located within a mile of the International Airport on the Pease International Trade Port (formerly the Pease Air Force Base). There are no facilities for dry-docking deep-draft vessels in Portsmouth Harbor (the nearest for large vessels is Boston). However, local machine shops can make minor repairs to machinery, and several boatyards are capable of hauling out boats up to approximately 26 m (85 feet) in length.

All active commercial deep-draft facilities are located on the south bank of the Piscataqua River between the first bridge, Memorial Highway Bridge, and Dover Point and have highway connections, and all except the Defense Fuel Support Point Newington Dock have rail connections. Deepwater facilities at Portsmouth include seven petroleum terminals and 3 general cargo terminals.

Depths of about 10.3 m (34 feet) are present in the marked channel through Portsmouth Harbor to the Memorial (U.S. Route 1) Highway Bridge. From this bridge, a dredged marked channel with a depth of 7.9 m (26 feet) leads for about 3.0 nm (3.5 miles) to a turning basin about 0.35 nm (0.4 mile) above Frankfurt Island in the Piscataqua River. The controlling depth in the turning basin is 10.7 m (35 feet).

The principal bridges in Portsmouth Harbor are Memorial (U.S. Route 1) Highway Bridge, which has a lift span with clearances of 5.8 m (19 feet) down and 45.7 m (150 feet) up, and the combined U.S. Route 1 Bypass highway and Boston and Maine railroad bridge, which also has a lift span with clearances of 3 m (10 feet) down and 41 m (135 feet) up.

5.2.3 Providence, Rhode Island

Providence is located at the head of navigation on the Providence River, approximately 6 nm (7 miles) above the junction of the Seekonk River, which empties into the head of Narragansett Bay between Nayatt Point and Conimicut Point. The port's chief waterborne commerce includes petroleum products, cement, lumber, steel scrap metal, general cargo, and automobiles. Providence is served by rail, highway, and air.

The piers and wharves of the Port of Providence are located along both sides of the Providence River below Fox Point. Deepwater facilities at Providence include six petroleum terminals, one LNG terminal, and six general cargo terminals. The alongside water depths range from 8.5 to 12.2 m (28 to 40 feet) with berth lengths ranging from 152 to 396 m (approximately 500 feet to 1,300 feet). All the facilities described have highway connections, and most have rail connections.

The port contains 42.5 hectares (105 acres) of on-dock rail, open storage areas and covered warehouses, and is a fully licensed, bonded deep water port specializing in dry, liquid bulk, and break-bulk commodities (see Figure 5-13). Among the principal products moving through the port are chemicals, heavy machinery, lumber, coal, scrap metal and steel products. The Providence and Worcester Railroad's on-dock rail facilities allow direct vessel to rail transfer, indoor rail for warehouse loading, and a rail line alongside 8.1 hectares (20 acres) of open lay down area. The Providence and Worcester rail line connects to all major rail carriers offering service from the Providence area to anywhere in the contiguous U.S. and Canada.

Figure 5-13 Port of Providence
(Source: http://www.provport.com)

The East Passage, the principal passage in Narragansett Bay, has a depth of about 18.3 m (60 feet) for approximately 9.6 nm (11 miles) up the marked channel to the entrance of the dredged channel to Providence. The Newport Bridge, a fixed highway suspension bridge, crosses East Passage about 3.1 nm (3.6 miles) above the entrance. Vertical clearance through the 457 m (1,500 foot) wide center span is 64.9 m (213 feet) at the center, with lower clearances towards the outside of the center span.

The Providence River has a 12.2 m (40 foot) deep channel from just below Prudence Island Light to Fox Point near the junction of Providence and Seekonk Rivers. A hurricane barrier crosses the Providence River about 183 m (600 feet) above Fox Point. The hurricane barrier has a group of three large movable gates that span the Providence River. Each of the three gates is 12 m (40 feet) wide. The narrow gates prohibit large ships from passing into the inner downtown harbor. However, modern ocean-going vessels now dock at the Port of Providence, located south of the barrier (Schachterle et al 2010). There are no bridges over Providence River between the mouth and the principal wharves.

5.2.4 Quonset Point / Davisville, Rhode Island

Situated between New York and Boston and at the entrance of Narragansett Bay, the Port of Davisville in Rhode Island provides one of the best deep water ocean ports on the east coast. Major cargo arriving at the port includes automobiles, quarried stone, and general cargo. The port has three major piers with over 2,073 m (approximately 6,800 linear feet) of deep water dockage and onsite rail tracks. The Port of Davisville is operated by the Rhode Island Economic Development Corporation (see Figure 5-14).

Figure 5-14 Quonset Business Park
(Source: RI Department of Environmental Management)

Quonset Point is located on the north side of Wickford Harbor, with Quonset Point Business Park located near the eastern end of the point. The site of two former U.S. Naval installations, Quonset Business Park comprises over 1,214.1 hectares (3,000 acres) of land. This land is currently administered by the Quonset Development Corporation (QDC), a subsidiary of the Rhode Island Economic Development Corporation. Land uses within the Park currently consist of mixture of industrial (light, heavy, and waterfront), office uses and public amenities, in addition to the Port of Davisville. The Port of Davisville offers 1,371.6 m (4,500 feet) of berthing space, consisting of two Piers (each 365.8 m [1,200 feet] in length), a bulkhead, 8.8 m (29-foot) channel draft, on-dock rail and a 5.7 hectare (14 acre) lay down area (Quonset Development Corporation website). Currently under construction at the Business Park is a mixed-use project with hotel, retail, restaurant, and office space. The piers at Quonset Point and Davisville are usually approached from East Passage and through a buoyed dredged channel with a depth of 10 m (33 feet) to a turning basin with depths between 9.75 and 10.7 m (32 and 35 feet), from which a channel leads to the piers at Davisville.

Rail service, provided daily by the Providence & Worcester (P&W) Railroad, consists of approximately 14 miles of track in two branches. The P&W rail network allows access to the entire United States and Canadian rail system. The railroad offers double-stack intermodal transportation services and provides a custom-house broker, shipping agent and forwards foreign freight for its customers. Interstate Routes 95, 195 and 295 allow access to regional and national markets. Direct trucking service is available to every state, Mexico, and most of the Canadian Provinces.

5.2.5 New Haven, Connecticut

New Haven Harbor, an important harbor of refuge, is located about 59 nm (68 miles) from New York, 155 nm (179 miles) from Boston via the Cape Cod Canal, and 149 nm (171 miles) from the Nantucket Shoals Lighted Whistle Buoy N (LNB). It is the largest deep water port in Connecticut and comprises all the tidewater northward of breakwaters constructed across the mouth of the bay, including the navigable portions of the West, Mill, and Quinnipiac Rivers. The inner harbor, northward of Sandy Point and Fort Hale, is shallow for the most part, except where the depths have been increased by dredging. Waterborne commerce in the harbor consists of petroleum products, scrap metal, lumber, automobiles, gypsum, paper and pulp products, steel products, chemicals, rock salt, and general cargo.

The main channel has a depth of 10.7 m (35 feet) and a width of 122 to 244 m (400 to 800 feet) to a point just below the junction of Mill River and Quinnipiac River (see Figure 5-15). This channel depth is sufficient for accommodating ships in the range of 18,156 to 36,312 mt (approximately 20,000 to 40,000 deadweight tons). Tomlinson Bridge, at the head of the main harbor at the confluence of Mill and Quinnipiac Rivers, is a vertical lift span with a horizontal clearance of 73.1 m (240 feet) and a vertical clearance of 4.0 m (13 feet) down and 18.6 m (61 feet) up. Just above this bridge is a fixed highway bridge with a clearance of 18.3 m (60 feet).

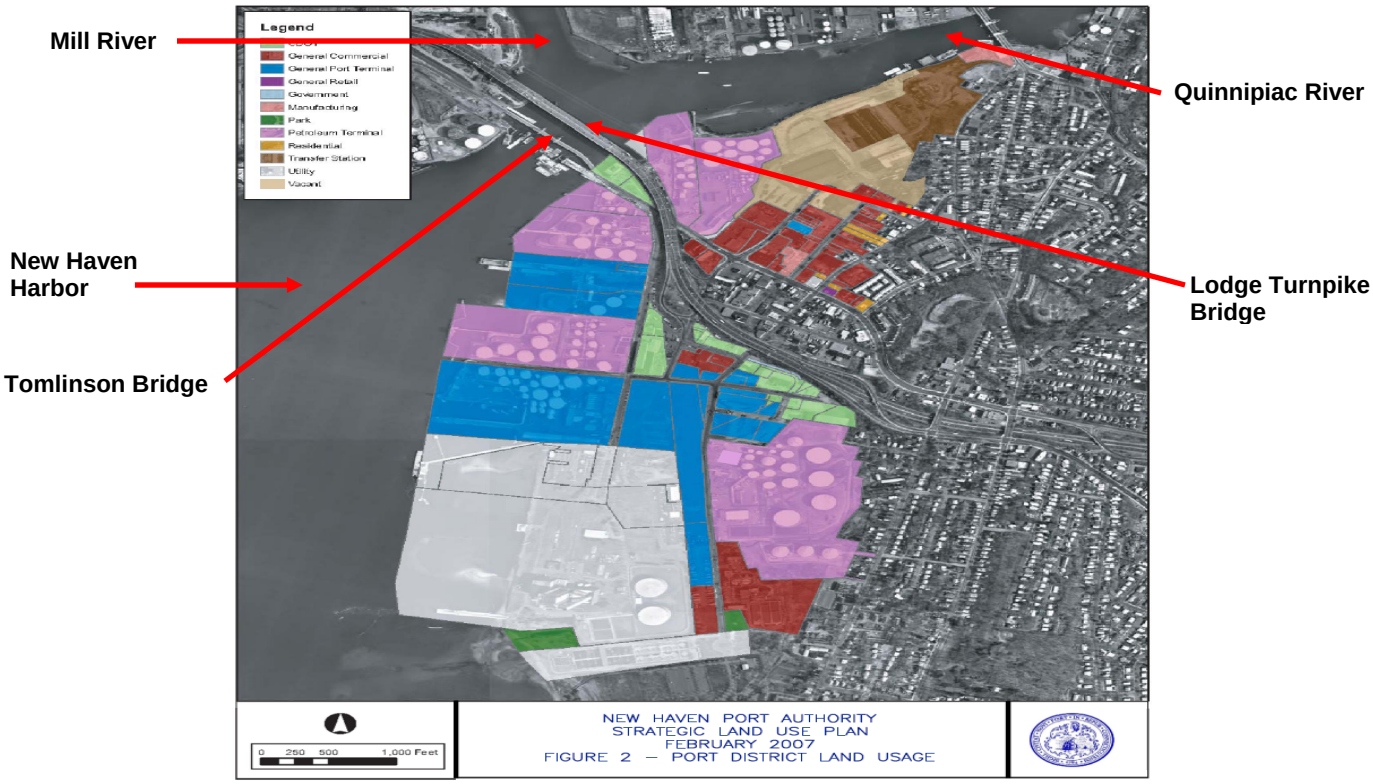


Figure 5-15 Aerial View of New Haven Harbor
(Source: http://www.cityofnewhaven.com/PortAuthority)

The deep draft facilities at the Port of New Haven are along the north and east sides of the inner portion of New Haven Harbor. Facilities for smaller vessels and barges are along the sides of the harbor and in Mill, Quinnipiac, and West Rivers. All deep draft facilities have direct highway connections, and most have railroad connections. The port is proximate to the regional highway network and I-95. Rail service is being restored to the port along with a series of siding tracks proposed for the private terminals. Rail service is provided by the P&W Railroad, and, although not serving the port directly, CSX provides rail freight service in the New Haven area.

New Haven has no facilities for making major repairs or for dry-docking deep draft vessels. However, machine shops in the area can make limited repairs to machinery and boilers and fabricate shafts and other pieces of equipment.

5.2.6 New York and New Jersey

New York Harbor is the principal entrance by water to New York City and the surrounding ports. The harbor is divided by The Narrows into Lower Bay and Upper Bay. The Battery, the southern tip of Manhattan, is at the junction of East River and Hudson River. The main channel from the sea to the deep water terminals in the Hudson River has a depth of 13.7 m (45 feet).

The Verrazano-Narrows Bridge between the Lower Bay and the Port of New York and New Jersey has vertical clearances of between 55.8 and 66.5 m (183 feet and 215 feet). There also are three fixed bridges with vertical clearances ranging from 127 feet to 135 feet.

The Port of New York and New Jersey (see Figure 5-16) has over 1,100 waterfront facilities. Most of these facilities are privately owned and operated, and the rest are owned or operated by either the railroads serving the port, the Port Authority of New York and New Jersey, the City of New York, the States of New York or New Jersey, the Federal Government, or other municipalities. This bi-state port includes terminals in New York City and across New York Harbor in Elizabeth, NJ and Newark, NJ. The port has a major steamship passenger terminal, containership terminals, break-bulk general cargo terminals, and petroleum and other liquid cargo facilities. Most of the waterfront facilities throughout the port have highway and railroad connections. The Port Authority is undertaking a $600 million ExpressRail project to build or expand on-dock and near-dock rail terminals. The Port of New York and New Jersey is served by three trunk line railroads and one short-line railroad, numerous trucking firms engaged in long-haul and short-haul freight service, and several bus companies. Elizabeth, NJ offers the only double-stack intermodal rail access to the port.

Figure 5-16 Terminal Areas at the Port of New York and New Jersey
(Source: http://www.panynj.gov/port)

5.2.7 Philadelphia, Pennsylvania

Philadelphia is one of the chief ports of the United States and is located at the junction of the Delaware and Schuylkill Rivers (see Figure 5-17). Philadelphia's seaport focuses on several areas of international trade, such as the importing of perishable cargoes from South America and high-quality paper products from Scandinavia. Philadelphia has both container and break-bulk terminals, along with good rail and highway connections. It is especially strong as a Northeast departure point for carriers in the Caribbean islands trades, and for inbound fruit shipments (from Latin America) and meats (from Australia). There have been efforts for years to create a bi-state port with the Port of South Jersey across the Delaware River in Camden, NJ.

The main channel from the sea to the Philadelphia Naval Shipyard has a depth of 12.2 m (40 feet), with the other channels through Philadelphia Harbor having varying depths. The Port of Philadelphia is in the process of deepening the main channel to 13.7 m (45 feet). There are four bridges between Delaware Bay and the Port of Philadelphia with vertical clearances ranging from 39 to 57.9 m (128 feet to 190 feet).

Figure 5-17 Port of Philadelphia
(Source: http://aapa.files.cms-plus.com/SeminarPresentations/07_OPSAFIT_Walsh_Jim.pdf)

The Port of Philadelphia is operated by the Philadelphia Regional Port Authority. Philadelphia has more than 45 deep water piers and wharves along its Delaware River waterfront and along the Schuylkill River. Port facilities can be accessed by vessel, rail and highway. The port facilities are serviced by three railroads. Norfolk Southern provides double-stack intermodal service between Philadelphia and major Midwest destinations. Terminal facilities are located in close proximity to interstate highways.

5.2.8 Baltimore, Maryland

The Port of Baltimore is located at the head of tidewater navigation on the Patapsco River. Baltimore Harbor consists of the entire Patapsco River and its tributaries. While part of the waterfront lies outside the municipal limits of Baltimore, by state law the port is within the

jurisdiction of the Maryland Port Administration. When compared to other East Coast ports, Baltimore has a logistical disadvantage as it is 109 nm (125 miles) inland from the ocean, up the Chesapeake Bay.

The main channel between the Virginia Capes and Fort McHenry, Baltimore has a depth of 15.2 m (50 feet), and other channels in the harbor have depths ranging from 12.2 to 15.2 m (approximately 40 to 50 feet). The main channel between the Delaware Capes and Baltimore via the Chesapeake and Delaware Canal is 10.7 m (35 feet) deep.

Principal imports include general cargo, petroleum products, coke of coal, iron ore, aluminum manganese, inorganic chemicals, salt, gypsum, lumber, motor vehicles, fertilizers and sugar; exports are chiefly: general cargo, coal, automobiles and machinery. Most of the piers and wharves in Baltimore Harbor have direct connections with mainline railroads. CSX offers double-stack intermodal service at the 28.3 hectares (70 acre) Seagirt Marine Terminal. More than 100 steamship companies connect Baltimore with principal U.S. and foreign ports. About 150 motor truck carriers service the port.

Baltimore is well equipped to make major repairs to large vessels. The largest graving dock and the largest floating dry-dock in the area are located at the Bethlehem Steel Sparrows Point yard. Marine railways can haul out vessels up to approximately 38 m (125 feet) and up to 270 mt (approximately 300 tons). A plan to dredge the port's berths to 15.2 m (50 feet), the same depth as the main channel, is under consideration (see Figure 5-18).

Figure 5-18 Port of Baltimore
(Source: http://en.wikipedia.org/wiki/File:Baltoport.jpg)

5.2.9 Wilmington, Delaware

The Port of Wilmington is a full-service deep water port and marine terminal handling over 400 vessels per year. This port has an annual import/export cargo tonnage of over 3.63 million mt (4 million tons). Today, Delaware's port is the busiest terminal on the Delaware River. Located at the confluence of the Delaware and Christina Rivers, 56.5 nm (65 miles) from the

Atlantic Ocean, the port is owned and operated by the Diamond State Port Corporation (see Figure 5-19). The Port of Wilmington has wharves that support barge traffic as well as deep water facilities. The Port facilities include seven deep water general cargo berths, a tanker berth, a floating berth for roll on/roll off vessels on the Christina River, and an automobile and roll on/roll off berth on the Delaware River. The Port of Wilmington has the nation's largest dock-side cold storage facility.

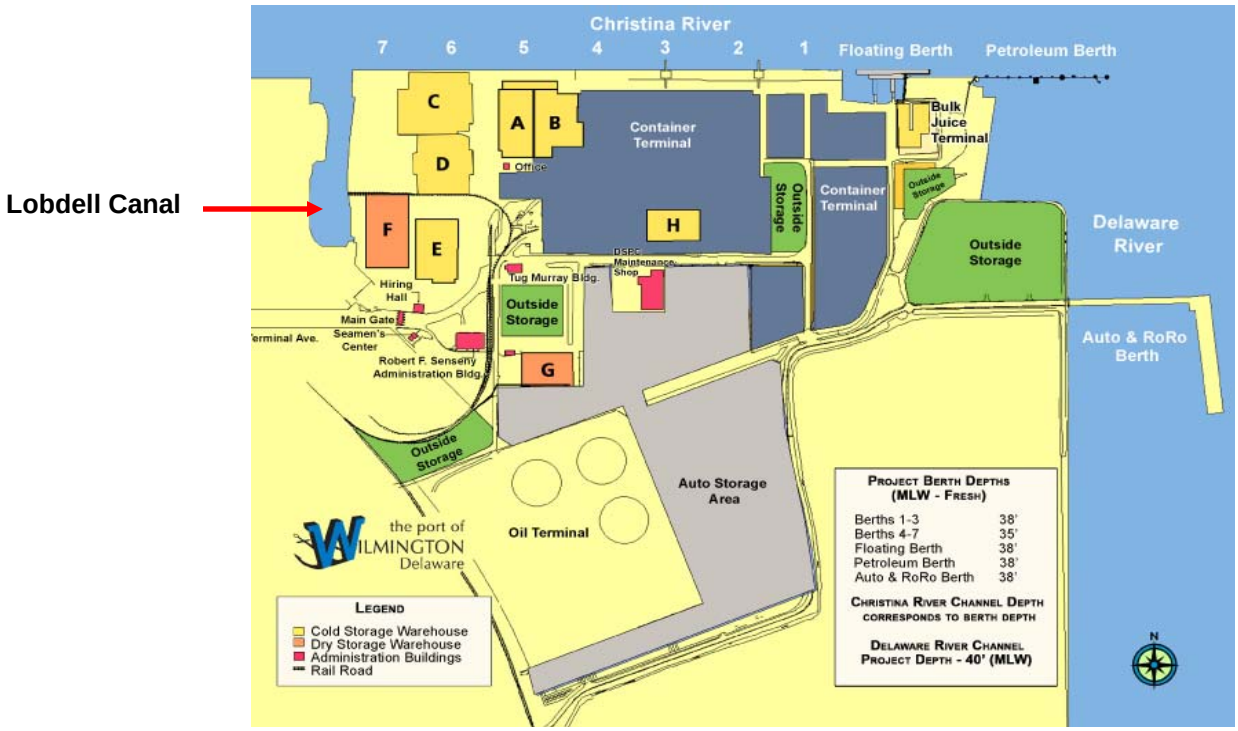


Figure 5-19 Terminal Areas at the Port of Wilmington
(Source: http://dedo.delaware.gov)

There are no bridges or overhead power cables over the deep water section of the Christina River. The Delaware Memorial Bridge has twin suspension spans over the main channel with a clearance of 57.3 m (188 feet). There is a 10.7 m (35 foot) channel from the Delaware River to Lobdell Canal and a 11.6 m (38 foot) deep turning basin opposite the Wilmington Marine Terminal.

Since it was founded in 1923, the Port of Wilmington has been a major Mid-Atlantic import/export gateway for a wide variety of maritime cargoes and trade. Future expansion is planned to provide more storage capacity for existing and future commercial businesses. Rail access to the port is available via Norfolk Southern and CSX Transportation, with railcar loading docks located next to terminal warehouses.

5.2.10 Virginia Port Authority

Chesapeake Bay, the largest inland body of water along the Atlantic coast of the United States, is 146 nm (168 miles) long with a width of 20 nm (23 miles). The bay is the approach to Norfolk, Newport News, Baltimore, and many lesser ports. Deep-draft vessels use the Atlantic entrance, which is about 8.7 nm (10 miles) wide between Fisherman's Island on the north and Cape

Henry on the south. Medium-draft vessels can enter from Delaware Bay on the north via Chesapeake and Delaware Canal, and light-draft vessels can enter from Albemarle Sound on the south via the Intracoastal Waterway. The Port of Virginia has the advantage of being served by the deepest ice-free channels on the East Coast. When the harbor is dredged to a 15.2 m (50 foot) depth, Norfolk will be the first East Coast port able to accommodate a fully loaded 8,000-TEU ship, which means the port would be able to accommodate large purpose-built offshore wind vessels (see Figure 5-20).

Figure 5-20 Port of Virginia
(Source: Google Earth)

Hampton Roads, at the southwest corner of Chesapeake Bay, is entered 13.9 nm (16 miles) westward of the Virginia Capes. It includes the Port of Norfolk and the Port of Newport News. Hampton Roads is the world's foremost bulk cargo harbor. Coal, petroleum products, grain, sand and gravel, tobacco, and fertilizer constitute more than 90 percent of the cargo handled at Hampton Roads ports. Hampton Roads ports are served by a terminal beltline, several large railroads, and by more than 50 motor carriers. In addition, over 90 steamship lines connect Hampton Roads with the principal U.S. and foreign ports.

Norfolk Harbor comprises a portion of the southern and eastern shores of Hampton Roads and both shores of the Elizabeth River. Norfolk Harbor has numerous wharves and piers of all types, the majority of which are privately owned and operated. All have freshwater connections and access to highways and railroads.

The Virginia Port Authority is expanding capacity to meet increased demand for terminal space. When this renovation is complete, it will be home to eight of the largest cranes in the world and the wharf will be a state-of-the-art facility capable of handling the heaviest cargo in the world. In addition, Maersk Sealand plans to invest a total of $450 million for a new terminal on approximately 100 hectares (250 acres) of Virginia Port Authority property in nearby Portsmouth, Virginia, the first major privately developed terminal in the United States.

Hampton Roads has extensive facilities for dry-docking and making major repairs to large deep-draft vessels. The shipyard at Newport News has one of the largest and best equipped graving docks in the United States. There are many other yards that are especially equipped to handle medium-sized and small vessels.

The approach to Hampton Roads is through the 16.7 m (55 foot) Thimble Shoal Channel. There are natural depths of 6.1 to 24.2 m (20 to 80 feet) in the main part of Hampton Roads, but the harbor shoals to less than 3 m (10 feet) toward the shores. Dredged channels lead to the principal ports. Two main Federal channels, marked by buoys, lead through Hampton Roads.

5.3 U.S. East and Gulf Coast Shipyard Construction and Repair Capacity

The construction of new tonnage and repair of marine equipment in both the propelled and non-propelled market has become an issue in recent years because of shifting shipyard capacity throughout the world. While new capacity in other parts of the world has replaced lost capacity in the U.S., declining domestic demand has reduced the number of available shipyards in this country for new construction or repair of large vessels. At the same time, recent regulations such as the Jones Act, require vessels in domestic service or operating in domestic waters to be built and serviced in U.S. yards. As the number of yards available for new construction or repair decreases due to declining demand, the number of yards able to comply with Jones Act requirements also decreases. This is particularly evident in the Northeast U.S. where shipyards able to handle large tonnage vessels, including deep water cargo ships, tankers and specialty vessels such as offshore delivery and support vessels, have dramatically decreased.

While yards that handle large tonnage vessels have decreased, the demand has remained relatively stable for yards that handle smaller vessels such as tugs, offshore service vessels and barges. Current and anticipated demand for commercial construction of cargo and petroleum vessels has been addressed by fewer facilities that have increased their size and capability in some cases.

Specialty wind farm vessels have unique construction and servicing requirements. For the purpose of this analysis, a purpose-built vessel with a length overall (LOA) of 143 m (470 feet) and a width (beam) of 39.6 m (130 feet) was selected to establish the largest dimensions for representative turbine import and installation vessels. Smaller service vessels including offshore supply boats (that can be readily adapted for serving offshore wind farm equipment) and tug and barges also were considered as they are employed regularly in offshore activities. Whereas installation and service vessels handling offshore wind turbine components within the territorial waters of the U.S. would be subject to the Jones Act, import/delivery vessels could be foreign flagged if their operation were limited to equipment delivery at a single U.S. port.

The following analysis assesses construction capacity and repair capacity at U.S. shipyards. See Appendix H for more detail.

5.3.1 Construction Demand and Capacity

Construction demand for small vessels over the last nine years in the U.S. has been steady and has increased due to the fact that numerous vessels are reaching the end of their serviceable life. A growing number of stricter regulations and replacement requirements have increased demand for new small vessel construction in recent years, particularly in the tug and barge industry. Tug and barge construction demand is illustrated in Table 5-2.

Table 5-2
Nine Year Tug and Barge Construction Demand-U.S. Shipyards
(Source: MARAD Shipbuilding Statistics)

Vessel Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	9-Year Totals	Average per Year
Tugs and Towboats	72	63	73	60	73	70	94	121	165	791	88
Dry Cargo Barges >5000 Gross Tons	1	3	2	0	4	1	3	2	4	20	2
Inland Dry Cargo Barges	775	609	672	217	427	219	672	846		4,427	553

Vessel construction has begun to increase over the last several years as the need for larger and more versatile vessels has risen. Towing and offshore supply companies are replacing smaller horsepower vessels with larger units, such as tractor tugs or higher capacity, higher horsepower supply vessels.

Barge construction is of particular importance as the servicing and installation of offshore renewable energy facilities may well be handled by tugs and barges because of their lower operational costs. The demand for barge construction is using up ship construction capacity in the yards where offshore specialty vessel construction could take place. Production of tank barges has increased to meet regulatory requirements for double-hulled barges under the Oil Pollution Act of 1990 (OPA 90). The age comparison between the overall barge fleet and tank barges is of note. Only 30% of all barges are more than 25 years old, whereas fully 50% of tank barges are 25 years or older. This is expected to result in a surge of tank barge orders in the next 5 years to replace existing barges aging past their prime. In 2008 alone more than 132 new tank barges were built, increasing delivery times and reducing capacity for other types of construction. While shipyards are positioned to meet most vessel construction demands, there are longer delivery times for new vessels. At present there is sufficient building capability to meet both new construction demands with backlogs running six months to one year. This is considered by the industry to be reasonable for vessel orders and deliveries. Due to the complexity and unique nature of specialty offshore vessels, a significantly longer lead time should be considered when calculating construction cycles and delivery needs.

There were recently 63 vessels under construction that have been delivered or planned for delivery by U.S. shipyards by the end of 2009, most being tugs and towboats. A compilation of the results of a survey conducted of shipyards with recently completed contracts is presented in Table 5-3.

Table 5-3
Recent Shipyard Contracts as of 2009
(Source: MARAD Shipyard Statistics)

Vessel Name	Shipyard	Owner	Type	GT	Delivery
Safety Team	B. & B. Boatbuilders	AEP River Operations	1,550-hp Towboat	157	May-09
Miss Lucy	B. & B. Boatbuilders		Pushboat	29	May-09
Shiney V. Moran	C. & G. Boat Works	Moran Towing	5,360-hp Tug	192	May-09
Roger Binsfeld	Hope Services	Brennan Marine	Towboat	144	May-09
Mountain State	Quality Shipyard	AEP River Operations	6,000-hp Towboat	774	May-09
Coon Wise	GNOTS Marine	GNOTS Reserve	2,400-hp Towboat	107	May-09
Blake Boyd	Eastern Shipbuilding	Florida Marine	2,600-hp Towboat	260	May-09
Pat Voss	Verett Shipyard		Towboat	347	Apr-09
Yellowfin	Thoma-Sea Shipbuilders	Penn Maritime	4,000-hp ATB Tug	223	Apr-09
San Brendan	Bludworth Shipyard	Buffalo Marine	1,320-hp Towboat	185	Apr-09
Elvis	Inland Boat Works		Pushboat	52	Apr-09
Hunter M	Orange Shipbuilding	Bay-Houston Towing	6,300-hp Escort Tug	425	Mar-09
Salvation	Raymond & Associates	Eckstein Marine	2,000-hp Towboat	167	Feb-09
Greg McAllister	Eastern Shipbuilding	McAllister Towing	6,000-hp Tug	172	Jan-09
Severn	Thoma-Sea Boatbuilders	Vane Brothers	4,200-hp Tug	341	Jan-09
Corpus Christi	Eastern Shipbuilding	US Shipping	12,000-hp ATB Tug	919	Jan-09
C-Tractor 19	GulfShip	Alpha Marine Services	Tractor Tug	298	4-May-09
Parker A. Settoon	Eastern Shipbuilding	Settoon Towing	3,000-hp Towboat	289	22-Apr-09
Joshua Caleb	A. & B. Industries	CLM Marine	Towboat	95	22-Apr-09
Lamar Golding	D.E.S. Boatworks	Golding Barge Line	Towboat	277	20-Apr-09
Susanne T	Hardrock Marine Services	Endeavor Marine		21	16-Apr-09
Scott Stegbauer	Steiner Shipyard	Southern Towing	3,200-hp Towboat	402	14-Apr-09
George	Main Iron Works	Harbor Docking	6,140-hp Harbor Tug	734	10-Apr-09
Miss Cassie	Robert Crawley	Robert Crawley	Pushboat	13	9-Apr-09
Safety Forever	B. & B. Boatbuilders	AEP River Operations	1,550-hp Towboat	157	9-Apr-09
Janis R. Brewer	Eastern Shipbuilding	Crounse Corp.	4,000-hp Towboat	472	9-Apr-09
Ruth M. Reinauer	SENESCO	Reinauer Transportation	4,000-hp ATB Tug	485	8-Apr-09
Capt C H Guidry	Eastern Shipbuilding	Florida Marine	2,600-hp Towboat	260	7-Apr-09
Mannie Cenac	Intracoastal Iron Works	Cenac Towing	Pushboat	95	3-Apr-09
Captain Robert	A. & B. Industries	Odyssea Vessels	4,200-hp Towboat	97	31-Mar-09
Anacostia	Thoma-Sea Boatbuilders	Vane Brothers	4,200-hp Tug	341	30-Mar-09
Genie Cenac	Tres Palacios Marine	Cenac Towing	3,200-hp Towboat	189	27-Mar-09
Delta Billie	Nichols Bros Boatbuilding	Bay Delta Marine	6,800-hp Escort Tug	194	26-Mar-09
Commitment	VT Halter Marine	Crowley Marine	9,280-hp ATB Tug	465	26-Mar-09
Holy Cross	Raymond & Associates	Eckstein Marine	2,000-hp Towboat	167	16-Mar-09
Affirmed	C. & C. Boat Works	Turn Services	Towboat	147	10-Mar-09
Kyle A Shaw	Hope Services	Maryland Marine	1,800-hp Towboat	144	4-Mar-09
Capt Dean	Eastern Shipbuilding	Florida Marine	2,600-hp Towboat	260	27-Feb-09
AK Hotchkiss	Progressive Industrial	Riverside Basin Marine	Pushboat	17	26-Feb-09
W. J. Authement	Intracoastal Iron Works	Intracoastal Iron Works	Towboat	95	25-Feb-09
Patuxent	Thoma-Sea Boatbuilders	Vane Brothers	4,200-hp Tug	341	25-Feb-09

Vessel Name	Shipyard	Owner	Type	GT	Delivery
Morgan City	Raymond & Associates	Kirby Inland Marine	1,800-hp Towboat	223	26-Feb-09
Austin C. Settoon	Eastern Shipbuilding	Settoon Towing	3,000-hp Towboat	289	19-Feb-09
Alton St. Amant	Sneed Shipbuilding	Blessey Marine	1,700-hp Towboat	249	19-Feb-09
Ted	Main Iron Works	Harbor Docking	6,140-hp Habor Tug	481	17-Feb-09
Safety Priority	B. & B. Boatbuilders	AEP River Operations	1,550-hp Towboat	157	17-Feb-09
Sesok	Diversified Marine	Vessel Mgmt. Svces.	1,362-hp Tug	143	12-Feb-09
Nachik	Diversified Marine	Vessel Mgmt. Svces.	1,362-hp Tug	133	12-Feb-09
Orca One	Geo Shipyard	Orca Maritime	Towboat	299	10-Feb-09
Panther	Serodino	Serodino	Towboat	75	10-Feb-09
Gladiator	Gulfbound	Dragnet Seafood	Towboat	90	10-Feb-09
Mr Nelson	Diversified Marine	AC Marine	Towboat	77	4-Feb-09
Danny L Whitford	Gulf Inland Marine	Hunter Marine Transport	Towboat	445	3-Feb-09
Celine B	Inland Boat Works	Joseph B. Fay Co.	Pushboat	23	29-Jan-09
Anna Marie	A. & B. Industries	Terral Riverservice	Towboat	80	29-Jan-09
Donnie Verret	Verret Shipyard	T & B Towing	Towboat	73	23-Jan-09
Cynthia G Esper	Marine Builders	SCF Marine	3,200-hp Towboat	256	23-Jan-09
Holy Rosary	Raymond & Associates	Eckstein Marine	2,000-hp Towboat	167	14-Jan-09
Perry M D	Perry & Son Towing	Perry & Son Towing	Towboat	82	12-Jan-09
Lady Loren	Lockport Fabrication	LA Carriers	1,980-hp Towboat	96	12-Jan-09
Blessed Trinity	Raymond & Associates	Eckstein Marine	2,000-hp Towboat	167	7-Jan-09
Citation	C. & C. Boat Works	Turn Services	Towboat	147	6-Jan-09
Safety Challenger	B. & B. Boatbuilders	AEP River Operations	1,550-hp Towboat	157	6-Jan-09
GT = Gross Ton = Long Ton = 1,016 kg = 2,240 pounds					

5.3.2 Shipyard Availability

The number of shipyards that have current capacity for large specialty vessel construction is limited within the U.S. Of the 350 active vessel construction companies in the U.S., only 52 have a history of significant vessel construction in the Eastern or Southern regions of the country. Eight are located on the U.S. Atlantic Coast and the rest on the U.S. Gulf Coast. Because of their proximity to potential offshore installation sites, Atlantic and Gulf coast shipyards were examined in more detail. A limited number of yards are capable of handling large specialty vessels based on yard size, but a number of them could handle smaller specialty vessels. The yards that can build vessels on the Atlantic and Gulf Coasts are highlighted in Table 5-4.

Table 5-4
Active East Coast and Gulf Coast Shipyards with Significant Construction Records
(Source: MARPRO Associates International 2009)

Shipyard	Location
Atlantic Coast	
Blount Boats	Warren RI
Chesapeake Shipbuilding	Salisbury, MD
Cianbro	Portland, ME
Derecktor Shipyards	Bridgeport, CT
Gladding-Hearn	Somerset, MA

Shipyard	Location
SENESCO	North Kingstown, RI
Washburn & Doughty	East Boothbay ME
Yank Marine	Tuckahoe, NJ
Gulf Coast	
A & B Industries	Morgan City, LA
B. & B. Boat Builders	Bayou La Batre AL
Bludworth Shipyard	Corpus Christi, TX
Boconco	Bayou La Batre, AL
C. & C. Boat Works	Belle Chase, LA
C. & C. Marine and Repair	Belle Chase, LA
C. & G. Boat Works	Bayou La Batre, AL
C. & G. Boat Works	Mobile, LA
Candies Shipbuilders	Houma LA
Conrad Industries	Morgan City, LA
Duckworth Steel Boats	Tarpon Springs, FL
Eastern Shipbuilding	Panama City FL
Eymard & Sons Shipyard	Harvey LA
Gulf Island Marine Fabrication	Houma, LA
Gulf Ship	Gulfport, MS
Halimar Shipyard	Morgan City, LA
Hope Services	Dulac, LA
Horizon Shipbuilding	Bayou La Batre, AL
Inland Marine	Bridge City, TX
Intracoastal Iron Works	Bourg, LA
Leevac Industries	Jennings LA
Lockport Fabrication	Lockport, LA
Main Iron Works	Houma LA
Marine Inland Fabricators / Sisco Marine	Panama City, FL
Master Marine	Bayou La Batre, AL
Master Boat Builders	Coden AL
Orange Shipbuilding	Orange TX
Patti Shipyard	Pensacola, FL
Portier Shipyard	Chauvin, LA
Progressive Industrial	Palmetto, FL
Quality Shipyards	Houma LA
Raymond & Associates	Bayou La Batre AL
Rodriguez Boatbuilders	Bayou La Batre, AL
Rodriguez Boatbuilders	Coden AL
SEMCO	Lafitte, LA
Sneed Shipbuilding	Channelview, TX
Sneed Shipbuilding	Orange, TX
Southwest Shipyard	Houston, TX
Steiner Shipyard	Bayou La Batre, AL

Shipyard	Location
Thoma-Sea Boatbuilders	Houma, LA
Thoma-Sea Shipbuilders (formerly Halter Lockport)	Lockport, LA
Trinity Madisonville	Madisonville, LA
Trinity Port Allen	Port Allen, LA
Verret Shipyard	Plaquemine, LA
West Gulf Marine	Galveston, TX

5.3.3 Capacity and Delivery Estimations

In the Northeast, many of the yards have compressed operations due to increasing environmental concerns and gentrification of industrial areas. Several of the yards confine activities to repair and have refocused their efforts on small craft (such as ferries, yachts and similar commercial watercraft). In the Gulf of Mexico, a number of the shipyards have not fully restored operations to pre-Katrina levels primarily due to a shortage of qualified personnel and absence of infrastructure.

The Gulf of Mexico region still has the highest percentage of multi-purpose construction and repair yards in the country. Average small vessel construction, such as tugs or offshore supply/service vessels, can run from six months to a year depending on complexity. Barge construction can run from 3 to 9 months depending on size and function. Construction of larger specialty vessels can exceed 12 to 18 months and run up to 24 months. There are several smaller yards in the Northeast and Gulf that have no backlogs and have immediate capacity for new vessel orders. Very few have multiple vessel capacity, and backlogs do not extend beyond 2011.

5.3.4 Vessel Repair Capacity

Most of the shipyards on the Atlantic Coast that build vessels also have some level of repair capacity. There is only limited repair capacity in New England. Some yards only handle military contracts. However, in recent weeks, General Dynamics has announced an expansion of its facilities in Bath, Maine to accommodate the construction of components for offshore wind farms. Atlantic Coast repair yards are listed in Table 5-5.

Table 5-5
Listing of Shipyards on the Atlantic Coast with Build and/or Repair Capacity
(Source: MARPRO Associates International 2009)

US Atlantic Coast	Type	Size	Location	State
Atlantic Marine Boston	R	L	Boston	MA
Atlantic Marine Florida	B	M	Jacksonville	FL
Bayonne Drydock	R	L	Bayonne	NJ
Blount Boats	B	S	Warren	RI
Broward Marine	B	Y	Dania Beach	FL
Caddell Dry Dock	R	S	Staten Island	NY
Chesapeake Sbldg.	B	S	Salisbury	MD
Cianbro	BR	S	Portland	ME
Davis Boat Works, Inc.	R	S	Newport News	VA
Derecktor Shipyard Connecticut	B	S	Bridgeport	CT

US Atlantic Coast	Type	Size	Location	State
Derecktor Shipyard Florida	BR	S	Dania	FL
Derecktor Shipyard New York	BR	S	Mamaroneck	NY
Detyens Shipyards	R	L	N. Charleston	SC
Detyens Shipyards	R	S	Jacksonville	FL
Fairhaven Shipyard	R	S	Fairhaven	MA
Fore River Dock and Dredge	BR	S	South Portland	ME
G.M.D. Shipyard	R	L	Brooklyn	NY
GD/Bath Iron Works	B	L	Bath	ME
GD/Electric Boat	B	L	Groton	CT
General Ship Repair Corp.	R	S	Baltimore	MD
Gladding-Hearn	BR	S	Somerset	MA
Global Ship Systems	R	S	Savannah	GA
Kelley Shipyard, D. N.	R	S	Fairhaven	MA
Lyon Shipyard	R	S	Norfolk	VA
Marine Hydraulics	R	T	Norfolk	VA
May Ship Repair Contracting	R	S	Staten Island	NY
Metro Machine of VA	R	L	Norfolk	VA
Muller Boat Works	R	S	Brooklyn	NY
Newport Shipyard Company	R	S	Newport	RI
Scarano Boat Building	B	S	Albany	NY
Seaboats	BR	S	Fall River	MA
SENESCO	B	S	North Kingstown	RI
Thames Shipyard & Repair Co.	R	S	New London	CT
Union Dry Dock & Repair	R	S	Hoboken	NJ
Washburn & Doughty	B	S	East Boothbay	ME
KEY Type Codes: B = Build; R = Repair Size Codes: S = small; M = medium; L = large				

5.3.5 Conclusions Relative to Construction and Repair Capacities on the Atlantic Coast

Large vessel construction and small vessel construction most likely would be handled by different shipyards. Yard capacity varies from region to region. The industry can meet the demand for a phased-in cycle of new vessels on a limited basis up to approximately three units per year using multiple yards in various regions of the U.S. Barge construction demand is expected to increase, thereby reducing overall new vessel construction capability. This will affect the ability of some shipyards to meet larger specialty vessel construction. New England has new construction capability limited to smaller vessels, but adequate repair capability for smaller vessels and some capacity for larger vessels. Both Atlantic and Gulf Coast shipyards will need to be considered to meet vessel construction and demand requirements. A developer should anticipate an 18-month lead time for design, contracting, construction and delivery of small vessels and up to 24 months for larger vessels.

6.0 SHORT-LISTING OF PORTS FOR FURTHER EVALUATION

Based on the evaluation criteria developed in Section 4 and analysis, the Team has concluded that New Bedford and Boston Harbor have the best potential to support the assembly and deployment of the planned and prospective offshore wind energy projects. The process by which these two short-listed ports were identified is described below.

6.1 Massachusetts Port Criteria Evaluation Matrix

As described in Section 4, the Team identified a broad set of direct requirements and highly desirable characteristics of port facilities relative to supporting offshore wind farm construction and operation. This list was further distilled down to a smaller set of criteria that could be used to differentiate the candidate port facilities based on the potential of that port to support offshore wind energy development. These criteria included some “hard” criteria that had minimum quantitative measures with which to judge the feasibility or suitability of a port relative to that consideration. Those ports that failed to meet the majority of our hard criteria (recognizing that modifications, upgrades or work arounds could potentially be made to ports relative to one or two characteristics to allow them to achieve the minimum threshold criteria) were eliminated from the evaluation process. This screening resulted in the selection of six Massachusetts ports (located in DPAs) for further consideration. The Massachusetts Port Criteria Evaluation Matrix (see Table 6-1) clearly demonstrates how these six Massachusetts ports compare against each other with respect to our established “hard” criteria. Application of the identified “soft” criteria was reserved for only the short-listed ports and is discussed later in this report.

Table 6-1
Massachusetts Port Criteria Evaluation Matrix

PARAMETERS		PORTS					
Criteria	**Recommended Values/Ranges**	**Boston**	**New Bedford**	**Fall River**	**Gloucester**	**Salem**	**Fore River**
First Tier Harbor Navigational Access							
Protected Harbor	Sheltered from Weather Conditions	Yes	Yes	Yes	Yes	Yes	Yes
Shipping Vessel Channel Depth	Minimum 7.3 m (24’)	12.2 – 13.7 m (40' - 45')	9.1 m (30')	10.7 m (40')	4.9 - 5.8 m (16' - 19')	9.4 m (31’)	9.8 m (32')
Overhead Clearance	No Vertical Obstruction	NVO, but FAA approval required	NVO	41 m (135')	NVO	NVO	53.3 m (175')
Horizontal Clearance	40 m (130') (beam plus overhang)	131 m (430')	45.7 m (150')	122 m (400')	61 m (200')	85.3 m (280')	53.3 m (175')
24/7 Operational Ability	24/7 operations	Yes	Yes	Yes	No	Yes	Yes
Exclusive Use of Port Facility	Ability to Offer Exclusive Use	Yes	Yes	No	No	No	Yes
Comments				Mt Hope Bridge height restriction	Navigational constraints	Salem DPA in full use by power plant	Fore River Bridge height restriction
Second Tier Port Facilities							
Berth Length	Minimum 138 m (450’)	549 m (1,800')	488 m (1,600')	189 m (620')	427 m (1,400')	177 m (580')	244 m (800')
Shipping Vessel Water Depth	Minimum 7.3 m (24’)	12.2 – 13.7 m (40' - 45')	9.1 m (30')	10.7 m (40')	4.9–5.8 m (16'-19')	9.4 m (31')	9.8 m (32')

Table 6-1
Massachusetts Port Criteria Evaluation Matrix

PARAMETERS		PORTS					
Criteria	**Recommended Values/Ranges**	**Boston**	**New Bedford**	**Fall River**	**Gloucester**	**Salem**	**Fore River**
Total Wharf and Yard Upland Area	4.0 hectares (10 ac)	5.7 – 6.9 hectares (14-17 ac)	4.0+ hectares (10+ ac)	2.8 hectares (7 ac)	3.2 hectares (7.8 ac)	NA	44.9 hectares (111 ac)
Rail Access	Rail Access	Limited	Limited	Yes	Yes	No	Yes
Highway Access	Highway Access	Yes	Yes	Yes	Yes	No	No
Comments				State Pier can only accommo date small cargo vessels.	Limited adaptable area	Insufficie nt work area; additional focus on tourism	Multiple berths/ rough estimate; plans for mixed-use waterfront development

Legend NVO = No vertical obstruction
= Criteria not met
NA = Not available for ROWEI staging

6.2 Implications of Applying the Hard Criteria Relating to Navigational Access and Port Facilities

6.2.1 Evaluation of Each Hard Criterion

Protected Harbor: All of the six Massachusetts ports are in protected harbors. The hurricane barrier in New Bedford adds an additional layer of protection for portside operations during inclement weather.

Shipping Channel Depth and Overhead Clearance: Navigational access to Fall River and Fore River is constrained by the overhead height restrictions of existing bridges (indicated by a shading of the matrix cell in Table 6-1), and the Port of Gloucester does not meet the minimum shipping channel depth of 24 feet. On the other hand, the shipping channels of New Bedford and Boston Harbors meet the minimum depth criterion. New Bedford's navigation channel is 30 feet deep, and the New Bedford HDC is proposing to dredge to extend the 30 foot channel to the planned bulkhead extension at the South Terminal. Navigation channels to Boston Harbor's DPA are between 40 feet and 45 feet deep. Both New Bedford and Boston Harbor have unobstructed overhead clearance. There are no vertical obstructions, such as bridges and/or power lines, which would prohibit offshore wind component delivery and installation vessels, including jack-up vessels, from accessing either harbor. However, as noted previously, FAA approval may be required in Boston Harbor because of the harbor's proximity to Logan International Airport.

Horizontal Clearance: None of the selected ports are restricted by horizontal (lateral) clearances less than 130 feet. The minimum horizontal clearance criterion eliminated facilities in New Bedford upstream of the New Bedford-Fairhaven Bridge (92 feet of lateral clearance). However, the South Terminal at New Bedford Harbor is downstream of the New Bedford-Fairhaven Bridge and upstream of the Hurricane Barrier.

24/7 Operational Ability and Exclusive Use of Port Facility: All ports being evaluated, with the exception of the Port of Gloucester, can operate around the clock and all year. The Ports of Gloucester and Salem also did not have the ability to offer exclusive use of their facilities.

Berth Length and Shipping Vessel Water Depth: Off-shore wind farm construction is associated with multiple berthing operations, including offloading of parts for final assembly or pre-assembly; loading of special barges with the pre-assembled or assembled elements (rotor with blades, foundations or tower sections); mooring of jack-up vessels, crane vessels or any type of specialty purpose-built vessel for service (fuel and maintenance), preparation and deployment; mooring and service of crew boats; emergency response support; and any other activity supporting staging and construction. The established berth length and channel and portside depth criteria reflected minimum requirements for accommodating these operations. The Port of Gloucester failed to meet the depth criterion. All other ports had sufficient length and depth.

Total Wharf and Yard Upland Area: Landside (upland) port facilities provide storage, staging and assembly work areas to facilitate offshore wind farm installation. To fulfill these tasks it is important that landside facilities have adequate acreage, warehouse space, onsite equipment, and high load bearing capacity. Most working ports have existing equipment that could be used or adapted to offload, assemble and load some or all current turbine and foundation components. The Team determined that given sufficient land area, storage, assembly, and load bearing issues could be addressed with improvements to the port. Neither Fall River, Gloucester, nor Salem has sufficient adaptable space for the work area required to support offshore wind farm staging.

Rail Access: None of the Massachusetts ports evaluated for this study has second generation rail access[7]. Existing tracks will not be able to handle the expected size of future generation nacelles and rolled steel components. Existing rail lines could be used primarily for delivery of aggregate and related products rather than turbine or foundation components. Whereas Fall River, Gloucester, and Fore River have existing freight rail lines to the waterfront, Boston and New Bedford currently have limited rail access, and Salem has none. Boston has active rail to the Boston Marine Industrial Park, but not to the North Jetty or Dry Dock #4. Boston has designed the rail extension to the North Jetty and Dry Dock #4, and funding for construction has been requested through a TIGER application[8]. New Bedford has rail access to the waters' edge, and there is a pending TIGER request[9] to connect the existing tracks to the State Pier, but not the South Terminal.

Highway Access: Road connections are important for transport of ancillary material and equipment, as well as personnel. Overweight and large shipment units are subject to state permitting requirements, which also take into account possible roadway infrastructure

[7] First generation rail clearance for container doublestack cargo is 19 feet above the rail (ATR). Second generation doublestack clearance is 22.5 feet ATR.

[8] The Boston Redevelopment Authority has requested a grant of $84 million for expansion of the Black Falcon Cruise Terminal; track improvements to the Boston Marine Industrial Park rail line; improvements to the East, North and South Jetties; and reconstruction of the FID Kennedy West and Access Roads.

[9] The New Bedford HDC has requested a grant of $36.4 million to improve North Terminal infrastructure; rehabilitate the rail line to the State Pier; update and rehabilitate Herman Melville Boulevard; procure cranes and modify terminals for roll on-roll off capability; and develop the southern portion of the South Terminal.

constraints, such as overhead utilities, road lighting, road curvatures and intersections. Neither Salem Harbor nor the Fore River Shipyard has capacity for high volume traffic flow due to local roadway congestion. There is no direct interstate highway access from the City of Salem; the nearest highway access to Route 128 is along Route 114 in neighboring Peabody. Fore River's access to the interstate highway network is via Route 3, a limited-access roadway that is about two miles away from the Shipyard.

6.2.2 Results of the Evaluations

Based on the hard criteria established in Section 4 and displayed in Table 6-1, the ports of Fall River, Gloucester, Salem, and Fore River fell short of the minimum requirements for navigational access and port infrastructure to support offshore wind development activities. The ports of New Bedford and Boston emerged as the two short-listed ports.

6.3 Engineering Cost Analysis of Port Upgrades at Short-Listed Ports

This section provides a further evaluation of the two short-listed ports and rough order of magnitude estimate of the required maintenance and upgrades that would improve the ability of those ports to serve offshore wind farm development.

6.3.1 New Bedford Harbor

The Team identified two possible locations in New Bedford Harbor that might reasonably support offshore wind farm construction. One is the South Terminal area (Figure 6-1) and the other is the State Pier facility (Figure 6-2). Both facilities failed to meet all of the hard criteria discussed above, and demonstrated some level of deficiency in their current physical condition.

6.3.1.1 South Terminal

The City of New Bedford has identified the expansion of the South Terminal (Figure 6-1) as a major priority. The City has applied for a TIGER grant to expand the berth by approximately 245 m (800 feet) and dredge a 9 m (approximately 30 feet) deep channel from the main channel to the new berth. The new facility would have significant backland load bearing capacity. There are between 5.6 and 8.1 hectares (14 and 20 acres) of land adjacent to the berth. The proposed rebuild would utilize a tied-back steel sheet pile bulkhead backfilled with the dredge spoils. The cost of the new bulkhead and dredging is estimated to be approximately $20 million. Table 6-2 presents the cost estimate for the South Terminal expansion.

Additional improvements, including paving, utilities and site equipment (such as a large crane), could add an additional $15 million and would provide a "future" life as a general cargo or container handling facility. The new bulkhead construction would allow the terminal to be designed to a high live load capacity, which will provide a significant number of options for material handling. Immediately adjacent to the site (across the street) there are several warehouses of approximately 930 m^2 (10,000 square feet) or more. There would be ample space to construct a shelter on the site without reducing the outside lay down space.

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Figure 6-1 South Terminal Port of New Bedford
(Source: Childs Engineering Corporation)

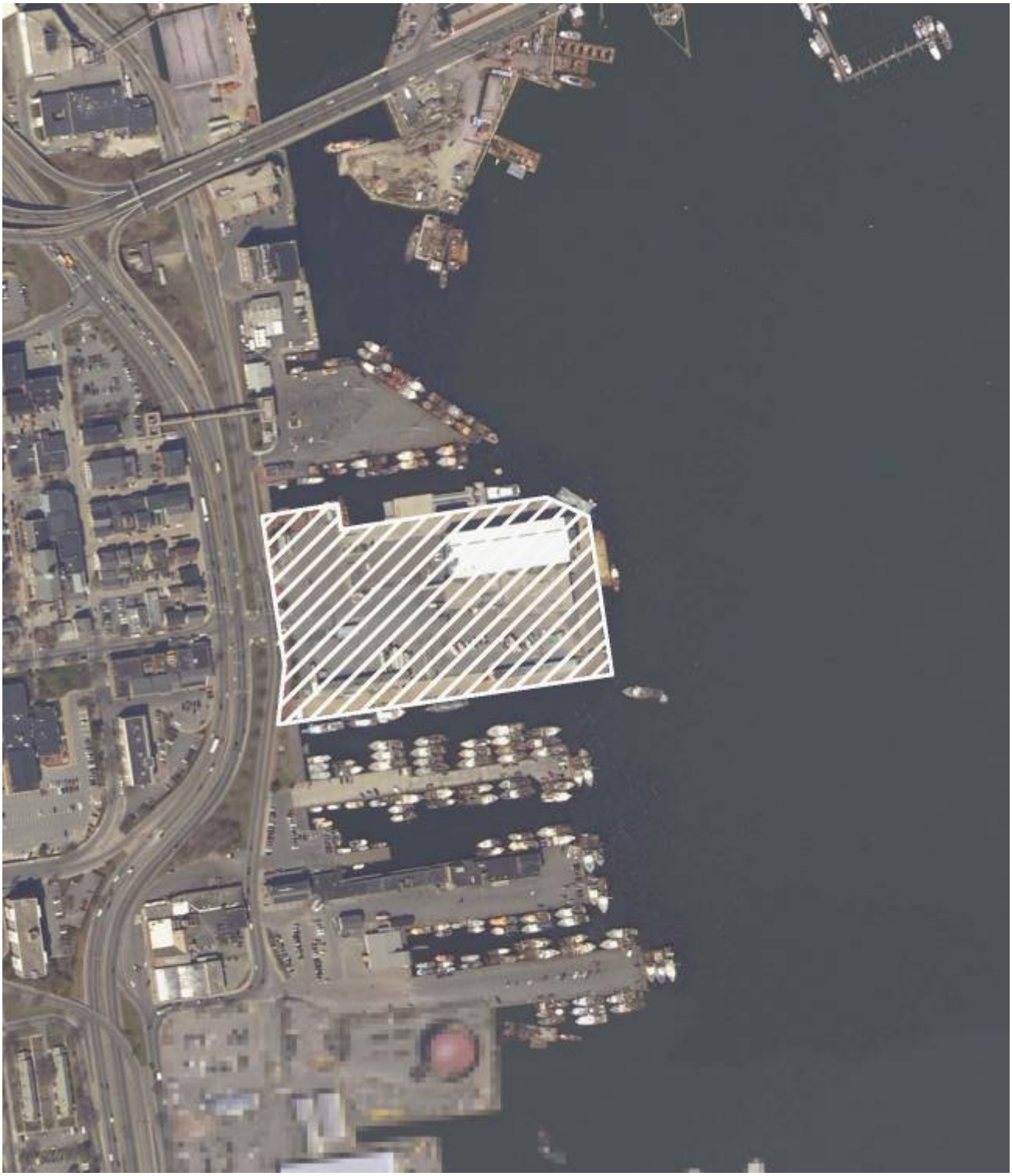

Figure 6-2 State Pier Port of New Bedford
(Source: Childs Engineering Corporation)

Table 6-2
Cost Estimate for New Bedford Harbor South Terminal Expansion
(Source: Childs Engineering Corporation 2009)

Item Description	Quantity	Units	Unit Cost	Item Cost
Harbor Development Commission Staff	3	LS	$ 40,000	$ 120,000
Final Engineering/Procurement	1	LS	$ 1,000,000	$ 1,000,000
Organics Removal	15,185	CY	$ 35	$ 531,481
Organics Disposal (CAD Cell)	15,185	CY	$ 55	$ 835,185
Sheeting - PZ40	1,706,940	LB	$ 3	$ 4,267,350
Shoes for Sheets	273	EA	$ 250	$ 68,333
Mudslab Installation	3,796	CY	$ 200	$ 736,158
Wale -][MC12x31	42,813	LB	$ 3	$ 128,438
Weep Drains @ 10' o.c.	83	EA	$ 150	$ 12,410
Steel Sheeting Deadmen	246,000	LB	$ 3	$ 737,389
Excavation - Tie-Rods	3,677	CY	$ 15	$ 55,157
Tie-Rod	53,593	LB	$ 6	$ 321,559
Structural Fill - Tie-Rods	3,677	CY	$ 35	$ 128,700
Concrete Bulkhead Cap	103	CY	$ 650	$ 66,625
Concrete Slab	1,063	CY	$ 500	$ 531,345
Bollards, 61 ton/bitt	29	EA	$ 5,500	$ 161,794
12" Dia. Timber Piles (Fender)	86	EA	$ 3,000	$ 258,032
Timber Bracing				
12" X 12" Fender	665	BFM	$ 4.50	$ 2,992
8" X 12" Fender	867	BFM	$ 4.50	$ 3,902
Dredge/Placement of Material Behind Bulkhead	153,000	CY	$ 40	$ 6,120,000
Dredging Channel to South Terminal	62,963	CY	$ 50	$ 3,148,148
			Total South Terminal Extension:	$ 19,235,000

6.3.1.2 State Pier

The State Pier (Figure 6-2) is constructed with a solid fill core surrounded by a marginal wharf. This construction is typical of many old New England ports. The solid fill is contained within an old stone seawall. The marginal wharf is comprised of treated timber piles and superstructure. The marginal wharf extends seaward from the stone seawall and allows the berth to be dredged without undermining the seawall. Table 6-3 presents the cost estimate for the needed improvements identified for the State Pier.

Table 6-3
Cost Estimate for Improvements to State Pier at New Bedford Harbor
(Source: Childs Engineering Corporation)

	Description	Initial Construction Cost	Contingency @ 15%	Total Initial Construction Cost	30th Year	40th Year	Estimated Maintenance Cost (Present Worth Cost)						Total Cost of Alternatives
							50th Year	60th Year	70th Year	80th Year	90th Year	100th Year	
1	Timber Piles, Concrete Deck	$13,340,031	$2,001,005	$15,341,036			Replace					Replace	$41,512,087
	Timber Piles - Replace 20% every 10 years starting 30th year				$2,668,006	$2,668,006	$13,340,031	$ -	$ -	$2,668,006	$2,668,006	$13,340,031	
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
2	Refurbish Timber Piles, Concrete Deck	$12,139,965	$1,820,995	$13,960,960			Replace					Replace	$38,151,902
	Timber Piles - Replace 20% every 10 years starting 30th year				$2,427,993	$2,427,993	$12,139,965	$ -	$ -	$2,427,993	$2,427,993	$12,139,965	
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
3	Steel Piles, Concrete Deck	$20,347,152	$3,052,073	$23,399,225				Replace					
	Steel Piles - Replace 20% every 10 years starting 40th year				$ -	$4,069,430	$4,069,430	$20,347,152	$ -	$ -	$ -	$4,069,430	$36,715,443

Table 6-3 (continued)

	Description	Initial Construction Cost	Contingency @ 15%	Total Initial Construction Cost	30th Year	40th Year	Estimated Maintenance Cost (Present Worth Cost)						Total Cost of Alternatives
							50th Year	60th Year	70th Year	80th Year	90th Year	100th Year	
3	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
4	Steel Bulkhead - Lightweight Fill - 1 Row Tiebacks	$31,058,195	$4,658,729	$35,716,924					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$3,105,820	$3,105,820	$3,105,820	$31,058,195	$ -	$ -	$ -	$44,535,654
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
5	Combi-Wall - 1 Row Tiebacks	$35,977,044	$5,396,557	$41,373,601					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$3,597,704	$3,597,704	$3,597,704	$35,977,044	$ -	$ -	$ -	$50,930,157
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	

Table 6-3 (continued)

	Description	Initial Construction Cost	Contingency @ 15%	Total Initial Construction Cost	30th Year	40th Year	Estimated Maintenance Cost (Present Worth Cost)						Total Cost of Alternatives
							50th Year	60th Year	70th Year	80th Year	90th Year	100th Year	
6	Soldier Piles, Concrete Lagging - 1 Row Tiebacks	$30,819,869	$4,622,980	$35,442,849					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$3,081,987	$3,081,987	$3,081,987	$30,819,869	$ -	$ -	$ -	$44,225,830
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
7	Cellular Cofferdam - Sand Backfill	$50,716,366	$7,607,455	$58,323,821					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$5,071,637	$5,071,637	$5,071,637	$50,716,366	$ -	$ -	$ -	$70,091,276
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
8	Cellular Cofferdam - Gravel Backfill	$51,588,891	$7,738,334	$59,327,225					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$5,158,889	$5,158,889	$5,158,889	$51,588,891	$ -	$ -	$ 71,225,558	

Table 6-3 (continued)

	Description	Initial Construction Cost	Contingency @ 15%	Total Initial Construction Cost	30th Year	40th Year	Estimated Maintenance Cost (Present Worth Cost)						Total Cost of Alternatives
							50th Year	60th Year	70th Year	80th Year	90th Year	100th Year	
8	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
9	Diaphragm Cofferdam - Sand Backfill	$51,402,764	$7,710,415	$59,113,179					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$5,140,276	$5,140,276	$5,140,276	$51,402,764	$ -	$ -	$ -	$70,983,593
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	
10	Diaphragm Cofferdam - Gravel Backfill	$52,275,289	$7,841,293	$60,116,582					Replace				
	Sheet Piles - Replace 10% every 10 years starting 40th year				$ -	$5,227,529	$5,227,529	$5,227,529	$52,275,289	$ -	$ -	$ -	$72,117,876
	Gangway and Float System - Replace 10% every 10 years starting at year 10				$390,000	$130,000	$1,560,000	$130,000	$130,000	$130,000	$130,000	$1,560,000	

The wharf structure is in poor condition according to recent inspections and must be replaced or a modified rebuild must be undertaken. The rebuild options include a repair/replace in kind, which would result in a low deck load capacity. The preferred alternatives would eliminate the wharf structure and replace it with solid fill behind a new bulkhead. A recent study suggested rebuild costs in the range of approximately $12.1 million to more than $52 million.

The immediate backland at State Pier is about 2.8 to 3.2 hectares (approximately 7 to 8 acres), which does not meet the landside criterion (see Table 6-1 above). This lack of space probably would result in material rehandling costs that would not be incurred at a larger site. The rehandling costs could result from offsite storage at other adjacent land facilities or perhaps from barge-based storage. There is covered space in the form of two small warehouses and the marine terminal building. The State Pier would be best described as a short-term, but immediately available, site. This also anticipates that no repairs are performed and a larger land-based unloading crane is employed inshore sufficiently of the wharf structure, which may require a higher-rated crane than would otherwise be needed to clear the low load bearing areas.

The Team believes the preferred option for New Bedford is the South Terminal. The site is the most desirable in terms of meeting the port criteria established by the Team. The South Terminal expansion cost is similar to the repair cost for the State Pier; however, the South Terminal has significantly more laydown area, which offsets any potential cost savings from the State Pier repair/rebuild.

6.3.2 Boston Harbor

The Team identified three possible locations in Boston Harbor that reasonably meet the established criteria. These include the North Jetty (Figure 6-3), Dry Dock #4 in the Boston Marine Industrial Park (Figure 6-4), and the former Coastal Oil site adjacent to Conley Terminal on the Reserved Channel (Figure 6-5). None of these facilities met all of the hard criteria discussed above, and demonstrated some level of deficiency in their current physical condition.

6.3.2.1 North Jetty

The North Jetty (Figure 6-3) is constructed with a solid fill core supported by a steel sheet pile bulkhead fronted by a marginal wharf. This construction was undertaken in the 1940s to meet the needs of the Department of Defense during World War II. The marginal wharf is comprised of steel h-piles supporting a reinforced concrete super structure. The wharf structure is currently in poor condition and must be replaced or rebuilt to be usable for offshore wind staging. A 1996 design suggested rebuild costs (in current dollars) of about $15 million. The immediate backland is about 2.8 to 3.2 hectares (approximately 7 to 8 acres) with an additional 4.0 m (10 acres) or more immediately adjacent.

The City has included the North Jetty rebuild in its application for a TIGER grant. Although the rebuild will correct current deficiencies, it will still leave the wharf with a deck capacity of only 2,930 kg/m^2 (approximately 600 lb/ft^2), which is insufficient for unit loading under certain situations. Depending on the developer's operations, this capacity may require the use of a high capacity crane set up on the solid fill backlands.

Figure 6-3 North Jetty Port of Boston
(Source: Childs Engineering Corporation)

6.3.2.2 Dry Dock #4

The BRA has identified a 5.2 to 5.7 hectares (13 to 14 acre) parcel at the Dry Dock #4 site in the Marine Industrial Park in South Boston (Figure 6-4) for possible expansion. The existing dry dock is in very poor condition, but could be rebuilt to provide a two-sided solid fill pier with almost 549 m (1,800 feet) of berthing. Table 6-4 presents the cost estimate for the improvements to Dry Dock #4 identified to be necessary to support offshore wind farm development.

Figure 6-4 Dry Dock #4 at the Port of Boston
(Source: Childs Engineering Corporation)

Table 6-4
Cost Estimate for Improvements to Dry Dock #4 at the Port of Boston
(Source: Childs Engineering Corporation)

COST ESTIMATE							DATE PREPARED Nov-09	SHEET 1 OF 1
ACTIVITY AND LOCATION Boston Harbor Drydock #4 Parcel - South Boston Install repair bulkhead, fender system, Fill drydock and pave Estimated in 2009 prices				CEC JOB NUMBER 2178-09 ESTIMATED BY DLP STATUS OF DESIGN _X_ PED ___ 35% ___ 65% __ 100% ___ FINAL ___ OTHER			IDENTIFICATION NUMBER CATEGORY CODE NUMBER JOB ORDER NUMBER	
	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
ITEM DESCRIPTION	NO.	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
Soft Costs								
Engineering/Permits/Procurement	1	LS					$1,000,000	$1,000,000
Site Prep								
Site cleanup	1	LS					$250,000	$250,000
Bulkhead								
Sheeting- PZ27	3,500,000	LB					$3	$10,500,000
Mudslab Installation	6,000	CY					$200	$1,200,000
Wale-][MC 12x31	100,000	LB					$3	$300,000
Weep Drains @ 10' o.c.	200	EA					$150	$30,000
Tie- Rod	100,000	LB					$6	$600,000
Structural Fill- btween old and new sheets	10,000	CY					$35	$350,000
Concrete Bulkhead Cap	200	CY					$650	$130,000
Concrete Slab	1,050	CY					$500	$525,000
12" Dia.Timber Piles (Fender)	200	EA					$3,000	$600,000
Drydock fill								
Placement of Material in Drydock	116,665	CY					$30	$3,499,950
Pave surface	70,000	SF					$10	$700,000
							Total Drydock Parcel Repair:	$19,684,950

Table 6-4 (continued)

	COST ESTIMATE					DATE PREPARED Oct-09	SHEET 1 OF 1	
ACTIVITY AND LOCATION Boston Harbor Drydock 4 Repair Estimated Maintenance Costs Estimated in 2009 prices				CEC JOB NUMBER 2178-09 ESTIMATED BY DLP STATUS OF DESIGN _X_ PED ___ 35% ___ 65% __ 100% ___ FINAL ___ OTHER			IDENTIFICATION NUMBER CATEGORY CODE NUMBER JOB ORDER NUMBER	
	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
ITEM DESCRIPTION	NO.	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
Soft Costs								
Engineering/Permits/Procurement	1	LS					$500,000	$500,000
Bulkhead Annual								
Recoating and anode replacement	25	EA	1% of cost				$105,000	$2,625,000
Fender system repair etc								
Bulkhead Five Year								
Recoating and anode replacement	1	EA	5% of cost				$525,000	$525,000
Fender system repair etc								
Bulkhead Ten Year								
Recoating and anode replacement	1	EA	5% of cost				$525,000	$525,000
Fender system repair etc								
Bulkhead Fifteen Year								
Recoating and anode replacement	1	EA	5% of cost				$525,000	$525,000
Fender system repair etc								
Bulkhead Twenty Year								
Recoating and anode replacement	1	EA	5% of cost				$525,000	$525,000
Fender system repair etc								
Bulkhead cost base is $10,500,000 Anticpated 25 year life no salvage						Total Drydock Parcel Maintenance:		$5,225,000

The dry dock would be filled with gravel, and new steel sheet piling would be installed around the deteriorated bulkheads. The estimated cost to rebuild the site is approximately $20 million.

This site would provide nominal laydown space, but the solid fill pier has very high ground capacity and the berth has “bonus” length. Although the site does not have covered space, there are such structures and warehouses in the Boston Marine Industrial Park that could be used or converted for use for this purpose.

Dry Dock #4 could accommodate the staging of offshore wind development with improvements at a reasonable cost. However, from a planning perspective, there are potentially permitting issues associated with these improvements due to Dry Dock #4’s proximity to Logan Airport. Tall equipment, such as cranes, as well as future installation vessels transporting assembled turbines in a vertical configuration, may require approvals from the FAA. Furthermore, the potential wind farm locations are much closer to New Bedford Harbor than Boston Harbor.

6.3.2.3 Coastal Oil Site

The Massachusetts Port Authority owns the former Coastal Oil Terminal in South Boston (Figure 6-5). The site is approximately 14.2 hectares (approximately 35 acres) and has a former oil tanker berth with a water depth in excess of 10.3 m (34 feet). The facility would require a new steel sheetpile bulkhead to be adequate for laydown. It also would need regrading and paving to “cap” any environmental contamination. The site does not have any covered space, and there is no covered space on the immediately adjacent parcel. The berth is a mooring dolphin-type structure seaward of an old seawall. The estimated cost for the repairs is approximately $20 million. Table 6-5 is the cost estimate for improvements to the Coastal Oil Terminal.

The Team believes the preferred option at the Port of Boston is Dry Dock #4. The site meets most of the established criteria. The rebuild cost is similar to the cost of repairs for the North Jetty. However, Dry Dock #4 has significantly more berthing space, which more than offsets any potential repair/rebuild cost savings.

Table 6-5
Cost Estimate for Improvements to the Coastal Oil Site at the Port of Boston
(Source: Childs Engineering Corporation)

COST ESTIMATE		DATE PREPARED Dec-09	SHEET 1 OF 1
ACTIVITY AND LOCATION Boston Harbor Coastal Oil - South Boston Install repair bulkhead, fender system, Fill between existing and new sheet piling, grade and pave Estimated in 2009 prices	CEC JOB NUMBER 2178-09 ESTIMATED BY DLP STATUS OF DESIGN _X_ PED ___ 35% ___ 65% __ 100% ___ FINAL ___ OTHER	IDENTIFICATION NUMBER CATEGORY CODE NUMBER JOB ORDER NUMBER	

ITEM DESCRIPTION	QUANTITY NO.	UNIT	MATERIAL COST UNIT COST	MATERIAL COST TOTAL	LABOR COST UNIT COST	LABOR COST TOTAL	ENGINEERING ESTIMATE UNIT COST	ENGINEERING ESTIMATE TOTAL
Soft Costs								
Engineering/Permits/Procurement	1	LS					$1,000,000	$1,000,000
Site Prep								
Site cleanup	1	LS					$250,000	$250,000
Bulkhead								
Sheeting- PZ27	1,700,000	LB					$3	$5,100,000
Mudslab Installation	4,000	CY					$200	$800,000
Wale-][MC 12x31	35,000	LB					$3	$105,000
Weep Drains @ 10' o.c.	80	EA					$150	$12,000
Tie- Rod	40,000	LB					$6	$240,000
Structural Fill- between old wall and new sheets	30,000	CY					$35	$1,050,000
Concrete Bulkhead Cap	100	CY					$650	$65,000
Concrete Slab	1,050	CY					$500	$525,000
12" Dia.Timber Piles (Fender)	80	EA					$3,000	$240,000
Regrade and Pave								
Grade	80,000	SY					$15	$1,200,000
Pave surface	900,000	SF					$10	$9,000,000
							Total Coastal Oil Repair:	$19,587,000

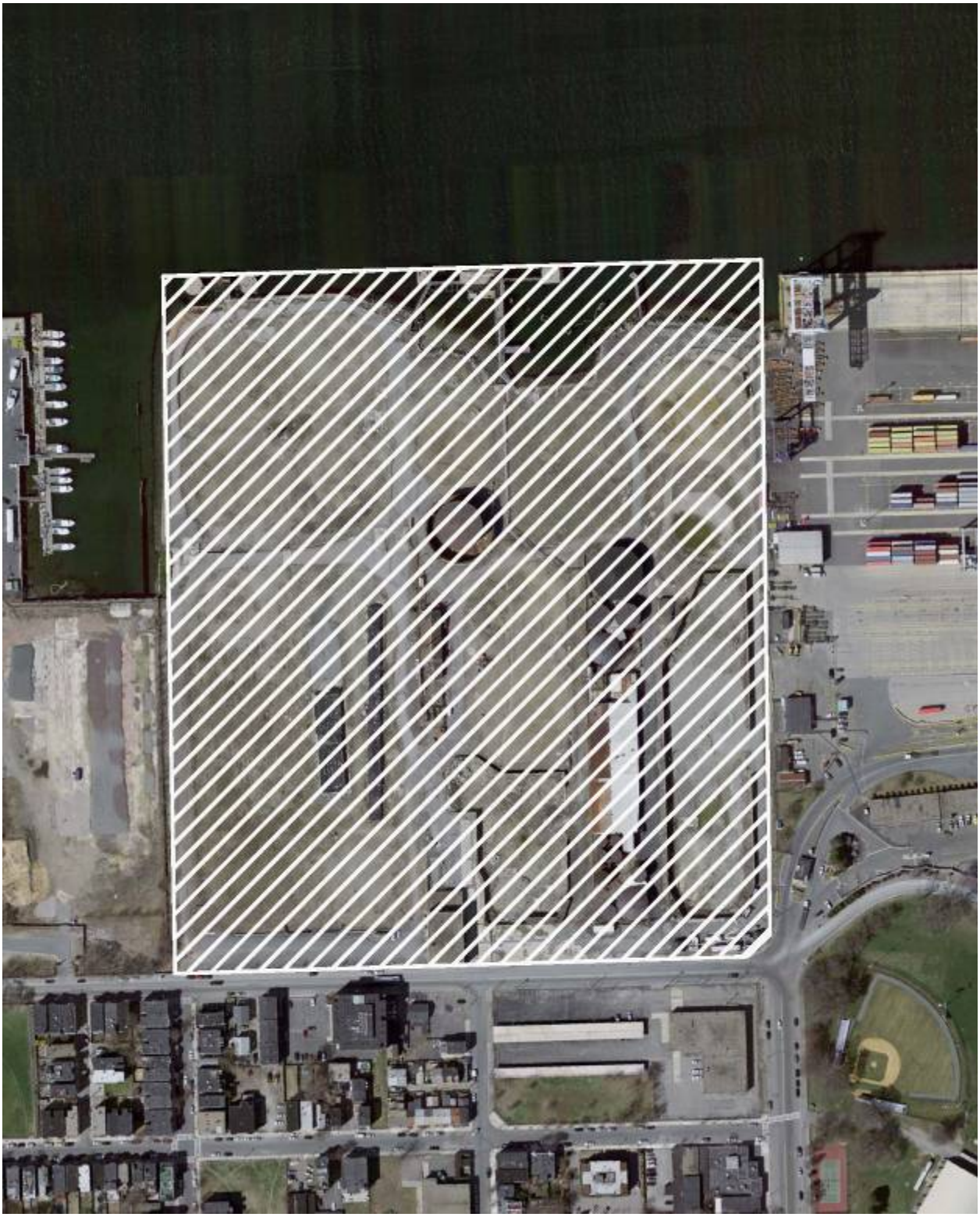

Figure 6-5 Coastal Oil Terminal Port of Boston
(Source: Childs Engineering Corporation)

6.4 Implications of Applying the Soft Criteria

The Team examined education and training needs required to support the offshore wind energy industry. See Appendix I for the questionnaire used to interview various educational and training institutions. More effective state support for renewable energy has encouraged investment in workforce training at many levels. The Massachusetts Maritime Academy (MMA) is nationally known for its mariner training programs, and a regional Marine Renewable Energy Center (MREC) at the University of Massachusetts/Dartmouth (UMass/Dartmouth) joins the resources of some of the region's leading academic institutions, community colleges, and trade unions to coordinate and plan appropriate training for this emerging industry. Given the relative proximity of the ports in this study to these educational resources, Massachusetts is well-positioned to assess the work force needs of each offshore wind energy developer and provide responsive, high-quality training.

Massachusetts has long been recognized as an international center for science, technology, and oceanography. There is considerable local and regional interest in developing technology and the necessary trade skills to harness renewable energy from the ocean. Since the late 1990s, when the idea of offshore wind energy projects first began to surface in Massachusetts, academic institutions and unions representing trade industries identified offshore renewable energy as an important field that would require new technologies and a corresponding demand for new training. Additional focus on Massachusetts as an emerging center for offshore construction occurred in 2004, when plans were developed for the first LNG deepwater port on the east coast of the United States, and the second such facility worldwide. The Northeast Gateway Deepwater Port was completed in 2007 and another similar facility is nearing completion. Both projects utilized local trade and construction workers to complete sub-sea pipelines and buoys.

A lengthy list of public and private academic institutions, including the Amherst and Dartmouth campuses of the University of Massachusetts system, Harvard University, the Massachusetts Institute of Technology, the Massachusetts Maritime Academy, and the Woods Hole Oceanographic Institute, (as well as other institutions in the region) have examined and will continue to explore numerous issues related to offshore renewable energy generation. These issues include energy production, facility design, transmission issues, and maritime training. These institutions, with evolving degree programs, unrivalled intellectual capital, and interest in furthering the development of offshore renewable energy, are an exceptional resource for policy makers, developers, builders, and maintenance firms.

State government, academic institutions, and local unions have all recognized the importance of offshore sites along the Massachusetts coast for both traditional and renewable sources of energy. At the state level, Governor Deval Patrick reversed the prior Administration’s opposition to the Cape Wind project and moved quickly to combine energy and environmental agencies in a cabinet-level secretariat with an emphasis on renewable energy. State agencies worked closely with the Massachusetts Renewable Energy Trust, part of a quasi-state agency funded through an excise tax on electricity consumption, and the Commonwealth’s Clean Energy Center to provide resources and expertise to move the Commonwealth toward the Patrick Administration’s 2020 goal of providing 2,000 MW of land- and ocean-based wind energy. With relatively shallow offshore waters and excellent wind resources, offshore wind energy became an increasing focus of renewable energy efforts. In a coordinated effort, the Patrick

Administration also pushed for passage of the Massachusetts Ocean Management Act, under which it has developed a plan that identifies sites within state waters for new offshore wind farm development, in addition to potential federal sites in adjacent waters that come under the jurisdiction of the U.S. Minerals Management Service.

The emerging field of offshore wind energy has already led to the development of a number of new technologies and applications, requiring a trained workforce to assemble, construct, operate, and maintain offshore wind turbines. Based on European experience, an eighty-turbine offshore wind energy project, for example, would typically need a number of trained individuals for the installation phase as presented in Table 6-6.

Table 6-6
Workers Required for Typical 80-Turbine Offshore Wind Energy Project
(Source: Thomsen 2009)

Turbine Installation	
Type of Worker	Number of Workers Required
Vessel officers and crew	25 people per shift per day
Installation crew	12 people per shift per day
Preassembly	12 people per shift per day
Harbor workers	12 people per shift per day
Project management	25 people to plan and execute all work
Crane and truck rental	25 people (e.g., crane operators, forklift/truck drivers)
Foundation Installation	
Vessel officers and crew	25 people per shift per day
Installation crew	18 people per shift per day (piling operations are more manpower intensive than turbine installation)
Preassembly	25 people per shift per day
Harbor workers	12 people per shift per day
Project management	25 people to plan and execute all work
Assistance from agents and port authorities	20 people
Crane and truck rental	25 people (e.g., crane operators, forklift/truck drivers)
Cable Installation	
Vessel officers and crew	25 people per shift per day
Diving crew	10 people
Installation crew	12 people per shift per day
Preassembly	12 people per shift per day
Harbor workers	12 people
Project management	25 people to plan and execute all work

Based on these figures, each phase of the construction process for offshore wind farms could require as many as 150 skilled workers, with another 80 workers for each additional daily shift.

European offshore wind developers have reported shortages among skilled workers in related trades, and potential offshore wind energy developers in the United States have described similar concerns. While the two short-listed Massachusetts ports have characteristics that make

them suitable for the construction, operation, and maintenance of offshore wind energy facilities, they also have ready access to considerable education and training resources that are geared to offshore and underwater construction, seamanship, and technical trades and services. Given the relative proximity of these ports (as well as all of the Massachusetts ports considered in this study) to these education and training resources, Massachusetts is uniquely situated to respond to developers' needs for a variety of construction and operational technologies.

Recognizing that a wide variety of skill sets would be needed to construct, operate, and maintain offshore renewable energy facilities in Massachusetts, the MREC, an organization of industry, academia, government agencies, municipalities, public interest groups, and concerned individuals, was established at the UMass Dartmouth in 2006. MREC's goal is to foster the development of ocean-based renewable energy, including wave, tidal current and offshore wind, and is unique in that it brings together the knowledge and needs of science, technology, and training in order to successfully maximize renewable energy resources from the ocean. MREC seeks to develop a network of technology developers and energy users who will collectively define the needs of this nascent industry and bring together the required technology, capital, infrastructure, and human resources to implement ocean-based renewable energy in the most economically, environmentally, and socially sustainable manner for the region.

MREC has also proposed a National Offshore Renewable Energy Innovation Zone (NOREIZ) and is working with state and federal agencies to designate an area off of Nantucket and Martha's Vineyard for this purpose. The proposed project would provide demonstration and training sites for marine renewable energy, particularly offshore wind, and is envisioned as a critical asset for training, technology development, and small scale energy generation.

In addition to UMass/Dartmouth, MREC's university research consortium partners include:

- the University of New Hampshire (UNH);
- the University of Rhode Island (URI);
- the University of Maine (UMaine);
- the Massachusetts Institute of Technology (MIT);
- the Woods Hole Oceanographic Institution (WHOI);
- the Massachusetts Maritime Academy (MMA);
- Roger Williams University (RWU); and
- other schools within the University of Massachusetts system.

MREC corporate partners include:

- Battelle;
- Alden;
- Raytheon;
- National Grid;
- NStar;
- Lockheed/Martin;
- the New England Clean Energy Council; and

- the Ocean Renewable Energy Coalition.

Understanding that the offshore energy industry is evolving within the United States and New England, MREC joined forces with Cape Wind, Resolute Marine Energy, Ocean Renewable Power Company, Local 56 Pile Drivers Union, the MMA, the New Bedford Department of Workforce Development, and the community college system to form the Ocean Energy Training Task Force. The Task Force meets regularly to identify issues and to discuss how best to meet the needs of offshore energy developers, and draws on the expertise of each of its members.

Under the MREC/Task Force umbrella, significant education and training programs related to offshore renewable energy are being developed and some are currently offered. It is anticipated that these courses will evolve significantly to address future development needs. The Task Force, in discussions with the European Marine Energy Center (EMEC) and the New and Renewable Energy Center (NaREC) UK, have developed framework for education and training that encompasses three elements:

1) University level education to produce a cadre of researchers, engineers, and other professionals for the development of new technologies.
2) Construction skills training by unions and Workforce Investment Boards to support the construction and installation of ocean based turbines.
3) Operation and Maintenance (O&M) technician training and certification following the NaREC model of instruction at community colleges and training/certification at the MMA and MREC-developed ocean test sites.

At the University level, Oceanography and Ocean Engineering programs are in place with MREC Research University Consortium members. UMass/Dartmouth offers masters and doctorates in marine science and technology through the School for Marine Science and Technology (SMAST), has a range of sustainability courses that can be tailored to address ocean renewable energy, and offers a masters degree in public policy with concentrations in economic development, marine science, and technology policy. As with other MREC members, UMass/Dartmouth is very much interested in the national effort to establish a certificate program aimed at training oceanographic science and technology operations personnel to service ocean observatories, many of the skills that are transferable to offshore energy projects.

The MMA is well-known for its traditional courses in seamanship for maritime officers, which are essential to the construction and maintenance of offshore energy facilities. MMA also offers established training for power plant operations and has aggressively implemented renewable energy on campus with wind, solar, tidal, and geothermal projects. Located at the west end of the Cape Cod Canal, MMA will be a key asset in any training program that would require water access. As with other MREC partners, MMA will revise, as appropriate, existing energy-related courses to address ocean energy needs and issues.

Two MREC partners, Cape Cod Community College and Bristol Community College, have joined forces to provide clean energy workforce training, have a proven track record of providing targeted training to their local communities, and have offered training programs in the marine technology subject area. Bristol Community College currently has a grant with the National Science Foundation to offer certificates in environmental technology, marine technology and geographic information systems and offered a pilot tidal energy technician training program in

2009 that will be expanded in the future. The MMA is a partner in this effort and has tailored existing energy-related courses to address ocean energy, as appropriate.

At the construction skills level, Massachusetts trade unions have been very active in identifying offshore energy construction needs and developing appropriate training courses. For example, Local 56 of the Massachusetts Pile Drivers is a statewide organization that has been at the forefront of training workers for offshore energy. Targeting vocational technical school students, Local 56 either currently offers, or is planning to offer, training in the following areas:

- Four-year apprenticeships in pile driving and marine construction, including rigging, welding burning and fitting, and marine construction safety;
- Commercial diving training, for the inspection, trenching, and maintenance of sub-sea electrical cables;
- Pile driving and welding for wind turbine towers;
- Rigging and material handling for loading and unloading; and
- Rigging for tower, nacelle, and blade assembly.

Local 56 has a proven track record in responding to industry needs by providing high-quality training. Since January, 2007, Local 56 has offered training for commercial divers and pile drivers to work in the offshore natural gas industry, with 60 commercial divers working on four different offshore pipeline jobs along the Massachusetts coast. Its training programs have expanded to include underwater welding, with successful graduates completing over 60,000 hours on eight different construction contracts since May, 2007. Local 56 is currently working with the Occupational Safety and Hazards Administration (OSHA) and the Carpenters International Training Fund to develop a course on Marine Construction Safety.

Similarly, the International Brotherhood of Electrical Workers (IBEW) Local 103 has demonstrated its leadership in support of the renewable energy industry through the erection of a publicly visible 100 kilovolt (kV) wind turbine and the installation of a 5.4 kV solar roof at its headquarters and Apprentice Training Facility in Dorchester. As the IBEW increases its focus on renewable energy, it uses working non-fuel energy systems for training and will open its “Big Green Room” in 2010 to present a variety of different training tools that relate to hydro, wind, and solar generation technologies. The union’s strong commitment to safety, and current training certifications in tower climbing, working in confined spaces, and scuba proficiency, all have direct applications in the emerging offshore wind generation industry. Currently one half of IBEW local workers are trained in scuba and wind technology. In addition, the IBEW has been working with the MMA on wind generation construction and marine training.

With the state aggressively supporting the development of offshore wind energy through policy initiatives, expertise, and financial support, and with academic institutions and trade unions actively developing and improving training opportunities, Massachusetts is well situated to respond to a wide variety of technologies used to harness renewable energy in offshore waters. Given its broad geographic coverage, extensive research facilities, in-depth industry expertise, and a trained, flexible work force, Massachusetts is in a unique position to successfully meet the needs of the offshore wind energy industry.

Soft criteria also include regulatory considerations. Port facility upgrades may require Massachusetts environmental review if the project meets or exceeds certain thresholds

established by the Massachusetts Environmental Policy Act (MEPA). A variety of federal, state and local permits also may be required, including, but not limited to:

- U.S. Army Corps of Engineers (USACE) Section 10 permit for structures in navigable waters;
- USACE Section 404 permit for discharge of dredged or fill materials into waters of the U.S.;
- Federal Aviation Administration (FAA) Determination of No Hazard;
- Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) permit;
- EPA Air Emission permit;
- Massachusetts Coastal Zone Management (MCZM) Consistency Determination;
- Massachusetts Department of Environmental Protection (MassDEP) Water Quality Certificate;
- MassDEP Chapter 91 License for work in, under, or over flowed or filled tidelands;
- Massachusetts Department of Transportation (MDOT) oversize/overweight vehicle permit;
- Local Conservation Commission Order of Conditions for alteration of “any bank, fresh water wetland, coastal wetland, beach, dune, flat, marsh, meadow, or swamp bordering on the ocean or on any estuary (a broad mouth of a river into which the tide flows.), creek, river, stream, pond, or lake, or any land under said waters or any land subject to tidal action, coastal storm flowage, or flooding”; and
- Local zoning, building or utility permits.

7.0 ECONOMIC AND TAX EFFECTS OF CONSTRUCTION AND OPERATING EXPENDITURES

Based on the criteria presented above, the New Bedford South Terminal and Boston Dry Dock #4 were selected for further evaluation and analysis. This section discusses the economic and fiscal effects of construction and operation of these ports to support a ROWEI 130-turbine wind farm. See Appendix J for a more detailed analysis of economic and tax effects.

7.1 Construction and Operating Period Economic Effects

Data in Table 7-1 show the estimated total direct, indirect, and induced economic effects of expenditures made to construct the New Bedford South Terminal port facility, Boston Dry Dock #4, and the ROWEI 130-turbine installation. These are one-time, non-recurring projected economic effects that are expected to accrue within the Massachusetts economy during a 3 to 5 year period that includes port facility construction and the ROWEI offshore wind turbine installation.

Table 7-1 also shows the annually recurring economic effects of maintaining a ROWEI and of handling, storing, and transshipping non-offshore wind related cargo at a multi-use South Terminal port facility in New Bedford. In the case of the Boston and New Bedford port facilities, economic effects during construction are shown for Suffolk and Bristol counties, respectively. The annually recurring economic effects of new non-offshore wind-related cargo operations at the South Terminal are shown for Bristol county as well as Massachusetts overall.

The measures of economic effects are:

- Output – which comprises business sales less the costs of materials and equipment produced outside Massachusetts;
- Employment – the full-time equivalent jobs expected to be held by Massachusetts residents;
- Income – the payroll and self-employment earnings of households; and
- GDP (Gross Domestic Product) – which measures the value added to the Massachusetts economy in terms of labor and proprietors' income, corporate profits, dividends, interest, rent and taxes.

The county-level economic effects in Table 7-1 are a subset of the Massachusetts totals and show the amounts of local and state direct, indirect, and induced economic effects that would accrue within communities in Bristol and Suffolk counties.

Table 7-1
Total Direct, Indirect, and Induced Economic Effects of Offshore Wind Installation and Related Port Facilities Construction and Operation
(Sources: FXM Associates, R/ECON™ Input Output Model, Tetra Tech Team, City of Boston, City of New Bedford, Cape Wind)

		Output (000 $)	Employment (Jobs)	Income (000 $)	GDP (000 $)
Construction Period Effects					
South Terminal Port Facility					
	Bristol County	*$ 44,100*	*380*	*$ 19,200*	*$ 26,100*
	Massachusetts	$ 65,500	540	$ 26,100	$ 36,200
Boston Port Facility					
	Suffolk County	*$ 19,800*	*110*	*$ 9,100*	*$ 12,400*
	Massachusetts	$ 30,100	190	$ 12,500	$ 17,200
Representative Offshore Wind Installation					
	Massachusetts	$ 457,300	1700	$ 162,900	$ 200,100
Annual Operating Effects					
South Terminal Port Cargo Operations					
	Bristol County	*$ 15,700*	*130*	*$ 5,900*	*$ 9,700*
	Massachusetts	$ 20,200	170	$ 7,400	$ 11,900
ROWEI O&M					
	Massachusetts	$ 27,500	110	$ 6,800	$ 11,000

7.2 Construction and Operating Period Fiscal Effects

The total direct, indirect, and induced tax effects shown in Table 7-2 correspond to the economic effects shown in Table 7-1. Local taxes include property and excise taxes paid to municipalities by workers in the jobs generated by the construction and operating period employment reflected in Table 7-1, as well as property and other local taxes by the companies employing those individuals. State taxes include income and sales taxes paid by individuals as well as payroll, income, and other taxes paid by the companies that employ those individuals. The taxes are thus proportional to the total direct, indirect and induced economic effects shown in Table 7-1. However, these totals do not represent all taxes paid by companies whose output is only partly affected by the changes in demand attributable to construction and operating periods of offshore wind energy installation and maintenance, port construction and terminal operation.

Table 7-2
Total Direct, Indirect, and Induced Tax Effects of Offshore Wind Installation and Related Port Facilities Construction and Operation
(Sources: FXM Associates and R/ECON™ Input Output Model)

		Local Taxes (000 $)		State Taxes (000 $)		Federal Taxes (000 $)
Construction Period Effects						
South Terminal Port Facility						
Bristol County	*$*	*480*	*$*	*440*	*$*	*1,820*
Massachusetts	$	1,190	$	1,440	$	7,280
Boston Port Facility						
Suffolk County	*$*	*190*	*$*	*220*	*$*	*1,290*
Massachusetts	$	500	$	640	$	3,540
Representative Offshore Wind Installation						
Massachusetts	$	8,850	$	10,090	$	45,940
Annual Operating Effects						
South Terminal Port Operations						
Bristol County	*$*	*300*	*$*	*240*	*$*	*730*
Massachusetts	$	480	$	500	$	2,180
ROWEI O&M						
Massachusetts	$	390	$	430	$	2,230

As shown in Table 7-2, nearly $9 million in taxes to be paid to municipalities throughout Massachusetts are estimated to be attributable to the direct, indirect and induced economic effects shown in Table 7-1 over the projected 3-year construction (assembly and installation) phase of the ROWEI. More than $10 million in taxes paid to the Commonwealth of Massachusetts and almost $46 million in federal taxes over this same 3-year period would be attributable to the economic effects of construction. Servicing and maintaining the ROWEI is projected to generate an annual amount of $390,000 in municipal tax receipts throughout Massachusetts, $433,000 in state taxes, and $2.2 M in federal taxes. The county-level tax totals in Table 7-2 are a subset of the Massachusetts totals and show the amounts of local, state and federal tax effects that would accrue within communities in Bristol and Suffolk Counties.

7.3 Summary

As can be seen from these projections, the economic and fiscal effects of port development and use are roughly comparable for both ports. Therefore, the selection of one port over the other is more likely to be determined by the balancing of the soft criteria.

8.0 SUMMARY AND RECOMMENDATION

There are no port facilities in Massachusetts that are currently ready to provide staging, installation, and operations and maintenance support to a commercial scale offshore wind farm development project in the region. However, if investment in targeted port upgrades is made, the opportunity to attract offshore wind developers exists.

Table 8-1 provides a summary of the side-by-side comparison between Dry Dock #4 at the Port of Boston and the South Terminal at the Port of New Bedford based on the hard and soft evaluation criteria developed for this study. With specifically targeted upgrades, both Dry Dock #4 and the South Terminal would have acceptable harbor access and the navigational parameters needed to accommodate wind turbine delivery and installation vessels (based on a comparison of port characteristics to the 1st Tier Hard Criteria).

For the most part, both ports also are capable of accommodating the assembly and installation of offshore wind turbines and foundations (based on a comparison of port characteristics to the 2nd Tier Hard Criteria). An exception at the present time may be Rail and Highway Access. The Boston Redevelopment Authority (BRA) has a “shovel-ready” design for modifications to expand the existing rail line to Dry Dock #4. New Bedford has submitted a TIGER application to extend the existing rail line to the State Pier, but not to the South Terminal (Mayor Scott Lang, 2009). Highway Access to both port areas is adequate. The Boston Haul Road currently has several bridges that would impose limitations on the transport of large turbine and/or foundation components. However, Massport and the BRA have plans to expand the freight roadway network at the Port. Despite the relative advantages and disadvantages associated with current rail/highway access at each port, neither port becomes a clear frontrunner based on these two criteria. Because rail and highway delivery of offshore wind generation components would be constrained by the weight and dimensions of the foundations and turbines, it is unlikely that this means of delivery would be used for these large primary components. And the distinction becomes less of an issue as the larger next generation wind turbine components currently in development will only be able to be transported by water.

Table 8-1
Comparison of the Two Short-Listed Ports

	Port of Boston Dry Dock #4	New Bedford Harbor South Terminal	Comments
1st TIER HARD CRITERIA			
Protected Harbor	●	●	Both ports are acceptable.
Shipping Channel Depth	●	●	Both ports are acceptable.
Overhead Clearance	●	●	Both ports are acceptable.
Horizontal Clearance	●	●	Both ports are acceptable.
24/7 Operational Ability	●	●	Both ports are acceptable.
Exclusive Use of Port Facility	●	●	Both ports are acceptable.
2nd TIER HARD CRITERIA			
Berth Length	●	●	Both ports are acceptable.
Shipping Vessel Water Depth	●	●	Both ports are acceptable.
Total Wharf and Yard Upland Area	●	●	Both ports are acceptable.

	Port of Boston Dry Dock #4	New Bedford Harbor South Terminal	Comments
Rail Access	●	⦿	BRA has a design to expand rail access to Dry Dock #4. New Bedford has submitted TIGER application to extend rail line to State Pier, but not to South Terminal.
Highway Access	⦿	●	Despite adequate highway access to port area, the Boston Haul Road currently has vertical/ horizontal limitations; however, a new freight roadway system is planned.
Proximity to Construction Site	⦿	●	South Terminal is closer to the planned offshore sites than Dry Dock #4 (as of January 2010).
SOFT CRITERIA			
Workforce Availability	●	●	
Education and Training Facilities	⦿	⦿	In U.S., education and training programs are now being developed for nascent offshore renewable energy industry. Given extensive research facilities, in-depth industry expertise, and trained, flexible work force, Massachusetts will be able to successfully meet education and training needs.
Political Climate/Community Acceptance	⦿	●	New Bedford has a Green Port initiative in place, has done study on South Terminal development, has submitted various proposals for infrastructure grants, and has the goal of strengthening its economy by focusing on renewable energy such as offshore wind. The BRA has emphasized a commitment to sustainability but may not be focused on the seaport. Dry Dock #4 currently has a tenant.
Regulatory Considerations	⦿	●	Required permits could include, but are not limited to: MEPA review; CZM Consistency Certification; USACE Section 404 and 10 Permits, FAA approval; Chapter 91 License/Permit; Water Quality Certification; NPDES Permit; Order of Conditions. Certain circumstances at each port may eliminate or reduce regulatory process. FAA approval at Dry Dock #4 may be problematic.

LEGEND:
- ● Acceptable / Most Supportive of offshore wind farm development
- ⦿ Qualified Acceptability / Degree of Supportiveness of offshore wind farm development
- ○ Unacceptable / Not Supportive of offshore wind farm development

The proximity of a port to prospective offshore wind farm sites is important in terms of minimizing cost and controlling transportation-related risk. These considerations indicate an advantage to the closer staging port. Based on available public information as of January 2010

regarding proposed offshore wind farm sites, the South Terminal at New Bedford Harbor is closer to these potential installation sites than is Dry Dock #4 at the Port of Boston.

A key soft criterion is Political Climate/Community Acceptance of the cities and towns associated with each port. The City of New Bedford has established a goal of strengthening its economy by focusing on supporting the renewable energy industry. New Bedford already has completed a study on development of the South Terminal as a port facility to support renewable energy technology companies (*Port of New Bedford Massachusetts, South Terminal Development, Renewable Energy Marine Park*, dated March 2009). The New Bedford HDC has received grant money from the Governor's Seaport Council for navigational dredging, identifying port infrastructure needs, and evaluating potential markets for the Port of New Bedford, among other projects. New Bedford has applied for a TIGER grant of approximately $36M for integrated intermodal transportation infrastructure improvements, which include expansion of the South Terminal. In Boston, the BRA has demonstrated its commitment to environmental sustainability by launching a pilot program to help small businesses improve their energy efficiency and sustainability practices. However, this initiative is not focused specifically on the seaport.

Another soft criterion, Regulatory Considerations, involves the environmental review and permitting processes that may be required for the port projects. Work in and around Massachusetts waters may require state environmental review, if one or more MEPA review thresholds is met or exceeded. Installing and operating an offshore wind farm also will require obtaining a number of federal, state, and local permits. MEPA review of a major port improvements project could take between six months and one year, depending on the type of MEPA review triggered and the amount and intensity of political and community support for the project. Permitting such a project may require a similar amount of time, depending on (among other factors) the complexities of the project, the number and length of public comment periods, and the duration of mitigation negotiations that must be conducted between the project proponent and the regulatory agencies.

Since some of the environmental impacts of the South Terminal site have already been assessed by the Commonwealth as part of the Superfund cleanup response for the site, MEPA review of the South Terminal expansion may be streamlined or limited. The permits required for this project are contingent on its projected impacts on regulated resources. The dredging component of the port expansion project may be covered under the State Enhanced Remedy CAD Cell Dredge Disposal Approval for the cleanup. However, other permits/approvals may still be required.

If the required upgrades to Dry Dock #4 at the Port of Boston can be defined as maintenance activities authorized under existing permits, the regulatory process may be circumvented or limited. Nevertheless, because of its proximity to Logan International Airport, obtaining FAA approval of crane heights at Dry Dock #4 could prove to be a lengthy process. The level of MEPA review required for the Dry Dock #4 improvements also would depend on which thresholds were exceeded, if any. Other permits/approvals may be required.

Determining the permits applicable to either project was not within the scope of this report. Additional research would be required to verify which, if any, permits would be needed. If support of renewable energy and immediate job creation are important political objectives in the Commonwealth, it would follow that the port project with the shortest regulatory track and the

greatest political and community support would emerge as the best project to meet those objectives.

Upon review of the side-by-side comparison of the two short-listed ports presented in Table 8-1, it is seen that:

- Both ports and highlighted wharf areas are equally acceptable with regard to the 1st Tier Hard Criteria relating to navigation.
- The South Terminal at the Port of New Bedford displays a slight advantage over Dry Dock #4 at the Port of Boston with respect to the 2nd Tier Hard Criteria associated with Highway Access and Proximity to Construction Sites.

Both ports are equally acceptable with regard to the Soft Criteria relating to Workforce Availability and Education and Training Facilities. In addition, the comparison of the projected economic and fiscal impacts (Section 7) indicated that the two short-listed ports also were very comparable relative to these projections as well.

- The South Terminal at the Port of New Bedford is indicated to be advantageous relative to Dry Dock #4 with respect to the Soft Criteria of Political Climate/Community Acceptance and Regulatory Considerations.

Based on this comprehensive side-by-side comparison, the Team has concluded that the expansion of the South Terminal at the Port of New Bedford represents the best opportunity for a Massachusetts port facility to accommodate assembly and installation of offshore wind energy projects. In addition, the new facility will provide sufficient economic and fiscal benefits to Bristol County and the Commonwealth of Massachusetts to make the investment attractive and worthwhile. This recommendation does not preclude and should not discourage possible future upgrades to Dry Dock #4 at the Port of Boston to service the offshore wind industry as the level of offshore construction activities increases and other roles become available. However, at this time, the political support, advanced planning effort, proximity to offshore sites, and absence of FAA obstacles have led the Team to recommend the South Terminal expansion.

9.0 PATH FORWARD – HIGH-LEVEL SOUTH TERMINAL BUSINESS PLAN

Based on the recommendation presented above, the Team prepared portions of a preliminary business plan for a multi-use cargo facility at the South Terminal in the Port of New Bedford (see Appendix K). Some specific objectives of this effort were to establish an initial path forward and identify:

(1) potential cargoes and revenues for the South Terminal facility, in addition to those associated with the staging, installation, and operations and management of a ROWEI;

(2) independent estimates of costs for facility upgrades;

(3) an appropriate governance model for multi-use terminal ownership and management; and

(4) preliminary standards of operation for the expanded facility.

Toward this end, the Team examined:

- prospective cargo demand;
- port governance/terminal management options;
- potential capital and operating costs;
- overall development feasibility; and
- potential economic effects associated with developing and operating a multi-use renewable energy terminal and general cargo facility at the South Terminal in the Port of New Bedford.

Sources for the analysis included: prior and ongoing studies (conducted by the New Bedford HDC and others); information obtained from offshore wind energy developers; and the relevant experience and related work of consultant team members and outside logistics experts. The following bullets summarize the findings of this effort:

- A new multi-use cargo facility at the South Terminal site represents the best option at the Port of New Bedford for servicing offshore wind energy development projects during the assembly and installation phases.
- A new multi-use port facility at the South Terminal can capture container, break-bulk (e.g., drums or crates), and bulk cargoes not now handled in New Bedford or other Massachusetts ports, and can generate economic development benefits and net operating income to the HDC with or without offshore wind energy development projects.
- The optimal model for governance of a new facility at the South Terminal would be ownership by the New Bedford HDC, which would lease offshore wind energy staging and other cargo handling, storage, and related facility operations to a qualified private operator.
- Capital costs for a new multi-use port facility at the South Terminal are estimated to total about $44 million ($44M) (in 2009 dollars). Approximately $32M of this total investment would be for land acquisition, bulkhead construction and dredging, and the buildings and site improvements that would be functionally necessary to attract and support offshore wind energy development projects (not including the Optional Fabrication Building for

offshore wind installation use). Approximately an additional $5M in capital expenditures would be for improvements necessary to attract and support new bulk, break-bulk, and container cargoes. Capital costs are shown in Table 9-1:

Table 9-1
South Terminal Capital Costs
(Source: FXM Associates, RECON™ Input Output Model)

SOUTH TERMINAL CAPITAL COSTS	Offshore Wind Installation	Non-Offshore Wind Cargoes
Bulkhead and Dredging	$ 19,990,977	$ 19,990,977
Site Acquisition	$ 2,100,000	$ 2,100,000
Backland Site Improvements (drainage, utilities, surfacing)	$ 6,000,000	$ 6,000,000
SUBTOTAL Basic Infrastructure	**$ 28,090,977**	**$ 28,090,977**
Buildings and structures (35,000 SF)	$ 3,500,000	$ 3,500,000
Crane		$ 3,000,000
Ground Equipment (fork lifts, trucks, etc.)		$ 1,500,000
Other Equipment & Fencing, Security	$ 485,000	$ 485,000
SUBTOTAL with Support Facilities & Equipment	**$ 32,075,977**	**$ 36,575,977**
Optional Fabrication Building (75,000 SF)	*$ 7,500,000*	*$ 7,500,000*
TOTAL with Fabrication Building	***$ 39,575,977***	***$ 44,075,977***

- Average net operating income to the HDC from a fully-developed South Terminal port facility is expected to total approximately $1.2M per year during a projected 3-year ROWEI and about $622,000 per year with full cargo operations. Projected operating revenues and costs are shown in Table 9-2 below:

Table 9-2
South Terminal Operating Income and Expenses
(Source: FXM Associates)

SOUTH TERMINAL OPERATING INCOME & EXPENSES	Offshore Wind Installation	Non-Offshore Wind Cargoes
Average Year Annual Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,500,000**	
Container Service		$ 280,000
Break Bulk Program		$ 240,000
Bulk Cargo		$ 432,500
Total Non-ROWEI Cargo		**$ 952,500**
Average Year Annual Operating Expenses		
HDC Personnel (contract/lessee management)	$ 140,000	$ 140,000
HDC Capital/maintenance reserve at 20% income	$ 190,500	$ 190,500
Average Year Annual Expenses	*$ 330,500*	*$ 330,500*
Average Year NET Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,169,500**	
Total Non-ROWEI Cargo		**$ 622,000**

- Based on the net operating income projected for the South Terminal, annual operating subsidies for either offshore wind energy development support or long term cargo operations are not anticipated to be required.

- The South Terminal can cover all of its operating expenses during the ROWEI use of the facility and annually thereafter based on non-ROWEI cargo operations. Approximately $12M of the capital costs for the new facility can be supported by annual net operating income combined with income from the 3 year ROWEI use of the facility. This leaves $32M of debt that would require financing from other sources.

- Construction of the South Terminal port facility is estimated to expand business output in Bristol County by approximately $44.1M over the projected 2-year construction period of the terminal, and provide 380 person years of employment and $19.2M in household income over the construction period. These projected economic impacts include total direct, indirect and induced economic effects within Bristol County. These effects are summarized in Table 9-3.

Table 9-3
Construction and Annual Direct, Indirect and Induced Economic Effects Associated with South Terminal Construction
(Source: FXM Associates)

		Output (000 $)	Employment (Jobs)		Income (000 $)
Construction Period Effects					
South Terminal Port Facility					
Bristol County	*$*	*44,100*	*380*	*$*	*19,200*
Massachusetts	$	65,500	540	$	26,100
Annual Operating Effects					
South Terminal Port Cargo Operations					
Bristol County	*$*	*15,700*	*130*	*$*	*5,900*
Massachusetts	$	20,200	170	$	7,400

- Construction of the South Terminal port facility is estimated to expand business output in Massachusetts overall (including Bristol County) by about $65.5M over the projected 2-year construction period of the terminal, and provide 540 person years of employment and $26.1M in household income over the construction period. These projected economic impacts include total direct, indirect and induced economic effects within Massachusetts over the construction period (see Table 9-3).

- The handling of cargoes not related to an offshore renewable wind energy installation (non-ROWEI), including container, break-bulk, and bulk cargoes, is estimated to expand business output in Bristol County by $15.7M annually, and provide 130 permanent jobs and $5.9M per year in new household income. These projected economic impacts include total direct, indirect, and induced economic effects within Bristol County estimated to recur annually following facility construction and do not include support of offshore wind energy projects (see Table 9-3).

- The handling of non-ROWEI container, break-bulk, and bulk cargoes at the South Terminal is estimated to expand business output in Massachusetts overall (including Bristol County) by approximately $20.2M annually, and provide 170 permanent jobs and $7.4M in new household income each year. These projected economic impacts include total direct, indirect, and induced economic effects within Massachusetts estimated to recur annually and do not include support of offshore wind energy projects (see Table 9-3).
- During the construction period for the South Terminal facility about $480,000 in local/municipal revenues within Bristol County communities would be attributable to the total projected direct, indirect and induced economic effects of construction. Within Massachusetts communities approximately $1.2M in municipal receipts (including Bristol County) would be attributable to the construction period economic effects (see Table 9-4).

Table 9-4
Construction and Annual Direct, Indirect and Induced Tax Effects
(Source: FXM Associates)

	Local Taxes (000 $)	State Taxes (000 $)	Federal Taxes (000 $)
Construction Period Effects			
South Terminal Port Facility			
Bristol County	*$ 480*	*$ 440*	*$ 1,820*
Massachusetts	$ 1,190	$ 1,440	$ 7,280
Annual Operating Effects			
South Terminal Port Operations			
Bristol County	*$ 300*	*$ 240*	*$ 730*
Massachusetts	$ 480	$ 500	$ 2,180

- During the construction period for the South Terminal facility about $1.4M in tax revenues to the Commonwealth of Massachusetts and approximately $7.3M in federal taxes would be attributable to the construction period economic effects (see Table 9-4).
- The handling of non-ROWEI container, break-bulk, and bulk cargoes at the South Terminal is expected to generate about $300,000 in new tax receipts annually for municipalities in Bristol County and $480,000 annually for municipalities statewide (including Bristol County) based on the projected annual economic effects attributable to cargo operations (see Table 9-4).
- The handling of non-ROWEI container, break-bulk, and bulk cargoes at the South Terminal is projected to generate about $500,000 in new tax receipts annually for the Commonwealth of Massachusetts and approximately $2.2M in federal taxes each year (see Table 9-4).

These components of a “path forward” relative to the development of an expanded multi-use cargo facility at the South Terminal address the key findings of preliminary business plan for

port expansion. (Appendix K provides a more detailed financial analysis of port expansion and operation.) This study demonstrated that the South Terminal at the Port of New Bedford meets the necessary requirements and possesses a number of the advantageous characteristics needed to successfully support a developing offshore commercial wind farm. The study also identified some areas where this port could make modifications and improvements to its harbor or wharf facilities that would further enhance the port's ability to support offshore wind energy. The path forward would continue the process outlined here, more fully develop the elements that were addressed in this study, and consider other important aspects of the port's development that were not considered to be critical to the scope of this study.

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APPENDIX 3

Apex Companies, LLC

Memo

To: File

From: Chet Myers, P.E., LSP

Date: April 8, 2010

List of Attendees:

Kristin Decas, Executive Director, NBHDC

Matt Morrissey, Executive Director, NBEDC

Craig Olmstead, Vice President, Projects, Cape Wind

David G. Inman, Key Account Manager, Siemens Energy, Inc., Power Systems

Jesper Pedersen, Tender Manager, Siemens Power Generation

Poul Martin Wael, Director Offshore Projects & Logistics, Siemens Wind Power

Preben Straarup, Tender Manager, Siemens Wind Power

Lars Humlebaek, Technical Project Manager, Siemens Wind Power

Jay Borkland, Division Manager, Apex Companies, LLC

Chet Myers, Senior Engineer, Apex Companies, LLC

Re: Summary of Meeting with Cape Wind and Siemens Personnel

Meeting was held at New Bedford City Hall at approximately 1 PM. NBHDC and NBEDC presented the plans for the expansion of South Terminal to support the offshore renewable energy industry. Cape Wind and Siemens described the needs of the offshore renewable energy industry for a shore-side support facility, based upon the needs of similar projects in Europe.

The following information was provided by Cape Wind and Siemens as crucial for the new facility to be feasible.

- There are a few types of vessels that would be used to transport wind turbine components from the manufacturer to the support facility. However, the approximate range in sizes of an international vessel is between 140 - 150

meters (460 – 490 feet) in length, 30 - 35 meters (98 - 115 feet) in width and requires 7 – 9 meters (23 – 29.5 feet) of draft.

- The international vessel would only carry components for 6 turbines. Therefore, for constructing an offshore wind energy facility for 130 turbines, 22 separate shipments from international vessels would need to be received at the support facility. The international vessel will require 3-4 days of docking for unloading each trip.
- Offshore renewable energy facility installation ships would consist of jack-up barges that would be approximately 91 meters (300 feet) in width and 30 meters (100 feet) in width.
- In order to keep the installation vessels stable during dockside loading, the barges would be deploy their spuds to "jack-up" the vessel for stability. This is to prevent the vessel from tipping over from uneven loading. Due to the loads anticipated to be borne by the spuds, it is necessary to ensure that the harbor floor at the quae-side is of a stable material. An unstable harbor bottom could cause the spuds to sink unevenly, which could tip the vessel and sink it. Harbor bottoms consisting of a thick layer of silt or clay could also cause the spuds to sink too deeply as it is loaded, and prevent the spuds from being withdrawn, which will trap the vessel at the facility.
- In order to efficiently run construction of the offshore renewable energy facility, multiple installation vessels must be utilized. At a minimum, one installation vessel will be at the construction site, one installation vessel will be loading at quae-side, and one installation vessel will be returning from the construction site. During much of construction, at least two installation vessels will be at quae-side either being loaded or arriving from the construction site and awaiting loading. Therefore, it is required that berthing space for the international vessel and two installation vessels be available.
- Vertical restrictions of any kind are not acceptable. This criteria is primarily in place due to the extremely large cranes (600 ton crawler cranes, which have boom lengths of up to 475 feet) necessary for loading and unloading of vessels and pre-assembly of wind turbines prior to delivery, the large spuds that are integral to the functioning of jack-up barges, which, as stated before, have multiple spuds that extend up to 250 feet above the barges when they are mobile) that will be utilized to transport pre-assembled wind turbines to the wind farms during construction, as well as the pre-assembled wind turbines themselves that will extend up to 250 feet into the air above the barges as they are transported to the construction site.
- The anticipated loading requirements for the entire facility will be 20 tonnes/square meter (4,000 pounds/square foot), due to the use of 600 ton crawler cranes (an example of which is a Lieberr 750 Crane) anticipated to be utilized throughout the facility to transport, stack, load, and unload renewable energy facility components.
- Due to the anticipated loading requirements, an asphalt or concrete surface would not work. The heavy cranes would demolish such a surface in very short order. Therefore, the preferred surface is crushed stone.

- If possible, it is preferred to have a facility closer to 35-40 acres in size (the specific request was for 150,000 square meters for an ideal facility); however, 20 acres is the minimum amount of space required for the staging, preconstruction, and storage of renewable energy components for the construction of a 130 wind turbine offshore renewable energy facility.
- The heavy cranes must be able to reach within a meter of the target loading area on the installation vessels.
- Interest was expressed for an area (outside of the 20 acre facility) for parking for up to 200 people. A 20 acre facility would not be large enough to accommodate parking as well as storage, assembly, etc.
- A high priority is to find a location within which vessels can dock and exit the harbor without waiting for other vessels.

APPENDIX 4

SIEMENS **Energy**

Cape Wind
Att.: Craig Olmsted

Name	Thomas Mousten
Department	E R WP AM
Telephone	
Mobile	+1 (617) 943-8043
E-mail	tmo@siemens.com
Date	August 24, 2010

Pre-construction stating area for offshore wind turbines

Dear Sirs,

Over the past several years, Siemens has routinely identified, managed and utilized staging areas for offshore wind projects. This letter summarizes some of the key specifications that are necessary for a staging area to be adequate and practicable, and comments on whether the proposed South Terminal meets these specifications.

The following activities summarize the anticipated operations on the site:

- Delivery of all wind turbine parts and material by international cargo vessel. This comprises tower sections, electronics components, nacelles, hubs and blades. These items will be off loaded by shore-based cranes to the quayside, for movement to their designated storage locations.
- Assembly of the electronic components inside a building, and transfer outside for installation of the assembled electronics in the lower tower sections.
- Final assembly of nacelle components, including attachment of the hub and installation of aviation lighting etc.
- Assembly all components in complete sets for loading onto the assembly vessel.
- Loading assembled components onto the installation vessel, using both on-shore and vessel-mounted cranes as appropriate.

It is critically important that the staging area be dedicated to the wind farm activities with unrestricted access on a 24-hour per day basis during pre-assembly and installation operations. Locations that would require Siemens to share space with other unrelated ongoing uses would not be feasible or practicable. The South Terminal meets these criteria, because it can be made available for wind farm use on a 24 hour exclusive basis.

Siemens Energy, Inc.

45 Fairfield st.
Boston, MA 02116
United States

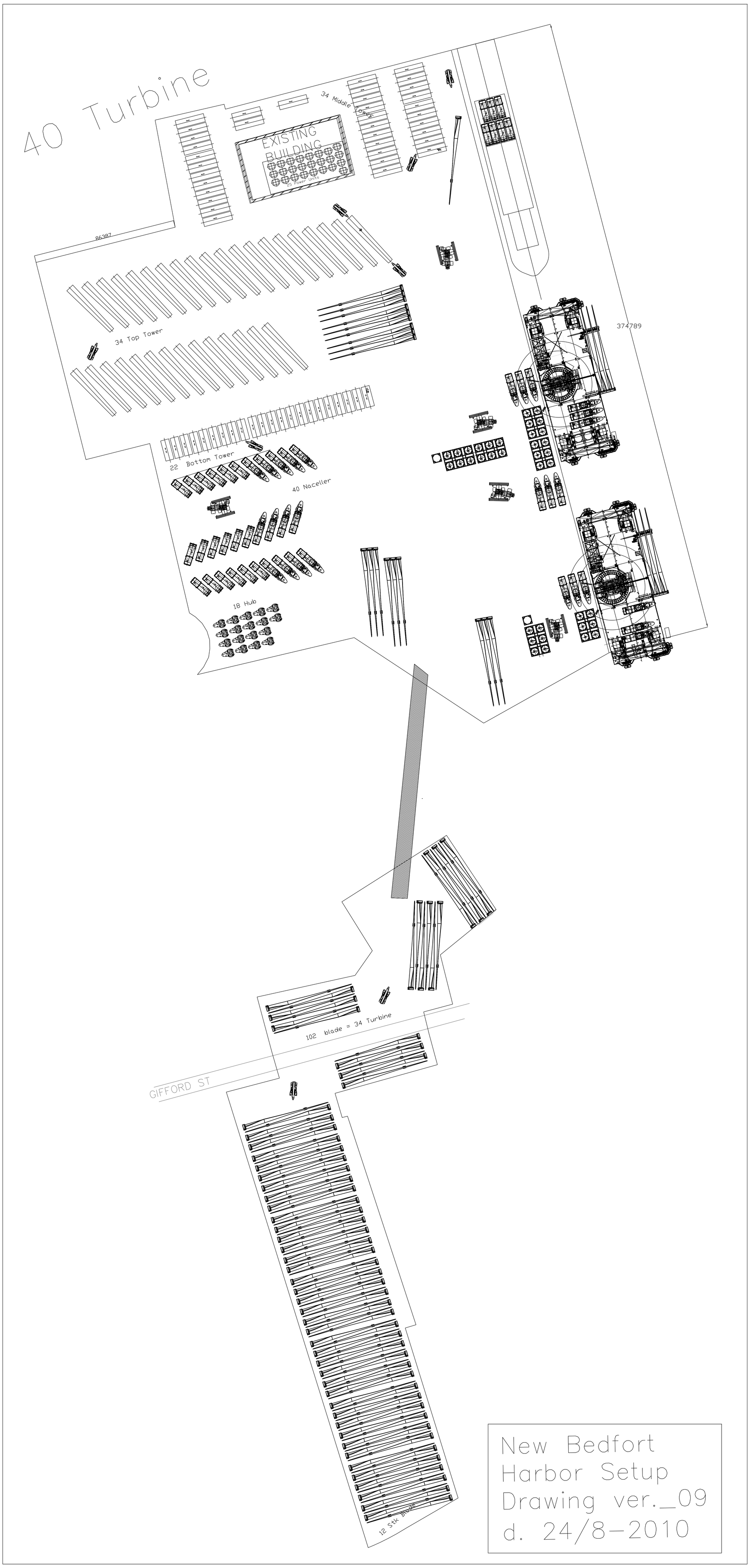
It is also vital that a minimum of 1200 linear feet of quayside at required depths be dedicated to the wind farm activities. Efficient operation requires the continuous access to three vessels. This is because, among other reasons, due to weather and other variables, arrivals and departures cannot be scheduled with precision, and we need to have enough space so that all three vessels can operate on the site simultaneously, so that they are not turned away when they arrive. This will likely be one international cargo vessel and two installation vessels. These vessels would be approximately 480 feet in length (requiring -30 foot depth) and 300 feet in length (requiring -20 foot depth) respectively. In addition, the vessels require about 60 linear feet between them for a total of 1200 feet minimum. It is not possible to use fewer vessels and install a 100+ turbine project in one construction season. Siemens understands that the proposed South Terminal will meet these criteria.

Available land contiguous to the quayside is a third important asset of an efficient staging area. For economic operations, to construct a 100+ turbine project in one season will require a minimum area of 25 to 30 acres contiguous with the quayside. The exact size depends on many variables, but as an example, Siemens has carefully considered the proposed build out of the South Terminal at New Bedford and determined that 28 acres is a minimum requirement for efficient operation at that location. We have carefully considered the way we would utilize a parcel of this size and shape, and have worked with the city and it's consultants to consider all feasible options for use of the site to minimize the amount of dredging and filling. In order to perform the operations listed above, we need storage space for an absolute minimum of 40 complete sets of turbine components (consisting of 3 tower sections, 1 nacelle, 1 hub, 3 blades and 2 electrical components per turbine). This is because we need to have a certain backlog of complete sets to ensure that when the installation vessels are present, there are complete sets to load on to them. Again, due to weather variables that are particularly problematic during the winter, we need to ensure that these installation vessels are not delayed for use in their intended purpose whenever they arrive. To ensure sufficient space for the storage, assembly, and loading of forty turbines, we need 7 acres for tower lay down, 2 acres for hub and nacelle lay dawn, 5 acres for loading and unloading operations, 5 acres for pre-assembly activities and 1 acre for buildings and services, and an additional 8 acres of contiguous, or directly accessible land for wind blade lay down. Attached is a conceptual diagram showing how Siemens would use the 28 acres for this purpose. Note that the diagram includes no vacant or idle space. It also details an arrangement of how 40 full sets of components are stored and worked on. For illustration purposes, note that we have shown some tower sections upright, ready to placed on board the installation vessel.

Vertical clearance is also an issue in the long run. As the offshore industry matures in the US, for Siemens to operate efficiently and competitively, we must begin to assemble the towers fully on shore. This would require 250 feet or more of vertical clearance both at the pre-assembly area and the transit route to the wind farm site. If the South Terminal is built out as proposed, it will be suitable for the staging of multiple projects along the East coast because there are no vertical restrictions of any kind. In the coming years, larger turbines, 6 MW or greater, will become available and the South terminal will be suitable for their pre-assembly. Limited vertical access either at the pre-assembly area or the route to the installation site would cause an unacceptable impediment to future installations.

Sincerely yours,

Thomas Mousten



New Bedfort
Harbor Setup
Drawing ver._09
d. 24/8-2010

APPENDIX 5

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July 23, 2009

Jack-Up Barge installs Germany's first offshore wind turbine

Jack-Up Barge B.V. recently marked a major milestone. On its maiden assignment, the company's newbuild monohull jack-up platform JB-114 completed the installation of Germany's first offshore wind turbine.

After mobilization in Eemshaven, the Netherlands, the JB-114 was towed to the offshore location, about 45 km north of the island of Borkum in the North Sea. Within 36 hours of arrival it installed the tower, turbine and rotor blades of the first wind turbine in the **Alpha Ventus wind farm**.

Ronald Schukking, Managing Director of Jack-Up Barge B.V., said: "The installation could not have gone any better. This project once again proves that our jack-up platforms are extremely suitable for utilization in the offshore wind turbine construction industry."

The JB-114 and twin sister the JB-115 **were both delivered last month by Drydocks World Nanindah** (former Labroy Shipyard) at Batam, Indonesia as part of an extensive newbuild program.

Both jack-ups will be working on the construction of the Alpha Ventus wind farm this summer. The JB-114 is chartered by German company Prokon Nord, which is responsible for the installation of six 5 MW Multibrid wind turbines on tripod foundations. The JB-115 is chartered by DOTI and will be installing the slots and templates on the seabed in preparation for the jacket foundations of the six remaining 5 MW REpower turbines.

The Alpha Ventus wind farm, with a total capacity of 60 MW, is expected to be completed before the end of this year, making it the first operational wind farm in German waters.

Jack-Up Barge B.V. specializes in the manufacturing, sales and rental of standard and modular self-elevating platforms and is a member of the Van Es Holding Group.

MARINELOG

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For Immediate Release

Drydocks World delivers two self-elevating platforms for wind farm installation

Singapore, 10 June 2009 – Drydocks World – Southeast Asia ("DDW-SEA"), the Southeast Asian subsidiary of Drydocks World, has announced the recent delivery of JB-114 and JB-115 from it's Drydocks World – Nanindah yard on Batam Island, Indonesia, to Self Elevating Platforms N.V. The unit will be operated by subsidiary company, Jack-Up Barge B.V., a leading supplier to the oil & gas, wind farm and civil construction industries and wind turbines market, as well as for the heavy civil construction market.

Ronald Schukking, Managing Director of Jack-Up Barge B.V. said, "Drydocks World has once again met our expectations – the quality and finish of JB-114 and JB-115 is excellent. We definitely look forward to working closely with Drydocks World in the future. "

Designed by Holland's GustoMSC and of the SEA 2000 design, JB-114 and JB-115 are the third and fourth of this type successfully built by DDW-SEA. Similar to the first and second vessels, which have now been renamed 'Sea Worker' and 'Seafox 7' respectively; the monohull jack-up barges JB-114 and JB-115 will be deployed in European waters involved in wind farm installations and related activities.

Designed with a 55.5 m x 32.2 m x 5 m hull, a 300 tonnes-capacity mounted pedestal crane together with four cylindrical legs, 3.0m in diameter and 78.85m in length, each platform is designed for operations in water depths up to 40m - in and around the Southern North Sea.

Mr. Denis Welch, CEO of Drydocks World – Southeast Asia said, "Both JB-114 and JB-115 are part of a series of sophisticated barges contracted by Self Elevating Platforms N.V., and we are pleased to have successfully delivered four of them to date. These barges will be used specifically for wind farm installation activities, which is one of the industries (alternative energy or power generation) that we are actively pursuing, given that ––our ship repair, conversion and new building capabilities can be easily extrapolated to suit this growing industry's requirements.

I would like to express my appreciation to our team in Drydocks World-Nanindah, the client's site team and our vendors and partners throughout the world for the successful delivery of this project."

Drydocks World - Southeast Asia, established in April 2008, is a member of the Drydocks World group of companies and a sister operation to Drydocks World – Dubai (formerly known as Dubai Drydocks). The Drydocks World Group has an esteemed heritage of providing a full spectrum of integrated maritime and offshore solutions in strategic locations in the Middle East and Far East. Currently housing four of Asia's premier shipyards in one of the world's busiest seaways, Drydocks World - Southeast Asia specialises in rig and shipbuilding as well as conventional ship repair and conversion, wholly supported by world-class engineering and design capabilities. With quality workmanship and competitive pricing, Drydocks World is one of the most prominent names in the maritime industry today.

- Ends -

About Drydocks World

Drydocks World, a Dubai World company, is one of the most prominent names in the maritime industry. Over the past 25 years, Drydocks World has established itself as a leading, and fast growing international player in ship repair, shipbuilding, rig building, FPSO conversion, offshore fabrication and fleet operations with facilities in the Middle East and Southeast Asia.

Drydocks World - SE Asia, brings together established offshore rig construction, shipbuilding, conversion, and ship repair expertise located at crossroads of the world's busiest shipping lanes and close to major offshore oil & gas field developments. Marine activities are focused on 4 shipyards, namely, Drydocks World – Graha / Nanindah / Pertama / Singapore, which house 29 building berths, 8 floating docks, and a specialized rig building yard. Extension plans are in place to expand operations further on Batam Island with the construction of a new yard PT Batam Maritime Centre.

For more information, please refer to the www.drydocks-sea.com, www.drydocks.gov.ae

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Issued for and on behalf of Drydocks World - Southeast Asia Pte Ltd

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APPENDIX 6

Allens Harbor Rd
Tidal Dr
Rudder St
Ash St
Nerove St
Keel St
Cooper St
Magnolia St
Plum St
Broadway
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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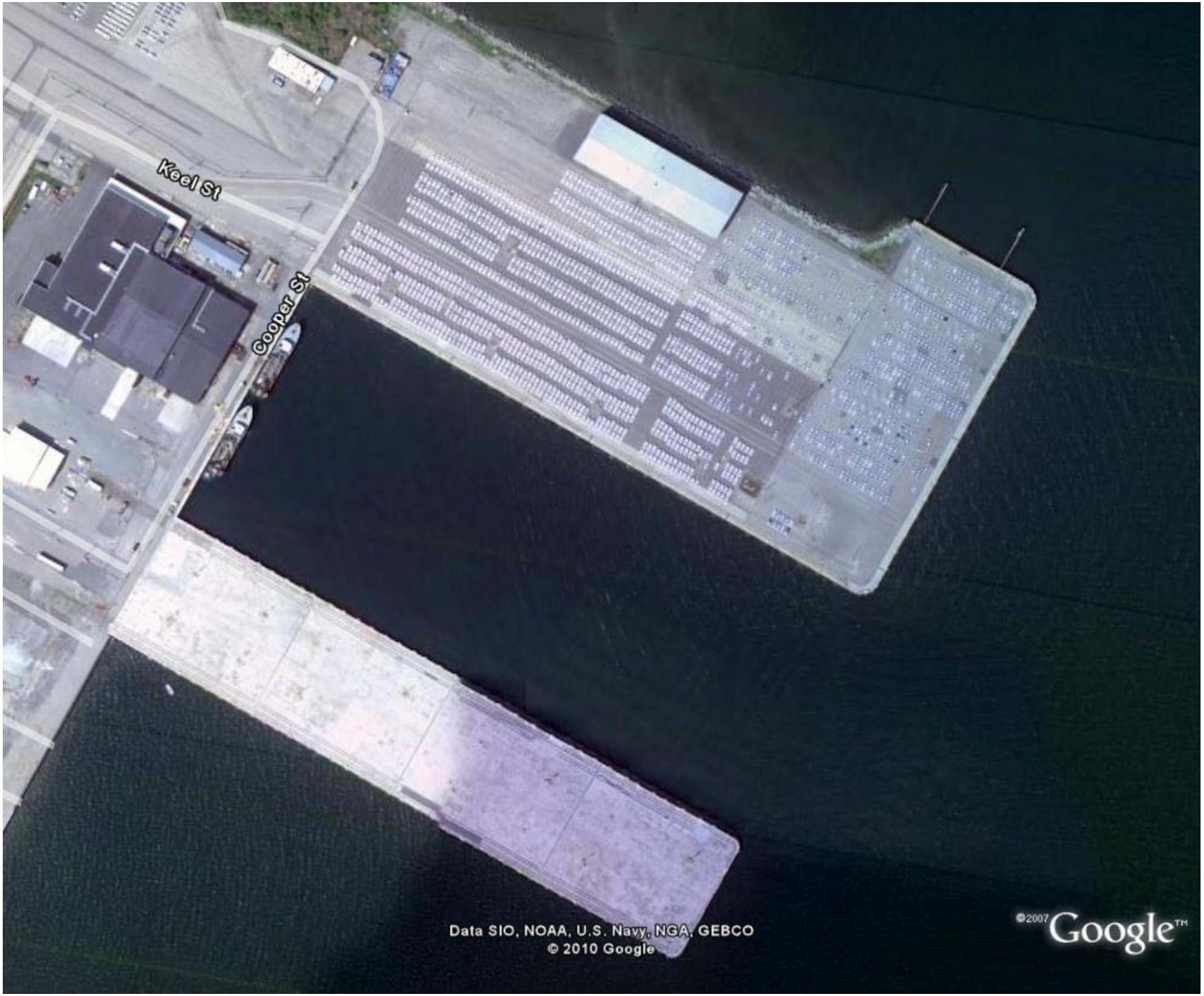
Keel St
Cooper St
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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Picture 1: Picture of New Car Storage on Pier 1. Note concrete surface of Pier 1.

Picture 2: Photo of new car staging/storage on Pier 2.

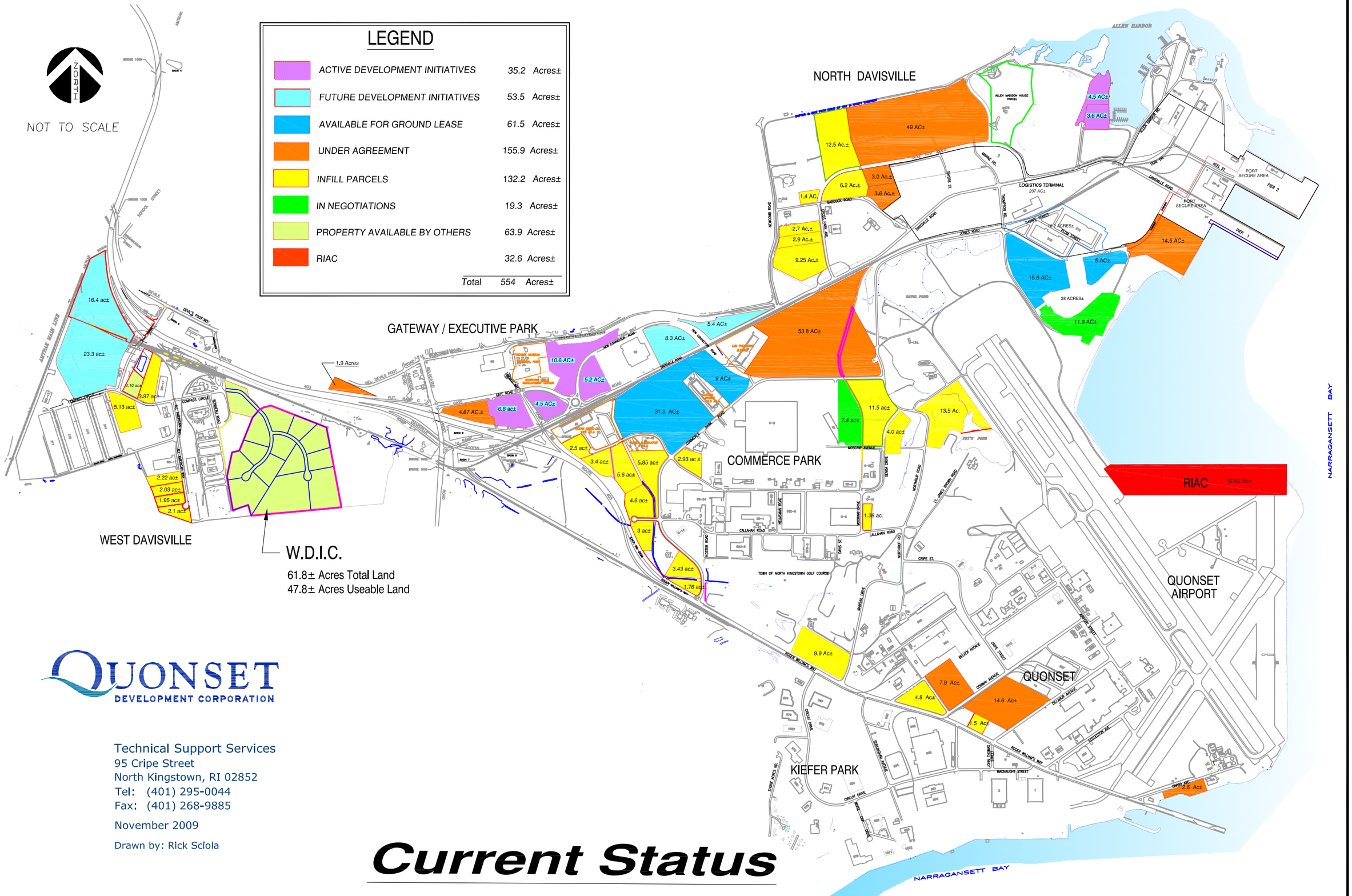
Photo 3: Photo of car importation vessel docked at Pier 2. Note concrete surface of Pier 2.

Photo 4: Photo of car storage within upland areas at Port of Davisville.

NOT TO SCALE

LEGEND

ACTIVE DEVELOPMENT INITIATIVES	35.2	Acres±
FUTURE DEVELOPMENT INITIATIVES	53.5	Acres±
AVAILABLE FOR GROUND LEASE	61.5	Acres±
UNDER AGREEMENT	155.9	Acres±
INFILL PARCELS	132.2	Acres±
IN NEGOTIATIONS	19.3	Acres±
PROPERTY AVAILABLE BY OTHERS	63.9	Acres±
RIAC	32.6	Acres±
Total	554	Acres±



QUONSET DEVELOPMENT CORPORATION

Technical Support Services
95 Cripe Street
North Kingstown, RI 02852
Tel: (401) 295-0044
Fax: (401) 268-9885

November 2009

Drawn by: Rick Sciola

Current Status

Pier 2
Pier 1
Magnolia Street Area
Broadway Street Area
Davisville Rd
Tidal Dr
Keel St
Cooper St
Nerove St
Magnolia St
Durfee St
Thompson Rd
Thopps St
Plum St
Broadway
Quonset Point, North Kingstown, RI 02852
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Imagery Date: May 1, 2010
41°36'39.74" N 71°24'42.55" W elev 31 ft
Eye alt 8963 ft

Plum St
Broadway
Mariner Rd
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© 2010 Europa Technologies
©2010 Google
Imagery Date: May 1, 2010
41°36'34.99" N 71°24'47.14" W elev 3 ft
Eye alt 2715 ft

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Imagery Date: May 1, 2010
41°36'39.23" N 71°24'46.93" W elev 41 ft
Eye alt 1006 ft

APPENDIX 7

Airspace Issues in Wind Turbine Siting

Wind turbine projects need to clear many hurdles before they can proceed to construction. One of the most important milestones in any wind project is securing a determination from the Federal Aviation Administration (FAA) that the project does not adversely affect air traffic or radar systems. This can be a complicated and uncertain process, and many projects have run into unexpected delays. The primer below explains how anticipate and avoid some of these conflicts, and how the FAA review process works. Several case examples are presented.

The FAA's Role and Procedures

The FAA has oversight of any object that could have an impact on the navigable airspace or communications/navigation technology of aviation (commercial or military) or Department of Defense (DOD) operations. The FAA requires that a Notice of Proposed Construction (Form 7460-1) be filed for any object that would extend more than 200 feet above ground level (or less in certain circumstances, for example if the object is closer than 20,000 feet to a public-use airport with a runway more than 3,200 feet long). As wind turbine heights have increased during the past couple of decades, this filing requirement has applied to increasing numbers of projects.

For any filed project, the FAA undertakes an initial aeronautical study within the relevant FAA region, and issues either a Determination of No Hazard to Air Navigation (DNH) — the "green light" for the project — or a Notice of Presumed Hazard (NPH). If an NPH is issued, the FAA will then initiate an in-depth technical analysis (commonly called an extended study), which will explain the cause of the NPH and evaluate impacts on air operations. If after the extended study, which may include a public comment period, there remains an operational impact, the FAA will try to negotiate an acceptable height for a project that has received a DNH. If no agreement can be reached, FAA will issue a Determination of Hazard (DOH). A DOH can be appealed to FAA Washington Headquarters. If the appeal does not secure a DNH, the proponent's main recourse is to bring the issue before a Federal Court.

The FAA analysis considers several types of airspace impacts: (1) imaginary surface penetration, (2) operational impacts, and (3) electromagnetic interference. A primer is helpful:

(1) **Imaginary Surfaces**: Both aircraft flight routes and the airspace near airports require great swaths of defined space dedicated to the takeoff, travel, and landing of aircraft. We might imagine these spaces as giant rooms and tunnels of airspace with very specific boundaries. The walls, ceilings, and floors of those rooms and tunnels are defined as imaginary surfaces. If an imaginary surface is penetrated by a constructed object (e.g., a turbine), the FAA then does an extended study to determine whether the turbine poses an operational problem for the relevant airport or for a specific visual flight route between airports. If the penetration does not pose an operational impact it may be determined not to be a hazard.

(2) **Operational Impacts**: The thousands of flights that leave and arrive each day at large airports, such as Boston's Logan International Airport (Logan), are possible because of very complex and exacting protocols known as visual flight rules (VFR) and instrument flight rules (IFR). Operational impacts are those that affect VFR and IFR operations. Examples of operational impacts include increasing the minimum flight altitude in a specific area (either for "enroute" air traffic or for circling at an airport),

diverting air traffic away from an obstacle, increasing the minimum climb gradient (steepness) for airport departure, or increasing the minimum descent altitude at the obstacle location for airport arrivals. For obvious reasons, the air transport industry is generally resistant to operational changes that would increase workload in the cockpit during critical takeoff and landing periods or impose non-standard flight restrictions.

(3) **Electromagnetic Interference** (EMI): Experience has shown that wind turbines can degrade performance of air traffic control (ATC) or air defense radar. The phenomenon can include sudden or intermittent appearance of radar contacts at the location of the wind turbine because of blade motion or rotation of the turbine to face the wind. For ATC radar the interference is generally limited to wind turbines that are within the radar line of sight. Studies indicate that this problem may be minimal for turbines more than 5 nautical miles from the radar.

A September 27, 2006 Department of Defense (DOD) report titled *The Effect of Windmill Farms on Military Readiness* identifies similar conflicts with air defense radar. These conflicts can extend for tens of miles from the radar facility due to atmospheric refraction).

And finally, interference with microwave transmissions is another form of EMI that is of concern because public safety radio systems typically use microwave-based technologies.

Resolving Adverse Impacts. As part of a Notice of Presumed Hazard or Determination of Hazard, the FAA may suggest modifications that could render the project acceptable – for example, a change in the height of a proposed turbine or the re-siting of a turbine at a greater distance from an airport. Such modifications can make a project possible while accommodating regulatory needs and preserving the quality of airspace or navigational operations at the nearby airport. For wind project proponents, these modifications often represent a tradeoff of efficiency for safety. In rare cases the FAA might agree to a procedural change that would sidestep the problem.

For conflicts with radar systems, there are technologies, such as geosensor mapping and "masking" that may prevent air traffic control (ATC) radar from picking up wind turbines as targets. However, masking also renders the radar ineffective in the subject area. DOD's recent report concludes that the only way to prevent signal degradation of air defense radar is to keep wind turbines out of the radars' lines of sight.

Identifying Potential Conflicts Early. Wind project developers may find it beneficial to consider how the FAA evaluates potential airspace obstruction as they screen potential sites for wind projects. MTC has found it useful to obtain an "Airspace Obstruction Report and Opinion Letter" from a qualified consultant at an early stage in a project. This relatively low-cost effort can help project proponents identify potential airspace conflicts early and avoid wasting time and effort on a dead-end project. It is important to note that the FAA's evaluation of potential conflicts with air traffic is significantly more predictable than its evaluation of radar issues. At present, the only reliable approach to identifying radar issues is to have the FAA conduct a "propagation study" as part of its formal review of a Notice of Proposed Construction.

Case Examples: Learning by Doing

MTC's understanding of airspace siting issues has evolved through experience with some early wind projects in Massachusetts. The following case examples provide some history and context for current conversations about securing approval for wind turbine sites, especially in the Boston Harbor area.

Hull and the IBEW: Early Successes

• The Hull Municipal Light Plant installed Massachusetts' first large scale wind turbine, a 164-foot turbine located at Windmill Point, in 2001. Five years later, it installed a 340 foot turbine on the site of a town landfill. Happily, both received DNH status from the FAA and are operational. It is unclear whether the FAA will ultimately conclude that these turbines have some effect on Logan Airport air traffic control radar.

• In 2005, Local 103 of the International Brotherhood of Electrical Workers received a DNH for a 150-foot wind turbine at their Dorchester office site. Today the turbine spins away. It is unclear whether the FAA will ultimately conclude that this turbine has some effect on Logan Airport air traffic control radar.

Boston Harbor: Airspace Concerns

Wind projects in the vicinity of Logan Airport raise special concerns, since Logan is one of the nation's busiest and most compact airports. MTC and project proponents filed Notices of Proposed Construction near the beginning of the development process for several Boston Harbor area projects so that any airspace or radar problems would be known early in the development process. For the Deer Island, Long Island, and Lynn projects (see below), the FAA had initial concerns about the heights of turbines.

• In late 2005 the Massachusetts Water Resource Authority (MWRA) filed a Notice of Proposed Construction for 394-foot turbines at five possible locations at the wastewater treatment plant on Deer Island in Boston. When the FAA concluded that turbines at the proposed heights were a potential hazard to aviation, the MWRA and MTC revised the project to use 190-foot turbines. As of February 2007, FAA has not issued an official determination on that plan. It is possible that the FAA will issue a DOH for any Deer Island turbines, regardless of height, because of radar impacts on Logan.

• The City of Boston, with support from MTC's Community Wind Collaborative, proposed a series of up to four 394-foot turbines on Long Island in Boston Harbor, a bit more than three nautical miles from Logan airport. Notices of proposed construction were filed on October 15, 2005. On February 10, 2006 the FAA issued initial NPH designations for all four locations based on its finding that "the structure[s] as described exceed[s] obstruction standards and/or would have an adverse physical or electromagnetic interference effect upon navigable airspace or air navigation facilities." (The FAA identified reduced heights at which the turbines may have been acceptable as 190, 233, 256, and 247 feet.) At that point, MTC hired an airspace specialist to determine whether there were options for overcoming the FAA's concerns. That specialist proposed a "step-down fix" by which minimum aircraft heights over Long Island would be increased. The FAA conducted an extended study of this proposal including a public comment process. In September of 2006, the FAA issued a DOH for the Long Island sites, saying that the "cumulative impact of the proposed structure[s] . . . is considered to be significant." It cited, among its reasons: the turbines would be in the only remaining quadrant around Logan that is not currently impacted by obstructions; building a step down fix would increase cockpit workload during final approach; and that, without complex geosensor mapping for each turbine, interference with air traffic control radar was likely. MTC and the City of Boston elected not to appeal those FAA determinations.

• The City of Lynn Community Wind Collaborative wind turbine project is slated for a regional wastewater treatment plant site. The initial FAA filing for the 397-foot structure resulted in a NPH, in part because of turbine height. Subsequent evaluation by an airspace specialist under contract to MTC indicated that the FAA would be unlikely to accept a modification of minimum aircraft altitudes for the Lynn location. Informal contact with the FAA indicated that there might also be conflicts with Logan

Airport air traffic control radar. MTC and the City then accepted a lower wind turbine height (254 feet) and asked that the FAA investigate the radar issue in greater depth. After further FAA study, the FAA issued a DNH in January 2007.

Outside the Boston Area: Barnstable and Paxton

• MTC is collaborating with Cape Cod Community College on a wind project to be built on the College's campus in West Barnstable. Initially, the project involved a 397-foot turbine on the east side of the campus. Early in the project development process, MTC and the college discussed the project with authorities at the local airport, and received informal assurances that the project should not raise airspace concerns. However, a subsequent filing with the FAA resulted in, first, a NPH, and then, a DOH. In response to the FAA's evaluation, the College modified the proposal to a 253-foot turbine on the west side of the campus. As of February 2007 the College and MTC are waiting for final FAA approval of this smaller turbine in the alternate location.

• In mid-2005 MTC filed a Notice of Proposed Construction for two wind turbine locations on Asnebumsket Hill in Paxton, Massachusetts. There are currently several telecommunications and radio transmitter towers at the site, one of which is 366 feet above ground level. In December 2005 the FAA issued NPH's for the two locations indicating that any object greater than 200 feet above ground level would result in a DOH. Subsequent evaluation by MTC airspace consultants led us to the conclusion that there was little change of mitigating FAA concerns. (This evaluation also concluded that the minimum height for one turbine location should have been 125 feet above ground level.) An important aspect of the Paxton situation is that the proposed wind turbine locations were closer to Worcester airport than the existing radio/telecommunications towers. Thus, wind turbines at the proposed heights would have constituted an additional deterioration of navigable airspace which was unacceptable to the FAA.

Guidelines and "Best Practice" Recommendations

It is not possible to predict perfectly the outcome of an FAA determination on a given project. However, from the above project experiences (and others), MTC has generated the following recommendations for the planning and development of wind turbine projects.

(1) Review airspace considerations early in the project development process; this increases efficiency, saving time, money, and stress.

(2) Be aware of the following general guidelines: a turbine under 200 feet in height is rarely problematic for navigable airspace, and a turbine site more than five nautical miles from an airport runs the least risk of a NPH or DOH on radar issues.

(3) Conduct, as early as possible, due diligence with local authorities, proponents, and stakeholders. This avoids, among other challenges, unanticipated opposition at the public comment stage of an FAA study.

(4) Enlist the services of professional aviation consultants, and bring them into the process early to advise on the technicalities of FAA regulations, which can be daunting. (A report commissioned by MTC states that FAA criteria "are highly complex, especially as they relate to operational impacts on air traffic. There are many instances where[in] FAA operational criteria . . . are modified on a case-by-case basis . . . . only an experienced airspace analyst should attempt to apply the Operational Impact criteria."). The consultant's analysis is relatively inexpensive (approximately $500) and results will be available quickly, whereas the FAA review process takes considerable time.

With this information in hand, you will be better prepared to tackle the exhilarating (and sometimes cumbersome) task of bringing a wind turbine project to life. At MTC we are constantly striving to provide accurate and current information regarding your wind turbine siting and permitting needs — please do not hesitate to contact us!

Resources/Links

This summary of FAA considerations in the siting of wind power projects draws on numerous resources and technical reports, available below:

Airspace Obstruction and Electromagnetic Interference Considerations for Wind Power Projects, prepared by Aviation Systems, Inc. for MTC, January 2007.

Filing with the FAA

- FAA Obstruction Evaluation / Airport Airspace Analysis web site.
- Notice of Propose Construction (form 7460-1). This form must be submitted for any structure that exceeds 200 feet above ground level, no matter where it is located.
- Advisory Circular – Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace
- Part 77 Airspace Obstruction Analysis – This webpage provides contact information, contains links to form 7460-1 and provides a concise description of how the FAA application & notification process works.
- All determined and proposed air obstruction cases filled with the FAA can be found here. You can also file your 7460-1 form electronically from this webpage. However, you do need to register as a new user.

Table 1 – Summary of Wind Projects in Massachusetts and FAA Determinations

Project/Location	Proposed Structure Height (feet)[1]	Distance from Airport Center (Nautical Miles)	Status
Eastern Massachusetts			
Boston (IBEW)	150	4.2 Logan	DNH
Boston (Long Island[2])	394	3.47 Logan	Determination of Hazard (DOH)
Boston (MWRA[3] Deer Island)	1st Filing – 394 2nd Filing - 190	2.19 Logan	1st - DPH 2nd - Pending
Cape Cod Community College	1st Filing – 397 2nd Filing – 253	2.75 3.1 Barnstable	1st - DOH 2nd - Pending
Falmouth	394	3.8 Otis	DNH
Gloucester (Varian)	480	12.0 Beverly	DNH

Project/Location	Proposed Structure Height (feet)[1]	Distance from Airport Center (Nautical Miles)	Status
Hull - 1	241	5.5	DNH not available
Hull - 2	340	9.05 Logan	Determination of No Hazard (DNH)
Lynn	1st Filing - 397 2nd Filing - 254	5.7 Logan	1st – Determination of Presumed Hazard (DPH) 2nd - DNH
Orleans	340	4.9 Chatham	DNH
Central Massachusetts			
Paxton	397	2.24 Worcester	DPH
Western Massachusetts			
Florida and Monroe (Hoosac Wind Project)	340	6.3 Harriman (North Adams)	DNH
Hancock (Berkshire Wind Project)	338	8.6 Harriman (North Adams)	DNH
Hancock (Jiminy Peak)	394	7.0 Pittsfield	DNH

1 – This includes the height of the turbine only (blade tip at highest point) and not the elevation of the site which FAA analysts include in their study.
2 – The City of Boston considered 4 different locations, all of which received a DOH.
3 – MWRA considered 5 locations at the wastewater treatment plant on Deer Island, all of which received a DPH.

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APPENDIX 8

PORT OF BOSTON ANALYSIS

An analysis was conducted to assess the magnitude of cost and logistical inefficiencies associated with utilizing the Port of Boston as a location for a support facility for offshore renewable energy. The basis for preparing this analysis were determinations made by the developers of the two closest proposed offshore renewable energy developers. However, beyond the opinion of the developers, there are elements which can be used to quantifiably disqualify a port for use as a staging facility. These are: Cost and Logistics, Increased Carbon Dioxide Emissions, Speed Restrictions, Potential Right Whale Ship Strikes, and Risks to Personnel and Material. These considerations are outlined in more detail below.

WIND ENERGY DEVELOPER'S DETERMINATIONS

The most important consideration for determining the Port of Boston's viability is the opinion of the developers who intend to undertake the development of offshore renewable energy projects. If the offshore renewable energy developers would not utilize a facility within the Port of Boston, construction of a facility at that location would be infeasible. Each offshore renewable energy project has specific requirements based on the conditions known to exist at the development site. The project proponents spend considerable time formulating plans which rely on carefully prepared schedules to solve complex logistical problems. Often the developers will not divulge all of the reasons that factor into their determination as to why a particular port is not viable for their project

because it reveals information and investments which are considered proprietary, nevertheless a developer's reasoned opinion is the most critical element in determining a ports' viability for use as a land side staging facility. During the assembly of the Tetra Tech report, officers from two of the proposed offshore renewable energy projects nearest to the Port of Boston, were asked about the potential use of the port as a staging area. Cape Wind's Vice President of Development, Craig Olmstead, told the Tetra Tech team that "Boston is too far away" to be used as a staging port (interview conducted by Tetra Tech on Tuedsy July 28, 2009). Subsequent to this interview, Tetra Tech interviewed Deepwater Wind's Chief Operating Officer, Chris Wissemann, who stated that the "major constraint for Boston is proximity."

COST AND LOGISTICS

For the purposes of evaluating the increased costs associated with the logistics of utilizing the Port of Boston, a simplified scenario was evaluated wherein wind turbine parts would be shipped to the Port of Boston for partial assembly prior to sortie to the Horseshoe Shoal site within Nantucket Sound (which the proposed location of the Cape Wind project). The Cape Wind project was utilized for this analysis because of the currently proposed off-shore wind development sites in Southeastern Massachusetts, Rhode Island, Connecticut and further South, the Horseshoe Shoal site is the closest project site to the Port of Boston; therefore, if costs and logistical concerns make the Port of Boston infeasible for the Horseshoe Shoal site, the Port of Boston would be infeasible for the other above-mentioned sites as well. For the purposes of this assessment, costs were compared with comparable costs from an alternate location (in this case a facility

located within New Bedford, Massachusetts). Certain assumptions were made in the preparation of this scenario including that each jack up barge would transport enough material to complete the installation of an entire Wind Turbine. Overtime rates for the barge crew and prevailing wage differences for the two ports were not considered or included in the evaluation. The cost of transport from the Port of Boston is contrasted with the costs associated with delivery and partial assembly into New Bedford in the table below:

Travel Logistics and Costs	
Distance and Fuel	• Distance between NBH and Horseshoe Shoals – 45 nautical miles • Distance between Boston and Horseshoe Shoals – 130 nautical miles • Average push speed for a tug is 10 knots/11.5 mph • Average Fuel consumption for a EMD 12-567C 1,200 HP (average barge pushing tug) is 68 Gallons/Hour • Price today for fuel at Sea Fuels in NBH is $2.83/gallon
New Bedford Harbor to Horseshoe	• Trip from NBH to Horseshoe Shoals – One way at an average of 10 knots • Trip would take approximately 4.5 hours, • One way trip would use 306 gallons of fuel costing $865.98 • A crew of 4 members would cost approximately $773.40 at prevailing wage. • Total for fuel and crew one way from NBH to Horseshoe Shoals

Shoals	= $1,639.38 • Round trip = $3,279.00 • Equipment cost for 10-hour trip = estimated to be $20,000. • Total Fuel and Transport Estimate (each Barge) = $23,279
Port of Boston to Horseshoe Shoals	• Trip from Boston to Horseshoe Shoals – One way at an average of 10 knots • Trip would take approximately 13 hours • One way trip would use 884 gallons of fuel costing $2,502.00 • A crew of 4 members would cost approximately $2011.00 at prevailing wage. • Total for fuel and crew one way from NBH to Boston = $4513.00 • Round trip = $9,026.00 • Equipment cost for 26-hour trip = estimated to be $52,000. • Total Fuel and Transport Estimate (each Barge) = $60,026

Based on the travel and logistical considerations noted, the round trip additional expense for each barge of material for transportation alone is approximately:

- $36,747 for the round trip to Horseshoe Shoal from Boston.

The additional transport costs associated with partial assembly in the Port of Boston would amount to $4,777,110 over the course of the 130 barge trips required to construct the proposed Cape Wind energy project evaluated in this scenario. In order to maintain the same shipping schedule as could be attained by locating the shore facility in New

Bedford, the project would need to add at least 2 additional tugs and jack-up barges. This would triple equipment costs during the project resulting in a total project cost increase of $18,297,110, without considering the additional personnel costs.

INCREASED CO_2 EMISSIONS

The same set of assumptions in the above table can also be used to estimate the potential increase in carbon dioxide emissions generated from locating the shore side staging facility further from the installation area. Using the fuel consumption figures calculated above, the transport of the wind turbine sections from Boston to Horseshoe Shoal, would require 496.4 gallons more fuel than the trip from New Bedford, resulting in the production of 11,020 pounds of carbon dioxide, per one way trip (U.S. Environmental Protection Agency, Office of Transportation and Air Quality. (2005) "Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel". EPA420-F-05-001). Over the course of the project this would add up to 2,865,220 pounds of additional carbon dioxide emitted to the atmosphere.

SPEED RESTRICTIONS

In addition to the additional distance and time associated with transporting the partially assembled windmills from Boston to the assembly site, the international delivery vessel will travel through a NOAA Mandatory Speed Restriction Area on its way past Cape Cod to Boston Harbor. This will require the delivery vessel to reduce its velocity to 10 knots or less, during specific dates, through a portion of the shipping channel.

Great South Channel Precautionary Area to Port of Boston	• Trip from Great South Channel Precautionary Area to the Port of Boston = 166 nautical miles • Average international vessel speed = 19 knots • Anticipated 22 vessel trips to complete project • Portion of year when NOAA 10 knot Mandatory Speed Restriction is in effect along the route of the Great South Channel = 41.6% and approximately half of the distance is subject to speed restrictions. • Trip would take 8.75 hours 58.3% of the time. • Trip would take 12.7 hours 41.6% of the time. • Total Project time = (22 vessel trips x 58.3% x 8.75 hours) + (22 vessel trips x 41.6% x 12.7 hours) = 238.7 hours
Great South Channel Precautionary Area to New Bedford	• Trip from Great South Channel Precautionary Area to the Port of New Bedford = 155 nautical miles • Average international vessel speed = 19 knots • Anticipated 22 vessel trips to complete project • Trip would take approximately 8.16 hours • Total Project Time = (22 vessel trips x 8.16 hours) = 179.5 hours

Based on the travel details noted in the table above, travel though the Mandatory Speed Restriction Area (MSRA) for the offloading of wind turbine equipment in the Port of Boston will add an additional 59 hours of international vessel travel time during the project. A survey of off-shore wind developers suggests that operating costs for the

international delivery vessels are approximately $40,000 per day, assuming that the only delay along this congested route is the speed restriction area, the MSRA' scan be expected to add $98,333 to the cost of the project. The actual cost of this change is difficult to quantify especially when compared with the potential for additional traffic delays within the Port of Boston caused by the 3,500 vessels which are already serviced by the Port and its shipping lanes (NOAA Press Release, "Changes in Vessel Operations May Reduce Risk of Endangered Whale Shipstrikes", May 26, 2009). These delays could also be compounded by the uncertain delays resulting from Liquified Natural Gas tanker arrivals (for which all traffic within the Port of Boston is stopped).

POTENTIAL RIGHT WHALE SHIP STRIKES

The Mandatory Speed Restriction Areas (and the associated Area To Be Avoided) established by NOAA were put in place in order to reduce the frequency of ship strikes to the endangered North Atlantic Right Whale. Although the speed restrictions and the Area to be Avoided do reduce the chances of a ship strike, they do not eliminate the chances of such an event. According to information published by NOAA reducing vessel speeds from 19 knots to 10 knots reduces the mortality rate of ship strikes of whales from 90 to 50 percent. Certainly from the perspective of protecting the endangered Right Whale reducing the volume of traffic which passes through its seasonal feeding grounds along the Great South Channel would provide greater benefit than reducing the speed of those vessels. Use of the Port of New Bedford for the receipt and partial assembly of wind turbines, will reduce the chances of a fatal ship strike within this critical habitat by both reducing the volume of traffic passing through this critical habitat, and also by

reducing the time and distance that vessels will be operating in waters which are outside of the habitat.

RISKS TO PERSONNEL AND MATERIAL

The time that each delivery vessel spends transporting the Wind Turbines to the construction site exposes the personnel, vessel and equipment to potential inclement weather. The use of jack-up barges allows the contractor to mitigate some of the risk of damage or loss during loading and unloading, however the loaded barges are not designed for long open ocean crossings. While transiting from the harbor to the construction site, the barge and tugboat are more vulnerable to dangerous sea conditions than when the barge is in port or jacked above the level of the water during installation of the turbine. The less time the barge spends in transport, the less risk of encountering dangerous weather conditions.

Placing hard dollar costs on the value of proximity for mitigating potential loss due to weather or rough seas is difficult because the variable nature of weather, and because the value of an unassembled turbine varies by manufacturer, size and project. In order to partially quantify the economic benefit of locating the shore side facility near to the installation site, a scenario in which a turbine is lost during transport to the installation point after partial assembly at the shore facility. Although each developer negotiates their own purchase price for a wind turbine from a selected manufacturer published costs for an installed on-shore 1.8 mega-watt turbine are approximately $3 million (T.Brenner, “Four more wind turbines planned off Nantasket”, Patriot Ledger, Jan 15, 2008), and estimates for a 2.3 mega-watt turbine are in the range of $5.5 million,

published costs for off-shore turbines were unavailable. Since the unit is partially assembled when it is placed on the jack-up barge for transport to the construction site, a portion of the installation cost has already been expended, and so the loss at this stage would include the manufacture and transportation costs, and a portion of the installation cost. If an assumption that three quarters of the installation cost have been expended and that the negotiated installed cost equals $5.5 million, then the loss of a turbine at the partially assembled transport stage would amount to $4.13 million. The value does not include any damage to the transport vessels, which may also result during such an event.

The risk of loss or interruption due to sea conditions is dependent on the time of transport and the expected sea conditions along the transport route. Although there is no data available on the frequency of losses or interruptions in the installation of off-shore wind turbines caused by sea or weather conditions, there is reliable historic sea condition data available from NOAA buoys in the area of the Great South Channel and between Buzzards Bay and Horseshoe Shoals. The use of the historic buoy data allows relative comparisons of conditions between the shipping routes from Boston and New Bedford to Horseshoe Shoals. Data available from Buoy 44018 which is located 30 miles East of Nantucket, showed that average wave heights were 50% higher on average than heights recorded between Buzzards Bay and Vineyard Sound (1.5 meters compared to 1.0 meters respectively) (NOAA, National Buoy Data Center, Stations BUZM3 and 44018.13 July, 2010). Additionally the Maximum Significant Wave height was 36% higher East of Nantucket and Cape Cod than those recorded between Buzzards Bay and Vineyard Sound (8.6 meters compared to 6.3 meters respectively)(ibid). In order for a developer to ensure the safety of the crew and cargo, transportation of wind turbines will have to be

scheduled during calm weather windows, and the longer the route the longer the opening in this weather window will have to be. With sea conditions 36% to 50% more severe East of Nantucket and Cape Cod, and the transportation route more than twice the distance, it is more likely that sea or weather conditions will cause delays or losses if partially assembled turbines are transported from Boston to Horseshoe Shoals.

CONCLUSION

The 130 mile distance from the Post of Boston to the nearest currently proposed off-shore renewable energy development site, makes its use as a shore side support site infeasible. The critical reason for this is a determination by both of the initial offshore renewable energy developers that the Port of Boston would present too many transportation inefficiencies to be a practicable alternative due to its proximity to the proposed construction sites; however, the basis for the decisions made by the renewable energy developers has been illustrated within the previous sections. The Port of Boston is revealed as an infeasible location for a support facility and the least desirable location for a off-shore wind energy support terminal due to the proximity criteria.

SUB-COMMITTEE ON SAFETY OF NAVIGATION
54th session
Agenda item 3

NAV 54/3/xx
15 March 2008
Original: ENGLISH

ROUTEING OF SHIPS, SHIP REPORTING, AND RELATED MATTERS

Area to be Avoided "In the Great South Channel"

Submitted by the United States

SUMMARY

***Executive summary*:** This document sets forth a proposal to establish a recommendatory, seasonal area to be avoided "In the Great South Channel" off the east coast of the United States for consideration and approval, and forwarding to the Maritime Safety Committee for adoption. The objective of this proposal is to significantly reduce the likelihood of ship strike deaths and serious injuries to North Atlantic right whales during the time when a large percentage of right whales are in the Great South Channel and are engaged in activities that make them particularly susceptible to ship strikes.

Strategic Direction: 5.2

High-level Action: 5.2.4

Planned Output: 5.2.4.1

Action to be taken: Paragraph 21.

Related documents: General Provisions on Ships' Routeing, Eighth Edition, Regulation 10 of Chapter V of the International Convention on the Safety of Life at Sea, MSC 83/28, MSC 82/24, MSC 76/23, MSC 70(23), MSC 69/Inf. 21, MEPC 56/Inf.10, MEPC 55/22, MEPC 40/Inf. 9, NAV 54/3/xx (Note to IMO Secretariat: TSS proposal), NAV 53/3/13, NAV 52/18, NAV 52/3/3, NAV 48/3/5, NAV 47/Inf. 2, NAV 44/3/1.

Introduction

1 The United States proposes to establish a recommendatory, seasonal area to be avoided (ATBA) "In the Great South Channel" for ships 300 gross tons and above as set forth in annex 1. A chartlet of the area is attached to annex 1[1]. This proposal is related to the U.S. proposal to amend the Boston Traffic Separation Scheme (TSS), NAV 54/3/x, because the western boundary of the ATBA is directly adjacent to the Traffic Separation Scheme.

[1] The charlet and Annexes 2 and 3 include the proposed change to the Boston Traffic Separation Scheme set forth in NAV 54/3/XX.

2 The primary area proposed for the establishment of the ATBA is one of the most important feeding habitats for right whales within the species' range and has thus been designated by the United States as "critical habitat" under domestic law necessary for the survival and recovery of the highly endangered North Atlantic right whale. Extensive data show the need for establishing this ATBA (annex 2). The United States proposes that it have a seasonally limited effective period for four months each year (April 1st – July 31st) when a large percentage of the right whale population is in the area. The configuration and limited seasonal duration will minimize the impact on the shipping industry. Maritime safety considerations have also been taken into account in determining the boundaries of the proposed ATBA.

3 Right whales have long been the subject of international protection. The species is listed internationally as endangered on Annex I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and in the International Union for the Conservation of Nature's Red Book. Additionally, a group of international scientists, convened by the International Whaling Commission (IWC) to evaluate the global status of all right whale species, has recognized the urgent need for protective measures to prevent the demise of this species in the North Atlantic. Moreover, most recently, the report of the Ship Strikes Working Group of the IWC's Conservation Committee was submitted to the October 2006 meeting of the Marine Environment Protection Committee (MEPC)(MEPC 55/22). The MEPC agreed with the IWC's Working Group that the International Maritime Organization is the competent body to address ship strikes of cetaceans and invited delegations to submit proposals to relevant Committees and Sub-committees for consideration. This proposal is in accordance with that invitation.

Background

4 The North Atlantic right whale is one of the world's most endangered large whale species and is in serious jeopardy of extinction. Ship collisions are the greatest known source of human-induced mortality of this whale; such collisions are a major contributing cause to the decline of the right whale and a significant obstacle to the species' recovery. The right whale population is estimated to consist of less than 350 individuals[2] and has either declined in size or remained static since the 1980s.

5 Right whales are especially vulnerable to ship strikes due to their distribution, behavior, and physical attributes. Right whales have a largely coastal, continental shelf distribution, thereby bringing them into contact with human population centers and major shipping lanes. They are highly buoyant and spend long periods resting at or just below the water's surface. Right whales may occur in surface active groups (*i.e.*, four to twenty individuals engaging in frequent physical contact and courtship behavior), and engage in skim feeding, in which they gather plankton by swimming slowly near the surface with their mouths open. During resting, feeding and surface active situations, whales may be unaware of approaching ships. Mothers nursing calves are frequently observed at the surface, and calves have limited diving capacities so they are the most vulnerable to ship strikes. Right whales are slow-moving, with occasional speeds of up to only five to six knots. They are also difficult for mariners to see, especially in rough seas and at night, due to their low profile and dark coloration. They are black in color, have a broad back, and no dorsal fin.

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[2] Waring GT, Josephson E, Fairfield CP, Maze-Foley K, editors. 2007. See www.nmfs.noaa.gov/pr/pdfs/sars/ao2006_whnr-w.pdf. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments (2006); NOAA Tech Memo NMFS NE 201, 378 See www.nmfs.noaa.gov/pr/sars/species.htm.

6 The Great South Channel off the U.S. east coast is one of the most important habitats for right whales within the species' range, including mothers and nursing calves. More than a third of the world's population of these whales aggregate there from April through July each year to feed on dense patches of their preferred prey, copepods, which are concentrated in this area because of sea floor bathymetry, water convergences driven by coastal and tidal currents, and other oceanographic features. Some individually identified right whales observed in the Great South Channel are seen rarely or not at all in other areas such as the Bay of Fundy, emphasizing the importance of the Great South Channel to the population. Annex 2 provides a map of right whale sighting densities from 1999-2005. In the Great South Channel, the distribution and movements of the whales coincide with substantial commercial ship traffic, leading to a serious risk of collision. This risk is likely exacerbated by right whales engaging in feeding and courtship behavior in this area, because these activities appear to render right whales less aware of sources of impending danger, such as approaching ships. Given the critical importance of this area to right whales and the high percentage of the population that occur there during the four month period from April through July, it is imperative that action be taken to reduce the threat of ship strikes.

7 The risk of ship strikes of right whales has been well demonstrated. Massive wounds (*e.g.*, fractured skulls, severed tails) found on right whale carcasses suggest that collisions with large ships were responsible for the deaths. Two right whales, on average, are known to be killed or seriously injured each year as a result of collisions with ships. During a 15 month period from February 2004 to April 2005, at least four adult females—three of which were carrying near term fetuses—were killed by ship strikes. The loss of these reproductive females is significant, particularly because two of them were at the beginning of their calf-bearing years. Necropsies performed on right whales have shown that over 50% of deaths can be attributed to ship strikes; however, the actual number of deaths from ship strikes may even be higher because many deaths likely go unrecorded as carcasses drift out to sea or the cause of death is undetermined.

8 The proposed ATBA "In the Great South Channel" is an integral part of the United States' approach to reducing the risk of ship strikes. The United States has held a significant number of consultations, public hearings, workshops, and industry and stakeholder meetings on this issue with representatives of the shipping industry, master mariners, harbor pilots, environmental interests, marine mammal researchers, and representatives of national and local governments. These stakeholders' concerns were carefully considered and taken into account in the development of this ATBA proposal, including the impact on industry and the protection of right whales. The United States Coast Guard also conducted a Port Access Route Study in which various options for routing measures were considered as well as the impact on maritime safety of this proposed measure. Additionally, by using information gained from the U.S. Northeast Mandatory Ship Reporting System (MSR),[3] it was possible to take into account the burden on, and practical navigation aspects for, the shipping industry.

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[3] In 1998, the Maritime Safety Committee approved the establishment of two Mandatory Ship Reporting systems off the U.S. east coast, one in the northeast United States (off the coast of Boston and Cape Cod) and one in the southeast United States (off the coasts of Georgia and Florida). Ships of 300 gross tons and above are required to participate in these systems when they cross into the reporting system and report such things as course, speed, entry into system, destination, and route. In response to a ship's report, the shore-based authority sends information to assist mariners navigating through the area, such as the latest known location of the whales and other guidance on ways to avoid a ship strike. GPSR, Part G, I/13-1.

Traffic considerations

9 The Great South Channel is the passage between the easternmost point of the Nantucket Shoals and the westernmost shoals of Georges Bank. The channel is approximately 27 miles wide and has depths of 19 fathoms and greater throughout, with lesser depths along the eastern and western edges. The bottom topography and related features in the area contribute to the presence of the right whales' preferred prey, copepods.

10 Container ships, bulk carriers, passenger ships, cargo ships, and tankers pass in and around the area of the proposed ATBA. Although the exact number of ships that actually transit the area is difficult to determine,[4] extrapolation from the data obtained from the MSR provides an estimate that around 200 vessels of 300 gross tons and above transit through the proposed ATBA each year during the four month period from April 1st - July 31st. Vessels bound for the port of Boston to and from points to the east, follow the Great Circle route to and from Europe and transit just north of Georges Bank to enter the Boston TSS well north of the proposed ATBA. Using data from the MSR for the period of April-July 1999-2005, it is estimated that there were approximately 1,400 voyages that passed through the proposed area during the four month season over this seven year period. The routes that will be affected by the proposed ATBA can be divided into three major categories:

a. Vessels that enter or leave points south of Cape Cod appear to follow the Ambrose-Nantucket TSS and then steer a northeasterly course into or out of the associated precautionary area to Europe. These vessels may transit from the southwest to the northeast, cutting across a small portion of the southeastern portion of the proposed area (526 vessel voyages or, if averaged over the 7 year period of the available data, approximately 75 voyages per season). See Annex 3, the area between points A and B;

b. Vessels coming from Cape Hatteras, Chesapeake Bay, Delaware Bay, or New York usually pass Nantucket Shoals Lighted Whistle Buoy N, and then go though the Great South Channel to Cape Cod or the Gulf of Maine. Some of these vessels transit just east of the Boston TSS (171 vessel voyages or approximately 24 voyages per season) while others use the Boston TSS (335 inbound voyages or approximately 48 inbound voyages per season). These numbers are based on an assumption that only those vessels inbound to Boston from the south through the TSS are reporting and, since the MSR does not require that vessels report in twice, these vessels would not report in on their outbound voyage. Therefore, based on this assumption, the number of actual voyages through the TSS over the seven year period may be double that reported into the MSR or 670 voyages or 96 voyages per season). See Annex 3, the area between points C and D; and

c. Some vessels proceed from east to west or vice versa across the proposed area (21-28 vessel voyages or approximately 3-4 voyages per season). See Annex 3.

[4] These difficulties include that some of the reports from ships are duplicative, some ships are simply in transit while others transit the reporting area both inbound and outbound, and, while compliance is increasing each year, it can be expected that some ships do not comply with the MSR. In developing this proposal, the United States attempted to take into account these difficulties by providing a higher estimate of the number of ships that might be impacted by the proposed ATBA.

11 There are adequate surveys and charts of the area and, with modern navigation equipment, mariners are able to determine their positions in relation to the proposed area to be avoided. There are appropriate aids to navigation in place and there is also complete differential GPS coverage and LORAN-C coverage. With respect to environmental conditions during the time of applicability for the proposed ATBA, the weather is highly variable, fluctuating from fair to cloudy to stormy. During April and May, low-pressure systems pass fairly regularly and produce precipitation on an average of one day in three. Much of the rainfall in June and July comes from showers and thunderstorms. The heaviest gales are usually from the northeast or east. The predominant wind direction is west through northwest. Fog is prevalent throughout the year, particularly so in the months of April through July.

Proposal

12 The United States proposes to establish a recommendatory, seasonal ATBA for ships of 300 gross tons and above for the four month period from April 1st– July 31st to significantly reduce the risk of ship strikes of right whales in the Great South Channel. As noted above, this area is of vital importance to right whales, and the whales engage in behavior in this area that makes them particularly susceptible to ship strikes. Right whales face their highest risk of ship strikes in this area during this four month period because of the significant seasonal whale aggregations that occur and their close proximity to ship traffic. Moreover, it is important to note that there are right whales in this area that are rarely, if ever, seen elsewhere. This was one of the bases for establishing right whale critical habitat in this area under U.S. domestic law.

13 The United States has carefully considered the impact on ship traffic that would result from the proposed ATBA. First, the time that the ATBA would be operational has been constrained to address an industry concern that the measure should be limited to that which is strictly necessary to accomplish the biological objectives of protecting the remaining right whales while minimizing the adverse impact on shipping.

14 Second, the ATBA has been configured to minimize adverse impacts on shipping and to take into account maritime safety considerations. For instance, the eastern boundary of the proposed ATBA aligns with part of the MSR boundary. The United States deviated from the right whale critical habitat boundary in this area to avoid mariner use of dangerous waters of the Cultivator Shoals. Additionally, the southern boundary of the proposed ATBA also deviates from the critical habitat boundary to provide an additional margin of protection to the greatest density of right whales and to safeguard maritime safety by aligning the ATBA boundary so that ships will enter the precautionary area at the seaward terminus of the traffic separation scheme.

15 Third, the ship tracks through the proposed ATBA have been carefully examined. The proposed ATBA affects the three major routes differently:

a. Ships cutting across the proposed area in a southwest to northeasterly direction would have to adjust their bearing to avoid this area for the applicable four month period. The boundary is configured to accommodate ships on this bearing and to reduce the adverse impact on this traffic. The increase in distance is estimated to be approximately 7 nautical miles;

b. For ships navigating to the east of the Boston TSS, they would presumably not join the TSS until approximately a point south of the major turn in the TSS, where they

would then continue their journey north or south. Since there are clear navigational and operational rules applicable for ships operating in the TSS, maritime safety would be safeguarded and possibly improved for these ships. Additionally, it is estimated that only approximately 24 vessels per season would be moved from navigating in the proposed ATBA to navigating in the TSS. It is not expected that this slight increase in the number of ships per year would adversely affect maritime safety. The increase in distance is estimated to be approximately 14 nautical miles; and

c. The relatively small number of ships that travel from east to west or vice versa (e.g., 3-4 voyages per season) would be impacted the most by the proposed ATBA. The increase in distance is estimated to be approximately 55 nautical miles.

16 Maritime safety considerations have been carefully taken into account in the development of this proposal, in particular through a Port Access Route Study conducted by the U.S. Coast Guard which considered various alternatives and scenarios. Maritime safety should be enhanced because of a decrease in the potential for any damage to a ship from hitting these large whales. Also, if there is a decrease in ship encounters with whales, there will be a decreased risk of collisions between a ship taking avoidance action and another vessel.

Additional Actions

17 In recognition of the significance of this area to right whales, the United States has taken several measures under domestic law to protect this endangered species. In 1994, the United States designated the area as "critical habitat" for right whales. Under U.S. law, critical habitat is a geographically defined area that is designated because it has physical and biological features essential to the survival and recovery of threatened or, as in the case of the right whale, endangered species. In designated critical habitat, special management considerations apply and special protections can be adopted. In the Great South Channel Right Whale Critical Habitat, the United States has adopted several restrictions to protect right whales, including measures applicable to U.S. fishermen. Examples include: closing the area to gillnet fishing during the spring to reduce the potential for entanglement in gillnet gear; in other times and places there are required gear modifications such as breakaway buoys, weak vertical lines, or sinking lines designed to allow whales to break through encountered gear or reduce the severity of an entanglement; and periodic workshops are conducted to increase awareness of fishing practices and gear technology that reduce entanglements of right whales.

18 The United States has also taken a number of steps internationally to identify and implement measures to reduce ship strikes of right whales. Importantly, the United States sought—and achieved—approval by this Sub-committee of its proposals to amend the Boston TSS to significantly reduce ship strikes of right and other large whales (COLREG.2/Circ. 58) and to establish two mandatory ship reporting systems which educate mariners about the threat of ship strikes and provide them with the last known location of right whales (GPSR, Part G, I/13-1).

19 Other steps that the United States has taken include the examination and identification of relevant information and management options. These options have formed the basis for the development of the U.S. Right Whale Ship Strike Reduction program, which addresses such issues as research and development of technologies to reduce the risk of ship strikes, a merchant mariner education and outreach program, and targeted operational measures. Guidelines for measures that mariners may take to avoid right whales are now published in various navigational aids such as U.S.

Coast Pilots, Notices to Mariners, Sailing Directions, and Admiralty Publications and broadcast over VHF radio by NOAA weather radio and U.S. Coast Guard facilities. Information brochures, placards, and computer CDs are also being distributed to mariners. Additionally, a combination of aerial and vessel surveys are conducted seasonally to attempt to locate right whales and this information is provided via various telecommunication networks to mariners operating in the vicinity of whales. While these surveys cannot result in a comprehensive picture of whale locations due to whale movement and weather limitations, they are the best means currently available for detecting the location of right whales and thus provide valuable information to mariners.

20 In addition to the actions taken by the United States, Canada—as the other State where the North Atlantic right whale occurs—has taken extensive measures to protect right whales, in particular from ship strikes. It sought—and achieved—approval by this Sub-committee and adoption by the Maritime Safety Committee of its proposal to amend the Bay of Fundy Traffic Separation Scheme (COLREG.2/Circ.52) and the establishment of a recommended, seasonal area to be avoided in Roseway Basin to reduce the risk of ship strikes (SN.1/Circ. 263).

Action requested of the Sub-Committee

21 The Sub-Committee is asked to approve this proposal for the establishment of a recommendatory, seasonal area to be avoided "In the Great South Channel" as set forth in the annex and forward the proposal to the Maritime Safety Committee for adoption. The United States also requests that the effective date of implementation be six months after adoption.

***

ANNEX 1

IN THE GREAT SOUTH CHANNEL

(Reference charts: United States 13009, 2007 edition; 13200, 2007 edition. ***Note***: These charts are based on North American 1983 Datum which is equivalent to WGS 1984 datum.)

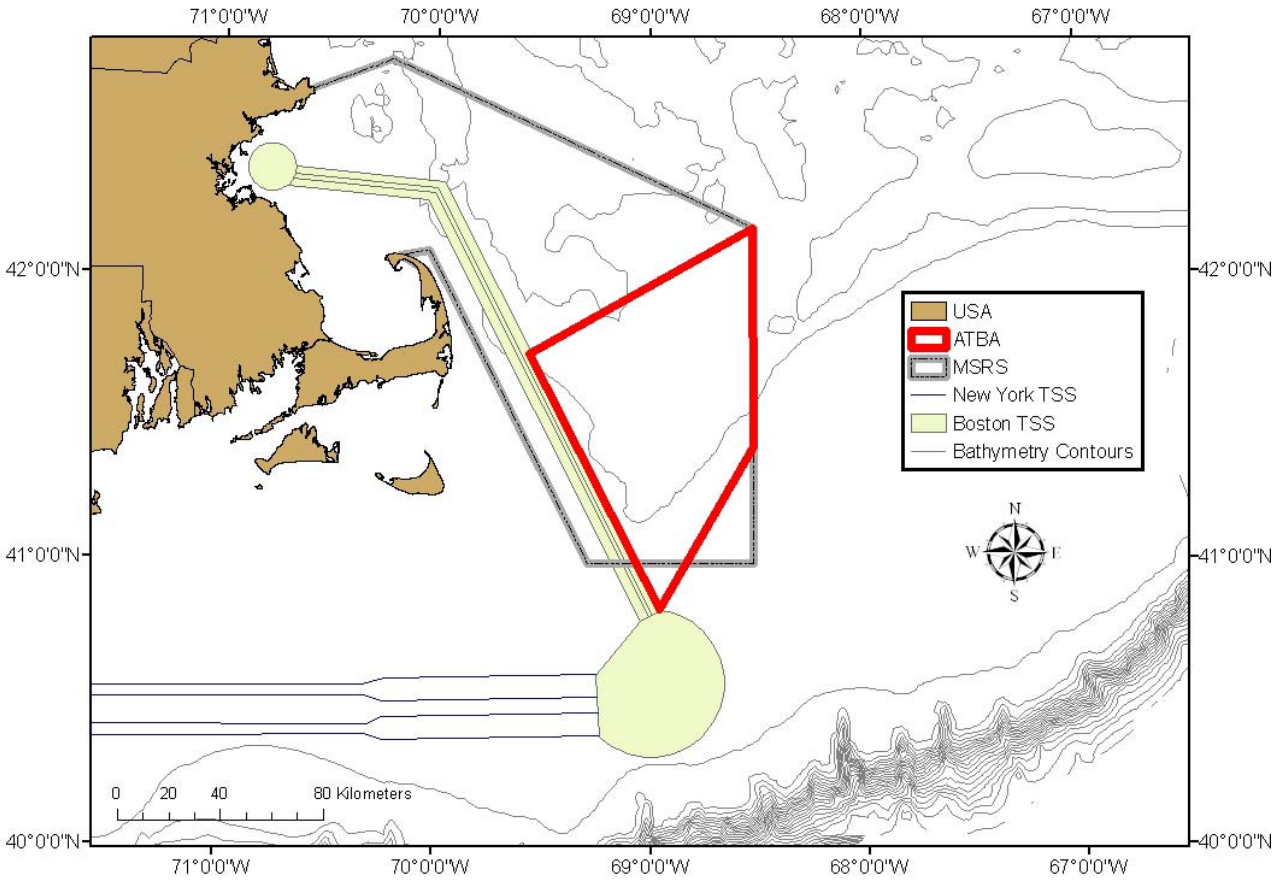
Description of the Area to be Avoided

In order to significantly reduce ship strikes of the highly endangered North Atlantic right whale, ships of 300 gross tons and above—during the period of April 1st through July 31st —should avoid the area bounded by lines connecting the following geographical positions:

(1) 41° 44'.08 N - 069° 34'.97 W
(2) 42° 10'.00 N - 068° 31'.00 W
(3) 41° 24'.89 N - 068° 31'.00 W
(4) 40° 50'.47 N - 068° 58'.67 W

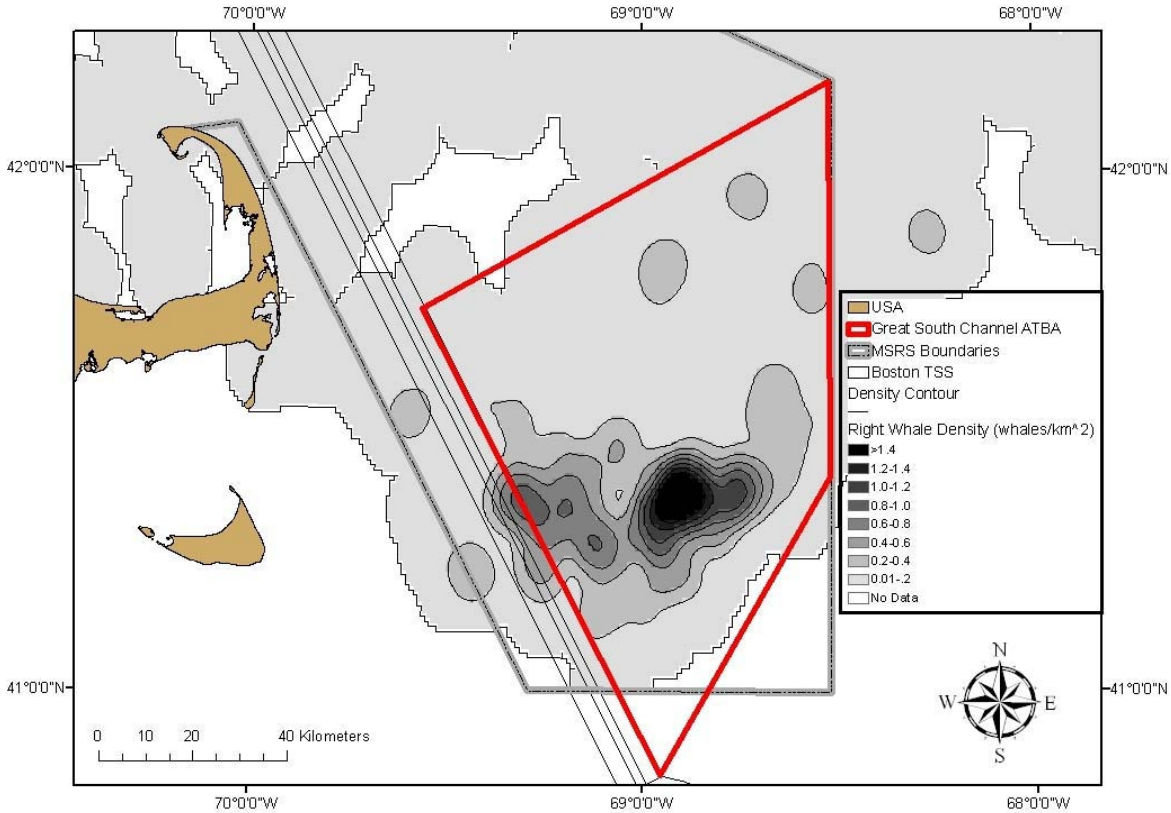
Annex 1

Chartlet



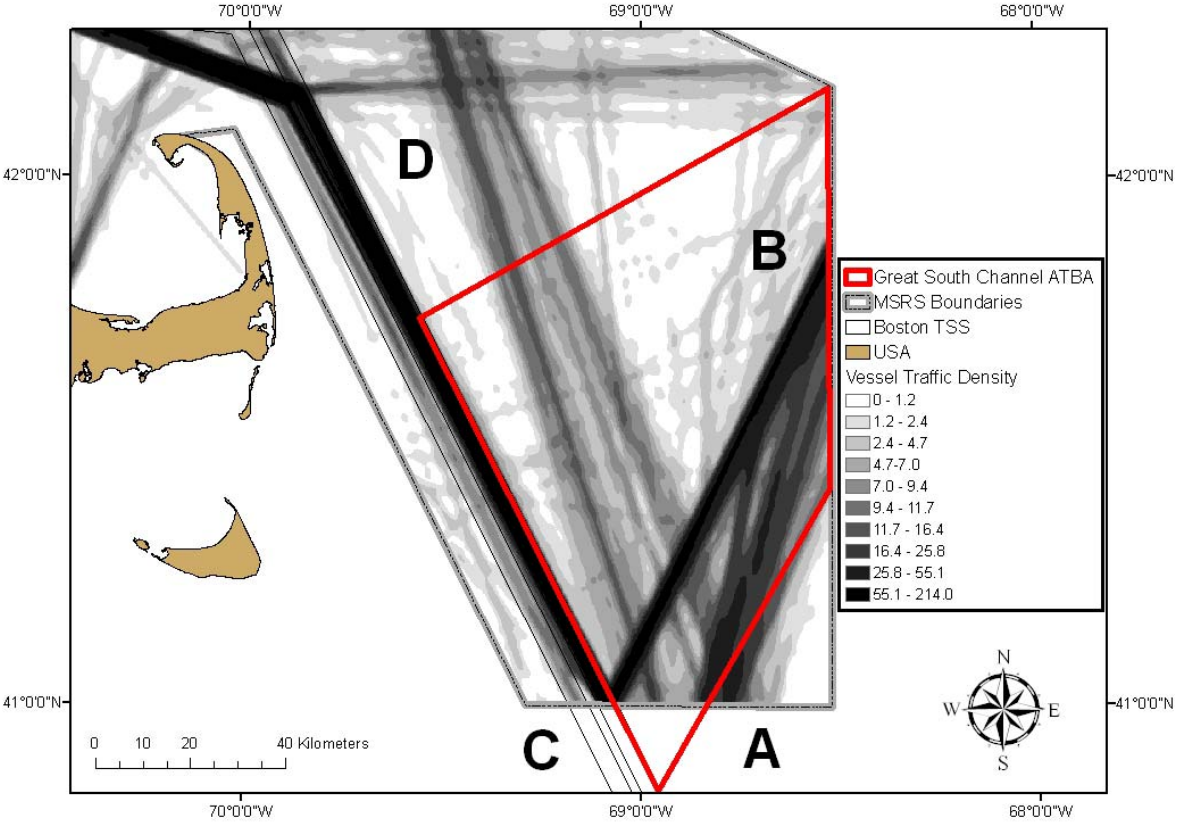
ANNEX 2

Northern right whale sighting densities (whales/km^2) in the Great South Channel during April-July, 1999-2005.



ANNEX 3

Mandatory ship reporting system boundaries and densities of ship track (km of ship track/km^2) through the proposed ATBA and existing TSS for April-July, 1999-2005.



NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

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FOR IMMEDIATE RELEASE
May 26, 2009

Changes in Vessel Operations May Reduce Risk of Endangered Whale Shipstrikes

Years of study and effort by NOAA and the U.S. Coast Guard will pay off this summer when two changes to shipping lanes into Boston are implemented. Both changes significantly reduce the risk of collisions between large ships and whales.

Beginning on June 1**,** ships 300 gross tons and above will be asked to avoid an area in the Great South Channel from April through July, when right whales face the highest chance of being struck by ships. The channel is a feeding area for the endangered North Atlantic Right Whale.

Also, ships transiting primarily from the south and entering Boston Harbor in shipping lanes will travel a slightly different path. The north-south traffic lanes have been modified to reduce the threat of ship collisions with endangered right whales and other whale species.

The width of the north-south portion of the lanes will narrow from a total of four miles to three miles. The width of the east-west portion of the lanes was narrowed and modified in 2007.

Implementing the “Area To Be Avoided” and narrowing the “Traffic Separation Scheme” by one nautical mile will reduce the relative risk of right whale ship strikes by an estimated 74 percent during April-July (63 percent from the area to be avoided and 11 percent from the narrowing of the Traffic Separation Scheme).

Slow moving North Atlantic right whales--among the most endangered whales in the world--are highly vulnerable to ship collisions, since their primary feeding and migration areas overlap with major East Coast shipping lanes. Along with existing measures to prevent entanglement of right whales in fishing gear and regulations to reduce ship strikes by slowing ships, these changes in vessel operations are a part of the comprehensive approach that NOAA has taken in its effort to help right whales recover.

“Through years of study we have determined that these changes will likely provide a safer environment for whales and mariners, and at the same time, provide the least amount of disruption and impact to the economy,” said Jim Balsiger, NOAA’s acting assistant administrator for NOAA’s Fisheries Service. “NOAA and our partners are working extremely hard to do all we can to help save this critically endangered species, while helping mariners stay safe and productive.”

Approximately 3,500 ships move through the entire Boston shipping lanes area every year, and more than half of the world’s North Atlantic right whales are known to be in this area during the spring. NOAA researchers used more than 20 years of sighting data to determine the risk of whales being struck by ships in and around the Boston shipping lanes to help develop these changes. Working with the Coast Guard, which assessed safety and navigational effects of ship lane modification to the shipping industry, NOAA proposed the changes to the International Maritime Organization in March 2008.

The International Maritime Organization adopted both of these changes, so they will be reflected on all charts globally and used by the international shipping industry. NOAA’s Fisheries Service is working with NOAA’s Ocean Service and the U.S. Coast Guard to have these changes added to nautical charts and to the U.S. Coast Pilot as well.

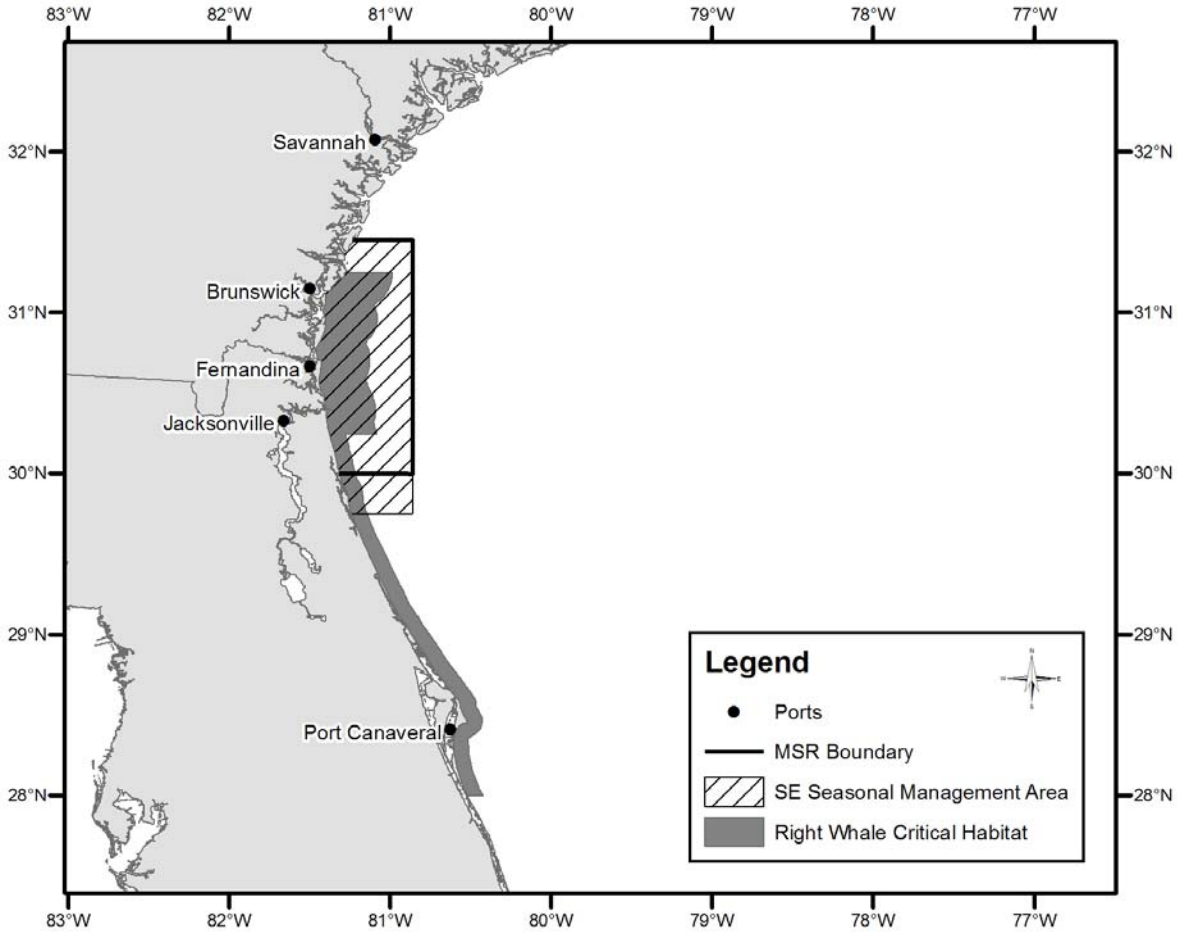
“NOAA's scientific expertise and their investment in research into the seasonal distribution of right whales provided the Coast Guard with valuable data and information and helped identify shipping lanes that reduce the likelihood of vessel interactions with this protected species. Fewer collisions involving commercial shipping vessels and right whales will be a great outcome for the agencies, for mariners and coastal commerce and for the public," said Steven Tucker, deputy chief for marine protected species, U.S. Coast Guard Law Enforcement Office.

Existing protective actions also include seasonal and dynamic vessel speed restrictions in selected areas, mandatory lanes into certain ports, surveying whale migration routes by aircraft and mandatory ship reporting systems that provide advisories and information on right whale locations to mariners.

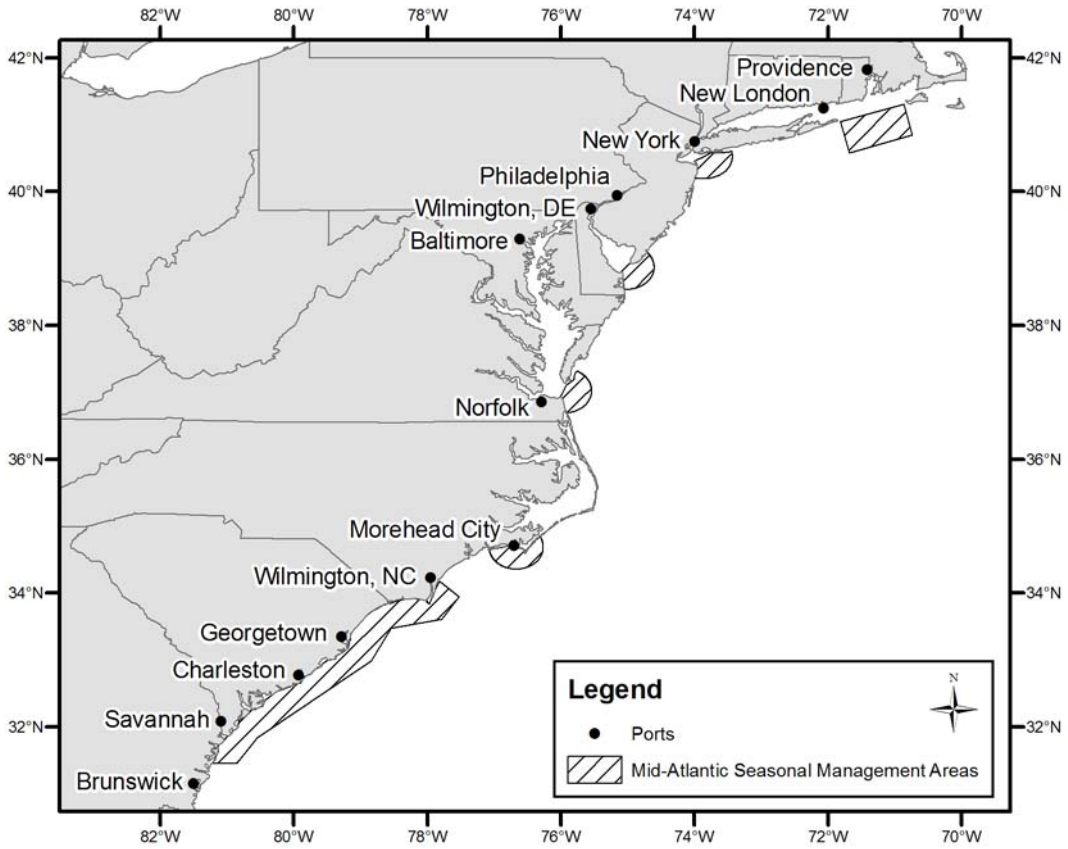
NOAA understands and predicts changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and conserves and manages our coastal and marine resources. Visit http://www.noaa.gov.

- 30 -

Southeastern U.S. Area
Mandatory Speed Restriction **November 15th through April 15th**
Calving and Nursery Grounds

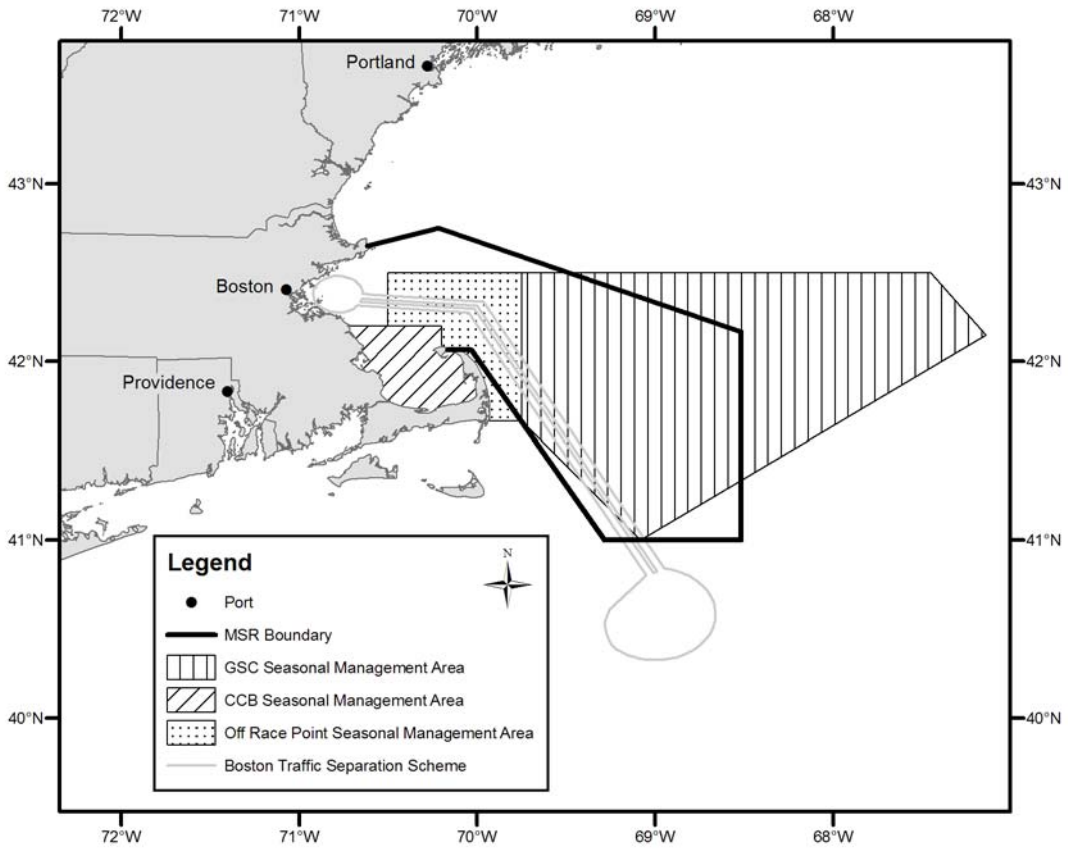


Mid-Atlantic U.S. Area
Mandatory Speed Restriction **November 1 through April 30**
Migratory Route



Vessel speed is restricted around each of the port or bay entrances identified and the designated area around Block Island Sound (a box with a 30 nm width extending south and east of the mouth of the Sound--reference points: Montauk Point and the western end of Martha's Vineyard). The areas are defined as the waters within a 20-nm area with an epicenter located at the midpoint of the COLREG demarcation line crossing the entry into the designated ports or bays.

Final Northeastern U.S Area
Mandatory Speed Restriction Times Vary
Feeding Areas



Right whales occupy and forage in four distinct areas in the NEUS from January through July: Cape Cod Bay; the area off Race Point at the northern end of Cape Cod; the Great South Channel; and the northern Gulf of Maine. Little is known about recurring whale presence or density, and vessel traffic patterns (besides Portland transits) are not consistent or predictable, in the northern Gulf of Maine. No seasonal speed restrictions are imposed in the northern Gulf of Maine. For the other three areas:

Cape Cod Bay	**Off Race Point**	**Great South Channel**
January 1st through May 15th	**March 1 through April 30**	**April 1st through July 31st**

	# OBS	556	-	-	555	714	711	741	733	711	712	687	697	6817
2006	MEAN	21.8	23.0	18.6	17.3	15.4	14.2	12.0	12.5	14.0	19.1	15.8	21.2	17.0
	MAXIMUM	48.2	50.5	43.2	37.1	40.6	41.8	43.2	27.0	32.1	50.2	37.9	38.5	50.5
	DAY-HR	18-20	13-00	01-03	24-05	14-08	07-14	21-09	07-12	11-14	29-14	23-19	08-22	FEB
	MINIMUM	4.5	1.9	0.6	2.3	2.3	4.1	0.2	2.5	1.9	3.7	2.3	3.3	0.2
	DAY-HR	03-00	21-11	29-10	27-16	28-20	15-00	16-00	18-13	27-10	08-23	07-05	07-22	JUL
	# OBS	703	623	705	690	716	715	735	732	689	675	642	644	8269
2007	MEAN	22.7	25.0	21.5	19.7	12.4	15.0	11.0	11.3	13.6	15.8	19.8	21.8	17.5
	MAXIMUM	44.9	51.5	44.7	42.2	18.1	33.0	29.4	26.8	36.4	33.0	62.2	50.2	62.2
	DAY-HR	21-02	14-20	06-22	16-04	31-07	13-20	05-14	08-19	15-12	20-06	03-23	04-08	NOV
	MINIMUM	4.1	3.1	4.7	0.2	6.8	1.9	1.9	2.1	1.7	3.3	3.9	1.4	0.2
	DAY-HR	07-22	28-13	26-02	12-00	31-12	01-03	17-09	30-07	21-08	30-23	20-20	26-17	APR
	# OBS	604	590	617	325	24	707	734	725	708	719	687	703	7143
2008	MEAN	21.8	20.3	20.5	14.9	16.4	11.9	10.9	11.5	15.1	18.4	17.9	22.7	16.8
	MAXIMUM	53.5	46.3	46.7	34.0	36.9	27.8	27.0	23.7	36.9	46.3	39.7	51.1	53.5
	DAY-HR	28-00	14-01	09-09	02-05	12-20	01-00	28-02	12-02	07-05	29-02	16-07	22-04	JAN
	MINIMUM	2.7	1.9	1.7	1.7	1.2	2.1	1.2	2.3	1.9	2.3	2.3	3.3	1.2
	DAY-HR	24-15	04-18	24-20	25-22	06-14	14-18	11-21	01-20	18-04	05-12	04-11	06-14	JUL
	# OBS	707	662	724	704	739	712	739	736	711	737	690	699	8560
POR	MEAN	22.7	23.4	19.9	17.2	14.7	13.0	11.5	11.9	13.5	17.9	19.2	22.9	16.9
	MAXIMUM	53.5	51.5	46.7	51.7	42.6	42.4	43.2	49.0	44.9	53.3	63.4	60.5	63.4
	YEAR	2008	2007	2008	2003	2005	2003	2006	2003	2004	2005	2005	2004	NOV/2005
	MINIMUM	1.2	1.9	0.6	0.2	1.2	0.8	0.2	1.2	1.6	1.2	2.1	1.4	0.2
	YEAR	2005	2008	2006	2007	2008	2003	2006	2003	2005	2004	2004	2007	APR/2007
	# OBS	3315	2542	2780	2988	3216	4283	4453	5151	4967	5059	4854	4953	48561

STATION: 44018 -- POR (7/2002 - 12/2008)

2 - MEANS & EXTREMES BASED ON HOURLY (GMT) OBSERVATIONS -- MONTHLY & ANNUAL BY YEAR

ELEMENT: SIGNIFICANT WAVE HEIGHT (METERS)

YEAR	ELEMENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
2002	MEAN	-	-	-	-	-	-	0.8	0.8	1.2	1.7	2.0	2.3	1.6
	MAXIMUM	-	-	-	-	-	-	0.9	2.3	5.1	5.4	6.6	8.2	8.2
	DAY-HR	-	-	-	-	-	-	31-08	31-20	12-08	16-21	07-05	26-13	DEC
	# OBS	-	-	-	-	-	-	20	738	717	732	716	732	3655
2003	MEAN	2.2	2.2	1.7	2.0	1.3	1.1	1.0	0.9	1.5	1.6	1.8	2.5	1.7
	MAXIMUM	6.5	6.6	4.4	4.9	4.2	4.8	2.4	2.2	3.8	4.2	5.7	7.6	7.6
	DAY-HR	02-17	18-04	03-17	08-15	03-17	02-02	23-23	06-07	29-01	16-04	29-18	06-21	DEC
	# OBS	733	665	733	712	708	720	742	743	710	734	715	731	8646
2004	MEAN	1.5	-	-	-	1.0	0.9	1.0	0.9	1.4	2.0	1.8	2.1	1.4
	MAXIMUM	2.6	-	-	-	1.6	2.7	2.7	2.7	4.9	5.8	6.0	8.6	8.6
	DAY-HR	07-13	-	-	-	29-22	01-22	20-04	31-13	30-00	24-09	14-04	27-08	DEC
	# OBS	68	-	-	-	309	717	742	742	715	740	709	730	5472
2005	MEAN	2.2	2.1	2.0	1.7	1.5	0.9	0.8	0.9	1.3	1.9	1.5	1.9	1.5
	MAXIMUM	8.6	4.0	6.0	5.3	5.9	2.2	2.2	2.4	2.8	6.9	6.5	5.3	8.6
	DAY-HR	23-19	04-22	09-10	03-20	25-02	15-11	01-21	16-00	27-11	25-15	22-23	09-23	JAN
	# OBS	719	652	720	675	683	710	731	731	700	672	672	671	8336
2006	MEAN	2.1	2.0	1.6	1.6	1.6	1.2	1.1	0.8	1.4	1.6	1.6	1.6	1.5
	MAXIMUM	5.7	6.6	3.8	3.7	4.5	3.2	4.9	2.1	4.1	5.4	5.3	4.4	6.6
	DAY-HR	04-03	12-15	26-22	24-09	02-04	07-20	21-09	29-19	12-17	29-05	09-09	02-09	FEB

	# OBS	669	599	673	678	703	711	729	718	676	647	583	595	7981
2007	MEAN	1.8	2.1	1.9	1.7	0.6	1.1	1.0	1.0	0.9	1.1	1.8	1.9	1.4
	MAXIMUM	4.3	6.1	4.8	4.1	0.8	3.5	2.4	2.8	2.2	3.0	8.5	5.7	8.5
	DAY-HR	21-06	14-20	17-03	16-04	31-15	05-03	21-07	18-18	29-02	29-06	04-04	17-06	NOV
	# OBS	558	544	559	302	24	687	704	705	686	651	602	606	6628
2008	MEAN	2.0	1.9	2.0	1.6	1.5	0.9	1.1	0.9	1.5	1.7	1.8	2.0	1.6
	MAXIMUM	8.1	5.9	5.8	3.6	4.9	2.5	2.4	2.0	4.3	5.7	4.8	5.2	8.1
	DAY-HR	28-08	14-06	09-12	07-15	10-19	01-09	22-15	26-11	07-09	29-02	26-10	20-05	JAN
	# OBS	605	588	632	662	708	701	704	715	687	701	622	622	7947
POR	MEAN	2.1	2.1	1.8	1.7	1.4	1.0	1.0	0.9	1.3	1.7	1.8	2.1	1.5
	MAXIMUM	8.6	6.6	6.0	5.3	5.9	4.8	4.9	2.8	5.1	6.9	8.5	8.6	8.6
	YEAR	2005	2006	2005	2005	2005	2003	2006	2007	2002	2005	2007	2004	JAN/2005
	# OBS	3352	3048	3317	3029	3135	4246	4372	5092	4891	4877	4619	4687	48665

STATION: 44018

3 - PERCENT FREQUENCY OF AVERAGE WIND SPEED(KNOTS) VS AVERAGE WIND DIRECTION(TENS OF DEGREES)

Month: JAN

	WIND DIRECTION													
WIND SPEED	CALM	35-01	02-04	05-07	08-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31	32-34	TOT %	TOT N
0	0.1	0.1	-	*	-	*	-	0.1	-	0.1	-	0.1	0.1	0.5	18
1 - 3		0.5	0.3	0.4	0.4	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.5	3.7	129
4 - 6		0.5	0.7	0.2	0.5	0.4	0.4	0.2	0.6	0.7	0.6	0.4	0.3	5.5	191
7 - 10		0.8	0.7	0.5	0.6	0.5	0.8	0.7	1.3	1.3	1.8	1.1	1.0	11.1	387
11 - 15		1.7	1.3	0.9	0.7	0.6	0.7	2.0	2.6	2.8	3.4	3.0	2.4	22.2	776
16 - 20		1.5	1.2	1.4	0.7	0.5	0.8	1.5	2.5	3.0	3.6	4.4	2.8	23.9	834
21 - 24		1.4	0.5	0.5	0.7	0.5	0.6	0.6	0.9	0.8	2.6	4.5	4.1	17.9	625
25 - 33		1.8	0.9	0.8	0.9	0.1	0.5	0.3	0.3	0.4	1.5	3.8	3.3	14.5	506
34 - 47		0.1	0.3	*	-	-	-	-	-	-	-	*	-	0.5	18
> 48		-	-	-	*	-	-	-	*	-	-	-	0.1	0.1	4
TOTAL %	0.1	8.4	5.7	4.8	4.6	2.8	3.9	5.5	8.5	9.4	13.9	17.7	14.6	100.0	
TOTAL N	2	293	200	169	160	99	137	193	295	328	485	618	509		3488

(* < 0.05%)

STATION: 44018

3 - PERCENT FREQUENCY OF AVERAGE WIND SPEED(KNOTS) VS AVERAGE WIND DIRECTION(TENS OF DEGREES)

Month: FEB

	WIND DIRECTION													
WIND SPEED	CALM	35-01	02-04	05-07	08-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31	32-34	TOT %	TOT N
0	0.0	-	-	-	-	*	*	0.1	-	-	-	-	-	0.2	5
1 - 3		0.1	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.3	2.6	69
4 - 6		0.6	0.3	0.4	0.2	0.3	0.3	0.5	0.8	0.6	1.4	0.5	0.6	6.4	171
7 - 10		0.9	0.6	0.6	0.7	0.6	0.5	0.9	1.1	1.0	1.8	2.1	1.4	12.2	325
11 - 15		0.5	0.9	1.4	1.2	1.1	0.5	1.1	1.0	3.7	3.8	3.6	2.6	21.3	567
16 - 20		1.1	0.8	0.7	0.8	1.1	0.9	0.7	1.1	3.0	4.9	4.3	3.1	22.4	596
21 - 24		0.8	0.6	0.9	0.4	0.3	0.6	0.8	0.4	1.0	3.3	5.7	2.2	16.9	451
25 - 33		0.7	0.2	0.9	0.4	0.2	0.1	0.5	0.5	1.3	4.0	6.3	1.8	17.0	452
34 - 47		0.1	-	0.1	0.1	0.1	-	-	*	*	0.2	0.2	0.1	0.9	25
> 48		-	-	*	-	-	-	-	-	-	-	-	-	0.0	1
TOTAL %	0.0	4.6	3.5	5.4	3.9	3.9	3.2	4.7	5.2	10.9	19.5	23.0	12.1	100.0	
TOTAL N	1	123	93	143	104	105	86	126	138	290	520	612	321		2662

(* < 0.05%)

	MAXIMUM	53.5	49.4	47.2	51.7	47.8	43.4	35.4	30.3	50.3	47.0	52.9	51.9	53.5
	DAY-HR	13-19	11-07	10-11	26-03	02-16	17-01	24-09	23-19	11-23	26-16	18-23	26-03	JAN
	MINIMUM	4.5	3.1	3.1	3.9	1.9	2.5	1.7	3.1	3.7	5.6	2.7	1.4	1.4
	DAY-HR	06-20	17-09	13-05	28-07	27-05	21-05	21-13	27-14	29-19	25-05	03-23	13-17	DEC
	# OBS	740	670	742	711	736	717	732	677	720	736	720	740	8641
2003	MEAN	24.2	22.3	18.2	20.1	16.2	14.3	14.8	15.0	15.4	20.9	21.4	25.8	19.0
	MAXIMUM	52.9	45.1	39.3	48.2	36.2	33.6	34.2	28.2	41.8	50.3	56.6	50.0	56.6
	DAY-HR	02-08	12-16	03-10	26-20	26-22	22-19	27-19	17-20	23-21	15-17	14-05	07-01	NOV
	MINIMUM	1.4	2.5	1.6	2.7	1.7	1.2	1.2	2.3	1.0	2.9	1.7	1.9	1.0
	DAY-HR	06-01	26-20	28-17	25-11	07-05	26-16	20-12	12-15	22-06	09-18	27-19	20-00	SEP
	# OBS	744	672	744	716	743	719	743	743	709	742	720	739	8734
2004	MEAN	25.8	19.5	20.9	19.2	15.4	15.5	14.2	15.0	16.0	19.4	21.1	22.9	18.7
	MAXIMUM	57.5	49.4	48.2	41.0	34.2	32.1	34.2	41.4	52.1	42.2	51.3	59.5	59.5
	DAY-HR	14-00	06-22	12-18	14-02	08-05	06-14	13-18	15-12	29-12	17-01	05-05	01-19	DEC
	MINIMUM	4.5	1.6	3.9	2.9	1.2	2.1	2.5	1.4	1.7	1.6	2.3	2.7	1.2
	DAY-HR	02-10	02-18	09-15	21-08	20-04	16-16	03-15	25-08	24-08	07-15	18-06	03-08	MAY
	# OBS	744	689	742	719	738	718	742	740	720	743	717	741	8753
2005	MEAN	22.1	18.9	19.6	18.4	18.3	15.5	14.3	13.4	15.1	22.1	22.5	23.0	18.6
	MAXIMUM	68.0	43.0	57.0	50.9	54.2	30.7	29.9	36.5	38.9	57.9	50.2	69.4	69.4
	DAY-HR	23-13	15-10	09-03	03-07	07-17	30-15	25-17	31-22	29-21	25-15	03-20	09-20	DEC
	MINIMUM	2.5	2.5	2.1	2.1	1.7	3.9	2.7	3.1	0.8	2.5	3.7	1.9	0.8
	DAY-HR	08-08	02-00	21-15	01-06	04-14	04-17	05-04	25-02	07-08	01-04	19-16	25-06	SEP
	# OBS	744	670	741	720	731	720	735	742	718	742	718	743	8724
2006	MEAN	22.4	24.5	19.9	18.7	18.8	17.5	16.4	13.9	16.2	22.6	18.3	21.8	19.7
	MAXIMUM	53.5	56.4	45.7	40.4	42.2	46.3	35.4	33.2	38.1	57.2	48.4	53.8	57.2
	DAY-HR	19-01	12-15	16-03	04-23	02-04	07-18	03-03	20-13	02-22	28-18	23-23	02-00	OCT
	MINIMUM	2.1	1.7	1.7	3.7	3.3	3.1	4.1	2.9	2.7	3.1	3.5	0.0	0.0
	DAY-HR	02-17	23-08	29-09	15-05	28-04	02-22	07-16	18-14	13-05	14-13	30-00	31-23	DEC
	# OBS	740	668	743	717	732	706	276	300	640	657	712	735	7626
2007	MEAN	18.0	-	17.8	19.9	16.4	17.5	14.1	13.9	16.0	18.6	22.7	22.3	17.9
	MAXIMUM	43.9	-	35.2	62.6	39.9	44.7	36.5	46.9	39.7	42.4	58.5	53.3	62.6
	DAY-HR	08-11	-	28-23	12-20	19-01	02-00	05-12	08-15	15-18	20-04	03-21	17-05	APR
	MINIMUM	0.0	-	3.7	1.7	1.7	1.9	2.1	0.8	2.9	1.9	3.5	3.3	0.0
	DAY-HR	16-07	-	28-02	11-14	13-12	03-15	17-15	19-15	02-04	03-03	14-07	19-16	JAN
	# OBS	320	-	168	701	735	712	736	736	709	741	717	669	6944
2008	MEAN	21.9	21.3	21.5	16.5	18.9	14.5	14.0	12.6	16.0	19.9	20.8	25.0	18.6
	MAXIMUM	50.7	56.4	56.2	43.2	42.2	35.6	50.9	39.9	45.3	51.9	42.0	55.6	56.4
	DAY-HR	30-20	11-05	09-07	02-01	13-15	24-20	27-20	11-15	07-09	29-04	16-14	22-05	FEB
	MINIMUM	3.9	2.1	2.5	2.9	3.1	1.9	2.3	1.9	1.6	2.9	2.7	4.5	1.6
	DAY-HR	26-18	26-11	27-13	17-04	05-14	19-15	06-08	21-16	13-17	16-02	08-07	26-20	SEP
	# OBS	737	688	735	708	738	719	739	740	714	734	701	727	8680
POR	MEAN	22.8	21.3	20.9	18.8	17.4	15.9	14.9	14.2	16.2	20.3	21.8	23.1	18.9
	MAXIMUM	75.4	56.4	58.1	62.6	54.2	48.0	52.9	52.9	57.2	57.9	66.3	69.4	75.4
	YEAR	1999	2008	1999	2007	2005	2000	2001	1998	1999	2005	1997	2005	JAN/1999
	MINIMUM	0.0	1.6	1.6	1.7	1.2	1.2	1.2	0.8	0.8	1.6	1.7	0.0	0.0
	YEAR	2007	2004	2003	2007	2004	2003	2003	2007	2005	2004	2003	2006	JAN/2007
	# OBS	7373	6735	7521	7828	8488	8574	7656	8279	8489	8618	8571	8782	96914

STATION: BUZM3 -- POR (10/1990 - 5/2006)

2 - MEANS & EXTREMES BASED ON HOURLY (GMT) OBSERVATIONS -- MONTHLY & ANNUAL BY YEAR

ELEMENT: SIGNIFICANT WAVE HEIGHT (METERS)

YEAR	ELEMENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1990	MEAN	-	-	-	-	-	-	-	-	-	1.1	1.1	1.4	1.2
	MAXIMUM	-	-	-	-	-	-	-	-	-	3.0	4.1	3.3	4.1
	DAY-HR	-	-	-	-	-	-	-	-	-	19-14	11-04	24-16	NOV
	# OBS	-	-	-	-	-	-	-	-	-	506	679	633	1818
1991	MEAN	1.2	-	-	-	-	-	-	-	-	-	-	-	1.2
	MAXIMUM	2.8	-	-	-	-	-	-	-	-	-	-	-	2.8
	DAY-HR	13-00	-	-	-	-	-	-	-	-	-	-	-	JAN
	# OBS	290	-	-	-	-	-	-	-	-	-	-	-	290
1992	MEAN	-	1.1	1.5	1.1	-	-	-	-	-	-	-	-	1.3
	MAXIMUM	-	2.9	4.4	1.6	-	-	-	-	-	-	-	-	4.4
	DAY-HR	-	16-18	12-05	03-23	-	-	-	-	-	-	-	-	MAR
	# OBS	-	457	400	29	-	-	-	-	-	-	-	-	886
1997	MEAN	-	-	-	1.3	1.1	0.7	0.7	0.7	0.8	0.8	1.2	-	0.8
	MAXIMUM	-	-	-	2.6	3.7	1.5	1.7	2.5	3.1	2.6	3.9	-	3.9
	DAY-HR	-	-	-	29-11	03-22	22-09	25-23	21-22	29-23	28-02	02-00	-	NOV
	# OBS	-	-	-	75	702	700	709	723	692	685	507	-	4793
1998	MEAN	1.2	1.2	1.3	1.0	0.9	0.5	0.4	0.6	0.4	0.5	-	-	0.8
	MAXIMUM	3.6	3.3	4.4	2.9	3.3	1.9	1.2	2.1	1.4	1.5	-	-	4.4
	DAY-HR	25-01	13-08	10-10	23-23	02-14	01-02	01-11	26-08	02-12	10-11	-	-	MAR
	# OBS	340	588	621	567	551	576	598	634	410	429	-	-	5314
1999	MEAN	-	0.9	1.3	0.8	0.7	0.7	0.8	0.8	1.1	1.0	1.2	1.2	0.9
	MAXIMUM	-	2.5	5.1	2.2	2.3	2.0	2.7	1.8	2.7	2.8	4.1	3.6	5.1
	DAY-HR	-	13-03	04-17	08-22	25-19	28-23	02-19	14-13	30-15	19-04	03-08	30-11	MAR
	# OBS	-	389	691	692	707	695	699	418	202	276	369	548	5686
2000	MEAN	1.3	1.2	1.0	1.3	0.8	0.8	0.7	0.8	0.8	0.7	0.9	1.3	1.0
	MAXIMUM	5.9	4.2	3.0	3.9	3.5	2.0	0.8	1.8	2.8	1.9	2.7	6.3	6.3
	DAY-HR	26-09	14-21	29-12	09-20	19-01	07-03	01-02	07-11	20-17	11-14	27-03	18-06	DEC
	# OBS	558	513	487	426	352	314	9	591	684	658	614	611	5817
2001	MEAN	0.9	1.1	1.2	0.8	0.7	0.7	0.8	0.8	0.7	1.0	1.0	1.0	0.9
	MAXIMUM	2.7	3.7	3.8	1.9	1.5	1.6	2.2	1.9	2.1	2.8	2.2	2.2	3.8
	DAY-HR	31-15	10-13	22-10	01-00	30-21	12-11	05-22	14-02	30-16	17-17	20-08	29-12	MAR
	# OBS	529	464	487	400	342	550	512	610	503	557	718	738	6410
2002	MEAN	1.3	1.2	1.3	0.9	0.9	0.9	0.7	0.6	0.8	0.9	1.3	1.2	1.0
	MAXIMUM	2.9	3.1	3.7	2.3	2.4	1.8	1.6	1.4	2.9	3.3	3.2	3.1	3.7
	DAY-HR	14-05	13-00	04-04	29-10	15-03	28-18	24-09	23-09	16-16	20-00	30-20	22-02	MAR
	# OBS	740	664	732	699	721	676	683	683	566	683	585	654	8086
2003	MEAN	1.1	1.1	0.9	0.9	0.7	-	-	-	-	-	-	-	1.0
	MAXIMUM	2.6	3.5	2.3	2.1	1.1	-	-	-	-	-	-	-	3.5
	DAY-HR	20-18	05-08	22-02	27-06	03-16	-	-	-	-	-	-	-	FEB
	# OBS	720	607	653	557	121	-	-	-	-	-	-	-	2658
2005	MEAN	-	-	-	-	0.7	0.7	0.6	0.6	0.9	1.1	1.3	1.3	0.9
	MAXIMUM	-	-	-	-	2.0	1.3	1.7	2.0	2.6	3.4	4.5	3.6	4.5
	DAY-HR	-	-	-	-	26-02	30-15	25-19	31-23	27-08	26-08	22-17	16-16	NOV
	# OBS	-	-	-	-	498	707	709	730	718	731	717	736	5546
2006	MEAN	1.3	1.3	0.9	0.9	1.1	-	-	-	-	-	-	-	1.1
	MAXIMUM	4.6	3.7	2.4	2.2	1.6	-	-	-	-	-	-	-	4.6
	DAY-HR	19-04	06-13	11-01	04-21	02-05	-	-	-	-	-	-	-	JAN
	# OBS	739	668	736	707	46	-	-	-	-	-	-	-	2896
POR	MEAN	1.2	1.1	1.2	0.9	0.9	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.0
	MAXIMUM	5.9	4.2	5.1	3.9	3.7	2.0	2.7	2.5	3.1	3.4	4.5	6.3	6.3

Port Statistics

CARGO VOLUMES AT MASSPORT FACILITIES

Containerized Cargo (Conley Terminal)

Category	Mar 08 – Feb 09	Mar 07 – Feb 08	% Change
Containerized Cargo Import TEUs * (Fulls)	100,013	107,559	-7.0%
Containerized Cargo Export TEUs * (Fulls)	60,535	70,681	-14.4%
Containerized Cargo Empty TEUs *	43,479	44,853	-3.1%
Containerized Cargo Total TEUs*	204,027	223,093	-8.5%
Containerized Import Short Tons	1,039,035	1,117430	-7.0%
Containerized Export Short Tons	540,578	631,181	-14.4%
Total Containerized Short Tons	1,579,613	1,748,612	-9.7%

Non-Containerized Cargo (Massport Marine Facilities)

Category	Mar 08 – Feb 09	Mar 07 – Feb 08	% Change
Automobiles Processed	28,974	9,769	196.6%
Cruise Passengers	272,548	234,284	16.3%
Cement Short Tons	169,613	194,804	-12.9%

* TEU (20-foot equivalent unit)
* Totals do not include Over-the-Road containers

Port Of Boston Activity

All Volumes in Metric Tons Unless Otherwise Indicated
Volumes Reported for Public & Private Terminals*

	2008	2007	% Change
Containerized Cargo			
Public & Private Terminals			
Import Metric Tons	973,409	1,113,654	-13%
Export Metric Tons	496,311	620,303	-20%
Total Containerized Cargo	1,469,720	1,733,957	-15%
Container Ships (includes barges)	242	281**	-14%
Auto Vessels	32	20	60%
Bulk Cargo Imports in Metric Tons			
Petroleum Products	6,837,017	7,679,205	-11%
Liquefied Natural Gas	2,556,039	3,154,858	-19%
Salt	688,695	715,339	-4%
Cement * **	161,656	257,508	-37%
Automobiles(Autoport)	29,150	10,971	166%
Gypsum	27,692	159,055	-83%
Other	2,105,133	1,223,565	72%

Sub-total Bulk Imports	12,405,382	13,200,501	-6%
Bulk Cargo Exports in Metric Tons			
Scrap Metal	643,217	539,966	19%
Automobiles (Autoport)	21,736	2,804	675%
Other	135,571	29,659	357%
Sub-total Bulk Exports	800,524	572,429	40%
Total Bulk Cargo	13,205,906	13,772,930	-4%
Bulk Cargo Vessels/Arrivals	435	481	-10%
Total Port of Boston Cargo	14,675,626	15,506,887	-5%
Container TEUs (Fulls Only)	164,548	177,013	-7%
Automobiles Processed (units)	26,779	10,079	166%
Cruise Passengers	269,911	234,284	15%
Cruise Vessel Sailings	113	101	12%

NOTES:
Container TEUs do not include Over-the-Road boxes
* Private Terminal Volumes are as reported by PIERS.
**Vessel arrivals for 2007 were previously reported in error as 361.
*** Cement includes barge volumes at Massport facilities.
Other bulk import cargoes include chewing gum, dyes, vegetable oil, putty and caulk, and adhesives.
Other bulk export cargoes include steel and used automobiles.

APPENDIX 9

The properties surrounding Fall River State Pier were carefully looked at to determine ownership, location and use. These properties from plot maps N-13, N-15, N-16, and T-03 were compared from the MassLandRecords 20/20 system to the Massgov PatriotProperties to ensure proper accuracy. Noted in the map below are the plot and lot numbers for the area surrounding Fall River State Pier.

- Map ID 1 N-13-0020 is owned by the Commonwealth of Massachusetts. This property encompasses State Pier. This property contains 7.180 acres; with one warehouse style building that is noted 'Fall River State Pier'. The area of State Pier is used for cargo shipment container storage.

- Map ID 2 N-13-0021 is owned by the Commonwealth of Massachusetts. This property contains 2.020 acres and is located to the northeast of the State Pier property. This property was also referred to as Steamship Dock; sign on property image states 'Battleship Massachusetts – Welcome Aboard'.

- Map ID 3 N-16-0016 is owned by Nasser Real Estate Trust. This property encompasses 0.744 acres; the property image states Waterfront Café.

- Map ID 4 N-15-0002 is owned by Borden & Remington F R LLC. This property is classified as industrial with 14 mill style buildings on 29.220 acres. This land is used for

industrial waterfront for textile rubber and chemical manufacturing. This property encompasses from 63 Water Street west to the north side of Ferry Street.

- Map ID 5 N-16-0030 and T-03-0019 are both owned by New York Central Lines LLC. These properties combined are 2.013 acres southeast of State Pier. These properties are noted to be undeveloped.

- Map ID 6 N-13-0003 is owned by the Commonwealth of Massachusetts C/O Department Environmental Management. This property is to the north of State Pier – opposite the 195 bridge. This property contains 2.060 acres; with one museum style building that is noted 'Fall River State Pier'.

- Map ID 7 N-13-0001 is owned by Jobs For Fall River Inc. This property encompasses the land beneath the 195 bridge directly north of State Pier. It is not noted how much land is contained only a museum style building.

- Map ID 8 N-16-0011 is owned by Azar Jeanne Etali. This property is classified as Restaurant/Bar and is located on 0.396 acres.

- Map ID 9 N-16-0001 is owned by Fall River Inc. Marine Museum. This property contains 0.438 acres and is noted as being the Marine Museum at Fall River.

APPENDIX 10

LEASE AGREEMENT

AGREEMENT made and entered into this 31st day of March 1986 by and between the CITY OF NEW BEDFORD, a municipal corporation established under the laws of the Commonwealth of Massachusetts, by and through its HARBOR DEVELOPMENT COMMISSION, hereinafter referred to as the "LESSOR", and HERMAN MELVILLE SHIPYARD, INC., a Massachusetts corporation having a usual place of business in Fairhaven, Massachusetts, hereinafter referred to as the "LESSEE".

WHEREAS, the LESSOR has available for occupancy and development a certain parcel of land in New Bedford, Massachusetts; and

WHEREAS, the LESSEE is desirous of leasing and developing a portion of said land in New Bedford; and

WHEREAS, the LESSOR is aware of the desire of the LESSEE to occupy and develop said land in New Bedford for the primary purpose of operating a shipyard including the sale, repair, and outfitting of vessels;

NOW, THEREFORE, in consideration of their mutual promises, covenants, and agreements herein contained, the parties hereto agree as follows:

ARTICLE I
PREMISES

The LESSOR does hereby let, lease, and demise unto the LESSEE for its exclusive use and that of its successors, and assignees a certain parcel of land as fully described in Schedule A attached hereto and hereby incorporated into this Agreement.

ARTICLE II
TERM OF LEASE

TO HAVE AND TO HOLD the demised premises unto the LESSEE for the term of ninety-nine (99) years commencing on March 31, 1986. The term of this lease is subject to the

first or any succeeding twenty-five (25) year term. In the event that the LESSEE elects to so terminate, he shall notify the LESSOR in writing at least twelve months prior to the end of the respective term. In the event that the LESSEE does not notify the LESSOR of termination, the parties hereto shall be bound each to the other for the next succeeding term of twenty-five years except for the last term which shall be twenty-four years.

ARTICLE III

RENT

The LESSEE covenants and agrees to pay the LESSOR at City Hall in New Bedford, Massachusetts, or at such other place as the LESSOR shall designate in writing, rent as hereinafter set forth:

a) For the first twenty (20) years of the term hereof Eight Thousand Four Hundred Thirty-one and 20/100 Dollars ($8,431.20) per annum in equal monthly installments of Seven Hundred Two and 60/100 Dollars ($702.60);

b) For the next succeeding five (5) years of the term hereof, the sum of Eight Thousand Four Hundred Thirty-one and 20/100 Dollars ($8,431.20) per annum payable in equal monthly installments of Seven Hundred Two and 60/100 Dollars ($702.60);

c) For the succeeding fifteen (15) years of the term hereof, the parties shall use their best efforts to agree to the annual rental applicable thereto at least eighteen (18) months prior to the commencement of said term. In the event that the parties cannot agree to the rental the LESSOR shall select one arbitrator and the LESSEE shall select one arbitrator at least seventeen (17) months prior to the commencement of the instant term and shall so notify the other of their respective choice. The two arbitrators so selected shall determine a third arbitrator

that the arbitrators selected by the parties cannot agree to a third arbitrator, the arbitrators shall select a third arbitrator from a panel of three disinterested nominees to be selected by the American Arbitration Association. If at the end of one week after the designation of such panel there remains disagreement as to which of said nominees shall serve, the LESSOR'S and LESSEE'S arbitrators, in that order, shall each strike the name of one of the nominees and the remaining nominee shall be the third arbitrator. The rental that shall be determined by a majority of the arbitrators in a decision of the arbitrators made at least fourteen (14) months prior to the commencement of the instant fifteen (15) year term shall be binding on all parties except that the rental so determined shall not exceed that of comparable land of the LESSOR leased for similar purposes, and in no event shall the rent for said term exceed Twelve Thousand Six Hundred Forty-six and 80/100 Dollars ($12,646.80) per annum, subject to subparagraph F herein. The arbitration proceeding shall be conducted under the rules of the American Arbitration Association.

d) For the succeeding twenty (20) years of the term hereof, the parties shall use their best efforts to agree to the annual rental applicable thereto at least eighteen (18) months prior to the commencement of said term. In the event that the parties cannot agree to the rental, then the same procedure as set out in (c) of this ARTICLE III shall be applicable, except that in no event shall the rental for said term exceed Twelve Thousand Six Hundred Forty-six and 80/100 ($12,646.80)Dollars per annum for the first ten (10) years of said twenty (20) year term.

e) For the succeeding twenty (20) year and nineteen (19)

year rental periods, the rental shall be determined in the same manner as set forth in paragraph (c) and (d) of this ARTICLE III, except that the arbitrators shall not be limited to the maximum of Twelve Thousand Six Hundred Forty-six and 80/100 Dollars ($12,646.80) per annum set forth therein.

f) In addition to the procedures for rental increases set out in paragraphs (c), (d), and (e) of this ARTICLE III, said rental shall be adjusted upward at the end of each period specified, if the cost of living index of the Bureau of Labor Statistics discloses an increase in the cost of living index, according to the United States Consumer Price Index. Said rental shall be adjusted upward by the percentage which said price index has moved upward during the past rental period or past year, whichever is greater. It is agreed and understood that said rental figure may therefore, with application of the cost of living increase, exceed the Cap set out in paragraphs (c) and (d).

g) It is specifically understood that said rental is exclusive of taxes on the structures on the demised premises which shall be treated as realty for taxation purposes, which taxes shall be assessed by the City of New Bedford.

ARTICLE IV
LESSEE'S USE OF PREMISES

The LESSEE shall have unrestricted right to build and install on the demised premises such structures, improvements, machinery and equipment as he may desire, but solely for the purpose of operating a shipyard, including the sale, repair, and outfitting of vessels and/or other water dependent activities, and use same for any purpose in conformance with all zoning and building regulations applicable thereto, all of which shall at all times remain the property of the LESSEE. A breach of said use shall be cause for termination hereunder by the LESSOR. In the event that

this Agreement is terminated for any reason, said structures, improvements, machinery and equipment may be removed by the LESSEE, provided the premises are put back in the same condition as they were at the time of the execution of the Lease and provided that all taxes and monies due to the City of New Bedford, the LESSOR, have been paid.

The LESSEE shall commence construction of the building on the demised premises within 180 days from the date of the execution of the Lease. Construction shall proceed, without delay, and be completed in accordance with the LESSEE'S Application Plan, as submitted to the Harbor Development Commission.

ARTICLE V

LESSOR'S REPRESENTATION AS TO THE DEMISED PREMISES

Section 1. The LESSOR hereby jointly and severally warrants and represents that:

a) It has a good, clear, and merchantable title to the demised premise and has at the execution of this Agreement delivered to the LESSEE a complete physical property survey of the demised premises prepared and certified by a land surveyor registered by the Commonwealth of Massachusetts.

b) The demised premises are free and clear of all encumbrances and liens and that upon notice by the LESSEE at any time of any undisclosed liens or defects the LESSOR will cause said liens to be removed or cleared.

c) The LESSOR represents and warrants that it has no knowledge of any circumstances which would prohibit construction, support or utilization of the demised premises or any portion thereof. However, the LESSEE shall make his own engineering determinations as to the structural suitability, the land having been created by the depositing of unclassified fill.

d) It has good and proper power and authority to enter into and to perform its warranties, representations and undertakings, all as set forth in this Agreement and will execute and deliver

to the LESSEE any further written certificates and authorizations reasonably required by counsel for the LESSEE at any time so as to further evidence its power and authority.

ARTICLE VI

LESSEE'S RIGHT TO ASSIGN OR SUBLEASE

Section 1. Notwithstanding any provision of this Agreement, the LESSEE shall at all times have the right, in his sole discretion, to assign the lease or sublease the demised premises, subject to all provisions hereunder. In the event of such sublease or assignment, the LESSEE shall at all times be responsible for the payment of the rentals due hereunder and all other provisions. Any sublease or assignment shall not relieve the LESSEE of any liabilities hereunder.

Section 2. In the event that the LESSEE does sublease all or any part of the demised premises, the LESSEE hereby represents and agrees that the rent to be received by him for the demised premises, shall not exceed one hundred ten percent (110%) of the rental then being paid by the LESSEE to the LESSOR for that portion so subleased. It is expressly understood and agreed that the provisions of Article VI, Section 2 shall not apply to any entity owned by the LESSEE hereunder.

ARTICLE VII

INDEMNITY AND PUBLIC LIABILITY INSURANCE

Section 1. The LESSEE agrees to indemnify and hold harmless the LESSOR from and against all claims of whatever nature arising from any act, omission, or negligence of the LESSEE or LESSEE'S sublessee, or their respective contractors, licensees, agents or employees, or arising from any accident, injury or damage whatsoever caused to any person, or to the property of any person occurring during the term hereof in or about the LESSEE'S demised premises or any improvements thereon except to the extent that such claim results from the LESSOR'S negligence or fault.

Section 2. The LESSEE agrees to maintain in full force,

during the term hereof, policies of public liability and property damage insurance under which the LESSOR (and such other persons as are in priority of estate with LESSOR as may be set out from time to time) and the LESSEE are named as assureds and under which the insurer agrees to indemnify and hold harmless the LESSOR from any liability arising out of or based upon any and all claims, accidents, injuries and damages set forth in Section 1. of this ARTICLE VII. Each such policy shall be non-cancellable with respect to the LESSOR and the LESSOR'S designees without ten (10) days prior notice to LESSOR, and a duplicate original or certificate thereof shall be delivered to LESSOR. The minimum limits shall be One Million Dollars ($1,000,000.00) combined single limit covering personal injury liability and property damage. Certificates of such insurance coverage shall be delivered to LESSOR not later than ten (10) days after LESSEE has first taken possession of demised premises. It is expressly understood and agreed that LESSEE shall be responsible for the payment of all premiums for insurance coverage hereunder.

ARTICLE VIII
DEFAULT

In the event of failure by the LESSEE to perform, fulfill, or observe any of the terms, covenants, agreements and conditions of this Agreement continuing for a period of 120 days after written notice from the LESSOR to the LESSEE specifying such failure without such failure being waived or its effect cured or the cure thereof commenced and diligently prosecuted thereafter, the LESSOR may, by written notice to the LESSEE, terminate this Agreement whereupon all of the LESSEE'S rights, obligations, and liabilities under this Agreement shall cease except that the LESSEE shall continue to be liable to the LESSOR for the obligations of the LESSEE which arose prior to such termination; provided, however, that the rights of the LESSOR under this Article shall be subordinate and subject to any and all mortgages, deeds of trust and other instruments in the nature of a mortgage or

LESSEE, including any rights of the holders of bonds or other obligations issued by the City of New Bedford, acting by and through its Industrial Development Financing Authority or otherwise, to finance facilities or equipment for use by the LESSEE on the demised premises, including the right of any such holders to cure any default by the LESSEE within thirty (30) days after the receipt by such holders of notice by the LESSOR of such default; and, provided further, that the LESSOR will permit any purchaser at a foreclosure or other sale or disposition of the demised premises or any of the facilities or equipment used or made a part of the demised premises by or on behalf of any such holders to fully perform, fulfill, and observe all of the terms, covenants agreements and conditions of the LESSEE under this Agreement and in such case such purchaser shall be entitled to all the rights of the LESSEE under this Agreement.

ARTICLE IX
MISCELLANEOUS PROVISIONS

Section 1. LESSEE, subject to the terms and provisions of this Agreement on paying of rent and keeping and performing all of the terms and provisions of this Agreement on his part to be observed, kept, and performed shall lawfully, peaceably, and quietly hold occupancy and enjoy the demised premises during the term hereof without hindrance or ejection by the persons or entitities claiming under the LESSOR.

Section 2. LESSEE agrees to make every reasonable effort to discharge any mechanics, materialman or other liens against the demised premises and/or the LESSOR'S interest therein, which may arise out of any payment due for or purported to be due for any labor, services, materials, supplies or equipment alleged to have been furnished for the LESSEE in, upon, or about the demised premises.

Section 3. In addition to the rents and covenants contained herein to be paid and performed by the LESSEE, the LESSEE agrees

to pay, when due, all real estate taxes on the demised premises and any improvements thereto and any utility charges pertaining thereto.

Section 4. Except as herein otherwise expressly provided, the terms hereof shall be binding upon and inure to the benefit of the successors and assigns respectively of the LESSOR and LESSEE.

Section 5. This Lease Agreement shall be governed exclusively by the provisions hereof and by the laws of the Commonwealth of Massachusetts.

Section 6. The parties hereto agree, upon request of the other, to execute a notice of a lease or short form lease in recordable form and complying with applicable local laws:

Section 7. Whenever by the terms of this Agreement, notice shall or may be given whether to the LESSOR or LESSEE, such notice shall be in writing and shall be sent by registered or certified mail, postage prepaid, and if to the LESSOR:

New Bedford Harbor Development Commission
Pier 3 - Wharfinger Building
New Bedford, MA 02740

and if to the LESSEE:

Herman Melville Shipyard, Inc.
42 Water Street
Fairhaven, MA 02719

Section 8. The LESSEE shall be subject to the following provisions:

1. Any additional structures within the waterways shall be subject to all local, state and federal rules, regulations, licenses and requirements.

2. Said premises shall be subject to the Army Corps of Engineers Permit, including Compliance for Contribution to Mitigation. Said contribution shall be determined by the Harbor Development Commission.

ARTICLE X

ADDITIONAL LEASE AND PURCHASE PROVISIONS

1. In the event the LESSOR substantially improves the area shown on the plan mentioned in Schedule A of this lease and offers for sale any portion of the land in the area shown on the plan mentioned in Schedule A, it shall forthwith notify the LESSEE of the terms and conditions of said sale and such notice shall automatically grant the LESSEE the right to purchase for the same cost per square foot as required of any third party purchaser. The area shown on the plan mentioned in Schedule A shall mean that area of land of which the demised premises are a part. The LESSEE shall have one hundred twenty (120) days from the date of receipt of said notice to exercise his right to purchase, by sending written notice to LESSOR. In the event of the LESSEE'S decision to so purchase, the LESSOR and LESSEE shall use their best efforts to complete the sale and purchase in a proper and orderly fashion.

2. The LESSEE shall have an option of first refusal to obtain any future land to be created or developed directly abutting his land. This option is subject to the LESSEE presenting an acceptable development plan to the Harbor Development Commission showing a continuation of or extension of his then existing business and is further subject to the sale or lease terms then being offered by the Harbor Development Commission.

3. Any additional filled land created as a result of future bulkheading shall remain solely the property of the LESSOR.

Any improvements made to the land seaward of the present mean high water line of the Acushnet River as indicated on the Plan referred to in Schedule A, shall be at the sole risk of the LESSEE and no compensation shall be due from the LESSOR in the event of the creation of said additional filled land.

ARTICLE XI

CONSTRUCTION

The LESSEE agrees that in the event that construction of a

to dispossess and remove therefrom any and all occupants and their effects without being liable to any prosecution therefor, and to hold premises as if this Lease had not been made. LESSEE expressly waives, in behalf of himself and all persons claiming under him, all rights of notice to quit or intention to re-enter under provisions of any statute or of this Lease, in case of such failure to commence construction.

IN WITNESS WHEREOF, the parties have hereunto caused these presents to be executed by their duly authorized officers and their seals to be affixed, duly attested as of the day and year first above written. This lease and execution thereof being duly authorized by Order of the City Council of the City of New Bedford and approval of the Mayor, and Vote of the New Bedford Harbor Development Commission, certified copies of such Order and Approval and Vote of the New Bedford Harbor Development Commission being attached hereto and made a part hereof.

APPROVED as to form
and legality

City Solicitor

Thomas R. Hunt
Counsel for H.D.C.

CITY OF NEW BEDFORD

By:
John K. Bullard, Mayor

NEW BEDFORD HARBOR DEVELOPMENT COMMISSION

By:
Vice Chairman

HERMAN MELVILLE SHIPYARD, INC.

By: Jacqueline M. Feener
Feener, President

SCHEDULE "A"

BOUNDARY DESCRIPTION

A certain parcel of land situated in the City of New Bedford, County of Bristol, and the Commonwealth of Massachusetts, being particularly bounded and described as follows:

BEGINNING at a point in the easterly line of Herman Melville Boulevard, said point forming the southeasterly point in the intersection of North Front Street, Wamsutta Street and Herman Melville Boulevard;

Thence north 82° 53' 29" east for a total of 465.00 feet to a point;

Thence south 7° 31' 59" east for a total of 250.00 feet to a point;

Thence south 26° 18' 45" west for a total of 314.00 feet to a point;

Thence north 88° 04' 00" west for a total of 310.00 feet to a point in the easterly line of said Herman Melville Boulevard;

Thence along the easterly line of said Herman Melville Boulevard in a northwesterly direction a total of 173.72 feet on a curve with a radius of 960.00 feet to a point in the said easterly line of Herman Melville Boulevard;

Thence north 7° 31' 59" west a total of 290.47 feet along the easterly line of said Herman Melville Boulevard to the point of beginning;

CONTAINING two hundred nine thousand, eight hundred sixty-six square feet, more or less (209,866 ±) , a total of four point eight one eight (4.818) acres, more or less;

Being part of lot 248 on Assessors Plot 72, as shown on a plan entitled "Plan of Land in New Bedford belonging to City of New Bedford", dated March 30, 1985.

ASSIGNMENT OF LEASE

KNOW ALL MEN BY THESE PRESENTS, THAT WE, DONALD GREEN of 26 Holly Drive, Fairhaven, Massachusetts, and SHERMAN C. SMITH of 1136 Russells Mills Road, So. Dartmouth, Massachusetts, in consideration of ONE DOLLAR and other valuable consideration assign and transfer to ACUSHNET RIVER SHIPYARD, INC., a corporation duly organized under the laws of the Commonwealth of Massachusetts, a certain lease dated June 20, 1988 made by HERMAN MELVILLE SHIPYARD, INC., to DONALD GREEN and SHERMAN C. SMITH of the following premises:

> BEGINNING at a point in the east line of Herman Melville Boulevard, said point being the northwest corner of Lot #2 as shown on "Subdivision Plan of Land in New Bedford, Mass. located at Herman Melville Shipyard, Scale 1" = 30' dated 1 June 1988" drawn by Benchmark Surveying and Engineering Assoc., 667 Cottage Street, New Bedford, MA; thence
>
> NORTH 82° 26' 38" east one hundred twenty and 42/100 (120.42) feet to an angle;
>
> Thence proceeding north 86° 56' 27" east three hundred forty-five and 46/100 (345.46) feet to the west bank of the Acushnet River;
>
> Thence turning and proceeding south 24° 4' west forty-one and 6/100 (41.6) feet to an angle;
>
> Thence proceeding south 37° 38' west seventy-three and 1/10 (73.1) feet to an angle;
>
> Thence proceeding south 45° 15' west eighty-seven and 9/100 (87.9) feet to an angle.
>
> Thence proceeding south 72° 36' west seventy and 2/10 (70.2) feet to an angle;
>
> Thence proceeding south 86° 44' west fifty-six and 5/10 (56.5) feet to an angle;
>
> Thence proceeding north 84° 41' west twenty-six and 8/10 (26.8) feet to an angle;
>
> Thence proceeding south 69° 27' west twenty-one and 7/10 (21.7) feet to an angle;
>
> Thence proceeding south 85° 52' west eighty-one and 6/10 (81.6) feet to an angle;
>
> Thence proceeding north 89° 23' west sixty-five and 6/10 (65.6) feet to an angle;

Thence proceeding north 55° 32' west twenty-three and 0/100 (23.0) feet to a point in the easterly line to Herman Melville Boulevard;

Thence along the easterly line of said Herman Melville Boulevard in a northerly direction a total of one hundred forty-five and 19/100 (145.19) feet on a curve with a radius of 560' to a point in the said easterly line of Herman Melville Boulevard to the point of beginning,

CONTAINING sixty six thousand seven hundred three (66,703±) square feet more or less.

and recorded in Bristol County (S.D.) Registry of Deeds Book 2191, page 0242 with all and singular the premises therein mentioned.

TO HAVE AND TO HOLD the same to ACUSHNET RIVER SHIPYARD, INC. and its assigns from September 1, 1988 for and during all the rest and remainder yet to come of the lease, subject to the rents, agreements, and conditions contained in the lease.

IN WITNESS WHEREOF the parties have hereunto set their hands and seals this 15th day of November 1988.

Donald Green
DONALD GREEN

Sherman C. Smith
SHERMAN C. SMITH

ACUSHNET RIVER SHIPYARD, INC.

By: Sherman C. Smith
Pres.
Title

CONSENTED TO:
HERMAN MELVILLE SHIPYARD, INC.

By: Jacqueline M. Fiore
President
Title

The CITY OF NEW BEDFORD, a municipal corporation established under the laws of the Commonwealth of Massachusetts acting by and through its HARBOR DEVELOPMENT COMMISSION, hereby consents to the assignment of lease of a portion of the premises leased by it to HERMAN MELVILLE SHIPYARD, INC., on March 31, 1986 to DONALD GREEN, 26 Holly Drive, Fairhaven, Massachusetts and SHERMAN SMITH, 136 Russells Mills Road, So. Dartmouth, Massachusetts.

In consideration of consent to this assignment of lease (partial) by the City of New Bedford, LESSEE/ASSIGNOR guarantees performance by ASSIGNEES, or by their heirs, executors, administrators, successors, or assigns of all agreements and conditions contained in said lease as applies to that portion assigned, on the part of ASSIGNEES to be performed.

WITNESS our hands and seals this 25th day of November 1988.

APPROVED as to form and legality:

Asst. City Solicitor

CITY OF NEW BEDFORD

By: John K. Bullard, Mayor

NEW BEDFORD HARBOR DEVELOPMENT COMMISSION

Vice-Chairman

APPENDIX 11

New Bedford State Pier Excerpt from the New Bedford Harbor Plan

The State Pier program represents another of the major initiatives proposed along the New Bedford waterfront. Numerous individual projects are proposed that collectively form the basis for a programmatic modification to the form and use of the Pier. This effort began with the new Ferry Terminal and roll-on/roll-off freight ramps added in the early 2000's, the establishment of a waterfront visitor center, and the startup of the annual Working Port Festival. Further improvements anticipated will enhance the Pier's ability to handle import and export cargo, service cruise ships and support tourism initiatives such as an open air seasonal market, facilities for Schooner Ernestina, an area to view the fishing fleet, and other facilities of public accommodation.

The projects range from replacing the pile supported portion of the Pier with a solid fill structure to improving buildings and other support facilities so that they can support new uses.

Specific infrastructure work includes pier rehabilitation and building reconfiguration. The plan is for the north, south, and east faces of State Pier to be demolished and replaced by a new filled-pier structure. The filled-pier structure will be comprised of a bulkhead that will be filled and capped by a concrete slab. With a few exceptions, the edge of the bulkhead will generally follow the edge of the existing pier. The two exceptions are:

- The northeast corner of the north and east faces of the Pier, which will be squared in order to accommodate the turning radius of future truck traffic;
- The southwest corner of the south face of the Pier, at which the bulkhead will be installed further north to accommodate, proposed floating excursion piers in that area.

The plans also call for building reconfiguration. A portion of the east side of Building 1 would be demolished. The remainder of Building 1 would be rehabilitated. Building 2 would be expanded to the south. A second floor would be added to Building 2. The former Coast Guard Building would be demolished. Building 3, previously demolished, would be replaced with a new, two story building with a larger footprint. An elevated walkway would be installed between Building 2 and Building 3. A floating excursion pier would be added in the southwest corner. The excursion pier would consist of two sets of multiple floating pier structures, the outer edge of which would be aligned with the former southern edge of the Pier.

The new building structure would allow the separation of public and cargo areas by keeping public areas primarily on the second floor of most buildings. Cargo would be handled and stored primarily on the first floor of most site buildings. Future public use of the Pier would be maximized by keeping cargo areas isolated from public areas. Flexibility goals would be met by creating multiple-use facilities in site buildings, by using pier structures for multiple types of vessels (cruise ship vessels, fishing vessels, and shipping vessels), by preserving space in the southwest corner of the facility to potentially add finger piers in the future, and by maximizing the flexibility of the types of cargo (roll-on/roll-off, break-bulk, and load-and-go/inter-modal) that can be accommodated at the Pier. The north, south, and east faces of the Pier would be replaced to prevent the gradual collapse of those structures. Site security and site safety concerns would be met by installing a filled pier structure when rehabilitating the north, south, and east faces of the Pier.

Proposals have also been made to establish the southwest corner of the State Pier as a publicly accessible waterfront destination space with berthing for commercial charter fishing and excursion vessels, interpretive facilities associated with the Schooner Ernestina and the National Park combined with other visitor facilities including an open air market incorporated within temporary structures.

Ferry Terminal/North Side

The Ferry Terminal was constructed in 1999 with service commencing in 2000. The Ferry Terminal currently provides passenger ferry service to Martha's Vineyard and Cuttyhunk Island. It is currently anticipated that this ferry service will continue. This Plan supports the further expansion of ferry service as opportunities are presented including possible service to Block Island, Providence, Nantucket and/or Woods Hole.

Cargo Shipments/East Side

The East Side (as well as portions of the North and South sides) of the State Pier will continue to be primarily used for cargo shipments. The City wishes to maximize the flexibility of the types of cargo (roll-on/roll-off, break-bulk, and load-and-go/inter-modal) that can be accommodated at the Pier. The City of New Bedford has completed a Memorandum of Understanding, along with the Cities of Fall River, Salem, and Gloucester, with the City of Cape Canaveral in Florida to facilitate the creation of a Short-Seas Shipping corridor in order to by-pass shipping along the eastern coast of the United States. Specific needs for accommodation of short-seas shipping vessels will need to be taken into account during the redevelopment of

the pier. In order to facilitate the flow of truck traffic on the pier that will be involved in loading and unloading of cargo, this Plan supports the extension of the Harbor Line located proximate to the northeast corner of the State Pier, in order to square the corner off during rehabilitation.

Storage Facilities

This Plan supports the expansion of warehouse and storage space on the eastern end of State Pier, particularly on the first floor of the building. The existing 30,000 square foot cooler storage facility on the State Pier was too small to attract significant cargo to the State Pier, as the storage space is smaller than the size of typical vessels that would transport goods and services to the City. Ultimately, the coolers were removed, and the facility now accommodates general cargo. New refrigerated facilities will need to be sufficiently large to accommodate typical cargo loads. Therefore, expansion of these facilities wherever possible will allow increased cargo shipments to arrive to the City and will allow for increased economic activity.

Cruise Ship Terminal/East Side and South Side

Cruise ship operations were first accommodated at the New Bedford State Pier in July of 2002, at which time the Regal Empress docked at State Pier. The visit was a success, but revealed the problems associated with the existing pile-supported structure of the south side of State Pier, when exposed to significant lateral loads from a large vessel.

Since 2002, a vessel of the size of the Regal Empress has docked only rarely at the State Pier (due to the damage such a vessel would cause); however, multiple smaller cruise ships have arrived and been serviced. DCR intends to upgrade the facilities at the pier such that cruise ship operations with larger vessels, such as the Regal Empress, can continue in the future.

Pursuant to the Cruise Ship Initiative, the City and the HDC have been actively marketing the Port of New Bedford as a full service port of call for appropriate cruise and other transient vessels. For the coming year, the City has signed a contract with American Cruise Lines for up to 25 cruise vessels per year to arrive in the Port. As a result of this increase in Cruise Ship activity and marketing efforts by the State to attract more cruise ships to the region under Historic Ports of Massachusetts initiative, the HDC would like to see the redevelopment of State Pier to include a Cruise Ship Terminal that will allow for waiting areas, refreshments, and tourist-themed areas that would allow for increased economic activity associated with the arrivals.

Southwest Corner/National Whaling Historical Park

The Harbor Plan designates an area on the southwest corner of the State Pier to function as a waterfront destination area for harbor visitors. The Harbor Plan supports continued use of the central berthing area in the southwest corner of the pier for commercial excursion and charter vessels, and the Ernestina, the official vessel of the Commonwealth (see below). The south wharf building will include a center for visitor services, programs, and support for the Schooner Ernestina, ticketing facilities for the excursion vessels, offices and classrooms to help support education of commercial and marine industrial uses of the Harbor, and will also include a fish market that will serve as a centralized location for Citizens to purchase fish for consumption at home. The south wharf will also include a harbor viewing area, allowing visitors to view the fishing fleet berthed on Steamship Wharf. This initiative will attract substantial numbers of visitors to the waterfront, enhancing its vitality and providing direct benefits to the downtown area as a whole.

Schooner Ernestina

The Schooner Ernestina is a National Historic Landmark and the official vessel of the Commonwealth; it was a gift from the Cape Verde government and is owned by the Department of Conservation and Recreation. It is currently berthed on the southwest corner of the State Pier. A center for visitor services, programs and support for the Schooner Ernestina will be developed on the southwest corner of the State Pier. The Harbor Plan concept for the southwest corner of the State Pier includes a berth for the Ernestina adjacent to its proposed visitor service facilities. The Ernestina anticipates a need for 5,000 square feet of support space onshore, some portion of which including interpretive facilities and storage space will be provided on the State Pier.

Floating Dock for Excursion/Charter Boats and Water Taxi/Shuttles

A substantial floating dock system is proposed to be placed adjacent to a portion of the Southwest Side of the State Pier to serve the Ernestina, and to establish an accessible central berthing area for charter fishing boats, excursion vessels, and other commercial boating services. These services have strong market support and will be the catalyst that establishes the waterfront as a visitor destination attracting visitors to the community and contributing directly to downtown revitalization goals. Establishing a critical mass of vessels in a central location will also bring tangible benefits to boat owners based on shared ticketing, shared advertising, and an established destination. Several such services currently exist around the harbor but they are dispersed and lack critical mass. Development of the proposed floating

dock system would be subject to any applicable leases and would require approval from the Commonwealth or its designee.

A similar opportunity exists on the northwest (inland) corner of State Pier including Tonnesson Park and adjacent to the existing Waterfront Visitor Center, where docking facilities should be improved to adequately support excursion boats and water shuttle/taxi services. Currently New Bedford/Fairhaven Harbor lacks the ability to provide adequate berthing for water taxis and launch service, excursion boats and space to berth security and port operational vessels.

> The City of New Bedford has requested $75,000 from the Massachusetts Seaport Council to build two (2) launch/berthing facilities that would support maritime operations and tourism on the waterfront. One site would support access from launch and excursion services to a newly built waterfront restaurant in the working port and access to the historic downtown area. The other site would support access by launch and excursion service to the historic down town area as well as berthing for the Port's security vessels (police patrol, harbor master, and fire boat). The project is considered critical to support commercial and recreational boating activities in the Harbor. Studies sponsored by the Maritime Trades Association indicate that for each $1 spent by a boater there is an $8 economic return to the community. By not having an adequate water/land interface to support water taxi, excursion, and recreational boating operations, the Port loses the opportunity for this economic spin-off. Further and equally important, this project would meet some of the security goals critical to the maritime operations of this Port.

Water Taxi/Launch Dock

A water taxi/launch dock will be provided on the northwest corner of the State Pier,

Use of the State Pier for Special Events

As efforts proceed to revitalize the State Pier through development of freight ferry service and with renewed efforts to attract break bulk cargoes, full use will be made of the Pier on an interim basis for special events, waterfront festivals, and related activities including parking. These activities may make use of exterior Pier areas, the Cooler Storage Facility and both levels of the Transit Shed to the extent that they are not otherwise in use. Incorporation of these activities will not require any significant alterations to Pier facilities and will not impede use of the Pier for its primary users. Temporary uses will be limited to activities that are fully compatible with the needs of other Pier users and consistent with any applicable leases.

APPENDIX 12

August 23, 2010

Mr.Roland Letendre
Owner
Hathaway Mills LLC
84 Gifford Street
New Bedford MA, 02740

Mr. Matthew Morrissey
Executive Director
New Bedford Redevelopment Authority
1213 Purchase Street
New Bedford MA 02740

Dear Mr. Morrissey:

I write to state at I am aware of the City and the Commonwealth's plans to establish an intermodal facility in the south terminal area of New Bedford. As a real estate owner in the immediate area, and one who is operating an existing business, I support and endorse the efforts to create such a facility. As we discussed, I anticipate working out a temporary access easement across a portion of my property bordering Gifford Street.

Do not hesitate to call me with any questions.

Sincerely,

Roland Letendre

Roland Letendre

August 23, 2010

Mr. Matthew A. Morrissey
Executive Director
New Bedford Redevelopment Authority
1213 Purchase Street
New Bedford, MA 02740

Dear Mr. Morrissey:

I am writing to state that at I am aware of the City of New Bedford and the Commonwealth's plans to establish an intermodal facility in the south terminal area of New Bedford. As a real estate owner in the immediate area, and one who is operating an existing business, I support and endorse the efforts to create such a facility.

Do not hesitate to call me with any questions.

Sincerely,

Robert K.Gardner III
President

Mr. Robert K.Gardner III
Bayline inc. Boatyard and Transport / DMD Development
109 Gifford Street / 4 Silva Street
New Bedford, MA 02744
508-994-2944

NEW BEDFORD HARBOR DEVELOPMENT COMMISSION

August 26, 2010

Curt Spalding
Regional Administrator for New England
US Environmental Protection Agency
5 Post Office Square
Mail Code: ORA01-4
Boston, MA 02109

Dear Mr. Spalding,

This letter is enclosed herein to express our full support of the South Terminal Marine Park project that will enable New Bedford to emerge as a leading hub for import /export trade and provide a state of the art port facility for the emerging offshore energy industry.

An important component of the existing proposal includes the use of the Gifford Street Boat Ramp to stage wind blade equipment. The Harbor Development Commission, as the governing entity for the Harbor, and manager of this city owned property agrees to make the acreage available at this site for this specific purpose, a total of 1 acre. To accommodate commercial haulers that currently use the boat ramp, a 36 foot wide accessway will be delineated apart from the staged wind blades. Use of the facility will be made via appointment with the Harbor Development Commission.

Recreational boaters will be directed to the City's boat ramps at East Rodney French Blvd. and West Rodney Blvd, boat ramps within minutes of Gifford Street. East and Rodney French Blvd. Boat Ramps are currently being rehabilitated and will be in superior condition to meet the use requirements of the recreational boating community. These ramps will also support the demands of commercial haulers.

It is important to note that the Gifford Street Boat Ramp is an underutilized facility in much need of repair. Given the low use of the facility and its inferior condition, we do not anticipate any problems with the temporary use of the site for staging wind blades. Engineering and permitting for the repair work is underway. We will proceed with construction after the temporary use of staging wind blades is no longer required.

I am happy to answer any questions and can be reached at (508) 961-3000. Thank you for your consideration of the South Terminal Marine Park Project that promises to bring thousands of jobs to our region as well as restore the environmental health of the Harbor through the removal of contaminated sediments.

Sincerely,

Kristin Decas
Executive Director

106 Co-Op Wharf P.O. Box 50899 New Bedford, MA 02745 Tel: 508-961-3000 Fax: 508-979-1517

APPENDIX 13

Apex Companies, LLC.

1 WAMSUTTA STREET
SUITE 8
NEW BEDFORD, MA 02740
(508) 996-9828

184 HIGH STREET
SUITE 502
BOSTON MA 02110
(617) 728-0070

REVISIONS

NO.	DATE	DESCRIPTION

THESE DRAWINGS PREPARED BY APEX FOR THIS PROJECT ARE INSTRUMENTS OF APEX'S SERVICE FOR USE SOLELY WITH RESPECT TO THIS PROJECT, AND APEX SHALL BE DEEMED THE AUTHOR OF THE DRAWING AND SHALL RETAIN ALL COMMON LAW, STATUTORY AND OTHER RESERVED RIGHTS WITH RESPECT THERETO, INCLUDING COPYRIGHT. THE DOCUMENTS SHALL NOT BE USED ON OTHER PROJECTS, FOR ADDITIONS TO THIS PROJECT OR FOR COMPLETION OF THIS PROJECT BY OTHERS, EXCEPT BY AGREEMENT IN WRITING AND WITH APPROPRIATE COMPENSATION TO APEX.

PREPARED FOR:

THE NEW BEDFORD HARBOR DEVELOPMENT COMMISSION
NEW BEDFORD, MASSACHUSETTS

DRAWING TITLE:

SOUTH TERMINAL MARINE INFRASTRUCTURE PARK PROPOSED BULKHEAD

Scale: 1"=150'

0 75 150 300 450 FEET

Date	3/24/10
Proj. Mgr.	JAB
Design	CWM
Check	CHM
Drawn	GCD
Job. No.	6690
Last Rev.	8/23/10

Drawing No.

P-4

P:\Jobs\6690 NBH_ Phase IV\PLANS\CAPEWIND\SOUTH_TERMINAL_EXPANSION_7-25-10_WORKING.dwg

APPENDIX 14

MEMORANDUM
Project: Proposed South Terminal CDF

Regarding: Input From Shipping Industry

Memo Date: January 28, 2011

The following is a summary of input received from Port Professionals, whose input was solicited in conjunction with design of the proposed South Terminal CDF. These port professionals typically work with (or in) the shipping industry, and were able to present their analysis of the facility in association with potential future use of the facility as a cargo terminal. Information was received from:

Ken Parkinson
North American Port Infrastructure LLC
2604 Alamanda Court
Fort Lauderdale, Florida 33301
Tel: 305.206.0849
kenneth.parkinson@napinfrastructure.com

Bruce McCellan
North American Port Infrastructure LLC
1021 Woodland Avenue
Plainfield, NJ 07060 USA
Tel 908.472.9186
bruce.mcclellan@NAPInfrastructure.com

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Capt. Jeffrey W. Monroe, MM
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HDR ONE COMPANY | Many Solutions
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mirage@maine.rr.com

The original proposed dredge footprint was reviewed by the shipping personnel listed above. The dredge footprint was reviewed in the context of anticipated uses of the facility associated with non-offshore wind activities, such as break-bulk cargo, container shipping, and bulk cargo. The following input was received:

Item 1: The port professionals stated that conventional cargo vessels will typically require 500 to 600 feet of berth in deep water. It was requested that the quantity of deep-draft area at the bulkhead be increased from the anticipated 500 linear feet to 600 linear feet or more of deep-draft length to be able to accommodate the full range of future potential shipping vessels at the facility. The port professionals requested a draft of -32 MLLW at the berth within deep draft areas.

Item 2: The port professionals felt that the 150 foot width of the channel would not be sufficient to accommodate maneuvering of future cargo vessels (which will likely be bigger than offshore wind international vessels) into port.

Item 4: The port professionals expressed concern that the orientation of the channel may need to be reviewed by the Northeast Marine Pilots for any potential concerns that may impact vessel traffic.

Item 5: The port professionals noted that dredge design restricted access of tug vessels, and that any alterations to the design to allow greater access and flexibility of use for tug vessels to guide ships into port would be very helpful to the operation of the facility.

Item 6: The port professionals noted that the nearest turning basin is in front of the New Bedford State Pier, and all effort should be made to make sure that the dredge footprint allow swift access to this turning area; preferably with a minimum of maneuvering.

APPENDIX 15

Meeting Minutes
Project: Proposed South Terminal CDF

Meeting No.: Marine Pilots

Meeting Date: February 11, 2011

Attendees: Captain Clinton L. Walker, Board Member, Northeast Marine Pilots, Inc.
Captain Paul Costabile, Executive Director, Northeast Marine Pilots, Inc.
Jay Borkland, Apex
Chet Myers, Apex

The following is a record of the above meeting held on February 11, 2011.

Item 1: The proposed dredge footprint was discussed for the proposed South Terminal CDF, as well as the dimensions and the proposed direction of vessel traffic. The pilots reviewed the proposed dredge footprint and stated that the alignment of the proposed channel connecting South Terminal to the Federal Turning Basin needed to be changed, that there was insufficient room in the channel to accommodate tugs, and that the overall channel width should be increased.

Item 2: The pilots indicated that there are significant logistical difficulties in guiding a large cargo vessel into a port area in anything other than the exact minimum number of straight channel lines. The channel shown on the existing drawings would require at least two turns of more than 45-degrees, as well as multiple re-positioning of the vessel. One of the turns would be immediately adjacent to the existing South Terminal turning basin, would likely block existing traffic, and would also be extremely difficult to maneuver. The turn would require a high degree of channel knowledge by the vessel operator (which would be unlikely since the vessel operator would most often be an international operator) or the Marine Pilot, and would increase the risk of the vessel accidentally straying out of the channel or turning basin.

Item 3: The most efficient method for maneuvering vessels into port is to find a straight channel that connects to your facility and also intersects with the Federal Channel in an area where there is sufficient maneuvering room for one turn to allow entry into either channel. Altering the angle of the existing channel only slightly (only 2 to 4 degrees) to the northeast would allow intersection of the South Terminal Channel with the Federal Channel in the vicinity of the New Bedford State Pier, which is immediately in front of the Federal Turning Basin. This would allow the vessels to enter along the Federal Turning Basin, turn in front of State Pier, and run straight to the South Terminal Boat Basin. The vessels would only need to stay in the channel once turned. They would be able to do this via channel markers and guide poles at the end of the channel (which could likely be placed at the facility itself).

Item 4: Cargo vessels anticipated to utilize the Port of New Bedford at the South Terminal CDF will be very large and will be unable to maintain their way within the channel unaided. The vessels will have their own power, but side-to-side motion will be

difficult within the confines of the harbor. It is likely that, due to currents, wave-action, and wind, that some drifting of the vessels will occur in some situations. Therefore, it is extremely likely that cargo vessels would be transported to the South Terminal CDF with tug assistance. The number and size of tugs would depend upon the vessel; however, larger harbor tugs (rather than ocean-going tugs) would be needed for larger vessels. The existing channel does not leave enough room for tugs, and a tug channel will be necessary. The tug would operate perpendicular to the vessel, and would help keep the vessel on line in the channel. The tug would then maneuver the vessel into position at the terminal once the vessel has reached its berth. The pilots suggested that the tug channel be 100 feet in width, to accommodate the type of tugs needed to maneuver a cargo vessel.

Item 5: The typical size of the largest cargo vessels that would dock at the new terminal is approximately 600 feet in length and 90 feet in width.

Item 6: The existing channel noted on the plans is 150 feet in width. The pilots stated that this width is likely not sufficient to accommodate the anticipated cargo vessels that are expected, as additional room for the vessels within the channel would be needed for maneuvering and safety (the vessels are not allowed to ever touch the harbor bottom). A width of 175 feet was suggested to the pilots. The pilots stated that they would like as much channel width as possible, and that a width of 200 feet for the channel with a 100 foot tug channel would be better.

APPENDIX 16

Meeting Minutes
Project: Proposed South Terminal CDF

Meeting No.: New Bedford Harbor Tug Operators

Meeting Date: February 18, 2011

Attendees: Conrad Roy, Tucker-Roy Marine Towing
Charles Mitchell, Mitchell Towing and Salvage
Bruce Beebe , Toscana Corporation
Jack Aruda, Cape Wind
Jay Borkland, Apex
Chris Morris, Apex
James Bowen, MassCEC

The following is a record of the above meeting held on February 18, 2011.

Item 1: The original proposed dredge footprint was discussed for the proposed South Terminal CDF, as well as the dimensions and the proposed direction of vessel traffic. An adjusted dredge footprint was also proposed to the tug operators. The adjusted footprint re-aligned the channel such that the channel extended to an area in front of State Pier, where a turning basin would allow access to the South Terminal Channel as well as the Federal Channel. The proposed width of the South Terminal Channel was increased from 150 feet to 175 feet and also included a 100 foot wide tug channel.

Item 2: The tug operators reviewed the proposed dredge footprint and stated that they would like as much channel width as possible, but generally agreed that the adjusted footprint could work with the facility. Discussions held with the Marine Pilots on 2/11/11 were discussed with the tug operators. The tug operators generally agreed with the statements of the Marine Pilots.

Item 3: The following basic tug information was obtained during the meeting:

Mitchell Towing and Salvage
PO Box 471
Fairhaven, MA 02719-0471
508.994.9003
Tug Jaguar
Length – 63’
Beam – 19.5’
Draft – 8’
Horse Power – 1000

Toscana Corporation
19 Arrowhead Drive
Nantucket, MA 02554

508.228.1418
Tug Buckey
Length – 65’
Beam – 25’
Draft – 6’
Horsepower – 900(2x450)

Tucker Roy Marine Towing
56 Ocean Drive
Mattapoisett, MA 02739
508-992-2229
Tug Tucker Roy
Length – 100’
Beam – 24’
Draft – 13’
Horsepower – 2880

Tug Janice
Length – 57’
Beam – 18’
Draft – 6’
Horsepower – Not reported.

Item 4: The tug operators agreed that there would be some variety with regard to which tugs would be guiding the vessels; however, it would likely be one of the local tugs (likely one of the companies at the meeting) or a combination of local tugs. As a result, the tug channel should be wide enough such that the largest of the tugs (Tug Tucker Roy) could be accommodated in the tug channel. Conrad Roy (Tug Tucker Roy’s Operator) requested that the tug channel be 105 feet wide, if possible.

Item 5: It was discussed that the draft of the deepest tug would drive the needed depth within the tug channel and the shallow draft areas of the facility. The deepest draft local tug is Tug Tucker Roy, which drafts 13 feet.

Item 6: It was discussed that the dimensions of two of the transport vessels that may be utilized for offshore wind installations was:

Vessel 1:
Length – 195’
Beam – 129’
Draft – 10’

Vessel 2:
Length – 200’
Beam – 135’
Draft – 15’

APPENDIX 17

Apex Companies, LLC.

1 WAMSUTTA STREET
SUITE 8
NEW BEDFORD, MA 02740
(508) 996-9828

184 HIGH STREET
SUITE 502
BOSTON MA 02110
(617) 728-0070

REVISIONS

NO.	DATE	DESCRIPTION

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PREPARED FOR:

COMMONWEALTH OF MASSACHUSETTS

DRAWING TITLE:

NEW BEDFORD MARINE COMMERCE TERMINAL

Scale: 1"=150'

0 75 150 300 450 FEET

Date	7/13/11
Proj. Mgr.	JAB
Design	CWM
Check	CHM
Drawn	GCD
Job. No.	6690
Last Rev.	7/13/11

Drawing No.

P-3

P:\Jobs\6690 NBH_ Phase IV\PLANS\CAPEWIND\OLD\SOUTH_TERMINAL_NEW_FOOTPRINT_7_13_11.dwg

Apex Companies, LLC.

1 WAMSUTTA STREET
SUITE 8
NEW BEDFORD, MA 02740
(508) 996-9828

184 HIGH STREET
SUITE 502
BOSTON MA 02110
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REVISIONS

NO.	DATE	DESCRIPTION

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PREPARED FOR:

COMMONWEALTH
OF
MASSACHUSETTS

DRAWING TITLE:

NEW BEDFORD
MARINE
COMMERCE
TERMINAL

Scale: 1"=250'

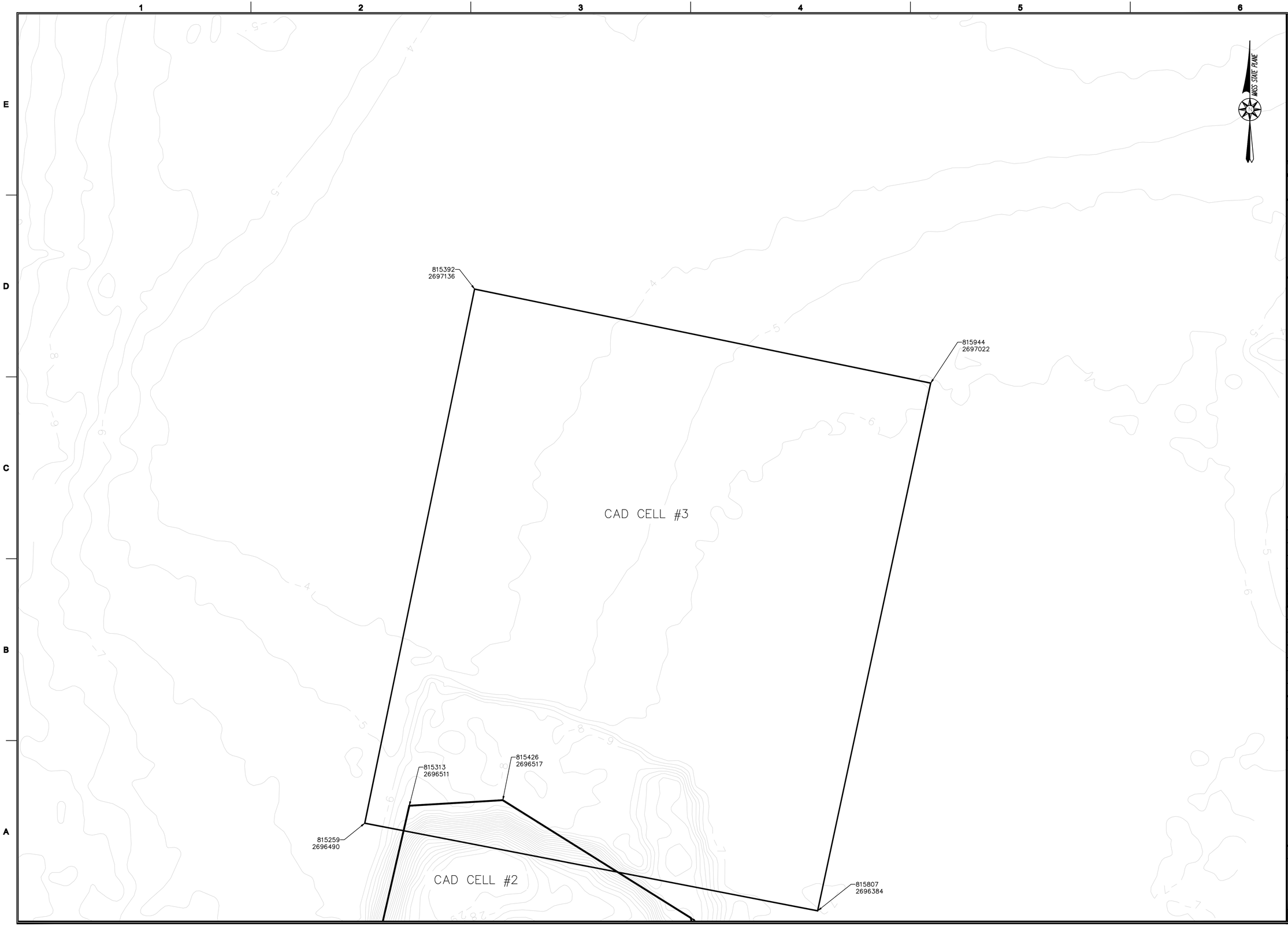
0 125 250 500 750 FEET

Date	7/13/11
Proj. Mgr.	JAB
Design	CWM
Check	CHM
Drawn	GCD
Job. No.	6690
Last Rev.	7/13/11

Drawing No.

APPENDIX 18

FAIRHAVEN
CAD CELL 2
DISPOSAL
AREA
CAD CELL 1
DISPOSAL
AREA
BORROW PIT
CAD CELL
CAPPING
AREA
POPES ISLAND
FEDERAL
CHANNEL
LIMITS
NEW
BEDFORD
U.S. ROUTE 6
ROUTE 6
SWING BRIDGE
FISH
ISLAND
FLOOD
EBB



APEX

ROCKVILLE, MD
SOUTH WINDSOR, CT - BOSTON, MA -
NEW BEDFORD, MA - HOLYOKE, MA

184 HIGH STREET, SUITE 502
BOSTON, MA 02210

58H CONNECTICUT AVENUE
SOUTH WINDSOR, CT

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100% DESIGN FOR REVIEW SET
NOT FOR CONSTRUCTION

PROJECT
NEW BEDFORD
MARINE COMMERCE
TERMINAL

OWNER
MASSACHUSETTS CLEAN ENERGY CENTER
55 SUMMER STREET, 9TH FLOOR
BOSTON, MASSACHUSETTS

NO.	DATE	DESCRIPTION	BY

PROJECT NO.	6690
CADD FILE	
DESIGNED BY	GCD
DRAWN BY	GCD
CHECKED BY	CMM
DATE	08/04/2011
DRAWING SCALE	1"=50'

GRAPHIC SCALE
SCALE: 1"=50'
0 25 50 75 125 FEET

SHEET TITLE

CAD CELL #3

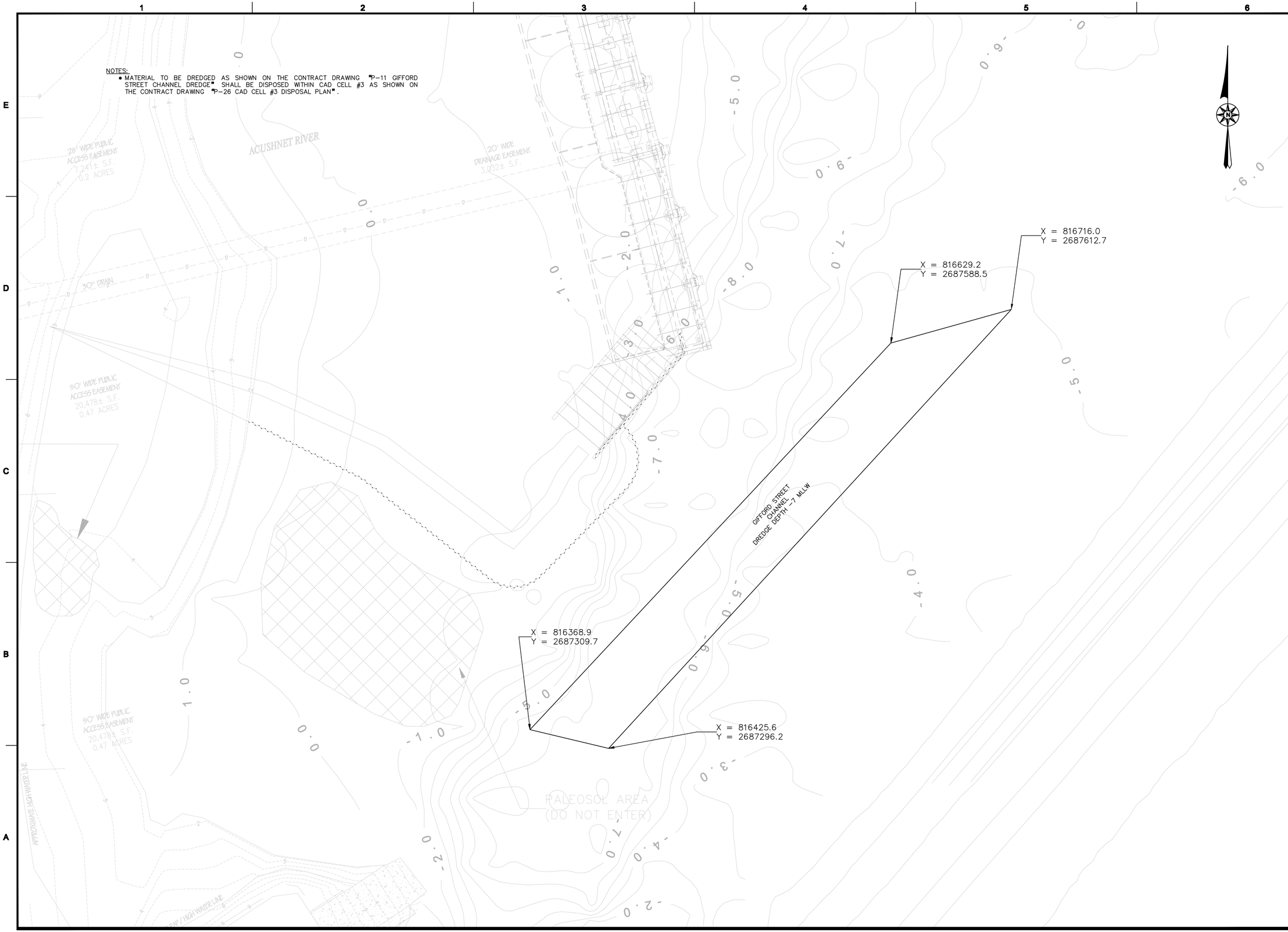
DRAWING NO.

E-7

APPENDIX 19

NOTES:

- MATERIAL TO BE DREDGED AS SHOWN ON THE CONTRACT DRAWING "P-11 GIFFORD STREET CHANNEL DREDGE" SHALL BE DISPOSED WITHIN CAD CELL #3 AS SHOWN ON THE CONTRACT DRAWING "P-26 CAD CELL #3 DISPOSAL PLAN".



APEX

ROCKVILLE, MD
SOUTH WINDSOR, CT - BOSTON, MA -
NEW BEDFORD, MA - HOLYOKE, MA

184 HIGH STREET, SUITE 502
BOSTON, MA 02210

58H CONNECTICUT AVENUE
SOUTH WINDSOR, CT

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PROJECT

NEW BEDFORD
MARINE COMMERCE
TERMINAL

OWNER

MASSACHUSETTS CLEAN ENERGY CENTER
55 SUMMER STREET, 9TH FLOOR
BOSTON, MA

NO.	DATE	DESCRIPTION	BY

PROJECT NO.	6690
CADD FILE	GIFFORD_ST
DESIGNED BY	CWM
DRAWN BY	CWM
CHECKED BY	CHM
DATE	8-30-11
DRAWING SCALE	1"=30'

GRAPHIC SCALE

SCALE: 1"=30'

0 15 30 60

SHEET TITLE

GIFFORD
STREET
CHANNEL
DREDGE

DRAWING NO.

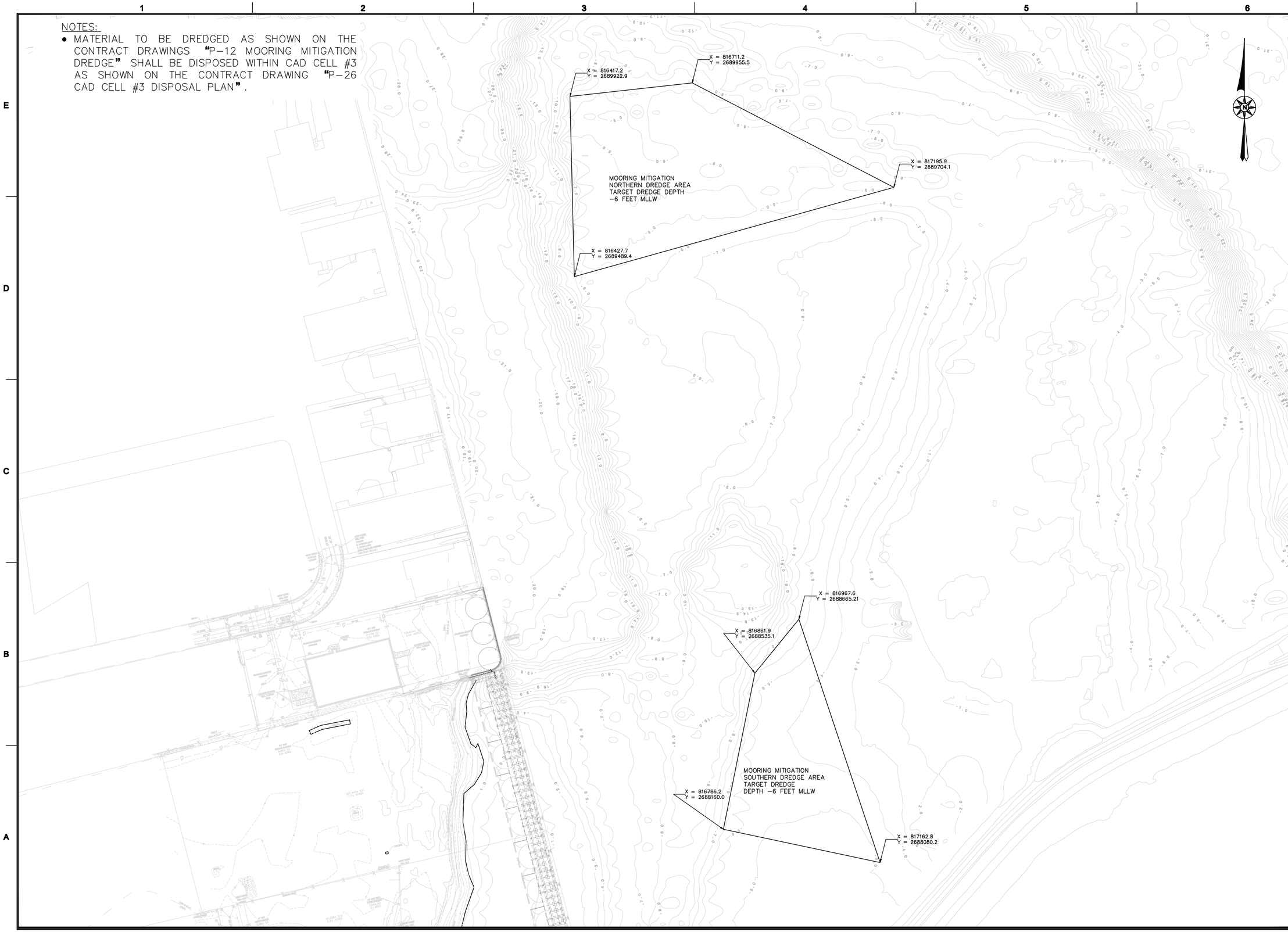
P-11

PLOT SCALE 1"=1'-0"

APPENDIX 20

NOTES:

- MATERIAL TO BE DREDGED AS SHOWN ON THE CONTRACT DRAWINGS "P-12 MOORING MITIGATION DREDGE" SHALL BE DISPOSED WITHIN CAD CELL #3 AS SHOWN ON THE CONTRACT DRAWING "P-26 CAD CELL #3 DISPOSAL PLAN".



APEX

ROCKVILLE, MD
SOUTH WINDSOR, CT - BOSTON, MA -
NEW BEDFORD, MA - HOLYOKE, MA

184 HIGH STREET, SUITE 502
BOSTON, MA 02210

58H CONNECTICUT AVENUE
SOUTH WINDSOR, CT

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PROJECT

NEW BEDFORD
MARINE COMMERCE
TERMINAL

OWNER

MASSACHUSETTS CLEAN ENERGY CENTER
55 SUMMER STREET, 9TH FLOOR
BOSTON, MA

NO.	DATE	DESCRIPTION	BY

PROJECT NO.	6690
CADD FILE	MOORING_MIT
DESIGNED BY	CWM
DRAWN BY	CWM
CHECKED BY	CHM
DATE	8-26-11
DRAWING SCALE	1"=100'

GRAPHIC SCALE

SCALE: 1"=100'

0 50 100 200

SHEET TITLE

MOORING
MITIGATION
PLAN

DRAWING NO.

P-24

63 OF 79

PLOT SCALE 1"=1'-0"

APPENDIX 21

APPENDIX K

Port of New Bedford South Terminal Business Plan

Port of New Bedford South Terminal Business Plan

Prepared by

FXM ASSOCIATES
Po Box 660
53 County Rd
Mattapoisett, MA 02739

Massachusetts Port-Wind Energy Project

Technical Memorandum

Port of New Bedford South Terminal Business Plan

To: Ken Fields, Project Manager via e-mail: ken.fields@tetratech.com
TetraTech
From: FXM Associates
Date: December 22, 2009 (*Revised January 5, 2010)*

I. Introduction

This technical memorandum summarizes the analysis and findings of work accomplished by FXM Associates in preparing a preliminary business plan for a multi-use cargo facility at South Terminal in the Port of New Bedford. The context for the business plan is three-fold:

- The concurrent "Port and Support Infrastructure Analysis for Offshore Energy Development Study," commissioned by the Massachusetts Renewable Energy Trust, and being prepared by the TetraTech consultant team of which FXM Associates is the economic consultant;
- *2009 New Bedford/Fairhaven Municipal Harbor Plan,* prepared by the New Bedford Harbor Development Commission (HDC) which describes port assets, needs, and market opportunities with recommended port development initiatives and infrastructure projects to sustain, grow, and diversify the local maritime economy; and
- City of New Bedford's "Integrated Intermodal Transportation Infrastructure Improvements Plan" description of the South Terminal Renewable Energy Marine Park development in its recent application for US DOT TIGER Grant ARRA funding.

FXM's specific assignment is to (1) identify potential revenues and cargoes for the South Terminal facility, in addition to a Representative Offshore Wind Energy Installation (ROWEI); (2) identify an appropriate governance model for multi-use terminal ownership, development, and management; and (3) prepare a preliminary terminal business plan with operating *pro forma*. This Technical Memorandum incorporates portions of the draft report prepared by Captain Jeffrey Monroe that describes port management and terminal operation models, optimum and cost-effective models for support of offshore wind energy installation projects as well as other cargo types; the capital cost estimates for the South Terminal facility developed by Childs Engineering based on critical review of the City's TIGER Discretionary Grant application and other sources; and other capital and operating cost estimates prepared by the consultant team.[1]

---

[1] *Comparison of Selected Northeast Ports for Potential Handling of Wind Power Offshore Energy Installations,* Captain Jeffrey Monroe, MAI (Draft October 2009); *South Terminal Capital and Maintenance Costs Spreadsheets,* Dave Porter, Childs Engineering (November 30, 2009).

FXM also considered input from its specialized affiliates regarding other potential cargo uses at the expanded South Terminal facility for the long term financial sustainability of the project.

FXM examined prospective demand, port governance/terminal management, overall development feasibility, and potential economic effects associated with developing and operating a multi-use Renewable Energy Terminal and General Cargo facility at South Terminal in the Port of New Bedford. This assessment was based on information obtained from the client/project consultant team, public and secondary data sources as referenced, as well as FXM independent research on potential cargo types and revenues to the facility owner other than those that are related to a representative offshore wind energy installation project(s). *An essential question to be answered in this report was whether and to what extent the South Terminal facility could be self-sufficient (that is, not require annual operating subsidies) during or after its use for offshore wind energy development*[2]. As such, this report focuses specifically on the proposed South Terminal project and does not address "quick response" or other possible options for handling Cape Wind's proposed project, or other prospective wind energy development projects that might be staged from New Bedford.

The following assumptions, drawn from related work of the consultant team, discussions with Cape Wind and City of New Bedford officials, underlie FXM's analysis:

- South Terminal represents the best option for the Port of New Bedford to capture off-shore wind developers, as well as other international and I-95 Coastal Highway cargo shipments.

- North Terminal may be useful for off-shore wind related or other cargo shipments to the port by rail until the Route 6 Bridge is replaced to eliminate current navigation/vessel impediments.

- The City of New Bedford or HDC will acquire an approximate 15-acre site in the South Terminal Area referenced in their TIGER grant application, finalize state/federal permit approvals in conjunction with the SER regulatory process, and complete final design and construction for a new, expanded South Terminal bulkhead, pier and dredged berthing areas, and other landside improvements to accommodate offshore wind energy installations and other potential cargo shipments/handling/storage/transshipments.

- Prospective South Terminal offshore renewable energy installation (OREI) users will have the technical capacity, permits, and financial capability to assemble/fabricate and ship to an offshore construction site OREI equipment and materials from a South Terminal facility. The South Terminal facility will include suitable depth of water, pier facilities, and backland/storage space to handle offloading, storage, assembly and loading of machinery and equipment to the offshore construction site. It is FXM's understanding, based on input received from other study team members, that all terminal operations, including contracted shipping, stevedoring and other labor, maintenance, insurance, equipment, and supplies will be borne by the Developer and that – based on ROWEI filings to date – the owner of the

[2] Cape Wind is the "representative" project example (ROWEI) used throughout this report but is not the only potential offshore wind energy development project that could be staged from South Terminal

South Terminal facility will receive approximately $1.5 million in lease payments for each year of the ROWEI's 3-year projected construction/installation period ($4.5 million total).

- A ROWEI may require the Developer to lease the entire South Terminal project area during the peak construction period, but the terminal facilities will accommodate other break-bulk, bulk, and container cargo as identified in this report. The Terminal owner will use suitable contracting/leasing and other arrangements as noted in this report to manage an effective multi-use terminal facility. Other prospective port calls related to reported HDC contacts with shipping companies, Port of Jacksonville, Port of Bayonne, and other American Maritime Highway (AMH) 'port pair' cities may represent additional cargo handling opportunities and potential revenue at the new South Terminal facility, although the cargo opportunities, business plan and operating *pro forma* developed in this report are sufficient to answer the questions FXM was contracted to address for this study.

This technical memorandum subsequently includes **Summary Findings** (Section II, page 4); and sections reporting the research and analyses accomplished on **Potential Cargo and Revenues** (Section III, page 8); **South Terminal Ownership, Development, and Management** (Section IV, page 12); **South Terminal Development Costs, Operating Income and Expenses** (Section V, page 19); and **Economic and Tax Effects of South Terminal Construction and Operation** (Section VI, page 22). It should be noted that economic effects of the ROWEI project's development and annual maintenance are NOT included in the economic and tax effects attributable specifically to South Terminal since at least one other Massachusetts port (Boston) may be capable of accommodating potential offshore wind energy development projects. Annual operating and maintenance economic and tax effects of the ROWEI are also not included in this report since they can be handled at other ports. In the event that the South Terminal facility represents an option for offshore wind energy developers that enables them to choose a Massachusetts port over a non-state facility – that is, Massachusetts facilities other than South Terminal are not competitive for a specific offshore wind energy development project – then the construction period effects of that project could be attributable to construction and operation of the South Terminal facility. Economic and tax effects of the ROWIE are discussed in FXM's technical memorandum "Economic Effects of Offshore Wind Energy and Related Construction and Operating Expenditures".

II. Summary Findings

- A new multi-use cargo facility at the South Terminal site represents the best option in the Port of New Bedford for servicing offshore wind energy development projects during assembly and installation phases.

- A new multi-use port facility at South Terminal can capture container, break bulk, and bulk cargoes not now handled in New Bedford or other Massachusetts ports, and can generate economic development benefits and net operating income to the HDC *with* or *without* offshore wind energy development projects.

- The optimal model for governance of the proposed new facility at South Terminal will be ownership by the New Bedford Harbor Development Commission (HDC) which would lease offshore wind energy installations and other cargo handling, storage, and related facility operations to a qualified private operator.

- Capital costs for a new multi-use port facility at South Terminal are estimated to total about $44 million (in 2009 dollars). Approximately $32 million of this total investment is for land acquisition, bulkhead construction and dredging, buildings and site improvements that are considered functionally necessary to attract and support offshore wind energy development projects, with an additional $5 million in capital expenditures ($37 million total) considered functionally necessary to attract and support new bulk, break bulk, and container cargoes. Capital costs are shown in the text table below:

SOUTH TERMINAL CAPITAL COSTS	**Offshore Wind Installation**	**Non-Offshore Wind Cargoes**
Bulkhead and Dredging	$ 19,990,977	$ 19,990,977
Site Acquisition	$ 2,100,000	$ 2,100,000
Backland Site Improvements (drainage, utilities, surfacing)	$ 6,000,000	$ 6,000,000
SUBTOTAL Basic Infrastructure	**$ 28,090,977**	**$ 28,090,977**
Buildings and structures (35,000 SF)	$ 3,500,000	$ 3,500,000
Crane		$ 3,000,000
Ground Equipment (fork lifts, trucks, etc.)		$ 1,500,000
Other Equipment & Fencing, Security	$ 485,000	$ 485,000
SUBTOTAL with Support Facilities & Equipment	**$ 32,075,977**	**$ 36,575,977**
Optional Fabrication Building (75,000 SF)	*$ 7,500,000*	*$ 7,500,000*
TOTAL with Fabrication Building	***$ 39,575,977***	***$ 44,075,977***

- *Net* operating income to the HDC from the fully-developed South Terminal port facility would total about $1.2 million per year during a projected 3-year representative offshore wind energy development project. Absent other wind energy developers use of the site, which might contribute higher net operating income, *net* income to the HDC is projected to average about $620,000 per year with full cargo operations. Potential operating revenues and costs are shown in the text table below:

SOUTH TERMINAL OPERATING INCOME & EXPENSES	Offshore Wind Installation	Non-Offshore Wind Cargoes
Average Year Annual Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,500,000**	
Container Service		$ 280,000
Break Bulk Program		$ 240,000
Bulk Cargo		$ 432,500
Total Non-ROWEI Cargo		**$ 952,500**
Average Year Annual Operating Expenses		
HDC Personnel (contract/lessee management)	$ 140,000	$ 140,000
HDC Capital/maintenance reserve at 20% income	$ 190,500	$ 190,500
Average Year Annual Expenses	*$ 330,500*	*$ 330,500*
Average Year NET Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,169,500**	
Total Non-ROWEI Cargo		**$ 622,000**

- Based on the net operating income projected for South Terminal, annual operating subsidies for either wind energy development support or long term cargo operations at South Terminal are not anticipated to be required.

- Net income from South Terminal operations could be used to stimulate additional economic development (jobs, income, business sales in the fishing and seafood or other industries) in the port of New Bedford as well as to finance some portion of South Terminal's capital cost.

- Construction of the South Terminal port facility is estimated to expand business output in *Bristol County* by about $44.1 million over the projected 2-year construction period, providing 380 person years of employment and $19.2 million in household income over the construction period. These economic impacts include total direct, indirect and induced economic effects within Bristol County.

- Construction of the South Terminal port facility is estimated to expand business output in *Massachusetts* overall (including Bristol County) by about $65.5 million over the projected 2-year construction period, providing 540 person years of employment and $26.1 million in household income over the construction period. These economic impacts include total direct, indirect and induced economic effects within Massachusetts over the construction period.

- The handling of cargoes not related to an offshore renewable wind energy installation (OREI) -- including container, break bulk, and bulk cargoes projected for South Terminal -- is estimated to expand business output in *Bristol County* by $15.7 million **annually**, providing 130 permanent jobs and $5.9 million in new household income each year. These economic impacts include total direct, indirect, and induced economic effects within Bristol County

estimated to recur annually following facility construction and do not include support of offshore wind energy projects.

- The handling of non-OREI container, break bulk, and bulk cargoes projected for South Terminal is estimated to expand business output in *Massachusetts* overall (including Bristol County) by $20.2 million **annually**, providing 170 permanent jobs and $7.4 million in new household income each year. These economic impacts include total direct, indirect, and induced economic effects within Massachusetts estimated to recur annually, not including offshore wind energy projects. Both construction period and annually recurring direct, indirect, and induced economic effects noted in the preceding bullet points are summarized in the text table below:

		Output (000 $)	Employment (Jobs)		Income (000 $)
Construction Period Effects					
South Terminal Port Facility					
Bristol County	*$*	*44,100*	*380*	*$*	*19,200*
Massachusetts	$	65,500	540	$	26,100
Annual Operating Effects					
South Terminal Port Cargo Operations					
Bristol County	*$*	*15,700*	*130*	*$*	*5,900*
Massachusetts	$	20,200	170	$	7,400

Source: FXM Associates, RECON™ Input Output Model

- During the construction period for the South Terminal facility about $480,000 in municipal revenues within *Bristol County* communities would be attributable to the total direct, indirect and induced economic effects of construction, and within *Massachusetts* communities overall $1.2 million in municipal receipts (including Bristol County) would be attributable to the construction period economic effects.

- During the construction period for the South Terminal facility about $1.4 million in tax revenues to the *Commonwealth of Massachusetts* and $7.3 million in federal taxes would be attributable to the construction period economic effects.

- The handling of non-OREI container, break bulk, and bulk cargoes projected for South Terminal would generate about $300,000 in new tax receipts **annually** to municipalities in Bristol County and $480,000 to municipalities statewide (including Bristol County) each year based on the annual economic effects attributable to cargo operations.

- The handling of non-OREI container, break bulk, and bulk cargoes projected for South Terminal would generate about $500,000 in new tax receipts **annually** to the Commonwealth of Massachusetts and $2.2 million in federal taxes each year. Both construction period and

III. Potential Cargo and Revenues

In a study comparing Northeast ports for OREI cargo handling, the Port of New Bedford is described as already an active freight seaport and a major logistical connection for agricultural products entering the New England market.[3] Highway connections are good and the port would benefit from expanded and improved rail connections to meet freight needs. New Bedford is a small niche port that can continue to expand activities with some infrastructure improvements and investment. The port has sufficient deep water access for the size and type of vessel common to most break-bulk and other cargo available to niche ports, and has available property for backland storage and expansion.

Related Reports by Others

In the City's TIGER Grant application, the HDC anticipates that the Renewable Energy Marine Park at the extended South Terminal will become a construction staging facility for offshore wind farm energy production in New England. The first offshore wind farm that is expected to be developed in New England (Cape Wind) is anticipated to generate up to 420 megawatts of clean, renewable energy. The planned infrastructure improvements and facility development could enable South Terminal Marine Park to become a key connection and marine terminus for renewable energy development projects on the coastline of New England, in addition to the Cape Wind project. Movement of container shipping from ports south of New Bedford will also help to reduce truck traffic on the heavily traveled I-95 corridor.

The HDC envisions development of South Terminal, a new deep water berth and cargo facility, to enhance and modernize the Port of New Bedford's vessel handling ability. The proposed development program for a multi-use South Terminal facility will service the Cape Wind 130 wind turbine project's assembly and installation phase and possibly foster additional local economic development. Following the completion (construction and installation) of the Cape Wind project, South Terminal will be available to other deep sea cargo operations for port services. The new customers will bring additional dockage, wharfage, and lease income to support HDC's long term port infrastructure investments. This section of the business plan identifies market opportunities and prospects for the new South Terminal facility which offer reasonably foreseeable cargo options for which the facility can be used after the completion of the proposed Cape Wind (and/or other) offshore renewable energy projects.

The City's TIGER Grant application references HDC's business development contacts with the Port of Jacksonville, the Port of Bayonne, and shipping companies as indicative of demand for AMH/SST (American Marine Highway/Short Sea Transport) services at the Port of New Bedford. The HDC has been approached by multiple shipping companies, some of which say they are willing to manufacture vessels especially for shipping to the Port of New Bedford. One shipping company indicated its willingness to transport up to 500 Container Equivalent Units (TEUs) per day to New Bedford once the proper facility improvements are in place to facilitate moving forward with shipping. The Reeve & Associates March 29, 2006 report estimated that

[3] *Comparison of Selected Northeast Ports for Potential Handling of Wind Power Offshore Energy Installations,* Captain Jeffrey Monroe, MAI (November 2009)

$45 million of direct income and $72 million indirect income per year in the New Bedford region would be generated by short-sea shipping. While AMH services have been slower than expected to materialize (based on unanticipated drops in oil prices compared to projections just 2 to 3 years ago), over the next several years these opportunities are expected to rekindle shipper interest.

Consultant Team Cargo and Revenue Projections

The following tables summarize three types of cargo potential based on the experience and judgment of existing operators in New Bedford and other port logistics experts. The types of cargoes projected for a fully developed South Terminal facility (see subsequent discussion in Section IV) include containers, break bulk, and bulk cargoes that are not now handled at the Port of New Bedford, and do not include the transfer of any cargo handling operations currently being carried out at other facilities in New Bedford (State Pier, Maritime Terminal, Fish Island, and North Terminal) or at other Massachusetts ports. Thus their economic and fiscal effects will be net new to New Bedford and to the State overall (see Section VI). The tables also identify the revenue implications for the facility owner assuming a public ownership/private lessee operating model (see subsequent discussion of port governance/management options in Section IV). *Revenues shown are net to the facility owner and the lessee is assumed to cover all operating, maintenance, insurance, and related costs of handling, storing, and transshipping the cargoes.* Data in Table 4 (page 19, Section V) summarize potential operating income and expenses, as well as capital costs, for South Terminal including the handling of a representative offshore wind energy installation project.

It is important to keep in mind that, in the experience of both niche and larger port operators, obtaining cargo for a port is a complex matching of pier and landside facilities and equipment, stevedoring and other labor costs, and point-to-point logistics involving specific shippers, carriers, and receivers. Cargoes can be won or lost to a port on very small variations in cost and delivery times, and success is largely driven by the motivation and skill of individual business entrepreneurs and public officials. Macro projections of commodity demands or cargo potential are not reliable for forecasting niche port operations.

annually recurring direct, indirect, and induced tax effects noted in the preceding bullet points are summarized in the text table below:

	Local Taxes (000 $)	State Taxes (000 $)	Federal Taxes (000 $)
Construction Period Effects			
South Terminal Port Facility			
Bristol County	*$ 480*	*$ 440*	*$ 1,820*
Massachusetts	$ 1,190	$ 1,440	$ 7,280
Annual Operating Effects			
South Terminal Port Operations			
Bristol County	*$ 300*	*$ 240*	*$ 730*
Massachusetts	$ 480	$ 500	$ 2,180

Source: FXM Associates, RECON™ Input Output Model

Table 1 – Potential Container Service at South Terminal

Program:	**Container Service**	
Mission:	Developing a terminal capable of handling a regular shipping service	
	for a small container route	
Goal:	Marketing a small container terminal which can bring 4,800	
	equivalent units (TEUs) per year	
Objectives:	Increase revenues for the South Terminal	
	Provide jobs and sales for local/regional/state businesses	
Revenues		
User fees per TEUs	$ 35	TEU
Yearly TEUs	4,800	
Total revenue	$168,000	
Dockage daily rate	$ 1,000	Daily
24 port calls at 2 days each	48	
Total dockage	$ 48,000	
Cross docking, wharfage	$ 2	Net ton
	2,500	
	$ 3,750	
Monthly licensing fees	$ 5,000	Monthly
Container yard	12	
Yearly revenue	$ 60,000	
Container revenue	**$279,750**	

Table 2 – Potential Break-Bulk Cargo at South Terminal

Program:	**Break-bulk Program**	
Mission:	Developing a terminal capable of handling refrigeration of dry	
	break-bulk cargo	
Goal:	Marketing a port terminal and warehouse which can bring 50,000	
	net metric tons of general break-bulk cargo per year	
Objectives:	Increase revenues for the South Terminal	
	Provide jobs and sales to local/regional/state businesses	
Revenues		
Wharfage per net metric ton	$ 2	Net ton
Yearly tonnage	50,000	
Total revenue	$ 75,000	
Dockage daily rate	$ 1,000	Daily
20 port calls at 2 days each	40	
Total dockage	$ 40,000	
Warehouse licensing fees	$ 2,500	Monthly
	12	
Yearly revenue	$ 30,000	
Storage revenue	$ 3	Net ton
	50,000	
	$125,000	
Break-bulk revenue	**$240,000**	

Table 3 -- Potential Bulk Cargo at South Terminal

Program:	**Bulk cargo**	
Mission:	Developing a terminal capable of handling bulk cargo including	
	aggregates and salt	
Goal:	Marketing a port terminal suitable for 150,000 metric tons of salt and	
	aggregates per year	
Objectives:	Increase revenues for the South Terminal	
	Provide jobs and sales to local/regional/state businesses	
Revenues		
Wharfage per net metric ton	$ 2	Net ton
Yearly tonnage	150,000	
Total revenue	$ 300,000	
Dockage daily rate	$ 1,000	Daily
10 port calls at 2 days each	20	
Total dockage	$ 20,000	
Gate fees per truck	$ 15	Per truck
20 tons per load	7,500	
Total gate fee	$112,500	
Bulk revenue	**$432,500**	

IV South Terminal Ownership, Development, and Management

Port Governance & Management

Ports need to function in a manner whereby they can control their finances, development, and management outside of unrelated political forces. The most effective port agencies are those that are self governing and self funding, and port management revolves around one essential factor: the ownership of property, which in most cases is retained for some public benefit. Quasi-governmental ports or commissions are created by State legislatures to allow separate governance but are dependent on the local or state government for funding and project approvals. Public port authorities are entities also created by state legislative action with independent management and bonding authority to focus on commercial marine terminal activities and can include other operations such as airports, marinas, real estate development, and rail or highway infrastructure.

Harbor Development Commission

The New Bedford Harbor Development Commission (HDC) was created by the Massachusetts General Court under Chapter 762 of the Acts of 1957 to serve as the governing entity for the Port. Chaired by the Mayor, the Commission consists of 7 members as appointed by the Mayor and approved by City Council. The crucial day-to-day operation and decision making are the responsibility of the HDC staff headed by the Executive Director. The HDC has jurisdiction over all the waters in New Bedford including the entire coastline of the peninsula, the harbor, and north along the Acushnet River to the City's boundaries. The HDC manages 20 commercial properties, a 198-slip marina on Pope's Island, the ferry terminal on State Pier and its supporting Whales Tooth Parking Lot, 5 piers and wharves, 10 mooring fields, and enforces rules regarding the use of piers, wharves, and adjacent parking areas under its jurisdiction. Being autonomous from City government, user fees, rents, and all other revenue streams do not go to the General Fund, but rather are reinvested by the HDC to support its operations, properties, infrastructure needs, and economic development initiatives. The HDC may borrow and issue municipal bonds for capital improvements. The goal of the HDC is to "support the maritime businesses of the Port, seek out new opportunities, and maximize the natural competitive advantage the Port provides to the New Bedford economy."

Optimal Port Governance Model

The HDC structure is an optimal management model for the Port of New Bedford governance, and the City of New Bedford and Town of Fairhaven have a long established inter-municipal approach to sustaining and growing the port. The *2009 New Bedford/Fairhaven Municipal Harbor Plan* identifies key port infrastructure/facility projects and port development priorities. The Port of New Bedford governance and management have many of the characteristics associated with optimal port models which are summarized below.

- *Separately Enabled*: An effective port agency is established as a separate incorporation with its own management, bonding authority, and ability to secure and retain revenue.

- *Community Connections*: Communities with port entities are best served when they have the ability to appoint governing boards with members who are committed to the vision and effective operation of the port.

- *Professional Staff:* Ports must hire and task professional port managers and staff who are trained and familiar with the port industry and its numerous complexities.

- *Effective Administration*: Agency administration should not be expansive but should be capable of supporting the mission of the port, including financial and legal services.

- *Optimized Assets*: Seaports are among several shared community assets, including airports, freight rail lines, public transit, and other transportation networks and services. Communities can optimize effectiveness by combining administration of some or all of these assets into an integrated system or into a single transportation authority.

- *Effective Marketing and Development*: Commercial growth is the result of an effective marketing plan coupled with an investment strategy that supports flexible development of assets. Many ports languish because they have limited staffs that are expected to manage, maintain, and market facilities. In most cases these efforts are unsuccessful because of insufficient resources.

- *Strategic Planning*: Port agencies need to have a concise strategic and business plan which is developed in cooperation with the local community and port stakeholders and has focused implementation.

South Terminal Ownership

Agency ownership includes port authorities or other agencies that are quasi-governmental and created by an act of a legislative body. Private ownership facilities are those that are fully in the control and ownership of a private corporation. Public ownership of the expanded South Terminal and OREI terminal facility is an underlying premise of this business plan, and the HDC will own and develop the terminal facility, and also may own/lease/rent terminal equipment such as mobile harbor cranes and load stackers.

South Terminal Development

The South Terminal Renewable Energy Marine Park is a component of the City's Integrated Intermodal Transportation Infrastructure Improvements Plan 2 for which the HDC has requested about $20 million of USDOT TIGER Discretionary Grant funds.[4] New Bedford seeks to emerge as a leader in alternative energy and build its Port and landside infrastructure to support the operations of renewable energy technology companies. Renewable energy industrial companies require waterfront support facilities for the manufacture, assembly, shipping, and maintenance of products such as wind blades, turbines, solar panels, wave energy turbines, and related products.

[4] *Integrated Intermodal Transportation Infrastructure Improvements,* New Bedford Harbor Development Commission (September 15,2009)

The HDC seeks to develop the southern portion of South Terminal to accommodate the nascent energy industry, with the long term goal of attracting a significant number of skilled manufacturing and operator jobs to the City of New Bedford. The project as proposed utilizes existing infrastructure which is to be enhanced and/or reconfigured. In-water and waterside development in New Bedford Harbor are afforded a unique permitting status so long as they are related to enhancements of the U.S. Environmental Protection Agency's ongoing superfund cleanup of the harbor. The expansion of South Terminal would require the filling of wetland resource area to create additional bulkhead space within the Harbor; however, portions of these resource areas are inundated daily with water and suspended sediment from the harbor which have elevated levels of heavy metals and PCBs. The bulkhead would allow for the construction of a Confined Disposal Facility (CDF), described by the City as a "Waterfront Development Facility (WDF)." The construction of the WDF would allow for continued confinement, monitoring and maintenance of contaminated sediments.

The City's TIGER Grant application characterized the southern portion of South Terminal as currently severely underutilized, and lacking sufficient space to utilize the area as a RO/RO terminal for prospective AMH cargo shipments. However, extension of the bulkhead will allow use of the contiguous 15-acre site as a multi-use marine terminal and potentially invite future renewable energy industry services, as well as provide additional storage and staging for containers and trucks at other port terminals (State Pier, North Terminal, Maritime Terminal). The new South Terminals facility also could be suitable for temporary relocation of maritime operations to expedite planned State pier reconstruction.

HDC procurement of heavy-lift cranes to unload containers and bulk goods and installation of RO/RO ramps are identified as very important steps in improving existing port facilities to be able to take advantage of anticipated AMH shipping as well as other container, break-bulk, and bulk cargoes. The multi-use South Terminal facility must also meet the OREI developer specifications, and be flexible and adaptable to short-sea shipping services, including the transport of ocean containers, aggregates, bulk, and dry break-bulk cargo as well as berth and vessel limitations with these requirements[5]. The development program outlined below will accommodate the longer term cargo opportunities identified earlier in this report.

Development Program

- An expanded 1,000 linear-foot bulkhead with a 50' apron to accommodate one large vessel and two small cargo vessels or barges simultaneously.

- Vessel operations involving container, bulk, break-bulk cargo, and sea barges need a depth of minimum 25' LLMW, and 30' LLMW is recommended for a maximum potential yield at this new facility in the years to come. The existing Federal channel and road from and to the port is at 30' of depth which allows any vessel and large barges to come into New Bedford Harbor with up to a 28' draft (8.50 meters) including a minimum allowance of 2' under the keel for safe navigation that accounts for the propeller wash. If the berth and the channel are dredged at only 25' (7.60 meters) a safe allowance for sailing would be 23' (7.0

[5] At the writing of this report, it is FXM's understanding that the development program specified also meets Cape Wind requirements.

meters) and at 22' (6.7 meters) the safe allowance is at 20' (6.0 meters). Additional details and guidance concerning vessel transit into New Bedford harbor can be obtained from the Northeast Marine Pilot Association.

- A 50' apron would be ideal to offload containers and other break-bulk commodities including over-dimensional cargoes. Container chassis could safely jockey under the vessel crane or a shore crane for the pickup and delivery of ocean containers.

- A 35,000 square feet (SF) building with office, shop, and storage spaces providing 5,000 SF of office and shop area, and a 30,000 SF cargo storage shed (about 20% larger than the existing State Pier building No. 2 building). A 35,000 SF facility with a minimum roof height of 27' would be ideal. It is imperative that this building design accommodate break-bulk cargo operations, and that the eastern end of the shed be at the same level as the berth apron. The western end should be where the loading docks are located at the standard 4' elevation. Roll-on and roll-off (RO/RO) transport units, trucks, and forklifts must be able to travel freely from the pier apron to the northern and southern entrances of the building.

- A building of 250' x 140' at a distance of no more than 100' from the berth fenders will be ideal for handling of break-bulk cargoes. The building must be built length parallel to the berth with the offices being located on a second level at the northwest corner, above a 60' x 40' shop for optimum space utilization. A loading dock with a least ten loading bays is to be located on the west side of the building. Doors at the north and south end of the cargo shed would allow for over-dimensional pieces to travel inside the cargo shed.

- The cargo shed's location to the 600' berth needs to be precise if the intent for the South Terminal is to be an efficient multi-purpose facility. The cargo shed's optimal position would be at the northeast section of the berth allowing for the southeast to be available for the handling of bulk aggregates or bulk salt.

Acreage

The expanded multi-use South Terminal facility will encompass a 15-acre terminal (about 653,400 SF) with the following land use allocations:

- 5 acres -- cargo shed operation including parking for 30 trucks and the needed space for maneuvering tractor trailers and the loading dock for 10 trucks is estimated to use about 5 acres of land.

- 10 acres -- available for paved container yard or to store bulk salt and aggregates and/or for other found purposes including additional cargo facilities.

A small container service of 200 forty-foot equivalents per vessel call will require about 2.5 acres of space for single stacked storage and less when the boxes are double stacked with a top pick forklift (empties stack three high). The concurrent inbound and outbound movement of containers, including the storage of empty boxes, would thus require 5 acres of land in total.

The vessels that carry bulk salts can no longer economically unload in New Bedford at a facility on the north side of the New Bedford-Fairhaven Bridge. The space allocation for this cargo assessed on the angle of repose can be supplied by the shipper, Morton Salt, which typically drops 50,000 MT or more per vessel call. For the purpose of this business plan, FXM has allocated 5 acres for all aggregates.

Development Schedule

The City of New Bedford TIGER Grant application presents a 24-month construction schedule for the South Terminal Renewable Energy Marine Park, with project closeout (availability to an OREI developer/terminal operator) targeted during the first quarter of 2013 (January to March).[6] As described in Section 7.0 and Appendix A of the City's TIGER Grant application the project may be authorized under a special expedited regulatory process referred to as the State Enhanced Remedy (SER) –Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, a SER project comes under the umbrella of a program where traditional local, State and Federal environmental permitting is not required for the waterways infrastructure portions of the project, relieving the project of conventional permitting process uncertainties.

The Application also states that the HDC is preparing specifications which will be completed in November 2009 for the project, and HDC will initiate project organization, construction bidding, and logistics to begin construction within two months of receiving the project funds.

South Terminal Operations

Consultant team research for this business plan indicated the level of direct control that a facility owner has over a terminal determines the level of income, expense, and liability the owner assumes. In the maritime industry, most private facility owners operate their own terminals while many public facility owners contract the facility out to the private sector. Generally, terminal operations are divided into several categories including:

- Facility Management
- Marine Operations
- Vessel Services
- Stevedoring Services
- Shoreside Terminal Operations
- Support and Maintenance Functions

A public entity that is also a terminal operating company may undertake all of the service areas, contract some services or lease the terminal to a third party operating entity. As the industry strengthened, many public entities that initially operated ports began leasing facilities to private sector firms, which are partners in both development and investment of publicly owned marine

[6] *Integrated Intermodal Transportation Infrastructure Improvements,* New Bedford Harbor Development Commission (September 15, 2009)

facilities. *A major reason for third party involvement is the limitation of liability for operating entities. Marine and terminal operations involve large numbers of personnel, and injuries, damage to facilities, cargo damage, and environmental issues pose a potential significant cost to terminal operators.*

Terminals that operate with multiple operators often face conflicts and control issues. Some terminals lease a portion of the facility out to a stevedore or terminal operator but this can often limit the port's utilization of space. The most effective models have a single entity handling all marine operations at the port and generally under license. The port has the right to set the terms of any license it issues and it can elect to control rates and limit cargo types. The terminal can also separate the marine component from the shoreside component particularly if the shoreside component involves a specialized field of cargo activity. The marine activities are contracted and the third party held responsible for performance, regulatory compliance, and liability.

Public entities that are 'landlord ports' often have a third party operator for cargo and marine operations, generally terminal operating companies that also serve as the terminal stevedore and handle all aspects of marine activities including administration. A terminal management company is the fully functional form of stevedoring operation that handles both the vessel and terminal cargo handling activities. To accomplish this successfully, a port needs to shift the cost center to the new operating entity. Many ports have structured agreements with operators in the following manner:

1. *Contract Operator* - The facility owner contracts a terminal operator to manage and control the facilities on a cost plus basis. All revenue and expenses are retained by the owner. Liability is assumed by the operator.

2. *Cost Share Operator* - The facility owner contracts a terminal operator to manage and operate the facilities based on a cost share formula. The owner assumes a portion of the infrastructure cost while the operator assumes the operating cost. The revenue is shared on a prorated basis and liability is assumed by the operator.

3. *Third Private Operator* - A private operator assumes full responsibility for the facilities and pays a fixed lease cost to the facility owner. This is only successful if there is adequate business revenue to justify the offsetting costs. In many cases, this is not generated solely by the marine activity.

A stevedore is an individual or firm employing longshoremen for the purpose of loading and unloading a vessel. Longshoremen are the personnel who handle the cargo aboard the vessel and ashore including yard and often ship equipment, as well as sort, check, stage, and manhandle when necessary all commodities in transit. The stevedore is the employing management firm while the longshoremen are employed on a regular or casual basis. While stevedoring is generally limited to cargo handling, line handling and other dockside services are generally handled by the same labor force. The stevedoring firm can either have regular employees or use contract labor. Personnel are often members of a longshoremen's union in the United States but there are also a number of non-union operations. The stevedore is responsible for all salaries, benefits, and care if a longshoreman is injured.

- When cargo (OREI components are considered to be project cargo) is received, the stevedore can act as the responsible receiving party or the cargo can be received by the terminal and handled on their behalf by the stevedore. Stevedoring arrangements can vary according to the practice and work arrangements in a port. The stevedore can have an exclusive or non-exclusive agreement for all cargo handling, may only handle one type of cargo on a terminal or may have leasehold on a portion of the terminal for a specific type of cargo handling, commodity, or operation.

- Based on the arrangement, a license fee, percent of gross, fixed leased area fee or per unit/tonne fee is collected by the port from the stevedoring company. Ports may also have the stevedore handle all billings and collections depending on the operation. In most cases, the stevedore will provide all ground equipment which includes forklifts, reach stackers or top loaders, yard hustlers, small cranes, and other basic pier handling equipment. Large cranes and similar equipment are generally provided by the port. Use time and a fuel surcharge are generally charged to the vessel along with other fees.

Terminal Lease

Most cargo terminals at US ports are leased or licensed to private operators for the purpose of economic development and the creation of local and regional jobs related to the logistics field. However, the port infrastructures are built with public funds as social/economic investment similar to the road system. For the governments to recover the financial investments in port facilities, infrastructure is considered payback in terms of job creation, taxes, etc., planned on a long term basis of 25 to 50 years. This regional investment and return to a region is compounded with the development of parallel business arising for the initial harbor investment.

In addition to the basic lease fees for the terminal, port authorities may also charge fees for activities associated with cargo handling. These include fees for wharfage, tonnage or container or user fees, lease rents, storage, dockage, equipment rental and other ancillary services and activities.

Security and US Customs

The HDC South Terminal will have to be in full compliance with the US Coast Guard, Customs and Border Protection, and any other governmental agency's laws and regulations.

V. South Terminal Development Costs, Operating Income and Expenses

The following Tables 4 and 5 show data that represent a composite and synthesis of detailed capital costs, income and expense estimates prepared by FXM Associates, other project team members, and outside logistics experts. It assumes that the optimal management model will be for the HDC to develop and own the South Terminal facility and then to lease its use to a qualified terminal operator(s) for offshore wind energy development and for the handling of non-OREI container, break bulk, and bulk cargoes. This approach is most likely to assure cargo opportunities will be realized, optimize net revenue to the HDC, and minimize liability and contingency costs, but it is not the only potential operating pro forma possible.

Table 4
Estimated Capital Costs of South Terminal Facility

SOUTH TERMINAL CAPITAL COSTS	Offshore Wind Installation	Non-Offshore Wind Cargoes
Bulkhead and Dredging	$ 19,990,977	$ 19,990,977
Site Acquisition	$ 2,100,000	$ 2,100,000
Backland Site Improvements (drainage, utilities, surfacing)	$ 6,000,000	$ 6,000,000
SUBTOTAL Basic Infrastructure	**$ 28,090,977**	**$ 28,090,977**
Buildings and structures (35,000 SF)	$ 3,500,000	$ 3,500,000
Crane		$ 3,000,000
Ground Equipment (fork lifts, trucks, etc.)		$ 1,500,000
Other Equipment & Fencing, Security	$ 485,000	$ 485,000
SUBTOTAL with Support Facilities & Equipment	**$ 32,075,977**	**$ 36,575,977**
Optional Fabrication Building (75,000 SF)	*$ 7,500,000*	*$ 7,500,000*
TOTAL with Fabrication Building	***$ 39,575,977***	***$ 44,075,977***

Capital Costs

As data in Table 4 indicate, capital costs for the multi-use South Terminal facility have been estimated by the consultant team to total approximately $44 million. Of this total, approximately $32 million is considered functional for servicing the offshore wind energy development cargo handling, assembly, and storage requirements required for a staging operation of similar scope to that shown for the Representative Offshore Wind Energy Installation (ROWEI). Approximately $20 million of this capital investment has been requested of the Federal government by the City of New Bedford in its TIGER grant application, which represents pier, bulkhead, and dredging cost estimates but does not include site acquisition or backland site improvements. The $6 million estimated for backland site improvements includes costs for drainage, utilities, surfacing, and mitigation. Experience of wind energy developers indicates that a fully paved backland area may not be necessary, but these costs have been included because of uncertainty over the condition of the site and whether or not paving or other mitigation measures may be required if contaminated soils or poor drainage areas are an issue. The $2.1 million acquisition costs assumes $150,000 per acre, a conservative high estimate given the $125,000 per acre costs reported by the New Bedford Economic Development Council (NBEDC)[7] for recent sales in this

[7] Conversation with Matthew Morrissey, Executive Director, NBEDC, November 2009.

area. Additional capital costs to competitively service offshore wind energy installation projects are estimated to include $3.5 million for a 35,000 SF building to provide interior storage and terminal operations space, and approximately $500,000 for security fencing and miscellaneous equipment.

Additional capital costs of approximately $4.5 million are estimated by the consultant team for the South Terminal facility to be able to competitively attract the container, break bulk, and bulk cargoes projected following the completion of offshore wind energy development operations. These include purchase of a 300-ton mobile crane ($3 million), other ground equipment ($1.5 million). Both the mobile crane and other ground equipment, if purchased prior to the facility's use for offshore wind energy development, could represent sources of net income to HDC. Currently, all equipment necessary for the offshore wind energy operation are assumed to be the cost of the developer and potential rental fees for such equipment are not included in the operating income shown in Table 5, below. A large transit shed/fabrication building has also been included in the multi-use facility building program at a cost of $7.5 million, primarily to handle break-bulk cargo storage or fabrication/assembly operations for offshore wind energy developers and could also represent a source of net income to the HDC not included in the Table 5 income estimates shown below.

Table 5
Potential Income and Expenses to the New Bedford Harbor Development Commission (HDC) Assuming Leasing of Terminal Operations

SOUTH TERMINAL OPERATING INCOME & EXPENSES	Offshore Wind Installation	Non-Offshore Wind Cargoes
Average Year Annual Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,500,000**	
Container Service		$ 280,000
Break Bulk Program		$ 240,000
Bulk Cargo		$ 432,500
Total Non-ROWEI Cargo		**$ 952,500**
Average Year Annual Operating Expenses		
HDC Personnel (contract/lessee management)	$ 140,000	$ 140,000
HDC Capital/maintenance reserve at 20% income	$ 190,500	$ 190,500
Average Year Annual Expenses	*$ 330,500*	*$ 330,500*
Average Year NET Operating Income		
Offshore Wind Energy Development (ROWEI)	**$ 1,169,500**	
Total Non-ROWEI Cargo		**$ 622,000**

Operating Income and Expenses

During the assembly/installation phase of Cape Wind's offshore wind farm development the HDC is expected to receive at least $1.5 million per year net of operating or maintenance costs for the developer's use of the facility ($4.5 million over the three year estimated construction period). In addition, the developer/facility operator under terms typical of such leases would assume all liability (insurance) costs, homeland security costs, and so forth. The HDC would be expected to receive about $950,000 per year in net income from the lease, dockage, wharfage, storage, equipment rental and so forth charges to a private facility operator shown by cargo type

in Section II of this report. As with the lease expected with the offshore wind developer (s), liability, homeland security, and maintenance costs would also be the responsibility of the private facility operator. The annual expenses to the HDC are estimated at $140,000 for personnel to administer and oversee the private lessee operations. Contributions to a capital/maintenance cost reserve fund by the HDC are shown as a $190,000 annual expense.

Net Income

As shown by the data in Table 5, annual income to the HDC net of projected expenses is estimated at about $1.2 million per year for the projected 3-year ROWEI and about $620,000 per year for the additional cargo handling, storage, and transshipment operations. The South Terminal port facility can thus cover its operating expenses during the offshore wind energy developer(s)' use of the facility and on an average annual basis without a wind energy installation project based on the container, break bulk, and bulk cargo opportunities identified.

VI. Economic and Tax Effects of South Terminal Construction and Operation

Data in Table 5 show the estimated economic effects attributable to the construction of the South Terminal port facility and the handling of non-offshore wind project related container, break bulk, and bulk cargoes identified in prior report sections. A complete discussion of the assumptions, data sources, and analytic methods used for the South Terminal project economic assessment, as well the economic assessments of offshore wind energy projects and other potential port construction in Massachusetts, is included in a separate FXM technical memorandum: "Economic Effects of Offshore Wind Energy and Related Construction and Operating Expenditures".

Table 6
Direct, Indirect and Induced Economic Effects of South Terminal Facility Construction and Annual Operations

	Output (000 $)	Employment (Jobs)	Income (000 $)	GDP (000 $)
Construction Period Effects				
South Terminal Port Facility				
Bristol County	*$ 44,100*	*380*	*$ 19,200*	*$ 26,100*
Massachusetts	$ 65,500	540	$ 26,100	$ 36,200
Annual Operating Effects				
South Terminal Port Cargo Operations				
Bristol County	*$ 15,700*	*130*	*$ 5,900*	*$ 9,700*
Massachusetts	$ 20,200	170	$ 7,400	$ 11,900

Source: FXM Associates and RECON™ Input Output Model

The construction period economic effects shown in Table 5 include a $65.5 million expansion in business output statewide ($44.1 million of that would accrue within Bristol County), 540 person years of employment statewide (380 person years in Bristol County), and $26.1 million in household income ($19.2 million in Bristol County) over the estimated 2-year construction period. Economic impacts attributable to construction expenditures are correctly interpreted as one-time, non-recurring economic effects.

Annually recurring economic effects of the non-OREI cargo handling operations at South Terminal, as shown in Table 5, include $20.2 million in expanded business output statewide ($15.7 million of that within Bristol County), 170 permanent jobs (130 within Bristol County), and $7.4 million in additional income each year to Massachusetts households ($5.9 million to households in Bristol County).

Data in Table 6 show the estimated tax effects attributable to the construction of the South Terminal port facility and the handling of non-offshore wind project related container, break bulk, and bulk cargoes identified in prior report sections.

Table 7
Direct, Indirect and Induced Tax Effects of South Terminal Construction and Operation

	Local Taxes (000 $)	State Taxes (000 $)	Federal Taxes (000 $)
Construction Period Effects			
South Terminal Port Facility			
Bristol County	*$ 480*	*$ 440*	*$ 1,820*
Massachusetts	$ 1,190	$ 1,440	$ 7,280
Annual Operating Effects			
South Terminal Port Operations			
Bristol County	*$ 300*	*$ 240*	*$ 730*
Massachusetts	$ 480	$ 500	$ 2,180

Source: FXM Associates and RECON™ Input Output Model

The construction period tax effects shown in Table 6 include $1.2 million in receipts to municipalities statewide ($480,000 of that would accrue to communities within Bristol County), $1.4 million in tax revenues to the Commonwealth of Massachusetts, and $7.3 million in federal taxes. These tax receipts are attributable to the economic impacts shown in Table 5 and are correctly interpreted as one-time, non-recurring tax effects.

Annually recurring tax effects attributable to the non-OREI cargo handling operations at South Terminal, as shown in Table 6, include $480,000 in receipts to municipalities statewide ($300,000 to communities within Bristol County), $500,000 in new tax revenues each year to the Commonwealth of Massachusetts, and $2.2 million in federal taxes annually.

Appendix A -- Port of New Bedford Description[8]

The Port of New Bedford is a deepwater commercial port with easy access to the maritime corridor from the Massachusetts coast, located on the northwestern side of Buzzard's Bay approximately 9 nautical miles from the Cape Cod shipping canal, 83 miles south of Boston and 166 miles north of New York. The Port serves as the City's greatest natural resource and most critical asset to stimulate investment, attract new industry, create jobs, and develop a healthy economy. Over 4,400 people are employed by the commercial port. New Bedford is the number one value fishing port in the nation generating economic activity in excess of $1 billion. The fishing fleet lands over 145 million pounds of product annually, leveraging $241 million in direct sales. New Bedford is connected to the world market through its port and can capitalize on unique import/export distribution opportunities developing rapidly in the free global marketplace. Currently, the Port of New Bedford supports a diverse market of cargo transport handling over $230 million in shipping of bulk commodities and break-bulk cargo. Barge operations move aggregate and break-bulk cargo to the Islands of Martha's Vineyard and Nantucket. Shipments of break-bulk cargo consisting primarily of household goods are exported to Cape Verde and Angola.

The Port of New Bedford has the largest throughput tonnage of break-bulk perishable commodities in New England. The Port handles reefer (refrigerated) vessels which handle fresh fruit as well as fresh and frozen fish. Fresh fruit is imported from North Africa, primarily clementines, and vessels are regularly loaded with New Bedford export herring product, direct call service from Norway handling product for Massachusetts fish processors and distributors. Each vessel load creates a $100,000 - $150,000 direct impact employing approximately 30 ILA for offloading and 20 teamsters for warehouse operations. Those vessels that include export fish product cargo generate a $3 million direct economic impact. Each shipment brings 100 to 150 truckloads of product through the Port. The Port currently sees up to 25 freighters per year and is implementing a rigorous marketing initiative to expand import/export opportunity looking at opportunities to support offshore energy farm developments and the emerging American Marine Highway. The maturing nexus between marine science and the fishing industry puts New Bedford on the forefront as a leader in marine education, research, and technology.

The Port also serves as an important land/sea intermodal center for ferry, cruise, excursion, water taxi, and other passenger operations bringing over 100,000 people through the Port annually. It is the charter of the HDC to support the maritime businesses of the Port, seek out new opportunities, and maximize the natural competitive advantage the Port provides to the New Bedford economy. Intermodal connections among port cargo facilities, rail, highway, and air freight are increasingly important as highways continue to become overly congested and the volume of East Coast ports goods movement is expected to realize exponential growth. The funding requested herein would be used to provide the intermodal connector infrastructure critical to supporting the existing significant fishing, bulk, and break-bulk cargo industries, expanding international trade, and capturing coastal trade opportunities from the emerging AMH market sector. Project elements incorporated into this work would seek to upgrade existing

[8] *Integrated Intermodal Transportation Infrastructure Improvements,* New Bedford Harbor Development Commission (September 15, 2009)

infrastructure to allow for full scale intermodal transport of goods. The proposal herein enables the Port to expand operations to include containerized cargo and oversized transport in addition to augmenting existing bulk and break-bulk shipping business.

Port of New Bedford Profile in Northeast Port Mix

The "Comparison of Selected Northeast Ports" study provides a description of New Bedford Harbor, and the Port of New Bedford in the terms of potential handling facilities for Offshore Renewable Energy Installation (OREI).[9] The report identifies a number of key ports in the Northeast with potential for handling wind generation units, including importing components, storage, assembly and exporting to the construction site. Massachusetts has a varied mix of marine activities in its five key port areas, and a number of ports that because of their existing or proposed marine terminals, geographic location and surrounding market area already have substantive marine activity including a wide range of freight activity. These ports serve as transition points where cargo moves to and from marine modes including ship and barge to land based modes, in particular truck or rail. This connection is being made to both international and domestic markets. The state has one major tonnage and diversified seaport and four smaller niche ports that operate in the marine network: Boston is the major seaport: and, the niche ports include Gloucester, Salem, New Bedford and Fall River.

Facilities

The New Bedford waterfront has a number of large and small piers and wharves which are primarily used by the commercial cargo and fishing industry. Most facilities have good highway connections as well as rail connections. Harbor regulations and berthing are enforced by the Harbor Development Commission (HDC) and the Port Maritime Security Unit except berthing for private terminals.

- New Bedford South Terminal Wharf has a 1,600 foot berth with 30 feet of depth and serves as the major offloading center for fish product. The wharf has 250,000 cubic feet of refrigerated storage on site and handles primarily seafood. The most southern portion of the facility has the potential to build out a 400 foot solid fill bulkhead and act as potential terminal. The site has 10 acres of backland.

- Sprague Terminal just North of South Terminal works off a 740 foot berth with 27 foot depth alongside. The pier primarily handles petroleum products.

- At the center of the inner Harbor is the State Pier Terminal which has three berths measuring 450 feet, 600 feet and 775 feet with 30 foot depth alongside. There is 125,000 square feet of covered storage for general cargo. Cargo service out of state pier includes the movement of break-bulk cargo to Cape Verde and Angola. The facility can support freighter service and store over 135 containers. American Cruise Lines operates out of the facility bringing in a minimum of 20 ports of call on an annual basis and up to 89 passengers per trip. Ferry services also operate out of State Pier, including passenger and

[9] *Integrated Intermodal Transpiration Infrastructure Improvements,* New Bedford Harbor Development Commission (September 15,2009)

cargo service to Cuttyhunk Island and passenger service to Martha's Vineyard. Ferry service brings over 115,000 passengers through the Port annually. The Quick Start Ferry facility on New Bedford State Pier allows intermodal transfers of waterborne freight and freight carried by truck and rail. The terminal features a 27-foot pier depth, roll on-roll off capability, offsite cold storage, and easy access to the interstate highway system. The ramp is 100 feet long and 18 feet wide and will hold up to 200 tons.

- Above the Route 6 Bridge are Maritime Terminal, Bridge Terminal and North Terminal. The Maritime Terminal Wharf, operated by Maritime Terminal International, has a 600 foot berth with 31 foot depth alongside. The facility has 3 million cubic feet of refrigerated storage and is one of the largest U.S. Department of Agriculture-approved cold treatment centers on the East Coast for the use of controlled imported agricultural products. The terminal receives approximately 25 vessels a year, each carrying between 1,500 and 4,000 tons of fish or approximately 2,000 to 3,000 tons of fruit.

- The Bridge Terminal Wharf, on the northeast side of the harbor, is 450 feet long with 28 foot depth alongside. The wharf has a 500,000 cubic foot refrigerator warehouse and handles frozen and chilled food products. The facility is owned and operated by Bridge Terminal Inc.

- American Pride Seafood is a private facility operating out of North Terminal and one of the world's leading seafood product processors. The bulkhead supporting their operation is 580 feet long with 25 foot depth alongside. The facility has 63,400 square feet of refrigerated warehouse space, 57,500 square feet of freezer space and 34,700 square feet of covered warehouse space.

- Within the New Bedford North Terminal Wharf are commercial properties managed by the HDC. These properties cover 25 acres of land. Tenants include the seafood processors Eastern Fisheries and Seawatch International, barge operators, ship repair facilities, and other maritime service businesses. A 2 acre terminal site is proposed to come on-line over the next 5 years. This facility is currently operated by the EPA as part of the superfund clean-up and will revert back to City in the next few years. The facility has rail connections that lead directly to the water's edge.

The port is considered a full service port and associated maritime industries include vessel maintenance and repair conducted at dockside or at repair facilities in New Bedford or in Fairhaven. The port has two moderate size shipyards, and equipment and provisions to support commercial and recreational vessels

Harbor Profile

The Port of New Bedford is considered a moderate deep-water port with overall depths of 30 feet at mean high water. The harbor is protected by a hurricane barrier that is constructed across the harbor entrance and equipped with a gate that can be closed during hurricane conditions and severe coastal storms. The port is considered a harbor of refuge for vessels in the region.

The Harbor approach is characterized by a number of ledges and shoals. The approach channel allows for safe navigation and avoids most of the obstructions. The hurricane barrier entrance is 150 feet wide and opens up to a 350 foot wide channel, at a depth of 30 feet, extending to a turning basin 350 yards (1,000 feet) just above the New Bedford-Fairhaven Bridge. The range of the tide is 3.5-4.0 feet and harbor currents are overall considered weak. Maximum ebb and flood tide currents are under 2.5 knots average.

There are vessel limitations due to the hurricane barrier and the highway bridge in the inner harbor. The hurricane barrier opening width is 150′ (45.7 meters), the New Bedford – Fairhaven Bridge is 92′ (28.0 meters) wide. All vessel transit from and to the New Bedford – Fairhaven Bridge are subject to daylight-only restrictions for vessels with overall length above 400′ (121 meters) and/or beam above 59′ (18 meters) and are subject to wind velocity restrictions.

Advantages

The port is well protected by the Hurricane Barrier and has support mechanisms in place for commercial and industrial vessel activity including OREI processing. The port is has good road and rail access, and adaptable warehouse capacity is significant. The port has excellent road and rail connections to its northern terminals and has several opportunities for expansion including OREI fabrication.

The harbor is challenged by a significant pollution problem due to local industries which up until the 1970's discharged wastes containing polychlorinated biphenyls (PCBs) and toxic metals into New Bedford Harbor. There are high levels of contamination throughout the waters and sediments of the Harbor which extends into Buzzards Bay. Hundreds of acres of marine sediment were highly contaminated. Biological effects of the contamination include reproductive impairment and death of marine life throughout the estuary, along with loss of marine biodiversity in areas of high contamination and gave New Bedford status as a Superfund Site. Since 2004 the EPA has been dredging to remove the PCBs through a complex process for dealing with contaminated sediments. The EPA is expected to explore new technologies (confined aquatic disposal) that will reduce the demand for land-side facilities bringing the terminal facility under City control and opening other waterfront parcels up for development.

Due to high levels of harbor contamination, no maintenance dredging had occurred for over 50 years and had become critical. The port faced the loss of waterfront businesses unless maintenance dredging could be implemented. In 2005, the first navigational maintenance dredging was conducted restoring portions of the harbor to useable depths. This has allowed business to increase and larger commercial vessels are returning to the harbor.

Disadvantages

Vessel draft is limited to 30 foot overall depth and the turning basin can only handle small cargo ships. The Route 6 Bridge limits the size vessel that can access the north terminal portion of the harbor and being an outmoded swing bridge causes delays in travel time. Some of the most critical infrastructure in the port is aging and in need of repairs and improvements.

Potential

There are several port areas adaptable for marine terminal expansion capable of supporting OREI processing. The State pier requires a significant amount of investment to bring it up to industry standards for cargo handling and there are several other facilities that require infrastructure improvements including bulkheads, piers and wharves. The rail corridor needs to be extended and track improved to accommodate increased and oversized shipments. Commuter rail improvements are being planned and the engineering of commuter rail should include freight adaptable considerations. Development and of staging areas for trucks is also critical for increased activity in the port.

The North Terminal owned by the Harbor Development Commission can be improved for handling of OREI fabrication and processing. Terminal facilities including the State Pier and North Terminal site should be equipped with a versatile mobile harbor crane and ground support equipment. This equipment can be used for both cargo handling and wind farm components. Additional dredging to provide better access to all deepwater berths should be completed and the turning basin should be lengthened to accommodate longer, higher tonnage cargo vessels. Improvements to the Route 6 Bridge are critical to the passage of vessels to North Terminal and maximizing vessel access. The suggested plan is to construct a double bascule bridge.

Appendix B -- Port Management and Governance Models[10]

Port Management Models

There are multiple models for port management which range from simple terminal management within a port to combined or collective port management which encompass multiple facilities or waterfront properties. Port management revolves around one essential factor, the ownership of property, which in most cases is retained for some public benefit. The amount of port property and jurisdictional locations often dictate how the management will be structured.

Ports or regions that manage their collective facilities cooperatively, or under the same management authority, often sustain growth more effectively. This is primarily because competition for public financial resources is limited. Over the last 50 years, public entities have taken over large expanses of waterfront property, including terminals and similar marine facilities, to insure the infrastructure was protected and allowed to provide public benefit. This was most significant during the transition from break-bulk to container operations in the maritime industry which stranded many waterfront properties and left many facilities with marginal use. In the United States, public entities include several types of management organizations:

- *Municipal ports* -- Municipal ports are more common in small port areas. The local municipal entity, town or city, provides management of the port's facilities. In most cases, the managers are a department of the local government, funded as part of the municipal budget. The advantage is cost effective management, the disadvantage is the port competes for funding with schools and community services. Portland, Maine is an example of a municipal port.

- *State ports* -- State ports are operated under the transportation department of a State and are managed or staffed with State employees. Many communities have State owned facilities which are either promoted by the State or leased to a public or private entity. In most cases State port management is limited to port promotion or infrastructure investment. The advantage is coordinated transportation programs under a single State entity. The disadvantage is funding competition. Connecticut has a program under its Department of Transportation similar to this model.

- *Federal ports* - Federal ports are owned and operated by the Federal government. They are used for specific purposes such as handling of military cargo. Earle, New Jersey is an example of a federal port.

- *Quasi-governmental ports or commissions* -- Quasi-governmental ports or commissions are ports created by State legislatures that have a form of separate governance but are dependent on the local or State government for funding and project approvals. They are intended to allow the local governmental entities to exert a level of local control over waterfront property

[10] *Comparison of Selected Northeast Ports for Potential Handling of Wind Power Offshore Energy Installations,* Captain Jeffrey Munroe, MAI (Draft October 2009)

in a community. The advantage is the involvement of local government in decision making. The disadvantage is that the waterfront issues can be so diverse that progress is often slow for industrial or commercial development. New Bedford's Harbor Development Commission is an example of this type of structure.

- *Public port authorities* -- Public port authorities are entities that are created or enabled by State legislative action and have independent management and bonding authority. They focus on commercial marine terminal activities but can often include other operations such as airports, marinas, real estate development, rail or highway infrastructure. The advantage is that they have the ability to promote their business activities with limited involvement from local government processes. The disadvantage is that they can have diverse policy from their host communities. The Massachusetts Port Authority (Massport) is an example of this type of entity.

- *Regional Ports* -- The regional port council concept includes independent port agencies that work together to achieve common regional goals. An effective model for a regional port cooperative is the Massachusetts Governor's Seaport Council. In this model each port is represented along with the key secretaries who have regulatory or development responsibilities for port areas, under the Office of the Governor. Acting similar to a Metropolitan Planning Office (MPO), the council reviews projects, coordinates State's response and allocates funding. The council also provides a policy development forum that is coordinated with other State objectives.

Ports themselves are a collection of marine terminals with associated landside transportation infrastructure. They are generally a collection of both publicly and privately owned facilities that have common interests in the growth and development of a port area. Public entities often have leadership roles in the port and work with private entities to foster growth and development. In many cases, public entities operate marine terminals in a similar fashion as the private entities. The primary difference is that public entities are generally willing to handle all types of operations including cargo, industrial activities, and other similar operations, where private terminals only handle their own cargoes or activities.

- Terminal ownership and management, public or private, along with their associated operational structures differ according to their location, historic staffing structure, and labor agreements.

A public entity that is also a terminal operating company may undertake all of the service areas, contract some out or in some cases lease the terminal out to a third party operating entity. Occasionally, the terminal owner will contract a third party management firm who will manage terminal staff and personnel on behalf of the owner. There was also a realization that ports needed to engage professional management and partner with the private sector to expand opportunities and create efficiencies. Rail and marine terminal operators began venturing into becoming transportation companies handling every aspect of cargo transportation "door to door." As the industry strengthened, many public entities that initially operated ports began leasing facilities out to the private sector who are becoming partners in both development and investment of publicly owned marine facilities.

Port Governance Models

To highlight how port governance might be best achieved for a potential port activity, several examples are available for review.

The Port of New Bedford is the first example. The New Bedford Harbor Development Commission (HDC) was created by the Massachusetts General Court under Chapter 762 of the Acts of 1957 to serve as the governing entity for the Port. Chaired by the Mayor, the Commission consists of 7 members as appointed by the Mayor and approved by City Council. The crucial day-to-day operations and decision making is the responsibility of the HDC staff headed by the Executive Director. The HDC has jurisdiction over all the waters in New Bedford, including the entire coastline of the peninsula, the harbor, and north along the Acushnet River to the City's boundaries. The HDC manages 20 commercial properties, a 198 slip marina on Pope's Island, the ferry terminal on State Pier and its supporting Whales Tooth Parking Lot, 5 Piers and Wharves, 10 mooring fields, and enforces rules regarding the use of piers, wharves, and adjacent parking areas under its jurisdiction. Being autonomous from City Government, user fees, rents, and all other revenues streams do not go to the General Fund, but rather are reinvested by the HDC to support its operations, properties, infrastructure needs and economic development initiatives. The HDC may borrow and issue municipal bonds for capital improvements. The goal of the HDC is to "support the maritime businesses of the Port, seek out new opportunities, and maximize the natural competitive advantage the Port provides to the New Bedford economy". Progress has been steady in achieving this goal.

Massport is another example. The Massachusetts Port Authority was created in 1956, when a politically encumbered and ineffective, locally-controlled port commission was replaced by the autonomous, self-supporting authority. Massport bought and rehabilitated abandoned or deteriorated property, began rebuilding rail and road connections and, invested in new facility development. In 1966 after the advent of containerization, Massport's built one of the first container terminals in the country at Castle Island in South Boston. In 1971, a second container terminal (Moran Terminal) was built by Massport in Charlestown. In 1980 and 1996, Massport rebuilt the container facility in South Boston expanding its footprint and upgrading its crane equipment. The terminal is now known as the Paul W. Conley Container Terminal.

In 1996, the process of optimizing Massport's marine terminals in Boston also began to occur. All of the container operations were shifted to Conley Terminal and Moran Terminal was converted to an auto import and processing facility. The newly expanded Conley Container Terminal and Boston Autoport were opened in 1997-1998. As a result of focused investment and dedicated efforts, marine traffic at Massport's terminals has increased substantially in the last thirty years. Container traffic has tripled and the cruise ship industry has also expanded from 28 ships in 1994 to over 100 ship calls in the last several years. Massport also operates two airports, a bridge and real estate development division in addition to port facilities. In general, port revenue covers most of the port's expenses, supplemented by revenue from other activities

applied to administrative expenses. Massport has bonding authority for financing of all capital improvements and repairs.

Portland, Maine, provides a third model. The port is municipally owned and operated and management was combined with the Portland International Jetport under the City's Department of Ports and Transportation. Port properties include a 15 acre cargo facility, 12 acre cruise ship and ferry facility and 12 acre fishing based industrial park. The fishing facility is managed by the Portland Fish Pier Authority while the other facilities re managed by the City. It just completed a State and federally funded $22 million ferry facility intended to be expanded into a new cruise ship terminal. All revenue from operations went into the City's general fund; all expenses were tax payer assessed. The port generated marginal income and recently, facing high infrastructure expenses, the City eliminated the marine division of the department and turned over control of the freight facilities to the Maine Port Authority. The City also had a process to offer development rights to a commercial developer for the former State pier, now the primary cruise ship terminal, which failed. Financial challenges and funding competition within the City have led to stagnant development in the port.

APPENDIX 22

Maritime Administration

Home

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America's Marine Highway Program

- Click here for Marine Highway Corridor (map)
- Click here for Marine Highway Corridor Descriptions
- Click here for Marine Highway Project Descriptions
- Click here for Marine Highway Initiative Descriptions
- Click here for Guidance on Applying for Marine Highway Grants
- Click here for America's Marine Highway Program - Report to Congress - April 2011

Department of Transportation Announces Selection of Marine Highway Corridors, Projects, Initiatives, and Grants as Part of *America's Marine Highway Program*

On August 11, 2010, U.S. Transportation Secretary Ray LaHood identified 18 marine corridors, 8 projects, and 6 initiatives for further development as part of "America's Marine Highway Program." In addition, the Maritime Administration made available $7 million for which these projects will be able to compete through a Notice of Funding Availability. Please see the entire press release at www.marad.dot.gov

The Marine Highway Program was fully implemented in April 2010 through publication of a Final Rule in the Federal Register (http://edocket.access.gpo.gov/2010/pdf/2010-7899.pdf). The Secretary's designations were made pursuant to the Final Rule, as required by the *Energy Independence and Security Act of 2007*.

Marine Highway Corridors: These all-water routes consist of 11 Corridors, 4 Connectors and 3 Crossings that can serve as extensions of the surface transportation system. These corridors identify routes where water transportation presents an opportunity to offer relief to landside corridors that suffer from traffic congestion, excessive air emissions or other environmental concerns and other challenges. Corridors are generally longer, multi-state routes whereas Connectors represent shorter routes that serve as feeders to the larger Corridors. Crossings are short routes that transit harbors or waterways and offer alternatives to much longer or less convenient land routes between points. By designating these Marine Highway Corridors, Connectors and Crossings, Secretary LaHood is taking the first step to focus public and private efforts to use the waterways to relieve landside congestion and attain other benefits that waterborne transportation can offer in the form of reduced greenhouse gas emissions, energy savings and increased system resiliency. Please click on this link to view the Marine Highway Corridors, Connectors and Crossings: Click here for Marine Highway Corridor Descriptions

Marine Highway Projects: The Secretary has also selected eight Marine Highway Projects for designation under the program. These projects represent new or expanded Marine Highway Services that offer promise of public benefit and long-term sustainability without future Federal operational support. These projects will receive preferential treatment for any future federal assistance from the Department and MARAD. The projects will help start new businesses or expand existing ones to move more freight or passengers along America's coastlines and waterways. The services have the potential to reduce air pollution and traffic congestion along surface corridors as well as provide jobs for skilled mariners and shipbuilders. The projects were selected from among 35 applications from ports and local transportation planning agencies received by the Department's Maritime Administration (MARAD). Please click on this link to view the designated Marine Highway Projects: Click here for Marine Highway Project Descriptions

Marine Highway Grants: Sponsors of Marine Highway Projects are eligible to compete for a share of up to $7 million in Marine Highway Grants. Please click on the attached Notice of Funding Availability for additional information concerning Marine Highway Grants: Click here for Guidance on applying for Marine Highway Grants

Marine Highway Initiatives: In addition to Projects, the Secretary has selected six applications that, while not developed to the point of proposing specific services and routes required of Project designation, they offer promise of potential in the future. While not eligible to compete for upcoming Marine Highway Grants, these "Marine Highway Initiatives" will receive support from the Department of Transportation in the form of assistance in further developing the concepts through conduct of research, market analysis and other efforts to identify the opportunities they may present. Please click on this link to view the Marine Highway Initiatives: Click here for Marine Highway Initiative Descriptions

The Final Rule (MARAD-2010-0035) for America's Marine Highway Program was published April 9, 2010. The Solicitation of Applications for Marine Highway Projects was published in the Federal Register on April 15, 2010.

Latest News!

The Maritime Administration's Office of Marine Highways & Passenger Services continues to work in Canada and Mexico through the Trilateral Working Group. Also, see additional latest news for stories and media reports related to the Marine Highway.

Additional Resources

America's Marine Highways are supported in several ways, including through reports and publications from Government and academia. Refer to the Program's Reference Library for more information.

In addition, the Marine Highways Cooperative is a consortium of public (Maritime Administration), private, and academic organizations committed to improving transportation mobility through domestic short sea shipping. Other marine highway resources include the National Waterways Conference, MTS Matters, the Waterways Council, and Inland Rivers Port & Terminals.

Additional Information

For additional information, please contact Noel P. Comeaux in the Office of Marine Highways and Passenger Services at 202-366-5527.

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M-95 Marine Highway Corridor

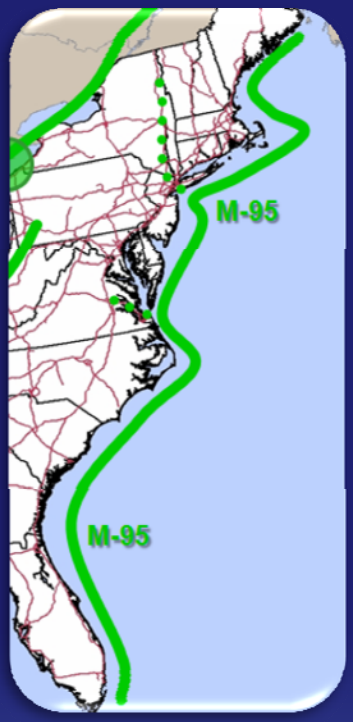
Sponsor: **Interstate-95 Corridor Coalition**

Supporters: Council of State Governments' Eastern Regional Conference, Commonwealth of PA, NJDOT, CT DOT, CT Maritime Commission, Florida DOT, East Central FL RPC, Space Coast Transportation Planning Authority, Economic Development Commission of Florida's Space Coast, DE Valley RPC, DE River & Bay Authority, SE Regional Planning & Economic Dev Commission, Richmond Regional RPC, NJ Transportation Planning Authority, NY Metropolitan Transportation Council, NYCDOT, NYSDOT, Port of Baltimore, NC Ports, Port of Mass., Port of New Bedford, MA, City of New London, CT, Philadelphia Regional Port Authority, MD Port Commission, Philadelphia Regional Port Authority, ME Port Authority, Port Authority of NY & NJ, Port Canaveral, FL, SC State Port Authority, VA Port Authority, Port of Davisville, RI, Jaxport, FL, and the Maritime Association of the Port of New York & New Jersey.

Landside Corridor Served: Interstate-95

Corridor Description:

The M-95 Corridor includes the Atlantic Ocean coastal waters, Atlantic Intracoastal Waterway, and connecting commercial navigation channels, ports, and harbors. It stretches from Miami, FL to Portland, ME and spans 15 states. It connects to the M-87 Connector and the M-90 Corridor near New York City; and the M-64 Connector at Norfolk, VA.



Attributes:

The 1,925 mile-long I-95 Corridor is the major North-South landside freight corridor on the East Coast. The U.S. Department of Transportation identified more than a dozen major freight truck bottlenecks along this route, along with significant critical rail congestion along the upper portions. Projections of future freight volumes indicate increasing freight congestion challenges, with limited opportunity to increase landside capacity.

The Corridor is home to 15 of the largest 50 marine ports in the United States (as ranked by total throughput). These ports handle approximately 582 million short tons of cargo, or 26 percent of the national total. Much of this freight begins or ends its journey with an I-95 transit. Fortunately, the East Coast also possesses a host of waterways, bays, rivers, and the Atlantic coast itself. The Corridor is also lined with less congested, smaller niche ports that could play a vital part in the developing marine highway service network. While several Marine Highway operations already serve this corridor, there is significant opportunity for expansion to help address growing congestion, reduce greenhouse gas emissions, conserve energy, and lower landside infrastructure maintenance costs.

East Coast Marine Highway Initiative

Sponsors: ***Ports of New Bedford, Baltimore, & Canaveral***

Corridor: *M-95 Marine Highway Corridor (Sponsor: I-95 Corridor Coalition)*

Project Snapshot: The East Coast Marine Highway Initiative proposes to develop a service utilizing a fleet of existing and new-build U.S. flag vessels to transport both international containers and trailers along the I-95 Corridor. The service would utilize ports near I-95, including New Bedford, Baltimore and Canaveral, offering multiple medium and long-haul options for shippers along the corridor. Each of these three ports has or is developing the infrastructure necessary to accommodate the proposed service.

Attributes: This Initiative is a corridor focused public-private effort that has considerable support. The I-95 Corridor accounts for 35 percent of the nation's vehicle miles and accommodates over 5.3 billion tons of freight annually. By proposing to construct new vessels as part of the initiative, sponsors can achieve greater emissions and efficiency benefits and help sustain the Nation's vital shipyard industrial base. A Marine Highway service along this corridor could provide public benefits such as reduced congestion and greenhouse gas emissions, energy conservation and increased safety for the vehicles transiting the corridor . Additionally, a service of this type could add valuable resiliency to this vital component of the surface transportation network.

The U.S. Department of Transportation will work with sponsors of both the Corridor and Initiative to better understand the feasibility, benefits and potential efficiencies of the East Coast Marine Highway Initiative. Analysis and research can help identify specific opportunities that could advance this Initiative to a regularly scheduled service.

New Jersey Marine Highway Initiative

Sponsor: ***New Jersey Department of Transportation***

Corridor : *M-95 Marine Highway Corridor* (Sponsor: I-95 Corridor Coalition)

Initiative Snapshot: Home to significant freight-related industries, including a major international East Coast seaport, the State of New Jersey seeks to develop a network of Marine Highway services as components of the New Jersey Marine Highway Platform Initiative. The Platform would consist of a system of waterborne freight projects between five New Jersey hubs and the States of New York, Massachusetts, Rhode Island, Connecticut, Maryland and Virginia.

Attributes: In developing the New Jersey Marine Highway Platform, multiple agencies are collaborating with private sector groups in a statewide effort to seek environmentally and financially sustainable solutions. Developing Marine Highway projects can improve New Jersey's multi-modal freight system by adding capacity in this densely populated state, while helping to reduce emissions, address fuel consumption and increase highway safety. This initiative can capitalize on existing container-on-barge and other surface transportation freight systems while exploring options to bring new services on line.

The U.S. Department of Transportation will work with the New Jersey DOT and the I-95 Corridor Coalition to better understand the feasibility, benefits and potential efficiencies that can be derived from this initiative. Analysis and research will further help develop the concept and identify specific opportunities where the Department of Transportation can provide support.

APPENDIX 23

Analysis of the Potential Market for Short Sea Shipping Services over the Ports of Fall River and New Bedford

Prepared for:

Massachusetts Department of Business and Technology and Seaport Advisory Council

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March 29, 2006

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I. Executive Summary

This reports contains the findings and conclusions from a project funded by the Massachusetts Department of Business and Technology and Seaport Advisory Council (MSAC) to assess the market potential for short sea shipping operations (coastal shipping) to connect the ports of Fall River and New Bedford (ports of Bristol County) with other U.S. ports that would provide a new mode of transportation for freight that is currently moving over the highway.

This report specifically addresses six key issues concerning the prospects for short-sea shipping services over the Bristol County ports:

- What is the status of the emerging short sea network and its outlook for the future?
- What is the potential impact of this network and the factors driving its development on the ports of Fall River and New Bedford?
- What is the potential cargo hinterland for the ports?
- What highway freight is currently moving into and out of this hinterland?
- What type of freight is moving on these lanes and who is carrying it?
- What is the likelihood of different segments of this highway freight market being diverted to short sea shipping through the two ports and the consequent prospects for the two ports becoming successful short sea shipping hubs for the region?

The following are the conclusions of the project team on each of these issues based on the research and analyses that is described in the following pages of this report:

Probability of Success for Bristol County Ports as Short-Sea Shipping Hubs

- Several factors point to a strong probability of success for short-sea shipping services being developed to serve the ports of Fall River and/or New Bedford:
  - There are substantial cargo volumes of truck traffic moving along the Atlantic seaboard with origins or destinations within the hinterland served by the Bristol County ports – options for such services include a short haul operation connecting with northern New Jersey and a longer haul operation connecting with ports in the South Atlantic such as Jacksonville, FL, Wilmington, NC, and/or Norfolk, VA.
  - Truckers, particularly truckload operators, are becoming increasingly aware of the short-sea shipping option, and view it as an additional intermodal opportunity that may offset constraints on their ability to continue to grow pure truck transportation services due to increasing highway congestion and driver shortages as well as limits on hours of driver operation and rising fuel costs.
  - The economics of short-sea shipping appear to be competitive with alternative modes, particularly on long haul lanes provided that "best in class" practices can be implemented in terms of vessel costs and manning levels as well as stevedoring operations that will enable short-sea shipping to achieve its full potential in terms of both cost and service efficiency.
  - The primary competition to the Bristol County ports as short-sea hubs will come from the Rhode Island ports of Providence and Davisville (Quonset Point). Although these

ports are well positioned in terms of physical facilities, they are at a greater distance from the central and northern New England hinterland that may potentially be served by the Bristol County ports.

- However, there are also a number of factors that need to be addressed in order for short-sea shipping operations to be effectively realized in the ports of Bristol County:
  - Current port capacity in both Fall River and New Bedford is limited in its ability to accommodate a major short-sea shipping operation such as envisioned in this project.
  - Fall River's State Pier could accommodate short-sea operations moving the equivalent of 140 trailers into and out of the port on a daily basis but that would entail adding more trailer parking area to that within the current State Pier footprint and also possibly displacing some current users of the facility – in addition, the large volume of truck traffic into and out of the facility projected for the short-sea operation must be balanced with the needs of the adjoining Battleship Cove tourist facilities and other planned recreation activities in the area.
  - New Bedford's current cargo facilities in terms of berth and yard capacity need to be improved to effectively support a short-sea service. In the long term, if the North Terminal is developed as a RoRo berth and adequate access to it is provided by reconstructing or relocating the Route 6 bridge, New Bedford would be an ideal location for a short-sea shipping operation.
  - In addition, factors that add to the cost of short-sea shipping such as Harbor Maintenance Tax (HMT) and the extremely high cost of commercial vessels built by U.S. shipyards must be addressed:
    - The elimination of HMT on coastal domestic shipping services may prove to be revenue neutral as any foregone tax may be offset by funds saved in highway construction and repair as trailers are removed from the highways by short-sea shipping services.
    - The high cost of U.S.-built commercial vessels may be addressed by increasing the percentage of such vessels that may be built overseas, by improved purchasing and sourcing practices by U.S. shipyards, by the application of modern vessel construction practices and technologies by the shipyards, and/or by a waiver of the U.S. Jones Act restriction on domestic operators using foreign-built vessels.

Status of the emerging short sea network and its future outlook

- Despite a number of efforts to develop short-sea shipping services along the U.S. coasts, there have been few successes to date – high costs on both the vessel and port side and slow acceptance of this alternative transport mode were primary factors that undercut these efforts.
- Most of these earlier short-sea initiatives were carried out prior to the current conflux of highway congestion, driver shortages, and high fuel costs that are creating a more favorable environment for short-sea shipping transport alternatives.
- Successful "short-sea" operations in the noncontiguous U.S. domestic trade lanes such as between the continental United States and Puerto Rico, Alaska, and Hawaii provide a business model that is applicable to coastal routes.

- There appears to be a significant opportunity that short-sea shipping services may be successfully launched in the near future if the cost issues are solved on the basis of current best practices within the U.S. and carefully planned partnerships between marine and ground transportation operators are developed to provide a true short-sea/land intermodal service option.

Potential Impact on the Ports of Fall River and New Bedford

- Both ports are well positioned to be significant players as short-sea shipping hubs although constraints on their capacity need to be addressed. The proximity of the two ports to each other may be a plus in terms of sharing labor and services.
- The total economic impact of the development of short-sea shipping services over the ports of Bristol County could be as high as $120 million, creating up to 800 jobs – at least fifty percent of this impact would occur in the immediate area of the Bristol County ports.

Potential Cargo Hinterland for the Ports of Bristol County

- The potential cargo hinterland for the ports of Bristol County extends a relatively short distance to the south by approximately 50-miles including much of Rhode Island, but a significant distance to the north and west to include most of central and northern New England up to 250-miles.

Volume of Highway Freight into and out of the Bristol County Ports' Hinterland

- A total of 1.9 million trailer loads of highway freight move to destinations within the Bristol County ports' hinterland annually from origins within 200-miles of a port along the U.S. Atlantic and Gulf Coasts seaboard – a total of 1.4 million trailer loads moves out of the Bristol County ports' hinterland to destinations within 200-miles of a port along the U.S. Atlantic and Gulf Coasts seaboard.
- The major port-pair partners for the Bristol County ports for short-sea shipping services appear to be Bayonne, NJ (total volume of 787,000 trailer loads) and Jacksonville, Florida (total volume of 418,000 trailer loads).

Type of Freight and Carriers on these Routes

- A broad assortment of manufactured goods, foodstuffs, and basic commodities move by highway freight on these potential short-sea shipping lanes.
- Truckload carriers play a predominant role in these potential markets and also appear to have the greatest interest in short-sea shipping as an alternative mode to direct over the road transport.

In summary, the ports of Bristol County appear to have a significant opportunity to become terminuses for short-sea shipping services. Focusing on implementation strategies that address both the positive and negative factors listed above should enable this opportunity to be achieved.

II. The Emerging Short Sea Network

Background

The highway transportation system of the United States is coming under increasing pressure as growth in over the road traffic is exceeding the growth of capacity at the same time as truck driver shortages, restrictions on driver hours of service, and rising fuel prices are increasing the cost of trucking services. Coincident with these developments, many American companies' supply chains have become more complex as they have internationalized much of their sourcing and reduced inventory levels through such strategies as "Just in Time" parts delivery to manufacturing plants. This has had the effect of increasing these companies' reliance on fast reliable freight transport. The resultant strain from growth in freight transport activity has impacted all modes of transport, but none more than trucking. Significantly increased highway congestion has come from the compound influences of the growth in freight and passenger traffic, especially in densely populated regions such as along the U.S. Atlantic Coast, particularly on the I-95 corridor.

Given the current limited plans for new highway construction and likely ongoing federal and state fiscal constraints, it is likely that congestion on U.S. highways will continue to increase. This will have the virtually inevitable effect of degrading the productivity of the nation's businesses in terms of their transportation and logistics performance. At the same time, the traveling public will be inconvenienced by further increases in traffic delays and the environment will be subject to additional damage from vehicle emissions (especially freight diesel emissions) that reduce air quality.

One potential avenue that offers to relieve some of this strain on the nation's transport infrastructure is the diversion of truck traffic from congested highways to the open sea – that is, to use what is termed "short-sea shipping" operations along the nation's coasts as well as on inland waterways to absorb a significant part of the projected growth in highway freight traffic. These short-sea shipping operations would move freight on an intermodal basis by combining a relatively short overland "drayage" move by truck to transport goods from their origin to a nearby port from which a vessel would carry the freight to another port where a second truck would transport the load over another relatively short distance to its ultimate destination. This short-sea model for domestic freight has already had some success through such operators as Osprey Lines in the U.S. Gulf and inland waterways. However, its application on the Atlantic Coast has been very limited and with no real success stories to date.

Nevertheless, with the recent significant shift in the nation's transportation equilibrium – highway capacity not keeping pace with the growth in demand, labor shortages for truck drivers becoming increasingly acute, and fuel prices rising dramatically – it is timely to take an objective and pragmatic look at whether short-sea shipping can provide a means to relieve some of the pressure on the nation's highways and provide new business for shipping services and ports such as Fall River and New Bedford in Massachusetts.

The Potential Market

The great majority of U.S. intercity truck freight travels only a relatively short distance, and is thus not conducive to an intermodal transportation mode such as short-sea shipping. Likewise, many freight movements occur in volumes and at frequencies not generally appropriate for intra or inter-coastal ocean service. Consequently, successful market penetration by short-sea shipping will be a function of two primary factors: (1) relative length of haul, and (2) the level of concentration of volume in specific traffic lanes. As the distance between freight origin and destination increases and lane volume (density) grows, intermodal services – such as short-sea shipping – become more competitive relative to highway transport, and their cost advantage increases. Where significant highway congestion exists, such as in the U.S. Northeast corridor, the distance at which short-sea shipping may be competitive with pure highway traffic may decrease. Consequently, analyzing the relative lengths-of-haul and lane densities of truck traffic moving into and out of various regions of the U.S. with access to coastal ports was the first step in quantifying transportation market prospects for short-sea shipping services that may utilize the ports of Fall River and New Bedford ("Bristol County ports").

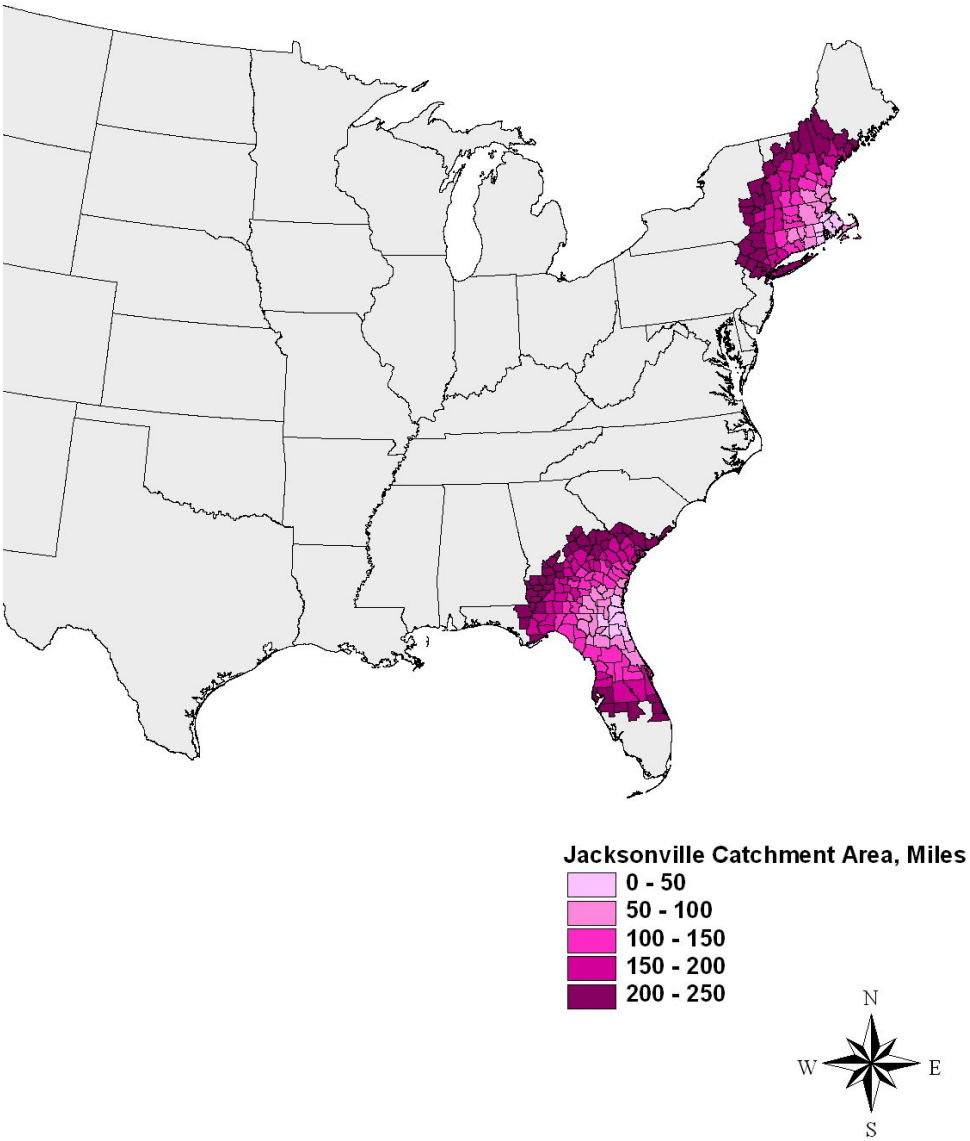
The key potential port partners of the Bristol County ports that were selected to be the focus of the market analysis were the following:

- Bayonne, NJ
- Norfolk, VA
- Wilmington, NC
- Charleston, SC
- Savannah, GA
- Jacksonville, FL
- Port Canaveral, FL
- Tampa, FL
- Pensacola, FL
- Mobile, AL
- New Orleans, LA
- Port Arthur, TX
- Galveston, TX
- Corpus Christi, TX

These ports were selected on an indicative basis only. Other neighboring ports (such as Fernandina Beach, Florida in the case of Jacksonville) that would have essentially the same cargo hinterland may be substituted for the selected port if so desired.

Cargo flows between the respective "hinterlands" of the various port-pairs were identified. The traffic flows were segmented at intervals of 50-miles as shown in the example of Exhibit II-1 below for traffic between the hinterlands of the Bristol County ports and the port of Jacksonville Florida. The analysis of potentially divertible traffic then focused on a "skewed" hinterland to reflect the key assumption that trucks would not backtrack very far to a port in the opposite direction of their desired direction of travel. Consequently, the scope of potentially divertible traffic was restricted to cargo moving between the respective port-pair hinterlands extending only 50-miles in the direction of travel (requiring a backtracking movement) and up to 250-miles in the opposite direction.

Exhibit II-1
Prospective Cargo Hinterlands for Short-Sea Shipping Traffic between Bristol County Ports and the Port of Jacksonville, Florida



Methodology

The purpose of the market-sizing task was to identify the U.S. East and Gulf Coast ports that, as trading partners of the ports of Fall River and New Bedford, may have the greatest potential for diverting current freight traffic from the highways to a short-sea shipping service between the respective port-pairs. Global Insight's TRANSEARCH ® database and ground freight analytical capabilities were used to size the potential short-sea shipping market for Bristol County ports.

TRANSEARCH is a commodity flow database that is produced annually from sample data provided by over 100 public and private data sources that is then subject to rigorous

economic modeling in order to develop an estimate of the total ground freight market on a county to county basis for North America. For this project, the starting point was truck traffic (truckload, private, less-than-truckload, and Canadian/Mexican movements) from the 2003 edition of county-level TRANSEARCH. A detailed description of TRANSEARCH and the methods used to create it is attached as Appendix 1. Traffic flow data from TRANSEARCH was analyzed for each port and its particular drayage hinterland, by direction for northbound and southbound traffic.

The key port-pair partners for the Bristol County ports were matched to corresponding Federal Information Processing Standards (FIPS) county definitions (as shown in Exhibit II-2 below). This geocoding process provided consistent geographic analysis regions for the various source data.

Exhibit II-2
Federal Information Processing Standards (FIPS) County Definitions for Selected Bristol County Port Partners

Port	State	FIPS
Bayonne	NJ	34017
Norfolk	VA	51710
Wilmington	NC	37129
Charleston	SC	45019
Savannah	GA	13051
Jacksonville	FL	12031
Port Canaveral	FL	12009
Tampa	FL	12057
Pensacola	FL	12033
Mobile	AL	1097
New Orleans	LA	22071
Port Arthur	TX	48245
Galveston	TX	48167
Corpus Christi	TX	48355

A sustainable short-sea shipping operation was assumed to provide a less expensive service alternative to other means of transportation, with the understanding that low costs may equate with longer cargo transit times. Reflecting this assumption, unique port catchment areas for a short-sea shipping service were determined using restrictions that take into account the characteristics of a short-sea shipping operation that must compete with the over the road transportation option.

The key assumption behind the determination of cargo hinterlands was that a viable short sea-shipping market may exist when sea/land intermodal transport is significantly cheaper than pure land transport. In our analysis, this was defined using the following criteria: a competitive market may exist when distance by land is greater than distance by sea (including land drayage) *and the unique aspects of sea/land intermodal transport are considered.* As mentioned, ocean transport is typically less expensive than truck transport. This means that, for the same price, goods transported by ship can travel

further than goods transported by truck. To capture these savings, the cost advantage accredited to sea travel is quantified by applying a factor of 0.6 to each port's Ocean Miles (i.e., the estimated transport miles by sea from each port to Bristol County, MA). Sea/land intermodal transportation may also have inherent disadvantages, such as additions to overall transit time due to marine terminal vessel loading and discharge and cargo receiving and delivery operations. In the potential market analysis, this disadvantage is accounted for by adding a 200-mile penalty (approximately four hours of drive time) to the calculated ocean miles for all ports except for Bayonne, which has a unique situation because of the highway congestion surrounding New York City. The application impact of quantifying these unique characteristics is shown in Exhibit II-3, in which Adjusted Ocean Miles are equal to 200 miles + (Ocean Miles × 0.6).

Exhibit II-3
Calculation of Adjusted Ocean Miles

Port	Ocean Miles	Adjusted Ocean Miles
Bayonne	223	134
Norfolk	408	445
Wilmington	644	586
Charleston	710	626
Savannah	784	670
Jacksonville	868	721
Port Canaveral	1,068	841
Tampa	1,477	1,086
Pensacola	1,682	1,209
Mobile	1,716	1,230
New Orleans	1,785	1,271
Port Arthur	1,945	1,367
Galveston	1,947	1,368
Corpus Christi	2,052	1,431

Under these restrictions, a county was included as part of a port's catchment area if the distance by truck to/from Bristol County, MA was greater than the distance of Adjusted Ocean Miles plus drayage distance (miles to/from port to ultimate origin/destination).

For each port catchment area, TRANSEARCH 2003 flow data for truck traffic, including origin, destination, mode, sub-mode, commodity, tons, and units, were extracted at the county level. The multiple layers of detail in the dataset provide the basis for a comprehensive analysis and for data and volume validations at a port-specific level. These extractions yielded a preliminary dataset of over one million records.

Once eligible flows were selected, flows that had a drayage distance of greater than 500-miles were eliminated, meaning if the flow originated or terminated within 500-miles of an eligible port, it was considered traffic available to that port. At this point, a commodity filter at the 2-digit Standard Transportation Commodity Code (STCC) level was applied to remove bulk commodities from the analysis. Specifically, STCCs 10, 11,

13, 14 representing Ores, Coal, Crude Oil, and Minerals were excluded, as those are not commodities likely to move in a short-sea shipping liner service and are likely to travel by water only in large bulk ships. In addition, traffic consisting of empty vehicles (STCC 4221) and secondary traffic (STCC 50) were also removed.

The database at this point contained "eligible flows," representing the traffic that could conceivably be captured by short-sea shipping services if certain other conditions were met. The other conditions, which were not analyzed in this assessment, would include scheduling concerns, transit time, commodity value, and other considerations.

Double-counting between port-pair flows was permitted, meaning one flow may be assigned as "available" to more than one port in the case where port hinterlands may overlap, for example between the ports of Jacksonville and Savannah, Georgia. This enables the comparison of traffic volumes between particular port-pair combinations in order to select those that may offer the greatest market. Of course, the port-pair combinations are not then additive if one were to seek to identify the total market.

A distinction should be drawn between the measurements of domestic truck volumes versus international container shipments. In the case of international traffic, volume is typically measured in Twenty-foot Equivalent Units (TEUs), which correspond to multiples of a standard twenty-foot ISO container. In contrast, domestic traffic is represented in truckloads as would be operated for a given commodity. For dry van traffic, this would typically be either a 48 or 53-foot long trailer. This difference in capacity must be taken into account when ship capacity requirements are examined. The traffic measures included in the market analysis in this report are in “truckloads.”

Findings on the Potential Market

The results of the port-pair traffic flow analysis are provided below in Exhibit II-4. Among the preselected prospective port partners, the largest single potential short-sea shipping market for the Bristol County ports is Bayonne, NJ followed by Jacksonville, FL and Corpus Christi, TX. It is noteworthy that traffic in all of the port-pairs is significantly imbalanced with northbound traffic invariably being the headhaul flow.

Exhibit II-4
Truckload Freight Movements between Bristol County Hinterland and Other Ports

	Southbound	Northbound	Total
Bayonne, NJ	190,342	596,972	787,314
Norfolk, VA	24,409	47,038	71,447
Wilmington, NC	20,909	91,637	112,546
Charleston, SC	41,517	222,536	264,053
Savannah, GA	66,267	218,970	285,237
Jacksonville, FL	140,773	277,086	417,859
Port Canaveral, FL	109,935	160,907	270,842
Tampa, FL	56,677	149,828	206,505
Pensacola, FL	24,711	113,975	138,686
Mobile, AL	70,539	307,285	377,824
New Orleans, LA	53,824	212,519	266,343
Port Arthur, TX	52,059	206,148	258,207
Galveston, TX	94,100	284,813	378,913
Corpus Christi, TX	158,594	258,382	416,976

Source: Global Insight Inc. TRANSEARCH database. See tables in the Appendix for supporting detail.

The TRANSEARCH data was also used to identify the type of commodities moving by truck on the selected Bristol County port-pairs. For example, as shown in Exhibit II-6 below, foodstuffs (no doubt, including large volumes of seafood) are the single largest commodity group moving from the Bristol County hinterland to the Jacksonville area.

Exhibit II-6
Commodities Shipped from Bristol County Hinterland to Jacksonville Hinterland

SOUTHBOUND

Port Name	Jacksonville

Loads	To South					
STCC 2	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
Apparel Or Related Products	56	2	-	338	1,425	1,820
Chemicals Or Allied Products	90	658	1,959	3,385	5,764	11,856
Clay, Concrete,Glass Or Stone	156	1,078	555	1,502	5,957	9,248
Electrical Equipment	276	875	139	203	1,464	2,957
Fabricated Metal Products	712	697	2,870	2,641	4,368	11,288
Farm Products	4	8	4	-	31	47
Food Or Kindred Products	999	2,451	343	5,220	12,712	21,724
Forest Products	-	-	-	-	0	0
Fresh Fish Or Marine Products	-	-	-	-	83	83
Furniture Or Fixtures	20	378	10	82	2,117	2,607
Instrum, Photo Equip, Optical Eq	217	77	171	319	909	1,692
Leather Or Leather Products	64	92	80	146	130	513
Lumber Or Wood Products	3	49	2	500	2,565	3,119
Machinery	264	791	1,158	1,985	5,411	9,609
Misc Manufacturing Products	31	164	108	370	603	1,275
Petroleum Or Coal Products	3,162	11,288	14	2,564	1,099	18,127
Primary Metal Products	847	4,123	1,295	1,513	5,046	12,823
Printed Matter	1,866	584	43	1,821	1,515	5,830
Pulp, Paper Or Allied Products	172	2,286	333	3,121	5,817	11,729
Rubber Or Misc Plastics	965	4,228	2,173	3,626	863	11,855
Textile Mill Products	335	188	120	138	419	1,200
Transportation Equipment	6	49	120	15	1,179	1,368
Grand Total	10,243	30,066	11,497	29,488	59,479	140,773

Source: Global Insight Inc. TRANSEARCH database.

In the reverse “headhaul” direction, chemicals are the major single item moving from the Jacksonville hinterland to the Bristol County hinterland with foodstuffs (including citrus and beef) also accounting for a significant share as shown in Exhibit II-7 below.

Exhibit II-7
Commodities Shipped from Jacksonville Hinterland to Bristol County Hinterland

NORTHBOUND

Port Name	Jacksonville

Loads	To Bristol County					
STCC 2	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
Apparel Or Related Products	1,085	1,051	731	254	3,441	6,563
Chemicals Or Allied Products	10,280	25,752	5,404	15,113	25,253	81,802
Clay, Concrete,Glass Or Stone	12,190	3,187	6,828	32,845	11,687	66,739
Electrical Equipment	238	1,013	583	349	757	2,940
Fabricated Metal Products	404	574	1,038	363	586	2,966
Farm Products	474	597	50	786	1,341	3,247
Food Or Kindred Products	8,043	9,421	3,720	5,531	9,093	35,808
Forest Products	-	-	-	-	6	6
Fresh Fish Or Marine Products	-	-	-	-	0	0
Furniture Or Fixtures	394	1,069	163	482	1,707	3,815
Instrum, Photo Equip, Optical Eq	117	253	317	1,025	220	1,932
Leather Or Leather Products	26	23	41	47	12	149
Lumber Or Wood Products	6,896	2,866	2,013	1,961	643	14,378
Machinery	669	1,978	1,178	1,174	1,393	6,392
Misc Manufacturing Products	117	505	91	24	673	1,410
Petroleum Or Coal Products	25	173	49	45	358	650
Primary Metal Products	562	524	382	439	2,668	4,575
Printed Matter	74	98	762	2,307	2,323	5,565
Pulp, Paper Or Allied Products	1,278	7,232	4,304	3,668	3,519	20,002
Rubber Or Misc Plastics	941	948	623	348	835	3,695
Textile Mill Products	725	1,182	246	168	875	3,196
Tobacco Products	5	-	-	-	-	5
Transportation Equipment	505	2,244	1,926	2,272	4,297	11,243
Waste Or Scrap Materials	-	-	-	-	9	9
Grand Total	45,050	60,690	30,449	69,202	71,695	277,086

Source: Global Insight Inc. TRANSEARCH database.

Given the type of commodities moving in the Bristol County/Jacksonville corridor, it is not surprising that tank and reefer trailers account for a significant share of the trailer loads in addition to the largest equipment type of dry vans as described in Exhibit II-8.

Exhibit II-8
Commodities Shipped from Jacksonville Hinterland to Bristol County Hinterland

SOUTHBOUND

Port Name	Jacksonville

Loads	To South					
Equipment Type	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
Flat	724	2,499	1,623	2,675	6,993	14,513
Dry Van	6,151	16,031	8,274	21,141	44,716	96,313
Tank	2,793	10,817	1,200	3,728	3,092	21,630
Bulk	8	335	5	287	1,345	1,980
Reefer	568	384	395	1,656	3,333	6,336
Grand Total	10,243	30,066	11,497	29,488	59,479	140,773

NORTHBOUND

Port Name	Jacksonville

Loads	To Bristol County					
Equipment Type	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
Flat	8,516	6,645	3,884	22,340	10,030	51,414
Dry Van	26,551	32,019	21,119	29,418	42,612	151,718
Tank	4,165	15,963	3,180	7,662	8,498	39,468
Bulk	1,390	2,046	758	6,622	2,640	13,456
Reefer	4,296	3,912	1,414	3,160	7,907	20,689
Auto	132	106	93	1	8	340
Grand Total	45,050	60,690	30,449	69,202	71,695	277,086

Source: Global Insight Inc. TRANSEARCH database.

Short-Sea Shipping Case Studies

Several recent examples of U.S. short-sea shipping operations were analyzed in order to identify key factors that contributed to their success or failure and their implications for the ports of Fall River and New Bedford. The examples are not intended to be a comprehensive listing of all recent short-sea shipping initiatives but were selected, rather, to reflect a range of type of operations and situations. The results of this analysis that was based on publicly available information as well as interviews with the companies involved are described in the following case studies.

Matson Navigation Company[1]

Background:

- Matson began operations in the U.S. mainland/Hawaii trade in 1882
- Matson has a major share of the U.S./Hawaii shipping market estimated at 70 percent
- Between 1994 and 1999 Matson ran a single surplus 2100 TEU container vessel on a Los Angeles/Seattle/Vancouver/Los Angeles weekly service
- Matson has recently taken delivery of two 2400 TEU U.S.-built container ships at a cost of $110 million each from Kvaerner Philadelphia Shipyard and another two 2400 TEU vessels on order at $140 million each from the same yard

Key Business Parameters:

- Service carried both international cargoes (as feeder vessel), empty containers requiring repositioning, and domestic loads (approximately 30 percent of total containers carried)
- Domestic loads increased from 25,000 to 45,000 annually between 1994 and 1997
- Service was priced at a discount to prevailing truck rates

Status:

- Service was discontinued in 1999 due to poor financial performance

Conclusions:

- Service failed primarily due to high stevedoring costs – ILWU was unwilling to provide concessions to enable the service to be economically viable
- Matson was able to gain a number of key accounts (e.g. Anheuser Busch)
- The service was difficult to sell to traffic managers – "required going further up the management chain"
- Matson was not successful in selling the service to truckers – many saw it as a "threat"

[1] Interview with Phil Grill, Vice President

Totem Ocean Trailer Express (TOTE)[2]

Background:

- Started roll-on/roll-off (RoRo) service between Tacoma, WA and Anchorage, AK in 1975
- Provides two sailings per week on 1,000-mile route
- Competes with AlCan Highway and container vessel and barge operators
- Took delivery of two new U.S.-built 600 trailer capacity RoRo vessels in 2003 at reported cost of $180 million each

Key Business Parameters:

- RoRo vessels complete cargo discharge and load (up to 1,200 trailer moves plus auto traffic) within eight hours at each port
- Primarily transports shipper-owned highway trailers

Status:

- Company has been consistently profitable
- Parent is also majority owner of Sea Star Line in U.S./Puerto Rico trade
- Possibly interested in other U.S. domestic shipping opportunities

Conclusions:

- Company gained strong market position by working closely with truckers and freight forwarders in the Alaska market
- RoRo operation provides truck-competitive transit times and costs for all types of cargo

Osprey Lines[3]

Background:

- Started business in 2000 as spin-off from Maersk's acquisition of Sea-Land in order to provide U.S. flag container feeder operation in the Gulf for mostly international cargoes
- Initially focused on shipping containers on barge between New Orleans and Houston
- Have recently expanded into domestic cargoes in containers – operating *Sea Trader* 13.5 knot 124 FEU containership (converted from an offshore service vessel) on weekly Houston/Tampa/ New Orleans deployment carrying a combination of domestic and international cargoes in containers

Status:

- Kirby Marine recently purchased majority holding in company – Osprey Lines founder has departed to form new company "Couch Lines"

[2] Interview with Bob Magee, CEO
[3] Interview with Rick Couch, CEO

- Couch reports he is currently working on a vessel newbuilding program with U.S. shipyards for four 125 FEU (13.5 knots) containerships and looking to enter new coastal markets on U.S. Gulf and East Coasts

Key Business Parameters:
- Loads/discharges containers in port using boom cranes
- Transported a total of 65,000 containers in 2004 (both international and domestic)

Conclusions:
- Domestic business built on incremental basis on top of international feeder loads
- Marketing focus on heavy and out of gauge cargoes – carry both in containers and as breakbulk
- Osprey seeks to control own terminals and trucking operations
- Sells service reliability and value – sees as more important than transit time
- However, believes still able to offer shippers truck-competitive transit time and significantly better transit time than rail intermodal

New England Fast Ferry[4]

Background:
- Operates passenger ferries (with limited cargo capacity) between New Bedford and Nantucket/Martha's Vineyard
- Subsidiary of Moran Towing
- Considering start-up of New Jersey (e.g. Bayonne)/New Bedford RoRo cargo service with medium speed vessels (catamaran hull design)

Key Business Parameters:
- Value proposition of new service is to provide truckers with overnight bypass of congested New York City/Connecticut area – e.g. depart New Jersey at 8 pm./ arrive New Bedford by 5 am next morning
- Two catamaran vessel designs under consideration
  - 260' RoRo with 24 trailer capacity at estimated capital cost of $25 million
  - 320' RoRo with 42 trailer capacity at estimated capital cost of $30 million
- Estimates economics of port to port move at $350 per trailer – key to holding down cost is using crew to load/discharge trailers

Status:
- Service still in planning stage

Conclusions:
- Looking for "cornerstone" contract with major trucker or truckers to provide base cargo volume
- Prefers New Bedford to Fall River as Massachusetts terminus due to perception of better highway access and terminal capacity at New Bedford (NEFF already operates over New Bedford's State Pier)

[4] Interview with James Barker, VP

- Proposed service offers opportunity for short-sea shipping start-up within relatively short term (2-3 years) if vessels are newbuilds in U.S. shipyard
- Service could build credibility with truckers before expanding into longer haul markets
- Question whether service economics can be achieved with small size of vessels – vessel with 150-trailer capacity may be able to operate at $300-350 per trailer load; smaller vessels may lack scale necessary to offset high fuel costs

Trailer Bridge[5]

Background:

- Runs both RoRo and LoLo container barges between U.S. mainland (New York and Jacksonville) and Puerto Rico
- Operated "Atlantic Highway" container barge service between Port Newark and Jacksonville from January to September, 1999 – service was terminated when hurricane delayed barge by four days leading to the loss of a major account (ToysRUs)

Key Business Parameters:

- Cargo on New York/Jacksonville service was entirely domestic
- Weekly capacity: 265 53' containers
- Major source of cargo was diversion from rail intermodal
- Pricing per container load was around $500
- New York/Jacksonville transit time was three days – comparable with rail intermodal but slower than truck
- Major southbound shippers included GM for cars relayed through Jacksonville to Puerto Rico
- Major northbound shippers included forest product shippers (packaging materials, lumber, and pulp)

Status:

- Service discontinued – no plans to restart

Conclusions:

- Service was sold primarily on price
- Relatively slow transit time was not a major disadvantage to a shipper such as Toys RUS but unreliability was
- Operating out of Port Newark added cost despite a "reasonable" deal with the ILA

The case studies lead to a number of important overall findings on the current state of short-sea shipping in the United States:

- Despite a number of recent efforts, domestic sort-sea shipping operations on the U.S. coasts have had only moderate success to date (e.g. Osprey Lines)
- Nevertheless, a number of major shippers have elected to support short-sea shipping services (e.g. ToysRUs, Anheuser Busch, General Motors)

[5] Interview with John McCown, CEO

- Osprey appears to have benefited from a dual marketing focus on selling domestic transportation to both shippers and truckers
- Truckers may be interested in the overall value proposition of adding short-sea shipping as an alternative mode, but they need to have the potential benefits clearly spelled out
- Close cooperation with trucking companies is essential in successfully developing and operating a short-sea service – a key asset is building base cargo support through commitments from major truckers on a particular route
- Schedule reliability may be at least as important a service factor in effectively marketing the service as door-to-door transit time
- Labor buy-in is critical to creating a cost-competitive short-sea service in terms of both vessel and marine terminal operations
- Short-sea shipping can be particularly competitive for heavy and/or hazardous shipments currently moving over the road such as chemicals
- Service frequency needs to be at least 2-3 sailings per week on relatively long haul routes – daily is probably not necessary except on short-haul routes (e.g. Bayonne/Bristol County)

In conclusion, there appear to be a number of factors that promote the emergence of a U.S. domestic coastal short-sea shipping network including increasing highway congestion (particularly in the Northeast), rising fuel costs, restrictions on truck driver hours of operation, and a shortage of drivers. In addition, there is a great deal of truck cargo moving to and from the Bristol County port hinterland along the Eastern seaboard, some of which may potentially be divertible to short-sea shipping services. However, despite the positive signs of a market opportunity, there is scant evidence of successful business plans being put in place to meet that market need. As both the Matson and Trailer Bridge attempts to put a short-sea service in place failed for economic reasons – primarily due to high costs – the next section of this report will analyze the economics of short-sea shipping, particularly as they relate to potential services utilizing the ports of Fall River and/or New Bedford.

The Economics of Short-Sea Shipping versus Alternative Modes

The market analysis of trucking movements into and out of the Bristol County ports' hinterland indicated that the prospective port partners of Bayonne, NJ and Jacksonville, FL had substantial potentially divertible traffic volumes. Consequently, an economic model was developed to calculate the cost to the shipper of moving a trailer load of freight on each of these corridors using a short-sea mode versus over the road trucking or rail intermodal where appropriate.

The economics of a short-sea shipping service include both direct vessel operating costs, capital costs, and other costs associated with the movement of a trailer-load of freight. Direct vessel operating costs include vessel manning, maintenance and repair, insurance (Hull & Machinery and P&I), capital, and vessel management costs, fuel and consumables, and port charges. These costs were developed based on information developed from ocean carrier and port operator interviews, and general industry knowledge of the project team.

Non-vessel operating costs for the short-sea shipping service include stevedoring and marine terminal operations, container, trailer, and chassis leasing and maintenance, drayage operations, and sales and general administrative overhead. These were developed from carrier and port operator interviews and the professional experience of the project team. In addition, the cost to shippers of Harbor Maintenance Tax (HMT) charged on shipments moving in and out of U.S. ports was also added as a line item in the model for short-sea shipping operations as would be applicable under the current U.S. tax regime.

The key assumptions concerning vessel operations for ships to be deployed on the short haul Bayonne potential service and the long haul Jacksonville service are summarized in the following Exhibit II-9.

Exhibit II-9
Key Assumptions on Potential Short-Sea Service Vessels

Vessel Operating Costs for Coastal Vessels

	Container Ship	**RoRo Vessel**	**RoRo Ferry**
Cargo capacity	200 Trailers	140 Trailers	40 Trailers
Key assumptions:			
Capital cost:	$38 million	$44 million	$30 million
Vessel speed:	25 knots	25 knots	20 knots
Fuel consumption:	30 TPD	30 TPD	4,300 gals MDO
Crew size:	10	10	8
Vessel expense per day			
Crew	$6,500	$6,500	$3,500
Maintenance & Repair	$875	$875	$700
Consumables	$600	$600	$250
Insurance & Other	$625	$625	$400
	$8,600	$8,600	$4,850
Depreciation	$4,164	$4,822	$3,288
Total	**$12,764**	**$13,422**	**$8,138**

*Assumes 25 years vessel life

The economics of the short-sea shipping option used in the transportation model are based on a theoretical level of costs that reflect some significant changes in current working practices that would need to be instituted by industry, labor, and government specifically for short-sea shipping but that are nevertheless reasonably achievable in the near term. The key areas for which such theoretical cost levels were used include vessel capital costs, vessel crew costs and manning levels, and port stevedoring costs. Although these cost levels are lower than those for most current Jones Act shipping operations, they should be attainable based on an analysis of current "best in class" industry practices within the U.S. today and U.S. and international benchmarks.

The following are the key assumptions made concerning the operations and costs for a prospective short-sea shipping service:

- Both RoRo trailer vessels and LoLo container vessels were tested for the long haul Jacksonville service but only a RoRo vessel was evaluated for the short haul Bayonne service given the relatively short steaming distance (less than 200-miles) and the consequent premium put on minimizing port time both for expediting vessel turnaround and cargo despatch
- Crew sizes of 10 for the larger container and RoRo vessels and 8 for the smaller RoRo vessel were based on the assumption that new manning agreements with the seafarer unions and the Coast Guard would be developed for a two-watch system for self-propelled vessels operating along the contiguous coasts of the U.S.
- Marine terminal loading and discharging costs are on an "all-in basis" and reflect current best practices that would require labor agreements specially designed for coastal short-sea shipping
- An average vessel operating speed of 25 knots was used for the Jacksonville service and 20 knots for the Bayonne service – this relatively high speed for conventional RoRo or container vessels on the Jacksonville service was deemed necessary to provide a "truck-competitive" transit time
- The vessel capital costs used are lower than current prices from U.S. shipyards but still substantially higher than international prices – the lower U.S. prices reflect the assumption that long vessel-building runs, more aggressive purchasing practices, and improved productivity by U.S. shipyards would bring down the cost of U.S.-built vessels

Similarly, the cost of trucking and rail intermodal operations on the respective Bayonne and Jacksonville corridors were also developed. For a truck operator, fully allocated cost data provided by a major motor carrier was used as the starting point in developing the truck economics. Truck operations were based on a single driver operating within current hours of service (HOS) restrictions. Future road congestion was not addressed – service and cost parameters are reflected as "current steady state". Additional highway cost data was developed using the TTS Blue Book of Trucking Companies (2004-2005 Edition) and allowed for the disaggregation of wages and benefits, equipment, insurance, fuel and other expenses. Global Insight's Intermodal Cost Analysis Model (ICAM) was used to prepare estimates of the rail intermodal door-to-door delivery costs for each of the pilot project corridors.

The key cost elements for motor carriers include pick-up and delivery, over the road vehicle operations, fuel, driver costs, dispatching, insurance, as well as other factors that would be directly affected by the choice of transport mode between the origin and destination markets in the particular lanes. Highway tolls are reflected as a separate cost item in the model, and are estimated based on average toll costs per mile and average toll miles adjusted for specific corridors. Sales and administrative overhead are also included. Source information was developed from public data, carrier interviews, and general industry knowledge of the project team.

Rail intermodal direct operating cost elements include locomotives and fuel, track and right-of-way, yard and terminal operations, lift-on and lift-off movements, railcar, crew, trailer/container, and drayage expense. Sales and administrative overhead are also included.

Again, this information was developed from public data, carrier interviews, and general industry knowledge of the project team.

The cost of repositioning trailers or containers in a particular corridor was also built into the model for each mode. Trucking and rail intermodal operations have an advantage in this area as they have greater latitude to search for return loads than the short-sea service that was assumed to be tied to a particular port-pair. In this case, the short-sea service was charged with the cost of vessel loading and discharging for all empty trailers/containers in the backhaul direction of each particular corridor.

A short-sea shipping carrier's cost of moving a trailer load of freight between Bristol County, MA and Jacksonville was calculated at approximately $1,100, as described in Exhibit II-10 below.

Exhibit II-10
Short-Sea Shipping Costs Between Bristol County and Jacksonville, Florida

US Coastal Liner Shipping Service Economic Model	Jacksonville/Bristol County				Jacksonville/Bristol County			
Origin:	**Jacksonville, FL**				**Jacksonville, FL**			
Destination:	**Bristol County, MA**				**Bristol County, MA**			
Ocean Transit (Nautical Miles):	993.00				993.00			
Vessel type:	**RoRo**				**Container**			
Vessel speed: (Knots)	25				25			
One Way Steaming Time (Hours)	40.0				40.0			
Frequency in R/T voyages per week:	3.00				3.00			
No. R/T voyages per year:	144				144			
R/T Ocean Transit Days:	3.50				3.50			
TTL Terminal Days:	1.50				1.50			
Total Ship Days	5.00				5.00			
TTL Drayage Days	2.00				2.00			
Total Container Days	7.00				7.00			
Total Volume of Lane Traffic (Truckloads):	**Truckloads**				**Truckloads**			
Northbound:	277,000				277,000			
Southbound:	141,000				141,000			
Share of Total Lane Traffic:	**Base**	**Freq. Adj**	**Net Share**		**Base**	**Freq. Adj**	**Net Share**	
Northbound:	7%	100%	7%		10.0%	100%	10.0%	
Southbound:	8%	100%	8%		11%	100%	11%	
Vessel Capacity (truckloads):	140				200			
NB capacity payload utilization:	96.2%				96.2%			
SB capacity payload utilization:	56.0%				53.9%			
	Per Unit	**Per Voyage**	**Per Year**	**Percent**	**Per Unit**	**Per Voyage**	**Per Year**	**Percent**
Freight Volumes (truckloads)								
Northbound Loads		135	19,390	50%		192	27,700	50%
Northbound Empties		-	-	0%		-	-	0%
Southbound Loads		78	11,280	29%		108	15,510	28%
Southbound Empties		56	8,110	21%		85	12,190	22%
Total Volumes		**269**	**38,780**	**100%**		**385**	**55,400**	**100%**
Service Economics								
Variable Costs								
Marine Terminal Cargo-Handling								
RoRo cost per unit (load & discharge): $100	$ 120	$ 32,317	$ 4,653,600		$ -	$ -	$ -	
LoLo cost per unit (load & discharge): $200	$ -	$ -			$ 200	$ 76,944	$ 11,080,000	
Mean terminal cargo handling cost per load	$ 152				$ 256			
Land Transportation								
Origin Dray	$ 193	$ 41,141	$ 5,924,290		$ 193	$ 57,962	$ 8,346,547	
Destination Dray	$ 228	$ 48,455	$ 6,977,549		$ 228	$ 68,267	$ 9,830,450	
Long haul drays	$ 70	$ 3,739	$ 538,374		$ 70	$ 5,267	$ 758,498	
Mean Truck Dray Expense	$ 438	$ 93,335	$ 13,440,213		$ 438	$ 131,496	$ 18,935,495	
Equipment Costs								
Container/Trailer	$51	$ 10,862	$ 1,564,170		$ 53	$ 15,904	$ 2,290,130	
Chassis	$ -	$ -	$ -		$ 18	$ 5,386	$ 775,600	
Mean Equipment Costs	$ 51	$ 10,862	$ 1,564,170		$ 71	$ 21,290	$ 3,065,730	
Total Variable Costs	**$ 641**	**$ 136,514**	**$ 19,657,983**		**$ 766**	**$ 229,731**	**$ 33,081,225**	
Fixed Costs								
Vessel	$ 315	$ 67,110	$ 9,663,840	28%	$ 213	$ 63,820	$ 9,190,080	20%
Vessel fuel*	$ 89	$ 18,900	$ 2,721,600	8%	$ 63	$ 18,900	$ 2,721,600	6%
Port Charges	$ 19	$ 4,000	$ 576,000	2%	$ 13	$ 4,000	$ 576,000	1%
Sales & Administration	$ 38	$ 8,000	$ 1,152,000	3%	$ 27	$ 8,000	$ 1,152,000	2%
Non-Vessel Depreciation	$ 5	$ 1,000	$ 144,000	0%	$ 3	$ 1,000	$ 144,000	0%
Total Fixed Costs	**$ 465**	**$ 99,010**	**$ 14,257,440**	**42%**	**$ 319**	**$ 95,720**	**$ 13,783,680**	**29%**
Total Operating Expenses	**$ 1,106**	**$ 235,524**	**$ 33,915,423**	**100%**	**$ 1,085**	**$ 325,451**	**$ 46,864,905**	**100%**
Operating Expense per Revenue Load:		**$ 1,106**				**$ 1,085**		

Operating Statistics	Jacksonville/Bristol County	Jacksonville/Bristol County
Number of Ships	2.00	2.00
Door-to-Door Transit (days)	6.00	6.00
Vessel Turns per Week	1.40	1.40

The cost of moving a trailer load of freight between Bristol County, MA and Northern New Jersey by short-sea shipping service was calculated at over $500 per trailer for a 40-trailer RoRo vessel and at around $260 for a 140-trailer RoRo vessel, similar to that tested for the Jacksonville run. The significant difference in the costs per trailer is due to the much greater scale economies that the larger vessel is able to achieve as well as its substantially greater fuel efficiency per unit of cargo. Given the volume of truck cargo moving in the Bayonne/Bristol County hinterlands corridor, the larger vessel would require a penetration rate of 7 percent of the total market versus 2 to 3.5 percent for the smaller vessel to achieve its projected cost per load as described in Exhibit II-11 below.

Exhibit II-11
Short-Sea Shipping Costs Between Bristol County and Bayonne, NJ

US Coastal Liner Shipping Service Economic Model	Bayonne, NJ/Bristol County Ocean Service Only				Bayonne, NJ/Bristol Larger Ship (140 Trailers)			
Origin:	**Bayonne, NJ**				**Bayonne, NJ**			
Destination:	**Bristol County, MA**				**Bristol County, MA**			
Ocean Transit (Nautical Miles):	178.00				178.00			
Vessel type:	RoRo				RoRo			
Vessel speed: (Knots)	21				21			
One Way Steaming Time (Hours)	8.5				8.5			
Frequency in R/T voyages per week:	7.00				7.00			
No. R/T voyages per year:	350				350			
R/T Ocean Transit Days:	0.70				0.70			
TTL Terminal Days:	0.30				0.30			
Total Ship Days	1.00				1.00			
TTL Drayage Days	2.00				2.00			
Total Container Days	3.00				3.00			
Total Volume of Lane Traffic (Truckloads):	**Truckloads**				**Truckloads**			
Northbound:	597,000				597,000			
Southbound:	190,000				190,000			
Share of Total Lane Traffic:	**Base**	**Freq. Adj**	**Net Share**		**Base**	**Freq. Adj**	**Net Share**	
Northbound:	2.0%	100%	2.0%		7.0%	100%	7.0%	
Southbound:	3.5%	100%	3.5%		7.0%	100%	7.0%	
Vessel Capacity (truckloads):	40				140			
NB capacity payload utilization:	85.3%				85.3%			
SB capacity payload utilization:	47.5%				27.1%			
	Per Unit	**Per Voyage**	**Per Year**	**Percent**	**Per Unit**	**Per Voyage**	**Per Year**	**Percent**
Freight Volumes (truckloads)								
Northbound Loads		34	11,940	64%		119	41,790	50%
Northbound Empties		-	-	0%		-	-	0%
Southbound Loads		19	6,650	36%		38	13,300	16%
Southbound Empties		-	-	0%		-	28,490	34%
Total Volumes		**53**	**18,590**	**100%**		**157**	**83,580**	**100%**
Service Economics								
Variable Costs								
Marine Terminal Cargo-Handling								
RoRo cost per unit (load & discharge): $100	$ 100	$ 5,311	$ 1,859,000		$ 100	$ 15,740	$ 5,509,000	
LoLo cost per unit (load & discharge): $200	$ -	$ -	$ -		$ -	$ -	$ -	
Mean terminal cargo handling cost per load	$ 100				$ 100			
Land Transportation								
Origin Dray		$ -	$ -		$ -	$ -	$ -	
Destination Dray		$ -	$ -		$ -	$ -	$ -	
Long haul drays		$ -	$ -		$ -	$ -	$ -	
Mean Truck Dray Expense	$ -	$ -	$ -		$ -	$ -	$ -	
Equipment Costs								
Container/Trailer	$ -	$ -	$ -		$ -	$ -	$ -	
Chassis	$ -	$ -	$ -		$ -	$ -	$ -	
Mean Equipment Costs	$ -	$ -	$ -		$ -	$ -	$ -	
Total Variable Costs	**$ 100**	**$ 5,311**	**$ 1,859,000**		**$ 100**	**$ 15,740**	**$ 5,509,000**	
Fixed Costs								
Vessel	$ 153	$ 8,138	$ 350	0%	$ 85	$ 13,422	$ 350	0%
Vessel fuel*	$ 154	$ 8,170	$ 2,859,500	41%	$ 25	$ 4,000	$ 1,400,000	15%
Port Charges	$ 19	$ 1,000	$ 350,000	5%	$ 10	$ 1,500	$ 525,000	6%
Sales & Administration	$ 94	$ 5,000	$ 1,750,000	25%	$ 32	$ 5,000	$ 1,750,000	19%
Non-Vessel Depreciation	$ 6	$ 300	$ 105,000	2%	$ 4	$ 600	$ 210,000	2%
Total Fixed Costs	**$ 426**	**$ 22,608**	**$ 5,064,850**	**73%**	**$ 156**	**$ 24,522**	**$ 3,885,350**	**41%**
Total Operating Expenses	**$ 526**	**$ 27,919**	**$ 6,923,850**	**100%**	**$ 256**	**$ 40,262**	**$ 9,394,350**	**100%**
Operating Expense per Revenue Load:		**$ 526**				**$ 256**		

Operating Statistics	Bayonne, NJ/Bristol County Ocean Service Only	Bayonne, NJ/Bristol County Full Service
Number of Ships	1.00	1.00
Door-to-Door Transit (days)	0.50	2.00
Vessel Turns per Week	7.00	7.00

In addition to the carrier's costs for the respective modes on each corridor, the total cost for moving a trailer-load of freight on the particular corridor that would be incurred by the shipper of that freight was also calculated. The cost to the shipper would include any "mark-up" or profit margin that the carrier would add to its costs as well as the incremental inventory carrying costs caused by the slower transit times of the rail intermodal and short-sea shipping service options versus trucking. In addition, Harbor Maintenance Tax (HMT) would apply to only the short-sea option. Carrier mark-ups were estimated based on current practices and conditions in the U.S. domestic freight markets for each of the modes.

As shown in Exhibit II-12 below, the short-sea shipping option on the Bristol County/Jacksonville Corridor is projected to achieve a significant cost advantage against both the truck and rail intermodal options, although with a longer transit time.[6]

Exhibit II-12
Comparative Performance of Short-Sea Shipping versus Alternative Modes on the Bristol County/Jacksonville Corridor

	Truck	Rail Intermodal	Short-Sea Shipping
Total miles (door to door)	1,183	1,340	1,342
Transit hours (door to door)	54.5	66.5	72.0
Carrier cost per highway mile	$1.59	$1.04	$0.90
Shipper cost per highway mile	$1.73	$1.26	$1.02
Differential versus Truck	--	-27%	-41%

In the case of the short haul Bayonne/Bristol County corridor, rail intermodal was not considered to be a viable option from a service viewpoint, so the service options were restricted to truck and short-sea shipping. A distance of 498 miles was used for the truck movement in order to represent traffic moving between the two port hinterlands, not simply between the ports. The impact of Harbor Maintenance Tax (HMT), an ad valorem duty, is immediately apparent when the short-sea costs for the Bayonne corridor are compared to truck as shown in Exhibit II-13 below. The cost advantage for short-sea service is increased from 17 percent to 31 percent with the simple exclusion of HMT.

[6] Details behind these calculations are included in Appendix VI-3.

Exhibit II-13
Comparative Performance of Short-Sea Shipping versus Alternative Modes on the Bristol County/Bayonne Corridor

	Truck	Short-Sea Shipping
Total miles (door to door)	498	558
Transit hours (door to door)	12	17.5
Carrier cost per highway mile	$1.49	$1.17
Shipper cost per highway mile	$1.62	$1.35
Shipper cost per highway mile (without HMT)	$1.62	$1.11
Differential versus Truck (with HMT)	--	-17%
Differential versus Truck (without HMT)	--	-31%

The results of the economic analysis demonstrate that short-sea shipping can be extremely competitive with other transportation options on key corridors into and out of the Bristol County ports' hinterland if certain key assumptions on vessel, crew, and stevedoring costs are met. This competitiveness is further enhanced by the waiving of HMT.

In order to further evaluate the commercial feasibility of short-sea shipping operations using the Bristol County ports, the competitiveness of short sea shipping economics and service levels versus alternative modes were tested in a number of interviews with prospective users. The results of this market research are described in the following chapter.

III. Market Feedback on Short-Sea Shipping Services over Bristol County Ports

Interviews were conducted in person and by phone with a total of seventeen prospective users of short-sea shipping services through the Bristol County ports that are described in Exhibit III-1. The interviewees consisted of twelve ground carriers (primarily truckers) and five shippers. The outline of the questionnaire as followed is included in Appendix VI-4. The output from the interviews is summarized in Exhibit III-2 (3 pages).

The following are the principal findings obtained from the interviews:

- All of the carriers interviewed, but only one of the shippers, professed some familiarity with short-sea shipping as a potential mode of transportation – a number of the carriers mentioned that they had been approached within the past year by groups looking for carrier support for a potential short-sea service start-up
- The potential level of possible support for a short-sea service over the ports of Bristol County varied widely – from a possible 150 trailer loads a day out of the Raritan Industrial Center (Raritan Central Railway) on the Bayonne/Bristol County overnight shuttle to a few trailers a week. In aggregate, however, the potential level of support based on this relatively small sample was very strong.
- In terms of the key requirements that a short-sea service must have in order to be considered a viable transportation option, the most frequently cited were the following:
  - Fast transit and reliable scheduling
  - Competitive price
  - Seamless service – "just like trucking…no port hang-ups"
- In probing on the issue of transit time for a short-sea service, the responses varied significantly
  - LTL operators tended to think that the multiple stages in a short-sea intermodal movement would not enable them to provide the "next day" delivery that their customers required, particularly on a regional basis
  - TL operators were less concerned over short-sea being able to match trucking transit times but required absolute schedule reliability and a competitive price – they tended to see short-sea as another intermodal option
  - The quoted transit times for both the Bayonne and Jacksonville short-sea prospective operations (10 hours port to port for Bayonne, 50 hours for Jacksonville) were generally acceptable to TL operators and most shippers
- Respondents' chief concerns varied widely
  - One carrier (US Express) that is well-informed on short-sea shipping felt that Jacksonville was not a good southern port partner and that Wilmington, NC or Norfolk, VA were better situated to service large volumes of truck freight from the Southeast, particularly Atlanta

Exhibit III-1
Commercial Feasibility of Short-Sea Shipping Interviewees

Ground Carriers

Company	Location	Person	Position	Phone
US Express Truckload operator	4080 Jenkins Road Chattanooga, TN 37421	Craig Fuller	President, Xpress Global Systems	(817) 829-5098
J.B. Hunt Truckload operator	615 J.B. Hunt Corporate Drv. Lowell, Arkansas 72745	Paul Bergant	EVP	(800) 643-3622
Schneider National Truckload & intermodal operator	3101 South Packerland Drive Green Bay, WI 54306	Brian Bowers	VP & GM of Intermodal Services	(920) 592-3584
Swift Transportation Co. Truckload operator	HQ in Phoenix, AZ	Mark Martin	EVP - East Coast	(602) 269-9700 ext. 17523
Wyatt Transfer Truckload operator	3035 Bells Road Richmond, VA 23234	Chick Rosemond	VP Sales	(804) 389-7299
Southeastern Freight Lines Primarily LTL operator	420 Davega Road Lexington, SC 29073	Bob Bullock	VP International Business & Partnerships	(704) 597-9828
Trimac Truckload bulk carrier	3663 N. Sam Houston Pkwy. Houston, TX 77032	David Perry	VP Business Development	(285) 981-0000
New England Motor Freight Regional LTL/TL carrier	1-71 North Avenue East Elizabeth, NJ 07201	John Karlberg	President & COO	(570) 386-4876
Werner Enterprises Truckload operator	14507 Frontier Road Omaha, NE 68138	Steve Phillips	SVP - Van Division	(800) 228-2240
DiSilva Transportation TL Specialist in Grocery Prod.	50 Middlesex Avenue Somerville, MA 02415	Tom DiSilva	CEO	(781) 229-6380
Heartland Express Regional TL operator	2777 Heartland Drive Coralville, IO 52241	Rich Meehan	VP Operations & Marketing	(800) 451-4621
Raritan Central Railway Short line RR & Warehouse operator	One Gateway Center Newton, MA 02458	Eyal Shapira	President	(617) 243-0137

Exhibit III-1
Commercial Feasibility of Short-Sea Shipping Interviewees

Shippers

Company	Location	Person	Position	Phone
Quaker Fabric	1082 Davoll Street	Mark Helwig	Supply Chain Manager	(508) 678-1951
Uphostlery fabric	Fall River, MA 02721			
Lightolier	631 Airport Road	Bill Torrens		(508) 679-8131
Lighting fixtures	Fall River, MA 02720	Bill Poole	Traffic Manager	(860) 886-2621
Titleist	333 Bridge Street	Jim Day	Footjoy Traffic Manager	(508) 979-2000
Golf equipment	Fairhaven, MA 02719			
Maritime International	276 MacArthur Drive	Pierre Bernier	Manager Shipping Ops	508 996-8500
Seafood	New Bedford, MA 02740		and Logistics	ext. 233
Weyerhaeuser	Federal Way, WA 98063	Craig Lawrence	CEO Westwood Shipping	(253) 924-4349
Forest Products		Mike Ocepek	Logistics Planner	

Exhibit III-2
Summary of Results from Market Research
Ground Carriers

Company	Familiarity with SSS	Volume of Potential Traffic	Key Requirements	Chief Concerns	Interest in Short-Haul Service	Interest in Long-Haul Service	Key Success Factors	Perceptions of Fall River/New Bedford
US Express TL operator	High	Most traffic from Wilmington NC/ Norfolk area to NE	Seamless service Excellent systems to track/manage freight	Jax may not be best southern port-does not serve Atlanta well	Very high-price is competitive, particularly on NB headhaul Maybe stop in Long Island	Also very high, although prefer service from NC or VA-weekly service with Friday NB departure would work	"Freight doesn't care about mode" - just make it work and SSS will succeed	No views
Swift Transportation Largest US TL operator (18,500 trucks)	High	Will not disclose	Most hauls less than 600 miles	Question feasibility "intermodal doesn't work well with short legs"	Low - too many handoffs	Low - don't have much longhaul freight	Focus on longer haul lanes-"intermodal doesn't work well with short legs"	No views
Wyatt Transfer Long distance TL operator	High	Low	Minimize trailer dwell time in port	Longer transit time with SSS	Low - sees cost about same	Higher - SSS cost is comp.	Make cost competitive	No views - thinks SSS will happen due to hwy congestion
Southeastern Freight Lines Primarily LTL operator with some TL as backhauls	High	Low Mostly shorthaul and limited in Atlantic corridor	Depends on customer requirements	Most of their traffic is LTL	Might work - need to minimize dray cost and time	Limited - little traffic with New England	Makes sense in NE due to congestion	No views
Raritan Central Railway Short line RR and warehouse/terminal operator	High	Possibly 150 TL's per day from Raritan Industrial Center	Reliable service Right economics	Availability of right vessels in Jones Act fleet	Very high-sees opportunity to cross-dock from NJ DC's to trailers run on overnight vessel SSS cost is comp. Working with truckers on concept	Medium-little freight in this lane Cost and transit time appear to be competitive Truck transit is 3 days and cost at $1.50/mile Rail intermodal cost is $1700 per TL	Need to get major truckers involved Deliver service at cost as estimated	Prefers FR location to NB - closer to NY and "less political" Has 10 acres site in Raritan for potential SSS terminal - next to Raritan Industrial Center
Werner Enterprises Truckload operator	Some familiarity	9,000 trucks Active in Atlantic corridor Started intermodal in 2004	Customer's needs for both transit time & reliability	Reliability is key - more important than transit time	Medium - price is in ballpark but does not offer major advantage	Higher - price is competitive Transit time is okay	"Absolute dependability" - then price advantage	No views
New England Motor Freight Regional LTL/TL carrier	Some familiarity	5 TLs/day in NE/Jax lane 40 TLs/night in NE/NY lane	Fast transit and absolute reliability necessary for LTL business	SSS may be most suitable for TL business, not LTL	Low-SSS cost is too high. NEMF does Pawtucket/ Plainfield NJ for $300/TL door to door Long Island service of more interest	Higher-cost and transit time are competitive Likes Jax as port-serve Puerto Rico	Focus on TL sector	No views
Heartland Express Short to medium haul TL carrier	Medium Feasible concept-depends on shipper's transit time requirements	86% freight is JIT - 30% volume is foodstuffs	Transit time	Driver shortage going to get worse	Low - likely to cost more	"Looks good on paper but may not work in practice" - concern about ILA slowing transit	Truck (single driver) costs need to rise by over 50% (from $1.45 per mile to $2.25) Mimimize port time Prove service reliability	No views

Exhibit III-2
Summary of Results from Market Research
Ground Carriers (continued)

DiSilva Transportation TL Grocery Specialist	High	25-30 trucks/ day to NY metro	Economics need to work	Increasing delays in CT and NY area	High-"very attractive" SSS cost and overnight transit are competitive	Lower-little freight in this lane Cost and transit time appear to be competitive Truck transit is 3 days and cost at $1.50/mile	Key is to be able to deliver service at costs as estimated	Both ports have good locations-fit well into current truck movements
Trimac Truckload bulk carrier	Very familiar	"Very active" along Eastern seaboard-currently not using intermodal	Competitive price and fast relaible transit	Increasing driver shortage Also concern that hazmat regs	Moderate-transit time okay but SSS price needs to be lower at $250-$300	No interest-very little chemical traffic from Jax hinterland	ISO containers may work for chemical traffic by SSS	No views
J.B. Hunt National truckload operator	Very familiar	High volumes of traffic along Eastern seaboard-currently major user of intermodal	Traffic density - ability to schedule and cost Consistency of service	Driver shortage Highway congestion - particularly on I-95	Pending review	Pending review	Motor carrier should play key role	No views

Exhibit III-2
Summary of Results from Market Research
Shippers

Company	Familiarity with SSS	Volume of Potential Traffic	Key Requirements	Chief Concerns	Interest in Short-Haul Svc	Interest in Long-Haul Svc	Key Success Factors	Perceptions of Fall River/New Bedford
Quaker Fabric Uphostelry fabric	Not familiar	Inbound: 10 TLs/wk from NC Outbound: Aprox same volume but consignee-controlled	Need service frequency 2-3/wk	Driver shortage Increasing hwy congestion	Limited interest-not much freight in the lane	High - but thinks Wilmington NC would be best port Price at $2200 roundtrip very competitive	Service must be door to door - sold by truckers	Prefers FR-good access from 195 and 24 Although NB a little further away, not a big difference
Lightolier Lighting fixtures	Not very	3-4 TLs/wk from CT to Fall River 90% of outbound from FR is LTL	Fast transit Safe handling Reliable service	Ocean may not be fast enough SSS does not fit well with LTL - too many handoffs	Cost sounds okay	Cost sounds okay Jax could serve all Florida	Ocean transits competitive with truck-adding any significant port time will kill competitiveness	Not sure ports have enough capacity
Maritime International Seafood processor Cold storage operator	Moderate	Ship total of 100 TLs/wk ex NB to all destinations ~5 TLs/day to NY ~1 TL/week to Fla	Need to make service operate just like trucking	Additional steps in process Costs of Jones Act vessels-need "proper vessel", not barge	High interest-use for Port Newark exports Useful for over-weight conts. Price okay-paying $800 NB and $550 SB	Also interested-price should work for drays up to 200 miles Service frequency of 3/wk is okay Good service for overweight TLs Jax is "good choice"	Get ships and port ops to function at competitive cost level	Either port okay Interested in participating in developing business-possibly in staging cargo or terminal ops
Weyerhaeuser Forest products	High - just implemented Canada/USWC short-sea service	Large vols lumber, pulp ex New Bern NC Also large vols lumber ex Valdosta GA Total traffic to NE region in area of 25-40 TLs per week	Match current intermodal service Service frequency of weekly for longhaul is okay	Lot of traffic controlled by major retailers (eg Home Depot)-need to integrate consol/ deconcolidation in service product	No real interest Not much traffic in this lane	Would consider-currently using rail intermodal and rates "not good" SSS price is very competitive Transit time is acceptable	Get major retailers to support-possibly by providing logistics services in addition to basic transportation	No views
Titleist Sports equipment	Not familiar	Inbound shipments are containerloads via Port Newark-ocean carriers arrange ground transport (18 TEU/wk)	Must be competitive with current service	All outbound shipments are LTL or parcel service-SSS may not be fast enough	No real interest	No real interest	Get ocean carriers to use from Port Newark	NB is convenient location

  - A number of interviewees believed that short-sea shipping services over Bristol County ports would be an important remedy to increasing road congestion in the New York and Connecticut metropolitan areas

- Although several of the carriers interviewed (primarily TL operators) voiced a strong interest in the Bayonne short haul service option, only one of the shippers (Maritime International, a seafood shipper) indicated a strong level of interest
  - Concerns over price competitiveness of the short-sea service (quoted at $300-$350 per trailer port to port) indicates that the service needs to be at the lower end of this range to be competitive with overnight truck prices
  - Late cut-offs and early deliveries will be important to make the short-sea service competitive – e.g. take deliveries up to 7pm in Bayonne, sail vessel at 8pm, arrive Bristol County at 5-6 am, commence deliveries at 7am
- For those with significant volumes of freight moving in the long haul Eastern seaboard truck market, the general feeling was that the economics of a Bristol County/Jacksonville short-sea service were very good ($1200 on a port to port basis)
- While daily frequency was considered necessary to be a credible player in the Bayonne short haul market, a frequency of 2 to 3 sailings a week was considered adequate in the long haul Jacksonville lane and two respondents (US Express and Weyerhaeuser) believed that one sailing per week, departing the South on a Friday evening in the headhaul direction, would be sufficient
- In terms of key success factors, several respondents noted that the service should be sold by truckers – that it was important to get the truckers involved at an early stage. The support of major retailer/shippers such as Home Depot and Stop and Shop was also noted as a potential major contributor to a successful launch, particularly if short-sea transportation operations could be effectively integrated with the shipper's total supply chain involving such steps as consolidation/ deconsolidation of loads at distribution centers at each end of the short-sea movement
- Of the interviewees that felt able to express an opinion between the ports of Fall River or New Bedford as a northern terminus of a short-sea service (over half the interviewees had no opinion between the two ports), the results were split fairly evenly
- Several interviewees expressed a strong interest in being involved in further steps on developing short-sea shipping services over the ports of Bristol County including US Express, Raritan Central Railway, DiSilva Transportation, and Maritime International

IV. Potential Impact on the Ports of Fall River and New Bedford

The short-sea potential market analysis, the economic analysis of short haul and long haul service options, and the market research with prospective service users, collectively demonstrate three key findings:

- There is substantial truck traffic they may be diverted to short-sea services over the Bristol County ports given the right economics and service levels
- The economics of long haul short-sea shipping operations over the Bristol County ports is very competitive with alternative modes and the short haul service economics are "in the ball park" of being competitive
- Service levels at least in terms of transit time are also within acceptable ranges of most of the prospective users interviewed, particularly among truckload carriers

Given these findings, it appears feasible that short-sea shipping services could be developed to operate over the Bristol County ports in the event that the contingency factors noted earlier in the economic analysis are effectively addressed, namely that vessels may be procured and manned on a cost-effective basis and that marine terminal operations are also carried out at a cost and productivity level consistent with high standards of performance currently being achieved at ports along the Atlantic seaboard.

Based on the findings of this project, the operational "footprint" of short-sea services over the ports of Bristol County would likely have the following characteristics:

- Short haul Bayonne RoRo shuttle service moving around 120 full trailers per voyage on average northbound and 40 full and 60 to 80 empty trailers southbound on a daily basis (may operate only 5-6 days per week depending on weekend demand)
- Long haul Jacksonville (or Wilmington NC/Norfolk VA depending on demand) RoRo service 2 to 3 times per week moving around 138 full trailers northbound and 78 full and 58 empty trailers southbound per voyage

The size of the vessels likely to be involved in such services would be similar with the following general characteristics:

- Length overall: 190-200 meters (623-656 feet)
- Beam: 24 meters (79 feet)
- Draft: 6.4 meters (21 feet)
- Deadweight: 12,000 DWT
- Road trailers: 140 –150 (primarily 48' and 53')
- Stern ramp or quarter ramp

Consequently, the key factors determining whether the ports of Fall River and New Bedford would be able to effectively handle one or more short-sea services as described above would be the following:

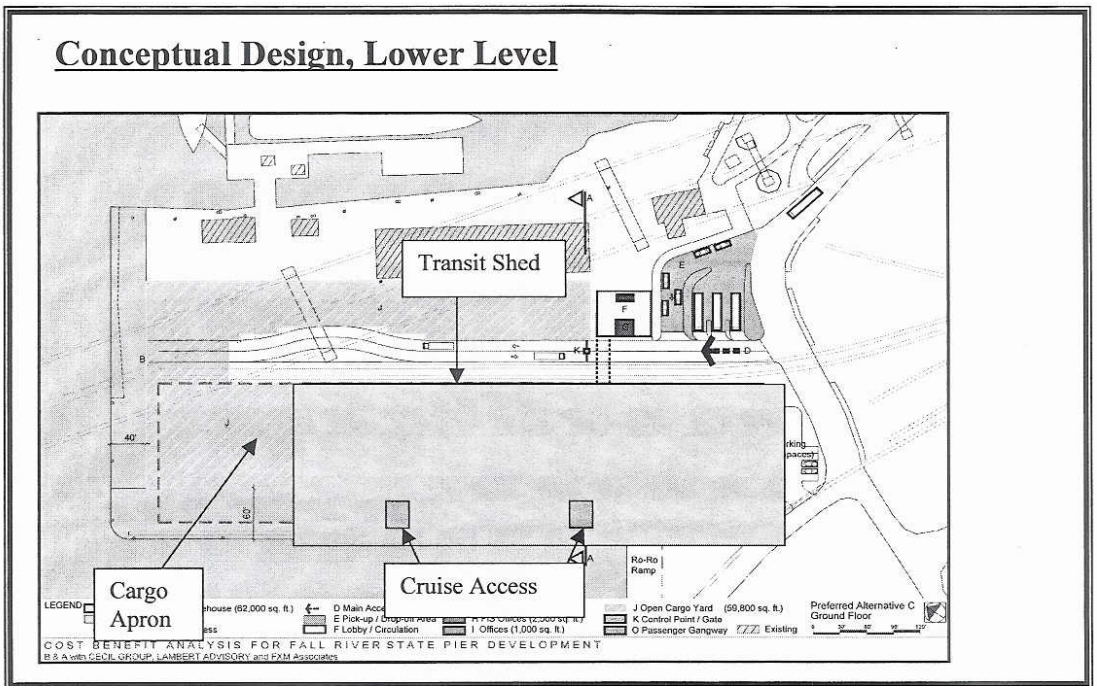
- Parking area for at least between 240 to 280 trailers requiring around 5.5 to 6.5 acres of open paved ground

- Local street access to the highway system that is able to accommodate a flow of up to 140 trailers into the terminal and out of the terminal (each direction) within a three to four hour period
- Vessel berthing facilities able to accommodate a RoRo vessel of the size noted above

The Port of Fall River

The primary facility being considered for use as a short-sea shipping facility within the port of Fall River is the State Pier. The current plans for the State Pier are for a multi-use facility combining marine cargo transportation, cruise ship visitation, and other public uses such as restaurants (see Exhibit IV-1 below). Proposed conversions to the State Pier facility that would convert current shed space into an open cargo apron and the available parking area within the existing marine terminal would provide approximately 2.5 acres of parking area for trailer staging. Use of the current CSX railroad area and Commonwealth of Massachusetts lots across Water Street would add close to another 2.5 acres of trailer parking area, bringing the Fall River facility close to the minimum requirement to handle one of the projected short-sea services. The space demands from either the short or long haul services would likely preclude the operation of other significant marine cargo businesses such as the current Atlantic Shipping tenant within the same facility.

Exhibit IV-1
Proposed Conversions to the Fall River State Pier



Source: Massachusetts Seaport Advisory Council

The South Berth appears to be suitable for RoRo vessel berthing and operations of the type projected, although the operational capability of the existing RoRo ramp is not known. However, high frequency/time sensitive calls of the type envisioned for a short-sea shipping operation may make it infeasible to berth cruise ships in the same location.[7]

Although access to Routes 195 and 24 is by local roads, the distance is relatively short at less than a mile. It is likely that the bulk of trailer traffic into and out of the marine terminal at Fall River would occur in the early morning (before 8:00 am) and/or in the evening (after 7:00 pm), so the disruption to local traffic should not be high despite the potentially large number of trailer movements into and out of the State Pier area.

The Port of New Bedford

Unlike Fall River, the port of New Bedford has extensive waterfront land that could potentially be used for a short-sea shipping terminal. However, use of this land in the near term (2-4 years) appears to be significantly inhibited by a number of factors:

- The existing State Pier facility is reportedly not in good condition,[8]and has minimal immediately adjacent RoRo trailer parking areas – the limited available parking areas are primarily required for current passenger and cargo ferry services (up to nine departures daily) to the Massachusetts Islands (see Exhibit IV-2 for a plan of the New Bedford State Pier)
- Substantial additional parking area is available in the North Terminal area of the port (future proposed Intermodal Transportation Center) but use of that facility would require trailers to be relayed over public roads approximately three-quarters of a mile, adding significantly to the cost of loading/discharging the vessels as well as road congestion
- There are substantial demands for existing port facilities from current users of the port including the fishing and fish processing industries as well as the ferry operators

The North Terminal itself appears to be an ideal long term solution as a short-sea shipping facility in view of its location in close proximity to Route 195 that could enable a direct roadway link to be built to carry trailer traffic removing the necessity of moving it over city streets – however, development of this facility as a major marine cargo terminal will require relocation of the current Route 6 swing bridge as the existing bridge openings are too narrow for vessels such as those considered for short-sea operation to safely pass through (see Exhibit IV-3).

[7] The reconfigured West Berth may be suitable for such a purpose.
[8] New Bedford/Fairhaven harbor Plan, 2002

Exhibit IV-2
New Bedford State Pier

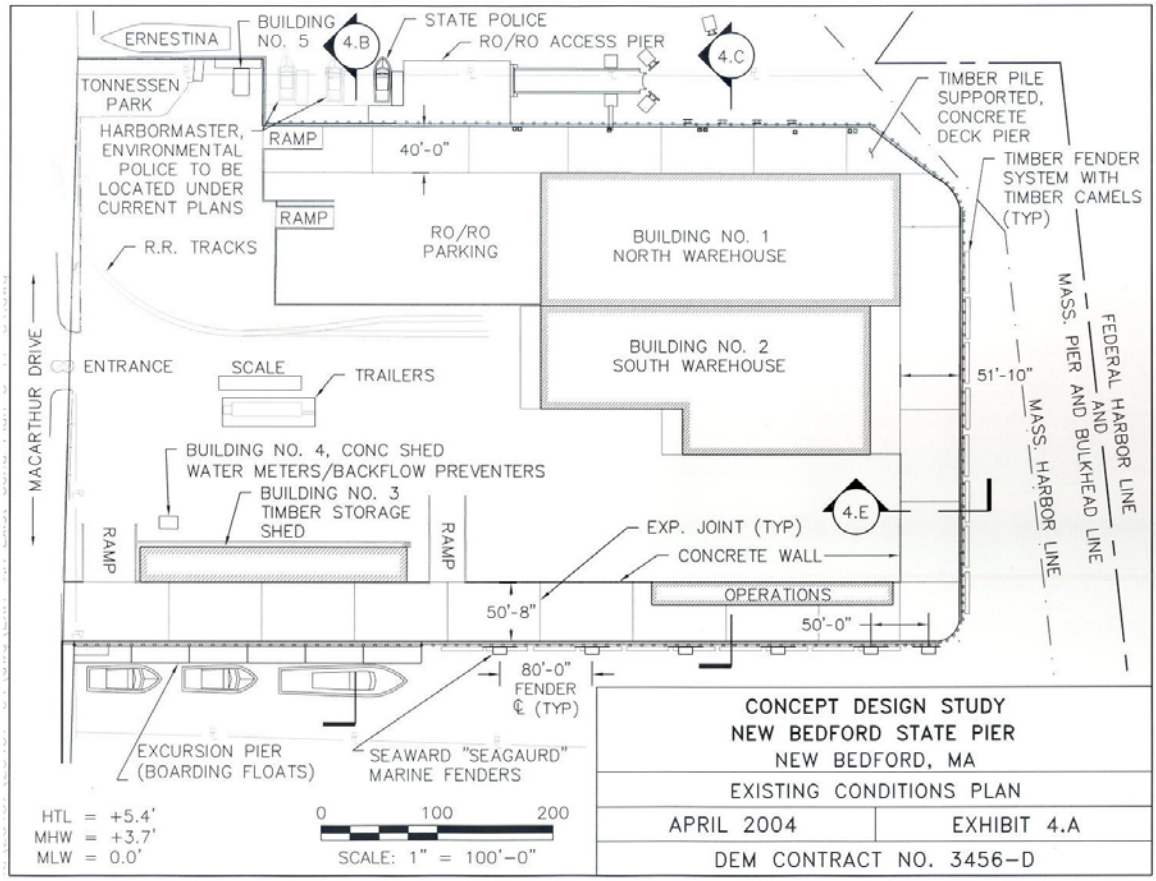
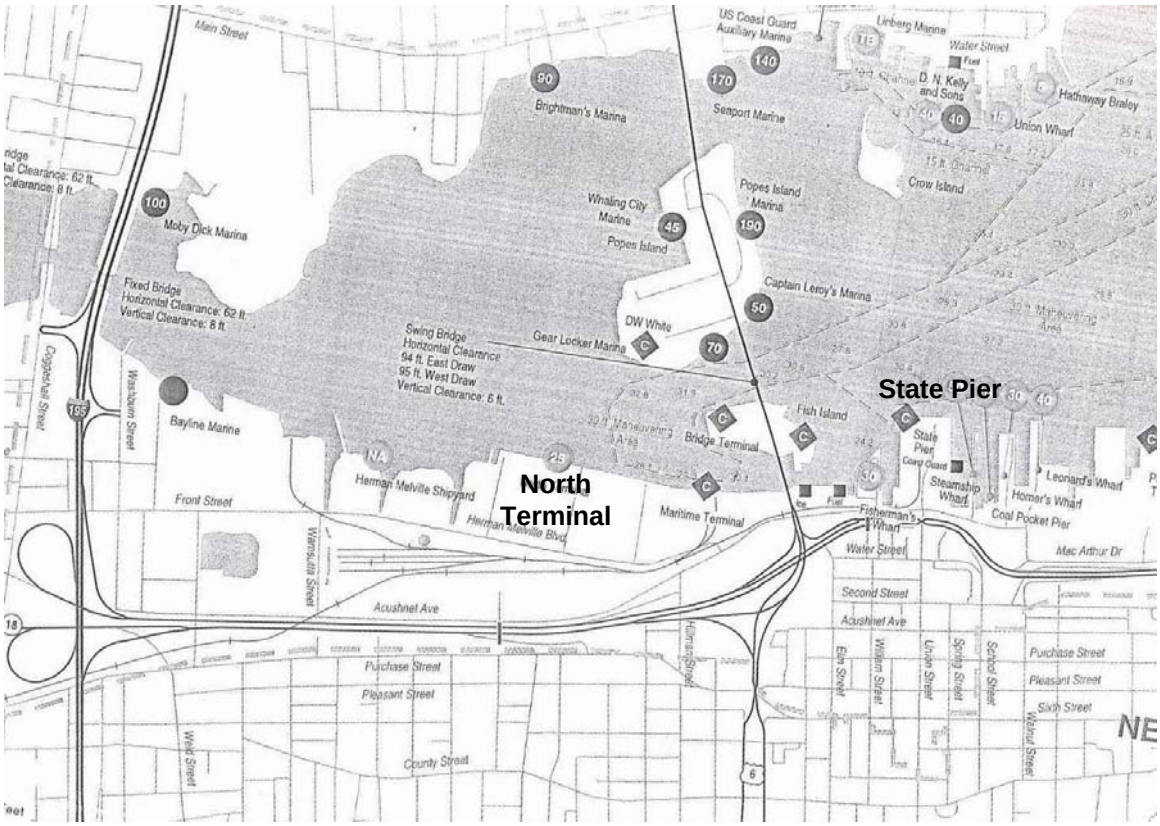


Exhibit IV-3
Inner New Bedford Harbor



Competitors to the Bristol County Ports

Although the Bristol County ports are well positioned geographically to serve the surrounding communities of greater Boston, Providence, and most of central and northern New England, neighboring ports in Rhode Island also have competitive locations and facilities:

- **Providence** is currently primarily a specialist in handling bulk and breakbulk cargoes – however, it has the basic infrastructure to serve as a short-sea terminus with six berths of 3,500 linear feet of berthing area and 20 acres of open paved storage area as well as onsite rail tracks. It also has good direct highway access to Routes 95 and 195.
- **Davisville/Quonset Point** is located at the entrance of Narragansett Bay and also offers deep-water cargo facilities. The port is currently handling large volumes of RoRo cargo (e.g. 80,000 automobiles per year) as well as bulk (e.g. quarried stone), and breakbulk general cargo. The port has three major piers with over 6,800 linear ft. of deep-water dockage with onsite rail tracks.

Further expansion of Davisville as a cargo facility faces major opposition from local environmentalists, which could inhibit the development of short-sea shipping operations at that port. There do not appear to be such limiting factors at Providence.

Ports further to the south in Connecticut such as New London, Bridgeport, and New Haven are potential short-sea terminuses as well, but they are better located to serve the southern New England market rather than the central and northern New England markets that are the natural hinterland of the ports of Bristol County. Longer highway times over the relatively highly congested roads of central Connecticut will substantially increase the drayage times and costs for short-sea cargoes moving over these ports to/from locations in central and northern New England

Economic Impact of Short-Sea Shipping Services over the Ports of Bristol County

The establishment of two short-sea shipping services operating over the ports of Bristol County as the northern terminus of (1) a daily short haul shuttle to a port in the northern New Jersey area, and (2) a twice weekly long haul service to ports in the South Atlantic such as Jacksonville or Wilmington, NC would have the following projected impact on local business activity and employment:

- The two short-sea services would generate an estimated total direct income of around $45 million per year – at least 50 percent of this would be generated within the Bristol County immediate area[9]
- Indirect income of $72 million would further be created by secondary spending by the companies and employees involved in short-sea shipping – at least 50 percent of this would be generated within the Bristol County immediate area.[10] Consequently, the total economic impact of the two short-sea services would be around $117 million per year, with at least 50 percent of this ($59-$60 million) generated within the Bristol County immediate area
- The creation of 300 jobs directly employed in short-sea shipping operations – at least 255 of these jobs would likely be in the Bristol County immediate area
  - 60 jobs manning the vessels (at least 50 percent within Bristol County region)
  - 30 jobs in shoreside and vessel management (at least 50 percent within Bristol County region)
  - 180 jobs in regional drayage operations as drivers and vehicle maintenance (100 percent within Bristol County region)
  - 30 jobs in longshore gangs (100 percent within Bristol County region)
- Another 500 jobs would be created in industries that provide goods and services to those directly involved in short-sea shipping – these additional jobs would include services such as shipbuilding and repair and financial services[11]
- Personal income for those directly employed in the short-sea shipping operations would be around $22.5 million and $35 million for those jobs that are indirectly created by the short-sea shipping operations[12]

[9] See details of economic analysis in the Appendix.
[10] Indirect economic multiplier for U.S. domestic shipping is 1.6 – source: Reeve & Associates, *Economic Impact of the U.S. Jones Act*, 2006
[11] Ibid
[12] Ibid

Of course, given that the intent of short-sea shipping is to remove trailers from the nation's highways, it can be argued that there will be a loss of jobs among long distance truck drivers that may partially offset the economic gains listed above. However, in view of the fact that there is an increasing shortage of long distance truck drivers within the U.S. and that trucking companies will be the primary marketers and operators of the overall door-to-door short-sea intermodal service, it is likely that any such job losses will be minimal, if they exist at all. In fact, it could rather be argued that the addition of transportation capacity through the provision of short-sea shipping traffic corridors will provide an economic stimulus by enabling the economy to continue to grow through the transport of goods that would otherwise be constrained by highway capacity limits.

V. Probability of Success of Short Sea Routes Serving Bristol County Ports

Several factors point to a strong probability of success for short-sea shipping services being developed to serve the ports of Fall River and/or New Bedford:

- There are substantial cargo volumes of truck traffic moving along the Atlantic seaboard with origins or destinations within the hinterland served by the Bristol County ports – options for such services include a short haul operation connecting with northern New Jersey and a longer haul operation connecting with ports in the South Atlantic such as Jacksonville or Wilmington, NC and Norfolk, VA
- Truckers, particularly truckload operators, are becoming increasingly aware of the short-sea shipping option, and view it as an additional intermodal opportunity that may offset constraints on their ability to continue to grow pure truck transportation services due to increasing highway congestion, increasing driver shortages and limits on hours of operation, and rising fuel costs
- The economics of short-sea shipping appear to be competitive with alternative modes, particularly on long haul lanes – provided that "best in class" practices can be implemented in terms of vessel costs and manning levels and stevedoring operations that will enable short-sea shipping to achieve its full potential in terms of cost and efficiency
- The primary competition to the Bristol County ports as short-sea hubs will come from the Rhode Island ports of Providence and Davisville (Quonset Point). Although these ports are well positioned in terms of physical facilities, they are at a greater distance from the central and northern New England hinterland that may potentially be served by the Bristol County ports.

However, there are also a number of factors that need to be addressed in order for short-sea shipping operations to be effectively realized in the ports of Bristol County:

- Current port capacity in both Fall River and New Bedford is limited in its ability to accommodate a major short-sea shipping operation such as envisioned in this project
  - Fall River's State Pier could accommodate a single short-sea operation but that would entail adding more trailer parking area to that within the current State Pier footprint and also possibly displacing some current users of the facility – in addition, the large volume of truck traffic into and out of the facility projected for the short-sea operation must be balanced with the needs of the adjoining Battleship Cove tourist facilities and other planned recreation activities in the area
  - New Bedford lacks berth and yard capacity to effectively support a short-sea service in its current configuration. In the long term, if the North Terminal is developed as a RoRo berth and adequate access to it is provided by reconstructing or relocating the Route 6 bridge, New Bedford would be an ideal location
- In addition, factors that add to the cost of short-sea shipping such as Harbor Maintenance Tax (HMT) and the extremely high cost of commercial vessels built by U.S. shipyards must be addressed

- The elimination of HMT on coastal domestic shipping services may prove to be revenue neutral as any foregone tax may be offset by funds saved in highway construction and repair as trailers are removed from the highways by short-sea shipping services
- The high cost of U.S.-built commercial vessels may be addressed by increasing the percentage of such vessels that may be built overseas, by improved purchasing and sourcing practices by U.S. shipyards, by the application of modern vessel construction practices and technologies by the shipyards, and/or by a waiver of the U.S. Jones Act restriction on domestic operators using foreign-built vessels

In summary, the ports of Bristol County appear to have a significant opportunity to become terminuses for short-sea shipping services. Focusing on implementation strategies that address both the positive and negative factors listed above should enable this opportunity to be achieved.

VI. Appendices

VI.1: Global Insight TRANSEARCH Methodology

VI.2: Port-Pair Truckload Volumes from TRANSEARCH

VI.3: Economic Analysis of Alternative Modes on the Jacksonville and Bayonne Lanes

VI.4: Market Research Questionnaire

VI.1: Global Insight TRANSEARCH Methodology

Transearch Database

Building from the original TRANSEARCH, the national database of freight traffic flows that Reebie Associates (and now Global Insight, Inc.) created and has maintained and provided to the transportation industry for 18 years and drawing on its experience with custom database development, the team researched information needs and data sources in the government and commercial markets and the capabilities of state-of-the-art software. The results of the effort have been to make available a national county-to-county and zip code-to-zip code data product. Key user needs like currency of the data, its reliability, flexibility in terms of seeing details of the traffic composition or relatively broad data summaries, and affordability can be satisfied.

Issued annually, the data can cover all modes and commodities, including empty truck movements, international shipping, and truck shipments of non-manufactured goods. Features like external trip ends, vehicle miles traveled, gross ton-miles, and forecasts can be provided, and traffic routed along major modal corridors can be displayed.

The database maps commodity flows (2, 3 and 4 digit STCC) in short tons between geographic entities (states, counties, BEAs) by mode (rail car, rail intermodal, truck load, less than truck load, private truck, air and water) for current year and forecast years. All volumes shown in tons are in short tons, for 2003.

A variety of data sources are used to compile the database ranging from government agencies to private sector industry associations and the carriers themselves, as shown in Figure A1.1.

The data sources vary by the different modes of transportation. The primary source for railroad data is the Carload Waybill Samples gathered from about 4% of total rail car traffic. Global Insight, Inc. sources this data from the Surface Transportation Board. This data is compiled to provide both volumes and patterns of flow.

The primary source for waterborne commodity flows is the Waterborne Commerce Statistics compiled by the Army Corps of Engineers. This data tracks the flow of commodities along domestic lakes, rivers and canals, and is used to develop both volumes and patterns of flow.

Figure A1.1
TRANSEARCH DATABASE DATA SOURCES

Mode	Data Source	Agency/Organization
Rail	– Carload Waybill Sample	– Surface Transportation Board
Water	– Waterborne Commerce Statistics	– U.S. Army Corps of Engineers
Air	– FAA Airport Originating Tonnages – Airport to Airport Flows – Commodity Flow Survey – TRANSEARCH	– Office of Airline Statistics (DOT Form 41) – BTS Office of Airline Information – Bureau of Transportation Statistics – Global Insight, Inc.
Truck	– Carrier Data Exchange Program – TRANSEARCH – Annual Survey of Manufactures – Freight Locater Data Service – General Statistics for Verification – Commodity Flow Survey	– Global Insight, Inc. – Global Insight, Inc. – U.S. Census Bureau – Global Insight, Inc. – Industry Associations – Bureau of Transportation Statistics

The air data is compiled from four major sources. The first is FAA (Federal Aviation Administration) airport originating tonnages primarily from Form 41 reports and compiled by the Office of Airline Statistics (Federal). This source establishes volume estimates at airports. The second source is airport-to-airport (ATA) flows compiled by the BTS Office of Airline information. These data are used to establish flow patterns. The third source is from Commodity Flow Survey (CFS) data, used to define the commodity types. The fourth source is Global Insight's TRANSEARCH Database, which supplements the CFS data.

The trucking data process is more complex and comes from a wide variety of sources developed over the course of 20 years. However, there are four primary sources. The first is a data exchange program Global Insight has with motor carriers, which is used to estimate patterns and volumes. The second source is a variety of industry associations (timber, plastics, chemical, automotive, etc.), which provide overall volume information for the respective industry sectors. The third major source is from the Annual Survey of Manufactures, primary employment and output data by industry, distributed at the state and local level. This data maps production and consumption of commodities and is used to calibrate the trucking flows. The Freight Locater data service is a database of industrial facilities and their exact location. This data supplements the previously mentioned sources to help calibrate the flows of goods between specific geographic entities.

TRANSEARCH Data Issues and Limitations – Reebie Associates recently developed a finer detailed version of its TRANSEARCH database in an FHWA sponsored project known as the Intermodal Freight Visual Database. It breaks down origin and destination market areas to the county level and is compatible with GIS applications. It has been incorporated into TRANSEARCH, with its most current base year as 2003.

For this study, TRANSEARCH data were identified at varying levels of detail. It is generally understood that large databases of this kind are never perfect, and TRANSEARCH is not an exception to the rule. It is, however, the best available source of its kind in the cognizance of the study team. TRANSEARCH is in use by virtually all major U.S. railroads and by more than a hundred motor carrier companies and several container shipping lines and air cargo carriers. State and federal planning agencies, as well as port authorities, equipment suppliers, investment banks and judicial and regulatory bodies also use it.

TRANSEARCH reports provide a broad picture of freight traffic movements in the United States. Various publicly available sources, as well as Global Insight's proprietary motor carrier data exchange information, are used in the development of the TRANSEARCH database. Understanding the nature of particular sources when using TRANSEARCH data is important to interpret the information correctly. The following guidelines should be helpful in gaining that understanding.

Freight Rehandled By Truck From Warehouse and Distribution Centers Is Identified as STCC 5010 and Referred to as Secondary Traffic at a 4-digit STCC level or STCC 50 at a 2-digit STCC level. Many of these types of facilities handle a wide range of different types of commodities, and outbound shipments may also be of mixed consists. For example, shipments from a supermarket chain distribution center are likely to contain a broad range of packaged food products and other consumer items.

The Truck Portion of Truck/Rail Intermodal Activity Is Shown as STCC 5020 at a 4-digit STCC level or STCC 50 at a 2-digit STCC level. This activity includes two segments: the truck shipment, by trailer or container, from true origin to the intermodal railhead, and from the intermodal railhead to final destination. The Rail Intermodal mode reveals the origin and destination points on the rail system, not the ultimate origin and destination.

STCC 5030 Is Used to Identify the Truck Drayage of Air Freight Traffic 5020 at a 4-digit STCC level or STCC 50 at a 2-digit STCC level. Both the true origin to airport, and airport to final destination are included. Origins and destination for movements classified in the air mode are airports. Volumes that are transloaded from one aircraft to another are not shown at the transloading point.

Large Portions of Today's Intermodal (TOFC or COFC) Traffic Are Reported In Non-Commodity Categories. Commercial arrangements in the railroad industry have fostered the use of "third parties" such as consolidators and forwarders. Such traffic typically is labeled as "Freight Forwarder Traffic", "FAK" (Freight: All Kinds), or "Miscellaneous Mixed Shipments". The specific commodities moving under these arrangements are not identified in the public use data sources.

Shipments Made Up Of Several Commodities Will Be Credited To The Dominant Commodity. This occasionally occurs in the commodity identification of rail shipments.

In these instances, the tonnage attributed to the predominant commodity is greater than it should be, and the other commodities in the shipment are understated.

To Provide Maximum Product Identification, Commodities Are Shown At the Greatest Level of STCC Detail For Each Code. Truck data is available and shown at the 4-digit level for the manufacturing sector. Rail data, however, can be shown at 5-digits. Because of the desire to include the greatest amount of detail possible, commodities in a traffic lane may be identified at different levels of detail for each mode. When this occurs, tonnages shown at the more detailed levels should be combined with those displayed at the more aggregate levels to gain a complete picture of modal share for the commodity. All freight traffic flow information in the study is expressed at the 4-digit STCC commodity code level, or consolidated to a 2-digit, or no commodity detail level.

Tonnage Data in Each Cell Should Be Used as an Indicator of Relative Value—since many of the sources for traffic flow information use sample data. Consequently, the more specific the definition of a particular flow, the greater its sampling variability. The more aggregated the definition of the Geography/Mode/ Commodity combination, the more reliable the results.

State-To-State Movements Of "Primary" Freight At The 2-Digit STCC (or SIC) Level Provide The Best Picture Of Primary Freight Moves In The Data Base. Analysts and planners, however, want and need more disaggregate pictures of the flow activity. Not all of the data used in TRANSEARCH comes into the process beneath the state level or with more than 2-digit commodity/industry classification.

VI.2: Port-Pair Truckload Volumes from TRANSEARCH

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Bayonne

Loads	Bristol County, MA Catchment					
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
50 miles	27,058	49,881	7,209	7,713	8,895	100,756
100 miles	9,751	9,745	803	1,845	4,604	26,747
150 miles	9,330	7,507	263	712	1,660	19,471
200 miles	4,112	8,155	1,029	1,224	1,795	16,315
250 miles	9,851	10,213	1,858	3,403	1,726	27,052
Grand Total	60,103	85,501	11,162	14,897	18,680	190,342

NORTHBOUND

Port Name	Bayonne

Loads	Bristol County, MA Catchment					
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles	Grand Total
50 miles	78,780	87,694	94,587	18,218	12,463	291,741
100 miles	34,435	34,290	9,831	6,606	6,116	91,277
150 miles	39,426	30,490	2,271	5,474	4,047	81,707
200 miles	29,505	25,793	9,248	8,597	6,603	79,748
250 miles	13,667	23,370	4,919	5,245	5,298	52,499
Grand Total	195,813	201,637	120,856	44,141	34,526	596,972

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Charleston

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	255	1,138	490	164	443
100 miles	1,590	2,352	2,163	716	626
150 miles	1,922	2,769	5,393	1,411	1,405
200 miles	1,508	5,260	1,068	718	637
250 miles	2,650	3,224	939	773	1,903
Grand Total	7,925	14,743	10,053	3,783	5,014

NORTHBOUND

Port Name	Charleston

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	3,312	14,234	5,299	5,900	5,591
100 miles	8,680	10,087	4,823	1,195	2,875
150 miles	6,850	16,443	14,576	4,503	6,060
200 miles	17,535	15,386	14,750	9,328	8,260
250 miles	10,253	18,367	6,152	3,047	9,028
Grand Total	46,631	74,517	45,600	23,973	31,815

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Corpus Christi

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	227	327	457	2,650	1,365
100 miles	5,523	14,738	6,030	12,965	36,485
150 miles	3,802	5,600	3,682	6,084	23,459
200 miles	872	2,927	3,069	3,228	5,877
250 miles	1,154	4,974	2,408	6,389	4,301
Grand Total	11,579	28,565	15,647	31,316	71,488

NORTHBOUND

Port Name	Corpus Christi

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	3,924	2,954	1,909	5,220	12,145
100 miles	1,217	5,635	1,883	6,149	21,630
150 miles	3,315	6,267	3,830	92,475	12,764
200 miles	7,779	5,010	2,383	861	1,739
250 miles	15,536	20,657	13,540	4,829	4,730
Grand Total	31,771	40,523	23,546	109,535	53,008

Port-Pair Truckload Volumes from TRANSEARCH

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Galveston

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	428	2,826	1,325	2,058	7,893
100 miles	1,231	3,608	1,525	1,130	5,772
150 miles	2,157	2,241	899	2,494	7,166
200 miles	4,721	2,796	3,408	3,058	6,434
250 miles	2,219	8,946	3,854	6,833	9,079
Grand Total	10,757	20,417	11,011	15,572	36,343

NORTHBOUND

Port Name	Galveston

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	18,111	17,014	15,853	31,979	76,919
100 miles	5,236	6,710	4,178	7,391	3,162
150 miles	11,828	7,128	3,012	2,408	4,260
200 miles	2,435	1,620	678	756	773
250 miles	13,580	15,457	5,654	12,967	15,702
Grand Total	51,191	47,930	29,376	55,501	100,816

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Jacksonville

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	1,146	4,588	440	2,529	6,870
100 miles	1,446	2,694	2,437	3,958	9,128
150 miles	1,318	6,888	4,593	8,178	15,239
200 miles	2,904	8,346	2,406	6,715	15,001
250 miles	3,429	7,550	1,620	8,107	13,241
Grand Total	10,243	30,066	11,497	29,488	59,479

NORTHBOUND

Port Name	Jacksonville

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	2,117	5,137	4,119	35,471	10,267
100 miles	3,472	1,088	1,446	2,066	7,143
150 miles	7,609	25,837	7,351	12,158	21,574
200 miles	16,206	13,398	12,195	7,146	16,634
250 miles	15,647	15,229	5,337	12,362	16,077
Grand Total	45,050	60,690	30,449	69,202	71,695

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Mobile

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	184	245	26	18	10
100 miles	364	581	60	332	331
150 miles	955	1,223	293	347	83
200 miles	1,380	5,878	1,138	12,839	101
250 miles	4,999	3,530	14	264	77
Grand Total	7,882	11,457	1,530	13,800	601

NORTHBOUND

Port Name	Mobile

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	1,513	14,757	15,717	429	126
100 miles	6,144	5,204	1,464	3,806	21
150 miles	11,247	16,951	6,137	718	5,506
200 miles	21,978	25,089	2,837	1,650	3,969
250 miles	3,999	3,920	216	211	34
Grand Total	44,881	65,921	26,371	6,814	9,656

Port-Pair Truckload Volumes from TRANSEARCH

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	New Orleans				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	1,142	4,658	2,481	4,185	35
100 miles	4,016	7,700	3,423	9,700	151
150 miles	2,854	2,901	95	253	120
200 miles	1,857	1,942	526	1,594	15
250 miles	2,033	1,084	839	68	151
Grand Total	11,903	18,285	7,364	15,801	471

NORTHBOUND

Port Name	New Orleans				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	19,603	55,397	25,347	1,742	8,026
100 miles	14,982	36,728	13,137	2,289	2,422
150 miles	4,162	4,540	509	903	28
200 miles	951	762	2,999	1,226	29
250 miles	7,786	5,825	1,086	625	1,417
Grand Total	47,483	103,251	43,078	6,786	11,921

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Norfolk				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	1,532	1,568	1,559	1,136	634
100 miles	1,387	1,643	422	292	227
150 miles	1,316	1,016	579	297	356
200 miles	1,017	2,751	500	1,254	982
250 miles	641	1,428	309	792	772
Grand Total	5,894	8,406	3,369	3,771	2,970

NORTHBOUND

Port Name	Norfolk				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	7,511	3,957	328	1,771	1,422
100 miles	1,391	2,437	158	100	138
150 miles	2,422	2,194	694	1,415	208
200 miles	2,813	2,191	954	1,429	735
250 miles	6,104	4,337	1,019	943	365
Grand Total	20,241	15,116	3,153	5,658	2,869

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Pensacola				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	116	675	93	17	47
100 miles	219	389	12	194	57
150 miles	218	104	19	282	127
200 miles	701	964	86	166	12
250 miles	1,140	4,919	1,352	12,755	51
Grand Total	2,394	7,049	1,562	13,414	293

NORTHBOUND

Port Name	Pensacola				
Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	1,637	686	955	594	21
100 miles	2,228	8,700	1,034	475	210
150 miles	2,182	3,150	1,167	113	8
200 miles	7,309	10,544	4,777	3,448	4,178
250 miles	24,498	26,013	3,292	1,808	4,949
Grand Total	37,854	49,094	11,225	6,438	9,364

Port-Pair Truckload Volumes from TRANSEARCH

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Port Arthur

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	274	2,111	710	574	9
100 miles	3,653	2,422	1,708	1,228	847
150 miles	1,983	7,326	1,221	2,761	273
200 miles	3,016	4,059	2,020	1,711	92
250 miles	4,194	3,166	3,414	1,634	1,655
Grand Total	13,121	19,083	9,072	7,908	2,876

NORTHBOUND

Port Name	Port Arthur

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	4,604	4,791	2,649	2,840	1,448
100 miles	22,219	20,358	15,971	27,430	43,209
150 miles	10,529	7,005	3,072	6,507	2,823
200 miles	4,503	4,845	3,218	1,657	552
250 miles	6,760	3,547	1,655	1,615	2,340
Grand Total	48,615	40,546	26,565	40,049	50,372

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Port Canaveral

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	493	6,243	517	2,484	4,539
100 miles	1,705	2,638	3,293	7,753	9,715
150 miles	4,152	11,907	3,762	6,055	7,495
200 miles	2,247	5,632	1,622	7,740	14,150
250 miles	647	917	36	995	3,198
Grand Total	9,244	27,337	9,230	25,028	39,097

NORTHBOUND

Port Name	Port Canaveral

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	2,097	5,260	2,500	2,491	2,527
100 miles	8,355	21,636	6,078	6,000	12,384
150 miles	3,817	7,586	3,711	20,213	12,271
200 miles	6,465	8,212	8,613	4,269	10,143
250 miles	506	2,177	2,258	323	1,015
Grand Total	21,238	44,871	23,160	33,296	38,342

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Savannah

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	740	1,251	1,030	1,635	381
100 miles	626	1,986	1,552	759	1,295
150 miles	2,413	3,900	1,000	1,001	1,907
200 miles	2,363	7,944	5,605	3,600	3,926
250 miles	2,198	8,068	3,847	3,692	3,548
Grand Total	8,341	23,149	13,035	10,686	11,056

NORTHBOUND

Port Name	Savannah

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	6,659	11,858	2,603	3,869	4,776
100 miles	6,623	3,757	4,005	3,873	5,699
150 miles	13,063	26,692	19,027	12,635	16,227
200 miles	8,438	7,960	9,435	6,348	4,805
250 miles	11,957	9,971	7,324	4,430	6,935
Grand Total	46,740	60,238	42,395	31,155	38,443

Port-Pair Truckload Volumes from TRANSEARCH

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Tampa

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	739	5,932	1,705	1,272	904
100 miles	2,100	2,681	816	538	386
150 miles	1,580	3,145	203	216	558
200 miles	2,077	956	84	179	43
250 miles	370	1,127	307	72	349
Grand Total	6,867	13,840	3,115	2,277	2,240

NORTHBOUND

Port Name	Tampa

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	3,251	7,424	5,389	6,529	5,018
100 miles	6,214	7,786	979	667	397
150 miles	5,015	4,374	1,058	371	527
200 miles	663	967	370	14	215
250 miles	2,958	3,678	5,520	812	4,716
Grand Total	18,101	24,230	13,317	8,392	10,873

Truckload Volumes by Drayage Distance

SOUTHBOUND

Port Name	Wilmington, NC

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	418	1,012	114	172	277
100 miles	915	1,631	297	382	652
150 miles	1,569	863	176	117	484
200 miles	832	2,019	156	410	834
250 miles	1,485	1,656	3,092	637	709
Grand Total	5,219	7,182	3,835	1,717	2,956

NORTHBOUND

Port Name	Wilmington, NC

Loads	Bristol County, MA Catchment				
Southern Port Catchment	50 miles	100 miles	150 miles	200 miles	250 miles
50 miles	2,801	2,382	635	462	172
100 miles	2,900	4,026	951	1,038	395
150 miles	3,154	5,756	1,749	927	2,417
200 miles	7,728	22,572	6,245	3,709	2,822
250 miles	7,229	8,460	754	1,016	1,336
Grand Total	23,812	43,197	10,334	7,152	7,143

VI.3: Economic Analysis of Alternative Modes on the Jacksonville/Bristol County Lane

Jacksonville, FL to Bristol County, MA

Truck			Rail Intermodal			Short Sea Shipping		
OPERATING STATISTICS			**OPERATING STATISTICS**			**OPERATING STATISTICS**		
Highway Miles		1182.6	Rail and Dray Miles		1340.2	Ocean and Dray Miles		1341.95
Transit Hours		26.5	Transit Hours		66.5	Transit Hours		72.0
Projected Door-to-Door Transit (Hours)		54.5	Projected Door-to-Door Transit (Hours)		66.5	Projected Door-to-Door Transit (Hours)		72.0
ESTIMATED OPERATING COSTS (Per Load)			**ESTIMATED OPERATING COSTS (Per Load)**			**ESTIMATED OPERATING COSTS (Per Load)**		
Driver - Wages & Benefits	$	738	Locomotives & Fuel	$	207	Vessel Costs	$	213
Equipment (Tractor & Trailer)	$	121	Track & R.O.W	$	144	Fuel Costs	$	63
Fuel - Tires - Oil - Maint.	$	435	Yard & Terminal / Lift On/Lift Off	$	129	Port Charges	$	13
Insurances	$	81	Railcar Costs	$	57	All Other	$	30
Repositioning	$	85	Crew & Other	$	108	Marine Terminal Costs	$	256
Tolls	$	71	Trailer/Container Costs	$	57	Trailer/Container Costs	$	51
All Other	$	251	Drayage Expense	$	421	Drayage Expense	$	438
Depreciation	$	99	Depreciation	$	112	Depreciation (included in vessel costs)	$	-
Total	$	1,881	Total	$	1,235	Total	$	1,065
Estimated Operating Cost per HWY Mile	$	1.59	Estimated Operating Cost per HWY Mile	$	1.04	Estimated Operating Cost per HWY Mile	$	0.90
Estimated Markup	$	0.14	Estimated Markup	$	0.21	Estimated Markup	$	0.09
SHIPPER COSTS			**SHIPPER COSTS**			**SHIPPER COSTS**		
						Shipper HMT Expense	$	24
			Incremental Inventory Carrying Cost	$	11	Incremental Inventory Carrying Cost	$	15
Total	$	-	Total	$	11	Total	$	40
Estimated Shipper Cost per HWY Mile	$	1.73	**Estimated Shipper Cost per HWY Mile**	$	1.26	**Estimated Shipper Cost per HWY Mile**	$	1.02
			Discount vs. Highway Transport		27%	**Discount vs. Highway Transport**		41%

Economic Analysis of Alternative Modes on the Bayonne/Bristol County Lane

Bayonne, NJ/Bristol County, MA

Truck			Short Sea Shipping		
OPERATING STATISTICS			**OPERATING STATISTICS**		
Highway Miles		498.4	Ocean and Dray Miles		558.00
Transit Hours		12.0	Transit Hours		17.5
Projected Door-to-Door Transit (Hours)		12.0	Projected Door-to-Door Transit (Hours)		17.5
ESTIMATED OPERATING COSTS (Per Load)			**ESTIMATED OPERATING COSTS (Per Load)**		
Driver - Wages & Benefits	$	334	Vessel Costs	$	85
Equipment (Tractor & Trailer)	$	55	Fuel Costs (25 TPD)	$	25
Fuel - Tires - Oil - Maint.	$	197	Port Charges	$	10
Insurances	$	37	All Other	$	32
Repositioning	$	30	Marine Terminal Costs	$	100
Tolls	$	20	Trailer/Container Costs	$	-
All Other	$	32	Drayage Expense	$	333
Depreciation	$	38	Depreciation (Vessel included in vessel costs)	$	4
Total	$	742	Total	$	585
Estimated Operating Cost per HWY Mile	$	1.49	Estimated Operating Cost per HWY Mile	$	1.17
Estimated Markup	$	0.13	Estimated Markup	$	0.12
Estimated Operating Margin		10%	Estimated Operating Margin		10%
SHIPPER COSTS			**SHIPPER COSTS**		
			Shipper HMT Expense	$	24
			Incremental Inventory Carrying Cost	$	5
Total	$	-	Total	$	29
Estimated Shipper Cost per HWY Mile	$	1.62	**Estimated Shipper Cost per HWY Mile**	$	1.35

VI.4: Market Research Questionnaire

Massachusetts Seaport Advisory Council:
Study of Potential Market for Domestic Coastal Shipping

Shipper/Carrier Interview Guide

Interviewer _____

Firm _____

Phone _____

Contact 1 _____

Contact 2 _____

Contact 3 _____

Cold Calling - Getting to the right person

For Shippers

Hello, my name is _____. I'm calling on behalf of the Massachusetts Seaport Council. We are conducting a study of freight transportation options in the Eastern United States and would like to speak for a few minutes with the manager of your firm that handles shipping decisions.

For Carriers

Hello, my name is _____. I'm calling on behalf of the Massachusetts Seaport Council. We are conducting a study of freight transportation options in the Eastern United States and would like to speak for a few minutes with the manager of your firm that develops and evaluates new services and market opportunities.

When you reach the key individual

Name, Title and Phone _____

Date and Time _____

Good Day, my name is _____
I am working on a project for the Massachusetts Department of Business and Technology and Seaport Council. The study is evaluating the market potential for **domestic coastal shipping** services that would connect ports in Massachusetts such as New Bedford and/or Fall River with other U.S. ports on the east coast that would provide a new mode of transportation for freight that is currently moving over the highway. I would like to discuss this opportunity with you and get your reaction to how your firm might use this type of service. I expect that the conversation might require 20-30 minutes of your time.

Background Information to be used as necessary to advance conversation and define terms

What is Short Sea Shipping? Many in the transportation industry are concerned that growing highway congestion will continue to increase the costs and reduce the reliability of shipping by truck. Short Sea Shipping provides an opportunity to relieve some of this strain on the nation's transport

infrastructure by diverting truck traffic from highways to the open sea. With "short sea shipping" operations along the nation's coasts portions of the projected growth in highway freight traffic would move via an "ocean highway" with consequent reduced demand for land highway capacity as well as drivers.

Short sea shipping operations would move freight on an intermodal basis by combining a relatively short overland "drayage" move by truck to transport goods from their origin to a nearby port from which a vessel would carry the freight to another port where a second truck would transport the load over another relatively short distance to its ultimate destination. This mode of operation for domestic freight has already had some success through such operators as Osprey Lines in the U.S. Gulf. However, its application on the Atlantic Coast has been very limited to date. We are working for the Massachusetts Seaport Council to explore how such a service may work for Massachusetts.

Begin the interview……..
All topics below should be addressed but as the interviews are expected to be with fairly senior people, the interview should be allowed to proceed on a fairly unstructured basis enabling the interviewee to provide as much of their perspective on an "unscripted" basis wherever possible.

1. **Basic familiarity with "short-sea shipping" concept:** Ask open question – probe on relative level of interest

2. **Background on interviewee's current freight operations:**

   - Determine volume of road and rail intermodal traffic (trailer loads and type of freight) that could potentially be moved by SSS

   - Identify key requirements in terms of cost and service levels (e.g. transit time, schedule reliability, safety, etc.)

3. **Concerns:** Probe on any concerns that they may have on being able to meet key shipping requirements (e.g. restrictions on driver hours, driver shortages, highway congestion, rising fuel costs, etc.)

4. **Opportunity for short-haul SSS:**

   - **Describe Short Haul Service –** Daily roll on/roll off (RoRo) service for truck trailers would be offered between a Northern New Jersey port (say, Bayonne) and a port on the Southeastern Coast of Massachusetts, say Fall River or New Bedford. Northbound service would depart New Jersey each afternoon at approximately 5 pm and arrive in Massachusetts at 2 am. Southbound service would depart Massachusetts for New Jersey at 6 am, arriving in New Jersey by 3 pm. Trailers could be dropped off at the port terminals up to one hour before vessel departure and would be ready for pick up within one hour of the vessel's arrival at the other end. Service would be by roll-on/roll-off vessel carrying standard highway trailers. It is anticipated that the charge for the service would be approximately **$300 - $350** per trailer on a port-to-port basis not including local truck transportation at both ends of the trip.

   - Probe on reaction to daily Bayonne/FR-NB service – type of service, frequency, points served, pricing, etc.

   - Preference for door-to-door service (ocean plus drayage) or ocean only

5. **Opportunity for long- haul SSS:**

   - **Describe Long Haul Service** – Three departures per week service between Northern Florida (say Jacksonville) and a port on the Southeastern Coast of Massachusetts, say Fall River or

New Bedford, is envisioned. The service would utilize roll-on/roll-off vessels that can handle any highway trailer. Northbound service would depart Florida on a Monday, Wednesday or Friday afternoon and arrive in Massachusetts two days (50 hours) later (e.g. Monday departure would arrive on Wednesday). Again, trailers could be dropped off at the port terminals up to one hour before vessel departure and would be ready for pick up within one hour of the vessel's arrival at the other end. It is anticipated that the charge for the service would be around **$1,200** on a port-to-port basis not including local truck transportation at both ends of the trip.

- Probe on reaction to Florida service or similar service to other East Coast ports (please specify any other preferences) – type of service, frequency, points served, pricing, etc.

- Preference for door-to-door service (ocean plus drayage) or ocean only

6. **Key factors for success and obstacles:**

   - What has to happen for SSS to be a real modal choice for their business?

7. **Massachusetts ports:**

   - Probe on perceptions of Fall River and New Bedford as prospective SSS gateways – advantages/disadvantages, respective strengths/weaknesses in terms of road access, port facilities, labor, etc.

8. **Close:**

Thank interviewee and determine if interested in participating in further analysis of the SSS opportunity

APPENDIX 24

Labor

- Strong, experienced, and diverse workforce
- ILA and Teamster crews available 24/7

Pilotage

- Pilotage is compulsory for foreign vessels of 350 gross tons or more and US vessels under register of 350 gross tons or more.
- Pilotage is provided by Northeast Marine Pilots.

Customs

- The port is designated as a US Customs port of entry.
- Excellent tug, stevedore, and repair services.

New Bedford Harbor - Vessel Parameters

- Hurricane Barrier Width: 150' (45.7 meters) (Access to Southern Terminals)
- New Bedford – Fairhaven Bridge 95' (29 meters) (Access to Northern Terminals)
- All vessel transit from and to the New Bedford – Fairhaven Bridge are subject to daylight-only restrictions for vessels with overall length above 400' (121 meters) and / or beam above 59' (18 meters)
- Any vessels in excess of the above stated restrictions will be allowed to enter the New Bedford Harbor subject to approval from Northeast Marine Pilots Association

Contacts:

Kristin Decas, Port of New Bedford
(508) 961-3000

Rick Cunio, New Bedford State Pier
(508) 993-1646

Tom Flarety, Sprague Terminal
(603) 431-1000

Steven Shuster, South Terminal
(508) 999-3261

Pierre Bernier, Maritime Terminal
(508) 996-8500 x 233

USCG New Bedford Office
(508) 999-6478

New Bedford Police Port Security Team
(508) 989-2925

Northeast Marine Pilots
(401) 847-9050

www.portofnewbedford.org

CONNECTING SHIPPERS

TO THE PORT OF NEW BEDFORD & NEW ENGLAND MARKETS

NEW BEDFORD.IS

Reliability, Speed and Efficiency, Connectability

- Meets Your Supply Chain Needs
- Intermodal (Sea, Highway, Rail, Air)
- No Congestion By Land or By Sea
- Safe and Secure
- Cost Efficiencies and Optimization

www.portofnewbedford.org

New Bedford Terminals

STATE PIER
- Harbor depth: 30′ (9 meters)
- Berthing – Maximum length overall 557′ (170 meters)
- Maximum ship beam allowable 70′ (21 meters)
- Maximum draft allowable 27′ (8.22 meters)
- Dock height at mean low tide: Approx. 12′

SPRAQUE TERMINAL
- Berthing Space: 740′ (226 meters)
- Pier Draft: 27′ (8.22 meters)

MARITIME TERMINAL
- Berthing Space: 600′ (183 meters)
- Pier Draft: 30′ (9 meters)
- Dock height at mean low water: Approx. 15′ (4.5 meters)
- Now takes foreign freighters

Future Sites

SOUTH TERMINAL
- Berthing Space: 400′ (121 meters)
- Pier Draft: Dredge to 30′
- 10 acres backland

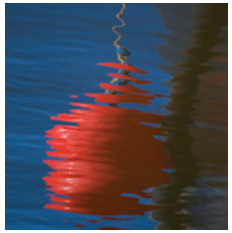
NORTH TERMINAL CARGO TERMINAL
- Berthing Space: 205′ (62.5 meters)
- Pier Draft: 27′ (8.22meters)
- Active Rail (intermodal connections)

An Exit Off The Marine Highway

The Port of New Bedford is a deep-water port with overall depths of 30 feet at mean low water. The Port of New Bedford is located on the northwestern side of Buzzard's Bay and is approximately 83 nautical miles south of Boston and 166 miles north of New York. The harbor entrance is approximately 10 nautical miles from the beginning of the west entrance of the Cape Cod Canal, a major shipping route. The approach channel allows for safe navigation. The Port entrance is 150 feet wide and opens up to a 350 foot wide channel, at a depth of 30 feet, extending to a 350 yard/1,000 foot wide turning basin just above the New Bedford-Fairhaven Bridge.

Safety

The port is one of the safest on the east coast being well-protected by a hurricane barrier (150 foot entrance) that is constructed across the harbor entrance. It is equipped with an opening that can be closed during hurricane conditions and severe coastal storms. The average range of the tide is 3.5-4.0 feet and harbor currents are overall considered weak.



Security

The US Coast Guard, State Environmental Police, New Bedford Port Security Unit have strong presence in the Port protecting the interests of maritime commerce.

Intermodal Connections

The port has excellent highway (I-95, I-93, Rte 128, Rte 140 and Rte 195, Rte 24), rail, and air connections (New Bedford Regional Airport)

Distribution

New Bedford offers excellent freight management services including:
- local and regional distribution centers
- shipping agencies
- freight forwarding and stevedore services
- warehousing and cold storage capacity
- truck-brokering facilities.

Foreign Trade Zone

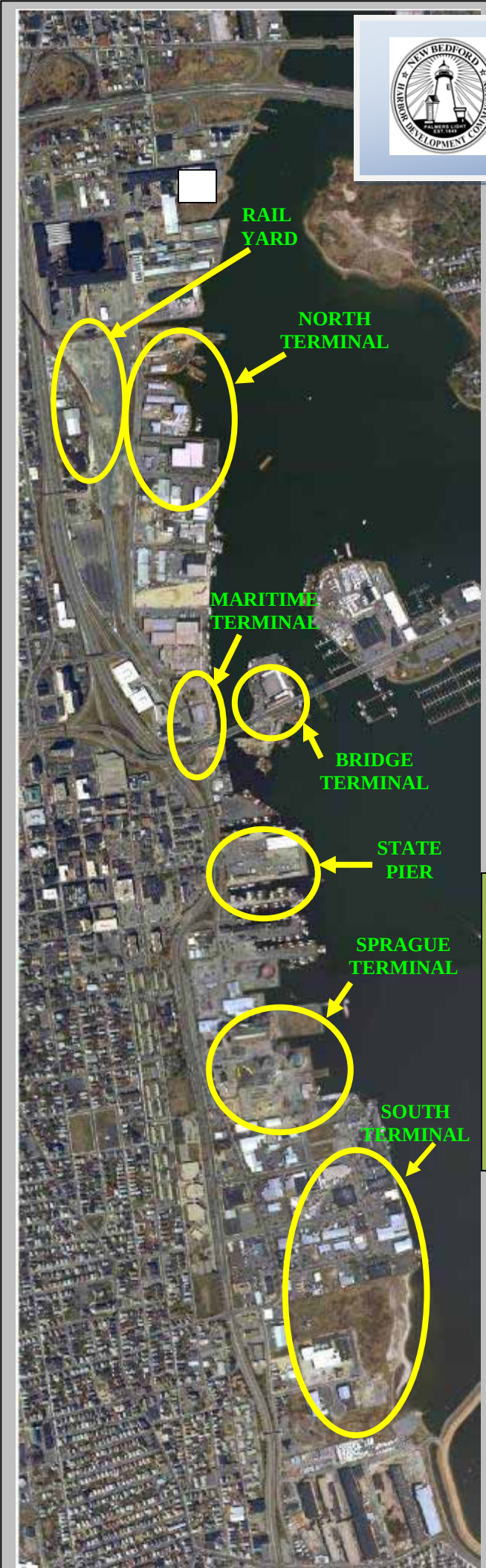
The City of New Bedford is the grantee and holder of Foreign Trade Zone (FTZ) #28 offering a competitive advantage to foreign businesses looking to trade in US markets. The Port, Regional Airport, and adjacent areas form the New Bedford FTZ #28, which provides duty-free manufacturing opportunities for importers and exporters.

PORT OF NEW BEDFORD MASSACHUSETTS

MAYOR SCOTT W. LANG

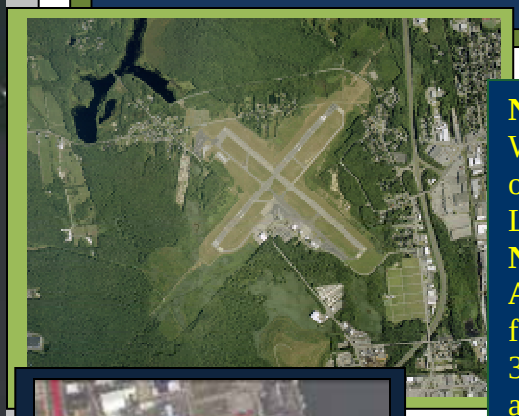
Port Infrastructure Assets

Contact: Kristin Decas, Port Director
(508) 961-3000 wk (508) 989-0103 cell



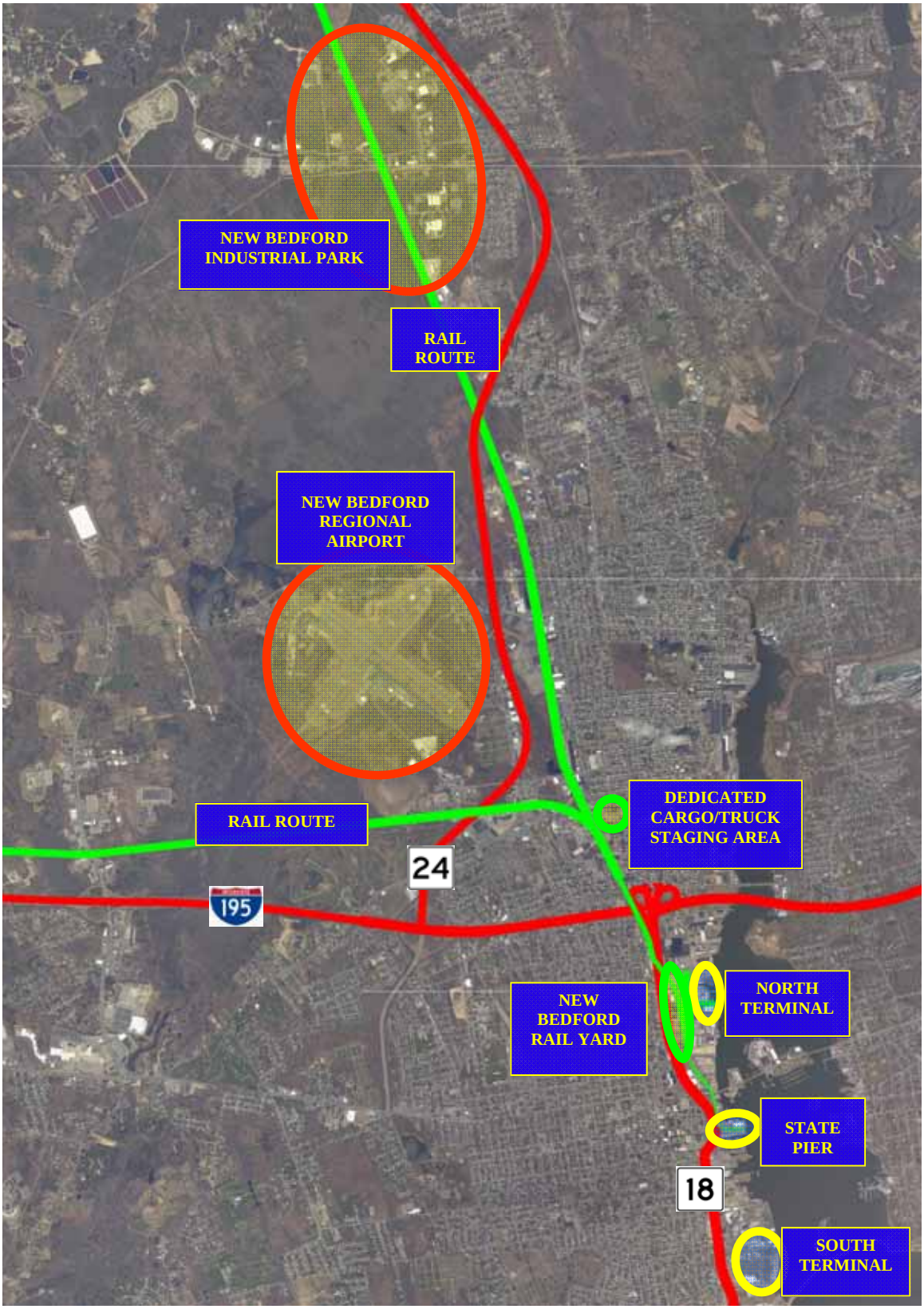
Staging and Lay–down areas at the Marine Terminals and within the Port Area

- North Terminal / Rail-yard = 33.5 acres
  - Paved Staging Area = 7.5 acres
  - Unpaved Storage Area = 14 acres
  - On-Rail Railcar Storage = 12 acres
  - Staging for more than 100 Railcars
- State Pier / Fisherman's Wharf
  - 4 acres at State Pier
  - Room for 500 Stacked Containers
  - Staging for 70 Trucks
  - 1,000-lineal feet of bulkhead for vessel berthing
- New Bedford Industrial Park
  - 30 acres of staging and lay-down area
- New Bedford Regional Airport
  - 20 acres of staging and lay-down area outside the Terminal areas.
- (Future) South Terminal
  - 20 acres of paved staging and lay-down area
  - 1,000-lineal feet of bulkhead for vessel berthing



New Bedford Industrial Park: Within 6-miles of the docks, over 30-acres of Staging and Lay-down Area is available.
New Bedford Regional Airport: Located only 3.5 miles from the docks, the Airport has 30 additional acres of Staging and Lay-down Area.

(Future) South Terminal: The future planned expansion of the existing South Terminal calls for the development of over 20-acres of paved staging and storage area to support multiple uses.



New Bedford Is: *Local Connections = National Markets = International Trade.*

With Three full service Marine Terminals to support shipping, a strong Import/Export business, Rail Connections from the Port to all major Rail Corridors in the Northeast and to the rest of the Nation, and a major Regional Airport within 3.5 Miles of the Marine Terminals; The Port of New Bedford is Ideally Suited to play a major Intermodal Shipping Role.

Apex Companies, LLC

Memo

To: File

From: Chet Myers, P.E., LSP

Date: April 14, 2010

List of Attendees:

Ronald A. Klempner, Managing Principal, Jersey Harborside

Daniel J. Wahle, Vice President Marketing, Mass Coastal

Chet Myers, Senior Engineer, Apex Companies, LLC

Jessica Fernandes, Assistant Port Director, NBHDC

Re: Summary of Meeting with Jersey Harborside Personnel

Meeting was held at New Bedford Harbor Development Commission at approximately 12 PM. NBHDC was marketing the port to Jersey Harborside, which plans to import containers to southeast Massachusetts. Jersey Harborside was particularly interested in the new South Terminal extension, which is anticipated to create a significant amount of potential loading and unloading area.

Containers would be shipped into the harbor on a very large vessel (Panamax-sized vessels) that are approximately 500 tons. They anticipate shipping of 3,000,000 tons of cargo per year. Ideal space requirements are between 10 and 20 acres for staging of materials. Of particular interest to Jersey Harborside was the potential to capture shipment of seafood processing output on their out-bound trips (i.e. a cargo being shipped from New Bedford could double the profitability of the operation, rather than just shipping to New Bedford).

Ideal warehousing corridors for material shipped through New Bedford are along the 128 corridor, along the Route 95 Corridor south of Boston, and the 495 Corridor north of Route 90 and Worcester. Shipping containers would require between 15 ft and 30 ft of draft, depending upon the vessel utilized.

NBHDC took Jersey Harborside on a tour of available resources within the Harbor, including the New Bedford Railyard, North Terminal, State Pier, South Terminal, and the NSTAR facility. Jersey Harborside restated that South Terminal was the ideal location for their shipping operation once it was completed.

Currently the team is evaluating multiple ports, but once settled on a port, would take apporoximately 18-24 months to ramp up the operation. Therefore, construction of the facility, and use of the facility (initially) by offshore renewable wind energy would not prevent its future use by Jersey Harborside.

Vision and Mission

The Realization of America's Marine Highway

AFL's Mission

Our thesis is simple: Build, own, and operate the first fully compliant Jones Act Short Sea/Feedering container liner

AFL will build, own, and operate 100% U.S. built, flagged, and manned Jones Act compliant container vessels.

AFL's fleet of ships will:

service in the United States. AFL will build ships based on proven European designs and deploy its vessels into a fully integrated container Short Sea/Feedering operation based on systems now in operation in Europe, Asia and South America.

AFL's Operational Management Team will be sourced from the pool of professional European managers who are currently running feedering operations and a unique team of American professionals.

AFL's Vision

AFL is the United States' first Short Sea/Feeder Shipping liner service with a business model based on successful International Short Sea/Feeder operations in existence today.

- Introduce and establish the Hub and Spoke container network in the U.S.,
- Be a logical replacement for the existing aging and obsolete Jones Act fleet,
- Facilitate the deployment of the fleet of "Super Ships" now being delivered to the International liner companies along the U.S. East and Gulf coasts. In the future, AFL's feeders will seamlessly distribute large numbers of containers unloaded at one time from the Super Ships that will soon be able make direct Asian/U.S. East/Gulf coast calls via the widened Panama canal, and
- offer a "green" coastal seaborne transportation solution to U.S. importers and exporters who rely on the international container liner system to move their goods around the world.

Follow American Feeder Lines

Studies:

"Building America's Future Educational Fund"

Building America's Future Educational Fund (BAF Ed Fund) is a bipartisan coalition of elected officials dedicated to bringing about a new era of U.S. investment in infrastructure. >> **Read more - PDF-Format**.

"Failure to Act - The economic impact of current Investment Trends in surface Transportation Infrastructure"

"Failure to Act - The economic impact of current Investment Trends in surface Transportation Infrastructure" illustrates how different types of surface transportation infrastructure deficiencies affect the U.S. economy. >> **Read more - PDF-Format**.

"We have a task before us to rebuild America. As a nation, we need to continue to be the world leader in infrastructure development. We cannot stand by while our infrastructure ages and crumbles."

Ray LaHood (Dec. 19, 2008), U.S. Secretary of Transportation since 2009

@AmericanFeeder

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Like 38

AFL TELL A FRIEND

AFL NEWSLETTER

Feeder Shipping

The Realization of America's Marine Highway

Feeder ships are common throughout the world in virtually all regions and on every continent except North America, where there is container on barge feeder service operating on limited routes in the Northeast-Mid Atlantic region. Feeder service has

Approximately 50 percent of the transshipment volume was feeder related volume. Accordingly, total 2006 worldwide short sea/feeder volume equaled approximately 57,500,000 TEUs.

become an established operation over the last 30 years elsewhere in the global marketplace.

In 1980, worldwide feeder volume was approximately 2,200,000 TEUs or six percent of the total combined market. By 1990, feeder volumes were constantly above ten percent of a growing total market. By 2006, the world transshipment market was about 115,000,000 TEUs or 26 percent of the world's TEU total throughput of 487,800,000 TEUs.

Feedering is deeply integrated into the deep sea container carrier networks in the competitive global marketplace.

The total U.S. feeder volume during the last several decades was and continues to be insignificant relative to the potential. AFL will address this shortcoming by providing capacity to shift more than one percent of total U.S. TEU shipments to the marine highway in a single marine highway project.

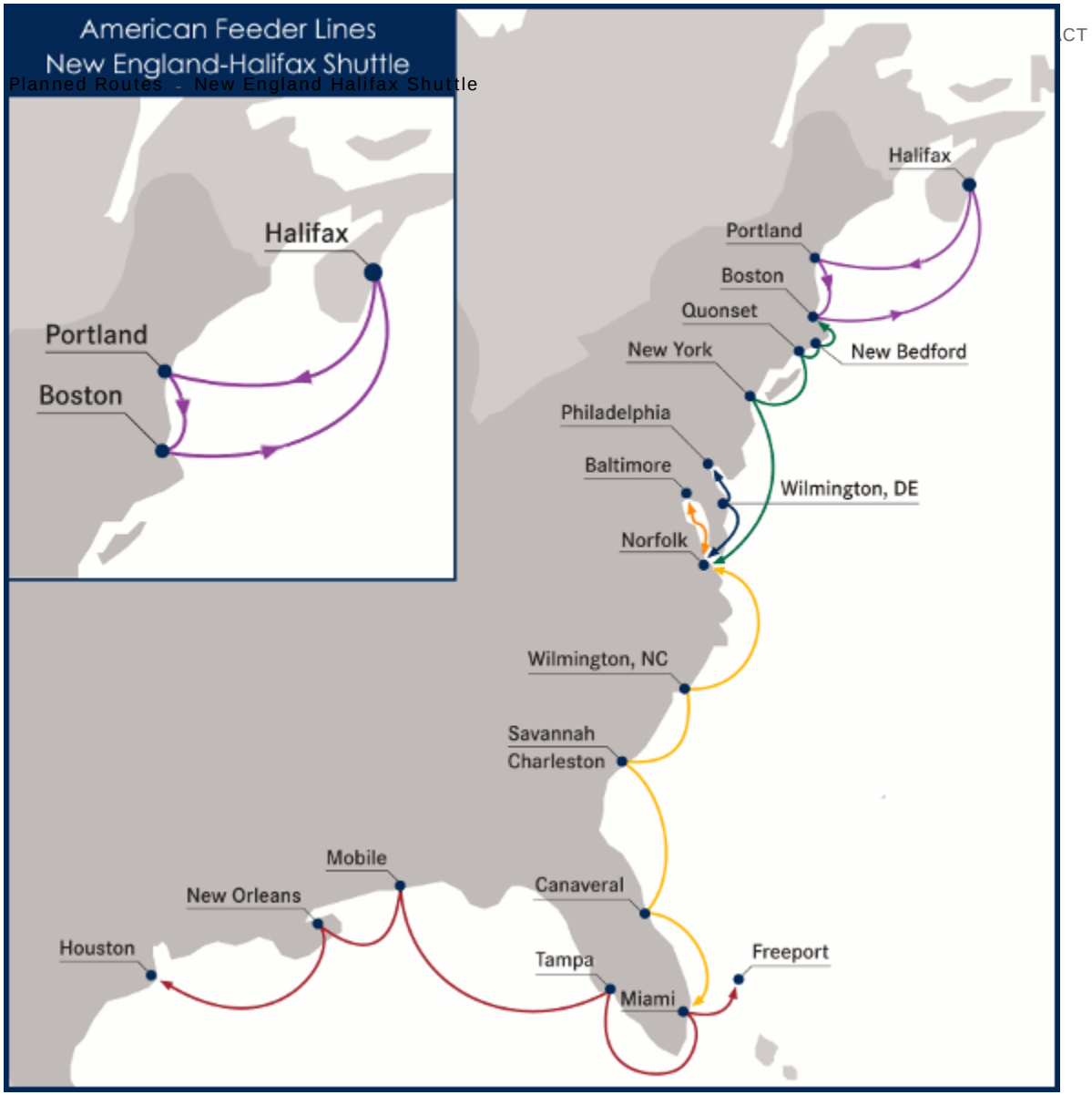
"Our current transportation model is broken. We need fresh approaches like new technology, congestion pricing, and greater private-sector investment to get America moving again."

Mary E. Peters, U.S. Secretary of Transportation 2006 - 2009

Ports, Routes and Schedules

The Realization of America's Marine Highway

Our thesis is simple: Build, own, and operate the first fully compliant Jones Act Short Sea/Feedering container liner service in the United States. AFL will build ships based on proven European designs and deploy its vessels into a fully integrated container Short Sea/Feedering operation based on systems now in operation in Europe, Asia and South America.


American Feeder Lines
New England-Halifax Shuttle
Planned Routes - New England Halifax Shuttle
Halifax
Portland
Boston
Halifax
Portland
Boston
Quonset
New York
New Bedford
Philadelphia
Baltimore
Wilmington, DE
Norfolk
Wilmington, NC
Savannah
Charleston
Mobile
New Orleans
Canaveral
Houston
Tampa
Freeport
Miami

APPENDIX 25

Apex Companies, LLC

184 High Street, Suite 502, Boston, MA 02110

(617) 728-0070

DATE: Tues. Aug. 10th, 2010

TIME: 3:33pm

☐ Incoming Call X Outgoing Call ☐ Return Call

CONTACT:

Name: US Coast Guard

Address: 918 S Rodney French Blvd

New Bedford, MA 02744

Project Name: New Bedford Harbor Phase IV

Project No.: 6690

Phone: 508-991-6812

SUMMARY OF CONVERSATION:

Contacted the U.S. Coast Guard to determine whether there were any restrictions upon the size of vessels that can enter or exit New Bedford Harbor due to the New Bedford Hurricane Barrier. Administrator on duty that answered the phone discussed the issue with other personnel available at the facility and answered that the Coast Guard does not impose these restrictions. She gave me the number for the U.S. Army Corps of Engineers in New Bedford (508-994-4243) and directed me to contact them instead.

184 High Street, Suite 502, Boston, MA 02110

(617) 728-0070

DATE: Fri. Aug. 13th, 2010

TIME: 12:20pm

☐ Incoming Call X Outgoing Call ☐ Return Call

CONTACT:

Name: Sgt. Jill Simmons

Address: Port Security Team
New Bedford Harbor
New Bedford, MA 02746

Project Name: New Bedford Harbor Phase IV

Project No.: 6690

Phone: 508-989-2925

SUMMARY OF CONVERSATION:

Unable to get in contact with representatives from the US Army Corps of Engineers. Instead spoke with Sgt. Jill Simmons, a member of the Port Security Team in New Bedford Harbor. I asked her about any restrictions imposed on vessels by the Hurricane Barrier (length, width, and draft of vessels) coming into New Bedford Harbor. She stated that there is no regulation on the length of a vessel coming through the barrier, and that draft and width are the deciding dimensions.

Additionally, she stated that the maximum vessel draft that the channel through the Hurricane Barrier allows is between approximately 30 and 35 feet, depending upon the tide. She also stated that the width of the opening in the hurricane barrier is 150 feet, and that any vessel with a width smaller than this is allowed through the barrier. When requested to evaluate whether a vessel with a width of 115 feet would be allowed through the barrier, she concurred.

Sgt. Simmons stated that the Hurricane Barrier manager for the US Army Corps of Engineers New Bedford could be reached at: 508-994-4243. She also stated that Mr. Bill Norman could be contacted for additional information: 978-318-8609, Willam.F.Norman@usace.army.nil.

Apex Companies, LLC

184 High Street, Suite 502, Boston, MA 02110

(617) 728-0070

DATE: Mon. Aug. 16th, 2010

TIME: 3:00pm

☐ Incoming Call X Outgoing Call ☐ Return Call

CONTACT:

Name: Marine Traffic Control Center Dispatcher

Address: Marine Traffic Control Center
US Army Corps of Engineers
Academy Drive
Buzzards Bay, MA 02532

Project Name: New Bedford Harbor Phase IV

Project No.: 6690

Phone: 978-318-8500

SUMMARY OF CONVERSATION:

Spoke with Maurice Beaudoin, Resident Engineer at the U.S. Army Corps of Engineers' New Bedford Resident Office. Mr. Beaudoin told me to call the dispatcher at the Marine Traffic Control Center to get information concerning restrictions on vessels going through the Hurricane Barrier in New Bedford.

Called the dispatcher at the Marine Traffic Control Center of the US Army Corps of Engineers and asked him about the Hurricane Barrier restrictions on the length, width, and draft of vessels coming into New Bedford Harbor. He told me that the US Army Corps of Engineers manages the hurricane barrier in New Bedford and that they have no specific restrictions on vessels passing through the barrier. He told me that the opening in the hurricane barrier is 150 feet wide and that any vessel with a width smaller than 150 feet the U.S. Army Corps of Engineers allows through. He then told me that the depth of the channel through the hurricane barrier fluctuates with the tide, and that any vessel with a draft small enough to pass through the barrier at that given time the U.S. Army Corps of Engineers allows through. He also told me that the U.S. Army Corps of Engineers does not restrict the length of vessels traveling through the hurricane barrier. He made it clear that any vessel that can physically fit through the hurricane barrier is allowed to navigate though, and that any other specific restrictions would come from the destination of the vessel in New Bedford Harbor.

APPENDIX 26

BORING LOG

Date: 9/14/2010
Time: 8:00 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816198.2
Location:	South Terminal Expansion		Y: 2688154.5
Elevation at mudline:	-23.15'	Datum: MLLW	
Casing Type: Steel		Boring Depth: -38.5' MLLW	Boring No: A-2010-B1
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	11,2,11,13	Dark Grey, fine to coarse SAND, some silt, some fine to coarse gravel.	-25.15
4		24" 5"	19,33,39,18	Grey SILT and fine to coarse SAND, some fine to coarse gravel - TILL	-27.15
4.75		9" 4"	15, 100/3"	Grey SILT some fine to coarse sand, some fine to coarse gravel. Refusal at -27.9 MLLW.	-27.9
5.35				Cleaned hole for coring run, start core run at -28.5 MLLW.	-28.5
11	50%	5' 4.6'	7,6,6,10,14	Rock Core #1: -28.5 to - 33.5 MLLW - Intensely to moderately fractured grey Granitic Gneiss	-33.5
16	97%	5' 4.85	6,6,6,9,11	Rock Core #2: -33.5 to -38.5 MLLW - Moderately fractured grey Granitic Gneiss	-38.5

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, so drill time is not a good indicator of rock competency.

BORING LOG

Date: 9/15/2010
Time: 11:30 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816277.4
Location:	South Terminal Expansion		Y: 2688458.0
Elevation at mudline:	-6.3'	Datum: MLLW	
Casing Type: Steel		Boring Depth: -39.4' MLLW	Boring No: A-2010-B2
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 15"	1,1,1,1	Black to dark grey, Organic SILT, some fine sand, little shell hash, becomes grey in nose of spoon	-8.3
4		24" 15"	2,5,10,14	Dark Grey fine SAND, some organic silt grades to fine SAND, some inorganic silt, trace fine to coarse gravel	-10.3
6		24" 21"	12,14,14,19	-10.3 to -10.8 MLLW Grey fine SAND some fine to coarse gravel, trace coarse -10.8 to -12.0 MLLW Grey fine SAND grading to inorganic SILT and fine SAND -12.0 to -12.3 MLLW Grey Coarse SAND and fine to coarse GRAVEL	-12.3
8		24" 15"	9,17,16,20	Grey, medium to coarse SAND, little fine to coarse gravel	-14.3
10		24" 14"	5,15,15,12	Grey, medium to coarse SAND, little fine to coarse gravel, grades to fine to medium SAND	-16.3
12		24" 21"	3,4,10,12	10 - 11 Grey, fine SAND, trace silt, grades to fine to medium SAND. 11-12 Grey, fine to coarse SAND, trace fine gravel, grading to coarse SAND	-18.3
14		24" 21"	6,7,9,12	Grey, fine to medium SAND, little fine to coarse gravel	-20.3
16		24" 12.5"	14,16,24,24	Grey fine to coarse SAND, some silt, some fine to coarse gravel, mottle at 15.0 to 15.4 red/orange tan.	-22.3
18		24" 11"	8,10,3,3	Grey and Tan mottled, fine to coarse SAND, some silt, some fine to coarse gravel, grades to fine to medium SAND and SILT in nose of spoon	-24.3
19.75		21" 16"	23,32,34, 100/3"	Grey and tan mottled, fine to coarse SAND, and SILT, some fine to coarse gravel. Refusal at -26.2' MLLW.	-26.05
23.6				Drilled with button tooth roller bit through cobbles, drove casing to refusal and began core run at -29.9 MLLW	-29.9
28.1	48%	60" 47"	6,8,8,10, 5min/6"	Rock Core #1: -29.9 to -34.4 MLLW - Moderately to intensely fractured grey Granitic Gneiss, core barrel jammed at 4.5 feet into core run.	-34.4
33.1	50%	60" 44"	7,8,10,10, 10	Rock Core #2: -34.4 to -39.4 MLLW - Moderately to intensely fractured grey Granitic Gneiss	-39.4

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency.

BORING LOG

Date: 9/16/2010
Time: 11:20 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816365.6
Location:	South Terminal Expansion		Y: 2688161.5
Elevation at mudline:	-1.1'	Datum: MLLW	
Casing Type: Steel		Boring Depth: -35.7' MLLW	Boring No: A-2010-B3
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 18"	7,5,5,4	Dark Grey, very fine to fine SAND, little organic silt, trace shell hash, one juvenile clam.	-3.1
7		24" 5"	10,13,20,17	Grey, fine to coarse SAND, trace silt, charp color change to tan, fine to medium SAND, little silt. Gravel caught in nose of spoon	-8.1
12		24" 6"	16,19,20,23	4" of Grey, fine to coarse GRAVEL and fine to medium SAND, trace silt. 2" of Grey tan, SILT, some fine to coarse SAND, some fine to coarse gravel. TILL.	-13.1
17		24" 4"	17,18,14,14	Grey, SILT and fine SAND, some fine to coarse gravel, little medium to coarse sand, gravel stuck in tip of split spoon.	-18.1
22		24" 5"	80,60,40,61	Tan, fine SAND, some silt, some fine to coarse gravel, trace medium to coarse sand, gravel stuck in top of split spoon.	-23.1
24.6				Refusal while advancing casing to next interval. Cleaned hole with button toothed roller bit, flushed hole and began coring at -25.7' MLLW	-25.7
29.6	25%	5' 3.3'	5,6,19 (Jams)	Rock Core #1: -25.7 to -30.7 MLLW - Very intensely fractured grey Granitic GNEISS, with pegmatic intrusions (pink and grey).	-30.7
34.6	37%	5' 4.6'	(Frequent Jams)	Rock Core #2: -30.7 to -35.7 MLLW - Intensely fractured grey Granitic GNIESS with pegmatic (pink and grey) intrusions.	-35.7

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency, drill times were not recorded after the first 3 feet of penetration, due to frequent starts and stops of coring process as barrel jammed and was cleared.

BORING LOG

Date: 9/20/2010
Time: 8:05 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816439.9
Location	South Terminal Expansion		Y: 2687856.3
Elevation at mudline:	-2.5'	Datum: MLLW	
Casing Type: Steel		Boring Depth: -43.75' MLLW	Boring No: A-2010-B4
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 24"	WOH, WOH, WOH, WOH	Black, Organic SILT, little shell hash, little fine to medium sand.	-4.5
4		N/A N/A	N/A	No split spoon this interval.	-6.5
6		24" 3.5"	1,1,1,1	Dark Grey to Black, fine to medium SAND and SILT, little shell hash.	-8.5
8		24" 13"	13,6,8,9	Grey, fine to medium SAND, some Silt, little fine to coarse gravel	-10.5
10		24" 12"	9,17,20,20	Grey, fine GRAVEL, some coarse sand, little coarse gravel. Coarse gravel stuck in nose of spoon.	-12.5
12		24" 11"	10,8,10,12	Grey, fine SAND, some silt, some fine to coarse gravel, trace medium to coarse sand.	-14.5
14		24" 8"	8,14,16,11	Grey, fine SAND, some fine to coarse gravel, trace silt.	-16.5
16		24" 9"	49,9,8,13	Grey SILT, some fine sand, little fine to coarse gravel, little medium to coarse sand. Mottled interval approx 0.25 to 0.5' becomes brown, then back to grey.	-18.5
18		24" 10"	24,20,18,16	SILT, some fine to coarse sand, some fine to coarse gravel, Color changes: 0.0-0.25' grey, 0.25-0.55' light grey,0.55-0.80' brown .	-20.5
20		24" 10"	13,12,21,14	Tan SILT and GRAVEL, some fine to coarse sand	-22.5
21.66		20" 10"	17,10,15, 100/2"	Tan, SILT, some fine to coarse gravel, some fine to coarse sand. 3" of grey, completely weathered Granitic Gneiss in nose of spoon. Refusal at -24.16 MLLW.	-24.16
22.7				Drilled with button tooth roller bit, cleaned hole, and began core run at -25.2 MLLW.	-25.2
26.7	0%	48" 20"	10,12,19, (Jam)	Rock Core #1: -25.2 to -29.2 MLLW - Shattered greenish Grey Granitic Gneiss (11" in pieces none longer than 3") Potassium Feldspar rich Pegmatic intrusion (9" in pieces none longer than 3"), core barrel jammed at 1.5, water return stopped intermittently through core run, drilling paused each time	-29.2
29.7	0%	36" 25"	6,6,14, (Jam)	Rock Core #2: -29.2 to -32.2 MLLW - Interface of Pegmatite and Granitic Gneiss (2"), highly fractured grey Granitic Gneiss (23") No unfractured pieces greater than 4"	-32.2
31.7	0%	24" 16"	(Frequent Jams)	Rock Core #3: -32.2 to -34.2 MLLW - Highly fractured grey Granitic Gneiss (16") No unfractured pieces greater than 4"	-34.2
36.7	0%	60" 36"	(Frequent Jams)	Rock Core #4: -34.2 to -39.2 MLLW - Highly fractured pink and greenish grey Granitic Gneiss (36") No unfractured pieces greater than 4", shattered between 18" and 25" includes quartz vein 19"-20"	-39.2
41.7	82%	60" 58"	(Frequent Jams)	Rock Core #5: -39.2 to -43.75 MLLW - Highly fractured pink and greenish grey Granitic Gneiss (21") Grades to grey Granitic Gneiss until sharp increase in potassium feldspar content at 56" changes hue back to pink and grey Granitic Gneiss.	-43.75

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency. Drill times were not recorded on portions of Rock Cores 1 and 2 as well as Rock Cores 3, 4, and 5, due to frequent starts and stops of coring process as barrel jammed and was cleared.

BORING LOG

Date: 3/7/2011
Time: 8:30 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816478
Location:	South Terminal Expansion		Y: 2687708
Elevation at mudline:	-3.7	Datum: MLLW	
Casing Type: Steel		Boring Depth: -45.30' MLLW	Boring No: A-2011-B5
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
3		36" 24"	WOR,WOR, WOR,WOR	Black, organic SILT, trace shell hash.	-6.7
5		24" 24"	WOR,WOR, WOR,WOR	Black, organic SILT, trace shell hash, trace gravel.	-8.7
7		24" 12"	3,1,5,10	Black, organic SILT, trace shell hash, trace fine gravel, grades to greenish-grey, fine to medium SAND, trace fine gravel.	-10.7
9		24" 18"	16,29,26,28	Greenish grey, fine to coarse SAND, some fine to coarse gravel, trace silt	-12.7
11		24" 6"	17,8,7,10	Greenish grey, fine SAND some fine to medium sand, little fine gravel	-14.7
13		24" 6"	37,31,20,30	Greenish grey, fine to medium SAND, some coarse sand, some fine gravel, trace silt	-16.7
15		24" 12"	14,10,12,17	Greenish grey, fine to medium SAND, some coarse sand, some fine gravel, trace silt	-18.7
17		24" 0	25,9,8,11	No Recovery	-20.7
19		24" 2"	20,18,21,17	Greenish grey, fine to medium SAND, some coarse sand, some fine gravel, trace silt	-22.7
21		24" 10"	16,16,19,22	Olive grey, medium to coarse SAND, some fine sand, some fine gravel	-24.7
23		24" 12"	7,9,11,8	Olive grey, medium to coarse SAND, some fine sand, some fine gravel	-26.7
25		24" 12"	23,24,21,15	Olive grey, medium to coarse SAND, some fine sand, some fine gravel, transitions to olive grey, fine to medium SAND, trace silt	-28.7
26.25		15" 7"	17,16, 100/3"	Olive grey, fine to medium SAND, some silt, some gravel. Refusal at -29.95.	-29.95
26.60				Drilled with mill tooth roller bit, cleaned hole, and began core run at -30.30.	-30.3
31.60	48%	5.0' 4.4	6,6,7,6,6	Rock Core #1 -30.30' to -35.30' MLLW. 0.0-4.0' intensely to moderately fractured grey, GRANITE, 4.0 to 4.4' intensely fractured moderately weathered grey GRANITE	-35.3
36.60	49%	5.0' 4.35	8-7-8-7-7	Rock Core #2 -35.30' to -40.30' MLLW. 0.0' - 0.6' moderate to heavily weathered, moderately fractured grey, granitic GNEISS, 0.6' - 3.4' fresh, moderately fractured, grey, granitic GNEISS, gneissic banding progressively decreases, 3.4'-4.4' grey GRANITE	-40.3
41.60	74%	5.0' 4.9'	7-8-8-7-7	Rock Core #3 -40.30' to -45.30' MLLW. 0.0-2.2' intensely to moderately fractured grey, granitic GNEISS. 2.2-3.6' gradual transition into and out of intensly to moderately fractured pink and grey granite PEGMATITE, 3.6-4.9' intensely to moderately fractured grey granitic GNEISS	-45.3

Comments: The descriptions of the rock in the cores above are descriptions of the sampled rock in each recovered core length.

BORING LOG

Date: 9/23/2010
Time: 9:30 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816518.5
Location:	South Terminal Expansion		Y: 2687561.6
Elevation at mudline:	-9.4	Datum: MLLW	
Casing Type: Steel		Boring Depth: -31.6' MLLW	Boring No: A-2010-B6
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	WOR,WOR, WOR,WOR	0-1' Black, organic SILT 1'-2' Olive grey, medium to coarse SAND, some fine sand, trace silt	-11.4
6		24" 12"	20,22,41,30	Greenish grey, medium to coarse SAND, some fine gravel	-15.4
10		24" 12"	12,16,22,15	Greenish grey, medium to coarse SAND, some fine gravel.	-19.4
12.2				Drove casing to refusal, cleaned hole, and began core run at -21.6 MLLW	-21.6
17.2	73%	60" 51"	7,7,6,5,7	Rock Core #1: -21.6 to -26.6 MLLW - Intensely to moderately fractured grey granitic Gneiss.	-26.6
22.2	27%	60' 50"	8,12,6,7,6	Rock Core #2: -26.6 to -31.6 MLLW - Intensely fractured grey Granitic Gneiss (0"-36"), intensely fractured pink and grey Granite Pegmatite (36" to 50").	-31.6

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency.

BORING LOG

Date: 9/24/2010
Time: 12:15 PM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816781.1
Location:	South Terminal Expansion		Y: 2687710.6
Elevation at mudline:	-5.5	Datum: MLLW	
Casing Type: Steel		Boring Depth: -28.0' MLLW	Boring No: A-2010-B7
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 12"	WOR,6,8,8	0-1' Black, organic SILT 1'-2' Olive Grey, fine to medium SAND, some shell hash, trace silt	-7.5
4		24" 12"	9/11/12/16	Olive Grey, fine to medium SAND, some shell hash, trace silt	-9.5
6		24" 12"	7/5/7/5	4'-4.5' Olive Grey, fine to medium SAND, some shell hash, trace silt 4.5'-6' Greenish grey, fine SAND and SILT	-11.5
8		24" 17"	15/23/100-5"	6'-7' Olive Grey, fine to medium SAND, some shell hash, trace silt 7'-7.4' Olive grey, fine SAND and SILT	-13.5
10		24" 24"	18/14/12/17	8'-8.5' Greenish grey, fine to medium SAND and fine angular GRAVEL 8.5'-9.5' Light grey, fine to medium SAND, some coarse SAND 9.5'-10' Greenish grey, fine SAND and SILT	-15.5
12		24" 24"	15/18/24/58	10'-11.5' Greenish grey, fine SAND and SILT, trace fine angular gravel 11.5'-12' Olive grey, medium to coarse SAND, trace rock fragments at tip.	-17.5
12.5				Drove casing to refusal, cleaned hole, and began core run at -18.0 MLLW	-18
17.5	88%	60" 56"	11/10/12/15/12	Rock Core #1: -18.5to -23.5 MLLW - Highly to moderately fractured grey and pink Granitic Gneiss	-23
22.5	61%	60" 40"	8/8/7/8/9	Rock Core #2: -23.5 to -28.5 MLLW - Highly to moderately fractured grey and pink Granitic Gneiss	-28

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency.

BORING LOG

Date: 9/27/2010
Time: 11:50 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816477.0
Location:	South Terminal Expansion		Y: 2688656.0
Elevation at mudline:	-17.4	Datum: MLLW	
Casing Type: Steel		Boring Depth: -46.2' MLLW	Boring No: A-2010-B8
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 0"	WOR,WOR, WOR,WOR	No recovery sample taken	-19.4
4		24" 18"	WOR,WOR, WOR,WOR	Black, organic SILT	-21.4
6		24" 12"	8/13/24/31	4'-5' Black, organic SILT 5'-6' Lt. grey, fine to medium SAND and SILT, trace rock fragments	-23.4
8		24" 12"	26/21/56/48	Lt. grey, fine to medium SAND and SILT, trace rock fragments	-25.4
10		24" 0"	100-0"	No recovery sample taken, drilled with button tooth roller bit through cobbles	-27.4
13				Drilled with button tooth roller bit through cobbles	-30.4
15		24" 12"	46/39/23/24	13'-15' Olive grey, coarse SAND, trace fine sand, trace fine gravel	-32.4
17		24" 12"	13/17/14/21	Olive grey, coarse SAND, some fine sand, trace rock fragments	-34.4
18				Drove casing to refusal, cleaned hole, and began core run at -36.2 MLLW	-34.5
23	53%	60" 54"	14/13/18/11/ 13	Rock Core #1: -36.2 to -41.2 MLLW - Intensely fractured dark grey Basalt(0-9.5"), moderately fractured pink and grey Granitic Gneiss (9.5-27"), dark grey intensely to moderately fractured Basalt (27"- 54").	-39.5
28	50%	60" 50"	12/15/11/12/ 14	Rock Core #2: - -41.2 to -46.2 MLLW - Intensely fractured dark grey Basalt (0-13"), moderately to intensly fractured pink and grey Granitic Gniess (13"-19"), dark grey intensely to moderately fractured Basalt (19"-50").	-44.5

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency.

BORING LOG

Date: 9/28/2010
Time: 11:10 AM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816215.8
Location:	South Terminal Expansion		Y: 2689415.8
Elevation at mudline:	-21.25	Datum: MLLW	
Casing Type: Steel		Boring Depth: -38.83' MLLW	Boring No: A-2010-B9
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 12"	WOR,WOR, WOR,WOR	Black, organic SILT	-23.25
4		24" 12"	10/24/22/19	2'-2.5' Black, organic SILT 2.5'-4' Olive grey, fine to medium SAND, some silt, some angular fine gravel.	-25.25
6		24" 12"	56/33/27/52	Lt. grey, coarse sub rounded SAND, trace rock fragments in tip	-27.25
6.58		7" 7"	53/100-1"	Lt. grey, fine to medium SAND, trace silt, trace rock fragments	-27.83
11.58	35%	60" 37"	6/7/7/6/9	Rock Core #1: -27.83 to -32.83 MLLW - Intensely fractured pink and grey Granitic Gneiss.	-32.83
12.58				Drilled with button tooth roller bit through fractured rock	-33.83
17.58	0%	60" 26"	(Frequent Jams)	Rock Core #2: -33.83 to -38.83 MLLW - Intensely fractured grey Gneiss	-38.83

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency. On second run, core barrel was jammed in the boring. Decision was made to move 20' north in order to obtain confirmation cores.

BORING LOG

Date: 9/29/2010
Time: 12:18 PM

Project:	Phase IV Dredging	Project No: 6690.005	X: 816207.2
Location:	South Terminal Expansion		Y: 2689452.9
Elevation at mudline:	-21.05	Datum: MLLW	
Casing Type: Steel		Boring Depth: -42.05' MLLW	Boring No: A-2010-B9A
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Todd Pentacost	Log By: GRM	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
6				Boring A-2010-B9A located 20 feet to the north along the South Terminal Bulkhead from Boring A-2010-B9. See boring log for Boring A-2010-B9A for overburden information. Advanced casing to refusal, cleaned hole, and began core at -27.05' MLLW.	-27.05
11	65%	60" 57"	5/6/8/10/11	Rock Core #1: -27.05 to -32.05 MLLW - Intensely to moderately fractured dark grey Gneiss.	-32.05
16	44%	60" 48"	3/7/8/5/7	Rock Core #2: -32.05 to -37.05 MLLW - Intensely to moderately fractured dark grey Gneiss.	-37.05
21	37%	60" 33"	3/5/6/2/4	Rock Core #3: -37.05 to -42.05 MLLW - Intensely to moderately fractured dark grey Gneiss.	-42.05

Comments: Core run was completed at less revolutions per minute than recommended by core barrel manufacturer, drill time is not a good indicator of rock competency. Overburden sampling not completed on this hole. For representative information of overburden material, see boring log for Boring A-2010-B9

BORING LOG

Date: 2/21/2011
Time: 8:20 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816322
Location:	South Terminal Expansion		Y: 2688299
Elevation at mudline:	-0.9	Datum: MLLW	
Casing Type: Steel		Boring Depth: -50.79' MLLW	Boring No: A-2011-B10
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 12"	2,4,4,4	Dark grey, very fine SAND, little organic silt, trace shell hash.	-2.9
7		24" 18"	2,1,1,1	Black to dark grey, organic SILT, little inorganic silt, trace fine sand.	-7.9
12		24" 20"	33,33,30,32	4" - Black to dark grey, organic SILT, little inorganic silt, trace fine sand. Grey, fine to coarse SAND, little silt, trace to little fine to coarse gravel.	-12.9
17		24" 14"	17,23,20,20	Grey, fine SAND, little medium to coarse sand, trace fine to coarse gravel, trace silt, TILL	-17.9
19.05				Boulder encountered approx. elev.= -18.75 to -19.95 MLLW.	-19.95
22		24 12"	16,41,46,35	Grey, fine to coarse SAND,some fine to coarse gravel, little silt, TILL	-22.9
27		24" 8"	98,36,44,57	Grey, becoming tan, fine to coarse SAND, some silt, some fine to coarse gravel, TILL.	-27.9
30.89				Drilled with mill tooth roller bit. Boulder encountered approx. elev. -29.60 to -30.40 MLLW. Cleaned hole and began core run at -31.79 MLLW.	-31.79
35.89	13%	5.0' 2.9'	5-5-5-5-15	Rock Core #1 -31.79 to -36.79 MLLW. Grey, intensely fractured to very intensely fractured Granitic GNEISS, sand filled seams throughout. Return water color changes at 2.3, 2.5, 2.8, 3.5-3.7, 3.9, 4.2. Barrel jamming last foot of run drilling time does not reflect hardness of rock.	-36.79
39.89	22%	5.0' 3.0'	4-3-3-10	Rock Core #2 -36.79 to -40.79 MLLW. Grey, intensely fractured to very intensely fractured Granitic GNEISS, with sand filled seams, Barrel jamming last foot of run drilling time does not reflect hardness of rock.	-40.79
44.89	50%	5.0' 5.0'	3-3-4-4-6	Rock Core #3 -40.79 to -45.79 MLLW. Grey, intensely to moderately fractured Granitic GNEISS,	-45.79
49.89	75%	5.0' 4.9'	5-4-3-3-3	Rock Core #4 -45.79 to -50.79 MLLW. Grey to pink, moderately to slightly fractured, Granite PEMATITE	-50.79

Comments:

BORING LOG

Date: 2/22/2011
Time: 12:42 PM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816397
Location:	South Terminal Expansion		Y: 2688013
Elevation at mudline:	-1.5	Datum: MLLW	
Casing Type: Steel		Boring Depth: -40.65' MLLW	Boring No: A-2011-B11
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 9"	2,3,4,4	Dark grey, fine to medium SAND, little organic silt, little shell hash.	-3.5
7		24" 15'	1,WOH,WOH, 2	3" Black organic SILT, little shell hash. 12" Dark grey to black, fine SAND and organic/inorganic SILT, trace shell hash.	-8.5
12		24" 14'	39,36,38,30	Grey, inorganic SILT and fine to medium SAND, trace fine to coarse gravel, Till like	-13.5
16		12" 5"	57, 100/6"	Dark grey to black with brown, micacious fine SAND and fine to coarse GRAVEL, little silt.	-17.5
17.2				Boulder encountered approx. elev.= -17.5 MLLW to -18.7 MLLW.	-18.7
22		24" 12"	15,16,25,19	Tan grey, fine to medium SAND, little to trace silt, trace coarse sand, trace fine gravel.	-23.5
25.83		10" 4"	55,100/4"	Tan, medium to coarse SAND, some fine to coarse gravel, trace silt. Cobble encountered at approximate elevation -27.33 MLLW.	-27.33
26.75				Drilled with mill tooth roller bit to approx. elevation -28.25 MLLW.	-28.25
29.15				Drove casing to refusal, drilled with mill tooth roller bit into rock and flushed casing before start of core run. Began first core run at -30.65 MLLW.	-30.65
31.75	74%	5.0' 4.9'	6-4-7-4-5	Rock Core #1 -30.65 to -35.65 MLLW Grey, moderately fractured Granitic GNEISS	-35.65
36.75	88%	5.0' 5.0'	4-4-5-5-5	Rock Core #2 -35.65 to -40.65 MLLW Grey, intensely to moderately fractured, Granitic GNEISS	-40.65

Comments:

BORING LOG

Date: 2/23/2011
Time: 10:32 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816344
Location:	South Terminal Expansion		Y: 2687989
Elevation at mudline:	-1.2	Datum: MLLW	
Casing Type: Steel		Boring Depth: -49.15' MLLW	Boring No: A-2011-B12
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 3"	4,1,WOH,2	Dark grey, very fine SAND, little organic silt, little shell hash.	-3.2
7		24" 6"	1,1,1,30	Greenish dark grey, SILT, little fine to coarse gravel.	-8.2
12		24" 0"	36,22,25,23	No Recovery in Split Spoon	-13.2
17		24" 15"	15,10,12,25	Grey, fine to medium SAND and GRAVEL, trace silt.	-18.2
22		24" 6"	33,37,29,81	Light grey, fine to medium SAND and SILT, some medium gravel.	-23.2
27.35				Drilled with mill tooth roller bit through cobbles with multiple sand seams. Encountered obstruction at approx. elev. -24.35 MLLW. Drilled through 1' boulder. Cleaned hole, and began core run at -26.15 MLLW.	-26.15
27.95	63%	3.0' 2.2'	no drill time available	Rock Core #1A -26.15 to -29.15 MLLW Grey and pink, moderately to intensely fractured, fresh to slightly weathered GRANITE pegmatite	-29.15
30.95	75%	2.0' 1.9'	no drill time available	Rock Core #1B -29.15 to -31.15 MLLW Grey and pink, moderately to intensely fractured fresh to slightly weathered granite PEGMATITE, shattered granite PEGMATITE -31.55 to -32.15 MLLW.	-32.15
34.95	82%	5.0' 5.0'	7-7-7-6-6	Rock Core #2 -31.15 to -36.15 MLLW Grey and pink, moderately to intensely fractured fresh to slightly weathered granite PEGMATITE, shattered granite PEGMATITE -35.65 to -36.15	-36.15
37.95	25%	3.0' 1.7'	4-4-5	Rock Core #3A -36.15 to -39.15 MLLW Grey and pink, intensely fractured, slightly weathered, granite PEGMATITE	-39.15
42.95	78%	5.0' 5.0'	4-3-4-4-4	Rock Core #3B -39.15 to -44.15 MLLW Grey, moderately fractured, fresh to slightly weathered, granitic GNEISS	-44.15
47.95	92%	5.0' 5.0'	4-4-3-5-4	Rock Core #4 -44.15 to -49.15 MLLW Grey, intensely to moderately fractured, fresh to slightly weathered, granitic GNEISS	-49.15

Comments:

Date: 2/24/2011
Time: 12:30 PM

BORING LOG

Project:	Phase IV Dredging	Project No: 6690.008	X: 816419
Location:	South Terminal Expansion		Y: 2687691
Elevation at mudline:	-1.3	Datum: MLLW	
Casing Type: Steel		Boring Depth: -46.6' MLLW	Boring No: A-2011-B13
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 3"	WOH, WOH, WOH, WOH	Black, organic SILT, little shell hash.	-3.3
7		24" 15"	WOR,1,5,6	Greenish grey, fine SAND and SILT, trace shell hash.	-8.3
12		24" 0"	30,45,53,63	No Recovery in Split Spoon, piece of Granitic GNEISS in nose cone.	-13.3
17		24" 0"	54,58,61,71	No Recovery in Split Spoon, piece of Granitic GNEISS in nose cone. Encountered obstruction at approx. 18.5' below mudline - apparent 1' boulder.	-18.3
22		24" 2"	16,18,17,18	Grey, SILT, some fine to coarse gravel.	-23.3
27		24" 3"	18,21,23,20	Tan, coarse SAND and GRAVEL, trace fine sand, trace silt.	-28.3
28.3				Casing advanced to refusal at -29.6 MLLW. Cleaned hole, and began core run at -29.6 MLLW.	-29.6
35.30	42%	7.0' 5.0'	4-5-6-5-4	Rock Core #1 -29.6' to -30.6' MLLW highly fractured Granitic GNEISS (potential cobble layer or obstruction). At approximate elev. -30.6' MLLW, core barrel penetrated potential cobble layer or obstruction and entered a 2' layer of apparent sediment. Wash changed color from milky white to tan, and contained sand. Continued coring from -32.6 MLLW to -36.6 MLLW - fractured Granitic GNEISS.	-36.6
40.30	79%	5.0' 5.0'	5-4-3-4-5	Rock Core #2 -36.6 to -41.6 MLLW fractured Granitic GNEISS	-41.6
45.30	51%	5.0' 4.8	6-5-7-7-6	Rock Core #3B -41.6 to -46.6 MLLW fractured Granitic GNEISS	-46.6

Comments:

BORING LOG

Date: 2/24/2011
Time: 12:30 PM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816360
Location:	South Terminal Expansion		Y: 2687402
Elevation at mudline:	-1.85	Datum: MLLW	
Casing Type: Steel		Boring Depth: -31.95' MLLW	Boring No: A-2011-B14
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	WOR, WOR, WOR, WOR	Black, organic SILT.	-3.85
7		24" 15"	51,48,49,55	6" of Light grey, fine SAND and SILT. Light grey, fine to medium SAND, trace silt.	-8.85
12		24" 10"	63,58,52,58	8" Lt grey, fine to medium SAND, trace silt, becomes lt. grey, fine to coarse SAND, trace silt, trace gravel, 0.8' boulder encountered -14.2' MLLW	-13.85
17		24" 4"	24,9,10,14	Grey, fine to coarse SAND and fine GRAVEL.	-18.85
20.1				Casing advanced to -20.45 MLLW. Drilled with mill-tooth roller bit to -21.95 MLLW, cleaned hole, seated casing, and began core run.	-21.95
25.10	67%	5.0' 4.9'	6-8-8-7-8	Rock Core #1 -21.95 to -26.95 MLLW 4.5' fractured grey Granitic GNEISS, 0.4' pink Granite PEGMATITE	-26.95
30.10	60%	5.0' 5.1	5-5-5-5-5	Rock Core #2 -26.95 to -31.95 MLLW 0.5' pink Granite PEGMATITE, 0.3' shattered interface, grey fractured Granitic GNEISS	-31.95

Comments:

BORING LOG

Date: 3/2/2011
Time: 7:15 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816254
Location:	South Terminal Expansion		Y: 2687498
Elevation at mudline:	-0.6	Datum: MLLW	
Casing Type: Steel		Boring Depth: -40.55' MLLW	Boring No: A-2011-B15
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 18"	WOR, WOR, WOR, WOR	Black, organic SILT	-2.6
7		24" 18"	3,3,3,10	12" Black, organic SILT 6" Black, fine SAND and organic SILT	-7.6
12		24" 6"	33,40,34,56	Light grey, fine to coarse SAND, some fine gravel.	-12.6
17		24" 8"	31,76,40,27	Grey, medium to coarse SAND, trace fine sand, trace silt.	-17.6
19.5		6" 6"	100/6"	Blue grey, fine to coarse SAND, trace rock fragments. Refusal at -20.10' MLLW.	-20.1
19.95				Casing advanced to -20.55 MLLW. Cleaned hole, and began core run at -20.55 MLLW.	-20.55
24.95	44%	5.0' 5.0'	6-5-7-6-5	Rock Core #1 -20.55 to -25.55 MLLW 0.0 -1.0' moderate to intensely fractured dark grey DIABASE, 1.0-4.6 moderately to intensely fractured grey granitic GNEISS, 4.6'-5.0' interface of grey granitic GNEISS and dark grey DIABASE	-25.55
29.95	59%	5.0' 5.0'	5-6-6-5-6	Rock Core #2 -25.55 to -30.55 MLLW 0.0-0.75' intensely to moderately fractured grey granitic GNEISS, 0.75-1.75 intensely to moderately fractured dark grey DIABASE, 1.75'-4.8' moderately fractured grey granitic GNEISS showing reoriented gneissic banding, 4.8'-5.0 DIABASE	-30.55
34.95	68%	5.0' 5.0'	6-5-6-7-6	Rock Core #3 -30.55 to -35.55 MLLW 0.0-0.9' moderately fractured green grey DIABASE, 0.9-5.0 moderately fractured contact metamorphic and igneous mixing zone Gneiss and Diabase Xenoliths in GRANITE PEGMATITE.	-35.55
39.95	38%	5.0' 5.1'	7-6-7-7-8	Rock Core #4 -35.55 to -40.55 MLLW moderately fractured contact metamorphic and igneous mixing zone Gneiss and Diabase Xenoliths in GRANITE PEGMATITE.	-40.55

Comments: DIABASE in this boring is moderately to highly weathered.

BORING LOG

Date: 3/3/2011
Time: 8:20 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816262
Location:	South Terminal Expansion		Y: 2688283
Elevation at mudline:	-0.4	Datum: MLLW	
Casing Type: Steel		Boring Depth: -50.45' MLLW	Boring No: A-2011-B16
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 14"	11,12,10,2	Grey, fine SAND, little silt, trace shell hash.	-2.4
7		24" 12"	2,2,3,4	Dark grey, organic SILT, trace shell hash, grades to grey, inorganic and organic SILT, and very fine SAND, trace shell hash.	-7.4
12		24" 14"	60,33,29,48	Grey brown fine to coarse SAND and SILT trace fine to coarse gravel, TILL	-12.4
17		24" 9"	13,20,47,25	Grey, fine SAND, some medium to coarse sand, little fine to coarse gravel, little silt.	-17.4
22		24" 14"	50,43,46,29	Grey, SILT, some fine to coarse sand, little fine ot coarse gravel, TILL, obstruction encountered -22.65' to approx. -24.05 MLLW (see comments).	-22.4
27		24" 6"	16,23,57,27	Grey and yellow brown, SILT and fine to coarse gravel, little fine to coarse sand, TILL.	-27.4
28.05				Drilled with mill tooth roller bit until obstruction encountered -27.95' MLLW. Cleaned hole, and began core run at -28.45 MLLW.	-28.45
33.05	72%	5.0' 4.9	5-7-8-22-7	Rock Core #1 -28.45 to -33.45 MLLW 0.0 -1.0' moderate to intensely fractured grey granitic GNEISS	-33.45
38.15	60%	5.0' 5.0'	5-5-7-7-7	Rock Core #2 -33.45 to -38.55 MLLW 0.0'-5.0' intensely to moderately fractured granitic GNEISS, shattered pegmatic intrusion 0.4'-0.9', high angle fractures @ 1.9-2.2' and 4.5-5.0'	-38.55
43.15	30%	5.0' 5.0'	7-16-6-8-7	Rock Core #3 -38.55 to -43.55' MLLW 0.0-1.4' intensely to moderately fractured grey, granitic GNEISS, 1.4-4.3' intensely to moderately fractured grey GRANITE, 4.3-5.0' intensely to moderately fractured grey granitic GNEISS, core jammed in barrel 1.4'	-43.55
48.15	77%	5.0' 4.8	6-15-7-6-7	Rock Core #4 -43.55 to -48.55 MLLW moderately fractured grey, granitic GNEISS	-48.55
50.05	100%	1.9 1.9	7-15	Rock Core #5 -48.55 to -50.45' MLLW slightly fractured grey, granitic GNEISS	-50.45

Comments: Obstruction encountered at -22.65 MLLW was not penetrated by roller bit, began coring at -23.25 MLLW, core barrel exited boulder at -24.05 MLLW, and soil cuttings in wash suggest till material encountered in interval above.

BORING LOG

Date: 3/8/2011
Time: 8:40 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816220
Location:	South Terminal Expansion		Y: 2689671
Elevation at mudline:	-20.8	Datum: MLLW	
Casing Type: Steel		Boring Depth: -36.4 MLLW	Boring No: A-2011-B17
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GAD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 8"	WOR,WOR, WOR,WOR	Black, organic SILT	-22.8
6.25		15" 9"	30,23, 100/3"	Greenish grey, fine to coarse SAND, some fine gravel	-27.05
8.5				Encountered Obstruction -28.9' MLLW, drilled with roller bit to -29.3' MLLW, then attempted core run.	-29.3
9.5	N/A	1.0' 1.0'	7	Rock Core #1 -29.3 to -30.3 MLLW - Penetrated obstruction (boulder). One foot of recovery in core barrel.	-30.3
15.6				Wash water indicates a series of nested boulders or highly fractured rock below obstruction. Unable to advance casing past obstruction. Drilled with roller bit through obstruction until top of competent rock (interpreted from cuttings in wash water). Final elevation at -36.4 MLLW.	-36.4

Comments:

BORING LOG

Date: 3/9/2011
Time: 8:15 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816257
Location:	South Terminal Expansion		Y: 2688603
Elevation at mudline:	-20.9	Datum: MLLW	
Casing Type: Steel		Boring Depth: -48.4' MLLW	Boring No: A-2011-B18
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 3"	WOR, WOR, WOR, WOR	Black, organic SILT, trace shell hash.	-22.9
7		24" 10"	7,9,15,19	First 6" - Gray, medium to coarse SAND and GRAVEL, some shell hash. Last 4" - Light brown, fine to coarse SAND, trace silt.	-27.9
10				Obstruction encountered -28.1' MLLW. Drilled with mill tooth roller bit through obstruction (approximately 8" thick). Collected split spoon from 10-12 feet.	-30.9
11.75		24" 8"	19,27,22,44	Light brown to gray, fine to coarse SAND, trace silt.	-32.65
12.5				Obstruction encountered -32.65' MLLW. Cleaned hole and began core run at -33.4 MLLW.	-33.4
17.5	68%	5.0' 4.75'	10-8-8-9-8	Rock Core #1 -33.4 to -38.4 MLLW 0.0 -2.7' Intensely to moderately fractured moderate to slightly weathered grey granitic GNEISS. 2.7' to 4.75' moderately to slightly weathered dark grey DIABASE.	-38.4
22.5	20%	5.0' 5.0'	8-9-8-8-9	Rock Core #2 -38.4 to -43.4 MLLW 0.0'-5.0' Intensely fractured moderately to slightly weathered dark grey DIABASE, iron stained vertical fractrues from 3.4' to 5.0'.	-43.4
27.5	46%	5.0' 5.0'	8-9-8-8-8	Rock Core #3 -43.4 to -48.4' MLLW 0.0-2.6' Intensely fractured moderately fracture dark gray DIABASE. 2.6' - 4.4' moderately fractured granitic GNEISS, 4.4' - 5.0' moderately fractured gray DIABASE.	-48.4

Comments:

BORING LOG

Date: 3/10/2011
Time: 8:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816372
Location:	South Terminal Expansion		Y: 2689000
Elevation at mudline:	-19.5	Datum: MLLW	
Casing Type: Steel		Boring Depth: -39.85' MLLW	Boring No: A-2011-B19
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	WOR, WOR, 5, 5	Black, organic SILT.	-21.5
5.25		3" 3"	100-3"	Gray, medium to coarse SAND, trace fine sand.	-24.75
7.45				Obstruction encountered at -24.7 MLLW. Drilled with roller bit through obstruction. After penetration of obstruction, tool dropped approximately 0.5 feet. Obstruction encountered at -26.9 MLLW.	-26.9
10.4				Drilled with roller bit through obstruction. After penetration of obstruction, tool dropped approximately 0.3 feet. Roller bit then advanced another 0.6 feet. Clean hole and prepared for core run at -29.85 MLLW.	-29.85
15.4	65%	5.0' 5.0'	8-8-8-9-8	Rock Core #1 -29.85 to -34.85 MLLW - 0"-37"Moderately to intensely fractured grey Granitic GNEISS, 37"-60" Moderately to intensely fractured pink grey Granite PEGMATITE.	-34.85
20.4	54%	5.0' 4.42'	8-9-8-8-9	Rock Core #2 -34.85 to -39.85 MLLW - 0"-20" Moderately to intensely fractured pin grey Granite PEGMATITE, 20"-53" Moderately to intensely fractured grey Granitic GNEISS.	-39.85

Comments:

BORING LOG

Date: 3/14/2011
Time: 8:50 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816746
Location:	South Terminal Expansion		Y: 2687940
Elevation at mudline:	-5.1	Datum: MLLW	
Casing Type: Steel		Boring Depth: -46.65' MLLW	Boring No: A-2011-B20
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 7"	3,3,3,6	First 5" - Black fine to coarse SAND and organic SILT. Next 2" - Grey fine to coarse SAND, some inorganic silt.	-7.1
7.5		30" 0"	8,2,2,WOH	No Recovery	-12.6
12		24" 13"	25,26,21,28	Grey, fine to coarse SAND, some silt, little fine to coarse gravel.	-17.1
16.1		13" 7"	13,25, 100/1"	Grey fine SAND and SILT, little fine to coarse gravel.	-21.2
17.7				Obstruction encounterd at -21.2 MLLW. Penetrated obstruction (8" thick) with roller bit to -22.8 MLLW.	-22.8
19.7		24" 7"	110,67,60, 27	Encountered second obstruction at -22.8 MLLW. Advanced roller bit through second obstruction and encountered coarse sand in drill cuttings. Advanced split spoon from -22.80 to -24.80 MLLW - Dark grey fine to coarse GRAVEL and SILT, little fine to coarse sand (TILL).	-24.8
25.07		2" 0"	110/2"	No recovery. Dark grey granite in light grey silty drill wash.	-30.17
29.9		0" 0"	100/0"	No recovery.	-35
31.55				Roller bit advanced to elevation -36.65 MLLW. Cleaned hole and prepared for core run.	-36.65
36.6	40%	5' 5'	5-5-6-6-6	Rock Core #1 -36.65 to -41.65 MLLW 0.0'-4.0' Intensely to very intensely fractured grey GNEISS, moderately to intensely fractured pink grey Granite PEGMATITE.	-41.65
41.6	40%	5' 4.0'	6-2-6-6-10	Rock Core #2 -41.65 to -46.65 MLLW - 0.0' - 3.1' Intensely to very intensely fractured pink grey Granite PEGMATITE, 3.1-4.0' intensely to very intensely fractured moderately weathered grey Granitic GNEISS. Core barrel penetrated a sediment-filled seam from between 1.3 to 2.0 feet.	-46.65

Comments:

BORING LOG

Date: 3/15/2011
Time: 8:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816566
Location:	South Terminal Expansion		Y: 2688336
Elevation at mudline:	-7	Datum: MLLW	
Casing Type: Steel		Boring Depth: -47.7' MLLW	Boring No: A-2011-B21
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 18"	WOR, WOR, WOR, WOR	Black, organic SILT and fine SAND.	-9
7		24" 12"	16,16,18,20	Greenish-gray, fine to medium SAND, trace silt.	-14
12		24" 11"	36,27,38,35	Gray, fine to medium SAND, trace silt, trace fine gravel.	-19
12.1				Obstruction encounterd at -19.1 MLLW. Penetrated obstruction with roller bit.	-19.1
15.9		11" 2"	36,100/5"	Gray, fine to coarse SAND and SILT, trace fine gravel.	-22.9
22.35		5' 3'	9,7,8,8,8	Encountered second obstruction at -23.95 MLLW. Roller bit advanced to elevation -24.35 MLLW. Cleaned hole and prepared for core run. Core run revealed nested boulders with seams of sediment. 1st Boulder estimated at 1.6 feet in length, 2nd Boulder at 0.3 feet in length, and 3rd boulder at 1.1 feet in length.	-29.35
27.6		24" 6"	25,20,12,10	Light gray, fine to coarse SAND and GRAVEL, trace silt.	-34.6
29.9		0" 0"	100/0"	Roller bit advanced to elevation -36.9 MLLW. Split spoon attempted at this elevation was 100/0". Cleaned hole and prepared for core run.	-36.9
31.9	28%	1.8' 1.33	7,14	Rock Core #1 -36.9 to -38.7 MLLW 0.0'-1.33' Intensely to moderately fractured pink grey Grantite PEGMATITE with xenoliths of granite, diabase and granitic gniess.	-38.9
35.9	63%	4' 4'	8,7,6,9	Rock Core #2 -38.7 to -42.7 MLLW 0.0'-4.0' Intensely to moderately fractured grey Granite PEGMATITE with xenoliths of granite, gneiss, and diabase.	-42.7
40.9	50%	5' 5'	6,8,9,6,6	Rock Core #3 -42.7 to -47.7 MLLW 0.0'-5.0' Intensely to moderately fractured grey Granite PEGMATITE with xenoliths of granite, gneiss, and diabase.	-47.7

Comments:

BORING LOG

Date: 3/16/2011
Time: 10:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816496
Location:	South Terminal Expansion		Y: 2689220
Elevation at mudline:	-5.7	Datum: MLLW	
Casing Type: Steel		Boring Depth: -50' MLLW	Boring No: A-2011-B22
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 3"	WOR, WOR, WOR, WOR	Black, organic SILT and shell hash.	-7.7
7		24" 18"	14,14,16,15	Greenish gray, fine SAND, trace silt, trace shell hash.	-12.7
12		24" 6"	10,10,10,10	Gray, fine to medium SAND, trace coarse sand.	-17.7
16.9		23" 5"	7,7,14, 100/5"	Gray, fine to coarse SAND.	-22.9
19.55		0" 0"	100/0"	No Recovery.	-25.55
24.92		5' 3'	9,7,8,8,8	Encountered obstruction at -25.55 MLLW. Roller bit advanced to bottom of obstruction at -26.3 MLLW. Roller bit advanced to -27.45 MLLW. Telescope set up to advance casing through obstruction to -30.62 MLLW.	-30.62
25.92		11" 0"	35,100/5"	No recovery.	-31.62
29.45		0" 0"	100/0"	Roller bit advanced to elevation -35.15 MLLW. Cleaned hole and began core run a 36.25 MLLW.	-35.15
34.30		1.8' 1.55'	8,5,7	Rock Core #1 -36.25 to -38.05 MLLW - Core run revealed a series of nested boulders and/or fractured rock. Roller bit advanced to -40 MLLW.	-40
39.3	48%	5' 4.3'	5,3,5,6,6	Rock Core #2 -40 to -45 MLLW 0.0'-5.0' Intensely to moderately fractured dark grey granitic GNEISS, Slightly to moderately weathered in fractures 2.5'-4.2' and 1.9'	-45
44.3	44%	5' 4.85'	5,7,6,7,8	Rock Core #3 -45 to -50 MLLW 0.0-1.5' Intensely to moderately fractured dark grey GNEISS, 1.5' - 4.8' Moderately fractured pink grey granite PEGMATITE.	-50

Comments:

BORING LOG

Date: 3/17/2011
Time: 1:00 PM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816606
Location:	South Terminal Expansion		Y: 2687892
Elevation at mudline:	-10.65	Datum: MLLW	
Casing Type: Steel		Boring Depth: -38.65' MLLW	Boring No: A-2011-B23
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 8"	WOR, WOR, WOR, WOR	Top 4": Black, organic SILT. Last 4": Dark gray, fine to medium SAND and SILT, trace shell hash.	-12.65
7		24" 12"	13,13,17,21	Light gray, fine to coarse SAND.	-17.65
10		0" 0"	100/2"	No recovery.	-20.55
18.25				Obstruction encountered at -23.4 MLLW. Advanced roller bit through a series of obstructions, believed to be either a series of boulders or rock fragments to -28.85 MLLW.	-28.85
18.25		0" 0"	100/0"	No recovery.	-28.85
18.25				Cleaned hole and began core run at -28.85 MLLW.	-28.85
23	65%	4.8' 4.55'	8,9,9,10,11	Rock Core #1: -28.85 to -33.65 MLLW 0.0'-4.8' Intensely to moderately fractured pink grey GRANITE.	-33.65
28	85%	5' 5'	8,8,7,9,9	Rock Core #2: -33.65 to -38.65 MLLW 0.0'-5.0' Moderately fractured pink grey granitic GNEISS.	-38.65

Comments:

BORING LOG

Date: 3/21/2011
Time: 8:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816632
Location:	South Terminal Expansion		Y: 2688166
Elevation at mudline:	-6.85	Datum: MLLW	
Casing Type: Steel		Boring Depth: -45.05' MLLW	Boring No: A-2011-B24
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 18"	WOR, WOR, 1, 1	Top 12": Black, organic SILT, trace shell hash. Next 3": Gray, fine SAND and SILT trace shell hash. Last 3": Light brown fine SAND and SILT, trace shell hash.	-8.85
7		24" 12"	14,10,10,12	Gray, fine to medium SAND, trace coarse sand, trace shell hash.	-13.85
12		24" 10"	21,20,12,10	Light gray, medium to coarse SAND, trace fine sand, trace shell hash.	-18.65
15				Obstruction encountered at -21.3 MLLW. Advanced roller bit through obstruction to -21.85 MLLW for next split-spoon.	-21.85
17		24" 12"	44,54,40,30	Light gray, fine to coarse SAND, some silt, trace fine gravel.	-23.85
22		24" 18"	13,12,23,16	Light gray, fine to coarse SAND, some silt and some fine gravel.	-28.85
25.92		11" 5"	46, 100/5"	Light gray, medium to coarse SAND, trace silt, trace fine gravel.	-32.76
28.2				Advanced casing to -33.25 MLLW. Advanced roller bit to -35.05 MLLW, cleaned hole and began core run.	-35.05
33.2	64%	5' 5'	6,6,6,6,6	Rock Core #1: -35.05 to -40.05 MLLW 0.0'-5.0' Intensely to moderately fractured grey granitic GNEISS.	-40.05
38.2	83%	5' 4.85'	7,6,6,6,6	Rock Core #2: -40.05 to -45.05 MLLW Intensely to moderately fractured grey granitic GNEISS.	-45.05

Comments:

Date: 3/22/2011
Time: 9:45 AM

BORING LOG

Project:	Phase IV Dredging	Project No: 6690.008	X: 816289
Location:	South Terminal Expansion		Y: 2687745
Elevation at mudline:	-1.2	Datum: MLLW	
Casing Type: Steel		Boring Depth: -34.74' MLLW	Boring No: A-2011-B25
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 0"	WOR, WOR, WOR, WOR	No recovery.	-3.2
7		24" 6"	WOR, WOR, WOR, WOR	Black fine SAND and SILT, some shell hash.	-8.2
10		24" 12"	7,14,30,38	Gray, fine to coarse SAND, trace silt, trace fine gravel.	-11.2
15		24" 5"	29,31,36,43	Light gray fine to coarse SAND, trace silt.	-16.2
20		24" 10"	36,65,31,41	Light gray, fine to coarse SAND, trace silt, trace fine gravel	-21.2
22.54				Obstruction encountered at -22.35 MLLW. Advanced roller bit through obstruction (0.8 feet in length) to -23.15 MLLW. Advanced roller bit to -23.74 MLLW. Cleaned hole and began core run.	-23.74
25.54	31%	3' 2.35'	7,6,7	Rock Core #1: -23.74 to -26.74 MLLW Intensely to very intensely fractured grey granitic GNEISS.	-26.74
28.54	58%	3' 2.7'	6,5,5	Rock Core #2: -26.74 to -29.74 MLLW Intensely to moderately fractured grey granitic GNEISS.	-29.74
33.54	72%	5.0' 5.0'	7,6,7	Rock Core #1: -29.74 to -34.74 MLLW Intensely to moderately fractured pink grey granitic GNEISS.	-34.74

Comments:

BORING LOG

Date: 3/23/2011
Time: 11:15 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816522
Location:	South Terminal Expansion		Y: 2688815
Elevation at mudline:	-16.75	Datum: MLLW	
Casing Type: Steel		Boring Depth: -47.65' MLLW	Boring No: A-2011-B26
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 5"	WOR, WOR, WOR, WOR	Black, fine SAND and organic SILT, trace shell hash.	-18.75
7		24" 12"	53,43,41,52	Top 6": Gray, fine to medium SAND. Middle 3": Black, fine to medium SAND, trace fine gravel. Bottom 3": Light gray fine to coarse SAND and fine GRAVEL, some ping stone fragments.	-23.75
10.25				Obstruction encountered at -24.8 MLLW. Advanced roller bit through boulder to elevation -27.0 MLLW.	-27
13.4		24" 6"	64,37,32,49	Light gray, fine to coarse SAND, trace silt, trace fine gravel.	-30.15
14				Obstruction encountered at -30.15 MLLW. Advanced roller bit through obstruction to -30.75 MLLW.	-30.75
18.2		10" 4"	34, 100/4"	Light gray, coarse SAND and fine GRAVEL, trace stone fragments.	-34.98
20.9				Advanced roller bit thru cobbles or fractured bedrock to -37.65 MLLW. Cleaned ho and began core run.	-37.65
25.9	47%	5' 5'	5,5,6,6,6	Rock Core #1: -37.65 to -42.65 MLLW 0.0' - 3.6' Intensely to moderately fractured dark grey DIABASE, 3.6'-5.0' Intensely to very intensely fractured dark grey DIABASE.	-42.65
30.9	26%	5' 4.2'	6,4,5,6,6	Rock Core #2: -42.65 to -47.65 MLLW 0.0'-1.3' Intensely to very Intensely fractured dark grey DIABASE highly weathered at interface, 1.3'-4.0' Intensely to moderately fractured grey granitic GNEISS	-47.65

Comments:

Date: 3/25/2011
Time: 12:30 PM

BORING LOG

Project:	Phase IV Dredging	Project No: 6690.008	X: 816356
Location:	South Terminal Expansion		Y: 2689759
Elevation at mudline:	-13.75	Datum: MLLW	
Casing Type: Steel		Boring Depth: -42.05' MLLW	Boring No: A-2011-B27
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	WOR, WOR, WOR, WOR	Black, fine SAND and SILT, trace shell hash.	-15.75
7		24" 16"	9,9,12,16	Top 3" - Gray, fine SAND, trace silt, trace fine gravel. Next 1/2" - Black, fine SAND, trace silt. Next 3" - Orange-brown, fine to coarse SAND, trace silt. Last 3" - Gray, fine to coarse SAND, trace silt.	-20.75
12		24" 15"	15,20,22,21	Top 10" - Gray, fine SAND and SILT, trace coarse sand and shell hash. Bottom 5" - Orange-brown, fine to coarse SAND and SILT, trace fine gravel.	-25.75
17		24" 4"	12,12,14,14	Gray, fine to coarse SAND and SILT, trace fine gravel, trace shell hash.	-30.75
21		12" 4"	62,80, 100/0"	Gray, fine to coarse SAND, trace silt and fine gravel.	-34.75
25				Obstruction encountered at -35.2 MLLW. Advanced roller bit through obstruction to elevation -38.30 MLLW.	-38.3
26.5		18" 16"	50,125, 172/6"	Tan, coarse to medium SAND, trace silt.	-40.25
28.3				Advanced roller bit to elevation -42.05 MLLW.	-42.05
				End of Boring	

Comments:

BORING LOG

Date: 3/28/2011
Time: 9:29 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816775
Location:	South Terminal Expansion		Y: 2687636
Elevation at mudline:	-5.2	Datum: MLLW	
Casing Type: Steel		Boring Depth: -24.0' MLLW	Boring No: A-2011-B28
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 14"	WOR, WOR, WOR, WOR	Black, organic SILT, trace fine to coarse sand, trace shell hash.	-7.2
4		24" 16"	10,6,10,12	Grey, fine to medium SAND, little shell hash.	-9.2
6		24" 16"	9,12,11,13	Tan to grey, very fine SAND, trace inorganic silt.	-11.2
8		24" 7"	10,18,17,18	Grey, fine SAND, little inorganic silt, little medium to coarse sand, trace gravel.	-13.2
10		24" 9"	10,20,29,32	Grey fine SAND, little silt, trace coarse gravel.	-15.2
12		24" 12"	20,27,29,43	Grey fine to coarse SAND, little silt, little fine to coarse gravel.	-17.2
13		12" 6"	24,37, 100/0"	Grey, fine to coarse SAND, little silt, little fine to coarse gravel.	-18.2
14.3				Encountered obstruction at -19.5 MLLW. Cleaned hole and began core run.	-19.5
18.8	36%	4.5' 4.5'	5,4,5,5	Rock Core #1: -19.5 to -24.0 MLLW - Intensely to moderately fractured pink grey granitic GNEISS.	-24.0

Comments: Intervals 0-2, 2-4. and 4-6 Sampled using a 3" diameter split spoon sampler, all of the other intervals were sampled using a standard 2" diameter split-spoon.

BORING LOG

Date: 3/29/2011
Time: 7:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816162
Location:	South Terminal Expansion		Y: 2689857
Elevation at mudline:	-27.75	Datum: MLLW	
Casing Type: Steel		Boring Depth: -40.3' MLLW	Boring No: A-2011-B29
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 9"	WOR, WOR, WOR, WOR	Black, organic SILT, trace fine sand, thin, hair-like filiments.	-29.75
6.25		15" 3"	WOR, WOR, 100/3"	Tan to grey, fine to medium SAND, some silt.	-34
7.55				Advanced roller bit through gravel/cobbles. Cleaned hole and prepared to core at -35.3 MLLW.	-35.3
12.55	82%	5' 4.2'	5,6,6,7,6	Rock Core #1: -35.3 to -40.3 MLLW - Moderately to slightly fractured grey and pink granitic GNEISS.	-40.3

Comments:

BORING LOG

Date: 3/29/2011
Time: 1:00 PM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816617
Location:	South Terminal Expansion		Y: 2688559
Elevation at mudline:	-7.8	Datum: MLLW	
Casing Type: Steel		Boring Depth: -36.6' MLLW	Boring No: A-2011-B30
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 6"	WOR, 2,2,2	Black, organic SILT and very fine SAND, little shell hash.	-9.8
7		24" 10"	10,12,10,13	Grey fine SAND, little medium to coarse sand. Grades to grey-tan medium SAND, little fine to coarse SAND.	-14.8
12		24" 10"	20,29,25,23	Grey fine to coarse SAND, some silt, little fine to coarse gravel.	-19.8
17		24" 3"	33,25,27,32	Grey fine to coarse SAND, some silt, little fine to coarse gravel (TILL).	-24.8
21.6		24" 5"	57,27,59, 126	Grey, fine to coarse GRAVEL and fine to coarse SAND, little silt (TILL).	-29.4
25.95		24" 2.5"	21,15,67,29	Coarse GRAVEL, some fine to medium sand, some silt (TILL).	-33.75
28.8				Refusal at -33.75 MLLW. Advanced roller bit through obstruction to -35.15 MLLW. Advanced roller bit to -36.60 MLLW. No rock core conducted.	-36.6
				End of Boring	

Comments:

BORING LOG

Date: 3/30/2011
Time: 10:05 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816259
Location:	South Terminal Expansion		Y: 2689246
Elevation at mudline:	-20.85	Datum: MLLW	
Casing Type: Steel		Boring Depth: -57.65' MLLW	Boring No: A-2011-B31
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
2		24" 3"	WOR, WOR, WOR, WOR	Black, organic SILT trace shell hash.	-22.85
7		24" 4"	16,27,31,40	Gray, medium to coarse SAND and fine GRAVEL, trace silt.	-27.85
8.35				Obstruction encountred at -28.3 MLLW. Advanced roller bit through obstruction un -29.2 MLLW.	-29.2
12		24" 6"	47,22,23,18	Gray, fine to coarse SAND, little fine gravel, trace silt.	-32.85
14.5				Obstruction encountered at -34.4 MLLW. Advanced roller bit through obstruction until -35.35 MLLW.	-35.35
16.8				Advanced roller bit to -37.65 MLLW. Cleaned hole and began core run.	-37.65
21.8	64%	5' 4.8'	5,3,4,5,5	Rock Core #1: -37.65 to -42.65 MLLW - Intensely to moderately fractured grey to dark grey granitic GNEISS.	-42.65
26.8	73%	5' 4.9'	6,5,4,4,4	Rock Core #2: -42.65 to -47.65 MLLW - 0.0-1.25' Intensely to moderately fractured pink grey GRANITE, 1.25-4.9' Intensely to moderately fractureed dark grey granitic GNEISS.	-47.65
31.8	58%	5' 4.9'	5,5,5,5,5	Rock Core #3: -47.65 to -52.65 MLLW - Intensely fractured dark grey GNEISS	-52.65
36.8	78%	5' 5'	5,5,5,5,5	Rock Core #4: -52.65 to -57.65 MLLW - Intensely to moderately fractured dark grey GNEISS	-57.65

Comments:

BORING LOG

Date: 3/31/2011
Time: 11:00 AM

Project:	Phase IV Dredging	Project No: 6690.008	X: 816364
Location:	South Terminal Expansion		Y: 2688225
Elevation at mudline:	-0.8	Datum: MLLW	
Casing Type: Steel		Boring Depth: -46.6' MLLW	Boring No: A-2011-B32
Casing Diameter:	4"	Drill Rig: CME 45	
Drill Co:	NH Boring	Method: Drill and Wash	Sheet: 1 of 1
Driller:	Norman Stuttard	Log By: GCD	

Depth below mudline (ft)	RQD	Penetration/ Recovery	Blows per 6" / Drill Min. per Foot	Description (Color, Texture, Structure) Trace < 10%, Little 10% to 20%, Some 20% to 35%, And 35% to 50%	Elevation (MLLW)
25.8		24" 3"	WOR, WOR, WOR, WOR	Encountered first obstruction at -25.7 MLLW. Advanced roller bit to -26.6 MLLW, cleaned hole and began core run.	-26.6
30.8	58%	5' 4.8'	4,4,4,4,4	Rock Core #1: -26.6 to -31.6 MLLW - 0.0'-3.25' Slightly fractured pink grey granitic GNEISS 3.25'-4.8' Intensely fractured highly weathered grey granitic GNEISS grades to unweathered quartz rich GRANITE.	-31.6
35.8	32%	5' 4.3'	6,5,5,5,4	Rock Core #2: -31.6 to -36.6 MLLW - 0.0'-4.2' Intensely fractured pink grey granitic GNEISS becomes very intensely fractured at 1.75'	-36.6
40.8	8%	5' 3.2	5,5,6,5,7	Rock Core #3: -36.6 to -41.6 MLLW - Intensely fractured pink grey granitic GNEISS	-41.6
45.8	47%	5' 5'	no drill time recorded	Rock Core #4: -41.6 to -46.6 MLLW - 0.0'-2.5' Intensely fractured grey granitic GNEISS 2.5'-4.9' moderately fractured grey granitic GNEISS	-46.6

Comments: Partial collapse of hole after withdrawal of Rock Core #4, due to presence of highly fractured rock falling into hole. Elevation of collapse approximately -38.85 MLLW.

APPENDIX 27

Apex Companies, LLC

184 High Street, Suite 502, Boston, MA 02110

(617) 728-0070

DATE: Wed. Aug. 11th, 2010

TIME: 12:45pm

☐ Incoming Call X Outgoing Call ☐ Return Call

CONTACT:

Name: Ed DeWitt, Manager

Address: New Bedford Airport
1569 Airport Road
New Bedford, MA 02746

Project Name: New Bedford Harbor Phase IV

Project No.: 6690

Phone: 508-991-6161

SUMMARY OF CONVERSATION:

Spoke with Ed DeWitt, the manager of the New Bedford Airport. Asked him whether there are any height restrictions surrounding the New Bedford Airport. He said that the New Bedford Airport's height restrictions involve a radius around the airport, and only reach as far south as Popes Island within New Bedford Harbor.

Specifically asked about the location within which the South Terminal CDF project is to occur. Mr. DeWitt stated that the proposed South Terminal CDF location does not lie within New Bedford Airport's height restricted area, and Mr. DeWitt agreed that since the South Terminal project will be located south of Popes Island, the New Bedford Airport will cause no overhead restrictions on the height of objects (i.e. cranes or spuds) on the South Terminal Project site.

APPENDIX 28

Twenty-foot equivalent unit

From Wikipedia, the free encyclopedia

A 20-foot-long (6.1 m) ISO container equals 1 TEU.

The **twenty-foot equivalent unit** (often **TEU** or **teu**) is an inexact unit of cargo capacity often used to describe the capacity of container ships and container terminals.[1] It is based on the volume of a 20-foot-long (6.1 m) intermodal container, a standard-sized metal box which can be easily transferred between different modes of transportation, such as ships, trains and trucks.[1]

One TEU represents the cargo capacity of a standard intermodal container, 20 feet (6.1 m) long and 8 feet (2.4 m) wide.[1] There is a lack of standardisation in regards to height, ranging between 4.25 and 9.5 feet (1.30 and 2.9 m), with the most common height being 8.5 feet (2.6 m).[2] Also, it is common to designate 45-foot (14 m) containers as 2 TEU, rather than 2.25 TEU.[3]

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- 1 Equivalence
- 2 See also
- 3 Footnotes
- 4 References

Equivalence

As noted above, the TEU is an inexact unit, and hence cannot be converted precisely into other units. The related unit **forty-foot equivalent unit** (often **FEU** or **feu**) however is defined as two TEU. The most common dimensions for a 20-foot (6.1 m) container are 20 feet (6.1 m) long, 8 feet (2.4 m) wide, and 8.5 feet (2.6 m) high, for a volume of 1,360 cubic feet (39 m^3). However, both 9.5-foot-tall (2.9 m) *High cube* and 4.25

TEU capacities for common container sizes

Length	Width	Height	Volume	TEU
20 ft (6.1 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	989 cu ft (28.0 m^3)	1
40 ft (12 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	1,980 cu ft (56 m^3)	2
45 ft (14 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,060 cu ft (87 m^3)	2[3] or 2.25
48 ft (15 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,264 cu ft (92.4 m^3)	2.4
53 ft (16 m)	8 ft (2.4 m)	8.5 ft (2.6 m)	3,604 cu ft (102.1 m^3)	2.65
High cube				
20 ft (6.1 m)	8 ft (2.4 m)	9.5 ft (2.9 m)	1,520 cu ft (43 m^3)	1[2]
Half height				
20 ft (6.1 m)	8 ft (2.4 m)	4.25 ft (1.30 m)	680 cu ft (19 m^3)	1[2]

-foot (1.30 m) *half height* containers are also reckoned as 1 TEU.[2][3] This gives a volume range of 680 cubic feet (19 m^3) to 1,520 cubic feet (43 m^3) for one TEU.

While the TEU is not itself a measure of mass, some conclusions can be drawn about the maximum mass that a TEU can represent. The maximum gross mass for a 20-foot (6.1 m) dry cargo container is 24,000 kilograms (53,000 lb).[4] Subtracting the tare mass of the container itself, the maximum amount of cargo per TEU is reduced to approximately 21,600 kilograms (48,000 lb).[4]

The MV *Emma Mærsk* officially carries 11,000 **TEU** (14 tons gross each), Maersk tells 14,770 TEU (space) and a loading plan 15,212 TEU.[5][6]

Similarly, the maximum gross mass for a 40-foot (12 m) dry cargo container (including the 9.5-foot-high (2.9 m) cube container) is 30,480 kilograms (67,200 lb).[4] After correcting for tare weight, this gives a cargo capacity of 26,500 kilograms (58,000 lb).[4]

Twenty-foot, "heavy tested" containers are available for heavy goods such as heavy machinery. These containers allow a maximum weight of 67,200 pounds (30,500 kg), an empty weight of 5,290 pounds (2,400 kg), and a net load of 61,910 pounds (28,080 kg).

See also

- Container ship
- Container terminal
- Containerization
- Panama Canal toll system

Footnotes

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APPENDIX 29

Port of Long Beach
Wharf Design Criteria

Version 2.0

1/30/2009

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List Symbols

A_e	Effective shear Area
A_{gross}	Gross cross-sectional area
A_{sc}	Total area of dowel bars in the connection
A_{sp}	Area of confining reinforcement
B	Width of a wharf unit
BE	Berthing Load
BU	Buoyancy Load
D	Dead Load
D'	Diameter of confining reinforcement core, measured to the centerline of the confinement
$D_{c.g.}$	The distance from the deck soffit to the center of gravity of the deck
D_p	Pile Diameter
DMF	Dynamic magnification factor
E	Earth Pressure Load
E_c	Modulus of elasticity of concrete
E_{ps}	Modulus of elasticity for prestressing steel
E_s	Modulus of elasticity of steel
EQ	Earthquake Load
F	Base shear of the wharf strip obtained from a pushover analysis
F_i	Lateral force per pile in row i from pushover analysis
F_p	Prestress compressive force in pile
G_c	Shear modulus (modulus of rigidity) for concrete
H	The distance between the center of the top hinge and center of the in-ground hinge
H'	The distance from the maximum in-ground moment to the center of gravity of the deck
I	Impact Load
I_{eff}	Effective moment of inertia
I_{gross}	Gross moment of inertia
J	Polar moment of inertia
J_{eff}	Effective polar moment of inertia
K	Factor applied to dead load to account for the effects of vertical ground acceleration
K_e	Confinement effectiveness coefficient
L	Live Load
L_c	The distance from the critical section of the plastic hinge to the point of contra-flexure
LB	Lower Bound
L_L	Length of the shortest exterior wharf unit
L_p	Plastic hinge length
L_s	Equivalent depth to fixity
M	Mooring Load
M_{dl}	Unfactored dead load moment

$M_{eq}^{R,L}$	The portion of M_{eq}^{pile} and $V_o \times D_{c.g.}$ (moment due to overstrength shear) distributed to the adjacent right or left deck span
M_{eq}^{pile}	The pile moment due to seismic loads that combines with the pile dead load and 10% live load moment to equal the pile overstrength moment, M_o.
M_{ll}	Unfactored live load moment due to 10% of the live load on the deck
M_n	Nominal moment capacity
$M_n^{deck,R,L}$	The nominal moment capacity of the adjacent right or left deck span
M_o	The pile overstrength moment capacity
M_p	Idealized plastic moment capacity
M_y	Moment at first yield
N	Number of pile rows
N_u	External axial compression on pile including seismic load
P	Mooring line loads
PGA	Peak ground acceleration
R	Creep/Rib Shortening Load
R_F	Force perpendicular to the fender panel due to berthing loads
S	Shrinkage Load
T	Temperature Load
T_{crane}	Period of the crane mode with the maximum participating mass
T_n	Effective period for iteration n
T_w	Effective elastic stiffness of the wharf system
T_{wi}	Initial period of the wharf based on cracked section properties
U	Pile unsupported length from the soffit to the ground
UB	Upper Bound
V_a	Shear strength due to axial load
V_c	Shear strength from concrete
V_{design}	Design shear, equal to V_o
V_F	Fender Shear Force
V_n	Nominal shear strength
V_o	The pile overstrength shear demand
V_p	The pile plastic shear
V_s	Transverse reinforcement shear strength
V_w	Wind speed at elevation 33 ft.
$V_\perp$	The ship approach velocity perpendicular to the wharf
W	Wind Load
W_{DL}	Dead load of the wharf segment
W_W	Waterside crane wheel loading
W_L	Landside crane wheel loading
c	Depth from extreme compression fiber to neutral axis at flexural strength
c_o	Concrete cover width to the center of hoop or spiral
d_{bl}	Diameter of longitudinal reinforcement
d_{gap}	Distance between the top of the steel shell pile and the soffit
e	Eccentricity between the center of mass and the center of rigidity
f'_c	28-day unconfined concrete compressive strength
f'_{cc}	Confined concrete compressive strength

f'_{ce}	Expected compressive strength of concrete
f_l'	Effective lateral confining stress
f_{pu}	Specified maximum prestressing steel tensile strength
f_{pue}	Expected maximum tensile strength of prestressing steel
f_{py}	Yield strength of prestressing steel
f_{pye}	Expected yield strength of prestressing steel
f_s	Steel stress
f_u	Specified maximum steel tensile strength
f_{ue}	Expected maximum tensile strength of steel
f_y	Yield strength of longitudinal reinforcing steel or structural steel
f_{ye}	Expected yield strength of the longitudinal reinforcement steel
f_{yh}	Yield strength of confining steel
f_{yhe}	Expected yield strength of transverse reinforcement
g	Acceleration of gravity
h	Elevation above water surface of wind data in feet
i	Pile row
k	Curvature ductility factor as a function of μ_ϕ
k_e	System secant stiffness
k_i	Initial stiffness of the structure taken from the pushover analysis
$k_{1,2}$	Stiffness of the wharf
l_a	Actual embedment length provided
l_{sp}	Strain penetration length
m	Seismic mass of the wharf segment
$m_{crane,deck}$	Part of the crane mass positioned close to wharf deck level
m_{wharf}	Mass of wharf portion occupied by the crane
n_i	Total number of piles in row i for length L_L
r	Ratio of the second slope over the elastic slop of the pile stiffness curve. Center to center spacing of confining reinforcement along pile axis
x_i	Distance of row i from the landside pile row
x_L	Distance of landside super-piles from the landside pile row
x_W	Distance of the waterside super-piles from the landside pile row
α	Angle between the line joining the centers of flexural compression in the deck/pile hinge and in-ground hinge and the pile axis
β	Axial pile shear strength reduction factor
γ	Displacement Capacity Factor
Δ_c	Pile displacement capacity
Δ_d	Pile demand displacement for three-dimensional response
$\Delta_{p,m}$	The plastic displacement capacity due to rotation of the plastic hinge at the OLE, CLE, or DE strain limits
Δ_t	Displacement demand based on transverse response
$\Delta_{t,0}$	Initial assumed displacement demand for Substitute Structure method
$\Delta_{t,n}$	Displacement demand based on transverse response for iteration
Δ_{X1}, Δ_{X2}	Combined X-axis displacement from motions in the transverse and longitudinal directions
Δ_{XL}	X-axis displacement due to structure excitation in the longitudinal direction
Δ_{XT}	X-axis displacement due to structure excitation in the transverse direction

Δ_{Y1}, Δ_{Y2}	Combined Y-axis displacement from motions in the transverse and longitudinal directions
Δ_{YL}	Y-axis displacement due to structure excitation in the longitudinal direction
Δ_{YT}	Y-axis displacement due to structure excitation in the transverse direction
Δ_y	Pile yield displacement
$\Delta_{y,i}$	Yield displacement of a pile in row *i* from pushover analysis
ε_c	Concrete compression strain
ε_{cc}	Confined concrete compressive strain at maximum compressive stress
ε_{co}	Unconfined concrete compression strain at maximum compressive stress
ε_{cu}	Ultimate confined concrete compression strain
ε_p	Total prestressing steel tensile strain
ε_{pi}	Initial prestressing steel tensile strain after losses
ε_{pue}	Expected ultimate strain for prestressing steel
ε_{pye}	Expected yield strain for prestressing steel
ε_s	Total steel tensile strain
ε_{smd}	Strain at maximum stress of dowel reinforcement
ε_{sh}	Steel tensile strain at the onset of strain hardening
ε_{spall}	Ultimate unconfined compression (spalling) strain
ε_{ye}	Expected yield tensile strain for steel
ϕ	Reduction factor for nominal moment capacity according to ACI-318
ϕ_m	Curvature at the OLE, CLE, or DE strain limit
$\phi_{p,dem}$	Plastic curvature at demand displacement
$\phi_{p,m}$	Plastic curvature for the OLE, CLE, or DE strain limit
ϕ_u	Ultimate curvature of the section
ϕ_y	Idealized yield curvature
ϕ_{yi}	Curvature at first yield
Φ	Reduction factor for shear, taken as 0.85
$\mu_{\Delta,i,n}$	Displacement ductility for row i at iteration n, defined as $\frac{\Delta_{t,n-1}}{\Delta_{y,i}}$
μ_ϕ	Pile curvature ductility
μ_f	Coefficient of friction
θ	Angle of critical crack to the pile axis
θ_m	Total rotation at the OLE, CLE, or DE strain limit
$\theta_{p,m}$	Plastic rotation for the OLE, CLE, or DE strain limit
$\theta_{p,dem}$	Plastic rotation at demand displacement
θ_u	Ultimate rotation
θ_y	Idealized yield rotation
ρ	Effective volumetric ratio of longitudinal reinforcing steel
ρ_s	Effective volumetric ratio of confining steel
$\xi_{eff,i}$	Effective damping for a pile at row *i*
$\xi_{eff,system}$	Effective damping of the entire wharf system

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1 Introduction

This handbook contains design guidelines and criteria for pile supported wharf construction. It is published by the Port of Long Beach (POLB) to assist engineering staff of the Port of Long Beach, as well as consulting firms providing consulting services related to the design of wharves for the Port of Long Beach. Any deviation from the criteria listed herein will require specific prior written approval from the Port.

Design guidelines and reference materials cited throughout this handbook will be revised from time to time as required. Updates and revisions occurring during design shall be followed as directed by the Port. The latest published editions of all references including all addenda shall be used in the design.

This document is Version 2.0 of the "Port of Long Beach Wharf Design Criteria" and it updates and supersedes the previous Version 1.0 that was published on March 20, 2007.

This document was prepared for the POLB under the leadership of Cheng Lai with the POLB and by a team of consultants consists of Moffatt & Nichol, PBS&J, Earth Mechanics, Inc. and P2S Engineering. The expert review team included Dr. Nigel Priestley, Emeritus Professor, Department of Structural Engineering, University of California, San Diego and Dr. Geoffrey Martin, Professor, Department of Civil Engineering, University of Southern California.

2 Geotechnical Considerations

Geotechnical evaluations identified in this section shall use methodologies that are considered acceptable standards of practice in the industry.

For seismic evaluations, ground motion criteria provided in Section 2.1 shall be used. Ground motions and response spectra are provided in the "Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21) and "Addendum to Port-wide Ground Motion Study, Port of Long Beach, California" (Ref. 22). No deviation from these ground motions shall be allowed unless prior approval by the Port is granted.

These guidelines are specific to pile-supported marginal wharves with engineered sloping ground conditions located under the wharf structure comprising dredged soils or cut slopes protected or stabilized by quarry run rock material. Applicability of these guidelines to other structures may be allowed upon review and approval by the Port.

2.1 Ground Motions

Three earthquake levels shall be used in the analysis and design of wharf structures: the Operational Level Earthquake (OLE), the Contingency Level Earthquake (CLE), and the Code-Level Design Earthquake (DE). The OLE and CLE correspond to different probabilities of occurrence (different average return periods). The DE corresponds to a larger and rare earthquake than the OLE and CLE. The three levels of ground motions are defined below:

Operating Level Earthquake (OLE)

The OLE is defined as the seismic event that produces ground motions associated with a 72-year return period. The 72-year return period ground motions have a 50% probability of being exceeded in 50 years. The OLE event occurs more frequently than the CLE and DE events and has a lower intensity.

Contingency Level Earthquake (CLE)

The CLE is defined as the seismic event that produces ground motions associated with a 475-year return period. The 475-year return period ground motions have a 10 percent probability of being exceeded during 50 years. The CLE event occurs less frequently than the OLE event, but more frequently than the DE event. CLE has a higher intensity than OLE but lower intensity than DE.

Code-Level Design Earthquake (DE)

The DE shall comply with the Design Earthquake requirements by the 2007 California Building Code (Ref. 17) and ASCE 7-05 (Ref. 11). The DE event occurs less frequently than the OLE and CLE events and has a higher intensity than the other two events.

Recommended design acceleration response spectra for OLE, CLE and DE for different ground conditions are shown in Figure 2-1 and Figure 2-2. Further details are provided in References 21 and 22.

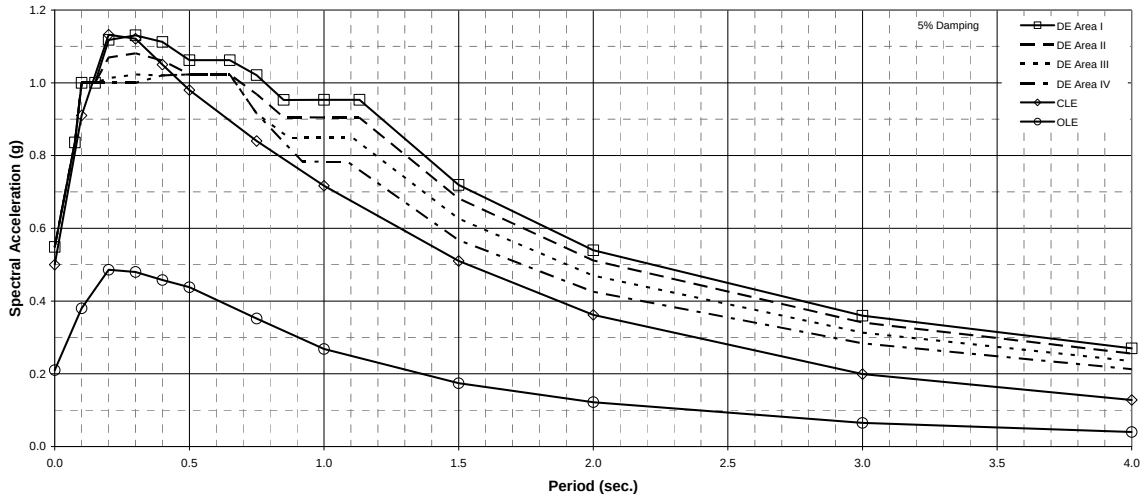


Figure 2-1: Design Acceleration Response Spectra for Unimproved Ground Conditions

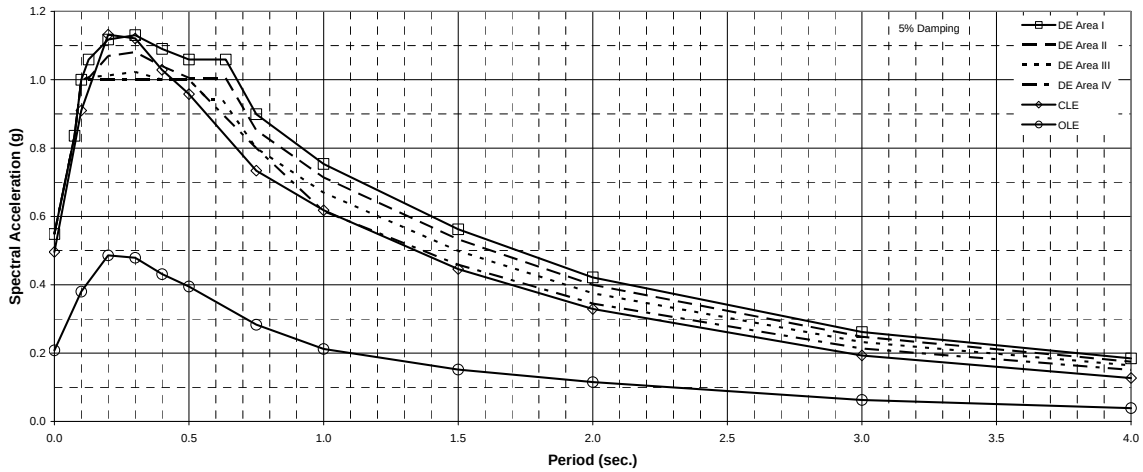


Figure 2-2: Design Acceleration Response Spectra for Improved Ground Conditions

2.2 Site Characterization

Site characterization shall be based on site-specific information. Reviewing and cataloging of available geotechnical information from past Port projects shall be performed to maximize the use of available data and to avoid conducting additional explorations where information already exists.

The presence of known active faults shall be verified using the available geological information such as the California Geological Survey (Ref. 25). If a known fault is found at the project site, a peer review is required per Section 4.14.

Adequate coverage of subsurface data, both horizontally and vertically, shall be provided to develop geotechnical parameters that are appropriate for the project. An adequate number of explorations should extend to depths of at least 20 ft. below the deepest anticipated foundation depths and should be deep enough to characterize subsurface materials that are affected by embankment behavior. Particular attention should be given during the field exploration to the presence of continuous low-strength layers or thin soil layers that could liquefy or weaken during the design earthquake shaking or cause embankment failure during dredging or other construction activities. Cone penetration tests (CPT) provide continuous subsurface profile and therefore, should be used on large projects to complement exploratory borings. When CPTs are performed, at least one boring shall be performed next to one of the CPT soundings to check that the CPT-soil behavior type interpretations are reasonable for the project site. Any differences between CPT interpretations and subsurface conditions obtained from borings shall be reconciled prior to developing geotechnical design parameters.

An appropriate and sufficient number of laboratory tests shall be performed to provide the necessary soil parameters for geotechnical evaluations. Guidelines for site characterization can be found in "Soil Mechanics" (Ref. 36) and "Design and Construction of Driven Pile Foundations" (Ref. 24) or other appropriate documents.

2.3 Liquefaction Potential

Liquefaction potential of the soils in the immediate vicinity of or beneath the wharf structure and associated embankment or rock dike shall be evaluated for the OLE, CLE, and DE. Liquefaction potential evaluation should follow the procedures outlined in "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils" (Ref. 43), "Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction Hazards in California" (Ref. 34), "Chapter 31F, 2007 California Building Code" (Ref. 18), "Liquefaction Susceptibility Criteria for Silts and Clays" (Ref. 16), and "Soil Liquefaction During Earthquakes" (Ref. 26) or other appropriate documents.

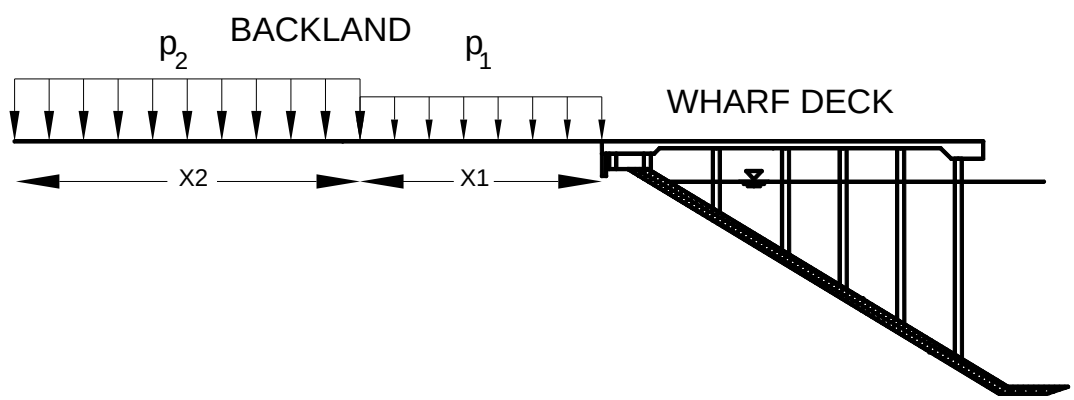
If liquefaction is shown to be initiated in the above evaluations, the particular liquefiable strata and their thicknesses (including zones of liquefaction induced in the backland area) should be clearly shown on site profiles. Resulting hazards associated with liquefaction should be addressed, including translational or rotational deformations of the slope or embankment system and post liquefaction settlement of the slope or embankment system and underlying foundation soils. If such analyses indicate the potential for partial or gross failure of the embankment, adequate evaluations shall be performed to confirm such conditions exist. In these situations and for projects where more detailed numerical analyses are performed, a peer review may be required by an engineering team selected by the Port.

2.4 Slope Stability and Seismically Induced Lateral Spreading

The surcharge loading values for different loading conditions and the required minimum factors of safety values are discussed in Sections 2.4.1, 2.4.2, and 2.4.3 and in Table 2-1.

The surcharge loading values recommended in the following subsections may be revised based on project-specific loading information, upon prior approval by the Port.

Table 2-1: Minimum Requirement for Slope Stability Analyses



Loading Conditions	p_1[a] (psf)	X_1 (ft)	p_2[a] (psf)	X_2 (ft)	Min. F.O.S[b]
Static Condition	250	75 ft	1,200	Remaining Backland	1.5
Temporary Condition (See Section 2.4.1)	250	Entire Backland	-	-	1.25
Pseudo-Static Seismic Condition	250	75 ft	800	Remaining Backland	- [c]
Post-Earthquake Static Condition	250	75 ft	800	Remaining Backland	1.1

[a] Loading values may be revised based on project-specific information, upon prior approval by the Port.

[b] F.O.S. – Factor of Safety.

[c] Yield acceleration shall be obtained from the analysis to determine lateral deformations per Section 2.9.2.

2.4.1 Static Slope Stability

Static stability analysis shall be performed for the slope or embankment system. Backland loading shall be considered in the analyses. Slope stability analyses should follow guidelines outlined in "Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landslide Hazards in

California" (Ref. 13), or other appropriate documents. Backland loading shall be represented by 250 psf for the first 75 ft. from the back end of the wharf deck and 1,200 psf for the remaining backland area. The long-term static factor of safety of the slope or embankment shall not be less than 1.5.

For temporary conditions, the static factor of safety shall not be less than 1.25. The loading considerations shall be based on project-specific information (such as terminal operation, construction staging etc.). The surcharge loading value shall not be less than 250 psf for the entire backland area.

2.4.2 Pseudo-static Seismic Slope Stability

Pseudo-static seismic slope stability analyses shall be performed to estimate the horizontal yield acceleration for the slope for the OLE, CLE, and DE. During the seismic event, the backland loading shall be represented by 250 psf for the first 75 ft. from the back end of the wharf deck and 800 psf for the remaining backland area.

If liquefaction and/or strength loss of the site soils is likely, residual strength of liquefied soils, strengths compatible with the pore-pressure generation of potentially liquefiable soils, and/or potential strength reduction of clays shall be used in the analysis. The residual strength of liquefied soils should be estimated using guidelines outlined in "Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction Hazards in California" (Ref. 34), "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework" (Ref. 41), "Soil Liquefaction During Earthquakes" (Ref. 26), or other appropriate documents.

Using a seismic coefficient of one-third of the PGA or 0.15g, whichever is greater, in the pseudo-static seismic slope stability analyses the factor of safety shall be estimated without considering the presence of wharf piles. If the estimated factor of safety is greater than or equal to 1.1, then no further evaluation for deformations or kinematic analysis as outlined in Sections 2.4.4 and 2.9.2 is necessary.

2.4.3 Post-Earthquake Static Slope Stability

The static factor of safety immediately following a design earthquake event shall not be less than 1.1 when post-earthquake residual strength of liquefied soils, strengths compatible with the pore-pressure generation of potentially liquefiable soils, and/or potential strength reduction of clays are used in the static stability analysis. The backland loading for post-earthquake stability analyses shall be represented by 250 psf for the first 75 ft. from the back end of the wharf deck and 800 psf for the remaining backland area.

2.4.4 Lateral Spreading – Free Field

The earthquake-induced lateral deformations of the slope or embankment and associated foundation soils shall be determined for the OLE, CLE, and DE using the peak ground acceleration at the ground surface (not modified for liquefaction) based on the "Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21) and "Addendum to Port-wide Ground Motion Study, Port of Long Beach, California" (Ref. 22). If liquefaction and/or strength loss of the site soils is likely, residual strength of liquefied

soils, strengths compatible with the pore-pressure generation of potentially liquefiable soils, and/or potential strength reduction of clays should be used in the analysis. The presence of the wharf foundation system should not be included in the "free field" evaluations.

For the OLE and CLE, initial lateral spread estimates should be made using the Newmark curves provided in "Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21). For the DE, initial lateral spread estimates should be made using the Newmark displacement curves provided in "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes and Embankments" (Ref. 43) or other appropriate documents. Additional analyses may be performed with prior approval by the Port.

2.5 Settlement

2.5.1 Static Consolidation Settlement

Long-term static consolidation settlement of sites that are underlain by continuous or large lenses of fine-grained soils shall be evaluated. The long-term static settlement should be estimated following guidelines outlined in "Foundation and Earth Structures" (Ref. 35) or other appropriate documents. If long-term settlement is anticipated, the resulting design impacts shall be considered, including the potential for development of downdrag loads on piles (See Section 2.7.1).

2.5.2 Seismically Induced Settlement

Seismically induced settlement shall be evaluated. The seismically induced settlement should be based on guidelines outlined in "Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction Hazards in California" (Ref. 34) or other appropriate documents. If seismically induced settlement is anticipated, the resulting design impacts shall be considered, including the potential development of downdrag loads on piles (See Section 2.7.1).

2.6 Earth Pressures

2.6.1 Earth Pressures Under Static loading

The effect of static active earth pressures on wharf structures resulting from static loading of backfill soils shall be considered where appropriate. Backfill sloping configuration, if applicable, and backland loading conditions shall be considered in the evaluations. The loading considerations shall be based on project-specific information, with a minimum assumed surcharge loading value of 250 psf. The earth pressures under static loading should be based on guidelines outlined in "Foundation and Earth Structures" (Ref. 35) or other appropriate documents.

2.6.2 Earth Pressures Under Seismic loading

The effect of earth pressures on wharf structures resulting from seismic loading of backfill soils, including the effect of pore-water pressure build-up in the backfill, shall be considered. The seismic coefficients used for this analysis should be based on the earthquake magnitudes, peak ground accelerations, and durations of shaking provided in

"Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21) and "Addendum to Port-wide Ground Motion Study, Port of Long Beach, California" (Ref. 22).

Backfill sloping configuration, if applicable, and backland loading conditions shall be considered in the evaluations. The loading considerations shall be based on project-specific information, with a minimum assumed surcharge loading value of 250 psf. Mononabe-Okabe equations may be used to estimate earth pressures under seismic loading, if appropriate [See "Foundation and Earth Structures" (Ref. 35); "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments" (Ref. 43)]. If Mononabe-Okabe equations are not appropriate, methods outlined in "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments" (Ref. 43) or other appropriate methods may be used.

2.7 Pile Axial Behavior

These guidelines are based on the assumption that piles are driven into the dense to very dense soil layer that is generally present throughout the Port area at elevations approximately -80 ft. to -100 ft. MLLW. If piles are not embedded into this layer, additional guidelines may be applicable and the geotechnical engineer should provide recommendations for review and approval by the Port.

2.7.1 Pile Capacity

Axial geotechnical capacity of piles shall be evaluated using the load combinations in Table 3-3. Guidelines for estimating axial pile capacities are provided in "Foundation and Earth Structures" (Ref. 35), "Recommended Procedures for Planning, Designing, and Constructing Fixed Offshore Platforms" (Ref. 7), and other appropriate documents. A minimum factor of safety of 2.0 shall be achieved on the ultimate capacity of the pile when using the largest of the service load combinations provided in Table 3-1. In addition, piles supporting the waterside crane rail should have a minimum factor of safety of 1.5 on ultimate capacity when using the broken pile load combinations provided in Table 3-1.

If long-term soil settlement is anticipated (See Section 2.5.1) above the pile tip, the effects of downdrag on axial geotechnical and structural capacity of piles shall be evaluated. The geotechnical capacity when evaluating the effects of downdrag loads should be estimated by considering only the tip resistance of the pile and the side friction resistance below the lowest layer contributing to the downdrag. Due to the short-term nature of transient loads (loads other than dead load), the factor of safety for the downdrag load evaluation may be reduced when downdrag loads are combined with transient loads. A minimum factor of safety of 1.5 should be achieved when combining the downdrag with the maximum of the service load combinations estimated from Table 3-3. For the earthquake load case in Table 3-3, an additional 10% of the design uniform live load should be included, per Section 4.6.4. However, the factor of safety should not be less than 2.0 when downdrag loads are combined with dead loads only. The geotechnical engineer should provide the magnitude of the downdrag load and its extent along the pile to the structural engineer.

An alternate approach to the evaluation of long-term settlement induced downdrag loads is to estimate the pile top settlement under the downdrag plus service load combinations and to design the structure to tolerate the resulting settlement.

If liquefaction or seismically-induced settlement are anticipated (See Section 2.5.2), the ultimate axial geotechnical capacity of piles under seismic conditions shall be evaluated for the effects of liquefaction and/or downdrag forces on the pile. The ultimate geotechnical capacity of the pile during liquefaction should be determined on the basis of the residual strength of the soil for those layers where the factor of safety for liquefaction is determined to be less than 1.0. When seismically-induced settlements are predicted to occur during design earthquakes, the drag loads should be computed, and the combination of drag load and service load should be determined. Only the tip resistance of the pile and the side friction resistance below the lowest layer contributing to the downdrag should be used in the capacity evaluation. The ultimate axial geotechnical capacity of the pile should not be less than the combination of the seismically induced downdrag force and the maximum of the service load combinations.

2.7.2 Axial springs for Piles

The Geotechnical Engineer shall coordinate with the Structural Engineer and develop axial springs (t-z) for piles. The t-z springs may be developed either at the top or at the tip of the pile, see Figure 2-3. If the springs are developed at the pile tip, the tip should include both the frictional resistance along the pile (i.e., side springs [t-z]) and tip resistance at the pile tip (i.e., tip springs [q-w]), as illustrated in Figure 2-3. If t-z springs are developed at the pile top, the appropriate elastic shortening of the pile should also be included in the springs. Linear or nonlinear springs may be developed if requested by the structural engineer.

During development of the axial soil springs, the ultimate capacity of the soil resistance along the side of the pile and at the tip of the pile should be used. Normally, it is assumed that the soil resistance along the side of the pile is developed at very small displacement (e.g., less than 0.5 inches) while the resistance at the tip of the pile will require large displacements (e.g., 5% of the pile diameter).

2.7.3 Upper and Lower Bound Springs

Due to the uncertainties associated with the development of axial springs, such as the axial soil capacity and load distributions along the piles and the simplified spring stiffnesses used, both upper-bound and lower-bound limits should be used for the axial springs. The upper-bound and lower-bound springs should be developed by multiplying the load values estimated in Section 2.7.2 by 2 and 0.5, respectively, for use in the analysis. Different values may be acceptable if supported by rational analysis and/or testing and upon approval by the Port.

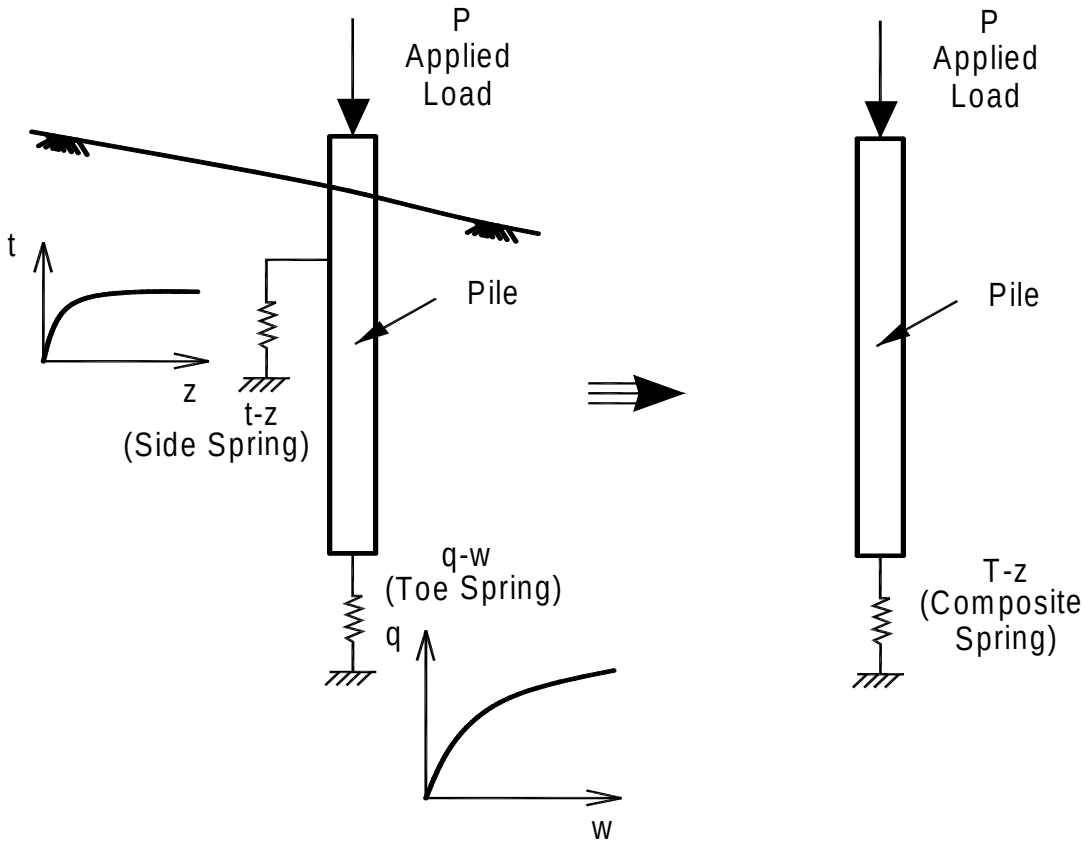


Figure 2-3: Axial Soil Springs

2.8 Soil Behavior under Lateral Pile Loading

2.8.1 Soil Springs for Lateral Pile Loading

For design of piles under loading associated with the inertial response of the superstructure, level-ground inelastic lateral springs (p-y) shall be developed. The lateral springs within the shallow portion of the piles (generally within 10 pile diameters below the ground surface) tend to dominate the inertial behavior. Geotechnical parameters for developing lateral soil springs may follow guidelines provided in "Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms" (Ref. 7) or other appropriate documents.

2.8.2 Upper and Lower Bound Soil Springs

Due to uncertainties associated with the development of p-y curves, including uncertainties arising from rock properties, rock placement method, and sloping rock dike configuration, upper-bound and lower-bound p-y springs shall be developed for use in the superstructure inertial response analyses. For typical marginal container wharf

slope/embankment/dike system at the Port, the stiffness of the upper-bound and lower-bound springs shall be 2 times and 0.3 times the stiffness of the lateral spring developed in Section 2.8.1. Upon approval by the Port, rational analysis and/or testing may be performed to justify the use of different values. For other wharf types, the upper-bound and lower-bound springs should be developed on a site-specific basis.

2.9 Soil-Pile Interaction

Two separate loading conditions for the piles shall be considered: (1) Inertial loading under seismic conditions, and (2) Kinematic loading from lateral ground spreading. Inertial loading is associated with earthquake-induced lateral loading on the wharf structure, while kinematic loading refers to the loading on wharf piles from earthquake induced lateral deformations of the slope/embankment/dike system.

For typical marginal container wharves at the Port (vertical pile wharf configurations with typical slope/embankment/dike system), the inertial loading condition induces maximum moments in the upper regions of the pile, and the kinematic loading condition induces maximum moments in the lower regions of the pile. The locations of the maximum moments from these two loading conditions are sufficiently far apart so that the effects of moment superposition are normally negligible. Furthermore, maximum moments induced by the two loading conditions tend to occur at different times during the earthquake. Therefore, for typical marginal container wharves at the Port, these loading conditions can be uncoupled (separated) from each other during design. For other wharf types, this assumption should be checked on a project-specific basis.

2.9.1 Inertial Loading Under Seismic Conditions

The evaluation of inertial loading response under seismic conditions is discussed in detail in Section 1. The lateral soil springs developed following the guidelines provided in Section 2.8 shall be used in the inertial loading response analyses. The evaluation of inertial loading can be performed by ignoring the slope/embankment/dike system deformations (i.e., one end of the lateral soil spring at a given depth is attached to the corresponding pile node and the other end is assumed fixed).

2.9.2 Kinematic Loading from Lateral Spreading

Kinematic loading from permanent ground deformation in the deep seated levels of the slope/embankment/dike foundation soils shall be evaluated. The lateral deformations shall be restricted to such amounts that the structural performance of wharf piles is not compromised, as defined by the pile strain limits outlined in Section 4.4 (Table 4-1). The lateral deformation of the embankment or dike and associated wharf piles and foundation soils shall be determined using proven analytical methods as outlined below.

Analysis for kinematic loading may not be required if it can be shown that a previously conducted dynamic soil-structure interaction analysis of a similar wharf representing a conservative upper bound solution results in higher pile curvature demands than the wharf under consideration, and still satisfies the strain limits for the pile.

Where analysis is required, initial estimates of free field dike deformations (in the absence of piles) may be determined using the simplified Newmark sliding block method

using the curves provided in "Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21) for the OLE and CLE, as discussed in Section 2.4.4. For the DE, initial estimate of the free field dike deformations should be made using the curves provided in "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes and Embankments" (Ref. 43) or other appropriate documents as discussed in Section 2.4.4. For the 24-inch octagonal, precast, prestressed concrete piles and pile configurations that are typically used for Port wharf projects, deformations are generally considered acceptable (in terms of pile strain limits and performance criteria) when the permanent free field dike deformations are less than about 3 inches for the OLE condition, less than about 12 inches for the CLE and less than about 36 inches for DE conditions.

In cases where dike deformations estimated using the simplified Newmark sliding block method exceed the displacement limits, site-response evaluations may be necessary to revise the free-field dike deformation analyses. Upon approval by the Port, one-dimensional site response analyses may be performed to incorporate local site effects in developing site-specific acceleration-time histories at the base of the sliding block ("within motions") for Newmark analyses. For the OLE and CLE, the firm-ground time histories provided in "Port-Wide Ground Motion Study, Port of Long Beach, California" (Ref. 21) should be used as the basis for determining input in the site-response evaluations. Sensitivity analyses should also be performed on factors affecting the results. The site-specific time histories representing the "within motions" should then be used in the simplified Newmark sliding block method to revise the dike deformation estimates. If the revised dike deformations still exceed the acceptable values, more detailed numerical soil-structure interaction evaluations may be necessary.

A full soil-structure-interaction numerical analysis for kinematic loading may not be required if it can be shown by structural analysis that reduced displacement demands estimated by simplified Newmark evaluations incorporating pile "pinning" effects are structurally acceptable, as discussed in the following publications: "Recommended LRFD Guidelines for the Seismic Design of Highway Bridges" (Ref. 10) and "Seismic Analysis and Design of Pile Supported Wharves" (Ref. 15). The geotechnical engineer should provide the structural engineer with level-ground p-y curves for the weak soil layer and soil layers above and below the weak layer using appropriate overburden pressures for performing a simplified pushover analysis to estimate the OLE, CLE and DE displacement capacities and corresponding pile shear within the weak soil zone. For the pushover analysis, the estimated displacements may be uniformly distributed within the thickness of the weak soil layer (i.e., zero at and below the bottom of the layer to the maximum value at and above the top of the weak layer). At some distance above and below the weak soil layer, see Figure 2-4, the pile should be fixed against rotation, and also against translation relative to the soil displacement. Between these two points (+/-10D from the soil layer), lateral soil springs are provided, which allow deformation of the pile relative to the deformed soil profile. The geotechnical engineer should perform pseudo-static slope stability analysis (Section 2.4.2) with the "pinning" effects of piles arising from pile shear in the weak zone incorporated and estimate the displacement demands using simplified Newmark analysis. If the estimated displacement demands are less than the displacement capacities as defined by the structural engineer, no further analysis for kinematic loading will be necessary.

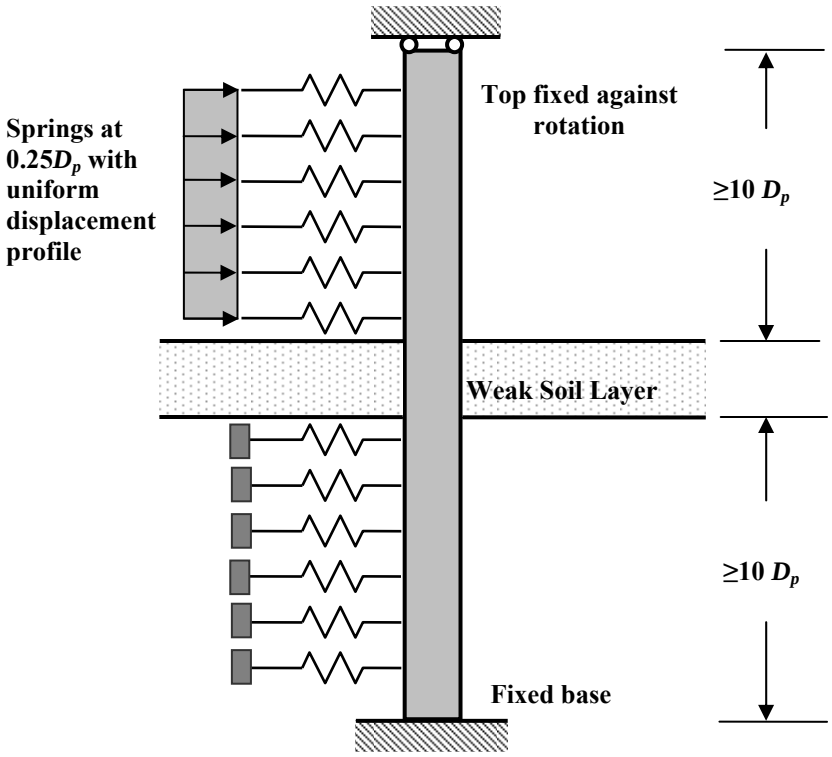


Figure 2-4: Sliding Layer Model

In cases where subsurface conditions indicate the presence of continuous, thin (less than 2 ft.), liquefiable and/or soft soils beneath the dike that could result in concentrated deformations within these layers, more detailed numerical analyses may be necessary. Such analyses shall not be performed without prior approval of the Port.

If more detailed numerical analyses are deemed necessary to provide input to the structural engineers, two-dimensional dynamic soil-structure interaction analysis of the wharf-pile-dike-soil system using numerical finite element or finite difference analyses should be performed. Sensitivity analyses should also be performed on factors affecting the results. As a minimum, deformation profiles along the length of the various pile rows should be provided to the structural engineer to estimate strains and stresses in the piles for the purpose of checking performance criteria. Such analyses should be coordinated with the structural engineer and shall not be performed without prior approval of the Port.

2.10 Ground Improvement

In the event that all the requirements set forth in the above sections cannot be met for the project, ground improvement measures may be considered to meet the requirements. Prior approval from the Port should be obtained before performing ground improvement evaluations. Ground improvement design recommendations should incorporate construction considerations including constructability, availability of contractors and equipment, schedule impact, and construction cost. Alternatives such as use of additional piles, or accepting greater damage due to larger displacements shall be discussed.

3 Structural Loading Criteria

3.1 General

All wharves shall be designed for the loading requirements provided herein. Where loading conditions exist that are not specifically identified herein, the designer should rely on accepted industry standards. However, in no case shall other standards supersede the requirements provided herein. For purposes of this document, the terms piers and wharves can be used interchangeably, and mean an engineered structure for the purpose of docking and mooring a vessel for cargo operations.

3.2 Dead Loads (D)

3.2.1 General

Dead load consists of the weight of the entire structure, including all the permanent attachments such as mooring hardware, fenders, light poles, utility booms, brows, platforms, vaults, sheds, service utility lines, and ballasted pavement. A realistic assessment of all present and future attachments should be made and included.

3.2.2 Unit Weights

Actual and available construction material weights shall be used for design. The following are typical unit weights:

Steel or cast steel	490 pcf
Aluminum alloys	175 pcf
Timber (untreated or treated)	50 pcf
Concrete, reinforced (normal weight)	150 pcf
Concrete, reinforced (lightweight)	120 pcf
Compacted sand, earth, gravel, or ballast	150 pcf
Asphalt paving	150 pcf

3.3 Vertical Live Loads (L)

3.3.1 Uniform Loading

The wharf shall be designed for a uniform live load of 1000 psf, except for areas outboard of the waterside crane rail, which shall be designed for 500 psf. When combined with crane loading, the uniform live load in all areas should be 300 psf, with no uniform loading within 5 feet of either side of the crane rails. For the design of wharf piles, the uniform live load may be reduced by 20%. All uniform live loads shall be distributed to produce maximum forces. At predetermined locations, the outboard deck slab will also be checked for the loads imposed during loading and unloading of container cranes or other large equipment from their transport vessel. This loading will be obtained from the equipment manufacturer and/or transporting company. Under some loading circumstances, a specified area may be designed into the wharf structure to accommodate those extreme loads.

3.3.2 Truck Loading

Truck loading shall be in accordance with the American Association of State Highway and Transportation Officials (AASHTO) Standard Specification for Highway Bridges (Ref. 1). All piers and wharves shall be designed for HL-93 loading shown in AASHTO, increased by a factor of 1.25. Lane loads need not be considered for the deck structure. Impact will be in accordance with Section 3.4. When truck loading is transferred through 2.0 feet or deeper ballast fill, the impact factor need not be considered in design.

3.3.3 Container Cranes

In the absence of actual crane load data from the manufacturer, the following values shall be used:

Crane Rail Loads

All crane rail beams and supporting substructures shall be designed for the container crane loads shown in Table 3-1 below. These rail loads are unfactored, and include both dead and live loads. The Table also indicates the load factors used for the various operating conditions, as well as the allowable stress and factors of safety for pile bearing in the soil. The uniform loading shown is based on eight wheels spaced at 5'-0" O.C. at each corner of crane.

The factored crane loads shall be used in combination with other loadings (Table 3-3) on the wharf deck for the design of the crane rail beam and piling.

The waterside crane rail beam shall be designed to span over interior pile(s) that may be damaged or broken. The load factors associated with a crane transiting over broken piles are shown in Table 3-1.

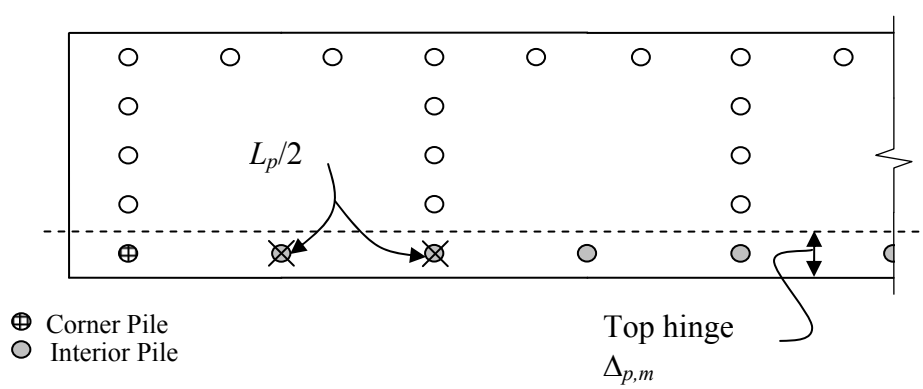


Figure 3-1: Broken Pile

Both waterside and landside crane rail beams shall be designed for a lateral load of 3.0 kips per linear foot applied at the top of rail.

Crane Stowage Pin

Crane stowage pins shall be designed for a horizontal force of 250 kips per rail at each location for strong wind conditions. For wind load see Section 3.10.

Crane Stop Loads

Crane stops shall be designed to resist a horizontal runaway wind blown crane impacting force of 350 kips per rail applied 6.0 feet above the top of the rail, and in a direction parallel to the rail.

Table 3-1: Vertical Container Crane Loading

Load Case	Crane Rail Loads		Load Factor[a]	Flexural Capacity[b]	Pile Soil Capacity Factor of Safety[c]
	W_W Waterside	W_L Landside			
Normal Operating[d]	50 klf	50 klf	1.3	ϕM_n	2.0
One interior pile broken[e]	50 klf	N/A	1.3	$1.1\phi M_n$	1.5
Two adjacent interior piles broken[e,f]	20 klf[g]	N/A	1.2	$1.1\phi M_n$	1.5

[a] These factors represent the combined dead and live load factors applied to the crane loading.

[b] ϕM_n is the reduced nominal moment capacity of the crane rail beam or supporting pile head, calculated based on ACI-318.

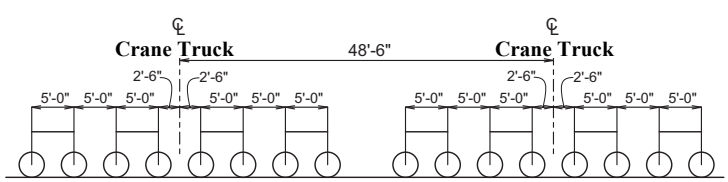
[c] This factor of safety is for service load design combinations.

[d] Crane rail loads are based on 3,000 kips crane dead load with 60 long ton lifting beam, servicing 22 box wide vessels.

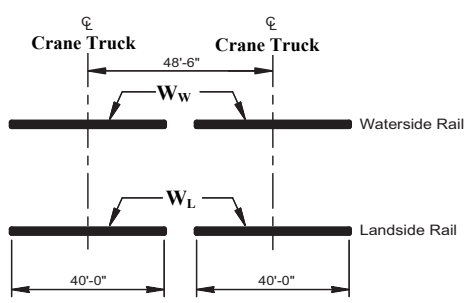
[e] Use for exterior waterside crane girder only. If truck lane exists the broken pile criteria are not applicable.

[f] Only wharf dead load and the waterside crane dead weight rail load specified above need be considered for the case of two adjacent interior piles broken.

[g] This value represents the crane dead load for transiting crane over broken piles only. No crane operations permitted.



Crane Wheel Spacing



Crane Loading Distribution

3.3.4 Container Handling Equipment Loading

Wharf decks slabs shall be checked for container handler wheel loads shown in Figure 3-2. Wheel load distribution shall be determined in accordance with AASHTO. For equipment with hard rubber wheels or other wheels not inflated, the wheel contact area shall be designed as a point load. If handling equipment load needs to be higher than the load shown in Figure 3-2, load values and distribution shall be provided to the port for approval.

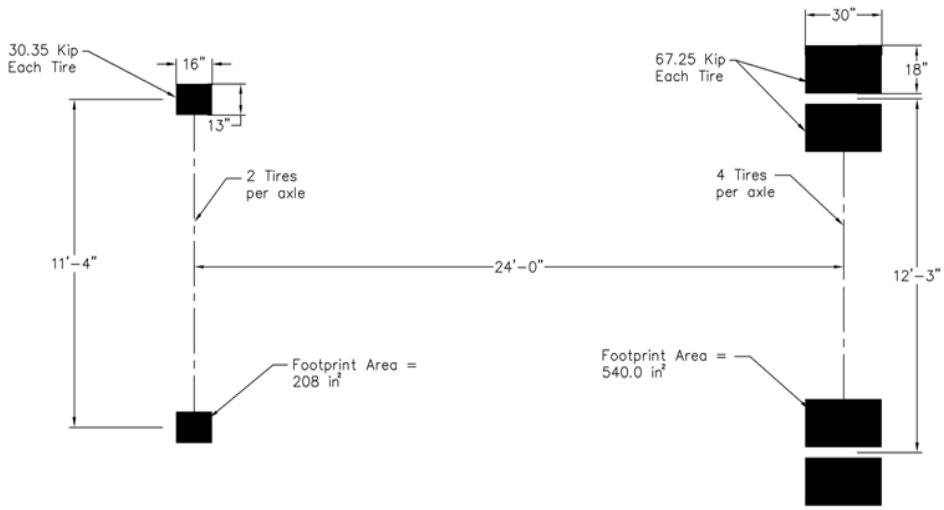


Figure 3-2: Design Wheel Loads

3.3.5 Railroad Track Loading

Piers and wharves accessible by freight car shall be designed for railroad loading. Wheel loads shall correspond to Cooper E-80 designation of "American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual" (Ref. 33).

3.4 Impact (I)

The impact factors shown in Table 3-2 shall be applied to uniform live loads and wheel loads for the design of deck slab, crane beams and pile caps. Impact factors should not be considered for the design of the piles and other types of substructures.

Table 3-2: Impact Factors

Loading	Impact
Uniform Load	0%
Truck Load	10%
Forklift & Container handler loading	10%
Railroad loading	20%

3.5 Buoyancy (BU)

Typically, piers and wharf decks are not kept low enough to be subjected to buoyancy forces. However, portions of the structure, such as utility lines and vaults and bent caps, may be low enough to be subjected to buoyancy forces. These are essentially uplift forces applied at the rate of 64 pounds per square foot of plan area for every foot of submergence below water level.

3.6 Berthing Loads (BE)

Berthing loads shall be based on the following vessel characteristics, unless otherwise specified. The approach velocity called out below includes the factor for abnormal berthing and assumes a favorable site condition. The berthing energy shall be determined by the deterministic approach as shown in "Guidelines for the Design of Fender Systems, 2002" (Ref. 28).

LOA (Length Overall)	1,300 feet
Maximum Displacement	220,000 metric tons (1 metric ton ≈ 2,205 lbs)
Beam	185 feet
Draft (Max)	48 feet
Allowable Hull Pressure	4 ksf
Approach velocity normal to fender line, $V_{\perp}$	0.35 foot/second

Smaller container vessels may berth with increased approach velocity normal to the fender line, but the kinetic energy of the vessel should not exceed the energy of the vessel with the maximum displacement, as stated above. Fender shear forces may be computed using a friction coefficient, μ_f = 30%, at the fender face/ship hull interface. The berthing energy of the rubber fender shall be based on a fender panel deflected angle of 10˚.

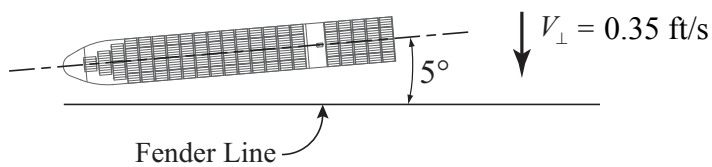


Figure 3-3: Berthing Load

$$V_F = \mu_f \times R_F \tag{3.1}$$

where:

V_F	=	Fender shear force
R_F	=	Force perpendicular to the fender panel due to berthing

3.7 Mooring Loads (M)

For the design of the wharf or pier structure, mooring line loads (P) shall be equal to the mooring hardware capacity. These line loads shall be applied at angles between horizontal and a maximum of 30° from horizontal in a vertical plane outboard of the wharf face, as shown in Figure 3-4. These load directions represent possible bow and stern breasting line loads. In applying these loads to the wharf or pier structure, consideration should be given to bow and stern breasting line separations as well as distances to possible adjacent vessel breasting lines. Where applicable, mooring line loads shall also be considered adjacent to expansion joints and/or the end of the structure.

Mooring hardware for container ships shall have a minimum capacity of 200 metric tons. For other types of vessels, which may require higher mooring hardware capacities, a more detailed mooring analysis shall be performed. For mooring analysis use 75 mph design wind speed (30 seconds duration with 25 years return period), for more details refer to 2007 CBC Section 3103F.5 (Ref. 18).

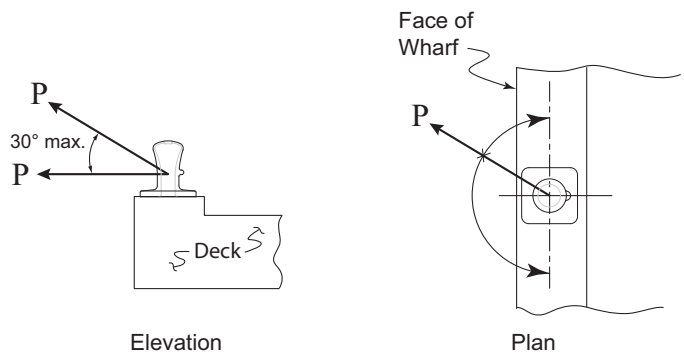


Figure 3-4: Mooring Lines Forces

3.8 Earth Pressure (E)

Detailed requirements for static and dynamic earth pressures are discussed in Section 2.

3.9 Earthquake (EQ)

All wharf structures shall be designed to resist earthquake motions by considering the relationship of the site to active faults, the seismic response of the soils at the site, and the dynamic response characteristics of the total structure and its individual components in accordance with the Seismic Design Criteria described in Section 1.

To account for the effect of vertical ground acceleration on the pile and deck, upper bound and lower bound dead load combinations shall be considered with seismic load. This shall be accomplished using a "*K*" factor as a function of PGA (Peak Ground Acceleration).

$$D(1 \pm K) \tag{3.2}$$

$$K = 0.5(PGA) \tag{3.3}$$

The lower bound and upper bound of the dead load shall be applied to the deck, as in Figure 3-5.

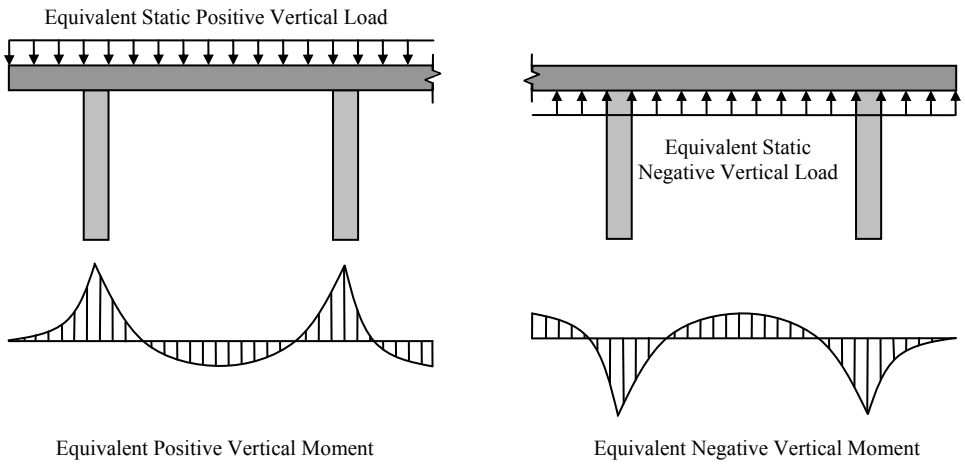


Figure 3-5: Equivalent Static Loads and Vertical Moments

3.10 Wind Load on Structure (W)

The wind load calculations should be based on 2007 CBC (Ref. 17) and ASCE7-05 (Ref. 11) with basic wind speed of 85 mph (3-second gust with 50 years return period).

3.11 Creep (R)

Creep is a material-specific internal load similar to shrinkage and temperature, and is critical only to prestressed concrete construction. The creep effect is also referred to as rib shortening and shall be evaluated using the PCI Design Handbook (Ref. 38).

3.12 Shrinkage (S)

Open pier and wharf decks, which are usually constructed from concrete components, are subject to forces resulting from shrinkage of concrete from the curing process. Shrinkage loads are similar to temperature loads in the sense that both are internal loads. For long continuous open piers and wharves and their approaches, shrinkage load is significant and should be considered. However, on pile-supported pier and wharf structures, the effect is not as critical as it may seem at first because, over the long time period in which shrinkage takes place, the soil surrounding the piles will slowly "give" and relieve the forces on the piles caused by the shrinking deck. The Prestressed Concrete Institute PCI Design Handbook (Ref. 38).is recommended for design of shrinkage.

3.13 Temperature (T)

Thermal stresses in structural elements shall be based on a temperature increase or decrease of 25° F.

3.14 Application of Loadings

Concentrated Loads

Wheel loads and outrigger float loads from container handling equipment may be applied at any point on a wharf deck except outboard of the waterside crane rail. The equipment may be oriented in any direction, and the orientation causing maximum forces on the structural members shall be used in the design. Trucks are permitted to operate outboard of the waterside crane rail. Power trench covers and utility vault covers outboard of the waterside crane rail shall be designed for wheel loads of trucks only; no other concentrated loads shall be used. Loaded containers shall not be stacked on the wharf deck. However, empties may be stacked inboard of the waterside crane rail, and the resulting corner casting compression or punching shear forces for empty containers stacked six high should be checked.

Simultaneous Loads

Uniform and concentrated live loads should be applied in a logical common sense manner. Designated uniform live loads and concentrated live loads from pneumatic-tired equipment shall not be applied simultaneously in the same area. However, a uniform live load shall be used between crane rails as described in Section 3.3.1. When railroad tracks are present between crane rails, both crane and railroad track loads shall be applied simultaneously, and no uniform load between crane rails shall be applied.

Loading for Maximum Stress

For determining the shear and bending moments in continuous members, the designated uniform loads shall be applied to produce the maximum effect.

Critical Loads

Concentrated loads are generally critical for punching shear and the design of short spans such as deck slabs, power trench covers and utility vault covers. Uniform loading, mobile crane floats, rail-mounted crane loading, and railroad loading are generally critical for the design of beams, pile caps, and supporting piles.

3.15 Load Combinations

3.15.1 General

Piers and wharves shall be proportioned to safely resist the load combinations represented in Table 3-3. Each component of the structure and the foundation elements shall be analyzed for all the applicable combinations.

Load Symbols

D	=	Dead Load
L	=	Live Load
I	=	Impact Load
BU	=	Buoyancy Load
BE	=	Berthing Load
E	=	Earth Pressure Load
EQ	=	Earthquake Load
W	=	Wind load
R	=	Creep/rib shortening Load
S	=	Shrinkage Load
T	=	Temperature Load
M	=	Mooring Load

3.15.2 Service Load Design

Load combinations used for service load design are presented in Table 3-3. The service load approach shall be used for designing and checking vertical foundation capacity and long-term vertical wharf loading, such as dead load. Timber structures for piers and wharves shall be designed using the service load combinations and allowable stresses. Mooring hardware and fittings (bolts and anchor plates) shall be designed using service load procedures.

3.15.3 Load Factor Design

Load combinations and load factors used for load factor design are presented in Table 3-3. Concrete and steel structures shall be designed using the load factor design method. However, they shall also be checked for serviceability (i.e., creep, fatigue, and crack control as described in ACI-318 (Ref. 2)), and temporary construction loads.

Table 3-3: Load Factors for LFD and LD

LOAD FACTOR DESIGN (LFD)[a]									
Case	LOAD COMBINATION FACTORS								
	D	L+I[b]	E	W	BE	R+S+T	EQ	BU	M
I	1.2	1.6	1.6	—	—	—	—	1.3	—
II	1.2	1.0	1.6	1.6	—	1.2	—	1.3	—
III[c]	0.9	—	1.6	1.6	—	1.3	—	1.3	—
IV	1.2	0.1[d]	1.6	1.0	1.6	—	—	1.3	—
V	1.2	1.0	1.6	1.3	—	—	—	1.3	1.3
VI	$1 \pm K$[e]	0.1[d]	1.0	—	—	—	1.0	—	—

SERVICE LOAD DESIGN (SLD)										
Case	LOAD COMBINATION FACTORS									Allowable Stress
	D	L+ I	E	W	BE	R+S+T	EQ	BU	M	
I	1.0	1.0	1.0	—	—	—	—	1.0	—	100%
II	1.0	1.0	1.0	1.0	—	1.0	—	1.0	—	133%
III	1.0	—	1.0	1.0	—	1.0	—	1.0	—	125%
IV	1.0	0.1[d]	1.0	0.3	1.0	—	—	1.0	—	100%
V	1.0	1.0	1.0	1.0	—	—	—	1.0	1.0	125%

[a]The Load Factor Design require the strength reduction factors, ϕ as specified in ACI-318 2005.

[b] For the load factor of crane load case see Table 3-1

[c] Reduce load factor to 0.9 for dead load (D) to check members for minimum axial load and maximum moment.

[d] For uniform live load only.

[e] K = 0.50 (PGA), to account for the affects of the vertical component of ground acceleration. The K-factor shall be applied to the vertical dead load (D) only, not to the inertia mass of the wharf.

4 Seismic Design Criteria

4.1 Introduction

The following criteria identify the minimum requirements for seismic design of wharves and piers. The criteria, which are performance based, require the displacement capacities of the structural members to be greater than the displacement demand imposed by the seismic loads. Where required, structural members are intentionally designed and detailed to deform inelastically for several cycles without significant degradation of strength under earthquake demand.

4.2 General Design Criteria

All wharf designs shall consider the following items:

Ductile Design

The wharf structure shall be designed as a ductile system. The pile to deck interface forms an integral part of the wharf structure, and shall be designed for ductile behavior.

Structural System

The structural system shall be based on the strong beam (deck), weak column (piles) frame concept. The pile-deck structural system shall be designed to develop plastic hinges in the piles and not in the deck. This concept is different from the strong column-weak pile structural system concept that is used for the design of buildings. Capacity design is required to ensure that the dependable strengths of the protected locations and actions exceed the maximum feasible demand based on high estimates of the flexural strength of plastic hinges.

Pile Connections

The pile shall be connected to the deck with mild steel dowels. Moment-resisting connections created by extending the prestressing tendons into the wharf deck shall not be permitted.

Vertical Piles

An all-vertical (plumb) pile system shall be used, with an appropriate connection at the pile to deck interface to ensure ductile performance of the structure. Battered piles shall not be used for the design of new wharves without prior written approval from the Port. Refer to Section 5.5.4 for the appropriate use of batter piles.

Crane Rails

Beams supporting crane rails shall be supported by vertical piles only. The gage between crane rails shall be maintained by structural members or a wharf deck that spans the two rails to prevent spreading or loss of gage due to earth movements.

Bulkheads

Bulkheads shall be designed for dynamic earth pressures induced during seismic events. Cut-off wall is mainly used to prevent loss of soil from backland and shall not be designed to provide seismic lateral resistant.

Slope Stability

A slope stability analysis, including seismic induced movements, shall be performed; see Section 2.

Utilities & Pipelines

Utilities shall be designed with flexible connections between the backland area and the wharf capable of sustaining expected wharf movements under CLE response. Flexible connections shall also be provided across expansion joints.

4.3 Performance Criteria

The ground motions levels provide in Section 2.1 shall be used for the seismic design. The permitted level of structural damage for each ground motion is controlled by concrete and steel strain limits in the piles. The performance criteria of the three-level ground motions are defined below:

Operating Level Earthquake (OLE)

Due to an OLE event, the wharf should have no interruption in operations. OLE forces and deformations, including permanent embankment deformations, shall not result in significant structural damage. All damage, if any, shall be cosmetic in nature and located where visually observable and accessible. Repairs shall not interrupt wharf operations.

Contingency Level Earthquake (CLE)

Due to a CLE event, there may be a temporary loss of operations that should be restorable within a few months. CLE forces and deformations, including permanent embankment deformations, may result in controlled inelastic structural behavior and limited permanent deformations. All damage shall be repairable and shall be located where visually observable and accessible for repairs.

Code-Level Design Earthquake (DE)

Due to a DE event, forces and deformations, including permanent embankment deformations, shall not result in the collapse of the wharf and the wharf shall be able to support the dead load including the cranes. Life safety shall be maintained.

4.4 Strain Limits

The strain limits for the OLE, CLE and DE performance levels shall be defined by the following material strains for concrete piles and steel pipe piles. Steel sheet piles and tie-back systems shall be designed to remain elastic under all three earthquake levels. Strain values computed in the analysis shall be compared to the following limits:

Table 4-1: Strain Limits

Component Strain		Design Level		
		OLE	CLE	DE
Solid Concrete Pile[a]	Top of pile hinge concrete strain	$\varepsilon_c \le 0.005$	$\varepsilon_c = 0.005 + 1.1\rho_s \le 0.025$	No limit
	In-ground hinge concrete strain	$\varepsilon_c \le 0.005$	$\varepsilon_c = 0.005 + 1.1\rho_s \le 0.008$	$\varepsilon_c = 0.005 + 1.1\rho_s \le 0.025$
	Deep In-ground hinge (>10D_p) concrete strain	$\varepsilon_c \le 0.008$	$\varepsilon_c \le 0.012$	No limit
	Top of pile hinge reinforcing steel strain	$\varepsilon_s \le 0.015$	$\varepsilon_s \le 0.6\varepsilon_{smd} \le 0.06$	$\varepsilon_s \le 0.8\varepsilon_{smd} \le 0.08$
	In-ground hinge prestressing tendon strain	$\varepsilon_p \le 0.015$	$\varepsilon_p \le 0.025$	$\varepsilon_p \le 0.035$
	Deep In-ground hinge (>10D_p) prestressing tendon strain	$\varepsilon_p \le 0.015$	$\varepsilon_p \le 0.025$	$\varepsilon_p \le 0.050$
Hollow Concrete Pile[b]	Top of pile hinge concrete strain	$\varepsilon_c \le 0.004$	$\varepsilon_c \le 0.006$	$\varepsilon_c \le 0.008$
	In-ground hinge concrete strain	$\varepsilon_c \le 0.004$	$\varepsilon_c \le 0.006$	$\varepsilon_c \le 0.008$
	Deep In-ground hinge (>10D_p) concrete strain	$\varepsilon_c \le 0.004$	$\varepsilon_c \le 0.006$	$\varepsilon_c \le 0.008$
	Top of pile hinge reinforcing steel strain	$\varepsilon_s \le 0.015$	$\varepsilon_s \le 0.4\varepsilon_{smd} \le 0.04$	$\varepsilon_s \le 0.6\varepsilon_{smd} \le 0.06$
	In-ground hinge prestressing tendon strain	$\varepsilon_p \le 0.015$	$\varepsilon_p \le 0.025$	$\varepsilon_p \le 0.025$
	Deep In-ground hinge (>10D_p) prestressing tendon strain	$\varepsilon_p \le 0.015$	$\varepsilon_p \le 0.025$	$\varepsilon_p \le 0.050$

Table 4-1: Strain Limits (Continued)

Component Strain		Design Level		
		OLE	CLE	DE
Steel Pipe Piles[c]	Top of pile hinge concrete strain	$\varepsilon_c \leq 0.010$	$\varepsilon_c \leq 0.025$	No limit
	Top of pile hinge reinforcing steel strain	$\varepsilon_s \leq 0.015$	$\varepsilon_s \leq 0.6\varepsilon_{smd} \leq 0.06$	$\varepsilon_s \leq 0.8\varepsilon_{smd} \leq 0.08$
	In-ground hinge hollow pipe steel strain	$\varepsilon_s \leq 0.010$	$\varepsilon_s \leq 0.025$	$\varepsilon_s \leq 0.035$
	In-ground hinge pipe in-filled with concrete steel strain	$\varepsilon_s \leq 0.010$	$\varepsilon_s \leq 0.035$	$\varepsilon_s \leq 0.05$
	Deep In-ground hinge (>10D_p) hollow pipe steel strain	$\varepsilon_p \leq 0.010$	$\varepsilon_p \leq 0.035$	$\varepsilon_p \leq 0.050$

[a] For solid round or octagonal piles.

[b] If a hollow concrete pile is in-filled with concrete, the strain limits are identical to solid concrete piles.

[c] Steel pipe pile deck connection shall be accomplished by concrete plug with dowels.

Definitions:

ε_c = Concrete compression strain.
ε_s = Total steel tensile strain.
ε_{smd} = Strain at maximum stress of dowel reinforcement; see Section 4.6.2.
ε_p = Total prestressing steel tensile strain.
ε_{pi} = Initial prestressing steel tensile strain after losses.
D_p = Pile diameter.

4.5 Analysis Methods

Analysis of wharf structures shall be performed for each performance level to determine displacement demand and capacity. The capacity will be based on the pile strain limits defined in Table 4-1. The following analysis methods may be used:

- Nonlinear Static Pushover
- Equivalent Lateral Stiffness Method
- Initial Stiffness Method
- Substitute Structure Method
- Modal Response Spectra
- Time-History Analysis.

The flow chart in Figure 4-1 shows the typical steps a designer should follow to complete the seismic design and analysis for a wharf structure. After the design for non-seismic loads has been completed, the performance design shall be completed for OLE, CLE and DE. The seismic design may require additional pile rows or a modified pile layout. A model including the effective section properties, seismic mass, and soil springs shall be prepared. An Equivalent Lateral Stiffness method may be used for preliminary design, if desired. Nonlinear static pushover analysis is always required, and will provide the displacement capacity limits for all methods. The structural analysis shall account for wharf torsional plan eccentricity, soil structure interaction, multi-directional effects of the ground motion and the interaction between adjacent segments. Displacement demand for regular wharves shall be estimated by the Initial Stiffness method, the Substitute Structure method, or Modal Response Spectra. For wharves with irregular geometry, special cases, or when demand/capacity ratios from Response Spectrum Analysis are too high, Time-History methods may be employed for the global model to verify the analysis results. Time-History analyses, however, shall not be conducted without prior approval from the Port.

The maximum pile displacement shall be determined from the demand analysis, and compared to the displacement capacity. The demand determined using the Initial Stiffness and Substitute Structure methods shall be adjusted for torsional effects using the Dynamic Magnification Factor. If the demand is greater than the capacity, the design must be revised. If the demand is less than the capacity, the pile shear, the beam/deck pile joint and P-Δ effects shall be checked. If geotechnical analyses indicate a potential for sliding failure of the dike, kinematic analysis of the deep in-ground pile hinge shall be performed in accordance with Section 4.12.

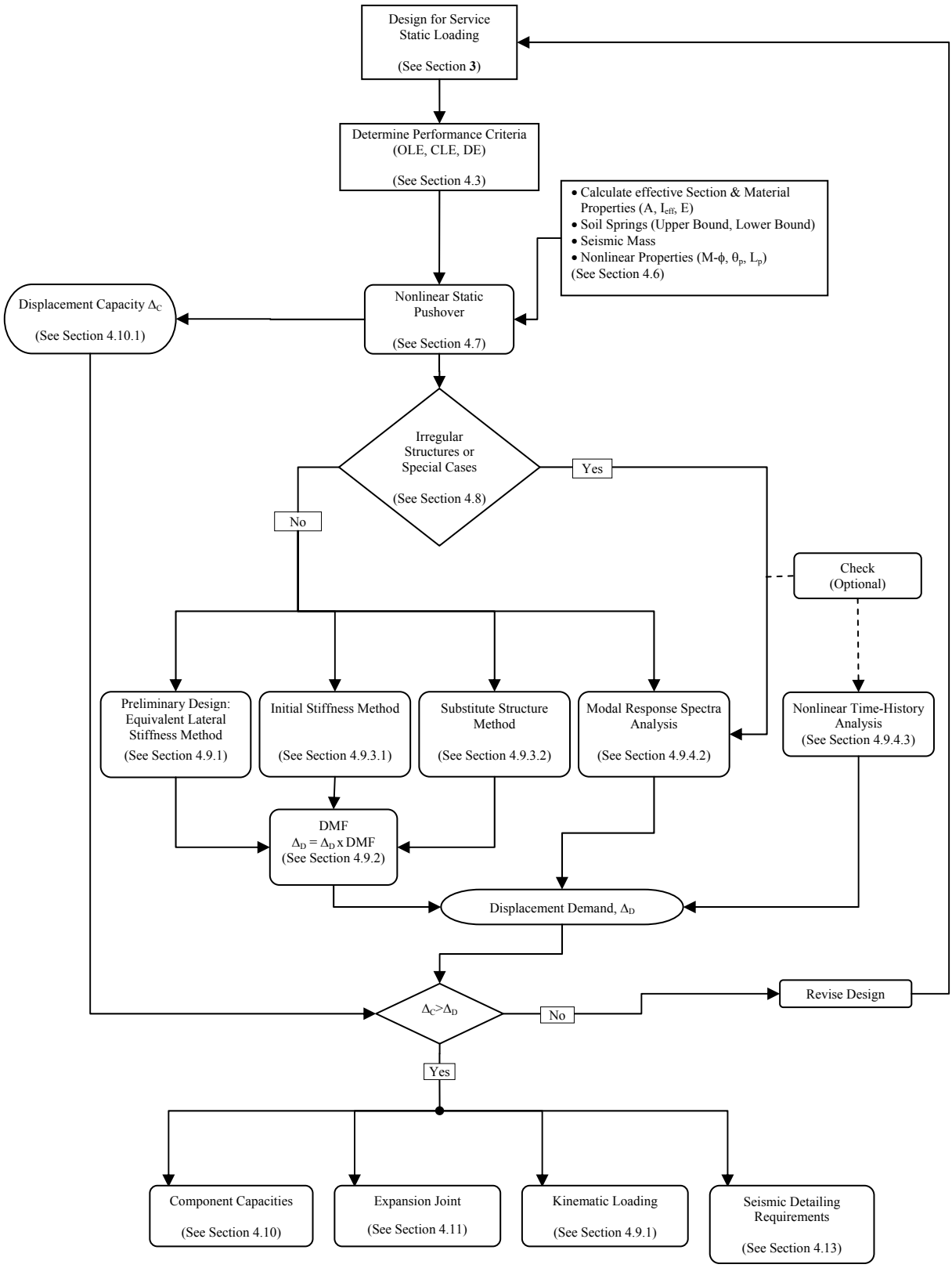


Figure 4-1: Flow Diagram for Seismic Analysis

4.6 Structural Model

4.6.1 Modeling

Due to the general uniformity and symmetry along the longitudinal axis of regular marginal wharves, the wharf may be modeled as a strip for pure transverse analyses. The number of piles considered in the strip should be modeled to reflect the pile spacing in each row, as shown in Figure 4-2.

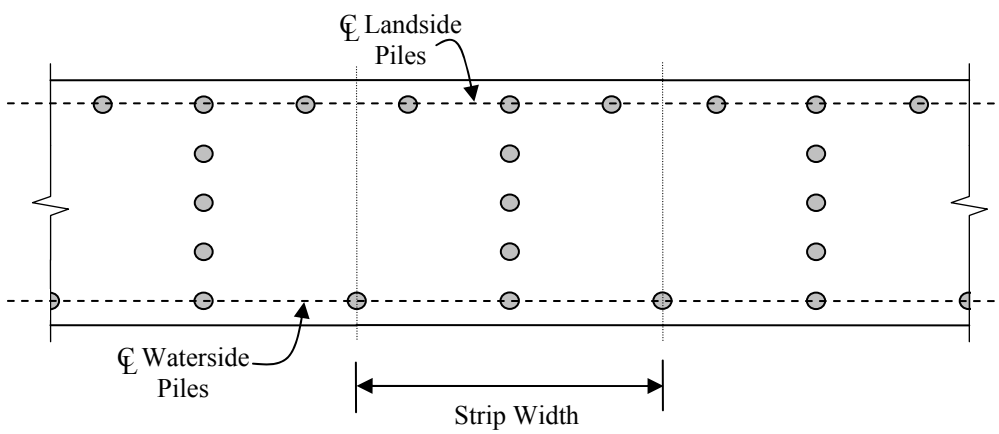


Figure 4-2: Pile Spacing for Typical Modeling Strip (Plan View)

The structural model shall incorporate components for the lateral resisting system. All members shall be modeled at the center of gravity of the section. A minimum of two members for the pile unsupported length from the soffit to the first soil spring shall be used in the modeling. The ratio of the stiffness between the rigid links and the surrounding elements should be no more than 100 to stabilize the stiffness matrix. Soil springs shall be used to model soil-structure interaction, and shall be spaced at each layer to accurately capture the soil behavior. Two distinct models shall be created to model upper bound and lower bound soil springs; see Section 0.

The interface between the deck and the pile should not be considered entirely rigid. The effective top of the pile should be located a distance l_{sp} into the deck to account for strain penetration. This additional length applies only to displacements. The strain penetration of the pile section into the deck shall be modeled as a member with properties equivalent to the top of the pile. The member between the strain penetration and the center of gravity (c.g.) of the deck shall be a rigid link. The length of the strain penetration member shall be equal to:

$$l_{sp} = 0.12 f_{ye} d_{bl} \tag{4.1}$$

where,

d_{bl} = The diameter of the longitudinal reinforcement

f_{ye} = Expected yield strength of the longitudinal reinforcement; see Section 4.6.2.

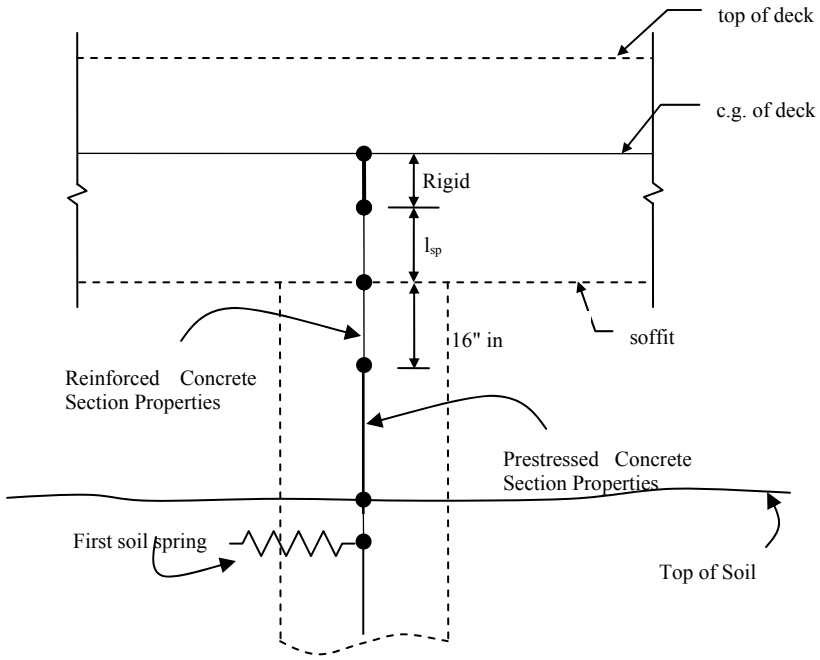


Figure 4-3: Pile Strain Penetration Length (Cross-Section)

For prestressed piles, the reinforced concrete effective section property shall be used for the first 16"of the pile below the soffit to account for development of the prestressing strands. Below the first 16" of the pile, the prestressed concrete effective section properties shall be used, see Section 4.10. Maximum moment shall be considered to develop at the soffit. Maximum in-ground moments will normally occur at between 50 and 100 inches below the dike surface for 24 inch diameter piles. This value depends on the soil stiffness and strength, and the clear height between the deck and dike. To insure adequate precision in modeling the pile moment profile, it is thus important that the soil springs be closely spaced in the upper region of the pile. For typical 24 inch diameter piles it is recommended that the first soil spring be located 6 inch below the dike surface, then springs be spaced at 12 inches to a depth of about 126 inches. Below this, the spacing can be increased to 24 inches to a depth of a bout 246 inches, then to 48 inches to a depth of about 390 inches. It will not normally be necessary to model the soil below this depth and the pile can generally be considered fixed against displacement and rotation at a depth of about 500 inches.

4.6.2 Material Properties

The capacity of concrete components to resist all seismic demands, except shear, shall be based on the most probable (expected) material properties to provide a more realistic estimate for design strength.

The expected concrete compressive strength, f'_{ce}, recognizes the typically conservative nature of concrete batch design, and the expected strength gain with age. The expected yield stress for reinforcing steel and structural steel, f_{ye}, is a "characteristic" strength and represents a low estimate of probable strength of the material, which is higher than the

specified minimum strength. Expected material properties shall be used to assess capacity and demands for earthquake loads. Seismic shear capacity shall not be based on the expected material strength, see Section 4.10.3. For the evaluation demand on of capacity-protected members, an additional overstrength factor shall be used when determining the capacity of pile plastic hinges as described in Section 4.10. Except for shear, the expected seismic material strengths shall be:

$$f'_{ce} = 1.3 f'_c \tag{4.2}$$

$$f_{ye} = 1.1 f_y \tag{4.3}$$

$$f_{yhe} = 1.0 f_{yh} \tag{4.4}$$

$$f_{pye} = 1.0 f_{py} \tag{4.5}$$

$$f_{pue} = 1.05 f_{pu} \tag{4.6}$$

where,

f'_c = 28-day unconfined compressive strength
f_y = Yield strength of longitudinal reinforcing steel or structural steel
f_{yh} = Yield strength of spiral reinforcement
f_{py} = Yield strength of prestressing steel
f_{pu} = Ultimate strength of prestressing steel
f'_{ce}, f_{ye}, f_{yhe}, f_{pye}, f_{pue} = Expected material properties

The following stress-strain curves may be used to compute the deformation capacity of the structural members. Alternative stress-strain models are acceptable if adequately documented and supported by test results.

Concrete

The stress-strain curves for both confined and unconfined concrete are shown below in Figure 4-4. This model is based on Mander's model for confined and unconfined concrete (Ref. 32).

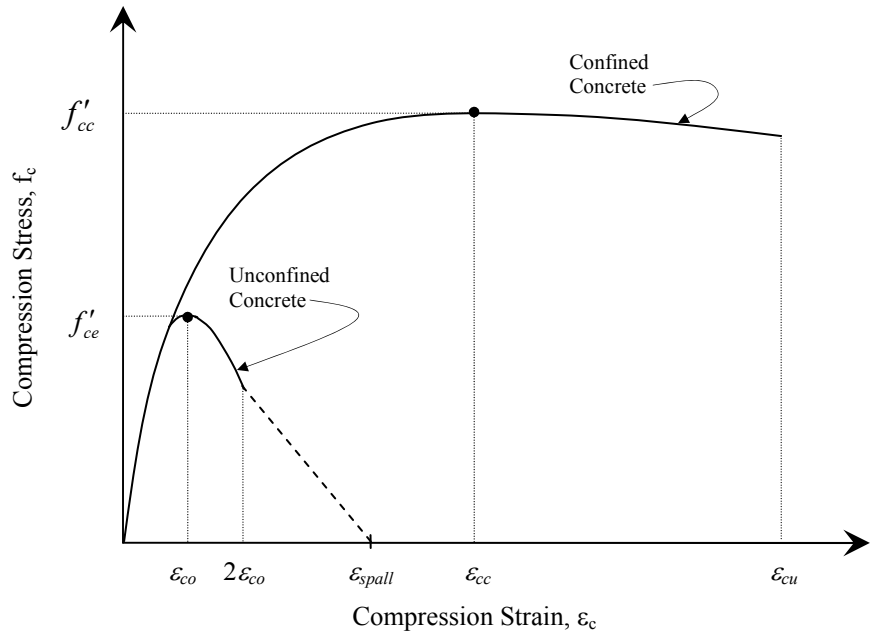


Figure 4-4:Stress-Strain Relationship for Confined and Unconfined Concrete

Unconfined Concrete:

Unconfined concrete either has no confinement steel or the spacing of the confinement steel exceeds 12 inches. For these cases:

ε_{spall} = Ultimate unconfined compression (spalling) strain, taken as 0.005

ε_{co} = Unconfined compression strain at the maximum compressive stress, taken as 0.002

Confined Concrete:

For confined concrete, the following are defined:

$$\varepsilon_{cu} = 0.005 + 1.1\rho_s \leq 0.025 \tag{4.7}$$

$$\varepsilon_{cc} = \varepsilon_{co}\left[1 + 5\left(\frac{f'_{cc}}{f'_{ce}} - 1\right)\right] \tag{4.8}$$

$$f'_{cc} = f'_{ce}\left(-1.254 + 2.254\sqrt{1 + \frac{7.94 f'_l}{f'_{ce}}} - 2\frac{f'_l}{f'_{ce}}\right) \tag{4.9}$$

where for circular core sections,

$$f'_l = \frac{1}{2}K_e \rho_s f_{yh} \tag{4.10}$$

$$\rho_s = \frac{4A_{sp}}{D's} \tag{4.11}$$

ρ_s	=	Effective volumetric ratio of confining steel
A_{sp}	=	Area of confining reinforcement
D'	=	Diameter of confining reinforcement core, measured to the centerline of the confinement
s	=	Center to center spacing of confining reinforcement along pile axis
f_{yh}	=	Yield stress of confining steel
ε_{cu}	=	Ultimate concrete compression strain
ε_{cc}	=	Confined concrete strain at peak stress
f_l'	=	Effective lateral confining stress
K_e	=	Confinement effectiveness coefficient, equal to 0.95 for circular cores
f'_{ce}	=	Expected concrete strength
f'_{cc}	=	Confined concrete strength

Figure 4-5 plots the ratio of confined concrete strength to expected unconfined concrete strength (f'_{cc} / f'_{ce}) with varying volumetric transverse steel ratios (ρ_s). This graph may be used to determine the confined concrete strength f'_{cc} for circular core sections.

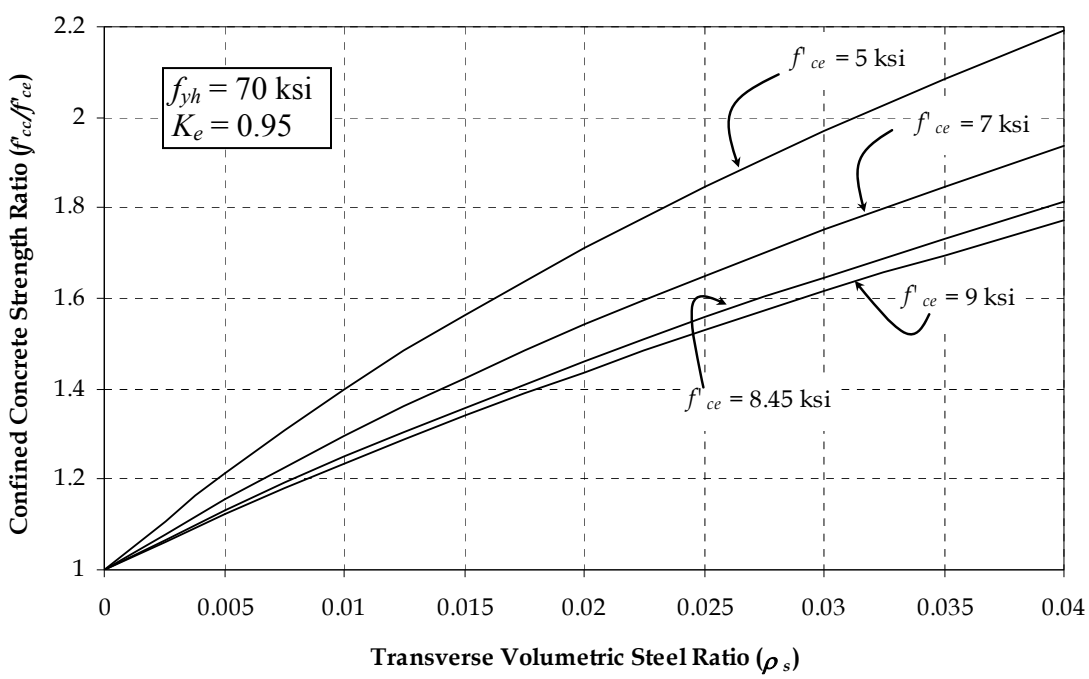


Figure 4-5: Confined Concrete Strength Ratio versus Transverse Steel Ratio

For pile sections with different transverse reinforcement strengths or shapes (i.e. rectangular stirrups), the confined concrete strength f'_{cc} may be approximated by 1.5 f'_{ce} or calculated according to Mander's model (Ref. 32).

Steel

The stress-strain curve for reinforcing steel is shown in Figure 4-6. The stress-strain curve for structural steel is similar to the curve for reinforcing steel.

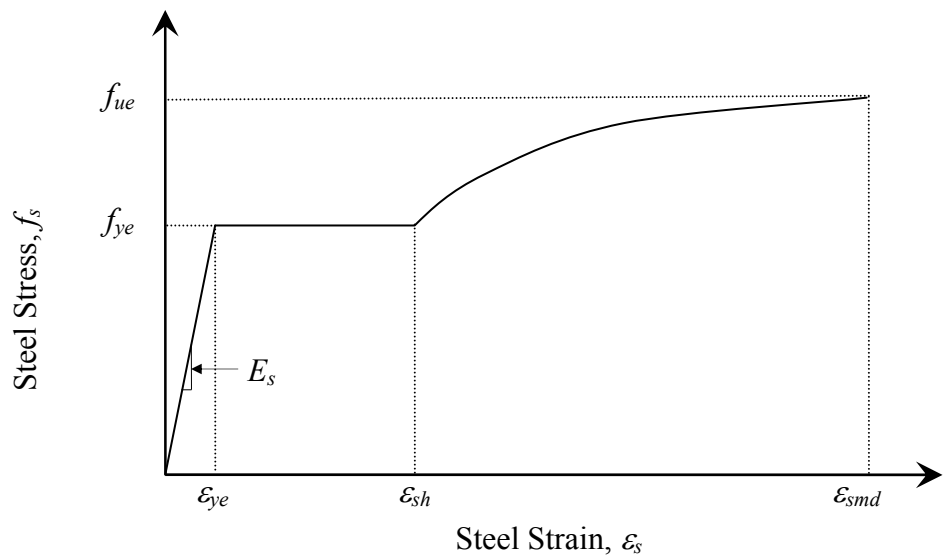


Figure 4-6: Stress-Strain Relationship for Reinforcing Steel

For ASTM A706 Grade 60 steel (Ref. 19):

Onset of strain hardening $\varepsilon_{sh} = \begin{cases} 0.0150 & \text{\#8 bars} \\ 0.0125 & \text{\#9 bars} \\ 0.0115 & \text{\#10 \& \#11 bars} \\ 0.0075 & \text{\#14 bars} \\ 0.0050 & \text{\#18 bars} \end{cases}$

Strain at maximum stress $\varepsilon_{smd} = \begin{cases} 0.120 & \text{\#10 bars and smaller} \\ 0.090 & \text{\#11 bars and larger} \end{cases}$

$f_{ue} = 1.4 f_{ye}$

f_{ue} = Expected maximum tensile strength of steel

E_s = 29,000 ksi

ε_{ye} = Expected yield strain of steel

Prestressing Tendons

The stress-strain curve for prestressing steel is shown in Figure 4-7.

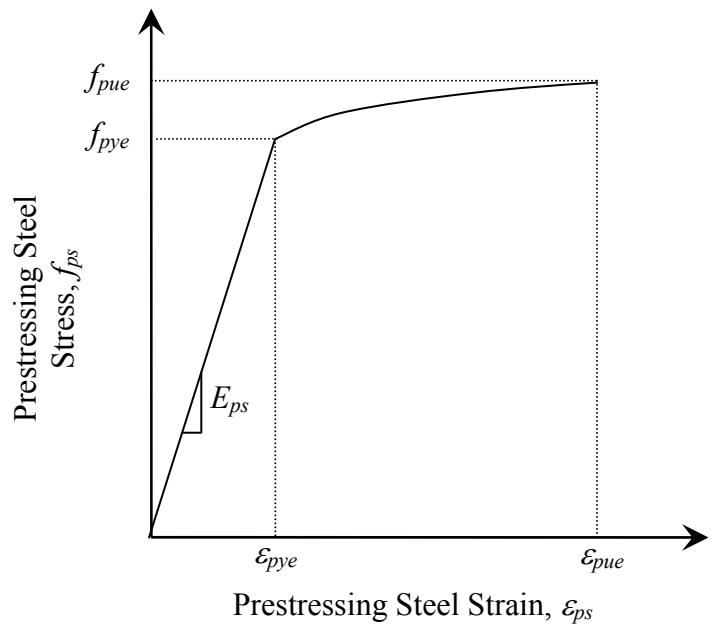


Figure 4-7:Stress-Strain Relationship for Prestressing Tendons

E_{ps} = Modulus of elasticity for prestressing steel, taken as 28,500 ksi

ε_{pye} = Expected yield strain for prestressing steel

ε_{pue} = Expected ultimate strain for prestressing steel, taken as 0.035

f_{pye} = Expected yield strength of prestressing steel, equal to $0.85f_{pue}$

f_{pue} = Expected maximum tensile strength of prestressing steel

4.6.3 Effective Section Properties

Elastic analysis assumes a linear relationship between stiffness and strength. Concrete members display nonlinear response before reaching their idealized Yield Limit State.

Section properties, flexural rigidity E_cI, and torsional rigidity G_cJ, shall reflect the cracking that occurs before the yield limit state is reached. The effective moments of inertia, I_{eff} and J_{eff} shall be used to obtain realistic values for the structure's elastic period and seismic demands.

The effective moment of inertia I_{eff} shall be used for the structural model. I_{eff} can be estimated by the secant slope of the moment-curvature curve between the origin and the point of first yield:

$$E_c I_{eff} = \frac{M_y}{\phi_{yi}}$$

where:

M_y = Moment at first yield; see Section 4.6.6.1 for definition

ϕ_{yi} = Curvature at first yield; see Section 4.6.6.1 for definition

For reinforced concrete piles and the pile/deck connection, see Figure 4-6 the effective moment of inertia ranges between 0.3-0.7I_{gross}. For prestressed concrete piles, the effective moment of inertia ranges between 0.6-0.75I_{gross}. The prestressing strands at the top of the prestressed pile near the pile/deck connection will not be developed, so I_{eff} of the dowel connection should be used. Use 0.5I_{gross} for the deck section. Sections that are expected to remain uncracked for seismic response should be represented by gross section properties.

The polar moment of inertia, J, of individual piles is normally an insignificant parameter on the global response of wharves and piers. Where the value of J is expected to affect the response, the following effective polar moment of inertia, J_{eff}, shall be used.

$$J_{eff} = 0.2\, J_{gross} \tag{4.12}$$

4.6.4 Seismic Mass

The mass considered for the dynamic analysis shall include the structural self-weight of the entire wharf, permanently attached equipment, and 10% of the design uniform live load. Also, 1/3 of the pile mass between the deck soffit and 5D_p below the dike surface shall be considered additional mass lumped at the deck. Hydrodynamic mass associated with piles, where significant, should be considered. For 24" diameter piles or less, hydrodynamic mass may be ignored.

The wharf mass shall include that part of the mass of supported cranes that can be considered rigidly connected to the wharf at deck level, $m_{crane,deck}$ if:

$$m_{crane,deck} > 0.05 m_{wharf}$$

where:

$m_{crane,deck}$ = part of the mass of all cranes positioned close to wharf deck level on the wharf segment under consideration

m_{wharf} = mass of the wharf segment under consideration

The mass of the higher part of the cranes supported by flexible members above the deck need not be considered when determining $m_{crane,deck}$.

The translational elastic period of the crane mode with the maximum participating mass, T_{crane} should be at least twice the effective elastic period of the wharf based on cracked section properties and effective elastic stiffness of the wharf system, T_w ($T_{crane} \geq 2T_w$). If this requirement is not satisfied, crane-wharf interaction analysis shall be performed with prior approval by the Port.

When analysis is based on a reduced strip width, as illustrated in Figure 4-2, the crane mass used for analysis, if required by the above definition, should be reduced from the total effective mass of cranes on the wharf segment between movement joints, in proportion to the strip length divided by the segment length.

4.6.5 Lateral Soil Springs

Upper and lower bound soil springs shall be used in the model to determine the maximum displacement demands and the corresponding displacement capacities. This recognizes the inherent uncertainties associated with soil-structure interaction. The higher of the two demand-to-capacity ratios so determined will provide a conservative estimate of compliance for displacement response. See Section 2 for further discussion on soil spring values.

4.6.6 Pile Nonlinear Properties

4.6.6.1 Moment Curvature Analysis

The plastic moment capacity, M_p, of the piles shall be calculated by Moment-Curvature (M-ϕ) analysis using expected material properties. The analysis must be capable of separately modeling the core and cover concrete, and must be capable of representing the enhanced concrete strength of the core concrete. The pile in-ground hinge section shall be analyzed as a fully confined section due to the soil confinement. Reinforcement and prestressing nonlinearity must also be realistically modeled as specified in Section 4.6.2. Moment curvature analysis provides a curve showing the moments associated with a range of curvatures for a cross section based on the principles of strain compatibility and equilibrium of forces. The analysis shall include the pile axial load and the effective prestress force.

The M-ϕ curve may be idealized by an elastic perfectly plastic response to estimate the plastic moment capacity as follows:

Moment-Curvature Curve Idealization: Method A

The idealized plastic moment capacity for typical concrete piles in the Port of Long Beach corresponds to the section moment associated with an extreme concrete fiber strain of 0.004, as shown in Figure 4-8. Typically, the M-ϕ curve peaks around 0.004, has a reduction in moment, and peaks again, depending on confinement, spalling of concrete cover and strain-hardening of reinforcement. If the second peak on the curve is less than the idealized M_p value, the moment at the lower second peak should be taken as M_p. However, for capacity protection analysis, the moment at the higher peak shall be used for M_p. The elastic portion of the idealized M-ϕ curve passes through the curvature at first reinforcing bar yield of the section or when concrete strain equals 0.002, whichever occurs first, and extends to meet M_p.

Moment-Curvature Curve Idealization: Method B

For other M-ϕ curves, the moment-curvature relationship may not exhibit the dramatic reduction in section moment capacity near the cover spalling strain. This may occur for larger diameter concrete piles, concrete-filled steel pipe piles with concrete plug

connections, and hollow steel piles. For these types, an equal area approach may be more appropriate. For this approach, the elastic portion of the idealized M-ϕ curve should pass through the point marking the first reinforcement bar yield or when $\varepsilon_c = 0.002$, whichever comes first (ϕ_{yi}, M_y). The idealized plastic moment capacity is obtained by balancing the areas between the actual and the idealized M-ϕ curves beyond the first yield point (Figure 4-9).

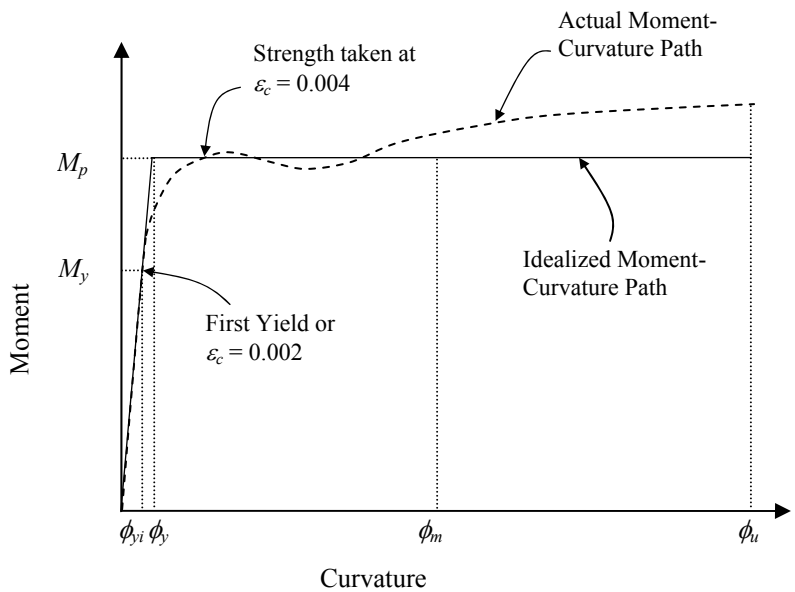


Figure 4-8: Moment–Curvature Curve and Idealization for Method A

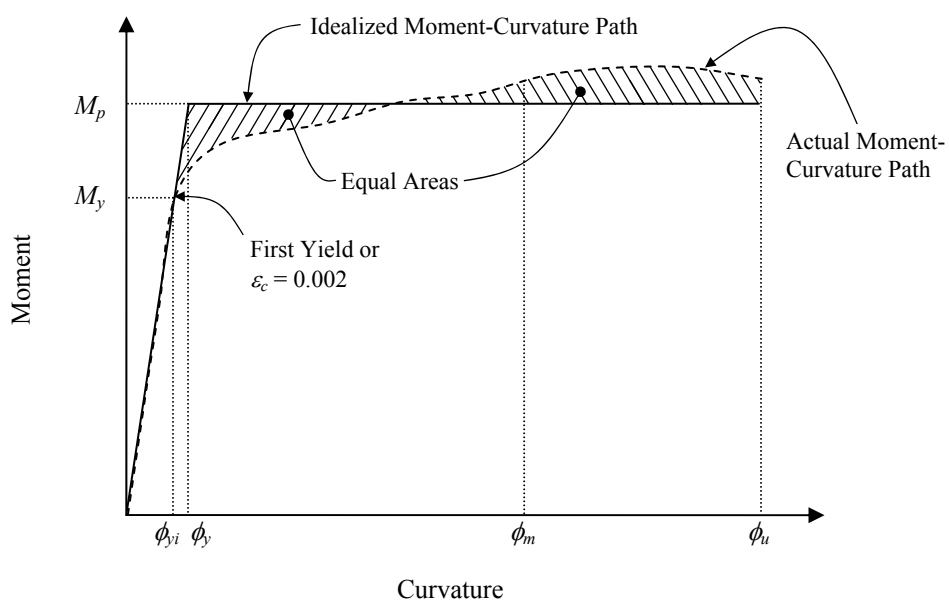


Figure 4-9: Moment-Curvature Curve and Idealization for Method B

where:

M_y = Moment at first yield, corresponding to ϕ_{yi}

ϕ_{yi} = Curvature at first yield (first rebar yield or $\varepsilon_c = 0.002$)

ϕ_y = Idealized yield curvature

ϕ_m = Curvature at the OLE, CLE or DE strain limit

ϕ_u = Ultimate curvature of the section

4.6.6.2 Plastic Hinge Length

The plastic hinge length needs to be determined to convert the moment-curvature relationship into a force-displacement or moment-plastic rotation relationship for the nonlinear pushover analysis.

Table 4-2: Plastic Hinge Length Equations

Section	Top	In-ground
Concrete Pile	4.13	4.15
Hollow Concrete Pile	4.13	4.15
Steel Pipe Pile (hollow with concrete plug connection)	4.14	4.15
Steel Pipe Pile (infilled with concrete)	4.14	4.15

For concrete pile dowel connections, the pile's plastic hinge length, L_p (above ground), when the plastic hinge forms against a supporting member, may be taken as:

$$L_p = 0.08L_c + 0.12 f_{ye} d_{bl} \geq 0.2 f_{ye} d_{bl} \tag{4.13}$$

where,

L_c = The distance from the critical section of the plastic hinge to the point of contra-flexure in the pile

d_{bl} = The diameter of the longitudinal reinforcement

f_{ye} = Expected yield strength of longitudinal reinforcement (ksi)

For steel pipe sections connected to the deck by a concrete plug with dowels, the plastic hinge length for the top of pile hinge may be taken as:

$$L_p = 0.3 f_{ye} d_{bl} + d_{gap} \tag{4.14}$$

where,

d_{gap} = The distance from the top of the steel shell to the soffit

The plastic hinge length L_p for all in-ground hinges may be taken as:

$$L_p = 2D_p \tag{4.15}$$

where,

D_p = Pile diameter

4.6.6.3 Plastic Rotation

The plastic rotation can be determined from the following equations:

$$\theta_{p,m} = L_p \phi_{p,m} = L_p(\phi_m - \phi_y) \tag{4.16}$$

where,

$\theta_{p,m}$ = Plastic rotation for the OLE, CLE or DE strain limit

$\phi_{p,m}$ = Plastic curvature for the OLE, CLE or DE strain limit

The idealized Moment-Rotation (M-θ) diagram is shown below:

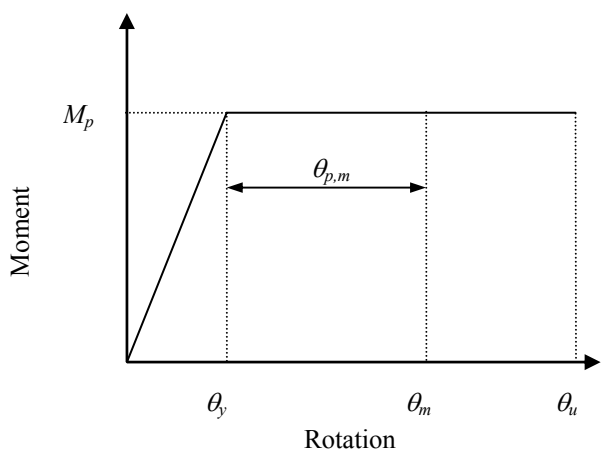


Figure 4-10: Idealized Moment-Rotation Curve

θ_u = Ultimate rotation

θ_y = Idealized yield rotation= $\phi_y L_{sp}$

θ_m = Total rotation at the OLE, CLE or DE strain limit

4.7 Nonlinear Static Pushover Analysis

Two-dimensional nonlinear static (pushover) analyses shall be performed for all wharf structures. The pushover curve shall have sufficient points to encompass the system's initial elastic response and predicted earthquake inelastic demand. The pushover curve shall also encompass the OLE, CLE and DE displacement capacities. The yield displacements and OLE, CLE or DE displacement capacities may be obtained directly from the pushover analyses when plastic rotation and hinge definitions are included in the model. This method incorporates soil deformation into the total displacement capacity of the pile. Pushover models shall use effective section properties and shall incorporate soil stiffness with nonlinear upper and lower bound *p-y* springs, as shown in Figure 4-11. The

results from the pushover analysis will provide the displacement capacities for OLE, CLE or DE earthquake levels, as well as the tools for the initial stiffness and substitute structure methods, see Figure 4-12. The pushover curve shall not experience a significant drop (greater than 20%) in base shear at the target strain limits.

For the purpose of determining displacement demand for a specified limit state, the pushover curve may be approximated by a bilinear response, as illustrated in Figure 4-12

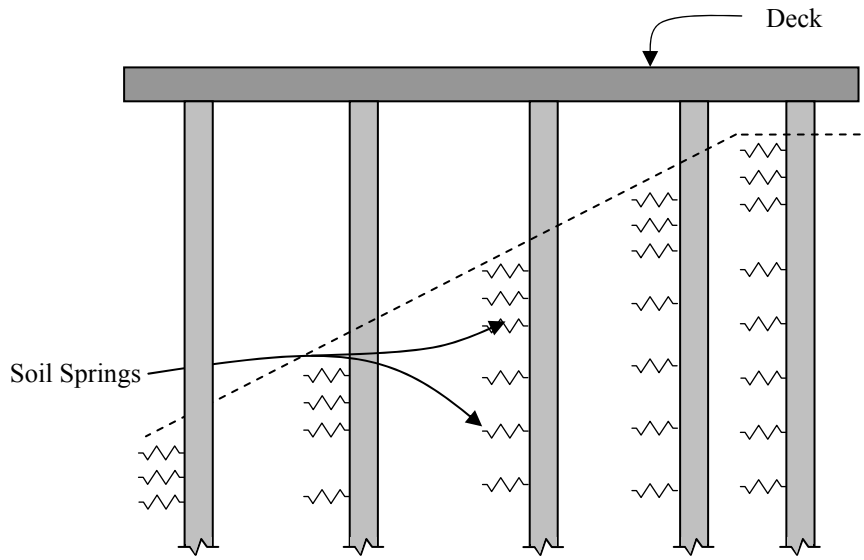


Figure 4-11: Pushover Analysis Model with P-y Springs

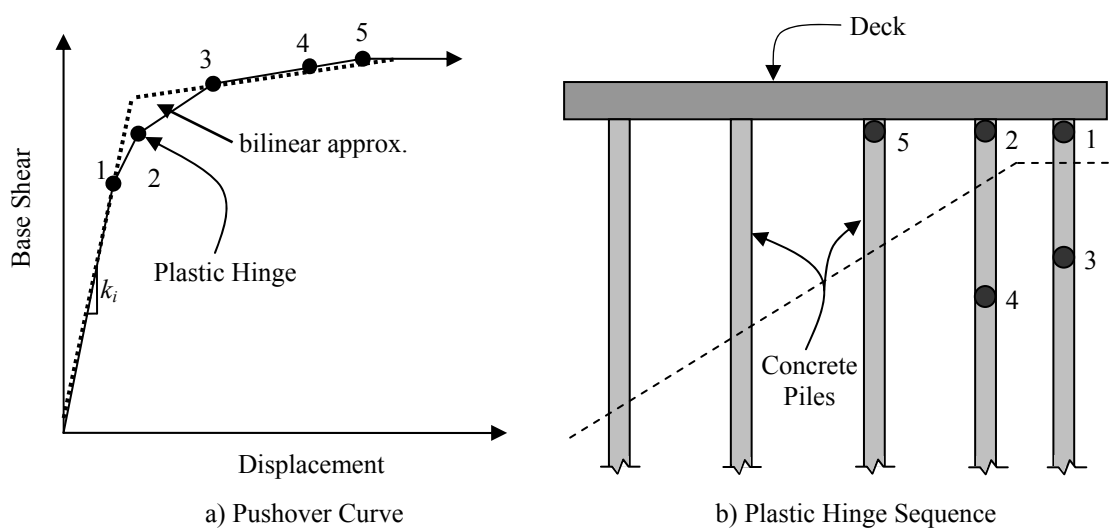


Figure 4-12: Example of Pushover Curve and Plastic Hinge Sequence

4.8 Irregular Structures and Special Case

4.8.1 Irregular Structures

Horizontal irregularity occurs when wharves have unsymmetrical pile and/or dike layouts, and when wharves have an angle point; see Figure 4-13. Figure 4-13 a) depicts a regular marginal wharf structure. The wharf in Figure 4-13 b) shows an irregular marginal wharf constructed with a partial dike. Figure 4-13 c) shows two adjacent wharves with large differences in stiffness, which may occur between two adjacent structures with different pile stiffness or different soil stiffness. Figure 4-13 d) shows an irregular wharf with an angle point.

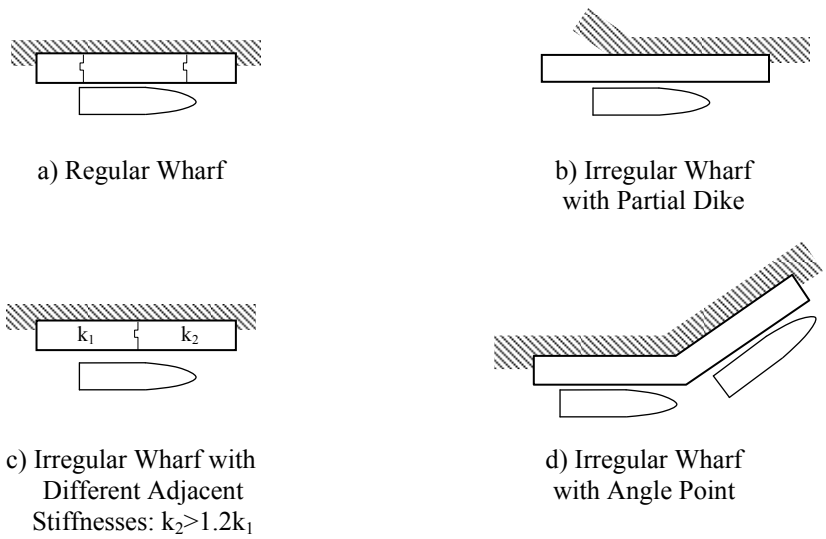


Figure 4-13: Horizontal Wharf Configurations

Vertical irregularity occurs when soil profiles below the wharf have sharp variations in lateral soil deformation over short vertical distances under seismic response.

4.8.2 Special Case

A special analysis case shall be considered to exist if the crane mass impacts the wharf behavior according to Section 4.6.4.

4.9 Demand Analysis

4.9.1 Equivalent Lateral Stiffness Method

In this approach, the equivalent depth to the point of fixity, L_s, is determined as the depth that produces the same top of pile displacement as that given by an individual lateral analysis for a given lateral load at the top of pile. For different assumed displacements and different pile head conditions (free-head or fixed-head), L_s will vary. The equivalent pile length has all soil (and associated lateral stiffness) removed above its supported base, as shown in Figure 4-14.

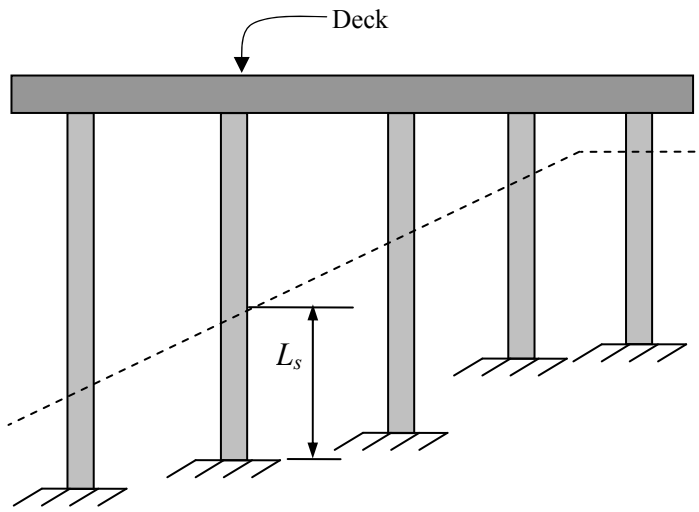


Figure 4-14: Equivalent Lateral Stiffness Method

This method produces adequate response results for the global elastic response. Pile-top moments will be underestimated and in-ground pile moments will be over-estimated, and hence the Equivalent Lateral Stiffness method may be used for preliminary design, but shall not be used for final design.

4.9.2 Dynamic Magnification Factor (DMF)

Most of the seismic lateral resistance of marginal wharves is provided by landward piles. The seaward piles are mainly for gravity loads and might provide about 10% of the overall lateral resistance. This creates eccentricity between the center of mass and the effective center of rigidity for the wharf, which will induce torsional response in the structure under longitudinal excitation. An upper bound of displacement demand of the critical piles at the end of a segment can be established by multiplying the displacement response calculated under pure transverse excitation by the Dynamic Magnification Factor, which accounts for torsional response and simultaneous longitudinal and transverse excitation. An analytical study utilizing non-linear time-history analysis was performed to calculate the DMF (Ref 15) using OLE and CLE ground motions with lower and upper bound soil springs conditions. The study was performed on 110-ft wide wharf with single segment, two linked segment and three linked segments. The segment lengths varied between 400', 600', and 800'. The study results show that DMF for CLE case is always lower than DMF for OLE case. Therefore, DMF for DE case may conservatively be assumed to be equal to DMF for CLE case.

Based on the study results, the Dynamic Magnification Factor may be calculated as follows:

Single Wharf Unit:

OLE:

LB or UB springs: $DMF = 1.80 - 0.05\, L_L / B \geq 1.10$ (4.17)

CLE/DE:

UB springs: $DMF = 1.65 - 0.05\, L_L / B \geq 1.10$ (4.18)

LB springs: $DMF = 1.50 - 0.05\, L_L / B \geq 1.10$ (4.19)

Two or More Linked Wharf Units:

Exterior

OLE:

LB or UB springs: $DMF = 1.55 - 0.04\ L_L / B \geq 1.10$ (4.20)

CLE/DE:

UB springs: $DMF = 1.35 - 0.02\ L_L / B \geq 1.10$ (4.21)

LB springs: $DMF = 1.16 - 0.02\ L_L / B \geq 1.10$ (4.22)

Interior

OLE/CLE/DE:

LB or UB springs: $DMF = 1.10$ (4.23)

Where:

L_L = length of the shortest exterior wharf unit

B = width of a wharf unit

LB = lower bound soil spring

UB = upper bound soil spring

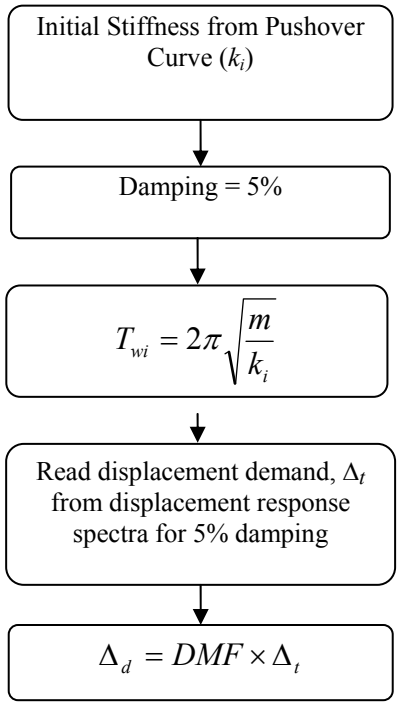
4.9.3 Two Dimensional Response Spectra Analysis

Reasonable estimates of displacement demand may be obtained from elastic analyses based on the Initial Stiffness method by using initial cracked-section elastic stiffness for the piles. However, improved representation of displacement demand will be obtained using the Substitute Structure approach. If the Initial Stiffness method described in Section 4.9.3.1 is used for the wharf design, the displacement demand to capacity ratio (DCR) shall be less than or equal to 0.85. If the DCR is larger than 0.85, the Substitute Structure method described in Section 4.9.3.2 shall be used for verification.

4.9.3.1 Initial Stiffness Method

The Initial Stiffness method is a pure transverse analysis of a typical wharf strip (see Figure 4-2). This method uses the initial stiffness, k_i, of the structure taken from the pushover curve to calculate the displacement demand (see Figure 4-12). This method assumes a damping ratio of 5%.

The results shall then be modified with the Dynamic Modification Factor (DMF) to include the influence of simultaneous longitudinal response, interaction across movement joints, and torsional effects, to calculate the displacement demand Δ_d. The flow chart shown in Figure 4-15) demonstrates the analysis steps for the Initial Stiffness method.



T_{wi} = Initial period

m = Seismic mass of the wharf segment per Section 4.6.4

g = Acceleration of gravity

Δ_t = Displacement demand based on transverse response

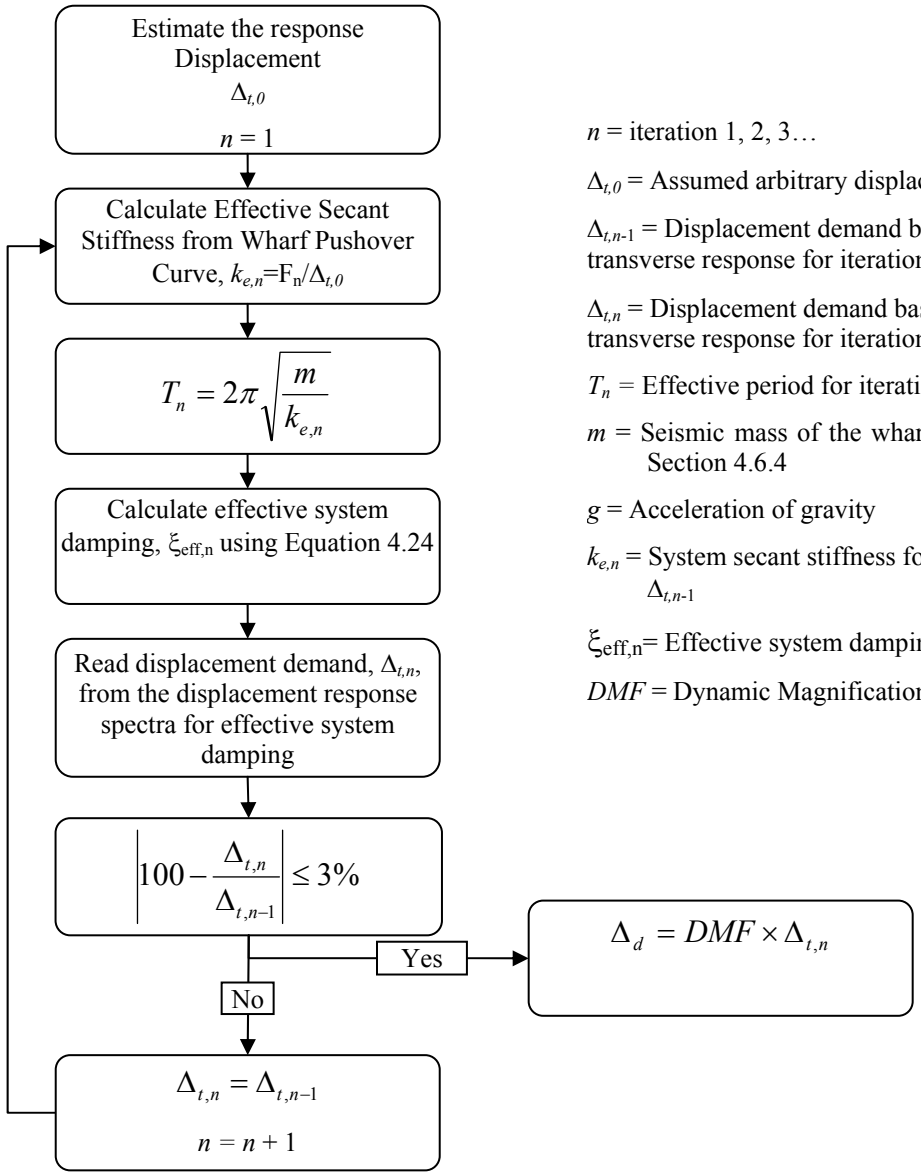
DMF = Dynamic Magnification Factor

Figure 4-15: Flow Diagram for the Initial Stiffness Method

4.9.3.2 Substitute Structure Method

The Substitute Structure method is an iterative process that uses the effective secant stiffness (k_e) at the response displacement, and an equivalent elastic damping representing the combined effects of elastic and hysteretic damping to determine the pure transverse displacement demand for each iteration, Δt,n (see Figure 4-17).

This approach is a single-mode pure transverse analysis, modified for simultaneous transverse and longitudinal excitation by the DMF. Figure 4-16 graphically shows the steps involved in computing the maximum displacement by the Substitute Structure method.



n = iteration 1, 2, 3…

$\Delta_{t,0}$ = Assumed arbitrary displacement

$\Delta_{t,n-1}$ = Displacement demand based on transverse response for iteration n-1

$\Delta_{t,n}$ = Displacement demand based on transverse response for iteration n

T_n = Effective period for iteration n

m = Seismic mass of the wharf segment per Section 4.6.4

g = Acceleration of gravity

$k_{e,n}$ = System secant stiffness for iteration n at $\Delta_{t,n-1}$

$\xi_{eff,n}$= Effective system damping

DMF = Dynamic Magnification Factor

Figure 4-16: Flow Diagram for Substitute Structure Method

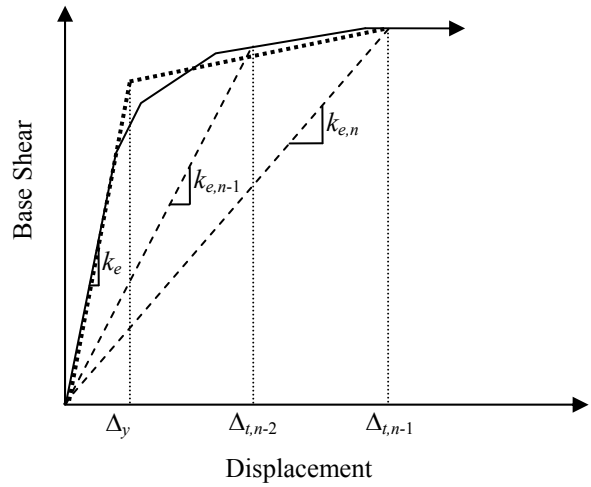


Figure 4-17: Effective Stiffness for Wharf System from Pushover Analysis

The yield displacement is the system yield displacement, found from the intersection of the elastic and post-yield branches of the bilinear approximation. This will always be larger than the first yield of piles. The "equal energy" approach may be used to estimate the bi-linear approximation of the system pushover curve. The system displacement ductility demand is found from the bilinear approximation to the system pushover curve (Figure Figure 4-12 and Figure 4-17) as:

$$\mu_n = \frac{\Delta_{t,n}}{\Delta_y} \tag{4.23}$$

The effective system damping is then found from Equation (4.24):

$$\xi_{eff,n} = 0.10 + 0.565\left(\frac{\mu_n - 1}{\mu_n \pi}\right) \tag{4.24}$$

The wharf transverse displacement demand based on pure transverse excitation may be considered to have converged when $\left|100 - \frac{\Delta_{t,n}}{\Delta_{t,n-1}}\right| \leq 3\%$. Once the transverse displacement demand converges, the result is modified using the *DMF*.

4.9.4 Three Dimensional Analysis

Three dimensional demand analyses include Modal Response Spectra Analysis and Nonlinear Time-History Analysis. A typical wharf segment between movement joints has a large number of piles, which will result in unacceptable matrix sizes for analysis. As an alternative, the structural characteristics of a wharf segment may be modeled by using the "Super-Pile" concept, as explained below.

4.9.4.1 Super-Pile Model

Four super-piles may be used to represent the combined properties and stiffness of the piles in the model for a regular wharf segment between movement joints. For the analysis of an irregular wharf, the super-pile concept should be used with special consideration of the irregular elements.

The super-pile locations are determined by the locations of the gravity piles and the seismic piles. The gravity piles mainly carry vertical loads, usually carrying less than 10% of the total lateral seismic load, and have less stringent detailing requirements. Seismic piles also carry vertical loads and provide most of the lateral seismic resistance with stringent detailing requirements.

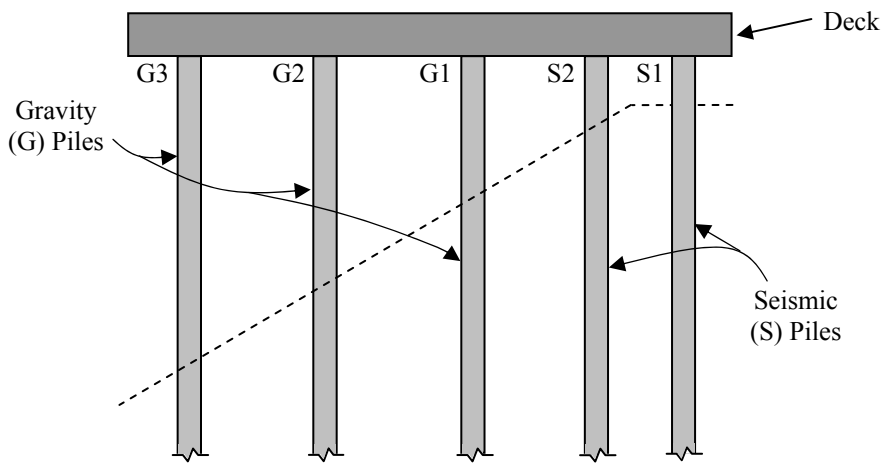


Figure 4-18: Elevation View of Transverse Wharf Segment

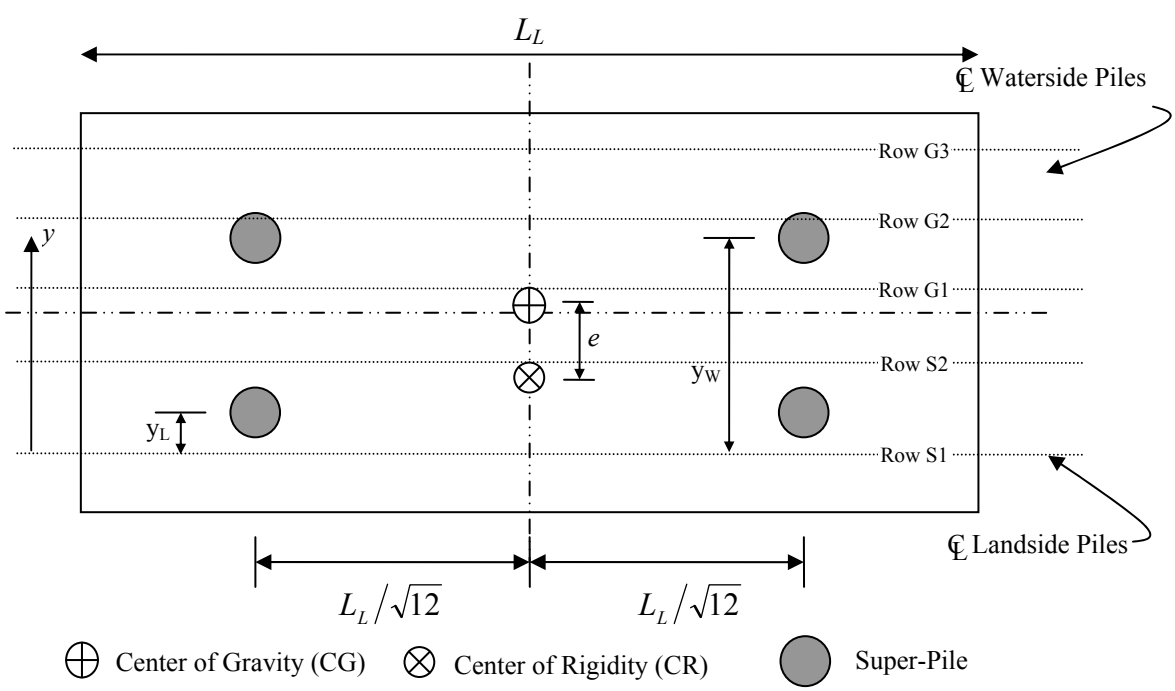


Figure 4-19: Plan View of Super-Pile Locations for a Wharf Segment

The super-piles shown in Figure 4-19 are located at distances y_L and y_W from the landside pile row:

$$y_L = \frac{\sum_{i=S1}^{S2} n_i F_i y_i}{\sum_{i=S1}^{S2} n_i F_i} \text{ and } y_W = \frac{\sum_{i=G1}^{G3} n_i F_i y_i}{\sum_{i=G1}^{G3} n_i F_i} \tag{4.24}$$

where:

i = Pile row (i.e. S1, S2, G1-G3 as shown in Figure 4-19 and Figure 4-18)
n_i = Total number of piles in row i for length L_L
F_i = Lateral force per pile in row i from pushover analysis
y_i = Distance of row i from the landside pile row

The super-pile stiffness is calculated from the pushover curve for the piles represented. The landside super-pile stiffness is equal to the stiffness of the piles on the landside of the dike. The remainder of the pile stiffness goes to the waterside super-piles. For a regular structure, the two landside super-piles should have equal stiffness, and the two waterside super-piles should have equal stiffness. In order to ensure the correct torsional stiffness under longitudinal response, the super-piles must be located at the center of gyration of the wharf segment; that is, for a regular wharf segment they must be located at a distance of $L_L / \sqrt{12}$ from the segment centroid, as shown in Figure 4-19.

The simplified model described above is suitable for both elastic modal analysis and inelastic time-history analysis.

4.9.4.2 Modal Response Spectra Analysis

This method is essentially a linear response spectrum analysis for a stand-alone wharf segment. A three dimensional linear elastic modal response analysis shall be used with effective section properties (Section 4.6.3) applied to components to establish lateral displacement demands.

Sufficient modes shall be included in the analysis such that 90% of the participating mass is captured in each of the structure's principal horizontal directions. For modal combinations, the Complete Quadratic Combination (CQC) rule shall be used. A damping ratio of 5% for spectral analysis shall be used unless a higher ratio can be justified.

When wharf segments are linked by shear keys at movement joints, elastic modal analysis will not provide adequate representation of shear key forces or displacement of the movement joint.

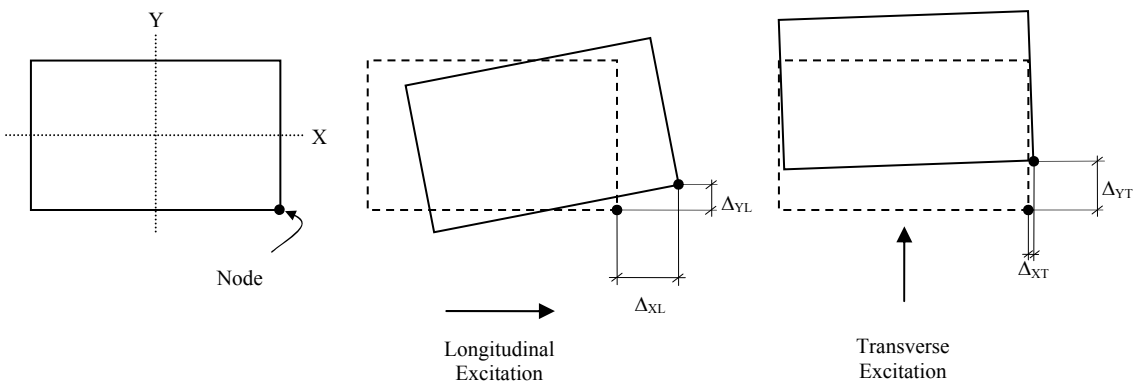


Figure 4-20: Wharf response from seismic motions

Input response spectra shall be applied separately along two orthogonal global axes (longitudinal and transverse). Spectral responses shall be obtained by the maximum of the following two loading cases:

Case 1: Combine the response resulting from 100% of the longitudinal loading with the corresponding response from 30% of the transverse loading.

$$\Delta_{X1} = \Delta_{XL} + 0.3\Delta_{XT}$$
$$\Delta_{Y1} = \Delta_{YL} + 0.3\Delta_{YT}$$

Case 2: Combine the response resulting from 100% of the transverse loading with the corresponding response from 30% of the longitudinal loading.

$$\Delta_{X2} = 0.3\Delta_{XL} + \Delta_{XT}$$
$$\Delta_{Y2} = 0.3\Delta_{YL} + \Delta_{YT}$$

where,

Δ_{XL} = X-axis displacement due to structure excitation in the longitudinal direction

Δ_{XT} = X-axis displacement due to structure excitation in the transverse direction

Δ_{YL} = Y-axis displacement due to structure excitation in the longitudinal direction

Δ_{YT} = Y-axis displacement due to structure excitation in the transverse direction

Δ_{X1}, Δ_{X2} = Combined X-axis displacement from motions in the transverse and longitudinal directions.

Δ_{Y1}, Δ_{Y2} = Combined Y-axis displacement from motions in the transverse and longitudinal directions.

The magnitude of seismic demand for a node (Δ_d) is defined as:

$$\Delta_d = \max\left(\sqrt{\Delta_{X1}^{\ 2} + \Delta_{Y1}^{\ 2}} \text{ or } \sqrt{\Delta_{X2}^{\ 2} + \Delta_{Y2}^{\ 2}}\right) \tag{4.25}$$

Nonlinear time-history analysis has shown that the 100% + 30% spectral combination rule to be non-conservative for wharf structures (Ref. 15). If Modal Response Spectra Analysis method described in Section 4.9.4.2 is used for the wharf design using soil initial lateral stiffness, the displacement demand to capacity ratio (DCR) shall be less than or equal to 0.85. If the DCR is larger than 0.85 other analysis methods shall be used.

4.9.4.3 Nonlinear Time-History Analysis

Nonlinear time-history analysis (NTHA) is the most accurate method for determining displacement analysis. Since the inelastic characteristics of the piles can be directly incorporated in the response, the longitudinal and transverse excitation can be simultaneously applied, and the complexities of the movement joints can be directly modeled. NTHA must always be used in conjunction with another, simplified analysis approach (e.g. the Substitute Structure method) to check results. When modeling reinforced or prestressed concrete members or steel members with concrete plugs, degrading stiffness models such as the Modified Takeda rule (Ref. 42) should be adopted.

Displacement demands from NTHA shall be based on simultaneous orthogonal horizontal input motions, as defined in Section 2.1. Multiple time histories will be required to achieve a representative displacement demand for the global model.

When three sets of spectrum-compatible Time-History records are used, the envelope value of each response parameter shall be used in the design. When seven sets or more of spectrum-compatible Time-History records are used, the average value of each response parameter shall be used.

When Time-History methods are used, a peer review shall be conducted per Section 4.14.

4.10 Structural Capacities

For the evaluation of capacity-protected members and actions, such as shear in piles, and shear and flexural demand deck beams, and deck slabs, the calculated demand on the members or action shall be determined from equilibrium considerations assuming an amplified flexural strength of pile plastic hinges together with gravity loads.

$$M_o = 1.25M_p$$

.The pile shear demand can be determined by

$$V_o = 1.25V_p$$

where

V_p = The pile plastic shear, which can be calculated based on pile plastic moments or as the maximum shear in the pile from both Upper Bound and Lower Bound pushover analyses

M_p = The idealized plastic moment capacity of the pile calculated by M-ϕ analysis

V_o = The pile overstrength shear demand

M_o = The pile overstrength moment capacity

Deck design moments and design shear forces shall be in equilibrium with the enhanced pile plastic moment capacity defined in this section.

4.10.1 Pile Displacement Capacity

For typical piles at the Port, the top and in-ground plastic hinge moment capacities are similar ($M_{p,\ in\text{-}ground} / M_{p,\ top} \leq 1.25$). For these cases, the distance L_c to the point of contraflexure is approximately the same for the top hinge and the in-ground hinge, so the displacement capacity, Δ_c, may be defined by:

$$\Delta_c = (\Delta_y + \Delta_{p,m}) \tag{4. 26}$$

$$\Delta_{p,m} = \theta_{p,m} \times H \tag{4.27}$$

where:

Δ_y = The pile yield displacement from its initial position to the formation of the plastic hinge being considered (i.e. top hinge or in-ground hinge)

$\Delta_{p,m}$ = The plastic displacement capacity due to rotation of the plastic hinge at the OLE, CLE or DE strain limits

H = The distance between the deck soffit and the center of the in-ground hinge

The pile yield displacements, Δ_y, of the top and in-ground hinges are obtained from the pushover analysis. Δ_c shall be calculated for top and in-ground hinges, and the smaller value shall be used for the displacement capacity. Figure 4-21 shows a graphical representation of the displacement capacity calculation for a top hinge. The concept is similar for the in-ground hinge.

For piles with a large unsupported length, U and in-ground and top hinges with a ratio $M_{p,\ in\text{-}ground} / M_{p,\ top} > 1.25$, the displacement capacity calculation becomes more complex, and the procedure used above will not provide accurate results. Therefore, a more detailed analysis using software with hinge definition capabilities that include plastic curvature or rotation limits should be used to determine the displacement capacity.

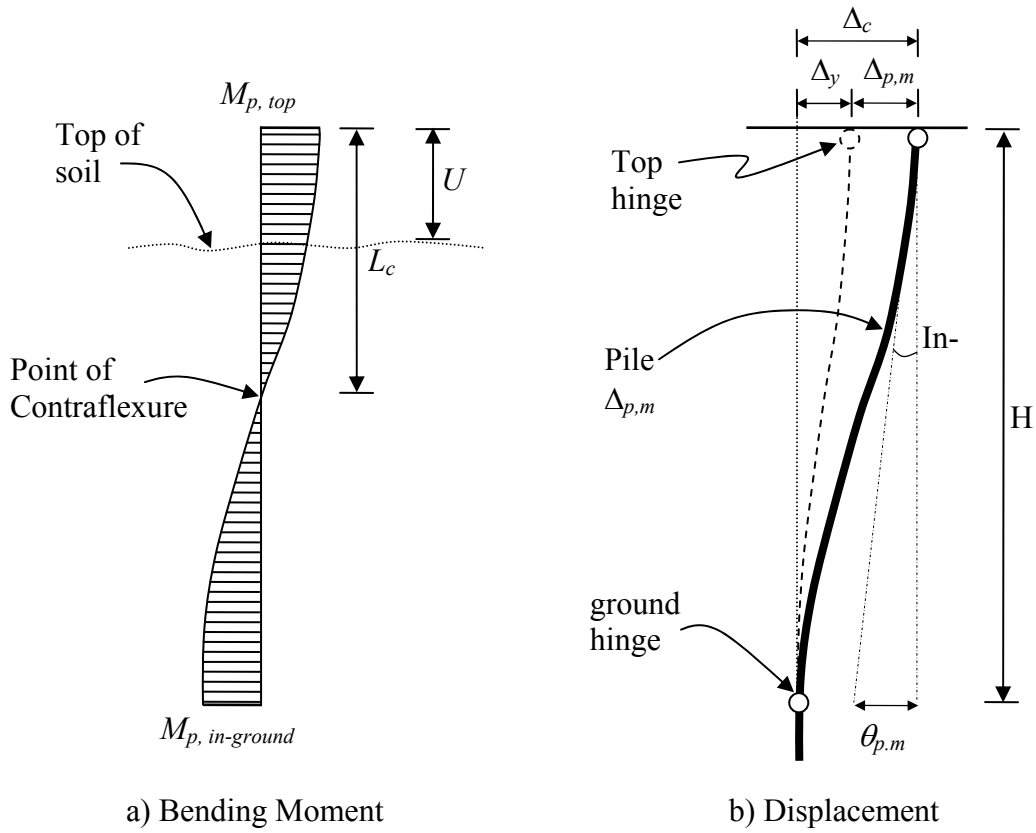


Figure 4-21: Schematic Pile Moment and Displacement Diagrams

4.10.2 Pile Beam/Deck Joint

The nominal strength capacity of the pile cap or deck shall be sufficient to ensure the piles have reached their plastic limit prior to the pile cap or deck reaching its expected nominal strength. The pile cap or deck shear and flexural capacities shall be based on ACI-318 using strength reduction factors. The superstructure flexural capacity shall be greater than the largest combination of deck dead load moment, deck moment due to 10% of live load, and pile overstrength moment distributed on each side of the pile joint. Any distribution factors shall be based on cracked sectional properties.

For the joint details shown in Figure 4-27, joint shear requirements are satisfied by providing adequate confinement. The effective volumetric ratio ρ_s of confining steel around the pile dowels anchored in the joint shall be:

$$\rho_s \geq \frac{0.46 A_{sc}}{D' l_a}\left[\frac{f_{ye}}{f_s}\right] \tag{4.28}$$

where:

f_s = Permitted spiral steel stress taken as $0.0015E_s$, where E_s is the modulus of elasticity of the spiral reinforcement
f_{ye} = Expected yield strength of the dowels
l_a = Actual embedment length provided

A_{sc} = Total area of dowel bars in the connection
D' = Diameter of the connection core, measured to the centerline of the spiral confinement

Less conservative mechanisms for joint shear transfer are suggested in Ref. 39 If an alternate detail is proposed, joint shear principal stresses shall be checked according to ACI-318.

4.10.3 Pile Shear

Shear strength shall be based on nominal material strengths and shear strength reduction factors. Maximum overstrength shear demand, V_o established from nonlinear pushover analyses shall be used as the design shear:

$$V_{design} = V_o \tag{4.29}$$

where V_o is defined in Section 4.10.

Steel Pile

The shear capacity shall be established from AISC-LRFD or API where applicable.

Concrete Pile

The following applies to concrete piles and to the pile-deck connection of tubular steel piles with dowels and concrete plug. The shear capacity, V_n, shall be calculated using the method described below, and is dependent upon the curvature ductility, μ_ϕ:

$$\mu_\phi = \phi_m/\phi_y \tag{4.30}$$

where for shear strength calculations, ϕ_m is the curvature at the OLE, CLE or DE strain limits.

This method is based on the modified UCSD three-parameter model (Ref. 40) with separate contributions to shear strength from concrete to obtain the nominal shear strength, V_n:

$$V_n = V_c + V_s + V_a \tag{4.31}$$

where,

V_c = Shear strength from concrete, Equation (4.33)
V_s = Transverse reinforcement shear strength, Equations (4.35) and (4.36).
V_a = Shear strength due to axial load, Equation (4.37)

A shear strength reduction factor Φ = 0.85 shall be applied to the nominal strength for OLE and CLE conditions to determine the design shear strength. A value of Φ =1.0 may be used for the DE case:

$$V_o \le \Phi V_n \tag{4.32}$$

Concrete mechanism shear strength:

$$V_C = k\sqrt{f_c^{'}}A_e \tag{4.33}$$

where:

k = Curvature ductility factor as a function of μ_ϕ (see Figure 4-22).
μ_ϕ = Curvature ductility based on Equation 4.35.
A_e = Effective shear area (80% of gross cross-sectional area for solid circular and octagonal piles)
f'_{ce} = Expected strength of unconfined concrete strength (in psi)

The curvature ductility shall be calculated at the demand displacement, and can be found using the formula below:

$$\mu_\phi = 1 + \frac{\phi_{P,dem}}{\phi_y} = 1 + \frac{\theta_{P,dem}}{L_p \phi_y} \tag{4.34}$$

where:

$\phi_{P,dem}$ = plastic curvature at the demand displacement
ϕ_y = yield curvature of the pile
$\theta_{P,dem}$ = plastic rotation at the demand displacement
L_p = plastic hinge length, (see section 4.6.6.2)

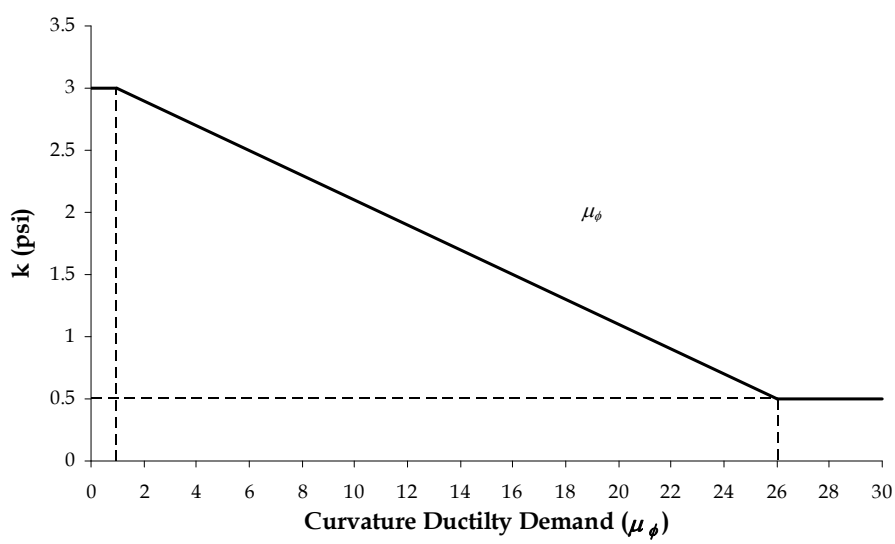


Figure 4-22: Relationship between Curvature Ductility and Strength of Concrete Shear Resisting Mechanism.

Transverse Reinforcement (Truss) Mechanism Shear Strength:

Spirals:

$$V_s = \frac{\pi}{2}\frac{A_{sp} f_{yh}(D_p - c - c_o)\cot(\theta)}{s} \tag{4.35}$$

where:

A_{sp} = Spiral cross section area

f_{yh} = Yield strength of transverse reinforcement

D_p = Pile diameter or gross depth (in the case of a rectangular pile with spiral confinement)

c = Depth from extreme compression fiber to neutral axis (N.A.) at flexural strength (see Figure 4-23)

c_o = Concrete cover thickness to the center of hoop or spiral (see Figure 4-23)

θ = Angle of critical crack to the pile axis (see Figure 4-23) taken as 30° for existing structures and 35° for new design

s = Spacing of hoops or spiral along the pile axis

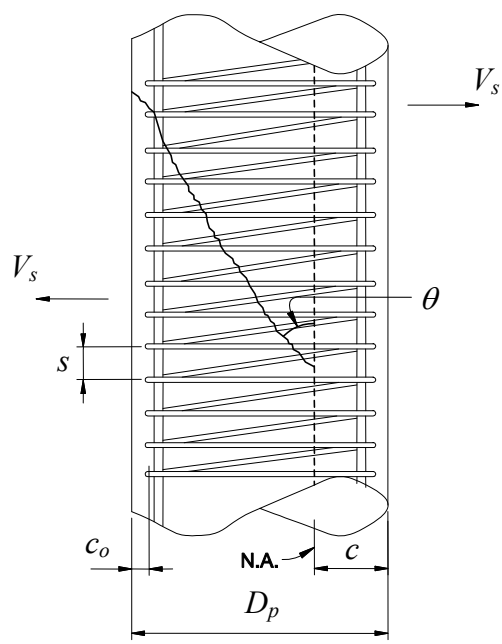


Figure 4-23: Transverse Shear Mechanism

Rectangular stirrups:

$$V_s = \frac{A_h f_{yh}(D_p - c - c_o)\cot(\theta)}{s} \tag{4.36}$$

where:

A_h = Cross-sectional area of transverse reinforcement

Shear strength from axial mechanism:

$$V_a = \beta(N_u + F_p)\tan(\alpha) \tag{4.37}$$

where:

N_u = External axial compression on pile including seismic load. Compression is taken as positive, and tension as negative.

F_p = Prestress compressive force in pile

α = Angle between line joining centers of flexural compression in the deck/pile and in-ground hinges and the pile axis (see Figure 4-24)

β = 1.0 for existing structures, and 0.85 for new design

Prestress compressive force F_p in the top hinge shall be taken as zero.

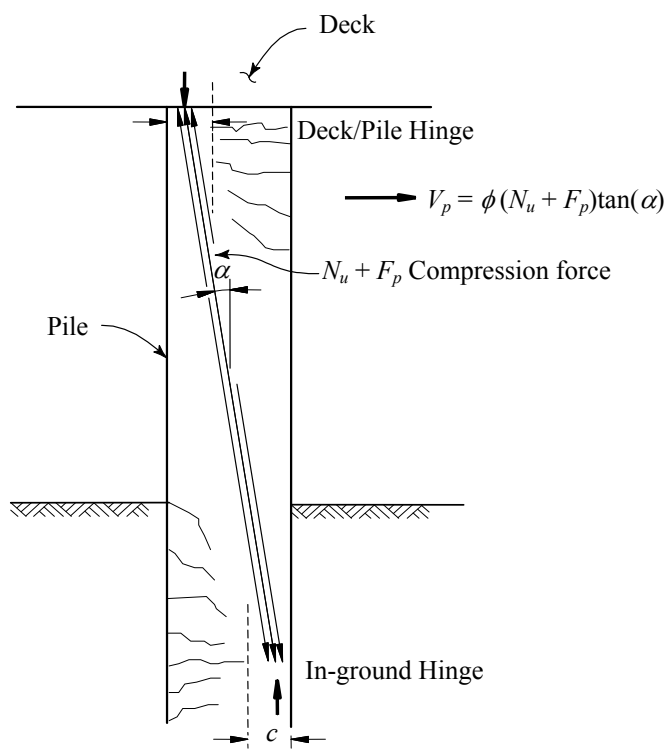


Figure 4-24: Axial Force Shear Mechanism

As an alternative to the above method, the shear strength may be calculated in accordance with the provisions of ACI-318 for piles with curvature ductility $\mu_\phi < 2$.

4.10.4 P-Delta Effects

The effects of P-Δ may be ignored when:

$$\frac{F}{W_{DL}} \geq 4\frac{\Delta_t}{H'} \tag{4.38}$$

where:

F = Base shear strength/total lateral force of the wharf strip (see Figure 4-2) obtained from a pushover analysis

W_{DL} = Dead load of the wharf strip considered

Δ_t = Displacement demand in the transverse direction

H' = Distance from the maximum in-ground moment to center of gravity of the deck

4.11 Expansion Joint

Spectral Analysis does not directly predict shear key forces between wharf segments at expansion joints. A series of time history analyses were conducted as part of a research study at UCSD (Ref. 15) to obtain shear key forces for different wharf configurations, soil properties and ground motion intensities. The results of the study are based on a 110' wide wharf section. Different wharf segment length combinations were used for the analyses. The segment lengths were varied between 400', 600', and 800', and the analysis was conducted using both lower and upper bound soil characteristics and OLE and CLE ground motions.

The study results show that for two linked wharf units, the shear key should be designed for a seismic shear key force demand, V_{sk} as shown below:

$$V_{sk} = \beta\left(\frac{V_{\Delta}e}{L_L}\right) \tag{4.39}$$

where,

V_{Δ} = Lateral force at the maximum displacement calculated from the pushover analysis of a wharf transverse section

e = Wharf eccentricity between the center of mass and center of rigidity

L = Wharf segment length

β = Factor calculated as a function of wharf segment length, see Figure 4-25, (Ref. 15).

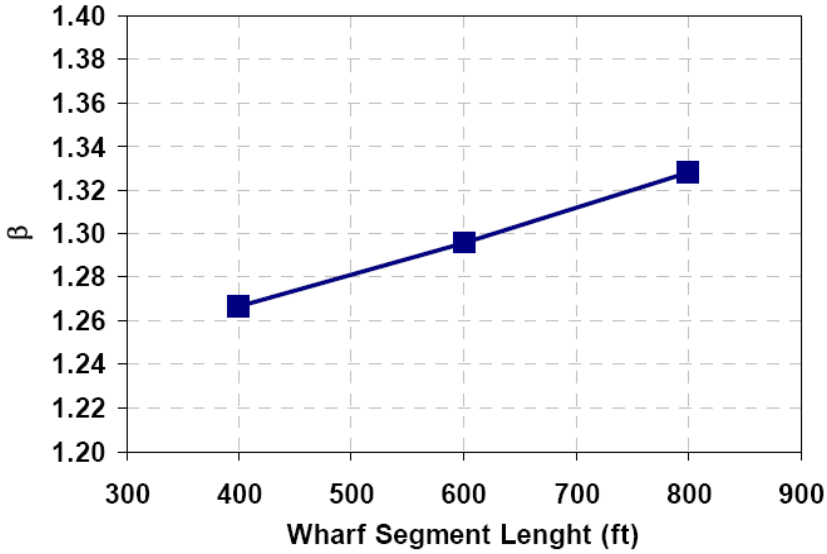


Figure 4-25: β variation

For wharf sections with different configurations, special analysis needs to be performed with prior approval by the port.

For calculating expansion joint shear capacity according to ACI-318, a reduction factor of 0.85 should be used.

4.12 Kinematic Loading

Kinematic loading occurs when the dike begins at depth on a weak soil layer sliding in an earthquake, inducing bending moments beneath the soil surface in the pile. Deep in-ground hinges may form due to the dike movement, as shown in Figure 4-26.

Section 2 provides screening criteria for kinematic analysis of the dike. If a kinematic analysis is required, the Geotechnical Engineer shall provide displacement profiles for the piles under kinematic loading. The piles shall be analyzed for the given displacement profiles, and the material strains in the piles shall be checked according to the strain limits provided in Table 4-1. The shear in the pile shall also be checked.

For the 24-inch octagonal, precast, prestressed concrete piles and pile configurations that are typically used for port wharf projects, kinematic loading at shallow pile embedments ($\leq$ 20 ft.) need not be analyzed. For shallow embedments, lateral soil springs are expected to be softer and piles are expected to have higher displacement capacities than for deeper embedments. Therefore, kinematic loading at shallow embedments is not expected to be a controlling case.

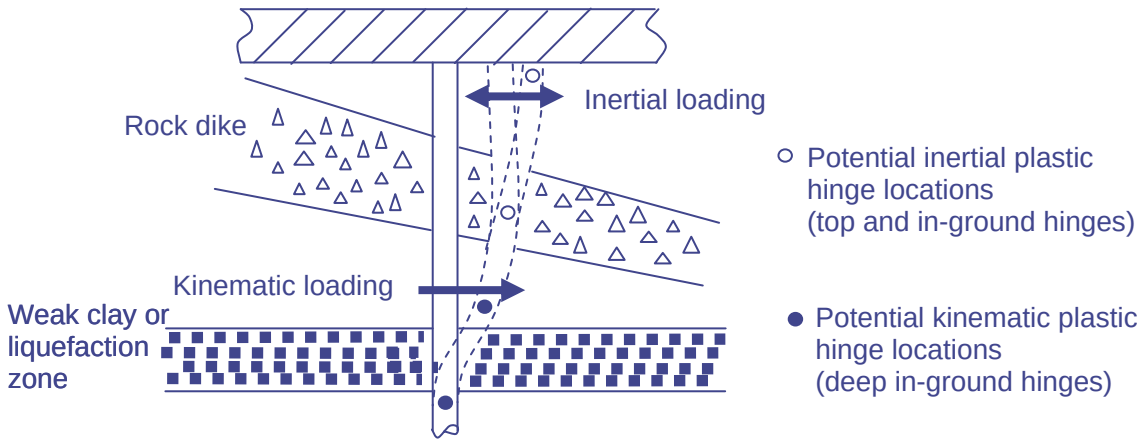


Figure 4-26: Hinge Formation for Kinematic Loading

4.13 Seismic Detailing

The details shown in Figure 4-27 are acceptable confinement details for the pile/deck connection. The volumetric ratio of longitudinal dowel reinforcement (ρ) shall be between 1% and 4%. The maximum dowel bar size should be No. 11. The dowels shall be developed into the pile to satisfy ACI-318 requirements. The joint transverse reinforcement volumetric ratio shall be provided according to Section 4.10.2. The pile prestressing strands shall be cut-off and removed at the top of the pile.

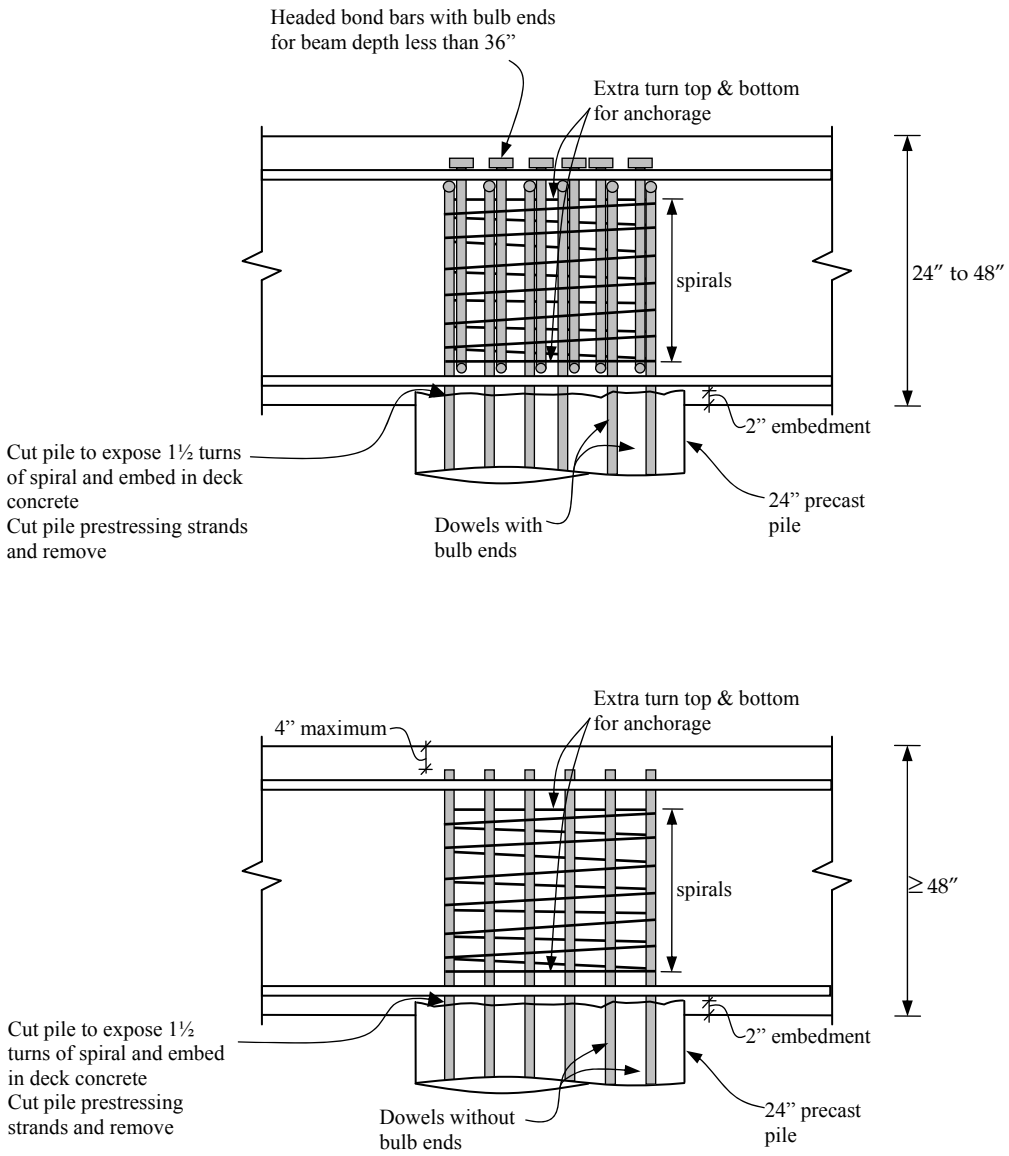


Figure 4-27: Anchorage Details for Dowels

4.14 Peer Review

A peer review of the analysis and design shall be performed by an engineering team selected by the Port for:

1. Irregular wharf structures
2. Time-History Analyses
3. Presence of faults at the project site
4. Kinematic Analysis

5 Structural Considerations

5.1 Design Standards

The following design codes shall be used where appropriate. The latest published editions of all references with all addenda shall be used in the design.

1. California Building Code (CBC), California Code of Regulations, Title 24 (Ref. 17).
2. American Concrete Institute, Building Code Requirements for Structural Concrete and Commentary, ACI 318 (Ref. 2)
3. ASCE 7-05, Standard, Minimum Design Loads for Buildings and Other Structures (Ref. 11)
4. American Institute of Steel Constructions, Code of Standard Practice for Steel Buildings and Bridges (Ref. 6)
5. ANSI/AWS D1.1, Structural Welding Code – Steel (Ref. 8)
6. California Building Code "Chapter 31F [For SLC], Marine Oil Terminals", also known as Marine Oil Terminal Engineering Standards (MOTEMS) (Ref. 18)
7. American Petroleum Institute, Recommended Practices 2A (Ref. 7)

5.2 Wharf Geometrics

5.2.1 Controls

The Engineer shall refer to the CONTROL Section of the Design Criteria and Standard Plans under General Criteria for specific instructions as to survey controls.

Vertical Datum

The tidal range for the Port of Long Beach is based on NGVD 29 (National Geodetic vertical Datum of 1929), with MLLW = 0.0'. The City of Long Beach uses NGVD 29 with MSL=0.0'. As a reference, NAVD 88 (North American Vertical Datum of 1988) is provided in Table 5-1:

Monuments

The Engineer shall indicate on the Project Plans the location and type for installation of baseline monuments. The Port survey section shall provide to the Engineer the required locations and type of monuments.

Table 5-1: Tidal Elevations

Abbreviation	Description	Elevation (ft)	
		NGVD 29	NAVD 88
---	Highest Observed Water Level[a]	+7.54	+7.16
MHHW	Mean Higher-High Water	+5.43	+5.05
MHW	Mean High Water	+4.71	+4.33
MSL	Mean Sea Level	+2.80	+2.42
MLW	Mean Low Water	+0.95	+0.57
MLLW	Mean Lower-Low Water	0.0	-0.38
---	Lowest Observed Water Level	-2.56	-2.94

[a] The extreme elevations should be used with caution. Irregularities in the predicted tide (seiches) have been known to cause variations of up to 1.0 ft.

5.2.2 Structure Elevations

In general, wharf elevations shall maintain facility operations under all tidal conditions. Where applicable, the wharf elevation shall also match that of adjacent facilities, unless directed otherwise by project criteria. Wharf elevations for RO-RO, barge loading and unloading, and special purpose docks are to be determined by project criteria.

5.2.3 Crane Rails

Rail Elevations

The top of crane rails (except for wheel flange notches) shall be level with the adjacent deck surface. The top of rail elevation is dictated by drainage conditions for the wharf. This normally results in a relative elevation difference between the waterside and landside crane rails, due to deck transverse cross-slope. If cross-section elevations differ, crane designer shall accommodate by fabricating crane legs to match. The longitudinal elevation of a crane rail shall be constant.

Typical rail elevations are +15.0 for the waterside crane rail. The landside crane rail elevation is based on minimum grade requirements, typically 0.75%.

The allowable tolerances for the top of crane rail elevations shall be 1/8” for the design elevation, and 1/16” in any 10’ of rail length.

Support System

Crane rails shall be supported by a continuous weight distributing sole plate with attached rail clips, a continuous flexible impact pad, and the appropriate crane rail. The assembly shall be galvanized and installed in a recessed pocket with an epoxy fill under the sole plate and AC fill around the rail assembly to match the finished grade of the wharf deck, with block-outs for wheel flanges. Crane rails shall be continuously welded at expansion joint.

Crane Stops

Crane stops are provided at the ends of the wharf to restrict crane motion beyond their intended travel limits. The crane stop bumpers shall be positioned per crane manufacturer's recommendation. See Section 3.3.3 for further discussion on crane stops.

Crane stowage pin pockets

The number of crane pin pockets and their location is based on operational considerations. They are typically placed at ends of wharf, and at intermediate points for long wharves. Consideration should be given to the number of cranes, length of wharf, location of power source, and distance between pin pockets. The number and placement of stowage pin pockets are also based on operational considerations.

5.2.4 Fenders and Mooring Hardware

Fender spacing will be as required by evaluation of the prescribed design vessels. Mooring devices will be located so as to not cause line interference with the fenders. Due to the likelihood of bulbous bow vessels, a minimum distance of 8.5 feet shall be provided between the supporting structure piling and the face of compressed fender. This requirement is not applicable to fender piling, if used.

To minimize additional crane boom reach, the maximum allowable stand off for fenders is 5 feet. Fenders will be located along the wharf face at a distance that will minimize the chance the vessel will contact the concrete face of the wharf. Vessel dimensions and allowable hull pressure should also be considered in positioning and sizing fenders.

Mooring bollards will be placed at intervals based on multiples of bent spacing, but no more than 60' to avoid hull/ wharf strikes. Refer to Section 3 for mooring hardware loads.

Safety Ladder Spacing

Maximum safety ladder spacing shall be 400' along the face of wharf.

5.3 Construction Materials and Types of Construction

5.3.1 Construction Materials

Portland Cement

Type II modified

Reinforcing

Grade 60 reinforcing, no epoxy coating unless approved by the Port.

Prestressing Tendons

270 ksi strands

Admixtures

Refer to specifications.

5.3.2 Cast-in-place concrete

Cast-in-place concrete strength (f'_c) shall be 5,000 psi minimum at 28 days. Minimum concrete cover over reinforcing bars shall be 2" for the top of wharf face, and 3" for all other faces.

5.3.3 Precast concrete

Non-prestressed concrete

Precast, non-prestressed concrete strength (f'_c) shall be 5,000 psi minimum at 28 days. Minimum concrete cover over reinforcing bars shall be 2" for the top face, and 3" for all other faces.

Prestressed concrete (other than piles)

Precast, prestressed concrete strength (f'_c) shall be 6,000 psi minimum at 28 days. Minimum concrete cover over reinforcing bars shall be 2" for the top face, and 3" for all other faces.

Prestressed concrete piles

Precast, prestressed concrete pile strength (f'_c) shall be a minimum of 6,500 psi at time of driving, and 4,500 psi at time of tendon stress transfer. Minimum concrete cover over spiral reinforcing bars for piles shall be 2½".

5.4 Structural Systems and Components

5.4.1 Wharf Deck

Beam / Slab

This system consists of a wharf slab supported by pile caps (beams) that are supported by piling. When pile caps exist both longitudinally and transversely, this system is also called a “waffle slab”.

Flat Slab

The flat slab system consists of a cast-in-place concrete deck supported by piles. The thickness of the deck slab is normally controlled by punching shear from the pile reactions. The slab depth in this case can be reduced by the use of capitals or shear caps under the deck at the pile locations.

Flat slab systems need to consider the larger associated seismic mass when compared to a beam/slab configuration.

Precast Panels

This system consists of precast deck slabs placed on top of cast-in-place bent caps, which are supported by the piles. The entire system can also be covered with a reinforced cast-in-place topping slab for continuity. Precast deck slabs have the advantage of reducing the amount of falsework required, which lowers both the construction cost and construction duration. However, the bent cap beams reduce the construction tolerance of the pile placement (i.e. misalignment). This can be an important factor in locations of existing construction, where submerged obstacles can be expected during pile driving. Additionally, the depth of the bent cap beams with this type of deck can become relatively large as the pile spacing is increased. This can place portions of the beam in the tidal zone, potentially increasing the corrosion potential of the superstructure.

Ballasted Decks

Ballasted decks are normally not a preferred system due to their high mass and associated higher seismic demands. However, this type of system works well when deck accessories such as railroad tracks are necessary, and a large number of utilities and pipelines are required. A dropped deck or ballasted section is necessary in utility corridors, and can be combined with any of the above structural systems. Ballasted decks are also useful for non-container and general cargo (break-bulk) wharves where point loads from odd shaped equipment and freight are operated.

5.4.2 Expansion Joints

Transverse expansion joints are determined by thermal forces, and are typically placed at a maximum of approximately 800’ along the wharf.

5.4.3 Cut-off walls

Cutoff walls are vertical subsurface barriers designed to prevent erosion of yard materials under the wharf. They are normally constructed along the back edge of wharf, and are of sufficient depth to maintain kick-out stability, while still providing erosion protection. They can be of either precast or cast-in-place construction. Cut-off walls should not be relied on for seismic resistance.

5.5 Piling

5.5.1 Clearance

An approximate minimum of 4'-0" clearance shall be used between the deck/ beam soffit and top of dike to allow for adequate post earthquake inception and repairs.

5.5.2 Concrete Piles

The standard pile is a 24" octagonal precast prestressed concrete pile. Larger size solid or hollow piles may be proposed for situations where the 24" octagonal pile is not a cost effective solution. The Port prefers to use only one size pile for the entire structure, varying only the length and prestress level, unless project conditions and/or cost savings prove otherwise. The use of piles other than the standard 24" octagonal precast prestressed piles shall be approved by the Port.

5.5.3 Steel Pipe Piles

The use of steel piles is strongly discouraged due to the corrosion potential and associated higher maintenance cost. Additionally, corrosion barrier coating systems and encasements impede routine visual pile inspections. Steel piles should only be used when project criteria and site circumstances dictate.

5.5.4 Battered Piles

The use of battered piles to support the wharf or pier shall not be used without prior written approval from the Port; see Section 4.2. However, battered piles may be used for isolated structures with low seismic mass, such as landside anchors, mooring and breasting dolphins.

5.6 Structural Analysis Considerations

Materials

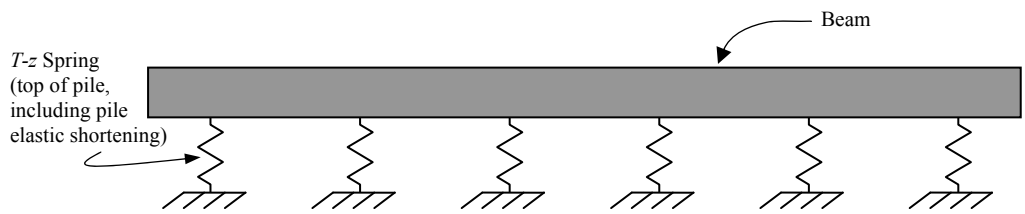
For service load analysis (dead load, live load, wind, etc.), the material properties shall be based on the relevant design code (Section 5.1):

Section Properties

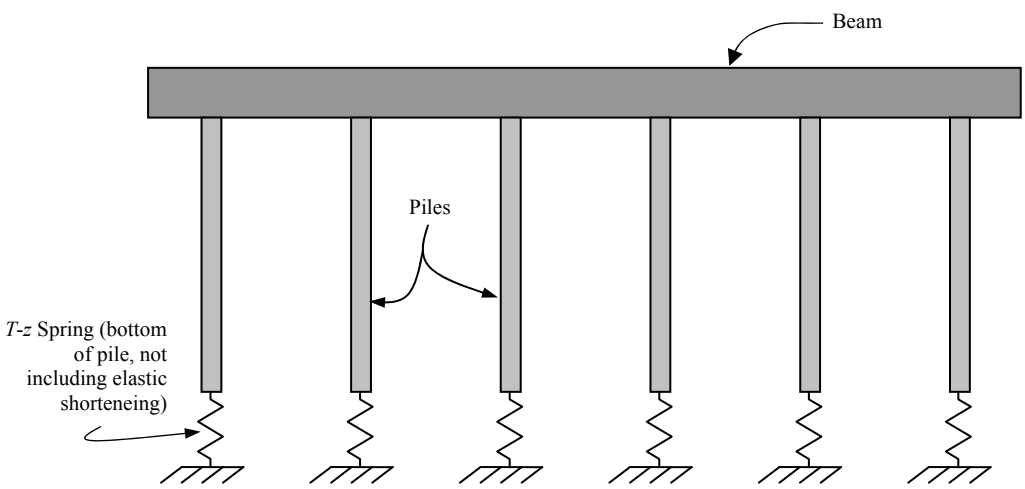
For temperature or creep/rib shortening loads, the effective moment of inertia (I_{eff}) should be used for piles; see Section 4.6.3. For all other service loads, gross moment of inertia (I_{gross}) shall be used.

Beam on Elastic Foundation Model

For modeling the wharf structure frame as beams on elastic foundations, vertical (*T-z*) springs shall be used for the analysis. To find moments in the girder and axial force in the piles, the *T-z* springs may replace modeling the pile, as shown in Figure 5-1-a). The piles should be modeled to determine moments and shear in the piles, if needed, as in Figure 5-1-b). For more discussion on vertical springs, see Section 2.



a) Model for Beam Analysis



b) Model for Beam and Pile Analysis

Figure 5-1: Beam on Elastic Foundation

5.7 Miscellaneous Considerations

5.7.1 Guard Timber

On the waterside edges of piers and wharves, a curb or guard timber (chemically treated) 10” high by 12” wide shall be provided. Notches shall be provided on the underside of the guard timber to permit drainage. The guard timber shall be anchored to the deck slab via recessed bolts or pins, and should include ship’s net anchor rings.

5.7.2 Trench Cover Plates

Galvanized steel checker plate shall be used for trench covers. Special consideration should be given to the hinge design due to the weight of the plates. The preferred location of the power trench is on the waterside of the waterside crane rail. The design loading on the cover plate shall be the applicable loadings specified in Section 3.3.

5.7.3 Cable Slot

Slots for Cable Reel cable shall be covered with a flexible material, such as reinforced rubber, and shall be a minimum width.

5.7.4 Inclinometer Tubes/ Motion Instrumentation

The decision to instrument wharf structures and provide inclinometers tubes is made at the time of design, and is based on the other instrumentation functioning within the Port.

6 Electrical Considerations

6.1 General

Verify and confirm as to which edition of the California Electrical Code shall be used for checking plans and electrical standards specifications and clearly state this requirement on contract documents.

6.2 Electrical System

6.2.1 Underground Electrical Work

During the design stage of low voltage and high voltage cable systems, the cable manufacturer shall provide a set of their calculations and criteria for pulling the cables through the conduits. Also, the contract shall require the Contractor to provide this criteria and calculations as part of their submittal. The sidewall pressure of the conductors shall be monitored when pulling them through the conduit bends to ensure that the recommended limits for the cables are not exceeded. For trailing cable system, coordinate plans and requirements with the Port.

6.2.2 Crane System

Electrical power supply to the cranes shall be provided from crane substations supplying 12,000V power via a bus collector or trailing cable system installed below grade in a trench along the entire length of the wharf. The trench shall be located adjacent to and on the waterside of the waterside crane rail.

An analysis shall be provided for the crane bus bar and feeder calculations, voltage drop, and short circuit withstand rating. Isolation bars, expansion joints, and feeder connection points shall be staggered on all three phases, as opposed to side by side and in line. A weld shall be placed around the entire bracket when it is welded to the anchor plate

Crane substations shall be designed with redundant equipment in order to provide a highly reliable power supply to the cranes. Redundant components of a crane substation (or each substation where separate redundant substations are designed) should be sized to carry the load of all the available cranes and those anticipated for use in the future.

6.2.3 Shore-to-Ship Power System

The electrical power supply for the shore-to-ship power system shall be provided from a 7.5 MVA 6.6kV Unit Substation. If a 7.5MVA transformer is deemed inappropriate for the application, any deviation must be approved by the Port. The shore power feeder shall have a medium voltage circuit breaker with overcurrent protective relays for each ungrounded conductor installed in the switchgear. Protective relays shall be set to the maximum rating of the shore power outlet and shore power feeder. The voltage drop to shore power outlets shall be limited to two percent. The available fault from shore power shall be below the withstand rating of the ship service distribution.

The shore power feeder shall have a grounding switch to discharge the induced voltage before being disconnected from the shore power outlets. A grounding switch shall have a

mechanical interlocking scheme between the shore power circuit breakers and shore power outlets to prevent the mating or un-mating of a plug and receptacle while the shore power feeder is energized. An indicating light shall be illuminated when power is available from the shore, and a multifunction meter should be present to read shore power voltage, current, power (kVA, kW, & kVAR), harmonics, 15-minute demand and energy consumption.

A mechanical or electrical interlocking system should be implemented between the shore power circuit breaker and ship generator circuit breakers unless load transfer paralleling capability is provided. A ground check relay shall be provided to automatically open the shore power circuit breaker once the plug is released from the shore power outlet or once the ship circuit breaker provided for the shore power feeder is opened.

A shore-to-ship connection box mounted in exposed locations shall be rated for NEMA 4X enclosures, 14-gauge, and 304 stainless steel. It shall be properly sized to accommodate conductor bending radius and have provisions for bottom and end entrances. The Shore-to-Ship Connection Box assembly shall be rated for the maximum available fault and shall be designed to prevent moisture or water entrance.

Shore-to-ship power outlets shall have current and voltage ratings. Kirk Key interlocks shall be provided in accordance with the approved procedure. A ground switch shall be provided to discharge the induced voltage of the shore power feeder before being disconnected from the shore power outlets. The minimum clearance for live parts shall be per the latest National Electrical Code. Terminals shall be properly sized and shaped to facilitate satisfactory connections, and the phase sequence shall be marked and arranged per National Electrical Code.

6.2.4 Power Systems

The Contractor shall submit the short circuit analysis and coordination study on the electrical system. A review of the short circuit analysis and coordination study with the Port's engineer shall be required when the coordination study is completed and after the report is submitted to the Port for evaluation.

The National Electrical Code 2002 Article 110.16 requires flash protection. Arc flash calculations shall be provided in accordance with IEEE Std. 1584, stamped and signed by a licensed electrical engineer in the State of California. Labels for arc flash and shock hazard shall be provided and attached to equipment in accordance with the National Electrical Code.

6.3 Detailing

6.3.1 General

After contract drawings and the electrical drawings are considered 99% complete, the plans should be checked for interference with conduit runs, gas lines, water lines, manholes and pull box locations, fire hydrants, lighting poles and similar structures.

When an "existing" design is shown on plans, the reference drawing number from which the design originated shall be provided on the plans. This reference drawing number should be listed on the title sheet also. The title of a sheet listed on the title sheet shall be identical to the title on the individual sheet itself. Each electrical drawing shall be identified with an appropriate title, and titles on each drawing should be unique. Similarly, each detail shall have a unique title. For details, the word "Detail" should not be used in the title.

Repeated callouts and details on the drawings should be avoided. All drawings that have the same detail shall be referenced to one sheet with the complete detail.

The following shall be included in the Electrical Plans under "General Notes".

1. When references are made to specific code sections, standards and other similar guidelines, they are intended to add emphasis only. They are not in any way intended to relieve the Contractor of the responsibility of following other applicable references.
2. The Contractor shall be responsible for the testing of the ground-fault protection system after installed on site, in accordance with the latest National Electrical Code. A written record of this test shall be made and shall be available to the Engineer.
3. Conduit that is to be abandoned shall have wires removed. The conduit ends shall be removed to a depth of at least 12" below the finished surface. Both ends of abandoned conduits shall be crimped if the conduit is metallic; conduits made of non-metallic materials shall be capped at both ends with concrete.
4. All electrical equipment and materials shall be U.L. listed and labeled.

Instructions for removals shall clearly identify what is to be removed. The notes shall provide instructions on whether the item will be removed and disposed of by the Contractor or whether it will be salvaged. If the item is to be disposed of, clear instructions shall be provided on the contract drawings that the Contractor shall be responsible for disposal. If it is to be salvaged, clear instructions shall be provided on the contract drawings, including exactly where the item will be delivered and the name and telephone number of the contact person who has agreed to accept it.

To be considered equal, a note shall be included in the specifications or drawings, such as:

"The manufacturer to be considered as equal for a product must first submit all that is specified for similar work they have performed within the past five years. This submittal shall be complete and delivered to the Engineer in one package. This submittal will be first evaluated to determine if all that is listed in the contract documents is included in the submittal package; any missing item will be adequate reason to not approve the submittal. If the package is determined to be complete, it will next be reviewed to determine if the

information it contains can meet the requirements of the project specifications and industry standards. After successfully passing these two reviews, only then can the manufacturer be considered equal by the Engineer. The Engineer will make this final determination. Only after this approval is granted by the Engineer may the Contractor proceed with submitting shop drawings by the manufacturer determined to be equal in accordance with the plans and specifications."

If there is a charge for a service connection by the utility company that must be paid by the Contractor during construction, the note below shall be completed and added to the applicable drawing:

> "Contractor shall arrange to obtain the electrical service connection from Southern California Edison. Contractor shall be responsible for paying Southern California Edison charges for this service connection. Bids shall include a sum of $___ for each of these services by the Contractor. If this Southern California Edison charge is less than $___, the Contractor shall reimburse the balance to the Port. If it is more than $___, then the Port will reimburse this extra cost to the Contractor. The addition or reduction of the charge is strictly the difference between the Southern California Edison billing and the $___ included in this note. There will be no other considerations for profit, supervision, overhead, management or ANY OTHER similar items."

Note: *For $___ above, inquire what the approximate cost is from Southern California Edison and use that figure.*

The following note shall be added to drawings when a project requires new electrical service from the Utility Company:

> "Contractor shall be responsible for coordinating the electrical service connection. This includes:
>
> a. Two months prior to the required connection date, notify the Port of Long Beach project manager that a formal request to provide this service connection must be made to the utility company.
>
> b. Make sure the Port of Long Beach project manager follows Port of Long Beach procedures in notifying Port of Long Beach Accounting if Port of Long Beach is responsible for billing. Otherwise, notify the responsible party to request billing from the utility company."

For new electrical services, the Port of Long Beach Design Group can issue a street address shown on the drawing where the new electrical service meter is shown. For existing electrical services, the assigned address must be shown on the drawing where the electrical meter is shown.

Southern California Edison requires a note on the plans to state: "The Contractor shall install a service feed conduit from the existing Southern California Edison Transformer to the Southern California Edison service pole near the transformer per Southern California Edison requirements. The Contractor performing this work shall be a Southern California Edison approved Contractor."

Southern California Edison requires that manhole covers offer provisions for lifting the lids. Reproduce drawings that Southern California Edison has provided the Port onto the contract drawings. Reproduce only the manhole cover, not the lifting device, onto Port of Long Beach contract documents. Verify both with Southern California Edison and manufacturer that what is on the drawing is still valid, available, acceptable and applicable to the project in consideration. See "UNDERGROUND STRUCTURES - 30" ROUND CAST IRON MANHOLE COVER AND FRAME HS-20 LOADING" from the SCE Electric Distribution Manual. (An electronic copy of the drawing is filed under "SCEManholeCover.")

City of Long Beach, Planning and Building, requires separate drawings for separately addressed sewer lift pumps.

6.3.2 Electrical System

6.3.2.1 Underground Electrical Work

For underground conduits, Schedule 40 PVC conduits shall be used in backlands and wharves. Type EB conduits should not be used. The top of the underground conduit bank shall be a minimum of 3'0" below the finished surface. Pull ropes shall be provided in all empty conduits, including stubbed conduits or dead end conduits. For conduits for communications between buildings, manholes, and structures, a minimum of 4" conduits should be provided. For a typical conduit at expansion joints, see Figure 6-1.

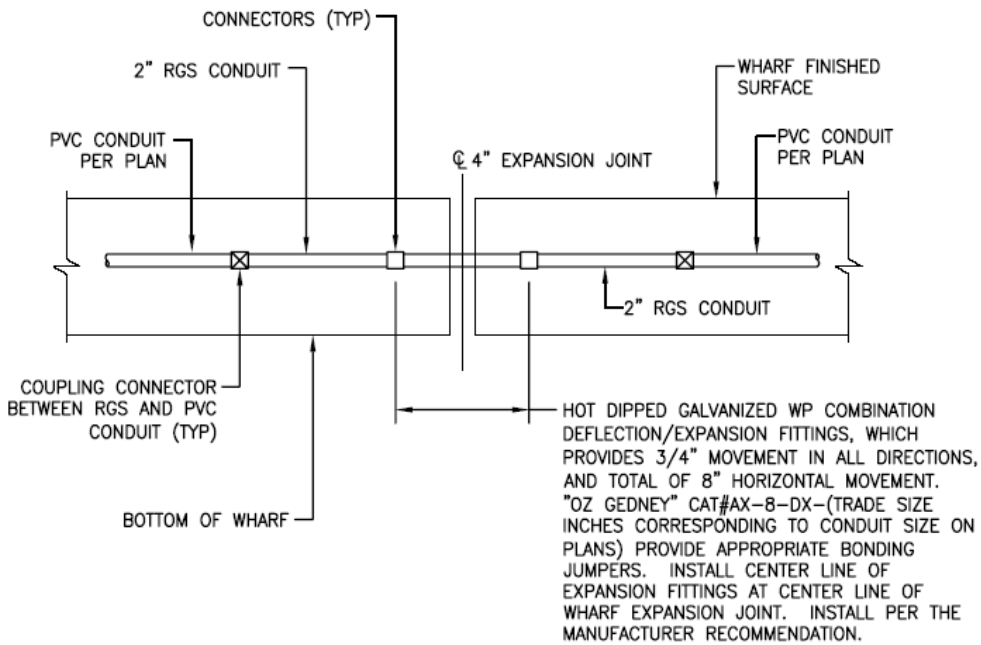


Figure 6-1:Conduit at Expansion Joints

Conduit stubs shall be capped with plastic caps, not with metal caps. For conduit stub detail, see Figure 6-2. The brass cap shall be engraved, indicating E or T, conduit

quantity, and size. All actual stub-out locations shall be shown on record drawings. One 90 degree elbow conduit and engraved brass cap shall be provided per duct bank.

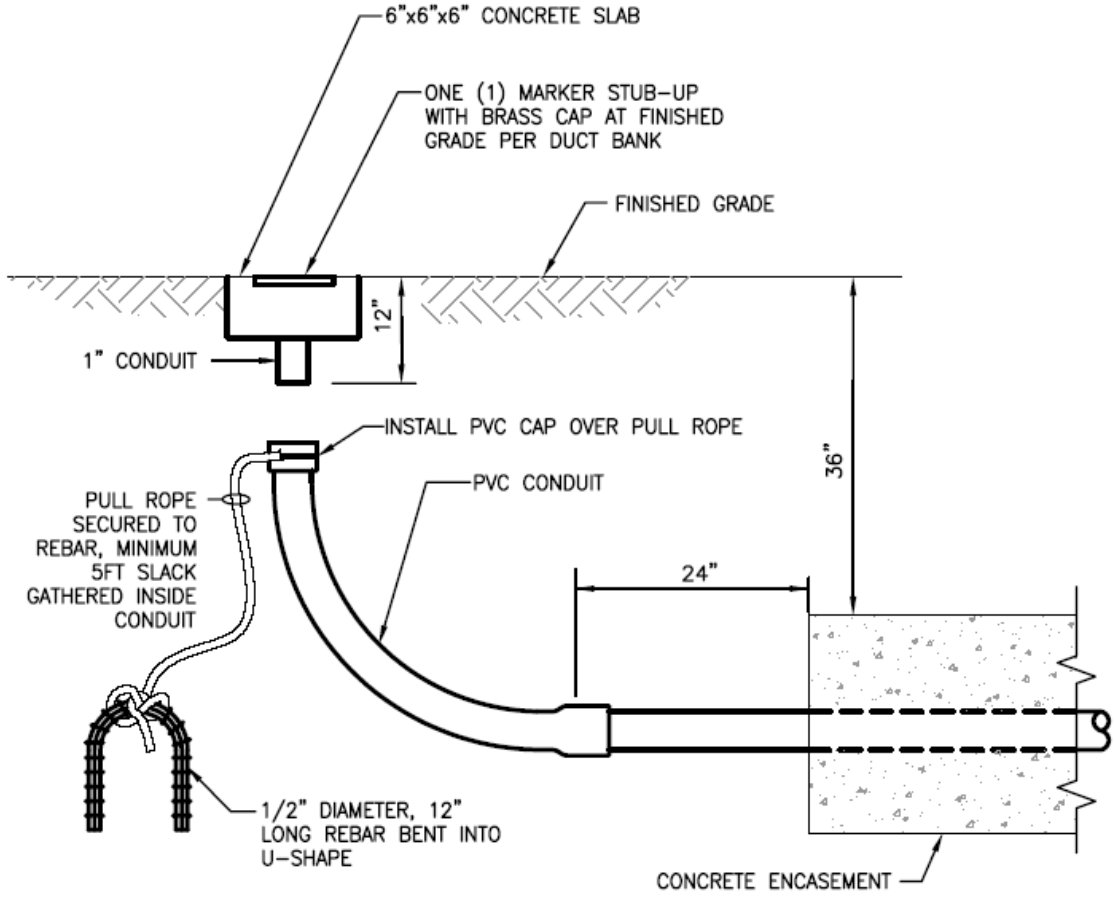


Figure 6-2: Conduit Stub

The following note shall be added to the drawings for underground duct banks to specify the slurry encasement:

> "Construct underground duct lines of individual conduits encased in red concrete slurry. The cement slurry shall consist of three sacks of Portland cement per cubic yard of sand with 10 pounds of red oxide or one gallon of red color. The slurry mix shall be allowed to solidify sufficiently to support a man's weight before beginning the backfill. Compaction of the backfill shall not begin until at least 36 hours after placement of the slurry. No deformed or broken pieces of conduit shall be used. The slurry encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 3-inches of slurry covering the ducts. Separate conduits using plastic spacers. Provide red color admixture in concrete to indicate the duct bank as electrical, except Southern California Edison duct banks. Southern California Edison design mix is required in all Southern California Edison duct banks."

Duct banks shall be separated and the space between them shall be filled with slurry. From a point no more than 60 ft away from a manhole, conduits in a duct bank may begin deflecting to terminate into the manhole. Ampacities of conductors used for electrical ducts shall be calculated per the latest National Electrical Code adopted by the City of Long Beach. A typical duct bank section is shown on Figure 6-3.

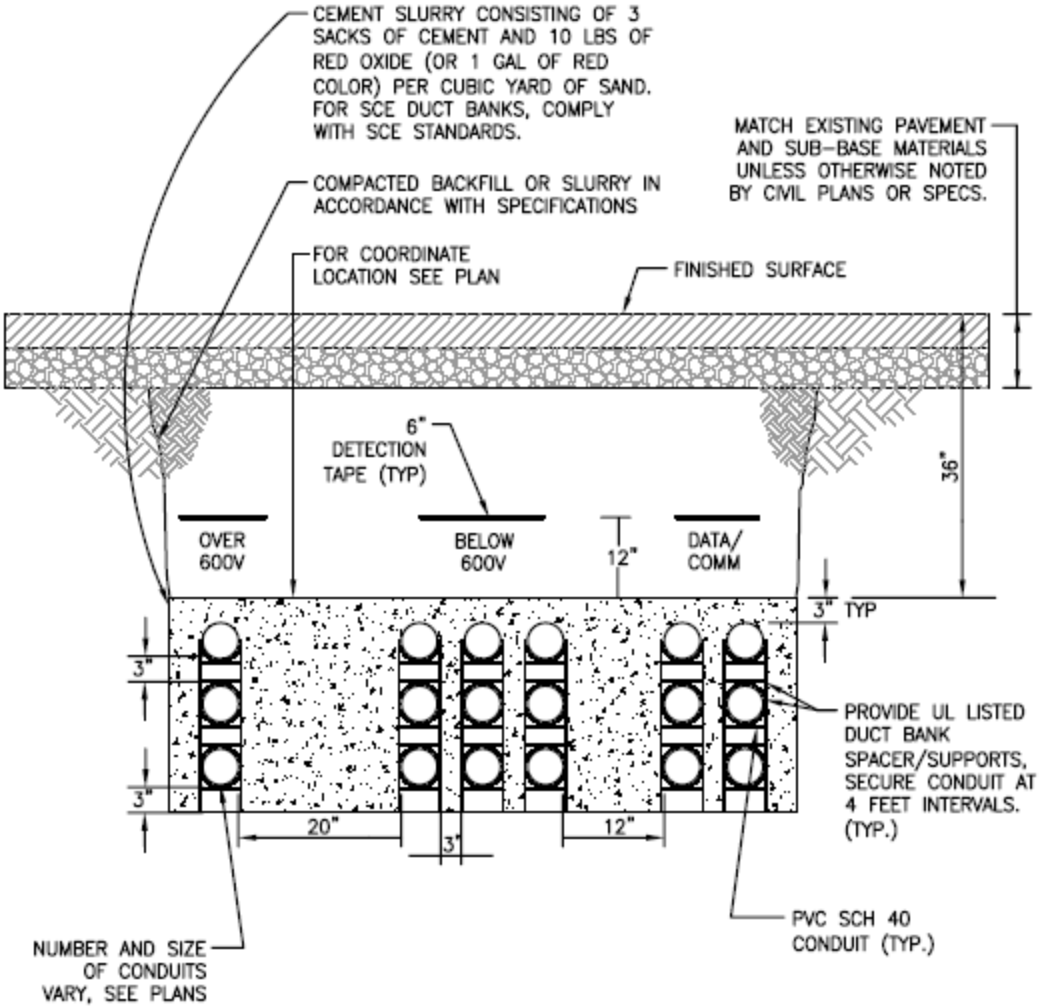


Figure 6-3:Duct Bank Section

The Contractor shall be required to attach a permanent waterproof tag to all conductors in outdoor pull boxes and manholes. Tags shall be marked appropriately.

If pull boxes are rectangular, a detail of the orientation of the box with respect to the conduits entering the box shall be clearly shown. The respective conduits shall allow proper bending radius for the conductors to be pulled through.

Sump drains in pull boxes shall be opened, and clear notes shall be provided on the drawing for the Contractor.

A narrative describing the steps of operation and the function of the components of the control wiring shall be included whenever control wiring is included in the contract drawings.

6.3.2.2 Crane System

The Contractor shall complete installation, include bus bar alignments and elevations, include torque connections and bolts based on Conductix Insul-8 provided data, secure all caps and covers, and clean the bar system including the power trench. Inspection should be coordinated with the Port.

Detail of the wharf trench and crane rail are shown in Figure 6-4, through Figure 6-7.

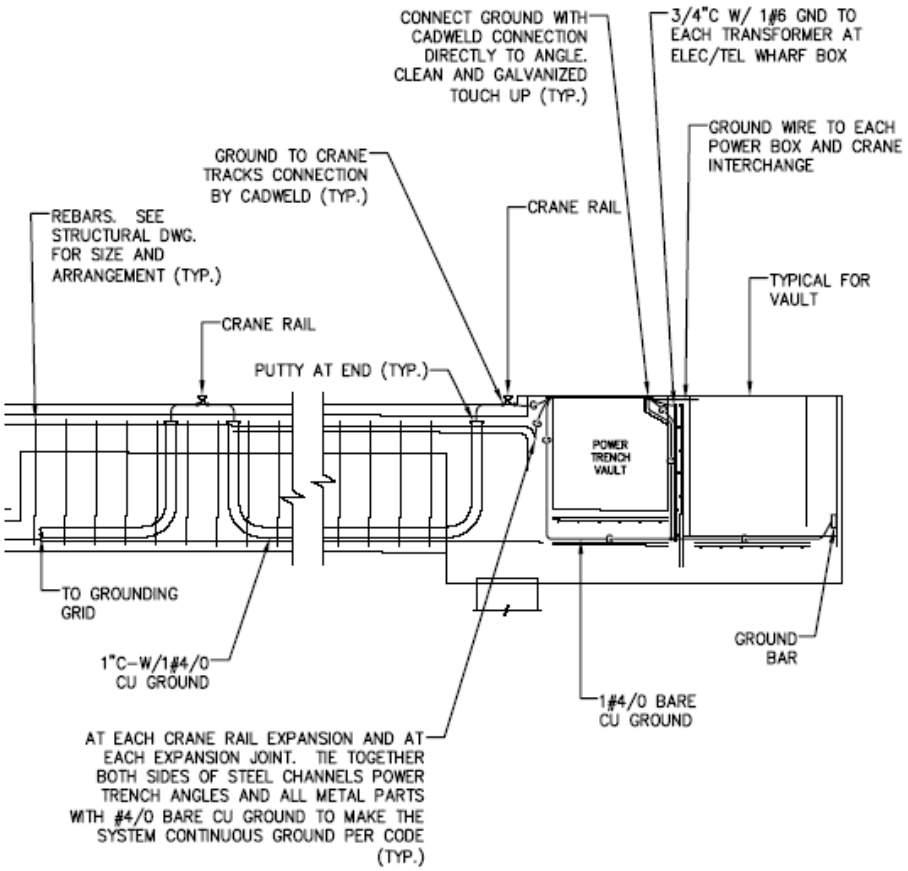


Figure 6-4: Wharf Trench and Crane Rail Cross Section

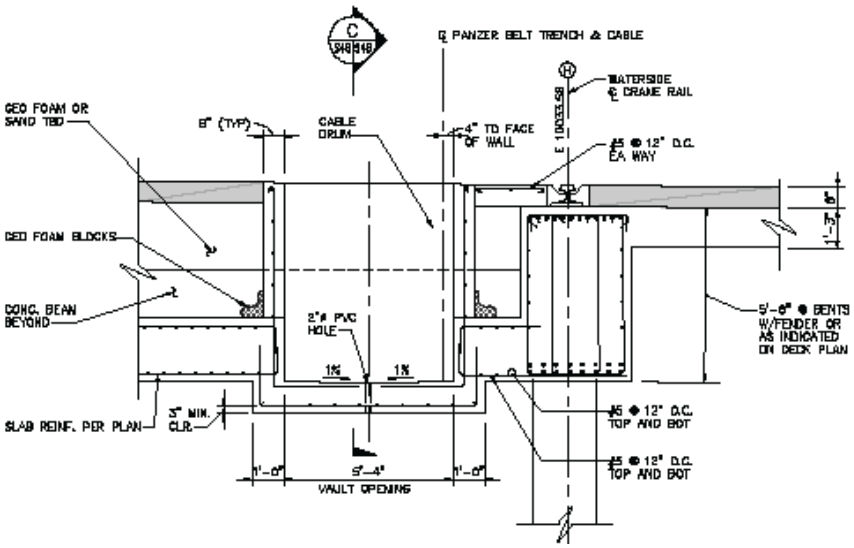


Figure 6-5: Crane Power/ Cable Vault Cross Section

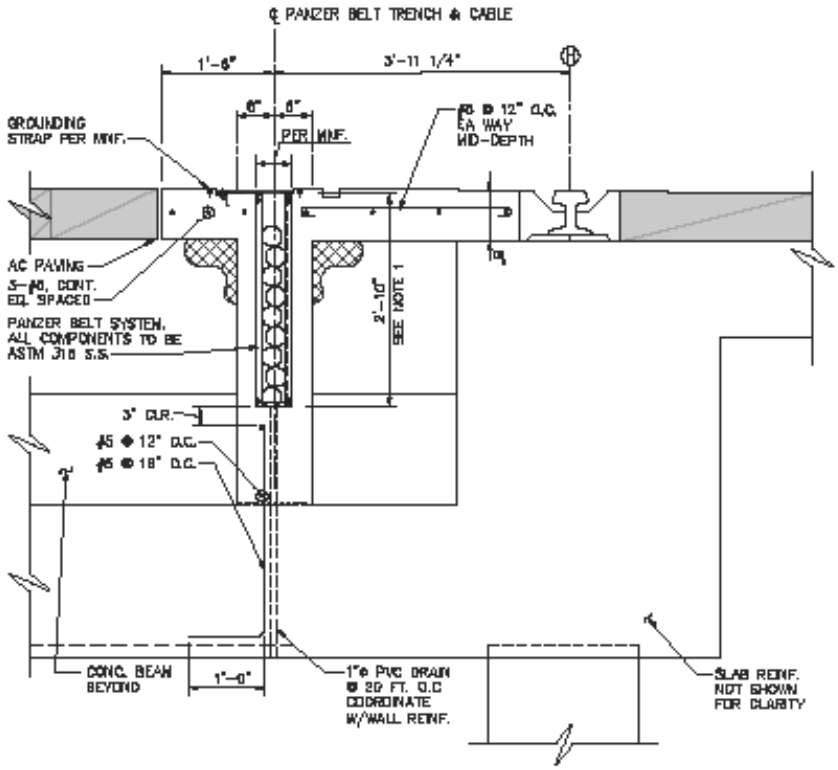


Figure 6-6: Panzer Belt Trench and Cable Detail

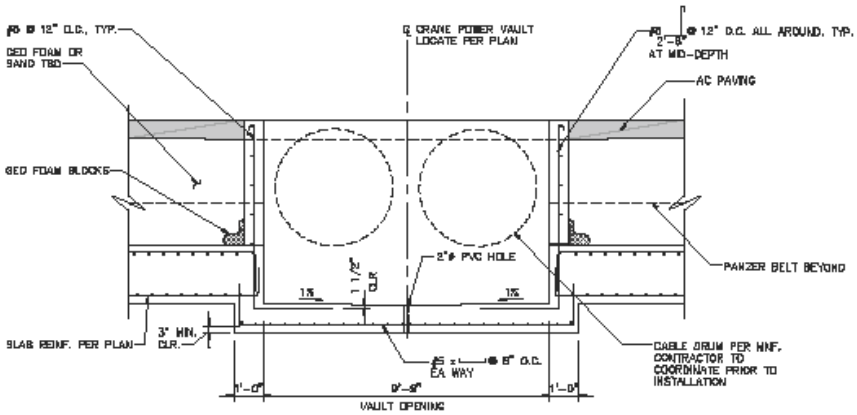


Figure 6-7: Cable Drum Vault Detail

6.3.2.3 Shore-to-Ship Power System

For the shore-to-ship connection box, green and red lights shall be provided to indicate whether the shore power feeder is energized. A nameplate shall be provided stating that when the green indicator light is on, the system is de-energized; a red light indicates that the system is energized. An instruction plate or a sheet indicating connection procedures shall be provided. Warning signals shall be provided that read "Do not engage or disengage plug and receptacle while energized." A nameplate indicating supply voltage, maximum current per outlet, and matching plug shall be provided. The shore-to-ship connection box assembly shall be constructed as shown on Figure 6-8 and a fiber optic box shall be provided.

A minimum of two 5" and two 2" PVC 40 conduits terminating at shore-to-ship connection box shall be provided. Watertight PVC fittings shall be provided, and all conduits shall be sealed with approved foam. Provide approved drop-in anchor, threaded hook. Exposed non-current carrying metal parts of equipment, conductor supports or racks, conduits and other metal appurtenances, including any metal cover and its supporting ring, shall be bonded together and connected to a common ground and to the incoming ground conductors per the National Electrical Code.

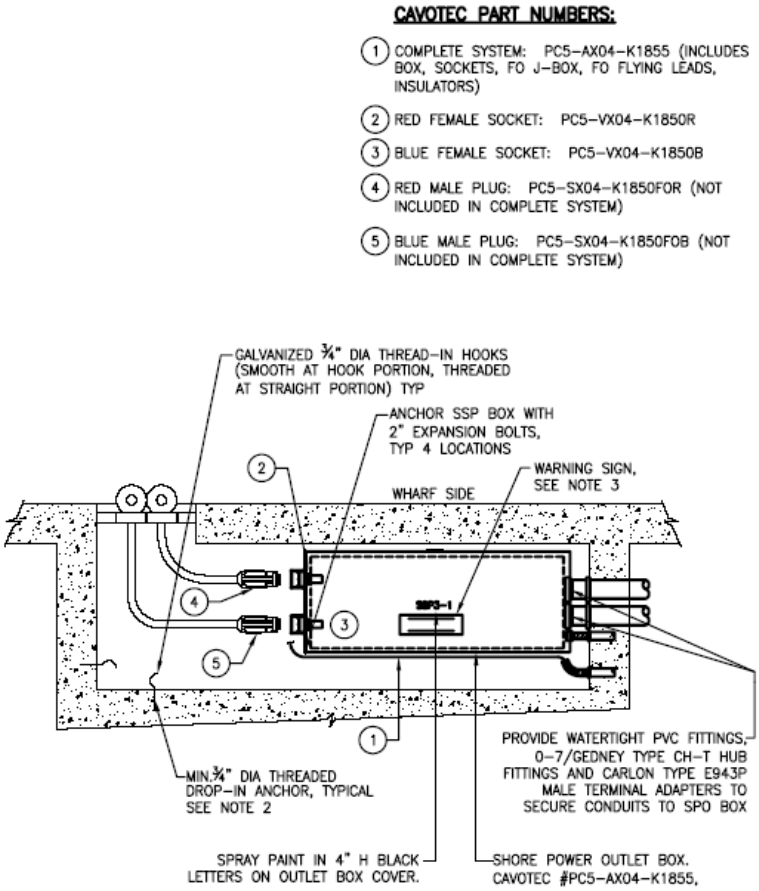


Figure 6-8: Shore-to-Ship Connection Box Assembly

6.3.2.4 Power Systems

The note on the drawings should read as follows:

> "The latest National Electrical Code requires flash protection. The Contractor shall be responsible to provide arc flash calculations in accordance with IEEE Std. 1584, stamped and signed by a licensed electrical engineer in the State of California. The Contractor shall be responsible to provide labels for arc flash and shock hazard, which shall be attached to each piece of electrical equipment, in accordance with the National Electrical Code."

The Arc Flash label and Calculation Results shall be followed as shown on Figure 6-9.

Project:
Location:
Contract:
Engineer:
Filename: PierC_Cold_Ironing

Study Case: PIER C SC

Page: 1
Date: 02-02-2009
SN: P2S-ENGIN
Revision: Base
Config.: Normal

Arc Fault at Bus: **SUB 3**
Bolted Fault Current: **1/2 Cycle**

Nominal kV = 12.000 Prefault Voltage = 100% of nominal bus kV
Base kV = 12.000 = 100% of base kV System Grounding = Grounded

Total Arcing Fault Current = 11.154 kA FCT = 0.508 Seconds For Protective Device: CB4@ Ia = 11.154 kA
Total Bolted Fault Current = 11.520 kA = 30.505 cycles Relay: SUB3 RELAY Type: Overcurrent

Working Distance = 18.00 inch Hazard/Risk Level* = 3
Incident Energy = 13.63 cal/cm² Flash Protection Boundary = 5.05 ft

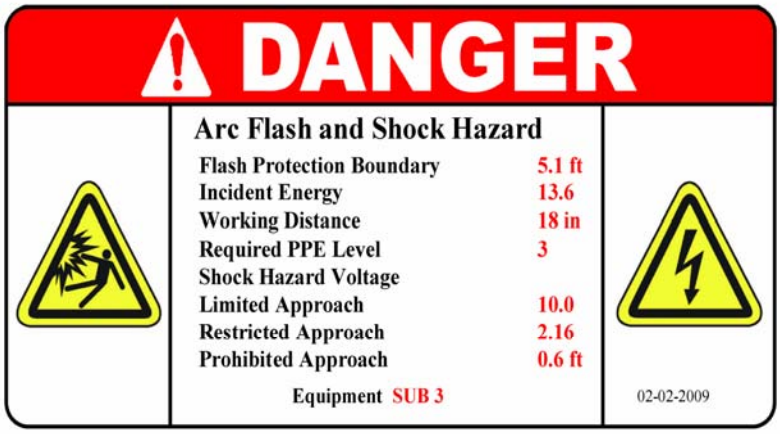
Device		Individual Contribution			Incident Energy					
ID	Type	Bolted (kA)	Arcing (kA)	FCT (cycles)	Arcing (kA)	FCT (cycles)	Protective Device ID for FCT	Incident E (cal/cm²)	FPB (ft)	Hazard/Risk Level*

NOTES:

1. THIS IS A SAMPLE REPORT, SHOWING THE MINIMUM DATA AS A RESULT OF ARC FLASH CALCULATIONS, IN ACCORDANCE WITH IEEE STD. 1584.
2. CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE THIS DATA AND SUPPORTING CALCULATIONS PRIOR TO SUBMITTING LABELS FOR ARC FLASH WARNING.

ARC FLASH CALCULATION RESULTS - TYP

SCALE: NTS



NOTES:

1. CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE LABELS, COMPLETE WITH DATA BASED ON AND SUPPORTED BY CALCULATIONS, AND MOUNT ON APPROPRIATE EQUIPMENT.
2. SUBMIT PROPOSED LABELS TO THE CITY AND OBTAIN APPROVAL OF THE CITY PRIOR TO RELEASING ORDER TO LABEL MANUFACTURER.

ARC FLASH LABEL - TYP

SCALE: NTS

Figure 6-9: Arc-Flash and Calculation Results

6.4 Specifications

6.4.1 General

The manufacturer's name and part numbers should be on the contract drawings, not in the specifications. Specifications should describe the features of the product specified on the plans. New products that have not been used for a Port of Long Beach project shall be approved by the Port and the Port tenant/operator, and shall satisfy building and safety requirements

If instruments or special equipment are specified, provisions shall be added for appropriate training by the manufacturer for the use and maintenance of the item specified. This applies especially to switchgear, lighting controls, sewer pump controls, high voltage splices, and terminations. For specialty systems or equipment such as Fire Warning Systems, cranes and hoists, or dimming systems, the model number and manufacturer's name shall be provided. Furthermore, the branch circuit conductor and overcurrent protection shall also be provided. If the Contractor makes a substitution, the Contractor shall be required to submit the whole system as a shop drawing.

The Port of Long Beach Electrical Standard Specifications shall be used as a reference for design. If changes to these specifications are necessary, the Port of Long Beach Administrative Control Section shall revise and adopt the changes before they are included in the final design specifications. If the electrical standard specification is not available on a particular item from the Port of Long Beach, the Administrative Control Section shall be informed of the proposed specification for their review and adoption before it is included in the final design specifications.

Two letters from Southern California Edison should be received and filed before the project is advertised. The first shall state that Southern California Edison will provide the new service, and it should be received from a Southern California Edison representative. The second letter shall state what the Southern California Edison available interrupting current (AIC) is at the service point.

Southern California Edison requires the name of a contact person for correspondence. The contact's name, address and telephone number should be listed on the drawing where the electrical service meter is shown. The cement around the duct banks shall be the natural gray color. Southern California Edison requires a minimum of 2-1/2" for the service conduit size. The electrical service design shall always be approved by Southern California Edison.

The size of the service riser conduit and the weatherproof entrance cap shall be shown on the service poles. The detail shall be reproduced in contract drawings, and Southern California Edison standards shall be referenced. The risers to the poles shall be PVC schedule 80.

When a wharf/terminal is developed, the address should be posted by the main gate of the terminal. An appropriate sign shall be provided and installed, and the sign shall meet the requirements and be approved by the Fire Department.

The name and phone number of the Contractor/manufacturer, years of warranty, related drawing and manual/specification shall be included in the warranties.

The Operations and Maintenance Manual shall have a cover page that includes as a minimum: Title, specification number of the Port of Long Beach project, the Port of Long Beach base drawing number of the contract set, date the manual was prepared, person to contact regarding the manual and his/her telephone number.

6.4.2 Electrical System

6.4.2.1 Underground Electrical Work

Megger tests for low voltage cables shall be required in the specifications. During the design stage, the manufacturer of the specified cables shall provide a written statement that cables have a 40 year warranty. High voltage cables shall be installed in the presence of the manufacturer's representative. The specifications and drawings shall clearly describe the cable splices and terminations required for the project.

For outdoor enclosed disconnect switches, the enclosure shall be NEMA 3R. NEMA 3R finish shall be specified as follows:

> "The finish for outdoor, weatherproof, NEMA 3R enclosures shall have all covers and doors thoroughly cleaned using a phosphate wash. Apply a zinc-rich corrosion resistant primer and then a polyester powder coat suitable for a marine environment. Exterior surfaces shall be given a final finish coat of ANSI 61 light grey air-dried acrylic enamel, covered with a clear polyurethane top coat."

The specifications shall state that the Contractor will provide narratives describing the steps of operation and the function of the components of the control wiring with the submittal of such shop drawings.

When alarms are designed, the consultant shall coordinate with the Port and any other interested parties to transmit the alarm signal to the proper area and to design an appropriate sign to be posted at the alarm equipment that reads "(insert telephone number) CALL FOR ALARM".

6.4.2.2 Crane System

High potential dielectric tests of the new bus system shall be performed. Results of these tests are to be provided to the Port. Tests shall be conducted by a qualified high voltage testing Contractor using a 20kVDC (15kVAC) high potential test instrument for a 5kVAC conductor bus and a 38kVDC (27kVAC) high potential test instrument for a 15kVAC conductor bus. Test results shall be followed with certified test report that includes the make and model of the test instrument, the date of the last calibration of the instrument, a statement on the weather conditions, including temperature, the signature and electrical license number of the high voltage test technician, and the date of the test.

Table 6-1: Maximum Acceptable Leakage

Conductor Length (ft)	Maximum Acceptable Leakage (total based on system length) (mA)	Test Unit Size Required (for AC test unit, increase size by 40% for DC units) (VA)	
		5kVAC Conductor Bus	15kVAC Conductor Bus
100	7.5	110	200
200	15	220	410
300	22.5	330	620
400	30	440	830
500	37.5	550	1040
600	45	660	1250
700	52.5	770	1460
800	60	880	1670
900	67.5	990	1880
1000	75	1100	2090
1500	112.5	1210	3130
2000	150	1320	4170
2500	187.5	1430	5210

Prior to testing, people in the vicinity of the high voltage test shall be instructed to clear the area. The system shall be free of trash and debris. Each phase of the conductor system shall be tested to ground and to each of the other phase conductors. The test leads shall be connected according to the High-Pot test unit instructions. The voltage shall be gradually increased to the required level and held for one minute. If the system leakage is within the levels outlined in Table 6-1, then the field test is a PASS. After the test has been passed, power shall be energized to the bus.

6.4.2.3 Power systems

The review period for the short circuit analysis and coordination study should take place in one day and should be eight hours long, and the Contractor must have the engineer who prepared the report available during this review period. For smaller projects, a four hour review session shall be required.

Available short circuit current shall be indicated on the plans at the service point and at all panelboards and switchboards. The characteristics of the first upstream protective device shall be indicated on the one-line diagram. If this device is a fuse, the manufacturer model number and ampacity shall be provided. If a relay is applied, the manufacturer model number and CT setting shall be provided. The one-line diagram shall also indicate the time margin Southern California Edison requires between its own protective device and the Port of Long Beach main overcurrent device at the maximum fault level.

6.4.2.4 Grounding

Copper-clad steel grounding electrodes, each with ¾" diameter and 10 ft length, shall be used for grounding where needed. Where a ground rod is needed, a ground well set flush with the finished surface shall be provided as required by the City of Long Beach Building and Safety Department. Otherwise, the ground rod and the attached grounding conductor may be buried under the finished surface or terminated above the finished surface in accordance with the National Electrical Code. Where multiple ground rods are to be installed, rods shall be placed at least 15 ft from any adjacent rods.

The ground resistance shall be measured by employing the "fall-of-potential" method using the Biddle "Megger Earth Tester" with two electrodes. This method shall be required in the specifications. The specifications shall also require that any grounding system test reports include the soil temperature at the time the test was conducted. The specifications shall require the Contractor to provide a copy of the test reports certified by the testing technician and the Engineer's representative authorized to witness the test.

7 References

1. American Association of State Highway and Transportation Officials (AASHTO), LRFD Bridge Design Specifications, 2007.
2. American Concrete Institute (ACI), Building Code Requirements for Structural Concrete, ACI 318, 2005.
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APPENDIX 30

MARINE TERMINALS

Bulk Cargo Terminal Rehabilitation
Eastern Minerals
Chelsea, MA
Construction Cost: $1,500,000+
Contact: Leo Mahoney

Project consisted of performing design of bulk cargo terminal rehabilitation handling 750 foot long and greater vessels. Services included design of large crane/berthing dolphins for 235 ton cranes used for unloading of cargo. Other services included design of steel sheet pile bulkheads, H-pile with lagging bulkheads, shore protection, dredging and permitting. Assisted owner for the preparation of construction documents, construction services and field inspection of work.

Bulk Cargo Terminal Modifications
Atlantic Salt, Inc.
Staten Island, NY
Contact: Leo Mahoney

Project consists of modifying existing bulk cargo terminal for unloading 750 foot plus long vessels containing salt for de-icing to meet the requirements of New York DEC requirements. Services include layout and design of crane/ berthing dolphins for 235 ton cranes used for off loading of vessels. Other services included design of slope protection, design of salt containment walls and storm water runoff control.

Derby & Central Wharf
Salem Maritime National Historic Site
Salem, MA
Construction Cost: $5,500,000
Contact: Tom Donald

Project included the design for rehabilitation of two wharfs while maintaining their 250 feet of cellular cofferdam historical significance. Major project elements included design of a 700 foot steel sheet pile bulkhead, 400 feet of timber bulkhead and repairs to an existing steel bulkhead. Facility designed to accommodate visiting Naval vessels during special events.

Terminal Street Rehabilitation
EDIC
Boston, MA
Construction Cost: $2,210,000
Contact: Paul Osborne

Project consisted of developing repairs for the existing piles and pile caps as well as design of a new concrete deck. Services included field inspection, design of repairs, design of a concrete composite deck, preparation of contract documents and

construction phase services.

North Haven Ferry Terminal
Maine DOT
Augusta, ME
Construction Cost: $2.5M
Contact: Paul Pottle

Project included field investigation, hydrographic survey and inspection of existing waterfront structures. In the design phase of the project BCE provided the layout and design of the berthing dolphins and established the critical elevations for the transfer bridge access for the ferries. The project allowed for phasing of construction such that no interruption of service was required and the project is currently under construction and scheduled for completion in 1995.

I-91 Platform - Boat Access Facility
Riverfront Recapture, Inc.
Hartford, CT
Construction Cost:
Contact: Joseph Marfuggi

Project included the design and preparation of contract drawings and technical specifications. The final design consisted of a sheet pile bulkhead with gangway access to seasonal floats. Dredging and rip rap were also required as part of the project. A critical element of the project was the limited space for the bulkhead and its tie-back/deadman structures because of other structures associated with this waterfront park and that all structures would be underwater during the seasonal flooding of the river.

Wharf Expansion*
Eastport Port Authority
Eastport, ME
Construction Cost: $3,200,000

Design of a 400 foot by 40 wharf expansion to provide 1000 pounds per square foot live loading and 40 foot drafts. Wharf had to accommodate Panamax vessels. Site was unique with standard 18 foot tide ranges and extreme tide ranges of 28 feet. Deck design included loading for a 100 ton mobile crane along face of wharf.

Marine Terminal Rehabilitation*
Cibro Petroleum
Port of Albany
Albany, NY
Construction Cost: $5.3 Million

Field inspection, design (limited) and resident engineer for the construction of a 1,500 foot long berth with 32 foot drafts for petroleum terminal utilized by crude oil cargo tankers and large ocean going barges. Construction included cellular cofferdams, tied-back and cantilever sheet pile walls.

Marine Terminal Reconstruction*
Ultramar Petroleum
Chelsea Terminal
Chelsea, MA
Construction Cost: $250,000

Inspection, permits, design and construction services for the construction of a

petroleum terminal for 700 foot plus vessels. Services included working closely with terminal manager to reduce costs and meet terminal requirements.

Petroleum Terminal - Pier Inspection*
East Boston Terminal
Mobil Oil Corporation
East Boston, MA

Performed above water and supervised underwater inspection of relieving platform. Original inspection to determine performance of pile wrapping resulted in findings of serious deterioration of other portions of structure. Performed feasibility analysis for client for determination whether facility should be repaired or replaced.

Marine Terminal Repairs*
BP Oil Company
Chelsea, MA
Construction Cost: $250,000

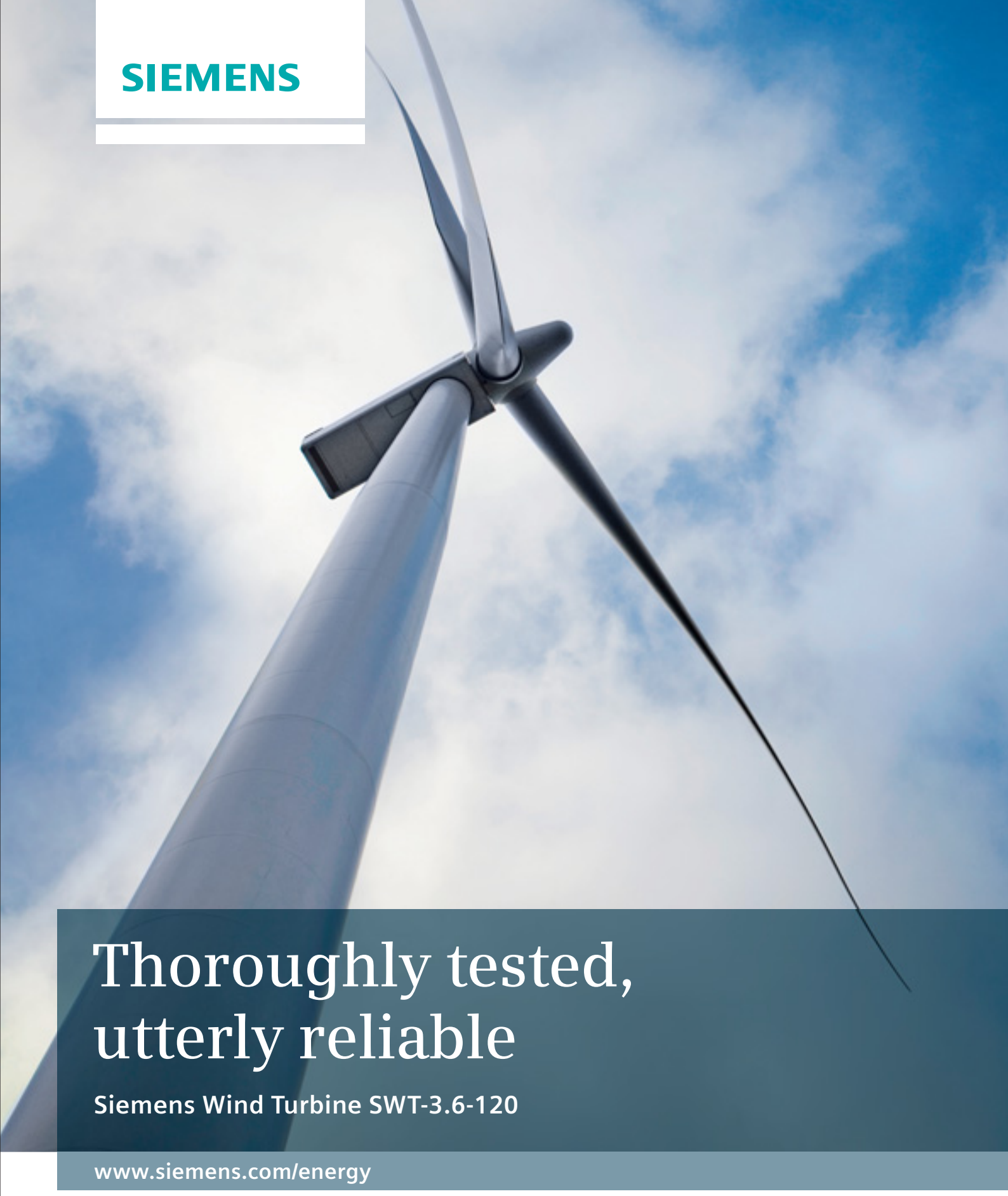
Performed inspection of Tanker/Barge facility and assessed existing conditions and made recommendations for repairs to access Pier, berthing area and large concrete berthing dolphins. Work included preparation of contract drawings, bid documents, and construction administration.

Pier Rehabilitation*
IMIT - Bayonne
Bayonne, NJ
Construction Cost: $500,000

Inspection of existing and design of marine terminal for berthing 700+ foot long liquid cargo vessel. Design included fender system, access walkways, pipe supports and phasing construction.

* Individual experience of Ronald R. Bourne, PE prior to Bourne Consulting Engineering.

APPENDIX 31



SIEMENS

Thoroughly tested, utterly reliable

Siemens Wind Turbine SWT-3.6-120

www.siemens.com/energy

Answers for energy.

Global pioneer

In recent times, the world has seen a dramatic increase in the nature and scope of offshore wind power plants. With larger projects heading farther out to sea, the reliability of the wind turbine is paramount.

Given the logistical challenges of offshore projects where even the smallest issue can amplify costs, having technology that works and continues to work under some of the harshest conditions on the planet is crucial.

In the offshore wind industry, Siemens has deservedly earned the reputation for having the most reliable technology, the broadest skill set, the deepest experience, and a name on which the industry can bank.

Siemens is the undisputed market leader when it comes to reliable products for harnessing the power of offshore wind energy. From pioneering the world's first offshore wind power plant at Vindeby (Denmark) in 1991 to the multi-gigawatt wind power plants of tomorrow, products like the SWT-3.6-120 continue to form the basis of a rock-solid technology platform.

Evolution of the series

Determined to create the right machine for the right application, Siemens has been progressively evolving its wind turbines, creating more powerful generators and larger rotors to give its customers a greater choice of technologies to meet their needs.

With the release of a new 3.6-megawatt wind turbine featuring a 120-meter rotor, Siemens has produced a machine that can generate more power than its predecessor could at similar wind speeds. The SWT-3.6-120 is based on the proven technology of the SWT-3.6-107, which is currently the world's most popular offshore wind turbine.

Basically, the only difference between the two machines' core components is the rotor. The SWT-3.6-120 is equipped with 58.5-meter long rotor blades, giving it a swept area of 11,300 m^2 or the equivalent to nearly two football fields. Tests indicate that the new machine will generate approximately 10 percent more electricity in comparison to similar wind turbines.

World's most tested wind turbine

To ensure that the SWT-3.6-120 is ready for 20 years of ocean life, Siemens put the wind turbine through one of the most rigorous testing schedules on the market. All major components have been through highly accelerated lifetime tests (HALT testing) to withstand the tests of time.

The test regime included tests on the blade, blade bearing, (including raceway and ring life test), generator platform, canopy, yaw bearing, main bearing, main bearing housing, bed frame, yaw system, hub components, and more.

The SWT-3.6-120 has a rugged, conservative structural design, automatic lubrication systems with ample supplies, climate control of the internal environment, and a simple generator system without slip rings that provides exceptional reliability at long service intervals.

Superior grid compliance

As more wind power enters the grid, there is a greater onus on turbine manufacturers to meet stringent grid stability requirements. The Siemens NetConverter® system used by the SWT-3.6-120 is designed for maximum flexibility in the turbine's response to voltage and frequency variations, fault ride-through capability, and output adjustment. The advanced wind farm control system provides state-of-the-art fleet management.

Safety first

Safety is at the heart of all Siemens operations. From production to installation, operation, and service, Siemens strives to set the standard in safety. The fail-to-safe capabilities within a turbine, combined with Siemens' superior lightning protection system, are designed to enhance security for the turbine.

Advanced operations support

Given the logistical challenges associated with servicing wind farms, Siemens has equipped its turbines with a turbine condition monitoring (TCM) system that reduces the need for on-site servicing.

Continuous monitoring of turbines allows for the discovery of small faults before they become major problems.

The TCM system continuously checks the external and internal condition of the wind turbine. Twenty-four hours a day, seven days a week, precise measurements are taken of vibrations in the gearbox, the generator, and the main shaft bearings. The system instantly detects deviations from normal operating conditions.

Using the knowledge gained from monitoring thousands of turbines over the years, Siemens' experts are exceptionally skilled at analyzing and predicting faults within a turbine.

This allows Siemens to proactively plan the service and maintenance of the turbines, as each fault can be categorized and prioritized based on severity. Siemens can then determine the most appropriate course of action to keep the turbine running at its best.

General components

The following is a brief technical description of the main components of the SWT-3.6-120 wind turbine.

Rotor

The SWT-3.6-120 rotor is a three-bladed cantilevered construction, mounted upwind of the tower. The power output is controlled by pitch regulation. The rotor speed is variable and is designed to maximize the aerodynamic efficiency.

Blades

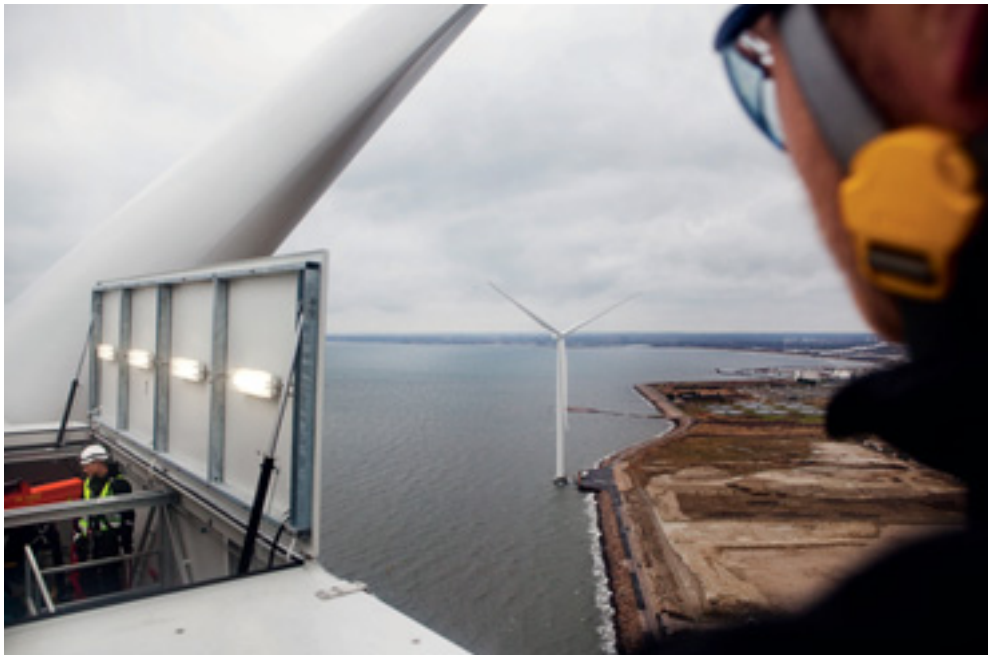
The B58 blades are made of fiberglass-reinforced epoxy in Siemens' proprietary IntegralBlade® manufacturing process. In this process, the blades are cast in one piece to eliminate weaker areas at glue joints. The blades are mounted on pitch bearings and can be feathered 80 degrees for shutdown purposes. Each blade has its own independent pitching mechanism capable of feathering the blade under any operating condition. The blade pitch arrangement allows for optimization of the power output throughout the operating range, and the blades are feathered during standstill to minimize wind loads.

Rotor hub

The rotor hub is cast in nodular cast iron and is fitted to the main shaft with a flange connection. The hub is sufficiently large to provide a comfortable working environment for two service technicians during maintenance of blade roots and pitch bearings from inside the structure.

Main shaft and bearing

The main shaft is forged in alloy steel and is hollow to facilitate the transfer of power and signals to the blade pitching system. The main shaft is supported by two self-aligning, double spherical roller bearings that are shrunk onto the main shaft. The bearings are grease lubricated and feature labyrinth seals.



Gearbox
The gearbox is a custom-built, three-stage, planetary-helical design. The first two high-torque stages are of a helical planetary design. The high-speed stage is of a normal helical design and provides the offset of the high-speed shaft that is needed to allow passage of power and control signals to the pitch systems.

The gearbox is shaft-mounted and the main shaft torque is transferred to the gearbox by a shrink-disk connection. The gearbox is supported in the nacelle with flexible rubber bushings.

The gearbox is fitted with an oil conditioning system. All bearings are lubricated with oil fed directly from a large in-line filter and are cleaned by an off-line filter unit.

The gearbox is fitted with sensors for monitoring temperature, oil pressure, and vibration levels.

Generator
The generator is a fully-enclosed, asynchronous generator. It has a squirrel-cage rotor without slip-rings. The generator rotor construction and stator winding are designed for high efficiency at partial loads. The generator is protected with thermal switches and analogue temperature measurement sensors.

It is fitted with a separate thermostat-controlled ventilation arrangement. Air is recirculated internally in the generator and heat is transferred through an air-to-air heat exchanger that separates the internal environment in the generator from the ambient air.

Mechanical brake
The mechanical brake is fitted to the gearbox high-speed shaft and has two hydraulic calipers.

Yaw system
The yaw bearing is an internally geared ball bearing fitted with a hydraulic disc brake. Six electric planetary gear motors drive the yawing.

Tower
The SWT-3.6-120 wind turbine is mounted on a tapered, tubular steel tower. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and internal electric lighting.

Controller

The wind turbine controller is a microprocessor-based industrial controller. The controller is complete with switchgear and protection devices. It is self-diagnosing and has a keyboard and display for easy readout of status and for adjustment of settings.

The NetConverter® power conversion system allows generator operation at variable speed, frequency, and voltage while supplying power at constant frequency and voltage to the medium-voltage transformer. The power conversion system is a modular arrangement for easy maintenance and is water-cooled.

SCADA

The SWT-3.6-120 wind turbine is equipped with the Siemens WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard Internet Web browser. The status views present information such as electrical and mechanical data, operation and fault status, meteorological data, and grid station data.

Turbine condition monitoring

In addition to the Siemens WebWPS SCADA system, the SWT-3.6-120 wind turbine is equipped with the unique Siemens TCM® condition monitoring system. This system monitors the vibration level of the main components and compares the actual vibration spectra with a set of established reference spectra. Result review, detailed analysis, and reprogramming can all be carried out using a standard Web browser.

Operation systems

The wind turbine operates automatically. It is self-starting when the wind speed reaches an average of about 3 to 5 m/s (about 10 mph). The output increases approximately linearly with the wind speed until the wind speed reaches 12 to 13 m/s (about 30 mph). At this point, the power is regulated at rated power.

If the average wind speed exceeds the maximum operational limit of 25 m/s (about 56 mph), the wind turbine is shut down by feathering the blades. When the average wind speed drops back below the restart average wind speed, the systems reset automatically.

Nacelle arrangement

1. Spinner
2. Blade
3. Pitch bearing
4. Rotor hub
5. Main bearing
6. Main shaft
7. Gearbox
8. Service crane
9. Brake disc
10. Coupling
11. Generator
12. Yaw gear
13. Tower
14. Yaw ring
15. Generator fan
16. Canopy

Technical specifications

Rotor	
Type	3-bladed, horizontal axis
Position	Upwind
Diameter	120 m
Swept area	11,300 m²
Nominal rotor speed	5–13 rpm
Power regulation	Pitch regulation with variable speed
Rotor tilt	6 degrees

Blades	
Type	B58
Blade length	58.5 m
Root chord	4.2 m
Aerodynamic profile	NACA63.xxx, FFAxxx
Material	GRE
Surface gloss	Semi-matte, < 30 / ISO2813
Surface color	Light grey, RAL 7035

Aerodynamic brake	
Type	Full span pitching
Activation	Active, hydraulic

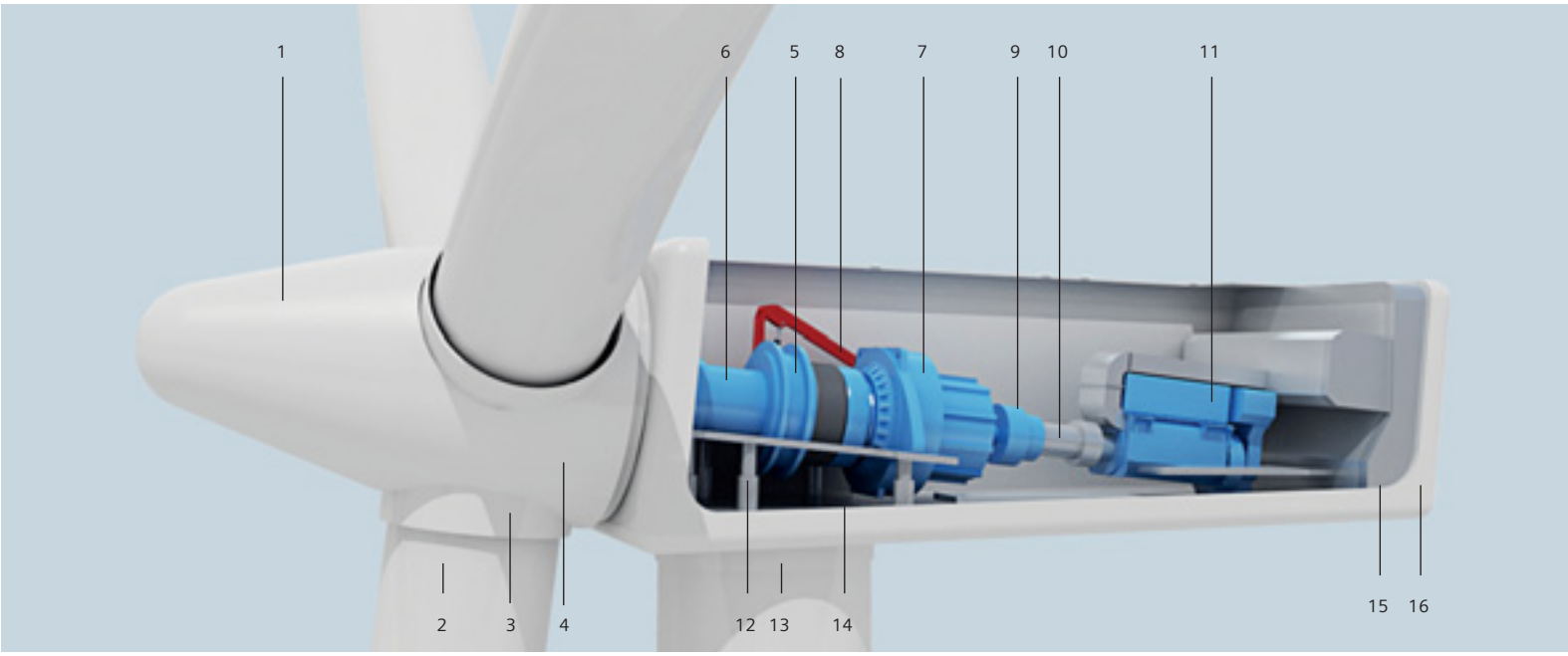
Load-supporting parts	
Hub	Nodular cast iron
Main bearings	Spherical roller bearings
Main shaft	Alloy steel
Nacelle bed plate	Cast iron

Transmission system	
Coupling hub – shaft	Flange
Coupling shaft – gearbox	Shrink disc
Gearbox type	3-stage planetary/helical
Gearbox ratio	1:119
Gearbox lubrication	Forced lubrication
Oil volume	Approx. 750 l
Gearbox cooling	Separate oil cooler
Gearbox designation	PZAB 3540
Gearbox manufacturer	Winergy AG
Coupling gear – generator	Double-flexible coupling

Mechanical brake	
Type	Hydraulic disc brake
Position	High-speed shaft
Number of calipers	2

Generator	
Type	Asynchronous
Nominal power	3,600 kW
Protection	IP 54
Cooling	Integrated heat exchanger
Insulation class	F

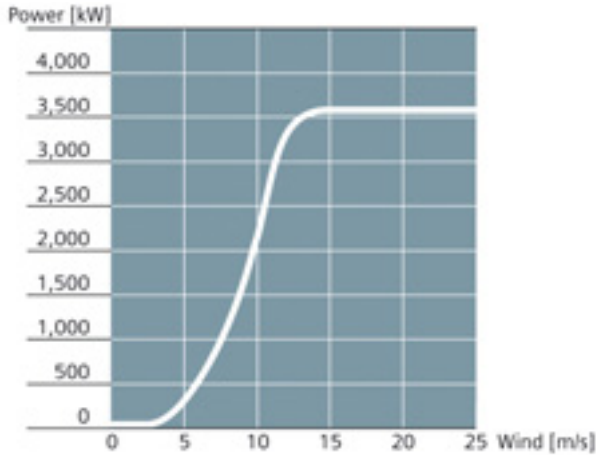
Canopy	
Type	Totally enclosed
Material	Steel/aluminium
Surface gloss	Semi-gloss, 30–50, ISO2813
Color	Light grey, RAL 7035



Yaw system	
Type	Active
Yaw bearing	Internally-geared ball bearing
Yaw drive	Six electric gear motors
Yaw brake	Active friction brake
Controller	
Type	Microprocessor
SCADA system	WebWPS
Controller designation	WTC 3
Tower	
Type	Cylindrical and/or tapered tubular
Hub height	90 m or site-specific
Corrosion protection	Painted
Surface gloss	Semi-gloss, 30–50, ISO-2813
Color	Light grey, RAL 7035
Operational data	
Cut-in wind speed	3–5 m/s
Nominal power at	12–13 m/s
Cut-out wind speed	25 m/s
Maximum 3 s gust	70 m/s (IEC version)
Weights (approximately)	
Rotor	100,000 kg
Nacelle	125,000 kg
Tower for 90 m hub height	Site-specific

Sales power curve

The power curve data are valid for standard conditions of 15° Celsius air temperature, 1,013 mBar air pressure, and 1.225 kg/m³ air density, clean rotor blades, and horizontal, undisturbed airflow.



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The information in this document contains general descriptions of the technical options available, which may not apply in all cases.
The required technical options should therefore be specified in the contract.

APPENDIX 32

Offshore-Wind

Multi-megawatt turbines

High-performance turbines with a rotor more than 100 m in diameter and an installed capacity of 3,6 to 5 MW have been developed by different producers. A small number of these turbines is already in operation.

	GE Energy	Siemens	Vestas
Type	4.0-110	3.6 MW	V120
Rated Power [kW]	4000	3600	4500
Gearbox	Triple stage	Triple stage	Triple stage
Generator	Permanent Magnet	Asynchronous	Asynchronous
Converter	Full Power Converter	Fully automated converter	n/a
Rotor diameter [m]	110	107	120
Top head mass [t] (nacelle+rotor)	295	215	210
Rated wind speed [m/s]	14	12-13	12
In operation since	May 2010	Dec 2004	n/a

	REpower Systems	Multibrid	Enercon
Type	5M	M5000	E-126
Rated Power [kW]	5000	5000	7500
Gearbox	Triple stage	Single stage	Gearless
Generator	Asynchronous double fed	Synchronous permanent magnet excited	Synchronous

	REpower Systems	Multibrid	Enercon
Converter	IGBT converter	4-quadrant converter	DC intermediate circuit converter
Rotor diameter [m]	126	116	127
Top head mass [t] (nacelle+rotor)	410	310	650
Rated wind speed [m/s]	12	12	17
In operation since	Nov 2004	Dec 2004	Aug 2007

	BARD	Nordex
Type	VM	5 MW Offshore
Rated Power [kW]	5200	5000
Gearbox	Triple stage	n/a
Generator	Double fed asynchronous	n/a
Converter	n/a	n/a
Rotor diameter [m]	122	115
Top head mass [t] (nacelle+rotor)	375	n/a
Rated wind speed [m/s]	12	n/a
In operation since	n/a	n/a

For further information on the various turbine please click on the following links:

Enercon E-126 (7.5 MW)

Multibrid M5000 (5 MW)

REpower 5M (5 MW)

GE Energy 4.0 (4 MW)

Siemens 3.6 (3.6 MW)

Vestas V120 (4.5 MW)

BARD 5.0 (5.2 MW)

Nordex N90 Offshore (5 MW)

APPENDIX 33

TEREX®

DEMAG CC2800-1 | Crawler Crane 660 ton Lifting Capacity

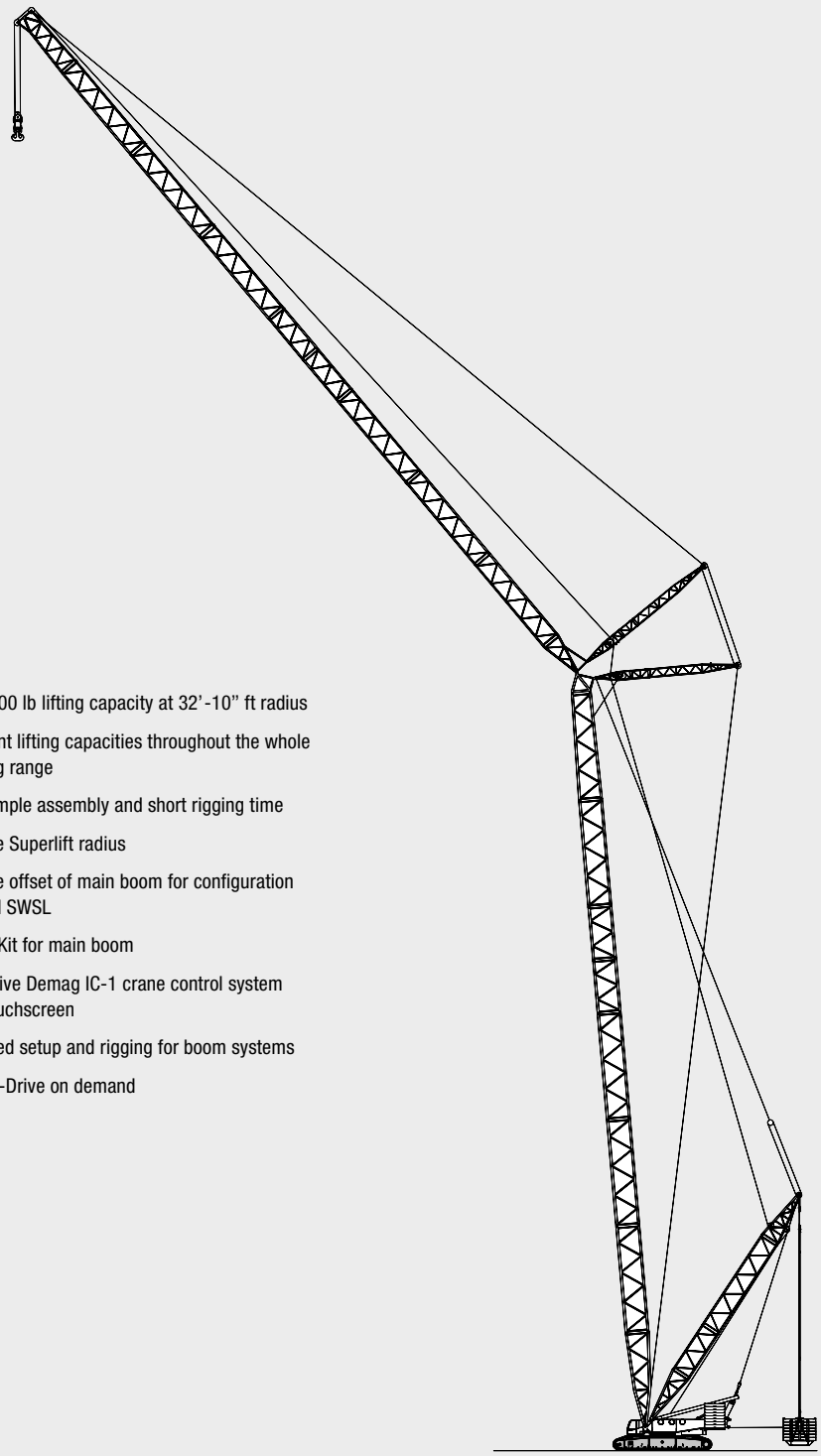
DEMAG CC2800-1

CRAWLER CRANE

TEREX®

DEMAG CC2800-1

HIGHLIGHTS



- 1323,000 lb lifting capacity at 32’-10” ft radius
- Excellent lifting capacities throughout the whole working range
- Very simple assembly and short rigging time
- Variable Superlift radius
- Variable offset of main boom for configuration SW and SWSL
- Power-Kit for main boom
- Innovative Demag IC-1 crane control system with touchscreen
- Improved setup and rigging for boom systems
- Quadro-Drive on demand

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
Please contact Bigge Crane and Rigging Co. at 888-337-BIGGE or email info@bigge.com for further information. BIGGE

TEREX®

DEMAG CC2800-1
CRAWLER CRANE

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SPECIFICATIONS

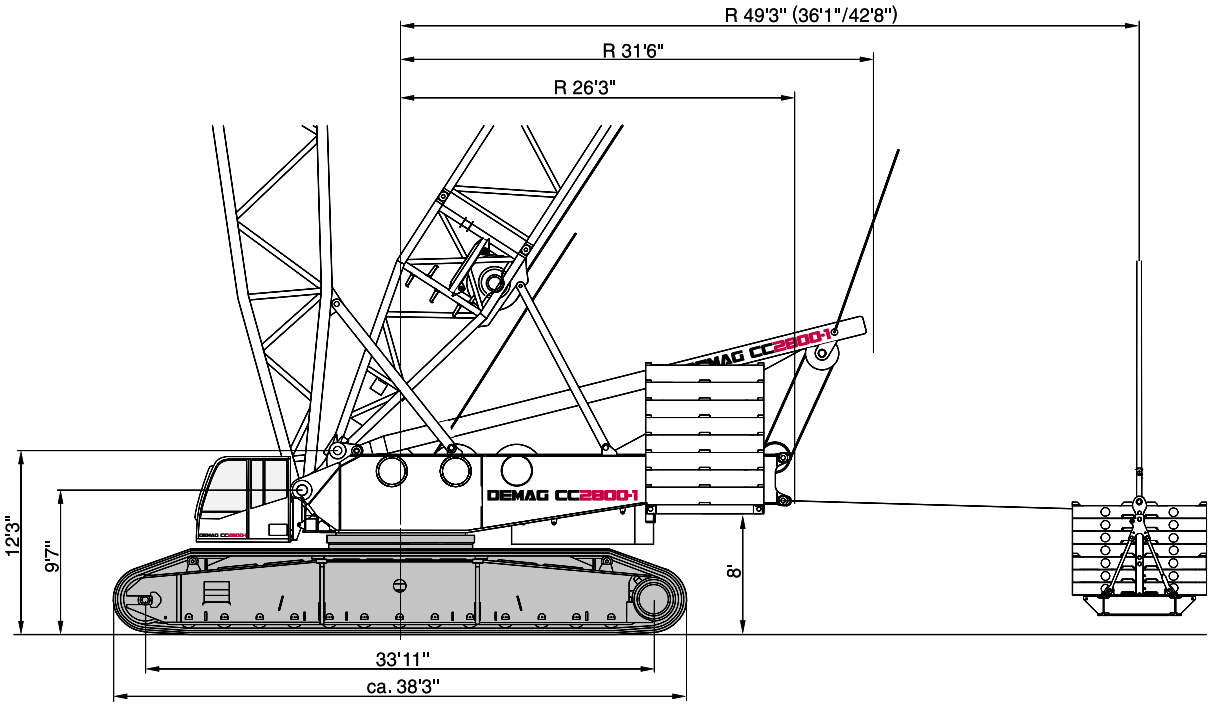
WORKING SPEEDS (INFINITELY VARIABLE)

Mechanisms	Rope ø	Speeds[1]	Single line pull	Length of hoist rope
Hoist I (H1)	1 3/32"	max. 394 ft/min	35,520 lb / 31,698 lb[2]	2953'
Hoist II (H2)	1 3/32"	max. 394 ft/min	35,520 lb / 31,698 lb[2]	2953'
Boom derricking (W2)	1 3/32"	max. 394 ft/min		
Boom hoist (E)	1 3/16"	max. 171 ft/min		
Jib luffing (W1)	1 3/32"	max. 394 ft/min		
Slewing (rpm)		0.7		

[1] top layer
[2] without / with reeving effect considered

BASIC CRANE DIMENSIONS

Basic crane dimensions with standard Superlift attachment



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DEMAG CC2800-1
CRAWLER CRANE

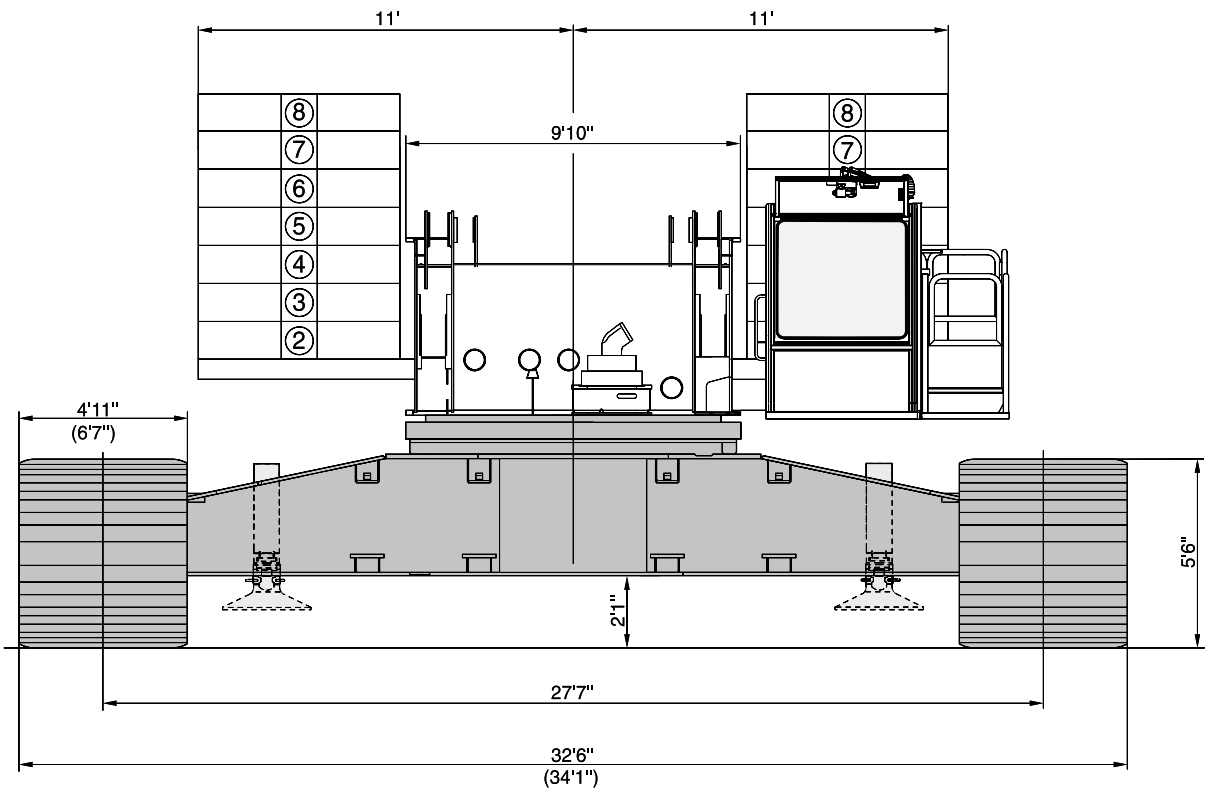
SPECIFICATIONS

CARRIER PERFORMANCE WITH STANDARD DRIVE

Mechanisms	Rope ø	Speeds[1)]	Single line pull	Length of hoist rope
1st gear				0 - 0.37 mph
2nd gear				0 - 0.75 mph

HOOK BLOCKS

Type	Possible load	Number of sheaves	Number of lines	Weight	„D“
2 x 300	1323,000 lb 545,000 lb	2 x 11 11	2 x 22 17	22,900 lb – 26,500 lb 15,700 lb – 17,400 lb	16’-5” 17’-9”
2 x 200	882,000 lb 432,000 lb	2 x 7 7	2 x 14 13	18,100 lb – 22,100 lb 11,700 lb – 13,700 lb	16’-5” 17’-9”
160	353,000 lb	5	11	7,280 lb – 10,600 lb	14’-1½”
110	243,000 lb	3	7	4,190 lb – 7,940 lb	14’-1½”
50	110,000 lb	1	3	6,170 lb	13’-1½”
16	35,300 lb	—	1	2,000 lb	9’-10½”



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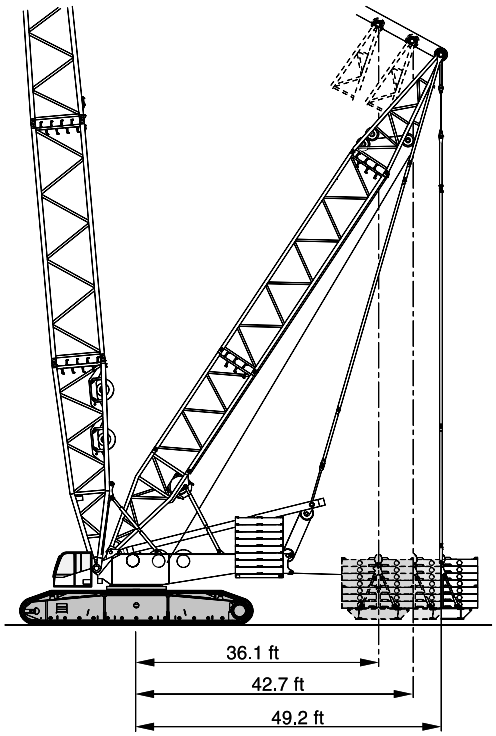
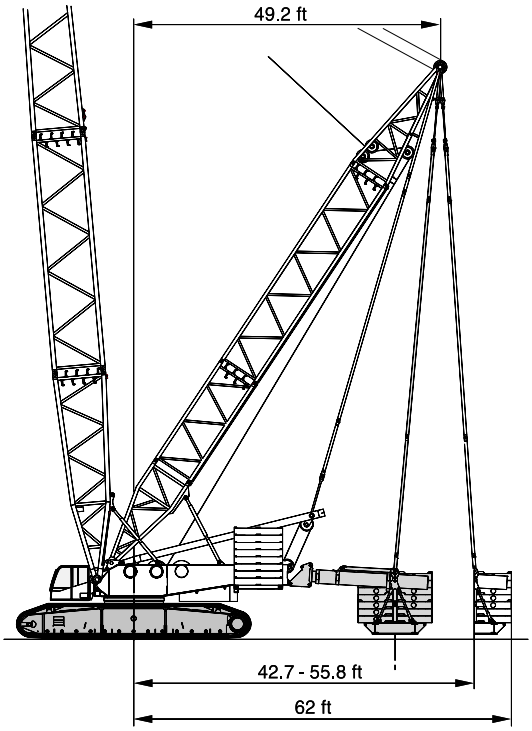
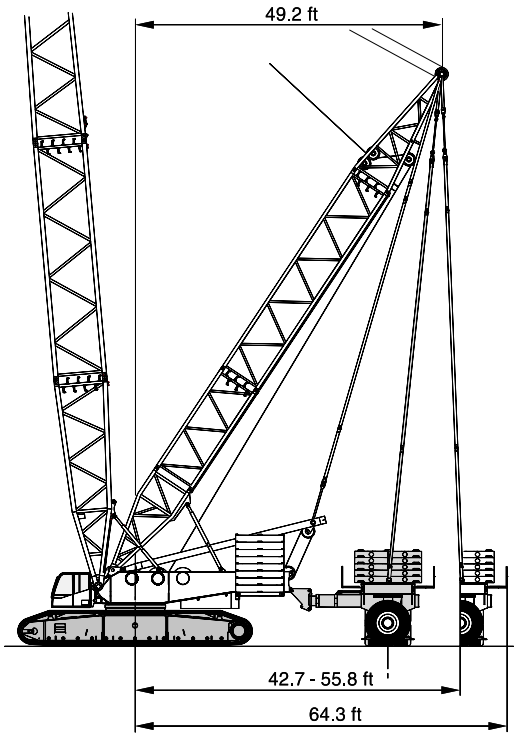
SUPERLIFT CONFIGURATIONS

STANDARD-SL 36.1 ft, 42.7 ft, 49.2 ft



TELE-SL 42.7 ft – 55.8 ft





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TEREX

DEMAG CC2800-1
CRAWLER CRANE

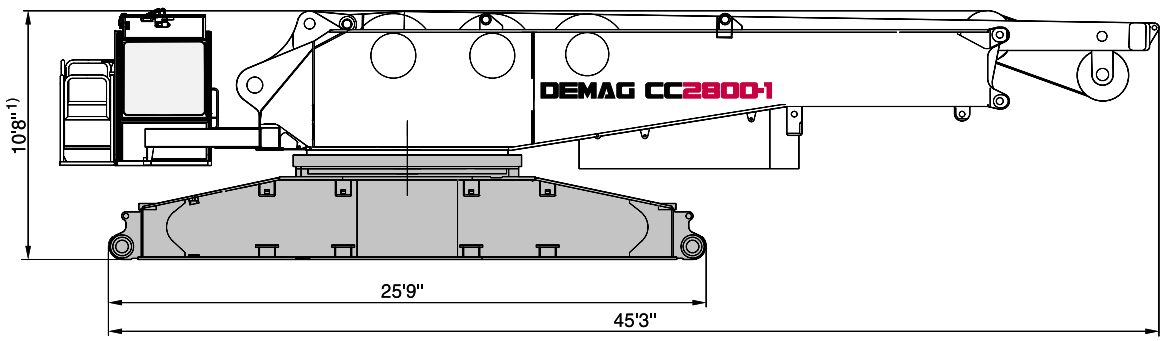
SPECIFICATIONS

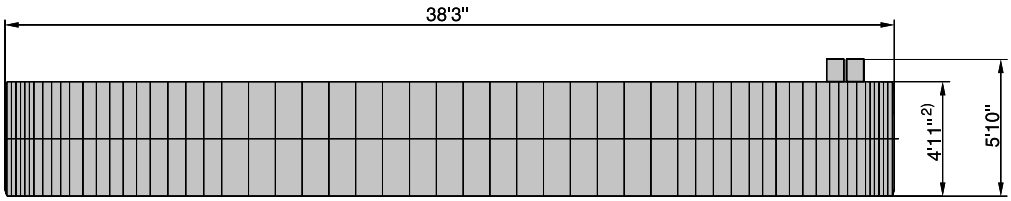
WEIGHTS

Total weight incl. counterweight 353,000 lb, 78.7 ft SH boom and hook block	794,000 lb
Superstructure (with three drums, A-frame, reeving drum and boom backstops)	121,000 lb
Superstructure (without drums H1/H2, reeving winch, boom backstops and A-frame) incl. part of quick-connection	81,100 lb
Carbody / Carbody with assembly jacks	57,300 lb / 61,700 lb
Crawlers with standard drive (option: quadro drive)	2 x 97,000 lb (2 x 106,000 lb)
Counterweight	353,000 lb

GROUND PRESSURE

Ground pressure, based on 794,000 lb total weight	20.3 lb / inch





1) With quick-connection 11'-4½"
2) optional 6'-7"

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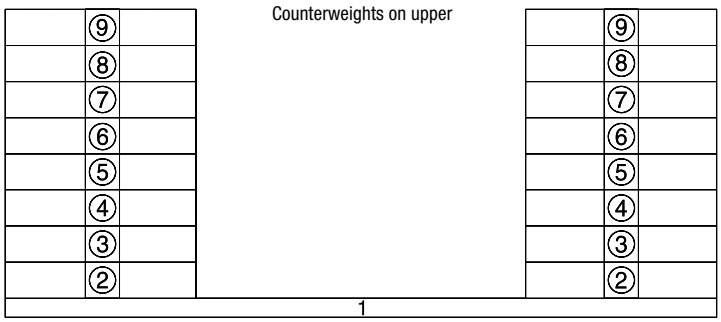
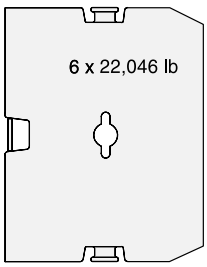
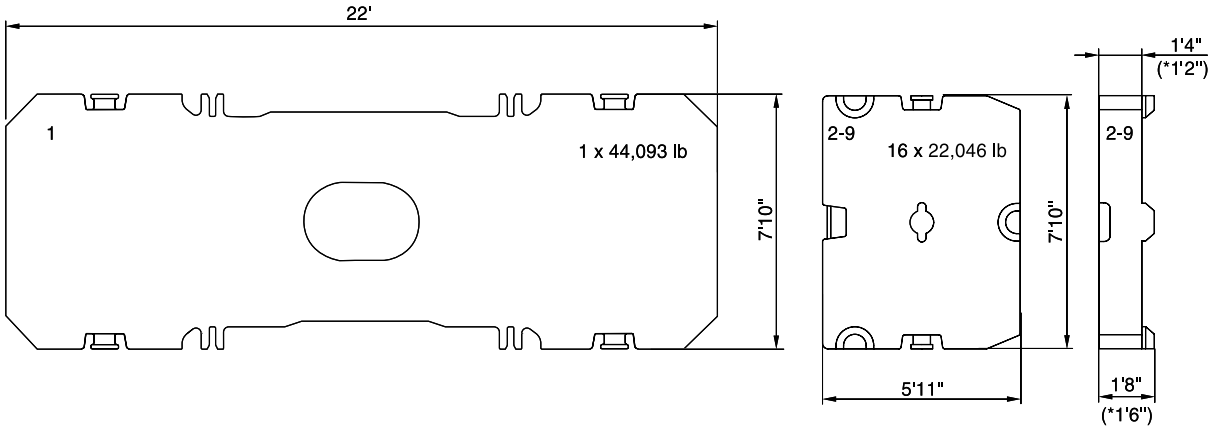
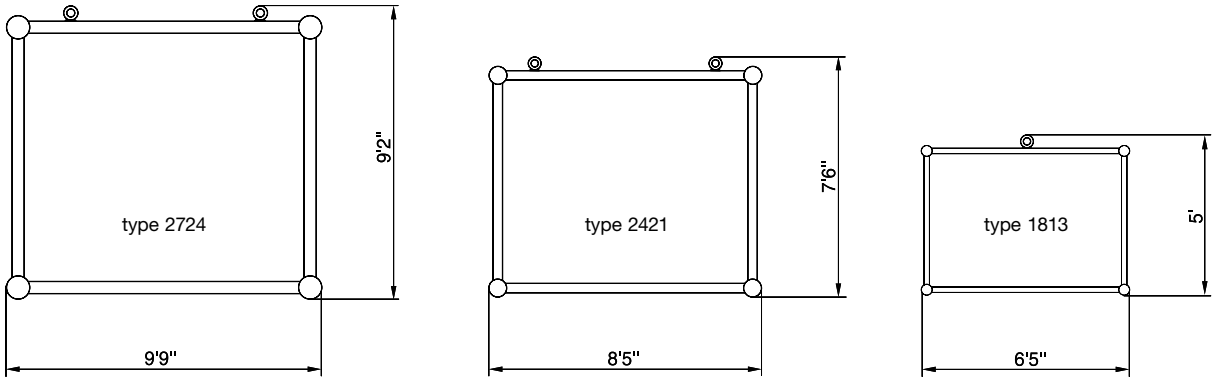
SPECIFICATIONS







* optional



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TEREX

DEMAG CC2800-1
CRAWLER CRANE

KEY

Track width

Counterweight + central ballast (ZB)

Superlift counterweight

Superlift radius

Load radius

Main boom

Fly jib

Main boom angle

Fly jib angle

„D“

S: heavy

L: light

H: Main boom

W: Luffing fly jib

F: Fixed fly jib

SL: Superlift

SGL: Heavy base length

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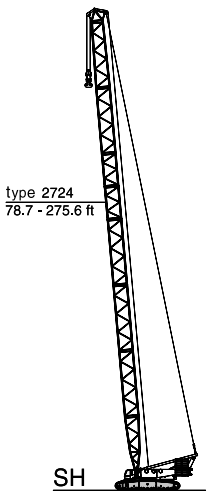
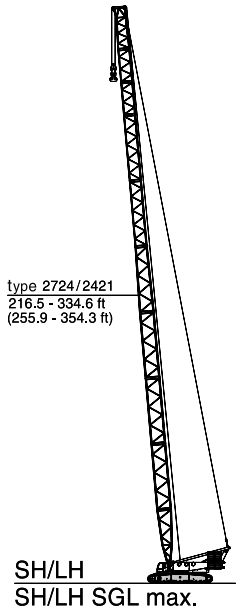
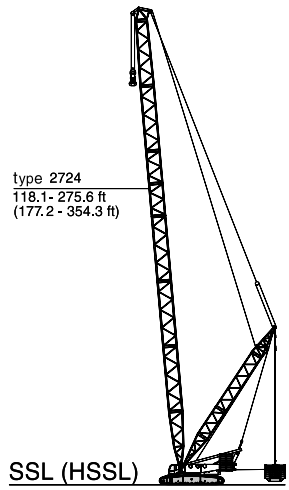
BOOM COMBINATIONS



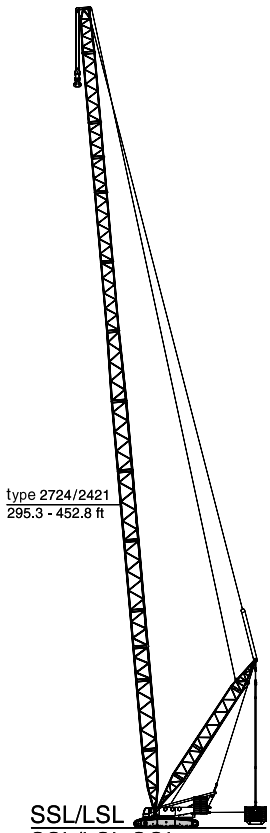
SH



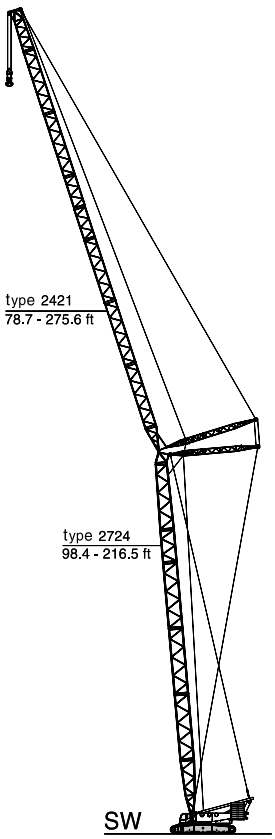
SH/LH
SH/LH SGL max.



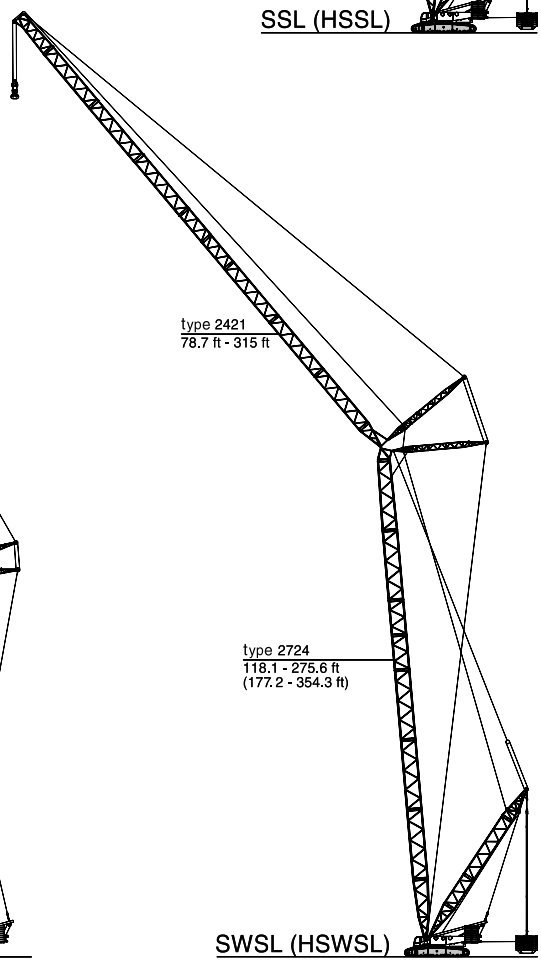
SSL (HSSL)



SSL/LSL
SSL/LSL SGL max.



SW



SWSL (HSWSL)

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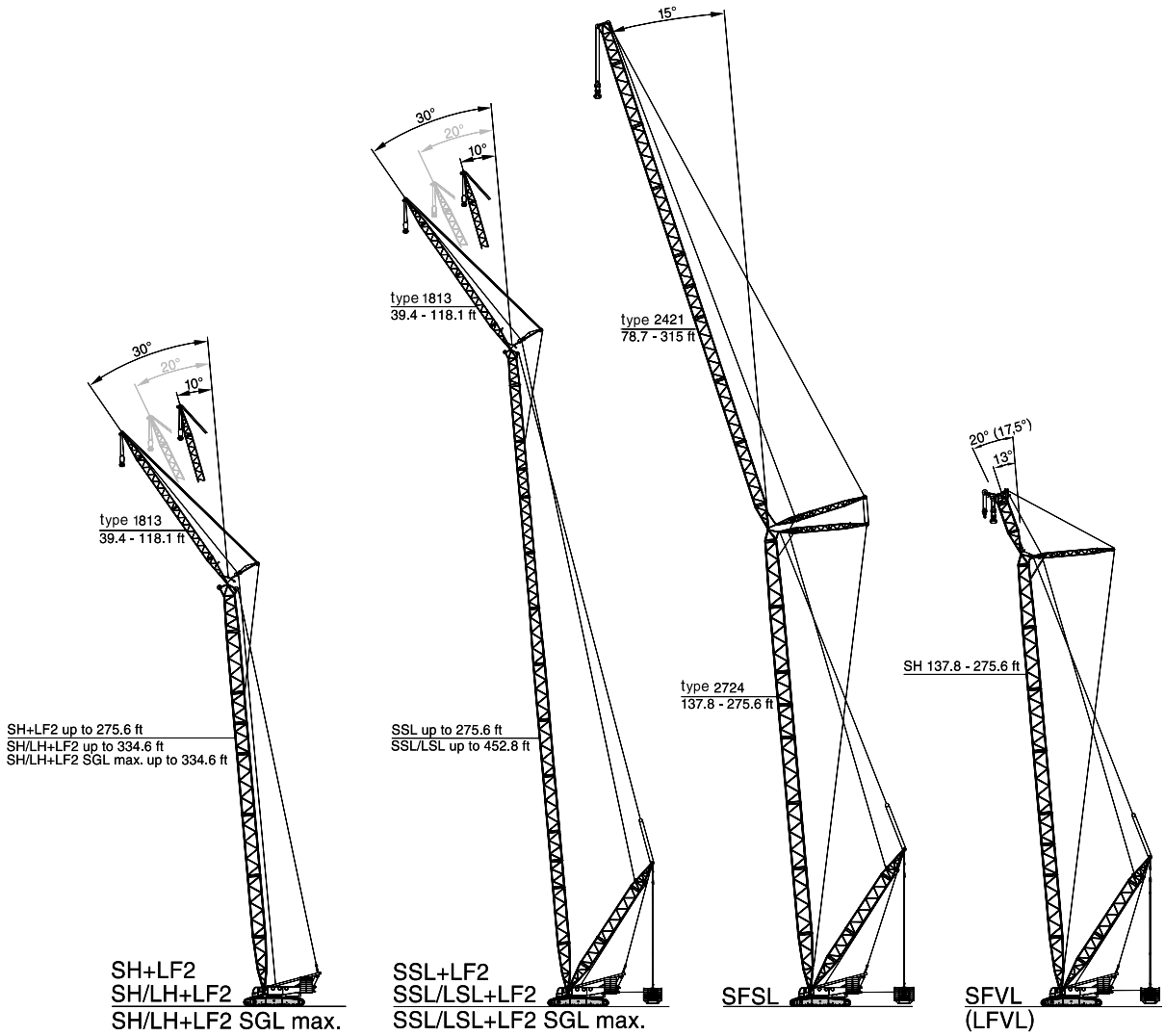
DEMAG CC2800-1
CRAWLER CRANE

BOOM COMBINATIONS



Special combinations available on request!

SFVL: Configuration with 1323,000 lb heavy-duty head

LFVL: Fitted with 661,400 lb jib top section (load charts on request)

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ERECTION / LOWERING OF THE CC 2800-1 BOOM SYSTEMS TO THE GROUND

352,700 lb – 396,800 lb ZB 0 - 132,300 lb 36.1 ft – 49.2 ft

Boom combination	Fly jib (ft)	Main boom (ft)																			
		78.7	98.4	118.1	137.8	157.5	177.2	196.9	216.5	236.2	255.9	275.6	295.3	315.0	334.6	354.3	374.0	393.7	413.4	433.1	452.8
SH		X	X	X	X	X	X	X	X	(X)	(X)	[X]	–	–	–	–	–	–	–	–	–
SH/LH		–	–	–	–	–	–	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–
SH/LH SGLmax.		–	–	–	–	–	–	–	–	–	X	[X]	[X]	[X]	[X]	–	–	–	–	–	–
SW	78.7	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	98.4	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	118.1	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	137.8	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	157.5	–	X	X	X	X	X	(X)	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	177.2	–	X	X	X	X	(X)	(X)	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	196.9	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	216.5	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	236.2	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	255.9	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
	275.6	–	X	X	X	X	(X)	[X]	[X]	–	–	–	–	–	–	–	–	–	–	–	–
SH+LF2	39.4	–	X	X	X	X	X	X	X	X	(X)	[X]	–	–	–	–	–	–	–	–	–
SH/LH+LF2	39.4	–	–	–	–	–	–	–	X	X	(X)	(X)	[X]	[X]	[X]	–	–	–	–	–	–
SH/LH SGLmax. +LF2	39.4	–	–	–	–	–	–	–	–	–	[X]	[X]	[X]	[X]	–	–	–	–	–	–	–
SSL		–	–	0	0	0	0	0	0	0	45	67	–	–	–	–	–	–	–	–	–
HSSL		–	–	–	–	–	0	0	0	23	56	111	122	177	221	265	–	–	–	–	–
SSL/LSL		–	–	–	–	–	–	–	–	–	–	–	133	166	188	232	276	309	353	364	408
SSL/LSL SGLmax.		–	–	–	–	–	–	–	–	–	–	23	67	111	155	199	254	298	353	419	486
LFVL		–	–	–	0	0	45	100	144	210	265	309	–	–	–	–	–	–	–	–	–
SFVL		–	–	–	12	56	89	144	177	232	276	331	–	–	–	–	–	–	–	–	–
SWSL/SFSL	78.7	–	–	0	0	23	78	133	188	243	276	331	–	–	–	–	–	–	–	–	–
	98.4	–	–	0	0	23	78	144	188	254	309	342	–	–	–	–	–	–	–	–	–
	118.1	–	–	0	0	0	56	122	188	254	320	386	–	–	–	–	–	–	–	–	–
	137.8	–	–	0	0	0	34	111	177	254	320	364	–	–	–	–	–	–	–	–	–
	157.5	–	–	0	0	0	23	89	155	232	287	364	–	–	–	–	–	–	–	–	–
	177.2	–	–	0	0	0	34	78	144	199	276	353	–	–	–	–	–	–	–	–	–
	196.9	–	–	0	0	0	45	89	133	188	254	342	–	–	–	–	–	–	–	–	–
	216.5	–	–	0	0	0	45	100	144	199	254	309	–	–	–	–	–	–	–	–	–
	236.2	–	–	0	0	12	56	111	155	210	265	320	–	–	–	–	–	–	–	–	–
	255.9	–	–	0	0	23	67	111	166	221	276	331	–	–	–	–	–	–	–	–	–
	275.6	–	–	0	0	23	67	122	177	232	287	342	–	–	–	–	–	–	–	–	–
	295.3	–	–	0	0	34	78	133	177	232	287	353	–	–	–	–	–	–	–	–	–
	315.0	–	–	12	0	34	89	133	188	243	298	364	–	–	–	–	–	–	–	–	–
SSL+LF2	39.4	–	–	0	0	0	0	0	0	0	12	56	–	–	–	–	–	–	–	–	–
HSSL+LF2	39.4	–	–	–	–	–	0	0	0	0	23	78	111	166	210	265	–	–	–	–	–
SSL/LSL+LF2	39.4	–	–	–	–	–	–	–	–	–	–	–	89	122	166	188	232	265	309	353	386
SSL/LSL SGLmax. +LF2	39.4	–	–	–	–	–	–	–	–	–	12	56	111	155	221	287	353	419	474	552	629

Remarks

X without assisting equipment

(X) idler wheel supported

[X] with additional side jack

Values for LF with 10° jib offset; values may differ for other offsets

All Superlift combinations can be erected or lowered to the ground without assisting equipment. The stated numbers represent the necessary SL-counterweight in 1,000 lb.

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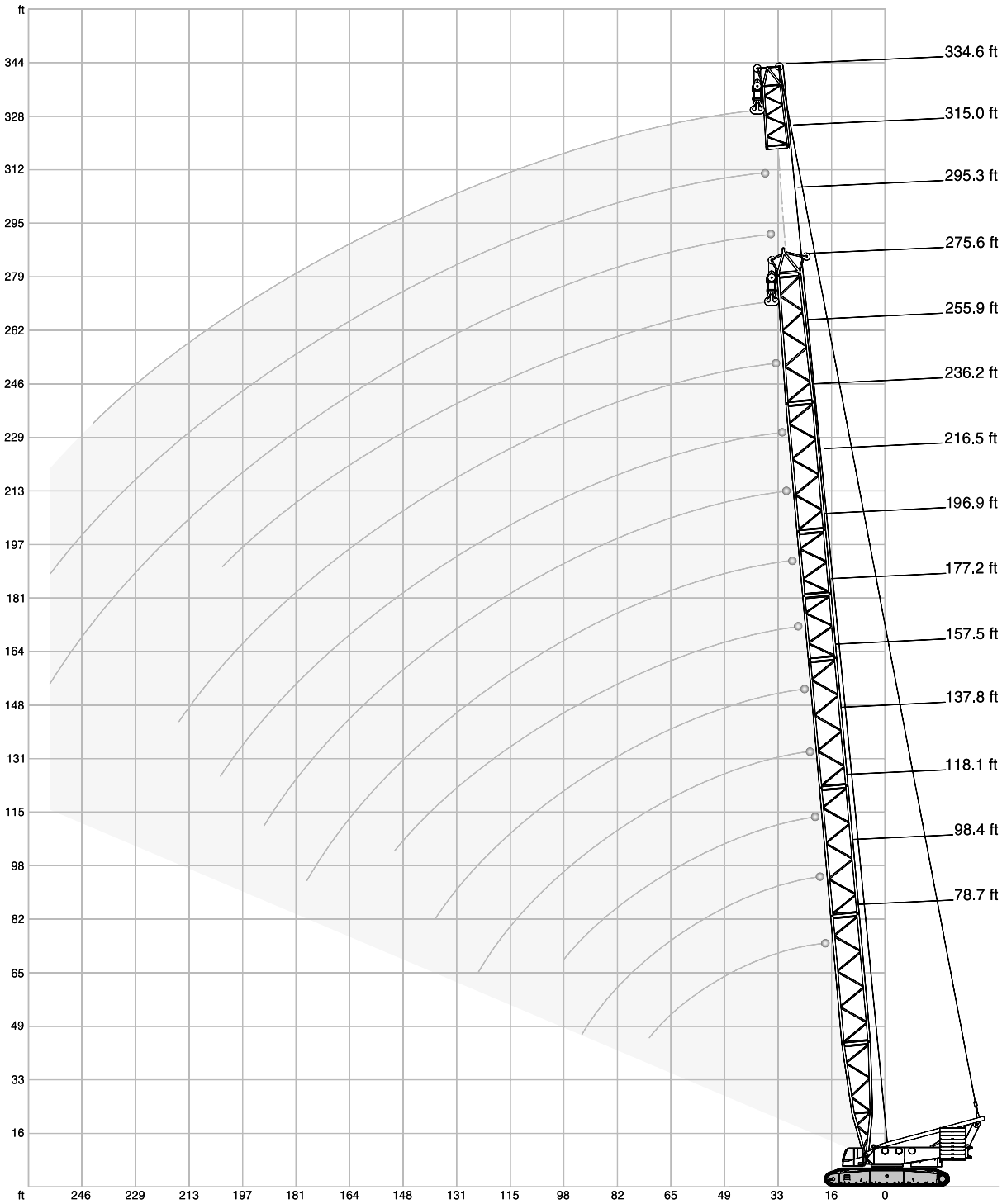
TEREX®

DEMAG CC2800-1
CRAWLER CRANE

SH, SH/LH WORKING RANGES



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TEREX

SH LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

ft	78.7 ft	98.4 ft	118.1 ft	137.8 ft	157.5 ft	177.2 ft	196.9 ft	216.5 ft	236.2 ft	255.9 ft	275.6 ft	ft
						1,000 lb						
19.7	1322.8	-	-	-	-	-	-	-	-	-	-	19.7
23.0	1236.8	1221.4	1250.0	-	-	-	-	-	-	-	-	23.0
26.2	1115.5	1106.7	1100.1	1093.5	1089.1	-	-	-	-	-	-	26.2
29.5	903.9	899.5	897.3	895.1	892.9	890.7	890.7	-	-	-	-	29.5
32.8	743.0	738.5	736.3	731.9	729.7	727.5	727.5	725.3	663.6	-	-	32.8
39.4	544.5	540.1	535.7	531.3	529.1	526.9	526.9	524.7	522.5	520.3	467.4	39.4
45.9	425.5	421.1	418.9	414.5	410.1	407.9	407.9	405.7	403.4	401.2	399.0	45.9
52.5	348.3	343.9	339.5	335.1	332.9	330.7	328.5	326.3	324.1	324.1	319.7	52.5
59.1	293.2	288.8	284.4	280.0	277.8	275.6	273.4	271.2	269.0	266.8	264.6	59.1
65.6	253.5	249.1	244.7	240.3	235.9	233.7	231.5	229.3	227.1	224.9	222.7	65.6
72.2	222.7	217.2	212.7	208.3	205.0	201.7	199.5	197.3	195.1	194.0	189.6	72.2
78.7	-	192.9	187.4	183.0	179.7	176.4	174.2	172.0	169.8	167.6	164.2	78.7
85.3	-	172.0	167.6	162.0	158.7	155.4	153.2	151.0	148.8	146.6	143.3	85.3
91.9	-	155.4	149.9	145.5	141.1	138.9	135.6	133.4	131.2	129.0	125.7	91.9
98.4	-	-	136.7	131.2	126.8	124.6	121.3	119.0	116.8	114.6	110.2	98.4
111.5	-	-	-	109.1	104.7	101.6	98.8	96.1	93.5	90.8	86.2	111.5
124.7	-	-	-	92.8	88.0	84.4	80.9	77.6	74.5	71.9	67.2	124.7
137.8	-	-	-	-	75.2	70.3	66.6	63.3	60.0	57.1	52.5	137.8
150.9	-	-	-	-	-	59.5	55.3	51.6	48.3	45.4	40.6	150.9
164.0	-	-	-	-	-	-	46.3	42.5	38.8	35.7	30.9	164.0
177.2	-	-	-	-	-	-	39.2	35.1	31.1	27.8	22.9	177.2
190.3	-	-	-	-	-	-	-	29.1	24.7	21.4	16.3	190.3
203.4	-	-	-	-	-	-	-	-	19.6	15.9	-	203.4
216.5	-	-	-	-	-	-	-	-	-	11.5	-	216.5
229.7	-	-	-	-	-	-	-	-	-	-	-	229.7

352,700 lb | 27.6 ft | 360° | DIN/ISO

ft	78.7 ft	98.4 ft	118.1 ft	137.8 ft	157.5 ft	177.2 ft	196.9 ft	216.5 ft	236.2 ft	255.9 ft	275.6 ft	ft
						1,000 lb						
23.0	934.8	1029.6	1119.9	-	-	-	-	-	-	-	-	23.0
26.2	892.9	950.2	948.0	943.6	943.6	-	-	-	-	-	-	26.2
29.5	747.4	743.0	740.8	738.5	736.3	734.1	734.1	-	-	-	-	29.5
32.8	612.9	608.5	606.3	601.9	599.7	597.5	597.5	595.2	590.8	-	-	32.8
39.4	447.5	443.1	438.7	436.5	432.1	432.1	429.9	427.7	425.5	425.5	421.1	39.4
45.9	350.5	346.1	341.7	337.3	335.1	332.9	330.7	328.5	326.3	326.3	321.9	45.9
52.5	284.4	280.0	275.6	273.4	269.0	266.8	264.6	262.4	260.1	260.1	255.7	52.5
59.1	240.3	235.9	231.5	227.1	222.7	220.5	219.4	217.2	215.0	212.7	209.4	59.1
65.6	206.1	201.7	197.3	192.9	189.6	186.3	184.1	181.9	180.8	178.6	175.3	65.6
72.2	180.8	175.3	170.9	166.4	162.0	159.8	157.6	155.4	153.2	151.0	147.7	72.2
78.7	-	154.3	149.9	144.4	141.1	138.9	136.7	134.5	132.3	130.1	125.7	78.7
85.3	-	137.8	132.3	127.9	124.6	121.3	119.0	116.8	114.6	112.4	108.9	85.3
91.9	-	124.6	119.0	113.5	110.2	107.4	104.9	102.5	100.3	97.9	93.5	91.9
98.4	-	-	107.6	102.3	98.3	95.5	92.8	89.9	87.3	84.9	80.2	98.4
111.5	-	-	-	84.0	79.6	75.8	72.5	69.4	66.6	63.9	59.5	111.5
124.7	-	-	-	70.5	65.0	60.8	57.1	54.0	50.9	48.3	43.7	124.7
137.8	-	-	-	-	54.0	49.4	45.4	42.1	38.8	35.9	31.3	137.8
150.9	-	-	-	-	-	40.6	36.2	32.6	29.1	26.2	21.4	150.9
164.0	-	-	-	-	-	-	28.9	24.9	21.4	18.3	13.4	164.0
177.2	-	-	-	-	-	-	23.4	19.0	15.0	11.7	-	177.2
190.3	-	-	-	-	-	-	-	14.3	-	-	-	190.3

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SH/LH LIFTING CAPACITIES

27.6 ft | 360° | DIN/ISO

	216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.
	352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb	
ft	1,000 lb											
29.5	657.0	657.0	-	-	-	-	-	-	-	-	-	-
32.8	608.5	657.0	-	549.0	549.0	-	445.3	445.3	489.4	-	-	-
36.1	524.7	597.5	-	494.9	543.4	-	443.1	445.3	479.5	-	-	474.0
39.4	440.9	537.9	-	440.9	537.9	-	440.9	445.3	469.6	372.6	372.6	454.2
45.9	341.7	418.9	-	341.7	418.9	-	341.7	383.6	392.4	330.7	330.7	381.4
52.5	277.8	339.5	-	275.6	339.5	-	275.6	337.3	337.3	273.4	293.2	326.3
59.1	229.3	284.4	-	229.3	284.4	-	229.3	284.4	282.2	227.1	262.4	277.8
65.6	196.2	242.5	-	195.1	242.5	-	195.1	242.5	240.3	192.9	235.9	235.9
72.2	168.7	211.6	-	168.7	210.5	-	167.6	209.4	207.2	165.3	208.3	205.0
78.7	147.7	185.2	-	146.6	185.2	-	145.5	184.1	181.9	144.4	181.9	178.6
85.3	130.1	164.2	-	129.0	163.1	-	127.9	163.1	159.8	126.8	160.9	157.6
91.9	115.7	146.6	-	114.6	146.6	-	113.5	145.5	143.3	111.3	143.3	140.0
98.4	103.6	132.3	-	102.7	131.2	-	101.9	130.1	127.9	99.9	129.0	124.6
111.5	84.0	109.1	-	83.1	108.2	-	82.2	107.4	104.7	80.0	105.4	101.9
124.7	69.0	91.5	-	67.9	90.4	-	66.6	89.3	86.6	64.2	87.3	83.6
137.8	56.7	77.4	-	55.3	76.3	-	54.2	75.2	72.1	51.6	72.8	68.6
150.9	46.7	65.9	-	45.4	64.6	-	44.1	63.3	60.0	41.4	60.6	56.4
164.0	38.8	56.2	-	37.3	54.7	-	35.9	53.4	50.0	33.3	50.7	46.5
177.2	32.2	48.3	-	30.6	46.7	-	29.1	45.2	41.9	26.5	42.5	38.1
190.3	26.9	41.7	-	24.9	39.9	-	23.4	38.4	34.8	20.7	35.5	31.3
203.4	-	-	-	20.3	34.2	-	18.5	32.4	29.1	15.9	29.8	25.4
216.5	-	-	-	-	-	-	14.6	27.6	24.0	11.7	24.7	20.3
229.7	-	-	-	-	-	-	11.2	23.4	19.8	-	20.3	15.9

	295.3 ft			315.0 ft			334.6 ft			354.3 ft		
	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.	SH/LH		SH/LH SGLmax.
	352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb		352.7 klb	396.8 klb + 132.3 klb	
ft	1,000 lb											
39.4	339.5	339.5	438.7	302.0	302.0	350.5	-	-	-	-	-	-
42.7	339.5	339.5	403.4	302.0	302.0	350.5	-	-	319.7	-	-	288.8
45.9	339.5	339.5	368.2	302.0	302.0	350.5	238.1	238.1	319.7	-	-	288.8
52.5	273.4	313.1	315.3	271.2	280.0	306.4	218.3	218.3	297.6	-	-	288.8
59.1	227.1	280.0	275.6	224.9	260.1	266.8	200.6	200.6	257.9	-	-	251.3
65.6	191.8	238.1	233.7	190.7	238.1	233.7	185.2	185.2	227.1	-	-	220.5
72.2	164.2	207.2	201.7	163.1	205.0	200.6	162.0	172.0	198.4	-	-	195.1
78.7	143.3	180.8	176.4	141.1	179.7	175.3	141.1	158.7	173.1	-	-	169.8
85.3	125.7	159.8	155.4	123.5	158.7	153.2	123.5	149.9	151.0	-	-	147.7
91.9	110.2	142.2	137.8	109.8	141.1	135.6	108.7	140.0	133.4	-	-	130.1
98.4	98.5	126.8	122.4	97.2	125.7	121.3	96.3	124.6	119.0	-	-	115.7
111.5	78.5	104.1	99.0	76.9	102.7	97.7	75.8	101.6	95.0	-	-	91.1
124.7	62.6	86.0	80.2	60.8	84.7	78.7	59.7	83.3	75.6	-	-	71.7
137.8	50.0	71.2	65.3	48.3	69.4	63.5	47.2	68.1	60.4	-	-	56.4
150.9	39.9	59.1	52.9	38.1	57.3	51.4	36.8	56.0	48.1	-	-	44.1
164.0	31.5	48.9	43.0	29.8	47.2	41.2	28.4	45.9	37.9	-	-	34.0
177.2	24.7	40.8	34.6	22.9	39.0	32.8	21.6	37.5	29.5	-	-	25.6
190.3	19.0	33.7	27.6	17.0	32.0	25.8	15.7	30.4	22.5	-	-	18.3
203.4	13.9	27.8	21.6	11.9	25.8	19.6	10.6	24.5	16.3	-	-	12.1
210.0	11.8	25.2	19.1	-	23.3	17.0	-	21.8	13.7	-	-	9.5
216.5	9.7	22.7	16.5	-	20.7	14.6	-	19.2	11.0	-	-	-
229.7	-	18.3	11.9	-	16.1	9.9	-	14.6	-	-	-	-
232.9	-	17.3	10.9	-	15.1	8.8	-	13.6	-	-	-	-
242.8	-	14.3	-	-	12.1	-	-	10.6	-	-	-	-
255.9	-	11.0	-	-	8.8	-	-	-	-	-	-	-

Remarks

For SH/LH SGLmax. a boom power-kit is required

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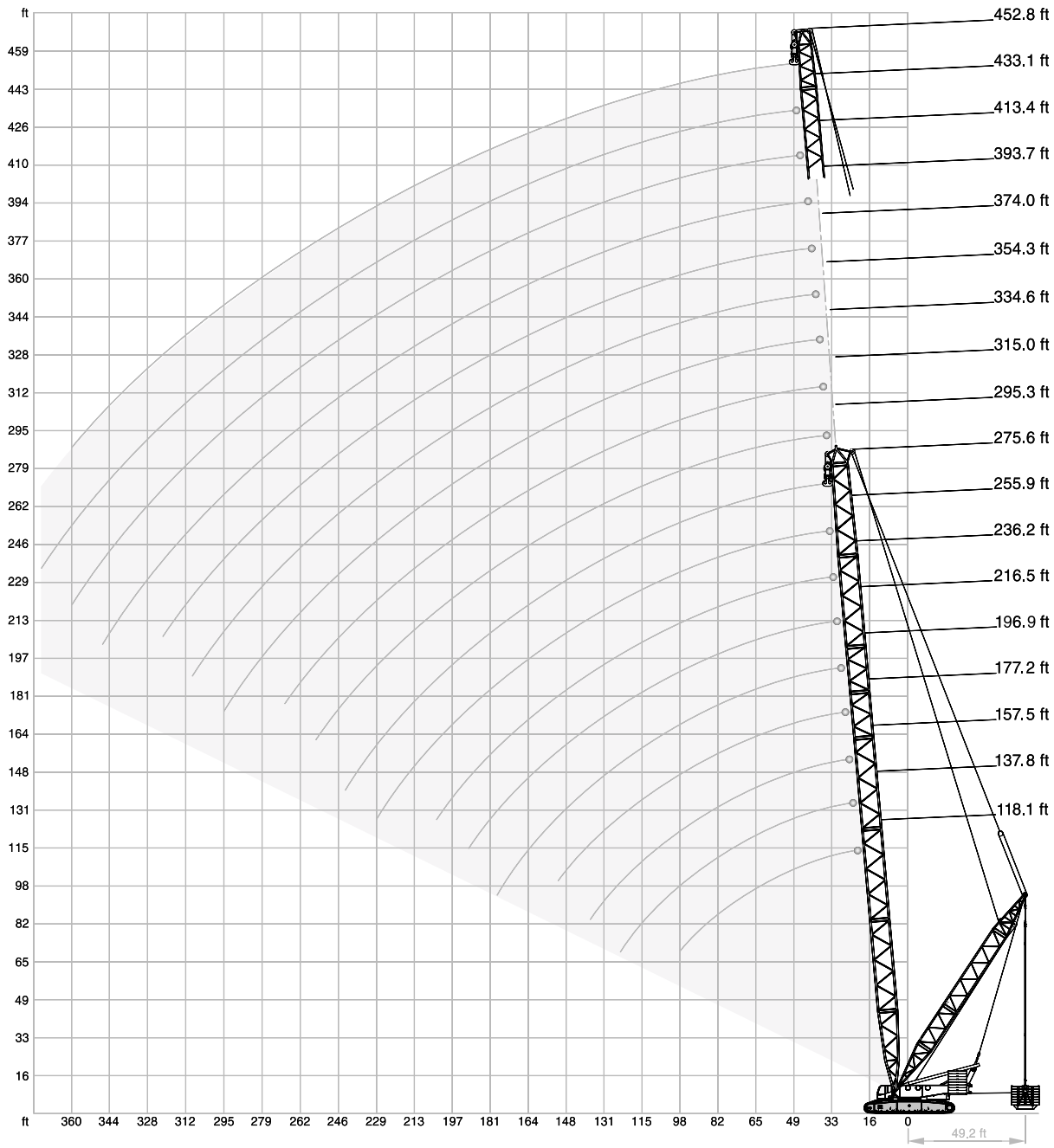
TEREX®

SSL/HSSL, SSL/LSL WORKING RANGES



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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL/HSSL LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

	118.1 ft				137.8 ft				157.5 ft				177.2 ft			
	SSL			HSSL	SSL			HSSL	SSL			HSSL	SSL			HSSL
	0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb		
	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft
ft	1,000 lb															
23.0	1274.3	1322.8	1322.8	-	-	-	-	-	-	-	-	-	-	-	-	-
26.2	1113.3	1322.8	1322.8	-	1111.1	1307.3	1307.3	-	1111.1	1278.7	1278.7	-	-	-	-	-
29.5	941.4	1322.8	1322.8	-	937.0	1307.3	1307.3	-	939.2	1278.7	1278.7	-	941.4	1157.4	1157.4	1157.4
32.8	789.3	1320.6	1320.6	-	784.8	1307.3	1307.3	-	782.6	1278.7	1278.7	-	780.4	1157.4	1157.4	1157.4
39.4	575.4	1285.3	1285.3	-	571.0	1265.5	1265.5	-	568.8	1278.7	1278.7	-	566.6	1157.4	1157.4	1157.4
45.9	449.7	1144.2	1210.3	-	445.3	1137.6	1177.3	-	443.1	1133.2	1172.9	-	440.9	1128.8	1157.4	1126.6
52.5	366.0	1000.9	1062.6	-	363.8	994.3	1056.0	-	359.4	989.9	1051.6	-	357.1	987.7	1047.2	983.3
59.1	308.6	888.5	943.6	-	304.2	884.1	939.2	-	299.8	879.6	932.6	-	297.6	875.2	930.4	873.0
65.6	264.6	800.3	817.9	-	260.1	793.7	842.2	-	255.7	789.3	837.8	-	253.5	784.8	833.3	782.6
72.2	229.3	712.1	712.1	-	224.9	718.7	760.6	-	222.7	714.3	760.6	-	220.5	709.9	756.2	707.7
78.7	203.9	626.1	626.1	-	199.5	648.2	672.4	-	196.2	646.0	694.5	-	192.9	646.0	690.0	643.8
85.3	181.9	553.4	553.4	-	177.5	593.0	601.9	-	174.2	588.6	626.1	-	170.9	586.4	630.5	584.2
91.9	164.2	502.7	489.4	-	159.8	540.1	540.1	-	155.4	537.9	564.4	-	153.2	537.9	577.6	535.7
98.4	148.8	447.5	432.1	-	144.4	485.0	485.0	-	140.0	498.2	515.9	-	137.8	493.8	526.9	493.8
111.5	-	-	-	-	120.2	396.8	392.4	-	115.7	425.5	427.7	-	112.4	423.3	445.3	426.2
124.7	-	-	-	-	103.2	328.5	315.3	-	98.3	354.9	354.9	-	94.8	368.2	377.0	366.7
137.8	-	-	-	-	-	-	-	-	84.7	302.0	293.2	-	80.5	321.9	321.9	315.3
150.9	-	-	-	-	-	-	-	-	-	-	-	-	69.0	271.2	271.2	268.2
160.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	242.5

	196.9 ft				216.5 ft				236.2 ft				255.9 ft			
	SSL			HSSL	SSL			HSSL	SSL			HSSL	SSL			HSSL
	0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb			0 lb	0 lb – 661,400 lb		
	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft
ft	1,000 lb															
29.5	939.2	1049.4	1049.4	1049.4	-	-	-	-	-	-	-	-	-	-	-	-
32.8	780.4	1049.4	1049.4	1049.4	778.2	912.7	912.7	928.1	771.6	822.3	822.3	866.4	-	-	-	-
36.1	673.5	1049.4	1049.4	1049.4	671.3	912.7	912.7	928.1	666.9	822.3	822.3	866.4	-	-	-	802.5
39.4	566.6	1049.4	1049.4	1049.4	564.4	912.7	912.7	928.1	562.2	822.3	822.3	866.4	562.2	696.7	696.7	802.5
45.9	438.7	1049.4	1049.4	1049.4	436.5	912.7	912.7	928.1	436.5	822.3	822.3	866.4	434.3	696.7	696.7	802.5
52.5	354.9	983.3	1036.2	978.9	352.7	901.7	901.7	928.1	352.7	822.3	822.3	866.4	350.5	696.7	696.7	802.5
59.1	295.4	870.8	925.9	868.6	293.2	855.4	855.4	864.2	293.2	798.1	798.1	859.8	291.0	694.5	694.5	802.5
65.6	251.3	780.4	831.1	778.2	249.1	778.2	809.1	773.8	246.9	760.6	760.6	769.4	246.9	674.6	674.6	767.2
72.2	218.3	707.7	751.8	703.3	216.1	703.3	749.6	698.9	213.8	701.1	723.1	696.7	211.6	657.0	657.0	692.3
78.7	190.7	643.8	685.6	641.5	188.5	641.5	683.4	637.1	186.3	637.1	676.8	632.7	184.1	634.9	639.3	630.5
85.3	168.7	584.2	628.3	584.2	166.4	584.2	626.1	579.8	164.2	582.0	615.1	579.8	162.0	582.0	601.9	577.6
91.9	149.9	535.7	575.4	533.5	147.7	533.5	571.0	531.3	145.5	533.5	564.4	529.1	143.3	531.3	551.2	529.1
98.4	134.5	493.8	529.1	491.6	132.3	491.6	524.7	487.2	130.1	487.2	518.1	485.0	127.9	487.2	509.3	485.0
111.5	110.2	421.1	449.7	422.6	107.8	416.7	449.7	419.6	105.4	414.5	445.3	417.4	103.2	412.3	438.7	415.9
124.7	91.7	363.8	388.0	365.2	88.8	361.6	388.0	362.3	85.8	359.4	388.0	360.1	83.1	357.1	381.4	357.9
137.8	76.7	321.9	335.1	319.7	73.4	317.5	341.7	315.3	70.1	315.3	339.5	313.1	67.5	313.1	337.3	310.9
150.9	64.6	286.6	288.8	282.9	61.1	284.4	297.6	282.9	57.8	280.0	302.0	279.3	54.7	277.8	299.8	277.0
164.0	55.1	249.1	249.1	245.4	51.1	253.5	260.1	252.1	47.6	251.3	266.8	249.9	44.5	249.1	266.8	247.7
177.2	47.6	215.0	212.7	213.8	43.2	227.1	227.1	222.7	39.2	227.1	235.9	224.9	35.9	224.9	238.1	222.7
190.3	-	-	-	-	36.8	197.3	197.3	191.8	32.4	207.2	208.3	200.6	29.1	205.0	212.7	202.8
193.6	-	-	-	-	-	-	-	186.3	31.0	200.9	201.7	194.6	27.6	200.6	206.7	197.9
203.4	-	-	-	-	-	-	-	-	26.9	181.9	181.9	175.7	23.1	187.4	188.5	182.2
213.3	-	-	-	-	-	-	-	-	-	-	-	159.8	19.5	171.7	172.0	166.3
216.5	-	-	-	-	-	-	-	-	-	-	-	-	18.3	166.4	166.4	160.9
229.7	-	-	-	-	-	-	-	-	-	-	-	-	14.6	145.5	145.5	142.2

Remarks

For HSSL a boom power-kit is required

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TEREX

SSL/HSSL LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

	275.6 ft				295.3 ft	315.0 ft	334.6 ft	354.3 ft
	SSL			HSSL	HSSL	HSSL	HSSL	HSSL
	0 lb	0 lb – 661,400 lb			0 lb – 661,400 lb	0 lb – 661,400 lb	0 lb – 661,400 lb	0 lb – 661,400 lb
	36.1 – 49.2 ft	55.8 ft		36.1 – 49.2 ft	36.1 – 49.2 ft	36.1 – 49.2 ft	36.1 – 49.2 ft	36.1 – 49.2 ft
ft						1,000 lb		
39.4	557.8	619.5	619.5	676.8	637.1	560.0	-	-
42.7	493.8	619.5	619.5	676.8	636.0	558.9	480.6	421.1
45.9	429.9	619.5	619.5	676.8	634.9	557.8	480.6	421.1
52.5	346.1	619.5	619.5	676.8	632.7	551.2	474.0	416.7
59.1	286.6	619.5	619.5	676.8	630.5	546.7	467.4	412.3
65.6	242.5	612.9	612.9	676.8	628.3	542.3	463.0	405.7
72.2	208.3	597.5	597.5	672.4	604.1	533.5	458.6	401.2
78.7	180.8	584.2	584.2	626.1	582.0	520.3	447.5	394.6
85.3	158.7	571.0	571.0	573.2	560.0	509.3	436.5	383.6
91.9	140.0	529.1	531.3	524.7	522.5	498.2	425.5	374.8
98.4	123.5	482.8	491.6	480.6	478.4	469.6	414.5	363.8
111.5	98.8	410.1	423.3	411.5	410.8	404.9	382.1	343.2
124.7	78.5	352.7	370.4	353.5	353.5	349.1	343.9	318.9
137.8	62.6	308.6	326.3	306.4	306.4	302.0	299.8	291.0
150.9	50.0	273.4	291.0	272.6	272.6	268.2	266.0	260.1
164.0	39.7	244.7	262.4	243.2	242.9	238.5	236.6	232.6
177.2	31.1	220.5	233.7	218.3	217.2	212.7	211.6	208.3
190.3	24.0	200.6	210.5	198.4	197.3	192.5	191.4	187.4
203.4	18.1	183.0	188.5	180.6	178.6	174.9	173.8	169.4
216.5	13.0	167.6	168.7	163.1	163.1	158.7	157.6	153.2
229.7	-	149.9	149.9	144.8	147.7	144.8	144.4	140.0
242.8	-	132.3	132.3	126.8	132.3	130.8	131.5	127.9
246.1	-	-	-	123.5	128.4	127.3	128.4	124.6
255.9	-	-	-	-	116.8	116.8	119.0	114.6
262.5	-	-	-	-	110.2	109.2	112.9	109.1
269.0	-	-	-	-	-	102.8	106.7	103.6
278.9	-	-	-	-	-	94.8	97.6	95.5
282.2	-	-	-	-	-	-	94.7	92.8
295.3	-	-	-	-	-	-	84.2	82.2
298.6	-	-	-	-	-	-	82.7	79.6
308.4	-	-	-	-	-	-	-	72.8
315.0	-	-	-	-	-	-	-	69.7
334.6	-	-	-	-	-	-	-	-

Remarks

For HSSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL/LSL LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 27.6 ft | 360° | DIN/ISO

	295.3 ft			315.0 ft			334.6 ft		
	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.
	0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb	
ft					1,000 lb				
39.4	526.9	546.7	551.2	456.4	474.0	496.0	-	-	-
45.9	445.3	546.7	551.2	445.3	471.8	491.6	381.4	399.0	447.5
52.5	359.4	546.7	551.2	359.4	469.6	485.0	359.4	394.6	438.7
59.1	299.8	546.7	551.2	299.8	467.4	478.4	299.8	392.4	432.1
65.6	255.7	542.3	549.0	255.7	465.2	474.0	253.5	388.0	425.5
72.2	220.5	531.3	531.3	220.5	460.8	463.0	219.4	383.6	418.9
78.7	194.0	518.1	520.3	192.9	451.9	451.9	191.8	379.2	407.9
85.3	170.9	507.1	507.1	169.8	445.3	440.9	169.8	374.8	396.8
91.9	152.1	493.8	493.8	151.0	438.7	429.9	149.9	370.4	385.8
98.4	136.7	467.4	451.9	135.6	427.7	414.5	134.5	366.0	374.8
111.5	111.3	421.1	388.7	110.2	392.4	374.8	109.3	343.9	346.9
124.7	91.9	366.0	335.8	90.8	359.4	333.6	89.9	319.7	318.2
137.8	76.1	321.9	293.2	74.7	319.7	291.0	73.6	295.4	288.8
150.9	63.3	284.4	260.9	61.7	284.4	258.7	60.6	273.4	256.5
164.0	52.5	255.7	233.0	51.1	253.5	231.1	49.8	251.3	228.5
177.2	43.7	231.5	209.4	42.1	229.3	208.3	40.8	229.3	205.0
190.3	36.2	210.5	191.1	34.6	209.4	190.0	33.3	208.3	186.3
203.4	29.8	192.9	174.2	28.0	191.8	173.1	26.7	190.7	170.1
216.5	24.3	177.5	159.8	22.5	176.4	157.6	21.2	174.2	155.4
229.7	19.4	163.1	147.3	17.6	162.0	145.9	16.3	160.9	142.9
242.8	15.2	151.0	136.3	13.4	149.9	134.8	11.9	148.8	131.5
255.9	11.7	134.5	126.8	9.7	138.9	124.6	-	137.8	121.3
269.0	-	-	-	-	124.6	115.7	-	127.9	112.1
282.2	-	-	-	-	-	-	-	115.7	102.7
295.3	-	-	-	-	-	-	-	104.1	93.7

	354.3 ft			374.0 ft			393.7 ft		
	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.
	0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb	
ft					1,000 lb				
45.9	324.1	337.3	403.4	284.4	295.4	357.1	262.4	269.0	321.9
52.5	315.3	330.7	399.0	277.8	291.0	354.9	257.9	266.8	321.9
59.1	297.6	324.1	396.8	273.4	288.8	352.7	253.5	264.6	319.7
65.6	251.3	319.7	394.6	251.3	284.4	350.5	246.9	260.1	317.5
72.2	218.3	313.1	394.6	217.2	280.0	348.3	217.2	257.9	315.3
78.7	189.6	306.4	390.2	189.6	277.8	346.1	189.6	253.5	313.1
85.3	167.6	299.8	383.6	166.4	273.4	341.7	166.4	251.3	310.9
91.9	148.8	293.2	374.8	147.7	269.0	339.5	147.7	246.9	308.6
98.4	132.3	286.6	366.0	132.3	264.6	335.1	131.2	244.7	304.2
111.5	107.4	273.4	338.0	106.7	257.9	321.9	106.5	235.9	298.4
124.7	87.5	262.4	313.8	86.6	249.1	304.2	86.2	229.3	284.4
137.8	71.4	251.3	284.4	70.5	238.1	282.2	69.9	220.5	266.8
150.9	58.2	238.1	252.1	57.3	229.3	249.9	56.9	213.8	243.2
164.0	47.4	227.1	224.5	46.5	218.3	221.8	45.9	205.0	219.0
177.2	38.4	216.1	201.7	37.5	209.4	198.4	36.8	198.4	196.2
190.3	30.9	205.0	182.3	29.8	200.6	180.0	29.1	189.6	177.1
203.4	24.3	188.5	165.7	23.1	187.4	163.1	22.7	180.8	160.2
216.5	18.5	173.1	151.0	17.4	172.0	147.7	17.0	170.9	145.5
229.7	13.7	158.7	138.5	12.6	157.6	136.0	11.9	157.6	132.3
242.8	9.3	146.6	127.3	-	145.5	124.3	-	145.5	121.6
255.9	-	135.6	116.8	-	134.5	114.6	-	134.5	111.3
269.0	-	126.8	108.6	-	125.7	105.8	-	124.6	102.1
282.2	-	116.8	100.8	-	116.8	97.4	-	115.7	93.5
295.3	-	105.8	93.3	-	107.6	89.5	-	108.2	85.8
308.4	-	95.0	86.3	-	97.7	82.7	-	99.2	78.9
315.0	-	-	82.9	-	92.9	79.4	-	94.8	75.4
321.5	-	-	-	-	88.2	76.3	-	90.4	72.5
334.6	-	-	-	-	-	-	-	81.8	66.6
347.8	-	-	-	-	-	-	-	73.4	60.4

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TEREX

SSL/LSL LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 27.6 ft | 360° | DIN/ISO

	413.4 ft			433.1 ft			452.8 ft		
	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.	SSL/LSL		SSL/LSL SGLmax.
	0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb		0 lb	0 lb – 661,400 lb	
ft					1,000 lb				
49.2	-	-	284.4	-	-	257.9	-	-	-
52.5	233.7	240.3	284.4	202.8	211.6	257.9	174.2	180.8	227.1
59.1	229.3	238.1	282.2	198.4	209.4	255.7	169.8	176.4	224.9
65.6	227.1	238.1	280.0	194.0	207.2	253.5	163.1	174.2	222.7
72.2	217.2	235.9	277.8	191.8	205.0	251.3	158.7	172.0	220.5
78.7	188.5	233.7	275.6	186.3	202.8	249.1	154.3	169.8	218.3
85.3	166.4	231.5	273.4	164.2	200.6	246.9	152.1	165.3	216.1
91.9	146.6	229.3	273.4	144.4	198.4	244.7	143.3	163.1	213.8
98.4	131.2	227.1	271.2	129.0	196.2	242.5	127.9	160.9	210.5
111.5	105.8	222.7	266.8	103.6	191.8	238.1	102.1	156.5	206.1
124.7	85.5	218.3	258.7	82.9	189.6	232.4	81.1	149.9	201.7
137.8	69.2	213.8	246.9	66.6	187.4	224.9	64.8	145.5	196.2
150.9	56.0	207.2	232.2	53.4	183.0	213.8	51.6	138.9	188.1
164.0	45.0	200.6	215.0	42.5	180.8	201.4	40.8	134.5	180.0
177.2	35.9	194.0	192.9	33.5	176.4	189.6	31.5	127.9	172.0
190.3	28.2	187.4	174.5	25.8	172.0	171.2	23.8	121.3	163.1
203.4	21.6	180.8	157.6	19.0	165.3	154.1	17.2	114.6	149.9
216.5	15.9	169.8	142.2	13.2	160.9	138.9	11.5	108.0	135.6
229.7	10.8	156.5	129.6	-	153.2	126.4	-	101.4	122.4
242.8	-	144.4	118.4	-	142.2	114.8	-	92.6	110.5
255.9	-	133.4	108.2	-	131.2	104.1	-	86.0	100.1
269.0	-	123.5	98.8	-	121.3	94.5	-	79.4	90.7
282.2	-	114.6	89.9	-	112.4	86.1	-	74.7	82.0
295.3	-	107.4	82.2	-	104.7	78.0	-	72.5	74.1
308.4	-	99.2	75.3	-	96.3	71.1	-	70.3	67.2
321.5	-	91.1	68.9	-	88.6	64.7	-	68.1	60.7
334.6	-	83.1	63.1	-	81.4	58.9	-	65.7	54.7
347.8	-	75.4	57.8	-	74.1	53.6	-	63.5	49.4
360.9	-	67.7	51.9	-	67.0	48.4	-	61.3	44.5
364.2	-	-	50.3	-	65.3	47.1	-	60.7	43.3
374.0	-	-	-	-	60.2	43.2	-	59.1	39.9
380.6	-	-	-	-	-	39.7	-	56.4	37.3
387.1	-	-	-	-	-	-	-	53.8	34.3
400.3	-	-	-	-	-	-	-	48.5	28.0
413.4	-	-	-	-	-	-	-	-	-

Remarks (page 19 + 20)

For HSSL a boom power-kit is required

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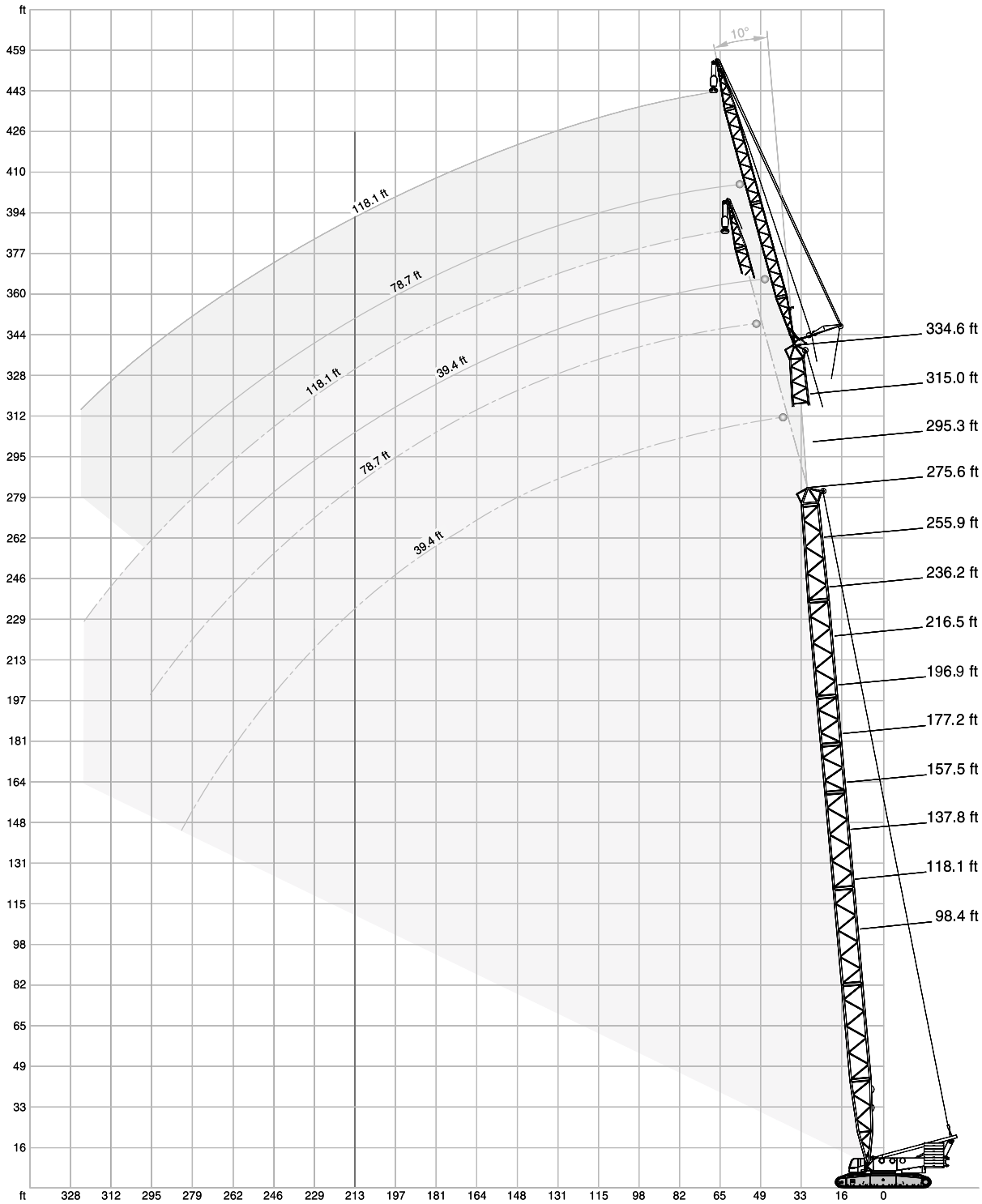
TEREX

DEMAG CC2800-1
CRAWLER CRANE

SH+LF2, SH/LH+LF2 WORKING RANGES 10°



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TEREX

SH+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	10°	15°	20°	10°	15°	20°	10°	15°	20°	10°	15°	20°	10°	15°	20°
ft								1,000 lb							
29.5	275.6	-	-	275.6	-	-	-	-	-	-	-	-	-	-	-
32.8	275.6	235.9	-	275.6	238.1	-	275.6	-	-	275.6	-	-	-	-	-
36.1	275.6	222.7	178.6	275.6	231.5	184.1	275.6	240.3	-	275.6	240.3	-	275.6	-	-
39.4	262.4	208.3	169.8	275.6	219.4	175.3	275.6	227.1	179.7	275.6	233.7	177.5	275.6	240.3	-
42.7	244.7	197.3	160.9	264.6	207.2	167.6	275.6	217.2	173.1	275.6	224.9	177.5	275.6	231.5	179.7
45.9	229.3	186.3	154.3	249.1	197.3	160.9	264.6	206.1	166.4	275.6	215.0	170.9	275.6	220.5	174.2
52.5	205.0	168.7	141.1	220.5	179.7	147.7	238.1	189.6	154.3	251.3	197.3	158.7	264.6	205.0	163.1
59.1	184.1	154.3	130.1	200.6	164.2	137.8	216.1	174.2	143.3	229.3	183.0	148.8	242.5	190.7	154.3
65.6	167.6	141.1	121.3	183.0	152.1	129.0	197.3	162.0	134.5	210.5	169.8	140.0	222.7	177.5	145.5
72.2	153.2	131.2	113.5	168.7	141.1	120.2	181.9	151.0	126.8	195.1	159.8	132.3	207.2	167.6	137.8
78.7	141.1	122.4	106.9	155.4	132.3	113.5	168.7	141.1	120.2	181.9	149.9	125.7	192.9	157.6	131.2
85.3	131.2	114.6	101.0	144.4	124.6	108.0	157.6	133.4	113.5	169.8	141.1	120.2	173.1	148.8	124.6
91.9	122.4	108.5	95.9	135.6	116.8	102.7	147.7	125.7	108.9	157.6	134.5	114.6	155.4	141.1	119.0
98.4	115.7	102.5	91.3	127.9	111.3	97.9	138.9	119.0	104.1	142.2	126.8	109.6	140.0	134.5	114.6
111.5	103.4	93.0	84.0	113.5	101.2	89.9	122.4	109.1	95.7	119.0	115.7	101.0	116.8	116.8	105.8
124.7	93.9	85.8	78.5	103.8	93.0	83.8	104.3	100.3	89.1	101.0	101.6	93.9	98.5	99.2	98.5
128.0	92.2	84.4	-	101.2	91.4	82.6	100.7	97.8	87.7	97.4	98.1	92.4	94.9	95.6	95.2
131.2	-	83.1	-	98.5	89.8	81.4	97.1	95.3	86.3	93.8	94.5	90.8	91.3	91.9	91.9
137.8	-	-	-	93.3	86.6	78.9	89.9	90.4	83.6	86.6	87.3	87.7	84.0	84.7	85.3
141.1	-	-	-	90.3	85.5	78.0	87.1	87.5	82.5	83.8	84.4	84.8	81.1	81.7	82.3
147.6	-	-	-	84.4	83.1	-	81.4	81.8	80.2	78.0	78.5	79.0	75.4	75.9	76.4
150.9	-	-	-	-	-	-	78.5	78.9	79.1	75.2	75.6	76.1	72.5	73.0	73.4
157.5	-	-	-	-	-	-	73.9	74.2	74.1	70.4	70.9	71.2	67.8	68.2	68.6
164.0	-	-	-	-	-	-	69.2	69.4	-	65.7	66.1	66.4	63.1	63.5	63.7
173.9	-	-	-	-	-	-	-	-	-	59.7	60.0	60.2	56.8	57.2	57.6
177.2	-	-	-	-	-	-	-	-	-	57.8	58.0	-	54.7	55.1	55.6
180.4	-	-	-	-	-	-	-	-	-	56.0	56.2	-	52.9	53.4	53.7
190.3	-	-	-	-	-	-	-	-	-	-	-	-	47.6	48.1	48.3
196.9	-	-	-	-	-	-	-	-	-	-	-	-	44.5	44.8	-
200.1	-	-	-	-	-	-	-	-	-	-	-	-	-	43.2	-
203.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SH+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	10°	15°	20°	10°	15°	20°	10°	15°	20°	10°	15°	20°	10°	15°	20°
ft	1,000 lb														
36.1	275.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.4	275.6	238.1	-	275.6	-	-	275.6	-	-	-	-	-	-	-	-
42.7	275.6	235.9	177.5	275.6	233.7	-	275.6	238.1	-	275.6	-	-	275.6	-	-
45.9	275.6	227.1	177.5	275.6	233.7	174.2	275.6	238.1	176.4	275.6	233.7	-	275.6	229.3	-
49.2	275.6	219.4	172.0	275.6	224.9	174.2	275.6	229.3	176.4	275.6	233.7	174.2	271.2	229.3	172.0
52.5	275.6	211.6	167.6	275.6	217.2	169.8	275.6	222.7	173.1	264.6	227.1	174.2	253.5	229.3	172.0
59.1	253.5	197.3	157.6	253.5	203.9	162.0	242.5	209.4	164.2	233.7	213.8	166.4	224.9	218.3	168.7
65.6	233.7	185.2	149.9	227.1	190.7	153.2	217.2	197.3	156.5	209.4	201.7	159.8	200.6	202.8	162.0
72.2	211.6	174.2	142.2	203.9	180.8	145.5	195.1	186.3	149.9	187.4	189.6	153.2	179.7	181.9	155.4
78.7	191.8	164.2	135.6	184.1	170.9	138.9	176.4	176.4	143.3	169.8	172.0	146.6	162.0	164.2	149.9
85.3	169.8	155.4	129.0	167.6	162.0	133.4	159.8	162.0	136.7	154.3	155.4	141.1	146.6	148.8	143.3
91.9	152.1	147.7	123.5	149.9	152.1	127.9	146.6	147.7	131.2	140.0	142.2	135.6	133.4	135.6	137.8
98.4	137.8	138.9	119.0	135.6	136.7	122.4	132.3	133.4	126.8	127.9	130.1	130.1	121.3	123.5	125.7
111.5	113.5	114.6	110.2	111.3	112.4	113.5	108.5	109.6	110.2	106.0	107.4	108.5	102.5	104.1	105.6
124.7	95.2	96.1	97.0	93.0	93.9	94.8	89.9	91.1	91.9	87.5	88.6	89.7	84.4	85.8	86.9
137.8	80.9	81.6	82.2	78.5	79.4	80.0	75.4	76.3	77.2	72.5	73.6	74.7	68.8	70.1	71.2
150.9	69.2	69.9	70.5	66.6	67.5	68.1	62.8	63.9	64.6	60.0	61.1	61.9	56.2	57.3	58.4
164.0	59.3	60.0	60.4	56.4	57.1	57.8	52.7	53.4	54.2	49.6	50.5	51.4	45.9	47.0	47.8
177.2	50.9	51.4	51.8	47.8	48.5	48.9	44.1	44.8	45.4	41.0	41.9	42.5	37.3	38.1	39.0
190.3	43.7	44.1	44.5	40.8	41.2	41.7	36.8	37.5	37.9	33.7	34.4	35.1	30.0	30.6	31.5
203.4	37.5	37.9	38.1	34.6	35.1	35.3	30.6	31.1	31.5	27.6	28.2	28.7	23.6	24.3	24.9
206.7	36.2	36.6	36.8	33.3	33.7	33.9	29.3	29.7	30.1	26.2	26.8	27.3	22.3	22.9	23.5
213.3	33.5	34.0	-	30.6	30.9	31.1	26.5	27.0	27.4	23.4	24.1	24.5	19.6	20.2	20.7
216.5	-	32.6	-	29.3	29.5	29.8	25.1	25.6	26.0	22.0	22.7	23.1	18.3	18.7	19.4
223.1	-	-	-	27.0	27.2	27.3	22.8	23.3	23.6	19.8	20.2	20.7	15.9	16.4	17.0
229.7	-	-	-	24.7	24.9	-	20.5	20.9	21.2	17.4	17.9	18.3	13.4	14.1	14.6
232.9	-	-	-	23.6	23.8	-	19.5	19.8	20.1	16.4	16.8	17.3	12.5	13.1	13.4
239.5	-	-	-	-	-	-	17.5	17.8	18.1	14.4	14.7	15.2	10.5	11.0	11.2
242.8	-	-	-	-	-	-	16.5	16.8	-	13.4	13.7	14.1	9.5	9.9	10.1
246.1	-	-	-	-	-	-	15.7	15.9	-	12.5	12.8	13.0	8.4	8.9	9.3
249.3	-	-	-	-	-	-	14.8	15.0	-	11.6	11.9	12.1	-	7.9	8.4
255.9	-	-	-	-	-	-	-	-	-	9.7	10.1	10.4	-	-	-
262.5	-	-	-	-	-	-	-	-	-	8.2	8.4	-	-	-	-

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TEREX

SH/LH+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	216.5 ft			236.2 ft			255.9 ft					
	SH/LH+LF2			SH/LH+LF2			SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.
	10°	15°	20°	10°	15°	20°	10°		15°		20°	
ft	1,000 lb											
39.4	275.6	-	-	275.6	-	-	-	-	-	-	-	-
42.7	275.6	244.7	-	275.6	235.9	-	255.7	275.6	-	-	-	-
45.9	275.6	235.9	183.0	275.6	235.9	175.3	255.7	275.6	222.7	257.9	-	-
49.2	275.6	227.1	177.5	275.6	227.1	175.3	251.3	275.6	222.7	253.5	172.0	195.1
52.5	275.6	219.4	172.0	275.6	220.5	170.9	246.9	275.6	219.4	249.1	172.0	195.1
59.1	255.7	206.1	163.1	246.9	208.3	163.1	240.3	273.4	209.4	235.9	164.2	186.3
65.6	229.3	192.9	154.3	220.5	197.3	156.5	215.0	246.9	200.6	215.0	157.6	177.5
72.2	207.2	181.9	147.7	200.6	187.4	148.8	194.0	213.8	190.7	192.9	151.0	169.8
78.7	187.4	173.1	141.1	180.8	178.6	144.4	175.3	187.4	177.5	175.3	145.5	163.1
85.3	170.9	164.2	134.5	165.3	166.4	138.9	159.8	165.3	162.0	158.7	141.1	156.5
91.9	152.1	154.3	129.0	151.0	152.1	133.4	146.6	147.7	147.7	145.5	136.7	146.6
98.4	137.8	138.9	123.5	135.6	136.7	127.9	134.5	132.3	135.6	133.4	131.2	134.5
111.5	113.5	114.6	114.6	111.3	112.4	113.5	110.2	108.7	111.3	109.8	112.4	110.2
124.7	95.2	96.1	97.0	93.7	94.6	95.5	92.2	89.9	93.3	91.1	94.1	92.2
137.8	80.7	81.6	82.2	79.1	79.8	80.7	77.6	75.4	78.5	76.3	79.4	77.2
150.9	69.0	69.7	70.3	67.2	68.1	68.8	65.5	62.8	66.4	63.7	67.2	64.6
164.0	59.1	59.7	60.4	57.1	57.8	58.4	55.3	52.5	56.0	53.4	56.7	54.0
177.2	50.5	51.1	51.6	48.5	48.9	49.6	46.7	43.9	47.4	44.5	47.8	45.2
190.3	43.2	43.9	44.3	41.2	41.7	42.1	39.5	36.6	39.9	37.3	40.6	37.7
203.4	37.3	37.5	37.9	35.1	35.5	35.9	33.1	30.2	33.7	30.9	34.2	31.3
216.5	31.7	32.2	32.4	29.5	30.0	30.4	27.8	24.9	28.2	25.4	28.7	25.8
223.1	29.5	29.9	30.0	27.2	27.7	28.0	25.5	22.5	25.8	22.9	26.2	23.4
229.7	27.3	27.6	-	24.9	25.4	25.6	23.1	20.1	23.4	20.5	23.8	20.9
232.9	26.2	26.5	-	23.9	24.3	24.5	22.1	19.1	22.4	19.5	22.8	19.8
239.5	-	-	-	21.9	22.2	22.5	20.1	17.1	20.4	17.4	20.7	17.8
242.8	-	-	-	20.9	21.2	-	19.0	16.1	19.4	16.3	19.6	16.8
249.3	-	-	-	19.2	19.4	-	17.2	14.2	17.5	14.6	17.7	14.9
252.6	-	-	-	-	18.5	-	16.3	13.2	16.6	13.7	16.8	13.9
255.9	-	-	-	-	-	-	15.4	12.3	15.7	12.8	15.9	13.0
265.7	-	-	-	-	-	-	13.0	10.1	13.3	10.3	-	-
269.0	-	-	-	-	-	-	-	-	12.6	9.5	-	-

Remarks

For SH/LH+LF2 SGLmax. a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SH/LH+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	275.6 ft						295.3 ft					
	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
45.9	235.9	275.6	-	-	-	-	200.6	275.6	-	-	-	-
49.2	235.9	275.6	211.6	246.9	184.1	-	200.6	275.6	184.1	244.7	-	-
52.5	233.7	275.6	211.6	246.9	179.7	189.6	200.6	275.6	184.1	244.7	169.8	188.5
59.1	227.1	275.6	207.2	231.5	172.0	186.3	195.1	262.4	180.8	220.5	168.7	188.5
65.6	207.2	244.7	202.8	207.2	164.2	178.6	189.6	235.9	176.4	198.4	164.2	180.8
72.2	187.4	211.6	189.6	186.3	157.6	170.9	180.8	209.4	172.0	178.6	159.8	174.2
78.7	169.8	185.2	172.0	168.7	151.0	164.2	164.2	181.9	165.3	160.9	153.2	163.1
85.3	154.3	163.1	156.5	153.2	144.4	154.3	148.8	160.9	151.0	145.5	147.7	147.7
91.9	141.1	145.5	143.3	138.9	140.0	141.1	136.7	142.2	137.8	133.4	140.0	134.5
98.4	130.1	130.1	131.2	127.9	132.3	129.0	124.6	126.8	126.8	121.3	127.9	123.5
111.5	108.7	106.0	110.0	107.4	110.2	108.7	106.3	103.2	107.6	102.3	108.9	103.8
124.7	90.2	87.3	91.3	88.6	92.4	89.7	88.4	84.2	89.5	85.8	90.6	86.9
137.8	75.6	72.3	76.5	73.4	77.4	74.5	73.6	68.6	74.7	69.9	75.8	71.2
150.9	63.1	59.5	64.2	60.6	65.0	61.7	61.1	56.0	61.9	57.1	63.1	58.2
164.0	52.9	49.2	53.6	50.3	54.5	50.9	50.7	45.6	51.6	46.5	52.5	47.6
177.2	44.3	40.6	45.0	41.4	45.6	42.1	42.1	36.8	42.8	37.7	43.7	38.6
190.3	36.8	33.3	37.5	34.0	38.1	34.6	34.6	29.5	35.5	30.2	36.2	31.1
203.4	30.6	26.9	31.3	27.6	31.7	28.2	28.4	23.1	29.1	23.8	29.5	24.5
216.5	25.1	21.6	25.8	22.0	26.2	22.5	22.9	17.6	23.6	18.3	24.0	19.0
229.7	20.5	16.8	20.9	17.2	21.4	17.6	18.3	13.0	18.7	13.4	19.2	13.9
242.8	16.3	12.6	16.8	13.0	17.2	13.4	14.1	8.8	14.6	9.3	15.0	9.7
246.1	15.4	11.7	15.8	12.1	16.3	12.5	13.0	7.7	13.4	8.2	14.0	8.6
255.9	12.8	9.0	13.0	9.3	13.4	9.7	10.4	-	10.8	-	11.2	-
259.2	12.0	8.2	12.2	8.4	12.6	8.8	9.6	-	10.0	-	10.4	-
262.5	11.1	-	11.5	-	11.8	7.9	8.7	-	9.2	-	9.5	-
269.0	9.5	-	9.9	-	10.1	-	-	-	-	-	7.7	-
275.6	8.2	-	8.4	-	-	-	-	-	-	-	-	-

	315.0 ft						334.6 ft					
	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.	SH/LH+ LF2	SH/LH+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
49.2	190.7	242.5	-	-	-	-	159.8	227.1	-	-	-	-
52.5	190.7	242.5	176.4	227.1	-	-	159.8	227.1	147.7	216.1	-	-
55.8	188.5	240.3	176.4	220.5	162.0	183.0	159.8	227.1	147.7	210.5	136.7	184.1
59.1	186.3	238.1	174.2	213.8	162.0	183.0	157.6	227.1	147.7	205.0	136.7	184.1
65.6	181.9	229.3	169.8	191.8	158.7	179.7	153.2	219.4	144.4	183.0	135.6	180.8
72.2	174.2	206.1	166.4	172.0	155.4	173.1	148.8	198.4	140.0	164.2	132.3	166.4
78.7	157.6	180.8	159.8	155.4	153.2	157.6	145.5	177.5	136.7	147.7	129.0	151.0
85.3	143.3	158.7	145.5	141.1	147.7	142.2	138.9	156.5	133.4	134.5	126.8	136.7
91.9	131.2	141.1	133.4	127.9	134.5	130.1	126.8	137.8	129.0	121.3	123.5	123.5
98.4	120.2	125.7	122.4	116.8	123.5	117.9	115.7	122.4	117.9	110.2	119.0	112.4
111.5	102.1	101.2	103.4	98.1	104.7	99.6	98.1	98.3	99.6	92.6	101.0	94.1
124.7	86.6	82.0	87.7	82.7	88.8	84.0	83.3	78.7	84.7	77.4	85.8	78.7
137.8	71.4	66.4	72.5	67.7	73.6	69.0	69.4	62.8	70.8	64.4	71.9	65.7
150.9	58.9	53.8	59.7	54.9	60.8	56.0	56.9	50.0	58.0	51.4	59.1	52.7
164.0	48.5	43.2	49.4	44.3	50.3	45.4	46.5	39.7	47.4	40.8	48.3	41.9
177.2	39.7	34.6	40.6	35.5	41.4	36.4	37.7	30.9	38.6	32.0	39.5	32.8
190.3	32.4	27.1	33.1	28.0	33.7	28.7	30.4	23.4	31.1	24.5	32.0	25.1
203.4	26.0	20.7	26.7	21.6	27.3	22.3	24.0	17.0	24.7	17.9	25.4	18.7
216.5	20.5	15.2	21.2	15.9	21.8	16.5	18.5	11.5	19.2	12.3	19.8	13.0
226.4	17.0	11.8	17.5	12.2	18.2	12.9	-	7.9	-	8.6	-	9.2
229.7	15.9	10.6	16.3	11.0	17.0	11.7	-	-	-	-	-	7.9
242.8	11.7	-	12.1	-	12.6	-	-	-	-	-	-	-
255.9	7.9	-	8.4	-	8.8	-	-	-	-	-	-	-

Remarks: For SH/LH+LF2 SGLmax. a boom power-kit is required

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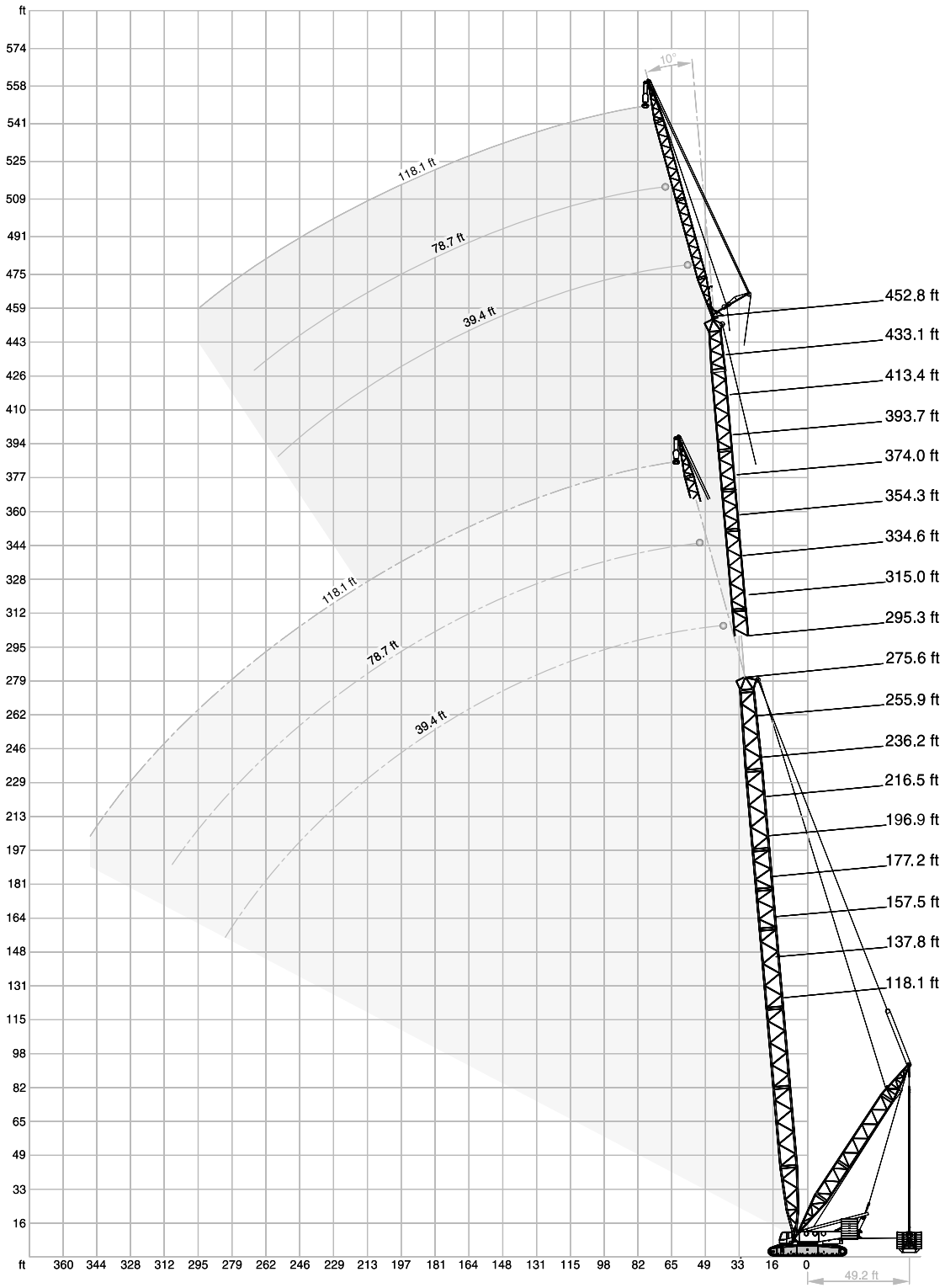
TEREX®

SSL+LF2, SSL/LSL+LF2 WORKING RANGES 10°



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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	137.8 ft			157.5 ft			177.2 ft					
	SSL			SSL			SSL	HSSL	SSL	HSSL	SSL	HSSL
	10°	15°	20°	10°	15°	20°	10°		15°		20°	
ft						1,000 lb						
32.8	275.6	-	-	275.6	-	-	-	-	-	-	-	-
36.1	275.6	240.3	-	275.6	246.9	-	275.6	275.6	-	-	-	-
39.4	275.6	227.1	179.7	275.6	233.7	184.1	275.6	275.6	240.3	240.3	-	-
42.7	275.6	216.1	173.1	275.6	224.9	177.5	275.6	275.6	231.5	230.4	180.8	180.8
45.9	264.6	206.1	166.4	275.6	215.0	170.9	275.6	275.6	220.5	220.5	174.2	174.2
52.5	238.1	188.5	154.3	251.3	197.3	158.7	264.6	266.8	205.0	205.0	163.1	163.1
59.1	216.1	174.2	143.3	229.3	183.0	148.8	242.5	242.5	190.7	190.7	154.3	154.3
65.6	197.3	162.0	134.5	210.5	169.8	140.0	222.7	224.9	177.5	177.5	145.5	145.5
72.2	181.9	151.0	126.8	195.1	159.8	132.3	207.2	208.3	167.6	167.6	137.8	137.8
78.7	168.7	141.1	120.2	181.9	149.9	125.7	192.9	194.0	157.6	157.6	131.2	131.2
85.3	157.6	133.4	113.5	169.8	141.1	119.0	180.8	180.8	148.8	148.8	124.6	124.6
91.9	147.7	125.7	108.9	158.7	133.4	113.5	169.8	170.9	141.1	141.1	119.0	119.0
98.4	138.9	119.0	104.1	149.9	126.8	109.6	159.8	160.9	134.5	134.5	114.6	114.6
111.5	124.6	109.1	95.7	134.5	115.7	101.0	144.4	145.5	122.4	123.5	105.8	106.3
124.7	112.4	100.3	89.1	122.4	106.9	93.9	131.2	131.9	112.4	113.8	98.5	98.9
137.8	104.1	93.0	83.6	112.4	99.2	88.2	120.2	120.2	105.4	105.4	92.6	92.6
150.9	96.3	87.3	79.4	104.1	93.0	83.3	111.3	112.1	98.5	98.8	87.3	87.6
157.5	93.4	85.1	77.6	100.6	90.4	81.5	107.7	108.0	95.7	95.5	85.2	85.1
164.0	90.4	82.9	-	97.2	87.7	79.6	104.1	104.6	92.8	93.0	83.1	83.3
177.2	-	-	-	91.5	83.6	-	97.9	97.9	88.2	88.2	79.6	79.6
180.4	-	-	-	90.4	82.7	-	96.6	96.6	87.2	87.3	78.9	78.9
190.3	-	-	-	-	-	-	92.6	92.9	84.2	84.5	76.9	76.9
196.9	-	-	-	-	-	-	90.2	90.4	82.7	82.7	-	-

	196.9 ft						216.5 ft					
	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL
	10°		15°		20°		10°		15°		20°	
ft						1,000 lb						
36.1	275.6	275.6	-	-	-	-	-	-	-	-	-	-
39.4	275.6	275.6	246.9	246.9	-	-	275.6	275.6	-	-	-	-
42.7	275.6	275.6	235.9	237.0	184.1	184.1	275.6	275.6	242.5	242.5	-	-
45.9	275.6	275.6	227.1	227.1	177.5	177.5	275.6	275.6	233.7	233.7	180.8	180.8
52.5	275.6	275.6	211.6	211.6	167.6	167.6	275.6	275.6	217.2	217.2	170.9	170.9
59.1	253.5	255.7	197.3	197.3	157.6	157.6	264.6	266.8	202.8	202.8	162.0	162.0
65.6	233.7	235.9	185.2	185.2	149.9	149.9	244.7	246.9	190.7	190.7	153.2	153.2
72.2	218.3	219.4	174.2	174.2	142.2	142.2	229.3	229.3	180.8	180.8	145.5	145.5
78.7	203.9	205.0	164.2	164.2	135.6	135.6	213.8	215.0	170.9	170.9	138.9	138.9
85.3	190.7	191.8	155.4	155.4	129.0	129.0	201.7	201.7	162.0	162.0	133.4	133.4
91.9	179.7	180.8	147.7	147.7	123.5	123.5	189.6	190.7	154.3	154.3	127.9	127.9
98.4	169.8	170.9	141.1	141.1	119.0	119.0	179.7	179.7	147.7	147.7	122.4	122.4
111.5	153.2	154.7	129.0	129.3	110.2	110.7	162.0	163.5	134.5	136.0	113.5	114.3
124.7	140.0	140.7	119.0	119.0	103.0	103.2	147.7	149.2	124.6	125.3	106.9	107.0
137.8	127.9	129.0	110.2	110.2	96.6	96.6	135.6	136.7	115.7	115.7	100.5	100.5
150.9	119.0	119.4	103.8	103.9	91.3	91.4	125.7	126.4	109.1	109.1	95.0	95.2
164.0	110.2	111.2	97.9	98.0	86.6	86.9	116.8	117.6	102.7	103.0	90.2	90.5
177.2	104.1	104.3	92.6	92.6	82.9	82.9	110.2	110.2	97.2	97.2	86.2	86.2
190.3	98.3	98.7	88.4	88.5	79.6	79.8	104.1	104.4	92.6	92.7	82.7	82.8
203.4	93.3	93.7	84.7	84.9	77.2	77.1	98.5	99.0	88.4	88.6	79.6	79.8
206.7	92.2	92.6	83.9	84.1	76.5	76.5	97.4	97.8	87.6	87.7	79.0	79.1
213.3	90.2	90.4	82.5	82.6	-	-	95.1	95.3	85.9	86.0	77.8	77.8
216.5	-	-	81.8	81.8	-	-	93.9	94.1	85.1	85.1	77.2	77.2
223.1	-	-	-	-	-	-	91.9	92.2	83.7	83.8	76.3	76.3
229.7	-	-	-	-	-	-	89.9	90.3	82.2	82.5	-	-
232.9	-	-	-	-	-	-	89.1	89.3	81.8	81.8	-	-
236.2	-	-	-	-	-	-	-	-	-	-	-	-

Remarks: see page 28

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BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
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TEREX

SSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	236.2 ft						255.9 ft					
	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL	SSL	HSSL
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
39.4	275.6	275.6	-	-	-	-	-	-	-	-	-	-
42.7	275.6	275.6	246.9	246.9	-	-	275.6	275.6	-	-	-	-
45.9	275.6	275.6	238.1	238.1	183.0	183.0	275.6	275.6	242.5	242.5	-	-
49.2	275.6	275.6	229.3	230.4	178.6	178.0	275.6	275.6	233.7	234.8	180.8	180.8
52.5	275.6	275.6	222.7	222.7	173.1	173.1	275.6	275.6	227.1	227.1	176.4	176.4
59.1	275.6	273.4	209.4	209.4	164.2	164.2	275.6	273.4	213.8	213.8	167.6	167.6
65.6	255.7	255.7	197.3	197.3	156.5	156.5	264.6	266.8	201.7	201.7	159.8	159.8
72.2	238.1	240.3	186.3	186.3	149.9	149.9	246.9	249.1	191.8	191.8	153.2	153.2
78.7	222.7	224.9	176.4	176.4	143.3	143.3	231.5	233.7	181.9	181.9	146.6	146.6
85.3	210.5	211.6	167.6	167.6	136.7	136.7	219.4	220.5	173.1	173.1	140.0	140.0
91.9	198.4	199.5	159.8	159.8	131.2	131.2	207.2	208.3	165.3	165.3	135.6	135.6
98.4	188.5	188.5	153.2	153.2	126.8	126.8	197.3	197.3	158.7	158.7	130.1	130.1
111.5	170.9	171.6	140.0	141.5	117.9	117.9	178.6	179.7	145.5	146.2	121.3	121.3
124.7	155.4	156.5	130.1	130.8	110.2	110.4	163.1	164.2	135.6	135.2	113.5	113.8
137.8	143.3	143.3	121.3	121.3	104.1	104.1	149.9	151.0	125.7	125.7	107.6	107.6
150.9	132.3	133.0	113.5	113.9	98.5	98.6	138.9	140.0	117.9	118.3	101.9	102.0
164.0	123.5	123.8	107.4	107.4	93.5	93.7	130.1	130.4	111.3	111.7	96.8	96.9
177.2	115.7	115.7	101.6	101.6	89.3	89.3	122.4	122.4	105.8	105.8	92.4	92.4
190.3	109.8	109.9	96.6	96.8	85.5	85.6	114.6	115.7	100.8	100.8	88.4	88.6
203.4	103.8	104.3	92.4	92.4	82.2	82.4	109.1	109.6	96.1	96.3	85.1	85.1
216.5	98.8	99.0	88.6	88.6	79.6	79.6	103.8	104.1	92.2	92.2	82.0	82.0
229.7	94.6	94.7	85.3	85.5	77.4	77.4	99.0	99.4	88.6	88.8	79.6	79.7
239.5	91.8	91.8	83.3	83.4	76.1	76.1	96.0	96.1	86.3	86.4	77.9	78.0
242.8	90.8	90.9	82.7	82.8	-	-	95.0	95.2	85.5	85.8	77.4	77.5
249.3	89.1	89.3	81.6	81.6	-	-	93.1	93.3	84.3	84.4	76.5	76.6
255.9	-	-	-	-	-	-	91.3	91.5	83.1	83.1	75.6	75.6
265.7	-	-	-	-	-	-	89.1	89.1	81.4	81.4	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
Please contact Bigge Crane and Rigging Co. at 888-337-BIGGE or email info@bigge.com for further information. BIGGE

TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	275.6 ft						295.3 ft			315.0 ft		
	SSL	HSSL	SSL	HSSL	SSL	HSSL	HSSL			HSSL		
	10°		15°		20°		10°	15°	20°	10°	15°	20°
ft	1,000 lb											
42.7	275.6	275.6	-	-	-	-	-	-	-	-	-	-
45.9	275.6	275.6	246.9	246.9	-	-	275.6	-	-	275.6	-	-
49.2	275.6	275.6	238.1	239.2	183.0	183.0	275.6	242.5	-	275.6	244.7	-
52.5	275.6	275.6	231.5	231.5	178.6	178.6	275.6	235.9	180.8	275.6	238.1	181.9
59.1	275.6	275.6	218.3	218.3	169.8	169.8	275.6	222.7	172.0	275.6	227.1	174.2
65.6	273.4	271.2	207.2	207.2	163.1	163.1	273.4	211.6	165.3	275.6	215.0	167.6
72.2	255.7	257.9	196.2	196.2	155.4	155.4	266.8	200.6	158.7	273.4	205.0	160.9
78.7	240.3	242.5	187.4	187.4	149.9	149.9	251.3	191.8	152.1	257.9	196.2	154.3
85.3	227.1	229.3	178.6	178.6	143.3	143.3	235.9	183.0	146.6	244.7	187.4	148.8
91.9	216.1	217.2	170.9	170.9	137.8	137.8	224.9	175.3	141.1	231.5	179.7	144.4
98.4	205.0	206.1	163.1	163.1	133.4	133.4	213.8	167.6	136.7	220.5	172.0	138.9
111.5	186.3	187.8	151.0	151.4	124.6	124.6	194.7	155.8	127.9	202.1	160.2	130.8
124.7	170.9	171.6	140.0	140.7	116.8	116.8	178.2	145.1	120.2	185.6	149.2	123.1
137.8	157.6	157.6	131.2	131.2	110.2	110.2	164.2	135.6	113.5	170.9	138.9	115.7
150.9	145.5	146.6	122.4	123.1	104.9	104.9	153.2	127.5	108.0	159.1	131.5	110.6
164.0	136.7	136.7	115.7	116.0	99.9	99.9	142.9	120.2	102.8	148.4	124.2	105.6
177.2	127.9	127.9	110.0	110.0	95.2	95.2	133.4	113.5	98.1	138.9	116.8	100.8
190.3	120.2	120.5	104.5	104.7	91.3	91.3	126.0	108.4	94.0	131.5	111.8	96.6
203.4	113.5	114.2	99.9	99.9	87.7	87.7	119.4	103.5	90.2	124.6	107.0	92.8
216.5	108.7	108.9	95.7	95.7	84.4	84.4	113.5	99.0	86.9	117.9	102.3	89.3
229.7	103.6	104.1	91.9	92.0	81.8	81.8	108.5	95.2	84.1	112.8	98.3	86.3
242.8	99.2	99.6	88.6	88.7	79.4	79.4	103.8	91.6	81.6	108.0	94.6	83.6
255.9	95.2	95.5	85.8	85.8	77.4	77.4	99.4	88.4	79.4	103.6	91.3	81.1
269.0	91.9	91.2	83.3	83.3	75.8	75.8	92.8	85.9	77.5	96.0	86.9	79.2
272.3	90.8	89.6	82.8	82.8	75.4	75.4	91.2	85.3	77.0	94.1	85.8	78.7
282.2	87.5	84.4	81.4	81.4	-	-	85.8	82.0	75.8	87.7	81.4	75.8
285.4	-	-	80.9	80.9	-	-	83.9	80.7	75.5	85.5	79.7	74.6
288.7	-	-	-	-	-	-	82.0	79.4	75.2	83.3	78.0	73.4
295.3	-	-	-	-	-	-	78.3	76.7	-	78.9	74.7	71.0
298.6	-	-	-	-	-	-	76.3	75.5	-	76.7	73.1	69.8
301.8	-	-	-	-	-	-	-	74.3	-	74.5	71.4	68.6
308.4	-	-	-	-	-	-	-	-	-	70.1	68.0	-
318.2	-	-	-	-	-	-	-	-	-	63.5	63.1	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

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TEREX

SSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	334.6 ft			354.3 ft		
	HSSL			HSSL		
	10°	15°	20°	10°	15°	20°
ft	1,000 lb					
49.2	275.6	-	-	271.2	-	-
52.5	275.6	242.5	-	271.2	244.7	-
55.8	275.6	235.9	179.7	271.2	239.2	181.9
59.1	275.6	229.3	176.4	271.2	233.7	178.6
65.6	275.6	219.4	169.8	271.2	222.7	170.9
72.2	275.6	209.4	163.1	271.2	212.7	165.3
78.7	264.6	199.5	157.6	271.2	203.9	158.7
85.3	251.3	191.8	152.1	257.9	195.1	154.3
91.9	238.1	184.1	146.6	244.7	187.4	148.8
98.4	227.1	176.4	142.2	233.7	180.8	144.4
111.5	208.7	163.9	133.4	215.3	168.3	135.6
124.7	192.2	152.9	125.7	198.4	156.9	127.9
137.8	177.5	143.3	119.0	183.0	146.6	121.3
150.9	165.0	135.2	113.2	171.2	138.5	115.4
164.0	154.0	127.9	107.9	160.2	131.2	110.2
177.2	144.4	121.3	103.2	149.9	124.6	105.6
190.3	136.3	115.4	99.1	141.8	118.7	101.3
203.4	129.0	110.2	95.2	134.5	113.5	97.4
216.5	122.4	105.6	91.7	127.9	108.9	93.9
229.7	117.2	101.5	88.6	119.6	104.6	90.7
242.8	112.1	97.7	85.8	112.0	100.7	87.7
255.9	106.9	94.1	83.1	104.5	97.0	85.1
269.0	98.5	90.0	80.9	96.7	93.8	82.7
282.2	90.1	84.4	77.1	88.8	88.3	78.8
295.3	81.6	77.4	71.7	80.9	80.7	73.2
308.4	73.2	70.3	66.4	73.1	73.0	67.2
318.2	66.7	65.0	62.2	67.2	67.3	62.6
321.5	64.6	63.2	-	65.3	65.4	61.1
334.6	56.2	56.0	-	57.3	57.8	54.9
347.8	-	-	-	49.6	50.0	-
351.1	-	-	-	47.6	48.1	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL/LSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	295.3 ft						315.0 ft					
	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
45.9	275.6	275.6	-	-	-	-	-	-	-	-	-	-
49.2	275.6	275.6	244.7	269.0	-	-	275.6	275.6	-	-	-	-
52.5	275.6	275.6	238.1	260.1	181.9	199.5	275.6	275.6	240.3	264.6	-	-
55.8	275.6	275.6	231.5	253.5	177.5	195.1	273.4	275.6	233.7	257.9	179.7	197.3
59.1	275.6	275.6	224.9	246.9	174.2	190.7	271.2	275.6	229.3	251.3	176.4	192.9
65.6	275.6	275.6	213.8	233.7	166.4	183.0	266.8	275.6	217.2	238.1	168.7	185.2
72.2	266.8	275.6	202.8	222.7	159.8	175.3	262.4	275.6	207.2	227.1	162.0	178.6
78.7	251.3	264.6	194.0	212.7	153.2	168.7	257.9	271.2	197.3	217.2	156.5	172.0
85.3	235.9	249.1	185.2	202.8	147.7	163.1	244.7	257.9	189.6	208.3	149.9	165.3
91.9	224.9	235.9	177.5	195.1	142.2	156.5	231.5	244.7	181.9	199.5	145.5	159.8
98.4	213.8	224.9	169.8	186.3	137.8	152.1	220.5	231.5	174.2	191.8	140.0	154.3
111.5	195.5	205.8	157.3	173.1	129.0	142.6	202.1	213.1	161.7	178.6	131.9	145.5
124.7	179.3	188.9	146.2	161.3	121.3	134.1	185.6	196.2	150.6	166.4	124.2	137.1
137.8	165.3	174.2	136.7	151.0	114.6	126.8	170.9	180.8	141.1	155.4	116.8	129.0
150.9	153.6	162.4	128.6	142.2	108.9	120.2	159.8	169.0	133.0	146.6	111.6	123.1
164.0	143.3	151.8	121.3	134.1	103.6	114.3	149.5	158.4	125.7	138.5	106.4	117.2
177.2	134.5	142.2	114.6	126.8	98.8	109.3	140.0	148.8	119.0	131.2	101.4	111.3
190.3	127.1	134.8	109.5	120.9	94.8	104.9	131.9	140.0	113.2	124.6	97.3	107.5
203.4	120.2	127.9	104.6	115.4	91.1	100.9	124.9	132.3	108.0	118.7	93.5	103.7
216.5	113.5	121.3	99.9	110.2	87.7	97.2	119.0	125.7	103.4	113.5	89.9	99.9
229.7	109.0	115.4	96.0	106.3	84.8	94.0	113.2	119.8	99.3	109.7	87.0	96.5
242.8	104.5	110.4	92.5	102.5	82.2	91.1	108.2	114.6	95.5	105.9	84.3	93.5
255.9	100.1	106.3	89.3	99.0	79.8	88.6	104.1	110.2	92.2	102.1	81.8	90.8
269.0	96.3	100.4	86.6	95.9	78.0	86.4	99.9	103.6	89.4	97.4	79.8	88.4
282.2	91.8	92.8	84.3	90.2	76.4	84.8	94.4	95.6	86.3	91.5	77.9	85.1
288.7	89.0	89.1	83.3	87.2	75.6	84.0	90.8	91.6	84.6	88.2	77.1	82.9
295.3	86.2	85.3	82.2	84.2	-	-	87.3	87.5	82.9	84.9	76.3	80.7
301.8	82.7	81.6	81.4	81.1	-	-	83.8	83.6	80.4	81.6	75.7	78.3
305.1	-	-	-	-	-	-	82.0	81.6	79.1	79.9	75.4	77.2
308.4	-	-	-	-	-	-	80.2	79.6	77.9	78.3	-	-
318.2	-	-	-	-	-	-	75.0	73.4	74.3	73.2	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

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Please contact Bigge Crane and Rigging Co. at 888-337-BIGGE or email info@bigge.com for further information. BIGGE

TEREX®

SSL/LSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	334.6 ft						354.3 ft					
	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
49.2	240.3	275.6	-	-	-	-	-	-	-	-	-	-
52.5	240.3	275.6	218.3	269.0	-	-	208.3	273.4	-	-	-	-
55.8	238.1	275.6	218.3	261.2	179.7	199.5	208.3	273.4	191.8	264.6	-	-
59.1	235.9	275.6	216.1	253.5	177.5	195.1	206.1	273.4	191.8	257.9	175.3	197.3
65.6	231.5	275.6	211.6	242.5	170.9	187.4	201.7	271.2	187.4	246.9	173.1	189.6
72.2	227.1	275.6	207.2	231.5	164.2	180.8	197.3	269.0	183.0	235.9	166.4	183.0
78.7	222.7	275.6	201.7	220.5	158.7	174.2	191.8	266.8	178.6	224.9	160.9	176.4
85.3	218.3	264.6	192.9	212.7	153.2	168.7	186.3	264.6	173.1	217.2	155.4	170.9
91.9	212.7	251.3	185.2	203.9	147.7	163.1	180.8	257.9	168.7	208.3	149.9	165.3
98.4	207.2	240.3	178.6	196.2	143.3	157.6	176.4	246.9	164.2	200.6	145.5	159.8
111.5	196.9	220.5	166.1	183.0	134.5	148.1	166.1	227.1	155.4	187.4	136.7	151.0
124.7	187.0	202.8	154.7	170.9	126.8	139.6	157.3	209.4	147.7	175.3	129.0	142.9
137.8	177.5	187.4	144.4	159.8	120.2	132.3	149.9	194.0	141.1	164.2	122.4	135.6
150.9	165.7	174.9	136.3	151.0	114.3	125.7	142.6	181.5	135.2	154.7	116.5	129.0
164.0	155.1	163.9	129.0	142.6	108.9	119.8	135.6	169.8	129.3	146.2	111.2	122.7
177.2	145.5	154.3	122.4	134.5	104.1	114.6	129.0	158.7	123.5	138.9	106.5	116.8
190.3	137.4	145.5	116.5	128.6	99.8	110.4	122.4	149.9	117.6	132.3	102.2	112.4
203.4	130.1	137.8	111.3	123.1	95.9	106.3	116.0	142.2	111.9	126.4	98.3	108.4
216.5	123.5	131.2	106.7	117.9	92.4	102.3	109.8	135.6	106.5	121.3	94.6	104.7
229.7	117.6	125.3	102.4	112.8	89.3	98.9	103.9	129.4	101.2	116.0	91.3	101.4
242.8	112.4	119.4	98.5	109.1	86.4	95.8	98.3	122.7	96.2	111.8	88.4	98.2
255.9	108.0	114.6	95.0	105.2	83.8	93.0	93.0	114.6	91.7	108.5	85.8	95.2
269.0	101.0	107.4	90.6	100.0	81.6	89.9	87.9	106.9	87.0	101.9	83.4	90.8
282.2	93.6	99.6	85.5	93.8	79.1	85.7	82.7	98.8	82.4	94.8	80.3	85.7
295.3	86.0	91.1	79.8	86.4	76.5	80.2	77.6	90.6	77.8	87.3	76.5	79.8
308.4	78.3	82.4	74.1	79.2	72.7	74.9	72.3	82.4	73.3	79.8	72.3	73.9
321.5	70.7	73.7	68.3	72.1	68.8	69.4	67.2	74.1	68.8	72.3	68.0	68.0
334.6	63.1	65.0	62.4	64.8	-	-	61.9	65.9	64.2	64.8	63.7	62.2
337.9	-	-	-	-	-	-	60.7	63.8	63.0	63.0	62.6	60.6
347.8	-	-	-	-	-	-	56.8	57.6	59.6	57.5	-	-
351.1	-	-	-	-	-	-	55.6	55.6	58.5	55.6	-	-
354.3	-	-	-	-	-	-	-	-	57.3	53.8	-	-
360.9	-	-	-	-	-	-	-	-	-	-	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL/LSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	374.0 ft						393.7 ft					
	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
52.5	188.5	253.5	-	-	-	-	-	-	-	-	-	-
55.8	188.5	253.5	175.3	244.7	-	-	166.4	235.9	-	-	-	-
59.1	187.4	253.5	175.3	244.7	162.0	199.5	166.4	235.9	154.3	231.5	-	-
62.3	186.3	253.5	175.3	243.6	162.0	195.7	165.3	235.9	154.3	230.4	143.3	197.3
65.6	185.2	253.5	174.2	242.5	162.0	191.8	164.2	235.9	153.2	229.3	143.3	194.0
72.2	181.9	253.5	170.9	238.1	159.8	185.2	162.0	235.9	151.0	227.1	141.1	187.4
78.7	178.6	253.5	168.7	229.3	157.6	178.6	159.8	235.9	148.8	222.7	140.0	180.8
85.3	175.3	253.5	165.3	220.5	155.4	173.1	156.5	235.9	146.6	220.5	137.8	175.3
91.9	172.0	253.5	162.0	212.7	152.1	167.6	154.3	235.9	144.4	216.1	135.6	169.8
98.4	168.7	249.1	159.8	203.9	147.7	162.0	151.0	235.9	142.2	208.3	133.4	164.2
111.5	162.0	231.5	153.2	190.7	138.9	153.2	145.1	227.1	136.3	195.1	128.2	155.4
124.7	155.4	215.0	147.0	178.6	131.2	145.1	139.3	216.8	130.8	183.0	123.5	147.3
137.8	148.8	199.5	141.1	167.6	124.6	137.8	133.4	205.0	125.7	172.0	119.0	140.0
150.9	142.9	187.0	136.0	158.7	118.7	131.2	129.0	192.5	122.0	162.4	115.4	133.4
164.0	137.4	175.3	131.2	150.3	113.4	125.3	124.6	180.8	117.9	154.0	111.9	127.5
177.2	132.3	164.2	126.8	142.2	108.7	120.2	120.2	169.8	113.5	146.6	108.7	122.4
190.3	126.4	155.4	121.6	136.3	104.4	115.0	115.7	158.0	109.9	140.0	105.2	117.9
203.4	120.5	146.6	116.5	130.4	100.5	110.7	111.3	146.6	106.0	133.2	101.6	113.6
216.5	114.6	137.8	111.3	124.6	96.8	107.1	106.7	135.6	102.1	125.7	98.1	109.3
229.7	109.5	127.2	106.6	119.6	93.5	103.6	102.1	124.6	98.0	119.0	94.4	105.8
242.8	104.1	118.7	101.6	115.0	90.4	100.3	97.5	114.5	93.8	112.9	90.8	102.5
255.9	98.5	111.3	96.3	111.3	87.7	97.2	92.8	105.4	89.5	107.1	87.1	99.4
269.0	93.1	104.0	91.1	104.3	85.2	93.8	87.8	96.3	85.1	100.2	82.8	96.6
282.2	87.6	96.5	85.8	97.0	82.3	88.9	82.9	87.5	80.6	93.3	78.6	92.6
295.3	82.0	88.8	80.5	89.3	78.9	82.5	78.0	79.1	76.1	86.2	74.3	85.8
308.4	76.5	81.2	75.2	81.6	73.9	76.0	73.2	71.5	71.5	79.1	70.0	78.9
321.5	70.9	73.6	69.9	74.1	68.9	69.5	68.3	64.3	66.9	72.2	65.8	72.0
334.6	65.5	65.9	64.6	66.6	63.9	63.1	63.5	57.5	62.4	65.3	61.5	65.0
347.8	59.9	58.3	59.3	58.9	58.9	56.6	58.6	51.4	57.8	58.2	57.2	58.2
354.3	57.1	54.5	56.7	55.1	56.4	53.4	56.2	48.3	55.6	54.7	55.1	54.7
360.9	54.4	50.8	54.0	51.3	-	-	53.8	45.6	53.4	51.2	52.9	51.3
367.5	51.6	46.9	51.4	47.5	-	-	51.4	42.8	51.1	47.8	50.7	47.8
370.7	50.3	45.0	50.0	45.6	-	-	50.2	41.5	49.9	46.0	-	-
374.0	-	-	-	-	-	-	48.9	40.1	48.7	44.3	-	-
387.1	-	-	-	-	-	-	44.1	35.5	44.3	37.3	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

3

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TEREX®

SSL/LSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	413.4 ft						433.1 ft					
	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.
	10°		15°		20°		10°		15°		20°	
ft	1,000 lb											
55.8	145.5	215.0	-	-	-	-	-	-	-	-	-	-
59.1	145.5	215.0	136.7	212.7	-	-	135.6	199.5	-	-	-	-
62.3	145.5	215.0	136.7	212.7	127.9	198.4	135.6	199.5	127.9	197.3	-	-
65.6	144.4	215.0	136.7	212.7	127.9	195.1	134.5	199.5	127.9	197.3	120.2	190.7
72.2	142.2	215.0	134.5	211.6	126.8	188.5	133.4	198.4	126.8	197.3	120.2	190.7
78.7	140.0	215.0	132.3	211.6	124.6	183.0	132.3	198.4	125.7	196.2	119.0	184.1
85.3	137.8	215.0	130.1	210.5	122.4	177.5	130.1	197.3	123.5	196.2	116.8	178.6
91.9	135.6	215.0	127.9	209.4	121.3	172.0	129.0	197.3	122.4	196.2	115.7	174.2
98.4	133.4	215.0	125.7	209.4	119.0	166.4	126.8	196.2	120.2	195.1	114.6	168.7
111.5	128.2	211.3	121.3	197.7	114.6	157.6	123.1	193.3	117.2	192.9	111.7	159.8
124.7	123.1	206.9	116.8	186.3	110.7	149.5	119.4	189.6	113.9	187.4	108.7	151.8
137.8	117.9	201.7	112.4	175.3	107.1	142.2	115.7	185.2	110.2	178.6	105.6	144.4
150.9	113.5	191.4	108.9	165.7	103.6	136.3	112.8	177.8	107.4	169.8	102.7	138.5
164.0	109.6	179.7	105.4	157.3	100.3	130.4	109.7	168.7	104.6	161.3	99.9	132.6
177.2	106.0	166.4	101.9	149.9	97.2	124.6	106.5	157.6	101.6	153.2	97.2	126.8
190.3	102.1	154.7	98.3	143.3	94.0	120.2	103.2	146.6	98.7	145.1	94.6	122.4
203.4	98.1	143.3	94.8	136.7	90.8	115.7	99.9	136.0	95.8	136.2	91.9	117.9
216.5	94.1	132.3	91.3	127.9	87.7	111.3	96.6	125.7	92.8	125.7	89.3	113.5
229.7	90.2	121.3	87.7	119.0	84.6	108.0	93.4	115.4	89.9	116.1	86.6	108.4
242.8	86.3	111.1	84.2	110.5	81.5	104.4	90.1	106.3	86.9	107.0	84.0	102.6
255.9	82.5	101.9	80.7	102.3	78.3	100.5	86.9	97.4	84.0	98.3	81.4	96.1
269.0	78.3	92.9	76.9	94.4	74.7	95.5	83.7	89.1	81.1	89.9	78.6	89.9
282.2	74.3	84.2	73.0	86.6	71.2	89.1	80.5	80.9	78.1	81.8	75.8	83.8
295.3	70.3	75.8	69.2	79.1	67.5	82.7	77.2	73.0	75.2	73.9	73.2	77.8
308.4	66.4	68.3	65.3	72.1	63.8	76.2	73.9	65.6	72.2	66.7	70.5	71.9
321.5	62.3	61.1	61.4	65.2	60.1	69.8	70.6	58.6	69.3	59.7	67.9	66.0
334.6	58.2	54.2	57.5	58.4	56.4	63.3	67.2	52.0	66.4	52.9	65.3	60.0
347.8	54.3	48.2	53.6	52.2	52.8	56.8	64.0	46.0	63.4	46.9	62.6	54.1
360.9	50.3	42.5	49.7	46.2	49.0	50.4	60.7	40.3	60.6	41.1	60.0	48.1
374.0	46.3	37.0	45.9	40.3	45.2	43.9	57.5	34.8	57.8	35.5	57.3	42.1
383.9	43.3	33.6	42.9	36.2	42.5	39.0	54.7	31.1	54.9	31.7	54.9	37.7
387.1	42.3	32.5	41.9	34.8	-	-	53.7	29.8	53.9	30.5	54.1	36.2
400.3	38.3	28.1	38.0	29.5	-	-	48.9	25.2	49.2	25.8	49.6	30.2
403.5	37.3	27.1	37.0	28.2	-	-	47.5	24.2	47.8	24.7	-	-
413.4	-	-	-	-	-	-	43.4	20.9	43.7	21.4	-	-
419.9	-	-	-	-	-	-	41.7	19.2	41.9	19.4	-	-
423.2	-	-	-	-	-	-	-	-	-	-	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SSL/LSL+LF2 LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	452.8 ft					
	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.	SSL/LSL+ LF2	SSL/LSL+LF2 SGLmax.
	10°		15°		20°	
ft	1,000 lb					
59.1	116.8	175.3	-	-	-	-
62.3	116.8	175.3	113.5	174.2	-	-
65.6	116.8	175.3	113.5	174.2	108.5	172.0
72.2	115.7	174.2	113.5	174.2	108.5	172.0
78.7	114.6	173.1	112.4	173.1	107.6	170.9
85.3	113.5	172.0	111.3	172.0	106.7	169.8
91.9	112.4	170.9	110.2	170.9	105.8	169.8
98.4	110.2	169.8	109.6	169.8	104.9	168.7
111.5	108.3	167.6	107.4	167.6	102.9	161.3
124.7	106.0	165.3	105.1	165.3	100.8	154.0
137.8	103.4	163.1	102.7	163.1	98.8	146.6
150.9	99.9	159.5	100.1	160.2	96.6	140.0
164.0	95.4	152.9	96.5	154.0	94.0	134.1
177.2	89.9	143.3	91.9	144.4	91.1	129.0
190.3	84.5	134.1	87.5	134.5	88.1	123.7
203.4	79.0	124.6	83.0	125.7	85.1	118.7
216.5	73.4	115.7	78.5	116.8	82.0	113.5
229.7	68.0	107.7	74.1	108.6	79.1	106.2
242.8	62.5	99.6	69.6	100.5	76.1	99.0
255.9	57.1	91.5	65.0	92.4	73.2	91.7
269.0	51.7	83.8	60.6	84.7	70.3	84.8
275.6	48.9	80.0	58.4	80.9	68.8	81.4
282.2	-	76.4	56.2	77.3	67.3	78.0
295.3	-	69.2	51.6	70.1	64.2	71.2
308.4	-	62.5	47.2	63.3	61.2	64.9
321.5	-	55.9	42.8	56.7	58.3	58.7
334.6	-	49.6	38.1	50.3	55.3	52.7
347.8	-	43.7	33.7	44.4	52.2	46.8
360.9	-	38.1	29.2	38.8	49.2	41.2
374.0	-	32.6	24.7	33.3	46.3	35.7
387.1	-	27.8	20.1	28.3	43.2	30.6
400.3	-	23.1	15.7	23.5	40.3	25.5
413.4	-	18.5	11.2	19.0	37.3	20.5
416.7	-	17.5	10.1	17.9	36.6	19.4
423.2	-	15.4	7.7	15.9	-	-
426.5	-	14.4	-	14.8	-	-
436.4	-	11.5	-	11.8	-	-
439.6	-	-	-	10.8	-	-
442.9	-	-	-	-	-	-

Remarks

SSL+LF2: SL radius 55.8 ft on request. Max. capacities with minimum counterweight.

For HSSL+LF2 a boom power-kit is required.

3

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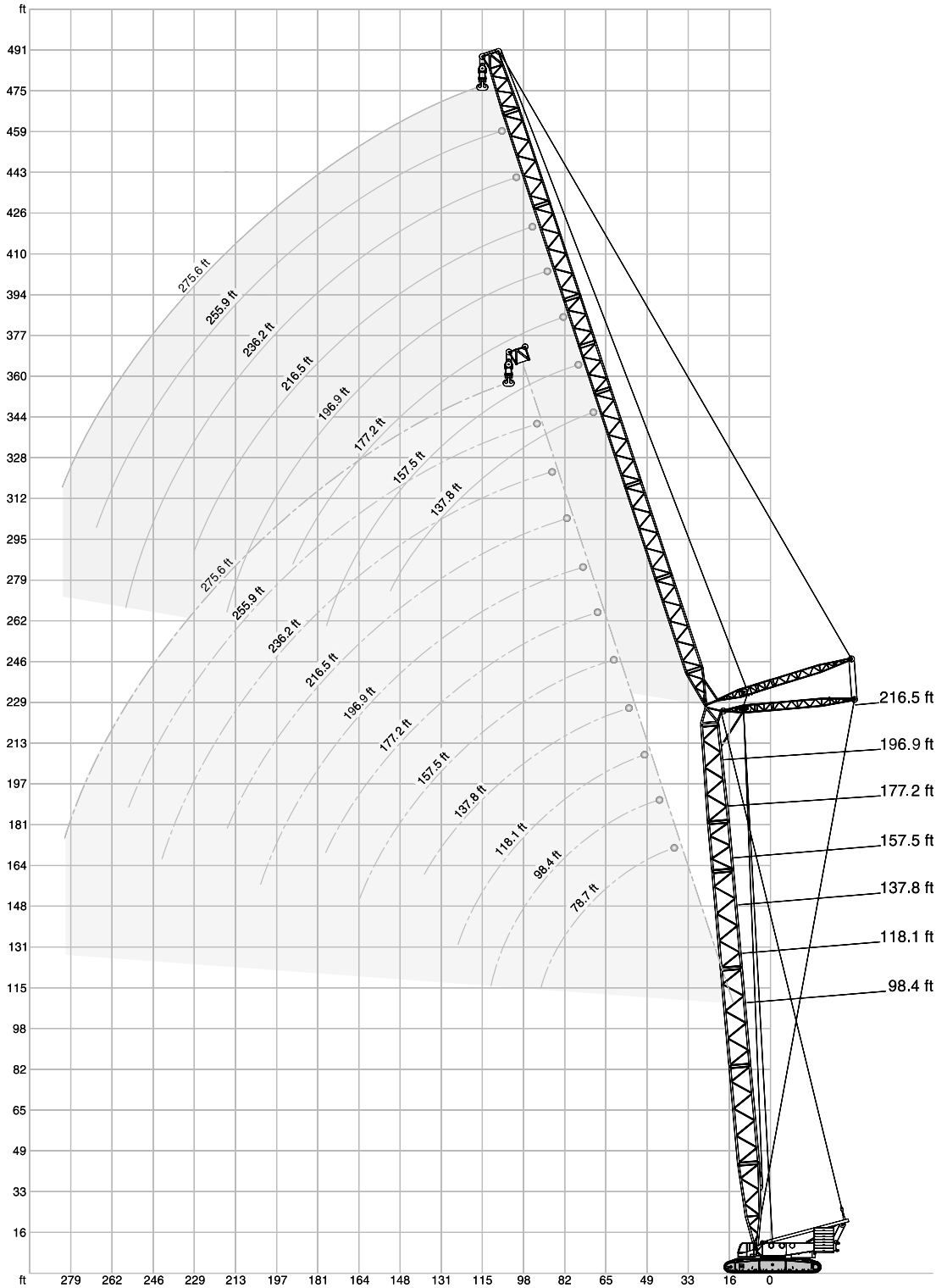
TEREX®

SW WORKING RANGES



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TEREX®

DEMAG CC2800-1
CRAWLER CRANE

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

98.4 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
45.9	458.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52.5	379.2	-	-	377.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.1	319.7	-	-	317.5	-	-	317.5	-	-	-	-	-	-	-	-	-	-	-
65.6	277.8	-	-	275.6	-	-	273.4	-	-	271.2	-	-	-	-	-	-	-	-
72.2	244.7	-	-	242.5	-	-	240.3	-	-	238.1	-	-	235.9	-	-	-	-	-
78.7	217.2	203.9	-	216.1	-	-	213.8	-	-	211.6	-	-	210.5	-	-	207.2	-	-
85.3	196.2	183.0	-	194.0	180.8	-	192.9	-	-	189.6	-	-	188.5	-	-	186.3	-	-
91.9	177.5	166.4	-	176.4	164.2	-	174.2	-	-	172.0	-	-	170.9	-	-	167.6	-	-
98.4	-	152.1	-	160.9	149.9	-	158.7	147.7	-	156.5	-	-	155.4	-	-	153.2	-	-
105.0	-	140.0	130.1	148.8	137.8	-	146.6	135.6	-	144.4	132.3	-	143.3	-	-	141.1	-	-
111.5	-	-	120.2	136.7	126.8	-	134.5	124.6	-	132.3	122.4	-	131.2	120.2	-	129.0	-	-
118.1	-	-	111.3	-	117.9	109.1	125.1	115.7	-	122.9	112.4	-	121.8	111.3	-	119.6	-	-
124.7	-	-	104.1	-	109.8	101.6	115.7	107.6	-	113.5	105.2	-	112.4	103.2	-	110.2	100.5	-
131.2	-	-	-	-	-	94.8	-	100.5	92.2	106.7	97.9	-	105.3	96.1	-	103.0	93.3	-
137.8	-	-	-	-	-	88.8	-	94.1	86.2	99.9	91.5	-	98.1	89.7	-	95.7	86.9	-
144.4	-	-	-	-	-	-	-	88.2	80.7	-	85.8	78.3	92.3	84.0	-	89.8	81.1	-
150.9	-	-	-	-	-	-	-	-	75.8	-	80.7	73.4	86.4	78.7	71.2	84.0	76.1	-
164.0	-	-	-	-	-	-	-	-	67.7	-	71.7	65.0	76.9	69.7	62.8	74.3	67.0	59.7
177.2	-	-	-	-	-	-	-	-	-	-	-	58.0	-	62.2	55.8	66.4	59.5	52.5
183.7	-	-	-	-	-	-	-	-	-	-	-	-	-	59.1	52.5	-	56.2	49.2
190.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49.6	-	53.4	46.3
203.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47.8	41.0
216.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36.6

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
85.3	184.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91.9	166.4	-	-	165.3	-	-	-	-	-	-	-	-	-	-	-
98.4	151.0	-	-	149.9	-	-	147.7	-	-	-	-	-	-	-	-
111.5	126.8	-	-	125.7	-	-	123.5	-	-	122.4	-	-	120.2	-	-
124.7	108.9	-	-	107.4	-	-	104.7	-	-	104.3	-	-	102.3	-	-
131.2	101.5	91.5	-	100.1	-	-	97.4	-	-	97.0	-	-	94.9	-	-
137.8	94.1	85.1	-	92.8	-	-	90.2	-	-	89.7	-	-	87.5	-	-
144.4	88.3	79.4	-	86.9	77.6	-	84.3	-	-	83.8	-	-	81.7	-	-
150.9	82.5	74.3	-	80.9	72.5	-	78.5	69.7	-	77.8	-	-	75.8	-	-
164.0	72.8	65.3	-	71.2	63.5	-	68.8	60.6	-	68.1	59.5	-	66.1	-	-
170.6	68.7	61.3	-	67.2	59.5	-	64.7	56.4	-	64.0	55.6	-	62.1	52.9	-
177.2	64.6	57.8	50.0	63.3	55.8	-	60.6	52.7	-	60.0	51.8	-	58.0	49.2	-
190.3	58.0	51.1	43.9	56.4	49.2	41.7	53.8	45.9	-	53.1	45.0	-	50.7	42.3	-
203.4	52.0	45.4	38.6	50.5	43.4	36.4	47.6	40.1	33.1	47.0	39.2	-	44.5	36.6	-
216.5	-	40.6	34.2	45.4	38.6	32.0	42.3	35.3	28.7	41.4	34.2	27.3	39.0	31.7	-
229.7	-	-	30.2	-	34.2	28.0	37.7	31.1	24.7	36.6	30.0	23.6	34.4	27.3	20.7
242.8	-	-	-	-	30.6	24.7	33.7	27.3	21.2	32.6	26.2	20.1	30.2	23.6	17.2
255.9	-	-	-	-	-	21.8	-	24.0	18.3	29.1	22.9	17.0	26.5	20.3	14.3
262.5	-	-	-	-	-	-	-	22.7	17.0	-	21.4	15.7	24.9	18.7	12.8
275.6	-	-	-	-	-	-	-	-	-	-	18.5	13.0	21.9	15.9	10.4
282.2	-	-	-	-	-	-	-	-	-	-	-	11.9	20.5	14.8	9.3
295.3	-	-	-	-	-	-	-	-	-	-	-	9.9	-	12.3	-
301.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75° and 65°, capacities for intermediate boom positions are calculated by the crane control system IC-1

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TEREX®

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

118.1 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
52.5	374.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.1	317.5	-	-	315.3	-	-	315.3	-	-	-	-	-	-	-	-	-	-	-
65.6	275.6	-	-	273.4	-	-	271.2	-	-	269.0	-	-	-	-	-	-	-	-
72.2	242.5	-	-	240.3	-	-	238.1	-	-	235.9	-	-	233.7	-	-	-	-	-
78.7	216.1	-	-	213.8	-	-	212.7	-	-	210.5	-	-	208.3	-	-	206.1	-	-
85.3	194.0	178.6	-	192.9	-	-	190.7	-	-	188.5	-	-	187.4	-	-	184.1	-	-
91.9	176.4	162.0	-	174.2	159.8	-	173.1	-	-	170.9	-	-	168.7	-	-	166.4	-	-
98.4	-	147.7	-	159.8	145.5	-	157.6	143.3	-	155.4	-	-	154.3	-	-	151.0	-	-
111.5	-	125.7	114.6	134.5	123.5	-	133.4	120.2	-	131.2	117.9	-	130.1	-	-	126.8	-	-
118.1	-	-	106.3	-	113.5	-	124.0	111.3	-	121.8	109.6	-	120.7	107.6	-	117.9	-	-
124.7	-	-	98.8	-	106.3	96.1	114.6	104.1	-	112.4	101.6	-	111.3	99.6	-	109.1	-	-
131.2	-	-	-	-	99.2	89.5	-	97.0	-	105.6	94.6	-	104.3	92.6	-	101.9	89.7	-
137.8	-	-	-	-	-	83.8	-	90.8	80.9	98.8	88.4	-	97.2	86.4	-	94.6	83.6	-
150.9	-	-	-	-	-	73.9	-	80.2	71.2	87.1	77.6	68.6	85.5	75.6	-	82.9	73.0	-
164.0	-	-	-	-	-	-	-	-	63.1	-	69.0	60.4	75.8	67.0	57.8	73.4	64.2	-
170.6	-	-	-	-	-	-	-	-	-	-	65.0	56.7	-	63.1	54.2	69.4	60.4	-
177.2	-	-	-	-	-	-	-	-	-	-	-	53.4	-	59.7	50.9	65.5	56.9	47.4
190.3	-	-	-	-	-	-	-	-	-	-	-	47.6	-	53.6	45.0	58.9	50.5	41.4
203.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40.1	-	45.0	36.6
210.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42.5	34.4
216.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.4
229.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.9
242.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
85.3	183.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91.9	165.3	-	-	163.1	-	-	-	-	-	-	-	-	-	-	-
98.4	149.9	-	-	148.8	-	-	145.5	-	-	-	-	-	-	-	-
111.5	125.7	-	-	124.6	-	-	121.3	-	-	121.3	-	-	119.0	-	-
124.7	107.6	-	-	106.0	-	-	103.6	-	-	103.0	-	-	101.0	-	-
137.8	93.0	81.8	-	91.7	-	-	89.1	-	-	88.6	-	-	86.4	-	-
144.4	87.2	76.3	-	85.9	74.3	-	83.2	-	-	82.7	-	-	80.6	-	-
150.9	81.4	71.2	-	80.0	69.4	-	77.4	-	-	76.7	-	-	74.7	-	-
157.5	76.6	66.6	-	75.2	64.8	-	72.5	61.5	-	72.0	-	-	69.9	-	-
164.0	71.9	62.4	-	70.3	60.4	-	67.7	57.1	-	67.2	56.0	-	65.0	-	-
177.2	63.7	54.7	-	62.2	52.7	-	59.7	49.4	-	59.1	48.5	-	57.1	45.9	-
190.3	57.1	48.3	39.2	55.6	46.1	-	52.9	43.0	-	52.0	41.9	-	49.8	39.2	-
203.4	51.4	42.5	34.2	49.6	40.6	32.0	46.7	37.3	-	45.9	36.4	-	43.4	33.7	-
216.5	-	37.9	30.0	44.5	35.7	27.6	41.4	32.6	24.3	40.6	31.5	-	38.1	28.9	-
229.7	-	34.0	26.2	-	31.7	24.0	36.8	28.4	20.5	35.7	27.3	19.4	33.3	24.7	-
242.8	-	-	23.1	-	28.2	20.7	32.8	24.7	17.2	31.7	23.6	16.1	29.3	20.9	13.2
255.9	-	-	-	-	-	18.1	-	21.6	14.6	28.2	20.5	13.2	25.6	17.9	10.4
262.5	-	-	-	-	-	-	-	20.3	13.2	-	19.0	11.9	24.0	16.3	9.0
269.0	-	-	-	-	-	-	-	-	11.9	-	17.6	10.6	22.5	15.0	-
275.6	-	-	-	-	-	-	-	-	11.0	-	16.3	9.5	21.1	13.7	-
282.2	-	-	-	-	-	-	-	-	9.9	-	15.2	-	19.6	12.3	-
295.3	-	-	-	-	-	-	-	-	-	-	-	-	-	10.1	-
301.8	-	-	-	-	-	-	-	-	-	-	-	-	-	9.3	-

Remarks

Main boom angle 85°, 75° and 65°, capacities for intermediate boom positions are calculated by the crane control system IC-1

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

137.8 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
52.5	372.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.1	315.3	-	-	313.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.6	273.4	-	-	271.2	-	-	269.0	-	-	-	-	-	-	-	-	-	-	-
72.2	240.3	-	-	238.1	-	-	235.9	-	-	233.7	-	-	-	-	-	-	-	-
78.7	213.8	-	-	212.7	-	-	210.5	-	-	208.3	-	-	206.1	-	-	203.9	-	-
85.3	192.9	173.1	-	190.7	-	-	189.6	-	-	186.3	-	-	185.2	-	-	183.0	-	-
91.9	174.2	156.5	-	173.1	-	-	170.9	-	-	168.7	-	-	167.6	-	-	164.2	-	-
98.4	-	143.3	-	157.6	141.1	-	156.5	-	-	154.3	-	-	152.1	-	-	149.9	-	-
105.0	-	131.2	-	145.5	129.0	-	144.4	126.8	-	142.2	-	-	140.0	-	-	137.8	-	-
111.5	-	121.3	-	133.4	119.0	-	132.3	115.7	-	130.1	-	-	127.9	-	-	125.7	-	-
118.1	-	112.4	-	-	110.2	-	122.9	108.0	-	120.7	105.4	-	119.0	-	-	116.7	-	-
124.7	-	-	92.8	-	102.7	-	113.5	100.3	-	111.3	97.7	-	110.2	95.7	-	107.8	-	-
131.2	-	-	86.6	-	95.7	-	-	93.5	-	104.4	90.8	-	103.1	88.8	-	100.6	86.0	-
137.8	-	-	81.1	-	89.5	78.3	-	87.3	-	97.4	84.9	-	95.9	82.9	-	93.5	80.0	-
150.9	-	-	-	-	-	68.8	-	76.9	65.7	86.0	74.3	-	84.4	72.5	-	81.8	69.7	-
157.5	-	-	-	-	-	-	-	72.5	61.5	-	69.9	-	79.7	67.9	-	77.1	65.3	-
164.0	-	-	-	-	-	-	-	-	57.8	-	65.9	54.7	75.0	63.9	-	72.3	60.8	-
177.2	-	-	-	-	-	-	-	-	51.1	-	58.9	48.1	-	56.7	45.4	64.4	53.6	-
190.3	-	-	-	-	-	-	-	-	-	-	-	42.5	-	50.5	39.9	57.8	47.2	36.4
196.9	-	-	-	-	-	-	-	-	-	-	-	-	-	47.8	37.5	-	44.5	34.0
203.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35.3	-	41.9	31.7
216.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31.3	-	-	27.8
229.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.5

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
85.3	180.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91.9	163.1	-	-	162.0	-	-	-	-	-	-	-	-	-	-	-
98.4	147.7	-	-	146.6	-	-	144.4	-	-	-	-	-	-	-	-
111.5	124.6	-	-	122.4	-	-	120.2	-	-	119.0	-	-	116.8	-	-
124.7	106.3	-	-	104.7	-	-	102.3	-	-	101.6	-	-	99.6	-	-
137.8	91.9	-	-	90.4	-	-	87.7	-	-	87.3	-	-	85.1	-	-
144.4	86.1	72.8	-	84.5	-	-	82.0	-	-	81.5	-	-	79.4	-	-
150.9	80.2	67.7	-	78.7	65.5	-	76.3	-	-	75.6	-	-	73.6	-	-
164.0	70.8	58.9	-	69.2	56.7	-	66.6	53.1	-	66.1	-	-	63.9	-	-
170.6	66.8	54.9	-	65.3	52.7	-	62.6	49.4	-	62.1	48.5	-	59.9	-	-
177.2	62.8	51.4	-	61.3	49.2	-	58.6	45.9	-	58.0	45.0	-	55.8	42.1	-
190.3	56.0	45.0	-	54.5	43.0	-	51.8	39.7	-	50.9	38.6	-	48.5	35.9	-
203.4	50.3	39.7	29.3	48.7	37.5	27.1	45.6	34.2	-	44.8	33.3	-	42.3	30.6	-
216.5	-	35.1	25.4	43.4	32.8	23.1	40.3	29.5	19.4	39.5	28.7	-	37.0	26.0	-
229.7	-	31.1	21.8	39.0	28.9	19.6	35.7	25.6	16.1	34.8	24.5	14.8	32.4	21.8	-
242.8	-	-	19.0	-	25.6	16.5	31.7	22.0	13.0	30.6	20.9	11.9	28.2	18.3	-
249.3	-	-	17.6	-	24.0	15.2	-	20.5	11.7	28.9	19.4	10.4	26.5	16.8	-
255.9	-	-	16.3	-	-	13.9	-	19.2	10.4	27.1	17.9	9.3	24.7	15.2	-
269.0	-	-	-	-	-	11.7	-	16.5	-	-	15.2	-	21.6	12.6	-
282.2	-	-	-	-	-	-	-	-	-	-	12.8	-	18.7	10.1	-
288.7	-	-	-	-	-	-	-	-	-	-	11.7	-	-	9.0	-

Remarks

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4

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SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

157.5 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
52.5	370.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.1	313.1	-	-	310.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.6	271.2	-	-	269.0	-	-	266.8	-	-	-	-	-	-	-	-	-	-	-
72.2	238.1	-	-	235.9	-	-	233.7	-	-	231.5	-	-	-	-	-	-	-	-
78.7	212.7	-	-	210.5	-	-	208.3	-	-	206.1	-	-	203.9	-	-	-	-	-
85.3	190.7	-	-	188.5	-	-	187.4	-	-	185.2	-	-	183.0	-	-	180.8	-	-
91.9	173.1	151.0	-	170.9	-	-	169.8	-	-	167.6	-	-	165.3	-	-	163.1	-	-
98.4	157.6	137.8	-	156.5	-	-	154.3	-	-	152.1	-	-	151.0	-	-	147.7	-	-
105.0	-	126.8	-	144.4	124.6	-	142.7	-	-	140.0	-	-	138.9	-	-	136.1	-	-
111.5	-	116.8	-	132.3	114.6	-	131.2	111.3	-	127.9	-	-	126.8	-	-	124.6	-	-
118.1	-	108.7	-	-	106.0	-	121.8	103.6	-	119.0	101.0	-	117.8	-	-	115.5	-	-
124.7	-	101.0	-	-	98.5	-	112.4	96.1	-	110.2	93.5	-	108.9	-	-	106.5	-	-
131.2	-	-	-	-	91.9	-	-	89.5	-	103.3	86.9	-	101.7	84.9	-	99.3	-	-
137.8	-	-	75.2	-	86.0	-	-	83.6	-	96.3	80.9	-	94.6	78.9	-	92.2	76.1	-
144.4	-	-	70.3	-	80.5	67.0	-	78.3	-	90.6	75.6	-	88.8	73.6	-	86.4	70.5	-
150.9	-	-	65.9	-	-	62.6	-	73.4	-	84.9	71.0	-	83.1	69.0	-	80.7	65.7	-
157.5	-	-	-	-	-	58.6	-	69.2	55.1	-	66.6	-	78.4	64.6	-	75.9	61.1	-
164.0	-	-	-	-	-	55.1	-	65.3	51.6	-	62.6	48.5	73.6	60.4	-	71.2	57.1	-
177.2	-	-	-	-	-	-	-	-	45.4	-	55.6	42.3	-	53.1	39.7	63.3	49.8	-
190.3	-	-	-	-	-	-	-	-	-	-	-	37.3	-	47.2	34.6	56.9	43.9	31.1
196.9	-	-	-	-	-	-	-	-	-	-	-	35.1	-	44.5	32.4	-	41.2	28.7
203.4	-	-	-	-	-	-	-	-	-	-	-	33.1	-	-	30.2	-	38.6	26.7
216.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.5	-	34.4	22.9
229.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.8
242.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.2

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
91.9	160.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98.4	146.6	-	-	144.4	-	-	-	-	-	-	-	-	-	-	-
111.5	122.4	-	-	121.3	-	-	117.9	-	-	117.9	-	-	115.7	-	-
124.7	104.9	-	-	103.4	-	-	100.8	-	-	100.3	-	-	98.1	-	-
137.8	90.6	-	-	89.1	-	-	86.4	-	-	86.0	-	-	83.8	-	-
150.9	79.1	63.5	-	77.6	-	-	75.0	-	-	74.5	-	-	72.3	-	-
157.5	74.4	58.9	-	72.9	56.7	-	70.2	-	-	69.8	-	-	67.6	-	-
164.0	69.7	54.9	-	68.1	52.7	-	65.5	49.2	-	65.0	-	-	62.8	-	-
177.2	61.7	47.6	-	60.2	45.4	-	57.5	42.1	-	56.9	41.0	-	54.5	-	-
183.7	58.4	44.5	-	56.9	42.3	-	54.0	39.0	-	53.4	37.9	-	50.9	35.3	-
190.3	55.1	41.7	-	53.6	39.5	-	50.5	36.2	-	49.8	35.1	-	47.4	32.4	-
203.4	49.4	36.4	24.3	47.4	34.4	-	44.5	30.9	-	43.7	30.0	-	41.2	27.1	-
216.5	-	32.0	20.5	42.3	29.8	18.1	39.2	26.5	-	38.4	25.6	-	35.9	22.7	-
229.7	-	28.2	17.2	37.9	26.0	15.0	34.6	22.7	-	33.7	21.6	-	31.3	19.0	-
236.2	-	26.5	15.9	-	24.3	13.4	32.7	20.9	-	31.7	19.8	-	29.3	17.2	-
242.8	-	-	14.6	-	22.7	12.1	30.9	19.2	-	29.8	18.3	-	27.3	15.4	-
255.9	-	-	12.1	-	19.8	9.7	-	16.3	-	26.2	15.2	-	23.8	12.6	-
269.0	-	-	-	-	-	-	-	13.9	-	23.1	12.6	-	20.5	9.9	-
275.6	-	-	-	-	-	-	-	12.8	-	-	11.5	-	19.2	-	-
282.2	-	-	-	-	-	-	-	-	-	-	10.4	-	17.9	-	-
288.7	-	-	-	-	-	-	-	-	-	-	9.3	-	-	-	-

Remarks

Main boom angle 85°, 75° and 65°, capacities for intermediate boom positions are calculated by the crane control system IC-1

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

177.2 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
52.5	366.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59.1	310.9	-	-	308.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.6	269.0	-	-	266.8	-	-	264.6	-	-	-	-	-	-	-	-	-	-	-
72.2	235.9	-	-	233.7	-	-	231.5	-	-	229.3	-	-	-	-	-	-	-	-
78.7	210.5	-	-	208.3	-	-	206.1	-	-	203.9	-	-	201.7	-	-	-	-	-
85.3	188.5	-	-	187.4	-	-	185.2	-	-	183.0	-	-	180.8	-	-	178.6	-	-
91.9	170.9	-	-	169.8	-	-	167.6	-	-	165.3	-	-	163.1	-	-	160.9	-	-
98.4	156.5	133.4	-	154.3	-	-	153.2	-	-	149.9	-	-	148.8	-	-	146.6	-	-
105.0	-	122.4	-	142.7	119.0	-	141.1	-	-	138.3	-	-	136.7	-	-	134.5	-	-
111.5	-	112.4	-	131.2	110.0	-	129.0	-	-	126.8	-	-	124.6	-	-	122.4	-	-
118.1	-	104.3	-	-	101.9	-	120.2	99.0	-	117.9	-	-	116.1	-	-	113.6	-	-
124.7	-	97.0	-	-	94.6	-	111.3	91.9	-	109.1	89.3	-	107.6	-	-	104.9	-	-
131.2	-	90.4	-	-	88.0	-	104.3	85.3	-	102.0	82.9	-	100.4	-	-	97.9	-	-
137.8	-	-	68.3	-	82.2	-	97.2	79.8	-	94.8	77.2	-	93.3	75.0	-	90.8	-	-
144.4	-	-	63.7	-	76.9	-	-	74.5	-	89.2	72.1	-	87.6	69.7	-	85.1	66.1	-
150.9	-	-	59.5	-	-	56.2	-	69.9	-	83.6	67.2	-	82.0	64.8	-	79.4	61.3	-
164.0	-	-	-	-	-	49.2	-	61.9	45.4	-	58.9	-	72.5	56.4	-	70.1	53.1	-
177.2	-	-	-	-	-	43.4	-	-	39.9	-	52.0	36.6	-	49.6	-	62.2	46.1	-
183.7	-	-	-	-	-	-	-	-	37.3	-	48.9	34.2	-	46.5	-	59.0	43.2	-
190.3	-	-	-	-	-	-	-	-	35.1	-	-	32.0	-	43.7	29.3	55.8	40.3	-
203.4	-	-	-	-	-	-	-	-	-	-	-	27.8	-	38.8	25.1	-	35.5	21.6
216.5	-	-	-	-	-	-	-	-	-	-	-	24.5	-	-	21.8	-	31.3	18.1
223.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.3	-	29.3	16.5
229.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.7	-	-	15.2
242.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.6

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
91.9	159.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98.4	144.4	-	-	143.3	-	-	-	-	-	-	-	-	-	-	-
111.5	121.3	-	-	119.0	-	-	116.8	-	-	115.7	-	-	-	-	-
124.7	103.4	-	-	101.9	-	-	99.2	-	-	98.8	-	-	96.6	-	-
137.8	89.3	-	-	87.7	-	-	85.1	-	-	84.7	-	-	82.5	-	-
150.9	77.8	59.1	-	76.3	-	-	73.6	-	-	73.2	-	-	71.0	-	-
164.0	68.6	50.9	-	67.0	48.5	-	64.4	-	-	63.7	-	-	61.5	-	-
170.6	64.6	47.2	-	63.1	45.0	-	60.3	41.4	-	59.6	-	-	57.3	-	-
177.2	60.6	44.1	-	59.1	41.7	-	56.2	38.1	-	55.6	-	-	53.1	-	-
183.7	57.3	41.0	-	55.7	38.8	-	52.7	35.3	-	52.0	34.2	-	49.6	-	-
190.3	54.0	38.1	-	52.2	35.9	-	49.2	32.4	-	48.5	31.5	-	46.1	28.7	-
203.4	48.3	33.3	-	46.3	31.1	-	43.2	27.6	-	42.5	26.7	-	40.1	23.8	-
216.5	-	28.9	15.7	41.2	26.7	-	37.9	23.4	-	37.3	22.3	-	34.8	19.6	-
229.7	-	25.4	12.6	36.8	22.9	-	33.5	19.6	-	32.6	18.5	-	30.2	15.9	-
242.8	-	22.0	10.1	-	19.8	-	29.8	16.3	-	28.7	15.4	-	26.2	12.6	-
249.3	-	-	8.8	-	18.3	-	-	15.0	-	26.9	13.9	-	24.5	11.0	-
255.9	-	-	-	-	17.2	-	-	13.7	-	25.1	12.6	-	22.7	9.7	-
262.5	-	-	-	-	15.9	-	-	12.3	-	23.7	11.2	-	21.2	-	-
269.0	-	-	-	-	-	-	-	11.2	-	22.3	9.9	-	19.6	-	-
275.6	-	-	-	-	-	-	-	10.1	-	-	8.8	-	18.3	-	-
282.2	-	-	-	-	-	-	-	9.0	-	-	-	-	17.0	-	-

Remarks

Main boom angle 85°, 75° and 65°, capacities for intermediate boom positions are calculated by the crane control system IC-1

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TEREX®

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

196.9 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
59.1	306.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.6	264.6	-	-	262.4	-	-	260.1	-	-	-	-	-	-	-	-	-	-	-
72.2	233.7	-	-	231.5	-	-	229.3	-	-	227.1	-	-	-	-	-	-	-	-
78.7	208.3	-	-	206.1	-	-	203.9	-	-	201.7	-	-	199.5	-	-	-	-	-
85.3	186.3	-	-	185.2	-	-	183.0	-	-	180.8	-	-	178.6	-	-	176.4	-	-
91.9	168.7	-	-	167.6	-	-	165.3	-	-	163.1	-	-	160.9	-	-	158.7	-	-
98.4	154.3	-	-	152.1	-	-	151.0	-	-	148.8	-	-	146.6	-	-	144.4	-	-
105.0	-	116.8	-	140.5	-	-	139.4	-	-	136.7	-	-	135.0	-	-	132.3	-	-
111.5	-	107.6	-	129.0	104.9	-	127.9	-	-	124.6	-	-	123.5	-	-	120.2	-	-
124.7	-	92.4	-	-	89.7	-	109.8	87.1	-	107.4	-	-	105.8	-	-	103.4	-	-
131.2	-	86.0	-	-	83.6	-	102.8	80.9	-	100.4	77.8	-	98.9	-	-	96.3	-	-
137.8	-	-	-	-	78.0	-	95.9	75.2	-	93.5	72.3	-	91.9	69.7	-	89.3	-	-
150.9	-	-	52.5	-	68.6	-	-	65.5	-	82.2	62.4	-	80.5	60.2	-	78.0	56.4	-
164.0	-	-	45.9	-	-	42.3	-	57.5	-	-	54.5	-	71.2	52.2	-	68.8	48.7	-
170.6	-	-	-	-	-	39.5	-	54.0	-	-	51.1	-	67.5	48.7	-	64.9	45.2	-
177.2	-	-	-	-	-	37.0	-	-	33.3	-	47.8	-	63.7	45.4	-	61.1	42.1	-
190.3	-	-	-	-	-	-	-	-	29.1	-	42.3	25.8	-	39.9	-	54.5	36.6	-
203.4	-	-	-	-	-	-	-	-	25.4	-	-	22.3	-	35.3	19.4	-	31.7	-
210.0	-	-	-	-	-	-	-	-	-	-	-	20.5	-	33.3	17.9	-	29.8	-
216.5	-	-	-	-	-	-	-	-	-	-	-	19.2	-	-	16.3	-	27.8	12.6
229.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.7	-	24.5	9.9
242.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.5	-	-	-
249.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
91.9	157.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98.4	142.2	-	-	141.1	-	-	-	-	-	-	-	-	-	-	-
111.5	119.0	-	-	117.9	-	-	114.6	-	-	110.2	-	-	-	-	-
124.7	101.9	-	-	100.3	-	-	97.4	-	-	97.0	-	-	94.8	-	-
137.8	87.7	-	-	86.2	-	-	83.6	-	-	83.1	-	-	80.9	-	-
150.9	76.5	-	-	75.0	-	-	72.3	-	-	71.9	-	-	69.7	-	-
157.5	71.9	50.0	-	70.3	-	-	67.7	-	-	67.1	-	-	64.8	-	-
164.0	67.2	46.5	-	65.7	-	-	63.1	-	-	62.4	-	-	60.0	-	-
170.6	63.4	43.0	-	61.7	40.6	-	59.0	-	-	58.3	-	-	55.9	-	-
177.2	59.5	39.9	-	57.8	37.5	-	54.9	34.0	-	54.2	-	-	51.8	-	-
183.7	56.2	37.0	-	54.3	34.6	-	51.4	31.1	-	50.7	30.2	-	48.3	-	-
190.3	52.9	34.4	-	50.9	32.0	-	47.8	28.4	-	47.2	27.6	-	44.8	-	-
196.9	49.9	31.7	-	48.0	29.5	-	44.9	26.0	-	44.2	25.1	-	41.8	22.3	-
203.4	47.0	29.5	-	45.0	27.3	-	41.9	23.8	-	41.2	22.9	-	38.8	20.1	-
216.5	-	25.6	-	39.9	23.1	-	36.8	19.8	-	36.2	18.7	-	33.5	15.9	-
229.7	-	22.0	-	35.5	19.8	-	32.4	16.3	-	31.5	15.2	-	29.1	12.3	-
242.8	-	19.0	-	-	16.8	-	28.4	13.2	-	27.6	12.1	-	25.1	9.5	-
249.3	-	17.6	-	-	15.2	-	-	11.9	-	25.9	10.8	-	23.4	-	-
255.9	-	-	-	-	14.1	-	-	10.6	-	24.3	9.5	-	21.6	-	-
262.5	-	-	-	-	12.8	-	-	9.3	-	22.7	-	-	20.1	-	-
269.0	-	-	-	-	11.9	-	-	-	-	21.2	-	-	18.5	-	-
282.2	-	-	-	-	-	-	-	-	-	-	-	-	15.9	-	-
288.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CRAWLER CRANE

SW LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 27.6 ft | 360° | DIN/ISO

216.5 ft

	78.7 ft			98.4 ft			118.1 ft			137.8 ft			157.5 ft			177.2 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb									
59.1	299.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65.6	262.4	-	-	260.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72.2	231.5	-	-	229.3	-	-	227.1	-	-	-	-	-	-	-	-	-	-	-
78.7	205.0	-	-	202.8	-	-	201.7	-	-	198.4	-	-	-	-	-	-	-	-
85.3	184.1	-	-	183.0	-	-	180.8	-	-	178.6	-	-	176.4	-	-	-	-	-
91.9	167.6	-	-	165.3	-	-	163.1	-	-	160.9	-	-	158.7	-	-	156.5	-	-
98.4	152.1	-	-	151.0	-	-	148.8	-	-	146.6	-	-	144.4	-	-	142.2	-	-
105.0	-	111.3	-	138.9	-	-	137.2	-	-	135.0	-	-	132.8	-	-	130.6	-	-
111.5	-	102.5	-	126.8	-	-	125.7	-	-	123.5	-	-	121.3	-	-	119.0	-	-
118.1	-	94.8	-	-	91.9	-	117.0	-	-	114.6	-	-	112.8	-	-	110.3	-	-
124.7	-	88.0	-	-	85.3	-	108.2	81.8	-	105.8	-	-	104.3	-	-	101.6	-	-
137.8	-	76.5	-	-	73.4	-	94.4	70.3	-	91.9	67.2	-	90.4	-	-	87.7	-	-
144.4	-	-	-	-	68.6	-	-	65.5	-	86.3	62.4	-	84.8	59.7	-	82.1	-	-
150.9	-	-	-	-	63.9	-	-	60.8	-	80.7	58.0	-	79.1	55.6	-	76.5	-	-
157.5	-	-	-	-	60.0	-	-	56.9	-	-	53.8	-	74.6	51.6	-	72.0	47.8	-
164.0	-	-	39.5	-	-	35.7	-	53.4	-	-	50.3	-	70.1	47.8	-	67.5	44.3	-
177.2	-	-	34.4	-	-	30.9	-	47.0	27.1	-	43.9	-	62.4	41.7	-	59.7	37.9	-
190.3	-	-	-	-	-	26.9	-	-	23.1	-	38.6	20.1	-	36.2	-	53.4	32.6	-
196.9	-	-	-	-	-	-	-	-	21.4	-	36.4	18.3	-	34.0	-	-	30.4	-
203.4	-	-	-	-	-	-	-	-	19.8	-	-	16.8	-	31.7	13.9	-	28.2	-
216.5	-	-	-	-	-	-	-	-	-	-	-	13.9	-	28.0	11.0	-	24.5	-
223.1	-	-	-	-	-	-	-	-	-	-	-	12.6	-	-	9.9	-	22.7	-
229.7	-	-	-	-	-	-	-	-	-	-	-	11.5	-	-	-	-	21.2	-
236.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.8	-
242.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	196.9 ft			216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°	85°	75°	65°
ft									1,000 lb						
91.9	145.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98.4	140.0	-	-	127.9	-	-	-	-	-	-	-	-	-	-	-
111.5	116.8	-	-	115.7	-	-	112.4	-	-	97.0	-	-	-	-	-
124.7	100.3	-	-	98.5	-	-	95.9	-	-	95.2	-	-	86.0	-	-
137.8	86.4	-	-	84.7	-	-	82.0	-	-	81.6	-	-	79.4	-	-
150.9	75.2	-	-	73.4	-	-	70.8	-	-	70.3	-	-	68.1	-	-
164.0	65.9	42.1	-	64.4	-	-	61.5	-	-	60.8	-	-	58.4	-	-
170.6	62.1	38.8	-	60.4	36.4	-	57.4	-	-	56.8	-	-	54.3	-	-
177.2	58.2	35.7	-	56.4	33.5	-	53.4	-	-	52.7	-	-	50.3	-	-
183.7	54.9	33.1	-	53.0	30.6	-	49.9	27.1	-	49.3	-	-	46.8	-	-
190.3	51.6	30.4	-	49.6	28.2	-	46.5	24.5	-	45.9	23.6	-	43.4	-	-
203.4	45.6	26.0	-	43.7	23.8	-	40.6	20.1	-	39.9	19.2	-	37.5	16.3	-
216.5	40.8	22.0	-	38.6	19.8	-	35.5	16.3	-	34.8	15.4	-	32.4	12.3	-
229.7	-	18.7	-	34.4	16.5	-	31.1	13.0	-	30.4	11.9	-	27.8	9.0	-
242.8	-	15.9	-	-	13.7	-	27.3	10.1	-	26.5	9.0	-	24.0	-	-
249.3	-	14.6	-	-	12.3	-	25.7	-	-	24.8	-	-	22.3	-	-
255.9	-	-	-	-	11.0	-	24.0	-	-	23.1	-	-	20.5	-	-
269.0	-	-	-	-	9.0	-	-	-	-	20.1	-	-	17.4	-	-
282.2	-	-	-	-	-	-	-	-	-	-	-	-	14.8	-	-

Remarks

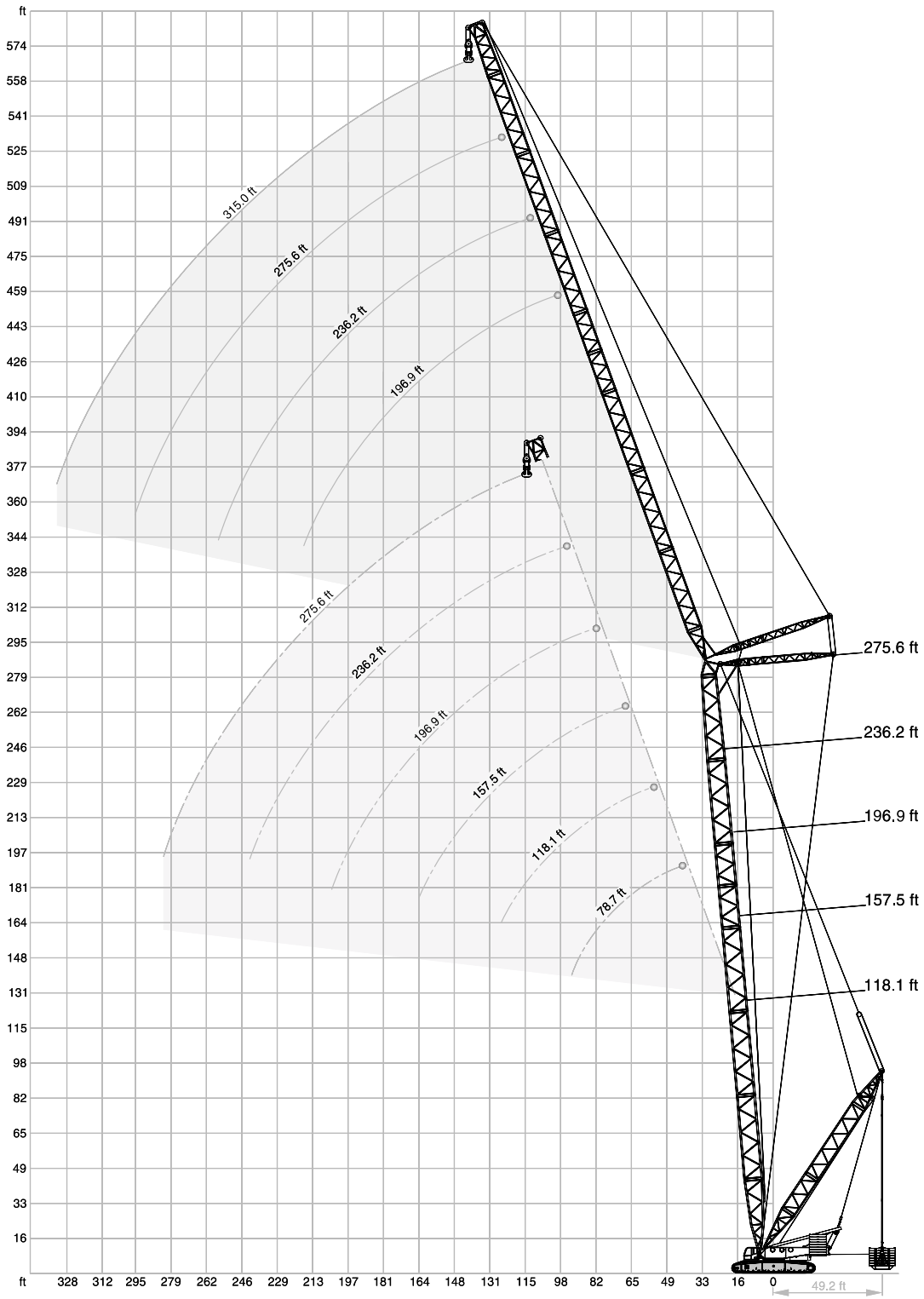
Main boom angle 85°, 75° and 65°, capacities for intermediate boom positions are calculated by the crane control system IC-1

4

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
Please contact Bigge Crane and Rigging Co. at 888-337-BIGGE or email info@bigge.com for further information. BIGGE

TEREX®

SWSL WORKING RANGES



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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

118.1 ft + 78.7 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
52.5	403.4	661.4	-	-	-	661.4	-
59.1	341.7	661.4	-	-	-	661.4	-
65.6	297.6	661.4	-	-	-	661.4	-
72.2	260.1	634.9	-	-	-	623.9	-
78.7	231.5	546.7	-	-	-	579.8	-
85.3	209.4	471.8	535.7	-	-	542.3	-
91.9	189.6	401.2	502.7	-	-	509.3	-
98.4	-	-	471.8	-	-	478.4	-
111.5	-	-	421.1	385.8	-	407.9	-
131.2	-	-	-	337.3	-	331.8	-
137.8	-	-	-	-	297.6	310.9	-
150.9	-	-	-	-	280.0	271.2	-
164.0	-	-	-	-	-	229.3	-
177.2	-	-	-	-	-	198.4	-
190.3	-	-	-	-	-	-	-

118.1 ft + 118.1 ft

ft	1,000 lb						
59.1	339.5	566.6	-	-	-	-	-
65.6	293.2	566.6	-	-	-	557.8	-
72.2	257.9	557.8	-	-	-	549.0	-
78.7	229.3	526.9	-	-	-	540.1	-
85.3	206.1	498.2	-	-	-	526.9	-
91.9	187.4	458.6	-	-	-	493.8	-
98.4	170.9	412.3	438.7	-	-	458.6	-
111.5	144.4	335.1	403.4	-	-	407.9	-
124.7	124.6	271.2	363.8	-	-	354.9	-
137.8	-	-	321.9	310.9	-	313.1	-
150.9	-	-	260.1	282.2	-	277.8	-
164.0	-	-	-	255.7	-	246.9	-
177.2	-	-	-	-	224.9	222.7	-
190.3	-	-	-	-	208.3	191.8	-
203.4	-	-	-	-	-	167.6	-
216.5	-	-	-	-	-	145.5	-

118.1 ft + 157.5 ft

ft	1,000 lb						
72.2	253.5	412.3	-	-	-	-	-
78.7	224.9	412.3	-	-	-	410.1	-
85.3	202.8	412.3	-	-	-	407.9	-
91.9	183.0	396.8	-	-	-	403.4	-
98.4	166.4	379.2	-	-	-	399.0	-
111.5	141.1	343.9	-	-	-	361.6	-
118.1	131.2	321.9	337.3	-	-	345.0	-
124.7	121.3	299.8	337.3	-	-	328.5	-
137.8	105.8	255.7	297.6	-	-	304.2	-
150.9	93.5	219.4	264.6	-	-	277.8	-
164.0	83.1	185.2	240.3	246.9	-	249.1	-
177.2	-	-	215.0	229.3	-	224.9	-
190.3	-	-	180.8	210.5	-	202.8	-
196.9	-	-	-	201.7	190.7	194.0	-
210.0	-	-	-	186.3	180.8	174.2	-
223.1	-	-	-	-	167.6	152.1	-
229.7	-	-	-	-	-	141.1	-
255.9	-	-	-	-	-	108.0	-

118.1 ft + 196.9 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
85.3	198.4	295.4	-	-	-	-	-
91.9	179.7	295.4	-	-	-	295.4	-
98.4	163.1	295.4	-	-	-	293.2	-
111.5	136.7	282.2	-	-	-	293.2	-
124.7	116.8	262.4	-	-	-	286.6	-
137.8	102.1	242.5	257.9	-	-	273.4	-
150.9	89.5	220.5	246.9	-	-	255.7	-
164.0	79.1	198.4	224.9	-	-	231.5	-
177.2	70.5	173.1	211.6	-	-	207.2	-
183.7	66.9	162.0	205.0	190.7	-	198.4	-
190.3	63.3	151.0	195.1	190.7	-	189.6	-
203.4	57.1	129.0	172.0	176.4	-	178.6	-
216.5	-	-	149.9	162.0	-	167.6	-
229.7	-	-	127.9	151.0	151.0	154.3	-
242.8	-	-	-	140.0	144.4	136.7	-
249.3	-	-	-	134.5	138.9	129.0	-
255.9	-	-	-	-	134.5	121.3	-
262.5	-	-	-	-	129.0	114.6	-
269.0	-	-	-	-	-	110.2	-
282.2	-	-	-	-	-	94.8	-
295.3	-	-	-	-	-	81.6	-

118.1 ft + 236.2 ft

ft	1,000 lb						-
98.4	158.7	211.6	-	-	-	-	-
111.5	133.4	211.6	-	-	-	209.4	-
124.7	113.5	207.2	-	-	-	207.2	-
137.8	97.9	200.6	-	-	-	205.0	-
150.9	85.3	191.8	-	-	-	200.6	-
157.5	80.1	187.4	191.8	-	-	197.3	-
164.0	75.0	183.0	189.6	-	-	194.0	-
177.2	66.4	174.2	185.2	-	-	183.0	-
190.3	59.1	158.7	178.6	-	-	172.0	-
203.4	52.7	141.1	172.0	-	-	160.9	-
210.0	49.8	132.8	166.4	147.7	-	155.4	-
216.5	47.0	124.6	157.6	146.6	-	149.9	-
229.7	42.1	109.8	141.1	141.1	-	141.1	-
242.8	37.9	94.4	125.7	133.4	-	134.5	-
255.9	-	-	110.2	126.8	126.8	125.7	-
262.5	-	-	103.2	123.5	122.4	120.2	-
269.0	-	-	-	119.0	119.0	114.6	-
282.2	-	-	-	109.8	110.2	101.4	-
295.3	-	-	-	-	103.8	92.6	-
301.8	-	-	-	-	100.5	87.1	-
308.4	-	-	-	-	-	81.6	-
321.5	-	-	-	-	-	70.5	-
334.6	-	-	-	-	-	61.7	

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

4

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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

118.1 ft + 275.6 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
111.5	130.1	152.1	-	-	-	-	-
124.7	110.2	152.1	-	-	-	152.1	-
137.8	95.5	149.9	-	-	-	149.9	-
150.9	82.9	149.9	-	-	-	149.9	-
164.0	72.5	147.7	-	-	-	147.7	-
177.2	63.7	145.5	138.9	-	-	145.5	-
190.3	56.2	143.3	138.9	-	-	141.1	-
203.4	49.6	138.9	136.7	-	-	136.7	-
216.5	43.9	130.1	134.5	-	-	132.3	-
229.7	38.8	116.8	132.3	-	-	125.7	-
236.2	36.5	110.7	130.1	110.2	-	123.5	-
242.8	34.2	104.5	129.0	110.2	-	121.3	-
255.9	30.4	93.0	116.8	110.0	-	114.6	-
269.0	26.9	82.0	105.4	106.7	-	110.2	-
282.2	24.0	70.3	94.4	103.0	-	101.4	-
288.7	-	-	88.8	101.0	97.2	98.1	-
295.3	-	-	83.6	98.5	97.2	94.8	-
301.8	-	-	77.8	96.1	96.3	90.4	-
308.4	-	-	-	93.7	93.3	86.0	-
321.5	-	-	-	83.6	87.1	79.4	-
334.6	-	-	-	-	81.8	70.5	-
341.2	-	-	-	-	79.1	65.0	-
347.8	-	-	-	-	-	59.5	-
374.0	-	-	-	-	-	46.3	-
387.1	-	-	-	-	-	-	-

157.5 ft + 78.7 ft

ft	1,000 lb						
52.5	399.0	654.8	-	-	-	657.0	-
59.1	337.3	654.8	-	-	-	657.0	-
65.6	293.2	646.0	-	-	-	654.8	-
72.2	255.7	617.3	-	-	-	652.6	-
78.7	229.3	584.2	-	-	-	621.7	-
85.3	206.1	504.9	-	-	-	573.2	-
91.9	187.4	432.1	509.3	-	-	520.3	-
98.4	170.9	357.1	480.6	-	-	474.0	-
111.5	-	-	412.3	-	-	401.2	-
124.7	-	-	361.6	-	-	346.1	-
131.2	-	-	-	326.3	-	325.2	-
150.9	-	-	-	277.8	-	269.0	-
164.0	-	-	-	-	-	240.3	-
177.2	-	-	-	-	-	216.1	-
190.3	-	-	-	-	-	194.0	-
216.5	-	-	-	-	-	145.5	-
229.7	-	-	-	-	-	-	-

157.5 ft + 118.1 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						-
65.6	288.8	491.6	-	-	-	-	-
72.2	253.5	482.8	-	-	-	487.2	-
78.7	224.9	467.4	-	-	-	482.8	-
85.3	202.8	447.5	-	-	-	480.6	-
91.9	184.1	427.7	-	-	-	476.2	-
98.4	167.6	407.9	-	-	-	454.2	-
111.5	142.2	350.5	403.4	-	-	405.7	-
124.7	122.4	284.4	357.1	-	-	350.5	-
137.8	-	-	317.5	-	-	306.4	-
150.9	-	-	284.4	-	-	271.2	-
157.5	-	-	271.2	257.9	-	255.7	-
164.0	-	-	240.3	244.7	-	240.3	-
177.2	-	-	-	224.9	-	216.1	-
190.3	-	-	-	-	197.3	196.2	-
203.4	-	-	-	-	181.9	178.6	-
216.5	-	-	-	-	-	163.1	-
229.7	-	-	-	-	-	147.7	-
242.8	-	-	-	-	-	125.7	-
255.9	-	-	-	-	-	112.4	

157.5 ft + 157.5 ft

ft	1,000 lb						
78.7	220.5	357.1	-	-	-	-	-
85.3	198.4	357.1	-	-	-	357.1	-
91.9	179.7	352.7	-	-	-	357.1	-
98.4	163.1	346.1	-	-	-	357.1	-
111.5	137.8	328.5	-	-	-	352.7	-
124.7	117.9	299.8	-	-	-	328.5	-
131.2	110.7	282.2	308.6	-	-	315.3	-
137.8	103.4	264.6	308.6	-	-	302.0	-
150.9	91.1	224.9	280.0	-	-	273.4	-
164.0	80.9	190.7	253.5	-	-	242.5	-
177.2	-	-	231.5	219.4	-	218.3	-
190.3	-	-	205.0	201.7	-	196.2	-
196.9	-	-	187.4	192.9	-	187.4	-
203.4	-	-	-	186.3	-	178.6	-
223.1	-	-	-	166.4	157.6	156.5	-
229.7	-	-	-	-	152.1	149.9	-
242.8	-	-	-	-	142.2	136.7	-
255.9	-	-	-	-	-	125.7	-
269.0	-	-	-	-	-	110.2	-
282.2	-	-	-	-	-	94.8	-
295.3	-	-	-	-	-	83.8	-
301.8	-	-	-	-	-	-	-
308.4	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

157.5 ft + 196.9 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
91.9	175.3	264.6	-	-	-	-	-
98.4	159.8	264.6	-	-	-	264.6	-
111.5	134.5	257.9	-	-	-	264.6	-
124.7	114.6	246.9	-	-	-	264.6	-
137.8	99.4	233.7	-	-	-	257.9	-
150.9	87.1	216.1	242.5	-	-	251.3	-
164.0	76.9	200.6	231.5	-	-	235.9	-
177.2	68.3	177.5	209.4	-	-	216.1	-
190.3	61.3	154.3	191.8	-	-	198.4	-
203.4	55.1	132.3	176.4	179.7	-	178.6	-
216.5	-	-	163.1	167.6	-	163.1	-
229.7	-	-	143.3	155.4	-	149.9	-
236.2	-	-	132.3	149.9	-	143.3	-
242.8	-	-	-	144.4	-	136.7	-
249.3	-	-	-	140.0	132.3	131.2	-
255.9	-	-	-	135.6	127.9	125.7	-
262.5	-	-	-	131.2	123.5	121.3	-
269.0	-	-	-	-	120.2	116.8	-
282.2	-	-	-	-	112.4	108.0	-
288.7	-	-	-	-	110.0	101.4	-
295.3	-	-	-	-	-	94.8	-
308.4	-	-	-	-	-	81.6	-
321.5	-	-	-	-	-	72.8	-
334.6	-	-	-	-	-	61.7	-
347.8	-	-	-	-	-	-	-

157.5 ft + 275.6 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
111.5	126.8	141.1	-	-	-	-	-
124.7	108.0	141.1	-	-	-	141.1	-
137.8	92.8	138.9	-	-	-	138.9	-
150.9	80.5	136.7	-	-	-	138.9	-
164.0	70.3	134.5	-	-	-	138.9	-
177.2	61.7	132.3	-	-	-	136.7	-
183.7	57.9	132.3	127.9	-	-	135.6	-
190.3	54.0	132.3	127.9	-	-	134.5	-
203.4	47.4	130.1	127.9	-	-	130.1	-
216.5	41.7	127.9	127.9	-	-	125.7	-
229.7	36.6	117.9	127.9	-	-	121.3	-
242.8	32.4	105.8	127.9	-	-	116.8	-
249.3	30.4	100.0	127.9	102.1	-	113.5	-
255.9	28.4	94.1	124.6	102.1	-	110.2	-
269.0	25.1	82.9	112.4	102.1	-	105.8	-
282.2	22.3	71.4	101.2	101.2	-	97.0	-
295.3	-	-	90.2	99.4	-	92.6	-
308.4	-	-	79.1	96.8	89.1	88.2	-
321.5	-	-	-	92.6	86.0	83.8	-
334.6	-	-	-	84.9	80.9	77.2	-
347.8	-	-	-	-	76.5	68.3	-
360.9	-	-	-	-	72.3	59.5	-
374.0	-	-	-	-	-	50.7	-
387.1	-	-	-	-	-	46.3	-
400.3	-	-	-	-	-	37.5	-

157.5 ft + 236.2 ft

ft	1,000 lb						
111.5	130.1	191.8	-	-	-	191.8	-
124.7	110.2	189.6	-	-	-	189.6	-
137.8	95.5	183.0	-	-	-	189.6	-
150.9	83.1	176.4	-	-	-	187.4	-
164.0	72.8	169.8	174.2	-	-	183.0	-
177.2	64.4	163.1	174.2	-	-	178.6	-
190.3	57.1	156.5	172.0	-	-	169.8	-
203.4	50.5	143.3	169.8	-	-	160.9	-
216.5	45.0	126.8	158.7	-	-	149.9	-
229.7	40.1	111.3	147.7	136.7	-	138.9	-
242.8	35.7	96.1	135.6	135.6	-	134.5	-
255.9	-	-	120.2	130.1	-	125.7	-
269.0	-	-	105.4	122.4	-	114.6	-
275.6	-	-	97.4	117.9	-	110.2	-
282.2	-	-	-	114.6	107.8	105.8	-
295.3	-	-	-	108.5	101.4	99.2	-
301.8	-	-	-	104.5	98.3	94.8	-
308.4	-	-	-	-	95.7	90.4	-
321.5	-	-	-	-	90.4	79.4	-
328.1	-	-	-	-	88.2	73.9	-
334.6	-	-	-	-	-	68.3	-
347.8	-	-	-	-	-	59.5	-
360.9	-	-	-	-	-	52.9	-
374.0	-	-	-	-	-	44.1	-
387.1	-	-	-	-	-	-	-

196.9 ft + 78.7 ft

ft	1,000 lb						
55.8	-	-	-	-	-	-	599.7
59.1	330.7	544.5	-	-	-	549.0	588.6
65.6	286.6	524.7	-	-	-	544.5	566.6
72.2	251.3	502.7	-	-	-	542.3	540.1
78.7	224.9	480.6	-	-	-	540.1	515.9
85.3	201.7	454.2	-	-	-	524.7	487.2
91.9	183.0	425.5	-	-	-	498.2	451.9
98.4	167.6	401.2	-	-	-	469.6	403.4
105.0	-	-	434.3	-	-	433.2	-
111.5	-	-	403.4	-	-	396.8	-
124.7	-	-	352.7	-	-	341.7	-
131.2	-	-	332.9	-	-	319.7	-
144.4	-	-	-	280.0	-	280.0	-
150.9	-	-	-	266.8	-	262.4	-
164.0	-	-	-	240.3	-	233.7	-
177.2	-	-	-	-	-	209.4	-
183.7	-	-	-	-	199.5	198.4	-
190.3	-	-	-	-	190.7	187.4	-
196.9	-	-	-	-	183.0	178.6	-
203.4	-	-	-	-	-	169.8	-
216.5	-	-	-	-	-	154.3	-
229.7	-	-	-	-	-	141.1	-
242.8	-	-	-	-	-	121.3	-
255.9	-	-	-	-	-	103.6	-
269.0	-	-	-	-	-	-	-

Remarks: see page 46

4

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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

196.9 ft + 118.1 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
65.6	282.2	399.0	-	-	-	-	432.1
72.2	249.1	399.0	-	-	-	394.6	425.5
78.7	220.5	388.0	-	-	-	392.4	414.5
85.3	198.4	377.0	-	-	-	392.4	403.4
91.9	179.7	363.8	-	-	-	392.4	390.2
98.4	164.2	352.7	-	-	-	392.4	377.0
111.5	138.9	328.5	-	-	-	374.8	350.5
124.7	119.0	302.0	348.3	-	-	343.9	302.0
137.8	104.7	240.3	308.6	-	-	299.8	240.3
150.9	-	-	277.8	-	-	264.6	-
164.0	-	-	251.3	-	-	235.9	-
170.6	-	-	238.1	222.7	-	223.8	-
177.2	-	-	-	213.8	-	211.6	-
190.3	-	-	-	197.3	-	189.6	-
203.4	-	-	-	181.9	-	172.0	-
216.5	-	-	-	-	157.6	156.5	-
229.7	-	-	-	-	146.6	141.1	-
236.2	-	-	-	-	142.2	135.6	-
242.8	-	-	-	-	-	130.1	-
255.9	-	-	-	-	-	119.0	-
269.0	-	-	-	-	-	105.8	-
282.2	-	-	-	-	-	90.4	-
295.3	-	-	-	-	-	-	-

196.9 ft + 196.9 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
91.9	172.0	224.9	-	-	-	-	240.3
98.4	155.4	224.9	-	-	-	224.9	238.1
111.5	130.1	222.7	-	-	-	224.9	229.3
124.7	111.3	216.1	-	-	-	224.9	219.4
137.8	96.8	209.4	-	-	-	222.7	205.0
150.9	84.7	200.6	-	-	-	220.5	190.7
157.5	79.6	195.1	211.6	-	-	220.5	183.5
164.0	74.5	189.6	211.6	-	-	220.5	176.4
177.2	66.1	180.8	207.2	-	-	205.0	165.3
190.3	59.1	160.9	198.4	-	-	191.8	154.3
203.4	53.1	138.9	185.2	-	-	174.2	138.9
216.5	-	-	170.9	158.7	-	158.7	-
229.7	-	-	158.7	146.6	-	143.3	-
242.8	-	-	138.9	136.7	-	132.3	-
255.9	-	-	-	127.9	-	119.0	-
269.0	-	-	-	120.2	-	110.2	-
282.2	-	-	-	112.4	104.1	101.4	-
295.3	-	-	-	-	97.9	92.6	-
308.4	-	-	-	-	92.4	83.8	-
321.5	-	-	-	-	-	77.2	-
334.6	-	-	-	-	-	66.1	-
347.8	-	-	-	-	-	57.3	-
360.9	-	-	-	-	-	48.5	-

196.9 ft + 157.5 ft

ft	1,000 lb						
78.7	217.2	297.6	-	-	-	-	319.7
85.3	194.0	297.6	-	-	-	297.6	317.5
91.9	175.3	297.6	-	-	-	297.6	310.9
98.4	159.8	291.0	-	-	-	297.6	304.2
111.5	134.5	277.8	-	-	-	297.6	288.8
124.7	115.7	262.4	-	-	-	291.0	271.2
137.8	100.8	249.1	275.6	-	-	280.0	253.5
150.9	88.6	235.9	271.2	-	-	266.8	231.5
164.0	78.5	201.7	246.9	-	-	238.1	201.7
177.2	70.3	165.3	224.9	-	-	211.6	165.3
190.3	-	-	206.1	-	-	191.8	-
196.9	-	-	197.3	184.1	-	183.0	-
203.4	-	-	189.6	176.4	-	174.2	-
210.0	-	-	180.8	169.8	-	165.3	-
216.5	-	-	-	163.1	-	156.5	-
229.7	-	-	-	152.1	-	143.3	-
242.8	-	-	-	142.2	132.3	130.1	-
255.9	-	-	-	-	123.5	119.0	-
269.0	-	-	-	-	115.7	110.2	-
282.2	-	-	-	-	-	101.4	-
295.3	-	-	-	-	-	92.6	-
308.4	-	-	-	-	-	79.4	-
321.5	-	-	-	-	-	66.1	-

196.9 ft + 236.2 ft

ft	1,000 lb						
105.0	-	-	-	-	-	-	174.2
111.5	126.8	169.8	-	-	-	169.8	173.1
124.7	107.6	167.6	-	-	-	169.8	167.6
137.8	92.6	163.1	-	-	-	169.8	162.0
150.9	80.5	158.7	-	-	-	167.6	156.5
164.0	70.3	154.3	-	-	-	165.3	149.9
177.2	61.9	149.9	156.5	-	-	163.1	143.3
190.3	54.5	145.5	156.5	-	-	158.7	136.7
203.4	48.1	138.9	156.5	-	-	152.1	130.1
216.5	42.5	131.2	152.1	-	-	143.3	123.5
229.7	37.7	115.7	141.1	-	-	136.7	115.7
242.8	33.5	101.2	132.3	123.5	-	127.9	101.2
255.9	-	-	123.5	122.4	-	119.0	-
269.0	-	-	114.6	114.6	-	110.2	-
282.2	-	-	102.7	108.0	-	101.4	-
295.3	-	-	-	101.6	-	92.6	-
308.4	-	-	-	95.7	85.8	83.8	-
315.0	-	-	-	93.3	83.1	80.5	-
321.5	-	-	-	-	80.7	77.2	-
334.6	-	-	-	-	76.1	70.5	-
347.8	-	-	-	-	71.9	63.9	-
360.9	-	-	-	-	-	55.1	-
374.0	-	-	-	-	-	46.3	-
387.1	-	-	-	-	-	37.5	-
400.3	-	-	-	-	-	33.1	-

Remarks

Main boom angle 85°, 75°, 65° and 55°;
capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

196.9 ft + 275.6 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
114.8	-	-	-	-	-	-	127.9
124.7	104.9	125.7	-	-	-	125.7	126.8
137.8	89.9	125.7	-	-	-	125.7	124.6
150.9	77.8	123.5	-	-	-	125.7	122.4
164.0	67.7	121.3	-	-	-	125.7	120.2
177.2	58.9	119.0	-	-	-	123.5	116.8
190.3	51.4	116.8	-	-	-	121.3	114.6
203.4	45.0	114.6	114.6	-	-	121.3	111.3
216.5	39.2	112.4	114.6	-	-	116.8	108.9
229.7	34.4	108.0	114.6	-	-	112.4	104.5
242.8	30.2	105.8	114.6	-	-	110.2	100.1
255.9	26.5	97.0	114.6	-	-	105.8	95.7
269.0	23.1	86.4	112.4	91.9	-	101.4	86.4
282.2	20.3	75.4	105.8	91.9	-	97.0	75.4
295.3	-	-	99.2	91.9	-	92.6	-
308.4	-	-	88.2	91.7	-	83.8	-
321.5	-	-	77.4	86.2	-	77.2	-
334.6	-	-	-	81.4	71.2	70.5	-
347.8	-	-	-	76.7	67.0	63.9	-
354.3	-	-	-	74.7	65.0	60.6	-
360.9	-	-	-	-	63.1	57.3	-
374.0	-	-	-	-	59.5	52.9	-
387.1	-	-	-	-	56.4	46.3	-
400.3	-	-	-	-	-	37.5	-
413.4	-	-	-	-	-	30.9	-
426.5	-	-	-	-	-	26.5	-
439.6	-	-	-	-	-	19.8	-

236.2 ft + 78.7 ft

ft	1,000 lb						
59.1	324.1	407.9	-	-	-	-	478.4
65.6	280.0	407.9	-	-	-	410.1	471.8
72.2	246.9	385.8	-	-	-	405.7	451.9
78.7	219.4	370.4	-	-	-	405.7	434.3
85.3	197.3	357.1	-	-	-	405.7	414.5
91.9	178.6	346.1	-	-	-	401.2	399.0
98.4	163.1	335.1	-	-	-	388.0	381.4
111.5	-	-	370.4	-	-	374.8	-
124.7	-	-	343.9	-	-	335.1	-
137.8	-	-	304.2	-	-	291.0	-
144.4	-	-	288.8	-	-	273.4	-
164.0	-	-	-	229.3	-	227.1	-
177.2	-	-	-	209.4	-	202.8	-
183.7	-	-	-	200.6	-	191.8	-
190.3	-	-	-	-	-	180.8	-
203.4	-	-	-	-	-	163.1	-
216.5	-	-	-	-	-	147.7	-
229.7	-	-	-	-	-	134.5	-
242.8	-	-	-	-	-	121.3	-
255.9	-	-	-	-	-	110.2	-
269.0	-	-	-	-	-	97.0	-
282.2	-	-	-	-	-	83.8	-
295.3	-	-	-	-	-	-	-

236.2 ft + 118.1 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
72.2	242.5	306.4	-	-	-	-	359.4
78.7	216.1	302.0	-	-	-	304.2	350.5
85.3	194.0	295.4	-	-	-	304.2	339.5
91.9	175.3	286.6	-	-	-	304.2	330.7
98.4	159.8	277.8	-	-	-	304.2	319.7
111.5	134.5	262.4	-	-	-	299.8	299.8
124.7	115.7	246.9	-	-	-	291.0	280.0
131.2	108.7	241.4	284.4	-	-	285.5	269.0
137.8	101.6	235.9	284.4	-	-	280.0	257.9
141.1	-	-	280.0	-	-	275.0	242.5
150.9	-	-	269.0	-	-	260.1	-
164.0	-	-	242.5	-	-	229.3	-
177.2	-	-	222.7	-	-	205.0	-
190.3	-	-	-	186.3	-	183.0	-
203.4	-	-	-	172.0	-	165.3	-
216.5	-	-	-	158.7	-	149.9	-
223.1	-	-	-	153.2	-	142.2	-
236.2	-	-	-	-	130.1	129.0	-
242.8	-	-	-	-	125.7	123.5	-
255.9	-	-	-	-	117.9	112.4	-
269.0	-	-	-	-	-	101.4	-
282.2	-	-	-	-	-	92.6	-
295.3	-	-	-	-	-	83.8	-
308.4	-	-	-	-	-	70.5	-
321.5	-	-	-	-	-	59.5	-

236.2 ft + 157.5 ft

ft	1,000 lb						
82.0	-	-	-	-	-	-	271.2
85.3	189.6	233.7	-	-	-	-	271.2
91.9	170.9	233.7	-	-	-	233.7	264.6
98.4	155.4	231.5	-	-	-	233.7	260.1
111.5	131.2	222.7	-	-	-	233.7	249.1
124.7	112.4	213.8	-	-	-	233.7	235.9
137.8	97.7	202.8	-	-	-	233.7	224.9
150.9	85.8	194.0	227.1	-	-	233.7	212.7
164.0	75.8	185.2	222.7	-	-	222.7	200.6
177.2	67.7	176.4	207.2	-	-	207.2	176.4
190.3	-	-	196.2	-	-	185.2	-
203.4	-	-	184.1	-	-	167.6	-
216.5	-	-	169.8	154.3	-	152.1	-
229.7	-	-	-	143.3	-	136.7	-
242.8	-	-	-	133.4	-	125.7	-
255.9	-	-	-	125.7	-	114.6	-
269.0	-	-	-	-	105.8	103.6	-
282.2	-	-	-	-	99.2	94.8	-
295.3	-	-	-	-	93.5	86.0	-
308.4	-	-	-	-	-	77.2	-
321.5	-	-	-	-	-	70.5	-
334.6	-	-	-	-	-	61.7	-
347.8	-	-	-	-	-	50.7	-
360.9	-	-	-	-	-	41.9	-
374.0	-	-	-	-	-	-	-

Remarks: see page 46

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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

236.2 ft + 196.9 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
95.1	-	-	-	-	-	-	206.1
98.4	151.0	180.8	-	-	-	-	206.1
111.5	126.8	178.6	-	-	-	180.8	199.5
124.7	108.5	174.2	-	-	-	180.8	192.9
137.8	93.7	167.6	-	-	-	180.8	185.2
150.9	81.8	160.9	-	-	-	180.8	176.4
164.0	71.9	156.5	-	-	-	180.8	168.7
170.6	67.8	154.3	174.2	-	-	179.7	164.2
177.2	63.7	152.1	174.2	-	-	178.6	159.8
190.3	56.7	145.5	174.2	-	-	169.8	148.8
203.4	50.5	141.1	169.8	-	-	158.7	140.0
216.5	45.0	122.4	163.1	-	-	149.9	122.4
219.8	-	-	160.9	-	-	147.2	115.7
229.7	-	-	153.2	-	-	138.9	-
236.2	-	-	147.7	133.4	-	132.3	-
242.8	-	-	143.3	127.9	-	125.7	-
255.9	-	-	133.4	120.2	-	114.6	-
269.0	-	-	-	112.4	-	103.6	-
282.2	-	-	-	105.6	-	94.8	-
295.3	-	-	-	99.6	86.6	86.0	-
308.4	-	-	-	-	81.4	77.2	-
321.5	-	-	-	-	76.7	70.5	-
334.6	-	-	-	-	72.5	63.9	-
347.8	-	-	-	-	-	57.3	-
360.9	-	-	-	-	-	48.5	-
374.0	-	-	-	-	-	41.9	-
387.1	-	-	-	-	-	33.1	-
400.3	-	-	-	-	-	28.7	-
413.4	-	-	-	-	-	-	-
426.5	-	-	-	-	-	-	-
439.6	-	-	-	-	-	-	-

236.2 ft + 236.2 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
108.3	-	-	-	-	-	-	154.3
111.5	122.4	138.9	-	-	-	-	154.3
124.7	104.1	138.9	-	-	-	138.9	151.0
137.8	89.3	134.5	-	-	-	138.9	146.6
150.9	77.4	132.3	-	-	-	138.9	142.2
164.0	67.7	127.9	-	-	-	138.9	136.7
177.2	58.9	123.5	-	-	-	138.9	132.3
190.3	51.6	119.0	132.3	-	-	134.5	126.8
203.4	45.4	116.8	132.3	-	-	130.1	121.3
216.5	39.9	112.4	132.3	-	-	123.5	115.7
229.7	35.3	105.8	130.1	-	-	119.0	111.3
242.8	31.1	99.2	130.1	-	-	114.6	105.4
255.9	27.8	89.5	127.9	-	-	108.0	89.5
262.5	-	-	124.6	105.2	-	105.8	-
269.0	-	-	120.2	105.2	-	103.6	-
282.2	-	-	113.5	99.9	-	94.8	-
295.3	-	-	99.2	93.5	-	86.0	-
308.4	-	-	-	87.7	-	77.2	-
321.5	-	-	-	82.5	-	70.5	-
328.1	-	-	-	80.2	67.7	66.1	-
334.6	-	-	-	78.0	65.5	61.7	-
347.8	-	-	-	-	61.7	57.3	-
360.9	-	-	-	-	58.2	50.7	-
367.5	-	-	-	-	56.7	48.5	-
374.0	-	-	-	-	-	46.3	-
387.1	-	-	-	-	-	37.5	-
400.3	-	-	-	-	-	30.9	-
413.4	-	-	-	-	-	24.3	-
426.5	-	-	-	-	-	19.8	-
439.6	-	-	-	-	-	13.2	-
452.8	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

236.2 ft + 275.6 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°		85°
ft	1,000 lb						
118.1	-	-	-	-	-	-	115.7
124.7	101.4	105.8	-	-	-	-	115.7
137.8	86.6	105.8	-	-	-	105.8	112.4
150.9	74.7	103.6	-	-	-	105.8	111.3
164.0	64.6	101.4	-	-	-	105.8	108.9
177.2	56.0	101.4	-	-	-	105.8	106.3
190.3	48.5	99.2	-	-	-	105.8	103.6
203.4	42.3	97.0	99.2	-	-	103.6	101.0
216.5	36.8	94.8	99.2	-	-	101.4	98.3
229.7	32.0	92.6	99.2	-	-	99.2	95.5
242.8	27.8	88.2	99.2	-	-	97.0	92.4
255.9	24.0	86.0	97.0	-	-	92.6	89.3
269.0	20.9	83.8	94.8	-	-	90.4	86.4
282.2	18.1	77.2	92.6	77.2	-	83.8	78.5
295.3	15.7	66.6	92.6	76.9	-	77.2	66.6
308.4	-	-	88.2	76.9	-	75.0	-
321.5	-	-	83.8	76.9	-	70.5	-
334.6	-	-	74.7	73.2	-	63.9	-
347.8	-	-	-	69.0	-	57.3	-
354.3	-	-	-	67.0	54.9	54.0	-
360.9	-	-	-	65.0	53.4	50.7	-
374.0	-	-	-	61.5	50.0	46.3	-
387.1	-	-	-	-	47.0	41.9	-
400.3	-	-	-	-	44.3	35.3	-
406.8	-	-	-	-	43.0	33.1	-
413.4	-	-	-	-	-	30.9	-
426.5	-	-	-	-	-	24.3	-
439.6	-	-	-	-	-	17.6	-
452.8	-	-	-	-	-	13.2	-
465.9	-	-	-	-	-	8.8	-
479.0	-	-	-	-	-	-	-

275.6 ft + 118.1 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°		85°
ft	1,000 lb						
75.5	-	-	-	-	-	-	284.4
78.7	209.4	231.5	-	-	-	231.5	284.4
85.3	188.5	224.9	-	-	-	231.5	275.6
91.9	169.8	218.3	-	-	-	229.3	269.0
98.4	155.4	211.6	-	-	-	229.3	260.1
111.5	131.2	200.6	-	-	-	229.3	244.7
124.7	112.4	191.8	-	-	-	227.1	231.5
137.8	98.1	183.0	-	-	-	224.9	218.3
144.4	-	-	220.5	-	-	221.6	211.6
150.9	-	-	220.5	-	-	218.3	-
164.0	-	-	209.4	-	-	202.8	-
177.2	-	-	198.4	-	-	189.6	-
190.3	-	-	189.6	-	-	178.6	-
203.4	-	-	-	160.9	-	158.7	-
216.5	-	-	-	148.8	-	143.3	-
229.7	-	-	-	138.9	-	130.1	-
236.2	-	-	-	133.4	-	123.5	-
242.8	-	-	-	-	-	116.8	-
255.9	-	-	-	-	-	105.8	-
262.5	-	-	-	-	101.9	100.3	-
269.0	-	-	-	-	98.8	94.8	-
275.6	-	-	-	-	95.7	89.3	-
282.2	-	-	-	-	-	83.8	-
295.3	-	-	-	-	-	77.2	-
308.4	-	-	-	-	-	68.3	-
321.5	-	-	-	-	-	59.5	-
334.6	-	-	-	-	-	50.7	-
347.8	-	-	-	-	-	41.9	-
360.9	-	-	-	-	-	33.1	-
374.0	-	-	-	-	-	-	-
387.1	-	-	-	-	-	-	-

4

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

275.6 ft + 157.5 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°			85°
ft	1,000 lb						
85.3	176.4	179.7	-	-	-	-	220.5
91.9	166.4	179.7	-	-	-	178.6	219.4
98.4	151.0	174.2	-	-	-	178.6	215.0
111.5	126.8	167.6	-	-	-	178.6	205.0
124.7	108.7	158.7	-	-	-	178.6	195.1
137.8	94.4	152.1	-	-	-	176.4	186.3
150.9	82.5	145.5	-	-	-	174.2	177.5
157.5	77.7	143.3	172.0	-	-	174.2	173.1
164.0	73.0	141.1	172.0	-	-	174.2	168.7
177.2	65.0	134.5	169.8	-	-	165.3	159.8
183.7	-	-	167.6	-	-	160.9	156.5
190.3	-	-	163.1	-	-	156.5	-
203.4	-	-	158.7	-	-	147.7	-
216.5	-	-	149.9	-	-	138.9	-
229.7	-	-	143.3	133.4	-	132.3	-
242.8	-	-	-	124.6	-	119.0	-
255.9	-	-	-	115.7	-	108.0	-
269.0	-	-	-	109.3	-	97.0	-
275.6	-	-	-	106.0	-	91.5	-
282.2	-	-	-	-	-	86.0	-
288.7	-	-	-	-	83.8	81.6	-
295.3	-	-	-	-	81.1	77.2	-
308.4	-	-	-	-	76.3	70.5	-
315.0	-	-	-	-	74.3	67.2	-
321.5	-	-	-	-	-	63.9	-
334.6	-	-	-	-	-	57.3	-
347.8	-	-	-	-	-	48.5	-
360.9	-	-	-	-	-	41.9	-
374.0	-	-	-	-	-	33.1	-
387.1	-	-	-	-	-	26.5	-
400.3	-	-	-	-	-	19.8	-

275.6 ft + 196.9 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°			85°
ft	1,000 lb						
98.4	135.6	141.1	-	-	-	-	169.8
111.5	122.4	141.1	-	-	-	136.7	165.3
124.7	104.7	136.7	-	-	-	136.7	159.8
137.8	90.2	130.1	-	-	-	136.7	154.3
150.9	78.5	125.7	-	-	-	136.7	147.7
164.0	69.0	121.3	-	-	-	136.7	142.2
177.2	60.6	114.6	132.3	-	-	136.7	135.6
190.3	53.6	110.2	132.3	-	-	134.5	130.1
203.4	47.4	105.8	130.1	-	-	127.9	124.6
216.5	42.3	101.4	127.9	-	-	123.5	119.0
223.1	-	-	125.7	-	-	120.2	115.7
229.7	-	-	123.5	-	-	116.8	-
242.8	-	-	119.0	-	-	112.4	-
255.9	-	-	114.6	102.3	-	105.8	-
269.0	-	-	108.0	100.8	-	97.0	-
282.2	-	-	-	96.3	-	88.2	-
295.3	-	-	-	90.4	-	79.4	-
308.4	-	-	-	85.1	-	70.5	-
315.0	-	-	-	82.7	-	67.2	-
321.5	-	-	-	-	65.0	63.9	-
334.6	-	-	-	-	61.1	57.3	-
347.8	-	-	-	-	57.5	50.7	-
354.3	-	-	-	-	56.0	47.4	-
360.9	-	-	-	-	-	44.1	-
374.0	-	-	-	-	-	37.5	-
387.1	-	-	-	-	-	30.9	-
400.3	-	-	-	-	-	24.3	-
413.4	-	-	-	-	-	17.6	-
426.5	-	-	-	-	-	13.2	-
439.6	-	-	-	-	-	-	-
452.8	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

275.6 ft + 236.2 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
111.5	105.8	108.0	-	-	-	-	129.0
124.7	100.1	108.0	-	-	-	105.8	126.8
137.8	85.8	105.8	-	-	-	105.8	122.4
150.9	74.1	103.6	-	-	-	105.8	119.0
164.0	63.9	99.2	-	-	-	105.8	115.7
177.2	55.6	97.0	-	-	-	105.8	111.3
190.3	48.5	92.6	-	-	-	105.8	108.0
196.9	45.4	91.5	103.6	-	-	105.8	106.0
203.4	42.3	90.4	103.6	-	-	105.8	104.1
216.5	37.0	86.0	101.4	-	-	101.4	100.3
229.7	32.4	83.8	101.4	-	-	99.2	96.3
242.8	28.4	81.6	99.2	-	-	97.0	92.6
255.9	25.1	79.4	97.0	-	-	92.6	88.8
259.2	-	-	95.9	-	-	90.9	87.7
269.0	-	-	94.8	-	-	86.0	-
275.6	-	-	92.6	78.0	-	81.6	-
282.2	-	-	90.4	78.0	-	77.2	-
295.3	-	-	88.2	77.4	-	75.0	-
308.4	-	-	86.0	75.4	-	70.5	-
321.5	-	-	-	73.0	-	61.7	-
334.6	-	-	-	69.2	-	55.1	-
347.8	-	-	-	65.3	50.5	48.5	-
360.9	-	-	-	-	47.4	44.1	-
374.0	-	-	-	-	44.5	37.5	-
387.1	-	-	-	-	41.9	33.1	-
393.7	-	-	-	-	40.6	29.8	-
400.3	-	-	-	-	-	26.5	-
413.4	-	-	-	-	-	22.0	-
426.5	-	-	-	-	-	15.4	-
439.6	-	-	-	-	-	11.0	-
452.8	-	-	-	-	-	-	-
465.9	-	-	-	-	-	-	-
479.0	-	-	-	-	-	-	-

275.6 ft + 275.6 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
121.4	-	-	-	-	-	-	98.1
124.7	83.8	88.2	-	-	-	-	98.1
137.8	80.9	88.2	-	-	-	83.8	96.6
150.9	69.7	86.0	-	-	-	83.8	94.6
164.0	60.2	83.8	-	-	-	83.8	92.4
177.2	52.5	81.6	-	-	-	83.8	89.9
190.3	45.4	79.4	-	-	-	83.8	87.3
203.4	39.2	77.2	-	-	-	83.8	84.9
216.5	34.0	75.0	81.6	-	-	83.8	82.2
229.7	29.3	72.8	81.6	-	-	81.6	79.6
242.8	25.1	70.5	81.6	-	-	81.6	76.9
255.9	21.6	68.3	81.6	-	-	79.4	74.3
269.0	18.5	63.9	79.4	-	-	77.2	71.7
282.2	15.7	61.7	77.2	-	-	75.0	69.0
295.3	13.2	59.5	77.2	-	-	70.5	66.6
298.6	-	-	76.1	-	-	68.3	65.9
301.8	-	-	75.0	58.4	-	66.1	-
308.4	-	-	75.0	58.4	-	61.7	-
321.5	-	-	72.8	58.4	-	55.1	-
334.6	-	-	68.3	57.5	-	52.9	-
341.2	-	-	54.5	56.9	-	51.8	-
347.8	-	-	-	56.2	-	50.7	-
360.9	-	-	-	54.5	-	44.1	-
374.0	-	-	-	52.2	-	39.7	-
380.6	-	-	-	51.4	38.1	36.4	-
387.1	-	-	-	50.3	36.8	33.1	-
400.3	-	-	-	-	34.4	28.7	-
413.4	-	-	-	-	32.0	24.3	-
426.5	-	-	-	-	30.0	19.8	-
433.1	-	-	-	-	29.1	16.5	-
439.6	-	-	-	-	-	13.2	-
452.8	-	-	-	-	-	8.8	-
465.9	-	-	-	-	-	-	-

4

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

315.0 ft + 118.1 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
78.7	173.1	178.6	-	-	-	-	219.4
85.3	173.1	178.6	-	-	-	176.4	216.1
91.9	164.2	170.9	-	-	-	175.3	210.5
98.4	149.9	165.3	-	-	-	173.1	203.9
111.5	125.7	154.3	-	-	-	168.7	191.8
124.7	108.5	144.4	-	-	-	164.2	179.7
137.8	94.4	136.7	-	-	-	158.7	168.7
147.6	-	-	-	-	-	154.6	160.9
150.9	-	-	148.8	-	-	153.2	-
164.0	-	-	144.4	-	-	146.6	-
177.2	-	-	136.7	-	-	141.1	-
190.3	-	-	130.1	-	-	136.7	-
203.4	-	-	120.2	-	-	132.3	-
216.5	-	-	-	-	-	127.9	-
223.1	-	-	-	115.7	-	125.7	-
229.7	-	-	-	113.5	-	123.5	-
242.8	-	-	-	106.0	-	110.2	-
255.9	-	-	-	97.7	-	98.5	-
269.0	-	-	-	-	-	88.0	-
282.2	-	-	-	-	78.9	78.3	-
295.3	-	-	-	-	74.1	69.7	-
301.8	-	-	-	-	71.9	65.7	-
308.4	-	-	-	-	-	61.7	-
321.5	-	-	-	-	-	54.5	-
334.6	-	-	-	-	-	47.2	-
347.8	-	-	-	-	-	39.2	-
360.9	-	-	-	-	-	31.5	-
374.0	-	-	-	-	-	23.8	-
387.1	-	-	-	-	-	17.2	-
400.3	-	-	-	-	-	-	-
413.4	-	-	-	-	-	-	-
426.5	-	-	-	-	-	-	-
439.6	-	-	-	-	-	-	-

315.0 ft + 157.5 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
88.6	-	-	-	-	-	-	168.7
91.9	133.4	133.4	-	-	-	-	168.7
98.4	133.4	133.4	-	-	-	135.6	166.4
111.5	122.4	125.7	-	-	-	133.4	158.7
124.7	104.7	119.0	-	-	-	130.1	151.0
137.8	90.4	112.4	-	-	-	127.9	143.3
150.9	79.1	107.1	-	-	-	123.5	135.6
164.0	69.7	101.9	-	-	-	119.0	129.0
170.6	65.8	99.2	114.6	-	-	117.4	125.1
177.2	61.9	96.6	114.6	-	-	115.7	121.3
187.0	-	-	111.3	-	-	111.6	116.8
190.3	-	-	110.2	-	-	110.2	-
203.4	-	-	105.8	-	-	108.0	-
216.5	-	-	101.4	-	-	103.6	-
229.7	-	-	94.8	-	-	101.4	-
242.8	-	-	90.4	89.3	-	97.0	-
255.9	-	-	-	86.9	-	94.8	-
269.0	-	-	-	81.6	-	90.4	-
282.2	-	-	-	76.3	-	80.9	-
288.7	-	-	-	73.4	-	76.5	-
295.3	-	-	-	-	-	72.1	-
308.4	-	-	-	-	-	63.9	-
315.0	-	-	-	-	61.5	60.3	-
321.5	-	-	-	-	59.5	56.7	-
334.6	-	-	-	-	56.0	49.8	-
341.2	-	-	-	-	54.5	46.7	-
347.8	-	-	-	-	-	43.7	-
360.9	-	-	-	-	-	37.0	-
374.0	-	-	-	-	-	30.2	-
387.1	-	-	-	-	-	23.6	-
400.3	-	-	-	-	-	17.2	-
413.4	-	-	-	-	-	10.8	-
426.5	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

315.0 ft + 196.9 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°		85°
ft	1,000 lb						
101.7	-	-	-	-	-	-	132.3
111.5	101.2	101.2	-	-	-	104.3	130.1
124.7	97.2	97.2	-	-	-	102.3	124.6
137.8	86.4	92.8	-	-	-	100.3	119.0
150.9	75.0	88.4	-	-	-	98.3	113.5
164.0	65.3	84.2	-	-	-	95.5	108.5
177.2	57.1	79.8	-	-	-	94.8	103.2
190.3	50.3	76.3	90.4	-	-	92.6	98.3
203.4	44.3	72.8	90.4	-	-	90.4	93.5
216.5	39.2	68.8	88.2	-	-	88.2	88.6
226.4	-	-	84.9	-	-	86.5	85.1
229.7	-	-	83.8	-	-	86.0	-
242.8	-	-	81.6	-	-	81.6	-
255.9	-	-	77.2	-	-	79.4	-
269.0	-	-	72.8	65.7	-	77.2	-
275.6	-	-	63.1	65.3	-	76.1	-
282.2	-	-	-	64.6	-	75.0	-
295.3	-	-	-	60.8	-	72.8	-
308.4	-	-	-	56.9	-	64.8	-
321.5	-	-	-	53.1	-	57.3	-
328.1	-	-	-	51.6	-	53.9	-
334.6	-	-	-	-	-	50.5	-
341.2	-	-	-	-	45.4	47.3	-
347.8	-	-	-	-	45.4	44.1	-
360.9	-	-	-	-	42.5	38.4	-
374.0	-	-	-	-	39.5	32.2	-
387.1	-	-	-	-	-	26.2	-
400.3	-	-	-	-	-	20.3	-
413.4	-	-	-	-	-	14.6	-
426.5	-	-	-	-	-	9.0	-
439.6	-	-	-	-	-	-	-

315.0 ft + 236.2 ft

	SWSL					SFSL	HSWSL
0 t	0 lb – 551,300 lb						
396.8 klb + 132.3 klb ZB	352,700 lb						
85°	85°	75°	65°	55°		85°
ft	1,000 lb						
114.8	-	-	-	-	-	-	101.0
124.7	77.8	77.8	-	-	-	80.0	99.4
137.8	75.2	75.2	-	-	-	78.7	96.1
150.9	68.3	72.3	-	-	-	77.2	92.6
164.0	59.3	69.2	-	-	-	75.4	89.1
177.2	51.8	65.9	-	-	-	73.4	85.3
190.3	45.0	62.6	-	-	-	72.8	81.8
203.4	39.0	59.5	-	-	-	72.8	78.3
210.0	36.5	58.4	70.5	-	-	71.7	76.6
216.5	34.0	57.3	70.5	-	-	70.5	75.0
229.7	29.5	55.1	68.3	-	-	68.3	71.7
242.8	25.6	52.9	66.1	-	-	66.1	68.1
255.9	22.3	50.7	63.9	-	-	66.1	64.8
262.5	-	-	63.9	-	-	65.0	63.3
269.0	-	-	61.7	-	-	63.9	-
282.2	-	-	59.5	-	-	61.7	-
295.3	-	-	57.3	48.9	-	59.5	-
308.4	-	-	53.4	48.1	-	57.3	-
315.0	-	-	45.4	47.2	-	56.2	-
321.5	-	-	-	45.9	-	55.1	-
334.6	-	-	-	43.0	-	50.0	-
347.8	-	-	-	39.9	-	41.9	-
360.9	-	-	-	37.3	-	37.5	-
367.5	-	-	-	35.9	-	34.7	-
374.0	-	-	-	-	32.0	32.0	-
387.1	-	-	-	-	30.6	26.2	-
400.3	-	-	-	-	28.4	20.9	-
413.4	-	-	-	-	26.2	15.7	-
426.5	-	-	-	-	-	10.6	-
439.6	-	-	-	-	-	-	-
452.8	-	-	-	-	-	-	-

4

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

BIGGE This information is for reference use only. Operators manual should be consulted and adhered to.
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TEREX

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

315.0 ft + 275.6 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
124.7	60.2	60.2	-	-	-	-	73.4
137.8	60.2	60.2	-	-	-	61.1	73.4
150.9	57.5	57.5	-	-	-	60.0	73.4
164.0	54.2	55.1	-	-	-	58.4	71.0
177.2	47.0	52.9	-	-	-	57.3	68.6
190.3	40.6	50.7	-	-	-	57.3	65.9
203.4	35.3	48.5	-	-	-	57.3	63.5
216.5	30.6	46.3	-	-	-	55.1	60.8
223.1	28.5	46.3	52.9	-	-	55.1	59.6
229.7	26.5	46.3	52.9	-	-	55.1	58.4
242.8	22.5	44.1	52.9	-	-	52.9	56.0
255.9	19.0	41.9	50.7	-	-	50.7	53.8
269.0	15.9	39.7	50.7	-	-	50.7	51.6
282.2	13.2	37.5	48.5	-	-	48.5	49.2
295.3	10.8	37.5	46.3	-	-	46.3	47.0
301.8	-	-	46.3	-	-	46.3	45.9
308.4	-	-	44.1	-	-	46.3	-
315.0	-	-	44.1	34.2	-	45.2	-
321.5	-	-	44.1	34.2	-	44.1	-
334.6	-	-	40.8	33.7	-	41.9	-
347.8	-	-	32.0	32.4	-	39.7	-
354.3	-	-	31.1	31.5	-	38.6	-
360.9	-	-	-	30.6	-	37.5	-
374.0	-	-	-	28.9	-	24.0	-
387.1	-	-	-	27.3	-	-	-
400.3	-	-	-	25.6	20.9	-	-
406.8	-	-	-	24.7	20.9	-	-
413.4	-	-	-	-	20.7	-	-
426.5	-	-	-	-	19.2	-	-
439.6	-	-	-	-	17.2	-	-
452.8	-	-	-	-	15.2	-	-

315.0 ft + 315.0 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
137.8	42.8	42.8	-	-	-	-	-
150.9	42.8	42.8	-	-	-	43.7	-
164.0	40.8	41.9	-	-	-	42.8	-
177.2	39.7	39.7	-	-	-	41.9	-
190.3	37.3	39.7	-	-	-	41.9	-
203.4	32.0	37.5	-	-	-	41.9	-
216.5	27.3	35.3	-	-	-	41.9	-
229.7	23.4	35.3	-	-	-	39.7	-
242.8	19.8	33.1	37.5	-	-	39.7	-
255.9	16.5	33.1	37.5	-	-	39.7	-
269.0	13.9	30.9	37.5	-	-	37.5	-
282.2	11.2	28.7	37.5	-	-	35.3	-
295.3	-	28.7	35.3	-	-	35.3	-
308.4	-	26.5	35.3	-	-	33.1	-
321.5	-	24.3	33.1	-	-	33.1	-
334.6	-	24.3	32.0	-	-	30.9	-
341.2	-	-	30.9	20.9	-	30.9	-
347.8	-	-	30.9	20.9	-	30.9	-
360.9	-	-	29.8	20.5	-	28.7	-
374.0	-	-	27.6	19.6	-	28.7	-
387.1	-	-	19.2	18.5	-	26.5	-
393.7	-	-	18.3	17.9	-	25.2	-
400.3	-	-	-	17.2	-	24.0	-
413.4	-	-	-	16.1	-	-	-
426.5	-	-	-	14.8	9.7	-	-
439.6	-	-	-	13.7	9.5	-	-
446.2	-	-	-	13.0	9.3	-	-
452.8	-	-	-	-	9.0	-	-
465.9	-	-	-	-	-	-	-
479.0	-	-	-	-	-	-	-
492.2	-	-	-	-	-	-	-

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1

For HSWSL a boom power-kit is required

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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SWSL / SFSL15° / HSWSL LIFTING CAPACITIES

27.6 ft | 36.1 – 49.2 ft | 360° | DIN/ISO

354.3 ft + 118.1 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
82.0	-	-	-	-	-	-	164.2
85.3	-	-	-	-	-	-	164.2
91.9	-	-	-	-	-	-	158.7
98.4	-	-	-	-	-	-	154.3
111.5	-	-	-	-	-	-	144.4
124.7	-	-	-	-	-	-	134.5
137.8	-	-	-	-	-	-	125.7
150.9	-	-	-	-	-	-	116.8
164.0	-	-	-	-	-	-	-

354.3 ft + 157.5 ft

ft	1,000 lb						
91.9	94.4	97.4	-	-	-	-	126.8
98.4	94.4	97.4	-	-	-	107.8	126.8
111.5	90.4	92.8	-	-	-	106.3	119.0
124.7	86.0	88.2	-	-	-	103.2	112.4
137.8	81.8	83.6	-	-	-	100.1	106.5
150.9	75.2	78.7	-	-	-	96.6	99.9
164.0	65.9	74.7	-	-	-	92.6	94.1
177.2	58.0	71.0	-	-	-	88.6	88.6
183.7	54.7	69.0	84.7	-	-	86.5	85.8
190.3	51.4	67.0	84.7	-	-	84.4	82.9
203.4	-	-	79.6	-	-	79.8	-
216.5	-	-	74.3	-	-	75.4	-
229.7	-	-	69.2	-	-	70.8	-
242.8	-	-	64.2	-	-	66.1	-
249.3	-	-	61.7	-	-	63.8	-
255.9	-	-	-	-	-	61.5	-
262.5	-	-	-	55.3	-	59.2	-
269.0	-	-	-	54.9	-	56.9	-
282.2	-	-	-	52.2	-	52.2	-
295.3	-	-	-	48.1	-	46.7	-
308.4	-	-	-	44.1	-	42.1	-
334.6	-	-	-	-	31.3	-	-
347.8	-	-	-	-	30.4	-	-
360.9	-	-	-	-	27.6	-	-
374.0	-	-	-	-	-	-	-

354.3 ft + 196.9 ft

	SWSL					SFSL	HSWSL
	0 t	0 lb – 551,300 lb					
	396.8 klb + 132.3 klb ZB	352,700 lb					
	85°	85°	75°	65°	55°		85°
ft	1,000 lb						
105.0	-	-	-	-	-	-	96.8
111.5	71.7	74.3	-	-	-	83.1	96.8
124.7	68.8	71.0	-	-	-	82.0	92.4
137.8	65.9	67.7	-	-	-	79.6	87.7
150.9	62.8	64.4	-	-	-	77.4	82.9
164.0	59.7	61.1	-	-	-	75.0	78.3
177.2	53.1	57.8	-	-	-	71.9	73.4
190.3	46.5	54.9	-	-	-	68.8	69.7
196.9	43.7	53.5	65.0	-	-	67.2	67.8
203.4	40.8	52.0	64.6	-	-	65.7	65.9
216.5	35.9	49.2	62.4	-	-	62.2	62.2
229.7	31.7	44.5	58.6	-	-	58.6	58.4
242.8	-	-	54.9	-	-	54.9	-
255.9	-	-	51.4	-	-	51.4	-
269.0	-	-	47.6	-	-	47.6	-
282.2	-	-	44.1	-	-	43.9	-
288.7	-	-	42.3	39.9	-	42.1	-
295.3	-	-	-	39.9	-	40.3	-
308.4	-	-	-	37.0	-	36.6	-
321.5	-	-	-	34.0	-	32.6	-
334.6	-	-	-	30.9	-	28.4	-
347.8	-	-	-	28.0	-	-	-
367.5	-	-	-	-	18.7	-	-
374.0	-	-	-	-	18.7	-	-
387.1	-	-	-	-	16.5	-	-
400.3	-	-	-	-	14.3	-	-
413.4	-	-	-	-	-	-	-

4

Remarks

Main boom angle 85°, 75°, 65° and 55°; capacities for intermediate boom positions are calculated by the crane control system IC-1
For HSWSL a boom power-kit is required

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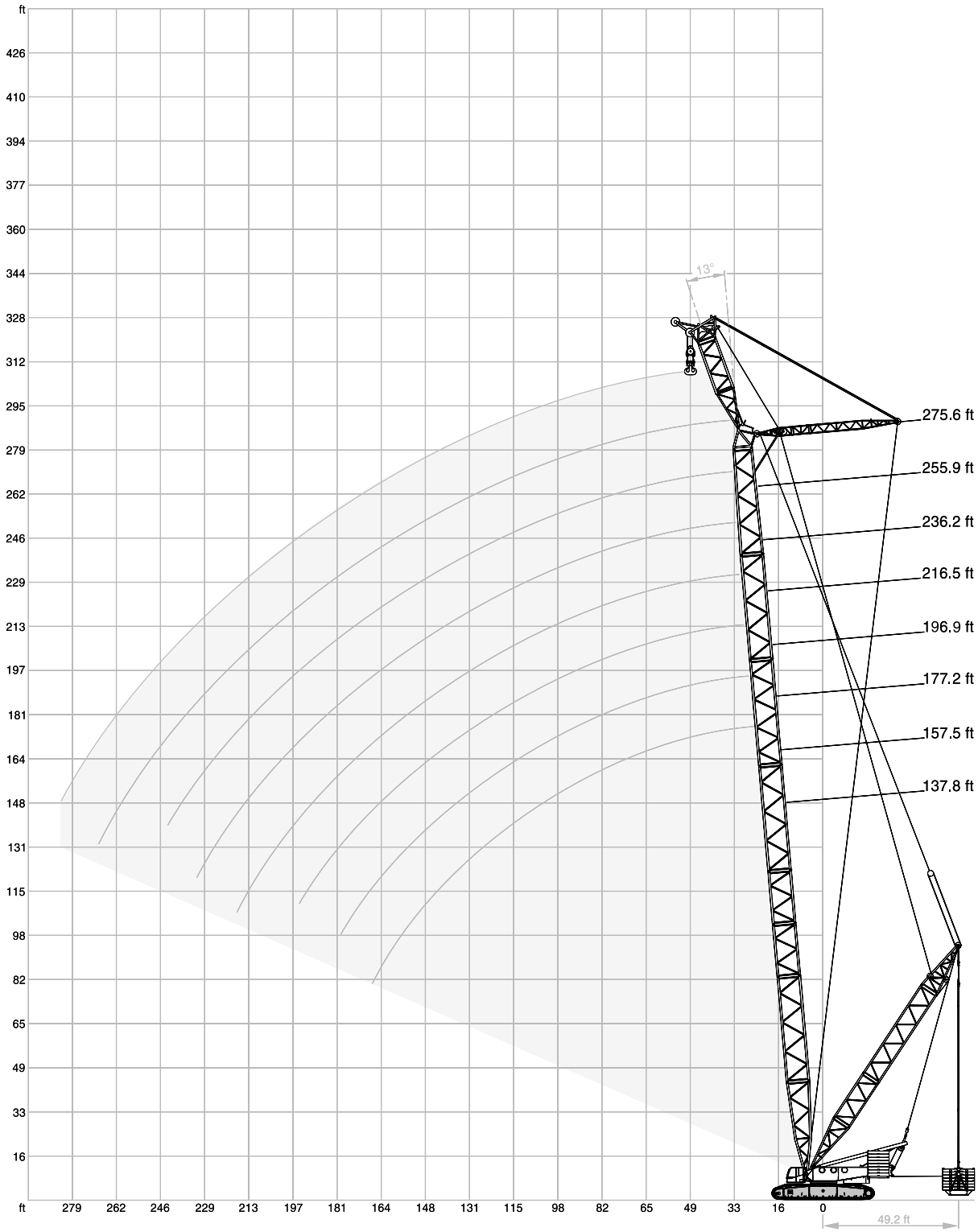
TEREX®

SFVL / LFVL WORKING RANGES 13°



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TEREX

DEMAG CC2800-1
CRAWLER CRANE

SFVL / LFVL LIFTING CAPACITIES

396,800 lb + 132,300 lb ZB | 36.1 – 49.2 ft | 0-661,400 lb | 39.4 ft | 27.6 ft | 360° | DIN/ISO

	137.8 ft			157.5 ft			177.2 ft			196.9 ft		
	SFVL		LFVL	SFVL		LFVL	SFVL		LFVL	SFVL		LFVL
	13°	20°	17,5°	13°	20°	17,5°	13°	20°	17,5°	13°	20°	17,5°
ft	1,000 lb											
42.7	1018.5	-	661.4	945.8	-	661.4	-	-	661.4	-	-	-
45.9	987.7	965.6	661.4	943.6	908.3	661.4	853.2	813.5	661.4	771.6	-	661.4
52.5	930.4	921.5	661.4	919.3	884.1	661.4	848.8	813.5	661.4	767.2	736.3	661.4
59.1	868.6	868.6	661.4	868.6	859.8	661.4	844.4	806.9	661.4	762.8	725.3	661.4
65.6	769.4	782.6	661.4	776.0	778.2	661.4	771.6	773.8	661.4	751.8	714.3	661.4
72.2	698.9	701.1	641.5	694.5	696.7	652.6	690.0	692.3	661.4	685.6	683.4	661.4
78.7	630.5	632.7	593.0	626.1	628.3	617.3	621.7	623.9	612.9	617.3	619.5	621.7
85.3	573.2	575.4	549.0	582.0	577.6	573.2	577.6	573.2	575.4	560.0	564.4	571.0
91.9	526.9	526.9	507.1	533.5	535.7	529.1	531.3	533.5	531.3	526.9	524.7	529.1
98.4	485.0	487.2	467.4	487.2	489.4	487.2	485.0	487.2	485.0	480.6	482.8	482.8
111.5	416.7	418.9	396.8	414.5	414.5	414.5	410.1	412.3	410.1	405.7	407.9	407.9
124.7	352.7	359.4	335.1	357.1	357.1	352.7	352.7	354.9	354.9	350.5	350.5	350.5
137.8	304.2	304.2	288.8	313.1	313.1	302.0	308.6	310.9	308.6	304.2	306.4	306.4
150.9	251.3	251.3	253.5	273.4	273.4	262.4	273.4	273.4	273.4	269.0	269.0	269.0
164.0	203.9	-	215.0	229.3	229.3	231.5	242.5	244.7	238.1	240.3	240.3	240.3
177.2	-	-	-	190.7	-	201.7	209.4	209.4	211.6	215.0	216.1	215.0
190.3	-	-	-	-	-	-	176.4	176.4	187.4	187.4	187.4	191.8
203.4	-	-	-	-	-	-	-	-	-	159.8	159.8	170.9
216.5	-	-	-	-	-	-	-	-	-	133.4	-	-

	216.5 ft			236.2 ft			255.9 ft			275.6 ft		
	SFVL		LFVL	SFVL		LFVL	SFVL		LFVL	SFVL		LFVL
	13°	20°	17,5°	13°	20°	17,5°	13°	20°	17,5°	13°	20°	17,5°
ft	1,000 lb											
45.9	-	-	610.7	-	-	-	-	-	-	-	-	-
49.2	652.6	-	610.7	-	-	-	-	-	-	-	-	-
52.5	650.4	626.1	610.7	571.0	555.6	540.1	482.8	465.2	451.9	-	-	399.0
55.8	648.2	623.9	610.7	568.8	553.4	540.1	480.6	465.2	451.9	425.5	-	399.0
59.1	646.0	621.7	610.7	568.8	551.2	540.1	478.4	465.2	451.9	423.3	412.3	399.0
65.6	641.5	617.3	610.7	566.6	549.0	540.1	474.0	460.8	451.9	418.9	407.9	399.0
72.2	621.7	610.7	606.3	560.0	544.5	540.1	469.6	456.4	451.9	416.7	403.4	399.0
78.7	595.2	588.6	577.6	542.3	533.5	529.1	465.2	451.9	449.7	410.1	401.2	399.0
85.3	557.8	560.0	549.0	526.9	518.1	511.5	458.6	447.5	445.3	403.4	394.6	394.6
91.9	509.3	511.5	520.3	504.9	504.9	493.8	451.9	440.9	438.7	394.6	388.0	390.2
98.4	478.4	476.2	478.4	463.0	465.2	474.0	445.3	434.3	434.3	388.0	379.2	385.8
111.5	403.4	405.7	403.4	399.0	401.2	401.2	392.4	394.6	396.8	363.8	361.6	370.4
124.7	346.1	348.3	346.1	341.7	343.9	343.9	339.5	341.7	339.5	328.5	328.5	337.3
137.8	302.0	302.0	302.0	297.6	299.8	297.6	295.4	295.4	295.4	291.0	293.2	291.0
150.9	266.8	266.8	266.8	262.4	262.4	262.4	257.9	260.1	257.9	253.5	255.7	255.7
164.0	235.9	235.9	235.9	231.5	233.7	231.5	229.3	229.3	229.3	224.9	224.9	224.9
177.2	211.6	212.7	211.6	207.2	208.3	207.2	203.9	205.0	203.9	199.5	200.6	200.6
190.3	190.7	190.7	190.7	186.3	187.4	186.3	183.0	184.1	183.0	178.6	179.7	178.6
203.4	167.6	167.6	173.1	168.7	168.7	168.7	164.2	165.3	165.3	160.9	160.9	160.9
216.5	143.3	143.3	154.3	146.6	146.6	153.2	146.6	146.6	148.8	143.3	143.3	145.5
229.7	121.3	-	132.3	126.8	126.8	137.8	127.9	127.9	135.6	125.7	125.7	131.2
242.8	-	-	-	107.8	-	117.9	111.3	111.3	122.4	110.2	110.2	117.9
255.9	-	-	-	-	-	-	95.0	95.0	106.0	95.5	95.5	106.5
269.0	-	-	-	-	-	-	78.7	-	-	81.1	81.1	92.2
282.2	-	-	-	-	-	-	-	-	-	67.0	-	-

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TEREX®

TECHNICAL DESCRIPTION

CRAWLER CARRIER

	3-section carrier comprising of carbody and two crawlers. Hydraulic pin connections between crawlers and carbody provide for easy assembly and removal to minimise width and weight for transportation.
Carbody	Bending- and torsion-resistant welded structure of box type construction, fabricated of high-strength fine-grain structural steel.
Crawlers	Side frames: bending-resistant welded structure of high-strength fine-grain structural steel. Track shoes, idler and drive sprockets are fabricated of heat-treated high-strength cast steel. 15 rollers on each side frame with hardened rolling surfaces. Automatic centralized lubrication is included as standard.
Power train	The tracks are powered by two hydraulic motors each through closed planetary gear reduction units running in oil bath, equipped with spring-applied hydraulically released holding brakes; the gear units are of very compact design to fit within the width of the crawlers. Each crawler is infinitely variable controlled, both independently and in opposite direction.
Assembly jacks	Four hydraulic jacking cylinders on carbody (folding within 9.8 ft width) for easy assembly of crawlers.

SUPERSTRUCTURE

Counterweight	352,700 lb / 396,800 lb as option in combination with central ballast.
Frame	Torsion-resistant welded structure fabricated of high-strength fine-grain structural steel. Connected to carrier by triple-row roller bearing slew ring.
Drive	DaimlerChrysler diesel engine type OM 502 LA, 390 kW (530 hp) at 1800 ^{1}/min, torque 2400 Nm at 1300 ^{1}/min. The engine complies with EUROMOT 3a, EPA T3 and Carb regulations. Pump distribution gearbox with five variable displacement axial piston pumps, and gear pumps. Silencer with spark-arrestor.
Rope drums	The standard superstructure equipment includes three rope drums – hoist 1, hoist 2 and boom hoist. The drums are powered by hydraulic motors through closed planetary gear units running in oil bath. All rope drums have spring-applied, hydraulically released multi-disk brakes and non-wearing hydraulic braking for load lowering. Rope ends H 1, 2, 3 and W 1, 2 equipped with quick-connect rope end fittings. Hoists H 1 + 2 are removable to minimise weight for transportation.
A-frame	Hydraulic raising system for A-frame as standard.
Slew unit	Powered by hydraulic motor through closed, planetary gear unit running in oil bath. Spring-applied, hydraulically released holding brake and non-wearing hydraulic braking.
Control system	Demag IC-1: Electronic proportional valve pilot control integrated in stored-program control system incl. diagnostics. 2 colour monitors, rated capacity limiter operated via a touchscreen. Working speeds infinitely variable controlled by the lever position. Automatic power control for optimal utilisation of engine output, emergency control system.
Cabin	Comfortable cab with large windscreen and airconditioner. Laminated glass all around, roof window, self-contained hot air heater, full instrumentation and crane controls. The cab can be tilted back for improved operator view of boom point. A camera system is installed to monitor the rope drums. For transportation, the cab swings in front of the superstructure to minimise width.
Electrical equipment	24 V d. c. system (2 x batteries 12 V, 200 Ah).

OPTIONAL EQUIPMENT

Counterweight	44,100 lb on the superstructure (only in conjunction with central ballast).
Central ballast	132,300 lb.
Hydraulic cylinder A-frame	For self-assembly of crawlers.
Sideways outriggers	For erection of long boom systems.
Counterweight carrier	Drive 4 x 4, total weight 705,600 lb, net weight 88,200 lb, in combination with SL telescopic system.
Quick-connection	Hydraulic quick-disconnect fittings on carrier and superstructure facilitate removal to minimise weight for transportation.
Track shoes	6'-7".
Quadro-drive	Add. two hydraulic motors on the crawlers to double the driving power. The driving speed will be reduced accordingly.

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DEMAG CC2800-1
CRAWLER CRANE

TECHNICAL DESCRIPTION

BOOM CONFIGURATIONS S AND L

SH:	Main boom: foot section 34.5 ft (used to install drums W1/H3), inserts 39.4 ft and 19.7 ft (type 2724) and tapered insert 39.4 ft, head with sheave assembly 1323,000 lb 4.9 ft. Main boom lengths: 78.7-275.6 ft.
SH/LH:	Main boom: same as SH, extended by type 2421 from the fly jib and by top section 24.6 ft. Main boom lengths: 216.5-334.6 ft.
SW:	Main boom: same as SH. Fly jib: foot section 14.8 ft, inserts 39.4 ft and 19.7 ft (type 2421) and top section 24.6 ft. Main boom lengths: 98.4-216.5 ft. Fly jib lengths: 78.7-275.6 ft.
SSL:	Main boom: same as SH. Superlift equipment, Superlift counterweight 0-661,400 lb (at 110,300 lb increments). Main boom lengths: 118.1-275.6 ft.
HSSL:	Main Boom: same as SH/SSL + boom power-kit. Superlift equipment, Superlift counterweight 0-661,400 lb (at 110,300 lb increments). Main boom lengths: 177.2-354.3 ft.
SSL/LSL:	Main boom: same as SH 275.6 ft, extended by type 2421 from the fly jib and by top section 24.6 ft. Superlift equipment, Superlift counterweight 0-661,400 lb (at 110,300 lb increments). Main boom lengths: 295.3-452.8 ft.
SWSL: (SFSL)	Main boom: same as SH. Fly jib: same as SW. Superlift equipment, Superlift counterweight 0-661,400 lb (at 110,300 lb increments). Main boom lengths: 118.1-275.6 ft. Fly jib lengths: 78.7-275.6 ft.
HSWSL:	Main Boom: same as HSSL. Fly jib: same as SW/SWSL. Superlift equipment, Superlift counterweight 0-661,400 lb (at 110,300 lb increments). Main boom lengths: 177.2-354.3 ft. Fly jib lengths: 78.7-315.0 ft.
LF2:	Main boom: same as SH, SSL, HSSL, SH/LH, SH/LH SGLmax; SSL/LSL, SSL/LSL SGLmax. Fly jib lengths: 39.4 ft, 78.7 ft, 118.1 ft. Fly jib offsets: 10°, 15°, 20° for jib length 39.4 ft. Fly jib offsets: 10°, 20°, 30° for jib lengths 78.7-118.1 ft.
SFVL:	Main boom: same as SH, lengths 137.8-275.6 ft, without sheave assembly. Fly jib: foot section 14.8 ft, insert 19.7 ft; heavy-duty head 4.9 ft. Sheave assembly 1323,000 lb same as SH.
SH/LH SGLmax:	Same as SH, extended by boom power-kit + jib top section. Main boom lengths: 255.9-354.3 ft.
SSL/LSL SGLmax:	Same as SSL, extended by boom power-kit + jib top section. Main boom lengths: 295.3-452.8 ft.
Reeving winch	Mounted on superstructure
Operator aids	Electronic load indicator, hoist limit switch, limit switches for boom movements, hydraulic boom backstops, anemometer.

OPTIONAL EQUIPMENT

Power-kit for main boom	Consisting of 2-4 additional heavy main boom sections; standard main boom 275.6 ft required.
Superlift equipment standard	Mast 98.4 ft, winch with rope and tray for 661,400 lb. Mast radii 36.1 ft, 42.7 ft and 49.2 ft by adjusting the Superlift mast.
Superlift equipment with telescopic cylinder	Mast 98.4 ft, winch with rope, SL telescopic cylinder and tray for 661,400 lb. Mast position 49.2 ft. Superlift counterweight can be adjusted from 42.7-55.8 ft.
Hoist H3	Additional rope drum on main boom (for LF2 or runner operation). Line pull same as H1, rope length 2133 ft.
Runner 66,150 lb	Approx. 6.6 ft for installation on boom head or top section (not in conjunction with LF2).
Runner 132,300 lb	
Hydraulic pinning of boom sections	

6

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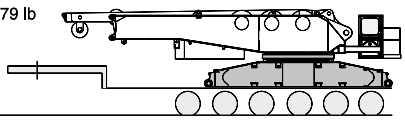
TRANSPORT EXAMPLE FOR CC 2800-1

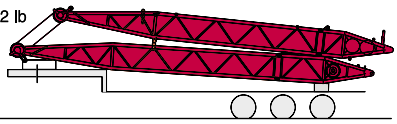
- Superlift counterweight
- Basic crane
- Boom combination SWSL 275.6 + 275.6 ft
- Containers, boxes, etc.
- Boom combination LF2 118.1 ft
- Trucks

Load approx. 180,779 lb



1x

Load approx. 48,502 lb



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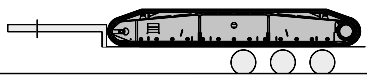
Load 99,208 lb



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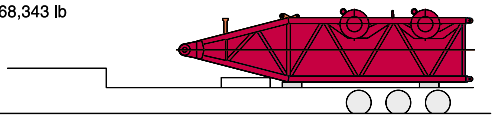
Load 68,343 lb



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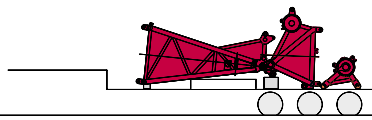
Load 44,093 lb



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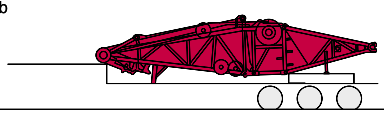
Load 59,525 lb



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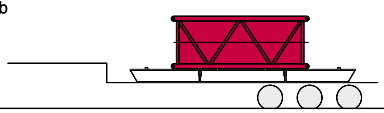
Load 44,754 lb



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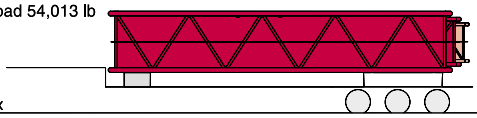
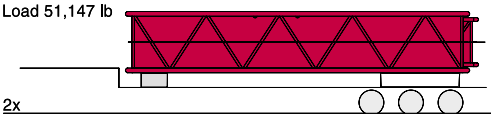
Load 54,013 lb



2x

Load 51,147 lb



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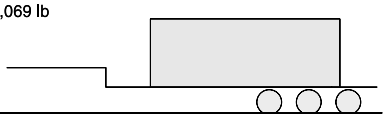
Load approx. 33,069 lb



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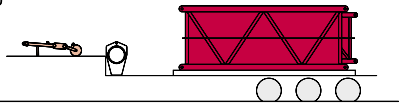
Load 66,800 lb



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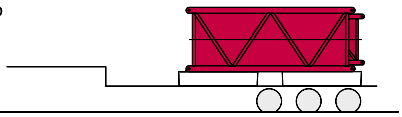
Load 59,525 lb



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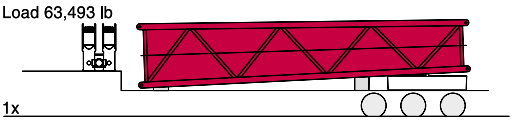
Load 63,493 lb



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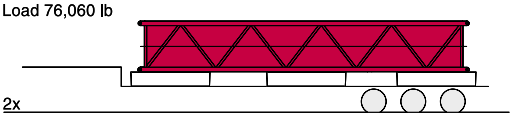
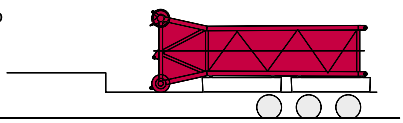
Load 76,060 lb



2x

Load 59,525 lb



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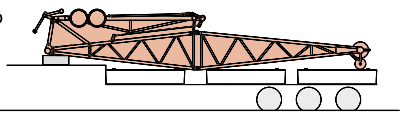
Load 73,855 lb



1x

198,416 lb Superlift counterweight can be transported together with the complete SWSL attachment 275.6 ft + 275.6 ft + 118.1 ft LF2. Depending on the load case, the remaining 462,971 lb Superlift counterweight and some mats as required, will have to be carried on separate trucks.

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NOTES TO LIFTING CAPACITY

Ratings are in compliance with ISO 4305 and DIN 15019.2 (test load = 1.25 x suspended load + 0.1 x dead weight of boom head).
Weight of hook blocks and slings is part of the load, and is to be deducted from the capacity ratings.

Consult operation manual for further details.

Note: Data published herein is intended as a guide only and shall not be construed to warrant applicability for lifting purposes.
Crane operation is subject to the computer charts and operation manual both supplied with the crane.

In some instances the superlift counterweight does not lift off the ground with the indicated load.

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TEREX®

DEMAG CC2800-1
CRAWLER CRANE

Effective Date: April 2007.
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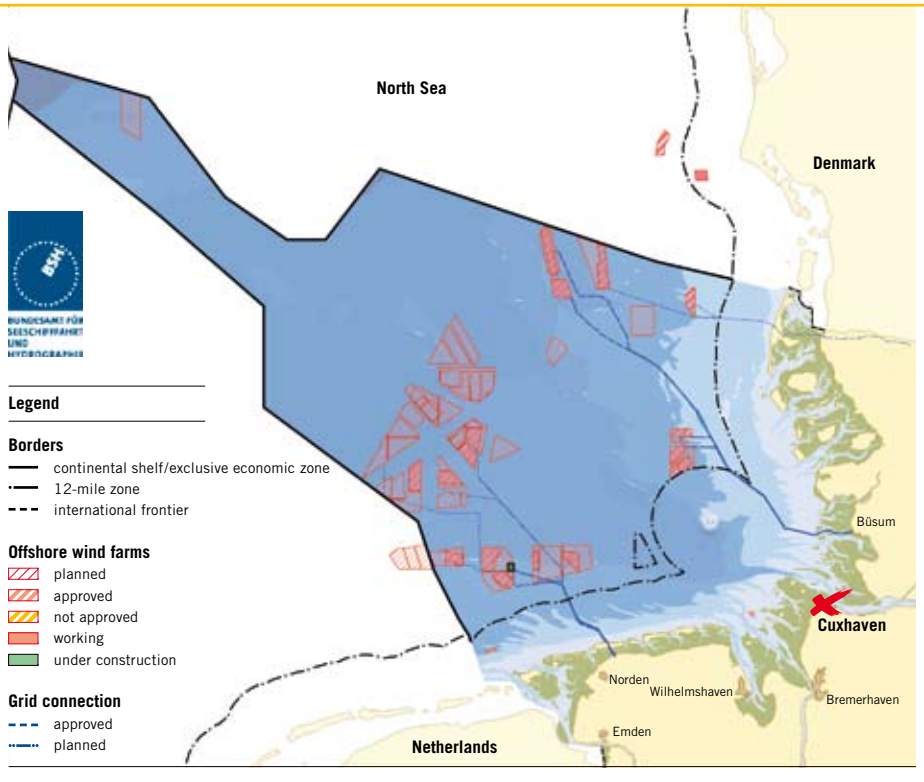
APPENDIX 34



Planned offshore windparks in the North Sea

Cuxport – Your partner for handling and storage of Offshore-Windmills

Our terminal is getting ready to support the energy needs of the future. The commencement of an ambitious extension project, together with the new heavy load and offshore platform for the transhipment of wind power plants, already today sends a fresh wind blowing through our terminals.

Specialist for wind energy plants and components

- ☐ Port of heavy lift operation with special offshore platform at a deep water berth, with vehicle access
- ☐ Handling capacity up to approx. 1,500 tons of wind energy installations
- ☐ Special cranes available for the setting up of wind energy plants
- ☐ Comprehensive heavy lift expertise and equipment
- ☐ In key position for a large number of supply chains
- ☐ Short sea crossing to the offshore fields in the German Bight
- ☐ Numerous scheduled services and excellent hinterland links

Geographical position

With its ideal location right at the Elbe Estuary, near the Kiel Canal and not far from the Weser and Jade Estuary, Cuxport is the optimal transhipment centre for all kinds of consignments.

Hinterland connections

From Cuxport you can easily reach the efficient European road and rail network in the shortest possible time. The nearby motorway link gives you direct access to the German and Central European hinterland, while the terminal rail head connects you to the biggest European marshalling yard Hamburg-Maschen. Cuxport is also directly connected to the European network of inland waterways via the river Elbe.

The universal port Cuxport is specialised in the handling of windmills.

The OffshoreBase Cuxhaven

Cuxport provides services for the OffshoreBase Cuxhaven. The latter combines the functions of a production site, a support point and a testing area for offshore wind energy systems. Cuxport is extending its facilities accordingly in order to meet the needs of the future. The heavy load berth has been specifically designed to cope with extreme stresses from foundation sections or generators. A new berth for ships of up to 270 metres in length including adjacent hinterland area is currently under construction. By 2010 this will increase Cuxport's facilities still further, with the addition of another 85,000 square metres of warehousing, storage and production site.

Heavy load berth

The rising demand for installation facilities where large modules can be assembled is catered for by our heavy load platform directly situated at berth No. 4. On an area of around 1,600 metres, wind mill structures weighing up to approx. 1,500 tons can be preassembled on a special purpose-built concrete ring foundation, so that entire offshore plants can be loaded directly via a deep water berth. The sustainable load comes to 90 tons per square metre. Our mobile harbour crane has a capacity of 100 tons and we have other mobile and floating cranes available as well, any time they are needed.

Heavy load platform of the OffshoreBase Cuxhaven.

Member of EWEA
THE EUROPEAN WIND ENERGY ASSOCIATION

Telephone +44(0)1502 509260 Contact Us

Private Roads	Yes
Distance to Helipad	
Distance to Intl. Airport	12 km
Any Comments	There is no helipad at the moment but Aalborg airport can be used.

Contact us to add your Port

Capacities at Port of Aalborg

Number Of Cranes	5
Crane Comments	5 Cranes owned by the port (including 140tonne, 45tonne and 36tonne cranes). There are 2 dedicated crane companies with high capacity cranes are located in the port.
Quay Length	200 metres
Quay Loading Capacity	42 tonnes/m2
Quay Comments	There are 2x 200m length quays.
Storage Space Available	25 hectares (250000 m2)
Storage Comments	The storage space is in excess of 250,000 metres squared.
Development Land Available	3000 hectares (3000000 m2)

Supply Chain Capabilities and Services

Suitable Installations Base?	Yes
Suitable Operations and Maintenance Base?	Yes
Can support manufacturing of ..?	**Towers** : Yes **Blades** : Yes **Foundations** : Yes **Cables** : Yes
Supplies ..?	**Provisions** : Yes **Water** : Yes **Fuel Oil** : Yes **Diesel Oil** : Yes
Services	All types of maritime services available.
Has Dry Dock?	No
Has Warehousing?	Yes
Security Level	

Hartlepool, Able Seaton Port

Space	**510,000 m²**
Quay length	**550 m**
Depth below LAT	**15.0 m**
Vessel capacity	**No limit**

Able Seaton Port is a 51 hectare multi-purpose, multi-user facility. With 15 m depth and up to 75 tonne/m² quay load out capacity (including a 2,000 tonne lift Ringer crane) the recently installed 312 m quay can handle the largest of vessels. Seaton also has the world's largest dry dock and is currently home to a number of re-cycling activities, including the so-called Ghost Ships from the US merchant fleet and the redundant French Aircraft Carrier, Le Clemenceau. The dry dock also provides crucial facilities for the construction of semi-submersible offshore drilling platforms and other marine structures.

This unique facility is located close to the mouth of the River Tees. The site has been developed for use as a facility for offshore, marine, specialist industrial and civil engineering fabrication and construction projects and also has significant potential for offshore wind construction. It offers good access by river, sea, rail and road. Durham Tees Valley Airport is 30 km away. The port also provides around 5,000 m² of covered storage and warehousing and has a full level of utility provision.

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APPENDIX 35

Design of Marine Facilities for the Berthing, Mooring, and Repair of Vessels

2nd edition

John W. Gaythwaite

ASCE PRESS

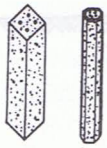
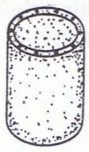
PILE TYPE	TYPICAL DIMENSIONS AND LENGTHS	USUAL RANGE OF CAPACITIES AND COLUMN LENGTHS	REMARKS
Timber	6"–8" Tip diameter 12"–20" Butt diameter Douglas fir to 80' Southern yellow pine to 65' lengths Special order up to 125'	Typically limited to between 15 and 20 tons for all column lengths	Either Southern yellow pine or Douglas fir with ready available lengths of up to 60 feet. Piles are usually pressure treated with creosote or CCA. Greenheart piles are usually untreated.
Steel H-Pile	Section depth 8" to 14" Unspliced–60'–80' lengths Splices–unlimited length	40 to 120 ton capacity with effective lengths of up to 60'.	Low displacement, able to penetrate through some obstructions, and easily spliced. The pile is vulnerable to corrosion and may be damaged or deflected when encountering obstructions. Favored for end bearing on rock.
Concrete Filled Steel Pipe	8" to 48" ϕ 5/16" to 3/4 wall thickness. Unspliced–60'–80' lengths Splices–unlimited lengths	40 to 200 tons with effective lengths up to 100'	Displacement type piles may be driven either open or close ended, easily spliced, and provides good bending resistance
Precast Concrete 	12" to 24" round, octagonal or square 60' to 120' lengths unspliced	20 to 120 tons with effective lengths up to 80'	High displacement pile may be provided with good corrosion resistance, tolerable of hard driving stresses and vulnerable to large handling stresses.
Concrete Cylinder 	30" to 54" diameter 150'–200' + lengths	120 to 240 tons with effective lengths up to 250'	Prestressing allows for large handling stresses and capable of tolerating high bending stress induced by lateral loading and long unsupported lengths.

Figure 7-5. Common marine pile types. (Prepared by GZA GeoEnvironmental, Inc.)

pile type selection and design can be found in references (21) through (23). Guidelines for pile structural design and allowable stresses can be found in the following references:

- For timber piles, references (12) and (24)
- Timber piles are normally specified to conform to ASTM D 25, *Standard Specifications for Round Timber Piles*
- For concrete piles and concrete-filled steel pipe piles, reference (25)
- For prestressed concrete piles, reference (26)