

## U.S. OFFSHORE WIND PORT READINESS

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## EXECUTIVE SUMMARY

As offshore wind energy develops in the United States, port facilities will become strategic hubs in the offshore wind farm supply chain because all plant and transport logistics must transit through these facilities. Therefore, these facilities must provide suitable infrastructure to meet the specific requirements of the offshore wind industry. As a result, it is crucial that federal and state policy-makers and port authorities take effective action to position ports in the offshore wind value chain to take best advantage of their economic potential.

The U.S. Department of Energy tasked the independent consultancy GL Garrad Hassan (GL GH) with carrying out a review of the current capability of U.S. ports to support offshore wind project development and an assessment of the challenges and opportunities related to upgrading this capability to support the targeted growth of as many as 54 gigawatts of offshore wind installed in U.S. waters by 2030. The GL GH report and the open-access web-based Ports Assessment Tool resulting from this study will aid decision-makers in making informed decisions regarding the choice of ports for specific offshore projects, and the types of investments that would be required to make individual port facilities suitable to serve offshore wind manufacturing, installation and/or operations.

**This study finds that sufficient port infrastructure exists or can be developed to meet anticipated project deployment out to 2030**

The offshore wind industry in the United States is still in its infancy; however this study finds that sufficient port infrastructure exists or can be developed to meet anticipated project deployment out to 2030. While there are currently no offshore wind farms operating in the United States, much of the infrastructure critical to the success of such projects does exist, albeit in the service of other industries. This conclusion is based on GL GH's review of U.S. ports infrastructure and its readiness to support the development of proposed offshore wind projects in U.S. waters. Specific examples of facility costs and benefits are provided for five coastal regions (North Atlantic, South Atlantic, Gulf of Mexico, Great Lakes, and Pacific) around the country.

GL GH began this study by identifying the logistical requirements of offshore wind ports to service offshore wind. This review was based on lessons learned through industry practice in Northern Europe. A web-based port readiness assessment tool was developed to allow a capability gap analysis to be conducted on existing port facilities based on the identified requirements. Cost models were added to the assessment tool, which allowed GL GH to estimate the total upgrade cost to a port over the period 2014-2030 based on a set of regional project build-out scenarios. Port fee information was gathered from each port allowing an estimate of the potential revenue to the port under this same set of scenarios. The comparison of these revenue and improvement cost figures provides an initial indication of the level of offshore wind port readiness.

To facilitate a more in-depth infrastructure analysis, six ports from different geographic regions, with varied levels of interest and preparedness towards offshore wind, were evaluated by modeling a range of installation strategies and port use types to identify gaps in capability and potential opportunities for economic development. Commonalities, trends, and specific examples from these case studies are presented and provide a summary of the current state of offshore wind port readiness in the U.S. and also illustrate the direction some ports have chosen to take to prepare for offshore wind projects. For example, the land area required for wind turbine and foundation manufacturing is substantial, particularly due to the large size of offshore wind components. Also, the necessary bearing capacity of the quayside and storage

area are typically greater for offshore wind components than for more conventional cargo handling. As a result, most U.S. ports will likely require soil strength improvements before they can fully support offshore wind project construction.

This Executive Summary describes each of these three steps: the development of port requirements, the development of the Port Assessment Tool, and the analysis of the 6 case study ports using the tool. The Executive Summary concludes with a brief discussion of key overall results and market opportunities.

## Part I: Port Requirements

The first task in this study was to identify the logistical requirements for moving offshore wind project components through a port facility. This information was largely informed by GL GH's knowledgebase developed through support of installed offshore wind projects in Europe. In keeping with the mission of this study, these requirements were then shared with a panel of industry stakeholders for review and comments were integrated. In addition, GL GH held a series of workshops, webinars, and interviews to discuss port usage with port operators, vessel operators, project developers, economic development interests, and other industry stakeholders around the country.

The cost implications of the expected use of jack-up feeder barges could be significant if vessels are required to jack up at quayside

A summary of the logistical requirements is presented in Table 1 below; additional details are provided in subsequent sections of this report. In addition, the report discusses offshore wind farm components, installation methodologies, vessels, and the implications and impacts of each of these on the port requirements in more detail. However, the requirements listed in Table 1 are very dependent on the technologies employed and so the values presented should be taken as generic. Full functionality has been provided in the Port Assessment Tool to vary these values depending on the technologies and methodologies employed. An in-depth port assessment should be carried out based on specific needs of a given project.

One notable example is the requirement for jack-up barges to be able to jack up at the quayside. Given that several of the vessels likely to be utilized for the turbine erection in early projects will be foreign-flagged, the turbine components will need to be transported from the port to the waiting installation vessel by a Jones Act-compliant feeder barge. Given the size and weight of the turbine components and delicacy of the transfer from one vessel to the other, this feeder barge will likely need to jack up before components can be transferred to the installation vessel. Similarly at the quayside, if the vessel is required to be stable during load-out to enable the components to be transferred and sea-fastened safely, the feeder barge may need to jack up at the quayside. The cost implications of retrofitting a facility to include this capability are significant and are expected to influence a port's decision about the economic benefit of such improvements.

Table 1: Summary of Typical Key Component Specs and Port Requirements

Component	Parameter	Units <sup>1,2</sup>	Wind Turbine Size [MW]				
			4	5	6	7	8
Wind Turbine	Rotor Diameter	m	120	135	150	164	175
	Blade Length	m	59	66	73	80	85
	Quayside Storage Area (one blade per frame – up to three blades)	m <sup>2</sup>	363	440	527	615	696
	Nacelle and Frame Bearing Pressure	t/m <sup>2</sup>	7	8	10	7 <sup>(3)</sup>	8
	Tower Bearing Pressure	t/m <sup>2</sup>	6	7	8	9	10
Monopile Foundation	Monopile mass (20 m LAT depth)	t	500	788	1,076	-	-
	Bearing Pressure Under Storage Blocks	t/m <sup>2</sup>	13	20	27	-	-
Jacket Foundation	Bearing Pressure Under Storage Blocks	t/m <sup>2</sup>	-	13	14	16	17
Gravity Based Structure Foundation (GBS) <sup>4</sup>	Total Mass Without Ballast	t	-	-	5,970	8,009	9,691
	Quayside Construction Area (per GBS)	m <sup>2</sup>	-	-	3,481	4,398	5,625
	Bearing Pressure (quayside construction and storage)	t/m <sup>2</sup>	-	-	12	11	10
	Minimum Width of Dry Dock for Construction	m	-	-	45	52	61
	Minimum Construction Barge Width	m	-	-	43	50	59
Substation	Topside Mass	t	500 – 4000 tonnes at approx. 6.5 tonnes per MW				
	Foundation	-	Generally same as for turbines, or jacket if required				
	Bearing Pressure	t/m <sup>2</sup>	Typically 2-9 t/m <sup>2</sup> , dependant on design				

- All masses given in metric tonnes (t)
- Unit conversion:
  - 1 m = 3.28 ft
  - 10,000 m<sup>2</sup> = 2.47 acres
  - 1 metric tonne = 1.10 short tons
  - 1 t/m<sup>2</sup> = 204.82 lb/ft<sup>2</sup>
- It is assumed that an additional SPMT vehicle will be utilized, thereby increasing the bearing area.
- Gravity Base Structure Foundations were not considered for 4 or 5 MW turbines, given the likelihood of developers to opt for jacket foundation technologies, considering the relative economics of the two concepts.

## Part II: U.S. Offshore Wind Port Assessment Tool

GL GH has developed a U.S. focused port readiness assessment tool consisting of a web-based user interface around a mathematical model and set of databases. The Port Assessment Tool was developed on the basis of current and anticipated technology trends and installation techniques for the offshore wind industry.

The two main objectives of the Port Assessment Tool are:

- To provide a publicly available tool that can be used by all stakeholders of the U.S. offshore wind industry to assess port readiness for offshore wind
- To serve this study in assessing the current status of the port infrastructure and readiness for offshore wind, in the form of opportunity assessments, cost-benefit analyses, and case studies

The web-based open-access assessment tool developed by GL GH allows users to identify suitable ports in the project vicinity and allows ports to prioritize areas of improvement

The Port Assessment Tool has been developed for multiple stakeholders, including port authorities, project developers, original equipment manufacturers, and other entities providing services to the offshore wind industry. For example, the developer of an offshore wind project can use the Port Assessment Tool to identify the nearest suitable staging port, or a port authority may wish to assess the suitability of its facilities to service regional offshore wind farm developments, while gaining some insight to the number of cost of infrastructure improvements required to better service these developments.

The Port Assessment Tool includes databases of port characteristics informed by the port owners, vessel specifications informed by GL GH's knowledgebase and by a parallel DOE-funded study conducted by Douglas-Westwood and generic turbine component characteristics informed by GL GH's knowledgebase and industry trends. Going forward, port owners have the ability to update their port information or add a facility within The Port Assessment Tool using private login details.

This assessment tool is freely available at [www.OffshoreWindPortReadiness.com](http://www.OffshoreWindPortReadiness.com).

## Part III: Case Studies: Analysis of 6 Ports Around the Country

In order to investigate port readiness for offshore wind construction and operations and to illustrate use of The Port Assessment Tool, GL GH carried out a series of case studies on representative ports in each of the coastal regions of the U.S. In keeping with other work conducted on behalf of the DOE, ports in five regions were selected for analysis. These regions are defined such that they include the following states:

- *North Atlantic*: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland
- *South Atlantic*: Virginia, North Carolina, South Carolina, Georgia, Florida (Atlantic Coast)
- *Gulf of Mexico*: Florida (Gulf Coast), Alabama, Mississippi, Louisiana, Texas
- *Pacific*: California, Oregon, Washington

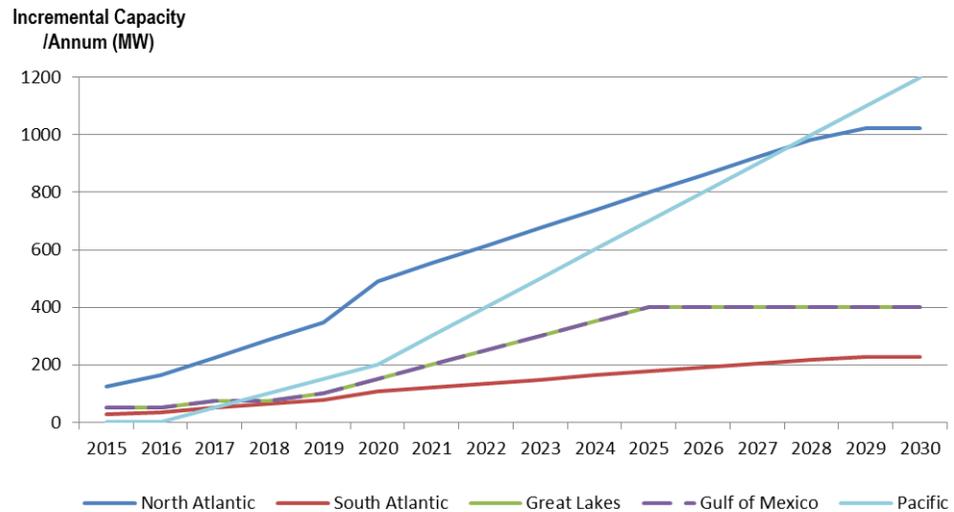
- *Great Lakes:* Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, New York

GL GH interviewed personnel from ports in each of the five regions identified and selected six ports for further analysis based in part on previous interest/investment in the port for use by the offshore wind industry. The selection of these ports is not intended to represent an endorsement of these facilities or constitute a recommendation over other nearby ports; rather, the results presented below should be interpreted as being representative of the capabilities and opportunities in these regions.

The selected ports provided information on current port capabilities and specifications. These data were added to the Port Assessment Tool, which was used to conduct the analyses summarized below.

This study considered the three primary operations for which port facilities are needed when constructing and operating an offshore wind project: manufacturing, construction staging, and O&M. For this study, the category of manufacturing was further subdivided into turbine manufacturing, foundation manufacturing, and offshore substation manufacturing.

To be consistent with other DOE-funded studies focused on the infrastructure and supply chain opportunities for offshore wind in the United States, this study uses the same set of technology and deployment assumptions developed by Douglas-Westwood, Navigant, and the National Renewable Energy Laboratory. Specifically, GL GH has based its analysis on the ‘moderate growth’ scenario defined with a target installed capacity of 28 GW in U.S. waters by 2030. Regional project deployment projections for this scenario are shown in Figure 1 below. Table 2 presents the assumed offshore wind project configurations throughout the study period.



Source: GL GH, Navigant

Figure 1: Estimated Incremental Capacity per Annum for U.S. Offshore Wind Industry – Moderate Growth Scenario

Table 2: Basic Project Assumptions

Commissioning Year	2016 – 2017	2018 – 2022	2022 – 2030
Distance to Port	<160 km (87 Nm)	Can be >160 km	Can be >160 km
Project Capacity	~ 250 MW	~ 500 MW	~ 500 MW
Turbine Capacity	4 MW	6 MW	8 MW
Water Depth	20 m	30 m	30 m
Offshore Substations	1 x 250 MW	1 x 500 MW	1 x 500 MW

GL GH conducted a gap analysis on the six selected ports by analyzing the upgrade costs required at each facility for a set 5 test cases and 5 port uses. The results of these 25 different configurations are summarized in Figure 2.



Note: Results for the ports of New Bedford, MA and Paulsboro, NJ assume that all planned facility upgrades have been completed.

Source: GL GH

Figure 2: Test Case Scenario Results

Many large and small ports around the country can be expected to see a similar result and be able to support offshore wind project O&M needs with little or no upgrade cost required

The results show that all six ports evaluated are well suited to host O&M activities and that little-to-no investment is required to close any gaps identified related to full O&M support. O&M ports are assumed to need to accommodate crew transfer and service vessels, while larger jack-up or heavy-lift vessels would be deployed out of a port designed to accommodate these vessels such as a construction staging port. As such, many large and small ports around the country can be expected to see a similar result and be able to support offshore wind project O&M needs with little or no upgrade cost required. This is advantageous to projects in that each one can then select one or more O&M ports that are in close proximity to the project site.

By contrast, today's ports generally require additional investment before they can serve as staging ports for offshore wind projects. The most common infrastructure improvement required is related to increasing the bearing capacity of the storage area and quayside. Based on the information gathered from ports around the country, typical bearing capacities are on the order of 5 t/m<sup>2</sup>, whereas turbine nacelles require bearing capacities of between 7 and 10 t/m<sup>2</sup>, depending on the size of the turbine. Furthermore, foundations require additional bearing capacity, with jackets needing between 10 and 20 t/m<sup>2</sup> and monopiles needing bearing capacities that can exceed 20 t/m<sup>2</sup>.

The most expensive gap identified by these results is related to the ability of jack-up vessels to jack up at the quayside. In ports where the seabed does not yet support jacking up, the costs of upgrading the seabed make turbine staging the most expensive operation for these ports. This study has assumed that seabed improvements would be made without changing the channel depth, thus requiring that material be removed by dredging before amendments can be added to strengthen the seabed.

## Summary

From this work, the following key conclusions are drawn:

The most common infrastructure improvement required is related to increasing the bearing capacity of the storage area and quayside.

- Overall, the level of interest in U.S. ports supporting a domestic offshore wind industry is high.
- The physical requirements for offshore wind projects are more onerous than for traditional cargo. The most common example of this is the ground bearing capacity within the storage area and quayside; most U.S. ports require soil strength improvements before they can fully support project construction.
- Sufficient port infrastructure exists or can be developed to meet anticipated project deployment between now and 2030. While there are currently no offshore wind farms installed in the United States, much of the required infrastructure already exists for other industries.
- Improvements are expected for ports to support staging and manufacturing operations, most commonly through additional ground bearing capacity and expanding available storage space.
- Most U.S. ports can already support O&M activities such as crew transfer and service vessels.

**To achieve 28 GW  
by 2030, GL GH  
determined  
minimum regional  
requirements:**

**North Atlantic:**  
20 projects (10 GW)  
2 staging ports

**South Atlantic:**  
4 projects (2 GW)  
1 staging port

**Gulf Coast:**  
8 projects (4 GW)  
2 staging ports

**Pacific:**  
16 projects (8 GW)  
3 staging ports

**Great Lakes:**  
8 projects (4 GW)  
2 staging ports

- The improvements required to support offshore wind will not typically preclude a port from continuing to service more traditional cargo. Given that the contracts with staging ports are expected to be for approximately 2 years, whereas ports typically require long-term commitments on the order of 10 to 20 years or more in order to designate specific facilities to an activity such as offshore wind staging, having the ability to support multiple industries is considered beneficial, especially during the early years.

It is clear that significant opportunities exist for port facilities that can provide support to the build-out and maintenance of offshore wind projects in the United States. These opportunities are summarized as follows:

- To achieve the DOE's moderate growth target of 28 GW of offshore wind in the United States by 2030 as mapped out by Navigant, GL GH estimates that 20 projects (10 GW) are needed in the North Atlantic region, 4 projects (2 GW) in the South Atlantic, 8 projects (4 GW) in the Gulf of Mexico, 16 projects (8 GW) along the Pacific coast, and 8 projects (4 GW) in the Great Lakes.
- If capacities on this order of magnitude are developed, multiple port facilities within a given region will be required to meet the demand. In the Pacific region, a minimum of 3 staging ports will be required to meet the high demand in the latter years of the study period. The North Atlantic, Gulf Coast, and Great Lakes regions will also require a minimum of 2 staging ports. Lastly, in the South Atlantic, a minimum of 1 staging port will be required.
- Assuming these deployment levels, the number of actual ports would likely be larger since they often require close proximity to projects to minimize vessel transit time.

As U.S. ports and offshore wind developers look to work together on specific projects, they will encounter synergies and challenges. The challenges they face will include identifying sources of funding for the facility improvements required, and addressing ports' typical desire to engage in long-term partnerships on the order of 10-20 years. Early projects will especially feel these challenges as they set the precedent for these partnerships in the United States. This study seeks to provide information about gaps, costs, and opportunities to aid these discussions. Given the level of interest from U.S. ports and the capabilities available today, GL GH finds that sufficient port infrastructure exists or can be developed to meet anticipated long term offshore wind energy project deployment.

## CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b>1</b>
1.1	Background .....	1
1.2	Market Potential.....	1
1.3	Previous Studies.....	2
1.3.1	Massachusetts.....	2
1.3.2	Great Lakes .....	2
1.3.3	Maryland.....	2
1.3.4	North Carolina.....	2
1.4	Study Objectives.....	3
1.5	Report Structure .....	3
<b>PART I: PORT REQUIREMENTS .....</b>		<b>4</b>
<b>2</b>	<b>OFFSHORE WIND FARM CHARACTERISTICS.....</b>	<b>5</b>
2.1	Wind Turbines .....	5
2.1.1	Wind Turbine Tower .....	6
2.1.2	Nacelle and Blades.....	6
2.2	Wind Turbine Foundations .....	7
2.2.1	Steel Monopile Structures.....	7
2.2.2	Gravity Base Structures.....	9
2.2.3	Jacket Structures .....	11
2.3	Electrical Balance of Plant.....	13
2.3.1	Inter-Array Cables.....	13
2.3.2	Offshore Substation .....	13
2.3.3	Export Cables .....	15
<b>3</b>	<b>OFFSHORE WIND FARM INSTALLATION ACTIVITIES.....</b>	<b>17</b>
3.1	Wind Turbine Rotor Installation .....	17
3.1.1	Single Blade Lift.....	17
3.1.2	Bunny-ears Lift.....	17
3.1.3	Full Rotor Lift .....	18
3.1.4	Full Wind Turbine Installation.....	19
3.1.5	Floating Turbine Installation.....	20
3.2	Foundation Installation .....	20
3.2.1	Steel Monopile Structures.....	20
3.2.2	Gravity Base Installation .....	23
3.2.3	Jacket Structures .....	24
3.3	Subsea Array Cables.....	26
3.4	Offshore Substation.....	27
3.4.1	Substation Foundation Installation.....	27
3.4.2	Substation Topside Load-out .....	27
3.4.3	Substation Topside Installation .....	28
3.5	Subsea Export Cable.....	28

<b>4</b>	<b>INSTALLATION VESSELS .....</b>	<b>32</b>
4.1	Types of Vessels Used on Offshore Wind Farms in Northern Europe.....	32
4.1.1	Floating Deck Barge with Crane .....	32
4.1.2	Shearleg Crane barge .....	33
4.1.3	Semi-Submersible Heavy Lift Vessel.....	34
4.1.4	DP2 Heavy Lift Cargo Vessels.....	35
4.1.5	Leg-Stabilized Crane Vessel.....	36
4.1.6	Self-Propelled or Towed Jack-Up Craft .....	37
4.2	Assumed U.S. Installation Vessel Scenarios .....	39
4.2.1	Scenario 1: Utilize Existing U.S.-built Vessels .....	39
4.2.2	Scenario 2: Utilize Non-U.S.-built Vessels from Northern Europe .....	40
4.2.3	Scenario 3: New Build U.S. Vessels .....	44
4.2.4	Heavy Lift Cargo Vessels.....	44
<b>5</b>	<b>OFFSHORE WIND FARM PORT REQUIREMENTS .....</b>	<b>46</b>
5.1	Types of Port Usage Addressed.....	47
5.2	Port Logistics .....	47
5.3	Component Storage .....	48
5.4	Component Load-out.....	49
5.4.1	Roll-on and Roll-off .....	49
5.4.2	Lift-on and Lift-off.....	50
5.4.3	Crawler Cranes.....	50
5.4.4	Quayside Cranes .....	52
5.5	Port Haulage (Quay Transportation).....	53
5.5.1	Self-Propelled Modular Transporters .....	53
5.5.2	Cranage & Ground Bearing Pressure .....	54
5.6	Wind Turbines .....	55
5.6.1	Wind Turbine Blades .....	56
5.6.2	Wind Turbine Nacelle .....	59
5.6.3	Wind Turbine Tower .....	61
5.6.4	Wind Turbine Port Criteria .....	64
5.7	Wind Turbine Support Structures .....	66
5.7.1	Steel Monopile Structures.....	66
5.7.2	Monopile Structure Port Criteria.....	68
5.7.3	Jacket Structures .....	69
5.7.4	Jacket Structure Port Criteria.....	72
5.7.5	Concrete Gravity Base Structures .....	72
5.8	Substation.....	77
5.8.1	Topside Port Requirements .....	77
5.8.2	Substation Foundation Port Requirements .....	78
5.8.3	Self-installing Substation Port Requirements.....	78
5.9	Wind Farm Electrical Plant .....	78
5.9.1	Array Cables .....	78
5.9.2	Export Cable .....	79
5.10	Operation & Maintenance.....	81
5.11	Port Requirements for Floating Offshore Wind Turbines.....	82

5.12	Miscellaneous Port Requirements .....	82
<b>PART II: U.S. OFFSHORE WIND PORT ASSESSMENT TOOL .....</b>		<b>83</b>
<b>6</b>	<b>PORT ASSESSMENT TOOL .....</b>	<b>84</b>
6.1	Introduction: Purpose of the Tool.....	84
6.2	Gap Analysis and Estimated Costs .....	84
6.2.1	Tool Functionality Overview.....	85
6.2.2	Port Assessment Tool Assumptions .....	87
<b>PART III: CASE STUDIES: ANALYSIS OF 6 PORTS AROUND THE COUNTRY .....</b>		<b>88</b>
<b>7</b>	<b>INTRODUCTION .....</b>	<b>89</b>
7.1	Ports Assessment Tool Application .....	89
<b>8</b>	<b>OPPORTUNITY ASSESSMENT .....</b>	<b>91</b>
8.1	Summary of Methodology.....	91
8.2	Assumptions .....	94
<b>9</b>	<b>COST-BENEFIT PREVIEW .....</b>	<b>96</b>
9.1	Overview.....	96
9.2	Assumptions .....	96
<b>10</b>	<b>CASE STUDIES .....</b>	<b>97</b>
10.1	Case Study Port Selection.....	97
10.2	North Atlantic: New Bedford, Massachusetts .....	98
10.2.1	Background and Current Conditions.....	98
10.2.2	Results.....	98
10.2.3	Discussion .....	103
10.3	North Atlantic: Paulsboro, New Jersey .....	104
10.3.1	Background and Current Conditions.....	104
10.3.2	Results.....	104
10.3.3	Discussion .....	109
10.4	South Atlantic: Morehead City, North Carolina .....	110
10.4.1	Background and Current Conditions.....	110
10.4.2	Results.....	110
10.4.3	Discussion .....	114
10.5	Gulf of Mexico: Galveston, Texas.....	115
10.5.1	Background and Current Conditions.....	115
10.5.2	Results.....	115
10.5.3	Discussion .....	120
10.6	Pacific: Coos Bay, Oregon .....	121
10.6.1	Background and Current Conditions.....	121
10.6.1	Results.....	121
10.6.2	Discussion .....	122
10.7	Great Lakes: Cleveland, Ohio.....	122

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10.7.1	Background and Current Conditions.....	122
10.7.2	Results.....	123
10.7.3	Discussion .....	128
<b>11</b>	<b>TRENDS AND COMMONALITIES.....</b>	<b>130</b>
11.1	Gap Analysis .....	130
11.2	Opportunity Assessment .....	133
11.3	Cost-Benefit Assessment .....	133
<b>12</b>	<b>CONCLUSIONS.....</b>	<b>135</b>
<b>13</b>	<b>REFERENCES.....</b>	<b>137</b>
<b>APPENDIX A</b>	<b>TOOL DIAGRAMS &amp; FUNCTIONS.....</b>	<b>138</b>
<b>APPENDIX B</b>	<b>GROUND IMPROVEMENT COST MODEL.....</b>	<b>140</b>