NC12 TRANSPORTATION IMPROVEMENTS

NC 12 Feasibility Study From Avon to Buxton

Dare County, North Carolina

State Transportation Improvement Program Project

Prepared For:

North Carolina Department of Transportation

Project Development and Environmental Analysis Unit

Prepared By:

URS Corporation—North Carolina

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FEASIBILITY STUDY

NC 12 Improvements
From Buxton to Avon
Dare County, North Carolina

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Prepared for the
Project Development and Environmental Analysis Unit
North Carolina Department of Transportation

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List of Acronyms and Abbreviations

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AEC	area of environmental concern
CAMA	Coastal Area Management Act
CSE	Coastal Science and Engineering
EFH	essential fish habitat
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FSC	Federal Species of Concern
GIS	geographic information system
HPO	[North Carolina State] Historic Preservation Office
HQW	High Quality Water
LUP	Land Use Plan
mph	miles per hour
NC	North Carolina
NC-CREWS	North Carolina Coastal Region Evaluation of Wetland Significance
NCCRC	North Carolina Coastal Resources Commission
NCDCM	North Carolina Division of Coastal Management
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCDWR	North Carolina Division of Water Resources
NCGS	North Carolina Geological Survey
NCNHP	North Carolina Natural Heritage Program
NCWRC	North Carolina Wildlife Resources Commission
NEPA	National Environmental Policy Act
NHPNA	Natural Heritage Program Natural Area

NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWI	National Wetlands Inventory
ORW	outstanding resource water
PNA	primary nursery area
ROW	right-of-way
SAV	submerged aquatic vegetation
SC	special concern
Seashore	Cape Hatteras National Seashore
SR	secondary road
STI	Strategic Transportation Investments
STIP	State Transportation Improvement Program
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

1. Project Description

1.1 Purpose of Study

This feasibility study is a preliminary step to the National Environmental Policy Act (NEPA) process to identify potential project scope, a range of estimated costs of completion, and project-specific concerns related to preserving the North Carolina (NC) 12 corridor between the communities of Buxton and Avon (the project) (Figure 1). This is not a funded project. This feasibility study provides information on various possible options to improve the stability of the NC 12 corridor over both a short-term (5-year) and long-term (50-year) timeframe. The short-term solutions will provide the North Carolina Department of Transportation (NCDOT) with potential options for maintaining or restoring the integrity of NC 12 with minimal interruption of traffic should a storm event or coastal processes compromise roadway access. The analysis of long-term solutions considers the costs of different alternatives so that the project can potentially be added to a list of funded projects within NCDOT's State Transportation Improvement Program (STIP). In some instances the project is referred to as the R-4070B Hot Spot project in this report.

1.2 Funding

As part of implementing the new Strategic Transportation Investments (STI) Law, NCDOT released its 10-year STIP in June 2015, which scheduled the statewide projects proposed for full or partial funding between 2016 and 2025 (NCDOT 2015a). The purpose of the STI Law is to allow NCDOT to maximize North Carolina's existing transportation funding to enhance the state's infrastructure and support economic growth, job creation, and high quality of life.

STI established the Strategic Mobility Formula, a new way of allocating available revenues based on data-driven scoring and local input. Proposed transportation projects go through a prioritization process during which they are evaluated through an analysis of the existing and future conditions, the benefits the project is expected to provide, the project's multi-modal characteristics, and how the project fits in with local priorities. Generally, the projects that increase capacity, safety, connectivity, and economic development score higher under the prioritization formula. The NC 12 R-4070B Hot Spot project was not included in the latest Prioritization 3.0 (P3.0) process, which closed on August 29, 2014. The project is anticipated to be included for evaluation and prioritization in the Prioritization 4.0 (P4.0) process. New candidate projects for P4.0 will be submitted in fall of 2015.

Depending upon the results of the P4.0 process, it is not certain that the proposed project will be included in the next STIP document. In the event that it is included, there is still no funding mechanism in place for recurring beach nourishment along NC 12.

1.3 Project Study Area

The project is located within Dare County on Hatteras Island, a barrier island on the Outer Banks of North Carolina. The project study area consists of the northern portion of the Buxton community from secondary road (SR) 1231 (Old Lighthouse Road) and extends north approximately 4.7 miles to SR 1421 (Ocean View Drive) in the southern portion of the Avon community. The Cape Hatteras National Seashore (Seashore) adjoins Buxton and Avon. The Seashore, administered by the National Park Service (NPS), makes up all lands within the project limits except those that are privately owned in Buxton and Avon. The topography throughout the Seashore between the communities of Buxton and Avon is characterized by ocean and sound side beaches, wetlands, overwash areas, and man-made dunes between NC 12 and the Atlantic Ocean. The dunes are maintained at an average height of 10 feet above

sea level. In many instances within the project study area, the ocean beach does not include protective dunes on residential/privately-owned property within Buxton and Avon.

The project study area extends beyond the project limits to allow consideration of a full range of transportation options, including roadway relocation and bridge options. Figure 1 shows the project study area and the project termini.

Figure 1: Vicinity map

1.4 Roadway Characteristics

NC 12 is functionally classified as a major collector route and is part of the National Highway System. NC 12 carries both local and regional traffic, and provides the only roadway access to Hatteras Island. The typical section of the roadway consists of a two-lane road with 11-foot wide lanes (Figure 2). Sand dunes of variable width and height are located adjacent to the roadway. It also includes a 4-foot grass or paved shoulder within the Buxton and Avon town limits. This typical section is consistent with other portions of NC 12 on Hatteras Island. The posted speed limit is 55 miles per hour (mph) within the Seashore, and between 25 and 35 mph in Buxton and Avon.

Figure 2: NC 12 roadway in Buxton

(Source: NCDOT 2013)

2. Need for Improvements

2.1 Background

NC 12 provides the primary transportation link to, from, and between the communities of Buxton and Avon and is needed to provide access for residents, visitors, businesses, services, and tourist attractions (Figure 3). Previous overwash events, such as Hurricane Dennis in 1999, have resulted in the relocation of portions of NC 12 (approximately 3,500 feet) just north of Buxton. The relocation was considered an interim improvement to maintain access, but flooding now occurs with greater frequency than when the relocation was implemented in 1999 (Figure 4).

Figure 3: Ramp 38, a recreational area served by NC 12

(see study area location on Figure 9, Source: URS 2013)

Island residents depend on NC 12 for access to mainland community services such as hospitals, emergency response, and waste collection. NC 12 also provides access to schools and other support service areas (e.g., retail stores, community centers, etc.) beyond the project limits but on Hatteras Island. There are two schools in Buxton on Hatteras Island, Cape Hatteras Elementary School and Cape Hatteras Secondary School. NC 12 is the only route for children living north of the project to travel to school. Further, NC 12 provides the only vehicular access to the Seashore for recreational use.

Figure 4: NC 12 section that was relocated after Hurricane Dennis, looking southward

(date of photo March 16, 2000, Source: Outer Banks Task Force)

Tourism is the number one industry in Dare County, and it plays an important role in the economic vitality of Buxton and Avon. NC 12 is a critical transportation component providing tourist access to Hatteras Island and the Seashore. It facilitates the transport of goods and services to and from the island and supports the tourism sector of the local economy. According to the *Hatteras Island Economic Impact* report (Lane 2013), Buxton leads other Hatteras Island communities in the number of businesses that accommodate tourism. Avon is among the top three communities with regard to the number of businesses that support tourism. Consequently, most employment in the area is related to the tourism sector.

The *Dare County Emergency Management Operations Plan* has designated NC 12 as the primary evacuation route for all permanent and temporary residents on Hatteras Island when severe weather is approaching (Dare County Government 2007).

The project study area is subject to overwash during storm events. Storms of varying strengths over time, when coupled with natural coastal processes, have contributed to the receding of the shoreline in a landward direction toward NC 12. The receding of the shoreline has also led to the erosion of dunes, which function as a protective barrier for NC 12.

2.2 Purpose of Potential Project

The purpose of this project is to provide stability to the transportation corridor between Buxton and Avon. The project would provide a corridor less vulnerable to overwash and flooding events as well as natural coastal processes. The expected overwash from hurricanes or other storm events already threatens the structural integrity of NC 12 and/or its protective dune barriers in the short-term. Over the long-term, this continued vulnerability coupled with the naturally occurring erosion of shorelines on both the Atlantic Ocean and sound side of NC 12 also threaten the reliability and stability of the roadway. This study examines potential projects to provide increased stability to NC 12 in both the short-term (5 years) and long-term (50 years) time horizons.

3. Design Options

Nine alternatives (four short-term and five long-term alternatives) have been evaluated for this feasibility study. Human and natural environment issues as well as costs were evaluated for each of these alternatives.

3.1 Design Criteria

Because the island within the limits of the project study area is narrow and prone to flooding and overwash, the development of study alternatives required consideration of road relocation and bridging scenarios coupled with beach nourishment and dune replenishment options.

3.1.1 Coastal Conditions and Non-Highway Criteria

Shoreline Forecasts

The shoreline change rate (with a 95 percent confidence interval) due to erosion varies from about 8 feet per year to less than 2 feet per year in the project study area. Due to the receding nature of the ocean shoreline, future shoreline limits for the short-term (5 year) and long term (50 year) alternatives were established using historical position data over a 45 year timespan. Future shoreline limits for each design alternative include an average shoreline model and a more conservative upper bound model that incorporated a 95 percent confidence level. This upper bound shoreline model, which has been referred to as the high erosion shoreline in other NCDOT NC 12 studies, indicates that there is a 95 percent chance that the shoreline position will be located oceanward of that position in the specified year. The high erosion shoreline position has been used for planning purposes in other NC 12 transportation projects on Hatteras Island (B-2500, B-2500A, and B-2500B). For this feasibility study, the average shoreline position was used for the development of the short-term alternatives, while the high erosion shoreline was used for the long-term alternatives. Use of the high erosion shoreline for long-term solutions allows for the alternatives to be designed to account for unexpected changes in the shoreline due to storm events as well as to minimize potential property impacts.

The forecast shorelines determined the location of the alternative centerlines. NCDOT has utilized a vulnerability criterion of a minimum 230 foot buffer from mean high water (existing shorelines) to the seaward edge of pavement for the NC 12 projects; the 230 foot distance was determined through an empirical analysis of roadway maintenance data.

The buffer distance criteria were applied to each alternative. In addition, bridges were developed to span areas where the forecast shoreline was less than 230 feet away from the current edge of roadway pavement.

Dune Construction

Each alternative design includes a dune structure between the roadway and the ocean shoreline except for bridged areas. In some cases, dunes currently located along the existing roadway may require relocation or structural fortification to provide adequate protection for portions of NC 12.

NCDOT recommends placing dunes approximately 25 feet from the edge of the NC 12 pavement, with potential variations from this width in some locations. The proposed dune geometry includes 3:1 slopes adjacent to NC 12, a 15 foot top width, and 5:1 slopes facing the beach, however this may vary in some

locations due to elevation changes. A continuous dune structure in areas void of other barriers serves to protect the roadway during storm events.

As the beach erodes due to long-term erosion, the shoreline will move closer to the dune and the dune will be more vulnerable to wave action. NCDOT will maintain existing dunes where possible instead of building new dunes. The alternatives developed for this project take into consideration the magnitude of the dune field as documented by NCDOT in 2009. Data documented in 2009 was the most recent information available at the time of this study. The need to reconstruct the dune with the landward relocation of the highway and to maintain the dune in place in combination with beach nourishment was also considered. It is reasonable to expect that the dunes will need to be maintained every 10 years.

The build-alternative dune geometry is provided for evaluation of alignment feasibility, but may change in the design process. The dune geometry will be determined by actual elevations and shoreline modeling information based on further project development (Table 1).

Table 1: Build alternative dune geometry

Category	Measurement
Dune offset from edge of pavement	25 feet
Dune height [a]	10 feet
Dune slope on NC 12 side	3:1
Dune top width	15 feet
Dune slope on ocean side	5:1

[a] This is an estimate. The actual dune height will depend on surrounding elevation.

Beach Nourishment

Beach nourishment involves the placement of a large quantity of beach compatible sand along the shoreline for purposes of elevating the dry beach and advancing the shoreline toward the ocean (i.e., widening the beach), and replenishing the volume of sand lost over some period of time. Compatible sand can in many cases be found in close proximity to where nourishment is needed. Over the project's design life, any design option would be expected to meet the objectives of increasing the storm protection function of the beach.

3.1.2 Highway Design Criteria

Based on existing conditions, NCDOT determined the design speed for the proposed project to be 60 mph. The existing right-of-way (ROW) width is 100 feet in the areas managed by NPS. The project-specific design criteria used in developing the alternatives are based on American Association of State Highway and Transportation Officials (AASHTO) standards and the *North Carolina Roadway Design Manual* (NCDOT 2014) (Table 2).

Table 2: Build alternative roadway relocation design criteria

Functional Classification	Collector
Terrain	Level
Design speed	60 mph
Posted speed	55 mph
ROW width within NPS	100 feet
Shoulder width (including 4 feet of paved shoulder)	8 feet
Lane width	11 feet

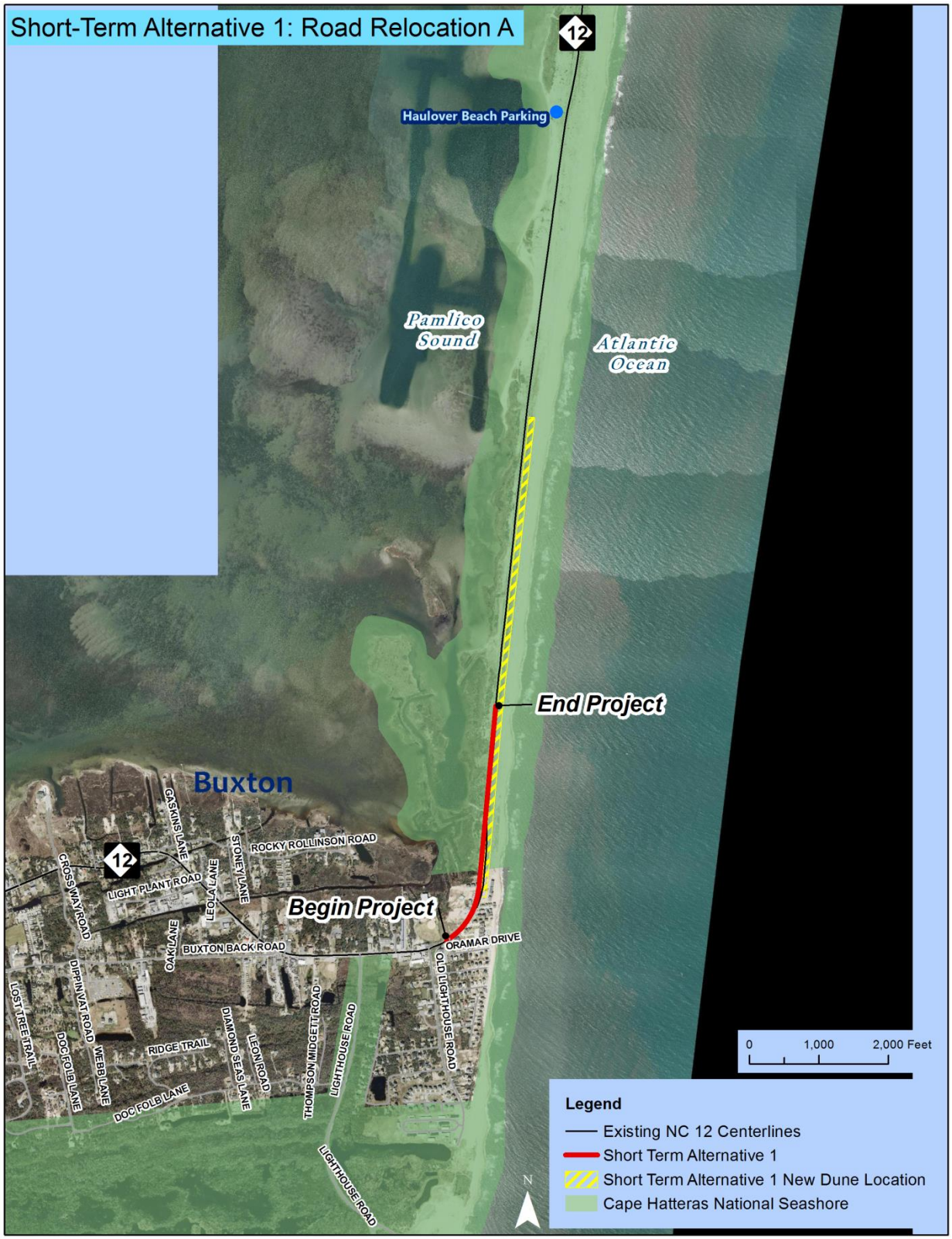
3.2 Short-Term Design Options

The short-term design options are designed for the 5-year project life and based on the 5-year average shoreline model unless otherwise noted. These options are designed to be implemented as expeditiously as possible in the event that NC 12 is damaged and before a long-term design option is constructed.

3.2.1 Short-Term Alternative 1: Road Relocation A

Short-Term Alternative 1 proposed improvement would begin at the southern project terminus near Old Lighthouse Road and extend north for 1.5 miles on new alignment, tying into the existing NC 12 roadway approximately 1 mile south of the existing Haulover Beach Parking area (Figure 5). This alternative would shift the roadway approximately 15 to 65 feet west of the existing roadway based on the preliminary assumption of available land suitable for roadway construction. The majority of new ROWs for this alternative would be on property managed by NPS. This alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1.

Figure 5: Short-Term Alternative 1: Road Relocation A



3.2.2 Short-Term Alternative 2: Road Relocation B

Short-Term Alternative 2 proposed improvements would begin at the southern project terminus near Old Lighthouse Road and extend north for 2 miles on new alignment, tying into the existing NC 12 roadway approximately 0.5 mile south of the existing Haulover Beach parking area (Figure 6). This alternative was designed for the 5-year high erosion scenario and would shift the roadway approximately 100 to 180 feet west of the existing roadway. The high erosion scenario represents worst case conditions. It is estimated that two 100-feet and two 200-feet, temporary, pre-stressed concrete bridges would be needed for locations where soils are not stable enough for roadway construction. The majority of new ROWs for this alternative would be on property managed by NPS. This alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1.

Figure 6: Short-Term Alternative 2: Road Relocation B

3.2.3 Short-Term Alternative 3: Beach Nourishment

Short-Term Alternative 3 would leave the existing roadway in current location, and implement a beach nourishment program to protect the roadway in the current location. Short-Term Alternative 3 proposes beach nourishment improvements for 1.1 miles, which would begin at the southern project terminus near Old Lighthouse Road and extend north (Figure 7). The beach nourishment would be provided to create a 230-foot minimum distance between the roadway and mean high water level. No dune construction would be associated with this alternative, only dune maintenance.

Figure 7: Short-Term Alternative 3: Beach Nourishment

3.2.4 Short-Term Alternative 4: Combination of Road Relocation and Nourishment

Short-Term Alternative 4 proposed improvements would begin at the southern project terminus near Old Lighthouse Road with approximately 0.9 mile of beach nourishment to protect the roadway in its existing location and minimize potential impacts to property owners located on the edge of Buxton community limits (Figure 8). Approximately 0.3 mile of the proposed 0.9 mile nourishment area has experienced a greater loss of sand, possibly due to the lateral spreading of sand in this area, which typically reduces the length of time that placed sand remains in position. At the northern end of the Buxton community limits, the roadway would extend on new location for 1.5 miles, tying into the existing NC 12 roadway approximately 0.5 mile south of the existing Haulover Beach parking area. This alternative would shift the roadway approximately 100 to 180 feet west of the existing roadway. This alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1. The new dune would be constructed along the entire length of relocated roadway.

Nourishment for this alternative would be required for a length of approximately 0.3 mile. However, short nourishment projects, such as 0.3 miles, are more likely to erode quickly compared to lengthier segments of nourishment due to lateral (alongshore) spreading. For this reason, additional beach nourishment sand (0.9 mile total) is included as an alternative design option to help ensure the stability of the sand seaward of existing NC 12 and for cost comparison purposes. One cycle of beach nourishment and dune construction, designed to last five years, is proposed for this alternative.

Figure 8: Short-Term Alternative 4: Combination of Road Relocation and Nourishment

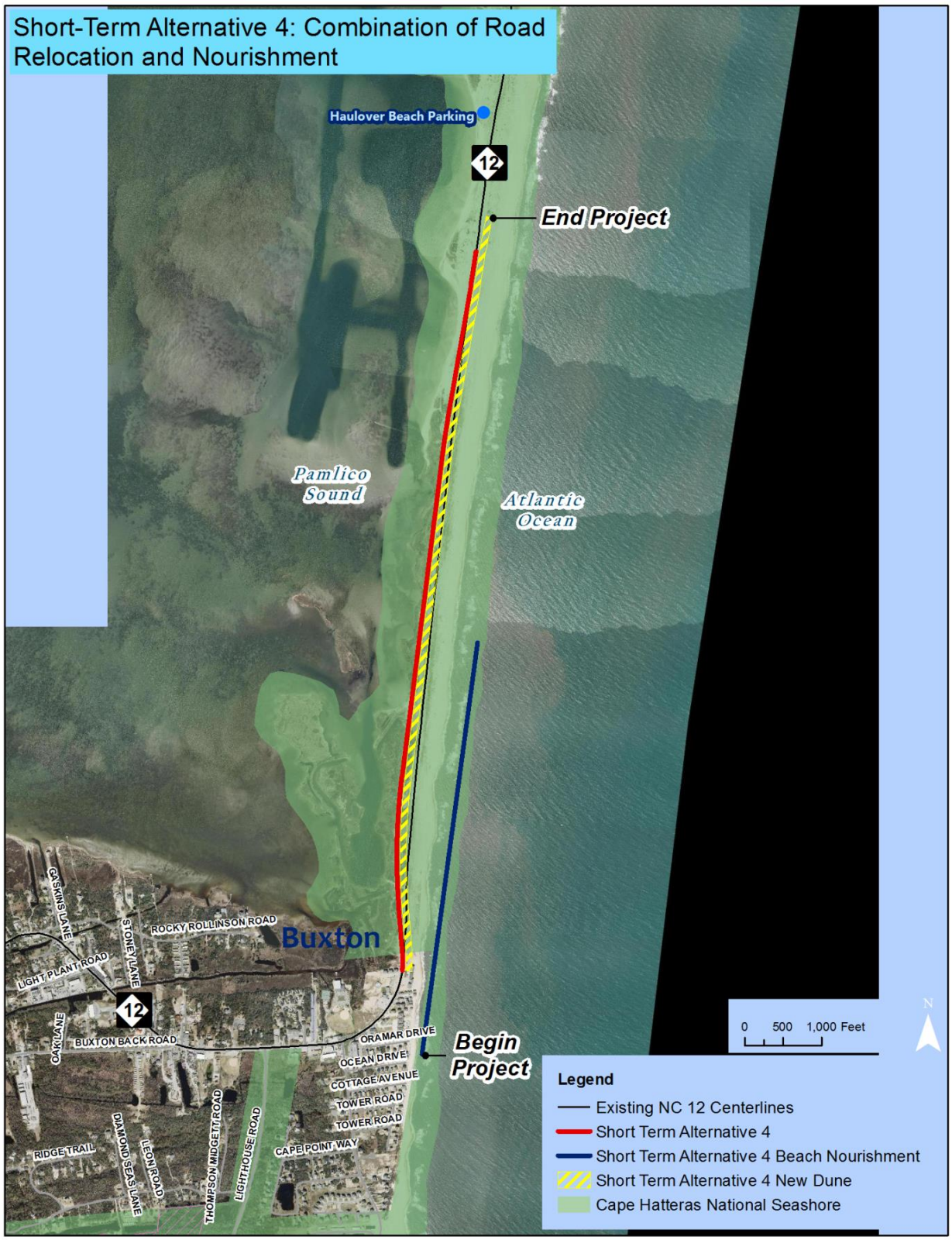


Table 3 provides the anticipated volume of sand required for dune maintenance and construction by short-term alternatives. Section 4 discusses potential sites that could be used to obtain suitable nourishment sand.

Table 3: Dune volume requirements for short-term alternatives

Short-Term Alternative	Description of Dune Maintenance Type	Dune Volume (cubic yards) at Time of Project Construction
Alternative 1: Road Relocation A	Construction	None
Alternative 2: Road Relocation B	Construction	273,389
Alternative 3: Beach Nourishment	Maintenance	111,778
Alternative 4: Combination of Road Relocation and Nourishment	Construction	585,833

Source: Overton 2015.

3.3 Long-Term Design Options

The long-term design options are designed for a 50-year project life, based on the 2063 forecast shoreline position. Unless otherwise noted, the high erosion shoreline was used in the development of the alternatives.

3.3.1 Long-Term Alternative 1: Road Relocation with Bridges

Long-Term Alternative 1 proposed improvements would begin at the southern project terminus near Old Lighthouse Road and extend north for 2.3 miles on new alignment, tying into the existing NC 12 roadway near the Haulover Beach parking area (Figure 9). This alternative was designed using the average shoreline forecast and would shift the roadway approximately 245 to 330 feet west of the existing roadway. The reason for using the average shoreline in lieu of the high erosion shoreline was to minimize impacts to privately owned property, including a hotel (Outer Banks Hotel) located adjacent to the roadway at the northern tip of Buxton. One 2-mile pre-stressed concrete bridge will be constructed over wetlands and unstable soils. The majority of new ROWs for this alternative would be on property managed by NPS. Where there is no bridge structure, this alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1.

Figure 9: Long-Term Alternative 1: Road Relocation with Bridges

3.3.2 Long-Term Alternative 2: Bridge within Existing Easement

Long-Term Alternative 2 proposed improvements would begin at the project terminus near Old Lighthouse Road and extend north for 2.5 miles on the existing alignment, tying into the existing NC 12 roadway near the Haulover Beach parking area (Figure 10). The 2.5 mile improvements would include one 2-mile pre-stressed concrete bridge, constructed west of the existing roadway. This alternative would be within the existing NC 12 transportation easement within the Seashore.

Figure 10: Long-Term Alternative 2: Bridge within Existing Easement

3.3.3 Long-Term Alternative 3: Bridge on New Location

Long-Term Alternative 3 proposed improvements would begin at Rocky Rollinson Road and extend north for 0.25 mile as a widening of the existing Rocky Rollinson Road (Figure 11). The roadway would extend for 2.5 miles on new alignment on a pre-stressed concrete bridge structure within the Pamlico Sound. The bridge would tie in to a roadway on new alignment near the Haulover Beach parking area; the new roadway would then extend for 1.5 miles north on new alignment, tying into the existing roadway south of Beach Access Ramp 38 (see Figure 11). Where there is no bridge structure, this alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1.

The existing NC 12 roadway within Buxton would be maintained as a service road for private properties.

The majority of new ROWs for this alternative would be on property managed by NPS. A quarter-mile of ROW would be necessary on private property in Buxton for the new alignment.

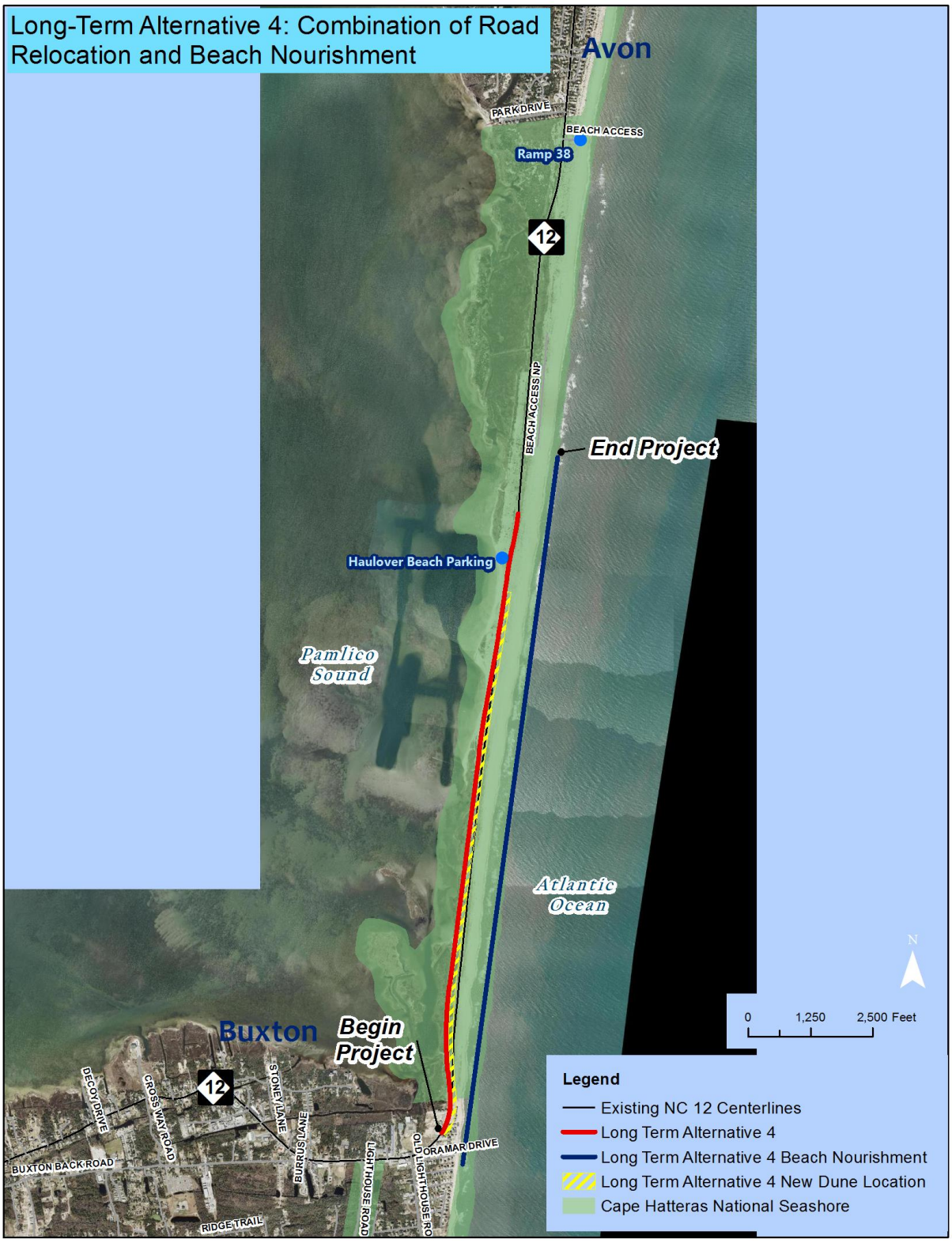
Figure 11: Long-Term Alternative 3: Bridge on New Location

3.3.4 Long-Term Alternative 4: Combination of Road Relocation and Beach Nourishment

Long-Term Alternative 4 proposed improvements would begin at the project terminus near Old Lighthouse Road with 2 miles of roadway on new alignment, tying into the existing roadway 1,000 feet south of the Haulover Beach parking area (Figure 12). The existing roadway would remain in place by using beach nourishment for 1 mile, with the improvements ending between Beach Access Ramp 38 and Park Drive in Avon. This alternative would shift the roadway approximately 90 to 160 feet west of the existing roadway. The majority of new ROWs for this alternative would be on property managed by NPS. This alternative would also include the placement of a sand dune 25 feet from the new edge of pavement on the ocean side, to be constructed as described in section 3.1.

Nourishment for this alternative would be required for approximately 3.1 miles. In combination with relocating the roadway, the beach nourishment would provide the minimum 230 foot buffer distance stipulated in the design criteria. Moving the road further landward would provide a longer period of time before the highway becomes vulnerable. For most of the road relocation area, it is estimated that nourishment would not be needed for approximately 20 years based on shoreline forecasts. Beach nourishment is expected to occur at five-year intervals over the life of the project.

Figure 12: Long-Term Alternative 4: Combination of Road Relocation and Beach Nourishment



3.3.5 Long-Term Alternative 5: Beach Nourishment

Long-Term Alternative 5 proposes a long-term beach nourishment alternative without any road relocation or bridging improvements (Figure 13). This alternative would require the utilization of fill sand to replace sand lost by the long-term erosion processes and to maintain a 230-foot distance between the edge of pavement and the shoreline. This alternative would require the implementation of a nourishment placement cycle that would replenish eroded sand every five years. The volume of sand required for long-term beach nourishment without other transportation-related improvements is estimated to be 6,629,700 cubic yards over the 50-year life of the project.

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Figure 13: Long-Term Alternative 5: Beach Nourishment

Table 4 provides the anticipated volume of sand required for dune maintenance and construction by long-term alternatives.

Table 4: Dune volume requirement for long-term alternatives

Long-Term Alternative	Description of Dune Maintenance Type	Dune Volume (cubic yards) at Time of Project Construction
Alternative 1: Road Relocation with Bridges	Construction	99,940
Alternative 2: Bridge within Existing Easement	Construction	None
Alternative 3: Bridge on New Location	Maintenance	195,278
Alternative 4: Combination of Road Relocation and Beach Nourishment	Maintenance	429,611
Alternative 5: Beach Nourishment	Maintenance	None

Source: Overton 2015.

Beach nourishment is included for four design alternatives (Table 5).

Table 5: Design alternatives requiring beach nourishment

	Alternative	Description
Short-Term Design (5 years)	Alternative 3: Beach Nourishment	Beach nourishment only
	Alternative 4: Combination of Road Relocation and Nourishment	Road relocation and beach nourishment
Long-Term Design (50 years)	Alternative 4: Combination of Road Relocation and Beach Nourishment	Road relocation and beach nourishment
	Alternative 5: Beach Nourishment	Beach nourishment only

Source: Overton 2015.

The volume of sand estimated for nourishment options consists of two parts. The first is to determine whether there is an existing deficit in sand volume relative to the 230-foot highway vulnerability criteria, and the second is to determine the amount of fill needed to maintain a minimum of 230 feet between the edge of pavement and the active shoreline for the length of time of the project. The volume of sand required is a function of the height of the berm, the length and width of beach required to meet the design needs, and the depth of closure, which is defined as the most landward depth at which there is no notable change in bottom elevation and no notable sediment transport. Within the project study area, the height of the berm is measured at 6 feet, and the depth of closure is 24 feet. The length of the beach nourishment project is determined from an analysis of shoreline position while the shoreline change rate is used to compute volumes. In addition, the volume needed in the last 500-foot section of the shoreline is doubled to allow for a transition length of 1,000 feet on both ends of the project. A 2,000-foot section in the southernmost part of the project study area currently has a sand deficit in regard to the volume of sand needed to meet the 230-foot highway vulnerability criteria. Based on the 230-foot buffer and the December 2013 shoreline position, approximately 50 feet of beach width is required to bring the distance from edge of pavement to active shoreline to the critical buffer distance. This critical buffer width is used throughout the project study area (including the town of Buxton).

The nourishment placement cycle is assumed to be five years. For the short-term design there is one placement with a volume required to offset both the deficit volume and the five year erosion volume.

For the long-term design, these are 10 placement cycles with a volume required to offset both the deficit volume and the 50 year erosion volume (10 placement cycles).

In the short-term, two distinct project lengths are given for Alternative 4 in Table 6. With Alternative 4, only 0.3 mile on NC 12 is estimated to need nourishment. However, short nourishment projects erode more quickly due to lateral (alongshore) spreading. Lengthening the project reduces this impact; therefore, the volume requirement for a 0.9 mile project is reported for comparison purposes along with the volume requirements of a 0.3 mile project.

The volume of sand required for the four proposed alternatives requiring nourishment is presented in Table 6. The volumes provided below do not include sand needed for the construction of prosed dunes. That information is provided in Table 3 and Table 4.

Table 6: Nourishment sand volume requirements

Project Design Period	Project Alternative	Project Distance (miles)	Deficit (Volume, cubic yards)	Expected Eroded Volume (Volume, cubic yards)	20% Assumed Losses (volume, cubic yards)	Total Volume Required (volume, cubic yards)
Short-Term (5 years)	Alternative 3 Beach Nourishment	1.1	222,222	313,063	107,057	642,342
	Alternative 4 Combination of Road Relocation and Nourishment	0.9	222,222	266,534	97,751	586,508
		0.3	222,222	103,484	65,141	390,848
Long-Term (50 years)	Alternative 4 Combination of Road Relocation and Beach Nourishment (Total Cycles 1-10)	2.7	222,222	5,386,247	1,104,800	6,629,700
	Alternative 5 Beach Nourishment (Cycles 1-10 or remaining total)	2.7	222,222	5,386,247	1,104,800	6,730,163

Source: Overton 2015.

4. Constructability Issues

Coastal conditions in the project study area present constructability issues that would vary in severity for each proposed long-term and short-term alternative. Construction issues are generally attributed to coastal conditions coupled with the loss of beach width. NCDOT Division 1 maintenance forces have indicated that erosion is especially severe at the northern tip of Buxton along the ocean side where NC 12 enters into the community limits.

Alternatives that would require sand for beach nourishment or dune construction may also face limitations of available fill sand that is suitable for both existing wildlife habitat and project construction. The grain size and geologic characteristics should be similar to the native beach. Sand within the project study area serves as a component of habitat for federally-protected sea turtles, plants, and birds, as well as other non-federally protected wildlife species (NPS 2013a, 2013b, 2013c). It is possible that suitable fill sands could be transported from the mainland or offshore locations, but that would substantially add to the cost of project construction. A report prepared for the Outer Banks Task Force and NCDOT by the North Carolina Geological Survey (NCGS) identified two sites suitable for nourishment sand that are located offshore just south of the project limits (NCGS 2009). The identified sites cumulatively have the potential to yield more than 120 million cubic yards of sand, although further testing is needed to definitively identify the amount and suitability of sand at those sites and the potential effect of sand extraction (NCGS 2009).

Alternatives requiring beach nourishment sand should consider the sand source and sediment size as further design is pursued. The sediment size characteristics of the sand source need to approximate the native beach sediment size. If sand size differs, then the predicted cost of the alternative could be different. Further, environmental considerations require sediment characteristics to be closely approximated to the native beach. In addition, the losses in the alongshore direction due to shoreline reconfiguration of the nourished beach relative to the adjacent beach can be notable and should be considered in the final design.

Two primary cost components of nourishment projects are mobilization/demobilization costs and pumping costs. Since pumping costs are a function of volume required, the re-nourishment interval should be evaluated through time to ensure the most economical intervals that still achieve protection of NC 12. Locations with low erosion rates (and thus lower expected eroded volumes for the same period of time) are candidates for long replacement cycles, which can lower the project cost.

Since nourishment volume estimates are based on long-term erosion, any individual sequence of storms can impact the apparent success of the project. Storm events may erode the beach and the dune face, depositing sand in the nearshore. The sand in the nearshore may take several seasons to be transported back to the beach and affect beach width. Dunes provide additional protection during storm events and can be a source of sediment feeding either the beach or the landward extent of the barrier island as dune erosion occurs. Maintenance of the dune field can be effective in managing the impact of storm events and should be repaired to design standards post storm. Further, dunes can be a factor in preventing island breaching due to soundside storm surges by acting as a barrier to cross-island flow.

The application of geotextile containers for the purpose of beach stabilization was not considered as part of this feasibility study. However, they could be considered in future studies of temporary shoreline protection measures. The use of geotextile containers for shoreline protection would be regulated by the North Carolina Administrative Code on Ocean Hazards. The Code prohibits the construction of

breakwaters on the oceanfront but allows for the use of sandbags or soft structures in temporary installations with restrictions; therefore, under the Code as it is currently written, the use of geotextile containers would likely be restricted to use as a dune core when reconstructing a dune field or other temporary installation landward of the high water line. In addition, the stability of geotextile container installations during storm events is a concern, due to the potential failure of these installations from scour, rotation, or displacement that has been documented following storms. The potential failure of these installations would need to be addressed in order to consider these installations as a viable temporary protection measure.

Each build alternative has the potential to encroach upon jurisdictional wetlands. Special care will be taken during planning and design to avoid or minimize impacts to wetlands. If impacts to wetlands are unavoidable, mitigation opportunities will be coordinated with the United States Army Corps of Engineers (USACE) and NPS. It is noteworthy that, in the context of other NCDOT projects, NPS has stated during project coordination activities that any wetland mitigation needed as a result of a transportation project impacting NPS land must be within the Seashore.

Construction-related activities would be coordinated with the United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA) Fisheries, and the NPS to minimize potential harm to protected sea turtles, plants, fish and bird species. Due to the potential to disturb sensitive wildlife nesting, spawning, and hatching habitat, NPS has requested consideration of a seasonal construction moratorium for construction-related activities.

Construction of the proposed project could involve the use of cored slab bridge structures for the 5-year options. Cored slab bridges can be constructed in a much shorter time span compared to a more permanent structure, but are intended to sustain use for a much shorter span of time than what would be expected from a permanent structure. In addition, core slab bridges would be constructed at lower elevations than permanent bridging structures; therefore, smaller storm events may damage these structures. Maintenance needs would be expected to be greater for a core slab bridge, although the use of cored slab bridge pieces may alleviate much of the expected additional maintenance due to the ease of simply replacing damaged slab with new slab pieces.

Construction staging could be a concern considering the limited area available for such use regardless of which build alternative is carried forward in the project development process.

Due to the presence of submerged aquatic vegetation (SAV) within the Pamlico Sound, dredging activities to accommodate barges would likely require coordination with NOAA Fisheries, North Carolina Division of Coastal Management (NCDCM), and other resource agencies.

5. Project Cost

5.1 Estimated Costs – Short and Long-Term Alternatives

Table 7 and Table 8 provide estimates for the total construction costs (including maintenance cycles) for both the short-term and long-term alternatives, respectively. The cost of dune construction is not included in the estimated cost totals provided below in Tables 7 and 8. The cost of dune construction is not included in the estimated cost total provided in Tables 7 and 8 due to the dynamic effects that storm events have on the dune sand volumes at any given snapshot in time. Estimated dune volumes in Tables 3 and 4 are likely to be different by the time either a short-term or long-term option is developed and recommended for construction. Assessing the condition of the dunes closer to project construction is recommended and will add some cost to the estimates provided in Tables 7 and 8 for options that benefit from dune maintenance.

Table 7: Project costs for short-term alternatives

Short-Term Alternative	Construction (millions of dollars)	Beach Nourishment (millions of dollars)	Total Cost of Construction and Nourishment (excludes dune construction) (millions of dollars)
Alternative 1: Road Relocation A	6.3	N/A	6.3
Alternative 2: Road Relocation B (cost includes pre-stressed concrete bridges)	13.0	N/A	13.0
Alternative 3: Beach Nourishment	N/A	11.3	11.3
Alternative 4: Combination of Road Relocation and Nourishment	7.5	10.7 (0.9 mile)/ 8.6 (0.3 mile)	18.2/ 16.1

Source: NCDOT. 2014c, Overton 2015.

Table 8: Project costs for long-term alternatives

Long-Term Alternative	Construction (millions of dollars)	Beach Nourishment (millions of dollars)	Total Cost of Construction and Nourishment (excludes dune construction) (millions of dollars)
Alternative 1: Road Relocation with Bridges (cost includes pre-stressed concrete bridge)	81.1	N/A	81.1
Alternative 2: Bridge within Existing Easement (cost includes pre-stressed concrete bridge)	154.7	N/A	154.7
Alternative 3: Bridge on New Location (cost includes pre-stressed concrete bridge)	145.4	N/A	145.4
Alternative 4: Combination of Road Relocation and Beach Nourishment	16.8	115.6	132.4
Alternative 5: Beach Nourishment	N/A	115.6	115.6

Source: NCDOT. 2014c, Overton 2015.

5.2 Beach Nourishment Cost Breakout – Short and Long-Term Alternatives

The total cost of beach nourishment is a function of the following components:

- Mobilization and demobilization costs
- Sand pumping costs
- Administrative costs (design, surveys, engineering, and construction)
- Regulatory permitting and state and federal environmental analysis
- Contingency costs

The approach taken to separate out the costs associated with beach nourishment is consistent with that provided to the Dare County Board of Commissioners by Coastal Science and Engineering (CSE 2013). The costs are based on the 2011 project at Nags Head, North Carolina. For Short-Term Alternative 4, two cost scenarios for beach nourishment were considered since it is typically more economically advantageous for beach nourishment projects to be at least 0.5 mile in length (Table 9).

Nourishment would not be needed for about 20 years for Long-Term Alternative 4, which could reduce the total cost for nourishment, including cycling maintenance costs, by as much as $35 million. The total estimated cost presented in Table 9 for the long-term alternatives represents a cumulative amount of nourishment cycles 1 through 10.

Table 9: Estimated costs for nourishment

Activity	Short-Term Alternative 3 (Beach Nourishment) (millions of dollars)	Short-Term Alternative 4 (Combination) (millions of dollars)	Short-Term Alternative 4 (Combination) (millions of dollars)	Long-Term Alternative 4 (Combination) (millions of dollars)	Long-Term Alternative 5 (Beach Nourishment) (millions of dollars)
		0.3 mile	0.9 mile	(Cycles 1-10)	(Cycles 1-10)
1. Mobilization/ Demobilization	4.0	4.0	4.0	4.0	4.0
2. Pumping	5.8	3.5	5.3	60.6	60.6
3. Administration	0.8	0.6	0.7	8.0	8.1
4. Reports & Permitting	0.2	0.1	0.2	2.0	2.0
5. Contingency	0. 5	0.4	0.5	5.0	5.0
Total	11.3	8.6	10.7	11.2	115.6

Source: Overton 2015.

6. Traffic Forecast

A Traffic Forecast Report (URS 2014) was prepared for this feasibility study. The Traffic Forecast Report used a base year of 2013 and a future year of 2040. The 2013 base year traffic forecast includes a No-Build Scenario for summer weekday and summer weekend daily traffic with the existing Herbert C. Bonner Bridge in use. The base year does not include a Build Scenario. The 2040 future year traffic forecast includes a Build Scenario for summer weekday and summer weekend daily traffic with a new Herbert C. Bonner Bridge in place. Since the new Herbert C. Bonner Bridge is expected to have the same number of lanes as the existing one, there was no change in roadway capacity and therefore no need to differentiate between Future Build and Future No-Build forecast scenarios.

The methodology for determining a reasonable growth rate to use for the purposes of this study involved the consideration of data from different sources for both population and traffic in Avon, Buxton, Frisco, and Hatteras Village. Information from the North Carolina Office of State Budget and Management, United States Census Bureau, the *2009 Dare County Land Use Plan Update* (Dare County 2010), and NCDOT's Ferry Division and Traffic Survey Group was collected and analyzed.

Building permits information from the *2009 Dare County Land Use Plan Update* (Dare County 2010) was used to estimate a growth rate for the permanent residents on Hatteras Island. The project study area was expanded to include the unincorporated areas of Rodanthe, Waves, and Salvo. Permanent population on the island was divided by residents who own and live in their homes and residents renting the homes they live in. This was done to account for the fact that the two groups revealed different occupancy rates. Another important factor in the calculations was the fact that only a portion of the homes on Hatteras Island are occupied year-round, and most homes are vacation or seasonal rental properties. This was later used to assign the proper number of occupants to the homes expected to be constructed in the future.

According to the *NC 12 Buxton Hot Spot Improvements Traffic Forecast* (URS 2014), the Dare County planning department established that not all building permits were issued exclusively for new home construction. It was assumed that about a third of the permits will be used to renovate and/or expand existing properties. Using the number of homes expected to be built in the future and available vacant acres, it was determined that land suitable for development will still be available even after year 2040. Thus, build out will not occur until after the forecast future year. It was assumed that the current ratio of visitors per permanent residents of 6:1 taken from the *2009 Dare County Land Use Plan Update* (Dare County 2010) will remain the same.

Based on the anticipated 2040 forecast traffic volume, a two-lane facility is still considered appropriate for this project. The resulting traffic estimates for 2013 are shown in Table 10.

Table 10: 2013 Base year no-build traffic forecast

Forecast Location	AADT Extrapolated to 2013	Base Year 2013 No-Build Forecast Volume	
		Summer Weekday	Summer Weekend
NC 12 east of SR 1232 (Buxton Back Road) (Buxton, Dare County)	8,900	13,900	20,200
NC 12 south of SR 1494 (Moore Way). *Outside of project study area (Avon, Dare County). Used for informational purposes.*	7,300	11,400	16,500

Data from the *Dare County Comprehensive Transportation Plan* (NCDOT 20115b), the North Carolina Office of State Budget and Management, and the United States Census Bureau were collected and analyzed to assist with the determination of the 1.15 percent traffic growth rate for the project. Correspondence with Dare County's planning staff was also beneficial to confirm that the growth rate was reasonable and appropriate for the purposes of this study. To estimate traffic volumes for the base year it was assumed that the new Herbert C. Bonner Bridge would function at full capacity. The resulting 2040 forecast traffic volume is presented in Table 11.

Table 11: Future year 2040 forecast traffic volume

Forecast Location	AADT Extrapolated to 2013	Future Year 2040 Build Forecast Volume	
		Summer Weekday	Summer Weekend
NC 12 east of SR 1232 (Buxton Back Road) (Buxton, Dare County)	8,900	18,900	27,500
NC 12 south of SR 1494 (Moore Way). *Outside of project study area (Avon, Dare County). Used for informational purposes.*	7,300	15,500	22,500

7. Environmental Considerations

This section considers the general environmental characteristics of both the naturally occurring a constructed environments within the project study limits.

7.1 Cultural Environment

Historically, Hatteras Island communities including Buxton and Avon have maintained economic self-sufficiency and a distinctive way of life, which is deeply rooted in both maritime and agricultural cultures. Although there is no agricultural land use within the limits of this proposed project, these cohesive characteristics are still present today in the remnant dialect of many who are native to the Outer Banks, often referring to themselves as “bankers.”

The cultural landscape of Hatteras Island and its communities began to change with the establishment of the Cape Hatteras National Seashore in the 1950s and the paving of NC 12 to better access island communities. Improving access to Buxton and Avon helped to establish these communities as destination points, which in turn influenced the emergence of the tourism sector and cleared the way for those desiring to retire to a coastal community or to purchase a vacation home. Today, NC 12 is a part of the Outer Banks Scenic Byway and the portion of NC 12 that runs through the project study area is well known for its scenic coastal beauty.

Both the Buxton and Avon communities maintain strong year-round residential occupancy, yet there is a distinct tourism season. During the summer season the population peaks due to an influx of tourists. During the winter season the population within both of these communities decreases notably.

Indicators of community cohesiveness among permanent residents in both Buxton and Avon include the use of local place or family names for streets, places of worship, fishing and beach areas, and cultural and historic features such as the Cape Hatteras Lighthouse. Community gathering places for local residents include the Fessenden Center and the Cape Hatteras Secondary School (Figure 14).

The project study area is frequently battered by heavy storms, resulting in a year-round population that is accustomed to the logistical challenges brought about from unpredictable natural events, such as hurricanes and Nor’easters. In an effort to protect the island and NC 12, dunes, originally build by the NPS, have been modified by NCDOT through maintenance and operation activities between the villages of Buxton and Avon to counteract the narrowing of the island between the ocean and sound side. The result is a community that is heavily engaged in the transportation decisions of the area and that recognizes the importance of maintaining access to NC 12 as the only roadway connecting the project study area to the mainland. Therefore, when the roadway is inaccessible due to breaches or construction, it prevents the delivery of goods, the flow of tourists, and the ability for residents to continue with their normal way of life.

7.2 Land Use

Land use adjacent to NC 12 consists of residential and commercial development. Notable resources include the Kinnakeet Shores residential community and one commercial shopping area in Avon (Hatteras Island Plaza), located on NC 12 with a Food Lion grocery store, restaurants, and various retail shops.

Figure 14: Community features map

Land use adjacent to NC 12 in Buxton is commercially oriented with a commercial district that stretches from the northeastern tip of Buxton to the NC 12/Buxton Back Road intersection. Medium to low density commercial development exists along both sides of NC 12 in this area with a few free-standing residences interspersed among the various businesses. Businesses cater to permanent residents as well as seasonal tourists and include restaurants, gas stations, motels, convenience stores, and retail shops. Free-standing residences and estates are located farther back from NC 12, both on the Pamlico Sound side of Buxton, north of NC 12, and the Atlantic Ocean side of Buxton, south of NC 12.

The Avon community is at the northern end of the project study area and is oriented more to resort and estate style living, which attracts seasonal populations. It is known as a second home destination with waterfront appeal.

Community services located within the project study area include Dare County Parks and Recreation-Fessenden Center, Buxton Volunteer Fire Department, Cape Hatteras Electric Cooperative, Dare County Department of Public Health, and Hatteras Island Rescue Squad. In addition, the Dare County Sheriff's Department has a satellite office located in Buxton.

Places of worship along NC 12 include Lighthouse Assembly of God, Buxton United Methodist Church, Our Lady of the Seas Catholic Church, and Cape Hatteras Baptist Church.

7.3 Existing Plans and Policies

The project study area includes properties subject to federal, state, and local plans and policies. The following NPS laws, policies, management plans, and guides may be applicable:

- National Park Service Organic Act of 1916
- National Park Service Management Policies (NPS 1988) (Chapter 4:20)
- Cape Hatteras National Seashore Enabling Legislation (1937), as amended
- Foundation Statement, Cape Hatteras National Seashore (NPS 2011)
- Natural Resources Management Reference Manual #77 (NPS 1991)

Other applicable plans, statutes, and guidance documents may include the following:

- ***2009 Dare County Land Use Plan Update*** **(Dare County 2010)** - The *2009 Dare County Land Use Plan Update* (LUP), adopted on December 6, 2010, notes that NC 12 on Hatteras Island is routinely inundated by storm tide from ocean overwash and/or sound-side flooding. During these events, NC 12 is impassable and closed to traffic or traffic is restricted to four wheel drive vehicles due to sand and water on the roadway. The LUP identifies the long-term protection and maintenance of NC 12 as essential for Hatteras Island. The need for continual maintenance and long-term solutions for NC 12 was noted during the plan update process and is reflected in the LUP policies.
- **Dare County Shoreline Management Commission** - Established in 2005 to oversee and advocate for the preservation and restoration of the shorelines of Dare County, the Shoreline Management Commission serves as an advisory board to the Dare County Board of Commissioners.
- **Coastal Area Management Act** - The North Carolina General Assembly approved the Coastal Area Management Act (CAMA) in 1974. This legislation is applicable to all 20 coastal counties, including Dare County. CAMA requires each of the 20 coastal counties in North Carolina to have

a local LUP that meets guidelines established by the North Carolina Coastal Resources Commission (NCCRC). To comply with CAMA regulations, Dare County adopted its Coastal Area Management Plan titled *2009 Dare County Land Use Plan Update* in December 2010 and it was then certified by the NCCRC in February 2011.

- ***Dare County Comprehensive Transportation Plan*** (NCDOT 2015) - The NCDOT Board of Transportation adopted the *Dare County Comprehensive Transportation Plan* on March 4, 2015. This long-range planning document will assist the county in making transportation decisions over the next 25 to 30 years.
- **Section 4(f) of the Department of Transportation Act of 1966, codified in Federal law at 49 United States Code § 303 -** Declares that "it is the policy of the United States Government that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites."

7.4 Economic Conditions

The primary driver of the economy in the project study area is tourism and the services associated with the tourism industry. This includes retail businesses, restaurants, hotels, and short-term rental of private homes (Figure 15). Boat building and commercial fishing are also common in Dare County (Dare County 2010). Businesses within the project study area would potentially see a positive economic benefit over the long term, as the proposed project would maintain connectivity and stabilize the primary access road through Avon and Buxton. If a bridge alternative is selected or if the roadway is relocated, there could be changes in property exposure and accessibility. The long-term improvements could also enhance the efficiency of transporting goods and services throughout the regional area.

Figure 15: Businesses within the project study area

(Source: URS 2013)

7.5 Tourism

On Hatteras Island, which includes the project study area, 25 percent of the businesses are directly involved in the tourism industry (Lane 2013). Estimates place tourism spending on Hatteras Island in 2011 at $204 million and the tourism industry is responsible for 2,618 jobs. Occupancy receipts in 2011 were $106 million, with a tax collection of $2.1 million. It is estimated that the tourism industry on Hatteras Island contributed $10.3 million in North Carolina state taxes and $9.4 million in local taxes.

7.6 Recreational Resources

There are both publicly-owned and privately-managed recreational resources within the project study area that support the emerging tourism section of the local economy. Privately-owned resources include art galleries, museums, fun parks, and water activity outfitters. The Cape Hatteras National Seashore is a national tourism destination and as such is considered to be a primary source of recreational resources and activities. In general, each alternative under consideration would affect recreational opportunities primarily through change in the recreational setting. NCDOT would work with NPS to maintain access to Seashore recreational resources and associated amenities within the project study area, where feasible.

7.6.1 National Park Service Amenities

NPS provides amenities for recreational resources in the project study area, including beach access (both sound and ocean), parking, and restroom facilities. Access to these recreational amenities is predominately dependent on a fully operational NC 12. NPS will balance the need to maintain access to their resources and amenities with their service mission to preserve the natural environment and resources that are located within its boundaries. The existing and proposed NPS amenities can be seen on Figure 16.

NPS is developing a plan for future public access facilities within the Seashore. A listing of the proposed future NPS amenities within the project study area is contained in Table 12.

Table 12: Future NPS amenities

NPS Proposed Facilities	Project
Haulover Beach ADA boardwalk	ADA boardwalk at Ramp 34
Kite Point parking	A 15-car parking area on west side of highway at/near Kite Point
Access 59 parking	A 15-car parking area at sound-side access #59
Access 60 parking	A 5-car parking area on west side of highway at/near sound-side access #60
Former Buxton CGS ADA boardwalk	A 50-car parking area at the former Buxton Coast Guard Station
Lighthouse Beach ADA boardwalk	A handicap accessible boardwalk at Lighthouse Beach
Loran Road parking area ADA boardwalk	A 3-car parking area at Loran Road
Lighthouse Road elevation	An elevated section of Lighthouse Road to address flooding at ramps 43 and 44

Source: NPS 2013d.

Alternatives that would protect the roadway in its current location would also provide protection for NPS properties through beach nourishment and dune construction. Alternatives that include bridges and roadways on new location would leave the ocean-side NPS resources free from construction-related impacts, but may also leave resources without the protection of dune structures and beach nourishment. In addition, maintaining access from the relocated roadway or new bridge may present challenges in maintaining access to beaches on the ocean side. Further analysis of the effects to NPS property could be considered in future studies.

Figure 16: Existing and proposed NPS amenities

7.6.2 Recreational Activities

Assessing the effects of the project on recreational resources within the project study area requires consideration of not only the activity associated with the resources but also its setting and the overall recreational experience of the user.

The visual effect associated with a roadway improvement project is often subjectively based on the viewer's experience to change in the project setting. For this project, each alternative has the potential to change the existing setting within the project study area. It is likely that the beach nourishment options would represent the least degree of visual change. Road relocation and, in some cases, introduction of bridge structures would be expected to represent greater degrees of change within the existing setting of the project study area.

The following sections address some of the most popular recreational activities afforded to locals and tourists within the project study area, as well as potential project related effects.

Windsurfing

Windsurfing is a popular activity on the sound side of the project study area. This sport requires open areas, wind, tide, and a suitable contour of the ocean floor that is conducive to the sport. The Canadian Hole is a popular windsurfing spot in the project study area located midway between Buxton and Avon in Pamlico Sound. The warm, shallow water of Pamlico Sound combined with the steady Outer Banks winds create unparalleled conditions for windsurfing and kite boarding. This site, Buxton/Canadian Hole, was originally named in the 1980s due to the large influx of tourists from Canada that frequented this area for windsurfing. The Buxton/Canadian Hole (Figure 14) has been the focal point of exceptional East Coast windsurfing for decades.

Any barriers or infrastructure that would reduce open areas, impede wind or tide currents, or modify the ocean floors has the potential to alter windsurfing activities. For example, placement of a bridge structure within Pamlico Sound would be expected to decrease areas most suitable for windsurfing, as structures in water increase the possibility of surfer structure collisions.

Recreational Fishing

Cape Hatteras National Seashore offers recreational fishing opportunities in a variety of ways. Many different types of fish can be taken from the surf, piers, and freshwater ponds as well as from boats in the inlets, the sound, and offshore in the Gulf Stream. Fishing is a year-round sport at Cape Hatteras. The proposed project is not anticipated to affect recreational fishing opportunities from the surf, piers, and freshwater pond. Access to these facilities would be maintained.

Water Activities

Water activities that occur within the project study area include kayaking and canoeing, snorkeling, swimming, surfing, and crabbing. Kayaking and canoeing occur on both the sound and ocean side. Haulover is a popular intake and outtake site for this activity on the sound side. Likewise, many residents and tourists choose Pamlico Sound for snorkeling and swimming due to the shallow waters. Cape Hatteras boasts some of the best surfing on the Atlantic Coast. Construction activities in beach areas would be expected to temporarily interrupt water activities in the areas of construction.

Hiking

Impacts to the NPS shoreline and access areas would affect the hiking areas available in the project study area. Relocating the roadway onto NPS lands would potentially remove areas currently used for hiking. This would require further analysis as the project moves into the NEPA phase.

Bird Watching

Birding is a popular year-round activity within the NPS due to the presence of native shorebirds, as well as migrating birds. Designated birding trails are located within Buxton Woods near the Cape Hatteras Lighthouse. Areas frequented by bird watchers may require further analysis as the project moves into the NEPA phase to assess potential effects such as changes in noise and vibration levels.

7.7 Natural Environment

A cursory evaluation of natural resources was completed for the project study area.

7.7.1 Biotic Resources

Biotic communities found within the project study area are largely dependent on topography, soils, hydrology, disturbance, and distance from tidal waters. Barrier island plant communities, in particular, are interrelated but separated into distinct zones based on proximity to the ocean or sound, elevation above sea level, and degree of shelter from wind-borne salt spray.

Six major terrestrial plant communities typical of the Outer Banks could be expected within the project study area. These include brackish marsh, salt shrub, maritime dry grassland, dune grass, upper beach, and maintained/disturbed land. The project study area also contains open water on both the sound and ocean side of the island.

Wildlife populations within the project study area and along the entirety of the Outer Banks are hindered by a species' ability to tolerate harsh salt environments and limited freshwater sources. While the Outer Banks are known for providing ideal bird nesting, foraging, and flyover habitat, other species groups are challenged by the environment. Specific wildlife surveys have not been performed for the project.

7.7.2 Terrestrial Wildlife

The North Carolina Natural Heritage Program (NCNHP) has compiled a list of Natural Heritage Program Natural Areas (NHPNA) as required by the Nature Preserves Act (NCNHP 2015). The list is based on the program's inventory of natural diversity in the state. An NHPNA is an area of land or water identified by the NCNHP as being important for their biodiversity. A natural area's significance may be due to the presence of rare species, exemplary natural communities, or important animal assemblages. The global and statewide rarity of these elements and their quality at a site is compared with other occurrences to determine a site's significance. Sites included on this list are the best representatives of the natural diversity of the state and, therefore, have priority for protection. However, inclusion on the list does not imply that any protection or public access to the site exists.

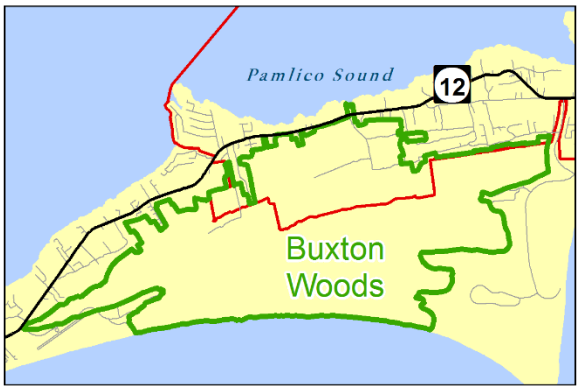


Figure 17: Buxton Woods NHPNA

According to NCNHP's most recent data layer, approximately 1,006 acres of the 4,195-acre Buxton Woods NHPNA is present in the southwestern portion of the project study area (Figure 17); and approximately 22 acres of the 36-acre Turtle Pond and Cape Hatteras Lighthouse Pond NHPNA is present in the southeastern portion of the project study area. Portions of both NHPNAs are contained within the Cape Hatteras National Seashore.

7.7.3 Water Resources

Water resources within the project study area are part of the Pasquotank River Basin (United States Geological Survey Hydrologic Unit 03020105). The project study area includes portions of Pamlico Sound, Buxton Harbor Channel, and Buxton Channel. Brooks Creek, Brigand Bay, Cape Creek, Long Point Creek, Boat Creek, and Askins Creek all drain sound-side along with a number of other unnamed tributaries, as shown on Figure 18. Water resources within the project study area are estuarine.

The best usage classification of all waters within the project study area is SA (marketing shellfishing, salt water); HQW (high quality waters) (North Carolina Division of Water Resources [NCDWR 2013]). The SA designation identifies tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC (aquatic life, secondary recreation, salt) and Class SB (primary recreation, salt water) uses. The HQW supplemental designation identifies high quality waters that are rated as excellent based on biological and physical/chemical characteristics through monitoring or special studies, primary nursery areas, critical habitat areas, water supply watersheds, and all Class SA waters.

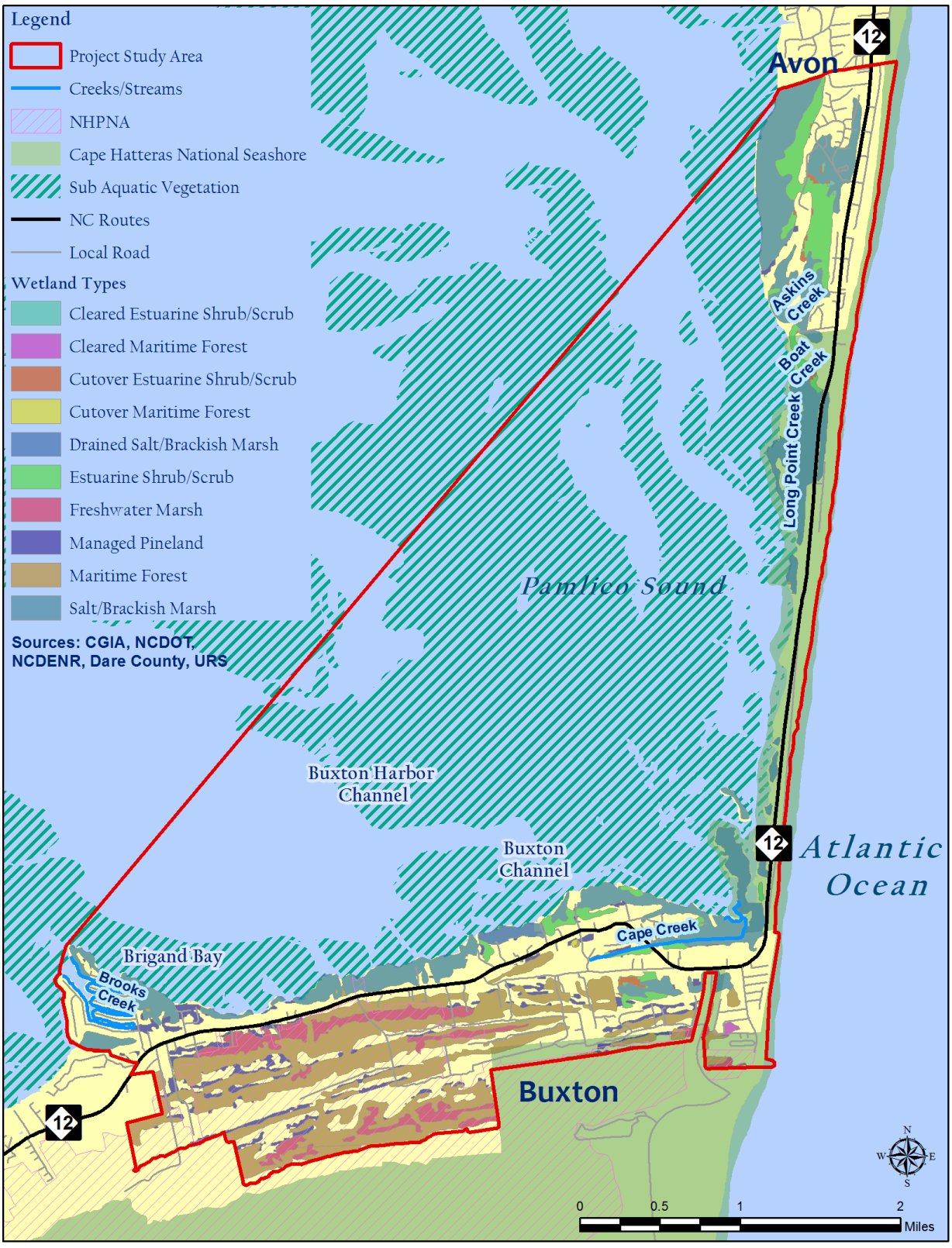
No water supply watersheds or outstanding resource waters (ORW) are present within the project study area.

Pamlico Sound, Brooks Creek, Cape Creek, and Askins Creek are present on the 2014 Draft 303(d) list of impaired waters (NCDWR 2014) as prohibited shellfish areas. Most of the waters immediately adjacent to land on the sound side of the project study area are closed to shellfish harvesting. The larger Pamlico Sound, Buxton Harbor Channel, and Buxton Channel areas are approved shellfish harvest areas.

Primary Nursery Areas

Primary nursery areas (PNA) are located in the upper portions of creeks and bays. These are usually shallow with soft, muddy bottoms and surrounded by marshes and wetlands. Low salinity and an abundance of food in these areas create an ideal habitat for young fish and shellfish. The majority of the shallow waters of Pamlico Sound, Buxton Harbor Channel, and Buxton Channel are considered PNA. All of the smaller creeks and tributaries within the project study area are PNAs.

Figure 18: Natural resources map



Submerged Aquatic Vegetation

SAV is a fish habitat dominated by one or more species of underwater vascular plants. These vegetation beds occur in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas. Freshwater vegetation may also grow in SAV beds. In North Carolina, SAV usually occurs in water less than 6 feet deep due to the inability of sunlight to penetrate below the depth necessary for SAVs to prosper. In addition to its role as critical habitat for many aquatic fauna species, SAV is an important bio-indicator of environmental health because of its sensitivity to aquatic stressors.

There are approximately 4,994 acres of SAV mapped within the project study area (North Carolina Division of Environmental and Natural Resources [NCDEQ] 2008). The effects on SAV will be considered not only for direct construction impacts, but also for sand dredging and beach nourishment efforts if sand from the sound was to be used for beach nourishment.

Essential Fish Habitat

The Magnuson-Stevens Fishery Management and Conservation Act (Public Law 94-265, as amended through October 11, 1996) requires federal action agencies that fund, permit, or carry out activities that may adversely impact essential fish habitat (EFH) to consult with the National Marine Fisheries Service regarding the potential effects of their actions. An EFH assessment has not been conducted for the project study area; however, SAV areas and the ocean surf zone are considered EFH.

The SAV present within the project study area is used by a wide range of aquatic species during some or all phases of their life cycle. These nursery areas are generally found in shallow, mid- to high-salinity waters that lie over muddy or grassy bottoms, such as those found in tributary creeks and embayments, and along the western edge of barrier islands.

7.7.4 Jurisdictional Issues

Sections 401 and 404 of the Clean Water Act require regulation of discharges into Waters of the United States. No formal stream or wetland delineations have been performed within the project study area; however, topographic mapping and existing geographic information system (GIS) data have been used to identify likely occurrences for purposes of this study.

Surface Waters

The Atlantic Ocean, Pamlico Sound, Buxton Harbor Channel, Buxton Channel, Brooks Creek, Brigand Bay, Cape Creek, Long Point Creek, Boat Creek, Askins Creek, and a number of unnamed tributaries are present within the project study area.

Wetlands

NPS utilizes a broader definition of wetland and adheres to the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979), which defines wetlands as lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land, is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Prior to this study there has been no formal identification or delineation of wetlands within the project study area. Estimates were made in regard to potential wetland encroachment for the purposes of this

study through the use of NCDCM wetlands mapping (NCDCM 2003). NCDCM wetlands are generated through analysis of National Wetlands Inventory (NWI) mapping, county soils mapping, and classified land use/land cover from satellite imagery. NCDCM's classification scheme is based on both vegetative cover and hydrogeomorphic character.

There are 1,892 acres of NCDCM-mapped wetlands within the project study area (Table 13). However, 157.9 acres are classified as a non-wetland type (drained salt/brackish marsh, managed pineland). The largest wetland component is salt/brackish marsh occurring along the edges of Pamlico Sound. The salt/brackish marsh grades back into estuarine shrub/scrub to the south and east.

Table 13 shows the known NCDCM-mapped wetlands in the project study area. NPS has a unique identification of wetlands that may include areas not already identified. As the project moves into the NEPA phase, the NPS wetlands will be delineated.

Table 13: NCDCM wetlands within the project study area

NCDCM Wetland Type	Acres
Cleared estuarine shrub/scrub	4.1
Cleared maritime forest	3.6
Cutover estuarine shrub/scrub	15.1
Cutover maritime forest	1.2
Drained salt/brackish marsh	18.8
Estuarine shrub/scrub	162.2
Freshwater marsh	161.8
Managed pineland	139.1
Maritime forest	674.6
Salt/brackish marsh	711.5
Total	1,892

NCDCM has created a watershed-based GIS wetland functional assessment model to assist in the classification and quality assessment of NCDCM-mapped wetlands. North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS) is the procedure that NCDCM uses to assess the functions of its wetlands (NCDCM 1999). NC-CREWS evaluates three main wetland functions: water quality, wildlife habitat, and hydraulic function. The overall wetland rating is based on each wetland's ability and opportunity to provide each of the three main functions. There are three relative ORW scores (in order from low to high): Beneficial Significance, Substantial Significance, and Exceptional Significance.

Of the 1,892 acres of wetlands within the project study area, 1,445 acres are rated Exceptional Significance; 408 acres are rated Substantial Significance; and 16 acres are rated Beneficial Significance.

Coastal Area Management Act Areas of Environmental Concern

CAMA requires permits for development in areas of environmental concern (AEC). An AEC is an area of natural importance. It may be vulnerable to erosion or flooding, or it may have environmental, social, economic, or aesthetic values that make it valuable to the state.

NCDCM has established coastal resource setback criteria for oceanfront construction based on the rate of shoreline change. The potential effects to AEC have not been fully assessed and would require further investigation should this project be carried forward in the project design process. NCDOT will be required to adhere to Rule 15A NCAC7H .0304 (Area of Environmental Concern within Ocean Hazard Areas).

7.7.5 Rare and Protected Species

Federally-Protected Species

As of April 20, 2015, USFWS lists 13 federally-protected species for Dare County (USFWS 2015). These species are shown in Table 14. A brief description of each species' habitat and probable biological conclusions are available in the NC 12 *Feasibility Study from Buxton to Avon-Natural Resources Technical Report* (NCDOT 2014a). If the proposed project moves forward, detailed field surveys would be conducted for species with the potential to occur and/or be affected by impacts from the proposed project.

Table 14: Federally-protected species listed for Dare County

Scientific Name	Common Name	Federal Status	Habitat Present
Alligator mississippiensis	American alligator	T(S/A)	Yes
Chelonia mydas	Green sea turtle	T	Yes
Eretmochelys imbricata	Hawksbill sea turtle	E	Yes
Lepidochelys kempii	Kemp's ridley sea turtle	E	Yes
Dermochelys coriacea	Leatherback sea turtle	E	Yes
Caretta caretta	Loggerhead sea turtle	T	Yes
Charadrius melodus	Piping plover	T	Yes
Calidris canutus rufa	Red knot	T	Yes
Canis rufus	Red wolf	EXP	No
Picoides borealis	Red-cockaded woodpecker	E	No
Sterna dougallii dougallii	Roseate tern	T	Yes
Trichechus manatus	West Indian manatee	E	Yes
Amaranthus pumilus	Seabeach amaranth	T	Yes

E = Endangered
T = Threatened
EXP = Experimental Population
T(S/A) = Threatened Due to Similarity in Appearance

Endangered Species Act Critical Habitat Designations

Critical habitat for piping plover, which can be found within the project study area along sandy beaches and dunes, is listed for Dare County (October 21, 2008, Federal Register, 73:62816-62841).

Construction Moratoria

Due to the number of protected species known to occupy the project study area and their nesting, flowering, and migration patterns, construction moratoria would likely be applicable for activities on the ocean beach. The need for moratoria will be coordinated with resource agencies during project development and prior to construction. This is a typical moratorium, but alternatives could be

developed to minimize impact so that work can be allowed during these times. Roseate tern and piping plover are present in late March/early April (NPS 2013b). Sea turtles begin to nest in May. Seabeach amaranth is present from May to September, and the roseate tern returns for August through October (NPS 2013c).

Federal Species of Concern

Federal species of concern (FSC) are not legally protected under the Endangered Species Act (ESA) of 1973 and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as threatened or endangered. The ESA does not formally protect federal-candidate or state-listed species. FSC is an informal term and is not defined in the federal ESA. In North Carolina, FSC is defined as those species that appear to be in decline or otherwise in need of conservation and are under consideration for listing or for which there is insufficient information to support listing at this time. Organisms listed as threatened, endangered, or special concern (SC) on the NCNHP list of rare plant and animal species are afforded protection under the ESA and the North Carolina Plant Protection and Conservation Act of 1979. The North Carolina Wildlife Resources Commission (NCWRC) and the North Carolina Department of Agriculture are responsible for enforcing and administering species protection.

As of April 20, 2015, the USFWS lists seven FSC for Dare County (Table 15).

Table 15: Federal species of concern for Dare County

Scientific Name	Common Name
Anguilla rostrata	American eel
Laterallus jamaicensis	Black rail
Dendroica virens waynei	Black-throated green warbler
Peromyscus leucopus ssp. 1	Buxton Woods white-footed mouse
Malaclemys terrapin terrapin	Northern diamondback terrapin
Corynorhinus rafinesquii	Rafinesque's big-eared bat
Trichostema sp. 1	Dune blue curls

Bald Eagle and Golden Eagle Protection Act

In the July 9, 2007, Federal Register (72:37346-37372), the bald eagle was declared recovered, and removed (delisted) from the federal list of threatened and endangered wildlife. This delisting took effect August 8, 2007. After delisting, the Bald and Golden Eagle Protection Act (Eagle Act) (16 USC 668-668d) became the primary law protecting bald eagles.

Habitat for the bald eagle consists primarily of mature forests in proximity to large bodies of open water for foraging. Large, dominant trees are utilized for nesting sites, typically within 1 mile of open water. Ideal habitat for the bald eagle is not present within the project study area. However, eagles are known as year-round transient species along the Outer Banks. A review of April 2014 NCNHP records indicates known occurrences of bald eagles within 1 mile of the project study area.

7.8 Bicycle and Pedestrian Facilities

NC 12 has 3- to 6-foot roadway shoulders to support bicycle traffic throughout the project study area. The *Dare County Comprehensive Transportation Plan* adopted by the NCDOT Board of Transportation on March 4, 2015 (NCDOT 2015) shows a proposed multi-use path along NC within the project study area.

The Outer Banks Scenic Byway includes NC 12 on Hatteras Island. Construction is underway for 7.9 miles of pathways in Rodanthe, Waves, Salvo, and Avon on Hatteras Island at the northern end of the project study area.

There are marked crosswalks for pedestrian traffic along existing NC 12 in front of Haulover Day Use area in Buxton and at Park Drive in Kinnakeet. Over the past several years bikeways and walkways have been constructed in many portions of Dare County. These improvements provide a safe alternative means of transportation for residents and visitors. “Share the Road” signs are present along the project study area, as shown on Figure 19.

Figure 19: "Share the Road" sign in project study area

(Source: URS 2013)

7.9 Historic Resources and Landmarks

A preliminary investigation of historic resources and landmarks has identified the following resources. As the project moves forward into the NEPA review process, this information will be updated.

7.9.1 Historic Resources

The 2005 *Intensive-Level Historic Architectural Survey of NC 12 for Proposed Interim Improvements for Protection Between Buxton and Avon (TIP Project No. R-4070B) and for Proposed Interim Improvements for Protection South of Oregon Inlet at the Old Sandbag Area in Pea Island National Wildlife Refuge (TIP Project No. R-3116E) and at the Canal Area in Northern Pea Island (TIP Project No. R-3116F) Dare County, North Carolina* (NCDOT 2005) identified two potential historic districts in the project study area, one in the old village of Avon, the other in Buxton. The report concludes that the potential Buxton Historic District is not eligible for listing in the National Register of Historic Places. It further advises that two resources within the historic district, the W. Rocky and Cynthia Tolson Rollinson House and the Urias O. and Caddie Midgett Gaskins House and Gaskins Cemetery, are individually eligible for National Register listing. The report also ascertains that the potential Avon Historic District is not eligible for listing in the National Register. However, it concludes that four resources within the historic district, the Emma Miller and Jarvis Gray House, the Henrietta Scarborough and Isaac T. Meekins House, the Zion Scarborough Cemetery, and the Thomas and Joseph Ann Gray House, are individually eligible for National Register listing. The Henrietta Scarborough and Isaac T. Meekins House was demolished before the report was finalized and is not a concern for this project.

The cultural resources in the project study area can be seen on Figure 20.

Because so much time has passed since the last thorough historic investigation of the area, there may be more properties eligible for National Register listing. If the project moves forward in the NEPA process a new investigation will be conducted to identify any additional historic properties.

Figure 20: Historic resources map

7.9.2 Landmarks

The Cape Hatteras National Seashore is a publicly-owned park and recreational area that is owned by the federal government and administered by NPS. The Cape Hatteras National Seashore boundary follows the mean low watermark along the Atlantic Ocean side of the project study area. On the Pamlico Sound side the boundary extends 150 feet from the shoreline. Outdoor recreational activities at the Seashore and Pamlico Sound include fishing, surf fishing, windboarding, walking, running, cycling, and bird watching.

To the south of the project study area is Cape Hatteras Lighthouse, a national landmark on NPS property (Figure 21). The lighthouse was completed in 1870 and along with the lighthouse keeper's quarters is considered an historic property. The lighthouse is still operational and maintained by the United States Coast Guard and continues to be a popular tourist attraction.

As the project moves forward in the NEPA process, further review of the impacts to the Cape Hatteras National Seashore will be necessary.

Figure 21: Cape Hatteras Lighthouse (Source: URS 2013)

8. Summary of Agency Coordination

A series of meetings have been conducted to engage cooperating agencies and local officials.

8.1 National Park Service

A meeting was held on April 22, 2014, between the NCDOT project team and NPS to discuss the initiation of the feasibility study. Representatives from NPS were briefed on the project and asked for input that would be valuable for the feasibility study.

Project study area details discussed at this meeting included the following:

- Dare County had recently submitted a proposal for beach nourishment in Buxton and northern Rodanthe to NPS. Generally, beach nourishment activities go against NPS management policy, but this policy is under review.
- NPS expressed interest in a high speed ferry service option because of extensive beach erosion in the project study area.
- All NPS properties in the project study area are a habitat for sea turtles, which would be sensitive to construction activities from mid-May through November.
- Recreational activities in the project study area include kite boarding, hiking, windsurfing, recreational fishing, and swimming.

8.2 Merger Team

On May 8, 2014, NCDOT conducted a NEPA/Section 404 Merger Team meeting to discuss this feasibility study. Representatives were in attendance from NPS, United States Environmental Protection Agency (EPA), National Marine Fisheries Service, USFWS, USACE, Federal Highway Administration, NCWRC, NCDCM, North Carolina State Historic Preservation Office (HPO), the Albemarle Rural Planning Organization, and NCDWR.

Project study area details discussed at this meeting included the following:

- There is a concern that suitable sand for NCDOT's conceptual improvements may not be available in close proximity of the project. Importing sand may be problematic from a biological suitability standpoint, as well as in terms of cost feasibility.
- The Outer Banks Task Force has an NCGS report that addresses areas that may contain sand suitable for nourishment and dunes.
- The NPS representative indicated that mitigation for wetland impacts may be problematic in that any wetland mitigation should occur within the management boundaries of NPS.
- NPS indicated that they have several proposals for projects from various entities that are causing them to review and reconsider the viability of their policies regarding the barrier islands. Proposals include a potential project to protect portions of the Oregon Inlet (new jetty on the north side of the inlet to reduce migration of sand) and the proposal from Dare County for beach nourishment to protect county resources.
- NPS remarked that a 5-year beach nourishment option would be markedly different from a 50-year option, which may require several iterations of activity similar to a one time 5-year option. NPS questions the availability of enough sand for a single 5-year beach nourishment option, let alone a 50-year option. A 404 permit has been needed in the past for dredging activities, and NPS has a positive relationship with USACE for these efforts.

- Deterioration of the Pamlico Sound shoreline from Hurricane Isabel, natural erosion, and dredging activities has led to the creation of Canadian Hole, a popular windsurfing area.
- Utility poles on the sound side of existing NC 12 are at risk of washing away; therefore, nourishment activities may help with the preservation of these utilities.
- Coastal resource setback criteria would need to be adhered to.

8.3 Local Officials

Dare County officials attended an information session on June 11, 2014, in which they were introduced to the study. NCDOT indicated that the estimated project costs generated as part of this feasibility study and others would be used to program and schedule projects in the upcoming STIP. This project is already included in the current STIP, but is funded for planning and environmental studies only. One local official voiced his position regarding the need for the project as not a matter of "if," but "when." NCDOT representatives went on to state that the feasibility study would consider both the short-term and long-term option to provide reliable access along NC 12 and to maintain the integrity and viability of the transportation network. The intent of the short-term feasibility options is to be able to act quickly if a storm event requires emergency repairs on any of the hot spots. The long-term options are intended to meet the needs of the project throughout its design life.

9. Summary of Project-Related Effects

Table 16: Short-term alternative analysis

Alternative	Construction				Human Environment			Natural Environment			
	Cost (Millions) (excludes the cost of dune construction)	Length of Project (feet)	Length of Proposed Bridges (feet)	Constructability Concerns	Right-of-Way	Recreational Resources	Tourism	Encroachment on NPS	New Stream Crossings	Jurisdictional Wetlands (acres) (Scale of severity: <1 acre= low, > 1 acre=high)	Submerged Aquatic Vegetation in Sound (potential for encroachment)
Alternative 1 (Road Relocation A)	6.3	7,755	0	Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Construction staging is likely a concern considering the limited area available for such use.	ROW (or at least an easement agreement) may be needed on private properties. The majority of ROWs impacted by this alternative are within the Seashore. An easement within NPS will be needed for construction activities.	Access to facilities and amenities would be maintained.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment on 8.39 acres of National Seashore	3 crossings (existing location)	Low	Not Likely
Alternative 2 (Road Relocation B)	13.0	11,450	0	Potential shortage of fill sand for dune construction. Approximate dune length in feet: 10,500 total. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Construction staging is likely a concern considering the limited area available for such use.	ROWs (or at least an easement agreement) may be needed on private properties. Easement within NPS will be needed for construction activities required within the Seashore. Five private properties have the potential to be impacted by this alternative. Two of the five would also be impacted by the proposed roadway.	Access to facilities and amenities would be maintained.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment on 25.27 acres of National Seashore	3 existing (existing location)	Low	Not Likely
Alternative 3 (Beach Nourishment)	11.3	4,752 (length of beach nourishment section)	0	Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Potential shortage of borrow sand for the purpose of beach nourishment may prevent consideration of this option. Potential shortage of fill sand for dune maintenance. Approximate dune	An easement agreement may be needed on private properties if beach nourishment extends upland of the mean high water line. Easement within NPS boundaries would be needed for nourishment within the Seashore.	Access to facilities and amenities would be maintained. Beach nourishment associated with this alternative could encroach upon beach areas used for swimming and fishing.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Beach nourishment would temporarily alter the naturally-occurring wildlife habitat and hydrological regime.	None	High, assuming beach nourishment to occur on areas meeting the criteria of NPS wetland.	Not Likely

Alternative	Construction				Human Environment			Natural Environment			
	Cost (Millions) (excludes the cost of dune construction)	Length of Project (feet)	Length of Proposed Bridges (feet)	Constructability Concerns	Right-of-Way	Recreational Resources	Tourism	Encroachment on NPS	New Stream Crossings	Jurisdictional Wetlands (acres) (Scale of severity: <1 acre= low, > 1 acre=high)	Submerged Aquatic Vegetation in Sound (potential for encroachment)
				maintenance in feet: 6,000 total. Further investigation is needed to determine whether sand suitable for beach nourishment is available for initial construction. NPS policy on beach nourishment proposals is under internal agency review. Construction moratoria due to protected species likely.							
Alternative 4 (Combination of Road Relocation with Nourishment)	18.2 for 0.9 miles option 16.1 for 0.3 miles option	9,350	0	Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Potential shortage of fill sand for dune construction. Approximate dune length in feet: 22,500 total. Potential shortage of borrow sand for the purpose of beach nourishment may prevent consideration of this option. Further investigation is needed to determine whether sand suitable for beach nourishment is available for initial construction. NPS policy on beach nourishment proposals is under internal agency review. Construction staging is likely a concern considering the limited area available for such use.	Easement within NPS would be needed for beach nourishment within the Seashore. Private property acquisition would be needed. The majority of ROW impacts would occur within the Seashore.	Access to facilities and amenities would be maintained. Beach nourishment associated with this alternative could encroach upon beach areas used for swimming and fishing.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment of 20.18 acres of National Seashore	3 crossings (new crossings)	High assuming beach nourishment to occur on areas meeting the criteria of NPS wetland.	Not Likely

Table 17: Long-term alternative analysis

Alternative	Construction				Human Environment			Natural Environment			
	Cost (Million) (excludes the cost of dune construction)	Length of Project (feet)	Length of Proposed Bridges (feet)	Constructability Concerns	Right-of-Way	Recreational Resources	Tourism	Encroachment on NPS	New Stream Crossings	Jurisdictional Wetlands [a] (acres) (Scale of severity: <1 acre= low, > 1 acre=high)	Submerged Aquatic Vegetation in Sound (potential for encroachment)
Alternative 1 (Road Relocation with Bridges)	81.1	11,500	8,030	Potential shortage of fill sand for dune construction. Approximate dune construction in feet: 3,800 total. Roadway construction possibly in unstable soils. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Construction staging could be a concern considering the limited area available for such use regardless of which build alternative is carried forward in the project development process.	Easement within NPS would be needed for construction activities within the Seashore. Private property acquisition would be needed. It is estimated that two property impacts could occur due to dune construction as well as the proposed roadway.	Maintaining access to NPS facilities and amenities in areas with proposed bridging may be a challenge and would require further investigation.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing.	Encroachment of 8.39 acres of National Seashore	3 crossings (existing location)	Low Bridge implementation would be expected to minimize the potential for wetland impacts.	Likely due to bridge footings in the Pamlico Sound
Alternative 2 (Bridge within Existing Easement)	154.7	22,150	1,720	Roadway construction possibly in unstable soils. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Construction staging could be a concern considering the limited area available for such use regardless of which build alternative is carried forward in the project development process.	This alternative would be within the existing NC 12 easement within the Seashore.	Access to facilities and amenities would be maintained.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment of 2.37 acres of National Seashore	None	Low	Not Likely
Alternative 3 (Bridge on New Location)	145.4	22,514	14,316	Large bridge construction. Potential shortage of fill sand for dune construction. Approximate dune construction in feet: 7,500 total. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. In SAV area, use of work bridges, top	Easement within NPS would be needed for beach nourishment within the Seashore. Private property acquisition would be needed. It is estimated that	Maintaining access to NPS facilities and amenities in areas with proposed bridging may be a challenge and would require further investigation.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment of 30.02 acres of National Seashore	None	Low	Likely with bridge footings in the Pamlico Sound

Alternative	Construction				Human Environment			Natural Environment			
	Cost (Million) (excludes the cost of dune construction)	Length of Project (feet)	Length of Proposed Bridges (feet)	Constructability Concerns	Right-of-Way	Recreational Resources	Tourism	Encroachment on NPS	New Stream Crossings	Jurisdictional Wetlands [a] (acres) (Scale of severity: <1 acre= low, > 1 acre=high)	Submerged Aquatic Vegetation in Sound (potential for encroachment)
				down construction likely. Construction staging could be a concern considering the limited area available for such use regardless of which build alternative is carried forward in the project development process.	one property impact could occur near the southern tip of Avon due to dune construction. No relocation is anticipated.						
Alternative 4 (Combination of Road Relocation and Beach Nourishment)	132.4	20,783	0	Roadway construction possibly in unstable soils. Potential shortage of borrow sand for the purpose of beach nourishment and dune construction may prevent consideration of this option. Approximate dune maintenance in feet: 16, 500 total. Further investigation is needed to determine whether sand suitable for beach nourishment is available for initial construction and a 5-year re-nourishment schedule. NPS policy on beach nourishment proposals is under internal agency review. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life. Construction staging could be a concern considering the limited area available for such use.	Easement within NPS would be needed for beach nourishment within the Seashore. Three private properties would be impacted by this alternative due to beach nourishment.	Access to facilities and amenities would be maintained.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment of 50.58 acres of National Seashore	1 crossing (new location)	Medium Some construction would be through wetlands.	Likely with bridge footings in the Pamlico Sound
Alternative 5 (Beach Nourishment)	115.6		0	Potential shortage of borrow sand for the purpose of beach nourishment may prevent implementation of this option. NPS policy on beach nourishment proposals is under internal agency review. Likely construction moratorium for construction activities occurring in areas managed by NPS due to protected species life.	Easement within NPS would be needed for beach nourishment within the Seashore. Private property acquisition would be needed.	Access to facilities and amenities would be maintained. Beach nourishment associated with this alternative could encroach upon beach areas used for swimming and fishing.	Construction activities in beach areas would be expected to temporarily interrupt beach-related activities in the area of construction such as swimming, fishing, bird watching, or surfing,	Encroachment of the National Seashore	None	High Assuming beach nourishment to occur on areas meeting the criteria of NPS wetland.	Not Likely

Alternative	Construction				Human Environment			Natural Environment			
	Cost (Million) (excludes the cost of dune construction)	Length of Project (feet)	Length of Proposed Bridges (feet)	Constructability Concerns	Right-of-Way	Recreational Resources	Tourism	Encroachment on NPS	New Stream Crossings	Jurisdictional Wetlands [a] (acres) (Scale of severity: <1 acre= low, > 1 acre=high)	Submerged Aquatic Vegetation in Sound (potential for encroachment)
				Construction staging could be a concern considering the limited area available for such use.							

10. Summary of Assessments and Recommendations

The reliability of NC 12 from Avon to Buxton within the project study area is anticipated to continue its trend of decline without the project. This feasibility study consists of the identification and preliminary assessment of a suite of alternatives, each of which, if constructed, would maintain or improve NC 12 within the project study area. It is important to recognize that the occurrences of storm events could result in some measure of storm surge, and erosion on both the sound and ocean sides of the island is expected to continue. The chronic effect of beach erosion and roadway damage caused by storm events, including hurricanes, will continue to increase the frequency of emergency repair efforts on NC 12 in order to maintain uninterrupted access. Routine maintenance costs will also continue to increase as the road becomes more vulnerable to overwash.

This feasibility report is not intended to specify a certain alternative for implementation. Rather a range of alternatives is presented that can be considered in funding decisions. This feasibility study considered various two-lane alternatives to address the established project purpose and need. Based on the anticipated 2040 forecast traffic volume, a two-lane facility is still considered appropriate for this project.

The short-term alternatives were developed to be implemented as expeditiously as possible in the event of a roadway washout before a long-term design option is carried forward for environmental review and construction. The long-term alternatives address the need of the project in a way that is more sustainable over the life of the project, given what is known about future coastal morphology changes. Both short-term and long-term alternatives would need further analysis through the federal NEPA review process and coordination with local, state, and federal resource agencies to assess each alternative's consistency with each agency's mission and current policies.

Alternative development for the purposes of this study considered two estimated limits of shoreline erosion, average shoreline limits, and the high-erosion limits. The difference between these two limits is discussed in section 3.1 of this report. The reasoning behind the utilization of the average shoreline limit was to minimize property impacts to NPS and to private properties such as the commercial hotel located at the northern tip of Buxton adjacent to the existing roadway.

Identifying a source of sand suitable for construction fill and mitigation activities, such as nourishment and dune restoration, is paramount to the construction of both the short-term and long-term alternatives. As mentioned earlier in this study, a report prepared for the Outer Banks Task Force and NCDOT by the NCGS (NCGS 2009) estimated that up to 120 million cubic yards of sand suitable for nourishment is located offshore just south of the project limits, which could fulfill project needs if deemed suitable. The finding of this report will need further vetting by resource agencies including NCDCM, EPA, and USACE. A detailed sediment analysis of potential borrow areas may be needed to fully address the question as to whether or not these borrow areas are sources of suitable sand for this project. In addition, a 404 permit has been required in the past on similar transportation projects prior to dredging for beach nourishment construction. Early identification of locations where dredging could occur could beneficial future project development, in the event that a short-term option is needed.

In the near term it is recommended that NCDOT coordinate with local governments and NPS to address any concern of competing nourishment proposals, some of which may be more comprehensive than this project and intended to protect homes and other infrastructure within the project study area. NPS has indicated that they have been requested by Dare County to review a proposal that would include

construction of double jetties and sand dunes ocean side in Dare County. Competing proposals may further limit the quantity of suitable sand for NCDOT's proposed improvement. It is noteworthy that NCDOT's proposed management measures, such as nourishment and restoration of dunes, are limited to what is needed to protect the transportation infrastructure only.

The tourism sector makes up a substantial portion of the local economy. Coordination with local officials, business owners, and NPS will be needed to minimize any disruption of access to areas that cater to seasonal tourists or to recreational facilities or the beaches on the ocean side or sound side.

The need for and benefit derived from the use of special construction techniques and/or temporary bridge components should be given further consideration. A cored slab bridge is a more likely option for short-term alternatives on this project, but Mabey bridge components could potentially be stockpiled in or near the project areas for rapid utilization in response to the occurrence of an inlet.

Interim steps that NCDOT should consider in order to be prepared in the event that a short-term option needs to be implemented to maintain access should include addressing project staging area concerns. Limited space within the project limits for potential staging areas indicated that other options should be considered, including the potential utilization of Hatteras Inlet ferry dock, the identification of suitable staging areas located outside of the Seashore, and the extension of work bridges within the Pamlico Sound.

Maintaining up-to-date inventories of historic, cultural, and natural resources to quickly identify the potential impacts of proposed designs is recommended. Additional coordination with NPS regarding their existing beach nourishment policies, wetland mitigation policies, construction moratoria, and potential construction staging areas is needed as recent meetings with NPS has suggested that a change in the current policy is being considered.

Coordination with the project's interagency merger team is recommended to address the protection of aquatic ecosystems and wildlife habitat as well as adherence to permitting requirements.

11. Literature Cited

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe 1979. *Classification of Wetlands and Deepwater Habitats of the United States. US Department of Interior, Wildlife Service, Office of Biological Services*. FWS/OBS-79/31. December 1979. http://www.fws.gov/wetlands/Documents/Classification-of-Wetlands-and-Deepwater-Habitats-of-the-United-States.pdf.

CSE. 2013. *Shoreline Erosion Assessment and Plan for Beach Restoration, Rodanthe & Buxton Areas, Dare County, North Carolina*. Prepared for Dare County Board of Commissioners.

Dare County. 2010. *2009 Dare County Land Use Plan Update*. Adopted by the Dare County Board of Commissioners on December 6, 2010.

Dare County Government. 2007. *Dare County Emergency Management Operations Plan*. March 2007.

Lane, Brent. 2013. *Hatteras Island Economic Impact*. 2013. Presented to Outer Banks Visitors Bureau. July 2013.

Magnuson-Stevens. 1996. Magnuson-Stevens Fishery Conservation and Management Act, as amended through October 11, 1996. http://www.nmfs.noaa.gov/sfa/magact/.

NCDCM. 1999. *NC-CREWS: North Carolina Coastal Region Evaluation of Wetland Significance*. A Report of the Strategic Plan for Improving Coastal Management in North Carolina. Division of Coastal Management, NOAA, EPA. May 1999.

NCDCM. 2003. DCM Wetland Data and Documents. NCDEQ, NCDCM. Shapefile. Published 12/30/03.

NCDEQ. 2008. Submerged Aquatic Vegetation – SAV. NCDEQ, Albemarle-Pamlico National Estuary Partnership (APNEP). Vector digital data.

NCDOT. 2005. *Intensive-Level Historic Architectural Survey of NC 12 for Proposed Interim Improvements for Protection between Buxton and Avon (TIP Project No. R-4070B) and for Proposed Interim Improvements for Protection South of Oregon Inlet at the Old Sandbag Area in Pea Island National Wildlife Refuge (TIP Project No. R-3116B) and at the Canal Area in Northern Pea Island (TIP Project No. R-3116B) Dare County, North Carolina.* URS Corporation.

NCDOT. 2014a. *Feasibility Study From Buxton to Avon-Natural Resources Technical Report*. NCDOT. July 2014.

NCDOT. 2014b. *North Carolina Roadway Design Manual*. https://connect.ncdot.gov/projects/roadway/pages/roadway-design-manual.aspx.

NCDOT. 2014c. Construction Estimate. NCDOT Project Services Unit, Preliminary Estimate Section. Doug Lane. July 25, 2014.

NCDOT. 2015a. 2016-2025 State Transportation Improvement Program. June 2015.

NCDOT. 2015b. *Dare County Comprehensive Transportation Plan*. July 2015.

NCDWR. 2013. *NC Water Quality Classifications by NC River Basin, Pasquotank River Basin. Surface Water Classifications, Division of Water Resources*. Updated December 9, 2013.

NCDWR. 2014. *2014 Draft Category 5 Water Quality Assessments – 303(d) List*. Water Quality Data Assessment, Division of Water Resourc3es. Updated February 21, 2014.

NCGS. 2009. *Offshore Sand Resorce Resource Investigation, North Carolina Outer Banks: Ocracoke Inlet to Oregon Inlet*. North Carolina Department of Transportation. Revised August 04, 2009.

NCNHP. 2014. Element Occurrence Shapefile (April 2014). North Carolina Natural Heritage Program, Department of Environment and Natural Resources. Vector digital data, publication date 20140401.

NCNHP. 2015. Natural Heritage Program Natural Areas (April 2015). North Carolina Natural Heritage Program, Department of Environment and Natural Resources. Vector digital data, publication date 20150416.

NPS. 1988. *Management Policies*. U.S. Department of the Interior, National Park Service.

NPS. 1991. NPS #77: *The Natural Resource Management Guideline*.

NPS. 2011. *Foundation Statement, Cape Hatteras National Seashore*. US Department of the Interior, National Park Service, Cape Hatteras National Seashore, North Carolina. September 2011.

NPS. 2013a. *Cape Hatteras National Seashore Sea Turtle Monitoring 2013 Annual Report.* US Department of the Interior, National Park Service, Cape Hatteras National Seashore, North Carolina.

NPS. 2013b. *Cape Hatteras National Seashore Piping Plover (Charadrius melodus) Monitoring 2013 Annual Report.* US Department of the Interior, National Park Service, Cape Hatteras National Seashore, North Carolina.

NPS. 2013c. *Cape Hatteras National Seashore Seabeach Amaranth (Amaranthus pumilus) Surveys 2013 Annual Report.* US Department of the Interior, National Park Service, Cape Hatteras National Seashore, North Carolina.

NPS. 2013d. *Proposal to Facilitate Additional Public Beach Access Environmental Assessment*. National Park Service. U.S. Department of the Interior. Cape Hatteras National Seashore, North Carolina. June 2013.

Overton. 2015. *Coastal Conditions Update*. NCDOT. February 2014.

Outer Banks Task Force. Buxton/Canadian Hole Image. website visited on 11/5/2015. http://www.obtf.org/nc12hotspots/hot/buxton/buximg1.html

URS. 2013. Camacho, C. (photographer), URS Coporation-North Carolina

URS. 2014. *NC 12—Buxton Hot Spot Improvements Traffic Forecast*. Dare County, North Carolina. State Transportation Improvement Program Project No. R-4070B. June 2014.

USFWS. 2015. Endangered Species, Threatened Species, Federal Species of Concern, and Candidate Species, Dare County, North Carolina. Updated April 20, 2015. US Department of the Interior, US Fish and Wildlife Service, Washington, DC.