
Reports

11-2002

An Analysis of Shoreline Development Risk for Secondary Dune Systems in Tidewater Virginia with Associated Management Recommendations

Lyle M. Varnell
Virginia Institute of Marine Science

C. Scott Hardaway Jr.
Virginia Institute of Marine Science

Follow this and additional works at: <https://scholarworks.wm.edu/reports>



Part of the [Environmental Indicators and Impact Assessment Commons](#), [Natural Resources Management and Policy Commons](#), and the [Water Resource Management Commons](#)

Recommended Citation

Varnell, L. M., & Hardaway, C. (2002) An Analysis of Shoreline Development Risk for Secondary Dune Systems in Tidewater Virginia with Associated Management Recommendations. Virginia Institute of Marine Science, College of William and Mary. <https://doi.org/10.21220/V53T5G>

This Report is brought to you for free and open access by W&M ScholarWorks. It has been accepted for inclusion in Reports by an authorized administrator of W&M ScholarWorks. For more information, please contact scholarworks@wm.edu.

**An Analysis of Shoreline Development Risk for Secondary Dune Systems in Tidewater
Virginia with Associated Management Recommendations**

Lyle M. Varnell
C. Scott Hardaway

Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, Virginia

November 2002

This project was funded by the Coastal Resources Management Program
of the Virginia Department of Environmental Quality
through Grant #NA17OZ1142 of the
National Oceanic and Atmospheric Administration, Office of Ocean
and Coastal Resource Management,
under the Coastal Zone Management Act of 1972, as amended.

Introduction

This project was done in response to concerns by environmental resource managers of historic and potential adverse impacts to Virginia's secondary dune ecosystems. Virginia environmental regulatory programs have little decision-making authority over the use of secondary dunes as these areas are not included in the Coastal Primary Sand Dune Act (the Dunes Act). These areas function as estuarine edge habitat and provide natural upland erosion control, and are thus valuable to estuarine and coastal plain fauna and adjacent upland property owners.

Methods

Secondary dunes were identified, characterized, and classified through a related project (Hardaway et al. 2001a). The lack of a legal or science-based definition of estuarine secondary dunes made this project problematic; however, working definitions and delineation criteria were developed through the previous project and formed the basis of these analyses.

Secondary dune physical parameters are based on the data of Hardaway et al. (2001a). The reported acreage represents only the secondary dune field and excludes adjacent primary dunes, uplands, and maritime forests that may be included in a land parcel.

Risk is defined as the potential for loss resulting from shoreline development of substrate and/or vegetation from secondary dunes. Risk of impacts from natural sources (erosion, storm effects) were not analyzed. Adverse impacts determinations were defined based on the relative amount of sand and vegetation removal and/or displacement.

Demographics for the localities containing secondary dunes were characterized from United States Department of Commerce, Bureau of Economic Analysis (BEA) data. Land parcels containing all or portions of secondary dunes, their associated ownership, and 2001 assessed values were obtained from locality records.

The criteria for determining the need for protection of individual secondary dune areas were based on the investigators' analyses of the area's character, location, potential for development (based in part on accessibility and local development), uniqueness, size, probable habitat value, probable sustainability (based on local sand resources and erosion rates), landscape setting, and degree of current impact.

Results and Discussion

Secondary Dune Metrics

There are 99,423 linear feet (18.83 miles) of shoreline containing secondary dunes (Figure 1). This constitutes approximately 47.9% of the total dune shoreline length in Virginia's Chesapeake Bay. These are found within the localities of Mathews (sites 2, 3, 8, and 13) (Figure 2),

Lancaster (sites 11, 32, 39A, 68, 72, and 73) (Figure 3), Northumberland (sites 4, 42, 43, 54, 58, and 59) (Figure 4), Northampton (sites 14, 15, 33, 41B, 42, 43, 48, 51, 53 54, 57, and 58) (Figure 5), Accomack (sites 27, 41, 61, 62, 65, 66, and 69) (Figure 6); and the cities of Norfolk (sites 5, 8, 9A, 9B, and 11) (Figure 7), Hampton (sites 4, 7, and 12) (Figure 8), and Virginia Beach (sites 4, 6, and 15) (Figure 9). Total estimated secondary dune acreage is 310.

Coastal Demographics

The Chesapeake Bay Coastal Zone population is expected to increase significantly and relatively rapidly (Year 2020 Panel 1988). Population increases will require the associated infrastructure development necessary to accommodate the added needs within the locality. Increases in coastal zone development may increase the risk to shorelines, including dunes.

Historical Coastal Plain demographics (1980-1999) support the projected growth trends (U.S. Dept. of Commerce 2002). Population in dune-containing localities generally has increased significantly during the time series (Table 1). Building permits issued in Virginia coastal localities increased from 19,682 in 1990 to 25,214 in 1999 (an increase of 22%), although the number of building permits per year has generally declined (Table 2). Per capita income in dune-containing coastal plain localities generally has shown significant increases (Table 3). Personal income is calculated as the sum of wage and salary disbursements, other labor income, proprietors' income, rental income, personal dividend income, personal interest income, and transfer payments to persons, less personal contributions for social insurance. It does not include the self-employed. In general, the higher the income, the more money is put into the local economy and the greater the economic vitality of the region. Per capita income is seen as the proxy for the overall economic health of a region or community, which can indicate the underlying potential for growth.

Population growth in Northampton County may exceed projections due to recent improvements to the Chesapeake Bay Bridge-Tunnel and toll reductions. Northampton County contains the largest dune resource in the lower Chesapeake Bay.

The information presented above provides evidence that the potential for risk to Virginia's secondary dunes is significant.

Protection Targeting

Table 4 presents site-specific information for all Virginia secondary dunes. Total value and zoning (2001) were not available for all parcels, and some minor assumptions were made concerning property limits and value. However, we are of the opinion that these data are accurate to the degree that supports reasonable evaluations, and that greater accuracy would not alter our conclusions.

Ownership and zoning designation were two significant factors in classifying probable risk. Ownership is not presented in Table 4, but is included in the archived data.

Approximately 55.1% of secondary dune shoreline length is privately owned (54,789 feet). The remainder is owned by the Commonwealth of Virginia (21.9%), federal entities (9.1%), local government (9.5%), and Non-Governmental Organizations (NGO) (4.4%). 28.9% (28,893 linear feet) of the secondary dune shoreline length is zoned for residential development; 24.3% (24,274 linear feet) is zoned agriculture/forestry; 10.5% (10,480) is zoned conservation; and 36.3% (36,356 linear feet) is zoned for other categories.

At least 33,342 linear feet of secondary dune shoreline (33.3% of total secondary dune shoreline) have been developed (dwellings/structures are located on the lot(s)), with varying degrees of adverse impact. Structures contribute to the overall economic value of the land, and the total assessed secondary dune land value (including structure values) is at least \$61,868,737.

Approximately 49.5% of secondary dune acreage and 36.8% of the total dune shoreline length are classified as “protected” due to government or NGO ownership (AC41, NH53/54, NH57/58, NH41B, VB4A/B, MA2, NL43, HP4, HP12, VB15, and NF11) (Figure 10). An additional 20.0% of the acreage and 16.9% of the dune shoreline length are classified as “protected” due to low potential risk from development (Figure 11). These areas are generally remote and/or inaccessible by road (MA8, MA13, LN72/73, NL58, NH14/15, AC27, AC61/62, AC65/66, and AC69). A minor percentage (1.0% of the acreage and 1.8% of the dune shoreline length) is contained in relatively small units and/or units with associated use resulting in questionable value from an ecological and management perspective (LN32, LN68, NL54, NH30, and NH48) (Figure 12).

It is not considered prudent environmental policy to recommend protection strategies for areas where impacts to the secondary dunes (and frequently the primary dune) are already significant. Therefore, areas meeting this criterion were excluded from the candidate group. The amount of secondary dunes impacted from development to the degree that function is significantly impaired is 15.2% of the total acreage and 31.8% of dune shoreline length (MA3, LN11, NL42, NL59, NF5, NF8, NF9, HP7, VB4C, and VB6) (Figure 13). Due to the degree of development at most of the significantly impaired sites, it is probable that little additional development will occur. Coupled with the relatively minor additional adverse environmental impacts that would result from further development, the need for environmental review was deemed minor.

Exclusion of the areas discussed above based on ownership, access, level of probable function, and degree of adverse impacts results in approximately 14.3% of the total acreage (44.4 acres) and 12.7% of the dune shoreline (2.4 miles) that may require management action to maintain their current level of natural function. These sites are Mosquito Point in Lancaster County (LN39), Bluff Point in Northumberland County (NL4), and sites in Northampton County consisting of Savage Neck (NH33), Cape Charles (NH42/43), and Pond Drain (NH51) (Figure 14). These are areas of generally high ecological value (expansive systems with high plant community diversity) that are considered vulnerable to development and/or alteration based on ownership, zoning, landscape situation, and ease of access.

Mosquito Point

Mosquito Point is located near the mouth of the Rappahannock River in Lancaster County. This 3.4 acre dune feature covers approximately 850 linear feet of shoreline. Mosquito Point is classified as a natural and relatively stable salient dune field with a broad beach (greater than 60 feet from primary dune crest to mean low water (MLW)) and a variable width nearshore gradient. The primary dune crest elevation ranges from 3.7 feet to 5.3 feet above MLW. There is no local SAV.

This dune feature inhabits a unique position in the landscape. Both Bay and river hydrology have influenced the development of Mosquito Point. Differences in the character of the primary dunes are evidence of the multiple forces that have shaped this feature. The highest elevation primary dune faces southeast toward the open Bay. The west-facing primary dune's crest elevation, formed from comparatively weaker upriver wind and hydrologic forces, generally rests 1.5 feet lower than the southeast-facing primary dune.



Mosquito Point

The primary dunes form a protective perimeter around a secondary dune field that supports a diverse herb and shrub community. Species present include saltmeadow hay (*Spartina patens*), American beach grass (*Ammophila breviligulata*), seaside spurge (*Chamaesyce polygonifolia*), sea rocket (*Cakile edentula*), running dune grass (*Panicum amarum*), switchgrass (*Panicum virgatum*), prickly pear cactus (*Opuntia compressa*), yucca (*Yucca filamentosa*), lazy daisy (*Aphanostephus skirrhobasis*), rabbit-tobacco (*Gnaphalium chilense*), horseweed (*Conyza canadensis*), buttonweed (*Diodia virginiana*), various asters (*Aster* spp.), loblolly pine (*Pinus taeda*), red cedar (*Juniperus virginiana*), wax myrtle (*Myrica cerifera*), groundsel tree (*Baccharis halimifolia*), persimmon (*Diospyros virginiana*), black cherry (*Prunus serotina*), and sweetgum (*Liquidambar styraciflua*).

Mosquito Point is a privately owned residential community. The dunes and beaches are used recreationally and currently there is minimal development on the secondary area. This is a unique feature in Tidewater Virginia and one of the few prominent secondary dune fields on the western Bay shore. Uncertainties as to the fate of this area exist based on natural and anthropogenic factors. All of Mosquito Point is zoned Residential and houses occupy all lots. It is probable that this area is “built out”, but accretion over the last few decades has created developable land that did not exist prior to initial residential development.

Mosquito Point was probably formed from erosion of the high banks immediately upstream. It appears that an erosion control structure placed near the downstream end of the peninsula in the 1960s provided the initial mechanism for sand accumulation. The feature currently appears to be in a state of natural equilibrium; however, should further erosion control occur on the upstream eroding banks thus removing the major sand supply that nourishes this feature, it is unclear how it will respond geologically.

Bluff Point

Bluff Point is an open Bay shoreline natural creek mouth barrier spit in Northumberland County. This three acre dune feature covers approximately 710 linear feet of shoreline. Bluff Point is characterized by a broad beach (greater than 140 feet from the primary dune crest to MLW) and a broad shallow offshore gradient. The primary dune crest elevation is approximately 5.6 feet above MLW. There are numerous small local patches of SAV, and a large persistent bed exists approximately 1000 meters north at Jarvis Point.



Bluff Point dune field is the result of the migration of a barrier spit that became

Bluff Point

trapped between eroding headlands. At this point in time Bluff Point is relatively stable, and should remain stable until the marginal headlands erode to the point that local winds and hydrology (primarily from the east) have greater influence on the geomorphology of this dune system. The dunes support a diverse herb community that includes sea rocket (*Cakile edentula*), saltmeadow hay (*Spartina patens*), running dune grass (*Panicum amarum*), switchgrass (*Panicum virgatum*), common reed (*Phragmites australis*), Russian thistle (*Salsola kali*), and others. This dune system is part of a mixture of diverse estuarine edge habitats. The surrounding land use is forest with some adjacent agriculture. Nontidal wetlands exist between the back of the secondary dune field and the forested upland.

Bluff Point is privately owned and zoned agricultural. Some of the local land parcels are currently for sale. The fate of this area is uncertain due to potential changes in local land use. The dune field is easily accessed from the upland, and surrounding upland development could impact the dune/wetland/adjacent shoreline complex.

Savage Neck

Savage Neck is a northwest/west facing natural open Bay linear dune field covering 2,680 linear feet of shoreline in Northampton County. Secondary dune acreage is relatively small, about 2.46 acres, due to the narrow herbaceous/shrub area between the primary dune crest and extensive maritime forest. The primary dune crest ranges from approximately 11 feet to 30 feet above MLW and is fronted by a broad beach (120 feet to 287 feet from the primary dune crest to MLW). Savage Neck dune field is classified as land transgressive, with erosion of the northern reach feeding the offshore bar complex immediately offshore of the southern, and relatively stable, end of the area. These offshore bars support extensive SAV beds.



Savage Neck

The vegetative character of the secondary dunes is created by the relatively rapid transition from the herb-dominated primary dune community of American beach grass (*Ammophila breviligulata*), saltmeadow hay (*Spartina patens*), and running dune grass (*Panicum amarum*) to the narrow shrub/woody-dominated community channelward of the maritime forest.

The Commonwealth of Virginia owns a small portion of this dune field, with the remainder held privately. The area is zoned for agriculture. Due to the projected growth of Northampton County and the market potential of beachfront property the fate of this area is uncertain.

Cape Charles

The Cape Charles dune field is located south of the Town of Cape Charles in Northampton County. This 7.7 acre natural open Bay linear dune field covers approximately 3,486 linear feet of shoreline below Cape Charles harbor. The Cape Charles dune field is characterized by high-elevation primary dune crests (ranging from 9.3 feet to 11.8 feet above MLW) fronted by a broad beach (greater than 120 feet from primary dune crest to MLW) and a broad shallow nearshore gradient. There are significant SAV resources immediately offshore of the beach.

The secondary dune area is vegetatively similar to the secondary dunes of Savage Neck. An herbaceous community dominated by American beach grass (*Ammophila breviligulata*),

saltmeadow hay (*Spartina patens*), and running dune grass (*Panicum amarum*) transitions into a dense shrub community that is relatively broad along the northern portion of the shoreline but narrows to the south.

This shoreline has been affected by the maintenance dredging of Cape Charles harbor and is currently undergoing changes on the upland landward of the secondary dunes. Accretion has occurred on the northern portion of the shoreline from dredge spoil placement and appears relatively stable. The southern portion of the shoreline contains no primary or secondary dunes and is experiencing erosion to its terminus at Elliots Creek.



Cape Charles

The two tracts that include the secondary dunes are zoned municipal and are owned by the Industrial Development Authority and an LLC. Thus, these are likely targeted for future development. The area landward of these parcels is a retirement/resort community and golf course complex. The fate of this area is highly uncertain due to zoning and adjacent land use.

Pond Drain

Pond Drain is natural open Bay linear dune field in Northampton County. This is the largest dune complex in the lower Chesapeake Bay and extends over 4,900 linear feet of shoreline and contains approximately 27.8 acres of secondary dune. This area is characterized by broad beaches (approximately 100 feet from the primary dune crest to MLW) and high primary dunes (10.3 feet to 14.5 feet above MLW). There are local beds of SAV to the north.



Pond Drain

Pond Drain's secondary dunes support a diverse herb and shrub community. Species present include American beach grass (*Ammophila breviligulata*), sea oats (*Uniola paniculata*), saltmeadow hay (*Spartina*

patens), sea rocket (*Cakile edentula*), running dune grass (*Panicum amarum*), bluestem (*Schizachyrium littorale*), yucca (*Yucca filamentosa*), various asters (*Aster* spp.), seaside goldenrod (*Solidago sempervirens*), trumpet vine (*Campsis radicans*), loblolly pine (*Pinus taeda*), red cedar (*Juniperus virginiana*), wax myrtle (*Myrica cerifera*), persimmon (*Diospyros virginiana*), black cherry (*Prunus serotina*), various oaks (*Quercus* sp.), and American holly (*Ilex opaca*).

This shoreline is considered relatively stable. Erosion south of the mouth of Elliotts Creek has supplied substrate to the Pond Drain dune field. Erosion control measures, now proposed for this reach could affect Pond Drain's current stability.

The Commonwealth of Virginia owns a portion of the Pond Drain dune field. The remainder is privately owned and zoned for agriculture. Due to the projected growth of Northampton County and the market potential of beachfront property the fate of this area is uncertain.

Policy Recommendations

Management options currently available include no action, modified implementation of the Chesapeake Bay Preservation Act (Bay Act), modifying the Dunes Act, establishing conservation easements, procuring development rights, land acquisition, or combinations of these.

The no action option is not recommended if greater oversight of secondary dune use is warranted.

Bay Act modifications would require that localities establish buffers entirely landward of the primary dune rather than from the high tide line. Many secondary dunes extend landward greater than the Resource Protection Area (RPA) width, leaving portions of some secondary dunes excluded from environmental review. If the Bay Act were implemented such that the channelward extent of the RPA began at the landward extent of the primary dune (i.e. no overlapping jurisdictions) with no granting of variances, approximately half (49,854 feet or 9.44 miles) of the total dune shoreline length and 22.7% of the secondary dune acreage (70.19 acres) would be completely captured for regulatory review. Additionally, greater than 75% of the secondary dune area could be captured for regulatory review for 10.6% (10,550 feet) of the shoreline and 8.6% (26.8 acres) of the acreage (cumulative 60.7% of the shoreline length and 31.3% of the acreage); greater than 50% of the secondary dune area could be captured for regulatory review for 20.5% (20,369 feet) of the shoreline and 20.1% (62.44 acres) of the acreage (cumulative 81.2% of the shoreline length and 51.4% of the acreage); and greater than 25% of the secondary dune area could be captured for all secondary dunes (i.e. the RPA covers at least 25% of all of the secondary dune areas). For the areas recommended for conservation action, the RPA would cover 100 % of NH33 and NH42, 57% of LN39, 54% of NL4, 68% of NH43, and 40.5% of NH51. Therefore, modified implementation of the Bay Act would provide limited

management opportunities.

Dunes Act modifications may be impracticable due to the political and financial resources required to establish and administer an expanded program, and the limited number of private holdings that would be regulated. The most cost effective, comprehensive protection strategies are land acquisition, purchase of development rights, conservation easements, or combinations of these (collectively termed “land control”). Land control could be achieved more rapidly than a new regulatory structure can be created, probably would require much less financial resources than those needed to develop, enact, and administer regulatory programs, and would afford a greater level of protection. The areas recommended for protection are currently assessed at \$10,201,400 (including structures where present). This equates to \$808 dollars per linear foot of shoreline. Further economic analysis is warranted, but this amount appears cost-effective when compared to restoration costs.

It would be imprudent to recommend expending public resources for protection of natural areas that are subject to significant and rapid degradation from natural causes. The probability of sustainability, absent anthropogenic impacts, was considered in our analyses and addressed above. The secondary dune areas recommended for protection appear to have either adequate local sand supplies or favorable landscape situations, or both, and are considered sustainable. Relating these characteristics to erosion rates would provide a more complete assessment of the probable sustainability of the targeted areas, but comprehensive erosion rates for Tidewater Virginia have not been quantified for many years and may not now be accurate. If land control is the chosen course of action, we recommend quantifying erosion rates for the targeted areas.

Literature Cited

Hardaway, C.S., L.M. Varnell, D.A. Milligan, G.R. Thomas, and C.H. Hobbs, III. 2001a. Chesapeake Bay Dune Systems: Evolution and Status. Final Report to the National Oceanic and Atmospheric Administration Office of Coastal Resources Management. 19 pp.

United States Department of Commerce, Bureau of Economic Analysis (2002). <http://www.bea.gov/bea/regional/reis/>.

Year 2020 Panel. 1988. Population growth and development in the Chesapeake Bay watershed to the year 2020. Unpublished report. Richmond, Virginia. Council on the Environment. 52 pp.

Table 1. Population trends for jurisdictional tidewater localities containing dunes.

Locality	1980	1995	1999	Percent Change 1980-1999	Percent Change 1995-1999
Accomack	31,288	32,062	32,121	+ 2.7	+ <1
Lancaster	10,149	11,232	11,349	+ 11.8	+ 1
Mathews	8,016	8,819	9,255	+ 15.5	+ 5
Northampton	14,580	12,903	12,810	- 12.1	- <1
Northumberland	9,836	11,134	11,668	+ 18.6	+ 4.8
Hampton	123,148	138,575	137,193	+ 11.4	- 1
Norfolk	268,469	239,723	225,875	- 15.9	-5.8
Virginia Beach	264,821	428,499	433,461	+ 63.7	+ 1.1

Table 2. Time series of building permits for single family and duplex dwellings issued to jurisdictional tidewater localities containing dunes.

Locality	1990	1995	1999
Accomack	144	189	141
Lancaster	148	71	109
Mathews	194	61	50
Northampton	77	48	49
Northumberland	312	104	132
Hampton	482	368	332
Norfolk	258	175	191
Virginia Beach	1,555	1,439	1,304

Table 3. Time series of per capita personal income (dollars) for tidewater localities containing dunes.

Locality	1980	1995	1999	Percent Change 1995-1999
Accomack	6,972	17,382	20,194	+ 16
Lancaster	9,079	25,393	29,430	+ 16
Mathews	9,005	22,911	27,081	+ 18.2
Northampton	6,238	16,453	20,233	+ 23
Northumberland	8,312	19,093	23,425	+ 22.7
Hampton	8,338	19,064	22,250	+ 16.7
Norfolk	9,223	19,405	22,390	+ 15.4
Virginia Beach	10,882	23,681	28,356	+ 19.7

Table 4. Secondary Dune physical and risk metrics by site.

Site ¹	Zoning	Value	Shoreline Length (ft)	Depth of Secondary(ft)	Secondary Acreage	Risk Category ²	Risk Rationale ³	Protection Target	Protection Rationale ⁴
MA2	Conservation	NA ³	1,600	168	6.17	P	NGO owned	No	Low Risk
MA3	Residential	\$6,160,200	4,290	90	8.86	I-MO	Developed	No	Impacted
MA8	Conservation	\$34,900	3,150	160	11.57	P	Remote/Zoning	No	Low Risk
MA13	Residential	\$158,800	450	31	0.32	I-MI	Local Land Use/Zoning	No	Low Risk/Small
LN11	Residential	\$265,700	990	45	1.02	I-MO	Sparce development	No	Impacted/Small
LN32	Residential	\$389,100	320	115	0.84	I-MI	Community commons	No	Small
LN39	Residential	\$311,700	850	175	3.41	V	Accessible/sparce use	Yes	Unique/High Value
LN68	Residential	\$300,100	250	60	0.34	I-MI	Adjacent development	No	Small/Isolated
LN72	Residential	\$322,100	870	60	1.20	I-MO	Adjacent development	No	Low Risk/Small
NL4	Agriculture	\$591,400	710	184	3.00	V	Accessible/developable	Yes	Locally Significant
NL42	Residential	Unknown	3,690	77	6.52	I-MI	Local development	No	Impacted
NL43	Other	\$930,000	2,750	74	4.67	P	NGO owned	No	Low Risk
NL54	Residential	\$39,800	240	22	0.12	I-MI	Adjacent development	No	Small/Low value

Table 4 continued

Site ¹	Zoning	Value	Shoreline Length (ft)	Depth of Secondary(ft)	Secondary Acreage	Risk Category ²	Risk Rationale'	Protection Target	Protection Rationale'
NL58	Residential	\$153,100	900	103	2.13	V	Accessible	No	Low Risk
NL59	Residential	\$275,500	1,680	39	1.50	I-MO	Adjacent development	No	Impacted/Low Risk
NH10	Agriculture	Unknown	300	64	0.44	V	Accessible/Impacted	No	Small
NH14	Ag/Forest	\$1,347,700	854	32	0.63	P	Remote/Unbuildable	No	Low Risk/Small
NH33	Agriculture	\$2,206,100	2,680	40	2.46	V	Accessible/developable	Yes	Large/High Value
NH41	Residential	Unknown	600	90	1.24	I-MO	Public beach	No	Government Owned
NH42	Municipal	\$883,800	3,486	90	7.73	V	Planned for Development	Yes	Large/High Value
NH48	Agriculture	Unknown	703	87	1.40	I-MI	Community Commons	No	Small/Planned Use
NH51	Agriculture	\$6,208,400	4,900	247	27.78	I-MI	Accessible/Minor Use	Yes	Large/High Value
NH53	NA	Unknown	4,900	237	26.66	I-MI	State Park	No	Low Risk
NH58	Agriculture	\$387,700	4,100	93	8.75	P	Federal Lands	No	Government Owned
AC27	Agriculture	\$26,000	970	151	3.36	P	Inaccessible/Unbuildable	No	Low Risk/Small
AC41	Agriculture	\$46,500	1,380	130	4.12	P	Inaccessible/Remote	No	Low Risk

Table 4 continued

Site ¹	Zoning	Value	Shoreline Length (ft)	Depth of Secondary(ft)	Secondary Acreage	Risk Category ²	Risk Rationale'	Protection Target	Protection Rationale'
AC69	Agriculture	\$234,700	650	43	0.64	P	Inaccessible/Remote	No	Low Risk/Small
AC62	Agriculture	\$543,700	4,880	203	22.74	P	Inaccessible/Remote	No	Low Risk
AC65	Agriculture	\$335,100	1,040	55	1.31	P	Accessible/Unbuildable	No	Low Risk
NF5	Residential	\$22,500,000	7,390	37	6.28	I-S	Cluster Development	No	Highly Impacted
NF8	Residential	\$5,640,000	2,500	52	2.98	I-S	Cluster Development	No	Highly Impacted
NF9	Residential	\$5,560,000	3,330	51	3.90	I-S	Cluster Development	No	Highly Impacted
NF11	Open Space	Unknown	900	285	5.89	I-MI	Adjacent Development	No	Low Risk
HP4	Unknown	NA	550	52	0.66	P	Federal Lands	No	Low Risk
HP12	Unknown	NA	4,200	106	10.22	P	City Owned	No	Low Risk
HP7	Residential	\$1,509,800	1,540	80	2.83	I-S	Cluster Development	No	Highly Impacted
VB4A	NA	Unknown	11,150	298	76.28	I-MI	State Park	No	Low Risk
VB4C	Residential	\$3,270,453	3,750	110	9.47	I-MO	Adjacent Development	No	Impacted

Table 4 continued

Site ¹	Zoning	Value	Shoreline Length (ft)	Depth of Secondary(ft)	Secondary Acreage	Risk Category ²	Risk Rationale ³	Protection Target	Protection Rationale ³
VB6	Residential	\$1,237,284	2,450	64	3.60	I-MO	Adjacent Development	No	Authorized Build
VB15	NA	Unknown	4,430	85	8.64	I-MO	Heavy Vehicle Use	No	Federal Lands
TOTALS		\$61,868,737	99,423		309.79				

¹ **MA**– Mathews County **LN**– Lancaster County **NL**– Northumberland County **NH**– Northampton County
AC– Accomack County **NF**– City of Norfolk **HA**– City of Hampton **VB**– City of Virginia Beach

² **P**– Protected **I-MI**– Impacted Minimal **I-MO**– Impacted Moderate **I-S**– Impacted Significant **V**– Vulnerable

³ **NA**– Not Available

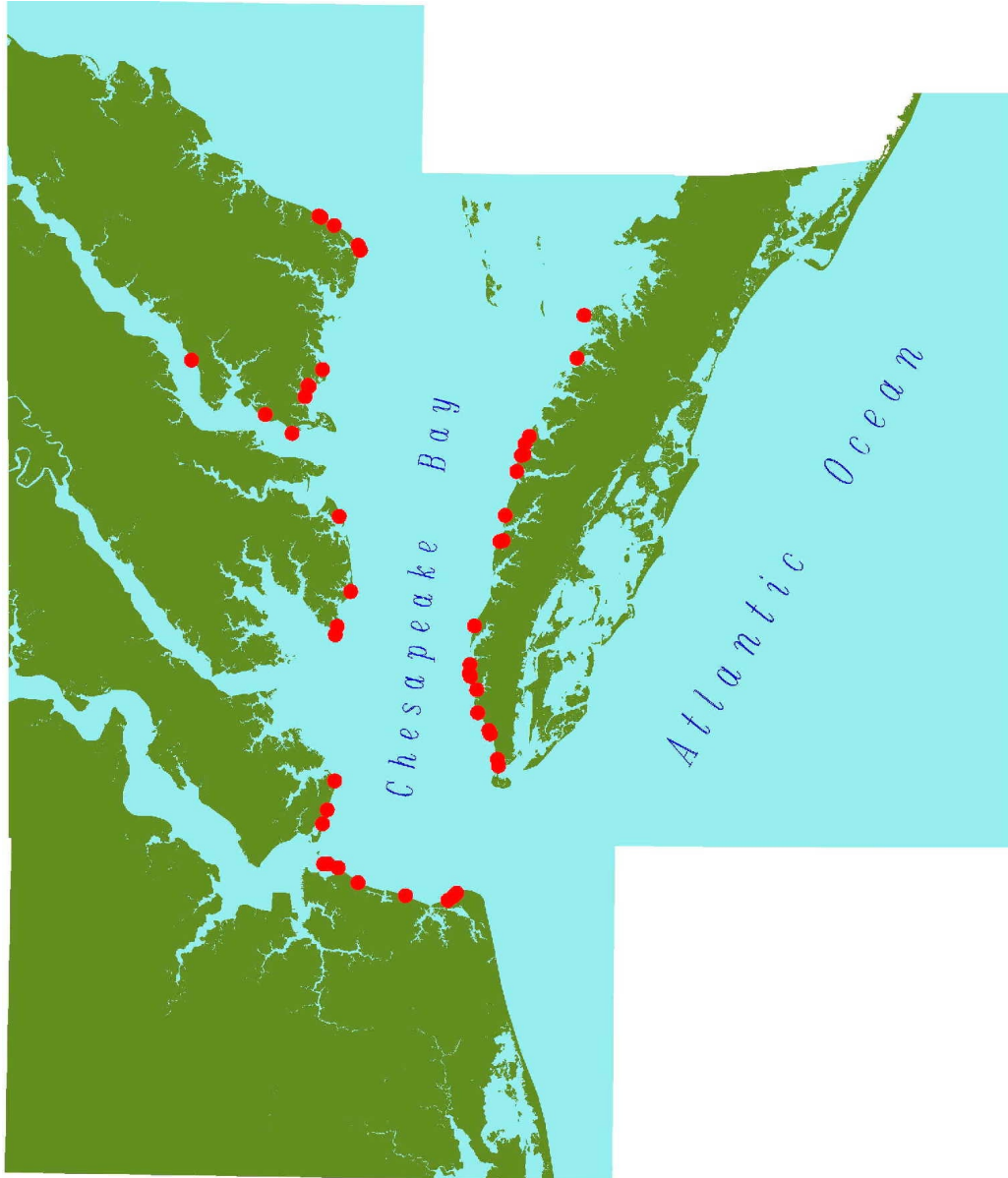


Figure 1. Locations (red dots) of all Virginia secondary dunes.

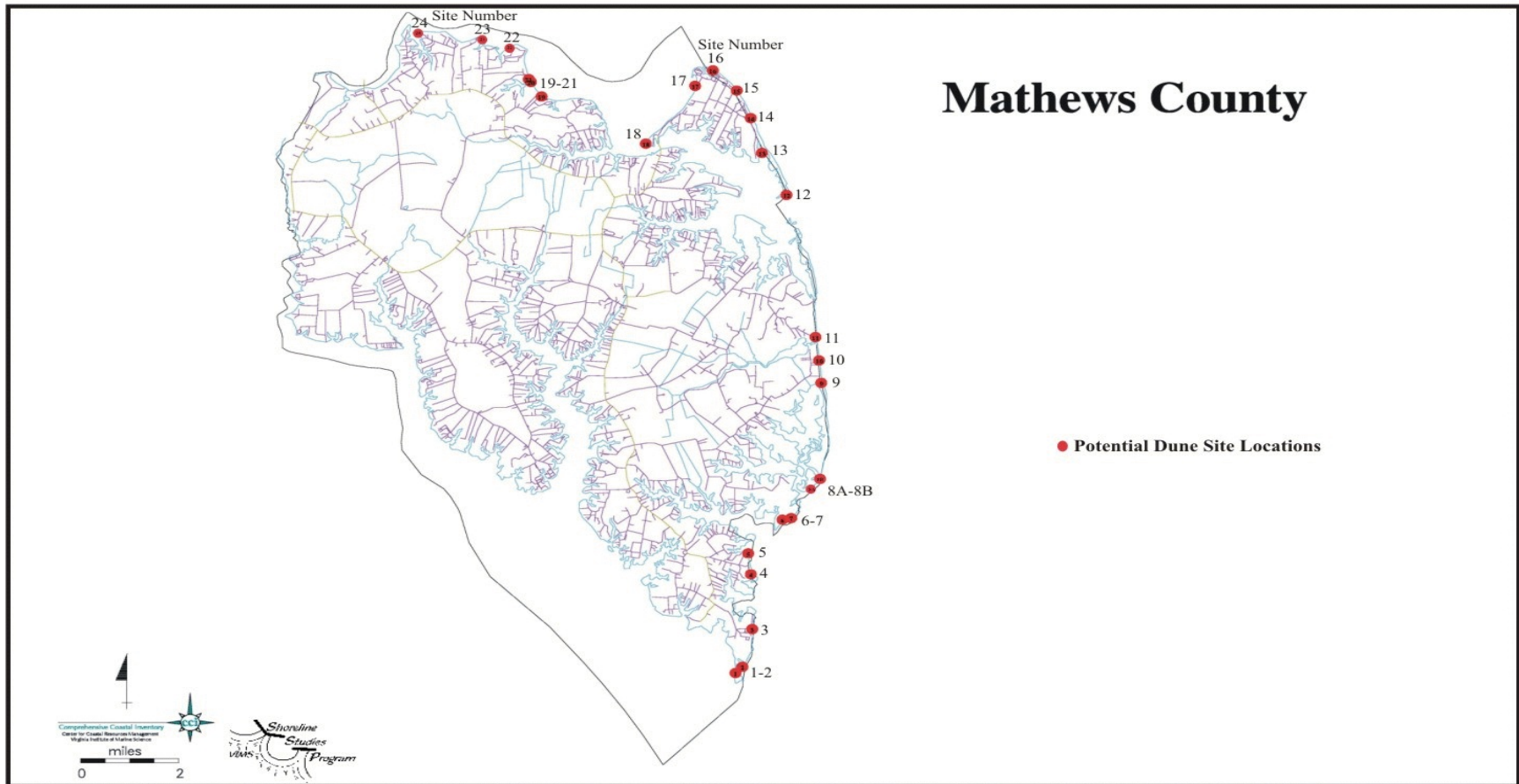


Figure 2. Mathews County dune locations.

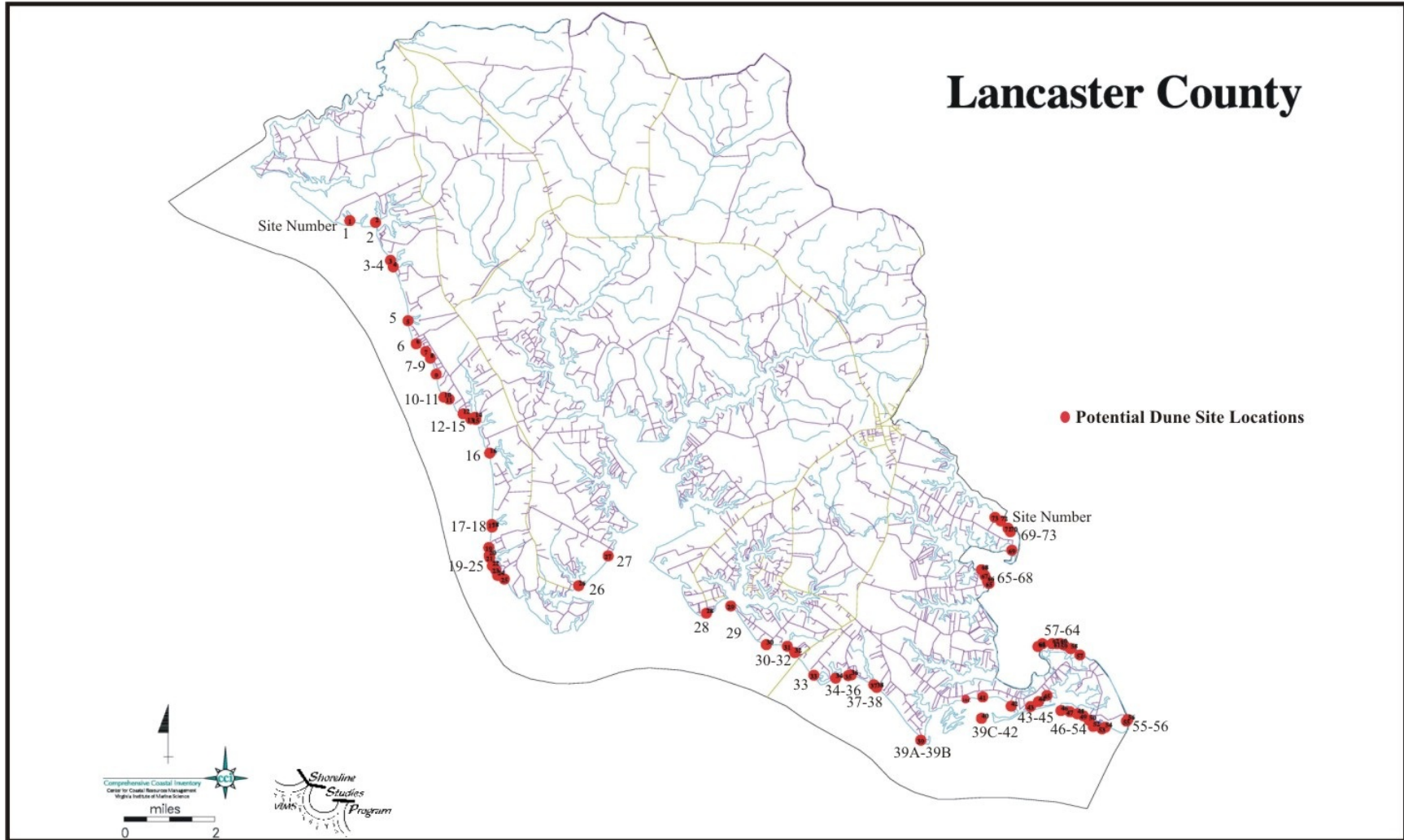


Figure 3. Lancaster County dune locations.

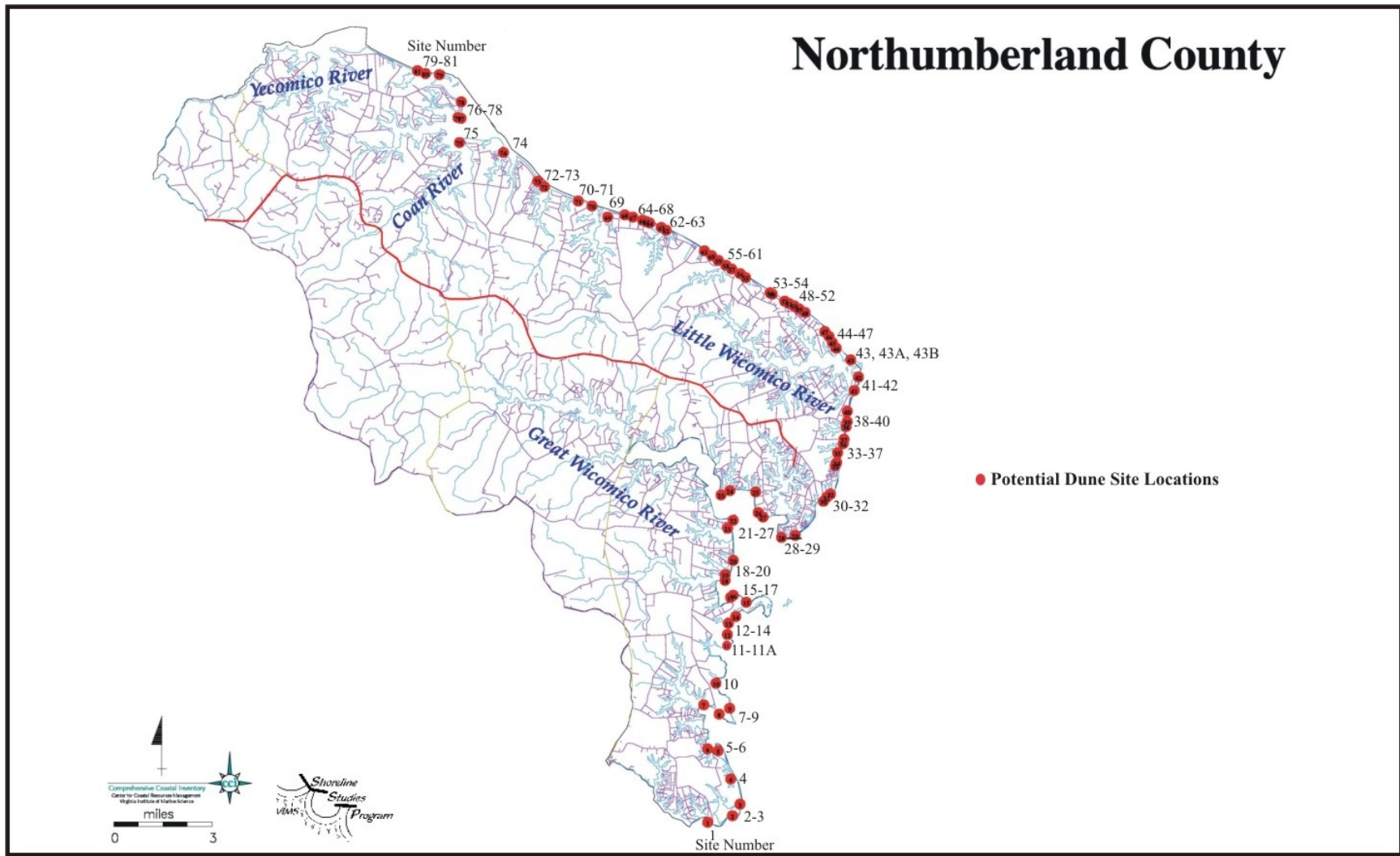


Figure 4. Northumberland County dune locations.

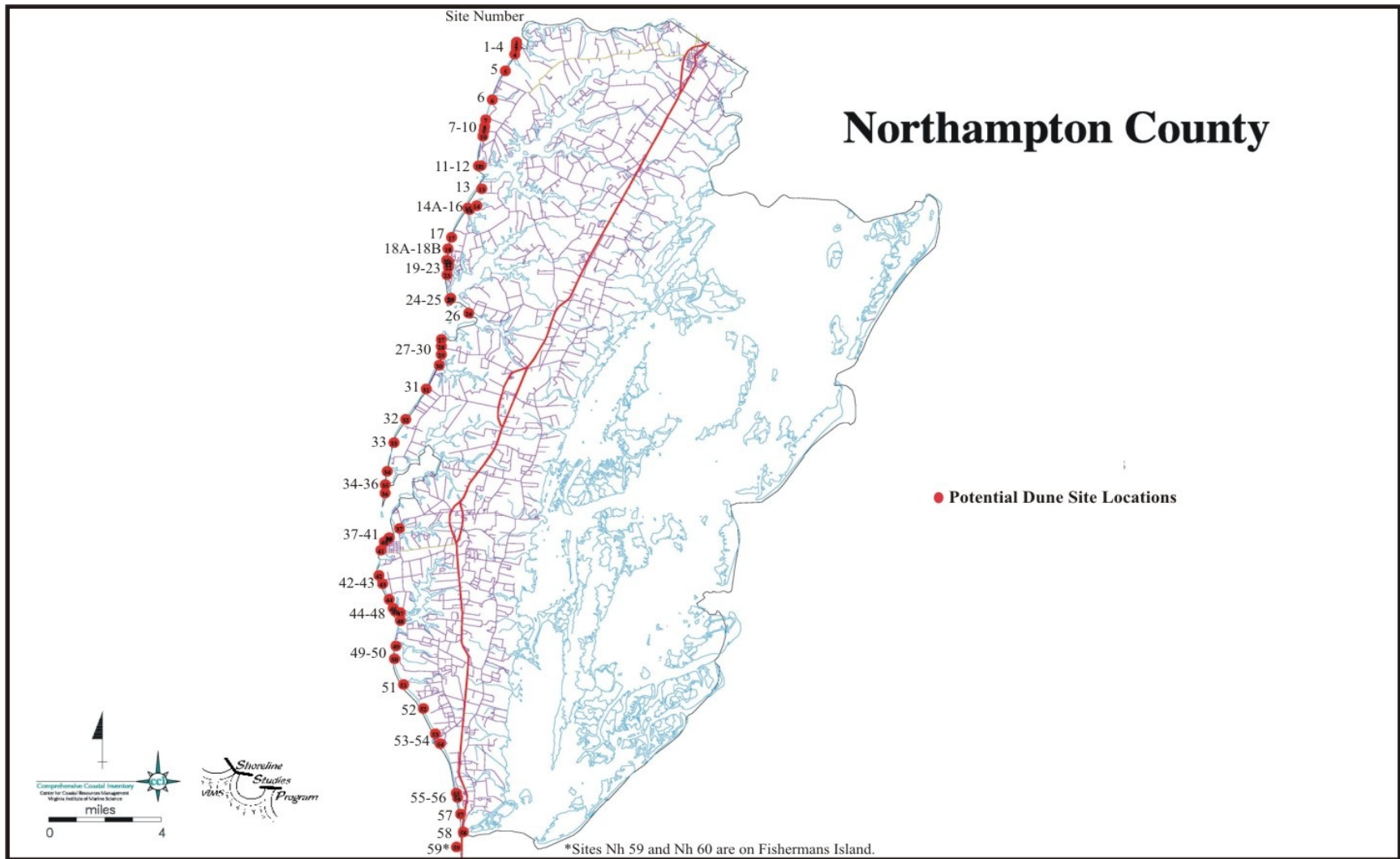


Figure 5. Northhampton County dune locations.

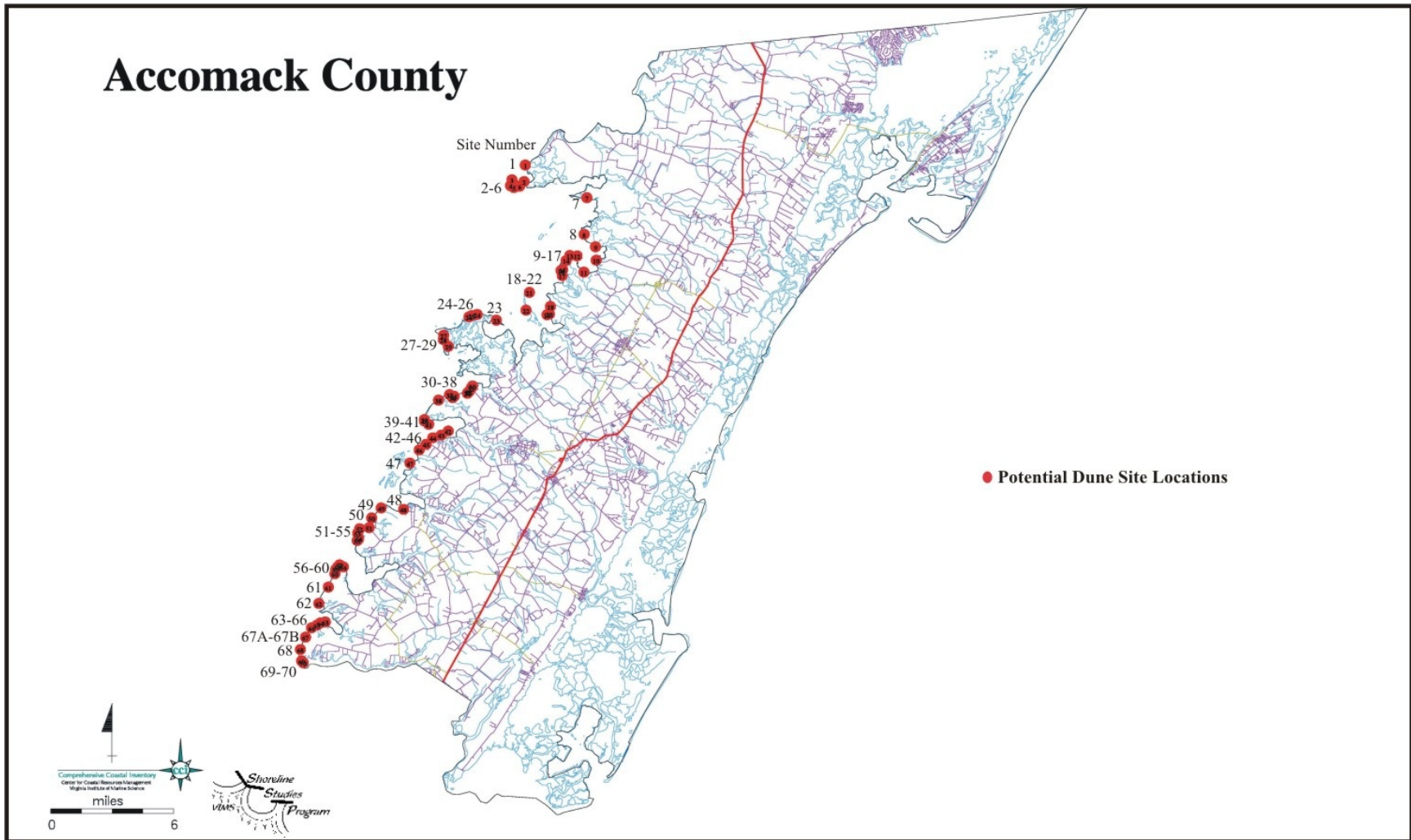


Figure 6. Accomack County dune locations.

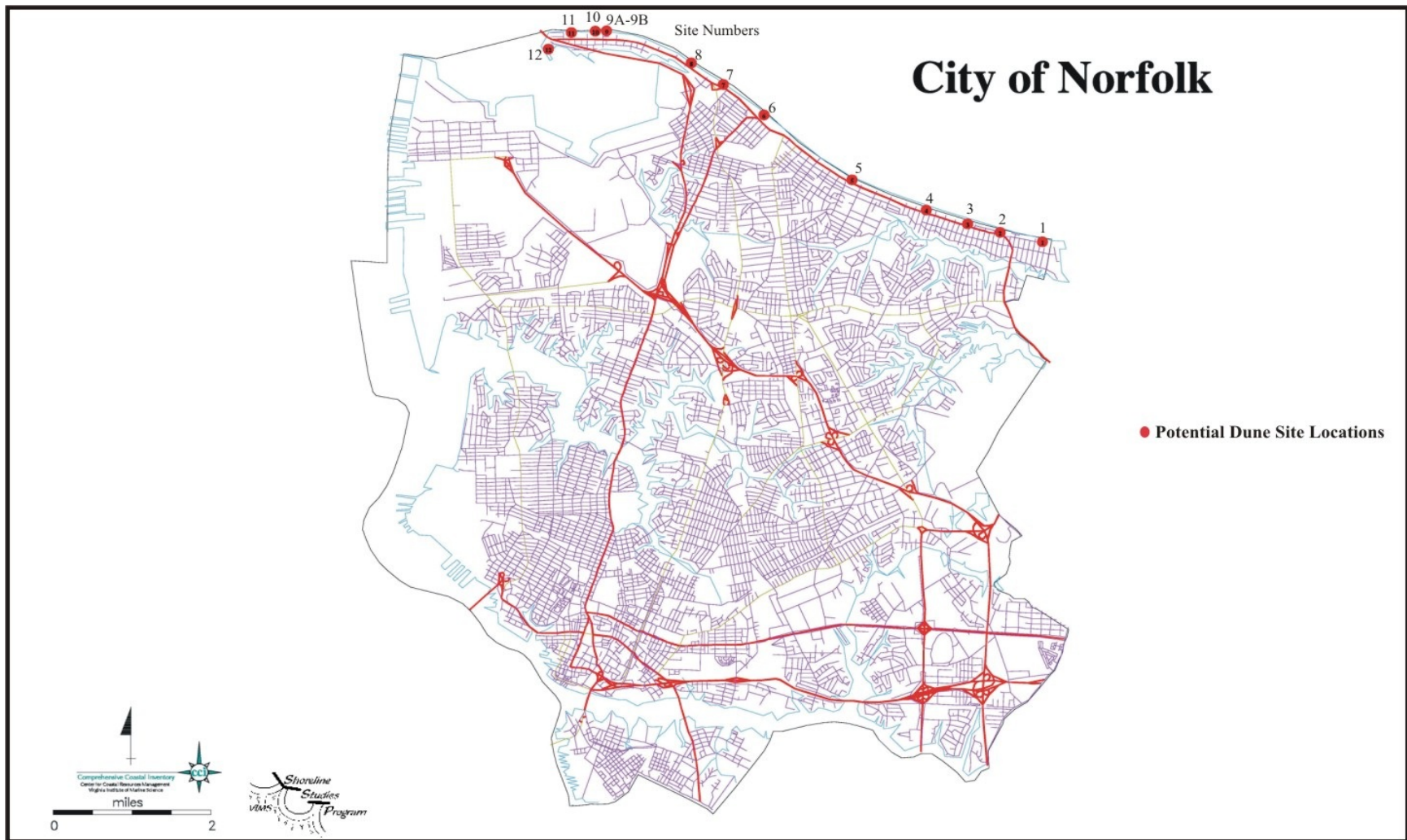


Figure 7. City of Norfolk dune locations.

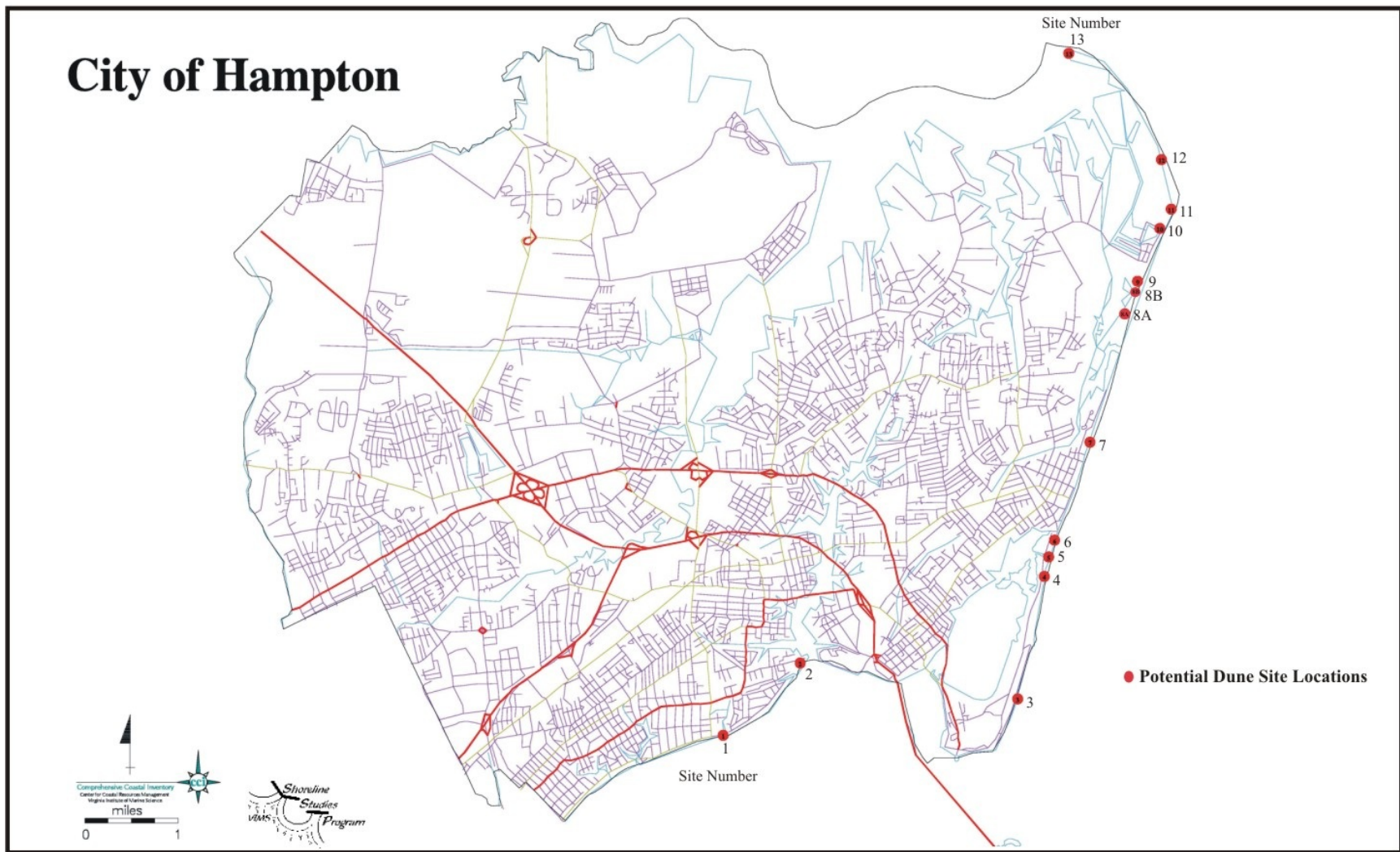


Figure 8. City of Hampton dune locations.

City of Virginia Beach

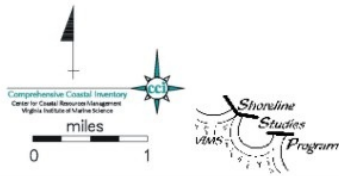
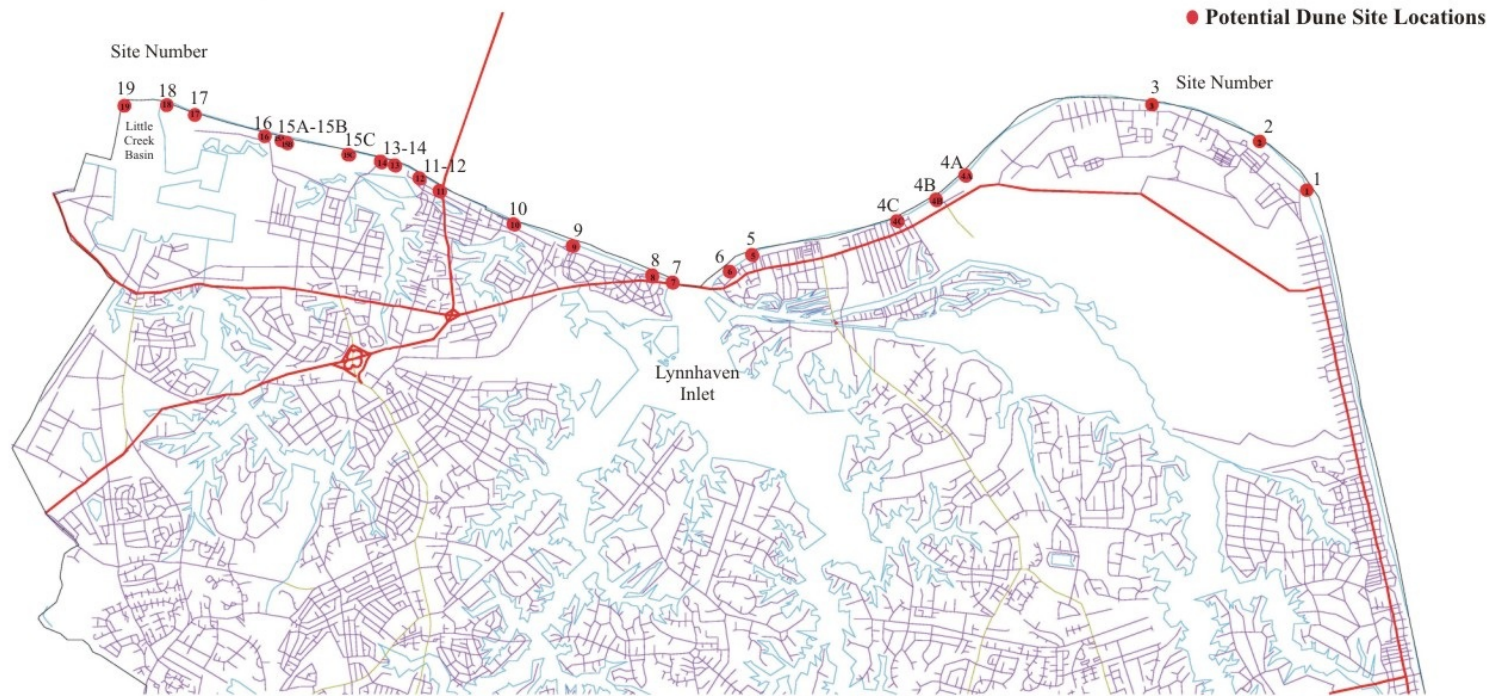


Figure 9. City of Virginia Beach dune locations.

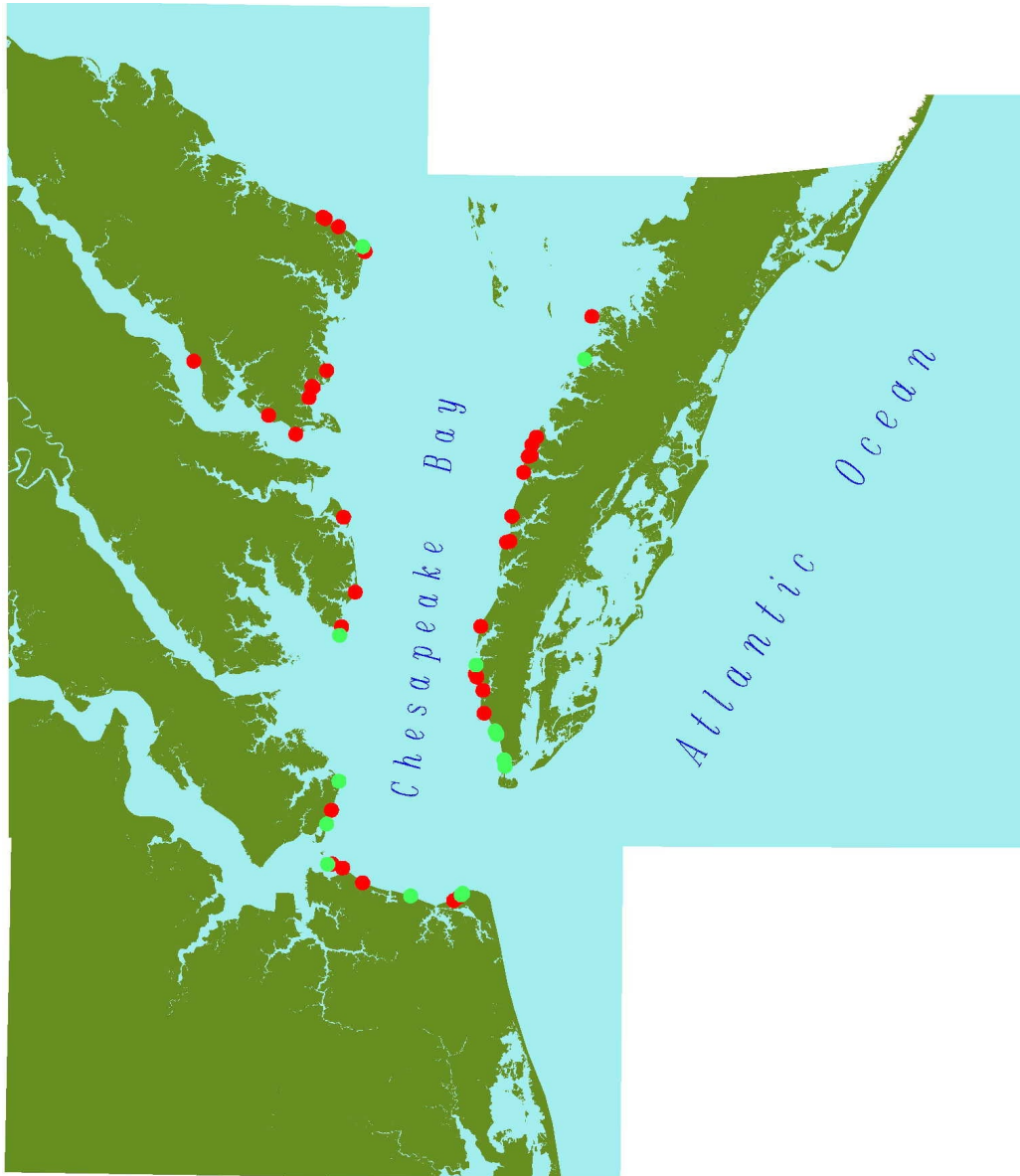


Figure 10. Locations of secondary dunes deemed protected by ownership (lime green dots) in relation to all Virginia secondary dunes (red dots).

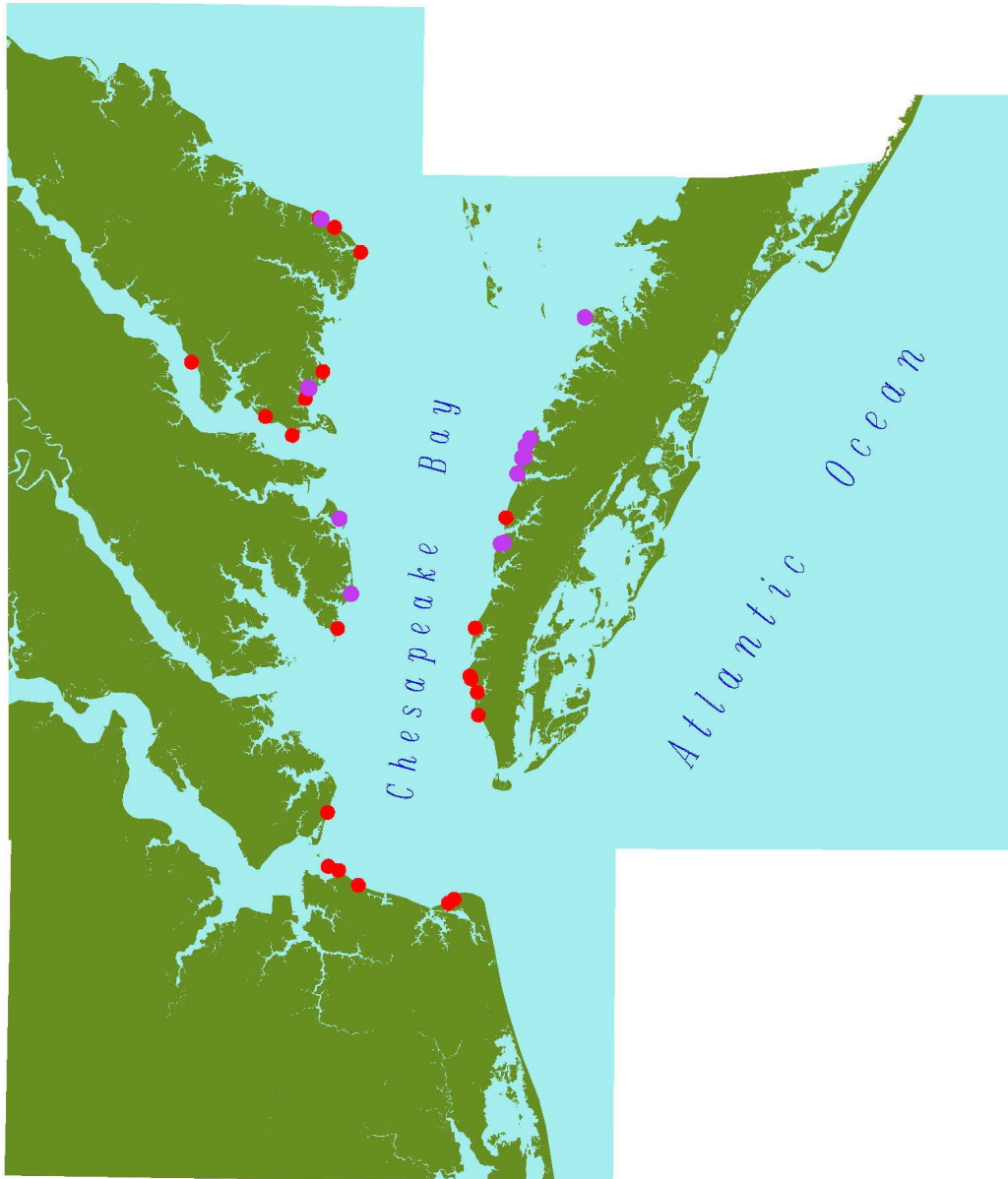


Figure 11. Locations of secondary dunes deemed protected by a low potential risk from development (purple dots) in relation to the Virginia secondary dunes remaining after removal of the areas deemed protected by ownership.

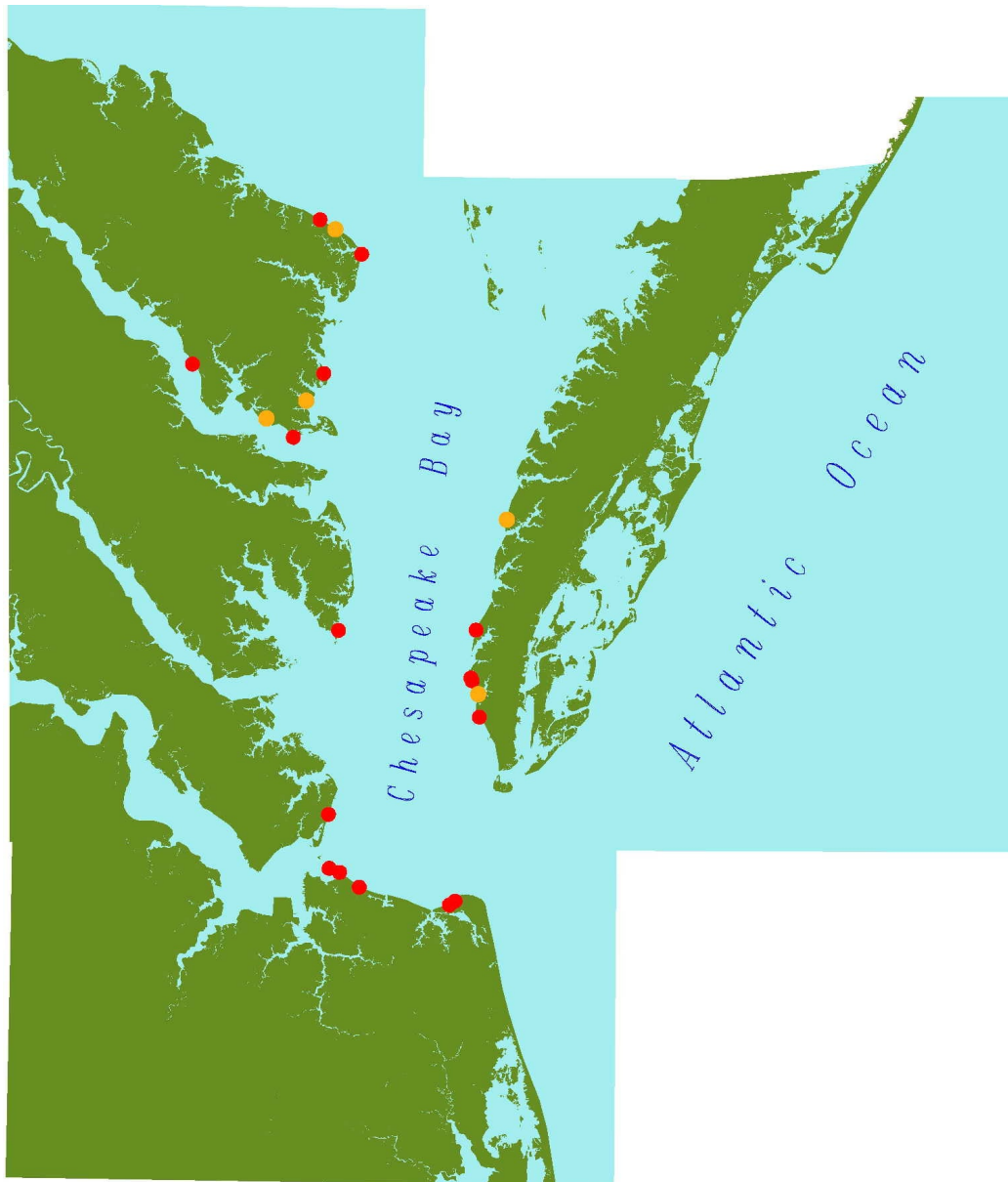


Figure 12. Locations of secondary dunes deemed to possess relatively low potential ecological and coastal hazard value (orange dots) in relation to the Virginia secondary dunes remaining after removal of the areas deemed protected by ownership and low development risk (red dots).

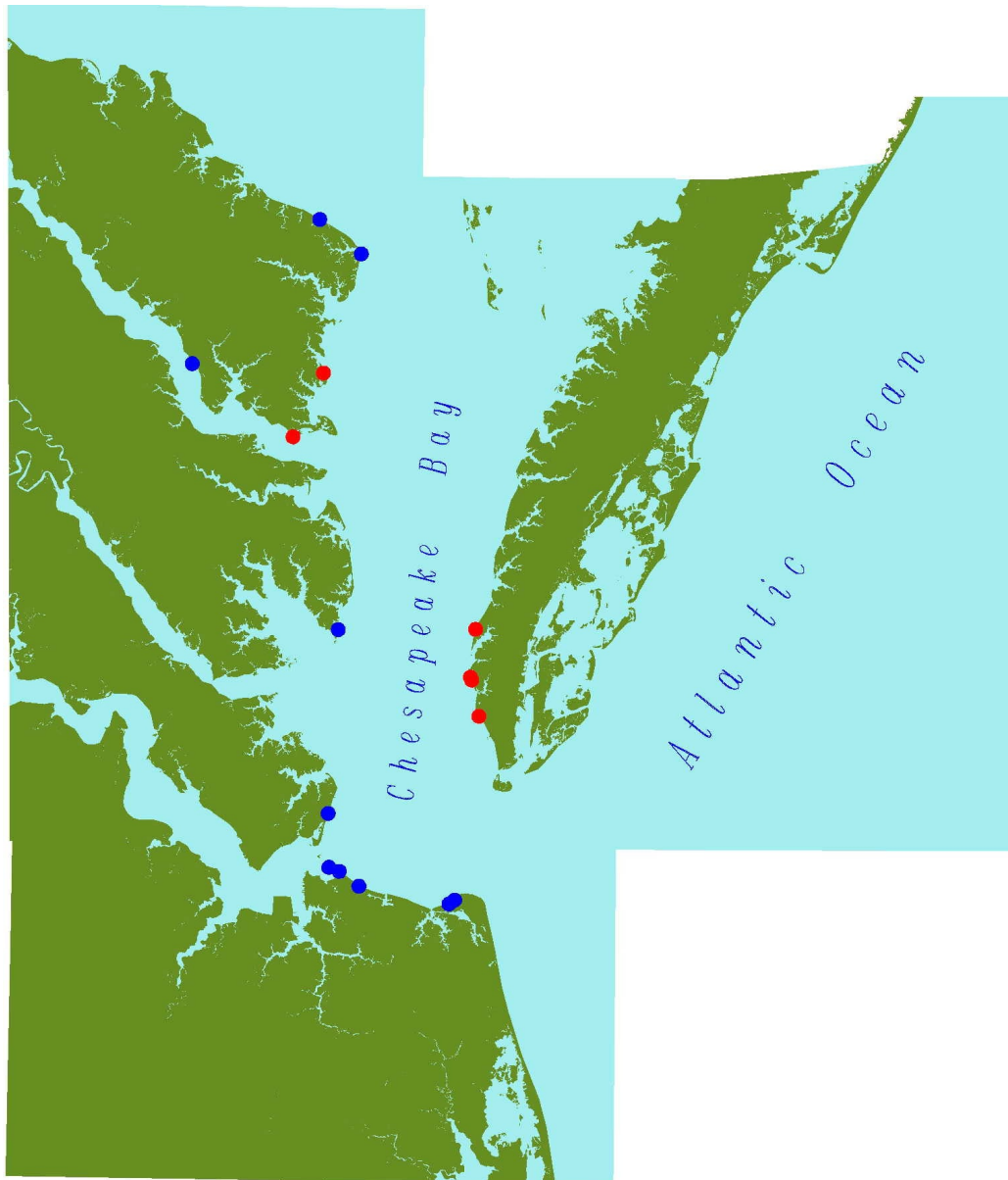


Figure 13. Locations of secondary dunes impacted by development (blue dots) in relation to the Virginia secondary dunes remaining after removal of the areas deemed protected by ownership, low development risk, and low ecological/coastal hazard value (red dots).

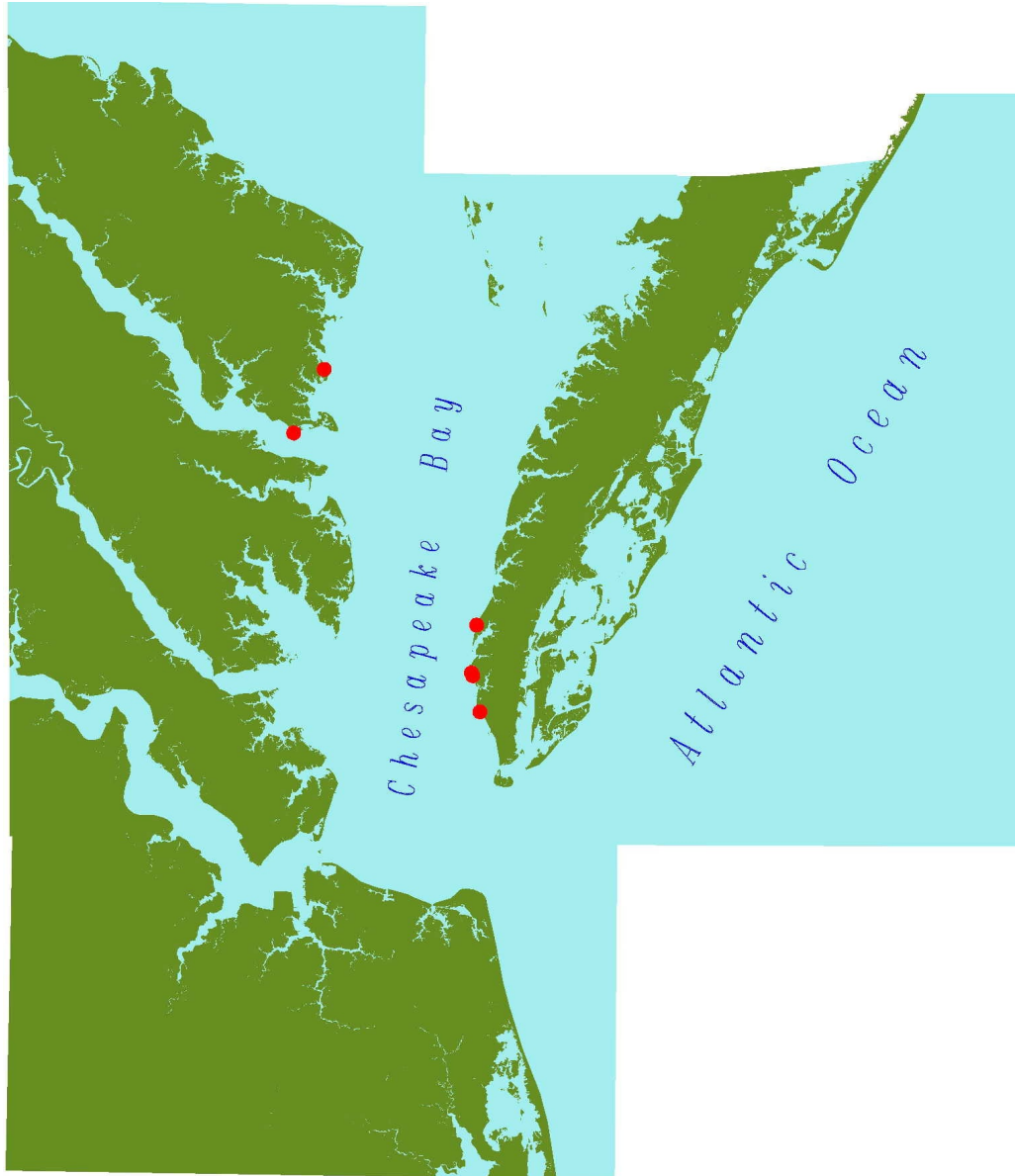


Figure 14. Locations of secondary dunes considered at risk from potential development (red dots). These are considered to have a high coastal hazard value and are ecologically important.