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Methods Report:
Water Access Infrastructure in Coastal Virginia

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Methods Report:
Water Access Infrastructure in Coastal Virginia

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Table of Contents

1. Introduction and Background 1
2. Data Sources and Preparation 1
2.1. Study Area 1
2.2. Water Access Infrastructure 2
2.2.1. Primary WAI data source 2
2.2.2. Typology of WAI 2
2.2.2.1. WAI classes 2
2.2.2.2. WAI types 2
2.2.2.3. Sites 4
2.2.3. Additional data sources 4
2.2.4. Assigning WAI to CBGs 4
2.3. Shoreline 5
3. Filtering 6
3.1. Filter 1 – Military/industrial 6
3.2. Filter 2 – Landlocked 6
3.3. Filter 3 – Minimum developable shoreline 6
References 7

1. Introduction and Background

Coastal environments provide numerous ecosystem services including provision of seafood for consumption and commercial use, outdoor recreation, and continuity of cultural practices. Access to these services is determined by the availability of infrastructure that allows people to enter the water and engage in marine activities. Such infrastructure includes docks, boat landings (ramps), marinas, and piers. These types of structures are referred to here as “water access infrastructure” (WAI).

This study developed a dataset of WAI available to the public across the entire Virginia coastal region as of 2025. Infrastructure open to the public is crucial to obtaining ecosystem services and benefits for those who do not own waterfront property. While bodies of water might be public in law, the lack of capacity to enter public waters prohibits access to services and benefits. The data can help identify areas in need of additional public WAI in order to increase access to ecosystem services and benefits provided by coastal environments. The dataset provides an updated region-wide inventory of publicly accessible WAI across coastal Virginia. However, users should be aware that the underlying sources, like those of most compiled spatial datasets, have inherent limitations, including potential temporal lag, unevenness in coverage, and limited information on the condition or quality of individual access points. Consequently, some areas or infrastructure types may be represented more completely than others, and end users should consider verifying local conditions before applying these data in research or planning contexts

2. Data Sources and Preparation

All steps in this section were completed in ArcGIS Pro Version 3.4.0 (ESRI, 2024) and R Version 4.4.2 (R Core Team, 2024). This document provides an overview of the methodology used to create the archived dataset; a complete methodology is provided in the “VA Access Detailed Methods” document available within the data archival package (https://doi.org/10.7910/DVN/XAFYIG).

2.1. Study Area

The study area comprised 48 sites including 29 counties and 19 independent cities on the Virginia coast. Virginia is unique from other U.S. states because it has both counties and numerous independent cities, which are politically independent of a county government and are therefore treated as county-level equivalents by the US Census Bureau. For brevity, the term county is used throughout this memo to refer to both counties and independent cities. The 48 counties were chosen based on their inclusion in, or adjacency to, the primary WAI data source, discussed in section 2.3.1.

All WAI were tabulated at the census block group (CBG) level. These counties contain 3,765 CBGs; however, we removed 12 CBGs that contained only water and no land area, resulting in an overall study area of 3,753 CBGs.

2.2. Water Access Infrastructure

2.2.1. Primary WAI data source

The primary source of data in this study was the Virginia Institute of Marine Science (VIMS) Shoreline & Tidal Marsh Inventory (hereafter, "VIMS Inventory"; Center for Coastal Resources Management, 2019). The VIMS Inventory characterized shoreline infrastructure in both a point and polyline layer. The point data contained seven distinct categories of infrastructure: boathouses, commercial docks, dilapidated docks, docks, outfalls, private ramps, and public ramps, while the polyline layer contained both marinas and armoring infrastructure. The marina data were isolated, converted to point data by placing a point at the midpoint of each marina polyline, and merged with the other point data. From there, boathouses and outfalls were deleted from the layer and not considered in the analysis because they were either redundant with other WAI (boathouses) or not related to water access (outfalls).

2.2.2. Typology of WAI

Although the VIMS Inventory served as an excellent starting point, it distinguished between privately and publicly owned WAI only in the case of boat landings (ramps). Additionally, it contained limited distinctions between different types of WAI and did not account for multiple WAI occurring at the same general location. The following typology was created and used to reclassify the existing records in the VIMS Inventory.

2.2.2.1. WAI classes

In order to distinguish between different WAI owners, three classes were developed:

- Business – a WAI that is privately owned but available to the public for a fee
    - Many boat landings listed as public in the VIMS data were not maintained by a government entity and were instead privately run businesses.
- Private – a WAI that is privately owned and not available to the public
    - Note this may include things like community- or club-owned structures such as docks, boat ramps, and marinas.
- Public – a WAI that is owned, operated, and/or maintained by a government entity
    - Although some public WAI requires a fee to use or park, the key distinction between public and business is the ownership.

2.2.2.2. WAI types

Within each class, there are multiple types of WAI, which are shown in Table 1, below. Although data were gathered on private WAI, this dataset contains only business/public WAI, and therefore, private WAI types were omitted from the table and dataset. The marina dock/ramp, landing dock, and duplicate ramp types were created to account for distinct uses of WAI. Further details on these types can be found in the "VA Access Detailed Methods" document. Adding additional WAI types also aided in accounting for multiple WAI occurring at the same site (2.2.2.3. Sites).

Table 1. Descriptions and final number of WAI types used in the study.

WAI Class	WAI Type	Final Number	Description
Business	Business landing	34	A boat landing that is open to the public for a fee but is not maintained by a government entity.
Business	Business landing dock	57	A dock that is associated with a business landing and is primarily intended to provide a place to moor the boat while trailering.
Business	Business ramp (duplicate)	10	An additional ramp at a business landing.
Business	Business pier	19	A pier that is open to the public for a fee but is not maintained by a government entity.
Business	Business marina	134	Any marina that is determined to be commercially owned/operated and open to the public.
Business	Business marina dock	28	Any dock that is clearly a part of a business marina or is a duplicate entry for the same marina.
Business	Business marina ramp	91	Any ramp that is clearly a part of a business marina. Not all marinas contain a ramp.
Public	Public landing	170	A boat landing that is owned, operated, and/or maintained by a government entity and open for use by the general public.
Public	Public landing dock	203	A dock that is associated with a public landing and is primarily intended to provide a place to moor the boat while trailering.
Public	Public ramp (duplicate)	46	An extra ramp at a public landing.
Public	Public pier	91	A pier that is open to the public and maintained by a government entity.
Public	Public marina	17	Any marina that is determined to be owned/operated by a government entity and open to the public.
Public	Public marina dock	0	Any dock that is clearly a part of a public marina or is a duplicate entry for the same marina.
Public	Public marina ramp	3	Any ramp that is clearly a part of a public marina.
Public	Unimproved access	14	A public access point that does not contain any notable infrastructure improvements.

2.2.2.3. Sites

Multiple WAIs of the same class can occur in the same general location. To account for the presence of multiple WAIs at the same location, unique ID numbers were assigned to each site:

- Business WAIs were considered to be at the same site if the structures occurred within the bounds of the same business.
- Public WAIs were considered to be at the same site if structures occurred within 1 km of each other and were not separated by a body of water or major infrastructure (e.g., a highway or railroad tracks). A 1-km cutoff was used to account for large public parks.

Sites are unique to each class of WAI. For example, a business marina and public pier that are within 1 km of each other are considered unique sites. Depending on the questions users ask, the total number of WAIs or the number of sites might be the more appropriate variable to consider.

2.2.3. Additional data sources

While the team was reclassifying the VIMS data, additional issues were discovered through a quality assurance/quality control process to verify the accuracy and completeness of the data. The year of completion for each county's inventory did not align, and some of the county data were over a decade old. Evaluation of the dataset highlighted that some landings were incorrectly classified as private or public in the original VIMS Inventory, and many public landings and piers were missing from the data.

To account for these issues, additional sources were drawn on to verify the class of structures in the VIMS Inventory and update the inventory to reflect business and public WAI as of 2025. Marinas were verified as a business or public using county/city webpages and Google Maps to identify if a business was listed at the site. Boat landings and piers were identified as public using county/city webpages, the 2024 Virginia Outdoors Plan (Virginia Department of Conservation and Recreation, 2024), and the Department of Wildlife Resources "Boating Access Locations" and "Fishing Piers" shapefiles (Virginia Department of Wildlife Resources, 2024). Unimproved access points were included despite not containing infrastructure because many county/city websites listed these in their records of public access points. Additional resources were used as needed to identify business landings. Every source used to verify a WAI is listed in the "Source" column in the attribute table for the WAI layer. A tabular form of these data is saved in the archive as "VIMS_WAI_Final_BusinessPublic.csv". Site ID values were updated and verified once all business/public WAI had been identified.

2.2.4. Assigning WAI to CBGs

Once all WAI were identified and classified, the Federal Information Processing Standard (FIPS) code of the CBG each WAI was located in was extracted to each point using the "Extract Multi Values to Points" tool in ArcGIS Pro. The CBG values for some WAIs showed signs of issues with the boundaries of the CBG polygons. CBG values were manually entered for the 12 WAIs that fell outside of CBG boundaries. Other boundary issues also appeared and are recorded in more detail in the "Split_WAI" Microsoft Excel document available within the data archival package (https://doi.org/10.7910/DVN/XAFYIG). Because marinas were originally represented as polylines, 14 marinas crossed CBG boundaries. These 14 marinas were assigned to whichever CBG contained the majority of the original polyline length (recorded in the "Marinas" tab). Likewise, seven sites crossed CBG

boundaries, and ten WAIs associated with these sites were assigned to different CBGs than other WAIs at the same site. These CBG values were corrected following the "Sites" tab of the "Split_WAI" Excel document. Lastly, an additional 41 WAIs exhibited issues due to CBG boundaries. These were individually examined and updated following the "Other corrections" tab.

2.3. Shoreline

Shoreline information was obtained from the land use and bank cover layer in the VIMS Inventory. Shoreline characteristics were originally collected by VIMS through a combination of high-resolution aerial imagery and boat-based shoreline surveys (Center for Coastal Resources Management, 2019). The VIMS layer contains information for the entire shoreline of the study area; however, not all types of shorelines are suitable for WAI. Shoreline segments were reclassified in the following series of steps.

1. Shoreline segments along beaches facing the open Atlantic Ocean or the mouth of the Chesapeake Bay were reclassified as "Beaches."
2. Shoreline segments along conservation lands were recorded as conservation lands either open or closed to the public.
    a. Conservation lands were determined based on the Virginia Department of Conservation and Recreation's Conservation Lands shapefile (Virginia Department of Conservation and Recreation, 2025). This layer contained information on whether each conservation parcel was open or closed to the public.
    b. The VIMS Inventory shore polylines were converted into contiguous stretches using the "Dissolve" tool in ArcGIS Pro.
    c. Polygons in the conservation lands shapefile were buffered by 25 m to increase the amount of overlap between the polygons and VIMS Inventory shore polylines.
    d. The "Pairwise Intersect" tool was used on the dissolved shore polylines and the buffered conservation lands layer to identify overlap of these features.
    e. A one-to-one "Spatial Join" was then run on the intersected layer and the original, undissolved shore polyline layer, resulting in the attribute table of the original shoreline layer containing information on whether the shoreline was associated with conservation lands.

Following reclassification of shoreline types, shoreline segments were assigned a new value based on whether that shoreline type could possibly contain business/public WAI. Areas considered unsuitable for business/public WAI included any shorelines along military land, land characterized by heavy industrial use, marsh detached from the mainland (e.g., marsh islands), conservation lands closed to the public, and beaches. These shorelines were labeled as unsuitable and not used in the analysis. All other shorelines were considered suitable and hereafter referred to as "developable shoreline."

Once all shoreline was reclassified, it was assigned to CBGs by using the "Pairwise Intersect" tool. A complete breakdown of these shoreline classifications can be found in Table 1 of the "VA Access Detailed Methods" document.

3. Filtering

Once all data were collected and reviewed in ArcGIS Pro, the shoreline, WAI, and CBG boundary layers were exported as .csv files and loaded in R Version 4.4.2 (R Core Team, 2024). The shoreline and WAI data were summarized at the CBG level and joined to the CBG boundary data frame.

Filters were applied in R to remove CBGs that could not reasonably contain business/public WAI. The number of CBGs lost during each filter are shown in Table 2 .

Table 2. The table below summarizes how many CBGs were removed with each filter.

Level	Original # of features	Pre-removal	Filter 1	Filter 2	Filter 3
CBG	3,765	12	51	2,939	31

3.1. Filter 1 – Military/industrial

Any CBGs that were primarily composed of military bases or heavy industrial land use were excluded from the study, unless a business or public WAI was present in that CBG. These CBGs were identified with a shapefile of U.S. military installations (United States Department of Transportation, 2025) and by visually scanning the shoreline (for heavy industrial areas). Three CBGs were primarily military or industrial but contained business or public WAI in them and were therefore kept in this filter. These were the Ronald Reagan Washington National Airport (Gravelly Point Landing and Columbia Island Marina), State Military Reservation Camp Pendleton (Owl's Creek Landing), Joint Expeditionary Base Little Creek–Fort Story, and Wallops Island (Queen's Sound Landing). This filter removed 51 CBGs (Table 2).

3.2. Filter 2 – Landlocked

Landlocked CBGs cannot contain WAI pertinent to this analysis and were removed from the study. This step was completed in R by summing all shoreline segments per CBG. This filter removed 2,939 CBGs (Table 2).

3.3. Filter 3 – Minimum developable shoreline

Any CBG with less than 100 meters of developable shoreline and no business or public WAI in them were removed from the analysis. This was done because the independent nature of the VIMS shoreline and CBG boundaries resulted in some CBGs with very small slivers of shoreline in them that could not reasonably accommodate a business or public site. This step was completed in R by summing the amount of developable shoreline per CBG. One public landing in Appamatuck Park (City of Colonial Heights) occurred in a CBG with 90 meters of shoreline. This CBG and site was preserved. No other WAI or site occurred in a CBG with less than 100 meters of shoreline. This filter removed 31 CBGs (Table 2).

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