

**Technical Report for the Massachusetts Sea Level Rise and
Coastal Flooding Viewer**

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INTRODUCTION

To support the assessment of coastal flooding vulnerability and risk for community facilities and infrastructure, the Massachusetts Office of Coastal Zone Management (CZM) developed the Massachusetts Sea Level Rise and Coastal Flooding Viewer. The viewer includes interactive maps of flooding extents and water level elevations associated with sea level rise scenarios, current coastal flood zones, and hurricane surge modeled by the National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency (FEMA), and U.S. Army Corps of Engineers (USACE). This technical report discusses the types of facilities and coastal flooding data used in the study, water levels and their associated datums, accessing the viewer on the web, guidance on appropriate use and interpretation of the inundation maps, and detailed metadata that provide a citation and technical details (origin, modifications [if any], and accuracy) for all constituent data sets.

DATA AND METHODS

Sources and methods used to prepare the data for inclusion in the viewer and assure data quality, applicability, and validity are briefly summarized below for the community facilities and infrastructure data and coastal flooding data (i.e., data used to prepare sea level rise, FEMA coastal flood zones, and hurricane surge maps).

Facility Data

The following community facility and infrastructure types were included in the viewer: active landfills, acute care hospitals, airports, community health centers, electrical generation facilities, fire stations, harbor master's offices, libraries, long-term care residences, Massachusetts Bay Transportation Authority (MBTA) commuter rail and subway stations, municipal wastewater treatment facilities, police stations, port facilities, prisons, public colleges and universities, public water supply sources, schools (pre-K through high school), town/city halls, United States Coast Guard bases, and water supply protection areas. Data for facility locations were obtained from the Massachusetts Office of Geographic Information (MassGIS), Massachusetts Department of Transportation, CZM, and other state and federal agencies. Facilities located inland of mapped coastal flooding areas were not included.

Facility data sets that began as point data were converted by CZM to polygons to represent facility (or building) footprints. For example, CZM acquired MassGIS point data representing schools and, after quality control, located the relevant building outlines (or "roofprints") developed by MassGIS for subsequent analysis of coastal flooding vulnerability. In other cases where facility data sets were coincident with parcels (airports for example), the polygon boundaries were edited to exclude open or undeveloped areas like parking lots and vegetated buffers.

All facility data went through the following general quality and validation analysis:

- Data were checked for completeness (i.e., to ensure that all facilities were accounted for and that those that were erroneously included were removed).
- Locations were verified using external data sources including MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, MassGIS Level 3 Assessors' Parcels, and web searches.
- Attributes, usually facility type and name, were checked and updated as necessary.
- ArcGIS software was used to check for topological errors.

More information about facility data, including summaries, credit, publication date, accuracy, and CZM modifications (if any), can be found in the metadata section of this report.

Coastal Flooding Data

To determine risk and vulnerability to possible flooding and water levels at specific facilities, the facility data were compared to three coastal flooding data sets: NOAA sea level rise scenarios, FEMA coastal flood zones, and hurricane surge inundation zones. A brief description of each is provided below.

Sea Level Rise

These data were created as part of NOAA's effort to visualize community-level impacts from sea level rise. The data were incorporated into a web-based visualization tool called Sea Level Rise and Coastal Flooding Impacts v2.0 (<https://coast.noaa.gov/slr>), which depicts the potential inundation of coastal areas resulting from a projected 1- to 6-foot rise in sea level above current Mean Higher High Water (MHHW) conditions.

The process used by NOAA to produce the sea level rise data can be described as a modified bathtub approach that creates a planar water surface representing the sea level rise scenario added to the current MHHW tidal elevation. The approach is "modified" by correcting for hydrologic connectivity where, for example, a road or other raised elevation feature apparently cuts off a waterbody from the ocean, yet in reality does allow for water exchange via a culvert, underground pipe, or other structure. The degree to which NOAA was actually able to account for hydrologic connectivity is variable. In addition, the model used to produce the sea level rise data does not account for erosion, subsidence, or any future changes in an area's hydrodynamics—it is simply a method used to visualize the potential scale, but not exact location, of inundation resulting from static sea level rise.

NOAA's steps used to develop the sea level rise data can be summarized as:

1. Use publicly, best available and accessible LIDAR data.
2. Use MHHW as the base elevation.¹
3. Map projected levels of sea level rise (i.e., 1-6 feet).
4. Evaluate inundation for hydrological connectivity.
5. Preserve hydrologically unconnected areas greater than one acre in size, but display separately from hydrologically connected inundation.

For further information on NOAA's data development methods, see *New Mapping Tool and Techniques for Visualizing Sea Level Rise and Coastal Flooding Impacts* (<https://coast.noaa.gov/data/digitalcoast/pdf/slr-new-mapping-tool.pdf>) (PDF, 3.4 MB).

¹ For inundation studies for which increased water level scenarios are required to determine the amount of land affected by sea level inundation, the elevation of a tidal datum (such as MHHW) is often used as the base elevation. This is because the high water datum represents the elevation of the normal daily excursion of the tide where the land area is inundated.

FEMA Coastal Flood Zones

The flood zones depicted on FEMA Flood Insurance Rate Maps (FIRMs) indicate the predicted magnitude and severity of flood hazards in Special Flood Hazard Areas (SFHAs). SFHAs are defined by FEMA as being areas subject to inundation in a 1% annual chance flood, or a flood that has a 1% chance of occurring in a given year. For each flood zone, FIRMs typically indicate the elevation the water is expected to reach in a 1% annual chance flood, referred to as the Base Flood Elevation (BFE).

Further information on flood zones can be found in the metadata section of this report and in CZM's 2015 publication, *Interpreting Federal Emergency Management Agency Flood Maps and Studies in the Coastal Zone* (<http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/interpreting-fema-maps.html>).

Hurricane Surge

Water levels resulting from hurricane storm surge come from the Sea, Lake, and Overland Surge from Hurricanes (SLOSH) computerized weather model. SLOSH was developed by the National Weather Service (NWS) to estimate storm surge (the rise of water generated by a storm, over and above the predicted astronomical tides) resulting from historical, hypothetical, and predicted hurricanes. The SLOSH model calculates a potential "worst-case" surge based on the results from thousands of combinations of hurricane category, forward speed, pressure, pre-landfall location, direction, and local topography.

USACE updated SLOSH hurricane inundation data for coastal communities in Massachusetts as part of an update to their Massachusetts Hurricane Evacuation Study (<http://www.nae.usace.army.mil/Missions/Projects-Topics/Massachusetts-Hurricane-Studies>). To account for tidal variation along the coast of Massachusetts, USACE increased SLOSH model outputs by five feet across entire communities from Plymouth northward as well as the following Cape Cod communities with any exposure to Cape Cod Bay: Bourne, Sandwich, Barnstable, Yarmouth, Dennis, Brewster, Orleans, Eastham, Wellfleet, Truro, and Provincetown. Modeled storm surge elevations for the remaining coastal communities along Nantucket Sound and Buzzards Bay were increased by two feet.

For more information, see the 2016 *New England Hurricane Evacuation Study - Technical Data Report* (<http://www.nae.usace.army.mil/portals/74/docs/Topics/HurricaneStudies/2016%20State%20Updates/Massachusetts/New%20England%20Hurricane%20Evacuation%20Study.pdf>) (PDF, 5.2 MB).

WATER LEVELS

All water levels are referenced to a common vertical datum, a reference system used by surveyors and other professionals to measure and relate elevations to the Earth's surface. Without a baseline for measurement, elevation values for the same location would be inconsistent. The North American Vertical Datum of 1988 (NAVD 88), the official vertical datum of the United States, is used in these maps. Flooding over land is depicted in the viewer in feet above 0 NAVD 88, rather than water depth above the ground surface.

CZM used NOAA’s vertical datum transformation tool, VDatum (<https://vdatum.noaa.gov>), to convert the sea level rise and hurricane surge data from their native tidal datum (MHHW) to NAVD 88. For the FEMA coastal flood zones, no datum transformations were necessary (flood levels are provided in NAVD 88 by FEMA). Note that the water levels for specific locations are reported in whole feet for all three coastal flooding data sets. The inaccuracies inherent in modeling and topography preclude reporting elevations with greater precision.

ACCESSING DATA IN THE VIEWER

The Massachusetts Sea Level Rise and Coastal Flooding Viewer (<https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=6f2797652f8f48eaa09759ea6b2c4a95>) can be accessed from a personal computer, tablet, or smart phone. Users are presented with a brief text introduction and tabbed maps of Sea Level Rise, FEMA Coastal Flood Zones, and Hurricane Surge. The maps can be zoomed in and out and panned. Facilities are symbolized with an outline and a clickable icon that provides a pop-up box with the facility name, type, town or city, and water level. To help users better understand the relative vulnerability associated with each of the coastal flooding types, the map scale is held constant between tabs.

USING THE DATA TO ASSESS RISK AND VULNERABILITY

To assess local vulnerability—the exposure of a facility to an approximate level to which water will rise at during a flooding scenario—a user must know the elevation of a feature of the facility, such as the ground elevation or first floor. Elevation data are most commonly found on either a building plan or site survey. If those documents are unavailable, a professional surveyor will be needed to determine accurate elevation levels. (Please note that elevation data from phones, other consumer grade Global Positioning System [GPS] devices, and online tools such as Google Earth typically have errors in vertical position that exceed one foot, and can exceed tens of feet.) When ground elevation is known at a facility in NAVD 88, water depth around the facility is equal to the water level provided in the viewer minus the ground elevation. For example, if the ground elevation at the foundation of the local police station is 13 feet NAVD 88, and the reported water level is 15 feet (also in NAVD 88), there would be approximately 2 feet of flooding at the building.

Note: It is extremely important to ensure that the topographic data on the site plan is relative to the same datum as that of the reported water level in the viewer. *One* datum must be used to maintain consistency between water levels and site topography, allowing for a correct water depth calculation. If datum conversions are necessary, NOAA’s VDatum tool enables a user to transform elevation data between any two vertical datums among a choice of 36 different vertical datums.

USE CONSTRAINTS

These maps and data should be used for planning purposes only. Site-specific assessments of elevation or boundaries (parcel, building, or other) should be made by a certified survey professional. The spatial and positional accuracy of this information will vary depending on the original source data and methods utilized. Inherent in any dataset used to develop geographical representations are limitations of accuracy as determined by the source, scale, and resolution of the data, among other factors. CZM is not liable for the improper or incorrect use of the data and information described and/or contained herein. The information contained in these maps and data are dynamic and can change over

time. It is the responsibility of the data user to use the data appropriately and consistent with the limitations of geospatial data in general and these data in particular.

CONTACT INFORMATION

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METADATA

This section provides abbreviated metadata on each data set used to develop the Massachusetts Sea Level Rise and Coastal Flooding Viewer.

NOAA Office for Coastal Management Sea Level Rise Inundation Data: Potential Extent of Mean Higher High Water with 1-6 ft Sea Level Rise

Summary - These data were created as part of the NOAA Office for Coastal Management (OCM) effort to depict the potential inundation of coastal areas resulting from a projected 1- to 6-foot rise in sea level above current MHHW (mean higher high water, the average higher high water of each tidal day observed over a 19-year period) conditions. The purpose of these data is to provide coastal managers and scientists with a preliminary look at sea level rise and coastal flooding impacts. The process used to produce the data can be described as a modified bathtub approach that attempts to account for both local/regional tidal variability as well as hydrological connectivity. The process uses two source datasets to derive the final inundation data for each sea level rise inundation scenario: 1) the Digital Elevation Model (DEM) of the area, and 2) a MHHW tidal surface model that represents spatial tidal variability, which is created using the NOAA National Geodetic Survey's VDatum datum transformation software in conjunction with spatial interpolation/extrapolation methods. The model used to produce these data does not account for erosion, subsidence, or any future changes in an area's hydrodynamics—it is simply a method to derive data in order to visualize the potential scale, not exact location, of inundation from sea level rise.

Credit - National Oceanic and Atmospheric Administration Office for Coastal Management (NOAA OCM), January 2013

Web link - <http://coast.noaa.gov/digitalcoast/tools/slr>

CZM modifications - The sea level rise scenarios were intersected with the footprints of the critical facilities to identify facilities wholly or partially located in the mapped inundation zones. The water surface elevations were determined using elevation and inundation data provided by NOAA OCM. Water levels were rounded to the nearest foot.

Accuracy - A thorough analysis of error is complex. In summary, the method adopted by NOAA OCM includes the uncertainty in the LIDAR-derived elevation data and the uncertainty in the modeled tidal surface inherent in the NOAA VDatum model. This uncertainty is combined and mapped to show that the inundation depicted in these data is not really a hard line, but rather a zone with greater and lesser chances of inundation. For a detailed description of the confidence level and its computation, please see the NOAA OCM Mapping Inundation Uncertainty document (https://coast.noaa.gov/slr/assets/pdfs/Elevation_Mapping_Confidence_Methods.pdf) (PDF, 1.4 MB). Each inundation scenario is assigned a confidence level where areas that have a low degree of confidence, or high uncertainty, represent locations that may be mapped correctly (either as inundated or dry) less than 8 out of 10 times. Areas that have a high degree of confidence, or low uncertainty, represent locations that will be correctly mapped (either as inundated or dry) more than 8 out of 10 times. NOAA OCM adopted an 80% rank (as either inundated or not inundated) as the zone of relative confidence. The use of 80% has no special significance. CZM does not include the error layers in the analysis due to cartographic constraints. See the NOAA Sea Level Rise and Coastal Flooding Impacts online viewer (<https://coast.noaa.gov/slr/>) to view or download the confidence data.

FEMA Flood Zones

Summary - The flood zones depicted on FEMA Flood Insurance Rate Maps (FIRMs) indicate the predicted magnitude and severity of flood hazards in Special Flood Hazard Areas (SFHAs). SFHAs are defined by FEMA as being areas subject to inundation in a 1%-annual-chance flood, or a flood that has a 1% chance of occurring in a given year. For each flood zone, FIRMs typically indicate the elevation the water is expected to reach in a 1%-annual-chance flood, referred to as the Base Flood Elevation (BFE).

Credit - Federal Emergency Management Agency. These data were released by MassGIS in November 2014 and represent the effective flood zones published by FEMA as of July 21, 2014.

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/nfhl.html> and <http://fema.maps.arcgis.com/home/webmap/viewer.html?webmap=cbe088e7c8704464aa0fc34eb99e7f30>

CZM modifications - Flood zones with a 1% annual chance of flooding were of interest, so CZM removed Zones D (areas of possible hazard where no analysis was conducted), which are not pertinent to facilities in the coastal zone, and X (areas with a 0.2% annual chance of flooding or of reduced flood risk due to levees). The National Flood Hazard Layer (NFHL) was then intersected with the footprints of the critical facilities to identify facilities wholly or partially located in the flood zones of interest.

Accuracy - The FEMA flood zones are based on a series of analyses conducted by FEMA's mapping consultants to predict what areas will be covered with water in a 1%-annual-chance flood, the extent and type of flood zones, and flood elevations. The flood zones are based on engineering predictions and best professional judgment of the nature and magnitude of the flood hazard in an area, given the uncertainties and variables in coastal processes during an extreme flood event (i.e., both detailed and approximate analyses are employed). The detailed analyses are only conducted at specific transects and engineering judgment is used to connect the delineations between these transects. Generally, detailed analyses are used to generate flood risk data only for developed or developing areas of communities. For areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data. Due to the nature of the flood zone delineation, vertical and horizontal

accuracy is not numerically calculated but is addressed in the FEMA Guidelines and Specifications for Flood Hazard Mapping Partners document.

Worst-Case Hurricane Surge Inundation Scenarios

Summary - USACE has developed hurricane inundation data for coastal communities in Massachusetts as part of a 2013 update to the New England Hurricane Evacuation Study. The data were created using output from the National Weather Service's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to calculate potential storm surge heights from various categories of hurricanes. (Storm surge is defined as the rise of water generated from a storm over and above the predicted astronomical tide.) The SLOSH model calculates a "worst-case" surge based on the results from thousands of combinations of hurricane category, landfall location, forward speed, and direction. Note that output surge value is measured in feet above MHHW plus two feet of additional inundation from Cape Cod south to the Rhode Island border and five feet from Plymouth north to the New Hampshire border. These values were added to include the effects of tide and storm surge, specifically the effect of a hurricane making landfall at high tide. The 2-foot and 5-foot values roughly approximate the difference between Mean Tide Level (MTL)² and MHHW in their respective locations.

Credit - U.S. Army Corps of Engineers, October 2013

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/hurr-inun.html>

CZM modifications - CZM did not make any modifications to the data. The hurricane surge inundation scenarios were intersected with the footprints of the critical facilities to identify facilities wholly or partially located in the mapped inundation zones. In areas with no elevation data, CZM interpolated the available data to calculate the water surface elevations. To account for vertical inaccuracies, water heights were rounded to the nearest foot. The critical facilities were intersected with the water surface elevation data to find the range of water elevations within each facility footprint.

Accuracy - Allen, Sanchagrin, and McLeod have written a thoughtful and concise analysis of error inherent in the SLOSH model. Below is an excerpt of the paper, *Visualization for Hurricane Storm Surge Risk Awareness and Emergency Communication*.³

"The accuracy of SLOSH is also limited by elevation data accuracy and resolution. Surge heights are represented by a +/- 20% accuracy of predicted maximum surge height.)...By design, SLOSH does not incorporate fine-scale landform features and potential inundation thresholds (such as the breaching of inlets in barrier islands, dunes, or engineered features such as levee). The grid resolution of SLOSH is variable and relatively coarse scale, with most cells on the order of 1 mile x 1 mile (1.6 km x 1.6 km). Elevations for grid cells are based on the averages of underlying Digital Elevation Models (DEMs), so the actual cell may really possess a non-normal distribution of elevation. Levee areas or areas protected by natural ridges may be overgeneralized. Furthermore, flooding in SLOSH cells is considered aspatially, wherein each cell is flooded as if it was inundated irrespective of the direction of flooding.

² The arithmetic mean of mean high water and mean low water.

³ Available for download at <http://www.intechopen.com/books/approaches-to-disaster-management-examining-the-implications-of-hazards-emergencies-and-disasters/visualization-for-hurricane-storm-surge-risk-awareness-and-emergency-communication>.

“...The degree of positional error [of inundation] is related to the uncertainty in vertical and horizontal measurements [of SLOSH model input data, notably elevation data] and issues surrounding datum conversion, projections, and interpolation methods...Airborne topographic LiDAR is increasingly available with a horizontal accuracy of +/- 2.0 m and a vertical accuracy of +/- 0.30 m (even as fine as +/- 5 to 10 cm). This amount of potential error may cause the position of the inundation zone to fluctuate either landward or seaward, but far less than any other modeling approach...'[T]he error inflation factor is [also] determined by the foreshore slope. For each beach with a gentle surface slope, a slight vertical error will be amplified and translated to a larger error.' Nonetheless, larger spatial error could result in poor decision making in the face of an extreme coastal event.”

Therefore, the maps should be used as a general guide rather than an absolute representation of areas that can expect to be inundated by worst-case hurricane storm surge for a particular hurricane category. In addition, users should note that there may be areas that are not shown to be inundated by hurricane surge, but are in fact surrounded by hurricane surge. Those areas may become isolated by hurricane surge.

Airports

Summary - This data layer contains the name and location of airports owned by the Massachusetts Port Authority or overseen by the Massachusetts Department of Transportation (MassDOT) Aeronautics Division. The spatial locations of the airports were digitized from 1:5,000 color orthophotos.

Credit - Massachusetts Department of Transportation, January 2012

Web link - <http://geo.massdot.opendata.arcgis.com/>

CZM modifications - CZM used the MassDOT data to locate all airports within the mapped coastal flooding areas. Airport borders were culled from the Massachusetts Office of Geographic Information (MassGIS) Level 3 Assessors' Parcels⁴ and subsequently edited to exclude wooded, marshy, or other undeveloped land not essential to airport function.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Community Health Centers

Summary - This data layer contains the location of community health centers in Massachusetts. The layer was produced by the Massachusetts Department of Public Health (DPH) Bureau of Environmental Health. The source material was provided by the Massachusetts League of Community Health Centers (League). The League defines a community health center as a non-profit community-based organization that offers comprehensive primary and preventive health care, including medical, social, and/or mental health services, to anyone in need regardless of their medical status, ability to pay, culture, or ethnicity.

⁴ Data available at <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/l3parcels.html>.

Credit - Massachusetts Department of Public Health, August 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/chcs.html>

CZM modifications - CZM used the DPH point data to locate all community health centers within the mapped coastal flooding areas. Health center roofprints were taken from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Electrical Generation Facilities

Summary - The U.S. Energy Information Administration's (EIA) survey Form EIA-860 collects generator-level specific information about existing and planned generators and associated environmental equipment at electric power plants with 1 megawatt⁵ or greater of combined nameplate capacity.

Credit - U.S. Energy Information Administration, December 2012

Web link - <http://www.eia.gov/electricity/data/eia860/>

CZM modifications - CZM downloaded the EIA's survey Form EIA-860 spreadsheet and parsed out generation facilities falling within communities in the Massachusetts coastal zone. The addresses provided in the spreadsheet were then geocoded (i.e., the postal addresses were used to find the coordinates of each facility). The point file was then used to locate all generation facilities occurring within the mapped coastal flooding areas. Facility borders were created from the MassGIS Level 3 Assessors' Parcels and subsequently edited to exclude wooded, marshy, or other undeveloped land surrounding the facility based on the most current MassGIS orthophotos and Bing Maps oblique imagery; in some instances, the facility footprint was further refined by excluding all lands outside a fenced perimeter.

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Fire Stations

Summary - This data layer shows the point locations of fire stations in Massachusetts. The Massachusetts Emergency Management Agency (MEMA), in cooperation with regional planning agencies and participating communities, created the data as part of the development of Homeland Security data layers.

⁵ One megawatt (MW) will supply approximately 500 homes in New England assuming an average demand per house of 2 kilowatts (KW).

Credit - Massachusetts Emergency Management Agency, February 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/fire-stations-.html>

CZM modifications - CZM used MEMA's point data to locate all fire stations within the mapped coastal flooding areas. Fire station roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Harbormasters

Summary - This point data layer contains the location of all municipal harbormaster offices in coastal Massachusetts. The addresses of harbormaster offices were located via the Massachusetts Harbormasters Association website, city or town websites, and other online sources. Addresses were geocoded and checked by comparing them to the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches. CZM used the point data to locate all the harbormaster offices within the sea level rise scenarios, FEMA flood zones, and hurricane storm surge inundation scenarios. Harbormaster office roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data.

Credit - Massachusetts Office of Coastal Zone Management, July 2014

Web link - Not applicable (n/a)

Publication date - July 2014

CZM modifications - n/a

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Hospitals

Summary - This data layer shows the location of acute care hospitals in Massachusetts. Acute care hospitals are those licensed under MGL Chapter 111, section 51, and which contain a majority of medical-surgical, pediatric, obstetric, and maternity beds as defined by DPH. The features in this layer are based on information provided to MassGIS from the DPH Office of Emergency Medical Services.

Credit - Massachusetts Office of Geographic Information, August 2009

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/hospitals.html>

CZM modifications - CZM used the MassGIS point data to locate all acute care hospital within the mapped coastal flooding areas. Hospital campus roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Landfills

Summary - This data layer was compiled by the Massachusetts Department of Environmental Protection (MassDEP) to track the locations of land disposal of solid waste. This statewide data layer contains the majority of locations currently regulated under MassDEP's solid waste regulations (310 CMR 16.000 & 19.000). Land disposal refers to an operation established in accordance with a valid site assignment for the disposal of solid waste into or on land (landfill), or a location for disposal of solid waste from one or more sources not established or maintained pursuant to a valid site assignment or permit (dumping ground).

Credit - Massachusetts Department of Environmental Protection, December 2013

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/sw.html>

CZM modifications - CZM used the MassDEP polygon data to parse all currently active disposal centers within the mapped coastal flooding areas.

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Libraries

Summary - This point data layer contains the locations of all libraries registered with the Massachusetts Board of Library Commissioners (MBLC) as of October 2004. Please note that not all libraries in the Commonwealth meet the MBLC eligibility requirements for registration and are therefore not included in this dataset.

Credit - Massachusetts Office of Geographic Information, February 2005

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/libraries.html>

CZM modifications - CZM used the MassGIS point data to locate libraries within the mapped coastal flooding areas. Library roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Long-Term Care Residences

Summary - This data layer contains the locations of licensed nursing homes, rest homes, and assisted living facilities in Massachusetts. Data on nursing homes and rest homes were provided by DPH's Division of Health Care Quality and are current as of February 2007. A list of assisted living facilities was provided by the Massachusetts Executive Office of Elder Affairs (publication dated May 2006). Long-term care residences provide housing and services for individuals who are managing illness and/or disability attributed to physical and/or mental health conditions. Non-residential care locations such as adult day health, rehabilitation, and senior centers are omitted.

Credit - Massachusetts Department of Public Health, March 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/longtermcare.html>

CZM modifications - CZM used the DPH point data to locate long-term care residences within the mapped coastal flooding areas. Residence roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

MBTA (Massachusetts Bay Transportation Authority) Commuter Rail Stations

Summary - This data layer includes MBTA commuter rail stations, as developed by the Central Transportation Planning Staff (CTPS).

Credit - Central Transportation Planning Staff, July 2014

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/trains.html>

CZM modifications - CZM used the CTPS point data to extract all MBTA commuter rail stations within the mapped coastal flooding areas. Point locations were manually adjusted to fall in the middle of station (i.e., a spot where the majority of embarking and disembarking occurs, often in front of a covered shelter). Because commuter rail station footprints are often ill-defined, each point was buffered to a 10m radius.

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

MBTA (Massachusetts Bay Transportation Authority) Subway Stations

Summary - This data layer represents the station stops on the five subway, streetcar/trolley, and Silver Line bus lines in the MBTA's rapid transit rail network. The layer was developed by CTPS, with additional editing by MassGIS based on current information from the MBTA's website. It should be noted that the Silver Line actually consists of buses, not trains, but the line is included in this layer because the MBTA includes it as part of its subway system.

Credit - Central Transportation Planning Staff, December 2012

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/mbta.html>

CZM modifications - CZM used the CTPS point data to extract all subway stations within the mapped coastal flooding areas. To map the station footprints, CZM created a 10m buffer around the station point data.

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Police Stations

Summary - This layer shows the point locations of law enforcement and sheriff's offices in Massachusetts, including local, county, and state jurisdictions. MEMA, in cooperation with regional planning agencies and participating communities, created the data as part of the development of Homeland Security data layers. The features represented include municipal police stations and Massachusetts State Police barracks. Although sheriffs are not technically charged with the same law enforcement tasks as local and state police, county sheriff headquarters are also included in this layer. Not included in this layer are Environmental Police, Campus Police, and other state and federal law enforcement.

Credit - Massachusetts Emergency Management Agency, January 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/policestations.html>

CZM modifications - CZM used MEMA's point data to locate police stations within the mapped coastal flooding areas. Station roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Port Facilities

Summary - This point data layer contains the locations of passenger and freight ports in Massachusetts and denotes whether a seaport transports freight and/or passengers and whether it is part of the National Highway System. The locations of the seaports were digitized from 1:5,000 color orthophotos.

Credit - Massachusetts Department of Transportation, June 2005

Web link - <http://geo.massdot.opendata.arcgis.com>

CZM modifications - CZM used the MassDOT point data to locate port facilities within the mapped coastal flooding areas. Port facility footprints were created from the MassGIS Level 3 Assessors' Parcels and subsequently edited to exclude subtidal, wooded, marshy, or other undeveloped land surrounding the facility based on the most current MassGIS orthophotos and Bing Maps oblique imagery; in some instances the facility footprint was further refined by carefully adjusting the parcel boundary to exclude areas below MHHW. If parcel data for the port facility were not available, the footprint was digitized from the most current MassGIS orthophotos.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Prisons

Summary - This data layer shows the location of all correctional facilities (state, county, and federal) in Massachusetts that house inmates. Ancillary support facilities—treatment centers, process divisions, resource centers, etc.—are not included because there are no inmates living at these facilities.

Credit - Massachusetts Office of Geographic Information, March 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/prisons.html>

CZM modifications - CZM used the MassGIS point data to locate all prisons within the mapped coastal flooding areas. Prison roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Public Colleges and Universities

Summary - This data layer shows the locations of public colleges and universities in Massachusetts. This layer was developed by MassGIS and is based on all Massachusetts colleges listed on the National Center for Education Statistics (NCES) website as of October 13, 2004.

Credit - Massachusetts Office of Geographic Information, July 2007

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/colleges.html>

CZM modifications - CZM used the NCES database to check the MassGIS data for spatial accuracy and completeness. The data were augmented with the inclusion of field station and other off-campus facilities. Point data representing the centroid of each college or university were used to locate all the schools within the mapped coastal flooding areas. Public college and university roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Public Water Supply Sources

Summary - This data layer contains the locations of public community surface and groundwater supply sources and public non-community supply sources as defined in the Massachusetts Drinking Water Regulations (310 CMR 22.00). The public water supply sources are based primarily on information in the MassDEP Water Quality Testing System database, which is MassDEP's central database for tracking water supply data.

Credit - Massachusetts Department of Environmental Protection, July 2014

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/pws.html>

CZM modifications - CZM extracted community water systems (CWS) and non-transient non-community water systems (NTNC) from the MassDEP public water supply sources data. The U.S. Environmental Protection Agency (EPA) defines CWS as a public water system that supplies water to the same population year-round and serves at least 25 people at their primary residences or at least 15 residences that are primary residences (e.g., municipalities, mobile home park, sub-divisions). Likewise, EPA defines NTNC as a public water system that is not a community water system and regularly serves at least 25 of the same persons over six months per year, but not year round (e.g., schools, factories, office buildings, and hospitals, which have their own water systems). The CWS and NTNC public water supply sources may be pump houses, surface water, well fields, or wellheads. The extracted point data were used to locate public water supply sources within the mapped coastal flooding areas. The points were then

buffered by an estimated horizontal accuracy value (unpublished data supplied to CZM from MassDEP) to create the facility footprints.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches), however the accuracy has not been formally assessed. Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Schools (Pre-K to High)

Summary - This data layer shows the locations of schools attended by students in pre-kindergarten through high school in Massachusetts. Categories of schools include public, private, charter, collaborative programs, and approved special education. This dataset was originally developed by MassDEP based on information provided by the Massachusetts Department of Elementary and Secondary Education. MassGIS now maintains the data.

Credit - Massachusetts Office of Geographic Information, October 2012

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/schools.html>

CZM modifications - CZM used the MassGIS point data to locate all schools within the mapped coastal flooding areas. School roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Town/City Halls

Summary - This data layer shows the locations of primary executive offices, including town or city halls and annexes. MEMA, in cooperation with regional planning agencies and participating communities, created the data as part of the development of Homeland Security data layers.

Credit - Massachusetts Emergency Management Agency, April 2013

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/townhalls.html>

CZM modifications - CZM used the MEMA point data to locate all town/city halls within the mapped coastal flooding areas. Building roofprints were culled from the MassGIS Building Structures (2-D, from 2011-2013 Ortho Imagery) data and were ground truthed with the most current MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors' Parcels, and web searches.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

United States Coast Guard Bases

Summary - This point data layer shows the locations of all United States Coast Guard bases within Massachusetts. The points were digitized using MassGIS 2005 1:5,000 orthophotos and NOAA nautical charts and were generally placed in the middle of the largest building on the base. The point data were used to locate all U.S. Coast Guard bases within the sea level rise scenarios, FEMA flood zones, and hurricane storm surge inundation scenarios. The base borders were culled from the MassGIS Level 3 Assessors' Parcels.

Credit - Massachusetts Office of Coastal Zone Management, August 2007

Web link - http://maps.massgis.state.ma.us/czm/moris/metadata/moris_uscg_bases_pt.htm

CZM modifications - n/a

Accuracy - Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Wastewater Treatment Plants

Summary - The EPA Environmental Facility Registry Services (FRS) is a centrally managed database that identifies facilities, sites, or places subject to environmental regulations or of environmental interest. The FRS provides access to a single integrated source of comprehensive (air, water, and waste) environmental information about those facilities, sites, or places.

Credit - U.S. Environmental Protection Agency, 2012

Web link - <https://edg.epa.gov/metadata/catalog/search/resource/details.page?uuid=%7B86C00471-0D39-4352-B629-14E3C0E2D042%7D>

CZM modifications - CZM downloaded the FRS data and extracted municipal wastewater treatment facilities. The facility coordinates were then used to locate all wastewater treatment plants occurring within the mapped coastal flooding areas. Plant borders were created from the MassGIS Level 3 Assessors' Parcels and subsequently edited to exclude subtidal, wooded, marshy, or other undeveloped land surrounding the facility based on the most current MassGIS orthophotos and Bing Maps oblique imagery; in some instances the facility footprint was further refined by excluding all lands outside a fenced perimeter.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches). Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

Water Supply Protection Areas

Summary - This data layer delineates those areas included in the Massachusetts Drinking Water Regulations (310 CMR 22.00) as Surface Water Supply Protection Zones that are active, inactive, or emergency. The zones are defined as the following:

- Zone A - a) the land area between the surface water source and the upper boundary of the bank of the waterbody; b) the land area within a 400 foot lateral distance from the upper boundary of the bank of a Class A surface water source, as defined in 314 CMR 4.05(3)(a); and c) the land area within a 200 foot lateral distance from the upper boundary of the bank of a tributary or associated surface water body.
- Zone B - The land area within one-half mile of the upper boundary of the bank of a Class A surface water source, as defined in 314 CMR 4.05(3)(a), or edge of watershed, whichever is less. Zone B always includes the land area within a 400 ft lateral distance from the upper boundary of the bank of a Class A surface water source.
- Zone C - The land area not designated as Zone A or B within the watershed of a Class A surface water source, as defined in 314 CMR 4.05(3)(a).

Credit - Massachusetts Department of Environmental Protection, October 2013

Web link - <http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/swp.html>

CZM modifications - CZM removed all Zones B and C from the data. These zones are deemed unlikely to have significant impacts from coastal flooding. Zone A data were then used to locate all the water supply protection areas within the mapped coastal flooding areas.

Accuracy - The accuracy of the critical facility data has been substantially improved by CZM via manual comparison of the source data with external data sources (e.g., MassGIS orthophotos, Bing Maps oblique imagery, Google Maps Street View imagery, Level 3 Assessors Parcels, and web searches), however the accuracy has not been formally assessed. Attribute accuracy, logical consistency, completeness, and positional error were not formally assessed.

DEFINITION OF TERMS

Attribute Accuracy - An assessment of the accuracy of the identification of entities and assignment of attribute values in the data set.

Community Water System (CWS) - A public water system that supplies water to the same population year-round and serves at least 25 people at their primary residences or at least 15 residences that are primary residences (e.g., municipalities, mobile home park, and sub-divisions).

Completeness - Information about omissions, selection criteria, generalization, definitions used, and other rules used to derive the data set.

Datum - A coordinate system and a set of reference points (such as sea level) that serves to provide known locations from which to begin creating floodplain maps, property boundaries, construction surveys, or other work requiring accurate coordinates that are consistent with one another. Horizontal

datums measure positions (latitude and longitude) on the surface of the Earth, while vertical datums are used to measure land elevations and water depths.

Digital Elevation Model (DEM) - A DEM is a simple, regularly spaced digital representation of elevation points referenced to a common datum. DEMs filter out non-ground points such as buildings and trees.

Flood Insurance Rate Map - The official flood map of a community on which the Federal Emergency Management Agency (FEMA) has delineated both the special flood hazard areas and the risk premium zones applicable to the community.

Geocoding - The use of a description of a location, most typically a postal address or place name, to find geographic coordinates from spatial reference data such as building polygons, land parcels, street addresses, and postal codes (e.g., ZIP codes).

Hydrological connectivity - Connection, via water flow, between the ocean and landward water bodies subject to tidal action. Hydrologic connectivity is often in question where a road or other raised elevation feature apparently cuts off a waterbody from the ocean, yet in reality does allow for water exchange via a culvert, underground pipe, or other structure.

Light Detection and Ranging (LIDAR) - LIDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. LIDAR can be used to produce highly accurate shoreline maps, make digital elevation models for use in geographic information systems (GIS), to assist in emergency response operations, and in many other applications.

Logical consistency - An explanation of the fidelity of relationships in the data set and tests used.

Massachusetts Coastal Zone - This zone includes the lands and waters within an area defined by the seaward limit of the state's territorial sea, extending from the Massachusetts-New Hampshire border south to the Massachusetts-Rhode Island border, and landward to 100 feet inland of specified major roads, rail lines, other visible rights-of-way, or, in the absence of these, at specified coordinates.

Mean Higher High Water (MHHW) - The average of the higher high water height of each tidal day.

National Flood Hazard Layer (NFHL) - A digital database that contains flood hazard mapping data from FEMA's National Flood Insurance Program (NFIP). These map data are derived from Flood Insurance Rate Map (FIRM) databases and Letters of Map Revision (LOMRs). The NFHL is a compilation of GIS data that comprises a nationwide digital FIRM.

North American Vertical Datum of 1988 (NAVD 88) - NAVD 88 is the vertical datum of orthometric height established for vertical control surveying in the United States. (Orthometric height is for practical purposes "height above sea level," but the current NAVD 88 datum is tied to a defined elevation at one point rather than to any location's exact mean sea level.)

Positional Accuracy - An assessment of how closely the coordinate descriptions of features compare to their actual location (horizontally and/or vertically).

Public Non-transient Non-community Water System (NTNC) - A public water system that regularly serves at least 25 or more of the same persons daily for more than six months per year. Examples include schools, factories, and office buildings.

Sea, Lake and Overland Surges from Hurricanes (SLOSH) model - The SLOSH model is a computerized numerical model developed by the National Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field which drives the storm surge.

Special Flood Hazard Area (SFHA) - The land area covered by the floodwaters of the base flood on NFIP maps. The SFHA is the area where the NFIP's floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies. The SFHA includes A and V Zones.

Storm surge - An rise of water generated by a storm, over and above the predicted astronomical tides.

Tidal datum - The average level of water at a tide gauge over time. Some examples of these are Mean Sea Level (MSL), Mean Low Water (MLW), and Mean Higher High Water (MHHW). It is important to remember that tidal datums are local datums, and they vary from location to location along the coast.

Topology - A set of rules that model how points, lines, and polygons share coincident geometry.

VDatum - A tool used to convert elevation data from various sources into a common reference system. VDatum converts elevation data between tidal, orthometric, and ellipsoidal vertical datums, allowing users to establish a common reference system for all elevation data sets.

Vertical Datum - A surface of zero elevation to which heights of various points are referred in order that those heights be in a consistent system. More broadly, a vertical datum is the entire system of the zero elevation surface and methods of determining heights relative to that surface.