Project Sub-Agreement

Development of a Coastal Storm Hazard Early Warning and Decision Support Dashboard for Delaware

FINAL REPORT

by

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Background:

Through its Resilient Community Partnership program, the DNREC Delaware Coastal Programs (DCP) is providing technical assistance to the City of Rehoboth Beach, the City of Lewes, Town of Henlopen Acres, Town of Dewey Beach, Town of Bethany Beach, Town of South Bethany and the Town of Fenwick Island (Figure 1) in order to conduct an assessment of impervious surface coverage due to increased development in their communities, and its corresponding impacts on stormwater management, flooding, and water quality both in present and future climate conditions. The project will additionally provide options for slowing the rate of increase of impervious surface coverage in future development, including the development of model ordinances to reduce rate of increase of impervious surface coverage amounts, nature based solutions to increase stormwater infiltration, and/or other options such as establishing in-lieu fees. Guidance will also be provided to each municipality seeking to tailor and implement the model ordinances in their areas.

Figure 1. Delaware Coastal Municipalities

To facilitate this process, the current (2016) and historic (2007) amounts of impervious surface in these communities needs be determined. The State of Delaware has impervious surface GIS layer for 2007 and the Chesapeake Conservancy produced a more recent land cover dataset (2016) using 2013 and 2014 NAIP and orthoimagery. However the accuracy of the data has not been validated in high density coastal communities. To correctly project trends in increasing impervious surface

area, an accuracy assessment of the data needs to be performed to define the range of potential errors in any prediction. In addition, some areas of impervious surface are inevitable; these include roads and other public infrastructure. To estimate the potential impact of any new ordinances, these non-affected regions must be separated out.

Objectives:

The project objectives were to:

1) assess the accuracy of the impervious GIS layer in 2007 and 2016 for the Delaware coastal communities of the Cities of Rehoboth Beach and Lewes, and the Towns of Henlopen Acres, Dewey Beach, Bethany Beach, South Bethany and Fenwick Island, and to
2) determine the change in impervious surface cover from 2007 to 2016.

Data:

Download impervious surface GIS layers for 2007 and 2016

2007 Delaware impervious surface layer (referred to as Delaware layer)
This layer was provided by Dr. Robert Scarborough as zip file (ssz_east_impervious.zip), and uncompressed as raster layer (ArcInfo GRID format). The layer is also available through ArcGIS Pro All Portal at:
(http://firstmap.gis.delaware.gov/arcgis/services/PlanningCadastre/DE_ImperviousSurface_SussexEast_2007/ImageServer).

Raster layer contains pixels values of;

0	background
1	pervious
2	impervious

2016 Chesapeake Conservancy impervious surface layer (referred to as Chesapeake layer)
Sussex County Delaware layer was downloaded from web at:
https://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/ as compressed zip file. Uncompressed file was in an Imagine (img) image format, and exported to file geodatabase for processing. User's manual indicates that 2013 and 2014 NAIP and orthoimagery along with other data were used to create this dataset. Dataset also available through image service at:
https://firstmap.delaware.gov/arcgis/rest/services/DE_Imagery/DE_Imagery_Sandy/ImageServer.

Raster layer pixel values shown in Table below.

SUSS_10005.img

Field: Selection:

OID	Value	Count	LandCover
0	1	142916273	Water
1	2	89577138	Wetlands
2	3	965912194	Tree Canopy
3	4	36357623	Shrubland
4	5	1153336337	Low Vegetation
5	6	18621704	Barren
6	7	36003615	Structures
7	8	45772060	Impervious Surfaces
8	9	44754344	Impervious Roads
9	10	5405006	Tree Canopy over Structures
10	11	6704482	Tree Canopy over Impervious Surfaces
11	12	4595087	Tree Canopy over Impervious Roads

The sections that follow describe the detailed processing of the data layers with the results discussed within each section.

Accuracy Assessment Preprocessing

The following step describe the processing tasks performed to complete the accuracy assessment of both the Delaware and Chesapeake layers:

1) Delaware and Chesapeake layers projected to Delaware State Plane, NAD83, meters using Project Raster tool and output as file geodatabase raster layers.
2) Generated point features to assess the accuracy of both layers. A stratified random sampling scheme was selected to ensure evenness of geographic coverage, but to also contain a random component for urban areas periodicity. This was a two-step process.
    a. Create a stratified sampling grid of square cells called a fishnet across study area encompassing the beach communities. Our objective was to create a fishnet fine enough to capture the spatial variation in land cover, while also keeping in mind the effort involved in checking each point. A grid with 300 by 300 meter grid cells resulted in 262 grid cells, or 262 sampling points to check. The Create Fishnet tool specifying cell size of 300 by 300 meters and geometry type polygon created the fishnet.
    b. Select a random point within each grid cell of the fishnet using the Create Random Points tool (specifying number points to 1) to create point features to assess accuracy of the Delaware and Chesapeake layers.

    Figure 2 displays the stratified sampling with an accuracy assessment point within each grid cell displayed in red.

Figure 2. Stratified random sampling scheme used to select assessment points.

3) The next step entailed subsetting the Fishnet Random Points layer to extract only the random points falling within the Delaware Beach Municipalities of City of Rehoboth Beach, the City of Lewes, Town of Henlopen Acres, Town of Dewey Beach, Town of Bethany Beach, Town of South Bethany and the Town of Fenwick Island. This was accomplished using the Clip tool (Figure 3).

Figure 3. Sampling points clipped to beach towns.

4) Assign the Delaware and Chesapeake raster layers' land cover to each assessment point in point feature class using the Extract Values to Points tool. This tool extracts the land cover information (raster cell values) geographically overlaying each fishnet random point and records the values in the assessment point feature class attribute table. Figure 4 displays point feature class (layer) and it attribute table. One assessment point selected in blue shows the land cover is impervious. This point layer is the layer used for the accuracy assessment (AccuracyAssessmentPoints)

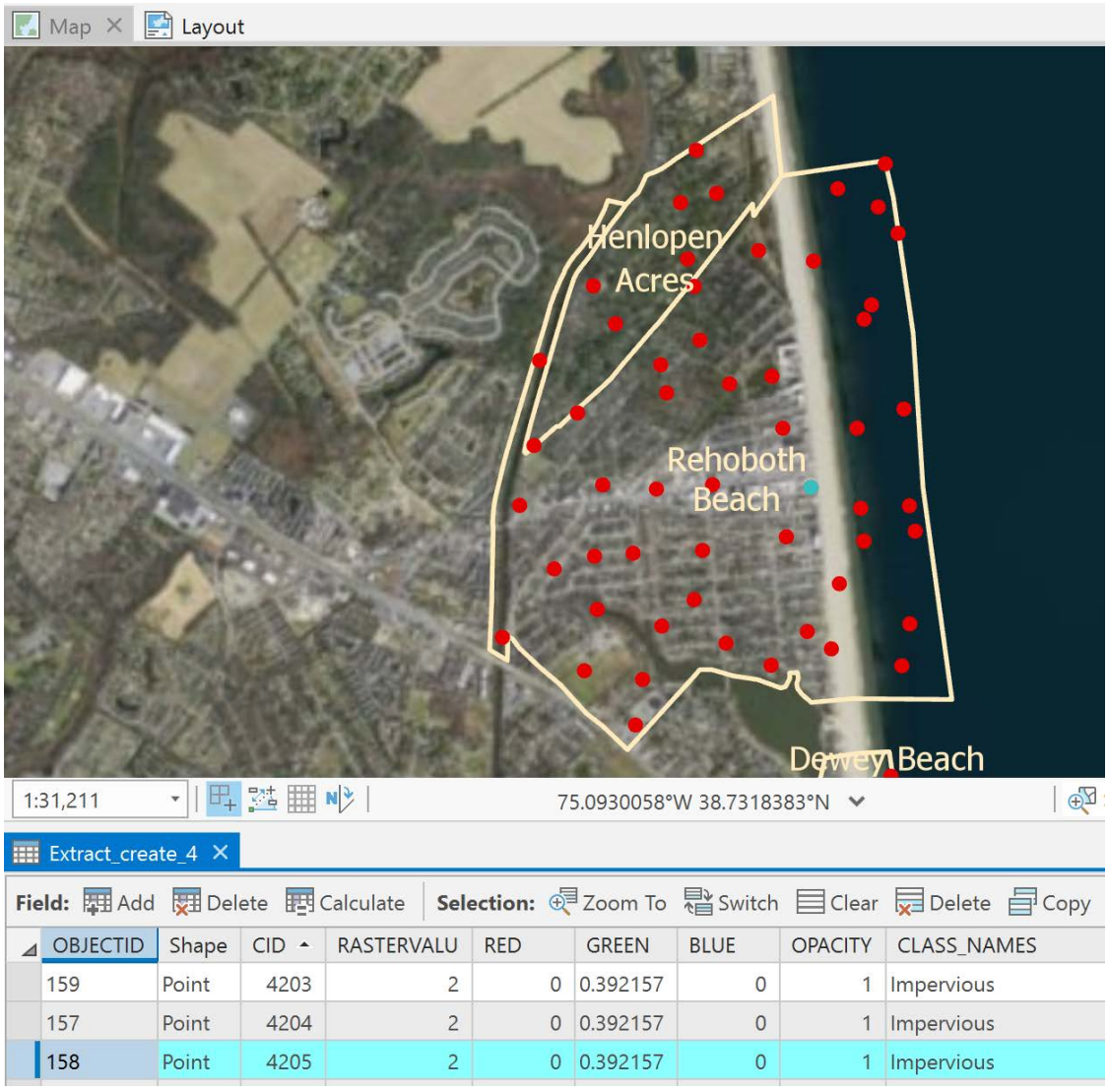


Figure 4. Zoomed in view displaying the accuracy assessment points for Henlopen Acres and Rehoboth Beach.

5) The last step consisted of creating news fields to specify if the land cover surfaces were accurate at the sample points and to make notes about the type of surface if incorrect or difficult to determine. The important fields in the point layer include:

Attribute Table Field	Description
RASTERVALU	Delaware layer raster pixel value
coding_system	Delaware layer raster accuracy code 0 unknown 1 for accurate 2 for not accurate, 3 out of bounds of data layer (background)
comments	Delaware raster accuracy notes
ChesapeakeData	Chesapeake layer raster pixel value <same as Delaware layer>
ChesapeakeComments	Chesapeake raster accuracy notes

The Chesapeake layer does not extend into the ocean, while the Delaware layer does extends into the ocean (e.g., Lewes). For all those points coded 0 originally, we went back through, evaluated again and assigned an accuracy.

Accuracy Assessment Process

To perform the accuracy assessment, Google Earth and Google Street View were used to visually check each sample point. The process started in ArcGIS Pro by right clicking on a point and selecting Copy Coordinates to get the X,Y coordinates of the point. Then in Google Earth Pro, these X,Y coordinates were pasted into the Search window to navigate to the exact location.

The Google Earth Historical Imagery slider (tool found under the View menu) was used to select the 2007 imagery for the Delaware layer. For the Chesapeake layer, we toggled between 2015, 2017, and 2018. Additional imagery for 2009 and 2011 were found, but at a reduced spatial resolution. The Zoom In/Out slider tool was invaluable to zoom to the appropriate scale to determine if the location was impervious or pervious.

At times, the surface was difficult to see because of tree cover, or if it was too close to the boundary between a concrete and grassy area. In cases where we were unsure, we toggled between Google Earth Aerial View and Google Earth Street View, and used the time series of imagery available to see if a structure existed before or after the layer's date to see what kind of surface was present at any given location and time. Street View was helpful occasionally when attempting to see more detail.

As one example, in some locations the Google Earth Aerial View (Figure 6 right panel) was not always clear enough to see if a driveway was gravel or concrete. When using Street View (Figure 6 left panel), viewing the surface from a different angle enabled the surface to be identified. However, Street View was not helpful to identify areas not visible from a street, such as backyards.

The most troubling surfaces were dark gravel driveways that appeared to be rather impervious with no ground showing through and possibly an asphalt slury mix (Figure 6). In most cases, using Google Earth and Google Street View were effective in determining if a surface was impervious or pervious, and allowed us to make a comment in the attribute table about exactly what type of surface was present at each point.

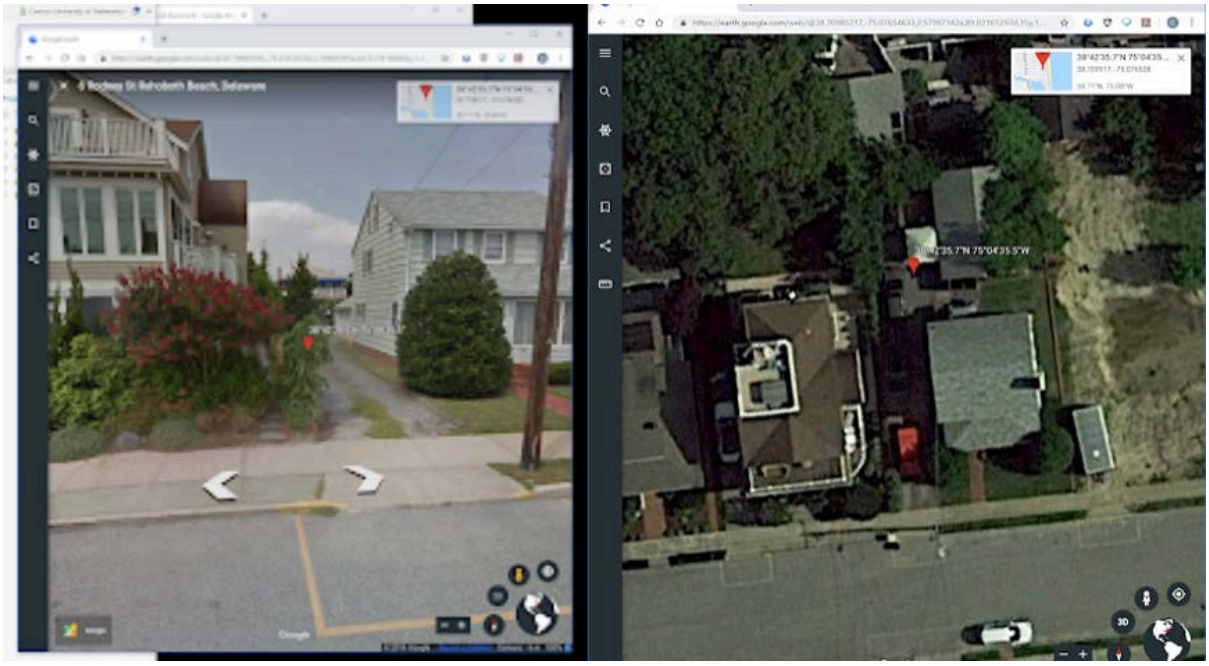


Figure 5. Google Earth Street View (left) and Aerial View (right)

Figure 6. Example of surfaces difficult to assess

Each point was evaluated twice, once by an undergraduate student followed by the Principal Investigator.

The accuracy assessment field for both layers were then summarized to determine the accuracy using the Statistics tool (right click on Delaware layer coding_system field and ChesapeakeData field for Conservancy layer).

Accuracy Assessment Results

Of the 262 assessment points, 2 were discarded for the Delaware layer within the background area and 32 discarded for Chesapeake layer. The larger number for the Chesapeake layer was because this layer's eastern edge border stopped at the ocean's water edge. The **Delaware layer** is **93.5% accurate** and the **92.2%** for the **Chesapeake layer**.

The breakdown of sample points assessed is displayed below, along with maps of the assessment points shown in Appendix 1 (accurate – green points, inaccurate – red points).

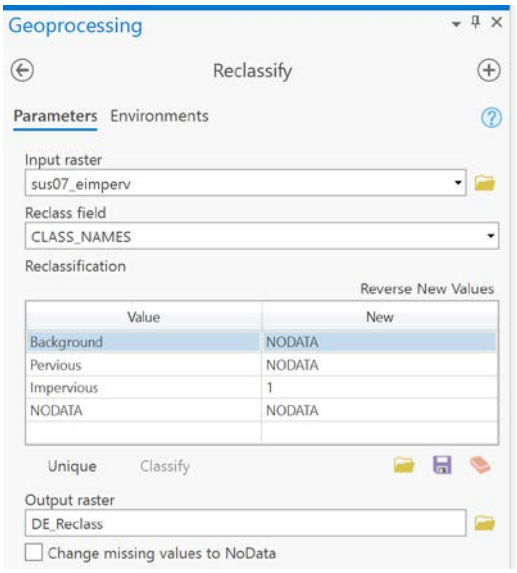
Delaware layer	243 accurate (of 260 points)
	17 not accurate
	2 background (not used in accuracy calculation)
93.46%	
Chesapeake layer	212 accurate (of 230)
	18 not accurate
	32 background
92.17%	

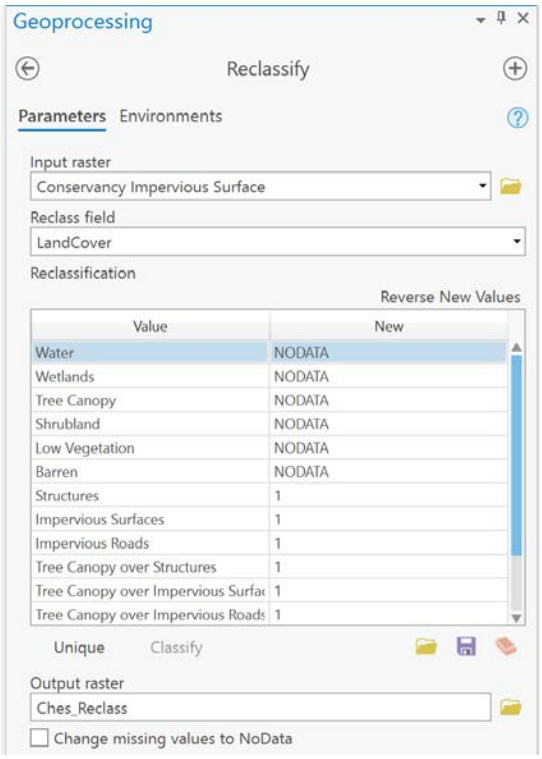
Total Impervious Cover Area by Municipality Processing

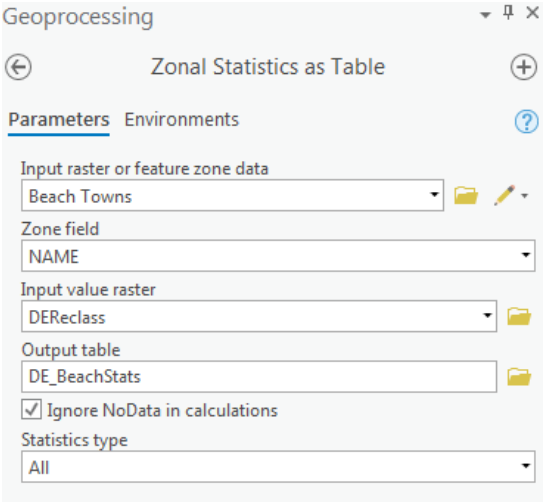
To compute the total area of impervious cover for each beach town (municipality) for both layers, two steps were completed.

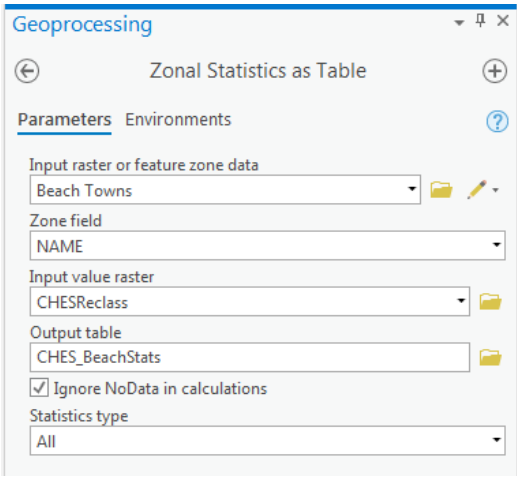
1) The first step entailed reclassifying the Delaware and Chesapeake layers using the Reclassify tool so that the impervious surface pixel values equaled 1 and all others pixel values set to NODATA.
2) The second step used the Zonal Statistics By Table tool to sum the number of pixels with value of 1 (impervious). This count of pixels was then multiplied by the cell size of each pixel, which in this case was 1 meter by 1 meter, and converted to square kilometers.

   The screen shots below display both the tools and their options specified.


Geoprocessing
Reclassify
Parameters Environments
Input raster
sus07_eimperv
Reclass field
CLASS_NAMES
Reclassification
Reverse New Values
Value New
Background NODATA
Pervious NODATA
Impervious 1
NODATA NODATA
Unique Classify
Output raster
DE_Reclass
Change missing values to NoData


Geoprocessing
Reclassify
Parameters Environments
Input raster
Conservancy Impervious Surface
Reclass field
LandCover
Reclassification
Reverse New Values
Value New
Water NODATA
Wetlands NODATA
Tree Canopy NODATA
Shrubland NODATA
Low Vegetation NODATA
Barren NODATA
Structures 1
Impervious Surfaces 1
Impervious Roads 1
Tree Canopy over Structures 1
Tree Canopy over Impervious Surfac 1
Tree Canopy over Impervious Roads 1
Unique Classify
Output raster
Ches_Reclass
Change missing values to NoData


Geoprocessing
Zonal Statistics as Table
Parameters Environments
Input raster or feature zone data
Beach Towns
Zone field
NAME
Input value raster
DEReclass
Output table
DE_BeachStats
Ignore NoData in calculations
Statistics type
All


Geoprocessing
Zonal Statistics as Table
Parameters Environments
Input raster or feature zone data
Beach Towns
Zone field
NAME
Input value raster
CHESReclass
Output table
CHES_BeachStats
Ignore NoData in calculations
Statistics type
All

Municipality Impervious Surface Results

The table (ImpSfcResults.xlsx) below summarizes the total municipality area (km^2), and the total area of impervious surface (Imp Sfc) (also the pixel count), percent of impervious surface, and change over the 10 year period (2016 - 2007) for each municipality.

Municipality	Town Area[1]	2007 Delaware Layer		2016 Chesapeake Layer		Imp Sfc Area Change[1,2]	% Imp Sfc Area Change
		Imp Sfc Area[1]	% Imp Sfc	Imp Sfc Area[1]	% Imp Sfc		
Bethany Beach	3.05	1.14	37.39	1.29	42.22	0.15	4.83
Dewey Beach	1.16	0.53	**45.18**	0.53	**45.13**	0.00	-0.05
Fenwick Island	1.30	0.41	31.45	0.48	37.10	0.07	5.66
Henlopen Acres	0.67	0.15	22.83	0.16	24.39	0.01	1.56
Lewes	11.94	2.12	17.74	2.32	19.41	**0.20**	1.67
Rehoboth Beach	3.90	1.35	34.44	1.35	34.70	0.01	0.25
South Bethany	1.37	0.48	35.27	0.59	42.97	0.11	**7.71**

[1]square kilometers

[2]2016 Chesapeake - 2007 Delaware

Dewey Beach has the highest percent of impervious surfaces at 45% for 2007 and a very slight decrease by 2016. Lewes has the lowest percent of impervious surface area at 17.4% in 2007 with an increase to 19.4% by 2016. The beach municipality with the greatest increase in impervious surfaces over the 10 year period was South Bethany at 7.7% increase. Bethany Beach and Fenwick Island also saw increases in impervious surfaces of 4.8% and 5.7% respectively from 2007 to 2016.

Non-Public Impervious Surface Area Processing

The private land areas were separated from public designated land (streets, parking areas, etc.) using Sussex County Parcel data obtained from Sussex County Mapping and Addressing Department. This was accomplished following the processing steps below. Careful notes are provided due to the complexity of the parcel data associated with parcel boundaries extending across two or more towns, Town Code not matching the municipality resides within, Land Code = MX includes both private and public land, and parcels containing attributes with nulls.

Parcel layer contains 146,493 polygons

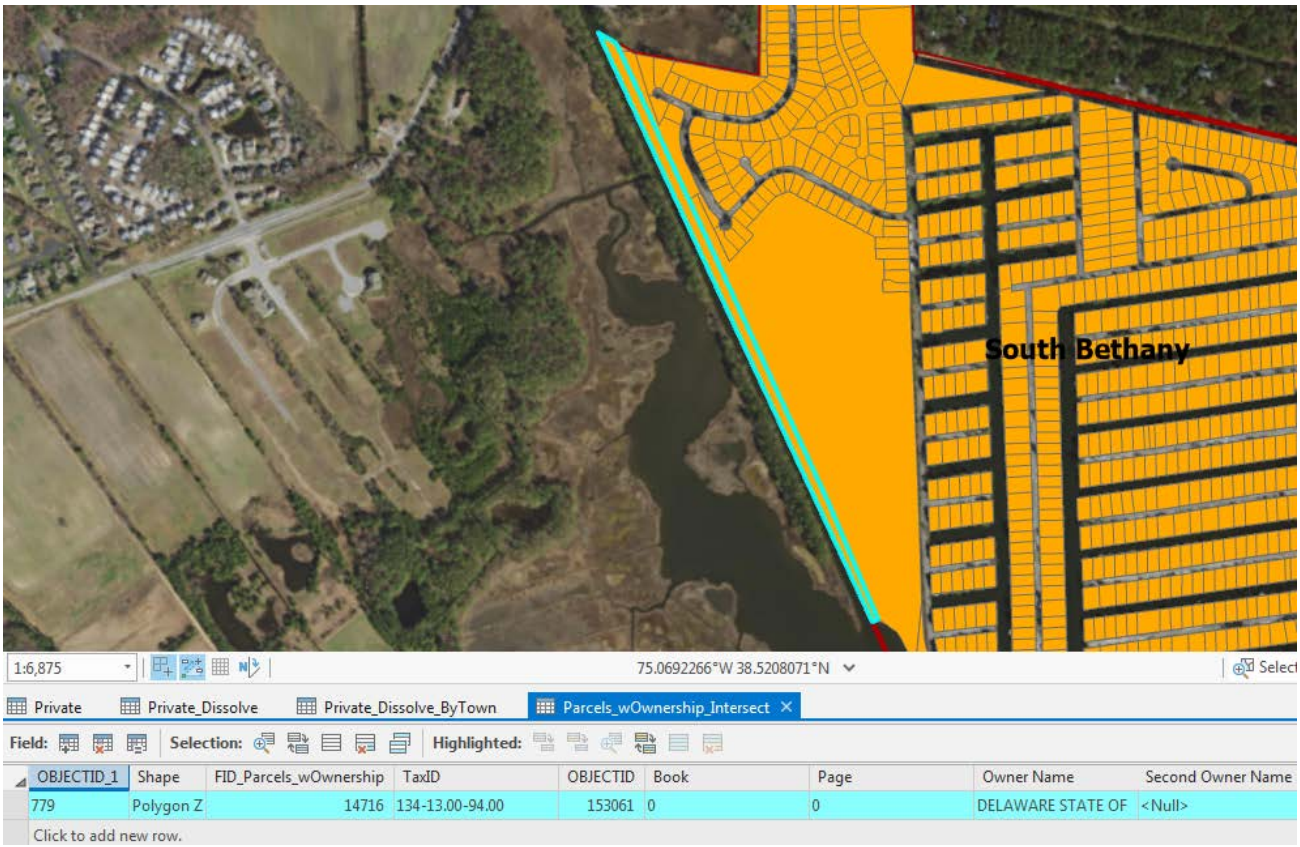
Parcels layer contains 26 parcels (rows) with TaxID equal to <New parcel>, 0, or 1. Also, 51 parcels with Shape_Area less than 25 m^2.

TaxID is not spatially unique. The same TaxID may be associated with multiple parcels, however each parcel is **spatially distinct**, not overlaying.

One parcel may cross into multiple towns as shown in the three figures below.

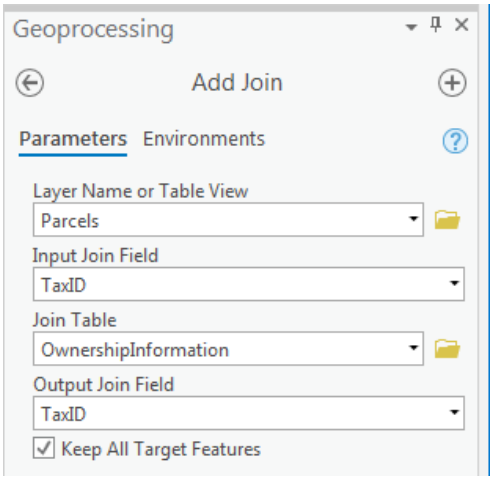
Parcel Land Code

= MX (Miscellaneous) with Town Code = BB (Bethany Beach), but located within South Bethany geographic area.



The steps below describe the processing tasks to compute the total private impervious surface area for each town.

1. Join Ownership table to Parcels layer using common identifier TaxID (Add Join tool). Export to new feature class (Parcel_wOwnership) by right clicking on the layer and select Data > Export Features. Remove all Joins by right clicking on layer, select Joins and Relates > Remove All Joins. (198,828 polygons)



   This keeps all parcels in the input layer. Some TaxIDs associated with same parcel (overlapping geographically). Example TaxID 134-13.00-101.00 – 5 overlapping parcels with same area.

   Joined layer contains parcels with Town Code = <NULL> and Land Code = <NULL>. (1922 parcels)

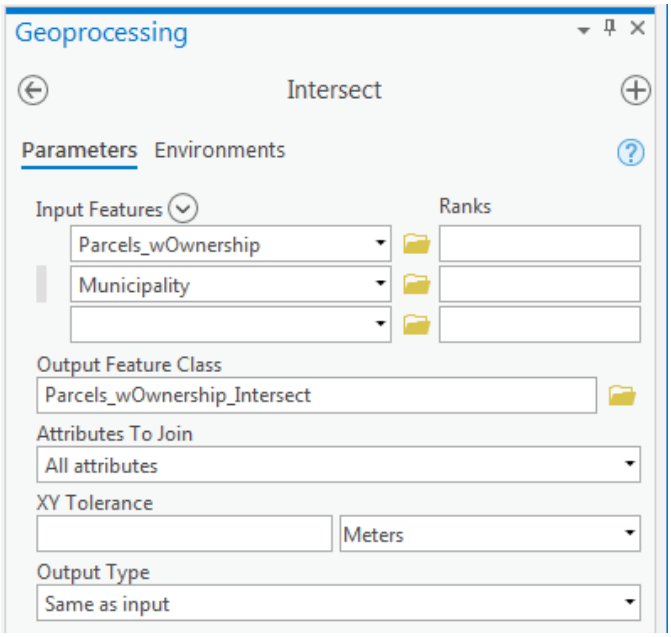
Joined layer contains parcels with Town Code = 00 (Seems to be parcels outside of towns, but a few parcels within beach towns.

2. Intersect the Parcels_wOwnership and Municipality layers so each parcel is tied to the town geographically within (Parcel_wOwnership_Intersect).

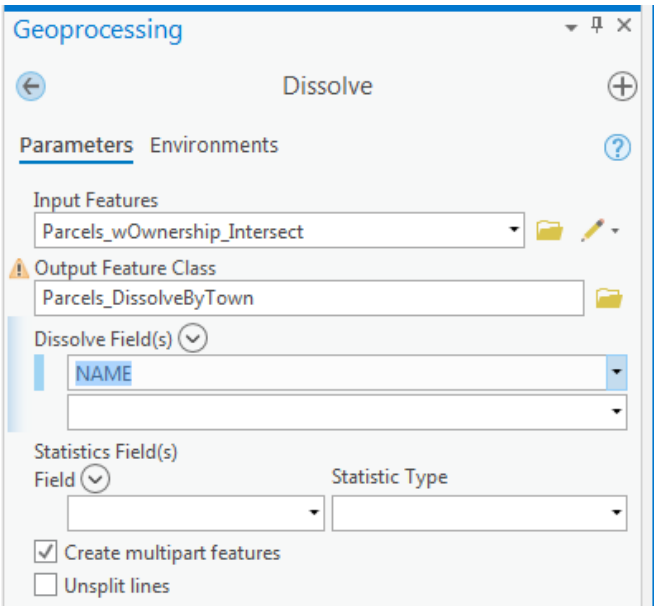
   This splits a parcel that crosses town boundaries.

   17 parcels Land Code = <Null>.

   1488 parcels with Town Code = 00. Land Code has values.



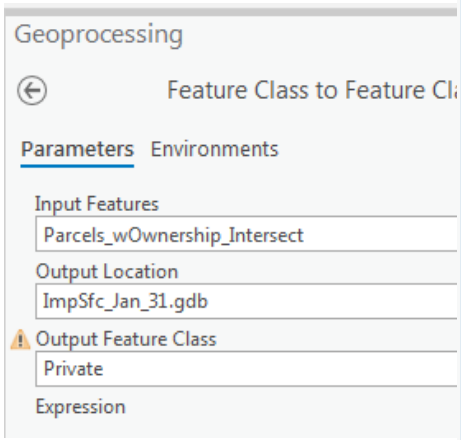
3. Compute total parcel area for each town using Dissolve tool, aggregating on Name (town name) (Parcels_DissolveByTown).

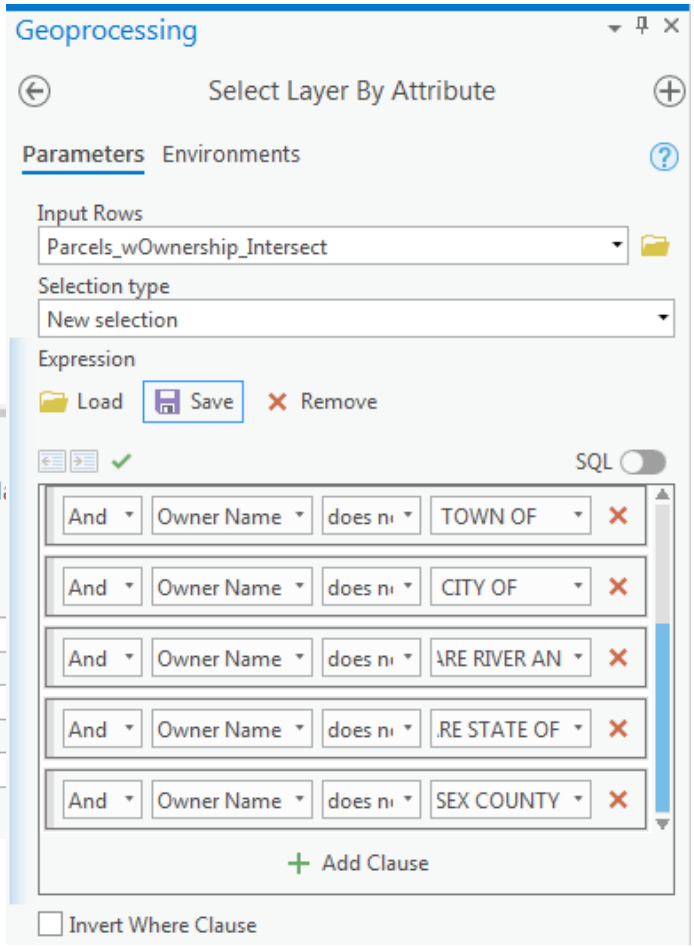


4. Select private parcels (Parcels_wOwnership_Intersect) using excel worksheet obtained from Sussex County Dept (Appendix 2). Private includes all Land Codes except local, state, and federal government and some miscellaneous. Commercial and industrial considered private.

   a. Select by Attributes all private parcels (not equal to LG, ST, and US, and specific miscellaneous values) (PrivateLandcodeQuery.exp).
   b. Export selected features to new feature class (Private) by right clicking on layer, select Data > Export Features. (Private), (15,805 parcels)
   c. Clear selection

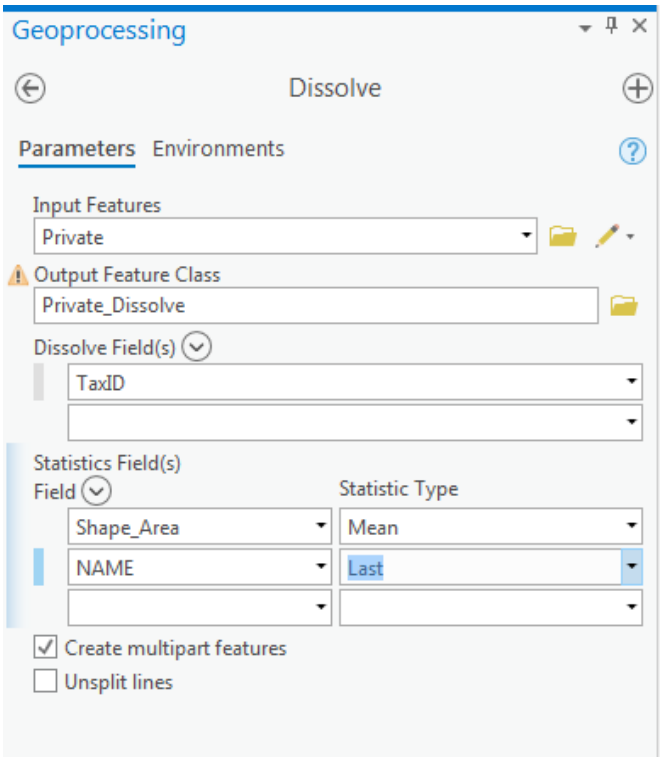
Checked parcels with Land Code = MX by Owner. Excluded Owner with Name of Town Of, City Of, Delaware River &/and Bay Authority, Delaware State of, Sussex County.



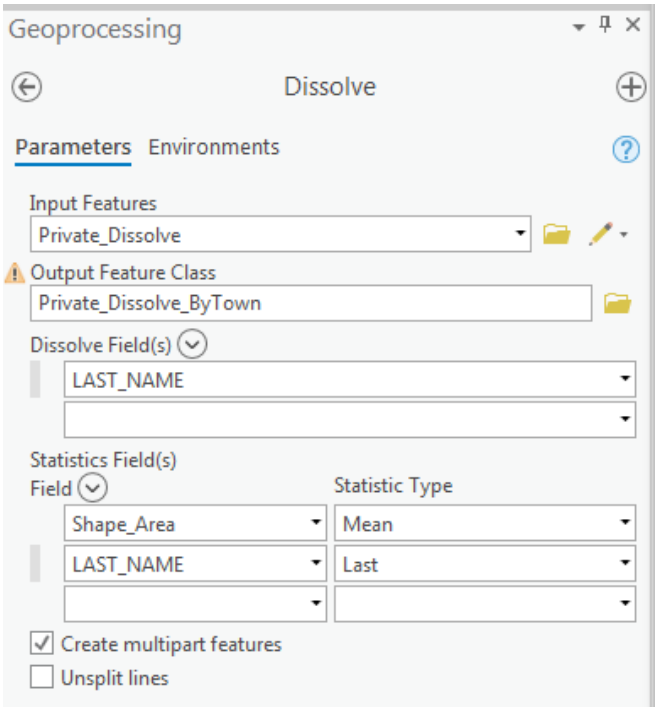


5. Aggregate the private parcels with same TaxID and average the parcels Shape_Area using Dissolve tool so each private parcel is spatially distinct (Private_Dissolve). (10,648 parcels)

   Example: TaxID 134-13.00-113.00 has 53 parcels all geographically same parcel with same Shape_Area 30284 m^2.



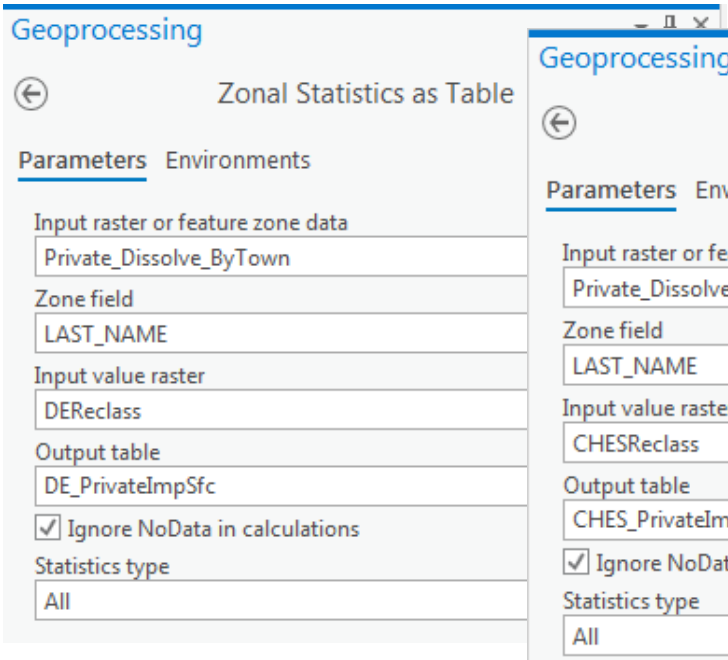
6. Dissolve Private_Dissolve by Municipality (Name) to summarize the private land area by town (Private_ Dissolve_ByTown).

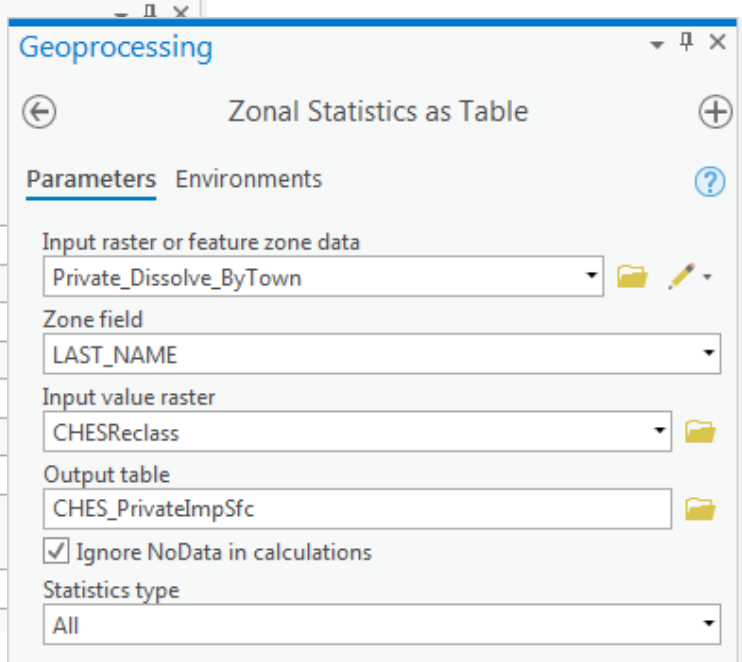


7. Compute the impervious surface (DEReclass, CHESReclass) for private land by municipality (NAME) using Zonal Statistics by Table (DE_Private, CHES_Private).

   For DEReclass and CHESReclass layers, impervious surface pixels value = 1 and all other pixels = NODATA.

   Also ran Zonal Statistics tool with Statistic type: Sum to check areal coverage of each town.





Zooming in to each municipality shows the individual parcels contained within the municipality and areas like roads, canals, beaches excluded within the parcel layer. The two images below display the City of Lewes (top) and zoomed in view (bottom) with private (orange) and public (green) parcels visible that are bounded by the roads and a canal. Lewes' total parcel area is 9.630 km^2, while the municipality area is 11.942 km^2.

The image below displays the town of South Bethany. South Bethany's municipality area is 1.372 km^2, while the total parcel area is 0.914 km^2.

Private Impervious Surface Area Results

The Table (PrivateImpSfcResults.xlsx) below summarizes the private parcel area (labeled Private Area), private impervious surface area (Private Imp Sfc), and the percentage of private impervious surface area to the **total private land area** (% Imp Sfc Private) in each municipality for 2007 and 2016. The percent change in impervious surfaces over the 10 year period is shown in the last column (% Private Change).

Municipality	Private Area[1]	**2007 Delaware Layer**		**2016 Chesapeake Layer**		**% Private Change[4]**
		Private Imp Sfc[1]	% Imp Sfc Private[2]	Private Imp Sfc[1]	% Imp Sfc Private[2]	
Bethany Beach	2.18	0.78	35.98	0.89	40.96	4.98
Dewey Beach	0.54	0.35	**64.54**	0.34	**64.10**	-0.44
Fenwick Island	0.58	0.29	50.03	0.35	60.31	**10.28**
Henlopen Acres	0.37	0.09	23.51	0.09	23.48	-0.03
Lewes	**4.90**	**1.21**	24.59	**1.36**	27.64	3.05
Rehoboth Beach	1.69	0.82	48.25	0.82	48.56	0.31
South Bethany	0.79	0.34	43.01	0.41	52.17	9.15

[1]square kilometers

[2]Private impervious surface area divided by total private land (%)

[3]2016 Chesapeake percent private impervious surface area minus 2007 Delaware percent private impervious surface area

In 2007, Dewey Beach has the largest percent of private impervious surface in comparison to **total private land area** at 64.5%, followed by Fenwick Island (50.0%) and Rehoboth Beach (48.3%). Henlopen Acres has the lowest percentage at 23.51% in 2007. A large increase in private impervious surfaces occurred in Fenwick Island (10.3%) and South Bethany (9.15%) over the 10 year period. Bethany Beach private impervious surfaces grew by nearly 5%. Dewey Beach (0.4%) and Henlopen Acres (0.03%) private impervious surface actually decreased slightly by 2016.

The table below summarizes the private impervious surface in comparison to the **total parcel area** (excludes lakes, canals, beaches) and **total town area** delineated by the Municipality layer.

Municipality	Private Area[1]	**2007 Delaware Layer**			**2016 Chesapeake Layer**			**% Private Parcel[4]**	**% Private Total[5]**
		Private Imp Sfc[1]	% Imp Sfc Parcel[2]	% Imp Sfc Town[3]	Private Imp Sfc[1]	% Imp Sfc Parcel[2]	% Imp Sfc Town[3]		
Bethany Beach	2.18	0.78	30.79	25.70	0.89	35.06	29.26	4.26	3.56
Dewey Beach	0.54	0.35	**52.92**	**29.64**	0.34	52.56	29.44	-0.36	-0.20
Fenwick Island	0.58	0.29	46.99	22.43	0.35	**56.64**	27.04	**9.66**	4.61
Henlopen Acres	0.37	0.09	17.69	13.06	0.09	17.66	13.04	-0.02	-0.02
Lewes	**4.90**	**1.21**	12.52	10.10	**1.36**	14.07	11.35	1.55	1.25
Rehoboth Beach	1.69	0.82	38.34	20.90	0.82	38.59	21.03	0.25	0.14
South Bethany	0.79	0.34	37.09	24.71	0.41	44.98	**29.97**	7.89	**5.26**

In 2007, Dewey Beach has the largest percent of private impervious surface in comparison to total parcel area (52.92%) and town area (29.64%). Lewes has the lowest percentage of private impervious surface to total parcel area and total town area for both years. Fenwick Island showed the largest percentage increase in private impervious surface to total parcel area at 9.7% followed by South Bethany (7.9%), while South Bethany showed the largest increase of 5.3% when comparing to total town area.

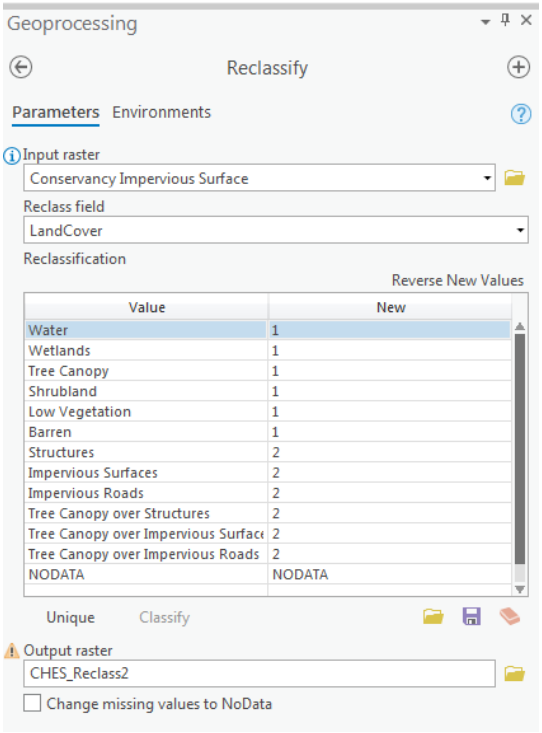
Impervious Surface Maps by Municipality Processing

To spatially display the change in impervious cover from 2007 to 2016 for each town the following processing steps were completed:

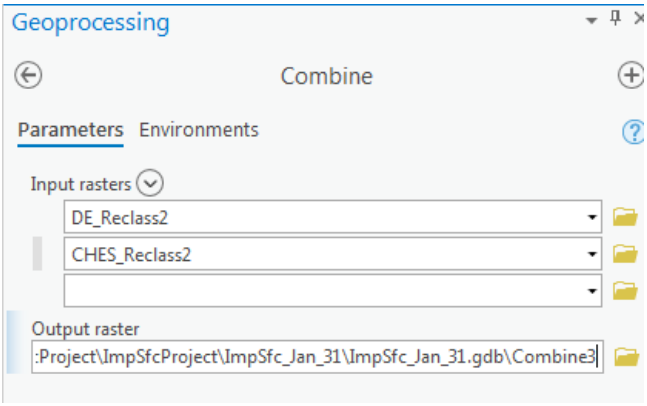
1) Reclassify the Delaware and Chesapeake layers so only impervious surface pixels have values and other pixels set to NoData.

   Delaware layer
   - Background (0) set to 1
   - Pervious (1) = 1
   - Impervious (2) = 2
   - Nodata = Nodata

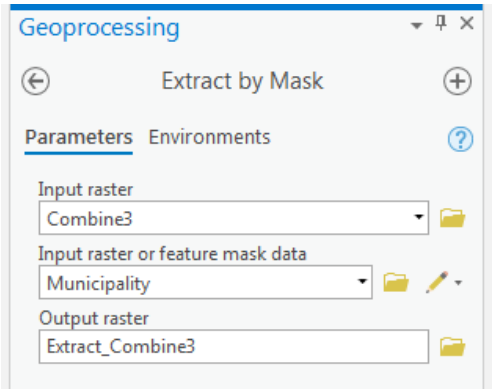
   Chesapeake layer (shown in tool)



2) Combine the two reclassified layers to determine any change. This tool combines rasters so that a unique output value is assigned to each unique combination of input values (DE_Reclass2, CHES_Reclass2).



3) Subset Combine layer to only the municipalities using Extract by Mask tool (Combine).



Impervious Surface Maps by Municipality

The Lewes impervious surface change map is displayed below as an example. The green shaded areas represent permeable surfaces for water to infiltrate, while the two red tones are impervious surfaces. Dark red areas represent surfaces that have changed over the last 10 years to impervious surfaces.

All the municipalities are included in **Appendix 3**.

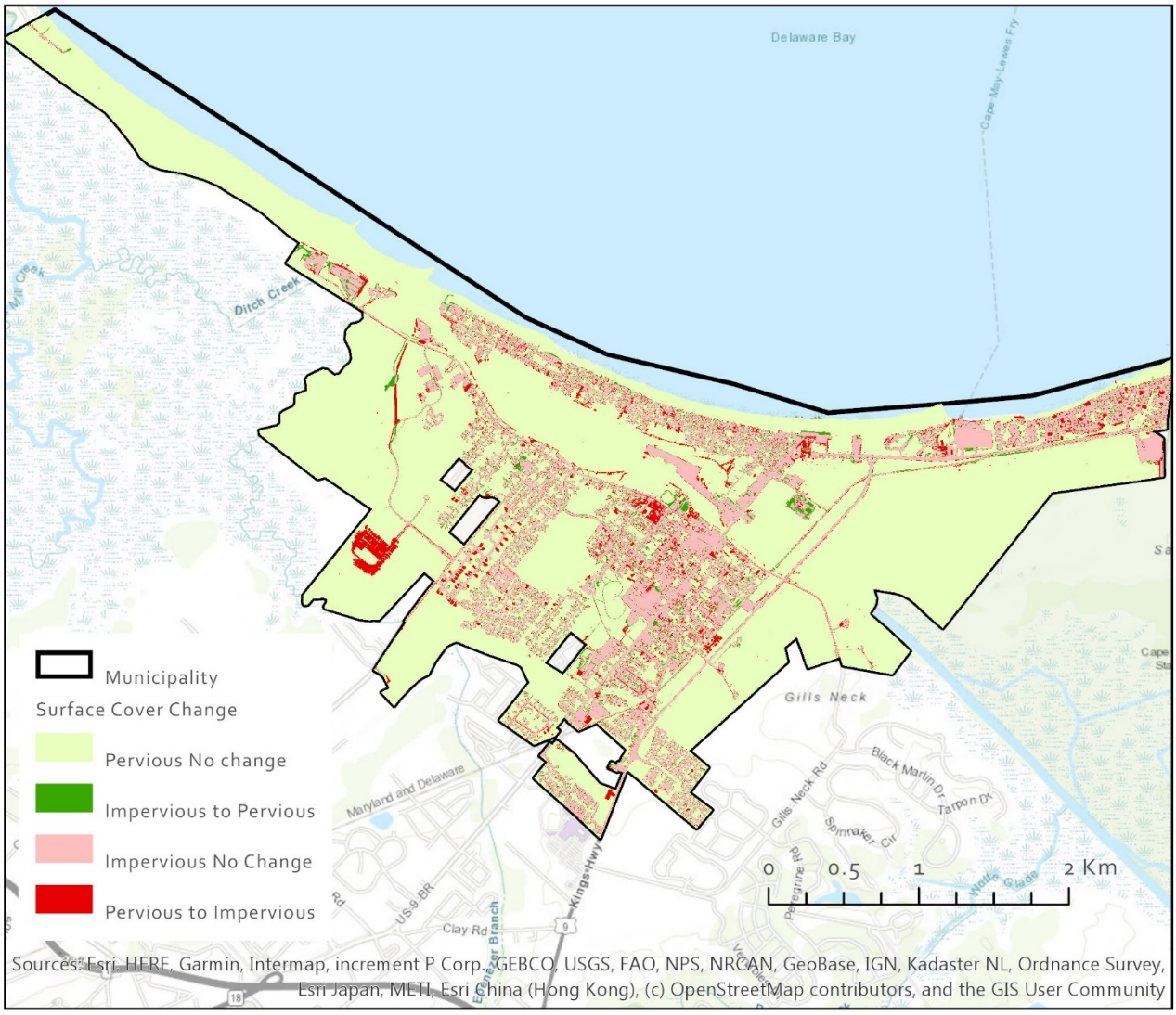


Figure 7. Lewes surface change map. Impervious surface change from 2007 to 2016. Green color represents pervious surface, while red impervious surface. Dark red is change from pervious to impervious surface.

SUMMARY

This work provides an analysis of the impervious surface area for the Delaware Beach communities. The impervious surface information is derived from two datasets with publication dates of 2007 and 2016.

On average, the beach towns' impervious surface area was 32% of the town area in 2007 with an increase to 35% by 2016. This 3% increase in impervious surfaces represented an increase in impervious surface area of 0.96 km^2. South Bethany showed the largest increase of 7.7% over the 10 year period, while Dewey Beach had a slight decrease its impervious surface cover from 2007 to 2016.

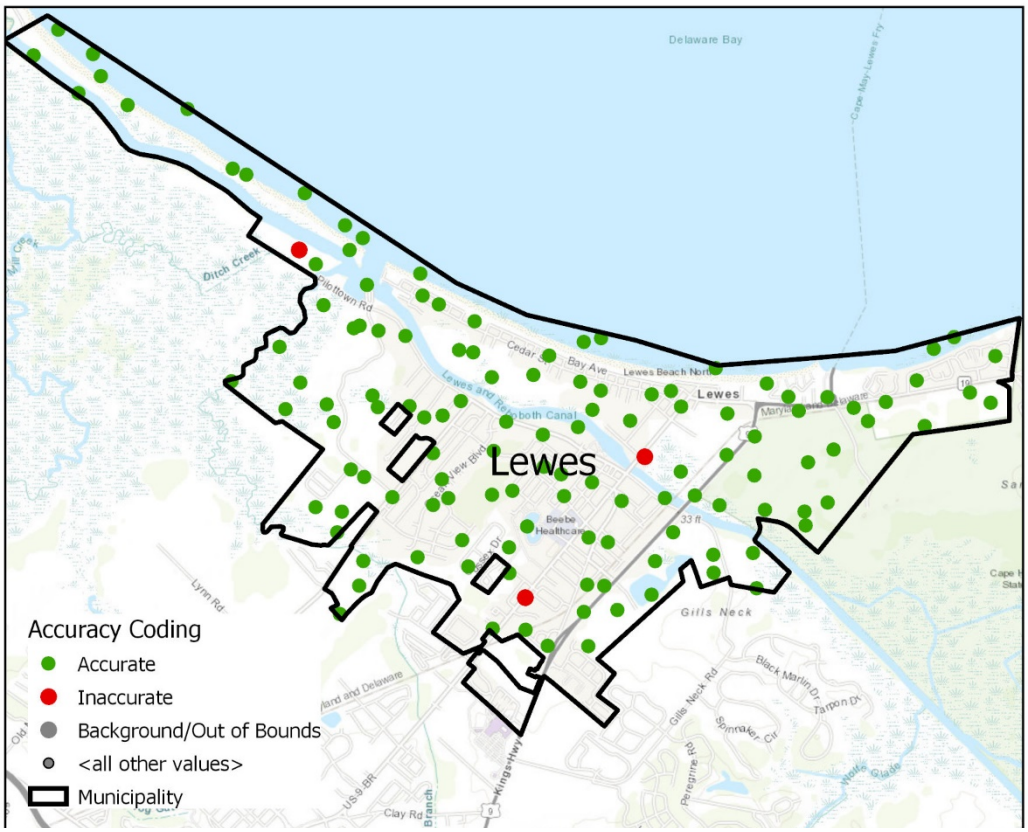
An analysis of only the private land areas revealed 41% private impervious surface area to total private land, 34% to total parcel area, and 21% of total town area for 2007. On average each town's private impervious surface grew by 0.06 km^2 and the percent change over the 10 year period was nearly 4% to total private land, 3% to total parcel area and 2% to total town area.

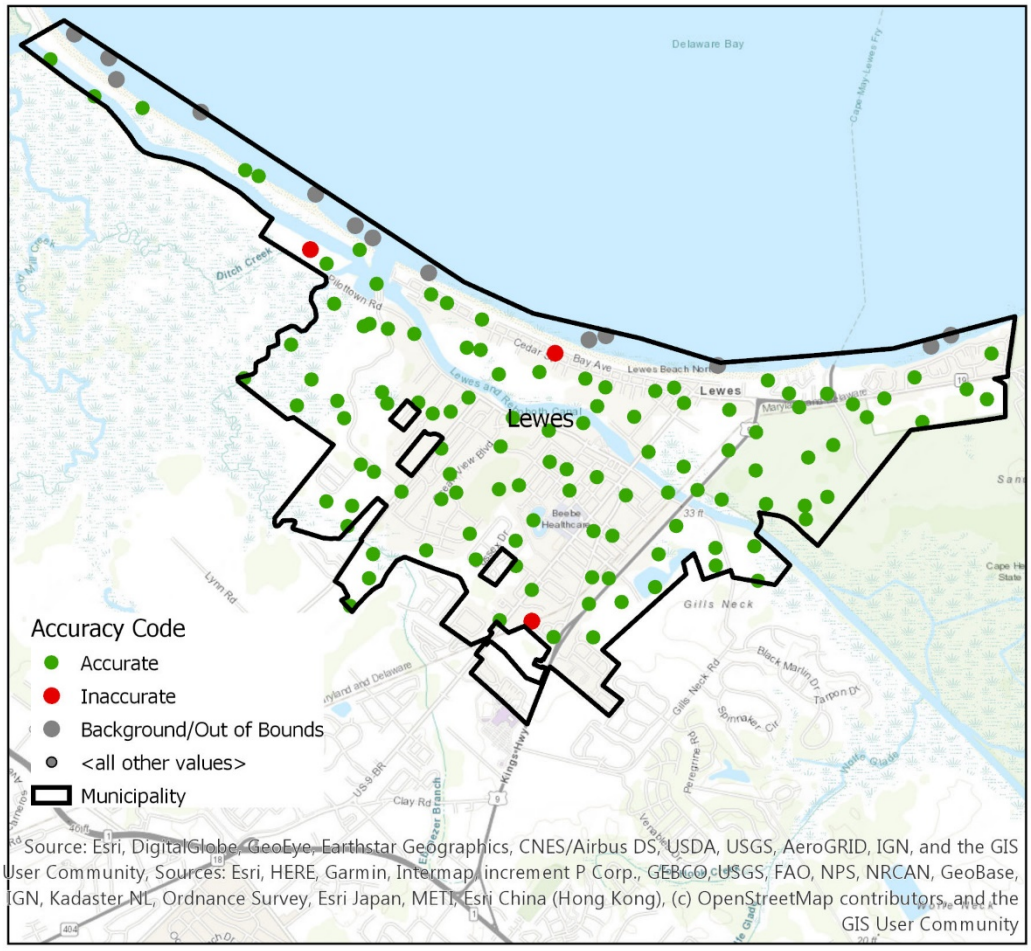
In conclusion, this analysis revealed a 3% increase in impervious surface area in the Delaware Beach Communities over the 10 year period. The private designated areas within the towns reveals a 2% increase (in comparison to total town area) from 2007 to 2016.

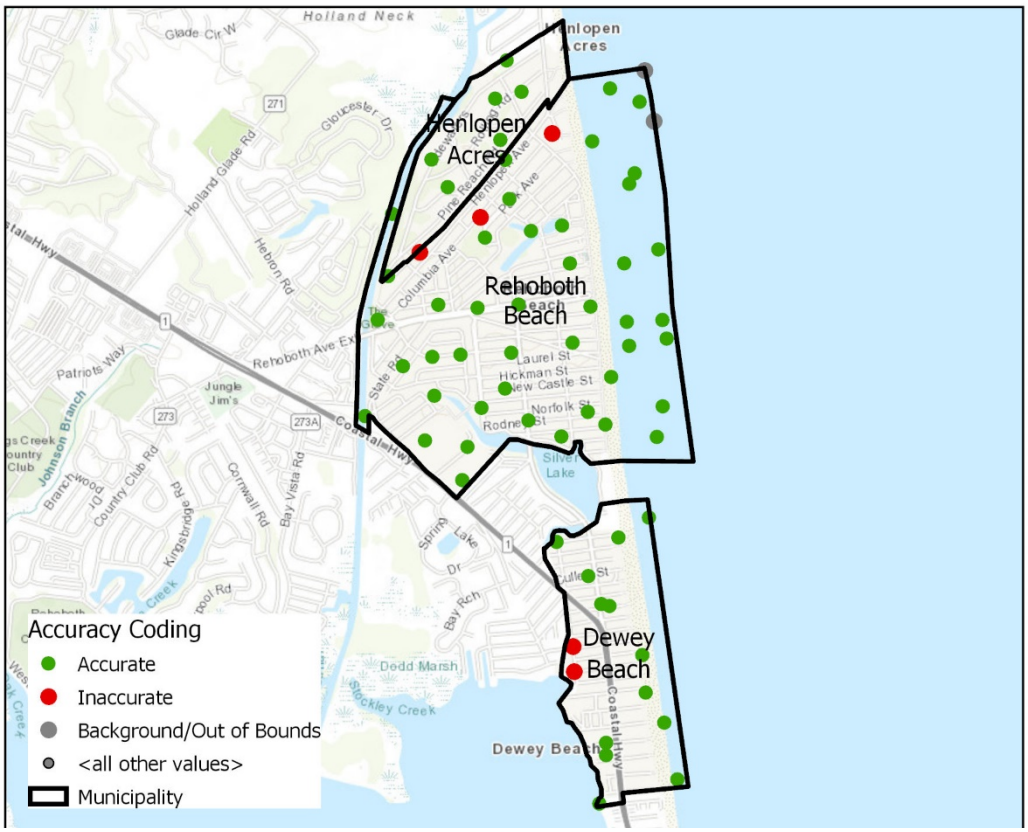
As a note of caution, care must be taken in using these results given the accuracy of the two impervious surface datasets (Delaware layer 93%, Chesapeake layer 92%) and the complexity of the parcels data noted in the discussion above which may have contributed to errors in these results.

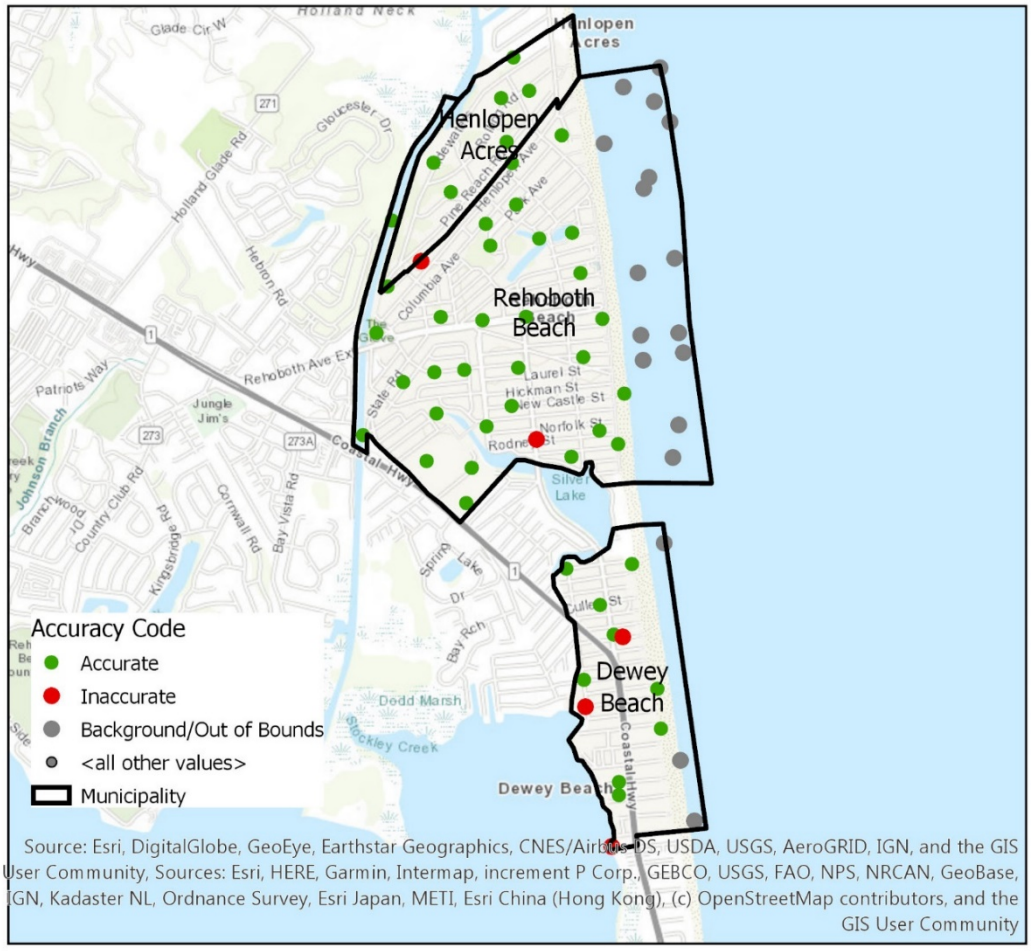
APPENDIX 1

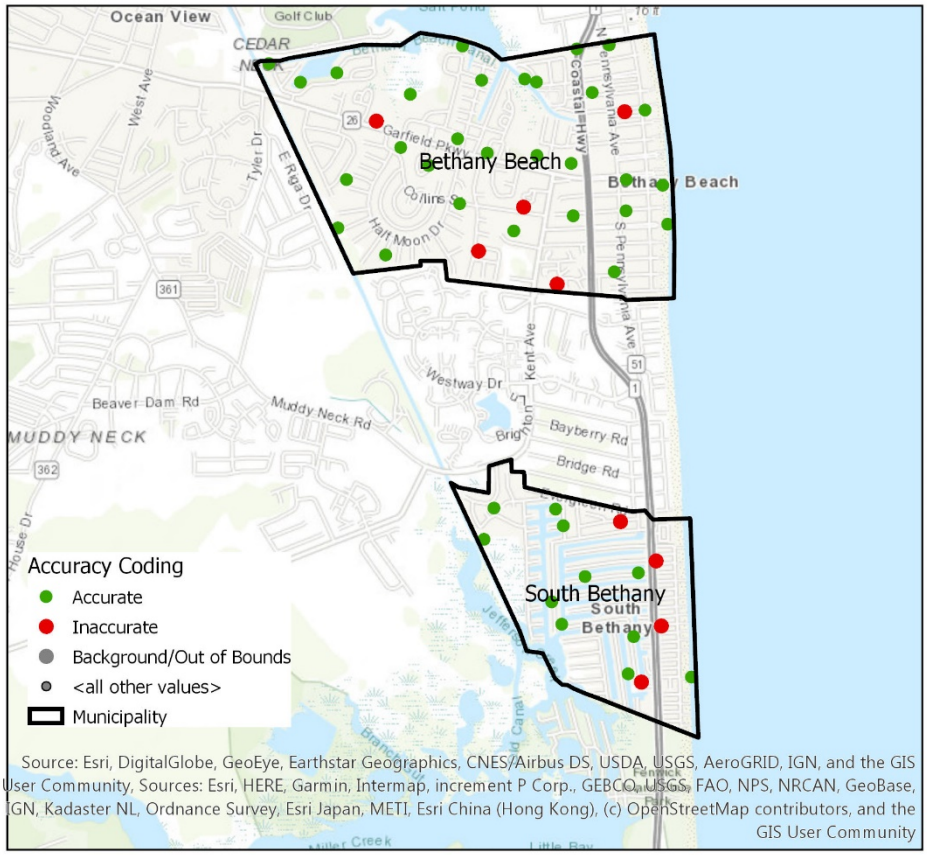
The accuracy of each point shown in the Figures below with the upper figure displaying the Delaware layer and the bottom figure the Chesapeake layer on each page. The green points are accurate, while red points are not.

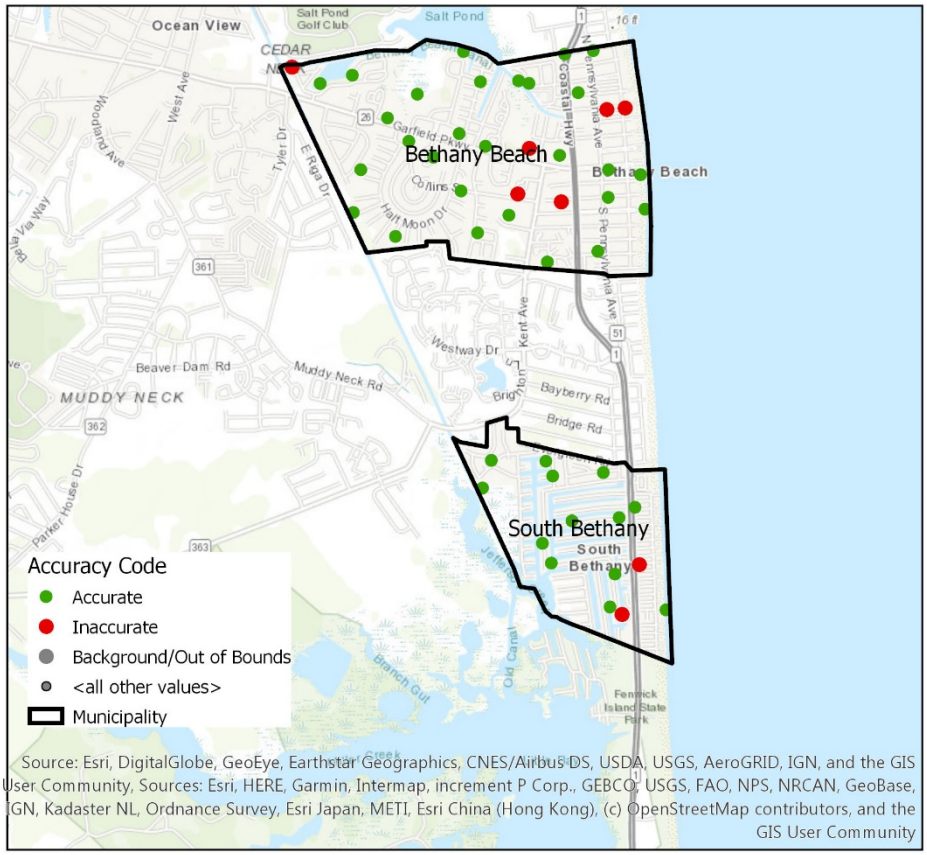

Delaware Bay
Lewes
Accuracy Coding
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality

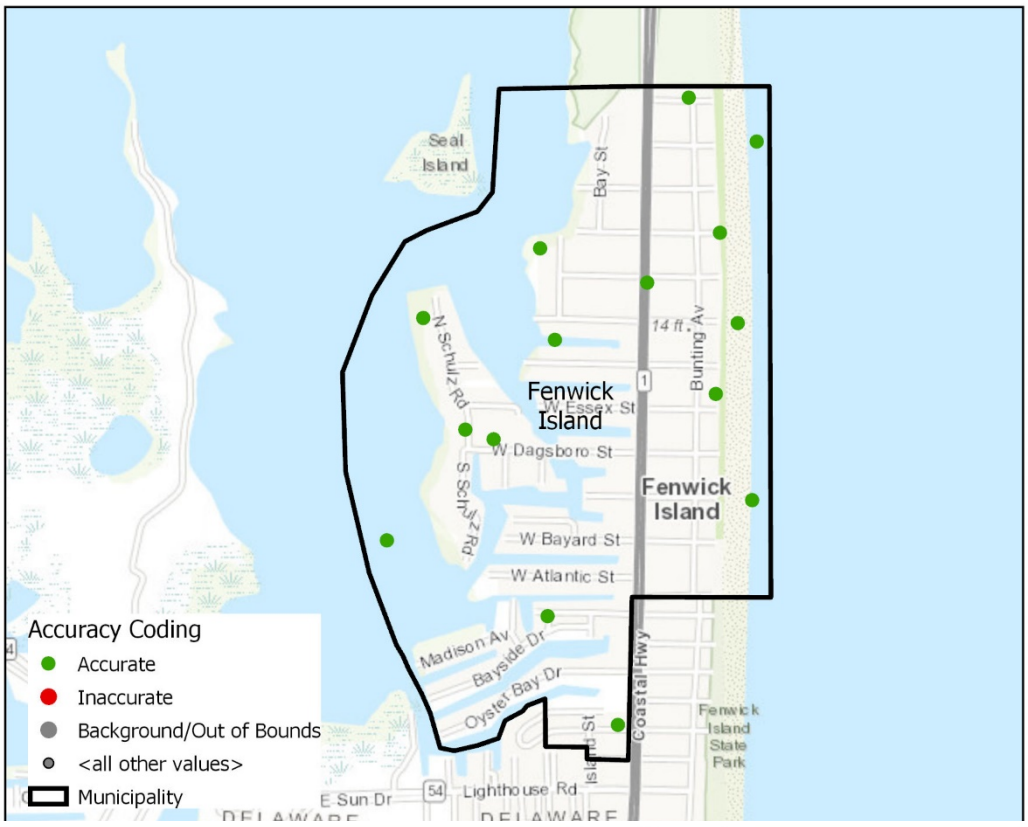

Delaware Bay
Lewes
Accuracy Code
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

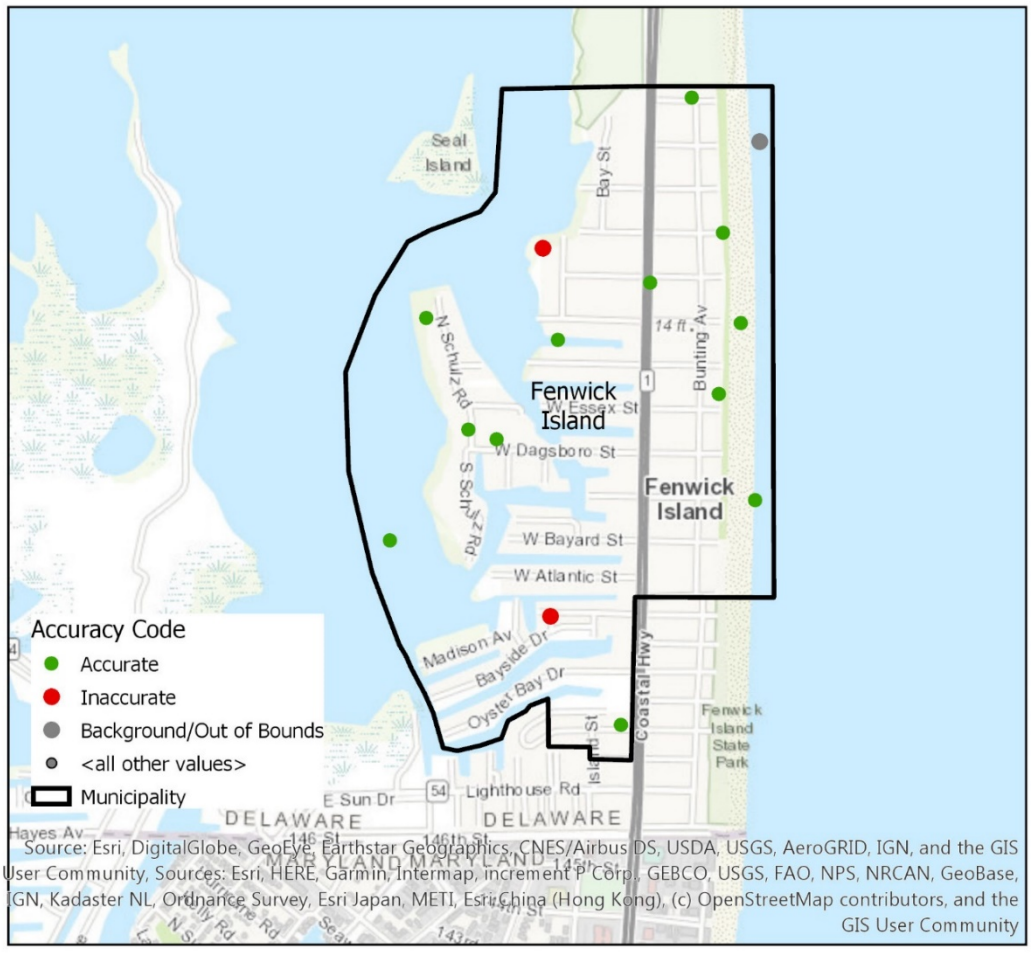

Holland Neck
Henlopen Acres
Rehoboth Beach
Dewey Beach
Accuracy Coding
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality


Holland Neck
Henlopen Acres
Rehoboth Beach
Dewey Beach
Accuracy Code
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Ocean View
Golf Club
CEDAR
Bethany Beach
Garfield Pkwy
Collins St
Half Moon Dr
Tyler Dr
E Rigg Dr
West Ave
Woodland Ave
Coastal Hwy
Pennsylvania Ave
S Pennsylvania Ave
Kent Ave
Westway Dr
Brighton
Bayberry Rd
Bridge Rd
Beaver Dam Rd
Muddy Neck Rd
MUDDY NECK
House Dr
361
362
51
1
South Bethany
South Bethany
Accuracy Coding
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Ocean View
Salt Pond
Golf Club
CEDAR
Bethany Beach
Garfield Pkwy
Collins St
Half Moon Dr
Tyler Dr
E Rigg Dr
West Ave
Woodland Ave
Coastal Hwy
Pennsylvania Ave
S Pennsylvania Ave
Kent Ave
Westway Dr
Brighton
Bayberry Rd
Bridge Rd
Beaver Dam Rd
Muddy Neck Rd
MUDDY NECK
Parker House Dr
361
362
363
51
1
South Bethany
South Bethany
Fenwick Island State Park
Accuracy Code
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Seal Island
Bay St
14 ft.
Bunting Av
N Schulz Rd
Fenwick Island
W Essex St
W Dagsboro St
S Schulz Rd
Fenwick Island
W Bayard St
W Atlantic St
Madison Av
Bayside Dr
Oyster Bay Dr
Coastal Hwy
Fenwick Island State Park
Island St
E Sun Dr
54
Lighthouse Rd
DELAWARE
DELAWARE
Accuracy Coding
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality


Seal Island
Bay St
14 ft.
Bunting Av
N Schulz Rd
Fenwick Island
W Essex St
W Dagsboro St
S Schulz Rd
Fenwick Island
W Bayard St
W Atlantic St
Madison Av
Bayside Dr
Oyster Bay Dr
Coastal Hwy
Fenwick Island State Park
Island St
E Sun Dr
54
Lighthouse Rd
DELAWARE
DELAWARE
Hayes Av
Accuracy Code
Accurate
Inaccurate
Background/Out of Bounds
<all other values>
Municipality
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

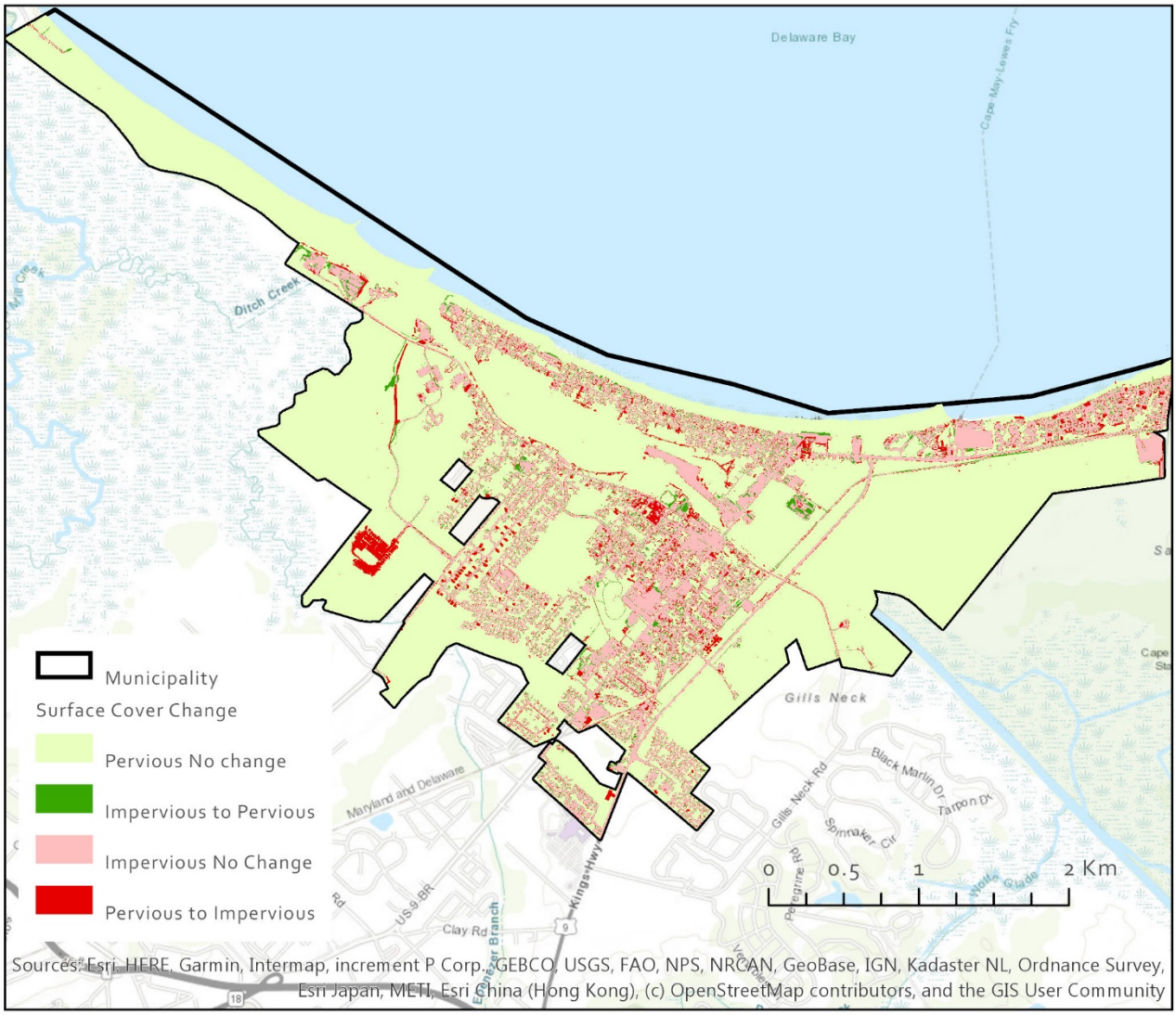
Appendix 2: Parcel Layer Land Code Description

Land Code	Description	Private (1)
AG	Farm	1
AH	Farm W/Homesite	1
AI	Farm W/Improvement	1
AS	Farm W/Leased Homesite W/RES IMP	1
BC	Boat Condo	1
CC	Commercial Condo	1
CH	Church	1
CM	Campground & Boat Marina	1
CO	Commercial	1
CX	Condominium Exempt(land billed out to common elements w/ units)	1
FG	Farm in the Farmland Assessment Act	1
FH	Farm W/Homesite in the Farmland Assessment Act	1
FI	Farm W/Improvement in the Farmland Assessment Act	1
FP	Farmland Preservation Act	1
FS	Land in Farmland Assess. Act W/Leased Homesite W/RES IMP	1
IN	Industrial	1
LG	Local Government (County, Town, School)	2
MA	Marina	2
MX	Miscellaneous	
N	No Not Possible	
NP	Non-Profit Organization	1
P	Residential if Property has a Residential Appraisal	1
PK	Trailer	1
PM	Home Park W/Boat Marina	1
R	Residential	1
RA	Residential, Apartment	1
RC	Residential, Condominium	1
RH	Residential, House No Land	1
RI	Residential, IMP (I.e. Shed, Chicken)	1
RM	Residential, Multiple-Duplex	1
RS	Residential, Single	1
RT	Residential, Trailer(on own property)	1
RV	Residential, Vacant Lot	1
ST	State Government	
TC	Trailer, Condominium	1
TP	Trailer, Park (Trailer located in park)	1
TR	Trailer, Residential (on lands of)	1
TX	Same as "MX" Temporary Exempt	
US	United States Government	

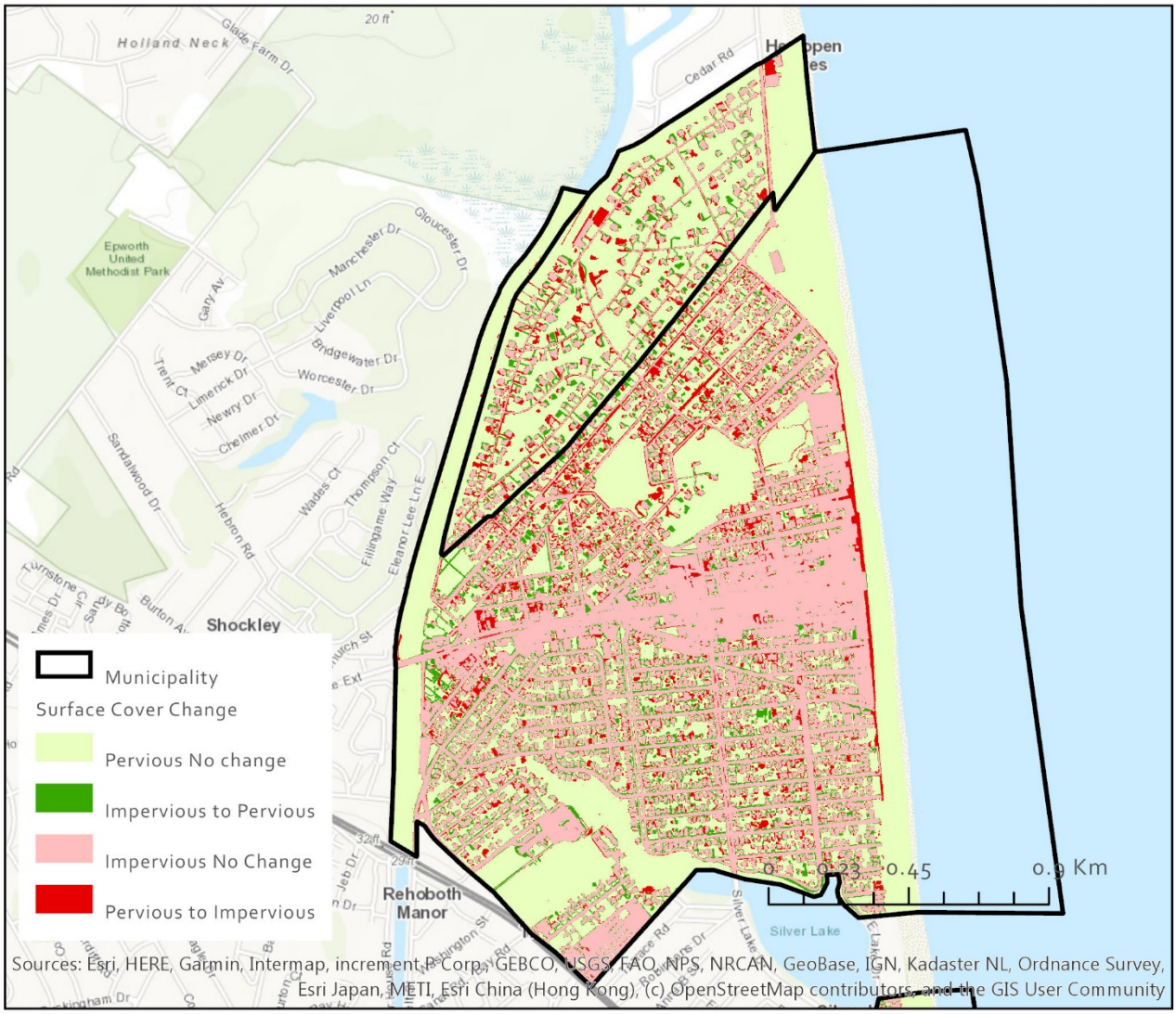
UT	Utility	1
WD	Woodland Program (Forestry)	1
RL	Residential, house on leased land	1

Appendix 3: Impervious Surface Cover Change from 2007 to 2016

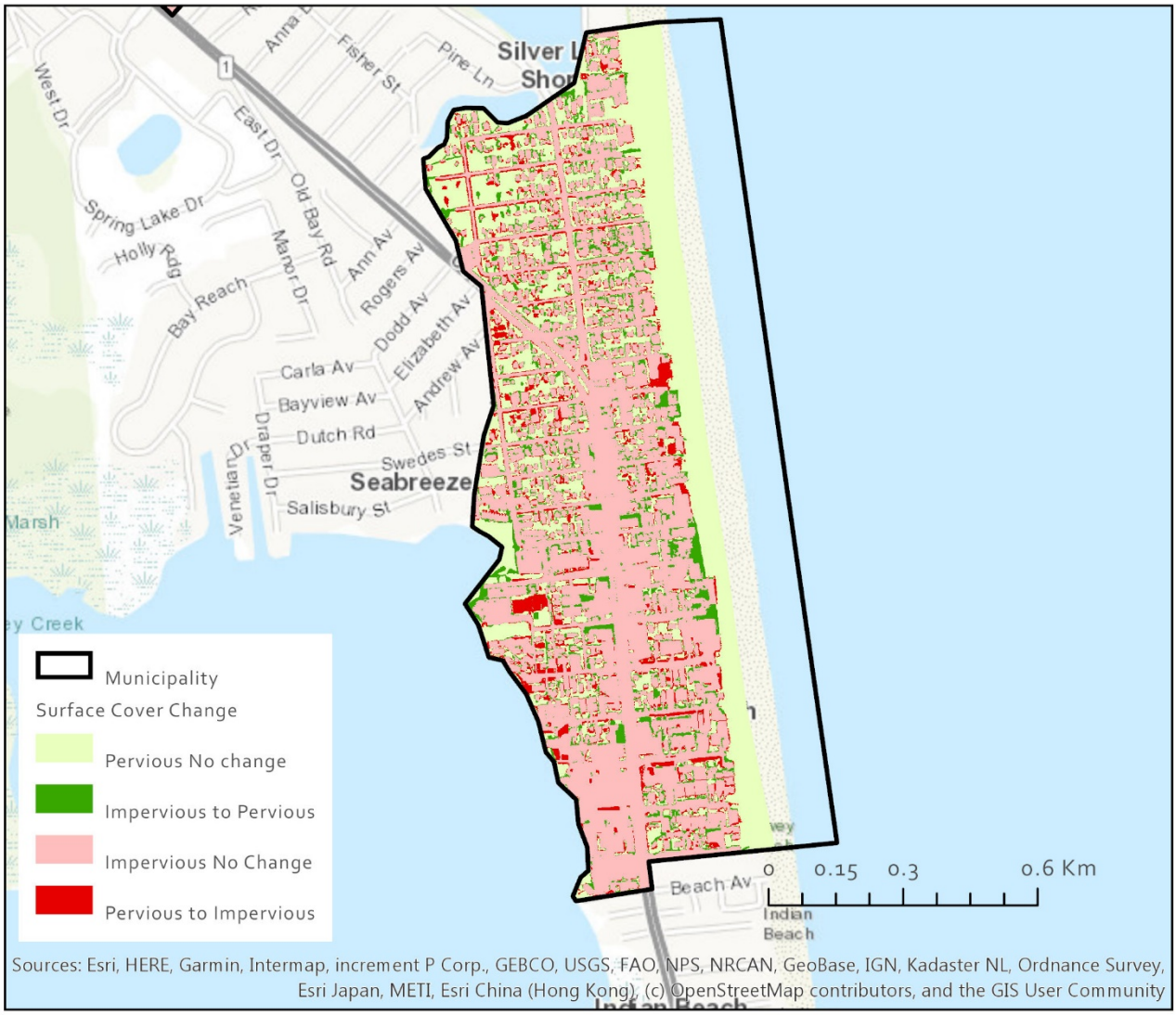
Lewes



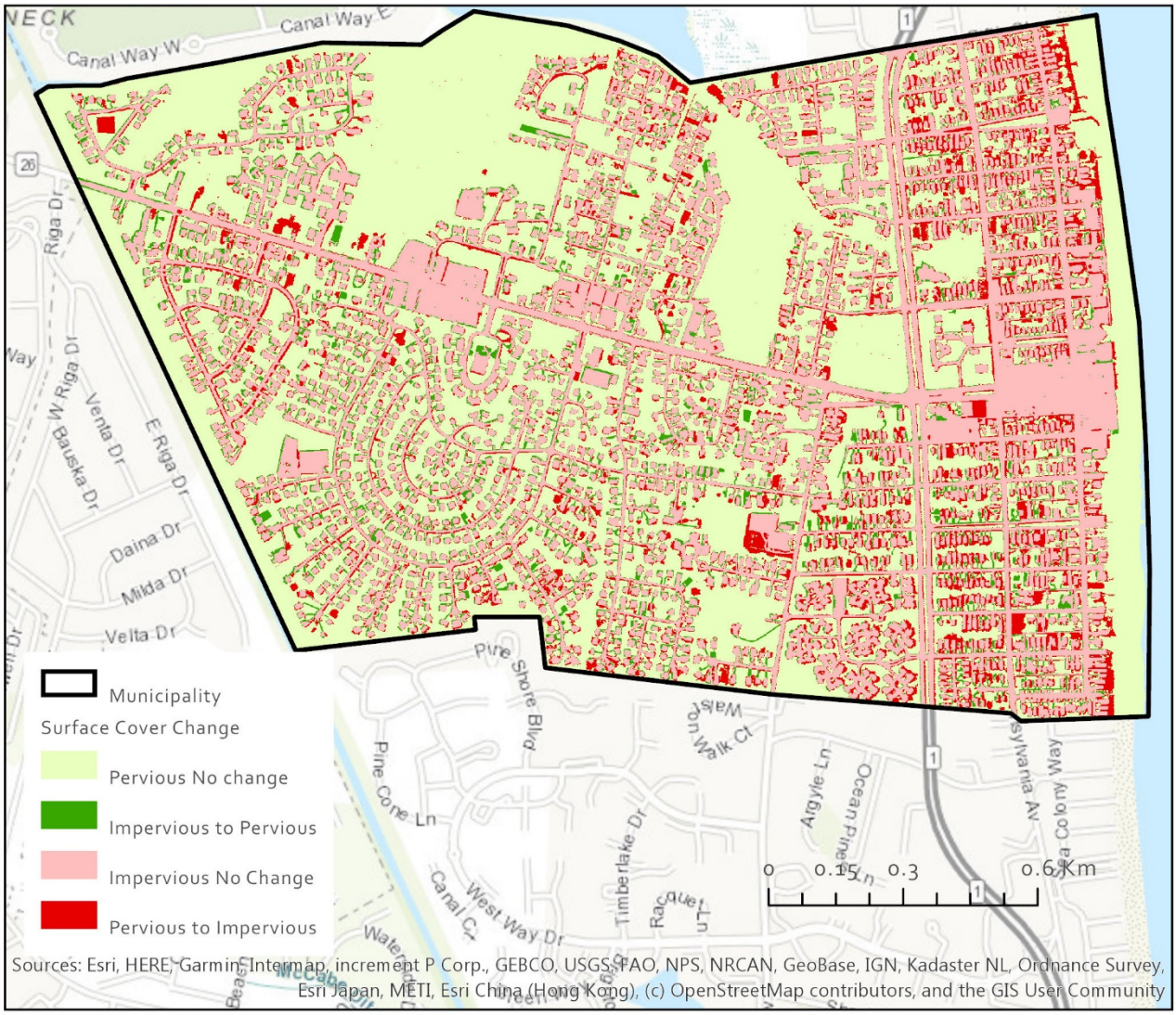
Henlopen Acres (northern town) and Rehoboth Beach (southern)



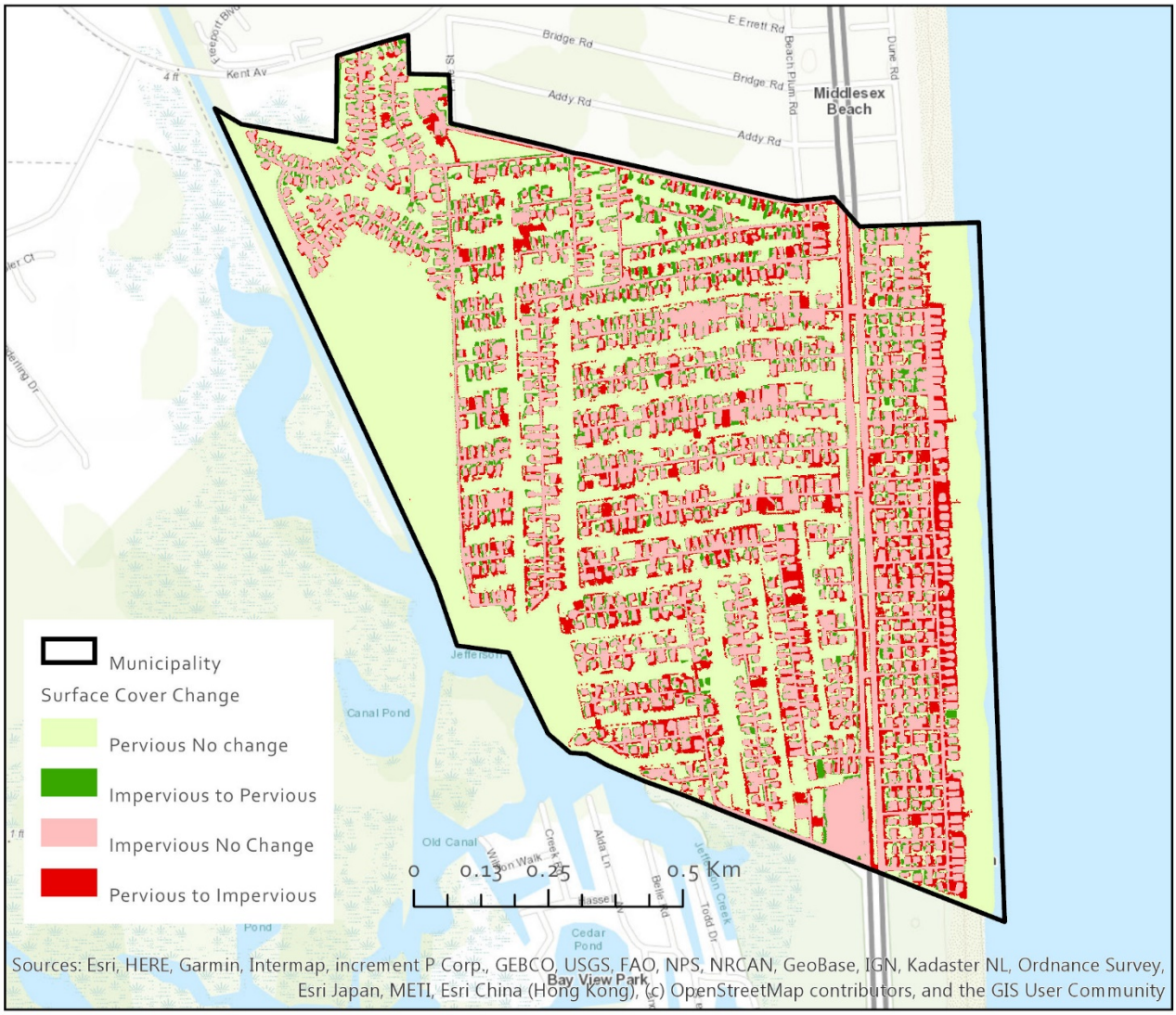
Dewey Beach


Municipality
Surface Cover Change
Pervious No change
Impervious to Pervious
Impervious No Change
Pervious to Impervious
0
0.15
0.3
0.6 Km
Seabreeze
Indian Beach
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Bethany Beach



South Bethany



Fenwick Island