

7th Street Peninsula Environmental Concerns

Flood Hazards

A public workshop was held on June 26, 2018 to gain insight from local shareholders on the constraints on developing the 7th Street Peninsula, as well as a vision for the future of the Peninsula under various development scenarios. The public indicated that they preferred limiting development on the Peninsula due to its exposure to flooding. Reported sources of flooding include: intense rainfall events; poor grading; poor state of the existing drainage system; a lack of drainage and storm water management infrastructure; the Christina River and Brandywine Creek being at flood stage from heavy rains within their watersheds; and storm surges in the Delaware River. Since flooding is a concern of local shareholders and the preferred development scenario is a resilient plan with outdoor recreation for the Peninsula, Century has reviewed publicly available information on potential flood hazards along the Peninsula and has performed calculations of those hazards under future sea level rise (SLR) scenarios. Century has compiled these flooding hazards, along with other environmental constraints along the Peninsula, in a mapping platform. This platform can be used to support proposed development plans for the Peninsula, which mitigate against flood hazards and are resilient against extreme flooding scenarios.

Nuisance Flooding

The public reported that there are several locations where flooding regularly occurs along the Peninsula owing to rainfall events or occasional high tides (spring tides). Century performed field visits on August 21st and 22nd to evaluate the Peninsula following an approximately 0.30-inch rain event. Flooding was observed in many of the low-lying areas along roadways and in the shallow swales between entrances on Industrial Avenue. Flooding up to 4-inches in depth was observed at the intersection of East 7th Street and Industrial Avenue. No other roadways appeared impacted.

The flooding observed appears due to underperforming and unmaintained drainage infrastructure. Site visits also revealed that there is poor grading on the Peninsula and its roadways. The primary road to and through the Peninsula is East 7th Street, which has a low point at its intersection with Industrial Avenue. During two field visits to the site, Century observed that the entire intersection of East 7th Street and Industrial Avenue was inundated by flood water as shown in the picture in Figure 1. Also visible in this photograph are grasses growing up through a catch basin located in the foreground, which indicates that the storm drain pipe is likely clogged with sediment. The underperformance of the drainage system, based on this preliminary investigation, is likely caused by debris/sediment clogging the drainage pipes. Evidence suggesting that the drainage system is severely clogged include the grasses growing through a catch basin and the fact that the ponding remained constant over the course of two days. It is noted that there was no evidence that the inundation limits at this location were tidally influenced (as would be indicated by debris or water stains on the pavement).

In addition to the flooding along East 7th Street, the Peninsula is poorly graded for drainage. The property at 1135 E. 7th Street (Wesbond Corp) is a developed parcel which is at the lowest elevation along the Peninsula. During the site visit, Century spoke with an employee for Wesbond Corp who was pumping storm water near the loading bay for their facility. This employee mentioned that other property owners have elevated their buildings by constructing building pads on fill, which has exacerbated flooding at Wesbond Corp. These buildings have done so to maintain a finished floor elevation above the Base Flood Elevation (BFE). Figure 2 shows a map displaying the ground elevations along the Peninsula. The upper

limit of the color scale representing the ground elevations (red) is 8.30' NAVD88, which is the 100 - Year flood elevation. The red rectangular shapes indicate where buildings have most likely been elevated to achieve finished floor elevations exceeding the BFE.



Figure 1: A photograph of the submerged intersection of 7th Street and Industrial Ave.

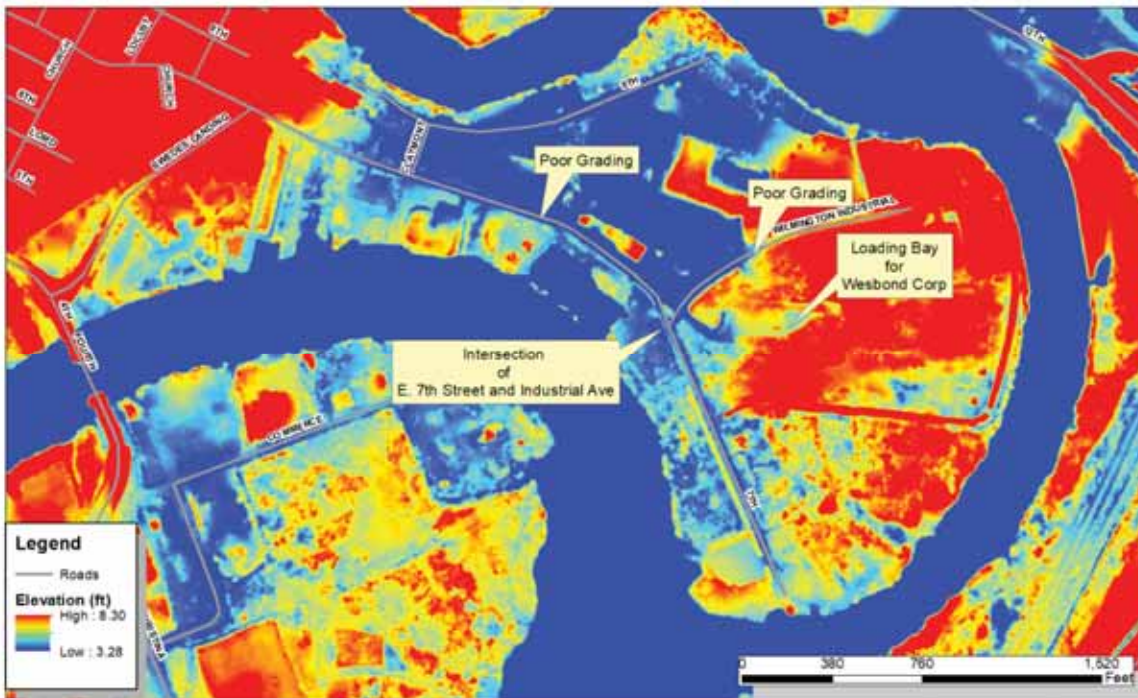


Figure 2: Elevations on the Peninsula

Figure 2 indicates several areas where building sites have been elevated, creating low areas between the sites where drainage has not been accommodated. Additionally, as the building pads have been raised, the road elevations have not, resulting in the roadways becoming a primary conduit for runoff during heavy rainfall events.

During the field visit, Century Engineering identified high water marks along shore protection or coastal armoring structures, as well as, searched for high water inundation debris lines. Century witnessed high water and debris lines along rip rap features and in vegetated areas. Century approximated the high-water elevation to be roughly 3.41' NAVD88 derived from the CoNED Topobathymetric Model for the New Jersey and Delaware, 1880 to 2014 LiDAR elevation dataset. This elevation approximately matched the indicators of the daily high tides. Figure 3, below, shows the limits of flooding due to regular tide cycles. It is noted that the catch basin at the lowest elevation along E. 7th Street is at 1.93' NAVD88. Therefore, it is possible that tidal flooding may result in backwater flooding through the drainage network, inundating the interior of the Peninsula as show in light blue in Figure 3. This action currently does not appear to occur due to the clogged drainage network. It is also notable that during regular tide events the northwest edge of the Peninsula, which has a depressed area along the Brandywine River, nearly overtops. If this location overtops, the interior of the Peninsula will fill with tidal waters, much like a bath tub. While this does not appear to occur during regular tie cycles, it likely does occur during monthly high tide cycles or during rain events coinciding with high tides.

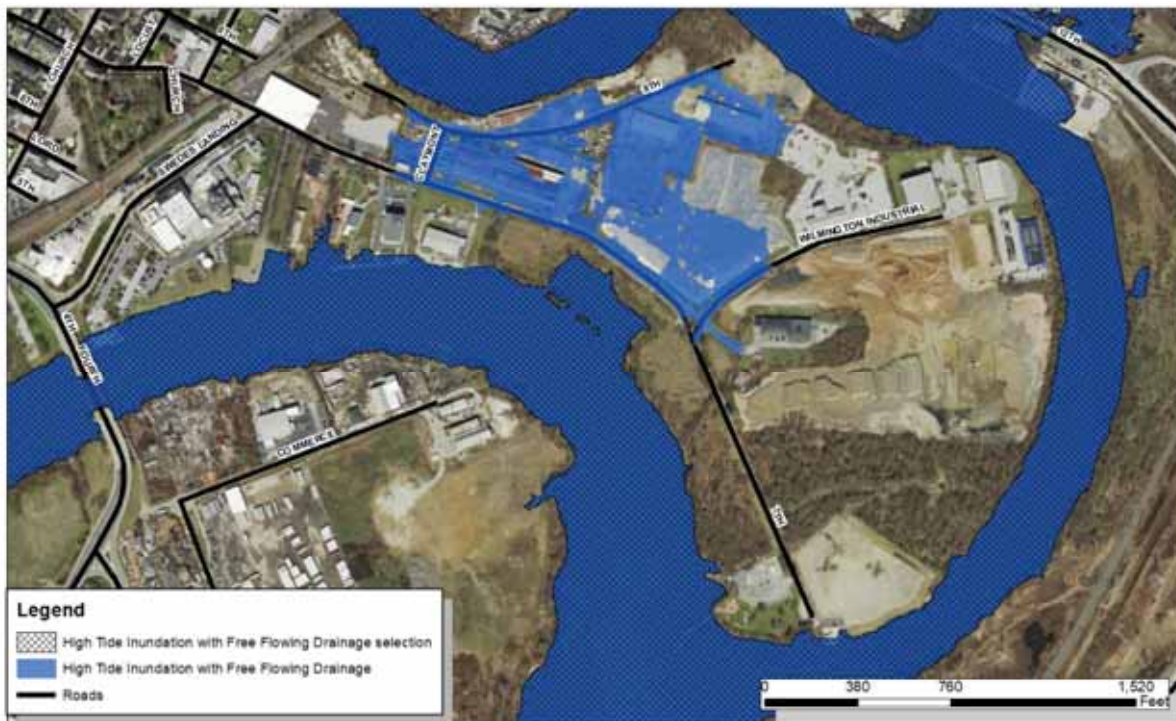


Figure 3: Tidal Flooding along the 7th Street Peninsula

Considering this, it is Century's opinion that nuisance flooding is primarily due to a lack of drainage and stormwater management infrastructure, poorly maintained drainage infrastructure, and lack of a comprehensive drainage plan for the Peninsula.

Extreme Flooding

The effective Digital Flood Insurance Rate Map (DFIRM) is the most technically sound basis from which to infer flood hazards surrounding the Peninsula. The DFIRM (4) shows nearly the entire Peninsula being submerged under water during the 1-percent-annual-chance (100 Year) flood event.



Figure 4: DFIRM for 7th Street Peninsula

Also demonstrated in the DFIRM is the fact that a portion of the Peninsula is impacted by ‘moderate’ wave energy – which are waves greater than 1.5’, but less than 3’, in height. During the production of the DFIRM, the potential wave energy along the Peninsula was interpolated between two (2) modeling transects, which originate along the Delaware River/Bay. Century also performed a local fetch analysis along the Peninsula to verify that, in fact, the Peninsula may be vulnerable to such wave energy. From this fetch analysis, wave heights as great as from 1.72’ to 2.65’ may be experienced along the Christina River coastline of the Peninsula. The results of the locally generated wave analysis are shown in Table 1, where the wave heights at the Skate Park and Kalmar Nyckel are based on 2,290’ and 3,573’ of fetch, respectively. During a visit to the site, Century confirmed with a local observer of flood and erosion conditions at Kalmar Nyckel who stated that waves of roughly 2-3’ are observed with strong winds blowing from the east-southeast direction.

Table 1: Wave Heights along 7th Street Peninsula

Return Period	Sustained Wind ¹ (mph)	Skate Park Wave Height (ft)	Kalmar Nyckel Wave Height (ft)
10-Year	61	1.72'	2.08'
25-Year	69	1.98'	2.39'
50-Year	70	2.02'	2.42'
100-Year	76	2.21'	2.65'

¹ Obtained from the Applied Technology Council (ATC)

It is also noteworthy that the 100 - Year flood plain along the Peninsula is governed by coastal surges/tides rather than riverine flooding; this is inferred by the fact that the AE zones on the DFIRM are labeled with the corresponding static base flood elevation (BFE) on the FIRM. In riverine dominated floodplains, the water surface is not uniform, as it declines in the downstream direction.

The Flood Insurance Study (FIS) report provides water levels for return periods in addition to the 100 - Year elevation as summarized in the table below:

Table 2: Summary of Still Water Levels²

	Still Water Level (SWL) (Ft)	Chance of Occurring in 25 Years	Chance of Occurring in 50 Years
10 - Year	6.9'	92%	99%
50 - Year	7.7'	40%	64%
100 - Year	8.3'	22%	39%
500 - Year	10.8'	5%	10%

The table also provides the percent chance that each of these water levels may be experienced at least one time during a period of 25 and 50 years. As can be seen in Table 2, it is almost certain that the 10 – Year water level will be experienced over the course of any expected period of engineering design. The flood depths resulting from this water level is shown in Figure 5.

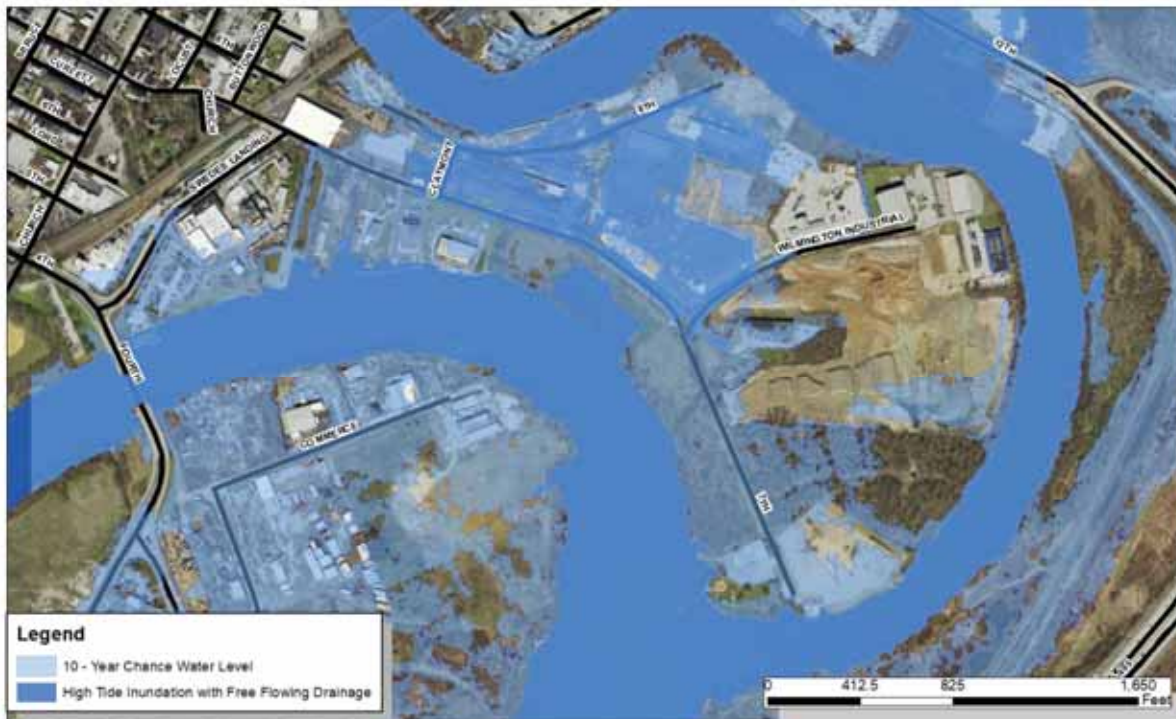


Figure 5: Inundation Extent of the 10-Year Water Level

² Obtained from the FIS Report for New Castle County, Delaware

In addition to the probabilistic flood scenarios, Century has investigated water surface elevations that have been observed in Christina River near the Peninsula in recent history. More specifically, Century has reviewed water level measurements from the USGS gauge on the Christina River, upstream of the Peninsula. This water level gage has been recording the water surface elevations in the Christina River since April of 2006. Over this 12-year period, the highest water surface elevation that has been recorded is 7.16' NAVD88³. This occurred on October 30th, 2012 and was the result of storm surge produced by Hurricane Sandy.

Sea Level Rise

It is accepted by the broader scientific community that sea level rise (SLR) may result in greater flood hazards along the entire Delaware coast, including the 7th Street Peninsula. For development to be resilient against flood hazards under future sea levels, Century has prepared maps displaying the inundation depths resulting from a 100 – Year event in the year 2050. It is noted that these depths were calculated by summing the 100 – Year water level with the SLR projections. This does not consider the potential for an increased intensity of storms in the future which may increase the water level associated with return-period events. These maps are displayed in Appendix C.

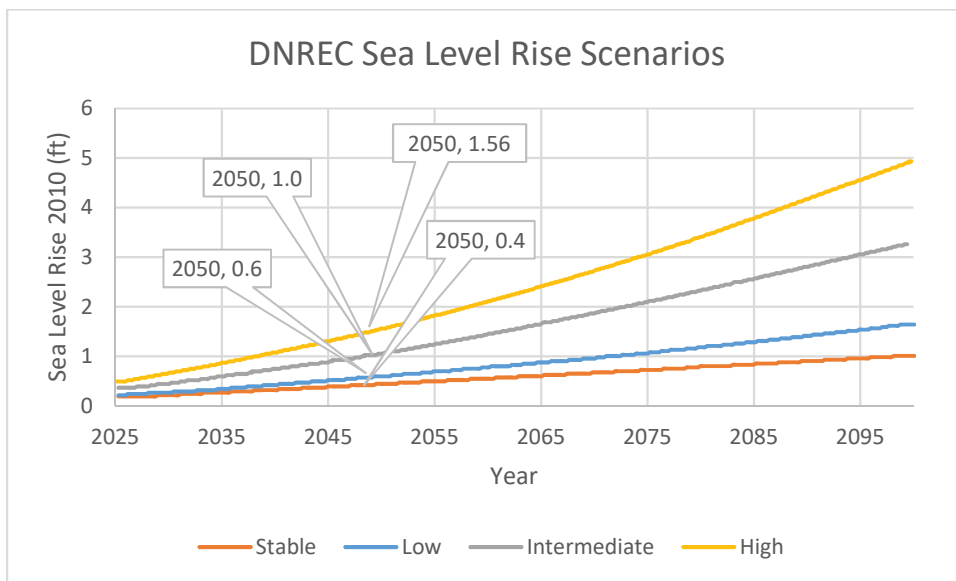


Figure 6: DNREC's Advisory Committee's Sea Level Rise⁴

For the resilient design of buildings and other infrastructure, it is important to consider all flood forcing. It is noteworthy that all coastal flood forces are proportional to water depth. In addition to inundation depth, wave energy may pose additional hazards owing to flood velocities, breaking wave loads, and other dynamic forces. Therefore, the permutation of depth maps for the various return period water levels and

³ The water levels from the USGS gage are referenced to NGVD 1929. Century has applied the datum conversion prescribed by the USGS to convert elevations to NAVD88.

⁴ Taken from the 'Recommended Sea Level Rise Scenarios for Delaware' report from December of 2009. According to this report, these scenarios are to be reviewed and revised, periodically, as new information and federal guidelines become available.

SLR scenarios the Century has produced provide a basis from which all flooding forces required for resilient design can be calculated.

Brownfields and Soil Contaminants

The 7th Street Peninsula has a history of environmental concerns related to soil contamination. Known soil contamination issues are handled by Delaware’s Department of Natural Resources and Environmental Control (DNREC), Division of Waste and Hazardous Substances. A review of data provided by DNREC identified the following information on brownfields and soil contamination;

Underground Storage Tanks

There are two known underground storage tanks located on the 7th Street Peninsula. These tanks are located on parcels owned by Drywall Associates and the former Fort Christina Marina.

The tank on the former Fort Christina Marina site was a 2,000-gallon gasoline storage tank and was a known leaking underground storage tank (LUST). The tank was removed in April of 1991 and sampling of the soil surrounding the tank indicated that contaminated soils existed on the site. The contaminated soils were excavated from the area, treated on site, and tested and found compliant per a No Further Action (NFA) letter dated November 5, 1991. It is unclear whether the treated soils were backfilled into the excavation or left as a stockpile.

During data review Century also noted that an underground storage tank registered to Delaware Solid Waste Authority (DSWA) is reported as being located on the Peninsula. A review of correspondence related to this tank references a location at the Pigeon Point Landfill in New Castle, Delaware. It is believed that the tank associated with DSWA is incorrectly reported as located on the Peninsula.

Brownfields and Contaminated Sites

The 7th Street Peninsula has a detailed history of use that continues to impact the Peninsula to present day. The southern portion of the Peninsula was the site of the City of Wilmington Landfill from approximately 1940 – 1960. Following use as a landfill, the area was utilized for disposal of coal ash from City incinerators. There are multiple contaminated sites documented on the 7th Street Peninsula. The sites are listed in the table below:

DNREC Program ID	DNREC Site Name	Reported Site Issues
DE-1148	East 7 th Street Peninsula Drum Site	Contaminated backfill material
DE-1294	Peninsula Ventures	Certified Brownfield.
DE-1328	Marina Overlook	
DE-1293	Christina Marina	
DE-0339	Kalmar Nyckel Challenge Program	
DE-1563	Kaiser Yacht Property	
DE-1384	Up the Creek Marina & Restaurant	Part of former Wilmington Landfill area. Property. Site also contained burn pit that was used for disposal of boats.

This table needs additional detailed research to finalize.

Groundwater Management Zones

The entire 7th Street Peninsula is within the City of Wilmington Groundwater Management Zone (GMZ). The GMZ established for the City was the result of the cumulative contamination of groundwater from multiple hazardous waste sites throughout the City. The GMZ prohibits use or withdrawal of groundwater unless compliant with the GMZ agreement.

Tree Health

Trees on the peninsula are a mix of native and non-native species that likely volunteered after closure of the Wilmington Landfill. Several maturing stands of trees exist along the southern edge of the peninsula. Currently these trees appear in good health but may show signs of stress in the future due to impacts from Sea Level Rise, erosion, and increasing salinity levels.

Trash and Debris

During public workshops trash and debris were of concern to the stakeholders. Trash and debris were observed during site visits, mostly in areas that were not immediately adjacent to occupied buildings. Some trash and debris could be traced back to the following sources:

- Open dumpsters in close vicinity,
- Users who park on the peninsula during lunch break and throw trash out of their window,
- Blown litter from trash receptacles and from sources beyond the peninsula,
- Construction/demolition debris associated with specific sites.

Proposed Infrastructure Improvements

Considering the existing state of flood hazards along the Peninsula and insight gained from field visits along with the information provided by the public, extreme engineering measures would be necessary to ensure a flood-proof Peninsula. However, measures can be taken to alleviate the impacts and frequency of nuisance flooding will also mitigating the severity of larger flood events.

Maintenance of the existing drainage system, as well as improvements to the connectivity of the drainage system will reduce nuisance flooding and mitigate impacts from smaller storm events. The installation of a tide gate or “flapper valve” will be required to prevent tidal backflow through the drainage system. The entire existing drainage system should be surveyed to evaluate the system for capacity and potential improvements.

Currently the lowest point on the Peninsula is the intersection of East 7th Street and Industrial Avenue. Consideration should be given to identifying areas for stormwater storage, most likely in the form of a wet pond. A stormwater management facility, such as a wet pond, will allow stormwater runoff to be temporarily stored at a less impactful location during high tides, then drained out through the drainage network during low tides.

As aforementioned, on an individual basis, property owners have filled individual sites to establish their buildings first finished floor above the BFE. Since each of these sites do not manage their storm water runoff this filling has likely exacerbating the underperformance of the drainage system. Therefore, developing a comprehensive development and drainage plan for the entire Peninsula is a fundamental design element in avoiding nuisance flooding from poor drainage and reducing future flood probabilities. A potential solution to nuisance flooding and a mitigating factor in extreme flooding scenarios would be

elevate the remaining building pads as well as East 7th Street and Industrial Ave to match the elevations of the raised building sites.

The Peninsula is currently shaped like a bathtub, with portions of the center of the Peninsula being lower in elevation than the perimeter. There is an area along the northwest side of the perimeter that is lower in elevation than the remainder. This low area should be elevated through either fill or bulkheading to increase the perimeter elevation and reduce the frequency of overtopping and subsequent tidal flooding.

Proposed Resilient Development

Since the Peninsula is inherently vulnerable to extreme flooding, which is likely to be exacerbated by SLR, it is recommended that the development proposed on the Peninsula be inherently resilient. Any proposed building should establish its first-floor elevation above the BFE, either through the use of fill, building on post, piers, and piling, or other form of resilient design. Also, the development should tend toward open space uses such as hiking or biking trails, sports and recreation fields, gardens, and boating.

Another fundamental element for a resilient development of the Peninsula is to maintain dense grasses and other vegetation along the coastline as a riparian buffer. Vegetation dissipates wave energy, thereby reducing breaking wave loads and flood velocities inland of these buffers. A buffer of any distance will likely do little to reduce inland flooding from storm surges, but such a buffer is still advised. The root mass of vegetation also helps prevent erosion and stabilizes the land along the coastline.

The vulnerability of the Peninsula may provide educational opportunities. For example, resilient building design can be highlighted, and the preservation and restoration of ecosystems can provide opportunities for environmental education.

At this stage, Century has prepared an initial concept for resilient development of the Peninsula. This concept does not consider environmental or transportation constraints, but merely is one example of developed Peninsula that is more resilient against flooding. This concept proposes a parking area adjacent to Kalmar Nyckel, which provides access to a hiking/biking trail. It is noted that this parking facility is adjacent to an existing marina which can be revitalized for boating and paddling activities. Additional boat ramps are proposed at the Southern end of the Peninsula adjacent to the existing skate park and at the southern end of E. 7th Street, providing direct access to Brandywine Creek. The restoration of a breakwater adjacent to the skate park is proposed to provide a quiescent harbor for launching kayaks and canoes, as well as for the establishment of living shoreline. Additional living shorelines are proposed along the Peninsula in several embayments along the coast of the Christina River and Brandywine Creek. An Educational/Informational building is proposed which could, itself, feature resilient design features and explain the living shorelines and engineering feats taken to achieve the re-development. Not explicitly shown on the map is extensive re-grading to improve the storm water management along the Peninsula. Since elevation constraints may be insufficient to convey storm water entirely through a closed conduit system, any excess storm water could be pumped to storm water management basins. An additional parking area is provided at the south end of East 7th Street specifically for food truck parking. No changes are proposed on the existing development along the northern end of the Peninsula, as this portion is already heavily developed.

Initial Resilient Design Concept



Appendix A

Map Panel Index

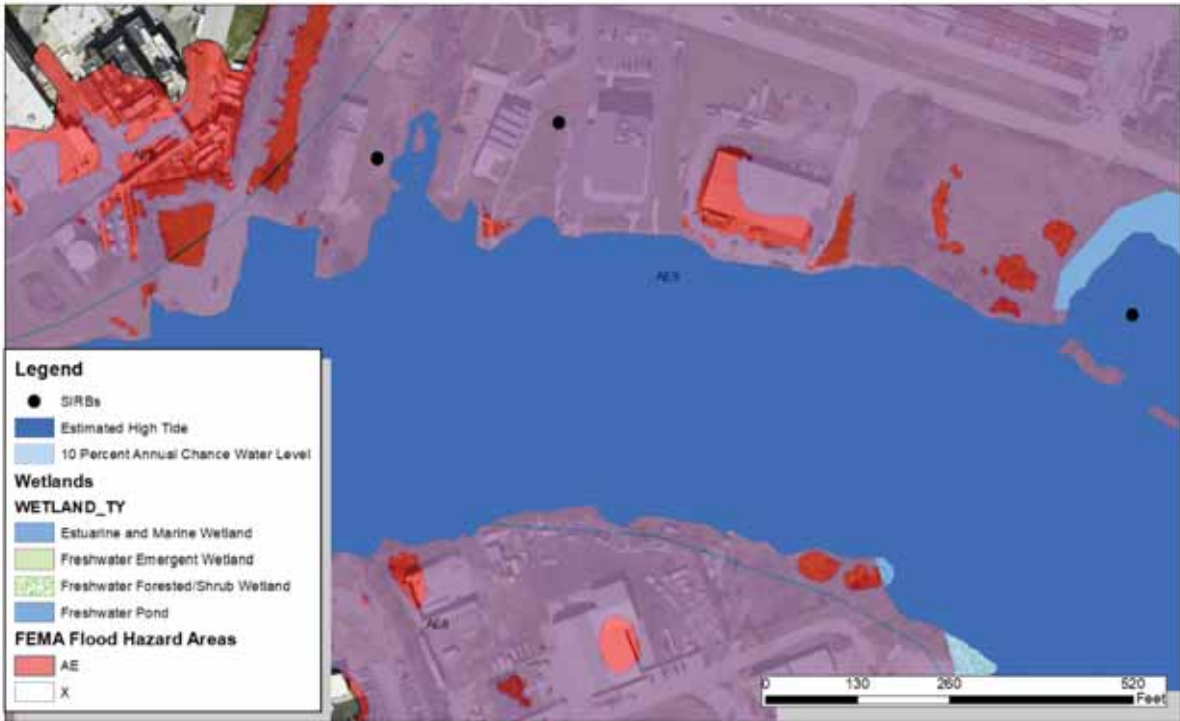


Appendix B

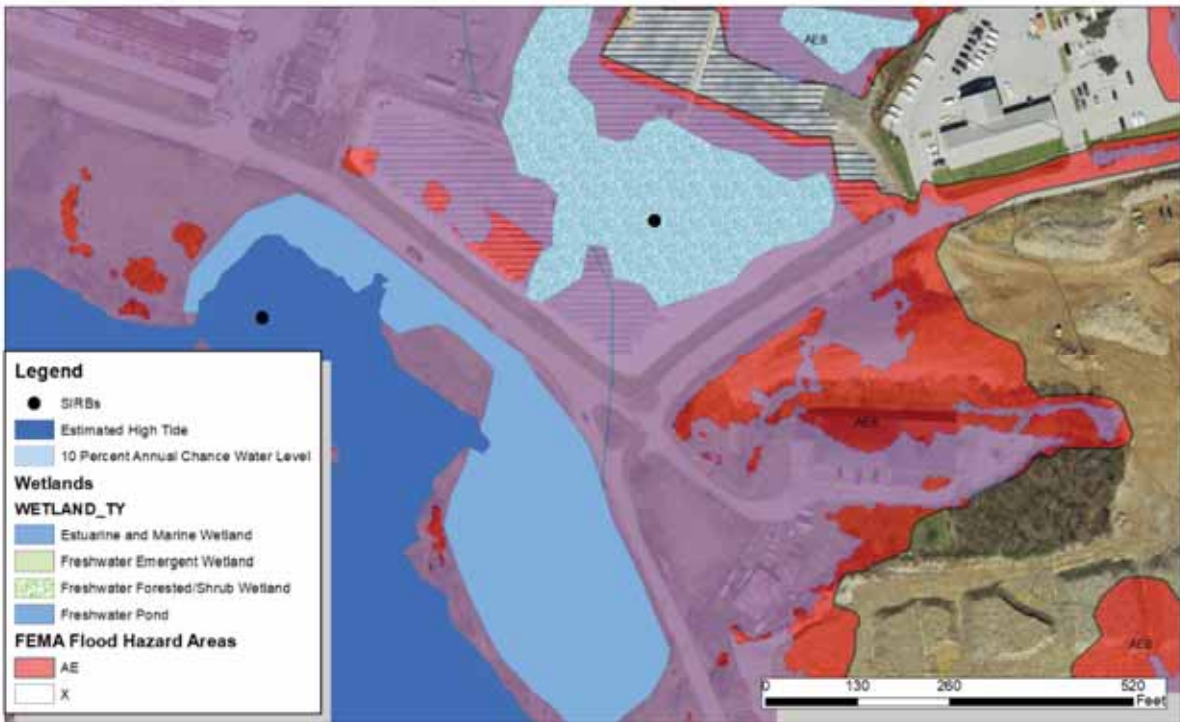
Current Sea Level Inundation Hazards Panel 1 of 9



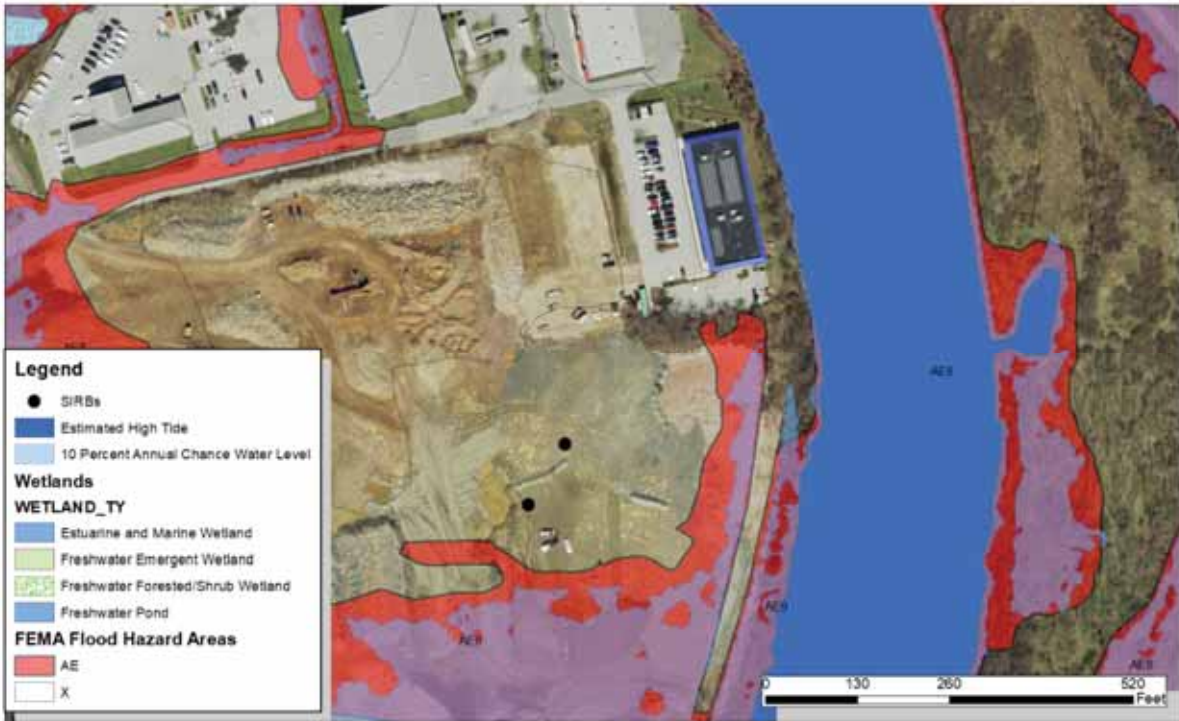
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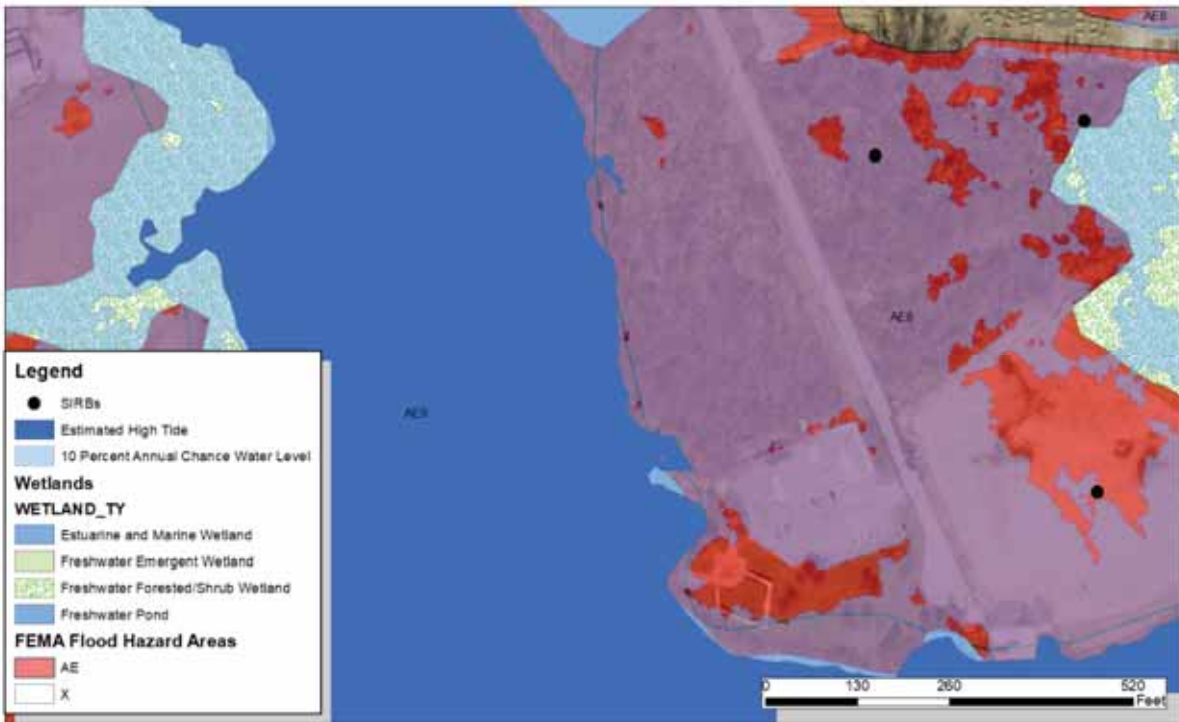
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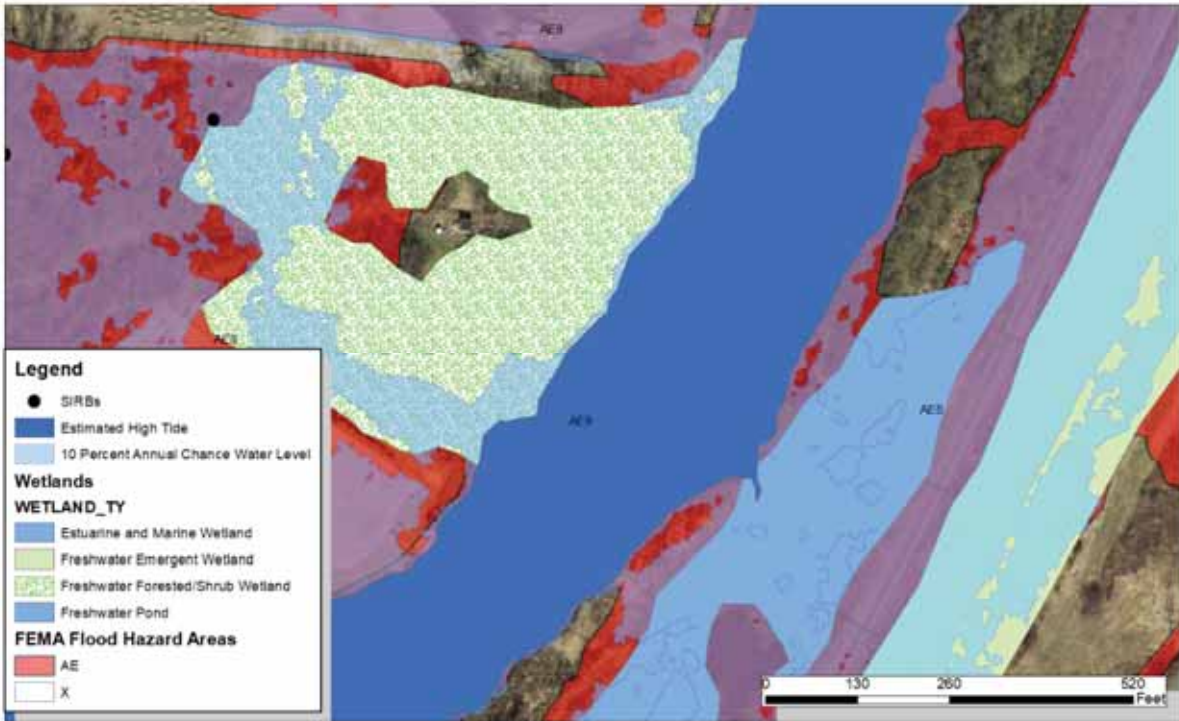
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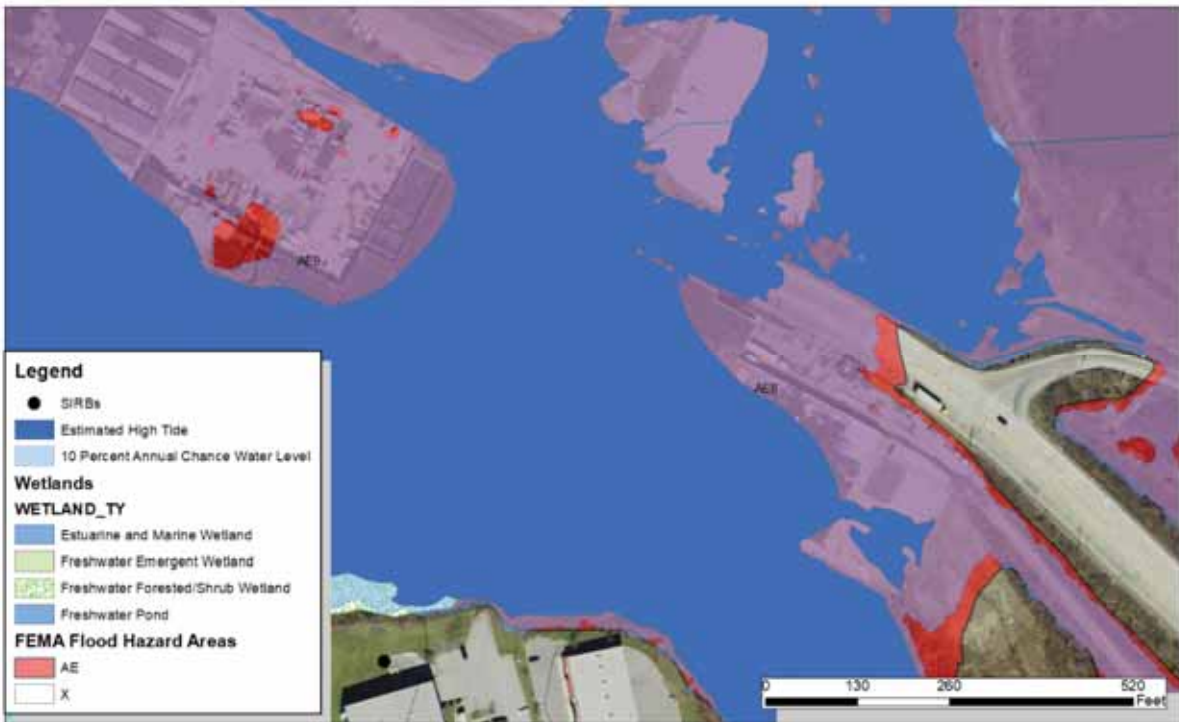
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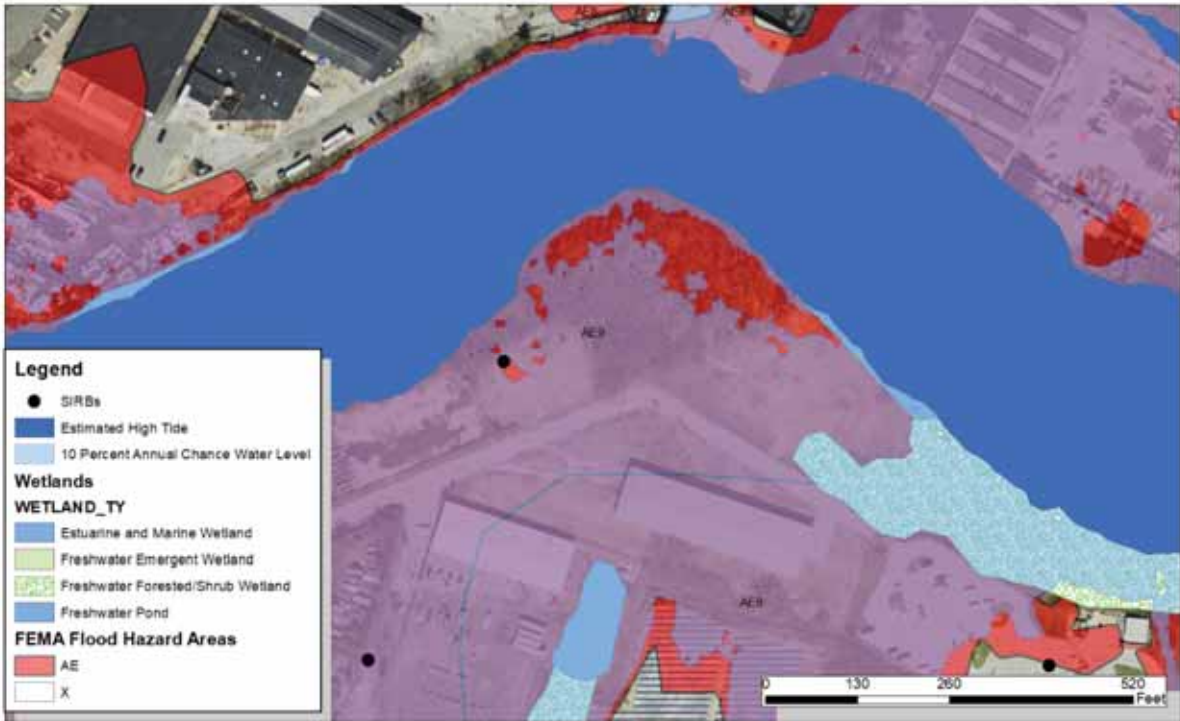
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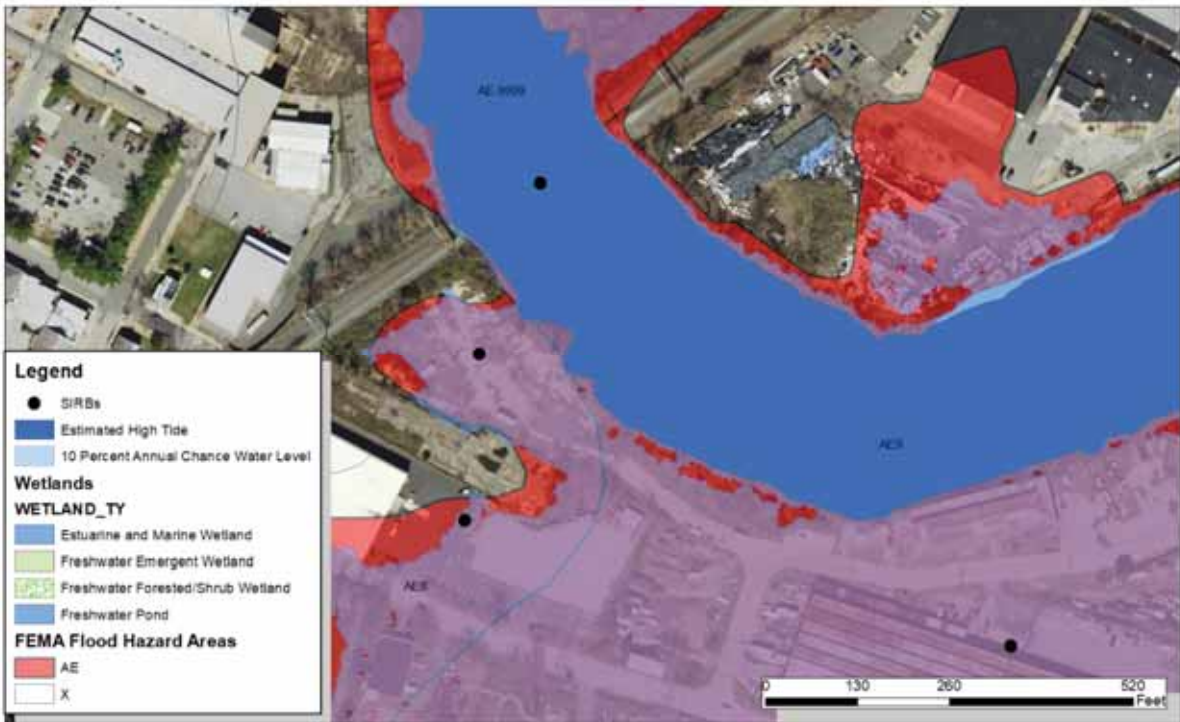
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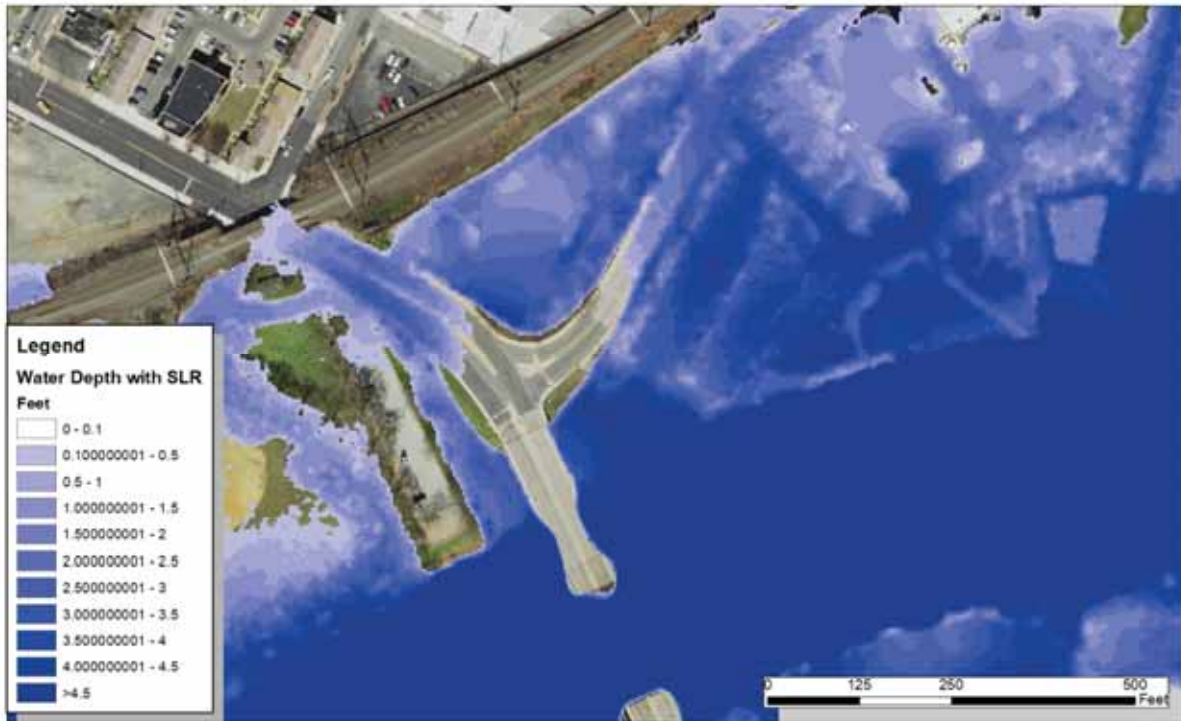


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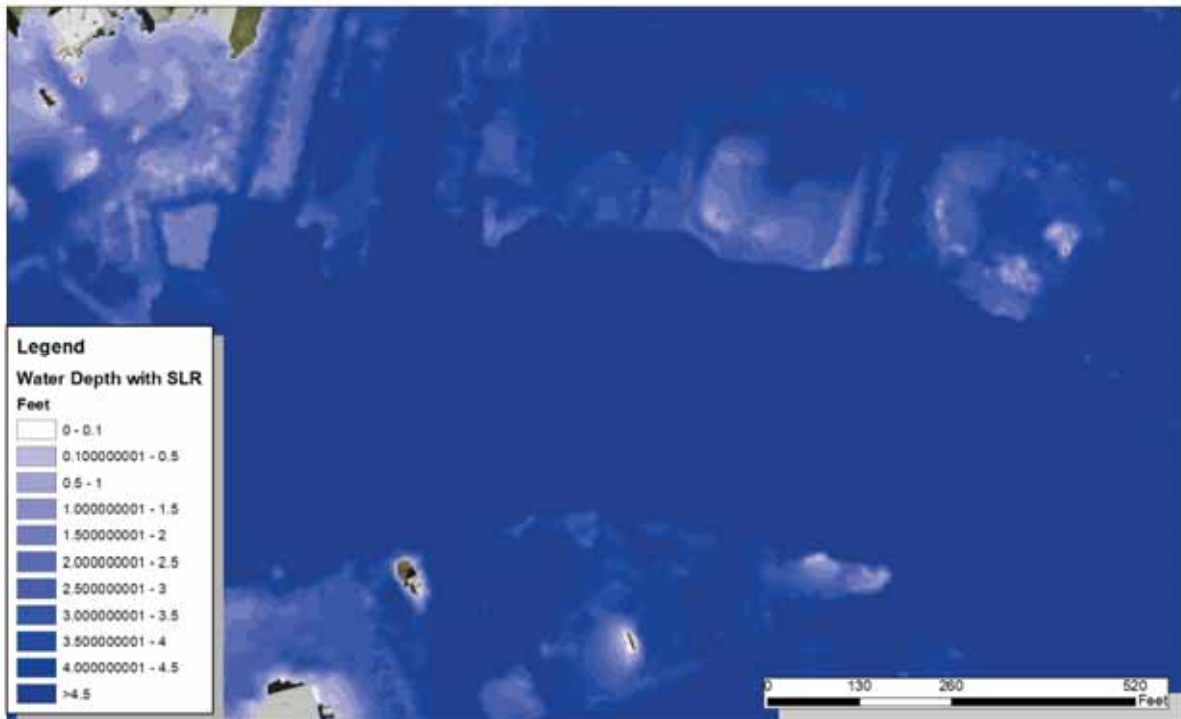


Appendix C

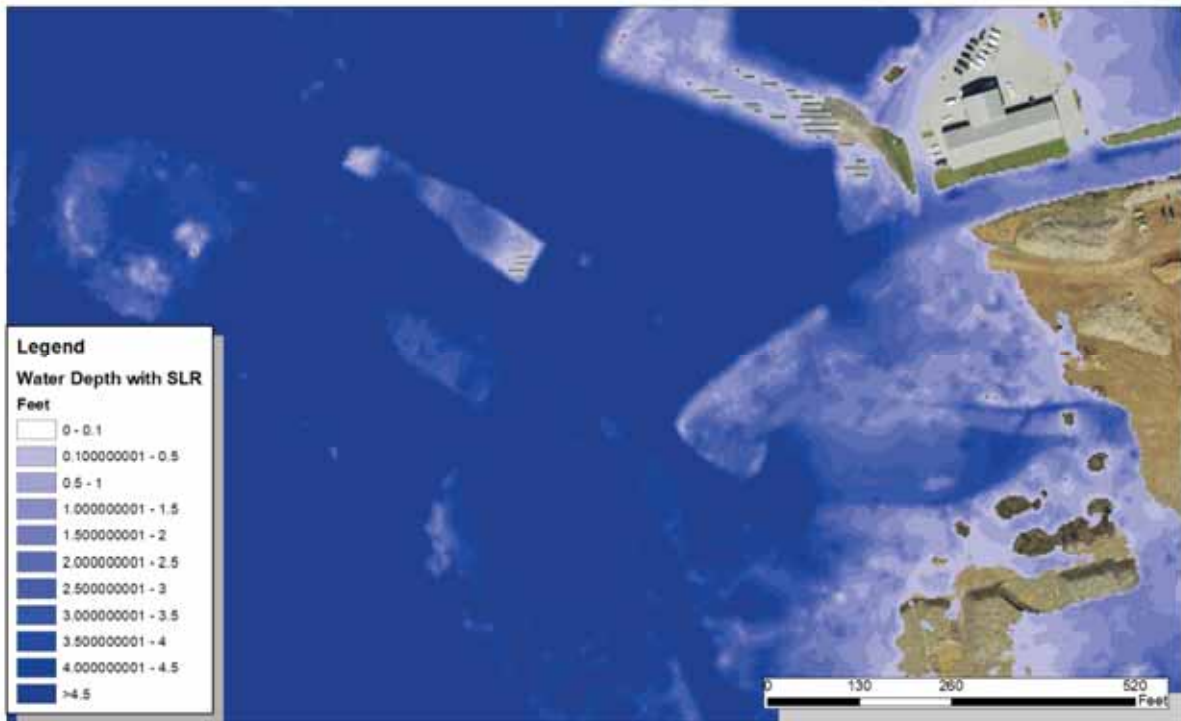
2050 Sea Level 1-Percent-Annual-Chance Depths 1 of 9



2050 Sea Level 1-Percent-Annual-Chance Depths 2 of 9



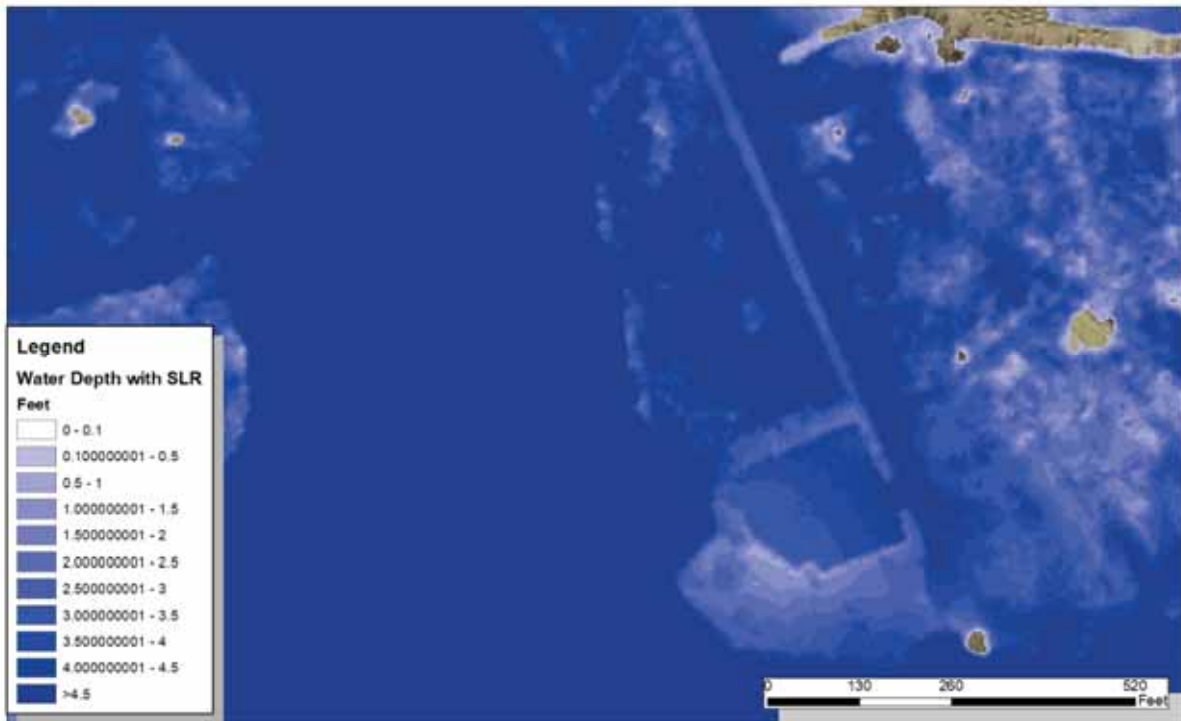
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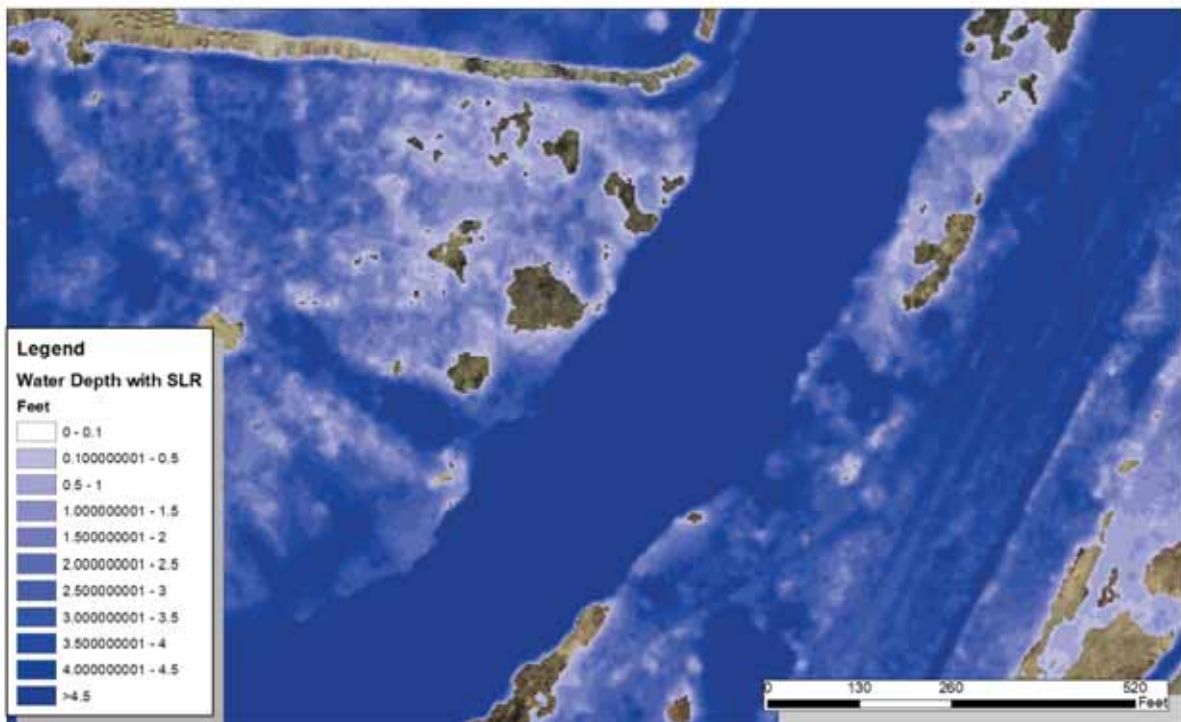
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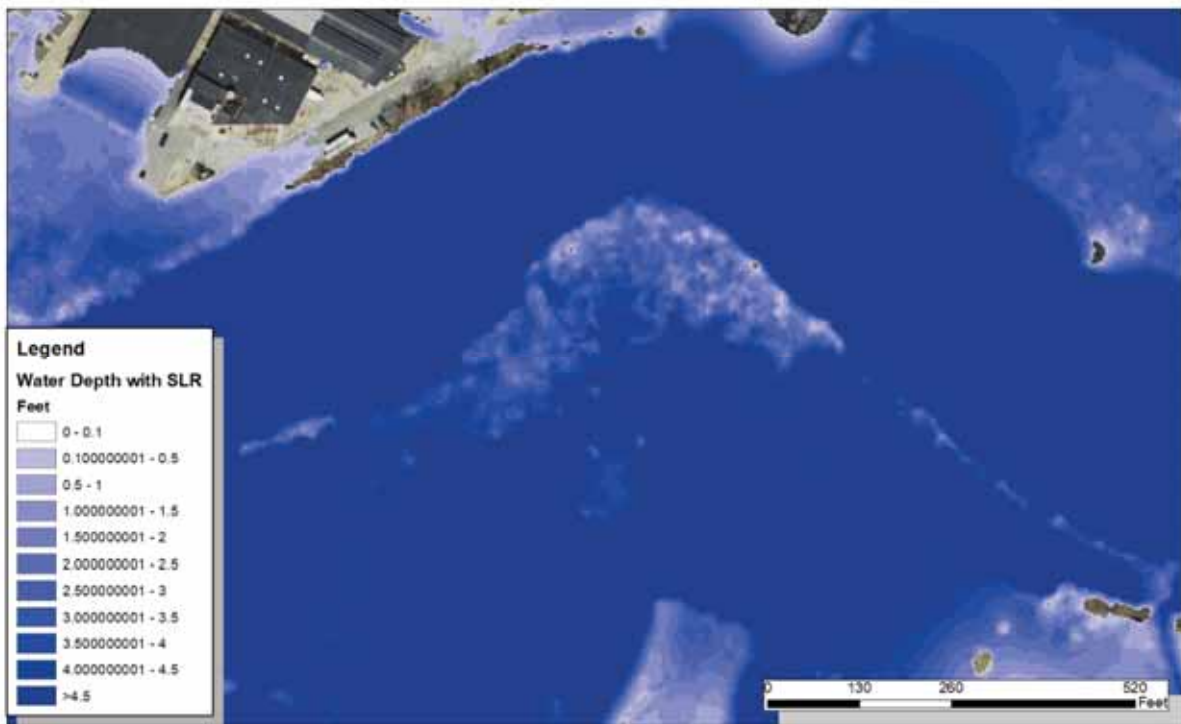
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