PLANNING FOR COASTAL RESILIENCY

IN GRAND HAVEN CHARTER TOWNSHIP

Identifying Coastal Dynamics, Resources, and Risks

This report summarizes the results of a year-long study of coastal dynamics in Grand Haven Charter Township. This project was developed by a Univeristy of Michigan project team as part of the Resilient Grand Haven planning process conducted by the Land Information Access Association (LIAA). All materials and presentations are available on the project's page on www.ResilientMichigan.org/grand_haven.asp.

This report was prepared by the Land Information Access Association (LIAA) as the product of a study conducted by the University of Michigan Taubman College of Architecture and Urban Planning as part of the Resilient Grand Haven project. Support for the project came from the Michigan Municipal League (MML), Michigan Association of Planning (MAP), and the University of Michigan's Taubman College of Architecture and Urban Planning. A special thank you is owed to the many organizations and individuals that contributed to the planning process.

This project was funded in part by Grand Haven Charter Township, the City of Grand Haven, the University of Michigan Water Center, the Michigan Coastal Zone Management Program, Department of Environmental Quality, Office of the Great Lakes; and the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

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PLANNING FOR COASTAL RESILIENCY IN GRAND HAVEN CHARTER TOWNSHIP

THE IMPORTANCE OF PLANNING IN COASTAL COMMUNITIES

It is no secret the Great Lakes are one of the most unique and precious environmental features in the world. In fact, "the Great Lakes basin contains more than 20% of the world's surface freshwater supplies and supports a population of more than 30 million people."[1] Michigan is home to nearly 3,300 miles of Great Lakes shoreline, with 36,000 miles of rivers and streams, and 11,000 inland lakes.[2]

Yet in general, riparian land throughout Michigan is not adequately protected from development pressures.[3] Coastal communities especially have an important role to play in protecting the Great Lakes. In 2001, the Michigan Department of Environmental Quality acknowledged "fragmentation of coastal habitats, loss of agricultural and forest lands, increased impervious surfaces and resulting stormwater runoff, and the increased development in coastal hazard areas, wetlands, and Great Lakes Islands, could be improved through better coastal land use planning."[4]

Planning for coastal areas at the local level requires knowledge of both local conditions and state and federal regulations. This report aims to address these challenges for the Grand Haven Community and provide clear, well-founded recommendations for future land use planning.

OVERVIEW OF COASTAL DYNAMICS AND THE GREAT LAKES

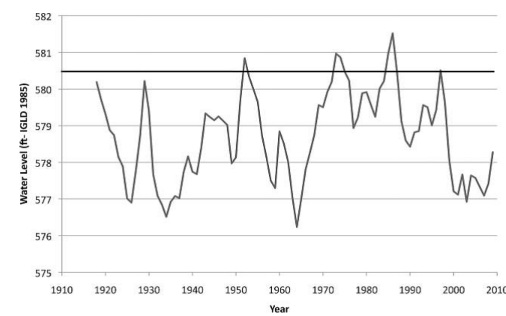
The Great Lakes function differently than other inland water bodies and tidal oceans. Understanding these dynamics can help Grand Haven Township plan for naturally occurring changes along the shoreline.

OSCILLATING WATER LEVELS OF THE GREAT LAKES

Great Lakes water level changes do not result from the moon's gravitational pull, but from cyclical changes in rainfall, evaporation, and riverine and groundwater inflows.[5] These factors work together to raise and lower the water levels of the Great Lakes in small increments daily, and larger increments seasonally and over the course of years and decades. Long-term water levels fluctuate by multiple feet as shown in Figure 1.

The Great Lakes are in a period of rising lake levels. Since the early 2000s, water levels have remained low, but historical patterns over the last century indicate higher water levels are sure to return.[6] Lake Michigan's water

Figure 1. Oscillating water levels of the Great Lakes and the mean water level



Source: NOAA, 2011

[1] Mackey, S. D., 2012: Great Lakes Nearshore and Coastal Systems. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators.

[2] Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.

[3] As cited by Norton 2007- Michigan Department of Environmental Quality. 2001. 309 Enhancement Grants Assessment/Strategy. Lansing, MI: DEQ Coastal Management Program.

[4] Ibid.

[5] Norton, Richard K. , Meadows, Lorelle A. and Meadows, Guy A.(2011) 'Drawing Lines in Law Books and on Sandy Beaches: Marking Ordinary High Water on Michigan's Great Lakes Shorelines under the Public Trust Doctrine', Coastal Management, 39: 2, 133 — 157, First published on: 19 February 2011 (iFirst)

[6] Meadows, Guy A., and Meadows, Lorelle A., Wood, W.L., Hubertz, J.M., Perlin, M. "The Relationship between Great Lakes Water Levels, Wave Energies, and Shoreline Damage." Bulletin of the American Meteorological Society Series 78: 4. (1997): 675-683. Print.

Erosion on Lake Michigan endangers homes built too close to the shoreline. This photo was taken on the Indiana coastline of Lake Michigan.

Source: EPA.gov

level in August of 2015 averaged 579.79 feet, which is equal to the water levels in fall of 1998.[7]

The decadal and multi-decadal shifts in water levels are not solely responsible for the movement of the shoreline landward and lakeward over time. The velocity and height of waves, erosion of shorelines, and variability in the oscillation of water levels also contribute to coastal dynamics on the Great Lakes.

WAVE ENERGY AND HEIGHT

The Great Lakes are subject to high energy waves and wave setup along the coastline. High energy waves are high in speed and strong in intensity and are primarily created as fast winds move across the surface of the water for extended distances.[8] Wave setup is the height of the water as waves reach the shore. High wave setup results as regional storm patterns create high winds on the bounded water bodies of the Great Lakes.[9] Powerful and tall waves are natural conditions that can increase the pace of erosion and damage structures on, or near, the shoreline.[10]

EROSION

The shorelines of Lake Michigan are mostly made of gravel and sands that easily erode during times of high energy waves.[11] Coastal erosion can flood and damage infrastructure along bluffs and beaches and is a natural occurrence on the geologically young Great Lakes. Erosion is caused mainly by storms and winds, not necessarily by rising lake levels.[12]

QUICKLY CHANGING CONDITIONS

The Great Lakes are contained in gradually shifting and tilting basins. This tilting results as the Earth slowly decompresses and rebounds from the immense weight of the glaciers that created the Great Lakes.[13] This shifting causes long-term water levels to change more quickly in some places than others, because the shape of the water basin varies along the coast.[14] This attribute of the Great Lakes makes it difficult to predict the pace of shoreline movement. Therefore, it is safest to plan for great variability and rapid change in water levels.[15] Figure 2 shows the movement of the shoreline in the Grand Haven Community.

CLIMATE CHANGE AND THE GREAT LAKES

Powerful waves, erosion, and quickly changing shorelines are natural processes of the Great Lakes, each having implications for planning efforts along the coast, however, augments these natural processes,

7 http://www.glerl.noaa.gov/data/dashboard/GLWLD.html

8 National Oceanic and Atmospheric Administration. "Coastal Currents." Ocean Service Education. NOAA, 25 March 2008. Web. Accessed July 2015. 9 Norton, Richard K. , Meadows, Lorelle A. and Meadows, Guy A.(2011) 'Drawing Lines in Law Books and on Sandy Beaches: Marking Ordinary High Water on Michigan's Great Lakes Shorelines under the Public Trust Doctrine', Coastal Management, 39: 2, 133 — 157, First published on: 19 February 2011 (iFirst)

10 Ibid.

11 Ibid.

12 Meadows, Guy A., and Meadows, Lorelle A., Wood, W.L., Hubertz, J.M., Perlin, M. "The Relationship between Great Lakes Water Levels, Wave Ener-gies, and Shoreline Damage." Bulletin of the American Meteorological Society Series 78: 4. (1997): 675-683. Print.

13 Dorr, J. A., and D. F. Eschman. 1970. Geology of the Great Lakes. Ann Arbor: University of Michigan Press.

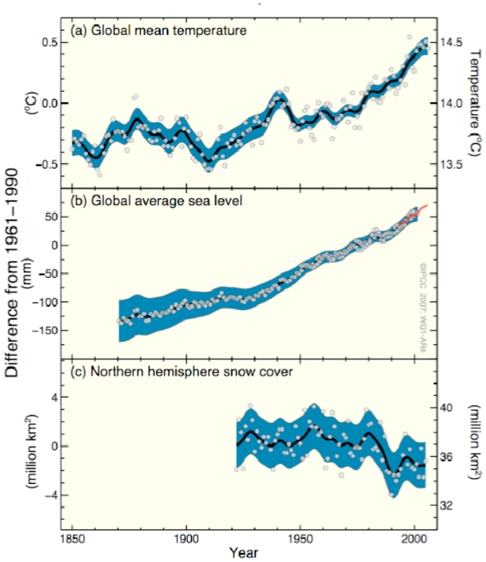
14 Wilcox, D.A, Thompson, T.A., Booth, R.K., and Nicholas, J.R., 2007, Lake-level variability and water availability in the Great Lakes: U.S. Geological Survey Circular 1311, 25 p

15 Ibid.

Figure 2. The shoreline in Grand Haven for various years, 2015 photo

Source: Google Earth Pro, 2015 Imagery

Figure 3.



Source: International Panel on Climate Change, https://www.ipcc.ch/publications_ and_data/ar4/syr/en/mains1.html

and requires preemptive planning in coastal communities. This section will discuss climatologist predictions of increased precipitation and storminess in the Great Lakes region, variable lake water levels, and rising water temperature. First, it is important to understand the global context of climate disruption.

GLOBAL CHANGES IN CLIMATE

Climate and weather are directly related, but not the same thing. Weather refers to the day-to-day conditions in a particular place, like sunny or rainy, hot or cold. Climate refers to the long-term patterns of weather over large areas. When scientists speak of global climate change, they are referring to changes in the generalized, regional patterns of weather over months, years and decades. Climate change is the ongoing change in a region's general weather characteristics or averages. In the long term, a changing climate will have more substantial effects on the Great Lakes than individual weather events.

Evidence collected over the last century shows a trend toward warmer global temperatures, higher sea levels, and less snow cover in the Northern Hemisphere (see Figure 3). Scientists from many fields have observed and documented significant changes in the Earth's climate.[16] Warming of the climate system is unequivocal and is now expressed in higher air and ocean temperatures, rising sea levels, and melting ice.[17]

To help predict what the climate will be in the future, scientists use computer models of the Earth to predict large-scale changes in climate. These General Circulation Models (GCM) have been improved and verified in recent years, resulting in relatively reliable predictions for climate changes over large regions.[18] Scientists downscale these techniques to predict climate change for smaller regions.

CLIMATE CHANGE ON THE GREAT LAKES

The Great Lakes Integrated Sciences + Assessments Center (GLISA) is a consortium of scientists and educators from the University of Michigan and Michigan State University that provides climate models for the Great Lakes Region in support of community planning efforts like this Master Plan. According to GLISA, the Great Lakes region experienced a 2.3 degree Fahrenheit increase in average air temperatures from 1900 to 2012.[19] An additional increase of 1.8 to 5.4° F in average air temperatures is projected by 2050. Although these numbers appear relatively small, they are driving very dramatic changes in Michigan's climate and greatly impact the Great Lakes.[20]

The National Climate Assessment for 2009 included a number of illustrations to help us understand the extent and character of anticipated climate change impacts.[21] One of these illustrations, Figure 4, shows Michigan under several emissions scenarios, each leading to changes in Michigan's climate. Just by maintaining current emission levels, Michigan's climate will feel more like present-day Arkansas or Oklahoma by the end of the century.[22]

16 Intergovernmental Panel on Climate Change. (2007). Observed changes in climate and their effects. Web. Accessed July 2015.
17 Ibid.
18 Intergovernmental Panel on Climate Change (2013). What is a GCM? Web. Accessed July 2015.
19 Great Lakes Integrated Sciences and Assessments (2015). Temperature. Web. Accessed July 2015.
20 Ibid.
21 U.S. Global Change Research Program. Global Climate Change in the United States, 2009. Cambridge University Press, Cambridge, MA.
22 Ibid.

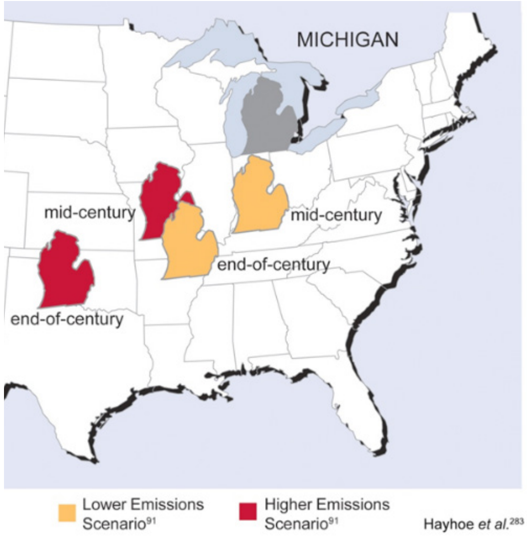
INCREASED PRECIPITATION AND STORMINESS

There is strong consensus among climate experts that storms, greater in number and intensity, will occur in the Great Lakes region.[23] This is already happening as "the amount of precipitation falling in the heaviest 1% of storms increased by 37% in the Midwest and 71% in the Northeast from 1958 to 2012."[24] As storms drop more precipitation and generate stronger sustained winds, the Great Lakes will see stronger and higher waves.[25] In addition to direct damage caused by storms, sustained increases in the number of storms and their intensity can both directly and indirectly pollute waters by overloading sewage and stormwater capabilities.[26] Increases in the intensity of storms also quickens the pace of erosion on Great Lakes shorelines. In fact, the Federal Emergency Management Agency (FEMA) projects approximately 28% of structures within 500 feet of a Great Lakes shoreline are susceptible to erosion by 2060.[27]

VARIABILITY OF LAKE WATER LEVELS

The natural ups and downs in the water levels of Lake Michigan will continue regardless of the impacts of climate change.[28] However, climate change is likely to augment this natural process resulting in more variable water levels as warmer air temperatures result in fewer days of ice cover and faster evaporation.[29] In other words, lake levels will rise and fall faster and with less predictability than in the past. Fortunately, much of Michigan's coastal infrastructure was built in previous decades during times of high water levels.[30] However, fast rising waters can erode shorelines, damage infrastructure, and cause extensive flooding in inland rivers.[31] When lake levels fall, access to infrastructure like docks may be restricted and navigation hazards in shallow waters may be exposed. Low lake levels pose a threat to coastal vegetation and can reduce the pumping efficiency of drinking water intake pipes.[32] Additional ramifications of changing lake levels include a drop in water supply,[33] restricted fish habitats,[34] more invasive species,[35] faster erosion, and an overall decline in beach health.[36] Climate change is likely to augment the natural highs and lows of lake levels, causing more variability and a faster rate of change, making each of these potential ramifications both more likely and less predictable.

Figure 4.



Source: National Climate Assessment, 2009

Hurricane Sandy caused an estimated 755 billion dollars worth of damage in 2012. The impacts of this Hurricane were felt on Lake Michigan, causing waves up to 33 feet.

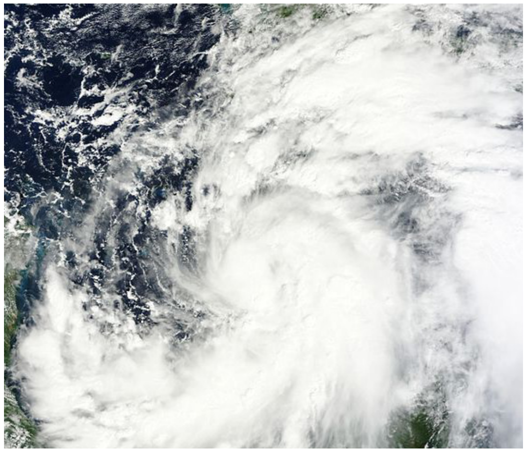


Photo Source: NASA 2012

23 Ibid.
24 Mackey, S. D., 2012: Great Lakes Nearshore and Coastal Systems. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators.
25 Great Lakes Integrated Sciences and Assessments. Climate Change in the Great Lakes Region. GLISA, 2014. Web. Accessed July 2015.
26 Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers–a Great Lakes supplement. Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management.
27 The Heinz Center. (2000). Evaluation of Erosion Hazards. Web. Accessed July 2015.
28 Dinse, Keely. Preparing for Extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
29 Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers–a Great Lakes supplement. Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management.
30 Dinse, Keely. Preparing for Extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
31 Ibid.
32 Ibid.
33 Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers–a Great Lakes supplement. Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management.
34 Ibid.
35 Ibid.
36 Dinse, Keely. Preparing for Extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.

Damage from a 1989 storm in Grand Haven.

Source: Grand Haven Charter Township

WATER TEMPERATURE

Climatologists predict there will be fewer days below freezing in Michigan and other Great Lakes states. As temperatures remain warm for a greater part of the year, the winter season will shorten and the lake ice cover that accompanies winter weather will decline. Lake ice cover allows heat radiation to be reflected, and when it declines, the surface water temperature will increase as more heat is absorbed by the water. The ice coverage on the Great Lakes and Lake St. Claire declined by 71% from 1973 to 2010, and ice covers the lake for an average of 15 fewer days each year.[37]

The associated impacts of rising water temperature include changes to where fish and other aquatic animals can live, increased vulnerability to invasive species, and increased risk of algae blooms.[38] Rising water temperature also enables winds to travel faster across the surface of the lake, increasing the vulnerability of coastal communities to damaging waves as storms and winds increase.[39] Lastly, ice cover protects the shoreline during winter storms. With less ice cover, the shoreline is more susceptible to erosion and habitat disruption.

PARTNERSHIP WITH THE UNIVERSITY OF MICHIGAN

In an effort to make planning decisions based on known information about the Great Lakes systems, a project team from the University of Michigan has collaborated with LIAA, with funding from the University of Michigan Water Center, to identify and analyze hazard areas and work with community groups to plan for better coastline management. The multi-disciplinary project team has integrated scientific knowledge and research with local planning processes in Grand Haven Charter Township and the City of Grand Haven.

Multi-disciplinary project team. The project team includes University of Michigan researchers and community planning staff from LIAA. The Principal Investigator is Richard K. Norton (UM Urban and Regional Planning). Co-investigators include Maria Arquero (UM Urban and Regional Planning); Jennifer Maigret (UM Architecture); Guy Meadows (Michigan Tech Great Lakes Research Center); Paul Webb (UM School of Natural Resources and Environment); and Lan Deng (UM Urban and Regional Planning).

Funding overview. Funding for the project came from the University of Michigan Water Center and the Michigan Department of Environmental Quality's Coastal Zone Management Program. The local governments of the City of Grand Haven and Grand Haven Charter Township also provided a local match.

Research questions and scope of work. The project sought to answer several key questions. First, what data is readily available for coastal planning, and how well does this data reflect current and future climate conditions? Second, does increasing access to coastal research help local jurisdictions plan for coastal changes? These questions are addressed using a scenario planning framework. Environmental and land use ramifications of increased flooding are considered.

The project team chose the jurisdictions of the City of Grand Haven and Grand Haven Charter Township as

37 Austin, J. A., & Colman, S. M. (2007). Oceans- L06604 - Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback (DOI 10.1029/2006GL029021). Geophysical Research Letters, 34, 6.).
38 Dinse, Keely. Preparing for Extremes: The Dynamic Great Lakes. Michigan Sea Grant. Web. Accessed July 2015.
39 Cruce, T., & Yurkovich, E. (2011). Adapting to climate change: A planning guide for state coastal managers–a Great Lakes supplement. Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management.

candidates for this work. LIAA's ongoing work with the *Joint Planning Commission* and the dynamic coastline in each community made the Grand Haven community a strong partner for this research.

Over the course of 18 months, the project team held several meetings with the Grand Haven *Joint Planning Commission* and was present for the Leadership Summit. The project team also held several public meetings to better inform the research and communicate progress.

GOVERNMENT REGULATIONS

Federal, state, and local policies play an important role in shaping land use and development along the shoreline. Here, the Federal Emergency Management Agency's National Flood Insurance Program is discussed, in addition to Michigan policies to protect wetlands, High Risk Erosion Areas, Critical Dune Areas, and the shoreline. Possible actions local governments can take to supplement state and federal regulations are outlined as well.

NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program (NFIP) is an optional program from which communities can receive flood insurance for disaster relief by agreeing to regulate development in the floodplain. The NFIP was created in 1968 under the National Flood Insurance Act. The NFIP is currently administered by FEMA and has four major goals:

- To charge flood insurance premiums to private property owners, ensuring taxpayers do not bear the sole burden of private property flood losses
- To provide residents with aid after flooding
- To guide development away from hazard areas
- To require building construction to minimize or prevent flood damage

Flood Insurance Rate Maps. The floodplain must be locally regulated to qualify for the NFIP, but FEMA defines what land is considered eligible in a floodplain for the NFIP. Floodplains are mapped in either a Flood Hazard Boundary Map (FHBM) or, more commonly, a Flood Insurance Rate Map (FIRM).

FIRMs are created and released by FEMA. FIRMs are generated for various return periods, like the 50-year storm, 100-year storm, and 500-year storm.[40] It is important to note that individual property owners can petition to change the flood zone designation for their property, so FIRMs may not be fully derived from scientific analysis.

The FIRMs for Ottawa County were adopted in 2011 by the City of Grand Haven and Grand Haven Charter Township.

In 1973, the Flood Disaster Protection Act was passed, which penalized communities that did not participate in the NFIP by limiting federal money to acquire floodplain property available to non-participating communities. This act also mandated buildings in floodplains must have flood insurance coverage in order to receive any federal financing, loans, or disaster relief.[41]

Community Rating System. In 1994, the Community Rating System (CRS) was added to the NFIP through the National Flood Insurance Reform Act of 1994. The CRS offers discounts in the premium a property owner must pay if a community's floodplain management exceeds the minimum NFIP regulations. A community can receive credit toward premium reductions by educating the public, increasing mapping and regulation, reducing flood likeliness by relocating and retrofitting flood-prone structures, maintaining drainage systems,

40 FEMA (2013). Great Lakes Coastal Flood Hazard Studies. Web. Accessed July 2015.
41 FEMA (2005). Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials. Web. Accessed July 2015.

and creating flood warning and response programs. Currently, 22 Michigan communities participate in the CRS,[42] and Grand Haven Charter Township is taking steps toward joining.

Local Government Role. A participating community has a number of responsibilities to remain compliant with NFIP regulations. These include monitoring floodplain development and building permits, inspecting development, maintaining records, revising and assisting in floodplain mapping, and providing information to the local public about the requirements of the program. Once a community's FEMA region releases updated FIRMs, a community has a period to review and appeal the drafted map. After that point, the community has six months to adopt the new FIRM through an ordinance.[43]

GREAT LAKES COASTAL FLOOD STUDY

In 2010, FEMA and the United States Army Corps of Engineers (USACE) began the Great Lakes Coastal Flood Study. The project seeks to update existing FIRMs to account for revised lake levels, wave setup, and wave energy. The process to create the drafted maps differs significantly from the process to create existing FIRMs. The existing FIRMs are determined using event-based modeling, where the projected flooding impacts are derived from a selected historical storm.[44] The updated approach is statistically based, where the influences of wave energy and wave setup are modeled using refined 100-year lake level elevations provided by the USACE.

The Great Lakes Coastal Flood Study is scheduled to release maps for public comment and adoption in 2016. Preliminary draft maps are available for Ottawa County and are used in the analysis further described in this report.

Local Opportunity. Both Grand Haven jurisdictions participate in the NFIP. The City of Grand Haven joined the NFIP in 1978 and the Township followed in 1981. Since that time, each jurisdiction has submitted claims as seen in Table 1. The Township has received over $229,000 in aid for 17 separate claims.

Table 1. NFIP Claims

	Total Number of Claims	Total Value of Claims
Grand Haven Charter Township	17	229,374
City of Grand Haven	19	309,623
Ottawa County	255	2,562,999
Statewide	11,183	66,748,379

Source: FEMA, 2015.

Under the Community Rating System, the Grand Haven community can receive credit for implementing several of the changes recommended in this report (see recommendations at the end of this report). As times of high intensity waves and inundation are expected to increase, the Grand Haven Community might consider making changes to zoning ordinances, building codes, and other policies to better manage floodplain development. Additionally, NFIP flood insurance premiums are rising nationwide, as storms increase and payouts rise.[45] Participating in the CRS is a proactive approach to keeping costs low while protecting both man-made, and natural, resources near the shoreline.

42 FEMA. https://www.fema.gov/media-library/assets/documents/26319
43 Ibid.
44 FEMA (2013). Great Lakes Coastal Flood Hazard Studies. Web. Accessed July 2015.
45 EDEN Inc. (201v4). Flood Premiums Rising Dramatically. Web. Accessed July 2015.

WETLANDS

BENEFITS OF COASTAL WETLANDS

Wetlands help to reduce flood damage by absorbing flood water and then slowly releasing it. One acre of the typical wetland is able to absorb one million gallons of water,[46] protect adjacent and downstream land from damage,[47] and slow the speed of flooding across an area.[48] The storage capacity of a specific wetland varies by its size, slope, type of vegetation, location relative to the flooding path, and water levels in the wetland prior to flooding.[49] Coastal wetlands also alleviate the severity of erosion along a shoreline during a storm.[50] Perhaps more than any other environmental asset, wetlands buffer the coast by absorbing high energy waves and disrupting the flow of currents.[51]

EXISTING REGULATION FOR WETLANDS

The Clean Water Act of 1972 mandated permits be granted for development on regulated wetlands. This federal act gives the United States Army Corps of Engineers (USACE) the authority to grant permits to build on regulated wetlands, with the Environmental Protection Agency (EPA) having the authority to veto permits issued to fill wetlands. The Michigan Department of Environmental Quality (MDEQ) is the co-administrator of the permitting process, sharing joint regulation with the Army Corps of Engineers.[52] Michigan was the first state, and is one of only two states, to assume a role in the permitting process for wetlands.[53] Here, the MDEQ issues a permit to build on wetlands if the applicant meets qualifications. Permitting decisions are subject to public comment, including those made by local governments.

A property owner must obtain a permit from the State before building on a regulated wetland. A wetland is regulated if it:[54]

- Is connected to or within 1000 feet of a Great Lake shoreline
- Is connected to or within 500 feet of an inland lake, pond, or river
- Is equal to or greater than 5 acres in size
- Is essential to the preservation of the state's natural resources, as designated by the MDEQ

Michigan has coastal, forested, and shrub wetlands, each inundated with water either all or part of the year.[55] The function and diversity of wetlands was misunderstood as European settlement began, and many wetlands were dredged, drained, and converted to serve industry and agriculture.[56] Today, less than half of the state's wetlands remain, and in a time of changing climate, the need to conserve and restore wetlands is paramount.[57] Wetlands face a number of challenges related to climate variability:

- Rising water levels will actually increase the number of naturally occurring wetlands on low-lying uplands. However, wetlands cannot expand where structures like bulkheads, dikes, and other structures block their advance.[58]
- As precipitation and storminess increase, runoff water and draining can increase sedimentation and nutrient input in wetlands.

46 Environmental Protection Agency (2001). Functions and Values of Wetlands: Wetland Fact Sheet. Web. Accessed July 2015.
47 Ibid.
48 Ibid.
49 Ibid.
50 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.
51 Ibid.
52 Ibid.
53 Ibid.
54 NREPA PA 451 of 1994, Part 303
55 Michigan Department of Environmental Quality. Wetlands Protection: Protecting Michigan's Wetlands. Web. Accessed July 2015.
56 NREPA PA 451 of 1994, Part 303
57 LIAA (2014). Climate Change Adaptation & Local Planning for Michigan's Coastal Wetland Resources. Web. Accessed July 2015.
58 Maryland Department of the Environment. Wetland Disturbance and Impact. Web. Accessed July 2015.

This can lead to algae blooms and invasive species.[59]

- Consistent high water levels endanger vegetation and animals that depend on the naturally fluctuating water levels in wetlands.

Local Opportunity. Local governments in Michigan can protect additional wetlands not regulated by the state.[60] Under Michigan's Natural Resources and Environmental Protection Act (NREPA), local governments can require wetlands less than 5 acres in size be regulated by a permitting process.[61] A local government must possess an inventory of existing wetlands to adopt a wetland ordinance. The MDEQ must be notified of a local wetland ordinance, though the State does not need to review or approve.[62]

Local governments can also protect wetlands through site plan review provisions and zoning ordinances.[63] Under the Michigan Zoning Enabling Act, protecting the natural environment is a justification for zoning requirements like buffers and other tools.[64] Site plan review provisions in the zoning ordinance can require wetland permits be obtained from the MDEQ as a condition of local zoning approval.[65]

HIGH RISK EROSION AREAS

The State of Michigan regulates development in what it designates as High Risk Erosion Areas (HREAs). The purpose of this regulation is to prevent costs associated with cleaning up damaged structures and moving infrastructure and buildings away from eroding bluffs, while protecting the life and health of residents and keeping insurance costs down. Preventing buildings in HREAs also protects the Great Lakes from pollutants from structure debris and septic fields.[66] The authority for this regulation comes from the Shoreline Protection and Management statute.[67]

The MDEQ compares new and historic imagery to designate areas of coastline that have eroded by more than 1 foot per year as HREAs. The MDEQ then uses erosion rates to calculate 30- and 60-year setbacks from the "erosion hazard line," or generally, the line of stable vegetation. Usually, new structures must be built landward of the erosion hazard line by either 30 times or 60 times the erosion rate, as designated by the MDEQ. While some small permanent structures may be permitted within the 30-year setback, all new structures must be built landward of the erosion hazard line. MDEQ is in the process of updating HREAs in some areas of Michigan.[68]

Local opportunity. Local governments can assume the MDEQ's permitting responsibilities for HREAs through an ordinance. To do so, the ordinance cannot be less restrictive than the State's regulations and the MDEQ must approve the ordinance. A local government can adopt an ordinance requiring greater and more uniform setbacks in HREAs than the MDEQ.[69]

Other actions can be taken through a local zoning ordinance, including performance standards for soil and vegetation, clustering development away from vulnerable erosion areas, and instituting site plan review processes for any development in HREAs.[70]

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59 Ibid.
60 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.
61 Ibid.
62 NREPA, Michigan Public Act 303, 324.30307
63 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.
64 NREPA, Michigan Public Act 303, 324.30307
65 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. Michigan Department of Environmental Quality, Coastal Zone Management Program with financial assistance from the National Oceanic and Atmospheric Administration, authorized by the Coastal Zone Management Act of 1972. 2010.
66 Ibid.
67 Ibid.
68 Ibid.
69 NREPA, 1994 Michigan PA 451, Part 323.
70 Michigan Department of Environmental Quality. High Risk Erosion Areas: Program and Maps. Web. Accessed July 2015.

SOIL EROSION AND SEDIMENT CONTROL

Eroding soil and sediment deposition into Michigan waterways damage wildlife habitats, pollute water, and decrease water depth. Sedimentation can also carry nutrients and toxic pollutants, mainly from agriculture and construction activities, directly into water systems.[71] Soil erosion and sediment control comes from a variety of activities, but construction and earth change is specifically monitored by the State under Part 91 of NREPA.[72] A permit is required for earth changes that disturb 1 or more acres of land or are within 500 feet of the water's edge of a lake or stream.

Local Opportunity. County governments can administer Soil Erosion and Sediment Control programs by adopting an ordinance. Ottawa County has done so and currently administers permits through the Ottawa County Water Resources Commission.[73] Local monitoring can be more restrictive than the state by permitting for earth changes adjacent to wetlands, storm drains, or environmentally sensitive areas, or earth changes on less than 1 acre.[74] Local governments, however, cannot expand Part 91 to monitor stormwater management control outside of soil erosion control.[75] Any local control program must be approved by the MDEQ, and the MDEQ offers assistance to communities looking to implement stricter regulation under NREPA.

Outside of NREPA, local governments can adopt stormwater control ordinances, impervious surface limitations, or require street sweeping to reduce pollutants in water runoff.[76]

CRITICAL DUNE AREAS

Michigan's dunes are one of the most striking environmental features in the nation. Together, they represent the largest freshwater dune ecosystem in the world.[77] The dunes provide unique habitats for rare and endangered species and hold priceless environmental and recreation value.[78]

Michigan's Sand Dune Protection and Management statute calls for the protection of Critical Dune Areas (CDAs) through state regulation, which is administered by the MDEQ. Under the statute, a property owner must receive a permit for any activity that alters the appearance or contour of a Critical Dune.

Generally, CDA regulation states development:

- Should not occur lakeward of the crest of the dune
- Should plan for soil erosion and water runoff
- Should not alter the elevation or slope of the dune

Recent updates to the Sand Dune Protection and Management Act. In 2012, Governor Snyder signed Public Act 297. This Act updates the Critical Dune regulation in several ways, which all make acquiring permits to build on the dunes easier. The amendment clarifies the MDEQ cannot deny a permit solely because "public interest" would be violated by the proposed development. It also limits who is able to challenge a permit to just property owners and those living nearby. The Act no longer requires an analysis of alternative placements for buildings and requires the MDEQ to issue permits for driveways and other paved pathways to permanent structures in a CDA. Additionally,

71 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.
72 Ibid.
73 Ibid.
74 Soil Erosion and Sedimentation Control of the Natural Resources and Environmental Protection Act 1995 PA 451, as amended: R 323.1704.
75 Ardizone, Katherina A. and Mark A. Wyckoff, FAICP. Filling the Gaps: Environmental Protection Options for Local Governments, 2nd Edition. 2010.
76 Ibid.
77 Ibid.
78 Ibid.

the Act now permits building on the lakeward-facing slope of the first foredune.[79]

Local Opportunity. Local opportunity under the updated Sand Dune Protection and Management Act is limited. While Part 353 allows the local government to assume the permitting process for CDAs, local governments can no longer be more restrictive than the State. As a result, adopting the permitting power of the State through the Sand Dune Protection and Management Act will not increase regulation on Critical Dune Areas. A local government can do much more to protect the dunes through zoning ordinances and other planning efforts.[80] Only 30% of the State's dunes are considered Critical Dune Areas and are subject to state regulation, unless wetlands, High Risk Erosion Areas, or other environmental areas are located on the property.[81] Local government administration of the permitting process has been met with mixed results, especially in areas with small coastal lot sizes, where the requirements of Part 353 may trigger a regulatory takings claim.

WATER MARK LINES

In addition to the above regulatory powers, there are also three water marks used by different entities to regulate activities along the shoreline.

First, the United States Army Corps of Engineers uses a high water mark line (called the Ordinary High Water Mark or OHWM) to determine the extent of navigational waters they regulate. This boundary is set based on a 581.5-foot water level above sea level for Lake Michigan. Second, the MDEQ regulates development below a separately determined water line. This is sometimes referred to as the Elevation Ordinary High Water Mark Line (EOHWM). This water line is elevation-based and is determined using a 580.5-foot water level above sea level for Lake Michigan.

There is only a 1-foot difference between the water level used to determine the regulatory authority of the USACE and the MDEQ. Because of this, the two bodies co-administer a joint permitting process for activities taking place below either water mark line. These include dredging, placing seawalls or rock revetment, or building of permanent docks.

Lastly, Michigan uses a water mark line sometimes referred to as the Natural Ordinary High Water Mark (NOHWM) to determine the extent of the public trust with regard to access along the shore. The NOHWM comes from the 2005 Michigan Supreme Court case Glass v. Goeckel, which determined the public has a valid right to walk below the NOHWM, defined as the point where natural vegetation begins or evidence of past high water levels exist.[82] This case also determined the NOWHM line is not equal to, or dependent on, the State's regulatory power defined by the Elevation Ordinary High Water Mark.

UNIVERSITY OF MICHIGAN RESEARCH STUDY

As part of this master planning process, the University of Michigan partnered with Grand Haven Charter Township and the City of Grand Haven to analyze shoreline dynamics to help Grand Haven manage its coastal areas. The remainder of this report summarizes the project team's framework, results, and recommendations pertinent to this planning effort.

OVERVIEW OF RESEARCH FRAMEWORK

The Research Framework of this study uses scenario planning to assess environmental and land use conditions under different management options and Climate Futures. Scenario planning, in general, identifies driving forces to inform a range of scenarios that are analyzed

79 Ibid.
80 Ibid.
81 Ibid.
82 Glass v. Goeckel. Michigan Supreme Court. 29 July 2009

and evaluated. In this context, the project team identified two driving forces: (1) rising levels of flood waters and (2) local government management options. These forces informed the creation of multiple Climate Futures each of which are managed differently. Each Climate Future was tested against each management option and evaluated for impacts on the environment and land use in the community. This framework is presented visually in Table 2.

Table 2. Research Framework

	Lucky Climate Future	Expected Climate Future	Perfect Storm Climate Future
Current Structures and Infrastructure			
Build-Out According to Current Zoning			
Build-Out According to Current Master Plan			
Build-Out According to Best Management Practices			

CLIMATE FUTURE DEFINITIONS

"LUCKY" FUTURE

Under the Lucky Climate Future, Great Lakes water levels will continue to stay relatively low. Although there will be wave and wind action, major storm events and wave impacts will not encroach on properties landward of current beaches. Potentially flooded inland areas will remain as currently delineated by FEMA under effective FIRMs (specifically, zones A and AE). Other climactic conditions (e.g., storm frequency and intensity, heat waves) will remain consistent with patterns in recent history. The Lucky Climate Future also accounts for riverine flooding. A Lucky flood projection is shown in Map 1 at the end of this report.

"EXPECTED" FUTURE

"Expected" Future – Under the Expected Climate Future, Great Lakes water levels will continue to fluctuate according to long-term decadal patterns, including recent extreme storm events incorporated into FEMA's ongoing Great Lakes Coastal Flood Study. There will be periods of high water levels similar to the long-term highs recorded in 1986, with Great Lakes still-water elevation closer to that of long-term average (580 feet). There will also be more frequent large storm events than in the past. During these high water periods, waves from a "100-year" storm event will encroach on properties, with areas subject to wave action as delineated by FEMA's proposed coastal high velocity (VE) zones; areas subject to sheet flow as delineated by FEMA's proposed AO zones; and nearshore areas subject to inundation as delineated by FEMA's proposed AE zones. During the "100-year" storm, areas located within the high velocity (VE) zone will be substantially damaged, and in some instances completely destroyed, while areas of the community within the AO and AE zones will be severely damaged by inundation. The Expected Climate Future also accounts for riverine flooding. Map 2 at the end of this report shows an Expected flood projection.

"PERFECT STORM" FUTURE

"Perfect Storm" Future – Under the Perfect Storm Climate Future, Great Lakes water levels will continue to fluctuate according to decadal patterns, consistent with assumptions made for the Expected future. However, still-water elevation will be higher than the long-term average and closer to the long-term high (583 feet). In addition to that assumption, because of increased frequency and intensity of storms, the shoreland areas subject to high velocity (VE) zones, as well as inundation as delineated by FEMA's proposed 500-year storm event (shaded-x zones), will essentially become the 100-year storm event (i.e., much more likely to occur), such that properties within these areas (i.e., in addition to the proposed AE and AO zones) will be severely damaged by inundation. Similar to the Expected Climate Future, during the "100-year" storm, areas located within the high velocity (VE) zone will be substantially damaged, and in some instances completely destroyed. The Perfect Storm Climate Future also accounts for riverine flooding. Map 3 at the end of this report shows a Perfect Storm flood projection.

MANAGEMENT OPTIONS

1. Current Structures and Infrastructure

   Under this option, the Grand Haven Community will continue to manage land in the same manner it currently employs, in accordance with adopted plans, zoning ordinances, and relevant local ordinances.

2. Build-out According to Current Zoning

   Under this option, the community will undergo a full build-out of development according to its existing zoning code. Additional homes are built in areas at the base flood elevation and are at risk for flooding. This is not an exact picture of the development capacity in the community; rather, this work equates to an estimate of where development may possibly occur under the current zoning, with additional land set aside for open space, driveways, streets, and yards. See Map 4 at the end of this report for a visual of where these points are located.

3. Build-out According to Master Plan

   Under this option, the community will achieve a full build-out in accordance with guidelines set forth in its master plan. This experimental option was intended to capture measurable differences between a master plan and a zoning ordinance, which could help local jurisdictions identify opportunities to improve both documents.

4. Build-out According to Best Management Practices (BMPs)

   Under this option, the Grand Haven Community will adopt and implement Best Management Practices to preserve natural resources and protect private property. See Map 4 at the end of this document for a visual of where these points are located. For this study, only several Best Management Practices are modeled. The selected BMPs were chosen as they have a significant spatial effect that can be easily modeled using CommunityViz software. Additionally, each has a policy or regulatory impact achieved through a zoning ordinance.

   The intent of including this management option is to present several amendments that could be adopted that may influence the impact on land use and the environment in the community.

   The BMPs modeled in this management option are:

   - 50-foot buffers around any inland water like rivers, lakes, and streams.
   - 50-foot buffers around any wetland 5 or more acres in size, as defined by the State of Michigan's Final Wetland Inventory data.
   - A complete restriction of any development within a wetland 5 or more acres in size, as defined by the State of Michigan's Final Wetland Inventory data.

Scope of analysis. Each Climate Future was tested against each management option for its impact on the land use and environmental conditions in the Grand Haven Community. The experimental "Build-out According to Master Plan" management option served as a useful conceptual aid during the planning process, but it did not yield enough measurable data to be effectively modeled. Therefore, only the results of the "Current Practices," "Build-out According to Current Zoning," and "Build-out According to Best Management Practices" management options are discussed in this report.

SCENARIO PLANNING TO ASSESS LAND USE AND ENVIRONMENTAL CONDITIONS

Each management option can be analyzed in each of the three Climate Futures. This creates an array of scenarios the Township could reasonably encounter in the foreseeable future regarding flooding and local government management options. Each scenario has a different impact on the land use and environmental conditions in Grand Haven Township. The remainder of this report presents the results of the modeling, derived by pairing each management option with each Climate Future. Land use impacts include the acreage, parcels, structures, and critical facilities that would be impacted under different Climate Futures for each management option. Environmental conditions include the acreage of wetlands, tree canopy, impervious surface, Critical Dune Areas, and High Risk Erosion Areas impacted in each Climate Future for each management option. Lastly, the fiscal conditions associated with scenario are evaluated.

LAND USE RESULTS

TOTAL ACRES IMPACTED BY FLOODING

The total acres of land impacted by flooding increases from the Lucky Climate Future to the Perfect Storm Climate Future. The number of acres impacted increases the most between the Lucky and Expected forecast (15%). Between the Expected and Perfect Storm, the total acres impacted increases by about 3%. Table 3 shows the total acres of land impacted under each future flood forecast in Grand Haven Township.

Table 3. Total Land Acres Impacted by Flooding

	Lucky	Expected	Perfect Storm
Grand Haven Township	1,195	1,381	1,418

PARCELS IMPACTED BY FLOODING

As Table 4 shows on the next page, between 700 and 950 parcels are impacted by flooding depending on the severity of the Climate Future.

In the Lucky Climate Future, 89% of the parcels impacted are zoned for some type of residential use. An additional 5% (37 parcels) are zoned agricultural, and nearly 3% (19 parcels) are zoned for Planned Unit Development.

In the Expected Climate Future, 91% percent of parcels impacted by flooding are zoned for some type of residential use. Between the Lucky and Expected Climate Futures, an additional 224 parcels are impacted. The bulk of this increase impacts parcels zoned R-1 Single Family Residential, which encompass the majority of the shoreline.

In the Perfect Storm Climate Future, the number of residential parcels impacted increased by 39% from the Lucky Climate Future to a total of 869 parcels. In this Climate Future, a greater number of Planned Unit Development parcels are also impacted.

In general, as the Climate Future causes more severe flooding, greater numbers of residential and publicly owned parcels may be impacted. Commercial parcels seem to bear the least impact across all Climate Future forecasts.

Maps 5, 6, and 7 visualize the type of parcels impacted under the Lucky, Expected, and Perfect Storm Climate Futures.

Table 4. Parcels Impacted by Zone

	Lucky		Expected		Perfect Storm	
Agricultural (AG)	37	5.3%	37	4.0%	37	3.9%
Commercial I (C-1)	3	0.4%	3	0.3%	3	0.3%
Industrial I (I-1)	1	0.1%	1	0.1%	1	0.1%
Planned Unit Development (PUD)	19	2.7%	22	2.4%	22	2.3%
Residential I (R-1)	303	43.3%	523	56.6%	535	56.3%
Residential II (R-2)	279	39.9%	279	30.2%	293	30.9%
Residential V (R-5)	1	0.1%	1	0.1%	1	0.1%
Rural Preserve	15	2.1%	15	1.6%	15	1.6%
Rural Residential (RR)	40	5.7%	40	4.3%	40	4.2%
Other	2	0.3%	3	0.3%	3	0.3%
Total Parcels Impacted by Zone	**700**	**100%**	**924**	**100%**	**950**	**100%**

NUMBER OF STRUCTURES IMPACTED BY FLOODING

Between 46 and 385 structures would be impacted in the Township depending on the severity of the Climate Future and the management practices the Township pursues. Table 5 summarizes the total number of structures impacted under the Climate Futures and management options.

Table 5. Number of Structures Impacted by Flooding

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	46	96	119
Build-Out According to Current Zoning *(Additional Structures Impacted)*	209	347	385
Build-Out According to Best Management Practices *(Additional Structures Impacted)*	52	145	171

In the Lucky Climate Future, 52 properties could be impacted if Best Management Practices are implemented for future development. If Best Management Practices are not implemented and the Township achieves a full build-out according to current zoning, 209 structures could be built in areas subject to inundation.

In the Expected Climate Future, 145 properties could be impacted if Best Management Practices are implemented for future development. If Best Management Practices are not implemented, 347 structures could be subject to inundation.

In the Perfect Storm Climate Future, 171 properties could be impacted if Best Management Practices are implemented for future development. If Best Management Practices are not implemented, 385 structures could be subject to inundation.

In general, as the Climate Future causes more severe flooding, implementing Best Management Practices reduces the number of structures impacted by over 60% as the community grows.

CRITICAL FACILITIES IMPACTED BY FLOODING

There were no critical facilities impacted under any future climate forecast. Critical facilities analyzed included current locations of police and fire stations, schools, places of worship, utilities, public facilities, and water treatment plants.

ENVIRONMENTAL RESULTS

WETLANDS

Wetlands are an important tool for community resilience, particularly for benefits related to flood control and water quality. GIS was used to compare existing wetlands to areas of potential wetland restoration in each Climate Future to give the Township a broader picture of areas that could best provide the flood-control benefits of wetlands. Additionally, the project team used GIS to count the number of unprotected wetlands under 5 acres in size using GIS. It is important that this analysis is an overall, generalizable study useful to compare one scenario to another. It should not be used to identify individual wetlands or areas of private property suitable to wetland restoration.

Table 6 shows the number of acres of wetlands impacted by flooding in each Climate Future. Existing wetlands are estimated using national and state data, and wetlands included in Maps 8, 9, and 10 either are, or are likely to be, a wetland. Table 6 shows the inundation of existing wetlands is relatively stable across the Climate Futures. There are nearly 1,400 acres of existing wetlands impacted by all three Climate Futures. These wetlands provide some flood protection by absorbing flood water. While this study does not quantify the benefit of the existing wetlands to the Township, studies have shown one acre of coastal wetlands can hold up to one million gallons of water.

Over 40% of the Township's existing wetlands are likely to received flood waters in the Lucky Climate Future. The existing wetlands compared to the three Climate Futures are shown in Maps 8, 9, and 10.

Potential wetlands are areas with hydric soils, are not currently developed, and have been identified by the National Wetland Inventory as potential wetland restoration areas. Table 6 shows there is some opportunity to increase wetlands in each flood zone – an increase of about 14% to 15% depending on the Climate Future. Potential wetlands compared to three Climate Futures are shown in Maps 11, 12, and 13.

Wetlands under 5 acres in size are considered unprotected, as they are not currently regulated by any local or state process. In aggregate, small wetlands can still have a large effect on the ecosystem's flood control. Table 6 shows the Township has between 80 to 90 acres of unprotected wetlands in areas likely to flood in each Climate Future, totaling over one-third of the Township's total unprotected wetlands. Unprotected wetlands are shown in Maps 14, 15, and 16.

Table 6. Wetlands Summary

	Lucky		Expected		Perfect Storm	
	Acres	% of total wetland type	Acres	% of total wetland type	Acres	% of total wetland type
Existing Wetlands	1,390	41%	1,394	41%	1,399	42%
Potential Wetlands	199	6%	201	6%	216	6%
Unprotected Wetlands	82	33%	89	36%	91	37%

WETLANDS AT RISK

It is difficult to estimate the impacts of future development on existing and potential wetlands, given the site-specific permitting process currently in place. That is, it is impossible to predict how many land owners may apply to develop a wetland area, or how many of those applications may be approved or denied. However, the project team was able to demonstrate the impact future development may have on wetlands by visually showing the wetlands on or near properties with room for development under current zoning. Map 17 shows existing wetlands and nearby areas that are open, under current zoning, for development. Many existing wetlands in the Township are near areas open to development.

If the Township pursues development in line with Best Management Practices, fewer existing wetlands are at risk as seen by comparing the orange and purple points in Map 17.

TREE CANOPY

Trees help absorb some inundation during times of flooding. In addition to flood mitigation, tree canopies reduce heat by providing shade and wildlife habitat, improving air quality, and adding aesthetic value. The Township has 11,168 acres of land covered by tree canopy.

The purpose of this tree canopy analysis is to roughly estimate the area on public properties and road right of ways that might be forested to better mitigate increased flooding and its associated impacts. It may lay a groundwork for future research into areas that could be strategically reforested to help reduce flood risk. Table 7 shows the acres of existing and potential tree canopy in each Climate Future.

This tree canopy analysis shows the potential for increased tree canopy on public properties and road right of ways (i.e., not including private property) in each flood zone. Map 18 shows the existing and potential tree canopy used in this analysis. In general, tree planting is a weak strategy for flood reduction in the Township, as the potential tree canopy is only three acres in each Climate Future. The high acreage of existing tree canopy suggests maintaining existing tree canopy is a key strategy the Township can use to increase resiliency.

Table 7. Tree Canopy Analysis

	Lucky	Expected	Perfect Storm
Existing Tree Canopy (Acres)	636	710	728
Potential Tree Canopy (Acres)	3	4	4
% of Potential Tree Canopy Increase	1%	0.5%	0.5%

IMPERVIOUS SURFACES IN AREAS LIKELY TO FLOOD

Impervious surfaces have a well-understood negative impact in a flood event. The increased runoff can exacerbate the risk of structural damage and reduce regional water quality. This is an especially important variable to consider in a flood zone. Impervious surface includes building footprints as well as sidewalks, driveways, and roads.

The purpose of this analysis is to roughly estimate the percentage of each flood zone that is currently impervious. These numbers only reflect current conditions and can be seen as conservative in light of inevitable future growth.

The Township has, compared to nearby urbanized areas, a low proportion of impervious surface as shown in Map 19. Table 8 shows a nominal percentage of each Climate Future’s flood area is paved. Studies recommend the percentage of impervious surface in any general area be below 10% to remain protected from harmful amounts of runoff.[83] This analysis suggests the Township should work to prevent large increases in impervious surface, especially in the Climate Future areas subject to flooding.

Table 8. Impervious Surfaces in Acres

	Lucky	Expected	Perfect Storm
Impervious Surface (Acres)	5	11	13
% of Impervious Land in Each Climate Future	0%	1%	1%

CRITICAL DUNE AREAS IMPACTED BY FLOODING

Critical Dune Areas are important assets for the Grand Haven Community and, due to their soil composition, may be especially vulnerable to damage from flooding. Our intent is to provide some base of analysis for the future health of Critical Dunes, especially as development on Critical Dunes is likely to increase due to weakened regulations noted earlier.

While it is impossible to predict the number and scope of development permits that may be granted in the future, the project team was able to provide some insight into parcels that may be developed in or near Critical Dune Areas (Maps 20 and 21).

Table 9 shows that relatively few acres of Critical Dune Area would be impacted by flooding in any of the Climate Futures analyzed. Around 10% of the Critical Dune land is impacted under Expected and Perfect Storm Climate Futures. While this analysis does not investigate how dune land behaves during flooding, the proportion of dune land in each flood zone is useful information for planning future development in the Township.

Perhaps more importantly, the potential for development in and near Critical Dune Areas is very high. Map 20 shows the "Build-out According to Current Zoning" management option in relation to Critical Dune Areas. It is clear the Grand Haven Community has intense build-out potential in areas designated as Critical Dunes. The Township should consider methods, as recommended in the next section, to restrict this potential for development. Map 21 shows the build-out potential of the Township in relation to Critical Dune Areas if the Township builds out according to Best Management Practices. Still, great potential for development is clustered in or near Critical Dune Areas, suggesting the Township should consider new methods, beyond what is modeled here, to address this concern.

Table 9. Critical Dune Areas

	Lucky	Expected	Perfect Storm
Critical Dune (Acres)	56	198	198
% of land in each climate future designated Critical Dune	3%	10.4%	10.2%

HIGH RISK EROSION AREAS IMPACTED BY FLOODING

Nearly the entirety of Grand Haven Township's shoreline is designated as a High Risk Erosion Area (HREA). As part of this study, we compared HREAs in the Township with VE zones, the zones designated in the Great Lakes Coastal Flood Study as having strong, high velocity waves that could increase the pace of erosion. Map 22 shows the areas along the coastline designated as an HREA as a line offset from the shore. The map also shows areas designated as a VE zone in the Great Lakes Coastal Flood Study.

[83] Flinker, AICP (2010). The Need to Reduce Impervious Cover to Protect Water Quality. Web. Accessed July 2015.

FISCAL RESULTS

The fiscal analysis is meant to give Grand Haven Charter Township an idea of the tax revenue, property values, and potential fiscal risk generated by residential homes in high risk flood areas. Using the project framework in Figure 1, the fiscal analysis determines the risk and benefit of development in coastal areas in the Lucky, Expected, and Perfect Storm Climate Futures under the various management options. For the ease of the reader, the results are organized in steps. First, the existing revenue generated by properties in high risk flood areas is identified. Next, the cost associated with public services and potential damages from flooding is calculated. Finally, the revenue (positive value) and costs (negative value) are added together to produce an overall net value. The end result of the fiscal study shows the net value as a negative number in each flood scenario. In other words, regardless of how extreme future flooding may be, the costs of servicing and repairing coastal properties outweigh the fiscal benefits to the Township.

In addition to analyzing existing properties, the project also estimated the fiscal conditions of homes that could be built in the Township under the current zoning classifications. To do this, the team used simply assigned a “future” property the average fiscal conditions of properties within a quarter mile radius of the future development.

STEP ONE: IDENTIFY THE REVENUE

There are two kinds of revenue looked at in this fiscal analysis. First, the share of the Township’s tax base residing in high risk flood areas was identified using the SEV or State Equalized Value. Second, this analysis identified the total property tax revenue the Township collects for homes located in high risk flood areas under each Climate Future and Management Option.

COMPARING THE TAX-BASE USING SEV VALUES

The number of properties and share of the tax-base impacted by flooding under the Lucky, Expected, and Perfect Storm Scenarios are included in Tables 10, 11, and 12. Each table shows a different management option.

Under current conditions (Table 10), only 0.27% of properties may be impacted under the Lucky Climate Future. If the Township builds to fully maximize its current zoning ordinance (Table 11), about 2.86% of properties may be impacted under the Perfect Storm Climate Future. If the Township grows instead according to Best Management Practices (Table 12), about 1.4% properties may be inundated in the Perfect Storm Climate Future.

The SEV of properties at risk is proportionately higher than properties not at risk under the various scenarios. In other words, a property in a high risk flood area tends to have a higher SEV than properties elsewhere in the Township. For example, if the Township builds to fully maximize its current zoning ordinance (Table 111), 385 homes are likely to flood in the Perfect Storm Climate Future. Those properties comprise 2.86% of the Township’s total stock yet 3.01% of the Township’s total SEV.

Table 10. Comparing the Taxbase under the Current Infrastructure Management Option

	Lucky	Expected	Perfect Storm
# of Properties Impacted by Flooding	23	96	119
# of Properties Outside the Flooded Area	8,636	8,563	8,540
Share of Flooded Properties (compared to total)	***0%***	***1.1%***	***1.4%***
Total SEV of Properties Impacted by Flooding ($)	20,460,600	56,208,600	59,617,400
Total SEV of Properties Outside the Flooded Area ($)	3,774,088,250	3,738,340,350	3,734,931,450
Share of Total SEV located in Flooded Areas	***1%***	***1.5%***	***1.6%***

Table 11. Comparing the Taxbase under the Build-Out According to Current Zoning Ordinance Management Option

	Lucky	Expected	Perfect Storm
# of Properties Impacted by Flooding	186	347	385
# of Properties Outside the Flooded Area	13,655	13,494	13,456
Share of Flooded Properties (compared to total)	***1%***	***2.6%***	***2.9%***
Total SEV of Properties Impacted by Flooding ($)	50,283,817	137,149,006	141,818,332
Total SEV of Properties Outside the Flooded Area ($)	4,805,355,624	4,471,490,435	4,713,821,109
Share of Total SEV located in Flooded Areas	***1%***	***2.9%***	***3.0%***

Table 12. Comparing the Taxbase under the Build-Out According to Best Management Practices Management Option

	Lucky	Expected	Perfect Storm
# of Properties Impacted by Flooding	29	145	171
# of Properties Outside the Flooded Area	12,398	12,282	12,256
Share of Flooded Properties (compared to total)	***0%***	***1.2%***	***1.4%***
Total SEV of Properties Impacted by Flooding ($)	22,618,123	82,589,741	86,241,018
Total SEV of Properties Outside the Flooded Area ($)	5,416,430,586	4,580,325,594	4,576,674,317
Share of Total SEV located in Flooded Areas	***0%***	***1.8%***	***1.9%***

PROPERTY TAX GENERATED BY HIGH-RISK PROPERTIES

The dollar amount of property tax revenue Grand Haven Charter Township collects from properties impacted under the various scenarios are presented in Table 13. This analysis shows the Township currently benefits from floodplain development in significant way (ranging from about 90,000 to 638,000 dollars depending on the extent of the flooding and management option). On one hand, the Township could gain significant tax revenue by encouraging development in high risk areas according to current zoning ordinances. However, by restricting development in high risk areas using Best Management Practices, the Township would still gain considerable tax revenue (around 388,000 dollars).

Table 14 shows the values of Table 13 in a standardized form to allow for an easier comparison between categories.

Table 13. Property Tax Revenue Collected by the Township

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	92,011	252,770	268,099
Build-Out According to Current Zoning *(Additional Tax Revenue)*	226,126	616,759	637,757
Build-Out According to Best Management Practices *(Additional Tax Revenue)*	101,713	371,406	387,825

Table 14. Property Tax Revenue Collected by the Township, Standardized

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	1.0	2.7	2.9
Build-Out According to Current Zoning *(Additional Tax Revenue)*	2.5	6.7	6.9
Build-Out According to Best Management Practices *(Additional Tax Revenue)*	1.1	4.0	4.2

STEP TWO: IDENTIFY THE COST

This analysis identified two kinds of costs for development in floodplains: the public cost to serve developments in high risk areas and the cost of flood damages based on depth of flooding and wave action. In the next step, these costs are summed together and compared to the revenue identified in step one.

PUBLIC SERVICE COST

Information on the Township's annual public cost to provide services is public information found in annual financial reports. The public cost included in the Table 15 is found by dividing the Township's total government expenses by the number of properties, and then multiplying by the number of properties impacted by flooding in each scenario.

In general, the Township spends nearly $10,000 to serve current residences in the Lucky Climate Future. If the Township builds out according to its current zoning ordinance, the public service cost would increase to about $167,000. If the Township builds out according to Best Management Practices, however, the public service cost would be around $74,000.

Table 16 shows the values of Table 15 in a standardized form to allow for an easier comparison between categories.

Table 15. Public Cost to Serve Development

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	9,956	41,555	51,511
Build-out According to Current Zoning	80,513	150,204	166,653
Build-out According to Best Management Practices	12,553	62,765	74,020

Table 16. Public Cost to Serve Development, Standardized

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	1.0	4.2	5.2
Build-out According to Current Zoning	8.1	15.1	16.7
Build-out According to Best Management Practices	1.3	6.3	7.4

DIRECT BUILDING DAMAGE

The project team developed a simple, repeatable method to estimate the cost of damages to properties in flooded areas. The method relies on the Base Flood Elevations and Wave Run-Up Heights to inform the depth and extent of flooding in the Township. Each flooded property was then assigned a percentage of damage based on its depth of flooding. The percent damage estimate is based on the Depth Damage Curves developed by the United States Army Corps of Engineers. A cost, using the property's SEV, was assigned to all properties impacted by flooding under the scenarios. The direct building damage estimates are shown in Table 17. A range of damage estimates are listed for the Current Infrastructure Management Option.

As Table 17 shows, the estimated damage costs escalate dramatically between the Lucky and Expected Climate Futures (from 560,000 dollars to upwards of 50 million dollars as a high estimate). However, by building out according to Best Management Practices, impacted properties would incur substantially less damage (from 1.5 to 35 million dollars) than if no Best Management Practices were implemented.

Table 18 shows the average value of each range in Table 17 in a standardized form to allow for an easier comparison between categories.

Table 17. Approximate Cost of Building Damages Caused by Flooding in High-Risk Areas

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	560,000	600,000 to 2 Million	2 to 53 Million
Build-out According to Current Zoning	11 Million	38 to 113 Million	59 to 121 Million
Build-out According to Best Management Practices	500,000	1.5 to 35 Million	3 to 36 Million

Table 18. Approximate Cost of Building Damages Caused by Flooding in High-Risk Areas, Standardized

	Lucky	Expected	Perfect Storm
Current Infrastructure and Development	1	92.9	94.6
Build-Out According to Current Zoning	20.6	294.6	310.7
Build-Out According to Best Management Practices	2	155.4	158.9

STEP THREE: COMPARE REVENUES AND COSTS

Steps One and Two identified likely revenues and costs for properties impacted by flooding under the various scenarios. In Step Three, the revenues and costs are compared in order to provide a greater understanding of the overall fiscal risk associated with floodplain development.

As Table 19 shows, the revenue gained from floodplain development each year far outweighs the cost to provide public services to floodplain properties. However, the damage incurred during times of flooding is exponentially higher than the net annual revenue. In other words, if damaged, the cost of building in high risk areas far outweighs the fiscal benefits the Township receives. The fiscal risk is lowered if the Township adopted Best Management Practices and restricts new development accordingly.

Table 19. Summary of Fiscal Conditions in Grand Haven Township

	Total Annual Revenues	Total Annual Costs	Net Annual Revenue	Potential Damage Cost
Management Option 1: Current Infrastructure and Development				
Lucky	97,996	9,956	*88,041*	*560,000*
Expected	277,751	41,555	*236,196*	*52,000,000*
Perfect Storm	299,066	51,511	*247,555*	*53,000,000*
Management Option 2: Build-Out According to Current Zoning				
Lucky	274,527	80,513	*194,015*	*11,560,000*
Expected	707,057	150,204	*556,852*	*165,000,000*
Perfect Storm	737,943	556,852	*571,290*	*174,000,000*
Management Option 3: Build-Out According to Best Management Practices				
Lucky	109,260	12,553	*96,708*	*1,060,000*
Expected	409,138	62,765	*346,373*	*87,000,000*
Perfect Storm	432,324	74,020	*358,304*	*89,000,000*

RECOMMENDATIONS

The analysis presented above modeled only several of many Best Management Practices. Yet, even these minimal interventions greatly reduced the land use and environmental assets at risk as the community and the climate continues to change. The goal of this exercise was to identify how the order of magnitude changes as flood risks rise. By implementing Best Management Practices, this analysis suggests the land use and environmental risks can be largely addressed.

Following is a list of Best Management Practices collected from other research throughout the state. This list is in not comprehensive, and each recommendation needs further research to determine if it is appropriate in either community.

These recommendations are summarized around six key areas of focus:

- Private Property
- Public Health
- Emergency Management
- Public Infrastructure
- Natural Resources and Ecosystem Services
- Water Quality

PROTECTING PRIVATE PROPERTY

a. Public acquisition of repetitive loss areas or areas identified as at risk for coastal flooding. Develop these areas as parks, trails, or other community amenities that can withstand temporary flooding and inundation.

b. Participate in the FEMA Community Rating System and set benchmarks to increase score.

c. Adopt a local wetland ordinance to protect smaller wetlands (less than 5 areas) to promote wetland services in neighborhoods.

d. Require that state and local wetland permits are obtained prior to a zoning amendment approval.

e. Enact deed restrictions stating the existence of an environmentally sensitive area on public property.

f. Encourage implementation of green infrastructure through incentives, stormwater utility fees and stormwater credit manuals.

g. Encourage cluster development that allows structures to be sited in less vulnerable coastal areas.

h. Adopt performance standards that minimize on-site soil and vegetative disruptions.

i. Implement a Transfer of Development Rights program, where development rights are transferred to inland areas away from coastal hazards.

j. Implement a Purchase of Development Rights program by working with a land bank or conservation district in order to purchase rights to development in areas at risk for coastal zone flooding.

PROTECTING PUBLIC HEALTH

k. Disconnect combined sewer system (stormwater and sanitary).

l. Provide incentives for on-site stormwater treatment to reduce standing water.

m. Increase capacity of stormwater sewer system to handle heavier precipitation events.

EMERGENCY MANAGEMENT

n. Regularly update the County Hazard Mitigation Plan to address coastal hazards and dynamic coastal conditions.

o. Ensure at least one municipal staff employee is a certified floodplain manager.

p. Convene collaborative discussions to integrate emergency management planning and land use planning from a climate adaptation perspective.

q. Implement and test emergency communications systems.

r. Identify public locations with back-up power supplies.

s. Require homes in areas prone to flooding and/or storm events to have back-up power supplies.

t. Ensure all large institutions have an all-hazards plan.

PROTECTING PUBLIC INFRASTRUCTURE

u. Update design standards to build roads, culverts, and bridges in adherence with updated precipitation tables.

v. Do not allow public infrastructure to be built in Special Flood Hazard Areas, VE zones, AE zones, AO zones, or X zones.

w. Ensure critical facilities are sited outside the VE/AE zones.

x. Encourage development to occur in high, vertical density in areas where infrastructure is available. This will help ensure the protection of natural spaces and help local governments maintain valuable infrastructure.

PROTECTING NATURAL RESOURCES AND MAXIMIZING ECOSYSTEM SERVICES

y. Identify high priority public lands for wetland restoration and apply for MDEQ grants to fund restoration projects.

z. Conduct a community inventory of environmentally sensitive areas and create 50-foot buffers around all environmentally sensitive areas.

aa. Require native vegetation on coastal properties, particularly near Critical Dune Areas and other environmentally sensitive areas.

bb. Zone for low intensity and low density around environmentally sensitive areas.

cc. Adopt a local soil erosion and sedimentation control ordinance.

dd. Adopt a stormwater control ordinance for stormwater retention and treatment.

ee. Adopt overlay zones, including: prohibition of off-road vehicles; special use permits and developments in well-protected and vegetative areas behind foredunes; impervious surface restrictions; design standards allowing for raised structures; and native vegetation requirements.

ff. Designate Critical Dune Areas and adopt a local critical dune ordinance to protect these areas.

PROTECTING WATER QUALITY

gg. Require street vacuuming or street sweeping on a regular basis.

hh. Prioritize open space protection through the master plan process for areas that are continuous, provide flood protection, and provide stormwater filtration.

ii. The Master Plan should recognize the relationship between water quality and stormwater management.

jj. Limit percentages of impervious surfaces in new developments (no more than 10%).

kk. Adopt lakeshore setbacks to regulate tree cutting, mowing, and fertilizer use.

ll. Regulate key hole development (large developments with narrow frontage on the water).

CONCLUSION AND NEXT STEPS

Overall, this project outlines a clear way for the Grand Haven Community to identify areas at risk of flooding. It includes a strategy for reasonably assessing build-out potential in relation to flood risk, and evaluates how that risk lowers when each jurisdiction adopts several Best Management Practices as ordinances. These carefully adopted Best Management Practices can make the community more resilient to flood risk in terms of land use (structures, roads, and critical facilities impacted) and environmental assets (wetlands, trees, pervious surface). This analysis suggests that the Grand Haven Community should conduct further research and choose Best Management Practices that best fit the community's unique needs. To that end, this report includes a library of Best Management Practices that could be adopted in this and future master plans, zoning ordinances, and other ordinances.

Map 1. "Lucky" Climate Future

"Lucky" Flood Scenario

1:42,000 — 0, 0.25, 0.5, 1, 1.5, 2 Miles

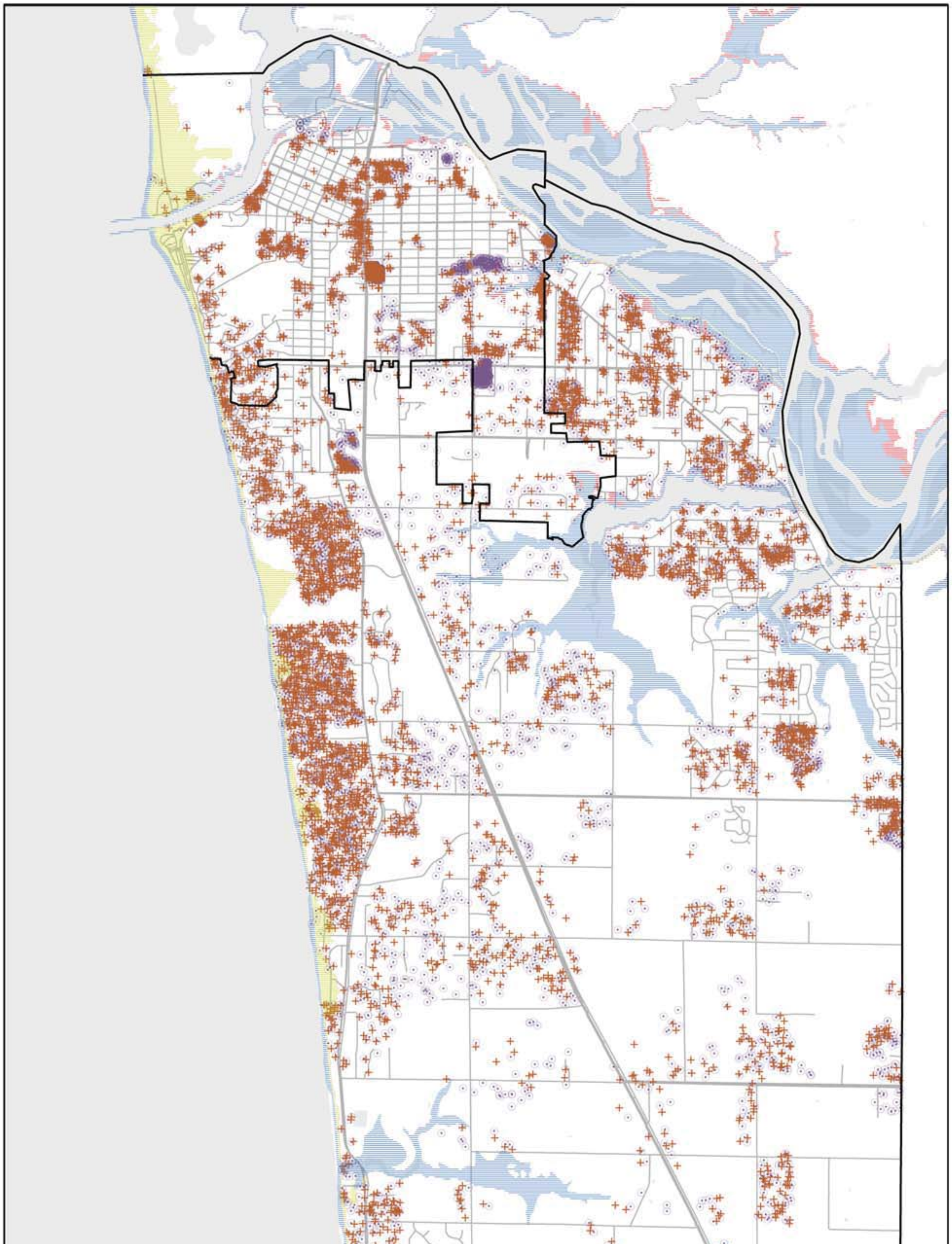
Map 2. "Expected" Climate Future

"Expected" Flood Scenario

1:42,000 0 0.25 0.5 1 1.5 2 Miles

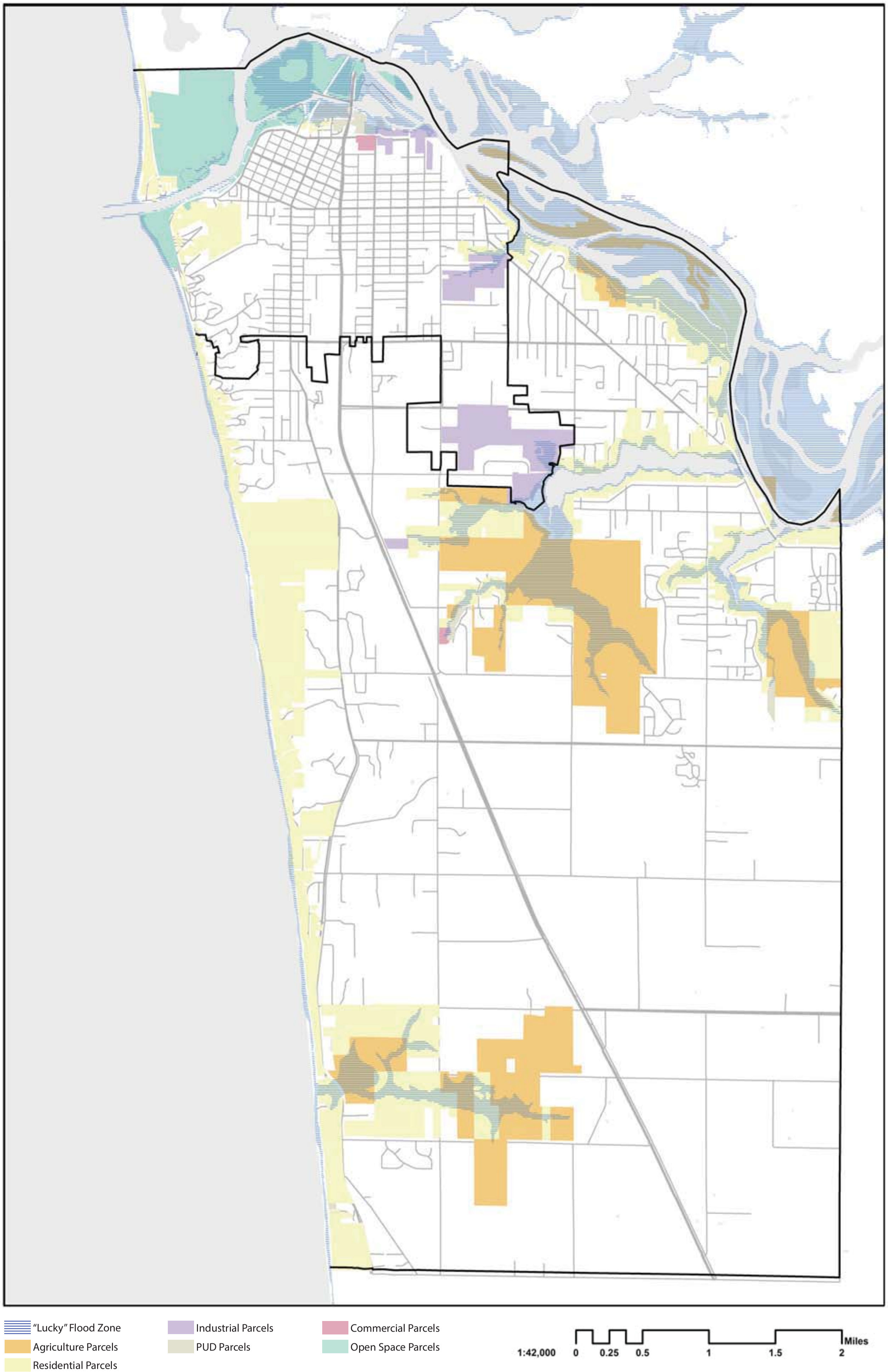
Map 3. "Perfect Storm" Climate Future

Map 4. Build-out Management Options and Climate Futures

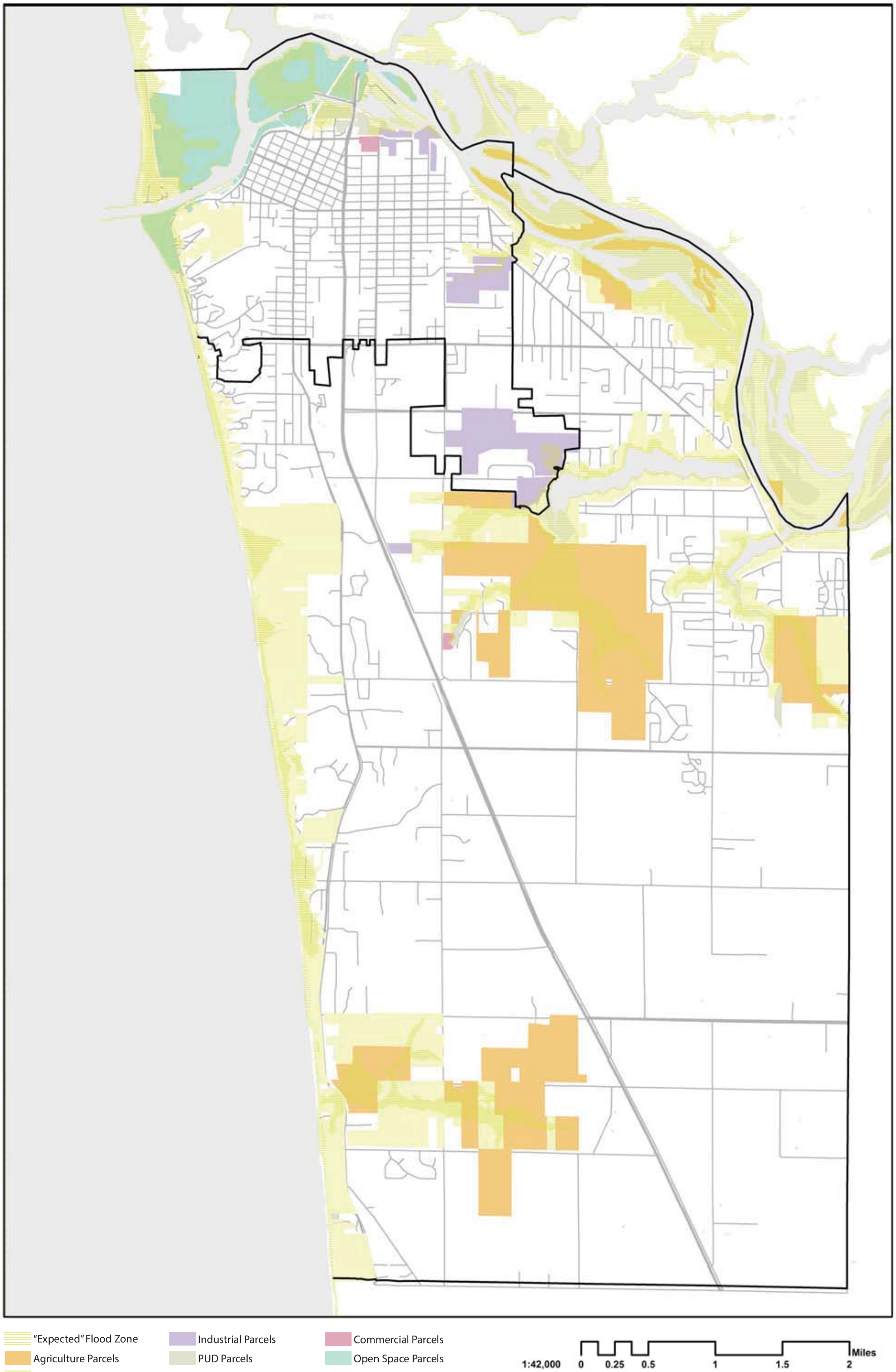


"Lucky" Flood Zone
"Expected" Flood Zone
"Perfect Storm" Flood Zone
Build-out According to Current Zoning
Build-out According to Best Management Practices
1:42,000 0 0.25 0.5 1 1.5 2 Miles

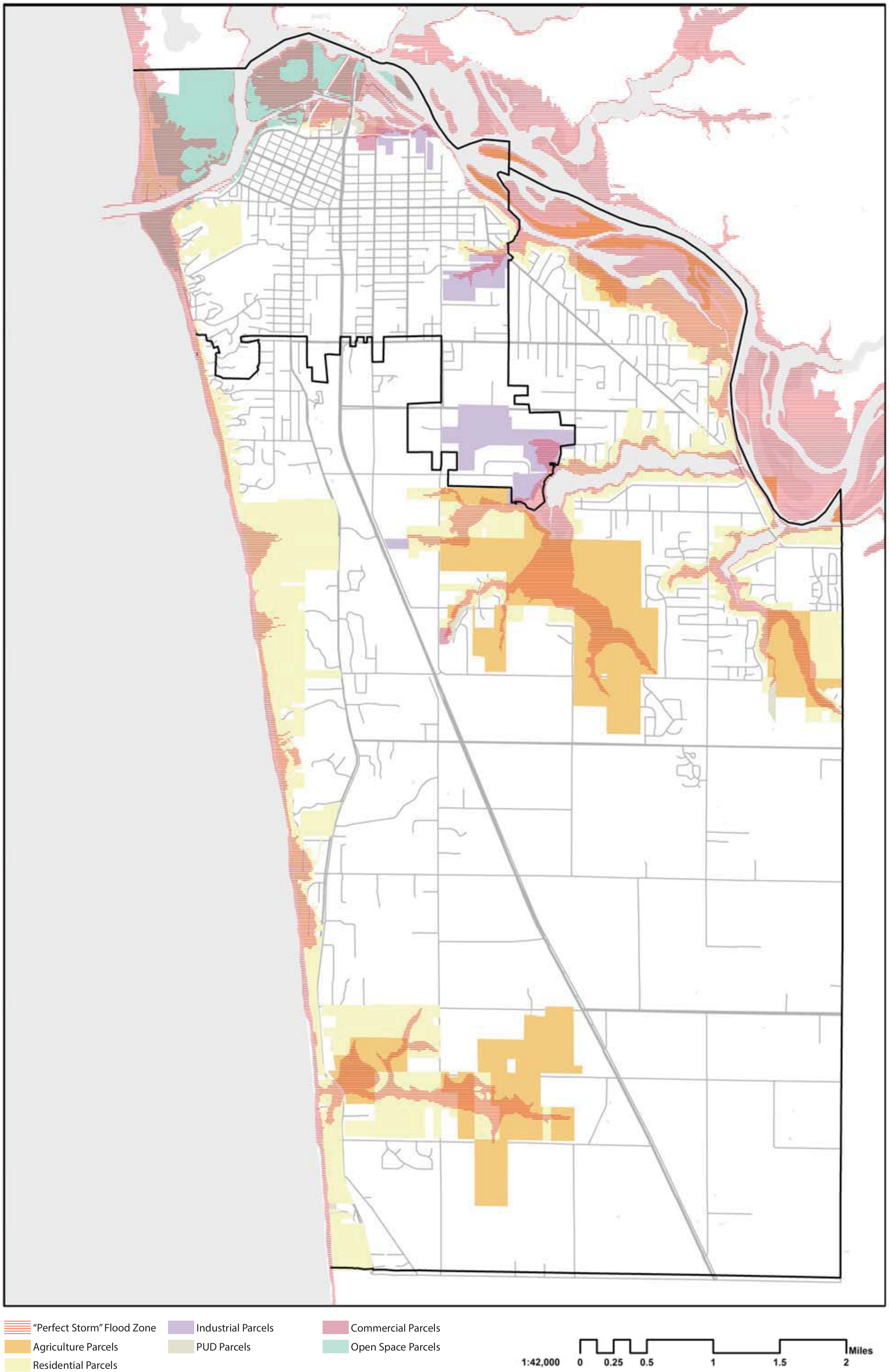
Map 5. Parcels Affected in the "Lucky" Climate Future



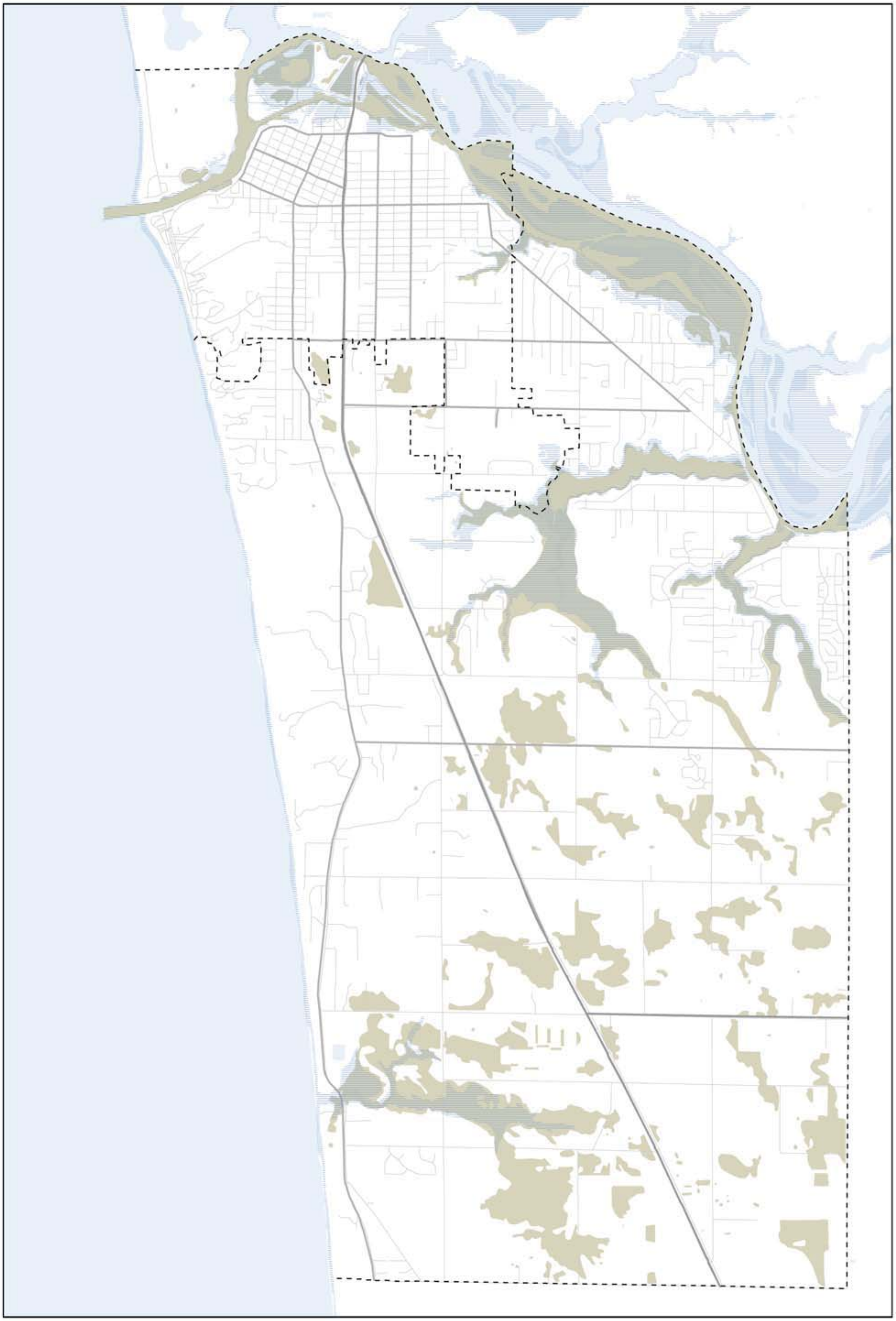
Map 6. Parcels Affected in the "Expected" Climate Future



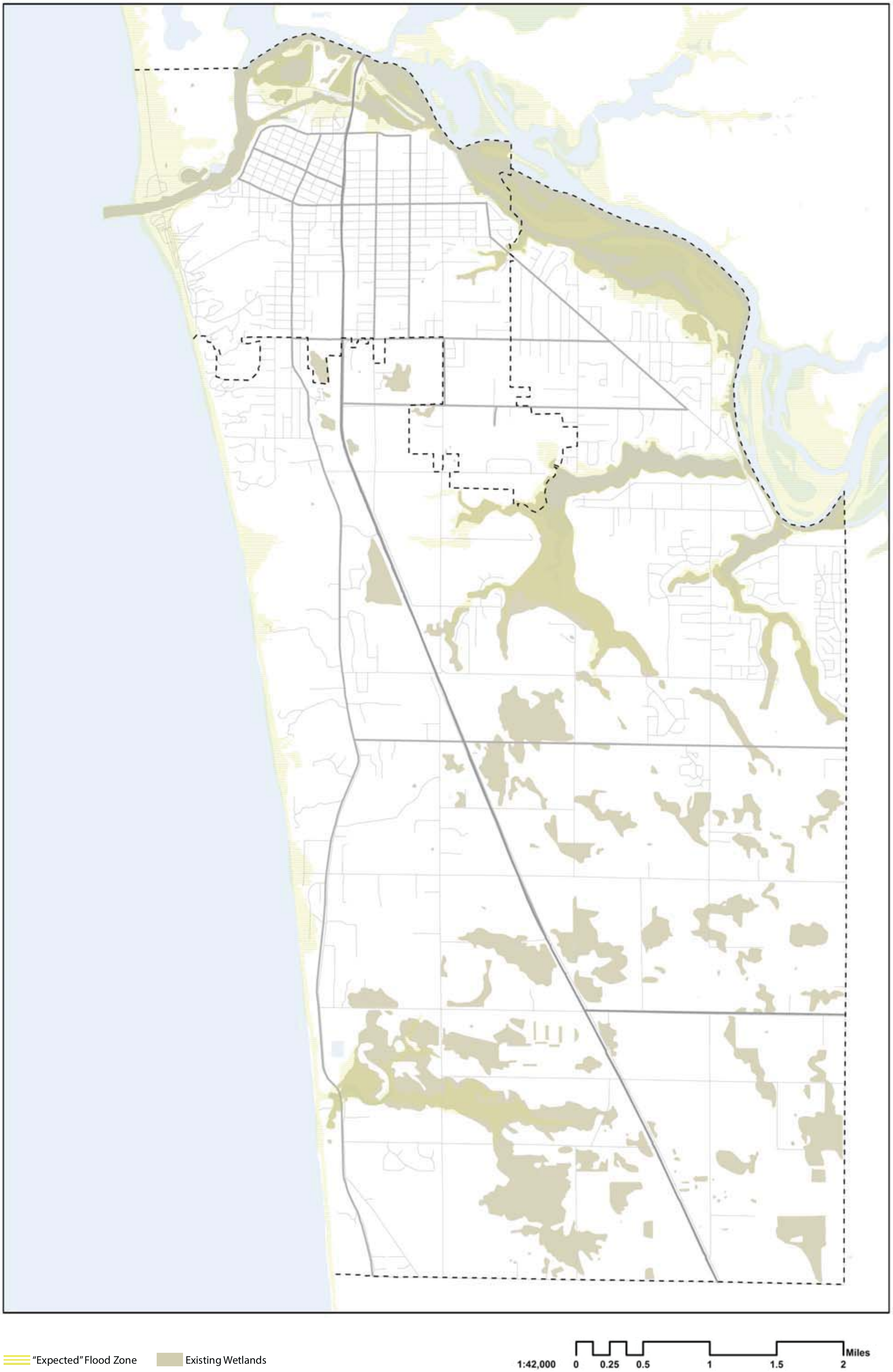
Map 7. Parcels Affected in the "Perfect Storm" Climate Future



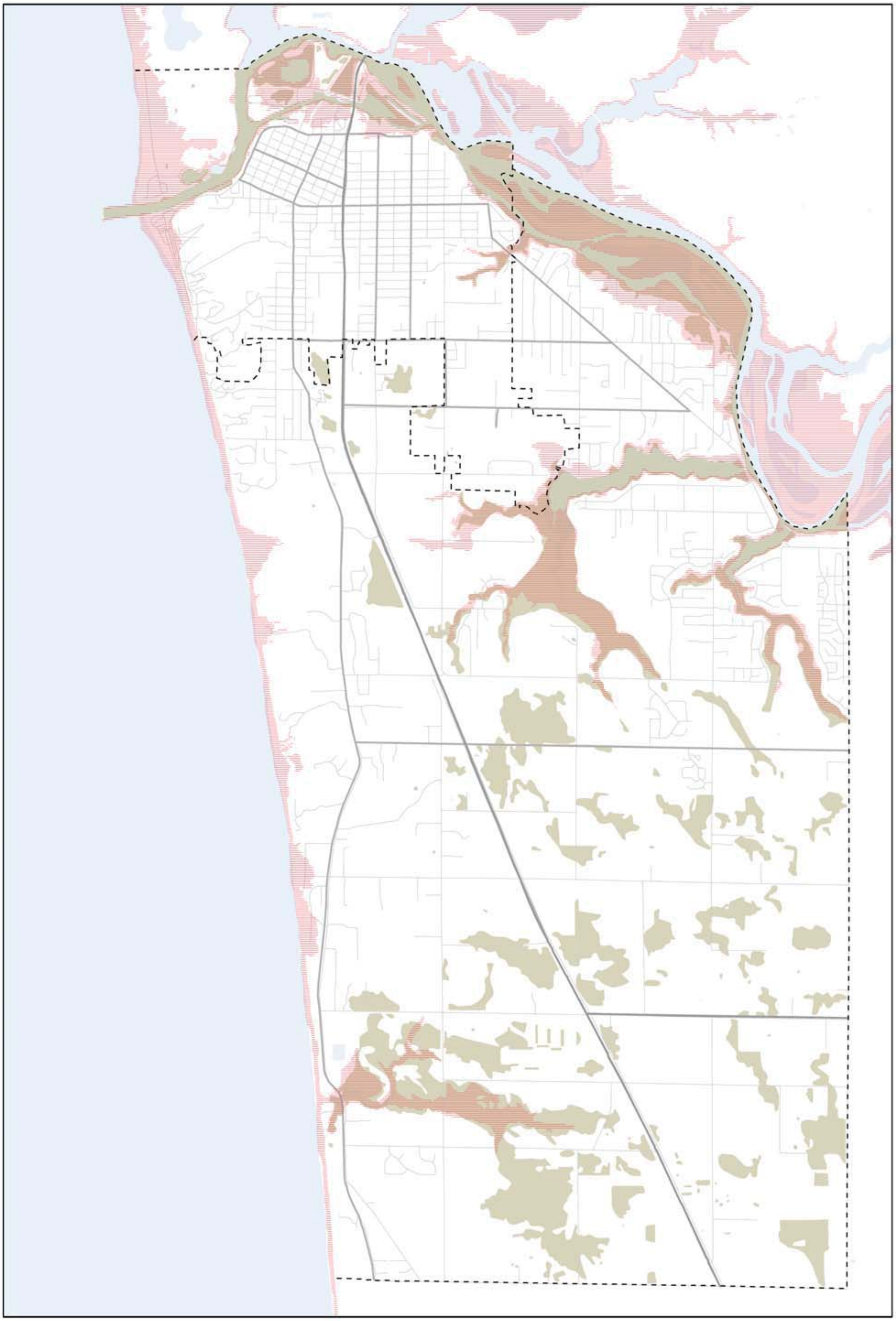
Map 8. Existing Wetlands under "Lucky" Climate Future



Map 9. Existing Wetlands under "Expected" Cimate Future



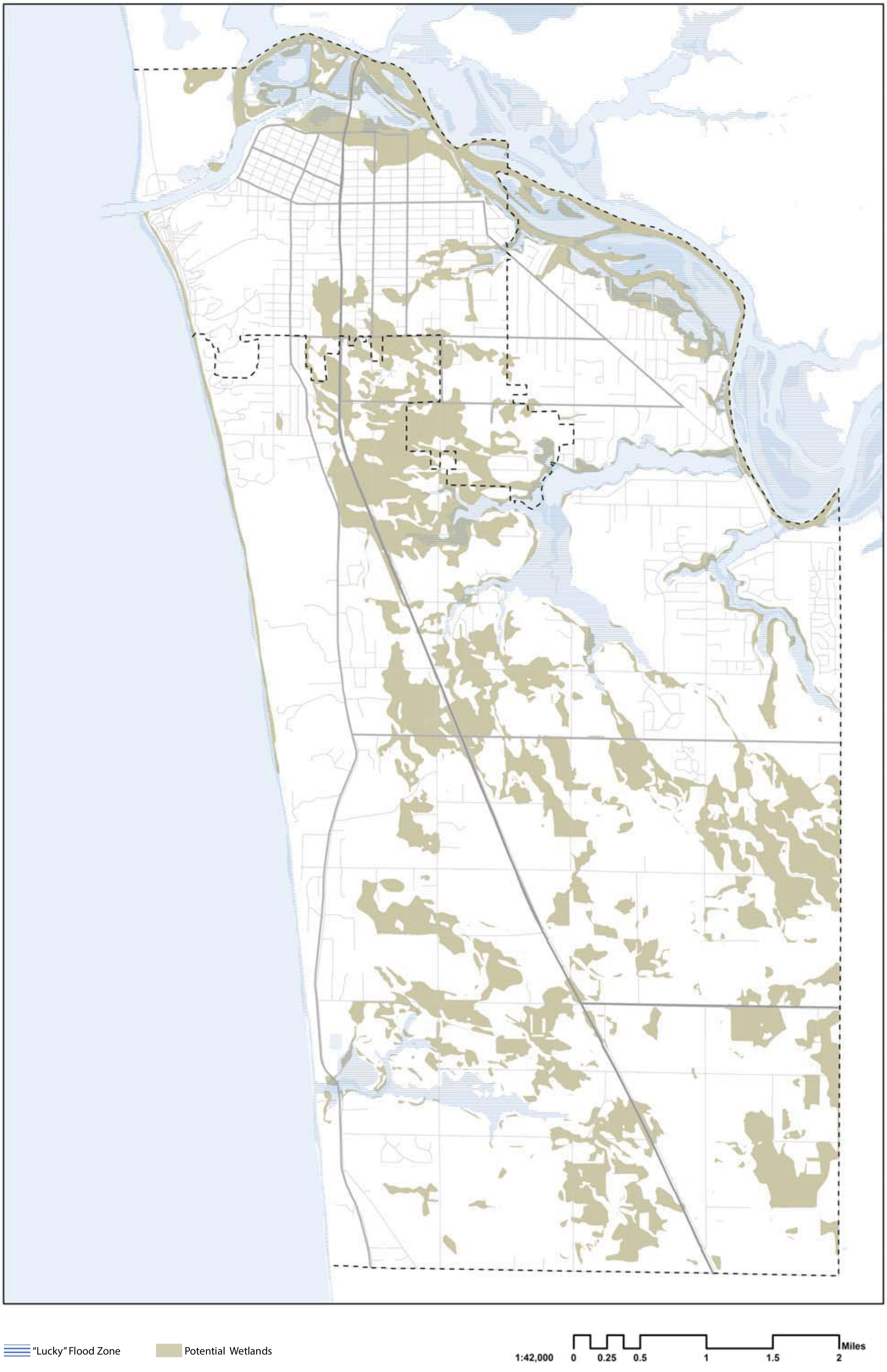
Map 10. Existing Wetlands under "Perfect Storm" Climate Future



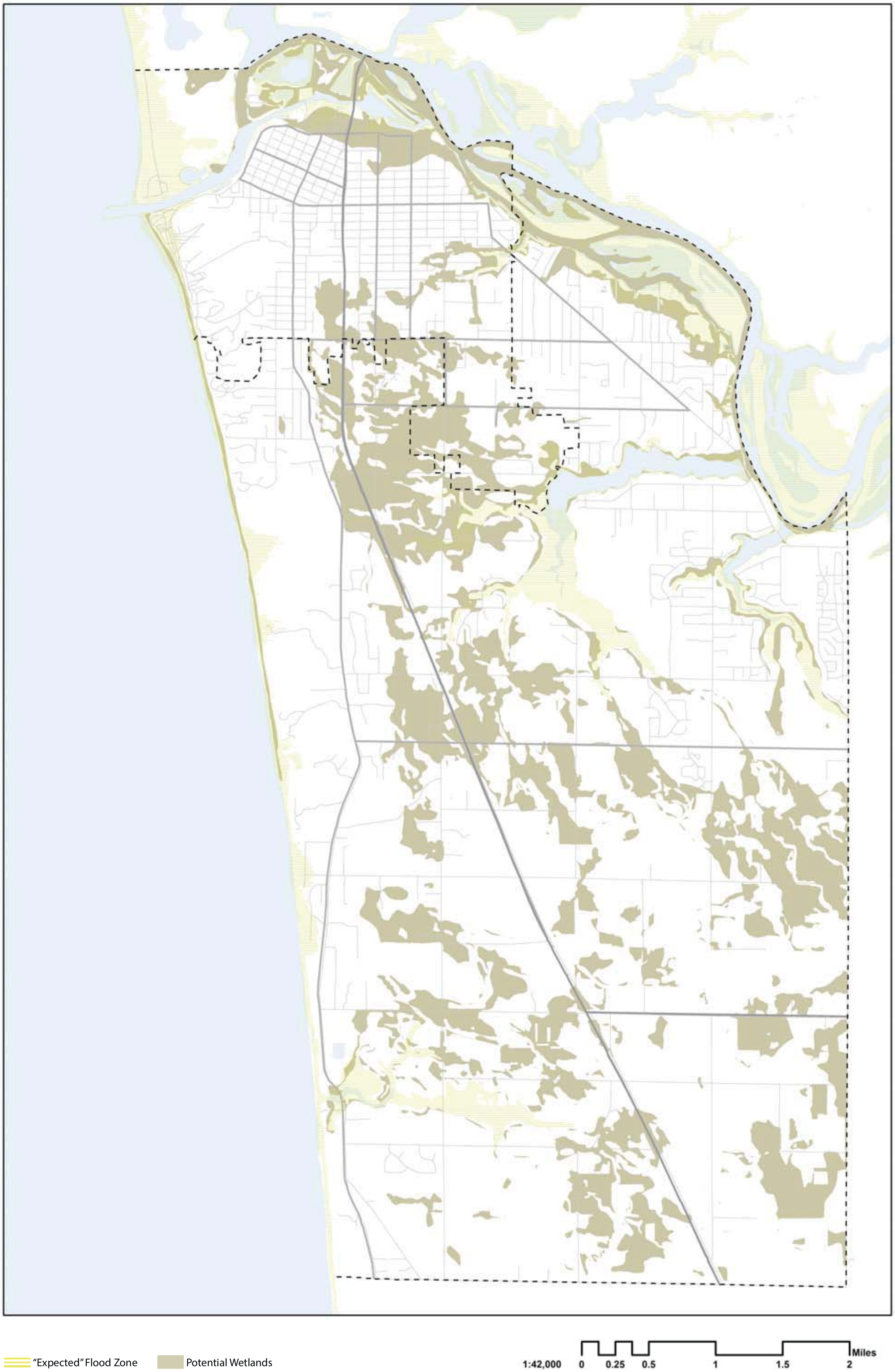
"Perfect Storm" Flood Zone
Existing Wetlands

1:42,000 0 0.25 0.5 1 1.5 2 Miles

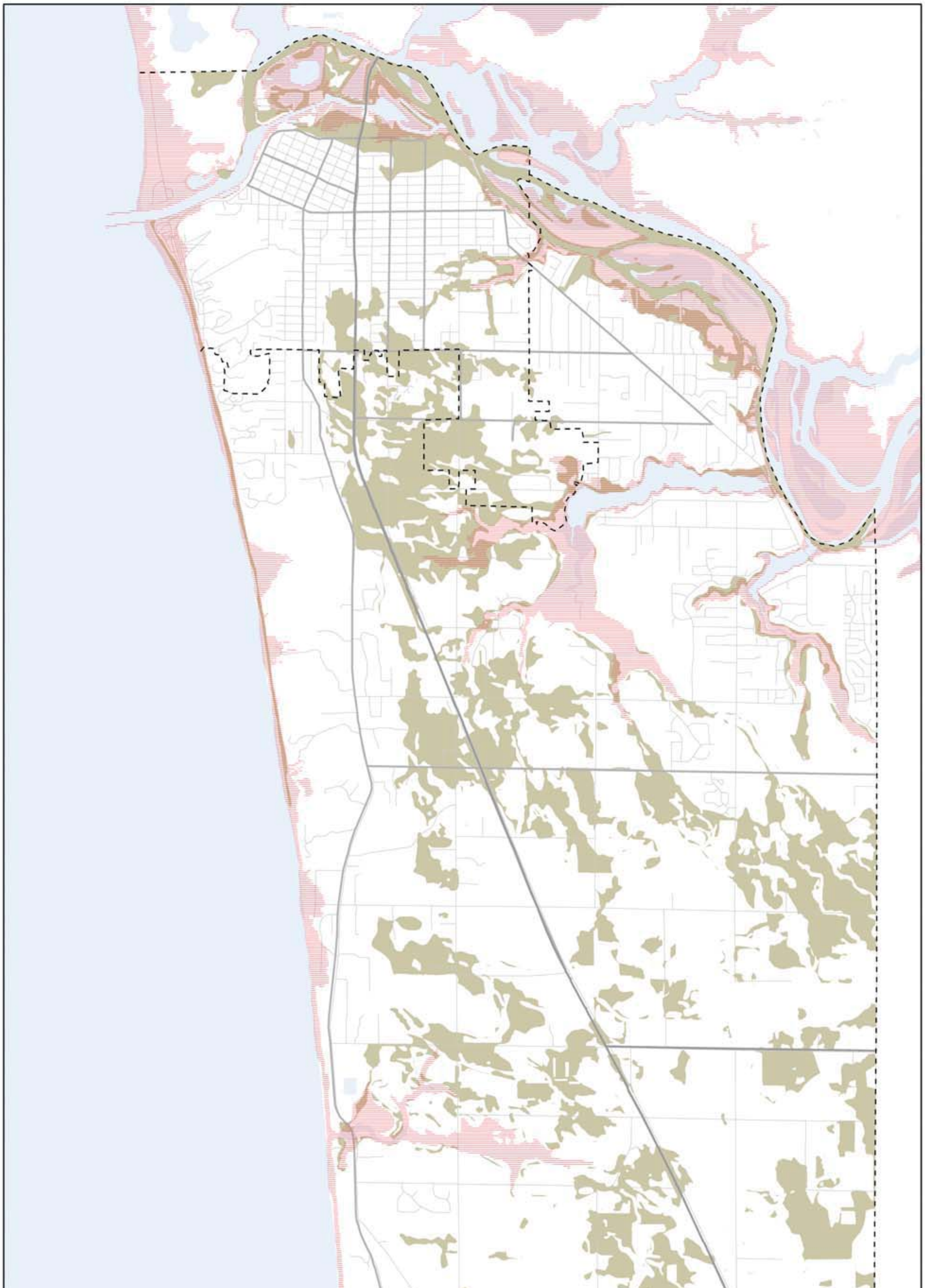
Map 11. Potential Wetlands under "Lucky" Climate Future



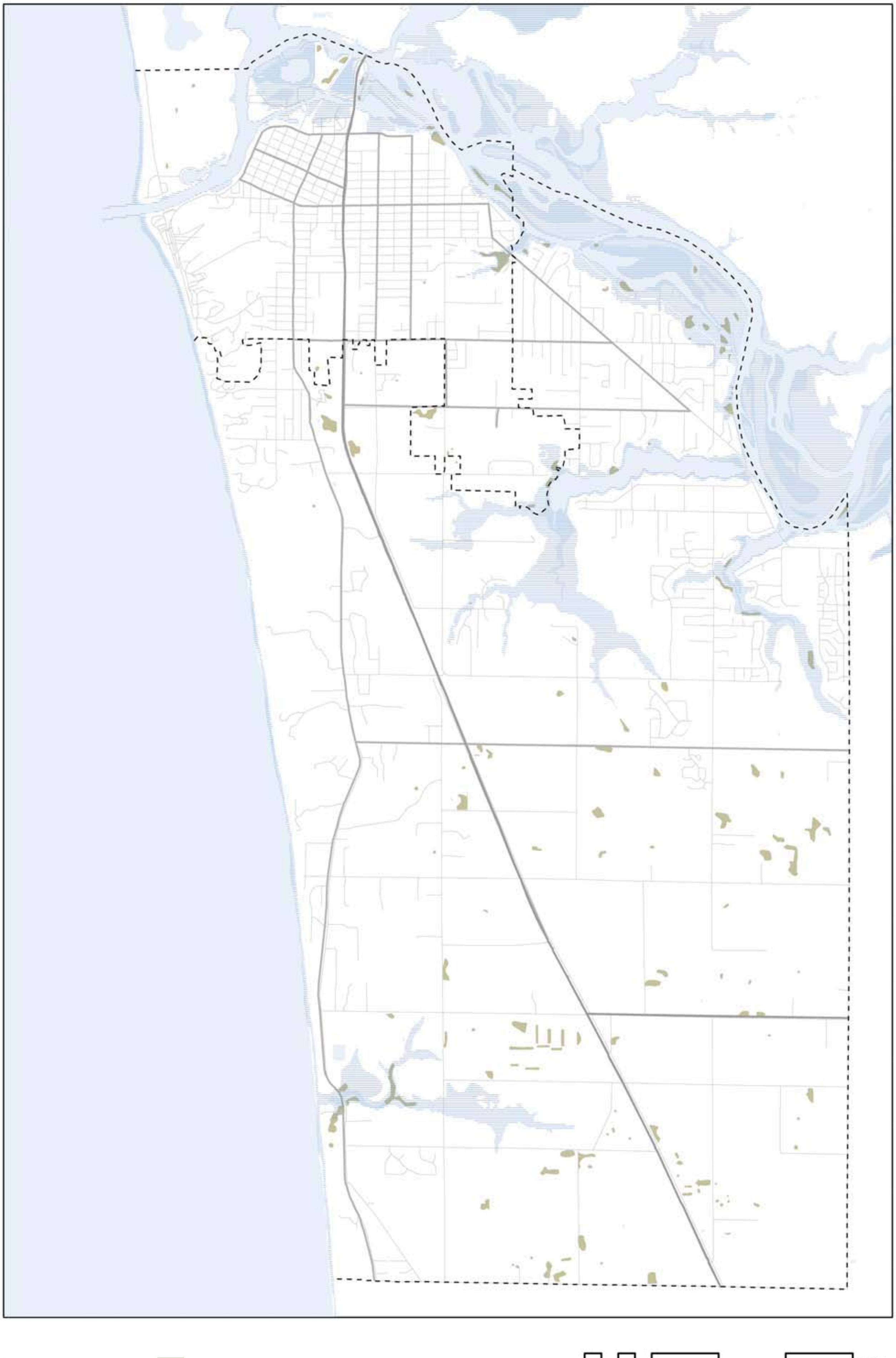
Map 12. Potential Wetlands under "Expected" Climate Future



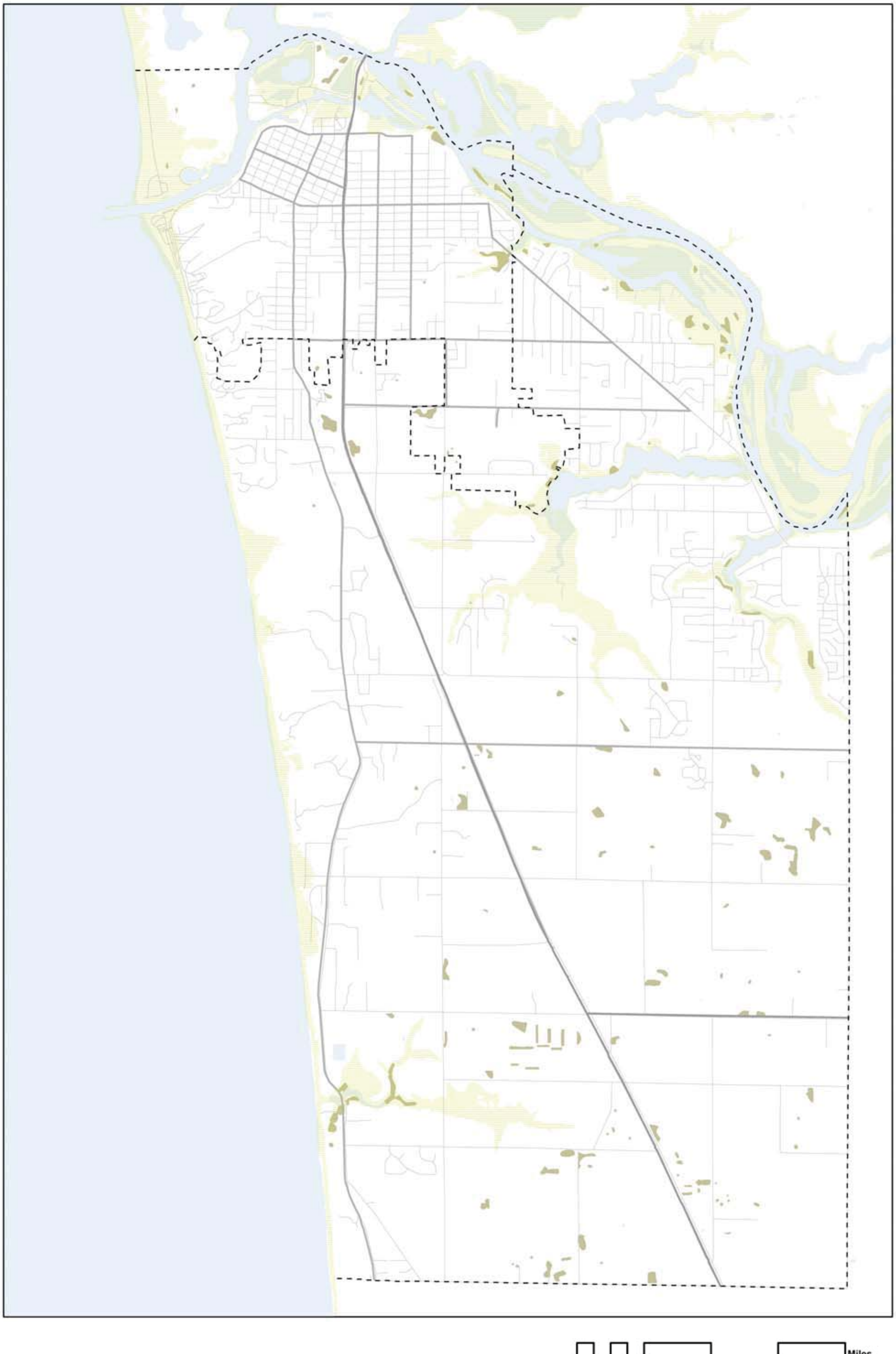
Map 13. Potential Wetlands under "Perfect Storm" Climate Future



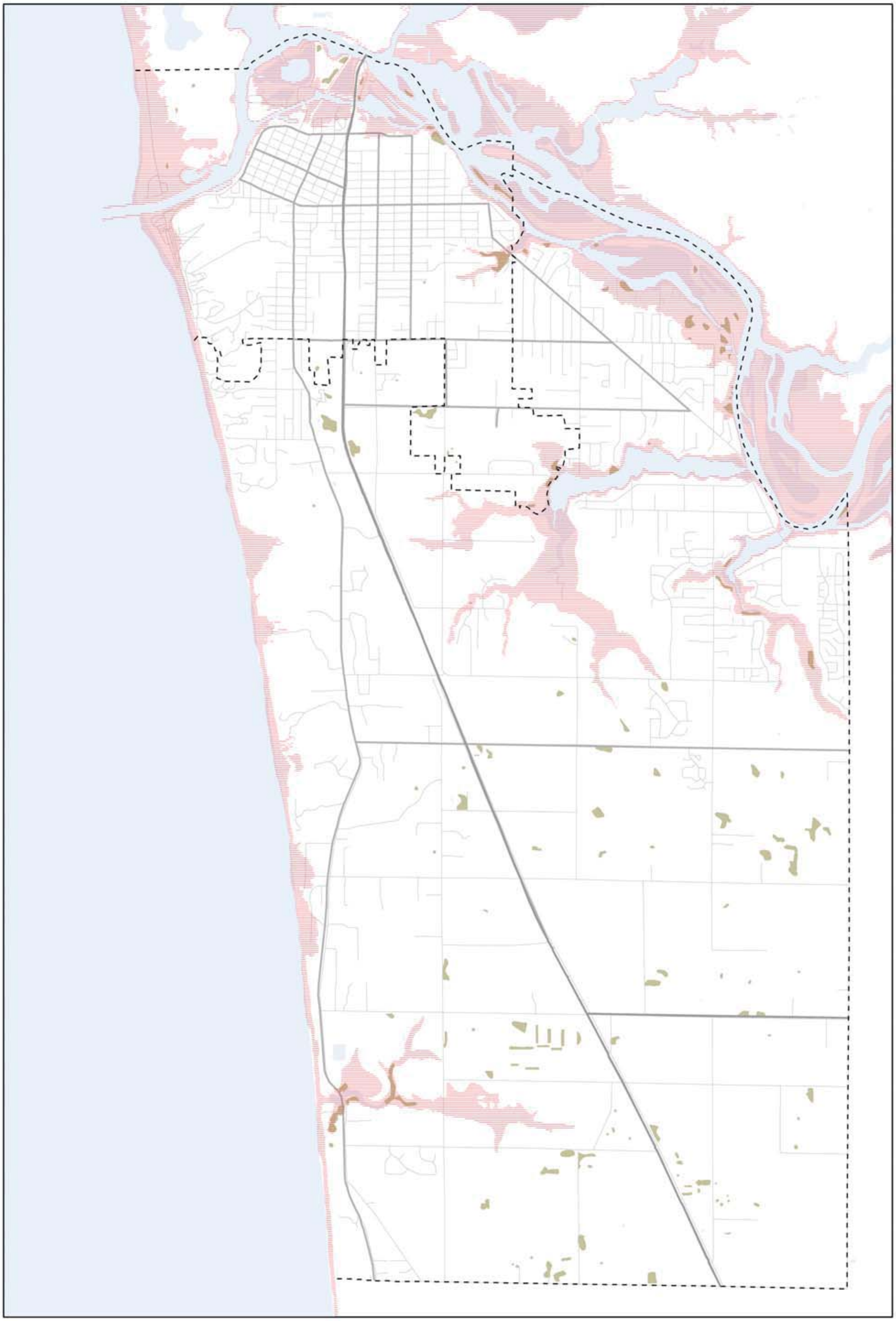
Map 14. Existing Wetlands under 5 Acres under "Lucky" Climate Future



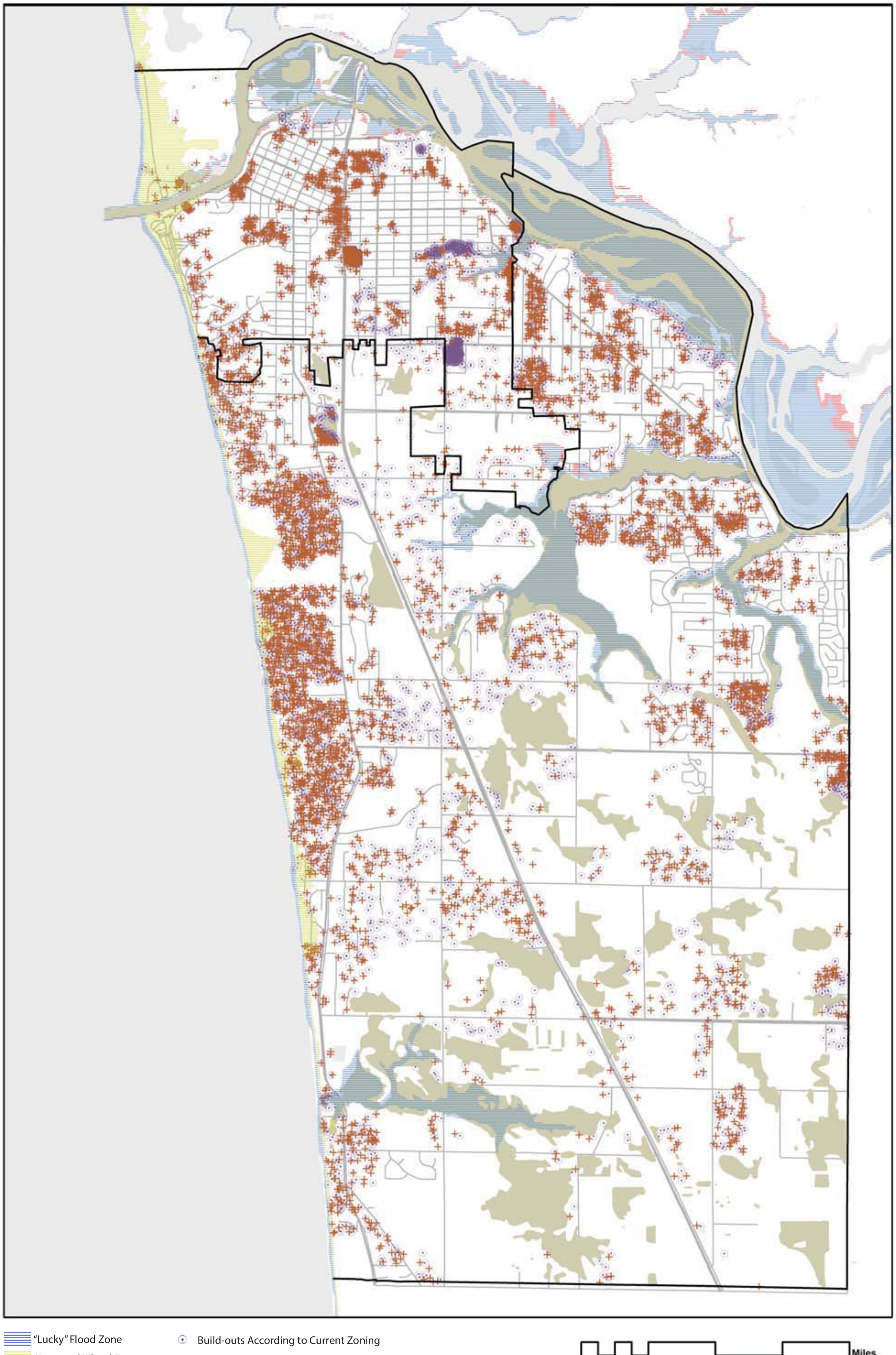
Map 15. Existing Wetlands under 5 Acres under "Expected" Climate Future



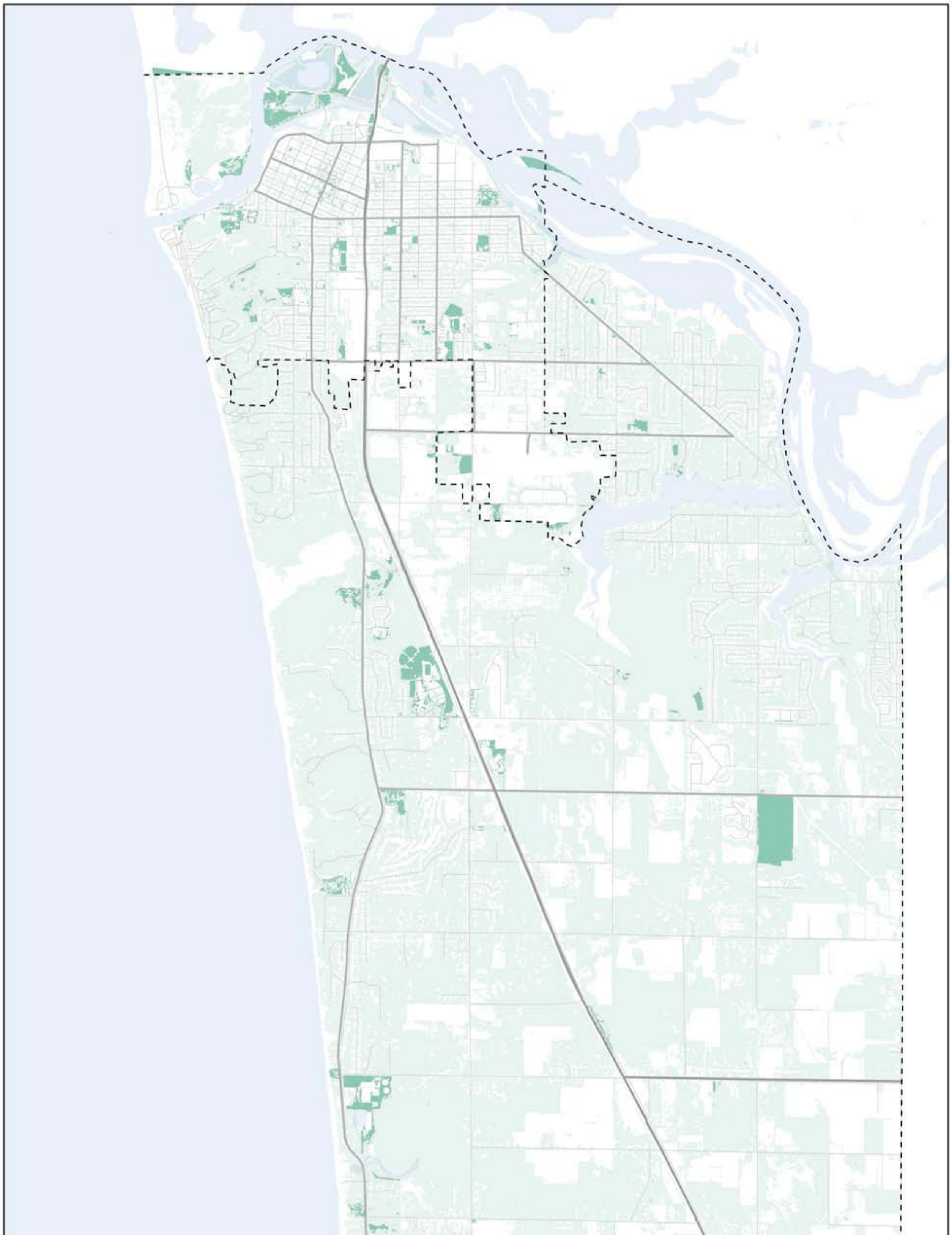
Map 16. Existing Wetlands under 5 Acres under "Perfect Storm" Climate Future



Map 17. Existing Wetlands with Climate Futures and Management Options



Map 18. Existing and Potential Tree Canopy

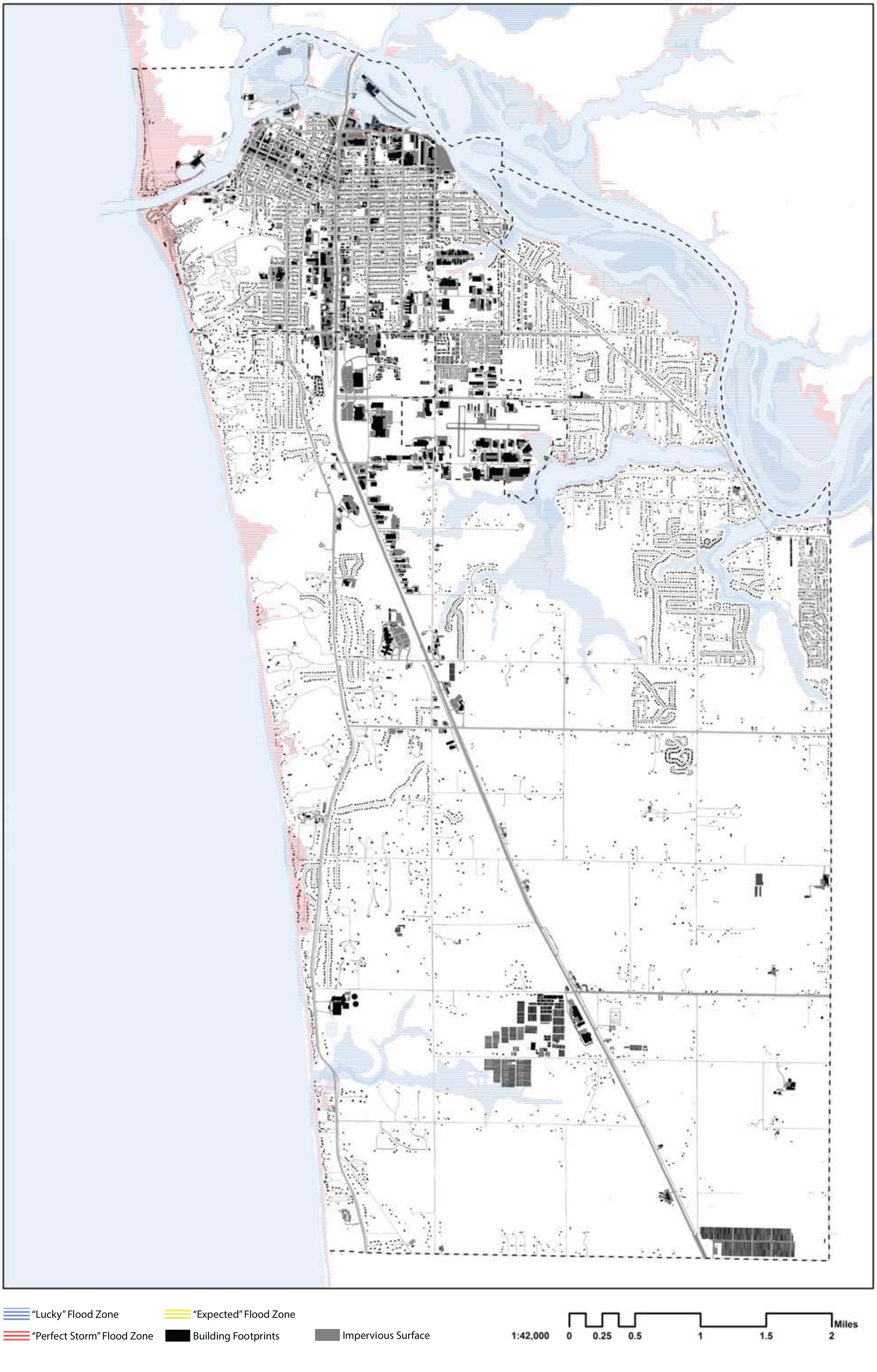


Potential Tree Canopy

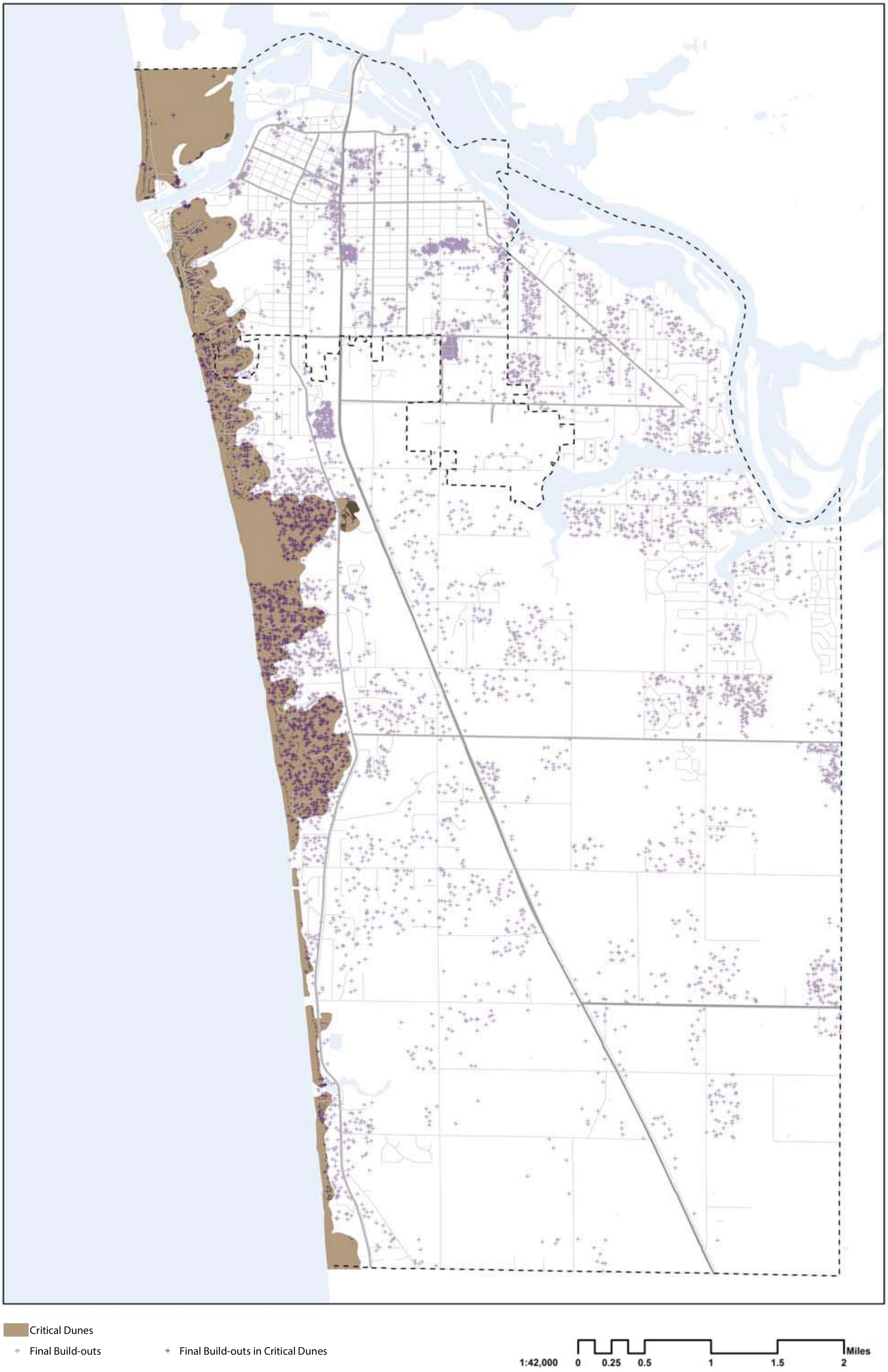
Existing Tree Canopy

1:42,000 0 0.25 0.5 1 1.5 2 Miles

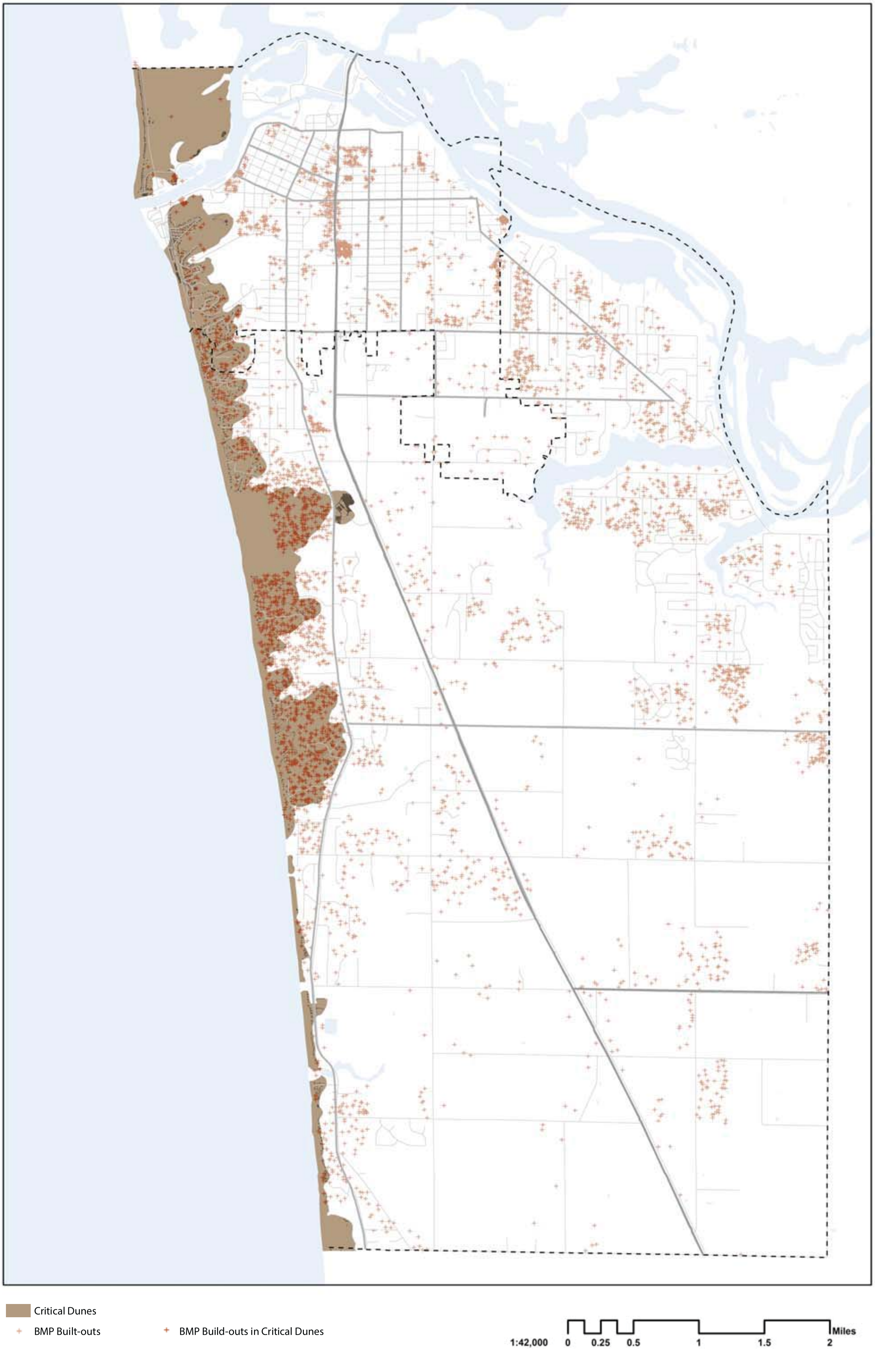
Map 19. Impervious Surface under Climate Future Scenarios



Map 20. Build-out According to Current Zoning and Critical Dune Areas



Map 21. Build-out According to Best Management Practices and Critical Dune Areas



Map 22. High Risk Erosion Area and Climate Futures