Barnegat Bay Partnership

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2021 COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN FOR THE BARNEGAT BAY-LITTLE EGG HARBOR ESTUARY

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One of 28 National Estuary Programs, the Barnegat Bay Partnership comprises federal, state, county, municipal, academic, business, and private stakeholders working together to help restore, maintain, protect, and enhance the water quality and natural resources of the Barnegat Bay estuary and its contributing watershed.

COVER PHOTO *Unplanned Deviation*, a marsh view at sunset. Used with permission of Greg Molyneux Photography.
BACK COVER PHOTO by Kathy White.

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We thank the many people, agencies, and organizations who have worked tirelessly to support the protection of the Barnegat Bay and its watershed.

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ACRONYMS AND ABBREVIATIONS USED IN THE DOCUMENT

AC ..... Advisory Committee
ACFHP ..... Atlantic Coastal Fish Habitat Partnership
ALO ..... Alliance for a Living Ocean
ALS ..... American Littoral Society
ANJEC ..... Association of New Jersey Environmental Commissions
ASMFC ..... Atlantic States Marine Fisheries Commission
ASR ..... aquifer storage and recovery
AWIA ..... America's Water Infrastructure Act
BB ..... Barnegat Bay
BBNEP ..... Barnegat Bay National Estuary Program
BBP ..... Barnegat Bay Partnership
BBSA ..... Barnegat Bay Study Act
bgy ..... billion gallons per year
BMP ..... Best Management Practice
BTMUA ..... Brick Township Municipal Utility Authority
CCMP ..... Comprehensive Conservation and Management Plan
CEC ..... Communication and Education Committee
CFR ..... Code of Federal Regulations
COA ..... Clean Ocean Action
CRS ..... Community Rating System (National Flood Insurance Program)
CRSSA ..... Center for Remote Sensing and Spatial Analysis (Rutgers University)
CWA ..... Clean Water Act
CWFNJ ..... Conserve Wildlife Foundation of New Jersey
CZMP ..... (New Jersey) Coastal Zone Management Program
DDT ..... dichlorodiphenyltrichloroethane
DO ..... dissolved oxygen
DSRT ..... Division of Science, Research, and Technology
DWQ ..... Division of Water Quality
EBFNWR ..... Edwin B. Forsythe National Wildlife Refuge
EBM ..... ecosystem-based management
e.g. ..... for example
EIT ..... Environmental Infrastructure Trust
ESA ..... Environmentally Sensitive Area
et al. ..... and others
etc. ..... and so forth
FEMA ..... Federal Emergency Management Agency
FIRM ..... Flood Insurance Rate Map
GIS ..... Geographic Information System
GFO ..... Grant Funding Opportunity
GTR ..... Getting to Resilience
HAB ..... harmful algal bloom
HUC ..... Hydrologic Unit Code
HUD ..... United States Department of Housing and Urban Development
i.e. ..... that is
JCNERR ..... Jacques Cousteau National Estuarine Research Reserve
JFY ..... Jersey-Friendly Yards
kg ..... kilogram(s)
l ..... liter(s)
LBI ..... Long Beach Island
LBIF ..... Long Beach Island Foundation
LEH ..... Little Egg Harbor
LID ..... Low Impact Development
LLC ..... Limited Liability Company
LOI ..... Letter of Intent
LR ..... Living Resources
LU ..... Land Use
LU/LC ..... Land Use/Land Cover
LVA ..... Literacy Volunteers of America
MACWA ..... Mid-Atlantic Coastal Wetland Assessment
MAFMC ..... Mid-Atlantic Fishery Management Council
MATES ..... Marine Academy of Technology and Environmental Science
MCNLT ..... Monmouth County Natural Lands Trust
mg ..... milligram(s)
mgd ..... million gallons per day
MLUL ..... Municipal Land Use Law
MOU ..... Memorandum of Understanding
MS4 ..... Municipal Separate Storm Sewer System
MSWCAP ..... Municipal Stormwater Compliance Assistance Program
MUA ..... Municipal Utilities Authority
N ..... nitrogen

Acronyms and Abbreviations used in the Document (continued)

NAACC ..... North Atlantic Aquatic Connectivity Collaborative
NEP ..... National Estuary Program
NFWF ..... National Fish and Wildlife Foundation
NGO ..... Non-governmental Organization
N.J.A.C. ..... New Jersey Administrative Code
NJAES ..... New Jersey Agricultural Experiment Station
NJCF ..... New Jersey Conservation Foundation
NJCMP ..... New Jersey Coastal Zone Management Plan
NJDA ..... New Jersey Department of Agriculture
NJDEP ..... New Jersey Department of Environmental Protection
NJDOH ..... New Jersey Department of Health
NJDOT ..... New Jersey Department of Transportation
NJF ..... New Jersey Future
NJGWS ..... New Jersey Geological and Water Survey
NJIB ..... New Jersey Infrastructure Bank
NJPC ..... New Jersey Pinelands Commission
NJSGC ..... New Jersey Sea Grant Consortium
NJSWSP ..... New Jersey Statewide Water Supply Plan
NOAA ..... National Oceanic and Atmospheric Administration
NLT ..... Natural Lands Trust
NMFS ..... National Marine Fisheries Service
NPS ..... nonpoint source
NPSP ..... nonpoint sources of pollution
NRC ..... Nuclear Regulatory Commission
NRCS ..... Natural Resource Conservation Service
NSF ..... National Science Foundation
OCC ..... Ocean County College
OCHD ..... Ocean County Health Department
OCNGS ..... Oyster Creek Nuclear Generating Station
OCNLT ..... Ocean County Natural Lands Trust
OCPD ..... Ocean County Planning Department
OCSCD ..... Ocean County Coil Conservation District
OCUA ..... Ocean County Utility Authority
OCVTS ..... Ocean County Vocational Technical School
OEM ..... Office of Emergency Management
PCMP ..... Pinelands Comprehensive Management Plan
PDE ..... Partnership for the Delaware Estuary
P.L. ..... Public Law
PPA ..... Pinelands Preservation Alliance
ppt ..... parts per thousand
psi ..... pounds per square inch
RCB ..... ReClam the Bay
RCE ..... Rutgers Cooperative Extension
REP ..... Restoration, Enhancement and Protection
RSU ..... Richard Stockton University
RU ..... Rutgers University
SAV ..... submerged aquatic vegetation
SBB ..... Save Barnegat Bay
SJ ..... Sustainable Jersey
SLR ..... sea level rise
SOTB ..... State of the Bay
SPPP ..... Stormwater Pollution Prevention Plan
STAC ..... Science and Technical Advisory Committee
SWAP ..... Source Water Assessment Program
SW ..... stormwater
SWG ..... Shellfish Working Group
SWQS ..... Surface Water Quality Standards
TBD ..... to be determined
TFW ..... Trash Free Waters
TMDL ..... Total Maximum Daily Load
TN ..... total nitrogen
TPL ..... Trust for Public Land
UCI ..... Urban Coast Institute (Monmouth University)
USACE ..... United States Army Corps of Engineers
U.S.C. ..... United States Code
USDA ..... United States Department of Agriculture
USDOD ..... United States Department of Defense
USEPA ..... United States Environmental Protection Agency
USFWS ..... United States Fish and Wildlife Service
USGS ..... United States Geological Survey
WBP ..... Watershed-based Plan
WMI ..... Wildlife Management Institute
WMP ..... Wastewater Management Plan
WPDG ..... Wetland Program Development Grants (USEPA)
WQ ..... Water Quality
WQMP ..... Water Quality Management Plan
WS ..... Water Supply
WSP ..... (New Jersey Statewide) Water Supply Plan
yr ..... year

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CHAPTER

ES

EXECUTIVE SUMMARY

This 2021 Comprehensive Conservation and Management Plan (CCMP) was developed by the Barnegat Bay Partnership (BBP), established as one of the nation's 28 National Estuary Programs (NEPs) in accordance with Section 320 of the Clean Water Act (33 U.S.C. § 1330; as amended by P.L. 100-4, 114-162, and 116-337. The BBP works collaboratively with its various partners to protect the Barnegat Bay–Little Egg Harbor estuary and its contributing watershed. This 2021 CCMP represents a revision of the BBP's original CCMP, completed in 2002, when the program was formally approved and accepted into the NEP by the Environmental Protection Agency. In 2016, USEPA's NEP guidance identified the need for all NEPs to update and/or revise their CCMP to reflect the accomplishments of programs to date, the changes in the status and trends in conditions within each NEP's Study Area (geographic boundaries), and any new challenges within the systems.

Like all NEPs, the BBP is a non-regulatory program that works by developing and implementing the CCMP – the "master plan" identified by its management conference partners – which includes municipal, county, state, and federal government agencies; academic institutions; and private, corporate, and non-governmental stakeholders. The BBP's management conference is organized into various committees (*i.e.*, Policy Committee, Advisory Committee, Science and Technical Advisory Committee, and Communication and Education Committee), each with different members, expertise, and responsibilities. As stated in the Clean Water Act, one primary purpose of the management conference is to develop a CCMP that identifies priority corrective actions and timelines addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the estuary. These actions include the restoration and maintenance of water quality; balancing indigenous populations of shellfishes, fishes, and wildlife with recreational activities in the estuary; and assuring that the designated uses of the estuary are protected. The plan contains a number of technical elements (*e.g.*, research, monitoring, and assessment), and equally important communication and education activities.

To oversee revision of its CCMP, the BBP established a Steering Committee, drawn from all its management conference committees (*i.e.*, Policy Committee, Advisory Committee, Science and Technical Advisory Committee, and Communication and Education Committee). The Steering Committee initiated the revision process with a review of the BBP's overall vision, its previous priority goals, objectives, and all previous actions.

To ensure an understanding of the public's concerns and priorities, and public engagement and support for the BBP's priorities, the BBP and its partners conducted outreach to the public during 38 events held during 2016-2018 to solicit input on the issues of concern about the estuary. The top issues of concern, in no particular order, were as follows: (1) reducing sources of NPS pollution, especially nutrients from fertilizers; (2) restricting future development and preserving more open space; (3) addressing blooms of nuisance bay nettle, *Chrysaora chesapeakei*, spreading throughout the bay; (4) protecting wetlands, eelgrass and shellfish beds, and other characteristic bay habitats; (5) increasing water conservation efforts, especially by seasonal residents; (6) addressing the issue of flooding and more frequent storms; and (7) educating children and adults about the Barnegat Bay and its watershed. As this information was accumulated, the Steering Committee began revising the BBP's vision, priority goals, objectives, and actions. These core components were revised with the assistance of contracted experts and aided by technical workgroups drawn from our partner organizations.

The growing human population and accompanying development in the watershed still represent a major challenge to the entire estuarine ecosystem; moreover, eutrophication due to excessive nutrient loadings (primarily nitrogen) from human activities remains one of the biggest problems within the bay itself. The BBP's vision and other components of the CCMP also reflect the growing recognition of climate change factors (*e.g.*, more frequent and larger storms, sea level rise, coastal acidification) and uncertainties regarding rates of change of those factors, all of which affect the bay's water quality, water supplies, habitats, living resources, and human uses of the ecosystem.

What's New in This CCMP?

This is the first revision of the BBP's CCMP since the publication of the original CCMP in 2002; the original document did not include the following phrases/words: climate change, sea level rise (SLR), and jellyfish. Most 2002 priority areas – water quality, water supply, habitats, and living resources – remain, while one 2002 priority – human activities and competing uses – was removed and a new priority – land use – was added (See Chapters 4-7). Many existing actions remain ongoing but have been modified and reorganized (See Appendix A, Status of 2002 CCMP Action Items and Crosswalk to 2021 CCMP). A number of previous actions were dropped for various reasons, including: no longer relevant and lack of funding (See Appendix A, Status of 2002 CCMP Action Items and Crosswalk to 2021 CCMP). This revised CCMP reflects significant improvements in our understanding of the bay's ecology and the efforts needed to protect and restore its water quality, water supply, habitats, and biotic resources. It builds upon outreach and actions initiated in Barnegat Bay that were implemented since 2002 to protect water quality, habitats, and living resources throughout the bay and its watershed; moreover, it also expands outreach activities of the BBP and its partners to communities with environmental justice concerns. This CCMP identifies holistic ecosystem targets (See Chapter 3). This CCMP identifies specific goals, objectives, and actions within each priority area (See Chapters 4-7), all of which were considered with regard to the effects of climate change (See Climate Change Vulnerability Assessment below).

Climate Change Vulnerability Assessment

With climate change recognized as increasingly impacting coastal communities and economies, USEPA guidance identified the need to assess the vulnerability of all CCMP actions to recognized climate change stressors, and, specifically, to consider the likelihood and magnitude of climate change impacts upon proposed CCMP actions. Thus, the BBP followed a process (USEPA, 2014) and made use of its own partners, regional experts, and the latest science to assess the vulnerability of its actions to the following stressors: 1) warmer and more variable winter weather, 2) warmer and more variable summer weather, 3) warmer water, 4) drought, 5) more frequent and bigger storms, 6) sea level rise, and 7) coastal acidification.

Figure ES.1. Flooding during a King Tide shows future sea level rise. Photo by Carole Bradshaw.

These climate stressors varied widely in their potential adverse impacts on different CCMP actions. Some categories of actions, such as education or coordination activities, were thought to be minimally affected by climate change stressors; however, other actions, such as wetland or shoreline restoration, were recognized to be potentially or significantly impacted by the identified climate change stressors. More frequent and bigger storms, sea level rise, and drought were recognized as the most likely and significant stressors affecting the largest number of CCMP actions. Changes in both winter and summer weather were considered equally likely but had different mechanisms of impact. Warmer water and coastal acidification, though generally considered to be the least likely and least consequential stressors to most CCMP actions, were identified as having significant potential impacts on some uses of the bay (*e.g.*, tourism, shellfish culture, fishing).

CCMP Goals and Ecosystem Targets

The BBP and its partners adopted an ecosystem-based management (EBM) approach to the development of the CCMP. This approach includes consideration of human and natural systems, an adaptive management framework, and public participation and engagement as central to developing technical, management, and policy solutions to environmental challenges. Using this approach, the BBP established goals in four priority areas.

Water Quality – To protect and improve water quality throughout Barnegat Bay and its watershed by reducing the causes of water quality degradation to achieve swimmable, fishable, and drinkable water, and to support aquatic life.

Water Supply – To ensure adequate water supplies and flow in the Barnegat Bay watershed for ecological and human communities now and in the future.

Living Resources – To protect, restore, and enhance habitats in the Barnegat Bay and its watershed as well as ensure healthy and sustainable natural communities of plants and animals both now and in the future.

Land Use – To improve and sustain collaborative regional approaches to responsible land use planning and open space preservation in the watershed that protect and improve soil function(s), water quality, water supply, and living resources.

While Action Items in the CCMP are organized into these four priority areas, some actions impact or affect more than one priority area; moreover, some goals require actions in more than one priority area. Thus, to guide our collective efforts, the following aspirational Ecosystem-Based Targets were developed. These targets are broad, with each individually spanning and integrating actions and changes in several priority areas. In addition, each of these targets is based upon existing data sets and is included as a component within an existing monitoring program. The targets identified below have been developed by considering the challenges of not only guarding against future loss/degradation in each respective area, but also working toward measurable improvement/restoration of these natural resources.

The BBP will work with its partners towards reaching the following **Ecosystem-Based Targets**.

- **Public Beach Openings/Closures** – Work with the partners to: 1) increase the number of bay beaches and lakes within the Barnegat Bay watershed open for swimming from the 2018 baseline of 32, and 2) reduce the average number of annual beach closure days below that of 2016-2018 (74 days).
- **Approved Shellfish Areas** – Upgrade 5% of the potentially harvestable shellfish acreage that is currently restricted or closed for shellfishing from the 2020 acreage (11,267 acres).
- **Submerged Aquatic Vegetation (SAV) Extent** – Maintain the overall extent of SAV present in 2009 (12,980 acres) and restore an additional 10 acres of SAV.
- **Wetland and Riparian Buffer Preservation** – Maintain or increase the current acreage of upland buffers adjacent to all wetland and riparian corridors. Baseline acreage is not currently available.
- **Wetland Protection** – Maintain overall extent of tidal wetland acreage (20,922 acres [as identified in 2015 baseline aerial imagery], an ambitious target in the face of sea level rise), and restore or enhance 10 acres of tidal wetlands impacted by sea level rise and erosion through nature/natural-based strategies.
- **Clam restoration –** Return the hard clam abundance to 1985/87 levels (approximately 370,000,000 clams). The most recent bay-wide population estimate (2011/2012) was 223.9 million clams.
- **Ecological Flows** – Maintain flow levels at least 30% over minimum ecological flows for gauged waterways within the watershed. To achieve this target, the minimum ecological flows for gauged waterways needs to be determined.
- **Water Conservation and Reuse** – Reduce five-year rolling average water withdrawals 10% below the 2010 estimate of 85.56 MGD. The target water withdrawal amount would be comparable to the withdrawals during the early 2000s.

Within each of the four priority areas, supporting objectives were developed to achieve the goals and broader ecosystem targets. Like the development of goals and targets, these objectives were developed by the Steering Committee and reviewed, refined, and approved by all program partners.

Water Quality Objectives

The bay's water quality is critical to the bay's overall condition, as well as to coastal communities within the region and their tourism-based economies. Eutrophication of the bay – caused by high nutrient loading – is the major problem affecting the northern portions of the bay, while recent science suggests sediment pollution may be an equally important challenge affecting the southern portion of the bay. Our understanding of the bay has improved substantially in recent years; however, continued monitoring and science are essential to improving the bay as our world changes. The primary **water quality objectives** are as follows:

1. Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution;
2. Assess status and trends of water quality throughout the watershed;
3. Conduct studies to improve scientific understanding of new and emerging issues pertaining to the chemical, physical, and biological conditions and dynamics in the Barnegat Bay and its watershed; and
4. Increase public education, engagement, and stewardship regarding water quality in the watershed.

Water Supply Objectives

The Barnegat Bay watershed provides important water supplies for human and non-human uses, and these supplies are vulnerable to sea level rise, storm surges, saltwater intrusion, drought, and contamination. Like all estuaries, the ecology of the Barnegat Bay-Little Egg Harbor ecosystem is primarily determined by the nature of its freshwater inputs. Thus, the primary **water supply objectives** include the following:

1. Protect, maintain, and enhance existing surface and groundwater flows;
2. Prevent degradation of water supplies;
3. Monitor and assess status and trends of water supply throughout the watershed;

4. Conduct studies to improve scientific understanding of new and emerging issues pertaining to water conservation, advanced potable treatment options, and reuse; and
5. Educate consumers regarding water supply and use issues, including conservation, efficiencies and reuse.

Living Resources Objectives

Healthy estuaries ensure the survival of many species of fishes, birds, mammals, and reptiles. They provide vital nesting and feeding habitats and help maintain a healthy environment by trapping sediments and pollutants from rivers and streams. Some organisms like hard clams and oysters live all year in estuarine habitats, whereas others, such as horseshoe crabs and striped bass, use them to complete a small part of their life cycle. Estuaries also provide stopovers for migratory bird species including snow geese and mallard ducks and deliver critical ecosystem services.

The Barnegat Bay ecosystem is comprised of a diversity of upland and wetland habitats, from submerged habitats within the bay, to low-lying coastal and freshwater wetland habitats, to uplands of pine and oak forests. **Five habitat types** were identified as characteristic of, and critical to, the living resources, ecology, and economy of the watershed, and will comprise the focus of the BBP's future Habitat Protection and Restoration Plan. All of these habitats are vulnerable to different factors, including climate change:

1. Tidal wetlands, including intertidal marshes;
2. Emergent, scrub-shrub, and forested freshwater wetlands;
3. Subtidal beds of submerged aquatic vegetation (SAV), mostly eelgrass and widgeon grass;
4. Shellfish beds and reefs of clams and oysters; and
5. Upland forest, including portions of the Pine Barrens ecosystem.

The protection and/or restoration of those priority areas serves as a means of improving water quality; protecting water supplies; and safeguarding productive habitats for fishes, shellfishes, and other wildlife. To protect, restore, and enhance habitats in the Barnegat Bay and its watershed, as well and to ensure healthy and sustainable natural communities of plants and animals both now and in the future, the primary **Living Resources Objectives** include the following:

1. Develop and implement Habitat Protection and Restoration Plans for ecologically sensitive habitats;
2. Restore and maintain sustainable populations of fish and wildlife;
3. Monitor and assess status and trends of living resources throughout the watershed;
4. Conduct studies to improve scientific understanding of living resources, as well as ecologically sensitive habitats; and
5. Increase education and public outreach related to habitats and living resources.

Land Use Objectives

The Barnegat Bay watershed has experienced intense growth and development over the last half-century. With more than 33% of the watershed developed to date, additional development increasingly impacts and threatens the remaining natural resources of the watershed. Sustaining the health, diversity, and economic importance of the watershed's natural resources, while continuing to manage development, is a shared responsibility among municipal, county, regional, and state planners, land-use managers, and government officials. Land use managers are also challenged by the impacts of sea level rise on the sustainability and resilience of the watershed's natural resources, built communities, citizenry, and the regional economy. Improving collaborative regional approaches to responsible land use planning and open space protection in the watershed is critical to protect and improve soil function, water quality, water supplies, and living resources.

Thus, the BBP developed these primary **Land Use Objectives**:

1. Work to raise the level of awareness of the BBP CCMP and provide technical support to state, counties, and municipalities to reflect and complement the CCMP goals and objectives in plans and land use practices;
2. Encourage economically and environmentally sustainable land-use development and redevelopment practices that conserve, restore, and enhance Barnegat Bay resources;
3. Support acquisition, planning, and sustainable management of open space for people and nature;
4. Support the conservation, protection, and restoration of wetlands;
5. Conduct studies to improve scientific and societal understanding of the impacts of current and future land use practices on the Barnegat Bay and watershed; and
6. Increase education and outreach efforts targeted at sustainable land use practices for public and private lands.

Monitoring and Habitat Plans

Since its establishment, the BBP has periodically reported the status and trends in the bay's condition (*i.e.*, the BBP's 2005, 2011, and 2016 State of the Bay Reports) using a comprehensive suite of agreed-upon indicators to assess water quality, water supply, critical habitats, and living resources. Development and use of indicators in the early reports was hampered by a lack of monitoring data consistently collected over time (*e.g.,* data were insufficient in 2011 to report trends for one-third of the 19 indicators), but data availability improved substantially by 2016 due to BBP and partner commitments to expand monitoring.

With the revision of the CCMP using an EBM approach, the BBP has established holistic ecosystem targets. Monitoring these ecosystem components and assessing cooperative

progress toward these newly established targets is important to assess the effectiveness of our collective. The BBP and its partners have agreed to review all existing monitoring programs for the next State of the Bay Report

and incorporate any additional monitoring components into the BBP 2022 Monitoring Plan.

The revised CCMP provides an overview of the characteristic habitats of the watershed: coastal marshes, freshwater wetlands, submerged aquatic vegetation, shellfish beds and reefs, and upland forests. Some of these habitats have been nationally and internationally recognized for their uniqueness and their importance to sustaining fish and wildlife populations, while some of these habitats also provide critical ecosystem services. General threats, including climate change and sea level rise and their potential impacts to these habitats, are also identified. A habitat plan will be developed in 2022 to provide more detailed information at a finer scale to support the protection and restoration of priority areas.

Financial and Communication Plans

Since the creation of the first CCMP in 2002, the Program Office has grown from four to more than 10 staff members, and now conducts research, monitoring, communication, and outreach activities. New challenges have emerged with this growth in BBP staffing and activities (*e.g.*, more offices, laboratory, field support, and other work areas, and the need for more comprehensive financial support of CCMP implementation). A recently completed BBP Needs Assessment (BBP, 2019) also recommended development of a new financial plan in 2021 to grow CCMP implementation to protect the bay and its resources and to address other identified challenges (*e.g.*, facilities).

The BBP has begun revising its 2016 Communication Plan as a separate document to be completed during the coming year. The revision will align the 2021 Communication Plan with the priorities of the revised CCMP and will also build on the recommendations of the Needs Assessment Report to grow the capacity and improve the effectiveness of the BBP, including its partners, to implement the CCMP. Social media outreach and marketing strategies will be incorporated into this revised Communication Plan, currently scheduled for completion during 2021-2022.

The 2021 CCMP

This CCMP represents the consensus of the public agencies, organizations, and bay stakeholders that comprise the management conference of the Barnegat Bay Partnership. It has been developed consistent with USEPA's 2016 Guidance and Section 320 of the Clean Water Act to protect and restore an "estuary of national significance," the Barnegat Bay-Little Egg Harbor estuary and its contributing watershed.

Figure ES.2. Great Blue Heron. Photo courtesy of Kathy White.

We thank our many partners for their engagement and encouragement throughout this entire revision process. We recognize their past efforts and continuing dedication to the protection and restoration of the bay and its invaluable living resources, and praise their support of their neighbors living, working, and playing in the bay's coastal communities. Lastly, we stand alongside them on our ever-changing coast, committed to our shared vision of a healthy and thriving Barnegat Bay watershed that sustains a vibrant coastal economy and our quality of life.

CHAPTER

1

INTRODUCTION

The Barnegat Bay, long called the "Crown Jewel of the Jersey Shore," is a critical natural resource located amidst two of the largest metropolitan areas in the United States. The Barnegat Bay watershed is a diverse and beautiful natural landscape, extending from its headwaters and tributary streams of the Pine Barrens; to Atlantic white-cedar swamps, cranberry bogs and lakes; to rivers flowing through riparian shorelines dense with native vegetation; through coastal intertidal wetlands; to the submerged aquatic vegetation and healthy shellfish beds of the bay. This area includes some of the most ecologically productive habitats on earth, and natural features that help buffer coastal communities from storms, improve water quality, and support thriving commercial and recreational fisheries.

Figure 1.1. Characteristic coastal intertidal marsh in the Barnegat Bay watershed. Photo courtesy of BBP staff.

The watershed includes a large portion of the New Jersey Pinelands National Reserve, the nation's first national reserve, which is the largest protected open space land area on the Mid-Atlantic seaboard between Richmond and Boston and is home to dozens of rare plant and animal species. Much of the Kirkwood-Cohansey aquifer system, which contains an estimated 17 trillion gallons of water, is also a part of the watershed, as is the Edwin B. Forsythe National Wildlife Refuge and adjoining marshes, which are internationally recognized as one of the most important wetland complexes in North America due to the value of its stopover habitats for migratory birds. The watershed's beaches and shorelines have long provided water access for residents and visitors alike; supported recreational and commercial fishing; nurtured a thriving tourist-based economy and other benefits, including educational and recreational opportunities; and previously led to Ocean County's recognition as one of the best places in the country to live.

1.1. The Barnegat Bay Estuary and Watershed

The 75-square mile (194 km^2) Barnegat Bay estuarine system is actually comprised of three shallow, micro-tidal bays (Barnegat Bay, Manahawkin Bay, and Little Egg Harbor). This estuarine system stretches over 42 miles (67 km) in length from the Point Pleasant Canal on the northern end to Little Egg Harbor Inlet at the southern end, and is separated from the open ocean by a nearly continuous barrier island complex of beaches, dunes, and wetlands.

The Barnegat Bay watershed is comprised of more than 600 square miles (1,554 km^2) of land areas that drain into the 11 rivers and streams that empty into the Barnegat Bay-Manahawkin Bay-Little Egg Harbor estuarine system. A significant source of freshwater for the Barnegat Bay estuarine system is derived from tributaries that drain the New Jersey Pine Barrens and other forested land. From the headwaters of these streams, pristine freshwater flows

eastward through predominantly forested areas along the coastal plain to the bay. A nearly continuous barrier island complex runs along the eastern edge of the Barnegat Bay system. Seawater enters the Barnegat Bay system through the Point Pleasant Canal via the Manasquan Inlet in the north, the Barnegat Inlet in the middle, and the Little Egg Inlet in the south. The flow of fresh water from rivers, creeks, and groundwater into the bay produces the variety of salinity zones that are needed for the survival of crabs, fish, birds, and other wildlife, as well as for human uses. Activities impacting Manasquan Bay to the north and Great Bay to the south are of significance to the Barnegat Bay watershed as well. The watershed encompasses most of the 33 municipalities in Ocean County, as well as four municipalities in Monmouth County and one municipality in Burlington County.

Figure 1.2. Barnegat Bay marina. Photo courtesy of B. Birdsall.

1.2. Map of the Barnegat Bay Partnership Study Area

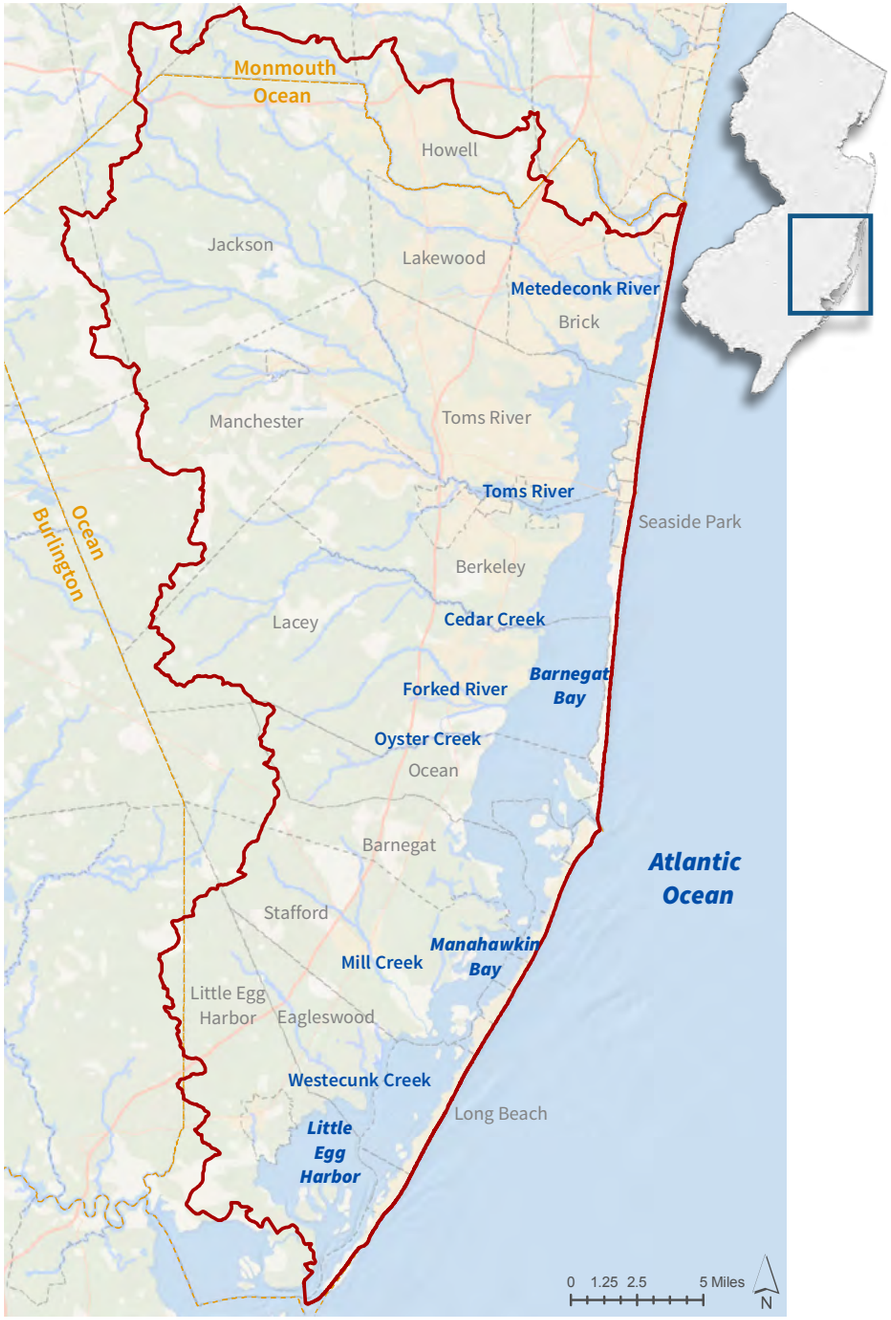


Figure 1.3. Map of the Barnegat Bay Watershed.

1.3. History

Around 1609, Henry Hudson sailed along the coast of New Jersey, arriving at an inlet he subsequently named "Barende-gat," a Dutch word meaning an inlet with breakers. The arrival of European settlers in Ocean County first affected the environment through changes in land use and the creation of colonial industries. As natural resources were extracted and depleted for colonial industries such as lumbering and sawmills, bog iron manufacture, and charcoal manufacturing, some settlers moved on from the area in search of new places to settle. However, those who remained in the colonial settlements survived by becoming skilled in farming, hunting, fishing, and berry-harvesting, and these ways of life endured for generations.

Marilyn Kralik, in her 1992 University of Pennsylvania dissertation, *Buying Barnegat Bay: A look at Ocean County shore resorts from the eyes of three women, August 1879*, shared how Barnegat Bay in the 1870s and '80s "was a turning point in how Americans perceived their landscape, took their leisure, and worked for a new and different future." The new and different future of the 1880s was initiated by expanding train lines, which made Barnegat Bay increasingly attractive as a summer playground for Philadelphians. Development – centered around various resorts that had sprung up in Barnegat and elsewhere on the Jersey Shore – was already profoundly affecting the futures of shore residents, from the baymen and others toiling on land and water to the entrepreneurs catering to an emerging summer tourist clientele.

The landscape was changing too. In 1926, the bay changed in new ways when the Point Pleasant Canal opened the upper bay and the Metedeconk River to tidal exchange. As freshwater habitats (*e.g.*, cranberry bogs, freshwater sago pondweed [*Potamageton* sp.] beds) were inundated with tidal brackish water and converted to estuarine habitats, declines in freshwater fishes and other dependent species (*e.g.*, canvasback ducks, which fed on pondweed) impacted traditional fishing and hunting. The canal caused erosion and shoaling problems that led to bridge, jetty, and other infrastructure changes for several decades. Nonetheless, the number of people living, working, and playing in the Barnegat Bay and its surrounding watershed continued to grow. The watershed had grown to about 60,000 inhabitants by the mid-1950s, when the completion of the Garden State Parkway laid the foundation for an even larger influx of people.

Other changes were to come as people continued to pour into the area. The Oyster Creek Nuclear Generating Station, one of the first commercial nuclear power stations in the United States, began using the bay's water to cool its reactor in 1969. The signing of the National Parks and Recreation Act of 1978 established the Pinelands National Reserve, which provided funds to acquire critically important ecological land areas, and requested that the State establish a planning entity to collectively manage and preserve the water and land resources of the Pinelands, without large-scale direct federal acquisition of the land. With the establishment of New Jersey's Pinelands Commission the following year, management plans for distinct preservation and protection applying to extensive lands within the Barnegat Bay watershed and other areas in the heart of New Jersey were initiated and then set into motion when the plans were approved in 1980.

The tremendous increase in the number of people living in Ocean County (350,000 by 1980) was clearly having a dramatic impact on the landscape, and the bay's ecology and living resources, especially its once vibrant fisheries. Oysters and clams, with their complex life cycles (*i.e.*, immotile benthic adults that cannot relocate to better environments and planktonic larvae undergoing complex metamorphoses), were particularly vulnerable to, and adversely affected by, many environmental factors (*e.g.*, salinity, temperature, dissolved oxygen, nutrients and other pollutant loadings) and to disturbances affecting large volumes of water (*e.g.*, power plant cooling water entrainment). All the while, shellfishes were harvested extensively.

Despite these changes in the bay, development in coastal communities, and the number of people living throughout the watershed, the Barnegat Bay clearly remained vital to the region's economy and the quality of life along the Jersey Shore, and was of increasing concern to the area's residents.

Figure 1.4. **Forked River State Marina. Photo courtesy of B. Birdsall.**

1.4. Recognition of the Bay's Stressors

The Barnegat Bay and its watershed are affected by an array of impacts that threaten its ecological integrity, including impacts of human activity. With the tremendous amount of growth and development in this region, negative consequences have emerged that are directly affecting the health of the Barnegat Bay and its watershed. These impacts include significant declines in water quality, increasing demands on water supply, habitat loss and fragmentation, and declines in our fisheries.

1.4.1. Eutrophication

As has been well documented over the past 15 years, the present-day Barnegat Bay-Little Egg Harbor estuary continues to face the decades-old problem of eutrophication. Eutrophication is an increase in the rate of supply of organic matter to the bay, which is manifested as blooms of drift algae, attached microalgae, or phytoplankton (including harmful algal species), and low or no dissolved oxygen. These conditions ultimately lead to other changes in the bay such as increased turbidity and changes in key biotic components such as loss of shellfish and submerged aquatic vegetation, as well as blooms of jellyfishes. Eutrophication is overwhelmingly driven by increases in nitrogen from nonpoint source pollution, the pollution caused by rainfall or snowmelt moving over and/or through the ground, where it picks up and carries various pollutants and deposits them into lakes, rivers, wetlands, coastal waters, and ground waters. However, eutrophication is also affected by other nutrients, such as phosphorus, as well as other processes and conditions including temperature changes, coastal currents, and seasonal climate patterns.

1.4.2. Stressed Water Supplies

The Barnegat Bay watershed in many ways reflects the water supply issues throughout the state of New Jersey. While water supplies are generally adequate overall, some Barnegat Bay subwatersheds (*i.e.*, Toms River, Metedeconk River, and Kettle Creek) are currently stressed. Increases in water demand with population growth in these areas could add significantly to this stress. Climate in both winter and summer are predicted to be warmer and more uneven; both can affect both the supplies and demands for water. Increasing sea levels are already affecting management of surface water supplies used for drinking water. In recognition of these and other issues, parts of the Barnegat Bay watershed are situated in the state's two Water Supply Critical Areas.

1.4.3. Habitat Loss, Alteration, and Fragmentation

The different habitats found throughout the Barnegat Bay estuary and watershed provide vital nesting, resting, rearing, and feeding areas to a wide variety of fish and wildlife, and help maintain a healthy environment for both humans and animals by trapping sediments and pollutants from rivers and streams. As humans have altered the landscape, we have reduced or fragmented these critical habitat areas. Approximately 28% of the Barnegat Bay salt marshes were eliminated or impacted by mosquito control ditching and development prior to 1970 (Lathop and Bognar, 2001); moreover, 71% of the Barnegat Bay shoreline was developed or altered, with 40% due to bulkhead stabilization of the shoreline. As much as 6%, or 4,633 acres, of freshwater wetlands were lost between 1972 and 1995 (Lathop and Bognar, 2001). Formerly large, contiguous tracts of forested areas have been fragmented by roads and development, limiting the ability of wildlife to easily access different habitats required throughout their life cycles. This is especially true for some fish species, which are no longer able to reach spawning areas that are cutoff by dams, spillways, or other barriers. Within the bay itself, the area of the bottom covered by seagrass meadows has dramatically declined due to eutrophication, sedimentation, warming water temperatures, and damage from direct human contact. Former oyster reefs were depleted by overharvesting and changing salinity, and the historic oyster habitat in many areas has been degraded over time due to siltation.

1.4.4. Overfishing

As mentioned earlier, the once abundant oyster beds of Barnegat Bay have been greatly reduced through a combination of overharvesting, changes in water quality, and siltation. Hard clams, once a major commercial fishery in the bay, have also experienced a major decline in population, likely due to a combination of overharvesting, deterioration in water quality, and changing habitat conditions. The estimate of hard clam abundance in the southern portion of the bay in 2011 was 57% less than that of 1985/1986. Finfish populations in the bay generally follow the larger coast-wide trends but have likely been affected over the long term by changing habitat quality, such as loss of seagrass beds, warming water temperatures, and changes in salinity.

1.4.5. Climate Change and Sea Level Rise (SLR)

Sea level has been rising by approximately 0.16 inches (4 mm) per year and is likely to rise even faster over the next 50-75 years. According to one report published by Rutgers University scientists, sea level along the Jersey Shore will likely rise approximately 0.8 feet by 2030 and 1.4 feet by 2050 (Kopp, 2016). Some areas may experience more frequent flooding from normal tidal events and from episodic storm events. Other low-lying

"back-bay" communities along the Barnegat Bay (*e.g.*, Beach Haven West), which are built on filled wetlands of soft sediments and have considerable exposure to long fetches of wind and waves, may be more vulnerable to SLR and coastal storms. Considerable changes in regional weather patterns – such as more frequent and larger storms and increased amounts and overall variability in temperature and precipitation – are also projected in the northeastern United States. This changing weather has the potential to affect the ecology and physiography of the entire region by increasing bay temperatures or increasing runoff amounts and timing due to increased rain and less snowfall. Areas already in or adjacent to coastal flood plains are vulnerable to inundation by rising waters, but some areas may be at greater risk to other processes such as erosion due to storm surge and wave action.

Changes in sea level and coastal climate have considerable potential impacts to: 1) the water quality, water supplies, habitats and living resources of the bay; 2) the coastal landscape and land uses throughout the watershed; and 3) the human population and economy of coastal communities. In addition, sea level rise and changing climatic conditions will continue to increase some costs and risks to living in vulnerable, low-lying areas along the coast.

Lastly, the slow rate of climate change sometimes does not catch our attention, but other changes, some already evident, will put new pressures on the bay and all of us living along the water's edge. The effects of Superstorm Sandy and other coastal storms are evidence of the potential for change. With the increased risks and costs of clean-up and recovery, we cannot ignore sea level rise, more frequent coastal storms, and other coastal changes. We should recognize that no matter where the storms hit, all people are increasingly invested in disaster response and recovery, both locally and nationwide. Our focus is on ensuring a better future for the Barnegat Bay and its watershed, and rethinking the vision for our coastal communities, especially those with extensive shorelines, which remain dependent on the bay to help sustain the economy and quality of life.

Figure 1.5. **Destruction in the Barnegat Bay Watershed after Superstorm Sandy in 2012. Photo courtesy of NJDEP.**

CHAPTER

2

COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN FOR THE BARNEGAT BAY

In response to growing concerns about the health of the Barnegat Bay and in recognition of the bay's economic importance, the New Jersey Legislature in 1987 passed the Barnegat Bay Study Act (BBSA, P.L. 1987, Chapter 397). The BBSA created the Barnegat Bay Study Group and mandated a study of the nature and extent of the impacts development had on the bay and its watershed. The planning process resulting from the BBSA involved significant coordination and public participation with citizens who lived, worked, and played in the bay area. A Citizens Advisory Group was formed to identify the issues and objectives of most concern to the citizens of the Barnegat Bay watershed and to define the focus of the plan.

Figure 2.1. The Barnegat Bay Estuary Program is part of the National Estuary Program.

2.1. Establishing the Barnegat Bay as an Estuary of National Significance

The work of the Study Group resulted in a three-part study of Barnegat Bay, including:

- Profile of the Barnegat Bay, a characterization of conditions and trends in bay water quality, ecosystem vitality, and human activities that rely on or affect the bay;
- Management Recommendations for the Barnegat Bay, an assessment of alternatives for managing the bay based on the above publication as well as issues of importance to the public;
- Watershed Management Plan for the Bay, a multi-objective management approach directed at achieving meaningful and measurable improvements to the quality of life and resources in the bay area.

After the release of the third and final report, members of the Citizens Advisory Group formed the Barnegat Bay Watershed Association. These actions, including the findings of the reports, led the Governor of New Jersey, Christine Todd Whitman, to submit an application to the U.S. Environmental Protection Agency in March 1995 that nominated Barnegat Bay to be identified as an estuary of national importance and to be included in the National Estuary Program (NEP).

The NEP was established by Congress in 1987 through Section 320 of the Clean Water Act to identify, restore, and protect nationally significant estuaries of the United States. In July 1995, USEPA accepted the nomination of the Barnegat Bay Estuary, officially making it one of the 28 estuaries of national significance in the United States. In April 1996, the USEPA and the NJDEP signed a joint agreement and officially convened the Barnegat Bay National Estuary Program Management Conference. The primary initial responsibility of the management conference was to develop a comprehensive conservation and management plan (CCMP) to restore and protect the health of the Bay. The CCMP was approved by USEPA in May 2002 and guided the organization's work for nearly a decade.

Along with developing the CCMP for the Barnegat Bay, Section 320 of the Clean Water Act also established the Barnegat Bay Partnership – formerly known as the Barnegat Bay Estuary Program – as a partnership of federal, state, county, municipal, academic, business, nonprofit, and private organizations working together to protect Barnegat Bay. The office has changed administrative hosts from the NJDEP (1996-1998) to the Ocean County Department of Planning (1998-2005) to Ocean County College (2005-2019). The BBP program office staff serves as the lead in overseeing the implementation of the CCMP for the Barnegat Bay.

The Barnegat Bay Partnership has continued to assess progress toward completion of the Goals, Objectives, and Actions established in the original 2002 CCMP and has updated its priorities periodically through the completion of two Strategic Plans, 2008-2012 and 2012-2016. This revised CCMP document considers both the original CCMP and the BBP's 2012-2016 Strategic Plan to ensure that all relevant issues and concerns were assessed and addressed. While ecological targets in this document have been set for a 20-year timeline for planning purposes, the CCMP is intended to be a 10-year plan. Tracking will be reported annually with input from partners using an agreed-upon format; reassessment will be conducted every 5 years and identify challenges to implementation, and any revisions that may be required. Currently, the BBP and other NEPs are authorized under 33 U.S.C. § 1330, as amended by P.L. 100-4 and P.L. 114-162.

2.2. Structure and Operation of the BBP

2.2.1. Structure

The Barnegat Bay Partnership (BBP) includes federal, state, county, municipal, academic, business, non-profit, and private organizations working together to protect, restore, and enhance the natural resources of the Barnegat Bay ecosystem. Since October 2003, the BBP and its staff have been administered through Ocean County College and supported with a cooperative agreement from the USEPA. The BBP is organized as a department of OCC, and currently has a staff of seven full-time employees and a variable number of part-time positions. The BBP also hosts the Barnegat Bay Watershed Ambassador through the NJDEP's AmeriCorps Watershed Ambassador Program. The Partnership's management structure includes the following committees.

2.2.2. Policy Committee

The Policy Committee, co-chaired by USEPA and NJDEP, comprises high-level municipal, county, state, and federal leaders, and a Citizen Representative as voting members, together with the non-voting chairs of the Advisory Committee (AC), Science and Technical Advisory Committee (STAC), and the Communication and Education Committee (CEC). The Policy Committee provides overall direction and sets priorities for the BBP, defines Advisory Committee membership, and selects the Program Director.

2.2.3. Advisory Committee (AC)

The Advisory Committee, co-chaired by the BBP Director and an elected member, is comprised of representatives from federal, state, and county agencies; other partners; and the chairs of the Science and Technical Advisory Committee and Communication and Education Committee. The AC refines the definitions of watershed problems and develops strategies to solve them, provides oversight to the scientific characterization of the watershed, prepares action plans for the CCMP, and plans programs to implement the CCMP.

2.2.4. Science and Technical Advisory Committee (STAC)

The Science and Technical Advisory Committee (STAC), with an elected chair and vice-chair, is composed of scientists, engineers, environmental professionals, planners, citizen interest groups, representatives from federal, state, and local governments, as well as individuals from academia and industry. The STAC provides the BBP and collaborating entities with objective, expert advice and peer review for overall scientific and technical matters related to National Estuary Program activities and goals, such as those specified in the CCMP. It works with the Advisory Committee to identify and prioritize science and technical needs within the Barnegat Bay-Little Egg Harbor estuary and its watershed and assists with the BBP's efforts to raise awareness and resources for addressing these needs. The STAC also facilitates communication among other specialized science and technical subcommittees and recommends forming and disbanding new STAC sub-committees and technical work groups as needed.

2.2.5. Communication and Education Committee (CEC)

The Communication and Education Committee (CEC), with an elected chair and vice-chair, provides the BBP and collaborating entities with objective, expert advice and peer review for overall communication, education, and outreach matters related to National Estuary Program activities and goals, such as those specified in the CCMP and the BBP's Communication Plan. The CEC works with the Advisory Committee to identify and prioritize communication, education, and outreach needs within the Barnegat Bay-Little Egg Harbor Estuary and its watersheds and assists with the BBP's efforts to raise awareness and resources for addressing these needs. The CEC also facilitates public participation and diverse stakeholder involvement in BBP-related activities and assists with the selection of the Citizen Representative to the BBP Policy Committee.

2.2.6. Working Together: Memorandum of Understanding, Charters, and Supporting Policies

Shortly after moving to Ocean County College, the BBP developed a Memorandum of Understanding (MOU) to clarify how the Program Office and the organizational partners of the Management Conference would work together. This document formalized the commitments and responsibilities of the BBP Office; OCC as the administrative host; and other organizations as members of the Policy Committee, Advisory Committee, Science and Technical Advisory Committee, and Communication and Education Committee. It was vetted and signed by representatives from all committees and the Program Office in 2011.

In addition to the MOU, the STAC (2011) and CEC (2011) developed Charters that formalized membership and operational procedures, which were critical for identifying priorities and processes for providing federal funding to other organizations. The BBP also developed Advocacy (2012) and Donation (2012) policies.

A needs assessment was undertaken in the summer and fall of 2018 to identify critical roles, process improvements, and resources needed by the BBP to facilitate the implementation of action items and reach the specific objectives and broader goals in the updated CCMP. The assessment was conducted with an outside facilitator and included an online questionnaire followed by a facilitated retreat. A draft report from the facilitator was revised by a workgroup of BBP partners drawn from all BBP committees, led by the Advisory Committee Co-Chair.

The retreat participants identified a number of specific roles that the BBP plays across different priority objectives and activities within the watershed; moreover, several critical and unique roles of the BBP were identified as being particularly important: 1) honest broker of the best available science, 2) central information hub: public education and outreach, and 3) supporter of science to inform management decisions. The report made a number of recommendations regarding additional staffing and other resources (*e.g.*, facilities) to facilitate CCMP implementation. During this process, it was also agreed that the BBP would review and revise its foundational, operational, and policy agreements, including additional policies (*e.g.,* data sharing) that may be needed after completing the revision of the 2021 CCMP. The full needs assessment report can be found on the BBP website.

2.3. Mission

A thriving Barnegat Bay ecosystem is important to the environmental, cultural, and economic well-being of all people who live near, work in, and enjoy the bay. The Barnegat Bay Partnership (BBP) comprises state, county, municipal, academic, business, and private organizations that work together with the communities of the Barnegat Bay watershed: **the BBP mission is to protect, restore, and enhance the Barnegat Bay ecosystem and to advance the sustainable use of its natural resources.** The BBP recognizes the need to focus on our priorities–water quality, water supply, living resources, and land use–and emerging issues–climate change and sea level rise–and to promote understanding of the value of functioning natural systems to our economy and quality of life.

Figure 2.2. ***Unplanned Deviation*, a marsh view at sunset. Used with permission of Greg Molyneux Photography.**

2.4. Our Vision

Our vision for the Barnegat Bay ecosystem is of clean and healthy lands and waters that:

- Sustain vigorous populations of native plants and animals; and
- Are publicly accessible, trash-free, and safe for educational, social, and recreational pursuits, such as sailing, fishing, canoeing, hunting, kayaking, swimming, or simply enjoying a sunny day on the water's edge.

Our vision was developed by knowledgeable and engaged citizens, sustained by public and private stewardship.

Our vision recognizes the dependence of the Shore's communities, economy, and quality of life on healthy lands and waters, and celebrates communities and citizens working together to develop a shared vision for a changing bay.

Our vision recognizes that the bay and its watershed are changing in uncertain ways and that our commitment to its protection and restoration must remain guided by the best available science and with participation by the public.

2.5. Revising the CCMP: Identification of CCMP Changes, Including Climate Change

Nearly 19 years have passed since the completion of the original CCMP for the Barnegat Bay. In that time, much has been accomplished in the way of working together, conducting research, and developing a better understanding of how the bay works and how best to manage these resources.

There are several key changes in the approach to developing the revised 2021 Barnegat Bay CCMP, reflective of our growing knowledge of the interconnectedness of the issues impacting our estuary and the best ways to effectively address these issues.

The first change is the incorporation of climate change vulnerability into our development of the CCMP Objectives and Actions. Estuaries and coastal areas are particularly vulnerable to sea level rise and other aspects of climate change (*e.g.*, higher temperatures; more precipitation; invasive species; and more frequent and intense storms, such as Superstorm Sandy). New Jersey coastal areas, including the Barnegat Bay estuary, are experiencing one of the highest rates of sea level rise in the continental United States. Current observations have shown recent rates of approximately 4 mm per year (about 16 inches per century) of sea level rise (Kopp, 2016). Though this may seem inconsequential to some, these rates are recognized by national and regional experts to be of sufficient magnitude to transform the character of the mid-Atlantic coast, with a large-scale loss of tidal wetlands and potentially significant changes to the topography of barrier islands and low-lying, "back bay" areas.

Adapting to climate change and sea level rise affects nearly every aspect of the work done by BBP and its partners, and is a challenge that requires site-specific remedies. This CCMP considers the impacts of climate change and identifies the objectives and actions most vulnerable to climate change and sea level rise (See Chapter 8.). Identification of Objectives and Actions most susceptible to climate change will allow BBP and its partners to prioritize actions and ensure that the proper strategies are in place. Information about the BBP climate change vulnerability assessment is provided in Chapter 8.

The second area of change involves the combining of the Habitat and Fish & Wildlife priorities from the original CCMP into a combined Living Resources priority area. In reviewing the original CCMP Goals, Objectives, and Actions, as well as the priorities included in the most recent BBP Strategic Plan, it was evident that these two priorities overlapped considerably. Combining the two categories into one priority area streamlines this document and allows the CCMP Goals, Objectives, and Actions to be more focused, without sacrificing detail or impacting intended ecological outcomes.

Figure 2.3. Sailing class. Photo courtesy of Cara Muscio.

Lastly, this document builds upon outreach and actions initiated in Barnegat Bay that were implemented since 2002 to protect water quality, habitats, and living resources throughout the bay and its watershed and also expands outreach efforts to communities with environmental justice concerns.

2.6. The CCMP: Ensuring Our Environmental and Economic Future

According to Kaufman and Cruz-Ortiz (2012), "The water, natural resources, and ecosystems in the Barnegat Bay watershed contribute an economic value of $2-4 billion annually to the New Jersey economy." This economic value is derived from water quality, water supply, fish/wildlife, recreation, agriculture, forests, and public park benefits. Commercial and recreational fishing, tourism, and other water-dependent recreation continue to generate many jobs, as do other industries based in or near the estuary. Using 2012 employment as a measure of value (Kauffman & Cruz-Ortiz, 2012), natural resources within the Barnegat Bay watershed, directly and indirectly, support more than 60,000 jobs, with over $2 billion in annual wages. In addition, a 2019 Economic Impact of Tourism Report observed that Ocean County experienced $4.98 billion in direct sales and $1.00 billion in recreational activities (Tourism Economics, 2019).

This revision to the Barnegat Bay Partnership's (BBP) Comprehensive Conservation and Management Plan is the blueprint for how to collectively move forward to ensure that flora and fauna can survive and flourish, that residents and visitors can continue to enjoy the benefits of living in vibrant coastal communities, and that environmental and economic prosperity is ensured for future generations.

CHAPTER

3

ECOSYSTEM-BASED APPROACH AND TARGETS

This 2021 CCMP uses an ecosystem-based management approach – a means of protecting and managing natural resources that considers the various interrelated parts of the ecosystem and how they interact with each other – instead of addressing each issue or species separately. Using this approach, resource managers, researchers, policy makers, elected officials, and residents identify ways to assess and address the often-complex issues facing a natural system such as the Barnegat Bay. By examining the many interrelated causes and/or modifiers of an identified problem, environmental decision makers can better understand the impacts of natural systems and human activity on the environment, leading to a much more holistic solution.

3.1. Priority Areas

Beginning in 2017, the BBP and its partners initiated a process of updating the CCMP to reflect changes in the Barnegat Bay's condition and in consideration of emerging threats. This revised plan focuses on four priority areas: Water Quality, Water Supply, Living Resources, and Land Use.

Each priority includes a specific Goal, several key Objectives, and multiple Actions to be undertaken to achieve the stated Objectives. Many partners and stakeholders have been instrumental in the creation of these updated Goals, Objectives, and Actions, which will guide the work of the BBP moving forward.

In adopting an ecosystem-based management approach to the development of the CCMP, factors including our changing climate, sea level rise, and other dynamic processes in the bay can be factored into decisions and management strategies in the four priority areas. The **goals for the four priority areas** are as follows:

- **Water Quality** – To protect and improve water quality throughout Barnegat Bay and its watershed by reducing the causes of water quality degradation to achieve swimmable, fishable, and drinkable water, and to support aquatic life.
- **Water Supply** – To ensure adequate water supplies and flow in the Barnegat Bay Watershed for ecological and human communities now and in the future.
- **Living Resources** – To protect, restore, and enhance habitats in the Barnegat Bay and its watershed as well as ensure healthy and sustainable natural communities of plants and animals both now and in the future.
- **Land Use** – To improve and sustain collaborative regional approaches to responsible land use planning and open space protection in the watershed that protect and improve water quality, water supply, living resources, soil function, and hydrology.

Chapters 4 through 7 provide a more detailed look at the important issues and considerations for each priority area, along with the current status and trends relevant to each, to provide a framework for understanding how focusing on these priority areas will lead toward a higher level of protection for the Barnegat Bay.

3.2. Ecosystem-Based Targets

While the focus of the Action Items in this CCMP are broken into four priority areas, many of these issues will require actions in more than one priority area. To guide our collective efforts, the following Ecosystem-Based Targets were developed. Ideally, ecosystem-based targets are broad, with each individually spanning and integrating environmental improvements from actions across changes in multiple priority areas. A number of targets were initially suggested by the Steering Committee or other management conference members based on that criterion. Those targets were then reviewed by the expert panels reviewing the actions for each priority area. The expert panels refined

the suggested targets, focusing on those that are based upon existing data sets and are included as a component within an existing monitoring program. Furthermore, the expert panels reviewed the metrics for each target, providing guidance on reasonable "stretch" goals based on prior actions within the watershed.

The eight targets identified below have been developed taking into account the challenges of not only guarding against future loss/degradation in each respective area, but also working toward measurable improvement/restoration of these natural resources. The BBP will work with its partners towards reaching the following Ecosystem-based targets within the next 20 years. The relationships between these targets and the objectives within each priority area is depicted in Figure 3.1.

- **Public Beach Openings/Closures:** *Increase the number of bay beaches and lakes within the Barnegat Bay watershed open for swimming from the 2018 baseline of 32, and reduce the average number of annual beach closure days below that of 2016-2018 (74 days).* Maintain and/or improve public notification and advisory processes to ensure timely notice even for bathing beaches not yet open for the season. These targets involve working with the NJ Department of Environmental Protection (NJDEP), the NJ Department of Health (NJDOH), the Ocean County Health Department (OCHD) & the Long Beach Island Health Department.
- **Approved Shellfish Areas:** *Upgrade 5% of the potentially harvestable shellfish acreage that is currently restricted or closed for shellfishing compared to the 2020 acreage (11,267 acres).* Areas are closed or restricted for shellfishing for a variety of reasons, including the presence of docks or marinas, incompatible adjacent land uses, and/or poor water quality. Poor water quality around shellfish beds is generally attributable to contamination from stormwater runoff and other nonpoint sources rather than single, point source discharges. This target is focused on reopening areas that are closed or restricted due to poor water quality through both watershed and in-bay improvements.
- **Submerged Aquatic Vegetation (SAV) Extent:** *Maintain the overall extent of submerged aquatic vegetation present in 2009 (12,980 acres) and restore an additional 10 acres of seagrass.* While the 2009 acreage is far less than the once prevalent historic beds found in Barnegat Bay, stopping the current declining trend would be a substantial accomplishment. Methods for restoring seagrass beds are an evolving technology, and are predominantly done at small scales. Achieving 10 acres of restoration in 10 years is an ambitious goal given the current limitations in restoration methodologies and resources available.
- **Wetland and Riparian Buffer Preservation:** *Maintain or increase the current acreage of upland buffers adjacent to all wetland and riparian corridors.* Baseline information for this target is not currently available and will require the development of baseline maps to determine buffer acreage. The completion of wetland and riparian buffer mapping is included in this plan as a high priority Action Item (LR 3-3; page 81). Because of the importance of riparian and wetland habitats, maintenance of the existing buffers is the minimum target.
- **Wetland Protection:** *Maintain overall extent of tidal wetland acreage (20,922 acres) as identified on the 2015 aerial imagery[1]. Restore or enhance 10 acres of tidal wetlands impacted by sea level rise and erosion through nature/natural based strategies to limit further loss.* While the 2015 acreage is diminished compared to the historic extent of salt marshes in the watershed, stopping the current declining trend, particularly in the face of sea level rise, would be a substantial accomplishment. Ideally, the program and partners would restore the 677 acres lost over the past 25 years; however, 10 acres of restoration in 20 years is a more realistic target given existing wetlands laws, regulations, and policies, currently available resources, and the high cost of such projects in New Jersey.
- **Clam restoration:** *Return the hard clam abundance in Barnegat Bay-Little Egg Harbor to 1985/87 estimated population size of roughly 377,000,000 clams (Celestino, 2003; Dacanay 2013) by means of stock enhancement, habitat restoration, and other management actions.* The most recent assessment of hard clam abundance in Little Egg Harbor was 85.7 million clams, a 57% decline from the 1985/87 levels, while north of the Route 72 bridge the estimated abundance was 138.2 million clams, a decrease of around 23% from the 1985/87 levels. Returning to the higher abundance levels within the target time frame appears reasonable to resource biologists and managers due to life history of this species**.**
- **Ecological Flows**: *Maintain flow levels at least 30% over minimum ecological flows for gauged waterways within the watershed.* To achieve this target, the minimum ecological flows for gauged waterways first needs to be determined. The determination of minimum ecological flow is included in this plan as a high priority Action Item (WS 1-2; page 54). The 30% buffer over the minimum will be protective of sensitive living resources. Available information suggests that waterways in the more developed areas of the watershed may not currently meet the target.
- **Water Conservation and Reuse***: Reduce five-year rolling average water withdrawals 10% below the 2010 estimate of 85.56 mgd. Explore appropriate water-reuse technologies used elsewhere in New Jersey and possibly other states.* The target water withdrawal level would be comparable to that of the early 2000s. Increased population growth within the watershed will require that effective water conservation and reuse measures be adopted to meet this modest target. The success in meeting this target will likely affect our ability to meet the ecological flows target described above.

A detailed list of actions, and how they relate to each of the ecosystem-based targets, can be found at the end of each of the priority area discussions in Chapters 4 through 7 and in Appendices B through E. Many of these actions are holistic (*e.g.*, implementing the nutrient TMDL to achieve water quality improvements) and may be expected to

1 The 2015 aerial imagery is of high quality, sufficient for regulatory work, and is the most recent imagery available. *It is recognized that some erosion is likely to have occurred since 2015, which is why periodic assessment of shorelines is crucial. However, net-zero erosion remains the best target, as it represents "equilibrium" where gains equal losses baywide.*

help achieve different targets, goals, objectives. In addition, it should be recognized that making measurable progress toward ecological improvement is a long and arduous process, and, as future conditions change and our science improves (*i.e.*, ecosystem-based management), may require additional actions not explicitly identified here.

While these targets are identified with 2040 as the target completion date, taking steps toward meeting these targets will start immediately. The relationships between these targets and the objectives within each priority area is depicted in Figure 3.1.

3.3. Preface to Chapters 4-7

The following four chapters establish the Goals, Objectives, and Actions for each of the four priority areas of the CCMP. These chapters were generated through a collaborative process by all BBP partners, including review of previous guidance documents such as the original CCMP, BBP Strategic Plan, and other BBP publications, state and local reports, *etc*. In addition, outreach to residents and stakeholders was conducted throughout the watershed to obtain input and feedback throughout this process.

This document presents a comprehensive and current set of Goals, Objectives, and Actions that take into consideration the many issues, challenges, and opportunities that exist for the protection and management of the Barnegat Bay Estuary. For each set of Goals, Objectives, and Actions, appropriate performance measures and milestones have been identified as a means to accurately track progress toward the established goals. Over the next 10 years of CCMP implementation, the BBP Management Committee expects to achieve specific accomplishments and outcomes. Each CCMP action contains measures for documenting that progress. Those measures will be the subject of ongoing tracking as part of our yearly progress report and workplan. The BBP commits to measuring, tracking, and reporting the implementation progress of this revised CCMP. In order to determine the effectiveness of CCMP actions, the BBP's monitoring plan will serve as a critical component that will be used to detect changes and improvements to Barnegat Bay. Those results will also be reported to the BBP Management Conference members, local stakeholders, and to USEPA.

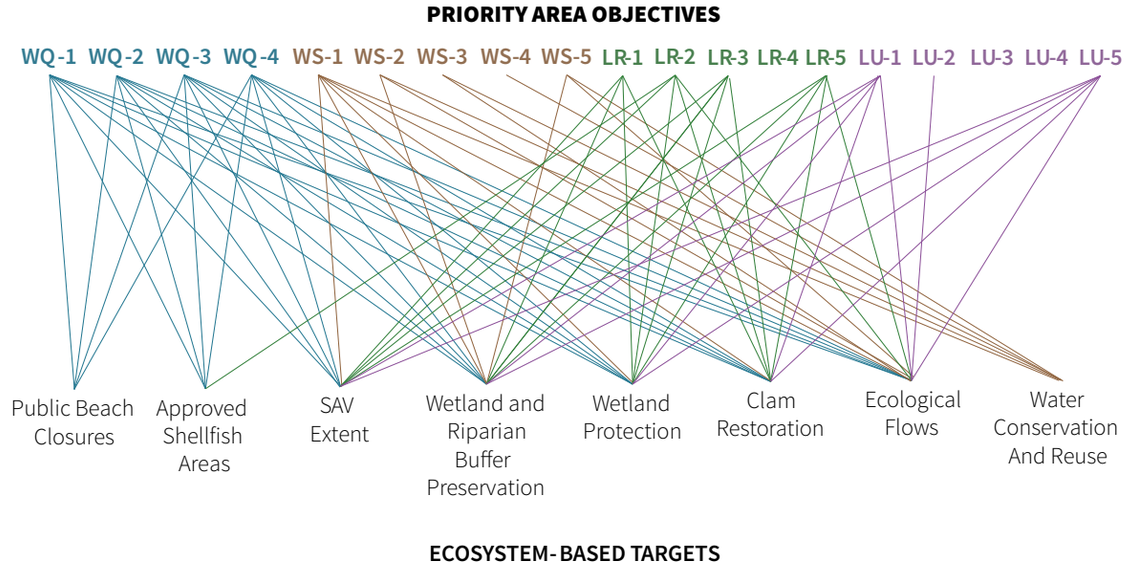


Figure 3.1. The interrelationships between the objectives within each priority area and the Ecosystem-Based Targets. The lines are color-coded based on the priority areas: **WQ-1 — WQ-4 = water quality, WS-1 — WS-5 = water supply, LR-1 — LR-5 = living resources,** and **LU-1 — LU-5 = land use.**

Figure 3.1-1. Bay beach. Photo courtesy of BBP.

3.4. Status and Trends Indicators

Status and trends infographics appear in each of the following four chapters. These infographics are taken from the 2016 State of the Bay Report, and serve as a quick reference to indicate the overall status and trends of these indicators, many of which have been tracked since 2005. The gauge provides a summary of the indicator's status and trend, incorporating quantitative measures, where available, and the best scientific judgment of the review panel. Determination of an indicator's status is based on data available for 2010-2015, while the trend is based on the longest complete dataset available for that indicator. In some cases, it was not practicable to use a five-year indicator for the status determination.

Figure 3.1-2. Barnegat Bay clams. Photo courtesy of Cara Muscio.

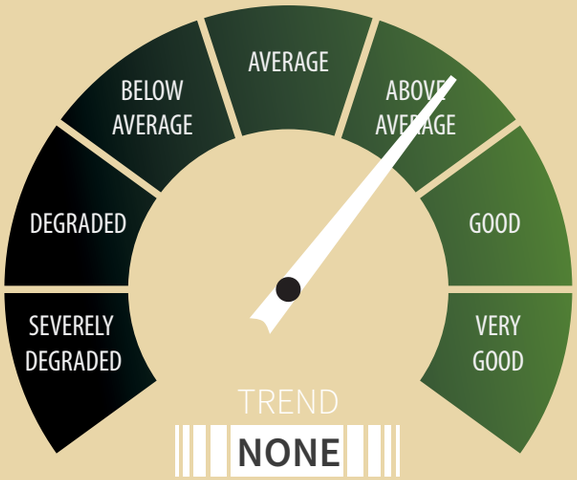


Figure 3.2. Status Ratings (Needle); status and trend indicator. The needle points to the appropriate status for the indicator. See text for explanation of status and trends ratings.

Trend ratings (internal arrow)

- A trend arrow pointing to the left indicates a deteriorating condition.
- A trend arrow pointing to the right indicates an improving condition.
- NONE indicates no discernable trend in the data.
- A question mark (?) indicates data were insufficient to develop a trend. As we work to protect and restore the bay and its contributing watershed, these indicators, reported every five years in future State of the Bay Reports, serve as a useful reference point to track progress toward achieving the stated goals.

CHAPTER

4

WATER QUALITY

4.1. Themes

- The bay's water quality is critical to the bay's overall condition, as well as to the coastal communities within this region and their tourism-based economies.
- Eutrophication of the bay caused by high nutrient loading is the major problem affecting the northern portions of the bay, while turbidity is an equally important problem affecting the southern portion of the bay.
- Improvements in the bay require aggressive efforts to reduce nonpoint source and other pollutant loadings to the bay.
- Our understanding of the bay has improved substantially in recent years; however, continued monitoring and science are essential to improving the bay as our world changes.

4.2. Water Quality Goal and Objectives

To protect and improve water quality throughout Barnegat Bay and its watershed by reducing the causes of water quality degradation to achieve swimmable, fishable, and drinkable water, and to support aquatic life.

1. Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution.
2. Assess status and trends of water quality throughout the watershed.
3. Conduct studies to improve scientific understanding of new and emerging issues pertaining to the chemical, physical, and biological conditions and dynamics in the Barnegat Bay and its watershed.
4. Increase public education, engagement, and stewardship regarding water quality in the watershed.

4.3. Introduction

4.3.1. Water Quality and Its Connection to Other CCMP Goals

NEPs were established in large part to address issues of water quality in estuaries of national significance. The ecology of the entire watershed, the health of people in all the communities and of the biotic resources living throughout the watershed, the economy of the region, and our quality of life are all dependent on good water quality. Water quality, because it is affected by land use and other human activities as well as by climatic changes, has become an increasing concern over the past few decades.

The Barnegat Bay Partnership's CCMP goal for water quality is built upon the foundation provided by the Clean Water Act (USEPA, Clean Water Act), to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This foundation translates into two fundamental aims: to eliminate the discharge of pollutants into the bay and its contributing watershed, and to achieve water quality levels that are fishable and swimmable, and meet all water quality criteria. The steady population growth and coastal development over the past century has not been without adverse impacts to the environment. Perhaps most troubling is the bay's eutrophication, though concern

about other issues, especially sea level rise and climate change, have also increased.

4.3.2. Eutrophication

Eutrophication – an increase in the rate of supply of organic matter to an ecosystem – remains one of the most critical challenges facing Barnegat Bay, and has been the subject of much attention in recent years (Kennish, 2007). Human-related activities that increased soil erosion and nutrient pollutant loadings (See Figure 4.1-Water Quality Status and Trends: Nutrient Loading) contribute greatly to the bay's eutrophication. Recent studies (Baker *et al.*, 2014) have quantified the increasing nutrient load from lawn runoff, especially in the northern bay.

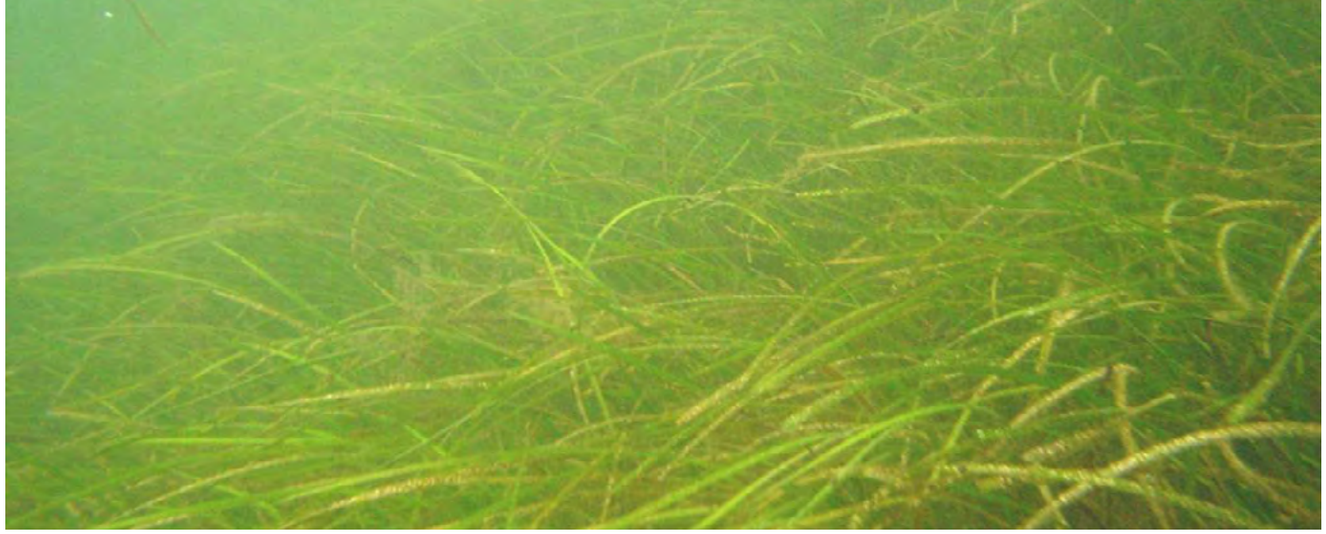
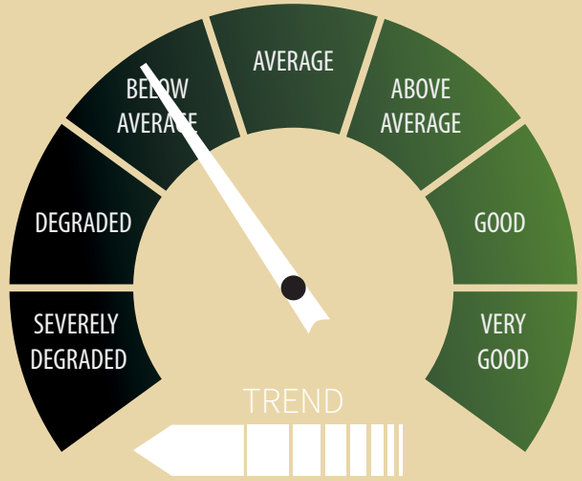


Figure 4.0. Eutrophication impacts seagrasses in the bay. Photo by Greg Sakowitz.

Figure 4.1. 2016 Water Quality Status and Trends: Nutrient Loading

Nitrogen and phosphorus are recognized as the two primary contributors to the bay's eutrophication. From 1989 to the present, estimates show an overall increase in nitrogen loading through time. Recent estimates of loading from the watershed have been more variable but approximately 25% higher (up to 857,000 kg N/yr) due to recognition of the substantial inputs of nitrogen entering the bay from the ocean, which had not been included in previous pollutant load estimates. It is important to note that the nitrogen concentration in the ocean water entering the bay is generally not high; however, the tidal volume of water entering the bay is large. This component of the load had not been assessed and included in prior estimates of total nutrient loading.

Nitrogen loading is far higher in the northern bay due to increasing inputs of stormwater contributions from the developed landscape. Phosphorus loadings to the bay (17,000-32,000 kg) from northern bay tributaries are higher than from southern bay tributaries; however, the phosphorus concentrations show the reverse pattern in bay water. This discrepancy merits further study.



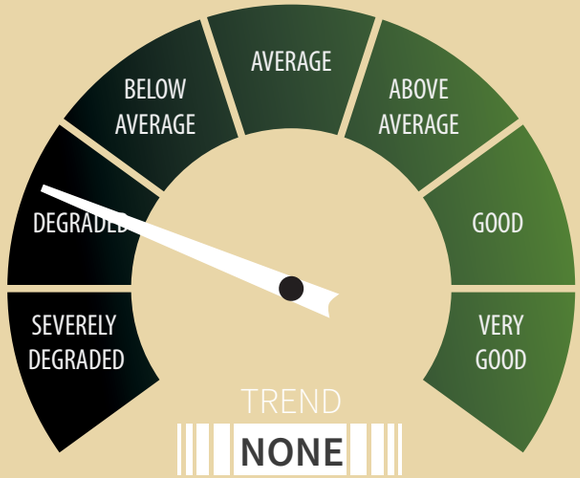
See the BBP's 2016 State of the Bay Report for additional information.

Figure 4.2-1. A summer algal bloom in Long Swamp Creek. Photo courtesy of BBP.

Eutrophication can lead to a cascading chain of negative environmental conditions, including blooms of drift algae or phytoplankton, which can cause other changes in the bay such as increased turbidity, hypoxia (low dissolved oxygen) or anoxia (no dissolved oxygen; See Figures 4.2., 4.3. and 4.4. regarding specific conditions.). It can also result in other changes in aquatic communities including loss of shellfishes, eelgrass, and other submerged aquatic vegetation. Changes in temperature and other water quality conditions – such as nutrient levels – in freshwater rivers, creeks, and streams may intensify eutrophic conditions and have other ecological impacts to the bay. Nutrient and sediment loadings pose challenges from the headwaters of the bay in the westernmost reaches of the watershed to the bay itself. Addressing eutrophication requires an overall reduction in the total nutrient loading to the bay and its tributaries throughout the watershed.

Figure 4.2. 2016 Water Quality Status and Trends: Northern Bay Algal Blooms

Algal blooms are typically characterized by explosive growth of a single plankton species, which can create a cascade of negative impacts (*e.g.*, high turbidity shading benthic habitats, low dissolved oxygen, release of algal toxins killing plankton and fishes, changes in community composition, and trophic dynamics). Algal blooms have been recorded in the bay at various time and spatial scales during the 2011-2015 time period, with the largest and most frequent blooms occurring in the northern portion of the bay. While routine monitoring for Brown Tide, a harmful algal bloom, was discontinued in 2004, studies have shown various small-scale blooms of Brown Tide during the 2011-2015 time frame. The NJDEP now conducts aerial flights over Barnegat Bay to assess chlorophyll A six days a week from May through October. Any areas with high chlorophyll A levels indicative of bloom conditions are sampled. Climate in the northeastern US is predicted to include more precipitation overall in the future, but is also predicted to be more variable, including both hotter and drier conditions. Thus, the frequency and intensity of algal blooms may change in the northeast, as brown tides have been linked to certain drought conditions in the bay and may be exacerbated by future drought conditions.



See the BBP's 2016 State of the Bay Report for additional information.

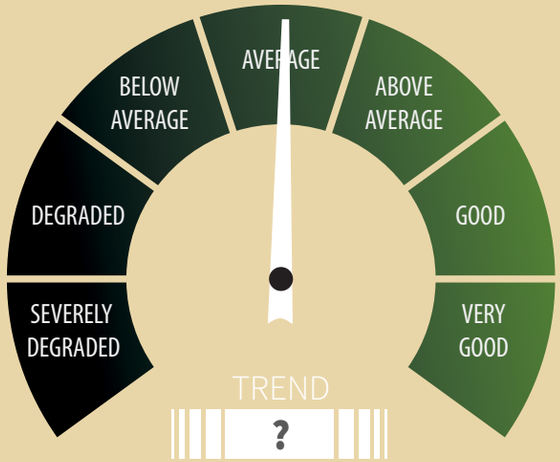


Figure 4.3. **2016 Water Quality Status and Trends: Turbidity**

There are three sections of the estuary that were listed as impaired for turbidity on the NJDEP (2014) List of Water Quality Limited Waters. During four of the five years evaluated, turbidity in Manahawkin Bay limited light transmission to below one meter during the seagrass growing season, a condition that can be detrimental to seagrass growth.

Long-term trends in turbidity are difficult to discern due to confounding environmental factors, *i.e.*, different sources of turbidity (*e.g.*, phytoplankton, pump stations, discharges of groundwater) in different parts of the estuary.

As with dissolved oxygen, variation in turbidity from year to year is affected by many factors, including weather, water temperature, nutrients, and time of day. Except for nutrients, nothing can be done to change those factors and their effects.

See the BBP's 2016 State of the Bay Report for additional information.

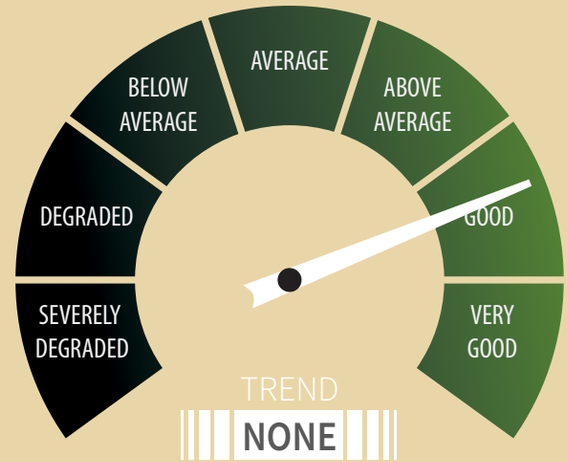


Figure 4.4. **2016 Water Quality Status and Trends: Dissolved Oxygen**

Dissolved oxygen (DO) is a fundamental requirement for the maintenance of balanced populations of fish, shellfish, and other aquatic organisms. The nature and extent of the organism's response to low oxygen concentrations depends on several factors, including the concentration of oxygen in the water, how long the organism is exposed to reduced oxygen, and the age and condition of the organism.

Three of the nine assessment units in the estuary were listed as impaired for dissolved oxygen on the NJDEP (2014) List of Water Quality Limited Waters. Between 2011 and 2014 a total of five sampling locations had values below 4 milligrams per liter (mg/l) in the summer, the level at which biota may begin to show signs of stress. All other stations sampled during those years did not drop below the threshold. Low dissolved oxygen is often localized in the bay, and may not be low throughout the entire water column (*e.g.*, usually lower in bottom waters). There has been no apparent trend in DO data since 2005. Variation in dissolved oxygen from year to year is affected by many factors, including weather, water temperature, nutrients, and time of day.

See the BBP's 2016 State of the Bay Report for additional information.

Over the past 10 years, considerable effort has been expended to better understand the nutrient loadings to the Barnegat Bay and their impacts on the bay's dynamic conditions. Key components of this effort have included the following:

- A comprehensive water quality monitoring program [see interactive NJDEP website (NJDEP, Barnegat Bay Mapper, n.d.)], several research studies focused on the major living resources of the bay [*e.g.*, plankton in the water column (Howson *et al.*, 2017), benthic communities living on or in the bottom sediments (Taghon *et al.*, 2017), fishes and motile invertebrates (Valenti *et al.*, 2017)].
- Other targeted studies [nutrient history of the bay (Velinsky *et al.*, 2017)], critical habitats (Lathrop *et al.*, 2017).
- The development of an integrated, hydrodynamic water quality model for the bay by the USGS (Defne *et al.*, 2017).

These investigations have been critical to our increased understanding of the current nutrient loadings and concentrations, the condition of the bay's biological resources, and their relationships. Understanding those relationships is essential to developing a decision-making framework for protecting and restoring the bay and its resources.

Water quality standards provide the decision framework that is used to both determine the current condition of the bay and guide restoration efforts. New Jersey's Surface Water Quality Standards (SWQS; N.J.A.C. 7:9B) do not currently include numeric nutrient criteria that are applicable for Barnegat Bay, though criteria are available for other related parameters, such as dissolved oxygen and turbidity. These measurable conditions can be used as a substitute for nutrients, in that excessive nutrients in the water column will result in depleted dissolved oxygen and excessive turbidity due to algal blooms (*i.e.*, the outcomes of the bay's excessive production). Currently, some parts of Barnegat Bay are impaired for dissolved oxygen and turbidity. Additionally, water chemistry is not the only indicator of condition. Whenever possible, water quality assessments include an evaluation of biological health and biodiversity in addition to water chemistry to obtain a more complete picture of the situation.

4.4. Objectives and Actions

4.4.1. Water Quality Objective 1

Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution. This will be addressed in a variety of ways, including support for establishment and implementation of TMDLs, development and implementation of Watershed-Based Plans, and effective stormwater management. Water Quality Actions include the following.

WQ Action 1-1 **Support development and implementation of a Barnegat Bay TMDL(s) (Total Maximum Daily Load), including the development and use of Barnegat Bay-specific biological indices of water quality, to address nutrient and other pollutant loadings and to guide future, science-based management decisions.**

A TMDL is a calculation that determines the maximum amount that a particular pollutant can contribute from all sources to a waterbody without violating a water quality standard. Any Barnegat Bay nutrient TMDL should identify the nutrient load reductions needed to meet water quality targets that are selected for the Barnegat Bay. Through comprehensive monitoring, research findings, and modeling investigations, the NJDEP has been working with many partners to develop biological indicators and an appropriate numeric nutrient standard for Barnegat Bay. Benthic invertebrate research in Barnegat Bay has shown a strong correlation between total nitrogen (TN) concentration in the water column and the abundance (percentage) of sensitive benthic invertebrate species (Taghon *et al.*, 2017). This relationship between the biological community and the nutrient levels is being used to develop: 1) a nutrient target to ensure sufficient survival and protection of sensitive invertebrate species, and 2) the means to assess aquatic life use in Barnegat Bay in the upcoming NJDEP Integrated Water Quality Assessment Report.

Identifying a "reference" or "close-to-natural" condition is an important consideration when developing a nutrient standard. This reference condition can be defined as the lowest pollutant level the system can achieve with no anthropogenic (human-caused) pollutant inputs. Findings from this research and the USGS water quality model potentially ensure the development of a numeric nutrient standard that can serve as a target for the bay's restoration.

The USGS integrated water quality model (Defne, 2017) establishes a correlation between the loadings of pollutants from all sources and simulates a response in nutrient concentrations and other parameters in the bay. In addition, the model can be used to simulate

various scenarios, including various climatic conditions (warm versus cold winters, wet versus dry years) or potential future conditions (closure of the Oyster Creek Nuclear Generating Station, or offshore inputs).

The NJDEP has indicated that this water quality model also will be used to develop a TMDL for nutrients in Barnegat Bay (NJDEP, 2017a). Once a TMDL is established, it will include reduction targets to meet the applicable water quality standards, protect sensitive species, and reduce algal growth. A TMDL would require load reductions from within the watershed and specific tributaries contributing to those portions of the bay not meeting the water quality standards.

4

WQ Action 1-2 Develop and implement watershed plans at the sub-watershed level.

A Watershed-Based Plan (WBP) identifies areas in need of restoration and protection at a smaller sub-watershed level. WBPs provide detailed technical assessment and management information, including the analyses, actions, participants, and resources related to developing and implementing the plan. WBPs that include USEPA's (2008) required elements (*e.g.*, WQMP/Section 319 plans) are eligible for federal pass-through funding that is provided to New Jersey via the CWA Section 319[h] (33 U.S.C. § 1329). At present, only one WBP, the 2013 Metedeconk River Watershed Protection and Restoration Plan (BTMUA, 2013) has been developed in the Barnegat Bay watershed that is in accordance with the USEPA (2008) guidance. Developing more WBPs enables the BBP and other organizations to qualify for priority restoration activities.

The NJDEP makes funding available through its Water Quality Restoration Grants (NJDEP, 2019a) for WBP development and to implement practices and activities designed to reduce pollutant load to a watershed. Presently, the NJDEP is funding the development of WBPs for four Barnegat Bay subwatersheds (Toms River, Oyster Creek, Cedar Creek, and Little Egg Harbor) in 2020-2022. Implementing nonpoint source and stormwater restoration projects in the Barnegat Bay watershed has been identified as a priority for funding over the past several funding cycles; completed projects in Barnegat Bay can be found on the NJDEP (2019b) website.

WQ Action 1-3 Implement the Soil Restoration Law and associated comprehensive soil restoration procedures for various land use activities.

Nonpoint source (NPS) pollution is caused by rainfall or snowmelt moving over and/or through the ground, where it picks up and carries various pollutants and deposits them into lakes, rivers, wetlands, coastal waters, and ground waters. Most naturally occurring soils within the Barnegat Bay watershed are relatively sandy; have minimal organic matter content; and maintain an interconnected system of small, medium, and large pores equal to as much as half of the soil's total volume. In the simplest terms, healthy porous soils act like a sponge, exhibit virtually no runoff, and reduce NPS pollution by increasing plant uptake of water and nutrients applied in fertilizers.

However, due to low organic matter in sandy soils in many coastal areas, nutrients can move quickly through unsaturated zones into the water table before the plants can uptake most of the fertilizer applied. The impacted groundwater contribution to surface nutrient levels will be smaller than surface runoff, but will be present and consistent in baseflow.

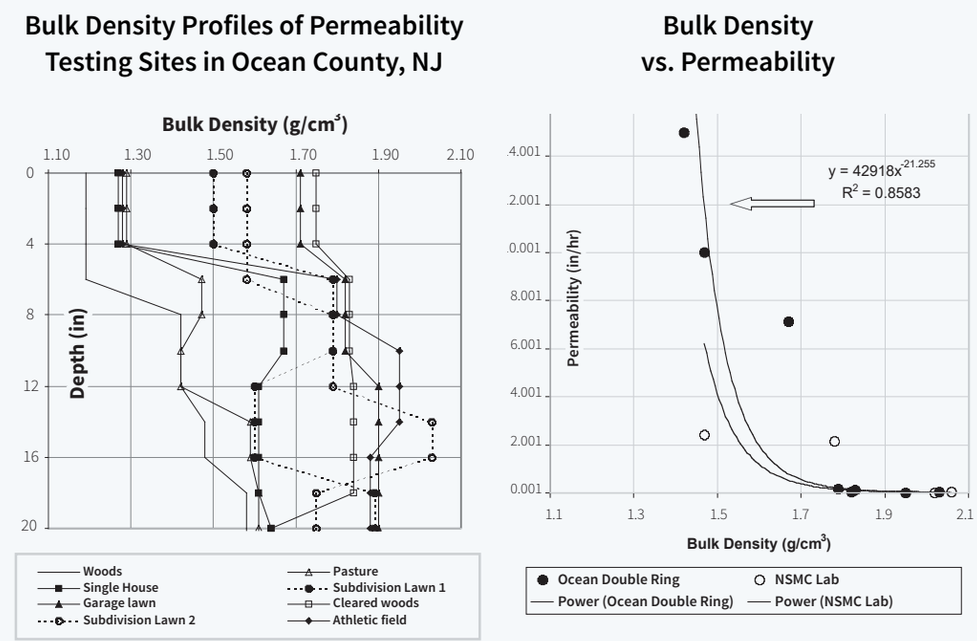


Figure 4.5a (left). Soil bulk density profiles at testing sites in Ocean County. Note that soil density is low in surface layers at undisturbed wooded sites, whereas soil density is high at the surface in residential and other developed sites. Soil density generally increases with depth but remains lower at undisturbed soils at all depths.

Figure 4.5b (right). Soil permeability as a function of bulk soil density at testing sites in Ocean County. Note that permeability decreases as soil density increases. Figures from OCSCD *et al.*, 2001.

Common development activity often changes soil features (*e.g.*, decreased porosity, increased compaction) and affects how water and pollutants move over or through the ground. Farmers, residential homeowners, and managers of parks, playgrounds, and athletic fields have experienced difficulty managing land areas that have been subjected to soil compaction. Compacted areas become impervious as densities approach values for concrete (Figs. 4.5a. and 4.5b.; OCSCD *et al*., 2001), and become increasingly plagued by surface ponding, poor plant growth, and localized flooding.

Perhaps most importantly, soil compaction affects the quantity and quality of water reaching the bay. With increasing soil compaction, NPS pollution to nearby waterbodies increases. The nutrients in fertilizers, instead of infiltrating into the ground and assimilating into plants, run over the ground and into waterbodies, where they fuel the bay's eutrophication. Protecting and improving soil functionality (*i.e.*, reducing soil compaction and increasing water infiltration) is one of the most critical and basic concepts to ultimately improve water quality throughout the Barnegat Bay watershed.

WQ Action 1-4 Support implementation and enforcement of stormwater rules and ordinances at state, county and municipal levels.

The NJDEP's Municipal Stormwater Regulation Program rules were initially developed to implement USEPA rules that became effective in 1999. The NJDEP issues general permits authorizing stormwater discharges from Tier A and Tier B municipalities, as well as public complexes and highway agencies, which discharge stormwater from municipal separate storm sewer systems (MS4s). Tier A municipalities, generally located within more densely populated regions of the state or along/near the coast, include most municipalities in the Barnegat Bay watershed. Public complexes include most colleges, prisons, hospitals, and military bases. Highway agencies include county, state, interstate, and federal government agencies that operate highways and other roadways.

NJDEP has adopted stormwater management rules (N.J.A.C. 7:8) to reduce stormwater volume, flow rates, associated erosion and flooding, and pollution loadings, which are implemented through issuance of the MS4 permits. For new developments, both NJDEP and the municipality may have a role in reviewing compliance with stormwater management rules. Maintenance of stormwater systems, including best management practices, is the responsibility of the owner and/or operator, which may include state and county transportation departments, municipalities, companies, and homeowner associations. Many towns have adopted stormwater ordinances as part of their municipal permits, requiring residents to clean up after their pets, place yard waste in a container for collection, and manage dumpsters to contain waste and prevent leakage. These ordinances also prohibit feeding wildlife, littering, over-fertilization, illicit connections to storm drains, and dumping to storm drains, among other strategies to reduce stormwater pollution.

Figure 4.6. Stormwater Runoff from Gudz Road, Lakewood, New Jersey. Increasing precipitation predicted for the northeastern U.S. is likely to result in localized flooding, which leads to higher stormwater management and roadway maintenance costs, and increased stormwater runoff from impervious surfaces resulting in NPS pollution. Photo courtesy of the BTMUA.

As part of its Phase 2 Restoration, Enhancement, and Protection Plan for the Barnegat Bay, NJDEP has developed a Municipal Stormwater Compliance Assistance Program (MSCAP) to aid municipalities in complying with existing regulatory requirements to ensure that maximum pollutant reductions are being attained. The Program will be working closely with municipalities to identify sources of nutrient loading, turbidity, and other water quality impairments using a cooperative "find-and-fix" approach. The main goals are to improve overall MS4 permit compliance; provide technical support to municipal officials; encourage innovative solutions to address non-compliance; and, of course, improve water quality in the bay. Toms River has agreed to work with the NJDEP and other local partners as the pilot project for this effort. Eventually, the process established through working with Toms River will become a model for conducting compliance assistance visits in the remaining municipalities in the watershed. The NJDEP will be providing guidance and technical assistance to municipalities as they work with other local partners (See Water Quality

Actions 1-5 through 1-7.). The Department will identify problems with the towns' MS4 permit compliance, which will help the towns ensure compliance with their municipal permit and regulations; furthermore, the Department will assist the towns in identifying other enhancements that could be implemented to reduce nonpoint source pollution and address other local problems, such as nuisance flooding (See Figure 4.6.) and wetland loss/erosion. Lastly, the NJDEP will also provide outreach relative to the use of the NJDEP's stormwater mapping application to assist municipalities with mapping of all stormwater BMPs within each municipality, and work with NJDEP and the town to create a database that is periodically updated as part of the compliance effort. This database can be used in various ways, such as ensuring scheduled maintenance and assessing needed improvements throughout the watershed.

WQ Action 1-5 Address nonpoint source pollution through stormwater basin management and restoration.

Stormwater basins are generally proposed as part of a large residential or commercial project to manage stormwater on-site as "major development projects," which triggers compliance with the NJDEP Stormwater Management rule under N.J.A.C. 7:8. Many people consider stormwater basins a way to also manage nutrients in stormwater; however, stormwater basins may be of several different types (*e.g.*, retention, detention, or infiltration) that function in different ways to address specific problems. Most of the 2,000 or more stormwater basins constructed in Ocean County outside of the Pinelands Area, especially the older (pre-2004) stormwater basins, were primarily designed to control peak flows. These types of basins were designed to hold a substantial volume of water that is slowly discharged from the basin into a municipality's MS4 and ultimately into a stream or the bay.

The primary role of these basins was to prevent flooding, especially flash flooding, and not to improve water quality. In contrast, all stormwater basins in the Pinelands Area are required to infiltrate the total runoff volume generated from the net increase in impervious surfaces from a 10-year, 24-hour storm, and from which there shall be no direct discharge of stormwater to any wetland, wetlands transition area, or surface water body.

The performance of many stormwater basins may be upgraded or enhanced via retrofits to increase nutrient uptake or may be simply improved through regular maintenance. The Ocean County Department of Planning and the Ocean County Soil Conservation District identified numerous stormwater basins in the Lower Toms River and Long Swamp Creek subwatersheds that did not recharge or infiltrate as designed. These basins, which held water on a permanent or nearly permanent basis, were restored to their original design function by addressing soil compaction or impermeable soil layers within the basins with Section 319 grant funds. Several organizations assessed a few problematic basins with BBP funding and then used Section 319 funds to restore capacity of basins to reduce flooding and improve nutrient management. One such example is located in Laurel Commons in Toms River (Figures 4.7 and 4.8). The NJDEP also funded renovation and/or construction of basins as part of New Jersey's Barnegat Bay Initiative (NJDEP, 2010); the Brick Township Municipal Utilities Authority also (BTMUA) is restoring basins as part of its Watershed Management Plan for the Metedeconk River.

Restoration of even a fraction of the 2,000 basins in the Barnegat Bay watershed represents a considerable financial commitment. Therefore, one important objective of the CCMP is to identify and map the location of all basins, develop and implement an assessment program, and prioritize basins for restoration to reduce nutrient and sediment loadings to the bay. In this way, funding can be focused on the most problematic basins that are contributing the greatest pollutant loadings to the bay or causing other substantial problems, such as flooding. By mapping and locating all basins, needed maintenance

Figure 4.7. Laurel Commons stormwater basin, pre-restoration. Photo courtesy of ALS.

Figure 4.8. Laurel Commons stormwater basin, post-restoration. Photo courtesy of ALS.

can also be identified and prioritized by each municipality. The Municipal Compliance Assistance Program will be assisting the municipalities in this process where needed.

WQ Action 1-6 **Address nonpoint source pollution (*e.g.*, pesticides herbicides, fertilizer, de-icers, and automotive wastes) from roadways and public works maintenance.**

Roadways and related infrastructure regularly collect pollutants from the highways and adjacent lands in the form of de-icers; herbicides for roadside vegetation control; and from cars, trucks, and buses, including heavy metals from tires, brakes, and engine wear, and hydrocarbons from lubricating fluids. Because their impervious surfaces can generate considerable stormwater runoff, major roadways require considerable attention for stormwater management. Similar to Tier A and Tier B municipalities, the NJDEP issues MS4 permits to federal, state, and county agencies that manage highways and related infrastructure (Highway MS4 permit). These permits also enforce statewide basic requirements. For example, the permits contain requirements that address post-construction stormwater controls, illicit discharge detection and elimination, pollution prevention and good housekeeping, use of Best Management Practices (BMPs; see Figure 4.9), and public education and outreach. They address the improper disposal of waste, solids, and floatable controls; maintenance yard operations; and employee training.

The Highway MS4 permit also requires that each highway agency develop a Stormwater Pollution Prevention Plan (SPPP), which describes how each agency will implement permit requirements. The implementation of Highway Agency SPPPs, together with the other nonpoint source objectives (See Water Quality Actions 1-4 to 1-7), addresses a catalog of issues (nutrient loading, flooding), identifies solutions (*e.g.*, stormwater source controls, basins, low-impact projects) and prioritizes future funding.

Figure 4.9. **A stormwater BMP: a rain garden designed to capture parking lot runoff at Brick Plaza. Photo courtesy of the BTMUA.**

With funding from the NJDEP REP Plan, the BTMUA and partners will be exploring alternative chemical de-icers and other approaches not only to reduce salt usage and subsequent environmental impacts to freshwater streams and riparian zones, but also to ensure roadway safety and protect public health (*i.e.*, lead in drinking water, which may increase as a result of chemical treatments to remove additional salt in drinking water supplies).

WQ Action 1-7 **Encourage municipalities and counties to map all stormwater BMP facilities/infrastructure within the watershed associated with major development, and review mapping of stormwater BMPs as an optional element of NJDEP Municipal Stormwater Compliance Assistance Program and a "preferred ranking element" in appropriate NJDEP funding programs.**

Climate changes, including more frequent and intense storms and more extreme flooding events, will likely increase stormwater runoff. An increase in stormwater runoff likely both exacerbates existing, and introduces new, pollution problems. More frequent and intense downpours projected for the northeastern U.S. may overwhelm the design capacity of municipal stormwater management systems and lead to localized flooding or greater runoff of pollutants such as trash, nutrients, sediment or bacteria into local waterways. Developing a plan for collecting information and mapping all stormwater BMPs with an associated database can help address this problem by enabling the public, local elected officials, consulting engineers, public works and related managers to become familiar with and periodically review stormwater contrivances, from major stormwater infrastructure to community green nature-based solutions, which help effectively reduce stormwater at its sources.

Initial development of this effort should focus on the information gathering process and the descriptive and other pertinent information (*e.g.*, location, type, cost, permitting requirements, environmental improvements, lessons learned, photos) that should be collected. The process should build off of reporting already required for the MS4 Program; moreover, the data and mapping should be consistent with information gathered by the NJDEP's locational mapping app. The information should be collected/reported annually for both public and private projects, and shared with the public as a report, online database, interactive website, or in another format.

WQ Action 1-8 **Address pollution from marinas and boating activities.**

Marinas and boating activity can also result in stormwater-related pollution as well as boat-related contaminants and debris. The New Jersey Clean Marinas Program encourages and supports marina owners, boatyards, and boaters to adopt practices that help prevent harmful impacts to water quality and living resources. The program helps marina operators reduce the sources of pollution, including sewage facility management, fueling operations, fish and solid waste management, and boat painting and cleaning (NJDEP Clean Marina Program).

Figure 4.10. **Aerial photo of Tices Shoal during "Floatchella," July 30, 2017. Such events may result in hotspots of trash and pathogen pollution. Photo courtesy of Ocean Air Support Squadron, Inc.**

WQ Action 1-9 **Develop, support and implement programs to reduce litter and plastic debris in and around waterways, including coordinating and conducting bay and community clean-ups.**

The BBP and its partners have worked collaboratively to reduce trash and other litter in a variety of ways from the Barnegat. For example, Clean Ocean Action and a number of other non-governmental organizations were instrumental in banning the offshore dumping of garbage in 1991, and in pioneering statewide beach-sweeps that have continued to the present day. Trash has also become a significant problem at a number of heavily used boating destinations (*e.g.*, Tices Shoal; see Figure 4.10 below) and at some popular gathering sites for off-road vehicles.

In 2011, a watershed-wide cleanup, known as the Barnegat Bay Blitz, was initiated by the NJDEP to expand the focus of clean-ups beyond beaches. The Blitz took on special importance after Superstorm Sandy, which distributed every imaginable kind of household belongings and debris throughout the watershed. The BBP has agreed to continue the Blitz as a watershed-wide effort.

The BBP and other partners also participate in a number of other efforts, including USEPA's Trash Free Waters program. For example, the BBP and other NEPs with large seasonal tourist populations and large tourist impacts have been working with USEPA to better assess seasonal trash problems and ways to reduce trash and debris from seasonal populations. The BBP and its partners have also submitted proposals and/or received funding from National Oceanic and Atmospheric Administration's Marine Debris program, specifically to reduce impacts from derelict fishing gear (*i.e.*, crab traps), which are recognized to catch and kill diamondback terrapins and other species. The BBP has worked with its Ocean County College host and other groups to install water bottle filling stations instead of water fountains to encourage and promote the use of reusable water bottles and reduce plastic bottles in the waste stream. The BBP and some partners also provide technical assistance in support of local legislation (*e.g.*, bag ordinances) to eliminate and reduce sources of litter locally.

WQ Action 1-10 Address pollution from agriculture, livestock, pets, and wildlife.

In the watershed, livestock numbers are low, large-scale animal farms do not exist, and agriculture lands and grasslands comprise only 1% of the landscape. However, legacy nutrient inputs from extensive historic chicken and dairy farms will continue to impact water quality due to slow transport of some nutrients in groundwater. Pets and wildlife scattered throughout the watershed also contribute substantially to bacterial and pathogenic loadings in some areas, including parks, playgrounds, and lakes, some of which can no longer be used for swimming and boating (*e.g.*, Pine Lake). Approximately 90,000 dogs are kept as pets in Ocean County, generating about 15 million pounds of waste a year. High numbers of Canada geese – estimated at close to 78,000 in NJ – produce an average of 1-3 pounds of feces a day, contributing to localized water quality impairments. Addressing these pollutant sources through enforcement of the towns' pet waste and wildlife feeding ordinances could substantially improve water quality in some bay tributaries and coastal lakes.

Figure 4.11. The Barnegat Bay Blitz logo, modified from the NJDEP design to promote the annual watershed-wide clean-up in the bay.

WQ Action 1-11 Address point source pollution from Oyster Creek Nuclear Generating Station, sewage conveyance systems, and septic systems.

In contrast to diffuse nonpoint pollution, point sources – such as wastewater treatment facility outfall pipes – are confined, discrete sources of pollution regulated by permits. Barnegat Bay has very few major point discharges; traditional point source discharges, such as wastewater, are generally not thought to be a significant source of nutrient loading to the bay.

Oyster Creek Nuclear Generating Station

Until its decommissioning began in fall 2018, the largest point source discharge to the bay was the Oyster Creek Nuclear Generating Station (OCNGS), which for decades used the bay's water for cooling purposes. The decommissioning of the OCNGS reduced the plant's use of 1.4 billion gallons of bay water a day for cooling purposes by 96%; moreover, this flow reduction also reduced thermal and chlorine pollution discharges and injuries and mortality to fish, plankton, and other marine life during water intake. Chlorine, along with mechanical damage during water uptake, transforms living plankton into nutrient-rich organic debris. The fates and fluxes of toxic chlorine byproducts – including chloramines, known to be toxic to some estuarine fishes in particular (*e.g.*, mummichog, Capuzzo *et al.*, 1977) – and their contributions to the bay's eutrophication and other impacts on the bay's biota remain unknown.

Modeling has suggested that shutting down OCNGS could change the biological community and alter some fish and shellfish distributions (Vasslides and Jensen, 2017). A Pre- and Post-Closure Biological Monitoring Plan is being used to assess various impacts of closure on the ecosystem and nutrient dynamics, and does include sampling and monitoring of biota and nutrients pre-closure (2018), transitional (2018-2019), and three to five years post-closure. The impact of the plant's prior operation (*i.e.*, the bay's warming) and the plant's chlorine by-products/chloramine discharge on the bay's eutrophication remain poorly assessed.

Sewage Treatment Plants

The Ocean County Utilities Authority (OCUA) operates three wastewater treatment facilities, with a total capacity of 84 million gallons per day (mgd) but generally operated around 50-55 mgd. An additional municipally owned sewage treatment plant (capacity = 0.6 mgd) is under construction in Plumsted in Ocean County, but will discharge into Crosswicks Creek, a tributary to the Delaware River.

The OCUA plants remove more than 90% of the pollutants from the sewage through its secondary treatment process before discharging through three ocean outfalls, all roughly a mile offshore.

Recent NJDEP-funded studies have identified that the water entering the bay with each tidal cycle is contributing about 25% to the bay's overall nutrient loading; this is not unexpected given the large volume of water entering the bay with each tide. The contribution of anthropogenic sources in the water entering the bay is not known but is thought to be small at this time. Offshore upwelling of deep, nutrient-rich ocean waters does occur off the New Jersey coast (Kohut, 2004; NASA, 2016). However, anthropogenic loadings offshore have been recognized as an issue in some other coastal waters (*e.g.*, Florida, Englehardt *et al.*, 2001; VanVelzer, 2017). A more complete assessment of this "ocean" load, including determining the sources and amounts of any anthropogenic loadings to New Jersey (from all dischargers to the New York Bight and New Jersey coast) could potentially help identify different approaches to reduce those sources. The discharge of treated sewage effluents offshore represents a consumptive loss of water from the system.

The OCUA collects waste from all municipalities in Ocean County and five in Monmouth County, and has an extensive preventative maintenance and capital repair and improvements program. However, aging municipal infrastructure that conveys wastewater has contributed to localized water quality problems (*e.g.*, pathogens in Beachwood Beach; see below) due to various problems (*e.g.*, illicit connections, pipe exfiltration, pipe settling in filled wetlands, delayed or incomplete maintenance or repair). Some problems were made worse by Superstorm Sandy and were fixed. Because some municipal maintenance programs remain underfunded, ongoing efforts to identify problem areas and needed upgrades for municipal stormwater and sanitary systems are important to improve water quality in the bay and at local pollution "hotspots." The NJDEP REP Strategy provided funding to Clean Ocean Action and its partners to identify pollution hotspots in the Toms River watershed.

Septic Systems

A substantial number of septic systems may be contributing to water quality impairments in some areas, especially in more rural/Pineland areas in Ocean County. Septic systems are subsurface wastewater treatment structures, often used in rural areas where centralized sewer systems do not exist. A typical system consists of a septic tank and drainfield (both subsurface), which can be a source of nutrient and pathogen pollution to groundwater if not properly designed or operated. The Water Quality Management Plan (WQMP) Rule, N.J.A.C. 7:15, requires wastewater management planning agencies to develop a Wastewater Management Plan (WMP) for their WMP area. One of the components of a WMP is demonstration that areas served by septics are subject to a maintenance program that ensures septics are inspected at a frequency to adequately determine if they are functioning properly.

The Ocean County Board of Commissioners is the primary WMP agency in the Barnegat Bay watershed. Acting on behalf of the Ocean County Commissioners, the Ocean County Planning (OCPD) and Health Departments (OCHD) have developed an inventory (block and lot location, septic permit type, and address) of the roughly 22,500 septic systems in the bay watershed. The data were used to develop Ocean County's 2017 Septic Maintenance Program, as required by NJDEP's WQMP rules [N.J.A.C 7:15-4.5(c)1.iv], which also requires notification to owners of septic systems installed after Jan. 1, 1990 of proper system operation and maintenance practices required by NJDEP's Standards for Individual Sewage Disposal Systems [required through N.J.A.C 7:9A-3.14 (a) and (b)], to guide policy, implement ordinances, guide the approval process for areas under development (*e.g.*, septic density), and to aid in other decision making. The data can also be used to provide the requisite annual report to NJDEP on the number of septic systems present in each municipality, the types and number of inspections performed on each system, the types and number of permits issued, the number type and apparent cause of non-compliant systems, and a description of the areas known to have higher than normal rate of non-compliance [required through N.J.A.C 7:9A-3.14(d)]. The data can assist in identifying areas with a history of failing systems, as well as areas with systems that are old and will potentially need to be updated and repaired or possibly connected to the sewer system. Improving the maintenance of septic systems can potentially reduce or eliminate some impairments in the watershed.

Remediating pollution from existing failing or improperly sited septic systems could be achieved by replacing them with a decentralized community treatment system that incorporates biological nutrient reduction prior to local groundwater recharge (where system density would make a community system economically feasible) or by replacing them with nitrogen attenuating individual septic systems, such as those in use in the Pinelands area. Impacts from septic systems serving new development could be reduced by each of these actions and could potentially eliminate some impairments in the watershed. Eliminating all septic systems from the watershed would *reduce* watershed-wide recharge of groundwater recharge and *increase* offshore discharges of treated wastewater by approximately 2 mgd, which is not a desirable outcome.

Lastly, to meet the future wastewater needs in sewer-service areas and non-sewer service areas, Ocean County Department of Planning has considered the growth trajectory of different areas in the county and identified potential capacity deficiencies, and management approaches and infrastructure improvements for both sewer service areas and non-sewer service areas. The NJDEP recently approved Ocean County's *Strategies To Mitigate Potential Capacity Deficiencies* (Ocean County Planning Department, 2019) as a component of its WMP.

4.4.2. Water Quality Objective 2

Assess status and trends of water quality throughout the watershed.

Knowing the status and trends in water quality provides the key foundation to protecting and restoring coastal ecosystems and to protecting public health. Without the proper quantity and caliber of data, it is difficult to accurately determine the true issues, and if any actions taken are addressing the problems. As previous studies in the Bay (Fertig *et al.*, 2014) have emphasized, assessing condition of water quality and other environmental parameter is dependent on having consistent, quality data collected over time. Each of the three CCMP water quality monitoring actions in this objective are led by different organizations.

WQ Action 2-1 **Identify the current status and trends in water quality within the watershed (*e.g.*, NJDEP Integrated Report, BBP State of the Bay (SOTB) Report) and identify pollutant sources and magnitudes.**

For the past 16 years, the BBP's primary monitoring reporting action has been achieved in large part through the publication of BBP's (2005, 2011, 2016) SOTB Reports. Such reporting, required of all NEPs every five years, was established to take a comprehensive look at the status and trends of many bay characteristics and resources. In 2011, the BBP recognized critical information gaps, which were addressed prior to publication of the 2016 SOTB.

WQ Action 2-2 **Maintain, review, and revise as necessary the existing comprehensive water quality ambient monitoring program throughout the watershed.**

Many information gaps were addressed primarily through implementation of the NJDEP's comprehensive water quality monitoring network throughout the Barnegat Bay watershed (available online here) and related monitoring. The NJDEP's state-of-the-art water quality monitoring network remains essential to provide the framework for decision-making and serve as justification for the bay's protection and restoration.

Figure 4.12. Installing a slider track system for coastal acidification sensors in the bay. Photo courtesy of BBP.

WQ Action 2-3 **Support the existing beach monitoring program, and work with NJDEP, NJDOH, OCHD, and LBI Health Department to evaluate possible monitoring strategies for known public recreational areas of high public use.**

Lastly, because of the large tourist population that uses Barnegat Bay extensively for recreation, this third monitoring action is important to reduce pathogens and protect public health. This action also helps potentially identify pathogen sources in a number of impaired bay and stream segments. All current monitoring activities will be reviewed by the STAC within the next two years for their possible incorporation a new BBP monitoring plan, both to strengthen SOTB reporting and provide better coordination with NJDEP reporting requirements (NJDEP, New Jersey Water Supply Plan 2017-2022, 2017b).

4.4.3. Water Quality Objective 3

Conduct studies to improve scientific understanding of new and emerging issues pertaining to the chemical, physical, and biological conditions and dynamic in the Barnegat Bay and its watershed.

WQ Action 3-1 **Support research that identifies and quantifies the sources and fates of nutrients within the watershed and bay.**

Periodic assessment of monitoring data can reveal new or recurring problems and identify data gaps that need to be addressed to improve our understanding of the bay and guide decision making to protect and improve the bay. Because eutrophication remains the bay's most substantial problem, WQ Action 3-1 remains a research priority. For example, most studies assessing nitrogen inputs to Barnegat Bay conducted before 2010 (Moser, 1997; Moser *et al.*, 1998; Castro *et al.*, 2003; Hunchak-Kariouk and Nicholson, 2001; Bowen *et al.*, 2007; Bricker *et al.*, 2007) did not assess nitrogen inputs entering the bay through inlets. Re-examination of a limited three-week study of nutrient flux at Barnegat Inlet in early spring (Guo, 2001) led NJDEP to examine nutrients flowing through all inlets as part of its comprehensive water quality monitoring network. As a result of the additional information gathered by subsequent studies (Defne and Ganju, 2015; Pang *et al.*, 2017), it is now known that, the bay's total nitrogen loadings are significantly higher than previously recognized due to the significant influx of nitrogen through inlets with the large volume of water entering the bay with each tide. This nutrient loading has undoubtedly contributed to the bay's production and likely includes both natural and anthropogenic sources, but does not appear cost-effective to address at the present time with our limited understanding of its sources. There are also unexplained differences in the loading and concentration

patterns of phosphorus to the bay (Pang *et al.* 2017). Resolving the questions regarding both nutrients is an important first step to reduce these nutrient loadings and the bay's eutrophication.

WQ Action 3-2 Identify and address data gaps and water quality issues of emerging concern (*e.g.*, coastal acidification, turbidity, watershed salinity increases).

Turbidity is unquestionably an emerging and complex problem in some parts of the bay: it can contribute to eelgrass loss, death of phytoplankton, and low dissolved oxygen. However, suspended sediments, which are a contributor to turbidity, may be a "solution" to another environmental concern (*i.e.*, wetland loss) in other parts of the bay. For example, wetlands trap suspended sediments in the water column to grow laterally and vertically – that is, to keep pace with sea level rise. Turbidity in estuaries potentially has many sources, with both natural (*e.g.*, phytoplankton production) and anthropogenic (stormwater discharges) causes. Additional monitoring and assessment (Ganju, 2014; Dickhudt, 2015) may be necessary to understand the many contributing sources of turbidity; moreover, addressing turbidity in different parts of the bay may require different solutions.

WQ Action 3-3 Support completion and expansion of source tracking for bacteria, pathogens, and novel and other pollutants.

This issue illustrates the importance of new science to address emerging issues. The BBP STAC periodically examines monitoring, assessment, and research concerns, and revises its science prospectus to emphasize priority data gaps and emerging issues.

4.4.4. Water Quality Objective 4

Increase public education, engagement, and stewardship regarding water quality in the watershed

WQ Action 4-1 Implement components of the BBP Communication Plan related to water quality improvement, including climate change/SLR impacts.

Public education and participation are central to the BBP's mission to protect and restore the water quality of the bay and its contributing watershed. Implementing the BBP's Communication and Outreach Plan provides a blueprint for collaborative partner outreach efforts; the Communication Plan identifies approaches and methods to engage distinct target audiences important to protecting water quality, including the impacts of climate change and sea level rise. The BBP's Communication and Education Committee (CEC) oversees implementation of the Communication Plan. The CEC Grant Program, meanwhile, funds projects which increase public understanding of human impacts on the bay, promote stewardship, and grow public participation in the bay's protection and restoration.

WQ Action 4-2 Share Barnegat Bay-friendly ordinances and establish a Jersey-Friendly Yards certification and training program for homeowners, businesses, and/or landscaping professionals to promote practices that reduce nonpoint source pollution.

Through a grant from the NJDEP, the BBP developed the Jersey-Friendly Yards website as a comprehensive resource to help property owners "landscape for a healthy environment" and cleaner water. The BBP will continue to grow this website as an important tool for engaging property owners in actions that can help improve water quality in the watershed. The BBP can also coordinate outreach efforts with municipalities in relation to compliance with the public education and outreach component of the MS4 permit.

WQ Action 4-3 Assist training and education/outreach programs to help municipalities meet permit compliance, *e.g.*, Tier A and Tier B MS4 permits at Part IV.B.1.

Because nonpoint source pollution represents a significant source of the watershed's overall nutrient loadings (Baker et al., 2014), providing training and outreach to assist municipalities with permit compliance supports a number of water quality actions (WQ 1-3–WQ 1-6) listed under Water Quality Objective 1.

4.5. Ecosystem Target, Objective, and Action Summary

Table 4.1. The relationships between the Ecosystem Based Targets and the Actions within the Water Quality priority area.

Public Beach Closures	Objective 1: Action Items 1, 2, 4, 5, 9 Objective 2: Action Item 3 Objective 3: Action Item 1 Objective 4: Action Item 2
Approved Shellfish Areas	Objective 1: Action Items 1, 2, 4, 5, 8, 9 Objective 2: Action Item 1 Objective 3: Action Items 1, 2 Objective 4: Action Items 2,3
Submerged Aquatic Vegetation Extent	Objective 1: Action Items 1, 2, 4, 5, 6, 8, 9 Objective 2: Action Item 1 Objective 3: Action Items 1, 2, 3 Objective 4: Action Items 2, 3
Wetland and Riparian Buffer Preservation	Objective 1: Action Item 2 Objective 2: Action Item 1 Objective 3: Action Items 2, 3 Objective 4: Action Item 2
Wetland Protection	Objective 1: Action Items 1, 2, 4, 5, 6, 8, 9 Objective 2: Action Item 1 Objective 3: Action Items 1, 2, 3 Objective 4: Action Items 2, 3
Clam restoration	Objective 1: Action Items 1, 2, 4, 5, 6, 8, 9 Objective 2: Action Item 1 Objective 3: Action Items 1, 2, 3 Objective 4: Action Items 2, 3
Ecological flows	Objective 1: Action Items 2, 3, 4 Objective 4: Action Items 2, 3
Water conservation and reuse	

Water Quality Objective 1: Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution.

WQ Action 1-1 Support establishment of a Barnegat Bay TMDL(s) (Total Maximum Daily Load), including the development and use of Barnegat Bay-specific biological indices of water quality, to address nutrient and other pollutant loadings and to guide science-based future management decisions.

WQ Action 1-2 Develop and implement watershed plans (*i.e.*, WQMP/Section 319 and watershed based plans) at the sub-watershed level.

WQ Action 1-3 Implement the Soil Restoration Law and associated comprehensive soil restoration procedures for various land use activities.

WQ Action1-4 Support implementation and enforcement of stormwater rules and ordinances at state, county, and municipal levels.

WQ Action 1-5 Address nonpoint source pollution through stormwater basin management and restoration.

WQ Action 1-6 Address nonpoint source pollution (*e.g.*, pesticides herbicides, fertilizer, de-icers, and automotive wastes) from roadways and public works maintenance.

WQ Action 1-7 Encourage municipalities and counties to map all stormwater BMP facilities/ infrastructure within the watershed associated with major development, and review mapping of stormwater BMPs as an optional element of NJDEP Municipal SW Compliance Assistance Program and a "preferred ranking element" in appropriate NJDEP funding programs.

WQ Action 1-8 Identify sources and reduce pollution inputs from marinas and boating activities. Assess need for enforcement of priority problems.

WQ Action 1-9 Develop, support and implement programs to reduce litter and plastic debris in and around waterways, including coordinating and conducting bay and community clean-ups.

WQ Action 1-10 Identify sources and reduce pollution inputs from livestock, agriculture, and wildlife.

WQ Action 1-11 Address point source pollution from Oyster Creek Nuclear Generating Station, sewage conveyance systems, and septic systems.

Water Quality Objective 2: Assess status trends of water quality throughout the watershed.

WQ Action 2-1 Identify the current status and trends in water quality within the watershed [NJDEP Integrated Report, BBP State of the Bay (SOTB) Report] and identify pollutant sources and magnitudes.

WQ Action 2-2 Maintain, review, and revise as necessary the existing comprehensive water quality ambient monitoring program throughout the watershed.

WQ Action 2-3 Support the existing beach monitoring program, and work with NJDEP, NJDOH, OCHD, and LBI Health Department to evaluate possible monitoring strategies for known public recreational areas of high public use.

Water Quality Objective 3: Conduct studies to improve scientific understanding of new and emerging issues pertaining to the chemical, physical, and biological conditions and dynamics in the Barnegat Bay and its watershed.

WQ Action 3-1 Support research that identifies and quantifies the sources and fates of nutrients within the watershed and bay.

WQ Action 3-2 Identify and address data gaps and water quality issues of emerging concern (*e.g.*, coastal acidification, watershed salinity increases).

WQ Action 3-3 Support completion and expansion of source tracking for bacteria, pathogens, and novel and other pollutants.

Water Quality Objective 4: Increase public education, engagement, and stewardship regarding water quality in the watershed.

WQ Action 4-1 Implement components of the BBP Communication Plan related to water quality improvement, including impacts from climate change and sea level rise.

WQ Action 4-2 Share Barnegat Bay-friendly ordinances and establish a Jersey-Friendly Yards certification and training program for homeowners, businesses, and/or landscaping professionals to promote practices that reduce nonpoint source pollution.

WQ Action 4-3 Assist training and education/outreach programs to help municipalities meet permit compliance, *e.g.*, Tier A and Tier B MS4 permits at Part IV.B.1.

Figure 4.13. Monitoring the water quality of Wrangle Brook. Photo courtesy of BBP.

CHAPTER

5

WATER SUPPLY

5.1. Themes

- Maintaining adequate flows of freshwater to the bay from streams and groundwater is critical to estuary health.
- The Barnegat Bay watershed provides important water supplies for human and non-human uses, and these supplies are vulnerable to sea level rise, storm surges, saltwater intrusion, drought, and contamination.
- As residential and tourist populations continue to grow, protecting, conserving, and efficiently using *and* reusing water supplies are increasingly essential to ensure adequate water supplies for people and a healthy bay ecosystem.

5.2. Goal and Objectives

To ensure adequate water supplies and flow in the Barnegat Bay watershed for ecological and human communities now and in the future.

Water Supply Objectives:

1. 1. Protect, maintain, and enhance existing surface and groundwater flows.
2. 2. Prevent degradation and encourage efficient use of water supplies.
3. 3. Monitor and assess status and trends of the water supply throughout the watershed.
4. 4. Improve scientific understanding of new and emerging issues (including climate change and sea level rise) pertaining to water conservation, advanced potable treatment options, and reuse.
5. 5. Educate consumers regarding water supply and use issues, including efficient water use, indoor/outdoor water conservation and reuse.

5.3. Introduction

The Barnegat Bay watershed provides the source of freshwater that is vital to the bay and the region's inland ecosystems, as well as to the human population that resides in and visits the watershed. This freshwater supply serves several critical functions. Freshwater inputs to the bay are critical for maintaining healthy salinity levels that support the estuarine ecosystem. Freshwater flowing in rivers and streams carries with it nutrients that are important for the living resources of the bay and sediment that nourishes tidal wetland habitats. The freshwater flowing into the bay from streams and groundwater helps to flush out contaminants and waste products, which helps to maintain healthy water quality. The watershed also provides an important water supply for human uses. Some of the freshwater flowing in the Metedeconk River is diverted and treated for human use. Fresh groundwater also flows from the Kirkwood-Cohansey aquifer system into streams, wetlands, and the bay, and some of this natural groundwater flow is diverted for human use by water-supply wells tapping the aquifer system. Some of the groundwater in deeper, confined aquifers is also diverted for human use.

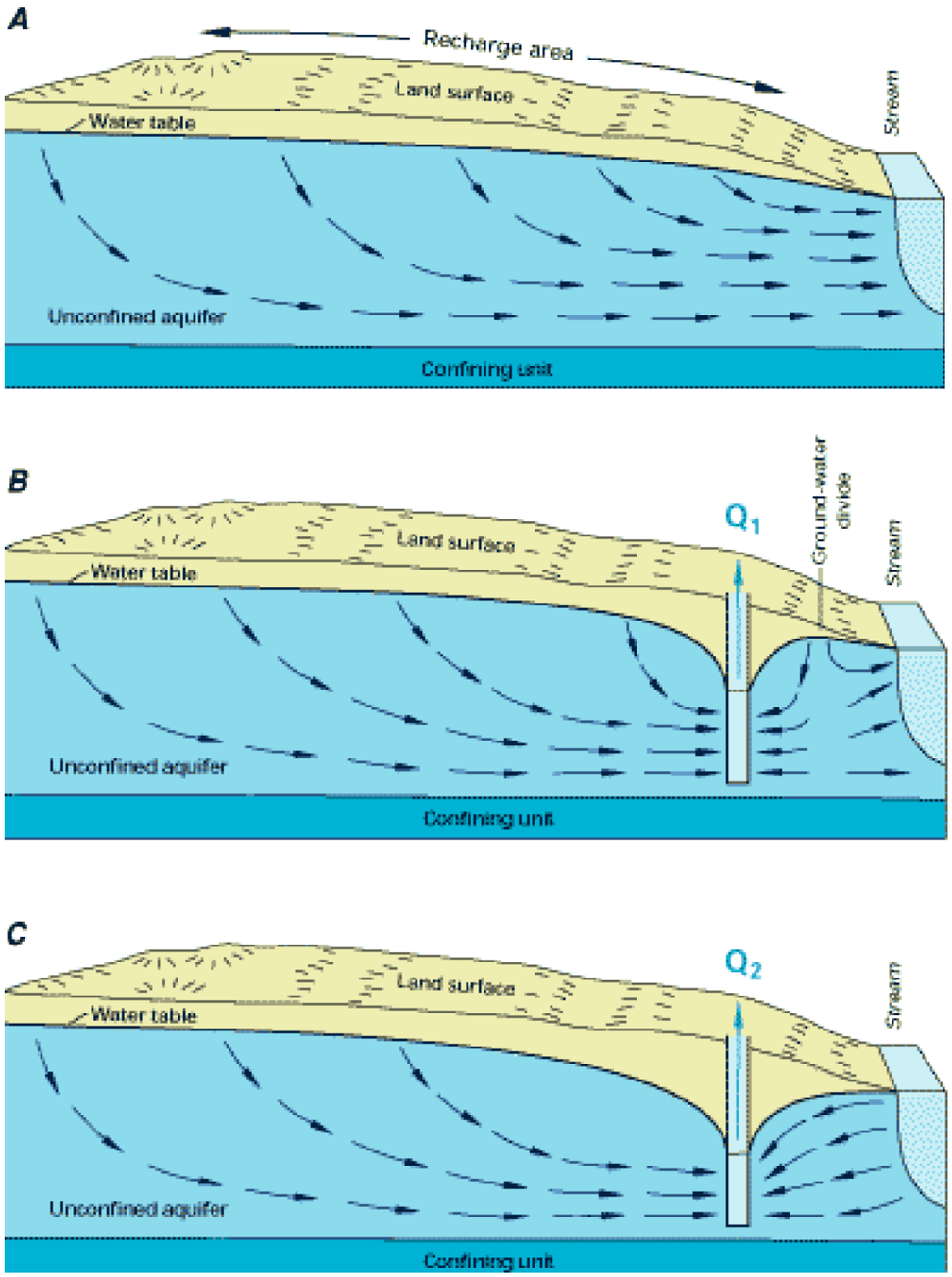


Figure 5.1. Effect of Groundwater Withdrawals on Water Levels and Streams. Figure modified from Winter *et al.*, 1998.

The cycle of freshwater flow involves several stages – such as precipitation, direct runoff, infiltration, groundwater flow, and streamflow – before reaching the bay or water-supply intakes and wells for human use (See Figure 5.1). Management issues arise at each stage of the water cycle and require planning consideration to ensure that these critical water supplies can be sustained in the face of increasing pressures from human activity and the effects of the changing climate. Climate change is expected to affect water supplies primarily through sea level rise and altered weather patterns (*e.g.*, warmer temperatures, stronger storms, and more severe droughts and floods). Climate change presents a relatively new challenge for water resource managers, who must continually integrate the latest scientific understanding of the issue into their work.

5.3.1. Streamflow Requirements

Managing streamflow is essential to ensuring that the rate of freshwater flow is adequate to support aquatic and estuarine habitats as well as human uses. Low stream flow can result in the loss of suitable habitat for freshwater invertebrate and fish species. If streamflow entering the bay is inadequate, bay salinity increases, and waste materials and nutrients are not adequately flushed. These low-flow conditions can contribute to the incidence of harmful algal blooms (HABs), such as Brown Tide.

The bay is especially vulnerable to these effects during drought conditions, which are expected to occur more frequently in the future as a consequence of climate change (Field, 2014). NJDEP's water-supply planning policies, rules, and permits are designed to help ensure that stream flows are adequate to avoid unacceptable ecological impacts. However, current diversions of freshwater flows are already impacting flows in headwaters streams and, in the absence of measures to mitigate impacts, increases in water demands for human use will exacerbate these impacts. Freshwater wetlands in the watershed are also vulnerable to the effects of excessive diversions. Extensive investigation conducted as part of the Kirkwood-Cohansey Project has demonstrated that a substantial percentage of wetlands in a given watershed can be altered or converted to uplands when even a small percentage of groundwater recharge has been diverted by pumping (Laidig *et al*. 2010). Flow conditions are monitored in several of the bay's major tributary streams, and regular assessments of these conditions are needed to ensure that adequate flows are maintained.

5.3.2. Stream Base Flow

Streams flowing into the bay receive inputs from stormwater runoff and from the underlying Kirkwood-Cohansey aquifer system in the form of groundwater seepage. The groundwater seepage component of streamflow is called base flow (See Figure 5.2). During periods of low or no precipitation, the flow in streams consists entirely of base flow. Base flow is critical to the health of Barnegat Bay because it constitutes 82% of the flow in streams that flow into the bay (Watt, 1994; Hunchak-Kariouk and Nicholson, 2001; Gordon, 2004), and provides necessary habitat for freshwater inhabitants and nutrients during drought periods when surface runoff is minimal. One study (Kampell, 2003) even observed a decrease in water quality, specifically an increase in nitrates, ortho-phosphates, chlorides, and sulfates in shallow ground-water during short-term drought conditions. The largest increase in concen-trations were nitrates under both agricultural lands and areas with septic tanks. These increases in groundwater nutrient concentrations may affect the baseflow of surface waters. These observations emphasize that monitoring and periodically assessing base flow is an important component of a program to track and manage the health of the bay.

5.3.3. Precipitation, Runoff, and Infiltration

Precipitation over the watershed follows four pathways of the hydrologic cycle: the water evaporates, transpires from vegetation, becomes runoff, or infiltrates the ground and becomes aquifer recharge. The proportions of these pathways are important because they affect the seasonality of flow to streams and the bay. Aquifer recharge is critical to the bay because most of the freshwater flowing into the bay previously flowed as groundwater before flowing into streams or directly into the bay. If evaporation and transpiration from vegetation (including irrigated lawns and other turfed areas) is high, then aquifer recharge is reduced. In the absence of effective stormwater management, land uses with a high percentage of impervious surfaces produce more runoff, leaving less water available for aquifer recharge. Land use regulations that minimize impervious surfaces and incorporate green infrastructure can lessen this effect. Implementation of soil restoration practices on new development, as currently required by state law, and broader application of soil restoration practices can further promote stormwater infiltration, reduced stormwater runoff, less flashy stream flow, better aquifer recharge, and improved water quality in support of the bay's aquatic resources.

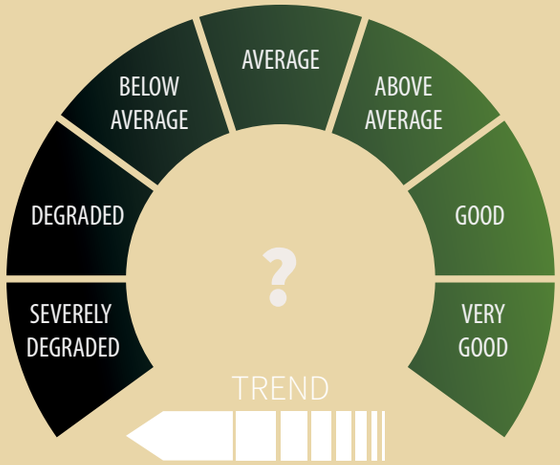


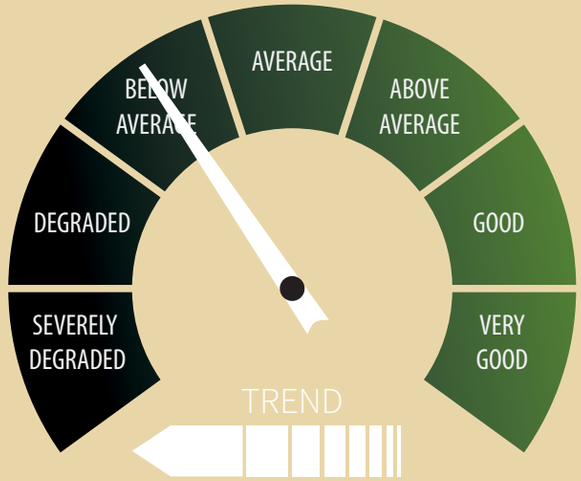
Figure 5.2. 2016 Water Supply Status and Trends: Streamflow

Approximately 590 mgd of freshwater enter Barnegat Bay through its rivers, streams, and creeks. The water in these streams and creeks can be split into two components: base flow and runoff. Base flow is the sustained flow of a stream that comes largely from groundwater entering the waterway. Runoff is the portion of streamflow that comes from precipitation, snow melt, or irrigation water flowing across the land surface (or piped) before entering the waterway. In undeveloped watersheds, runoff is a small part of the total flow. As development occurs, the fraction of total flow from base flow decreases. Reductions in base flow can have serious ecological repercussions, as changes in the timing and amount of freshwater entering the streams and eventually reaching the estuary can affect water quality and habitat for many bay species and humans!

Tributary base flows reflect the percentage of urbanization, lower in the north (67%) and higher in the south (94%). The status of streamflow within the watershed is classified as "unknown" because there is currently no minimum base flow criteria to judge the results against. From 2010-2014 there was a high degree of variability in base flow in all four streams, with no overall trend present. However, over the last 40 years the percentage of base flow in the total flow has significantly declined in the bay's northern tributaries.

See the BBP's 2016 State of the Bay Report for additional information.

Figure 5.3. 2016 Water Supply Status and Trends: Water Withdrawals



Fresh water is important for a variety of human activities, including public supply, agriculture, landscape irrigation, commercial and industrial uses. Sources of fresh water include both surface waterbodies and groundwater from aquifers. Due to their proximity to the surface, unconfined aquifers (*i.e.,* the Kirkwood-Cohansey Aquifer) are the easiest to access but are also the most impacted by drought and pollution. Fresh water is withdrawn from the system (85 mgd average for 2010-2015), mostly for public supply and industrial use locally. Fresh water withdrawals in the Barnegat Bay watershed (and centralized wastewater treatment discharges) have increased with population growth over the past several decades. One outstanding data gap is the amount of water withdrawn from small wells (withdrawals <100,000 gal/day), not regulated or specifically tracked.

Most areas with public water service also have public sewer service, with wastewater directed to one of three centralized wastewater treatment facilities and, ultimately, to the Atlantic Ocean. Where public supplies are drawn from surface water or shallow aquifers, water that would otherwise make its way to the Barnegat Bay is intercepted, utilized, treated, and discharged offshore. The existing centralized wastewater treatment system was developed to address water quality problems that resulted in the past from many small discharges of questionable-quality wastewater throughout the watershed. Returning high-quality treated wastewater to its point of origin in the watershed would be ideal, though it would require a higher level of wastewater treatment, commonly known as tertiary treatment, which would only be possible with significant infrastructure upgrades. Small-scale pilot projects would be useful to move this concept forward.

See the BBP's 2016 State of the Bay Report for additional information.

5.3.4. Effect of Groundwater Withdrawals and Offshore Discharge on Base Flow

Water withdrawals from wells tapping the unconfined Kirkwood-Cohansey aquifer system in the Barnegat Bay watershed intercept groundwater that would otherwise either flow directly into the bay or to streams that flow into the bay (See Figure 5.3). As a result of the withdrawal, water levels in nearby wetland habitats can be lowered and less freshwater flows naturally to the bay. Water used within the watershed is withdrawn from the unconfined aquifer and also from deeper confined aquifers and surface water. The water that is used in areas that are serviced by sanitary sewers is collected, treated, and discharged to the ocean through three offshore outfalls. The total average rate of this ocean discharge is 129 million gallons per day, which is equivalent to about 21% of the freshwater flow to the bay (NJDEP, 2017b). This water would have naturally flowed into the bay but is instead lost from the system. This percentage is higher during drought conditions, when natural freshwater flows to the bay are lower than average and during summer months when withdrawals for human uses are higher than average. This means that the effect of diverting water from the natural flow in the watershed is greatest during drought and summer.

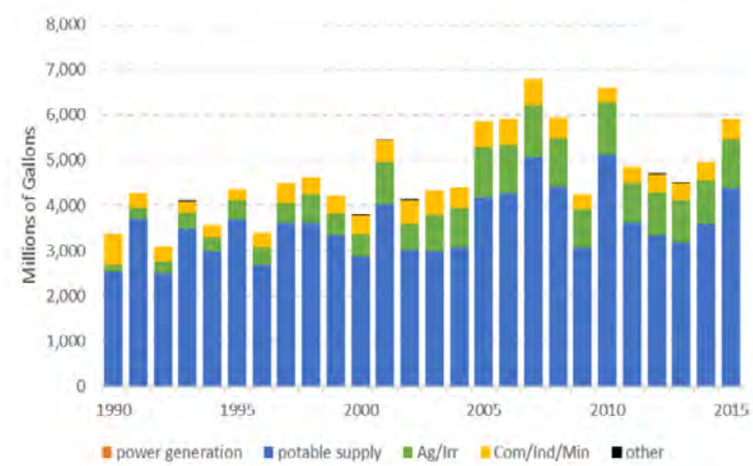


Figure 5.4. Annual consumptive loss from Watershed Management Area 13 (Barnegat Bay) by use sector (NJDEP, 2017b).

5.3.5. Importance of Soil and Riparian Buffers

Soil: Soil is perhaps the most important watershed component because of the role it plays in controlling the quantity, quality, and timing of freshwater that flows to the bay. Protecting and restoring soil health will maximize its role in controlling flooding, attenuating pollution, and recharging groundwater. The texture, structure, organic content, and consistency of soil controls how much precipitation runs off the land and how much infiltrates the land surface. Undisturbed soils in most upland areas of the watershed are permeable and allow high rates of infiltration. Soils in lowland and wetland areas, and soils that have been compacted or covered with building material – such as pavement or buildings – are less permeable, such that more precipitation runs off the land and less infiltrates the ground. Undisturbed soils also retain sediment and pollutants that could otherwise run off into streams. In riparian buffers, soils and natural vegetation are especially important in retaining sediment and pollutants and preventing them from entering streams and the bay.

Riparian Buffers

Riparian buffers are defined as those land areas that are adjacent or hydrologically connected to surface waters such as streams, rivers, lakes or reservoirs (See Figure 5.5). Sometimes they are described as the floodplain or riparian zone. Riparian areas differ from the uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there (Klapproth and Johnson, 2009). The riparian zone contains more organic matter, which provides sorption sites for nutrients, some geogenic and anthropogenic compounds. This is beneficial for preventing some pollutants from runoff and groundwater from entering the surface water. However, eventually the organic matter will release the nutrients and anthropogenic compounds as it becomes saturated with them into the surface water. Protecting the riparian zone is an important buffer, but will not prevent all nutrients and anthropogenic compounds from entering the surface, especially since not all geogenic or anthropogenic compounds will sorb to organic matter.

Riparian buffers support high levels of biodiversity and perform a variety of functions with environmental, economic, and social value. Examples include providing habitat for aquatic and terrestrial organisms, trapping and removing sediments and pollutants from stormwater runoff, stabilizing streambanks and reducing channel erosion, and storing floodwaters and decreasing potential for property damage (Klapproth and Johnson, 2009). Many of these functions are important for protecting the quality and quantity of drinking water supplies. Because they provide all of these services and more, maintaining healthy riparian buffers can be considered an economical means to ensure future water quality and natural flows (Wenger, 1999). Healthy riparian buffers in the watershed are critical to the protection of downstream ecosystems, such as the Barnegat Bay.

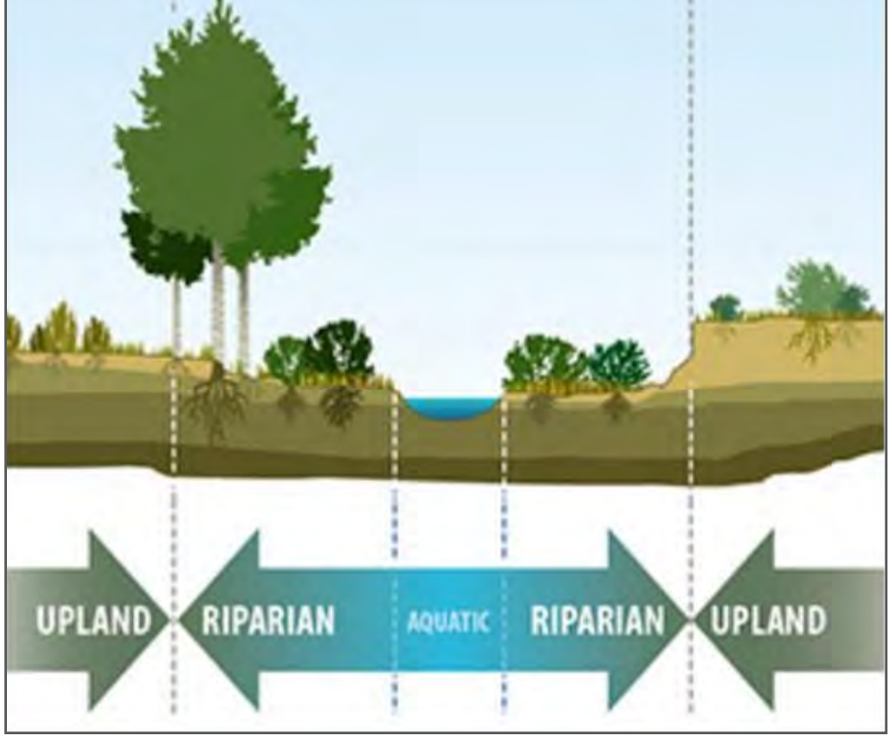


Figure 5.5. Configuration of upland, riparian, and aquatic zones within a watershed (Figure modified from City of Calgary, 2014).

Figure 5.6. Riparian buffer along the north branch of the Metedeconk River in Freehold Township. Photo courtesy of the BTMUA.

Disturbance of riparian zones from "urban and suburban creep" remains a continuing concern. Clearing of native vegetation and other disturbance activities can cause a cascade of unintended changes, such as altered streamflow, serious losses of stream habitat, and degradation of water quality. —Sedimentation, streambank erosion, changes in the amount and timing of water flows, and increases in the frequency and magnitude of flood events are commonly encountered problems associated with disturbed riparian buffers.

Protecting riparian buffers is often mandated through regulations at various levels of government. In the Barnegat Bay watershed and statewide, New Jersey regulates development proposed in riparian zones to protect surface waterways under the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13). (Riparian zones in this context are those lands identified as such under N.J.A.C. 7:13.) All regulated waterbodies in New Jersey have a riparian buffer; however, the size of the riparian buffer varies. For those waters designated as Category One (C1), the most stringent standard, the riparian buffer width extends 300 feet. C1-designated waterways are subject to an anti-degradation policy and intended to be protected from measurable changes in water quality. The 150 feet immediately adjacent to the water receives even more stringent protections. The Stormwater Management Rules (N.J.A.C. 7:8) also include this buffer by citing N.J.A.C. 7:13. Wetlands protection regulations impose similar buffers, called transition areas, to regulate activities within 50 or 150 feet of wetlands and thereby minimize impacts to wetlands and water quality. The Pinelands Commission requires a 300-foot buffer adjacent to all waters in the Pinelands area. Some municipalities also mandate riparian buffers in their local codes.

Intact riparian zones and other buffers that are presently occupied by forest or wetland vegetation should receive high priority in conservation planning and open space preservation. Restoration of select riparian zones adjacent to areas of intensive agriculture, managed lawns and other residential/commercial development would benefit the Barnegat Bay estuary.

5.3.6. Sustaining Water Supplies for Human Use

Water supplies for human uses are vulnerable to several threats that may affect their quality and quantity. These include effects of sea level rise and increasing risks of storm surges, saltwater intrusion of aquifers, drought, and contamination from human and natural sources. Human population increases may contribute to decreased supplies or availability and increased vulnerability to contamination. The level of vulnerability depends primarily on the type and location of the source. In the Barnegat Bay watershed, surface water and shallow aquifers are the most vulnerable supplies, while deeper confined aquifers tend to be least vulnerable. Protecting existing and future water supplies from these threats and building water-supply resilience can help to avoid the need for new supplies that could potentially divert additional freshwater flow from Barnegat Bay.

Human activities present the greatest threats to water supplies; moreover, water pollution from both point and nonpoint sources remains the most significant problem caused by humans (Clean Water Act, 33 U.S.C. 1251 *et seq.*). Pollutants may be released from point sources such as accidental spills, or from deliberate or unintentional discharges, and can directly affect a waterway or shallow groundwater. Groundwater contamination plumes are particularly difficult to manage and can take decades to properly clean up. Due to the close connection between the shallow aquifer and streams, groundwater contamination can also affect surface waterways. Nonpoint sources of pollution introduce small amounts of contaminants throughout a watershed that make their way into streams and rivers or infiltrate the sandy shallow aquifer. Examples include chloride from winter road salting, fertilizers and pesticides from lawns and agricultural areas, oil and chemicals from urban runoff, and bacteria from pet waste and septic systems. There are many types of known pollutants that water suppliers must monitor for regularly. In addition, water suppliers must be constantly vigilant for contaminants of emerging concern that may be introduced to our waters through direct and indirect wastewater discharges. A recent NJGWS study (Bousenberry, 2012) demonstrated that personal care products, pharmaceuticals, and some endocrine disrupting compounds are present in some areas from several potential sources. Even at low concentrations, some of these compounds may affect aquatic life. Further studies on the fates, transport, and impacts of these compounds are needed.

Human activities also affect water quantity. Water withdrawals must be carefully managed to ensure sufficient water remains for downstream uses and ecological needs. In some cases, withdrawals must be prioritized so that critical needs – such as providing drinking water or crop irrigation – are satisfied before discretionary uses, like lawn irrigation. Alteration of the watershed can also affect water quantity. Creation of impervious surfaces and stormwater conveyance systems may reduce the ability of stormwater to soak into the ground and replenish the shallow aquifer, leading to faster runoff during storms and lower river and groundwater levels during dry periods when the water is needed most.

Aside from human activities, natural environmental conditions can sometimes affect water supplies. The presence of naturally occurring radionuclides or metals in aquifers can render a water supply well unusable without expensive treatment. Forest fires may cover large areas and disrupt water quality. Water supplies are particularly vulnerable to weather events, such as droughts. On a larger scale, there is considerable concern about how sea level rise will affect coastal water supplies. Similarly, there is uncertainty about how climate change will affect rainfall patterns, droughts, and seasonal water availability. Many utilities are making infrastructure improvements to become more resilient to these potential long-term water supply complications. In October 2018, Congress passed the America's Water Infrastructure Act of 2018 (S. 3021, P.L. 115–270), which contains key provisions that will help advance the adoption of water recycling nationwide. Congress also reauthorized the Water Infrastructure Finance and Innovation Act, a critical low-cost

financing tool for water infrastructure, including water recycling infrastructure, for $50 million annually through 2021.

Some water purveyors develop source water protection programs to help safeguard the water quality and quantity of their supplies. These programs can be very effective and rely on collaboration with the communities where the supplies are located, for example a watershed or wellhead protection area, to institute protective measures. Such programs can have substantial ancillary benefits in terms of environmental protection, sustainability, ecosystem health, human health, social value and the economy. They also leverage and reinforce various surface and groundwater protection programs above.

5.4. Objectives and Actions

5.4.1. Water Supply Objective 1

Protect, maintain, and enhance existing surface and groundwater flows.

Actions that help protect, maintain, enhance, and monitor streamflow and groundwater flow will help ensure adequate hydrologic support for aquatic, wetland, and estuarine habitats as well as the water-supply needs of the human population. Sound, science-based water-supply planning is a critical element of the plan for achieving this objective. The water-supply planning process and CCMP actions need to be designed and conducted in consideration of hydrologic conditions that are likely under projected changes in future climate and sea level conditions. Selected actions include the following.

WS Action 1-1 Assess and implement existing shallow groundwater protection programs.

Programs to protect shallow groundwater can help to protect the integrity of freshwater inputs to the bay. The New Jersey Source Water Assessment Program (SWAP) provides for the protection and benefit of public water systems and increases public awareness and involvement in protecting the sources of public drinking water. Local land use ordinances can prevent activities that could potentially release contaminants or otherwise impact surface water or groundwater. Wellhead protection ordinances, for example, utilize information from SWAP to restrict land use activities in established wellhead protection areas. Stormwater regulations require recharge of clean stormwater runoff into the ground through surface basins, underground infiltration systems, or green infrastructure. Wastewater discharges to surface water or groundwater from commercial and industrial activities are regulated by NJDEP. There are opportunities to treat wastewater and recharge it back into the shallow aquifer to improve groundwater levels and reduce freshwater losses to Barnegat Bay. Other NJDEP regulations, such as those governing land use and water allocation, serve to protect groundwater resources. The effectiveness of these programs can be tracked and evaluated through sustained long-term surface water and groundwater monitoring. Research on contaminant sources, transport, and fate provide technical guidance for these programs.

WS Action 1-2 Determine minimum ecological flow requirements for priority streams, rivers, and wetlands within the watershed.

Maintaining an adequate flow of freshwater to the bay is critical to its health. Programs, policies, and regulations that sustain water supply for human use can also sustain water supplies for the bay. Programs that protect and restore natural soils and riparian zones also help to maintain water supplies. Comprehensive water-supply planning and permitting can help sustain natural flows by limiting withdrawals from surface water and unconfined aquifers. Reclamation and reuse of wastewater can help offset some of the effects of water transfer out of the watershed. Research and monitoring can help enhance our understanding and management of freshwater resources, conservation issues, advanced treatment options, and water reuse.

In recent years, NJDEP has advanced methodologies to better account for ecological flow requirements in water supply planning (Hoffman and Rancan 2009, Domber *et al*. 2013). One of these NJDEP methodologies suggests that the minimum flow of a continuously-gauged stream for a given month should remain within the 25th to 75th percentiles of an established baseline flow regime for that month. The minimum ecological flow requirement using this methodology, therefore, would be the 25th percentile for each of these baseline monthly flow values. Other ecological flow criteria that are more specific to ecological requirements for Barnegat Bay may emerge from ongoing monitoring and research. Regardless of the criteria used, an Ecosystem-Based Target proposed in this plan is to maintain flow levels at least 30% over minimum ecological flows for gauged waterways within the watershed. This threshold may or may not already be exceeded depending on the location, and recapturing the net loss of water from the basin is one way of moving towards restoring balance in the system.

WS Action 1-3 Support comprehensive planning that will guide sustainable water supply management, and to the maximum extent possible, maintain natural hydrology.

The New Jersey Water Supply Management Act (N.J.S.A. 58:1A-1 *et seq*.) declares that the State's water resources are public assets held in trust and managed for the residents by the NJDEP. The 1981 Act requires that a New Jersey Statewide Water Supply Plan (NJSWSP) be developed and periodically revised by NJDEP. The first NJSWSP was developed in 1982

and periodic updates have been completed since that time, including a major revision in 1996. In October 2017, NJDEP released the New Jersey Water Supply Plan 2017-2022 (NJDEP, 2017b), representing the second comprehensive revision to the NJSWSP. This most recent revision is intended to be a living document with updates on a continuous cycle.

WS Action 1-4 Assess HUC 11s for water supply capability related to streamflow, surface, and shallow groundwater withdrawal capacity.

The state-level water-supply planning process aims to plan for adequate water supplies in the future and can help address water-supply vulnerabilities. A part of this planning process is to determine the water availability in each of 20 statewide Water Management Areas, one of which is the Barnegat Bay watershed. Current and projected water demands in HUC 11 subwatersheds are compared with available water to determine if a water-supply deficit exists. The regional analysis of the Barnegat Bay watershed indicates that there is a net surplus of available water overall, but the analysis of the individual HUC 11 subwatersheds indicates that the Toms River, Metedeconk River, and Kettle Creek are currently overstressed. Increases in water demand could increase this stress. Currently eight shallow groundwater monitoring wells (all less than 30' in total depth) in the watershed are monitored as part of the NJ Ambient Ground Water Quality Monitoring Network. Four of the wells are in undeveloped land use and four are in urban land use. These wells could be used as the base to design and implement a watershed-specific network to better understand water supplies.

WS Action 1-5 Promote and support land use activities that enhance water supply protection and minimize water withdrawals and usage, especially in the most stressed water supply planning areas as identified in the State Water Supply Master Plan.

While the population of Ocean County has continued to grow, the rate of this growth has decreased since 1990, according to the U.S. Census. However, in some water-stressed parts of the county, the rate of population growth has increased dramatically since 1990. If this accelerating growth pattern in these areas continues, then larger increases in future water demand for human use would place even greater stresses on local wetlands and stream habitats and on the freshwater flow to Barnegat Bay. The statewide Water Supply Plan includes provisions for mitigating water-supply deficit areas through reductions in water use, increased storage, and increased recharge. The WSP also proposes policies for water-supply improvement (*e.g.*, maintain monitoring systems, advanced treatment technologies).

Fresh water is withdrawn from surface waterways and groundwater for a variety of purposes, including public supply, agriculture, landscape irrigation, commercial and industrial uses, mining, and power generation. Withdrawals have generally increased over the past several decades, and this increase is closely linked to population growth. Water withdrawals for human use in the Barnegat Bay watershed during 1990-2015 were compiled for the New Jersey Water Supply Plan. The compilation distinguishes total withdrawal (which includes water returned to the watershed after use) from consumptive water loss from the watershed (which is most relevant to estuary health). Consumptive water loss trended upward from 3.4 bgy (billion gallons per year) in 1990 to 5.9 bgy in 2015 (an increase of 74%) with a peak of 6.8 bgy in 2007 (NJDEP, 2017b). Almost all of the consumptive loss is from public supply uses. Further information on this is available from the New Jersey Water Supply Master Plan (NJDEP, 2017b).

Comprehensive planning encompasses not just water supply, but land use, transportation, housing, utilities, open space, and other aspects of community development. Comprehensive planning typically takes place at the municipal level. The state-level water supply plan provides important information for comprehensive planning. It is now more critical than ever that comprehensive planning account for limited water availability and the sustainable use of water supplies in order to provide for the growing human population and Barnegat Bay's environment.

5.4.2. Water Supply Objective 2

Prevent degradation and encourage efficient use of water supplies.

Water supply for habitats and human uses are threatened by sea level rise, storm surges, saltwater intrusion of aquifers, drought, and contamination from human and natural sources. Protecting existing and future water supplies from these threats helps protect habitats and the human population. Building water-supply resilience to threats – including threats posed by the changing climate – can help avert the need for new supplies for human use that could potentially divert additional freshwater flow from Barnegat Bay. Select priority actions include the following.

WS Action 2-1 Inventory and promote municipal land use regulations that emphasize water supply protection as a primary goal.

Numerous municipalities have adopted local ordinances aimed at protecting water supplies, including mandatory riparian buffers, wellhead protection areas, and outdoor irrigation restrictions. Similarly, the Pinelands Commission developed an especially protective Model Stormwater Control Ordinance (NJPC and NJDEP, 2006) to ensure that the site of proposed stormwater BMPs is properly assessed and that BMPs are properly maintained. A stormwater ordinance that emphasizes the use of green infrastructure is under development for the Metedeconk River watershed. Such ordinances serve as a model for towns that have yet to embrace these effective strategies. (See also LU Actions 2-1, 4-2, and 5-3.)

WS Action 2-2 **Identify, implement, and support voluntary and mandated conservation and infiltration practices and regulation to maintain and restore base stream flows and natural hydrology.**

Maintaining an adequate flow of freshwater to the Barnegat Bay is critical to its health. Programs, policies, and regulations that sustain water supply for human use can also sustain water supplies for the bay. Expanded initiatives aimed at promoting water conservation and reducing water demands will result in less water withdrawals and leave more water draining to the bay. Enhancing groundwater recharge in developed areas by taking advantage of the watershed's sandy, well-drained soils to capture rainwater near where it falls, and eliminating runoff to constructed stormwater systems, will help maintain natural hydrology and maintain baseflow. Simple and effective measures to address this action – such as rain barrels; rain gardens; soil restoration; and native, drought-tolerant landscaping plants – can be applied to virtually any property throughout the watershed.

WS Action 2-3 **Inventory and evaluate municipal ordinances; rate structures and other available information for opportunities to better ensure judicious water usage; and incentivize water conservation at the household and community levels, including metering all water usage.**

Until recently, not all water purveyors within the Barnegat Bay watershed metered all water consumers within their distribution areas. For example, water metering was not used to determine billing in some barrier island and parts of other communities. In other instances, including multi-family dwellings and non-residential buildings, service meters were provided for the entire building or complex instead of for each individual user (NJDEP, 2017b). Requiring metering for each individual user in complexes such as these and for separate meters for indoor and outdoor use is not within the scope of the NJDEP's regulatory authority. However, NJDEP (2017b) noted that source and service metering are necessary components to New Jersey's water supply management program, as both metering provide accurate accounting of water, including evaluation of leak detection and repair programs, quantification of withdrawals in stressed areas, and motivation for individual users to understand their water use habits and take action to conserve water and save money. Thus, further investigation into usage and rate structure may help facilitate further consideration of water conservation measures in the watershed.

5.4.3. Water Supply Objective 3

Monitor and assess status and trends of water supply throughout the watershed

The status and trends of flows and human water use need to be monitored and assessed in order to understand their relation to the health of the bay. Monitoring will also allow for the anticipation of challenges that may result from detrimental conditions and trends that may be due to human activities in the watershed and those that may occur as result of a changing climate. Monitored hydrologic conditions need to include both stream flow and groundwater. Select priority actions include the following.

WS Action 3-1 **Conduct shallow aquifer protection monitoring.**

This monitoring provides essential information for managing water resources within the Barnegat Bay watershed, where the residential and tourist populations continue to grow. In the Barnegat Bay watershed, surface water and shallow aquifers are the most vulnerable supplies. Due to the close connection between the shallow aquifer and streams, groundwater withdrawals and contamination can also affect surface waterways.

WS Action 3-2 **Monitor water use trends.**

Monitoring water use is critical to promote efforts to conserve water supplies, which may be increasingly stressed by climate change, sea level rise, and the increasing human population. Thus, these trends are essential to better manage water supplies and build water-supply resilience to avoid the need for new supplies that could potentially divert additional freshwater flow from Barnegat Bay.

WS Action 3-3 **Continue, and if possible, expand stream flow monitoring throughout the watershed to assess the effects of changing precipitation patterns, water use, and development.**

The USGS maintains a network of stream-gauging stations that measure the rate of flow in some of the major streams in the watershed on a continuous basis. However, flows in many smaller streams, as well as groundwater inputs, are not monitored but have been estimated. The average annual rate of freshwater flows to Barnegat Bay, including all streamflow and groundwater inputs, is estimated to total about 220 billion gallons per year. During drought periods, the rate of freshwater flows is only about one-third to one-half of this rate. Baseflow accounts for 67-94% of total streamflow at the monitored streams. Studies have shown that in recent decades, baseflow has significantly declined in the northern streams. Recent trends in streamflow in the watershed have not been

evaluated. Stream flow monitoring is critical to understanding the influences of human activities and climate change in the watershed.

WS Action 3-4 Assess water-supply trends and effects of current and projected surface and groundwater withdrawals.

Approximately one-fifth of the freshwater flow from the watershed does not reach the bay because it is withdrawn for use, collected in the sanitary sewer system for treatment, and ultimately discharged offshore (Hunchak-Kariouk and Nicholson, 2001). Fresh water is a limited resource in the Barnegat Bay watershed. Water resource managers must clearly understand how water is being used, how much is required for human and environmental needs, and how current and future withdrawals affect this balance. Assessing water supply trends and limitations at a finer scale than has been done historically will help enhance our understanding of freshwater resources and advance the necessary, perhaps innovative, solutions that will improve water supply management.

5.4.4. Water Supply Objective 4

Improve scientific understanding of new and emerging issues (including climate change and sea level rise), pertaining to water conservation, advanced potable treatment options, and reuse.

WS Action 4-1 Identify infrastructure, research and piloting options for the use of advanced treatment at wastewater treatment plants and water reuse, including wastewater and gray water

There are various opportunities to reuse water in the Barnegat Bay watershed. One water "reuse" technique already being employed is aquifer storage and recovery (ASR), in which the Brick Township MUA directly pumps potable water into an aquifer for later recovery and use. This allows the Brick MUA to build up water supplies when water is plentiful (winter and spring) and pump the water out of the aquifer when surface water supplies are low (summer and fall). ASR is also being used in Cape May and Monmouth counties. Other examples include irrigation or groundwater recharge with gray water or treated wastewater. For example, the Landis Sewerage Authority in the city of Vineland returns 5.6 mgd of treated wastewater to groundwater. A major impediment is the cost of the necessary water treatment and/or infrastructure improvements. However, water scarcity is becoming increasingly problematic in regions around the globe and innovative, cost-effective solutions are continually being developed. Similarly, green building has become a major sustainability initiative in recent years, with water saving measures being a key focus. The completion of small water reuse demonstration projects will help raise public awareness of the region's freshwater limitations and promote more widespread application of water reuse systems.

America's Water Infrastructure Act (AWIA) of 2018 includes some notable funding sources to save water and address other water issues. Section 2004 of AWIA encourages the use of non-potable water recycling to address water demand challenges, particularly for industrial applications, and sends an important signal to both the private and public sectors to consider a water recycling approach for their water supply needs. Section 2007 of AWIA established the Innovative Water Technology Grant Program, which provides $10 million annually to support investments in innovative water technology, including water reuse or recycling and technologies to increase water supplies. Lastly, Section 4101 of AIWA requires the USEPA to establish a Stormwater Infrastructure Funding Task Force – a multi-government and non-profit task force – to examine ways to improve stormwater infrastructure, including infrastructure that can facilitate greater capture and reuse of stormwater resources.

Figure 5.7. Moses Milch bioretention basin, restored by the BTMUA. Photo courtesy of the BTMUA.

WS Action 4-2 Conduct research on the effects of climate change, sea level rise, saltwater intrusion, and deicers/chlorides on regional water supply and coastal ecology.

Depending on specific features of climate change and rates of sea level rise (See Chapter 8, Melillo *et al.*, 2014), impacts to water resources and water infrastructure and their planning may be significant. For example, more frequent and severe storms may damage water infrastructure, and droughts may result in saltwater intrusion impacting surface and groundwater supplies (Van Abs, 2016). Increased use of deicers during winter storms is viewed as important to ensure highway safety; however, both environmental and human health impacts of increasing salt usage have been recognized (Corsi *et al.*, 2010; 2015). For example, increased salt usage for road de-icing may increase water treatment costs and concerns about impurities, including arsenic and lead, not only in the environment but also in drinking water (Stets *et al.*, 2018; ASDWA, 2020). There is considerable interest in alternative de-icers and other strategies to reduce salt usage while maintaining roadway safety and protecting water quality (*e.g.*, Fay *et al.*, 2013).

5.4.5. Water Supply Objective 5

Educate consumers regarding water supply issues, including efficient water use, indoor/outdoor water conservation, and reuse.

Building consumer knowledge of water use, conservation and water-supply protection, and water reuse can help promote and leverage actions designed to reduce water demand and improve water-supply protection. Educated consumers are more likely to support and participate in conservation and protection programs. Public education is also an important component to building resilience to climate change. Selected actions include the following.

WS Action 5-1 Promote water reuse demonstration projects for stormwater, gray water, and wastewater.

New Jersey's Water Supply Master Plan (NJDEP, 2017b) makes clear that water reuse is a potentially invaluable tool for drought mitigation and long-term water supply management, particularly for highly consumptive, non-potable purposes. Water reuse projects make use of what has previously been considered a waste product, gives it advanced and specialized level(s) and type(s) of treatment, and reuses the resulting reclaimed water for beneficial use. Water reuse projects can help meet growing demands for outdoor water uses, while protecting water supply resources, particularly in coastal areas where regional wastewater systems discharge to the ocean, thereby depleting local/regional water supplies (NJDEP, 2017b).

Unfortunately, while widely accepted nationally, water reuse/reclamation projects have received much less acceptance and thus been far more limited in their application throughout the state. For example, Evesham Township began using reclaimed water to irrigate its municipal golf course in 2002; moreover, that project was considered an immediate success, allowing for the effective maintenance of the course through subsequent summer droughts. In 2006, New Jersey's first residential application of reclaimed water was implemented at an active adult community in Burlington County, where this water now provides an alternate water source for irrigating the extensive grounds of the community. The success of these demonstration projects provide public reassurance and incentive for additional implementation; in addition, these projects have confirmed the need and importance for cooperation among agencies responsible for water treatment and the delivery of water supplies.

Figure 5.8. NJDEP Rain Barrel Challenge winners. Photo courtesy of BBP staff.

WS Action 5-2 Disseminating educational materials related to best practices for water conservation activities.

Community awareness is the first step towards improving water conservation. There are many available sources of public outreach materials geared towards water conservation, and programs are in place within the Barnegat Bay watershed to educate the public and build awareness about the need to conserve water. There are also opportunities to leverage other environmental education programs and public venues to promote water conservation. Substantial reductions in water demands can be achieved if the people who live, work, or otherwise spend time in the watershed are aware of the simple things they can do in their daily lives to conserve water. Reducing water demand is especially important in the face of changing climatic conditions that may place additional stresses on water supplies and the bay. Since 2006, USEPA has grown a national water conservation program (*i.e.*, WaterSense), now with more than 2,000 partners, including the BTMUA (2017), which has helped save 3.4 trillion gallons of water and $84.2 billion in energy and water bills from using WaterSense-labelled products, homes, and programs.

WS Action 5-3 **Develop and support programs to educate stakeholders on the source and value of their water.**

The NJDEP (2017) State Water Supply Master Plan makes clear, New Jersey has an abundance of water resources. Thus, it is also important to protect existing water supplies for future use. Continuing population growth, especially in areas of rapid growth, may be expected to increase demand for water. Changing climatic conditions and increasing sea level rise also may place additional stresses on water supplies and the bay. For the present and near future, the BBP will continue to support Save the Source, an award-winning outreach campaign developed by Pinelands Preservation Alliance to protect the 17-trillion gallon Kirkwood-Cohansey Aquifer, a vast reserve of fresh water that underlies southern New Jersey and all of the Pinelands. (See Chapter 12, Section 12.4. Success Stories: Water Supply for additional information about this program.)

WS Action 5-4 **Implement components of the BBP Communication Plan related to water supply protection).**

With its focus on specific audiences (such as tourists, who visit the Barnegat Bay in summer when water usage is high and supplies may be low), implementing the priorities of the BBP Communication Plan seems increasingly important for the BBP and partners in key sectors (*e.g.*, tourists, water purveyors, landscapers, emergency managers).

Figure 5.8-1. USGS Gaging Station on the North Branch of the Metededeconk River. Photo courtesy of BTMUA.

5.5. Ecosystem Target, Objective, and Action Summary

Table 5.1. The relationships between the Ecosystem Based Targets and the Actions within the Water Supply priority area.

Public Beach Closures	
Approved Shellfish Areas	
Submerged Aquatic Vegetation Extent	Objective 1: Action Items 1, 2, 3
Wetland and Riparian Buffer Preservation	Objective 1: Action Items 1, 2, 3, 5 Objective 2: Action Items 2, 2 Objective 5: Action Items 3
Wetland Protection	Objective 1: Action Items 1, 2, 3
Clam restoration	Objective 1: Action Items 1, 2, 3
Ecological flows	Objective 1: Action Items 1, 2, 3, 4, 5 Objective 2: Action Items 1, 2, 3 Objective 3: Action Items 1, 2, 3, 4 Objective 5: Action Items 1, 2, 3
Water conservation and reuse	Objective 1: Action Items 1, 2, 3, 4, 5 Objective 2: Action Items 1, 2, 3 Objective 3: Action Items 2, 4 Objective 4: Action Items 1 Objective 5: Action Items 1, 2, 3

Water Supply Objective 1: Protect, maintain, and enhance existing surface and ground water flow.

WS Action 1-1 **Assess and implement existing shallow groundwater protection programs, including wellhead protection; rainwater and treated wastewater recharge; and new septic designs that may better address the release of nutrients and anthropogenic compounds to groundwater.**

WS Action 1-2 **Determine minimum ecological flow requirements for priority streams, rivers, and wetlands within the watershed.**

WS Action 1-3 **Support comprehensive planning that will guide sustainable water supply management, and to the maximum extent possible, maintain natural hydrology.**

WS Action 1-4 Assess HUC 11s for water supply capability related to streamflow, surface, and shallow groundwater withdrawal capacity.

WS Action 1-5 Promote and support land use activities that enhance water supply protection and minimize water withdrawals and usage, especially in the most stressed water supply planning areas as identified in the State Water Supply Master Plan.

Water Supply Objective 2: Prevent degradation and encourage efficient use of water supplies.

WS Action 2-1 Inventory and promote municipal land use regulations that emphasize water supply protection as a primary goal.

WS Action 2-2 Identify, implement, and support voluntary and mandated conservation and infiltration practices and regulation to maintain and restore base stream flows and natural hydrology.

WS Action 2-3 Inventory and evaluate municipal ordinances; rate structures and other available information for opportunities to better ensure judicious water usage; and incentivize water conservation at the household and community levels, including metering all water usage.

Water Supply Objective 3: Monitor and assess status and trends of the water supply throughout the watershed.

WS Action 3-1 Conduct shallow aquifer protection monitoring.

WS Action 3-2 Continue to monitor water use trends.

WS Action 3-3 Continue, and if possible, expand, stream flow monitoring throughout the watershed to assess the effects of changing precipitation patterns, water use, and development.

WS Action 3-4 Assess water-supply trends and effects of current and projected surface and groundwater withdrawals.

Water Supply Objective 4: Improve scientific understanding of new and emerging issues (including climate change and sea level rise) pertaining to water conservation, advanced potable treatment options, and reuse.

WS Action 4-1 Identify and explore infrastructure, research, and piloting options for the use of advanced treatment at wastewater treatment plants and water reuse, including wastewater and gray water, within the watershed.

WS Action 4-2 Conduct research on the effects of sea level rise, saltwater intrusion, and deicer/chloride on regional water supply and ecology.

Water Supply Objective 5: Educate consumers regarding water supply issues, including efficient water use, indoor/outdoor conservation, efficiency and reuse.

WS Action 5-1 Promote water reuse demonstration projects for stormwater, gray water, and wastewater.

WS Action 5-2 Disseminate educational materials related to best practices for water conservation activities.

WS Action 5-3 Develop and support programs to educate stakeholders on the source and value of their water.

WS Action 5-4 Implement components of the BBP Communication Plan related to water supply protection.

Figure 5.9. Lake Carasaljo tree filter boxes retrofitted by the BTMUA in 2019. Photo courtesy of the BTMUA.

CHAPTER

6

LIVING RESOURCES

6.1. Themes

- The Barnegat Bay ecosystem is comprised of a wide diversity of habitats, from submerged aquatic vegetation to low-lying coastal and freshwater wetlands to uplands of pine and oak forests.
- The protection and/or restoration of priority habitats serves as a means of improving water quality, protecting water supplies, and ensuring necessary spaces for fish and wildlife.

6.2. Goal and Objectives

To protect, restore, and enhance characteristic bay and watershed habitats as well as ensuring healthy and sustainable natural communities of plants and animals both now and in the future.

Living Resources Objectives

1. Develop and implement habitat protection and restoration plans for the watershed's characteristic habitats, including ecologically sensitive areas.
2. Restore and maintain sustainable populations of fish and wildlife.
3. Monitor and assess status and trends of living resources throughout the watershed.
4. Conduct studies to improve scientific understanding of living resources and ecologically sensitive habitats.
5. Increase education and public outreach related to habitats and living resources.

6.3. Introduction

Natural ecological systems are composed of both physical habitats and the organisms that dwell within them. Estuarine habitats and the living resources they shelter – at the intersection of freshwater and marine waters – prove the most dynamic and complex ecosystems to study, maintain, and manage. This is due to the daily, monthly, and seasonal fluctuations in physical conditions such as tide, salinity, and dissolved oxygen, as well as the complex life histories of the resident and migratory populations of fishes, shellfishes, and wildlife that shelter, breed, and feed within the estuary.

The Barnegat Bay watershed is composed of 11 rivers and streams that empty into the Barnegat Bay-Manahawkin Bay-Little Egg Harbor estuary, including a continuum of overlapping and interdependent habitats extending from upland forests through freshwater streams and lakes, through tidal wetlands and salt marshes, to small tidal embayments and the bay proper.

The estuarine habitats of Barnegat Bay include barrier beaches and dunes, submerged aquatic vegetation beds, intertidal sand and mudflats, salt marsh islands, fringing tidal salt marshes, freshwater tidal marsh, and palustrine wetlands. These habitats also support a multitude of environmentally sensitive living resources including shellfish beds, waterfowl nesting grounds, and finfish nurseries.

6.3.1. Sustaining the Ecological Integrity of the Estuary

Healthy estuaries ensure the survival of many species of invertebrates, fishes, birds, mammals, and other species. They provide vital nesting and feeding habitats and help maintain a healthy environment by filtering out sediments and pollutants from rivers and streams. Some organisms – such as hard clams, oysters, terrapins, and blue crabs – live all year in the estuaries, whereas others, like horseshoe crabs and striped bass, use them to complete a small part of their life cycle (Figure 6.1). Estuaries also provide stopovers for migratory bird species such as snow geese and mallard ducks. In addition to providing shelter and food for living resources, estuaries deliver important ecosystem services.

Ecosystem services are fundamental life-support processes upon which all organisms depend (Sanchirico and Mumby, 2009). One of the common ecosystem services supplied by estuaries is water filtration. For example, salt marshes trap and remove pollutants from the water, including herbicides, pesticides, and heavy metals as well as excessive sediments and nutrients. A recent salt marsh soil study in Barnegat Bay showed that a significant amount of nitrogen (79%) and phosphorus (54%) runoff from upland sources (*e.g.*, fertilizer, stormwater) were trapped in the marsh sediments (Velinsky *et al.,* 2017). Removing these excess nutrients reduces eutrophication (*i.e.*, harmful algal blooms, anoxia, and fish kills) in the surrounding bay waters. Not only do salt marshes act as buffers to stabilize shorelines and protect sensitive natural habitats (*e.g.*, bird nesting and fish breeding areas), but they also protect human communities from floods and storm surges.

Figure 6.1. Diamondback terrapin laying eggs. Photo courtesy of New Leaf Photography.

6.3.2. Characteristic Habitats

Approximately 88,018 acres of wetlands (more than 25% of the watershed's total land area of 348, 015 acres) remained in the Barnegat Bay watershed in 2012. From 2007-2012, the latest years for which data are available, approximately 235 acres of tidal wetlands were lost (mostly due to SLR) and 284 acres were lost (mostly due to development). See the BBP's 2016 State of the Bay Report for additional information.

Coastal and Freshwater Wetlands

Salt marshes are among the most productive habitats in the world and perform a wide variety of vital ecosystem services. They buffer inland areas from tidal and storm damage; store water to protect against flooding; serve as important spawning and nursery habitats for valuable fishery species and other wildlife, including waterfowl; trap pollutants and help sustain water quality; support recreation; and provide aesthetic value. Salt marshes are clearly critical to the overall ecology of Barnegat Bay. A 2012 study valued the ecosystem services of saltwater wetlands in Barnegat Bay at $155 million per year (Kauffman & Cruz-Ortiz, 2012). Salt marshes within the Barnegat Bay estuary are dominated by salt marsh grasses such as salt marsh cordgrass (*Spartina alterniflora*), salt hay (*Spartina patens*), and salt marsh spike grass (*Distichlis spicata*). Marshes fringe most of the bay's undeveloped lands and consist of back barrier marshes, as well as expansive tracts of marshes adjacent to the landward side on the western edge of the bay (Figure 6.2). However, Barnegat Bay salt marshes have been sediment starved due to minimal deposition of sediment associated with extensive bulkheading and landscape alterations,

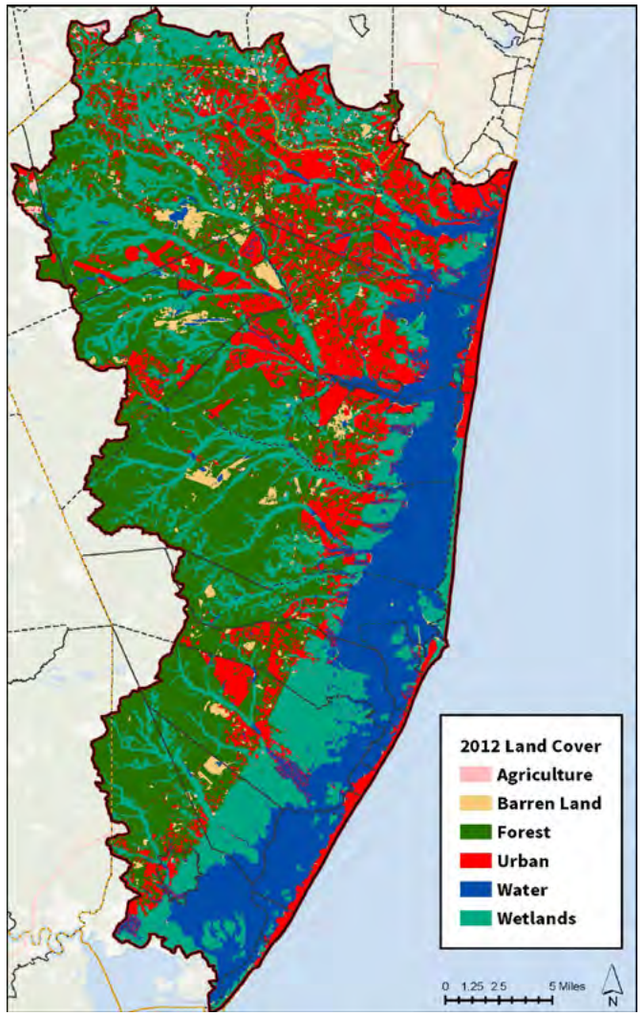


Figure 6.2. 2012 Land Cover Map. Figure from BBP *2016 State of the Bay Report*.

Figure 6.3. Swamp pink: Ocean County is home to the largest population of this federally-listed (Threatened) species. Photo courtesy of G. Wilders.

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especially in the upper areas of the watershed (Ganju *et al.*, 2017), and are being lost at an accelerating rate (Figure 6.2). Other contributing factors for wetland losses include erosion from boat traffic, wind-generated wave energy, and sea level rise.

The Barnegat Bay watershed has approximately 67,000 acres of freshwater wetlands, comprised of emergent, scrub-shrub, and forested types. Generally found at low points in the landscape, these wetlands can be fed from groundwater sources, or are located adjacent to rivers, streams, and creeks. Freshwater wetlands act as "natural sponges," holding excess floodwater and filtering nutrients that might otherwise end up in our waterways and the bay. They are also home to a wide variety of wildlife, including some of our more well-known threatened and endangered species, such as the Pine Barrens tree frog (*Hyla andersonii*) and swamp pink (*Helonias bullata*; Figure 6.3). Freshwater wetlands loss within the watershed is typically associated with human development of the land, either for agricultural or residential purposes. Reductions in groundwater flow is also of concern for wetlands in developed areas of estuary. The societal, cultural, recreational, and economic benefits of freshwater, salt marsh, and forested wetlands have been well documented and can no longer be discounted (*e.g.*, Kauffman & Cruz-Ortiz, 2012).

It is estimated that the Barnegat Bay watershed has lost in excess of 28% of its tidal wetlands to development from many factors, including sea level rise, edge erosion, anthropogenic impacts (*e.g.*, ditching, open marsh-water management for mosquito control), subsidence due to ground-water withdrawal, and loss of sediment supply through the removal of channel-dredged materials (Lathrop & Bognar, 2001; NJDEP, 2017a). These activities continue to stress wetland resources, threaten their integrity, the ecosystem services they provide, and the adjacent built environment. Efforts to restore lost wetlands can be costly in New Jersey (*e.g.*, $1 million per acre) for many reasons, and sometimes cannot replace or replicate specific ecosystem functions; thus, protection of existing wetlands remains increasingly vital.

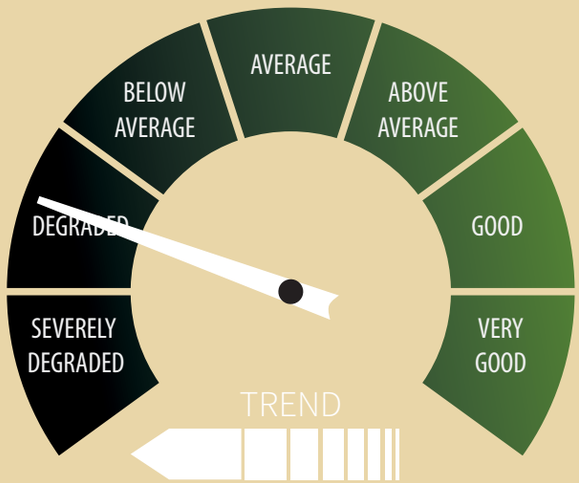
While New Jersey has had strong environmental regulations[1] specific to both coastal and freshwater wetlands, the state has and continues to experience a loss of these important features. It is estimated that the Barnegat Bay watershed lost as much as 6%, or 4,633 acres, of freshwater wetlands between 1972 and 1995; 28% of the Barnegat Bay salt marshes were eliminated or impacted by mosquito control ditching and development prior to 1970; and 71% of the Barnegat Bay shoreline was developed or altered, with 40% due to bulkhead stabilization of the shoreline (Lathrop & Bognar, 2001). During Hurricane Sandy, marshes prevented $425 million in direct flood damages to property in New Jersey alone (Narayan *et al.*, 2017). It was further reported that in Barnegat Bay, marshes annually reduce flood losses by 16% compared to areas where marshes have been destroyed or developed; moreover, in the highest risk areas (*i.e.*, those less than five feet above sea level), marshes reduced risks to property by as much as 70 percent Narayan *et al.*, 2017).

Wetlands have long been appreciated for their habitat and aesthetic value and are now also recognized for the economic value of the ecosystem services they provide for carbon sequestration and, as previously cited, for their value in reducing flood losses to development. The Barnegat Bay watershed still retains expanses of protected wetlands, but also has lagoon communities interspersed in the wetland expanses and development along remaining shorelines. The sustainability of wetlands and the ecosystem services they provide present a key challenge to land use and natural resource managers alike. Resource managers are concerned with sustaining the health and integrity of the wetlands for their natural resource values, while land managers are concerned with the same factors, but for the ecosystem services that sustain existing development. These concerns are not mutually exclusive, nor are the strategies to achieve sustainability and protect the bay's living resources altogether different; the challenge will be in balancing the goals of achieving sustainability and protecting living resources.

Empirical data from Barnegat Bay support concerns about wetland losses. Marshes must be replenished naturally, with sediments transported onto the surface by tides, or else succumb to erosion or subsidence. A recent salt marsh study in Barnegat Bay (Velinsky *et al.*, 2017) showed that sedimentation rates were barely keeping up with the measured rate of sea level rise recorded by nearby tide gauges. This relatively low rate of accretion renders the marshes in Barnegat Bay vulnerable to inundation and erosion should the rate of sea level rise accelerate in the future. In addition, a recent study of water quality data from the 1970s through 2013, to determine if significant changes and trends occurred over decadal spans, showed increasing trends for temperature and salinity (Goodrow, 2017). This

1 Freshwater Wetlands Protection Act: N.J.S.A. 13:9B, first enacted July 1987, implementing rules at N.J.A.C. 7:7A; Wetlands Act of 1970: N.J.S.A. 13:9A, first enacted 1970 (obvs); CZM Rules at N.J.A.C. 7:7

Figure 6.4. Living Resources Status and Trends: Wetlands Area



Wetlands provide essential ecosystem services to communities throughout Ocean County and especially to those along the Barnegat Bay; they provide flood protection, water quality improve-ments, biogeochemical cycling, and carbon sequestration.

There were approximately 22,795 acres of tidal wetlands and 67,034 acres of freshwater wetlands within the Barnegat Bay watershed in 2012. This represents a loss of 238 acres of tidal wetland area and 284 acres of freshwater wetland area since 2007. The rate of tidal wetland loss has been increasing over the past 20 years, while that of freshwater wetland loss has been decreasing.

See the BBP's 2016 State of the Bay Report for additional information.

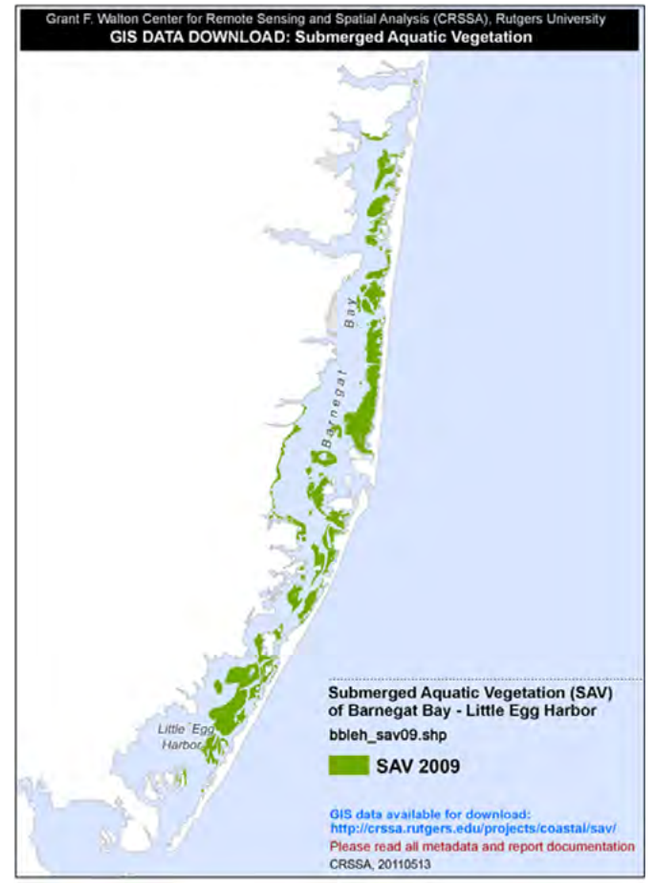


Figure 6.5. Distribution of submerged aquatic vegetation in Barnegat Bay in 2009 (Lathrop & Haag, 2011).

may be due to increasingly warmer summers (*i.e.*, climate change) and sea level rise (*i.e.*, saltwater intrusion).

Submerged Aquatic Vegetation

Seagrasses serve as habitat and food for many recreationally and commercially important estuarine and marine species [*e.g.*, bay scallop (*Argopecten irradians*), blue mussel (*Mytilus edulis*), blue crab (*Callinectes sapidus*), and weakfish (*Cynoscion nebulosus)*]. Seagrass beds also play a significant role in nutrient cycling, carbon sequestration, filtering of essential elements, and wave dampening. In addition, seagrasses are excellent indicators of water and sediment quality, as they indicate changes in water quality and benthic attributes. Seagrasses also play an important role in sediment stabilization, which is of particular importance in the southern portions of Barnegat Bay, where there is higher turbidity as seagrass populations have declined. Seagrasses are impacted by water nutrient levels, elevated water temperatures, ice scouring, damage from boat props and anchors, disease and light intensity fluctuations caused by dredged or storm-tossed sediments, and algal blooms or overgrowth. By assessing the condition of seagrass beds over time, it is possible to establish accurate trends in estuarine condition. Within Barnegat Bay, eelgrass (*Zostera marina*) dominates the seagrass beds south of Toms River, while mixed eelgrass and widgeon grass (*Ruppia maritima*) beds are found in the central and northern portions of the bay. The difference reflects different and changing conditions in parts of the bay. Although the ecological roles of both of these species are not entirely recognized and may differ somewhat, both are considered desirable.

In addition, SAV, like the grass in a meadow, serves as the base of the web that supplies food to grazers and energy to the entire ecosystem. Approximately 75% (6000 ha) of the seagrass beds in New Jersey occur in the Barnegat Bay Estuary (Fertig, 2014; Figure 6.4). Unfortunately, major declines in biomass and percent SAV cover have been reported in some sectors of the estuary since the 1970s (Bologna *et al.*, 2000). A more recent study revealed an ongoing decline in biomass and percent cover of bay bottom (Kennish *et al.*, 2009) attributed to increasing eutrophication due to shading of the shallow SAV beds by algal blooms and attached microalgae on the stems. Additionally, the species composition of seagrass beds in the bay appear to be changing from eelgrass to widgeon, which can affect the ecosystem services provided.

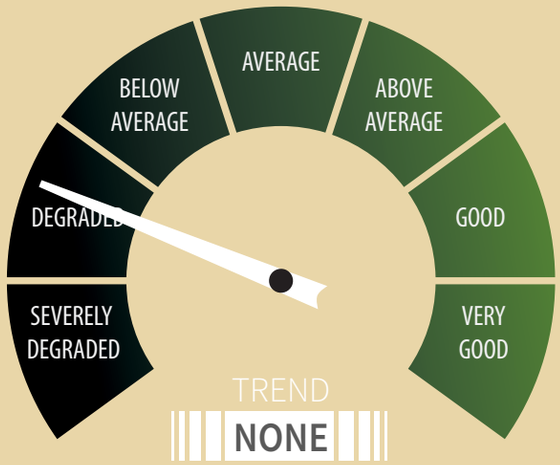


Figure 6.6. 2016 Living Resources Status and Trends: Submerged Aquatic Vegetation

Seagrasses serve as habitat and food for many recreationally and commercially important estuarine and marine species (*e.g.,* bay scallop, blue crab, and weakfish). Seagrass beds also play a significant role in nutrient cycling, carbon sequestration, and wave dampening. In addition, seagrasses are excellent indicators of water and sediment quality, as they indicate changes in water quality and benthic attributes. Seagrasses are negatively impacted by water nutrient levels, elevated water temperatures, ice scouring, damage from boat props and anchors, disease and light intensity fluctuations caused by dredged or storm-tossed sediments, and algal blooms or overgrowth.

A comprehensive evaluation and delineation of SAV beds has not been performed since 2009, when they covered approximately 14% of the estuarine bottom. From a bay-wide perspective, eelgrass biomass reached its lowest level in 2009, and though the 2015 levels were encouraging, they do not represent a statistically significant improvement from the lows of the late 2000s.

See the BBP's 2016 State of the Bay Report for additional information.

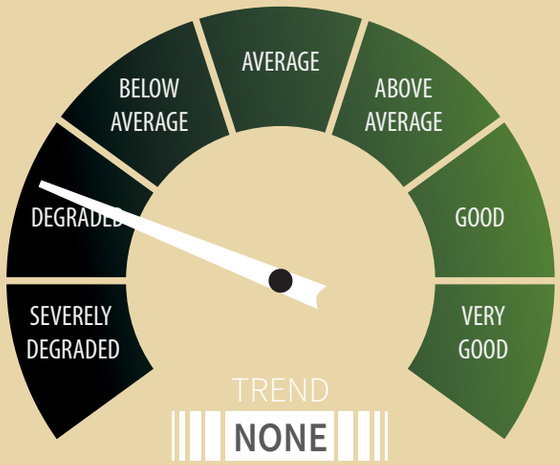


Figure 6.7. 2016 Living Resources Status and Trends: Hard Clam Abundance

Estuarine shellfishes have limited mobility, are sensitive to environmental changes, and are a commercially and recreationally impor-tant species, making them key indicators for assessing ecological conditions of estuarine systems nationwide. Historical records note the presence of hard clams (*Mercenaria mercenaria*), eastern oysters (*Crassostrea virginica*), and bay scallops (*Argopecten irradians*) in Barnegat Bay, but abundance data are only available for hard clams.

Bay-wide surveys for hard clams conducted in 2011 (Little Egg Harbor) and 2012 (Barnegat Bay) estimated a standing stock of approximately 224 million clams. Overall, the abundance of hard clams in Barnegat Bay in 2012 was down approx-imately 23% from the last survey, completed in 1985/1986. For Little Egg Harbor, the overall abundance in 2011 was down approximately 57% com-pared with the 1985/1986 survey. However, the abundance of hard clams in Little Egg Harbor increased 32% between 2001 and 2011.

See the BBP's 2016 State of the Bay Report for additional information.

Shellfish Beds/Reefs

There has been a documented decrease in the hard clam population based on surveys conducted in the southern part of the bay by the NJDEP in 1985/1986 (Joseph, 1987), 2001 (Celestino, 2003), and 2011 (Celestino, 2013). The 2011 survey estimated the hard clam resource in Little Egg Harbor at 85.7 million clams, an increase of 32% from the 2001 survey, but a 57% decline from the 1986/87 survey. The 2012 survey of Barnegat Bay north of Manahawkin Bridge (Dacanay, 2015) estimated a population of 138.2 million clams, a decrease of around 23% from the 1985/86 survey. A 2013 post-Sandy truncated investigation of hard clams throughout the entire system was undertaken to determine if hard clams suffered marked mortality or changes in local abundance due to the storm. No statistically significant difference was found in either hard clam abundance or mortality after the storm. While hard clams are subject to both a commercial and recreational fishery, the lack of a fishery management plan and landings requirements reduces our ability to fully understand the complexities of shellfish population dynamics within the Barnegat Bay system and assess the potential impacts, if any, from harvest.

Historically, the oyster beds of Barnegat Bay extended from the southern end of the bay to the mouth of Forked River (Ford, 1997). These beds were abundant in the late 1880s and were used as a source of seed oysters for planting in other areas of New Jersey and New York. In 1880, it was estimated that 675 vessels harvested a total of 330,000 bushels of oysters in the Atlantic coast of southern Jersey (Ingersoll, 1881). Overfishing pressure on the oyster resource in the late 1800s and early 1900s, coupled with a change in salinity in the bay resulting from a 1919 storm, began to take its toll on the oysters in the bay (Ford, 1997). The resource suffered a prolonged period of spat settlement failures and by the 1950s was only producing a few thousand bushels of oyster per year (Ford, 1997), and today has essentially lost commercially viable wild beds. Currently, almost all of the historic oyster habitat (exposed shell) has been degraded due to siltation. Very few leases remain in Barnegat Bay and northern Little Egg Harbor Bay. A new, experimental two-acre reef near Tuckerton has been constructed over the past few years by Stockton University with funding from the BBP and other public and private; results to date suggest that oyster reef restoration can be successful within the bay.

Upland and Wetland Forests

Nearly 40% of the land area of the Barnegat Bay watershed is classified as upland forest, including the western portion of the watershed that lies within the Pinelands Area containing the Pine Barrens ecosystem and hard wood and cedar swamps (BBP, 2016). The Pine Barrens include nearly contiguous stands of pure pitch pine (*Pinus rigida*), mixed pine species stands, pine-oak stands, and, finally, mixed oak stands. While not entirely undeveloped, the Pine Barrens are one of the few comparatively natural landscapes remaining on the eastern seaboard. The pitch pine-dominated forests are fire-dependent; they have developed adaptations that allow them to recover quickly from fire events and out-compete hardwood species for space and light. Changes in fire regime associated with human development and fire control are thought to be contributing to the transition from pine- to oak-dominated forests in the region. Forest area within the watershed is typically lost due to conversion to agricultural or suburban land use. The southern pine beetle (*Dendroctonus frontalis*), a destructive beetle common in the southeastern U.S., was found in the Pine Barrens in 2010, and poses a significant threat to pine trees.

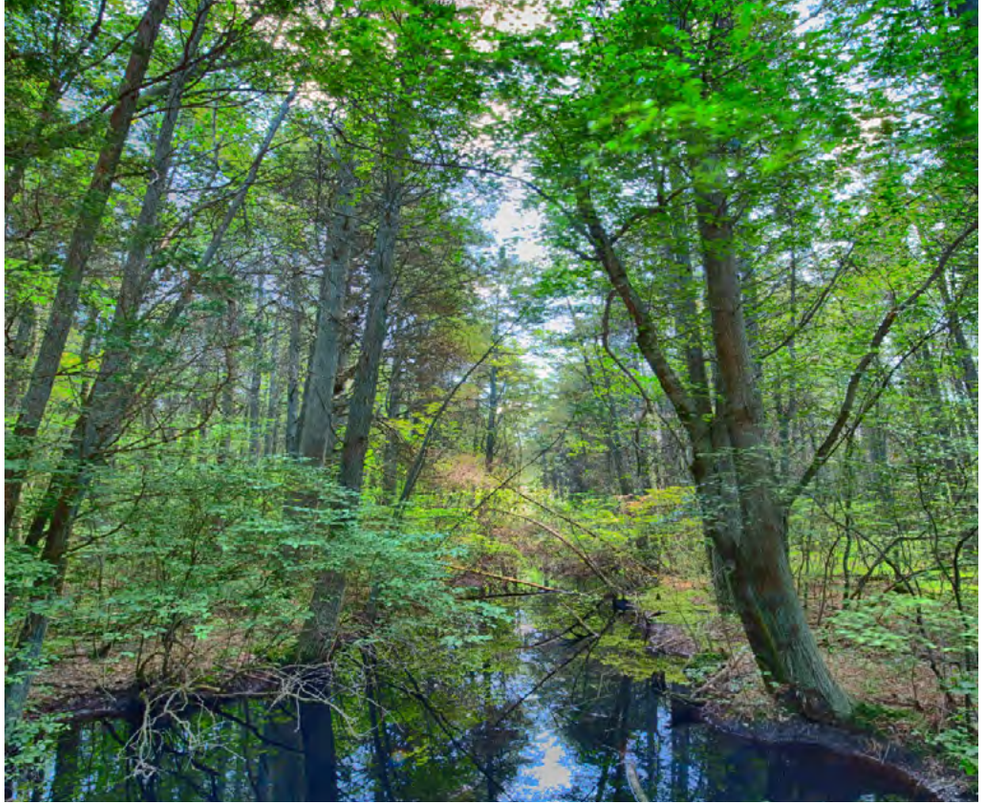


Figure 6.8. **Atlantic White-Cedar forest in the Barnegat Bay watershed. Photo courtesy of G. Wilders.**

Palustrine (freshwater wetland) forests of Atlantic white cedars (*Chamaecyparis thyoides*) stands can be found in the riparian zones immediately adjacent to freshwater streams and swamps, primarily in the portion of the of the watershed within the Pinelands Area (Figure 6.8). They contribute to the productivity of wetland communities; provide habitat for wildlife and plant life, including threatened and endangered species; and add to the diversity within the watershed. Once common throughout the region, white cedar are in decline due to development and related disturbance, wildfire, deer browsing, salt water inundation, and illegal harvesting.

6.4. Objectives and Actions

6.4.1. Living Resource Objective 1

Develop and implement habitat protection and restoration plans for the watershed's characteristic habitats, including ecologically sensitive areas.

The Barnegat Bay ecosystem is comprised of a wide diversity of habitats, from submerged aquatic vegetation to low-lying coastal and freshwater wetlands to uplands of pine and oak forests. Until a few decades ago, many estuarine wetland areas were drained and converted into uplands for development, while bay bottoms were filled or dredged to facilitate human uses, thereby decreasing the productivity of these important habitats. Since then, environmental laws and regulations have come into existence, slowing this destructive process.

However, there is still a need to protect and restore both terrestrial and subaqueous estuarine habitats, such as forests, wetlands, and submerged aquatic vegetation. In addition, there is a need to assess habitat vulnerabilities from threats such as development, pollution, invasive species, sea level rise, storm surge, and drought. The protection and/or restoration of priority habitats serves as a means of improving water quality, protecting water supplies, and ensuring the necessary spaces for fish and wildlife.

The watershed has experienced rapid development over past decades, especially in the northern reaches of the bay. The population in Ocean County has increased more than 175% from 1970 to 2010 (U.S. Census Bureau, 2020). Land-use changes between 1986 and 2010 (NJDEP, 2018) reveal an increase in urban land of 12.4% and 14.1% in the Toms River and Metedeconk River watersheds, respectively. This urbanization has largely occurred in upland forest and wetlands, converting them into developed landscapes. The effects of these land use changes, and others, on the functioning of the ecosystem can be substantial. Thus, it is imperative to bring together appropriate landscape-level and other information to maximize the efficient use of scarce resources to protect and restore these valuable habitats through the development of Habitat Protection and Restoration Plans.

LR Action 1-1 Compile existing data and maps, and determine and collect missing data for ecologically sensitive habitats and associated buffers.

The first step in the creation of these Plans would include the compilation of existing data and maps; without knowing where the habitats are, and what their status is, it would be difficult to properly manage them. These data may include the distribution of a given habitat type on a watershed-wide scale (*e.g.*, a forested area GIS layer), the status and trends of a habitat on a sub-watershed scale (BBP MACWA wetlands data for northern bay coastal wetlands), or a collection of site-specific data (locations of ephemeral vernal pools). There will undoubtedly be information about these ecologically sensitive habitats that is missing (*e.g.*, the current distribution of SAV in the bay); therefore, the acquisition of necessary data would be the second step.

LR Action 1-2 Develop and implement conservation/restoration plans for ecologically sensitive terrestrial, coastal, and aquatic habitats.

With the appropriate data in hand (from *LR Action 1-1*), it will be possible to develop conservation/restoration plans for priority areas. These plans will identify the historic and current state of the resources together with known and likely threats. Potential conservation/restoration strategies will be described for each habitat (*e.g.*, reforestation of disturbed forested lands, thin-layer placement on degraded marsh platforms, creation of oyster reefs through spat-on-shell plantings, acquisition of riparian buffers) and identified, on-the-ground opportunities (*e.g.*, wetland restoration at Cattus Island County Park in Toms River, expansion of Tuckerton Oyster Reef in Little Egg Harbor, living shorelines at the Lighthouse Center for Natural Resource Education in Waretown).

LR Action 1-3 Create a web-accessible database of habitat protection and restoration activities completed by the BBP and partners.

As habitat protection and restoration opportunities are identified through the development of the various plans (from *LR Action 1-2*), they will be entered into a web-accessible database that can be updated as new plans are formulated. Completed habitat protection and restoration activities will also be included in the database. The database of potential opportunities allows managers and restoration practitioners to identify needed actions within a resource type or geographic area, while the completed activities will provide those same groups with example projects, costs, outcomes, and other pertinent information.

LR Action 1-4 Encourage the protection and management of habitats on a sub-watershed basis through coordination and collaboration across municipal boundaries.

Ideally, working together, partners will develop a plan for protecting and managing habitats on a sub-watershed basis through coordination and collaboration across municipal boundaries. Habitats do not recognize man-made jurisdictional boundaries (the Cedar Creek has one bank in Berkeley Township and one bank in Lacey Township, with Atlantic white-cedar on both sides), and the health of the habitat on one side can be substantially impacted by the actions on the other. Thus there is a need for holistic, cross-jurisdictional planning and management.

LR Action 1-5 Promote management of ecologically sensitive and other target areas.

Currently there are priority habitats and sensitive areas that are publicly held but not under active conservation management. These areas should be identified so that parcel-specific management plans can be implemented (*e.g.*, prescribed burning, limited vehicular access, invasive species removal) to ensure that the habitats remain viable.

6.4.2. Living Resource Objective 2

Restore and maintain sustainable populations of fish and wildlife.

Estuaries provide habitat for more than 75% of the U.S. commercial fish catch, and an even greater percentage of the recreational fish catch (Sissenwine and Rosenberg, 1993). Estuaries are also important recreational areas; millions of people visit estuaries each year to boat, swim, watch birds and other wildlife, and fish. The annual value of the goods provided by New Jersey's natural capital is estimated to be $2.8–$9.7 billion, with wetlands and marine ecosystems supplying the highest eco-service values (NJDEP, 2007). Overall, the study concluded that commercial and recreational uses of estuarine resources and wildlife-related tourism are a significant component in New Jersey's economy.

Underpinning this natural capital are the environmentally sensitive habitats that fish, birds, and wildlife use to sustain their populations. However, many of these habitats are at risk, including seagrass beds. Seagrass beds and other types of submerged aquatic vegetation (SAV) support many commercially, recreationally, and ecologically important shellfish and finfish species. Larvae and juveniles of many important commercial and sport fish – such as bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), herring (Clupeidae) and many others – appear in eelgrass beds in the spring and early summer (Fonseca *et al.*, 1990). Studies from the lower Chesapeake Bay found that SAV beds are important for the brooding of eggs and for fishes with demersal eggs, and as habitat for the larvae of spring-summer spawners such as anchovies (*Anchoa* spp.), gobies (*Gobiosoma* spp.), weakfish (*Cynoscion regalis*), and silver perch (*Bairdiella chrysoura*). Heck and Thoman (1984) concluded that SAV beds are also important nursery habitats for blue crabs (*Callinectes sapidus*). According to Kenworthy *et al.* (1988), shallow dwelling hard clams (*Mercenaria mercenaria*) may be protected from predation by the rhizome layer of seagrass beds.

The Barnegat Bay estuary has historically supported high rates of primary production and large stocks of the commercially valuable hard clam and oyster, although a marked historical decline of stocks has been observed (Bricelj, 2017). Although over-fishing cannot be ruled out as a primary factor in this decline, several other possible causes have been suggested, including a shift in food availability to lower-quality sources associated with increased eutrophication, and the reduced ability of young clams and oysters to successfully survive their first year due to poor habitat. Human activity may also impact hard clam populations via physical disturbance from dock construction, dredging, and boat scarring (Lathrop and Haag, 2011).

While protecting existing habitats and improving degraded ones will aid in the restoration and maintenance of populations of fish and wildlife, there are several specific actions that can be undertaken that will enhance the sustainability of these populations against future adverse impacts and climate change. The following actions have a species focus, and therefore cut across multiple habitats.

LR Action 2-1 Develop a bay-wide multi-use management plan that supports sustainable aquaculture, commercial and recreational fish and shellfish harvest, recreation, and habitat and shellfish restoration.

This plan would take a Marine Spatial Planning approach to further our understanding of how water-dependent activities utilize the bay, and lay out recommendations to avoid conflicts not only between various shellfish-related activities (wild harvest, mariculture, restoration), but also with other user groups (powerboating, sailing, fishing, SAV restoration) in one of the most popular summer destinations in the region. This planning process will also help us to envision what the bay may look like in the future, as it would designate areas in which restoration activities for SAV and shellfish would be directed.

LR Action 2-2 Restore fish passage and other riparian habitats to improve habitat quality and connectivity.

Diadromous fish like alewife (*Alosa pseudoharengus*), blueback (*Alosa aestivalis)*, and American eel (*Anguilla rostrata*) travel from the ocean to rivers, streams, and lakes to reach their preferred freshwater spawning and maturation sites. As dams and roadways have restricted their ability to move upstream, their populations have seen sometimes dramatic declines, to the point where there is a statewide moratorium on the harvest of alewife and blueback. These same dams and roadways also prevent native freshwater fish from freely moving along stream corridors, potentially trapping them in less than suitable habitat. This action includes the identification of barriers to fish passage (dams, undersized or damaged stream crossings) and riparian habitats in need of improvements (deforested stream buffers, eroding stream banks), and the implementation of projects designed to improve stream connectivity.

LR Action 2-3 Participate in the implementation and periodic update of the New Jersey State Wildlife Action Plan.

The New Jersey State Wildlife Action Plan provides the linkages between watershed, statewide, and regional approaches to managing our wild resources. Proactive management actions identified in the SWAP are intended

Figure 6.9. Southern pine beetle. Smaller than a grain of rice, this beetle can cause devastating and unpredictable damage as they spread northward with warming climates. Photos: adult, under pine tree bark (left, from the NRCS NJ Southern Pine Beetle Website); pitch tubes (center, a sign of ongoing or recent infestation) and exit holes (right, an indication of old infestation, usually in dead or dying trees). Center and right photos from the NJDEP Southern Pine Beetle in New Jersey Website, which provides links to homeowner management, financial assistance, and other information.

Figure 6.10. Spotted laternfly. This leafhopper species was recently introduced in eastern Pennsylvania from Asia, has spread throughout western New Jersey, and is likely to spread through New Jersey. Clockwise from upper left: early stage nymphs, late stage nymph, adult with wings open and adults with closed wings. The species feeds preferentially on another Asian introduction, tree-of heaven; however, it will feed on and damage many native trees, vines, and vegetable species. All photos courtesy of the New Jersey Department of Agriculture; see the NJDA Spotted Lanternfly Website for reporting and other information.

to keep species from becoming threatened or endangered or to aid in the recovery of those that are already listed. Within the Barnegat Bay watershed, focal wildlife species of greatest conservation need include beach-nesting birds, marsh birds, Pine Barrens snakes, vernal pond/pond breeding amphibians, freshwater (*i.e.*, Pinelands) and anadromous fishes, and several invertebrates (select bees, moths, butterflies, tiger beetles, odonates, and mussels). The Barnegat Bay watershed also includes the Greater Barnegat Bay Conservation Focal Area and parts of the Northern Pinelands Fringe Conservation Focal Area and Core Pinelands Area Conservation Focal Area. The BBP will participate in the implementation and periodic update of the Wildlife Action Plan.

LR Action 2-4 Create and restore wildlife corridors for habitat quality and connectivity.

The creation of wildlife habitat corridors will allow terrestrial wildlife to move between habitats in a changing environment. As large, contiguous habitat parcels are fragmented by development and infrastructure, suitable passage corridors ensure that wildlife can access the habitats they need for the different stages of their life history. This action includes the acquisition of land that will serve as connections between larger habitat parcels as well as the restoration of habitat within existing corridors.

LR Action 2-5 Monitor, manage, and control invasive and nuisance aquatic and terrestrial species through ecologically appropriate methods.

Lastly, the monitoring, management, and control of invasive and nuisance species, through ecologically appropriate methods, will give our plants and wildlife the space they need to rebuild. Invasive species like southern pine beetle (*Dendroctonus frontalis*, the most destructive insect pest in the southern U.S.; Meeker *et al.*, 2017; see Figure 6.9) and spotted laternfly (*Lycorma delicatula*, first discovered in the U.S. in 2014, now reported in 5 states, including New Jersey; USDA, 2020; see Figure 6.10) can damage or destroy

crops (grape, hops, fruits and vegetables) and vegetation that serves as important habitat for a variety of wildlife. Active monitoring, management, and control of invasive species when first recognized not only protects important habitats, but also saves money in the long term compared to the costs of restoring damaged habitats and the loss of ecosystem services.

6.4.3. Living Resource Objective 3

Monitor and assess status and trends of living resources throughout the watershed.

As required by federal law, the BBP reports the status and trends of an agreed-upon suite of indicators every five years. Without appropriate monitoring, it will be difficult to tell if our restoration and protection efforts are working, and, if not, what steps should be taken to get the actions on track. To this end, several monitoring actions address the distribution, functioning, or related aspects of key habitats (*e.g.*, SAV, tidal wetlands, riparian and tidal buffers).

LR Action 3-1 Assess distribution and abundance of SAV through coordinated, regular surveys to evaluate their structure and function

Different species of SAV, including some no longer abundant (*e.g.*, sago pondweed, *Potamogeton pectinatus*), have been recognized as characteristic of the bay since 1900. Eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*) have generally been recognized as the most abundant species remaining in the bay. SAV serves as critical habitat for many fishes and invertebrates, provides many other ecosystem services (See Characteristic Habitats section), has been recognized by estuarine scientists as a keystone species (Duffy 2006), and is vulnerable to many anthropogenic factors and changing environmental conditions. This CCMP revision established an SAV ecosystem target for the Barnegat Bay (*i.e.*, *Maintain the overall extent of submerged aquatic vegetation present in 2009 [12,980 acres] and restore an additional 10 acres of seagrass*). In order to determine if we are meeting our ecosystem target related to SAV (See Chapter 3), it will be necessary to assess their distribution and abundance through coordinated, regular surveys. These surveys would be done via aerial (or other spatially broad technique) assessment of the SAV bed size and locations, as well as on-the-ground demographic assessments of bed condition to evaluate their structure and function (*e.g.*, Kennish *et al.*, 2008; Lathrop and Haag, 2011; Lathrop *et al.*, 2014).

LR Action 3-2 Continue the ongoing Mid Atlantic Coastal Wetlands Assessment (MACWA) program to evaluate the condition and function of wetlands and address priority information gaps for wetlands management.

Coastal wetlands provide many ecosystem services and are vulnerable to climate change and other factors (See Chapter 6, Characteristic Habitats section); thus, monitoring and assessment remain essential to informing restoration and adaptive management. For example, coastal wetlands are thought to be sediment limited, with management of sediment resources, including dredged materials, thought to be increasingly important to restoring wetlands and shorelines under different sea level rise predictions. Due to their importance to the natural and built environments, an ecosystem target was developed that includes the total coastal wetland acreage and acreage of coastal wetlands restored (See Chapter 3 Ecosystem Targets). Continuation of MACWA by the BBP and its partners, ongoing for 10 years, not only will allow us to grow our understanding of wetlands but also will undoubtedly enable us to understand the success of our wetland protection, management and restoration efforts.

LR Action 3-3 Update and/or complete mapping of riparian areas, tidal wetlands, and their buffers.

Riparian zones are recognized as important components of the landscape (See *Importance of Soil and Riparian Buffers* section in Chapter 5); thus, maintaining or expanding the current buffer acreage is identified as an ecosystem target (See Chapter 3 Ecosystem Targets). Unfortunately, mapping and assessment of buffers have not been conducted in some time; thus, we do not have current data on the extent of natural and developed riparian areas or shoreline hardening. Previous mapping of riparian zones revealed that considerable development and conversion of natural areas had occurred in most northern subbasins of the Barnegat Bay watershed (Lathrop and Haag, 2007). More recently, undeveloped riparian areas have been recognized for the opportunities they may provide for wetlands migration and mitigating sea level rise.

LR Action 3-4 Continue to monitor and assess the status of commercially-, recreationally-, and ecologically-important aquatic species.

Despite their recognized importance to the environment of the bay and the economy of communities along the Jersey Shore, commercially-, recreationally-, and ecologically-important aquatic species historically have not been assessed on a watershed-level scale throughout most of New Jersey. For the past 10 years, the BBP, NJDEP, Rutgers University, and other partners have been working to address some information gaps for economically important (*e.g.*, hard clam, blue crab) and some other species (*e.g.*, jellyfishes). Recent research (Valenti *et al.*, 2017; Valenti 2020) concluded that the community composition of the fishes in the Barnegat Bay did not reflect a strong urbanization gradient, but recognized that specific anthropogenic land-use practices (*e.g.*, bulkheads, lagoons) have a localized effect on community assemblage and potentially on individual species.

LR Action 3-5 **Monitor and assess target animal and plant species, such as pollinator and migratory species, threatened and endangered species, and plant communities of special importance (see Habitat Plan).**

The watershed includes extensive areas within the Pinelands National Reserve, home to many rare and endemic plant species (*e.g.*, see Figure 6.3, Swamp Pink.), and coastal wetlands of the E.B. Forsythe National Wildlife Refuge, recognized by international treaty (1971 Ramsar Convention on Wetlands of International Importance) as one of the most important migratory bird stopovers in North America. Several partners have regular ongoing monitoring and assessment programs for priority species and communities; the BBP has periodically assisted partners with such efforts when requested.

LR Action 3-6 **Monitor and assess the impact of the closure of the OCNGS on living resources in the Barnegat Bay.**

Lastly, assessment of the ecological impact(s) associated with the closure of Oyster Creek Nuclear Generating Station (OCNGS) is also included within this Objective and elsewhere; see WQ Objective 1 and WQ Action 1-11. The NJDEP pre- and post-closure studies were designed to build upon the portions of the *Comprehensive Assessment of Barnegat Bay-Little Egg Harbor* (Buchanan *et al.*, 2017) completed in 2017.

6.4.4. Living Resource Objective 4

Conduct studies to improve scientific understanding of living resources and ecologically sensitive habitats.

To develop the appropriate habitat and living resources protection, restoration, and management plans described above, it is imperative that the interactions between living resources and their habitats is understood: how they both might respond to any management changes undertaken, or their response to climate change. This understanding should be based in and supported by scientific studies, such as the identification and documentation of appropriate mechanisms and strategies to support restoration of sensitive habitats, the assessment of stream connectivity throughout the watershed, and the documentation of the life history and ecology of key living resources.

LR Action 4-1 **Conduct studies that identify and document appropriate mechanisms and strategies to support restoration of ecologically sensitive habitats identified in Objective 1.**

While the means to effectively restore many terrestrial habitats is well known, the restoration of subtidal (SAV) and intertidal (tidal wetland) habitats is still relatively new.

Figure 6.11. Osprey in flight. Photo courtesy of USFWS.

Different restoration techniques and styles will need to be tested and verified to determine the best way to move forward with limited restoration funds.

LR Action 4-2 **Identify and assess habitat suitability, connectivity, and barriers to fish passage.**

The BBP and its partners (*e.g.*, NJDEP, USFWS) are working to identify and prioritize those waterways which are limiting passage of fishes and other wildlife for restoration. Before designing and implementing restoration actions, the BBP and its partners collectively are assessing habitat connectivity using agreed-upon protocols (*e.g.*, North Atlantic Aquatic Connectivity Collaborative). These efforts potentially result in improvements to water quality, reduce localized flooding, and improve habitat quality for other non-fish species.

LR Action 4-3 **Conduct studies that identify and document the life history and/or ecology of priority living resources.**

The BBP and its partners (*e.g.*, NJDEP, CWFNJ, USFWS; Rutgers, Richard Stockton, and Montclair universities) are also working to identify and document the life histories and ecology of priority species, with a growing emphasis on climate-related changes in the living resources throughout the watershed. Changing conditions may lead to new ecological interactions which promote both climate-change "winners and losers," in both an environmental and economic sense.

6.4.5. Living Resource Objective 5

Increase education and public outreach related to habitats and living resources.

Sharing information and educating the public will ensure that watershed residents and visitors understand and support the previously mentioned Objectives and Actions, and help them to celebrate our successes. This will be accomplished through a suite of outreach activities focusing on key priorities.

LR Action 5-1 Disseminate information to promote an understanding of science-based decision-making in the management of habitats and living resources.

At times there seems to be a disconnection between how science is used in habitat and living resource protection and restoration and how the public perceives how it is used. It is critical that the public: 1) understands the important role that science plays in informing decisions related to habitat and living resources, and 2) supports the use of the best available information. Similarly, an informed public understands how actions impact the natural environment and can make wise choices regarding the protection of living resources held in the public trust.

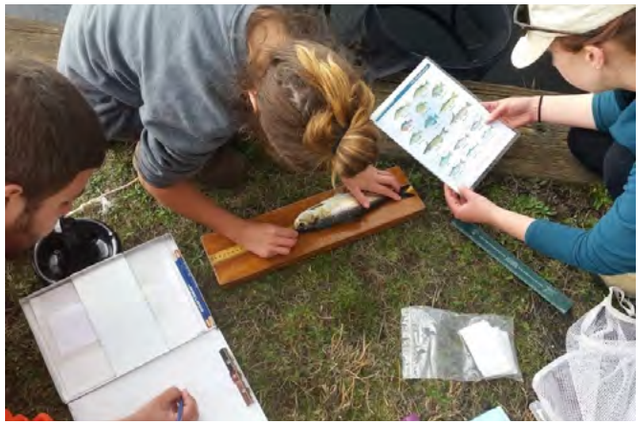


Figure 6.12. Herring monitoring in Barnegat Bay. Photo courtesy of BBP staff.

An example of the importance of using the best available science for decision-making is the story of jellyfishes in the Barnegat Bay. Over the past three years, "jellyfish" have been reported to the BBP as the single biggest public concern by bay stakeholders. However, despite ongoing research and education, public understanding about jellyfishes includes many misconceptions. We offer the following information summary to improve everyone's awareness and advance the public understanding of the challenges to managing jellyfishes in the Barnegat Bay

Stinging Nettle

The earliest records of stinging nettles in Barnegat Bay date back to 1928 (New Jersey State Agricultural Experiment Station, 1928), when they were identified as sea nettle (*Chrysaora quinquecirrha*), a species that commonly occurs from Cape Cod southward along the U.S. East Coast and into the Gulf of Mexico. Because jellyfish were rarely recorded in scientific surveys of the bay during the 1900s and early 2000s, we do not know how common they were during that time period. Interviews with longtime bay users suggests an increase in abundance in the late 1990s and early 2000s to the levels that we see now (Young, 2016). Recent research has identified them as having the potential to disrupt the community ecology of the bay in potentially troublesome ways (Bologna *et al.*, 2017). In 2017, we also learned that the nettles in Barnegat Bay were not stinging sea nettle (the species), but a new and different species, *Chrysaora chesapeakei* (the bay nettle) named after the water body where the species has long been a scourge (Bayha *et al.*, 2017).

Clinging Jellyfish

Three years ago, at least one new "jelly" invader, the clinging jellyfish (*Gonionemus vertens*) was first reported along the Jersey Shore, including the Barnegat Bay.

Figure 6.13. Bay nettle (top) and clinging jellyfish (bottom; Gaynor *et al.*, 2017).

Originally identified in the Pacific Ocean, this species has been reported to be present in Massachusetts since the 1800s, while a second and far more potent form invaded one or more New England estuaries in the 1990s (Govindarajan and Carman, 2016), and has been hypothesized as the likely source of clinging jellies in New Jersey. The clinging jellyfish is not really a true jellyfish (scyphozoan) like the bay nettle, but actually a close relative known as a

hydrozoan. It has a bell no more than one inch in diameter and tentacles two to three inches in length. The sting is reported to be excruciating and may cause muscle cramps, chest tightness, and swollen throats; in more severe cases, liver and kidney failure have been reported. Several people have been hospitalized after being stung in New Jersey.

These two jellyfish occupy slightly different habitats and appear in the bay at different times. The bay nettle prefers salinities from 10-16 ppt and can be found in open bay areas, lagoons, and shallow waters of intertidal creeks. The medusa (floating stage) are typically present in the bay from June through September. The clinging jellyfish prefers saltier waters, typically those with salinities from 18–30 ppt. Clinging jelly medusae can often be found clinging to eelgrass, other vegetation, mats of drift algae, and even shell and other debris during the day, and swimming in the water column at night. In New Jersey, it has only presented a problem in spring, usually disappearing in June as waters warm above its temperature threshold.

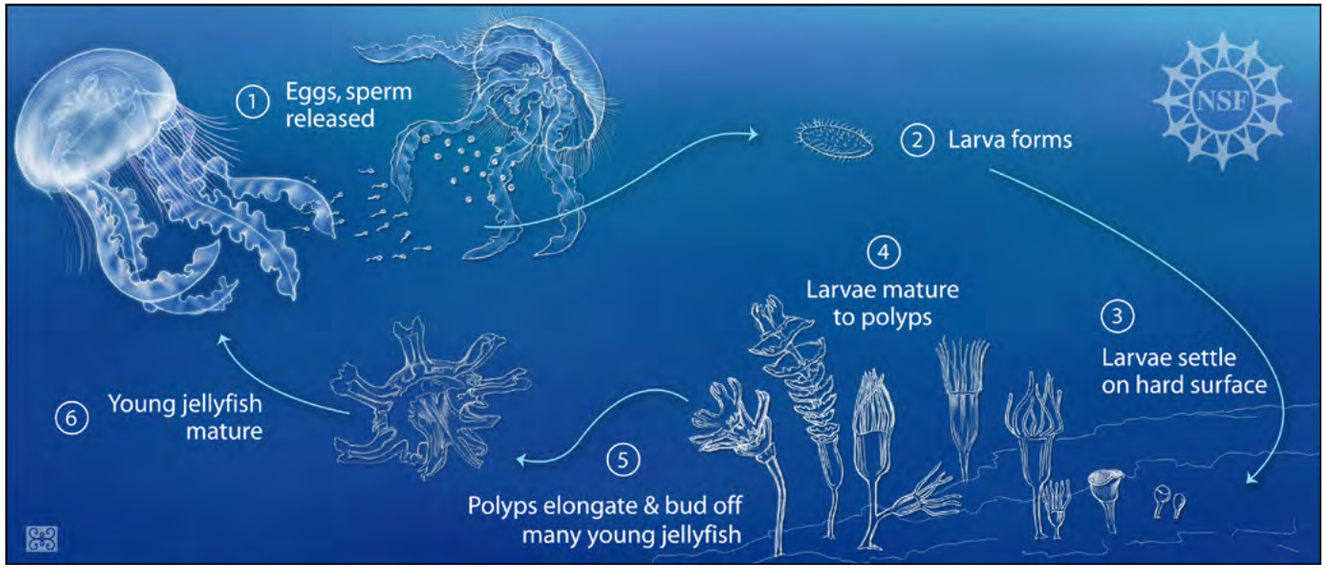


Figure 6.14. **Jellyfish life cycle. Figure courtesy of the National Science Foundation.**

What We Don't Know

While scientists have identified several potential reasons why jellyfish abundances have increased over the past 25 years, their complex life history (Figure 6.14) suggests that it is likely a combination of several factors (see Purcell, 2007), the interactions of which we are still trying to understand. Human activities within the bay almost certainly play a role. The bottom dwelling stage of their life (known as a scyphistoma, or polyp) attach to bulkheads, pilings, rocks, the undersides of floating docks, and other hard surfaces. A single floating dock can hold thousands of scyphistoma, which asexually produce millions of jellyfishes. Development of the waterfront around the bay – especially pilings, floating docks, and bulkheads – may have inadvertently contributed to the spread of jellyfish.

We are just now starting to understand how widespread these polyps are in the bay. Changes in the abundance of plankton-eating fishes, whether through fishing or other impacts, may remove potential competitors of jellyfish, as diets of jellyfishes and those fishes overlap. Environmental changes are also thought to play a role in bay nettle abundance. Bay nettles have a fairly narrow salinity preference; thus, factors causing large-scale changes in salinity, including weather conditions and certain human activities affecting the water cycle, may affect the distribution of nettles in the bay. Both increasing water usage throughout the watershed and sea level rise may change salinities in the bay and affect the distribution and abundance of nettles. Warming waters have been shown to increase asexual reproduction by the scyphistoma and lead to more production of jellyfishes.

Finally, the bay's eutrophication may also be creating favorable conditions for nettles. The nutrient inputs to the bay often lead to high production (*i.e.*, growth) of certain flagellates and other small zooplankton, known as microplankton. Some jellyfishes can feed efficiently on microplankton in the bay's turbid waters and may outcompete fishes and other visually feeding predators. Nettles may be less sensitive to low dissolved oxygen, which occurs episodically during summer and early fall in certain parts of the bay (*i.e.*, lagoon dead ends).

As clinging jellyfish are a relatively new phenomenon in Barnegat Bay, there is a great deal we do not know. For example, will warming water temperatures or higher salinity increase their presence in the bay? We also do not know what the most appropriate management actions might be for these species. If bay nettles have long been a part of the bay's ecosystem, should we be seeking to reduce their populations to some threshold level, or do we need to learn to coexist with them as is? And what unintended consequences might we face from various actions, such as shutting down the OCNGS? New research from the Chesapeake Bay shows that when bay nettle populations there are reduced due to changes in environmental factors, other commercially-important species (*i.e.*, hard clam) may be reduced in abundance through food web effects (Stone, 2019).

LR Action 5-2 **Develop educational materials, programs, and online resources to promote restoration of habitats and living resources (*e.g.*, living shorelines, shellfish).**

For restoration activities to be successful over the long-term, they need local stakeholders to serve as stewards of the resource, ensuring that the stressors underlying the restoration need are addressed. This is accomplished by engaging with the stakeholders through a variety of outreach activities to be developed as part of this action.

LR Action 5-3 **Develop materials, programs, and online resources to educate about the functional role of critical bay habitats, such as seagrass beds and wetlands, and the early life stages of estuarine-dependent species.**

Coastal wetlands were once thought of by the general public as nothing more than swamps and mosquito breeding grounds, to be filled in for the development of housing units and other infrastructure. The scientific community now knows that wetlands not only provide important ecosystem services valued by coastal communities (storm surge reduction, flood amelioration, *etc.*) but also are critical to the early life history stages of many estuary-dependent fish and bird species. The same is true for other important bay habitats (seagrass beds, oyster reefs, bay islands). The more local stakeholders recognize these important aspects of bay habitat, the more they will serve as stewards of these resources and support their protection and restoration.

LR Action 5-4 **Produce educational materials and online resources about the impacts of climate change on the living resources of the bay.**

As evidenced by the information contained in the climate change vulnerability assessment completed as part of the CCMP process (See Chapter 8), living resources within the watershed will be negatively impacted by various climate change stressors. Important decisions regarding the future of critical bay habitats, and the species that depend on them, will need to be made by local stakeholders. A well-informed public will be in a better position to understand the ramifications of decisions made now regarding our changing environment.

LR Action 5-5 **Promote an improved understanding of the economic and ecological importance of fisheries through fisheries programs and activities.**

Commercial harvest of shellfish (hard clams, oysters, blue crabs) and finfish was an important aspect of the economy of the watershed from colonization through the middle of the twentieth century. While not as prevalent today, commercial harvest of finfish and shellfish is still an active part of the economy, mariculture (farming of shellfish) is growing in size, and recreational fishing, clamming, and crabbing is a major tourist draw to the region. These activities also have impacts on water quality, habitats, and other living resources that are not well understood by the watershed community at large.

LR Action 5-6 **Promote education and enforcement of regulations and best practices for responsible use of ecologically sensitive and target areas (*e.g.*, personal watercraft and boating, off-road vehicles).**

Human activities within critical habitats that are incompatible with conservation practices pose serious threats to the resiliency of those areas and often lead to the need for expensive restoration activities. Often the individuals engaged in those activities are not aware of the damage that they could potentially be causing. Educational campaigns (*e.g.*, Don't Harass the Seagrass) focused on key user groups can change deleterious behaviors and convert those groups to good stewards of the resource.

Figure 6.15. **ReClam the Bay volunteers planting clam seed. Photo courtesy of W. Dalzell.**

6.5. Ecosystem Target, Objective, and Action Summary

The actions discussed above, when combined with the actions in the other priority areas, will enable us to begin to attain the ecosystem-based targets laid out in Chapter 3.2 (See Table 6.1 below for a details of which actions apply to each target). To fully reach our targets, we acknowledge that other actions not included in this CCMP may be necessary. This may be due to changing or unanticipated environmental conditions, or new research findings. However, these actions represent the first steps along the path to a healthy and resilient bay.

Table 6.1. The relationships between the Ecosystem Based Targets and the Actions within the Living Resources priority area.	
Public Beach Closures	
Approved Shellfish Areas	Objective 2: Action Items 1, 5
Submerged Aquatic Vegetation Extent	Objective 1: Action Items 1, 2, 5 Objective 2: Action Item 1 Objective 3: Action Items 1, 6 Objective 5: Action Items 2, 3, 6
Wetland and Riparian Buffer Preservation	Objective 1: Action Items 1, 2, 4, 5 Objective 2: Action Items 2, 4 Objective 3: Action Item 3 Objective 5: Action Items 2, 3, 6
Wetland Protection	Objective 1: Action Items 1, 2, 4, 5 Objective 2: Action Item 4 Objective 3: Action Item 3 Objective 5: Action Items 2, 3
Clam restoration	Objective 1: Action Items 1, 2, 5 Objective 2: Action Item 1 Objective 3: Action Items 3, 6 Objective 5: Action Items 2, 3
Ecological flows	Objective 2: Action Item 2 Objective 5: Action Item 2
Water conservation and reuse	

Objective 1. Develop and implement habitat protection and restoration plans for the watershed's characteristic habitats, including ecologically sensitive areas.

LR Action 1-1 Compile existing data and maps, and determine and collect missing data for ecologically sensitive habitats and associated buffers.

LR Action 1-2 Develop and implement conservation/restoration plans for ecologically sensitive terrestrial, coastal, and aquatic habitats.

LR Action 1-3 Create a web-accessible database of habitat protection and restoration activities completed by the BBP and partners.

LR Action 1-4 Encourage the protection and management of habitats on a sub-watershed basis through coordination and collaboration across municipal boundaries.

LR Action 1-5 Promote management of ecologically-sensitive and other target areas.

Objective 2. Restore and maintain sustainable populations of fish and wildlife.

LR Action 2-1 Develop a bay-wide multi-use management plan that supports sustainable aquaculture, commercial and recreational fish and shellfish harvest, recreation, and habitat and shellfish restoration.

LR Action 2-2 Restore fish passage and other riparian habitats to improve habitat quality and connectivity.

LR Action 2-3 Participate in the implementation and periodic update of the New Jersey State Wildlife Action Plan.

LR Action 2-4 Create and restore wildlife corridors for habitat quality and connectivity.

LR Action 2-5 Monitor, manage, and control invasive and nuisance aquatic and terrestrial species through ecologically appropriate methods.

Objective 3. Monitor and assess status and trends of living resources throughout the watershed.

LR Action 3-1 Assess distribution and abundance of SAV through coordinated, regular surveys to evaluate their structure and function.

LR Action 3-2 Continue the ongoing Mid Atlantic Coastal Wetlands Assessment (MACWA) program to evaluate the condition and function of wetlands and address priority information gaps for wetlands management.

LR Action 3-3 Update and/or complete mapping of riparian and tidal wetlands and their buffers to monitor and assess condition (natural, developed, hardened, *etc.*) and wetland migration potential.

LR Action 3-4 Continue to monitor and assess the status of commercially-, recreationally-, and ecologically-important aquatic species.

LR Action 3-5 Monitor and assess target animal and plant species, such as pollinator and migratory species, threatened and endangered species, and plant communities of special importance (See Habitat Plan).

LR Action 3-6 Monitor and assess the impact of the closure of the Oyster Creek Nuclear Generating Station on living resources in the Barnegat Bay.

Objective 4. Conduct studies to improve scientific understanding of living resources and ecologically sensitive habitats.

LR Action 4-1 Conduct studies that identify and document appropriate mechanisms and strategies to support restoration of ecologically sensitive habitats identified in Obj. 1.

LR Action 4-2 Identify and assess habitat suitability, connectivity, and barriers to fish passage.

LR Action 4-3 Conduct studies that identify and document the life history and/or ecology of priority living resources.

Objective 5. Increase education and public outreach related to habitats and living resources.

LR Action 5-1 Disseminate information to promote an understanding of science-based decision-making in the management of habitats and living resources.

LR Action 5-2 Develop educational materials, programs, and online resources to promote restoration of habitats and living resources (*e.g.*, nature-based shorelines, shellfish).

LR Action 5-3 Develop materials, programs, and online resources to educate about the functional role of critical bay habitats, such as seagrass beds and wetlands, and the early life stages of estuarine-dependent species.

LR Action 5-4 Produce educational materials and online resources about the impacts of climate change on the living resources of the bay.

LR Action 5-5 Promote an improved understanding of the economic and ecological importance of fisheries through fisheries programs and activities.

LR Action 5-6 Promote education and enforcement of regulations and best practices for responsible use of ecologically-sensitive and target areas (*e.g.*, personal watercraft and boating, off-road vehicles).

Figure 6.16. BBP Staff and partners installing a living shoreline at Sedge Island in July, 2019. Photo courtesy of NJDEP.

CHAPTER

7

LAND USE

7.1. Themes

- The Barnegat Bay watershed has experienced intense growth and development over the last half-century.
- With more than 33% of the watershed being developed to date, the sustainability of ecosystem services and the bay's biotic resources is increasingly at risk.
- Sustaining the health, diversity, and economic importance of the watershed's natural resources while managing development is a shared responsibility between local, county, regional, and state land-use managers.
- Climate change and sea level rise increasingly threaten the sustainability and resilience of the watershed's natural resources, built communities, citizens, and economy.

7.2. Goal and Objectives

To improve protection of open space throughout the watershed, and to develop collaborative regional approaches to responsible land use and resilient communities that protect and improve water quality, water supply, living resources, soil function, and hydrology.

Land Use Objectives

1. Promote and support open space acquisition, planning, and management for people and nature.
2. Promote and support resilient and sustainable land use practices (*e.g.*, soil restoration, low-impact development, shoreline restoration, and dredged material management) to increase resiliency of vulnerable communities.
3. Incorporate CCMP goals and objectives into regional, county, municipal, and other policies, plans, and regulations where applicable to support BBP-related priorities.
4. Assess status and trends in land uses, land cover, and landscapes, especially those directly impacted by climate change and sea level rise (*e.g.*, inundated and regularly flooded lands), and improve understanding of the impacts of land uses and land management practices on the Barnegat Bay and its watershed.
5. Increase education and outreach efforts focused on: a) promoting land acquisition, protection, and management; b) implementing sustainable land use practices across both developed and undeveloped landscapes; c) integrating CCMP priorities, including climate change and sea level rise, into regional, state, local, and municipal planning, and d) reducing land use impacts on natural resources throughout the watershed.

7.3. Introduction

While New Jersey has a history of strong environmental regulations (*e.g.*, Freshwater Wetlands Protection Act: N.J.S.A. 13:9B, first enacted July 1987, implementing rules at N.J.A.C. 7:7A; Wetlands Act of 1970: N.J.S.A. 13:9A, first enacted 1970; CZM Rules, N.J.A.C. 7:7), development in coastal counties has resulted in extensive losses of forests, agricultural lands, freshwater and tidal wetlands, and their dependent biotic resources, and has contributed to other significant adverse impacts (*e.g.*, habitat fragmentation, losses and changes in ecosystem service, chemical contamination). Between 1972 and 1995 (TPL, 2008), approximately 33,853 acres, 20% of upland Pine

Barrens habitats, were developed more than at any other time in New Jersey's history. During the same time frame, approximately 4,633 acres, 6% of wetlands in the Barnegat Bay watershed, were lost to development and erosion (TPL, 2008). Local planning, zoning regulations, and preservation programs were implemented to slow the loss of natural lands. However, losses and other anthropogenic impacts to natural lands have persisted throughout the coastal zone, including the Barnegat Bay watershed, as the human population has continued to grow.

7.3.1. Changes in Land Use

Changes in land use and land cover are among the most important drivers of water quality in, and the integrity and resilience of, the entire watershed; more than 33% of the landscape has already been developed to date (See Figure 7.1). Development of natural lands negatively impacts water quality, water supply, and the quality and connectivity of wildlife habitats, and affects the character of the watershed and the quality of life of its residents. In addition, climate change and sea level rise are also likely to affect the landscape directly (*e.g.*, inundation of low-lying areas by sea level rise, higher tides, storm surge) and indirectly (*e.g.*, relocation of vulnerable infrastructure, installation of gray and green infrastructure to mitigate risks).

Challenged by the intense development and volume of people, the shared resources of the Barnegat Bay watershed require collaboration among those agencies with management responsibility and authority. Environmental protection and community resilience to climate change and sea level rise need to be more strongly incorporated into local community planning and economic development. Strategic planning, stewardship, and sound and collaborative decision-making at all levels of government will balance sustainable economic growth, natural resource protection, and community resilience, and will maintain the quality of life in the Barnegat Bay Estuary watershed.

The priority land use actions of the Barnegat Bay CCMP build on previous successes (*e.g.*, land acquisition) and make use of existing tools, plans, programs, and efforts. More importantly, they require greater collaboration across all levels of government to develop, adopt, and implement, new policies, plans, and strategies that not only conserve, restore, and enhance natural resources but also lead to more resilient communities. This section addresses the challenges related to land use management, development, and sustainability in the Barnegat Bay watershed by:

- Promoting the collective integration of environmental protection, economic development, and resiliency through sustainable approaches to local community planning, decision making, and development;

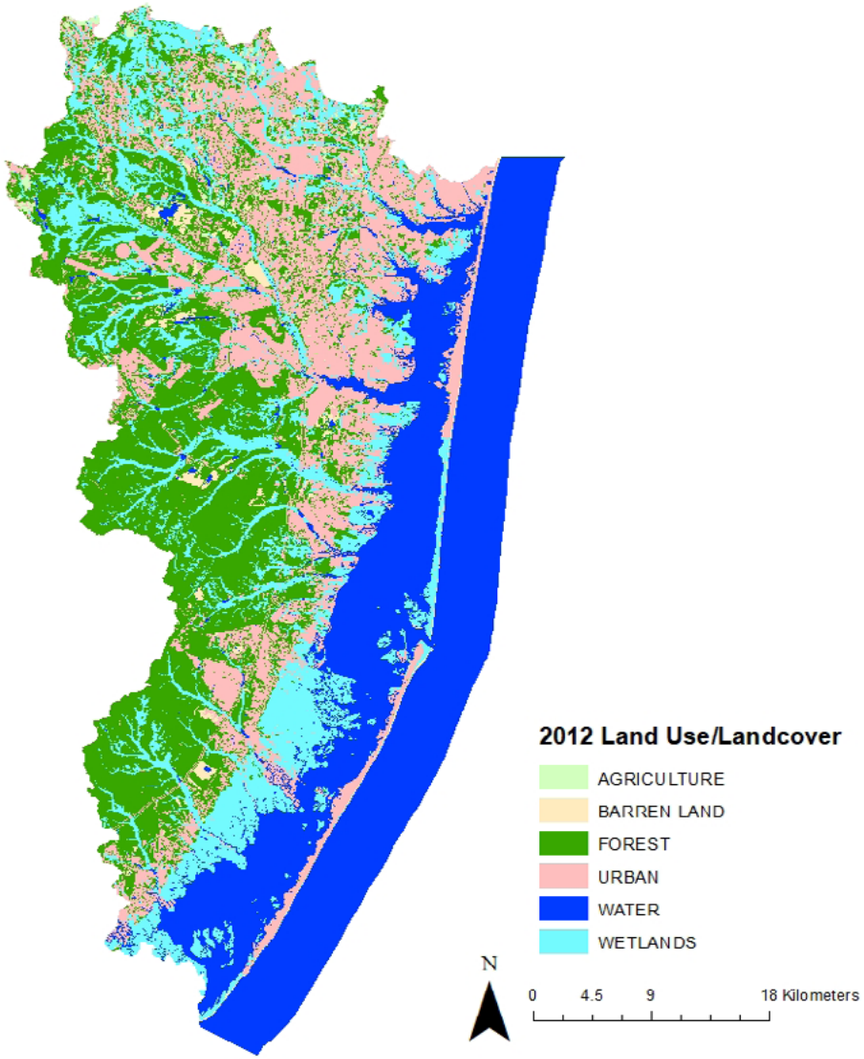


Figure 7.1. 2012 Map of Land Use/Land Cover in the Barnegat Bay Watershed Management Area (WMA-13). Figure courtesy of Rutgers University CRSSA.

- Focusing on cross-jurisdictional collaboration by using the strengths of each municipality and agency to support initiatives, share experiences and knowledge, and take advantage of economies of scale;
- Ensuring that decision-making is informed by sound science and current data; and
- Promoting innovative strategies and sustainable land use practices to maintain natural resources and ecosystem services to ensure communities are resilient to sea level rise and climate change.

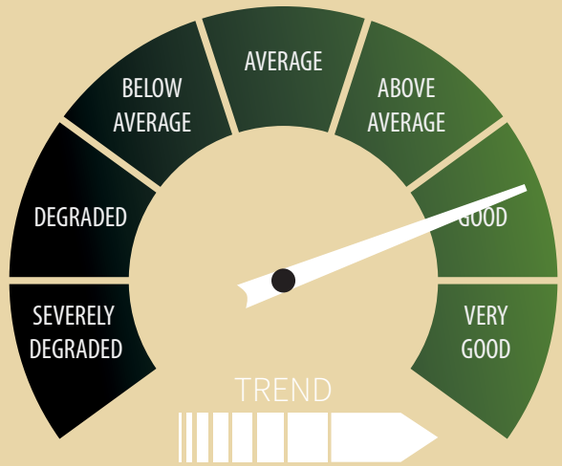
Status and Trends – Shoreline Hardening

Approximately 45% of the bay's shoreline has been hardened or bulk-headed (Lathrop *et al.*, 2001). While hardened shorelines do provide some protection to waterfront (residential and commercial) properties, these structures have a significant cost to construct and exacerbate erosion and the impacts of storm surge (Smith *et al.*, 2018). This loss of habitat has had a negative impact on many ecosystem functions and biological diversity, and may promote the spread of some nuisance species (*e.g.,* bay nettle, *Chrysaora chesapeakei*) throughout the bay (Bologna *et al.*, 2017).

To date, shoreline hardening has **not** been one of the BBP's indicators of health and integrity of the bay; however, other Mid-Atlantic States (*e.g.*, Maryland and Virginia) are placing increasing restrictions on shoreline hardening. In addition, practitioners in New Jersey are continuing to assess and promote nature-based shoreline projects that can enhance resiliency to storms as well as provide ecosystem services to the estuary.

With increasing concern about shoreline restoration and community resilience, the 2021 State of the Bay Workgroup will consider development of an appropriate indicator of shoreline hardening or related measures of condition.

Figure 7.2. 2016 Living Resources Status and Trends: Protected Areas

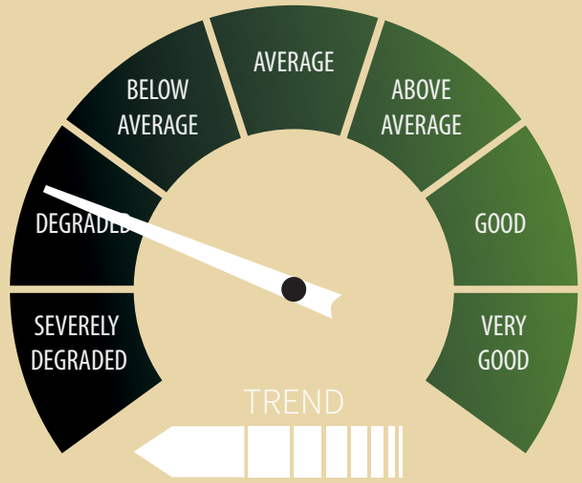


Protecting open space is extremely important, especially in areas where development is occurring in a rapid manner. Fortunately, Ocean and Monmouth Counties – and a number of federal, state, government, and non-governmental organizations – have made land conservation a priority.

Between January 1, 2010, and September 30, 2015, approximately 11,114 acres in the Barnegat Bay watershed were acquired by federal, state, county, local, and non-governmental agencies for conservation purposes. These purchases bring the total acreage of publicly owned land in the watershed to more than 141,935 acres, or nearly 41% of the watershed's land area.

See the BBP's 2016 State of the Bay Report for additional information.

Figure 7.3. 2016 Living Resources Status and Trends: Land Use/Land Cover



Changes in land use can have dramatic and far-reaching impacts on the environment. The conversion of natural lands into urban settings directly reduces the amount of habitat available for plant and animal species not adapted to living near humans.

Urbanization has continued to increase throughout the watershed, from approximately 22% of the watershed in 1986 to approximately 32% in 2012.

As of 2012, urban land use occupied approximately 110,665 acres of the Barnegat Bay watershed, excluding water. Including all altered land uses (*i.e.,* urban + barren + agriculture lands), the total altered land area is 121,347 acres, or nearly 35%.

See the BBP's 2016 State of the Bay Report for additional information.

7.4. Objectives and Actions

Land uses affect water quality, water supplies, and the quality and connectivity of wildlife habitats, as well as the character of the watershed and the quality of life in coastal communities. Priority objectives in the land use section are designed to be complimentary and supportive of other BBP priorities. Objectives and actions herein expand on previous efforts to acquire, protect, and better manage open space. They support improved inter-governmental and public-private communication and coordination to integrate all CCMP goals and objectives into other regional and local planning and related activities. We also seek to promote and implement a variety of best management practices (*e.g.*, nature-based shorelines, buffers, soil restoration) to reduce our individual and collective impacts on water quality and water supply.

In the years since Superstorm Sandy, most of the damaged infrastructure has been repaired or rebuilt, but recovery of residential and commercial property has lagged in part due to uncertainty about future risks (Van Abs and O'Neill, 2016). We seek to promote and support comprehensive planning and coordination to develop a vision and transition plan for the most vulnerable coastal neighborhoods and communities. We strive to base all decision-making on the best available science, and we will continue our efforts to monitor and assess the changes across the Barnegat Bay landscape and educate everyone on how they can reduce their impacts on the bay and its natural resources.

7.4.1. Land Use Objective 1

Promote and support open space acquisition, planning, and management for people and nature.

- The acquisition and protection of open space has a history of strong public support in New Jersey, and especially in the Barnegat Bay watershed. Public and private partners have identified and preserved critical habitat from development pressures.
- The USFWS Edwin B. Forsythe National Wildlife Refuge, which is celebrating its 80th anniversary in 2019, now includes more than 22,000 acres in two refuge complexes (Barnegat and Brigantine), lying in the Barnegat and Great Bay/Mullica River estuaries.
- Since the 1960s, acquisitions by NJDEP's Department of Parks and Forestry's Division of Fish and Wildlife Green Acres Program have protected some of the most iconic landscapes within New Jersey (*e.g.*, Island Beach State Park, Barnegat Light State Park, and Double Trouble State Park).
- In 1997, Ocean County residents overwhelmingly voted to establish the Ocean County Natural Lands Trust (OCNLT) Program, creating a system of protected lands that help maintain the county's rural characteristics, protect its critical environmental resources and water supplies, and buffer areas that are not compatible with development (*e.g.*, military bases, power plants). The OCNLT now generates more than $10 million annually and has protected over 25,000 acres. OCNLT properties are administered by the Ocean County Planning Department with maintenance by the Ocean County Parks and Recreation Department.
- The Monmouth County Board of Chosen Freeholders, meanwhile, established an Open Space Trust Fund in 1987. Under that fund, the Freeholders allocated $2 million for their Municipal Open Space Grant Program. In 2018, Millstone Township was awarded a $180,000 grant to help fund the acquisition of the new Barnegat Bay Conservation Area.

LU Action 1-1 **Compile a comprehensive inventory of open space and lands held in permanent and temporary easements.**

The purpose of this action is to develop and maintain a current map (See Figure 7.4), comprehensive inventory, and database of all of the open space acquisitions in the Barnegat Bay Study area. The inventory will look at existing gaps and ecologically sensitive areas to help prioritize future acquisition activities and support of greater ecosystem connectivity.

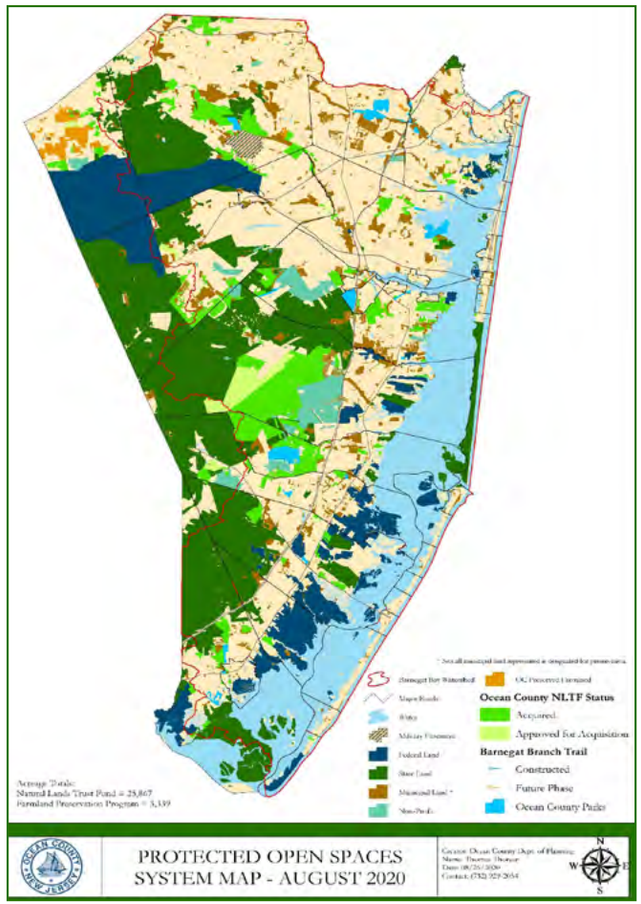


Figure 7.4. Publicly owned properties in Ocean County. Map courtesy of OCPD.

LU Action 1-2 **Convene a working group to review all existing public and private planning documents (such as Green Acres Inventory, County and Municipal Open Space Inventories, TPL 2020 Plan, Ocean County's All Hazard Mitigation Plans, Conservation Blue Print initiative) and holdings, to coordinate future efforts to acquire additional lands and maximize ecological services of preserved lands.**

With the ongoing acquisition programs funded through the Ocean County Natural Lands Trust New Jersey Green

and Blue Acres programs, Trust for Public Land and other NGO and municipal activities, this action seeks to better coordinate future efforts to acquire additional lands and maximize ecological services of preserved lands. This action would utilize the products developed under LU Action 1-1 as the blue print for its work. For example, the TPL's (1995) Century Plan identified and prioritized 100 unique conservation and public access sites and contributed to the acquisition of more than 24,000 acres throughout the Barnegat Bay watershed. That initial effort was followed up by the TPL (2008) Barnegat Bay 2020 Report, which pulled together numerous public and private entities with diverse expertise to identify and prioritize parcels for acquisition.

LU Action 1-3 **Promote the acquisition and management of lands to achieve: a) community resilience for flooding and water supply protection (*e.g.*, forested riparian buffers providing multiple ecosystem benefits and floodplains), b) natural resource protection, including sensitive species and their habitats, c) diverse recreational opportunities, and e) promotion and education of cultural heritage.**

Acquisition of open space to date has provided diverse environmental, recreational, and other opportunities. As development and population growth continue, and climate change and sea level rise continue to impact portions of the landscape throughout Ocean County, partners must coordinate to strengthen identification and acquisition of parcels that may address several new priorities. This action builds off of LU Actions 1 and 2.

After Superstorm Sandy, NJDEP expanded the Blue Acres Program to acquire flood-prone properties in New Jersey and to dedicate those lands that are purchased for recreation and conservation purposes. Once restored as open space, those Blue Acres properties can serve to retain and dissipate flood waters and possibly even to provide areas for wetland migration. Over time, these acquisitions reduce the risks and the costs of damages that would result from any future flooding. Open space can be utilized to counter the effects of urban heat islands[1].

Forested areas acquired in the past and the future will likely have to be increasingly managed, as such open areas face new threats from climate change (*e.g.*, southern pine beetle) and a continuing human threat from illegal off-road vehicle use, both of which increase the risks of forest fires. While open space acquisition and conservation will remain a major component of land use planning and management in New Jersey, actions recommended in this plan emphasize a greater role in planning to increase the resilience of coastal communities, such as storm surge protection and flood reduction, and to address other climate change impacts.

Providing diverse recreational opportunities and promoting our cultural heritage are also critical to our communities and our quality of life; thus, supporting these efforts is consistent with the goals and objectives within the NJ Coastal Management Rules (N.J.A.C. 7:7. A). It is also widely recognized that the bay's natural resources provide a valuable economic engine for communities (Kauffman, 2012).

7.4.2. Land Use Objective 2

Promote and support sustainable land use practices (*e.g.*, soil restoration, low-impact development, shoreline restoration, and dredged material management) to increase resiliency of vulnerable communities.

There are a number of actions that can be implemented on public and private properties that broadly address CCMP priorities, improving water quality and groundwater recharge, reducing flooding, and improving community resiliency to climate change and sea level rise. Some of these actions are implemented by individual landowners, whereas others are more appropriately implemented by municipalities or other governmental entities.

LU Action 2-1 **Support and encourage land use practices that incorporate BMPs including but not limited to Jersey-Friendly Yards, Low Impact Development (LID) and Sustainable Jersey actions. These practices should: a) promote nature-based infrastructure to minimize loss of natural vegetation b.) optimize opportunities for ground water recharge and c) minimize soil disturbance and promote soil health and restoration.**

Individual landowners, both residential and commercial, can take a number of local to improve water quality, reduce water consumption, and increase groundwater recharge simply by paying more attention to soil properties and functions (See WQ Action 1-3). These steps enhance the viability of native vegetation, enhance the value of the developed landscape to support living resources, and also improve environmental quality for people.

LU Action 2-2 **Promote and support development of shoreline and wetlands restoration strategies and related technologies (*e.g.*, sediment management) to promote community resiliency to storms and flooding.**

While most beachfront communities have mostly recovered from the damages caused by Superstorm Sandy, a number of back-bay lower lying communities have been slower to recover and exhibit more uncertainty in redevelopment and long-term sustainability. In low-lying and highly exposed parts of these neighborhoods, tidal and storm-related flooding continues to increase, with increasingly higher costs and risks in the future as sea level continues to rise. Thus, promoting and supporting

1 urban heat islands = built-up areas that are hotter than nearby rural areas

projects (*e.g.*, nature-based shorelines and other green infrastructure solutions) may improve these neighborhoods for some period of time.

LU Action 2-3 Promote land use practices that recognize and prioritize water-dependent uses; ensure that authorized waterfront uses are compatible with supporting commercial and recreational activities.

With coastal populations and attendant development continuing to increase, the availability of waterfront landscapes for water-dependent uses continues to decline. Waterfront landscapes will also change with sea level rise. Ensuring access to waterfront landscapes may become more complex and costly over time.

7.4.3. Land Use Objective 3

Incorporate CCMP goals and objectives into regional, county, municipal, and other policies, plans, and regulations where applicable to support BBP-related priorities.

The BBP CCMP includes numerous goals, objectives, and actions developed by partners drawn from all levels of government, academic institutions, non-governmental organizations, and other entities. To achieve sustainability and resilience throughout the Barnegat Bay watershed, the 37 municipalities, two counties, numerous state agencies, and other decision-makers must work together consistently toward CCMP goals and objectives. Recognition of CCMP objectives and actions, and incorporation of various CCMP elements into municipal, county, and other local planning activities, makes available some significant funding streams (*e.g.*, State Revolving Funds) to protect and improve water quality and enhance community resilience to climate change and sea level rise.

As an example, future predicted changes in land use must also be considered. Lakewood is the fastest growing municipality in the state and is anticipated to become the third-largest city in the state by 2030 (Asbury Park Press, 2017). Watershed development, together with climate change and sea level rise, has already placed some strains on water supplies (*e.g.*, construction of water main to transport water from Monmouth County into Lakewood, NJDEP, 2019d; tide- and salinity-dependent operation of surface supply intake and use of ASR by the BTMUA, see WS Action 4-1). These issues have the potential to have downstream impacts on groundwater-driven base water flows to the Metedeconk River and the bay. Headwater areas of the Metedeconk and Toms rivers are situated in the state's most critical water supply planning areas (NJDEP, 2017b).

LU Action 3-1 Identify regulatory gaps and overlaps and promote planning tools (*e.g.*, draft local and state ordinances, zoning, transfer of development rights) to achieve priority objectives (*e.g.*, long-term comprehensive localized, and/or regional plans for vulnerable, low-lying, or repetitive loss neighborhoods, fire-prone neighborhoods, promote compatible commercial, recreational, public access and other waterfront land uses).

This action identifies current gaps and inconsistencies in overlaps in land-use and planning regulations at the state, county, and municipal level to achieve priority objectives (*e.g.*, protection of priority waterfront-dependent uses of lands reduction in future risks and costs). For example, current rules allow rebuilding of storm-flooded properties, even in vulnerable, low-lying neighborhoods; such policies ensure that risks and rebuilding costs will continue to grow in some coastal communities.

LU Action 3-2 Align and expand existing municipal incentive programs, and other related planning tools (*e.g.*, Ocean and Monmouth Counties All-Hazards Mitigation Plan, GTR, Sustainable Jersey, Floodplain Management Plans, USEPA/NJDEP Watershed Management Plans and USACE New Jersey Back Bay Study) to achieve priority objectives.

Sustainable land use and community growth are regional concepts. We know the natural resources of the BB do not recognize political boundaries. In order to achieve sustainability and resilience in the BB Watershed the 37 communities, two counties, state agencies and other decision makers that share this resource must work together to identify and address issues that affect all jurisdictions. If a community is to become more resilient and sustainable, collaboration across all levels of government is critical to vet and incorporate resiliency projects into various planning efforts (*e.g.*, Municipal Floodplain Management Plans, Master Plans and Hazard Mitigation Plans).

LU Action 3-3 Coordinate with municipal, county, regional, and state planning representatives to develop one or more Land Use Elements (Working Waterfronts, Regional Resilience, Restoration and Enhancement activities/targets) for inclusion in planning documents to achieve priority objectives (*e.g.*, long-term comprehensive, localized and/or regional plans for vulnerable, low-lying or repetitive loss neighborhoods, fire-prone neighborhoods) and promote compatible commercial, recreational, and other waterfront land uses.

Historically, the Barnegat Bay watershed was known for its fishing, shellfisheries, hunting, trapping, waterfowl, birding, and boating activities; many of these activities contribute to the current tourism economy and improve the quality of life of many residents. The history, culture, and identity of many of our communities are inextricably linked to their "working waterfronts," which are places for active, water-related commerce and desirable areas in which to live and work. Thus, developing a working waterfront land use element would help ensure addressing this important historical use of waterfront properties and also ensure access to the bay to other user groups.

Sea level rise, shoreline erosion, development pressure, increasing runoff from recent and future storms will also have a direct impact on the character of water-dependent facilities along the Barnegat Bay shoreline. These stressors have resulted in the loss of waterfront services that have historically supported these activities. Sometimes water-dependent services were incompatible with subsequent encroaching development or were severely impacted by storm events and were converted to non-water dependent uses. Retaining water-dependent land uses is critical to maintaining the character of the Barnegat Bay, providing public access, retaining a commercial and recreation driver of the economy, and providing opportunities for implementing adaptation strategies to enhance shorelines. Another potential priority for designation of a land use element is property at high risk of inundation due to SLR and other identified factors.

7.4.4. Land Use Objective 4

Assess status and trends in land uses, land cover, and landscapes, especially those directly impacted by climate change and sea level rise (*e.g.*, inundated and regularly flooded lands), and improve understanding of the impacts of land uses and land management practices on the Barnegat Bay and its watershed.

LU Action 4-1 **Support the development of an updated Land Use/Land Cover Map, which includes changes in LU/LC, impervious surfaces, shoreline hardening, and other priority metrics, in V Datum.**

The BBP recognizes the importance of sound science in land use decision-making and management. Future decision making must include: 1) recognition of changing land use and land cover in response to dynamic development and economic pressures, and 2) recognition and accommodations for climate change, to be responsive to protecting biotic resources and the social and economic needs of communities.

LU Action 4-2 **Promote and support new science and monitoring to understand and reduce impacts of land uses and land management practices on the bay/watershed.**

The studies identified in this section are important to help inform land use decision-makers in achieving progress towards the goals and objectives of maintaining sustainable and resilient communities and natural resources within the watershed. The priority land use objectives and actions focus on establishing a collaborative, science-based approach at all levels of government to protect and enhance water quality and other resources upon which our economy and quality of life depend, and to make our communities more resilient to future climate change, including sea level rise.

LU Action 4-3 **Identify the social, economic, and environmental impediments and solutions for implementing sustainable land use practices, including green and gray infrastructure strategies.**

Leichenko *et al.* (2013) recognized that the population of Ocean County was vulnerable due to climate change and sea level rise for a variety of social (*e.g.*, age) and economic (*e.g.*, fixed income) issues. These vulnerabilities also create challenges to solving various problems via land use and other implementation projects and strategies. Recognizing such vulnerabilities and challenges improves our ability to find solutions.

7.4.5. Land Use Objective 5

Increase education and outreach efforts focused on: a) promoting land acquisition, protection, and management; b) implementing sustainable land use practices across both developed and undeveloped landscapes; c) integrating CCMP priorities, including climate change and sea level rise, into regional, state, local, and municipal planning, and d) reducing land use impacts on natural resources throughout the watershed.

LU Action 5-1 **Promote the understanding of the recreational, educational, and social uses; ecosystem services; and economic benefits and values of wetlands and other natural habitats.**

All of us recognize the importance of education to growing the collaboration to protect and restore the bay. In 2012, the Barnegat Bay Watershed was recognized as one of the most valuable watersheds in the United States (Kaufmann *et al.*, 2012). Educating everyone (residents and tourists alike) about the economic value of the watershed, the dependence of shore communities on clean water and the region's living resources, and the ecosystem services that different habitats provide promotes additional public and private investment in the bay's protection. Land use managers (including municipalities, counties, regional agencies, developers) and citizens need assistance in acquiring, translating, and applying the best available science to develop and implement strategies and practices that support healthy natural resources and ecosystem services and balance the impacts of development in the Barnegat Bay watershed.

LU Action 5-2 **Promote the understanding of working waterfronts and their historical, social and economic value of this places to their respective communities.**

Working waterfronts have long been integral components of bay communities along the Jersey Shore. Working waterfronts continue to evolve while facing many challenges; understanding the traditional uses of the bay and their importance to our economy and quality of life promotes investment in the bay and its adjoining communities.

LU Action 5-3 **Disseminate information and provide workshops that help watershed communities plan and prepare for climate change/sea level rise.**

This action will help communities prepare for climate change impacts and resulting cultural, economic, and ecological changes/disruptions. Participation in recent BBP workshops has been growing significantly.

LU Action 5-4 **Develop a BBP Recognition Program for municipalities implementing CCMP actions which reduce land-use impacts on natural resources.**

This action will help grow awareness of the BBP and the CCMP within municipalities and other community stakeholders, which will hopefully contribute to greater public awareness of the collective efforts to protect and restore the bay.

LU Action 5-5 **Maintain and expand the Jersey-Friendly Yards website and related programming (*e.g.*, workshops, demonstration projects) as comprehensive sources of information about sustainable landscaping/land-use practices, including soil restoration techniques, and low-impact development.**

The BBP will implement several new and/or updated education and outreach programs aimed at increasing understanding of the CCMP and its implementation, especially regarding land-use practices affecting water quality and supply issues. A series of workshops and educational materials will be developed to educate various audiences about topics including sustainable land use practices, habitat protection, and sustainable land management.

LU Action 5-6 **Provide landowners with existing information and interactive web-based tools that identify hazard vulnerability, climate adaptation, and response actions.**

As sea level continues to rise and our climate continues to change, the BBP will continue to work with partners to share information and promote tools

Figure 7.5. Potter Creek Crusaders at the Potters Creek, a property in Berkeley Township acquired by the Ocean County Natural Lands Trust. Photo courtesy of B. Birdsall.

7.5. Ecosystem Target, Objective, and Action Summary

Table 7.1. The relationships between the Ecosystem Based Targets and the Actions within the Land Use priority area.

Public Beach Closures	Objective 2: Action Item 3
Approved Shellfish Areas	Objective 1: Action Item 3
Submerged Aquatic Vegetation Extent	Objective 1: Action Item 3 Objective 5: Action Item 3
Wetland and Riparian Buffer Preservation	Objective 1: Action Item 3 Objective 2: Action Item 2 Objective 5: Action Item 3
Wetland Protection	Objective 1: Action Item 3 Objective 2: Action Item 2 Objective 5: Action Item 3
Clam restoration	Objective 1: Action Item 3 Objective 5: Action Item 3
Ecological flows	Objective 1: Action Item 3 Objective 2: Action Item 2 Objective 5: Action Item 5
Water conservation and reuse	Objective 1: Action Item 3

Land Use Objective 1. Promote and support open space acquisition, planning, and management for people and nature.

LU Action 1-1 Compile a comprehensive inventory of open space and lands held in permanent and temporary easements.

LU Action 1-2 Convene a working group to review all existing public and private planning documents (such as Green Acres Inventory, County and Municipal Open Space Inventories, TPL 2020 Plan, Ocean County's All Hazard Mitigation Plans, Conservation Blue Print initiative) and holdings, to coordinate future efforts to acquire additional lands and maximize ecological services of preserved lands.

LU Action 1-3 Promote the acquisition and management of lands to achieve: a) community resilience for flooding and water supply protection (*e.g.*, forested riparian buffers providing multiple ecosystem benefits and floodplains), b) natural resource protection, including sensitive species and their habitats, c) diverse recreational opportunities, and d) promotion and education of cultural heritage.

Land Use Objective 2. Promote and support sustainable land use practices (*e.g.*, soil restoration, low-impact development, shoreline restoration, and dredged material management) to increase resiliency of vulnerable communities.

LU Action 2-1 Support and encourage land use practices that incorporate BMPs including but not limited to Jersey-Friendly Yards, Low Impact Development (LID) and Sustainable Jersey actions. These practices should: a) promote nature-based infrastructure to minimize loss of natural vegetation b.) optimize opportunities for ground water recharge and c) minimize soil disturbance and promote soil health and restoration.

LU Action 2-2 Promote and support development of shoreline and wetlands restoration strategies and related technologies (*e.g.*, sediment management) to promote community resiliency to storms, and flooding.

LU Action 2-3 Promote land use practices that recognize and prioritize water-dependent uses; ensure that authorized waterfront uses are compatible with supporting commercial and recreational activities.

Land Use Objective 3: Incorporate CCMP goals and objectives into regional, county, municipal, and other policies, plans, and regulations where applicable to support BBP-related priorities.

LU Action 3-1 Identify regulatory gaps and overlaps and promote planning tools (*e.g.*, draft local and state ordinances, zoning, transfer of development rights) to achieve priority objectives (*e.g.*, long-term comprehensive, localized and/or regional plans for vulnerable, low-lying or repetitive loss neighborhoods, fire-prone neighborhoods, promote compatible commercial, recreational, public access and other waterfront land uses).

LU Action 3-2 Align and expand existing municipal incentive programs, and other related planning tools (*e.g.*, Ocean and Monmouth Counties All-Hazards Mitigation Plan, GTR, Sustainable Jersey, Floodplain Management Plans, USEPA/NJDEP Watershed Management Plans, and USACE New Jersey Back Bay Study) to achieve priority objectives.

LU Action 3-3 Coordinate with municipal, county, regional, and state planning representatives to develop one or more Land Use Elements (Working Waterfronts, Regional Resilience, Restoration and Enhancement activities/targets) for inclusion in planning documents to achieve priority objectives (*e.g.*, long-term comprehensive, localized and/or regional plans for vulnerable, low-lying or repetitive loss neighborhoods, fire-prone neighborhoods) and promote compatible commercial, recreational, and other waterfront land uses.

Land Use Objective 4: Assess status and trends in land uses, land cover, and landscapes, especially those directly impacted by climate change and sea level rise (*e.g.*, inundated and regularly flooded lands), and improve understanding of the impacts of land uses and land management practices on the Barnegat Bay and its watershed.

LU Action 4-1 Support the development of an updated Land Use/Land Cover Map, which includes changes in LU/LC, impervious surfaces, shoreline hardening, and other priority metrics, in V Datum.

LU Action 4-2 Promote and support new science and monitoring to understand and reduce impacts of land uses and land management practices on the bay/watershed.

LU Action 4-3 Identify the social, economic, and environmental impediments and solutions for implementing sustainable land use practices, including green and gray infrastructure strategies.

Land Use Objective 5: Increase education and outreach efforts focused on: a) promoting land acquisition, protection, and management; b) implementing sustainable land use practices across both developed and undeveloped landscapes; c) integrating CCMP priorities, including climate change and sea level rise, into regional, state, local, and municipal planning, and d) reducing land use impacts on natural resources throughout the watershed.

LU Action 5-1 Promote the understanding of the recreational, educational, and social uses; ecosystem services; and economic benefits and values of wetlands and other natural habitats.

LU Action 5-2 Promote the understanding working waterfronts and their historical, social, and economic value of this places to their respective communities.

Figure 7.6. Superstorm Sandy. Photo courtesy of NOAA.

LU Action 5-3 Disseminate information and provide workshops that help watershed communities plan and prepare for climate change/sea level rise.

LU Action 5-4 Develop a BBP Recognition Program for municipalities implementing CCMP Actions to reduce land use impacts on natural resources.

LU Action 5-5 Maintain and expand the Jersey-Friendly Yards website and related programming (*e.g.*, workshops, demonstration projects) as comprehensive sources of information about sustainable landscaping/land-use practices, including soil restoration techniques, and low-impact development.

LU Action 5-6 Provide landowners with existing information and interactive web-based tools that identify hazard vulnerability, climate adaptation, and response actions.

CHAPTER

8 CLIMATE CHANGE IN THE BARNEGAT BAY

8.1. Introduction

Climate change and sea level rise have the potential to alter ecosystem processes and life in coastal communities in ways that we are just beginning to recognize and have yet to truly address. Changes in air and water temperatures, precipitation, surface water hydrology, and sea/land surface elevation will have significant impacts on New Jersey's marine/estuarine, freshwater, and terrestrial ecosystems.

The impacts of climate change have already been observed here in New Jersey. Our coastal areas, including the Barnegat Bay estuary, are experiencing one of the highest rates of sea level rise in the continental United States. In Atlantic City, where records extend back to 1911, the relative sea level trend is an increase of 4.09 mm/yr, which is equivalent to a change of 1.34 feet in 100 years (NOAA, 2019). Of equally great concern, the "Intermediate" scenario in the Fourth National Climate Assessment has a 21st century rate of sea level rise that is three times as fast (Sweet *et al.*, 2017).

Estuaries and coastal areas are particularly vulnerable to sea level rise and other aspects of climate change, such as higher temperatures, more precipitation, invasive species, and more frequent and intense storms, which makes the changing climate a top concern for BBP and our many stakeholders. Recognizing Barnegat Bay's vulnerability to climate change impacts, the BBP engaged experts to assess the Revised CCMP Actions to determine the degree to which the implementation of these Actions may be impacted by climate change (BBP, CCMP Vulnerability Assessment) (Yozzo, 2019). The subsequent sections address the identified climate change risk factors, and which Actions are most impacted by these risk factors.

8.2. Identification of Major Risk Factors

The consequences of a changing climate are forecast to pose significant threats to New Jersey's natural ecosystems and wildlife. Recognized climate stressors include the following.

8.2.1. More Variable Summer and Winter Weather

One projected outcome of climate change is a greater degree of climate variability, including more intense precipitation/storm events in both summer and winter (Kopp, 2016). More intense precipitation could cause greater flooding and erosion in streams and rivers, impacting fish and aquatic invertebrate populations. More frequent and destructive flooding may force riparian landowners to reinforce or "harden" river and stream banks to protect property and infrastructure, further altering important habitats and natural areas.

Figure 8.1. Flooding during Superstorm Sandy, October, 2011. Photo courtesy of BBP staff.

The U.S. Climate Resilience Toolkit projects the average daily maximum temperature across Ocean County will rise 8°F to 15°F above historic levels by 2100 under a "business as usual" scenario (U.S. Climate Resilience

Toolkit, 2019). If this were to happen, New Jersey can expect a dramatic increase in the number of days over 100°F. As temperatures have risen, temperate zones like New Jersey have seen an earlier onset of spring. This can have severe consequences for our native flora and fauna, which rely on these temperature changes as a cue for important life history events.

A projected trend towards warmer winter temperatures will allow species intolerant of colder weather, such as problematic invasive plants, insects, and pathogens, to expand their ranges into New Jersey, affecting native wildlife and their habitats. For avian species, shifts in nesting times or egg incubation durations can limit breeding success and recruitment. Changes in the seasonal cycles of plants and animals can lead to increased competition for resources and hybridization among species, as north-south distribution patterns change (NJDEP, 2017c).

8.2.2. Increases in Oceanic, Estuarine, and Freshwater Temperatures

Increases in water temperature due to climate change are already occurring in marine and estuarine systems along the Atlantic coast. Most estuarine and aquatic species are adapted to living within an optimal temperature range, and departures from that range can cause stress, leading to reduced feeding, impaired reproductive cycles, altered metabolic rates, and, in some cases, direct mortality. Warming of ocean waters reduces the total amount of dissolved oxygen (DO) that can be held in water and increases the demand for oxygen in cold-blooded aquatic animals, directly affecting fish survival and health (Najjar *et al.*, 2000). Warmer waters can increase plankton blooms, which decreases water clarity. Additionally, warmer waters have significant negative impacts on SAV – especially eelgrass – growth and survival through warmer summer months. Harmful algal blooms (HABs), triggered by elevated water temperatures, can discolor coastal waters (to, typically, red, yellow, or brown) and may negatively impact fish and shellfish, including hard clams and scallops (Hallegraeff, 2010), as well as seagrasses. Higher water temperatures will also affect New Jersey's rivers, streams, and freshwater wetlands, potentially impacting freshwater fish, turtles, amphibians, and invertebrates, which may not be as adaptable as marine/estuarine species (NJDEP, 2017c; Gobler *et al.*, 2017).

8.2.3. Increased and/or Prolonged Drought

As the population in the bay's watershed has grown, the amount of water withdrawn from rivers, streams, and aquifers for human uses has increased. Greater withdrawals can result in reductions in stream base flow, causing changes in the timing and amount of fresh water reaching the estuary. This also concentrates nutrient and pollutant loadings, which in turn may alter water quality and habitat for both resident and transient species (Van Abs, 2016). Anticipated higher summer temperatures may result in more frequent short-term summer droughts and lower stream and river flows in summer, exacerbating this problem. Higher evaporation (and evapotranspiration) rates throughout the growing season, but especially in the summer, will further reduce groundwater recharge and increase soil moisture losses, reducing stream flows. In addition, lower water levels in rivers and streams could impede fish access to spawning and overwintering areas. Drought conditions may impair and isolate important wildlife habitats in the upper watershed, such as vernal pools (NJDEP, 2017c). And extended drought conditions, combined with warmer winters/summers, will encourage insect/pest outbreaks and invasions by non-native plant species, which will affect the survivability of native tree species in riparian and forested habitats (NJDEP, 2017c).

8.2.4. Increased Frequency and/or Magnitude Of Storms

Changes in precipitation patterns are projected to bring an increase in the frequency of heavy precipitation storm events (Kopp 2016). An increase in overall storm intensity would raise the threat of greater storm surges and more devastating coastal flooding throughout the bay. A projected continued increase in sea level rise in future decades will exacerbate these problems (Strauss *et al.*, 2014). Marine/estuarine, freshwater, and terrestrial wildlife are likely to experience a wide range of impacts associated with an increase in storminess, including: impacts on critical breeding, nesting, and foraging areas for seabirds, shorebirds, terrapins, and horseshoe crabs; changes to offshore or back-bay benthic environments; increased water column turbidity; and damage to SAV beds (NJDEP, 2017c). In the upper reaches of the watershed, more intense precipitation will induce more flooding and erosion in streams and rivers, with a variety of potential impacts on fish, freshwater mussels, and other aquatic invertebrates. Furthermore, increased flooding may motivate landowners within coastal and riparian areas to reinforce or "harden" shorelines to protect properties and infrastructure, in ways which further impact critical wildlife habitats.

8.2.5. Sea Level Rise

Sea level rise is predicted to be greater in New Jersey than the global average due to coastal subsidence (Strauss *et al.*, 2014). Since the land is sinking while sea level is also rising, there is a higher local "relative rate of sea level rise." The effects of predicted rates of sea level rise in the coming decades along the New Jersey's Atlantic coast will result in substantial changes in coastal features, including tidal marshes, shallow-open water habitats (including SAV beds), and coastal uplands. Sea level rise will also result in an increase in salinity throughout the bay, and will affect the distribution, abundance, and life history patterns of

plants and animals dependent on these imperiled coastal habitats (Haaf *et al.*, 2015). In addition to the effect of sea level rise, the bay will experience higher salinity levels due to reduced stream base flows.

Tidal wetlands (salt, brackish and freshwater tidal marshes) provide essential ecosystem services to the coastal communities of Barnegat Bay, including essential habitat for estuarine-dependent fish and wildlife species, flood protection, water quality improvements, nutrient retention/cycling, and carbon sequestration cycling. These services benefit the surrounding natural and human communities of the bay and its watershed (BBP, 2016). Sea level rise will also increase saltwater intrusion into inland freshwater systems, including tributary streams that provide spawning habitat for anadromous fish, and will contribute to the salinization of coastal aquifers on which residents of the Barnegat Bay watershed rely (Van Abs, 2016). Areas of high salt marsh will eventually convert to low salt marsh, threatening wildlife species that depend on high marsh habitat. Sea level rise will also eventually promote the transition of some upland habitats to tidal wetlands, potentially displacing resident terrestrial species (Haaf *et al.*, 2015; NJDEP, 2017c).

8.2.6. Ocean Acidification

In recent years, ocean acidification—a decrease in the pH of ocean waters—has raised concern among climatologists, marine ecologists, and coastal resource managers. Among the troubling consequences of increased acidification is the potential inhibition of marine invertebrates' ability to incorporate calcium in the formation of shells and exoskeletons. The effects of ocean acidification on commercially important species such as clams and oysters in the region are not as well recognized as the effects on corals in tropical waters, but also are of significant environmental and economic concern.

8.3. Impacts on CCMP Priorities and Action Implementation

A vulnerability assessment is a means to gain consensus on the range of potential impacts to the Barnegat Bay watershed. Potential impacts range from threats to coastal infrastructure (such as public access and recreational facilities, water-dependent businesses, and public water supply and sewer pipelines) to impacts on the effectiveness of natural resource and water supply planning, mapping, and public education programs. The goals of conducting a vulnerability assessment are to:

- Provide essential context for communication, coordination, and decision support among regional partners and stakeholders (*e.g.*, municipalities, public utilities, educational institutions, and public advocacy groups).
- Obtain funding, resources, buy-in, or regulatory approval.
- Serve as a tool that can help answer questions about risks and mitigating options in the development of a regional climate resilience action plan (USEPA, 2014).

Among the four BBP programmatic focus areas, certain consequences of climate change and strategies for adaptation to, and mitigation for, impacts were identified as "high-priority," and in greatest need of response. These Barnegat Bay-specific consequences and recommended actions are summarized as follows for each of the major programmatic priority areas.

8.3.1. Water Quality

In the future, increased variability and unpredictability in stream flow will alter water quality and water supply within Barnegat Bay and its tributary watersheds. Various climate change stressors will change the loads and pathways of nutrients and other pollutants, including pathogens; potentially decrease dissolved oxygen concentrations in

Figure 8.2. Flooded road on Long Beach Island, October, 2011. Photo courtesy of A. Andersen.

surface waters; and potentially affect monitoring programs and implementation of the nutrient TMDL now under development. More variable summer weather, including more frequent/intense storms, is likely to affect water quality, human use, and monitoring programs at public recreation beaches. This may also increase pollution impacts from boating activities and marinas throughout the bay.

Increased runoff associated with stronger, more frequent storms will affect the conveyance of polluted runoff from roadways (deicers), automobiles (hydrocarbons), and yard maintenance (pesticides, insecticides, and fertilizers) throughout the Barnegat Bay watershed.

Future damage to existing stormwater systems from anticipated increases in stream erosion and sea level rise will challenge efforts to satisfy existing regulatory requirements for system maintenance. Saltwater intrusion will increase corrosion of concrete and steel water supply and wastewater system pipelines, necessitating more frequent replacement and/or upgrades. Damage to municipal water or sewer systems from stream erosion and

inundation of outfalls from sea level rise can result in uncontrolled release of pollutants to streams and the estuary, increasing the existing challenges of meeting TMDLs as well as the development and implementation of watershed plans.

Table 8.1. Priority Water Quality Actions identified by the BBP STAC that could be impacted by one or more climate stressors, potentially inhibiting implementation.

Action Number	Action Description
WQ 1-1	*Support development and implementation of a Barnegat Bay TMDL(s) (Total Maximum Daily Load), including the development and use of a Barnegat Bay validated biological indices of water quality, to address nutrient and other pollutant loadings and to guide future, science-based management decisions.*
WQ 1-2	*Develop and implement watershed plans at the sub-watershed level.*
WQ 1-5	*Address nonpoint source pollution through stormwater basin management and restoration.*
WQ 1-6	*Address nonpoint source pollution (e.g., pesticides herbicides, fertilizer, de-icers, and automotive wastes) from roadways and public works maintenance.*
WQ 1-7	*Encourage municipalities and counties to map all stormwater BMP facilities/infrastructure within the watershed associated with major development, and review mapping of stormwater BMPs as an optional element of NJDEP Municipal Stormwater Compliance Assistance Program and a "preferred ranking element" in appropriate NJDEP funding programs.*
WQ 1-9	*Identify sources and reduce pollution inputs from livestock, agriculture, and wildlife.*
WQ 3-1	*Support completion and expansion of source tracking for bacteria, pathogens, and novel and other pollutants.*

Sea level rise and **increased storminess** have been identified as the primary climate stressors that will impair the ability to implement the recommended water quality actions.

Table 8.2. Mitigation strategies identified by the BBP STAC to minimize the risk of climate change adversely impacting implementation of priority water quality actions.

Action Number	Action Description
WQ 1-1	*Anticipated climatic impacts should be accounted for in TMDL development. Specifically, limits and implementation actions should plan for increased runoff associated with stronger, more frequent storms.*
WQ 1-2	*Anticipated climatic impacts should be accounted for in Watershed Plan development. Field methodologies may need to be modified to take dynamic hydrologic conditions, including their effects on people and equipment, into account. Furthermore, implementation projects developed under Watershed Plans should include an assessment of their vulnerability to climate stressors, particularly drought.*
WQ 1-5	*Stormwater mapping methodology may need to be modified to consider outfalls submerged due to sea level rise. Field methodologies may need to be modified to take dynamic hydrologic conditions, including their effects on people and equipment, into account.*
WQ 1-6	*Pollution reduction strategies will need to account for more precipitation and stronger, more frequent storms, and address communities with environmental justice concerns.*
WQ 1-7	*Basin assessments will need to incorporate climate change stressors into their methodology, paying particular attention to the effects of stronger, more frequent storms.*
WQ 1-9	*Pollution reduction strategies will need to account for stronger, more frequent storms.*
WQ 3-1	*Source tracking methodologies may need to be modified to take dynamic hydrologic conditions, including their effects on people and equipment, into account.*

8.3.2. Water Supply

The most important actions for water supply involve additional monitoring/assessment to improve forecasting of potential impacts on stream base flow and maximize the extent to which base flow is maintained and enhanced, including the minimization of consumptive and depletive groundwater withdrawals from surficial aquifers. Reduced base flows from recharge losses and increased water demands will change the estuary's salinity profiles, which will also require enhanced monitoring to track changes and responses. Increased runoff will concentrate pollutants in waterways, and monitoring programs should be designed to capture major storm events and detect elevated pollutant concentrations associated with extreme weather. Additional research and monitoring is needed to better understand the extent to which increased storm intensity will change flood frequency and floodplain/riparian zone delineation and mapping. These changes will, in turn, affect how water supplies throughout the Barnegat Bay watershed can be safeguarded through the protection and restoration of tributaries and riparian areas.

Table 8.3. Priority Water Supply Actions identified by the BBP STAC that could be impacted by one or more climate stressors, potentially inhibiting implementation.

Action Number	Action Description
WS 1-1	*Assess and implement existing shallow groundwater protection programs.*
WS 1-2	*Determine minimum ecological flow requirements for priority streams, rivers, and wetlands within the watershed.*
WS 1-4	*Assess HUC 11s for water supply capability related to streamflow, surface, and shallow groundwater withdrawal capacity.*
WS 4-1	*Identify and explore infrastructure, research, and piloting options for the use of advanced treatment at wastewater treatment plants and water reuse, including wastewater and gray water, within the watershed.*

Sea level rise and **increased storminess** have been identified as the primary climate stressors that will impair the ability to implement the recommended water supply actions.

Table 8.4. Mitigation strategies identified by the BBP STAC to minimize the risk of climate change adversely impacting implementation of priority Water Supply Actions,

Action Number	Mitigation Strategy
WS 1-1	*Implementation of shallow ground water protection programs and new septic designs will need to account for impacts due to climate change stressors through enhanced monitoring.*
WS 1-2	*Increased monitoring/assessment will be needed to improve forecasting of potential climate impacts on stream base flow, particularly drought.*
WS 1-4	*Increased monitoring will be needed to improve forecasting of potential climate impacts on stream base flow and consumptive and depletive ground water withdrawals.*
WS 4-1	*?: Mitigation is potentially affected by considerable uncertainties dependent upon specific technologies, potential locations, and climate trajectories; planning coordinated across all levels of government appears critical with increasing scale and scope of any such project. All planning should consider communities with environmental justice concerns.*

8.3.3. Living Resources

The ability of coastal scientists, resource managers, and restoration practitioners to monitor the bay's natural resources and landforms, and to implement effective conservation and restoration strategies, will be challenged in the future. Sea level rise will gradually render baseline mapping of sensitive habitats obsolete, requiring regular updates of current mapping resources and databases to keep pace with the bay's changing environment. The direct and indirect effects of sea level rise will gradually render baseline mapping of the bay's wetlands, including tidal marshes and riparian buffers, obsolete, requiring recurring updates. Ongoing tidal wetland monitoring programs (*e.g.,* MACWA) will require continuation and expansion to capture changes occurring throughout the bay, with regular updates commensurate with the rate of change being experienced by the system. Wetland restoration and enhancement (including consideration of "thin-layer" dredged material placement) requires continuing research and should be prioritized and incorporated into a bay-wide sediment management plan.

With an anticipated increase in the frequency and magnitude of coastal storms, and the increased potential for ecosystem and infrastructure damage or disruption, the nature

Figure 8.3. Erosion of wetlands along the bay's shoreline. Photo courtesy of BBP.

and frequency of post-disturbance monitoring may change, requiring more frequent monitoring events (and more rapid mobilization of monitoring staff and resources throughout the bay). Concerns regarding the safety of monitoring personnel – from agencies, research institutions, and NGOs – will likely increase, especially for staff engaged in projects involving operation of vessels and/or access of remote coastal locations, under conditions of escalated storm frequency and magnitude.

Potential challenges associated with designing and implementing effective natural resource mapping and monitoring programs were identified. For example, sea level rise may eliminate SAV in areas where it presently occurs, while providing opportunities for new areas to be colonized in the future. SAV mapping for the bay requires periodic updates and monitoring frequently enough to detect system-wide declines at a point when management interventions can be effective and/or not too costly.

Additionally, with increased frequency and intensity of storm events due to climate change, it will become imperative to monitor SAV beds within the bay after large storms in order to track ecosystem recovery. Although impacts to the bay's SAV resources are anticipated in the future, consequences can be mitigated through a more comprehensive mapping effort, with periodic updates commensurate with the rate of change experienced by the system.

Similar concerns exist regarding the ability to track impacts on the bay's remaining tidal wetlands, already considered moderately to severely stressed and at substantial risk from erosion; changes in sediment and nutrient availability; and prolonged inundation. The bay's freshwater wetlands are also at risk of direct loss and/or alteration from sea level rise and more variable/intense weather.

Saltwater intrusion into freshwater areas can occur in short bursts during storms or over longer time periods from a gradual increase in sea level rise. In either case, increasing salinity in the bay's tributaries will alter the composition of freshwater wetlands (*e.g.,* loss of Atlantic White Cedar forest).

Table 8.5. Priority Living Resources Actions identified by the BBP STAC that could be impacted by one or more climate stressors, potentially inhibiting implementation.

Action Number	Action Description
LR 1-1	*Compile existing data and maps; determine and collect missing data for ecologically sensitive habitats and associated buffers.*
LR 1-2	*Develop and implement conservation/restoration plans for ecologically sensitive terrestrial, coastal, and aquatic habitats.*
LR 2-2	*Restore fish passage and other riparian habitats to improve habitat quality and connectivity.*
LR 2-4	*Create and restore wildlife corridors for habitat quality and connectivity.*
LR 2-5	*Monitor, manage, and control invasive and nuisance aquatic and terrestrial species through ecologically appropriate methods.*
LR 3-2	*Continue the ongoing Mid Atlantic Coastal Wetlands Assessment (MACWA) program to evaluate the condition and function of wetlands and address priority information gaps for wetlands management.*
LR 3-3	*Update and/or complete mapping of riparian and tidal wetlands and their buffers.*

Warming temperature trends, **drought**, **sea level rise**, and **increased storminess** have been identified as the primary climate stressors that will impair the ability to implement the recommended actions.

Table 8.6. Mitigation strategies identified by the BBP STAC to minimize the risk of climate change adversely impacting implementation of priority Living Resources Actions.

Action Number	Mitigation Strategy
LR 1-1	*Mapping will need to occur at regular intervals to identify time scale-relevant changes to sensitive habitats.*
LR 1-2	*Conservation and restoration plans will need to include climate change vulnerability during their assessment process to ensure resiliency to climate stressors and include concerns of communities with environmental justice concerns.*
LR 2-2	*Fish passage designs will need to account for larger variability in flows than current design standards.*
LR 2-4	*Planning for wildlife corridor restoration will need to account for changing habitats and species movement patterns in response to climate change stressors.*
LR 2-5	*Additional monitoring and research will be required to document and understand potential changes in species distributions and adaptations in response to climate change stressors.*
LR 3-2	*The MACWA methodologies and field protocols will need to be reviewed, and potentially modified, to account for changes in wetland habitats and personnel exposures.*
LR 3-3	*Mapping will need to occur at regular intervals to capture changes in riparian and tidal habitats associated with climate stressors.*

8.3.4. Land Use

As climate changes, communities in the Barnegat Bay watershed will become increasingly vulnerable to permanent inundation from rising sea levels, more frequent nuisance flood events, and more intense coastal storms and precipitation. Areas in the watershed are already experiencing nuisance flood events with increasing frequency. It is anticipated that increasing frequency and duration of droughts will impact water reserves, and saltwater intrusion may contaminate groundwater aquifers.

Successful and effective implementation of current and future open space plans throughout the watershed must ensure that water-dependent uses are prioritized. With warmer summers and increasing heavy precipitation events, increasing green spaces in developed areas will be important for climate change adaptation. Because the watershed encompasses many municipalities, promoting and encouraging conservation and management across municipalities is critical for biodiversity conservation as well as climate change adaptation and resilience. Limiting the development of forested lands to support water conservation and recharge areas, as well as habitat for at-risk species, will also be necessary. The BBP and its partners should promote natural area conservation and green infrastructure in urban/ suburban areas of the watershed. Natural areas and green infrastructure (bioswales, green roofs, green walls, *etc.*) in urban and suburban areas are important to mitigate high temperatures, intercept stormwater, and increase water quality.

Table 8.7. Priority Land Use Actions identified by the BBP STAC that could be impacted by one or more climate stressors, potentially inhibiting implementation.

Action Number	Action Description
LU 2-2	*Promote and support development of shoreline and wetlands restoration strategies and related technologies (e.g., sediment management) to promote community resiliency to storms and flooding.*
LU 4-3	*Identify the social, economic, and environmental impediments and solutions for implementing sustainable land use practices, including green and gray infrastructure strategies.*

The BBP STAC identified **sea level rise** and **increased storminess** as the primary climate stressors that will impair the ability to implement the recommended actions.

Table 8.8. Mitigation strategies identified by the BBP STAC to minimize the risk of climate change adversely impacting implementation of priority Land Use Actions.

Action Number	Mitigation Strategy
LU 2-2	*Develop a watershed-wide dredge material management plan that takes sea level rise into account.*
LU 4-3	*All land use plans and sustainable land use practices should assess climate change vulnerability, particularly for communities with environmental justice concerns, during development.*

Figure 8.4. Park in Little Egg Harbor Township rebuilt after Superstorm Sandy. Photo courtesy of B. Birdsall.

CHAPTER

9

MONITORING AND HABITAT PLANS

The Barnegat Bay Partnership and many of its partners, especially the NJDEP, routinely conduct and support monitoring throughout the watershed to help track the status of various conditions within the bay and watershed, as well as to identify emerging issues. This information is analyzed and reported on in a variety of formats; some is incorporated into the NJDEP's Integrated Water Quality Report, some into other agencies' regular reports, and much of it is incorporated into the BBP's State of the Bay Reports, published in 2005, 2011, and 2016. Representing the consensus of technical experts working on these issues in the bay or elsewhere, the BBP State of the Bay reports give us a big picture of the bay's condition and our collective efforts to protect and improve the bay. These reports also enable us to identify where we need more and/or other information to address existing concerns and to identify emerging issues of potential concern. Thanks to substantial commitments to monitor the watershed and bay from our partners, especially the NJDEP's Comprehensive Baywide Water Quality Monitoring program, our understanding of the bay has improved considerably over the past 10 years and should continue to improve with commitments to continue most ongoing monitoring activities.

9.1. Monitoring Plan

Why is monitoring important? Monitoring is an often overlooked but critical activity to support environmental assessment and ecosystem management. Single alterations, such as the invasion of bay nettle, common reed, or southern pine beetle, may produce ripple effects (*e.g.*, ecological or trophic cascades) that profoundly affect our local ecology or our use of the bay. We also recognize that the environment is changing in many ways on many scales that may be difficult to predict; nonetheless, as the physical environment changes, the impacts of any biological changes may also change. Ecosystem management cannot proceed without thoughtful attention to these changes. Monitoring and evaluation then become the essential tools for detecting, measuring and interpreting these changes over time. Assessing changes in environmental conditions, populations, and habitats over time, especially in response to management actions, may require monitoring at different levels (species, natural communities, implementation activities) and across multiple spatial (local, regional, statewide) and temporal (continuous, monthly, yearly; short-term versus long-term) scales. Through varying styles of monitoring, we can identify challenges or impacts of management activities or landscape alterations. Finally, monitoring is required to simply understand the effects, intended or otherwise, of any management approach.

The BBNEP Science and Technical Advisory Committee released the first Monitoring Program Plan for Barnegat Bay (BBNEP, 2003). The monitoring plan was the culmination of a series of workshops and described plans for critical activities that would track progress and achievement of the original CCMP objectives. At the heart of the 2003 Monitoring Program Plan was a series of environmental and programmatic indicators that provided an effective mechanism for evaluating progress toward the full achievement of the CCMP goals. A group of nine primary indicators (Table 9-1) that were easily communicated to the public were selected to provide a broad basis for evaluating a range of CCMP actions. A group of twenty-one secondary indicators provided an additional basis for evaluating the programmatic output and specific environmental outcomes of CCMP implementation. For each indicator, the plan identified which CCMP objectives and actions the indicator addressed, what questions the monitoring would answer, any existing partner monitoring programs that could provide data, and what information needs and data gaps were outstanding. The plan appendix also contained a description of 62 existing monitoring activities.

The primary and secondary indicators in the 2003 Monitoring Program Plan formed the basis for the initial State of the Bay Report in 2005 (BBNEP, 2005). This report documented the status and trends of six of the primary indicators for which there was sufficient data: submerged aquatic vegetation, shellfish beds, bathing beaches, algal blooms, freshwater inputs, and land use/land cover. Subsequent reports in 2011 (BBP, 2011) and 2016 (BBP, 2016) incorporated additional primary and secondary indicators to provide a more holistic look at the status of the bay and watershed.

With a transition to an Ecosystem-Based Management approach in this CCMP, it is time to revisit our Monitoring Program Plan. Under a revised monitoring plan, the primary indicators do not solely reflect individual CCMP actions, but instead reflect the broader ecosystem-based targets set forth in Chapter 3. As our understanding of the bay improves and implementation action helps improve some aspects of the bay and watershed, some indicators previously thought necessary may become less critical, whereas other indicators may increase in importance. Furthermore, the monitoring programs currently occurring in the bay have changed since the monitoring program survey in 2001. Several programs are no longer active, many new ones have been initiated, and ongoing programs have been modified (*i.e.*, improved).

Over the next two years the BBP Program Office staff, along with the BBP Science and Technical Advisory Committee (STAC) and our partners, will work together to develop a comprehensive Monitoring Plan for the Barnegat Bay and Watershed, in support of CCMP implementation. The plan will take into consideration the new information we have learned about the bay, our shift to an ecosystem-based management approach, and the impacts of climate change and sea level rise. The Monitoring Plan will be completed in 2022.

Table 9.1.
Environmental indicators contained in the 2003 Monitoring Program Plan.

PRIMARY INDICATORS	■ SAV distribution, abundance, and health ■ Land use / land cover change ■ Signature species ■ Watershed integrity ■ Shellfish beds ■ Bathing beaches ■ Water-supply wells / drinking water ■ Harmful algal blooms ■ Freshwater inputs
SECONDARY INDICATORS	■ Temperature ■ pH ■ Salinity ■ Dissolved oxygen ■ Nutrients ■ Turbidity ■ Fecal coliform / enterococcus bacteria ■ Phytoplankton abundance and composition and chlorophyll a concentrations ■ Macrophyte abundance ■ Shellfish and finfish abundance ■ Benthic community structure ■ Toxic contaminants in aquatic biota and sediments ■ Floatables ■ Shoreline habitat / sensitive areas ■ Boating use ■ Atmospheric and other pollutant inputs ■ Rare plant and animal populations ■ Stream flow ■ Water allocations ■ Saltwater intrusion ■ Turf grass

9.2. Habitat Plan

As described in the ecosystem-based targets and in many of the objectives and individual actions within this document, fully functioning habitats of many different types are required to support the full range of ecosystem services that human and wildlife communities are dependent on in various ways. To help focus our efforts to protect these habitats and restore them when necessary, the BBP will develop a Habitat Restoration Plan. The Plan will build on the habitat information contained within the CCMP, providing context on their importance, describing their current status, and identifying and prioritizing potential protection and restoration projects.

Under the guidance of BBP's STAC, a Habitat Restoration Work Group will be established and will work with a contractor to develop a strategic plan and potential projects. The work group will utilize existing decision support tools (*e.g.*, TNC Restoration Explore, NJ Shoreline and Marsh Restoration Decision Support Tool, the Trust for Public Land (2008 *Barnegat Bay 2020 Report: A Vision for the Future of Conservation)*. It is anticipated that the Habitat Restoration Plan will include updated habitat mapping where available, will direct managers and restoration practitioners to tools and resources, and will identify key mapping and data gaps where appropriate. The Habitat Plan is scheduled for completion in 2022.

Figure 9.1. BBP staff monitoring seagrass in the bay. Photo courtesy of BBP.

CHAPTER

10

ORGANIZATIONAL AND FINANCIAL PLANNING

10.1. Introduction

The Barnegat Bay Partnership was established in 2002 as the Barnegat Bay National Estuary Program. Over the past 18 years, the BBP has undergone many changes: it has changed administrative hosts and relocated its offices several times while growing its staffing, activities, and organizational partners and commitments for the bay's protection. The BBP's activities include coordination with local, regional, state, and national policy and management decision-makers on issues related to the protection and improvement of the bay, environmental education and outreach, student education, and monitoring and scientific research. Day-to-day operations are led by the Program Office, which presently includes seven full-time positions, one part-time staff position, and a varying number of seasonal, part-time field staff supported by NEP funding. Other staff positions (whether full-time, part-time or seasonal) are contingent on other funding. The BBP Program Office is housed at Ocean County College (OCC), a two-year community college in Toms River, and operates as a department within OCC.

Funding to support BBP's work comes in several forms. Some work related to the CCMP is completed by the BBP's partner organizations, with funding from outside sources unrelated to the BBP's operations. For the operation of the BBP Program Office; overseeing CCMP implementation; and its various science, education, and policy efforts, the BBP receives annual funding through the USEPA National Estuary Program in accordance with Section 320 of the Clean Water Act, which was most recently re-authorized in 2016 (P.L. 114-162). Section 320 CWA funding remains critical to the continuing operation of the BBP and all other NEPs.

The Ocean County Board of Commissioners, through the Ocean County Natural Lands Trust Program, provides the matching funds for land acquisition; this funding match is essential to the continued operations of the BBP.

Lastly, since 2005, OCC has served as the host for the program and also provided substantive support for program administration and operation of the BBP Offices.

To help supplement the funding received from USEPA, the BBP Program Office identifies and applies for other grant funding, mainly from state and local government sources, to support project implementation.

10.2. Organizational Needs Assessment and Financial Planning

To maintain the level of work currently underway and grow various protection, restoration, and education efforts to meet the challenges of the future, the BBP and its partners recognize that they will need to continue to diversify their funding and increase the overall funding level for CCMP implementation. As part of this effort, the BBP initiated an Organizational Needs Assessment in summer 2018 to investigate the Program Office's long-term staffing and facility needs (including staff office space, laboratories, field facilities, storage, exhibit space, visitor center, outreach, and educational space), and to evaluate the organizational structure of the BBP and its working relationships with OCC and the many partners that comprise its management conference. The BBP and its many partners have begun acting on the recommendations included in the Needs Assessment Report (BBP, 2019). For example, additional technical staff has been hired and collaborations with some partners have been expanded.

The Needs Assessment Report also makes clear the need to review to create a Financial Strategy for the Program Office. The Financial Strategy will document the current sources of income (NEP funding, other grant funding, *etc.*) and identify opportunities to increase revenue from each of these sources as well as potential new funding sources. The goals for income diversification in each category, along with the steps needed to work toward those goals, will be identified for future consideration. The Financial Strategy will be completed in 2021-2022.

Figure 10.1. BBP Advisory Committee meeting. Photo courtesy of BBP.

Figure 10.2. BBP Policy Committee meeting. Photo courtesy of BBP.

CHAPTER

11

COMMUNICATION AND EDUCATION PLAN

Public participation, education, and outreach are central to the BBP's mission to restore, maintain, protect, and enhance the water quality and natural resources of the Barnegat Bay estuary and its contributing watershed. The BBP includes a number of well-established and active organizations that implement various forms of public education and outreach programs on watershed- and estuary-related topics. Historically, these organizations, individually and collaboratively, have carried out a variety of communication projects and educational programs.

The purpose of the BBP's Communication and Outreach Plan is to establish clear objectives, approaches, and methods to engage distinct target audiences important to protecting the Barnegat Bay ecosystem. The Communication Plan defines strategies for effectively leveraging and coordinating the efforts of *all* communication and outreach practitioners working in the Barnegat Bay watershed.

11.1. History and Background

In February 2009, the Barnegat Bay National Estuary Program Office convened its first "Education and Outreach Retreat." The retreat brought together education and outreach professionals working on Barnegat Bay-related topics to share information and discuss how to collaborate on Barnegat Bay education and outreach efforts. As a follow-up to the first Education and Outreach retreat, the Program Office conducted an online survey of 47 partner organizations during the summer of 2009. The purpose of the survey was to assess Barnegat Bay outreach efforts and identify opportunities for improvement. The survey collected detailed information about outreach and education topic areas, target audiences, and the tools and methods utilized. Thirty partners (64% of those asked) participated in the survey.

The first Communication and Outreach Plan, entitled "*Putting All the Pieces Together: A Communication and Outreach Plan to Support the BBNEP 2008-2011 Strategic Plan*," summarized the survey results and provided a blueprint for partner education and outreach efforts. In 2010, the BBP formally approved the plan and formed a Communication and Education Committee (CEC) to manage its implementation.

After the BBP partners developed and approved the 2012-2016 Strategic Plan, the CEC completed a revised *Communication and Outreach Plan to Support the BBP 2012-2016 Strategic Plan*, which the BBP approved in February of 2014. The updated Communication Plan outlines education and outreach objectives, actions, and deliverables for each of the five priorities in the Strategic Plan: water quality, water supply, land use, habitat, and fish and wildlife. It also expands outreach efforts to communities with environmental justice concerns.

11.2. Goal and Objectives

The goal of the 2014 Communication Plan was to identify ways to enhance and improve the BBP's communication, outreach, and public involvement in support of the CCMP. To achieve this goal, the BBP CEC established the following overall objectives:

- Support the priorities of the CCMP.
- Improve coordination among partner organizations to minimize duplication, while leveraging additional education and outreach opportunities.
- Effect better two-way interaction with stakeholders and target audiences, including communities with environmental justice concerns.
- Include an education and outreach component in science and research projects by BBP and its partners.
- Establish BBP recognition for all projects, programs, and events that are part of the CCMP and funded in all/or part by the BBP.
- Provide for measurable outcomes and regular evaluation.

11.3. Implementation

The BBP's CEC made significant progress in implementing the recommended actions in the Communication Plans. Accomplishments include the following:

- Conducting a Communication and Education Grants Competition annually to support innovative projects which increase public understanding of the bay's ecology and human impacts, promote stewardship of the bay's resources, and encourage public engagement in protecting and restoring the bay
- Development of a new logo and brand style guide for use in all BBP communications.
- Website redesign and expansion of social media outreach.
- Inclusion of an education and outreach component in science projects funded by the BBP.
- Outreach to new audiences (*e.g.,* Spanish speaking residents, tourists, and communities with environmental justice concerns).
- Production of new outreach materials, including publications (*e.g.,* "Going Native") and videos.
- Development of a new website, "Jersey-Friendly Yards," to educate property owners about best landscaping practices.
- New citizen science opportunities, including the "Paddle for the Edge" shoreline assessment project.
- New volunteer opportunities, including the Barnegat Bay Volunteer Master Naturalist Program.
- Annual Education and Outreach Retreat to promote collaboration between watershed educators.

Figure 11.1. Getting ready to kayak at Sedge Island. Photo courtesy of BBP.

11.4. Next Step: Revision

The BBP has reviewed and begun revising the Communication Plan with the goal of supporting the objectives and actions in the new CCMP. Social media outreach and marketing strategies will be incorporated into this revised Communication Plan, scheduled for completion in 2021.

CHAPTER

12

PARTNERSHIP SUCCESS STORIES

12.1. STAC- and CEC-Funded Science and Outreach Projects

Since its inception, the BBP has provided funding for (1) research projects that advance scientific understanding of the estuary and (2) education and outreach projects that increase awareness and promote watershed stewardship. The availability of funding for projects is announced publicly as a grant funding opportunity (GFO) focused on CCMP priority topics; the GFO includes an application identifying eligibility, funding amounts, priority topics, target audiences (in the case of education and outreach projects), and deadlines and other requirements. Letters of interest (LOIs) submitted in response to the GFO are reviewed by BBP staff; those submitting LOIs consistent with the announcement are invited to submit full proposals. BBP committee members and external reviewers review and rank project proposals based on pre-determined evaluation criteria and in accordance with BBP conflict of interest policies. The Advisory Committee recommends final selection and funding decisions to the Program Office, which ultimately contracts with the principals and manages all projects.

STAC-Funded Research Projects

Since 2003 the BBP has funded more than 38 research projects in topics across all priority areas.

Table 12.1. STAC-funded research projects from 2001-2018.

12.1 Organization	Project Title	Fiscal Year
Rutgers University	Barnegat Bay Build-out Analysis	2001
Rutgers University	Establishment of a Biodiversity Index for the Barnegat Bay-Little Egg Harbor Estuary	2002
USGS	An Analytical Framework For Evaluating Present And Future Watershed Inputs to the Barnegat Bay-Little Egg Harbor Estuary	2003
Rutgers University	Submerged Aquatic Vegetation and Benthic Habitat Mapping for the Barnegat Bay-Little Egg Harbor Estuary	2003
Rider University	The Effect of Artificial Shoreline on Habitat Quality and Mortality of Blue Crabs (*Callinectes sapidus*)	2004
Ocean County Soil Conservation District	Sub-aqueous Vegetation Sediment Classification System and Mapping Study for the Barnegat Bay	2005
Montclair University	Assessing Harmful Macroalgal Blooms on Submerged Aquatic Vegetation	2005
Rutgers University	GIS Based Tool for Riparian Zone Health Assessment	2005
Rutgers University	Demographic Investigation of Submerged Aquatic Vegetation in Barnegat Bay	2005
Birdsall Inc.	Silver Bay Bacterial Source Tracking	2006
Birdsall Inc.	FC/FS Sampling in Long Swamp Creek Watershed	2006
USGS	Assessment of Shallow Groundwater Quality Indicator	2006
Rider University	The Impacts of Artificial Shoreline on Species Diversity	2007
Rider University	Assessing Population Structure, Reproductive Potential and Fishing Efforts for Blue Crab in Barnegat Bay	2008
USGS	Determining Sources of Nitrogen Inputs to Barnegat Bay-LEH Estuary	2008
Rutgers University	Development of Nutrient Pollution Indicators for the BB-LEH Estuary Using Eelgrass	2008
Rutgers University	SAV Remote Sensing and in situ survey of SAV in BB	2009
USGS	Evaluating Present and Future Watershed Inputs to the BB-LEH, Nitrogen Inputs to Groundwater	2009
ALS	An Analysis of pollution reduction Capability of Existing BMPs Located in the TR Sub-watershed of BB	2009
Rider University	Assessing Population Structure, Reproductive Potential, and Movement of Adult Blue Crab in Barnegat Bay	2009
Montclair University	Assessment of Sea Nettle Polyps in Barnegat Bay	2009
USGS	Quantifying Sources of Nutrient Inputs to BB-LEH: Monitoring and Discrete Sampling of Streams and Shallow Groundwater	2009
Rider University	Fecundity of BB Blue Crab: The Influence of Size, Seasons, and Relative Fishing Efforts	2010
Rutgers University	Status and Trends of Shellfish Populations in BB with a Focus on Hard Clam	2010
Rutgers University	Implementing American Eel Passage on Existing Dams	2011
USDA-NRCS	Subaqueous Soil Survey of Barnegat Bay	2012
Stockton University	Derelict Crab Trap Identification and Removal in Barnegat Bay	2013
Rutgers University	*In situ* Surveys of Seagrass in Northern Barnegat Bay	2011
OCSCD	Soil Health Improvement Project	2011
Rutgers University	Characterization of Phytoplankton Functional Taxonomic Groups	2012
Stockton University	Modeling Zostera Marina Restoration Potential in Barnegat Bay	2012
Montclair University	Plant and Soil Community Structure in Riparian Soil Nutrient Retention	2013

12.1 Organization	Project Title	Fiscal Year
Stockton University	Assessing the Status of Barnegat Bay Submerged Aquatic Vegetation	2015
Stockton University	Barnegat Bay-Little Egg Harbor Oyster Spat Settlement Evaluation	2016
Rutgers University	Restoration Planning for Hard Clams in Barnegat Bay	2016
Stockton University	Barnegat Bay Oyster Reefs: Biological and Cost Benefit Analyses	2016
Stockton University	Barnegat Bay Seagrass Monitoring	2017
USGS, UNCW	Seagrass Vulnerability to Climate Change in Barnegat Bay	2018

CEC-Funded Public Outreach and Education Projects

Since 2002, the BBP has funded more than 70 education and outreach projects that support the priorities in the CCMP and BBP Communication Plan. Funded projects have included outreach to communities with environmental justice concerns and under-targeted audiences, such as Spanish-speaking residents.

Table 12.2. CEC-funded education and outreach projects from 2001-2018.

12.2 Recipient	Project Title	Fiscal Year
Forked Mountain River Coalition	Documentation of Rare, Threatened & Endangered Species in the Headwaters of the Middle Branch of the Forked River	2002
Ocean County Voc. Technical School	Lesson Plans for Guardians of Barnegat Bay video	2002
NJ Audubon Society	Seniors on the Bayshore	2002
Alliance for a Living Ocean	Barnegat Bay Watch Monitoring Program 2	2002
DM Group Inc.	Advanced Water Recycling System	2002
NJ Society of American Foresters	Watershed-Friendly Demonstration Garden	2004
Barnegat Bay Decoy & Baymen's Museum, Inc.	Tuckerton Seaport Horseshoe Crab Project	2004
Save Barnegat Bay	Restoration & Conservation Programs at Island Beach State Park	2004
Jersey Shore Council of Boy Scouts of America	Scouting Out the Bay	2004
Anastasia Nast Roda	LBI – Not Just Another Vacation Spot	2004
Seaside Park Recreation Department	"S.P.E.N.D." the Day in the Park	2004
Literacy Volunteers of Ocean County (LVA)	Literacy Volunteers for Barnegat Bay	2004
Ocean County Soil Conservation District	Environmental Educator's Roundtable	2004
ALO	Eco Tour of a Barrier Island	2004
OCVTS	Incorporating Barnegat Bay Research Directly into the Classroom at all Levels	2004
Rutgers Cooperative Extension of Ocean County	What the Bay HINGES On	2004
Ocean Nature and Conservation Society	Nature Discovery Backpacks	2005
Barnegat Bay Decoy & Baymen's Museum, Inc.	Family Summer Science Project	2005
Pinelands Preservation Alliance	Up Close & Personal: Pinelands Curriculum	2005
Crawford Rodriguez Elementary School	Metedeconk Watershed Map Deck	2005
OCSCD	Blue Card Training Program	2005
Natural Resource Education Center of NJ	Experience Barnegat Bay	2005
Master Gardeners of Ocean County	2008 Master Gardeners Calendar	2006

12.2 Recipient	Project Title	Fiscal Year
Long Beach Island Foundation of the Arts & Sciences (LBIF)	Marine Science Program	2006
Save Barnegat Bay	Student Scholarship Program	2006
Jersey Shore Council of Boy Scouts of America	Nature Activity Trail	2006
Georgian Court University	Increasing Water Conservation Awareness	2006
Toms River Regional Schools	Environmental Service Learning Project	2006
OCVTS	Citizens and Educators Stewardship Program	2006
New Jersey Audubon Society	Ecosystem Education	2006
The Crab Chix, LLC	Horseshoe Crabs: Pretty as a Picture?	2006
Borough of Point Pleasant Beach	Pet Waste Stations	2006
Parkday Organization	Multimedia Barnegat Bay Watershed Map	2007
LBIF	LBI Blue Pages	2007
Stockton University	Sedge Island Natural Resource Education Center Marine and Estuarine Habitat Course – Volunteer Master Naturalist Certificate Program	2007
Berkeley Township Elementary School	Potter Creek Crusaders	2007
Borough of Point Pleasant	Earth Day Education Program	2007
South Toms River Municipal Alliance	South Toms River Rain Garden	2007
American Littoral Society	Speaking for the Bay	2007
OCSCD	Rain Gardens as Outdoor Classrooms	2007
ALO	Shellfish, Fish and a Healthy Bay	2007
Bay Head Environmental Commission	Rain Garden	2008
Nellie F. Bennett Elementary	Learning Today for a Cleaner Barnegat Bay	2008
Borough of Lavallette	Island Bay Front Gardens	2008
Master Gardeners of Ocean County	2010 Master Gardeners Calendar	2008
NJ Audubon Society	Teaching Inquiry Through Environmental Investigations In the Barnegat Bay Watershed	2008
Ocean County Board of Agriculture	Sustainable Landscapes Education Project	2008
LBIF	Coastal Rain Garden	2008
Borough of Seaside Park	Native Vegetation Garden Walking Tour	2008
The Berkeley Shores Homeowners' Civic Association	Allen Road Beach: A Living Shoreline	2009
Girl Scouts of the Jersey Shore	Water, Water Everywhere But not a Drop to Drink	2009
Borough of Seaside Park	Multi-objective Stormwater Management Demonstration Projects for Coastal Communities (Phase II)	2009
Tuckerton Seaport & Baymen's Museum	Just Enough: Working the Cycle Past, Present and Future	2009
St. Stephen's Episcopal Church	A Garden of Native Plants	2009
LBIF	Got Milkweed	2009
Conserve Wildlife Foundation of NJ	Barnegat Bay Birder-in-Residence Program	2009
Lake Riviera Middle School	Kettle Creek Crusaders	2009
Island Beach State Park	Harvest the Bay	2013
ReClam the Bay	Shellfish in the Classroom	2013
Meadows of Lake Ridge Homeowners Association	A Pathway to Possibilities	2013
LBIF	Discovery Fridays in Spanish	2013
Conserve Wildlife Foundation of NJ	Businesses for a Healthier Bay	2013
Conserve Wildlife Foundation of NJ	Barnegat Bay Turtle Gardens: Supporting Living Shorelines to Safeguard Terrapins for Sea Level Rise	2015

12.2 Recipient	Project Title	Fiscal Year
OCSCD	From Lawn to Garden – Going Green, Saving Green!	2015
Boating Education and Rescue	Everything Eventually Ends Up in the Water	2015
Cedar Hollow Consulting and Bob Birdsall Photography	Streaming the Rivers and Creek in the Barnegat Bay Watershed	2015
Church of the Visitation, Visitation Relief Center	The Beneficial Indigenous Plants Project	2015
Ocean County Soil Conservation District	Experience Jersey-Friendly Yards!	2017
BTMUA	Greening Your Landscape While Protecting the Watershed	2017
Borough of Beach Haven	Conserve Water and Reduce Pollution at the Native Garden	2017

12.2. BBP Decision-Making: Using the Best Available Science

One hallmark of all National Estuary Programs is their commitment to utilizing sound science to provide a good foundation for decision-making. Embracing this commitment, in 2009-2010 BBP's Science and Technical Advisory Committee, comprised of the BBP staff and expert technical partners, developed a research prospectus identifying outstanding science information gaps and research needs to advance our understanding of the bay's condition and its challenges. The 2010 *Barnegat Bay Prospectus: Monitoring, Assessment, And Research Priorities For The Barnegat Bay-Little Egg Harbor Ecosystem To Support Science-Based Watershed Management*

provided the foundation for the monitoring, research, and other activities undertaken as part of the NJDEP's 2010 Barnegat Bay Initiative. Much of this monitoring and research was later published as Special Issue #78 of the Journal Of Coastal Research titled *A Comprehensive Assessment of Barnegat Bay-Little Egg Harbor, New Jersey*. In turn, this science helped generate considerable public support and guided additional efforts and investment in bay protection and restoration[2].

12.3. Success Stories: Water Quality

Reducing Nutrient Pollution from Residential Landscapes: Development and Passage of the Statewide Fertilizer and Soil Restoration Laws

One hallmark of the National Estuary Program is its commitment to making decisions based on the best available science.Sometimes, such efforts require pulling together information from diverse disciplines, identifying critical issues and data gaps, and building consensus across audiences with conflicting agendas.

In 2009, NJDEP developed the Healthy Lawns – Healthy Waters Initiative as part of its effort to address nonpoint source pollution.In support of the initiative, the BBP STAC reviewed the available science developed and reached consensus on two separate memoranda, one on fertilizer (Barnegat Bay Partnership, 2009a) and one on soil health (Barnegat Bay Partnership, 2009b).The fertilizer memorandum was based entirely on a review of available science elsewhere, whereas the soil health memorandum was based on pioneering science conducted on soil permeability in the Barnegat Bay watershed (Ocean County Soil Conservation District *et al.*, 2001).Each document represented agreement among the many different interests and perspectives among BBP partners. To address data gaps and further build on these documents, Rutgers University's Agriculture Experiment Station, Institute for Turf Science, and Water Resources Research Institute, teamed up with the NJDEP and BBP to co-sponsor a Nutrient Management Summit, which resulted in a technical document entitled *Summary of the Summit Meeting on the Role of Nutrient Management in Urban and Suburban Landscapes in Nutrient Loading of Surface and Ground Waters* (New Jersey Agriculture Experiment Station *et al.*, 2010).Together, these documents provided a critical foundation to the development and passage of a statewide fertilizer law and statewide soil restoration act, which both benefitted from tremendous advocacy from non-governmental advocates of the BBP's management conference, most notably Save Barnegat Bay and the American Littoral Society.

Statewide Fertilizer Law

The New Jersey Fertilizer Law (New Jersey Act, P.L. 2010, c. 112; C.58:10A-64, signed January 5, 2011) established statewide fertilizer standards in an effort to reduce nutrient pollution from fertilizers. Implemented in three phases over several years, the law:

- sets standards for fertilizer content, requiring at least 20% slow release nitrogen content and eliminating all phosphorus, except for application on new lawns and certain fertilizers made from recycled biosolids;
- restricts the amount of nitrogen used in a single application and the total amount applied in a year;

Statewide Fertilizer Law, continued

- sets limits for when and where lawn fertilizer can be applied by homeowners and landscape professionals; and
- requires professional applicators to be trained and/or certified in proper fertilizer use.

Presently, the law is being fully implemented; however, the efficacy of the law in reducing nutrient loadings to the bay has not yet been assessed. See NJDEP's Healthy Lawns – Healthy Waters web page for the latest information regarding implementation of the state's fertilizer law.

Statewide Soil Restoration Act

The New Jersey Soil Restoration Act (P.L. 2010, CHAPTER 113, signed January 5, 2011) required that the N.J. Secretary of Agriculture and the Commissioner of the NJDEP, through the State Soil Conservation Committee, propose modifications to the existing statewide soil erosion and sediment control standards to set limits to soil compaction in the Barnegat Bay watershed and across the state, and thus improve infiltration and reduce NPS pollution throughout New Jersey. In 2017, the N.J. Department of Agriculture proposed and adopted compaction standards for new development that are included in the Technical Standards for Soil Erosion and Sediment Control in New Jersey (New Jersey Department of Agriculture, 2017). The NJDEP is also developing a model ordinance to apply the soil restoration standards for both new construction and redevelopment projects and support additional soil restoration.

At present, soil restoration is required when critical compaction (*i.e.*, root-limiting compaction) occurs when a subsoil resistance of 300 pounds per square inch (psi) occurs at 6 inches or less (New Jersey Department of Agriculture, 2017). This standard has been criticized for not adequately reducing bulk density of soils to an adequate depth on new development and thus not ensuring adequate infiltration of water. In addition, the procedure for testing compliance with the law is inadequate. NJDEP proposed that Barnegat Bay communities and counties consider developing and adopting a more effective standard as part of its Phase 2 Plan for the Barnegat Bay.

Figure 12.0

Reducing Nutrient Pollution from Residential Landscapes: Jersey-Friendly Yards

In 2012, the NJDEP awarded the BBP a 319(h) grant to develop a comprehensive online resource, Jersey-Friendly Yards, to help New Jersey property owners understand the complex issues associated with non-point source pollution and implement best management practices in their own yards. The website brings together multiple state-specific resources and provides web-based tools, including a searchable plant database, to encourage and assist property owners to landscape for a healthy environment and cleaner water. It guides users through the 8 steps to a Jersey-Friendly Yard: 1) plan before you plant, 2) start with healthy soil, 3) water wisely, 4) fertilize less, 5) minimize risks when managing pests, 6) reduce lawn size, 7) create wildlife habitat, and 8) reduce, reuse, recycle in the yard. These steps support the four priorities in the CCMP and encourage stewardship actions by watershed citizens. Since Jersey-Friendly Yards launched in 2015, more than 1900 users have registered on the site to save the plant lists they generate using the searchable database.

Reducing Nutrient and Pathogen Pollution: the Ocean County Pump-Out Boat Program, the New Jersey Clean Vessel Act (CVA) Program, and the No-Discharge Zone

Various locations around the Barnegat Bay (*e.g.*, Tices Shoal, F-Cove) have long been recognized as gathering spots for hundreds of recreational boaters; these spots have also been recognized for a variety of water quality problems, especially after a long weekend. In 1998 the Ocean County Board of Commissioners, OCPD, and OCUA established a Pump-out Boat Program to supplement land-based sewage pump-out facilities in service at marinas in Ocean County waters. The boats have been highly successful in addressing the needs of non-marina-based boats, such as those moored in open waters or in lagoon developments. With OCPD, OCUA, and NJDEP funding, six full-time sewage pump-out boats currently provide services from Memorial Day through September for free. A seventh boat, the Circle of Life, which was the first pump-out boat in anywhere in NJ, continues to be operated on a part-time schedule during peak times. Through the 2019 boating season, the pump-out boats removed about 1.9 million gallons of waste

Figure 12.1. Ocean County pump-out boat, 2018. Photo courtesy of OCPD.

from about 90,055 recreational vessels that could have otherwise have ended up in the Bay. (See OCPD [2020] for additional information.) In its 22nd year of operation, this service continues to be critical in assuring the continued designation of the Bay as a "No Discharge Zone" and protecting the Bay from effluent pollution discharge.

Established in 1994, the New Jersey's Clean Marina Program uses federal and New Jersey Clean Vessel Act funds to fund most of the cost of installing pump-out stations at marinas and public facilities along New Jersey's coastal waters. A portion of the cost is also provided by the State of New Jersey through the "Shore to Please" license plate program. The Clean Marina Program is overseen by the NJDEP Coastal Management Office and the New Jersey Sea Grant Consortium, and includes representatives from the JCNERR, Manasquan River Watershed Association, Marine Trades Association of New Jersey, NJDOT Office of Maritime Resources, PDE, Rutgers Cooperative Extension, U.S. Coast Guard Auxiliary, and the BBP on its Steering Committee. As a result of this partnership, there has been a tremendous increase in the number of pump-out stations available to area boaters over the last 15 years. Most of the state's "Clean Marinas" are located in Barnegat Bay.

Several years later the NJDEP, BBP, and other partners took a number of steps, which ultimately led the USEPA to designate the Barnegat Bay-Little Egg Harbor estuary complex a No-Discharge Zone (33 U.S.C. 1322) in June 2003. In a No-Discharge Zone, it is illegal to discharge even treated effluent.

Reducing Nutrient and Pathogen Pollution: Source-Tracking at Beachwood Beach

Using a "find it and fix it" approach, the NJDEP's Pollution Source-Tracking program targets improvements in water quality that have been degraded by NPS pollution and sewage infrastructure failures. The NJDEP implemented a five-step process involving work with local partners to perform intensive monitoring to narrow down and identify sources and solutions to problems. NJDEP and BBP partners performed a Source Tracking project at a recreational bathing beach on the Toms River in Beachwood Borough in 2015-17. The site, Beachwood Beach West, had frequent closures, with as little as 0.1 inches of rain resulting in exceeded beach standards. Sampling upstream and downstream of the bathing area during various weather and tidal conditions resulted in the identification of two nearby stormwater outfalls as the main sources of pollution.

Beachwood Borough, along with Ocean County, developed a plan to connect the two outfalls and relocate the discharge away from the beach. The borough also inspected nearby sewer lines, identified some cracks, and made repairs in July 2017. These actions reduced the number of beach closures during rain events totaling less than 0.5 inches. Closures still occur with rain events larger than 0.5 inches due to other sources, and investigations continue to track down pollution sources along the Toms River that impact this beach.

The NJDEP will be funding a source tracking study for the Toms River through a grant to Clean Ocean Action (COA), which has been investigating and responding to pathogen impairment of the Navesink River watershed since 2015. COA's Toms River project will use advanced monitoring techniques to identify potential cross-connections between the sanitary and stormwater systems and other infrastructure issues in the Toms River watershed. This information will be used to implement corrective measures and water quality improvements, thereby reducing closures of recreational bathing beaches on the Toms River.

12.4. Success Stories: Water Supply

Water Supply Plan Update

As described previously, in 2017 the NJDEP released the New Jersey Water Supply Plan 2017-2022 (NJDEP, 2017b), which addresses the protection and management of the state's water supplies. The 2017-2022 plan is the second comprehensive revision to the NJWSP, and it is designed to be a "living" resource that can be updated on a continuous basis as new data becomes available.

NJDEP/USGS Hydrologic Monitoring and Water Supply Studies

Streamflow and groundwater levels at many sites in the Barnegat Bay watershed are monitored on a continuous or recurring basis by the USGS, in cooperation with and primarily funded by the NJDEP and others. The USGS/NJDEP cooperative program also monitored tidal flow continuously at the Point Pleasant Canal, Barnegat Inlet, and

Figure 12.2. The N.J. Water Supply Master Plan.

Figure 12.3. Save the Source Campaign. Image courtesy of the PPA.

Little Egg Inlet in support of the development of the hydrodynamic model of the bay. At present, these and other water quality data streams, including BBP-generated data, are made available online at the Barnegat Bay Monitoring Project Website (NJDEP, 2020a) and affiliated websites (*e.g.*, NJDEP, 2020b).

Several scientific, watershed-scale studies have been conducted by the USGS in cooperation with and funded primarily by the NJDEP to assess water levels in confined and unconfined aquifers, the effects of groundwater withdrawals on streamflow, and the extent to which the groundwater system is susceptible to potential saltwater intrusion into near-shore supply wells. Results of these studies informed the 2017-2022 Water Supply Plan. A USGS study (Defne *et al.*, 2017) in cooperation with NJDEP developed a hydrodynamic model of the bay that describes circulation patterns and residence times and provides the framework for modeling water quality. The hydrodynamic model was recently reviewed by a Model Evaluation Group (MEG) comprised of external reviewers to determine its validity as a foundation for modeling nutrients and determining the Barnegat Bay's nutrient total maximum daily load; the MEG review is under consideration by NJDEP.

Pineland Preservation Alliance's Water Conservation Campaign: "Save the Source"

"*Save the Source*" is a campaign by Pinelands Preservation Alliance to protect the Kirkwood-Cohansey Aquifer, a 17 trillion-gallon reserve of fresh water that underlies southern New Jersey and all of the Pinelands. Protecting the quantity and quality of water in the aquifer is critical for freshwater supplies for humans and for the bay's ecosystem. In addition to supporting the strengthening of water policy to protect the aquifer, the campaign encourages everyone to take steps to conserve water. A series of videos on the Save the Source website tell the stories of the importance of the aquifer to the region, including two specifically about the Barnegat Bay (*i.e.*, "Priming the Bay and Our Seafood Buffet" and "Barrens to Bay: An Aquifer Flows to It").

12.5. Success Stories: Living Resources

Shellfish Working Group Recommendations

The BBP Shellfish Working Group (SWG) is an *ad-hoc* STAC committee originally formed in May 2014 to review the conclusions and recommendations of the BBP sponsored white paper, *Status and Trends of Hard Clam, Mercenaria mercenaria, Shellfish Populations in Barnegat Bay, New Jersey* (Bricelj *et al.*, 2012), and develop short-, medium-, and long-term research, rehabilitation, and policy recommendations that the BBP and its partners could pursue as part of an overall shellfish restoration program. The Shellfish Working Group used that initial recommendation document to support additional BBP-funded activities.

Oyster Reef Restoration Program

In 2016, the BBP funded a partnership among Stockton University, the American Littoral Society, and Parsons Mariculture LLC to establish an oyster restoration program throughout the Barnegat Bay. The goals of this project were to establish oyster populations in the bay and increase public awareness of the ecological and economic benefits of healthy oyster beds. Researchers planted young oysters at one northern and one southern site in the Barnegat Bay during 2016 and then compared restoration methods and monitored survival rates at two sites in the bay over the next two years.

Both sites have built rich oyster reef communities, complete with resident fish and crab species (including blennies, oyster toadfish, tautog, black sea bass, mud crabs, and blue crabs). The reefs have shown promise as a tool to rebuild a viable commercial harvest and to help re-establish sustainable oyster populations within the Barnegat Bay system. The BBP awarded a second grant to Stockton University in 2019 to enlarge the reef and continue monitoring.

Hard Clam Modeling

In 2016 and 2017, a joint Rutgers University, USGS, and BBP team collaborated on a STAC-funded research project to modify the USGS-developed hydrodynamic model to aid in the understanding of how hard clam larvae are dispersed throughout the bay. The model demonstrated that specific regions in the southern bay may serve as effective sources of hard clam larvae, supplying nearly all of the rest of the system. In 2018, the Rutgers Film Center created the documentary titled *RU a Happy Clam?* about the importance of shellfish restoration and the efforts underway to rebuild clam populations in the Barnegat Bay.

Figure 12.4. RU a Happy Clam? Rutgers University researchers study hard clams in the Barnegat Bay. Photo courtesy of Rutgers University.

Figure 12.4-1. Shell added to the Tuckerton oyster reef restoration site. Photo courtesy of Stockton University.

Figure 12.5. Survey of osprey nest being tended by Conserve Wildlife of New Jersey. Channel markers and other man-made structures are occasionally used by ospreys and other birds as nesting sites. Photo courtesy of Northside Jim.

Osprey Rebound

The return of ospreys to the Barnegat Bay watershed is an encouraging wildlife management success story. Ospreys (*Pandion haliaetus*) are well-loved birds of our coastal bays and marshes. Formerly known as the fish hawk, ospreys rely almost exclusively on fish for their diet. Much like eagles and falcons, the osprey had succumbed to the effects of DDT, habitat loss, and persecution, which contributed to a population decline to about 60 pairs statewide by the early 1970s. Since inclusion on New Jersey's Endangered Species List in 1973, the osprey population has shown a steady increase, with 668 pairs of ospreys observed nesting throughout New Jersey in 2017, exceeding historic numbers of approximately 500 nesting pairs pre-DDT exposure (Wurst and Clark, 2018). In the Barnegat Bay watershed, there were 112 active nests in 2017, the most in any watershed in New Jersey (Wurst and Clark, 2018). The Barnegat Bay watershed nests averaged 1.34 young per nest in 2017, more than twice the number needed for a stable population (Wurst and Clark, 2018).

Figure 12.6. BBP Field technicians monitoring wetlands. Photo courtesy of BBP staff.

Wetland Monitoring: Mid-Atlantic Coastal Wetlands Assessment (MACWA)

Tidal wetlands in New Jersey are critically imperiled by overdevelopment and sea level rise. Recognizing a need to coordinate monitoring of the extent and condition of tidal wetlands in New Jersey, the BBP and the Partnership for the Delaware Estuary (PDE) collaborated in 2009 to establish an integrated wetland monitoring program for the Barnegat and Delaware Bays, known as the Mid-Atlantic Coastal Wetlands Assessment (MACWA). Data consistently collected across long-term reference and other sites in Barnegat Bay, Delaware Bay, and other estuaries helps informs wetland and other resource managers working to protect and enhance wetlands or priority biotic resources.

This monitoring initiative expanded on USEPA's three-tier wetlands guidance by including an Intensive Studies component. Monitoring consists of remote sensing analysis, rapid assessments, and long-term fixed station monitoring, and special studies of wetlands in

Figure 12.7. A 2015 volunteer citizen scientist collects data and takes a photo at a shoreline monitoring site on Barnegat Bay. Photo courtesy of BBP staff.

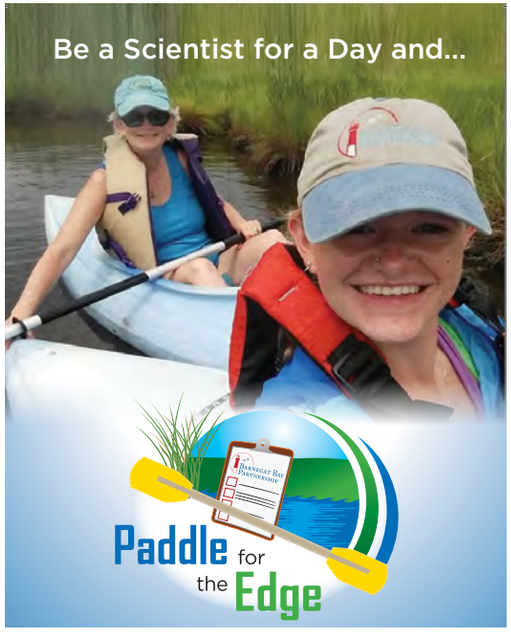


Figure 12.8. Paddle for the Edge promotional (left) and map showing data points collected (right).

both estuaries. Of the nine continuously monitored sites in New Jersey, four are in the Barnegat Bay watershed: Reedy Creek, Island Beach State Park, Dinner Point, and Horse Point. The BBP and PDE work closely with other MACWA partners, including the NJDEP, USEPA Region 2, and US Fish and Wildlife Service; MACWA has been supported by USEPA Wetlands Program Development Grants and NJDEP Section 319 (h) program funding. The MACWA has been incorporated into NJDEP (2019c) State Wetlands Monitoring Plan.

Citizen Science Shoreline Monitoring: "Paddle for the Edge

In 2015, the BBP launched *Paddle for the Edge*, a citizen science shoreline monitoring project. Each year, trained volunteers paddle the bay to collect important data about shoreline conditions using a smartphone app. The data are useful to planners and resource managers by providing information about flooding and storm impacts, predicting how shorelines may react to sea level rise, and identifying potential wetland restoration areas. By the end of 2019, volunteers had paddled a total of 101.6 miles of shoreline and collected 5,368 data points.

12.6. Success Stories: Land Use

Trust for Public Land's Barnegat Bay 2020 Plan

Barnegat Bay 2020: A Vision for the Future of Conservation (Trust for Public Land, 2008) outlined the future of a rejuvenated watershed by making a case for land conservation as a water quality protection tool; identifying the highest priority parcels to protect; evaluating land for passive recreational access and use; and enhancing the scenic quality of the watershed. The Barnegat Bay 2020 report built upon the Century Plan (Trust for Public Land, 1995), which led to the acquisition of almost 24,000 acres throughout the watershed. The TPL 2020 report pulled together regional stakeholders (local, state, and federal agencies, educational institutions, and other non-governmental organizations, including the BBP) to identify the most important remaining open space and to renew our commitment to its protection.

Ocean County Natural Lands Trust and the Ocean County Parks and Recreation Department

Since 1997, the Ocean County Natural Lands Trust Program (OCNLT) has established a system of protected lands which, in combination with the Farmlands Preservation Program, enhances the quality of life in Ocean County by helping to maintain the county's rural characteristics; protect critical environmental resources and water supply; maintain and enhance active agriculture; and buffer areas not compatible with development. The program generates more than $10 million annually for natural lands acquisitions

Figure 12.9. The Trust for Public Land's Barnegat Bay 2020, A Vision for the Future of Conservation.

Figure 12.10. OCNLT property along Tuckerton Creek in 2019. Photo courtesy of the OCPD.

Figure 12.11. Monmouth County's Metedeconk River Greenway (top) and Turkey Swamp County Park (bottom). Photo courtesy of Monmouth County Planning Department.

and farmland preservation. Between 2010 and 2015, approximately 11,114 acres in the Barnegat Bay watershed were acquired by federal, state, county, local, and non-governmental agencies for conservation purposes. The OCNLT also coordinates and leverages funding with federal, state, municipal, and private programs, including NJDEP Green Acres and Blue Acres Programs, Pinelands Commission, Department of Defense, US Fish and Wildlife Service's Edwin B. Forsythe National Wildlife Refuge (EBFNWR), and private land trust organizations. Examples of such acquisition efforts include the Brick Township portion of the EBFNWR at Reedy Creek, the Barnegat Township portion of the EBFNWR at Good Luck Point, and more than 5,000 acres of buffer around Joint Base Fort Dix Maguire Lakehurst. Properties acquired by the OCNLT are administered by the OCPD and maintained by the Ocean County Parks and Recreation Department with the assistance of many other county departments.

Monmouth County Parks System Expansion

The Monmouth County Parks System established the 457-acre Metedeconk River Greenway to protect water quality and wildlife habitat along the Metedeconk River. This greenway helps protect and buffer floodplains from adjacent land use and development. The Park System is preserving land along the Metedeconk stream corridor in conjunction with similar efforts in the Ocean County portion of the watershed. It also expanded the 2,266-acre Turkey Swamp County Park within the Metedeconk River subwatershed; this wooded park features camping and other outdoor venues, including miles of trails and a 17-acre lake for fishing, boating, and ice-skating.

Pinelands National Reserve and Management Plan

The New Jersey Pinelands Commission (NJPC) protects the Pinelands through implementation of the Pinelands Comprehensive Management Plan (PCMP) (New Jersey Pinelands Commission, 1981). The PCMP contains the rules that guide land use, development, and natural resource protection programs in the state Pinelands Area. The NJPC was granted the authority to preserve this special part of New Jersey through the passage of the National Parks and Recreation Act of 1978 (P.L. 95-625; 92 STAT. 3469) and the New Jersey Pinelands Protection Act (N.J. 13:18A-1 *et seq.*)

Figure 12.12. View from Apple Pie Hill Fire Tower. Photo courtesy of John Bunnell.

in 1979. Fifty-three municipalities within seven counties in the Pinelands Area have incorporated the PCMP into their municipal plans to help enforce protection of the Pinelands within their communities. Similarly, BBP aims to have municipalities in the watershed reference the BBP's CCMP in their municipal plans.

The PCMP, established in 1981, has been very successful in preserving the unique Pine Barrens ecosystem, particularly in pristine headwater areas of the bay's watershed. The PCMP incorporates landmark regional land use and environmental controls and is responsible for the permanent protection of large tracts of forest and extensive wetland systems. In addition to protecting large tracts from development, the PCMP incorporates a nitrogen dilution model to ensure that development does not exceed the assimilative capacity of the environment. The water quality of the lower tributaries of Barnegat Bay stands as a testament in part to the success of the PCMP.

Metedeconk Watershed Restoration and Management Plan

The Brick Township MUA completed a comprehensive watershed protection and restoration plan for the Metedeconk watershed (Brick Township Municipal Utility Authority, 2013). The main goals of the plan are to preserve the Metedeconk River as a viable water supply source for the region and to protect the health of the Barnegat Bay watershed by reducing NPS pollution, eliminating water quality impairments, addressing TMDLs, and attaining compliance with the surface water quality standards throughout the watershed. The plan includes a prioritized listing of projects/management actions that will help protect the Metedeconk watershed. Subsequent to the state's approval of the plan, the Brick Township MUA acquired funding from several agencies and organizations, including the BBP, to implement projects to enhance water quality.

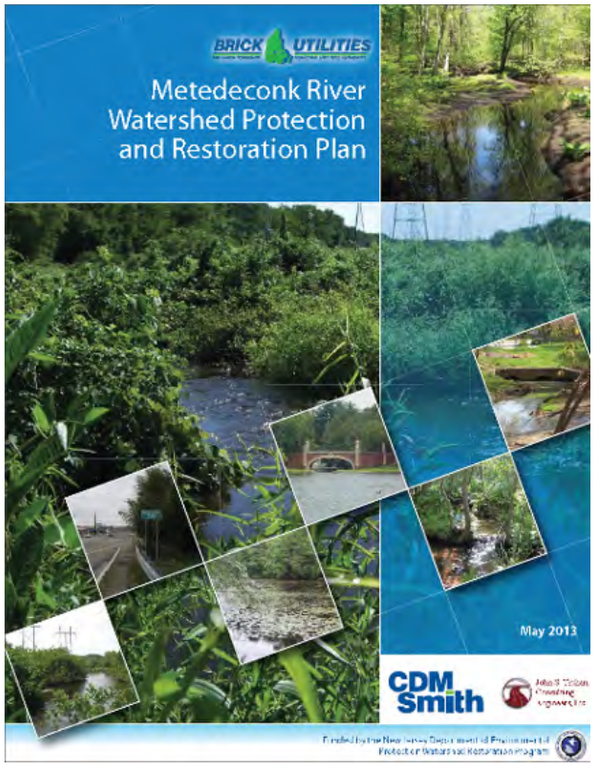


Figure 12.13. The BTMUA 2013 Metedeconk River Watershed Protection and Restoration Plan.

NJDEP's Coastal Zone Management Program

The BBP's CCMP is recognized as part of the NJ Coastal Zone Management Program (NJCMP). The NJCMP is part of the National Coastal Zone Management Program, which addresses some of today's most pressing coastal issues, including sustainable and resilient coastal community planning, climate change, ocean planning, and planning for energy facilities and development. The NJCMP is comprised of a network of offices within the NJDEP that serve distinct functions yet share responsibilities that influence the state's coastal areas. An important aspect of the NJCMP is ensuring that coastal resources and ecosystems are conserved as a key part of local, state, and federal efforts to enhance sustainable coastal communities.

Critical Habitats Management: Ecologically Sensitive Areas Designation

In 2001, the New Jersey Legislature passed a Joint Resolution supporting establishment of a marine conservation zone for the Sedge Islands area near Island Beach State Park and directing the Department of Environmental Protection to consider the establishment of other marine conservation zones in environmentally sensitive areas. To reach a spectrum of the recreational boating community, a three-pronged approach was enacted in 2012 that included public education in responsible boating practices. In 2014, the NJDEP established the Sedge Island Marine Conservation Zone via Administrative Order 2014-09. The overall purpose of the Marine Conservation Zone was to protect the aquatic and adjoining riparian habitats of the zone and its living resources.

In support of this purpose, a number of related goals were established: 1) to reduce environmental impacts of personal watercraft; 2) to better manage wildlife, recreational activities, and traditional uses of the area; 3) to provide a learning environment for interpretation of the natural and cultural history; to conduct research, monitoring, and assessments to better understand the system; 4) to manage access and reduce user conflicts; and 5) to supplement statutes and regulations with new management approaches to protect biodiversity. In support of these goals, commercial crabbing and clamming were prohibited.

To help address the adverse effects associated with motorized boating activities in Barnegat Bay, a network of ecologically sensitive areas (ESAs) were identified (Lathrop *et al.*, 2016) to receive special consideration and management. The boundaries for these ESAs were based on a GIS interpretation of both habitat natural features (*e.g.*, shellfish beds, submerged aquatic vegetation) and living resources (*e.g.*, presence of endangered species, hard clam densities, and proximity to shorebird nesting areas) and recognized impacts (*e.g.*, prop scarring in eelgrass beds). The mapping clearly showed extensive prop scarring in these ESAs, confirming that some form of spatial zoning, with slow speed regulations or outright closures, was warranted to protect submerged aquatic vegetation.

Other research (Jivoff *et al.*, 2017) suggested that additional protections to these Ecologically Sensitive Areas could have positive impacts for blue crabs, shellfish, and submerged aquatic vegetation.

Figure 12.14. Map of the Sedge Island Conservation Zone courtesy of the NJDEP.

12.7. Success Stories: Climate Change And Sea Level Rise

Climate Ready Estuaries Program

In recognition of Barnegat Bay's vulnerability to climate change impacts, the BBP received funding through the United States Environmental Protection Agency's "Climate Ready Estuary Program" to support research, planning, and outreach activities to address future impacts of climate change.

Adapting to climate change and sea level rise is a local challenge that requires site-specific remedies. As Superstorm Sandy and other recent storm events have demonstrated, local planners and managers need access to detailed information on critical infrastructure that is potentially at risk, as well as tools to plan and prepare for the future. To address these needs, two new online tools have been developed for use in New Jersey: NJ Flood Mapper and Getting to Resilience.

New Jersey Flood Mapper

The NJ Flood Mapper is an interactive mapping tool that provides ready access to sea level rise simulations and FEMA flood/storm surge maps, along with the location of key facilities, coastal evacuation routes, and social and environmental vulnerabilities. Through a user-friendly Google Maps platform, the website helps users visualize different flooding scenarios and their potential impacts. Users can see how sea level rise from one to six feet and coastal flooding events will affect key facilities – hospitals, schools, police, and fire stations – and emergency evacuation routes. Users can also print their maps and share them electronically with others, and they can see on-the-ground photo visualizations of sea level rise and flooding impacts at iconic Jersey Shore locations.

Getting to Resilience

Developed to be used in association with NJ Flood Mapper, Getting to Resilience is the next step in community planning for the risks associated with climate change and sea level rise. Getting to Resilience is an online self-assessment tool developed to assist communities in reducing vulnerability and increase preparedness by linking planning, hazard mitigation, and adaptation. A Getting-to-Resilience questionnaire was developed to be completed by a set of individuals from a community and over a period of time. Creating an account allows key municipal officials and staff to work together on one set of answers. Participants in the online assessment include land use planners, hazard mitigation planners, floodplain managers, emergency managers, stormwater managers, natural resource planners, municipal engineers, municipal leaders, zoning and permitting officials, and public works officials.

Figure 12.15. Getting to Resilience webpage. Image courtesy of JCNERR.

Through the interactive Getting-to-Resilience process, communities learn how their preparedness can yield valuable points with voluntary programs like FEMA's Community Rating System and Sustainable Jersey. The assessment process will also increase the community's understanding of where future vulnerabilities should be addressed through hazard mitigation planning.

Ocean County's All-Hazards Mitigation Plan

In 2011, the Ocean County Office of Emergency Management began the process of compiling the county's multi-jurisdictional All-Hazards Mitigation Plan. The BBP was asked to participate on the Steering Committee and provide technical support and input to the plan concerning future climate risks that might affect Ocean County. Approved by FEMA in 2013, the plan was the first approved county-wide plan in New Jersey to include climate risks. In 2018, BBP provided technical support to the County on the five-year update to Ocean County's multi-jurisdictional All-Hazards Mitigation Plan, released in June 2019.

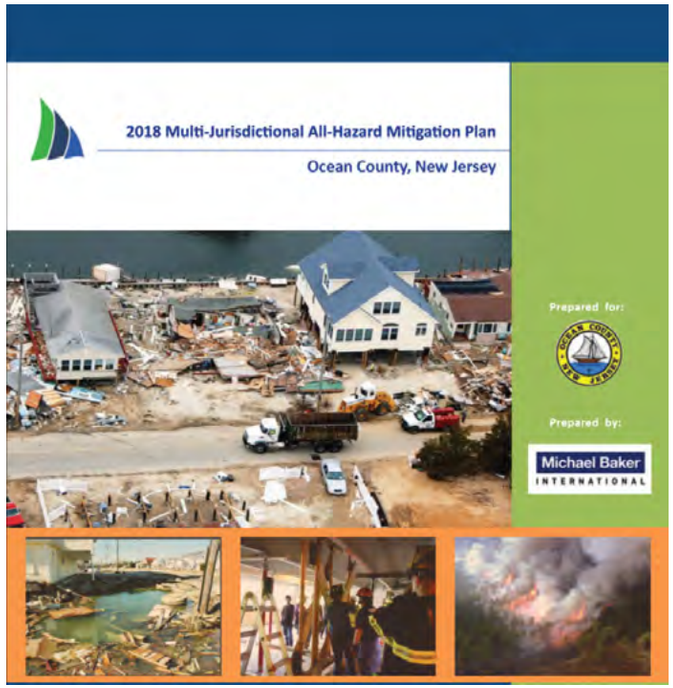


Figure 12.16. The Ocean County 2018 Multi-Jurisdictional All-Hazards Mitigation Plan.

Study of Economic Vulnerability and Adaptation to Climate Change

With funding provided by a grant from the USEPA Climate Ready Estuaries Program, the BBP contracted with Rutgers University to study economic vulnerabilities to climate change and adaptation options in the Barnegat Bay region of New Jersey. The study, *Economic Vulnerability and Adaptation to Climate Hazards and Climate Change: Building Resilience in the Barnegat Bay Region*, (Leichenko *et al.*, 2013), drew on stakeholder knowledge of the region, including their understanding of existing development stresses, in order to identify critical economic vulnerabilities to climate change and identify feasible options for adaptation. The study paid particular attention to key economic assets and activities that may be at risk from climate change, concluding that Ocean County had among the most vulnerable populations to climate change and sea level rise due to the large number of elderly and retired people living on fixed incomes and the large number of people working for small, family-owned businesses. Information collected for this BBP-funded study was also included in broader comparative studies in New Jersey (Leichenko *et al.*, 2014), which further emphasized the vulnerability of communities in Ocean and other counties to sea level rise and climate change.

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GLOSSARY

Accretion: an increase by natural growth or by gradual external addition; growth in size or extent.

Adaptive Management: a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously meets one or more resource management objectives and accrues information needed to improve future management.

Biodiversity: the range of variation (species richness) found among microorganisms, plants, fungi, and animals that form complex assemblages of communities and ecosystems.

Carbon Sequestration: the trapping of a carbon in the atmosphere or environment and its isolation in a natural or artificial storage area.

Ecological: relating to the interactions between living organisms and their environment.

Ecosystem: a community of living organisms, their physical environment, and their interrelationships within a particular area.

Ecosystem-Based Management: a place-based approach to natural resource use that aims to restore and protect the health, function, and resilience of entire ecosystems for the benefit of all organisms.

Ecosystem Services: the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems. Ecosystem services are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits.

Estuary: a coastal area where freshwater from rivers and streams mixes with saltwater from the ocean.

Eutrophication: increase in the amount of organic matter in a water body caused by excessive nutrients or other factors.

Flood Plain: an area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

Green Infrastructure: methods of water management that use vegetation, soils, and other elements to restore some of the natural processes for managing water on a site.

Greenhouse Gas: any gas which has the property of absorbing infrared radiation emitted from the earth's surface and re-radiating it back, thus contributing to a warming of the earth's surface and atmosphere.

Groundwater: the water beneath the surface of the ground, consisting largely of surface water that has seeped down, the source of water in springs and wells.

Harmful Algal Bloom (HAB): the rapid growth of algae that can cause harm to animals, people, or the local ecology. A HAB can look like foam, scum, or mats on the surface of water and can be different colors. HABs can produce toxins that have caused a variety of illnesses in people and animals. HABs can occur in warm fresh, marine, or brackish waters and are becoming more frequent with climate change.

Hydrology: the science that encompasses the occurrence, distribution, movement, and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle.

Impervious: not allowing the passage of water.

Invasive Species: species (plants, animals, or pathogens) that are non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health.

Low Impact Development: an innovative approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.

Marine Spatial Planning: a process that aims to organize the use of the ocean space, as well as the interactions among human uses (*e.g.*, fisheries, aquaculture, shipping, tourism, renewable energy production) and between users and the marine environment.

Mitigation: an action or activity intended to remedy, reduce, or offset known negative impacts.

MS4 Permits: a term from the federal nonpoint source pollution permitting program. Polluted stormwater runoff is commonly transported through municipal separate storm sewer systems (MS4s), from which it is often discharged untreated into local waterbodies. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a NPDES (National Pollutant Discharge Elimination System) permit and develop a stormwater management program.

Non-Point Source Pollution: pollution that comes from many diffuse sources. It generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient Cycling: the movement and exchange of organic and inorganic matter back into the production of living matter.

Reforestation: the process of replanting an area with trees.

Resiliency: ability to recover or adapt to disturbances or stresses in the environment.

Riparian Buffer: area of natural vegetation along a waterway that provides protection from excessive runoff and pollution.

Sea Level Rise: an increase in the level of the world's oceans due to the effects of global warming. While the elevation of mean sea level and the rate of rise (or fall) has fluctuated dramatically over the course of time, global mean sea level has been rising during the last 10,000+ years, and the accelerated rate of sea level rise since the mid-19th century is considered a result of human-induced climate change.

Sedimentation: the deposition or accumulation of sediment.

Soil Functions: general capabilities of soils providing a range of essential services, such as storing and purifying water, recycling nutrients, serving as a medium for plant growth, and providing habitat for soil organisms.

Storm Surge: an abnormal rise in the level of the sea along a coast caused by the onshore winds of a severe storm, such as a hurricane.

Stormwater Runoff: unfiltered water from storm events that reaches streams, lakes, bays, and oceans by means of flowing across impervious surfaces. These surfaces include roads, parking lots, driveways, and roofs. Stormwater often contains pollutants including fertilizers, petroleum products, pesticides, and pathogens.

Stormwater Retrofit: reconfiguration and reconstruction of existing local drainage systems to better address erosion, stream protection, and water quality goals.

Submerged Aquatic Vegetation (SAV): rooted plants that grow completely underwater except for periods of brief exposure at low tides.

Subsidence: the sinking of land to a low or lower level.

Sustainable: able to be maintained at a certain rate or level.

Thin-Layer Placement: the purposeful placement of sediment or dredged material in a manner that produces a specific layer of thickness or ground surface elevation necessary to achieve the overall project objectives.

Total Maximum Daily Load (TMDL): a regulatory term in the U.S. Clean Water Act that identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Turbidity: the quality of being cloudy, opaque, or thick with suspended matter.

Vernal Pool: a unique type of wetland habitat, typically small, shallow, ephemeral water bodies. Unlike a pond or a lake, they have no permanent inlet or outlet. They are filled each spring by rain and snow melt, then dry up for a period of time during the summer. These qualities of vernal pools distinguish them from other wetlands, and they support several species of animals that require these temporary wetland habitats for survival.

Watershed: an area of land draining to a specific body of water.

A APPENDIX A

Status of 2002 CCMP Action Items and Crosswalk to 2021 CCMP

The following table shows the status of Action Items from the 2002 Barnegat Bay CCMP and whether they are included in the 2021 CCMP.

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
Water Quality and Water Supply Action Plan						
5.01	Development of Total Maximum Daily Loads for areas listed on the 303(d) list of impaired waterbodies.	High	NJDEP	$300K	Ongoing	Included in 2021 CCMP in WQ1-1.
5.02	Complete a high-intensity Natural Resources Inventory to identify pollution sources from land use information and site conditions.	High	OCSCD, NRCS, OCPD, municipalities	$375K	Ongoing	Included in 2021 CCMP in WQ1-2.
5.03	Retrofit retention or detention basins, and retrofit stormwater basins to increase infiltration and recharge of rainfall runoff.	Medium	NJDEP, OCPD OCSCD	$200K	Ongoing	Included in 2021 CCMP in WQ1-5.
5.04	Implement Phase II Municipal Stormwater Rules in the BB Watershed.	High	NJDEP, OCPD, BBNEP, Envir. Joint Ins. Fund	Base Program	Ongoing	Included in 2021 CCMP in WQ1-4.
5.05	Encourage native species landscaping to minimize water use and fertilizer and pesticide application.	Medium	BBNEP, OCSCD, NJDEP	Base program	Ongoing	Included in 2021 CCMP in LR3-6.
5.06	Develop a financial incentives mechanism, *"Water Quality Rebate,"* for implementing BMPs on non-federal, non-agricultural lands.	Medium	OCSCD	$75K	Dropped	No action due to lack of funding and changing perspectives.
5.07	Institute the Nonpoint Education for Municipal Officials (NEMO) program within the BB watershed.	Medium	Rutgers Cooperative Extension, OCPD	$65K	Ongoing	Included in 2021 CCMP in WQ4-1.
5.08	Promote existing technical and financial assistance programs to implement soil management practices on agricultural lands.	Medium	USDA-NRCS, OCPD, OCSCD	$20K	Dropped	No action due to changing priorities.

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
5.09	Identify and reduce water quality problems from livestock farms and manure piles	Low	USDA-NRCS, OCPD, OCSCD, NJDEP DWM	$66K	Ongoing	Included in 2021 CCMP in WQ1-10.
5.10	Develop a management strategy to reduce the congregation of Canada Geese populations in urban areas.	Medium	Ocean County Health Department		Ongoing	Included in 2021 CCMP in WQ1-10.
5.11	Sample and analyze water to evaluate fertilizer and pesticide residues introduced into surface water systems.	Medium	Rutgers Cooperative Extension	$37K	Completed	
5.12	Continue publication of "Pesticides for NJ" to include site-specific recommendations for the use of pesticides on golf courses and public lands.	Medium	Rutgers Cooperative Extension	$1K	Dropped	Changes in pesticide regulations regarding application and training.
5.13	Promote *Home *A*Syst for the BB Watershed* (RCE, 1998) through widespread distribution.	Medium	Rutgers Cooperative Extension	$7K	Dropped	No action due to lack of funding and changing priorities.
5.14	Periodically examine technical and permit data on small point source discharge permit holders in order to promote and maintain understanding of their relationship to the overall ecological health of the bay.	Medium	BBNEP STAC	$1,500	Ongoing	Included in 2021 CCMP in WQ 1-11.
5.15	Periodically examine technical and permit data on the Oyster Creek Nuclear Generating Station in order to promote and maintain an understanding of its relationship to the overall ecological health of the bay.	Medium	NJDEP, BBNEP STAC	$2,500	Ongoing	Included in 2021 CCMP in WQ1-11.
5.16	Eliminate the discharge of boat sewage into the bay by promoting the use of sewage pump-out facilities.	High	NJDEP Clean Vessel Program (CVA/CMP), NJMSC, OCPD, MTANJ	Base Program	Ongoing	Included in 2021 CCMP in WQ1-8.
5.17	Acquire a sewage pump-out boat for BB and its major tributaries.	High	CVA, OCPD	$57K	Completed/ ongoing	Seven pump-out boats have been acquired to date by Ocean County and its partners; included in 2021 CCMP as WQ1-8.
5.18	USEPA designation of BB as a No Discharge Zone.	High	NJMSC, OCPD	$15K	Completed	
5.19	Develop Clean Marinas Program	High	MTANJ, OCPD	$10K	Ongoing	Included in 2021 CCMP in WQ1-8.

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
5.20	Establish a comprehensive water supply plan for the BB watershed that will guide water supply development, use, and reuse through the year 2040 and, to the maximum extent possible, maintain the natural hydrology of the watershed.	High	NJDEP, OCPD, OCSCD	$500K	Ongoing	Included in 2021 CCMP in WS1-3.
5.21	Develop a workplan and institute controls for management of water demand/water conservation.	High	NJDEP, OCPD, OCSCD	$125K	Ongoing	Included in 2021 CCMP in WS1-3.
5.22	Integrate existing shallow groundwater protection programs.	High	NJDEP		Ongoing	Included in 2021 CCMP in WS1-1.
5.23	Establish a network of three weather stations in the watershed tied to the South Jersey Resource Conservation and Development RISE network.	Low	South Jersey Resource Conservation & Development, OCPD	$7K	Completed	
5.24	Establish a demonstration project for wastewater reuse, which will be discharged back to the watershed, and which alleviates the need for potable water for irrigation of lawns, golf courses, or other public areas.	Medium	OCUA, OCPD		Ongoing	Included in 2021 CCMP in WS5-1.
5.25	Assist municipalities in their involvement in the NJDEP Shellfish Waters and Bathing Beaches protection strategies for the BB watershed.	High	Toms River, Seaside Heights, NJDEP, BBP STAC	$500K	Ongoing	Included in 2021 CCMP in WQ3-1.
Habitat and Living Resources Action Plan						
6.01	Protect and improve vegetated buffer zones adjacent to coastal wetlands and freshwater tributaries to maintain continuous riparian corridors, for habitat protection and low-impact recreational pursuits.	High	NJDEP, OCPD	$37K	Ongoing	Included in 2021 CCMP in LR1-1, LR3-3, and LU1-3.
6.02	Conduct a BB ecosystem restoration feasibility study.	High	USACE, NJDEP	$2,500K	Completed	
6.03	Control erosion in threatened shoreline areas.	Low	NJDEP, OCPD	$75K	Ongoing	Included in 2021 CCMP in LR1-2, LR1-5, and LU2-2.
6.04	Manage tidal wetlands to preserve un-ditched wetlands and to rehabilitate wetlands that have been ditched or otherwise altered.	Low	USFWS, OCPD	$15K	Ongoing	Included in 2021 CCMP in LR1-2, LR3-2, LU2-1 and LU2-2.

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
6.05	Maintain intact large blocks of Pinelands habitat within state parks and forests and other publicly owned lands.	Medium	NJDEP, OCPD	$25K	Ongoing	Included in 2021 CCMP in LR1-2, LR1-4, LR1-5, and LU1-3.
6.06	Implement more effective enforcement of regulations regarding sensitive coastal habitats.	Medium	State and federal law enforcement agencies	$50K	Completed	
6.07	Coordinate and integrate management of federal lands for natural habitat values.	Medium	USDOD, MAFPE	$50K	Ongoing	Included in 2021 CCMP in LR1-4.
6.08	Facilitate partnerships for habitat protection and restoration projects.	High	NJDEP, OCNLT, NRCS, ONLM, TPL, OCPD		Ongoing	Included in 2021 CCMP in LR1-2, LR1-4, LR1-5.
6.09	Revise municipal master plans to encourage subwatershed planning to minimize impervious coverage and maintain natural habitat and landscape values.	High	NJDEP, OCPD, municipalities	$100K	Ongoing	Included in 2021 CCMP in LU3-2 and LU3-3.
6.10	Assess the effectiveness of CAFRA II regulations within the BB Coastal Zone Boundary.	Low	NJDEP		Completed	
6.11	Identify and manage impaired sub-watersheds through local government cooperation to address water resource issues that cross municipal boundaries.	Medium	USEPA, OCPD	$50K	Ongoing	Included in 2021 CCMP in WQ1-1 and LU1-3.
6.12	Develop a cooperative approach among the Pinelands Commission, state parks, state wildlife management areas, state forests, and other state agencies to coordinate watershed protection on state lands.	Medium	NJDEP, Pinelands Commission, OCPD	$50K	Ongoing	Included in 2021 CCMP in LU1-3 and LU2-2.
Human Activities and Competing Uses Action Plan						
7.01	Draft a BB personal watercraft (PWC) management strategy, thereby setting an example for statewide policy.	High	PWC Task Force	$10K	Completed	
7.02	Promote the use of the "Boater's Guide to BB and Little Egg Harbor" to protect sensitive areas by mitigating boater impacts to water quality and natural resources.	Medium	RCE, MTANJ, OCPD	$20K	Completed	
7.03	Follow-up the Municipal Outreach Project with continued production of "Community Connection" newsletter and with a community awards program.	Medium	BBWEF	$10K	Ongoing	Outreach continued part of LU5-4.

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
7.04	Use environmental commissions to foster the watershed approach.	Medium	BBNEP, municipal environmental agencies	Base Program	Ongoing	Included in 2021 CCMP in LU1-1, LU3-2, and LU4-3.
7.05	Support the BB Watershed and Estuary Foundation (BBWEF) to protect BB and its watershed resources.	High	Municipal and county governments, OCPD	$55K	Foundation suspended operations.	To be considered in development of CCMP Financial Strategy.
7.06	Establish a BB Blue Card certification program on soil health, low-input landscapes, and balancing the water cycle.	Low	OCSCD, OCPD	$75K	Completed	
7.07	Use data and information from the Natural Resources Inventory (NRI) to promote the use of Best Management Practices (BMPs).	Low	OCSCD	$75K	Ongoing	Included in 2021 CCMP in WQ2-1, WQ4-2, and LU5-5.
7.08	Design and construct environmentally sensitive demonstration gardens in all municipalities.	Low	Rutgers Cooperative Extension, OCPD	$35K	Ongoing	Included in 2021 CCMP in WQ1-3, WQ4-2, and LU5-5.
7.09	Construct an environmentally sensitive demonstration lawn for homeowners to use as a model for landscaping plans.	Medium	RCE, OCSCD, NJDEP, BBNEP	$6,500	Completed	
7.10	Conduct shellfish resource survey of the bay to examine potential causes of stock decline and meat discoloration in hard shell clams and explore resource enhancement strategies so than an adequate supply of shellfish exists to reap the benefits of improved water quality resulting from Action Item 5.24 in the Water Quality/Water Supply Action Plan.	Medium	NJDEP	$190K	Completed	
Public Participation and Education Action Plan						
8.01	Post the Pinelands Curriculum Guide Lessons for Grades 4-6 and 7-8 on the World Wide Web.	Low	Pinelands Commission	$20K	Completed	
8.02	Conduct 2 two-day summer teacher workshops through the Ocean County Vocational-Technical School (OCVTS) that focus on the BB estuary and watershed.	Medium	OCVTS	$5,100	Completed	
8.03	Revise and reprint the BB Watershed Educational Resource Guide.	Medium	BB Environmental Education Roundtable	$5K	Completed	

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
8.04	Conduct an annual Environmental Educators Roundtable.	Medium	OCSCD	$3K	Ongoing	Included in CEC Communication Plan as part of revised CCMP.
8.05	Support the *Sea Grasses for Classes* Project-Institute of Marine and Coastal Sciences (IMCS), Rutgers University.	High	RU/ JCNERR	$55K	Completed	
8.06	Develop the Forest Resource Education Center (FREC) as a resource and interpretive center that promotes an understanding of the human and resource connections and a stewardship ethic among students, scouts, and the general public.	Medium	NJDEP, OCPD	$20K	Completed	
8.07	Develop a BB Water-shed Education Campaign to be imple-mented in elementary schools via a mascot, "Barnie the Crab."	Medium	BB Watershed and Estuary Foundation	$60K	Dropped	No interest due to availability of online resources.
8.08	Develop a BB watershed-specific activity guide.	High	OCSCD, OCPD	$60K	Completed	
8.09	Continue the Alliance for a Living Ocean eco-tour of a barrier island for school children and the public.	Medium	Alliance for a Living Ocean	$5K	Ongoing	Programming of partners included in CEC Communication Plan as part of revised CCMP.
8.10	Promote the development and use of outdoor classrooms.	Medium	OCSCD, OCPD	$5K	Ongoing	Programming of partners included in CEC Communication Plan as part of revised CCMP.
8.11	Establish a Bay Keeper Program as a public watchdog for the protection of BB.	Low	Water Keeper Program	$60K	Com-pleted[1]; ongoing	
8.12	Create a BB-specific educational guide outlining the natural and cultural ecotourism opportunities in Central New Jersey, with an emphasis on the BB watershed region.	Low	NJMSC	$20K	Completed	
8.13	Establish one water-way cleanup per year within the BB watershed.	Medium	MTANJ, BBWEF, COA	$10K	Ongoing	Included in 2021 CCMP in WQ1-9 and in CEC Communication Plan

1 Established by American Littoral Society in 2011 (https://www.littoralsociety.org/barnegat-bay.html).

2002 CCMP Action Item #	2002 CCMP Action Item Title	2002 CCMP Priority	2002 CCMP Lead/Partners	2002 Cost Estimate	Status	Crosswalk to 2021 CCMP/Comments
8.14	Provide interpretive exhibits, programs, and activities focusing on the historical human uses of the environ-mental resources within the BB watershed.	High	BB Decoy and Baymen's Museum	$2K	Ongoing	Programming of partners included in CEC Communication Plan as part of revised CCMP.
8.15	Provide education and technical training to local government officials and other coastal decision- makers in the BB watershed.	High	JCNERR	$893K	Ongoing	Included in 2021 CCMP in LU5-1 through LU5-5.
8.16	Revise and reprint the "Low-Maintenance Landscaping Homeowners' Guide."	Medium	OCSCD, RCE, OCPD	$35K	Completed	Included in 2021 CCMP in WQ4-2 and LU5-5.
8.17	Educate professional landscapers, municipal grounds personnel, and facility managers on more efficient and environmentally sensitive use of pesticides.	Medium	RCE	$25K	Completed	
8.18	Promote the use of IPM methods.	Medium	RCE, OCSCD	$26K	Ongoing	Included in 2021 CCMP in WQ1-6, LR4-2, and LU5-5.
8.19	Incorporate BBNEP outreach and education displays and programs at the Ocean County Environmental Learning Center.	Low	OCVTS, OC Environmental Learning Center	$40K	Completed	
8.20	Experience Barnegat Bay, a project of YES.	Medium	NREF	$150K	Completed	

B APPENDIX B

Objectives and Actions for Water Quality

Goal

To protect and improve water quality throughout Barnegat Bay and its watershed by addressing the causes of water quality degradation to achieve swimmable, fishable, and drinkable water, and to support aquatic life.

Time Frame

The time frame from adoption of the CCMP in which the action should be completed. Short (S) indicates completion within 1-2 years, Medium (M) actions within 5 years, and Long (L) actions within 10 years. Steps (*e.g.*, 1a, 1b, etc.) are listed in chronological order; initial steps are generally shorter-term than later steps, unless noted.

Cost Range

The anticipated costs of action components:

- $ < $100K
- $$ = $100K - $500K
- $$$ = $500K - $1 Million
- $$$$ > $1 Million

Priority

High, Medium, or Low

Climate

CCMP actions likely impacted by one or more climate stressors, potentially inhibiting implementation, are shaded. See Chapter 8 for details.

WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Objective 1:	**Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution.**			
WQ Action 1-1; High	**Support development and implementation of a Barnegat Bay TMDL(s) (Total Maximum Daily Load), including the development and use of Barnegat Bay-specific biological indices of water quality, to address nutrient and other pollutant loadings and to guide future, science-based management decisions.** **Metrics:** Nitrogen and other pollutant reductions to be determined by NJDEP TMDL process. **Milestones:** 1-1a: Review relevant nutrient and other pollutant loadings and other information as available and make recommendations to establish and implement TMDL based on best available science. 1-1b: Promote information exchange and consensus building on implementation priorities and make recommendations based on best available science. 1-1c: Promote, support, and conduct monitoring and planning to help inform and guide decision-making. 1-1d: Using best available science and giving due consideration to climate change, promote adaptive, ecosystem-based management to achieve nutrient reductions and ecosystem targets.	**Partners:** NJDEP, USEPA, USGS, BBP **Lead(s):** NJDEP **Funding Sources:** USEPA CWA 104(b)(3) and 319; DEP State Revolving Funds, EIT	Ongoing S M L M	 $ $$ $$$ $$$
WQ Action 1-2; High	**Develop and implement watershed plans at the sub-watershed level.** **Metrics:** Number of plans developed, funded, and implemented together with estimated nutrient reductions. **Milestones:** 1-2a: Using NJDEP WQ and other data, develop WQMP/Section 319 and other watershed-based plans. 1-2b: Identify, promote and support funding of plan development. 1-2c: Implement plans and estimate nutrient and other pollutant reductions.	**Partners:** Counties, Municipalities, Utility Authorities (208 Plan), BBP, NJDEP (approval) **Lead(s):** Counties, Municipalities, Utility Authorities (208 Plan), BBP, NJDEP (approval) **Funding Sources:** CWA Section 319 and 320; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	Ongoing M M L	 $ $ $$$$

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-3; High	**Implement the Soil Restoration Law and associated comprehensive soil restoration procedures for various land use activities.** **Metrics:** Numbers of inspections performed and percent compliance. **Milestones:** 1-3a: Implement existing and/or develop revised (county or statewide) soil restoration standard with supporting assessment and cost-benefit justification. 1-3b: Work with partners to promote review and consideration of soil restoration standard. 1-3c: Once adopted, assist with implementation of soil restoration standard. 1-3d: Reassess program after five years.	**Partners:** NJDA, NJDEP, NJDOT, Counties, Municipalities, Soil Conservation Districts **Lead(s):** Soil Conservation Districts **Funding Sources:** NJDA Section 251; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	Ongoing M M L M	 $ $ $$ $
WQ Action 1-4; Medium	**Support implementation and enforcement of stormwater rules and ordinances at state, county, and municipal levels.** **Metrics:** Increase and improve compliance with rules and MS4 permits through NJDEP Municipal Stormwater Compliance Assistance Program (MSCAP); DEP, BBP, and municipalities review compliance annually to develop priority list for subsequent actions by municipalities. **Milestones:** 1-4a: Develop Municipal Stormwater Compliance Assistance Program with Toms River as the pilot (include Objectives 1-5 to 1-7 below, where feasible). As part of the program, identify possible sources of nutrient loading and other water quality stressors and work with township officials toward solutions. 1-4b: Develop recommendations for Toms River compliance/improvement. 1-4c: Develop schedule to conduct compliance assistance visits in municipalities within the watershed to improve overall compliance with MS4 requirements and achieve nutrient loading reductions throughout the watershed. 1-4d: Initiate review and recommendations to make improvements. 1-4e: Reassess MSCAP after five years.	**Partners:** NJDEP, USEPA, Counties, Municipalities, Soil Conservation Districts, SBB, Others TBD **Lead(s):** NJDEP, NJDOT, Municipalities **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	Ongoing S M M M M	 $$ $ $$$ $$ $

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-5; Medium	**WQ 1-5: Address nonpoint source pollution through stormwater basin management and restoration.** **Metrics:** Increase in 1) comprehensive mapping (see above) of stormwater basins by municipalities and other SW reporting entities; 2) stormwater basin assessment, prioritization, and restoration plans by those same entities; and 3) implementation basin restoration construction to reduce stormwater loadings of nitrogen, phosphorus, TSS, pathogens, and other pollutants. **Milestones:** 1-5a: Work with counties, municipalities, and their partners and volunteers to increase comprehensive mapping of stormwater basins. 1-5b: Develop assessment programs (*e.g.*, infiltration, nutrient management) and maintenance schedules for stormwater basins, and identify related infrastructures and/or areas of concern (*e.g.*, repetitive flooding). 1-5c: Promote and assist development of efforts to repair and restore stormwater basins.	**Partners:** NJDEP, USEPA, Counties, Municipalities, Schools & other entities for public complexes, Soil Conservation Districts, BBP, SBB **Lead(s):** NJDEP, Municipalities, Public complexes with SW permits **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	Ongoing M M L	 $$ $$ $$$$
WQ Action 1-6; Medium	**Identify sources and reduce pollution inputs from roadways and yard maintenance (*e.g.*, pesticides, herbicides, fertilizer, deicers, and automotive waste).** **Metrics:** Reductions in chemical usage and/or increases in green alternatives via regular reporting by responsible stormwater entities; annual reporting and review of required maintenance operations (*e.g.*, roadside sweeping); and identification of pollution hotspots or other problems. **Milestones:** 1-6a: Regular reports of chemical usage and application policies and green alternatives by stormwater permittees. 1-6b: Review roadway waste, flooding, and other information (tributary data) to identify problem "hot spots" for each municipality or other responsible agency. 1-6c: Develop improvement plans directed at priority areas within each municipality.	**Partners:** Municipalities, Counties, Schools/other entities with public complex permits, NJDOT, NJDEP **Lead(s):** Municipalities, Counties, Schools/other entities with public complex permits, NJDOT, NJDEP **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	Ongoing S M M	 $$ $$ $$$

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-7; Low	**Encourage municipalities and counties to map all stormwater BMP facilities/ infrastructure within the watershed associated with major development, and review mapping of stormwater BMPs as an optional element of NJDEP Municipal Stormwater Compliance Assistance Program and a "preferred ranking element" in appropriate NJDEP funding programs.** **Metrics**: County, municipal, and other permittees' lists of all BMPs associated with major development, with summary information regarding project type, features, *etc*. **Milestones**: 1-7a: Develop a plan (*i.e.*, information gathering process, and summary/descriptive information to be collected) for mapping all stormwater BMPs. Any plan should be consistent with information gathered by the NJDEP's locational mapping app. 1-7b: Collect other pertinent summary/descriptive information and map the BMP using the NJDEP mapping app (or other comparable application tool) for locational information. 1-7c: Share the BMP information with the public as a report, online database, interactive website, or in another format.	**Partners:** Counties, Municipalities, Other stormwater permittees, Soil Conservation Districts, NJDEP, RCE, BTMUA, BBP **Lead(s):** Counties, Municipalities, Other stormwater permittees, NJDEP, Soil Conservation Districts, BBP, others TBD **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; HUD Block Grants	S M M	$ $$ $$

WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-8; Medium	**Identify sources and reduce pollution inputs from marinas and boating activities. Assess need for enforcement of priority problems.** **Metrics**: Participation of marinas in pollution source ID and reduction programs and projects; ultimately, a reduction in pollution inputs from marinas and boats. **Milestones**: 1-8 a: Identify marinas identifying pollution sources and their potential improvement projects. 1-8b: Work with marinas, municipalities, and other programs and partners to develop funding mechanisms and implement improvement projects and programs annually. 1-8c: Work with existing programs and partners to reduce pollution from boating (*e.g.*, trash, derelict vessels). 1-8d: Target/fund additional law enforcement, where necessary (*e.g.*, F-Cove, Tice's Shoal), at priority problems (*e.g.*, vessel discharges, boating in shallow habitats, littering [see below]). 1-8e. Continue to support the designation of Barnegat Bay as a No Discharge Zone.	**Partners:** NJDEP Clean Marina and Clean Vessel Program partners (NJSGC, Marine Trades NJ, OCHD, OCUA, Counties including their Health Depts. & Utility Authorities, BBP, Municipalities, USEPA **Lead(s):** NJDEP, NJSGC **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; County Planning Depts. and Utility Authorities; HUD Block Grants	Ongoing M M L L L	 $$ $$$ $$ $$ $$

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-9; High	**Develop, support and implement programs to reduce litter and plastic debris in and around waterways, including coordinating and conducting bay and community clean-ups.** **Metrics**: Reductions in a variety of plastic and other pollutants, some of which have adverse impacts to humans and wildlife, in the environment; reductions in derelict fishing gear in the bay; reductions in single-source plastic bottles used in the watershed; increases in local ordinances to reduce single-use plastic and other containers **Milestones:** 1-9a: Work with partners annually to develop schedule and priority target list of sites to be included in "clean-ups." 1-9b: Work with partners periodically to submit proposals to funders for source reduction project funding. 1-9c: Work with partners to install bottle filling stations at schools, high traffic public sites (*e.g.*, beach boardwalks, parks). 1-9d: Work with partners to assess trash problems created by seasonal/tourist populations and other priority target sources	**Partners:** BBP, USEPA, USFWS, NJDEP, Ocean County Dept. of Planning, Richard Stockton University, Conserve Wildlife Foundation of New Jersey, Clean Ocean Action, Save Barnegat Bay; MATES **Lead(s):** BBP, others **Funding Sources:** USEPA CWA Section 319 and TFW; NOAA Marine Debris; NJDEP Clean Vessel and Clean Marina Programs; Planning Depts. and Utility Authorities.	Ongoing L L L L	 $ $ $$ $
WQ Action 1-10; Low	**Identify sources and reduce pollution inputs from livestock, agriculture, and wildlife.** **Metrics:** Reductions in pollution (nitrogen, phosphorus, pathogen) inputs from livestock and nuisance wildlife (*e.g.*, Canada geese). **Milestones:** 1-10a: Assess nutrient inputs from livestock on farms, ranches, and animal husbandry/ other facilities and other hotspots, such as waterbodies that are pathogen-impaired by Canada geese. 1-10b: Develop plans, including cost estimates, to reduce nutrient loading at locations identified in 1-9a with existing USDA, NRCS, NJDEP, NJDA, and other funding sources. 1-10c: Implement plans as funds allow to reduce nutrients and pathogens. 1-10d: Delist waterbodies via state/federal review processes.	**Partners:** NJDEP (compliance assistance; WMPs); BBP **Lead(s):** TBD (NJDA?) **Funding Sources:** CWA Section 319; DEP State Revolving Funds, EIT; Stormwater Utilities; County Planning Depts.; HUD Block Grants	L L L L	$ $ $$$ $$

B

WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 1-11; Medium	**Address Point Source Pollution from Oyster Creek Nuclear Generating Station, Sewage Conveyance Systems, and Septic Systems.** **Metrics:** Reductions in pollution (*e.g.*, nitrogen, phosphorus, pathogens) inputs from point sources. **Milestones:** 1-11a: Assess impacts of OCNGS closure; explore options for mitigating impacts. 1-11b: Assess and minimize nutrient loads and impacts of sewage conveyance systems (*e.g.*, offshore inputs). 1-11c: Implement septic maintenance program and strategies for mitigating sewer and septic capacity deficiencies.	**Partners:** NJDEP and academic partners; Ocean County Depts of Planning and Health; Monmouth County Div. Planning **Lead(s):** NJDEP, OCUA, OCPD, Pinelands Comm. **Funding Sources:** NRC/OCNGS owner/operator; DEP State Revolving Funds, EIT; County Planning Depts.; HUD Block Grants	Ongoing L L L	 $$$$ $$$$ $$$$
WQ Objective 2:	**Assess status and trends of water quality throughout the watershed.**			
WQ Action 2-1; High	**Identify the current status and trends in water quality within the watershed [NJDEP Integrated Report, BBP State of the Bay (SOTB) Report] and identify pollutant sources and magnitudes.** **Metrics:** Completion of status and trends reporting in NJDEP Integrated Reports and BBP SOTB reports, including estimation of nitrogen and phosphorus source loading on regular schedule (*i.e.*, at least every five years). **Milestones:** 2-1a: Assemble BBP SOTB Workgroup one year prior to anticipated date of publication and develop SOTB QAPP. 2-1b: Complete draft SOTB report for external review. 2-1c: Revise report as per review and publish. 2-1d: Hold BBP-sponsored SOTB Symposium. 2-1e: Review listings of impairments within Barnegat Bay and provide comments to the draft 303(d) list as prepared by NJDEP in accordance with the Clean Water Act. 2-1f: Review "off-year" report for Barnegat Bay watershed.	**Partners:** NJDEP, BBP, USGS, USEPA, BTMUA, others TBD **Lead(s):** NJDEP and BBP **Funding Sources:** CWA Section 106, 319, and 320; DEP State Revolving and other funds, EIT; Stormwater Utilities.	Ongoing S S S S M M	 $ $ $ $ $ $

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 2-2; High	**Maintain, review, and revise as necessary the existing comprehensive water quality ambient monitoring program throughout the watershed.** **Metrics:** The extent of the bay and its tributaries that are covered by the existing comprehensive water quality monitoring program and the water quality parameters (*e.g.*, DO, temperature) that are included in the program. **Milestones:** 2-2a: Conduct periodic review of existing comprehensive monitoring plan findings, including identification of monitoring and data gaps and compilation of problem findings (*e.g.*, exceedance of criteria). 2-2b: Develop cost estimates, justification, and schedule of addressing data gaps in revised monitoring plan.	**Partners:** USEPA, NJDEP, USGS, BBP, JC NERR, OCHD, Monmouth University, Stockton University, BTMUA **Lead(s):** NJDEP **Funding Sources:** CWA Section 106 and 319; DEP State Revolving Funds, EIT; Stormwater Utilities.	Ongoing M M	 $$ $
WQ Action 2-3; High	**Support the existing beach monitoring program, and work with NJDEP, NJDOH, OCHD and LBI Health Department to evaluate possible monitoring strategies for known public recreational areas of high public use.** **Metrics:** Number of areas of high public use where primary contact-recreation is occurring with percentage of those covered by regular/periodic monitoring programs. **Milestones:** 2-3a: Generate annual list of known recreational area of high public use (*e.g.*, Tice's Shoal, F-Cove, Pine Lake, Cedar Creek, *etc.*) which are not recreational bathing beaches as defined in NJ State Sanitary Code, Public Recreational Bathing N.J.A.C. 8:26 Chapter IX, including process to identify those receiving high public use. 2-3b: Identify those to be assessed regularly. If 100% of high-use beaches are not monitored, develop justification for those to share with state and local elected officials. 2-3c: Work with NJDEP, NJDOH, and local municipalities to explore development of agreed-upon signage for non-monitored beaches in impaired waterbodies and/or stream segments.	**Partners:** OCHD, NJDEP **Lead(s):** NJDEP, OCHD **Funding Sources:** CWA Section 106 and 319; DEP State Revolving Funds, EIT; Stormwater Utilities	Ongoing S S M	 $ $ $

WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Objective 3:	**Conduct studies to improve scientific understanding of new and emerging issues pertaining to the chemical, physical, and biological conditions and dynamics in the Barnegat Bay and its watershed.**			
WQ Action 3-1; Medium	**Support completion and expansion of source tracking for bacteria, pathogens, and novel and other pollutants.** **Metrics:** Number of source-tracking studies conducted for bacterial, pathogenic, novel, and other pollutants every five years. **Milestones:** 3-1a: STAC periodically reviews available data of bacteria and pathogenic bacterial and novel contaminant "hotspots" and compiles into draft report. 3-1b: STAC workgroup develops agreed-upon process (*i.e.*, QAPP); prioritizes source-tracking problems into report, distributed to partners and local and state officials. 3-1c: Commit STAC funding, when feasible and available; pursue other funding.	**Partners:** USEPA, NJDEP, OCHD, Counties, Utility Authorities, Municipalities, COA **Lead(s):** NJDEP, OCHD **Funding Sources:** USGS, USDA, CWA Section 106, 319, 320; DEP State Revolving Funds, EIT; Stormwater Utilities.	Ongoing M M L	 S $S $$
WQ Action 3-2; Medium	**Continue to identify and address data gaps and water quality issues of emerging concern (*e.g.* coastal acidification, watershed salinity increases, *etc.*)** **Metrics:** Number of recognized data gaps and identified issues of emerging concern identified by partners and the public compiled and reviewed every five years. **Milestones:** 3-2a: STAC workgroup compiles and reviews available data gaps into draft report. 3-2b: STAC workgroup prioritizes data gaps and issues with funding justification for partners and local and state officials. 3-2c: Commit STAC funding, when feasible and available.	**Partners:** USEPA, BBP STAC, NJDEP, NJPC, USGS **Lead(s):** BBP STAC, NJDEP **Funding Sources:** CWA Section 106, 319, 320; DEP State Revolving Funds, EIT; Stormwater Utilities.	Ongoing M M L	 $ $ $$$

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 3-3; Medium	**Continue to support research that identifies and quantifies the sources and fates of nutrients within the watershed and bay.** **Metrics:** Number of studies of sources and fates of nutrients conducted every five years. **Milestones:** 3-3a: STAC workgroup compiles list of published studies of nutrient sources and fates within past five years and summarizes data gaps for funding consideration with funding justification. 3-3b: Commit STAC funding, when feasible and available.	**Partners:** NJDEP, USGS, USEPA, BBP **Lead(s):** BBP, NJDEP **Funding Sources:** CWA Section 106, 319, 320; DEP State Revolving Funds, EIT; Stormwater Utilities.	Ongoing S L	 $ $$$
WQ Objective 4: Increase public education, engagement, and stewardship regarding water quality in the watershed.				
WQ Action 4-1; Medium	**Implement components of the BBP Communication Plan related to water quality improvement, including impacts from climate change and sea level rise.** **Metrics:** Number of BBP Communication Plan components implemented and their effectiveness. **Milestones:** N/A: Contingent on development of specific programs.	**Partners:** USEPA, BBP, Save Barnegat Bay, JCNERR, NJDEP **Lead(s):** BBP **Funding Sources:** CWA Section 319 and 320; DEP State Revolving Funds, EIT.	Ongoing L	 $$
WQ Action 4-2; Medium	**Share Barnegat Bay-friendly ordinances and establish a Jersey-Friendly Yards certification and training program for homeowners, businesses, and/or landscaping professionals to promote practices that reduce nonpoint source pollution.** **Metrics:** Adoption of ordinances, number of certifications, and number of education recipients implementing best practices. **Milestones:** 4-2a: Review model ordinances, revise as needed, and distribute to municipalities. 4-2b: Develop JFY certification and other education/outreach programs, including those targeting communities with environmental justice concerns. 4-2c: Implement programs with BBP/other funding (*e.g.*, fees).	**Partners:** BBP, OCSCD, RCE, ANJEC, Municipalities **Lead(s):** BBP, OCSCD, Other TBD **Funding Sources:** Clean Water Act Section 319 and 320; DEP State Revolving Funds, EIT.	Ongoing S M L	 $ $$ $$

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WQ Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WQ Action 4-3; Medium	**Assist training and education/outreach programs to help municipalities meet permit compliance (*e.g.*, Tier A and Tier B MS4 permits at Part IV.B.1).** **Metrics:** Number of municipalities fully compliant with training and education outreach requirements; number of ancillary/optional programs with other entities (*e.g.*, businesses, schools, *etc.*) **Milestones:** 4-3a: Identify and review existing stormwater training and education/outreach programs for effectiveness. 4-3b: Use existing and/or develop new training and education/outreach programs for key target audiences, including officials, residences, businesses, schools, and communities with environmental justice concerns.	**Partners:** USEPA, NJDEP, JCNERR, BBP, SBB **Lead(s):** BBP, JCNERR, Other TBD **Funding Sources:** Federal (USEPA, NOAA), JCNERR Coastal Training Program; CWA Section 319 and 320; DEP State Revolving Funds, EIT.	M L	$ $

C

APPENDIX C

Objectives and Actions for Water Supply

Goal

To ensure adequate water supplies and flow in the Barnegat Bay watershed for ecological and human communities now and in the future.

Time Frame

The time frame from adoption of the CCMP in which the action should be completed. Short (S) indicates completion within 1-2 years, Medium (M) actions within 5 years, and Long (L) actions within 10 years. Steps (*e.g.*, 1a, 1b, *etc.*) are listed in chronological order; initial steps are generally shorter-term than later steps, unless noted.

Cost Range

The anticipated costs of action components:

- $ < $100K
- $$ = $100K - $500K
- $$$ = $500K - $1 Million
- $$$$ > $1 Million

Priority

High, Medium, or Low

Climate

CCMP actions likely impacted by one or more climate stressors, potentially inhibiting implementation, are shaded. See Chapter 8 for details.

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Objective 1:	**Protect, maintain and enhance existing surface and groundwater flows.**			
WS Action 1-1; High	**Assess and implement existing shallow groundwater protection programs.** **Metrics**: The number of shallow groundwater protection programs, including local ordinances and project sites **Milestones**: 1-1a: Assess programs (*e.g.*, wellhead protection, rainwater and treated wastewater recharge, and new septic designs) already in place to better address the release of nutrients and anthropogenic compounds to groundwater.	**Partners:** Municipalities, Utilities, NJDEP **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, EIT; Other funding TBD	S	$
	1-1b: Identify areas where programs could be located.		M	$$
	1-1c: Implement programs.		L	$$$$
	1-1d: Evaluate results.		L	$-$$
WS Action 1-2; High	**Determine minimum ecological flow requirements for priority streams, rivers, and wetlands within the watershed.** **Metrics**: Number of waterways with minimum ecological flows determined. **Milestones**: 1-2a: Compile available data and determine where sufficient data exists and where there are data gaps.	**Partners:** USGS, NJPC, NJDEP **Lead(s):** NJDEP and NJPC; USGS **Funding Sources:** DEP State Revolving Funds, EIT; Others TBD	S	$$
	1-2b: Identify priority data gaps and cost estimates, which may be substantial.		M	$$
	1-2c: Perform ecological flow assessments.		L	$$$$
	1-2d: Peer review and publishing of assessments.		L	$

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 1-3; High	**Support comprehensive planning that will guide sustainable water supply management, and, to the maximum extent possible, maintain natural hydrology.** **Metrics**: Percentage of a Barnegat Bay-specific water supply plan completed, and percentage of a Barnegat Bay-specific water supply plan implemented. **Milestones**: 1-3a: Identify plan elements and additional detail needed beyond the existing NJDEP Statewide Water Supply Plan.	**Partners:** NJDEP, Water/ Wastewater Utilities, NJPC **Lead(s):** NJDEP, NJPC **Funding Sources:** DEP State Revolving Funds, EIT; Other funding TBD	M	$$
	1-3b: Develop plan with stakeholder involvement.		M	$$
	1-3c: Implement plan with stakeholders and through the regulatory process.		L	$$$$
	1-3d: Review progress, revise and update plan.		L	$$
WS Action 1-4; High	**Assess HUC 11s for water supply capability related to streamflow, surface, and shallow groundwater withdrawal capacity.** **Metrics**: Number of assessments completed by HUC11 watershed. **Milestones**: 1-4a: Compile available data and prioritize data gaps by HUC 11.	**Partners:** NJDEP, NJPC **Lead(s):** TBD **Funding Sources:** DEP State Revolving Funds, EIT; Other funding TBD.	M	$$
	1-4b: Rank areas in terms of capacity and potential ecological issues, and address data gaps in those HUC 11s.		M	$$$
	1-4c: Publish information to inform regulatory decision-making and guide mitigation.		L	$$$

C

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 1-5; High	**Promote and support land use activities that enhance water supply protection and minimize water withdrawals and usage, especially in the most stressed water supply planning areas as identified in the State Water Supply Master Plan.** **Metrics**: Stabilized water demand figures; acres of land uses with low water demand. **Milestones**: 1-5a: Examine NJ Ambient Ground Water Quality Monitoring data by land use (developed/ undeveloped) to classify per capita and regional water demands. 1-5b: Design groundwater monitoring plan for priority areas. 1-5c: Identify and implement land use changes necessary to stabilize water demands. 1-5d: Evaluate and revise approaches, as necessary.	**Partners:** NJDEP, Municipalities, Land Conservancies **Lead(s):** NJDEP, PC, Ocean and Monmouth Counties, municipalities **Funding Sources:** DEP State Revolving Funds, EIT; Other funding TBD	M M M L	$ $ $$ $$
WS Objective 2: Prevent degradation and encourage efficient use of water supplies.				
WS Action 2-1; Medium	**Inventory and promote municipal land use regulations that emphasize water supply protection as a primary goal.** **Metrics**: Number of municipalities inventoried; number of new municipal regulations/ ordinances. **Milestones**: 2-1a: Identify local regulations/ordinances that are effective in protecting water supplies. 2-1b: Identify municipalities where regulations are in place. 2-1c: Identify water supply sources by municipality. 2-1d: Target promotion of land use regulatory improvements where improvements can be made and with respect to the local water supply source(s). 2-1e: Update inventory and re-promote where needed.	**Partners:** NJDEP, BBP **Lead(s):** BBP, JCNERR, NJ Future, Sustainable Jersey, others TDB **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	S S S M L	$ $ $ $$ $$

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WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 2-2; Medium	**Identify, implement, and support voluntary and mandated conservation and infiltration practices and regulation to maintain and restore base stream flows and natural hydrology.** **Metrics**: Number of ongoing conservation programs and regulations identified, implemented, and supported. **Milestones**: 2-2a: Identify effective water conservation and infiltration practices and programs, both voluntary and mandatory. 2-2b: Build upon existing programs to incorporate new practices, increase effectiveness, and expand coverage across the Barnegat Bay watershed.	**Partners:** NJDEP, Municipalities, Utilities, Pinelands, USEPA **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	M L	$ $$
WS Action 2-3; Medium	**Inventory and evaluate municipal ordinances, and rate structures and other available information for opportunities to better ensure judicious water usage and incentivize water conservation at the household and community levels, including metering all water usage.** **Metrics**: Water use in developed and developing areas **Milestones**: 2-3a: Develop list of strategies to decrease water usage at the household and community level. 2-3b: Pursue opportunities/partners to implement these strategies. 2-3c: Evaluate success.	**Partners:** NJDEP, Municipalities, Utilities **Lead(s):** BBP, others TBD **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	S M L	$ $$ $

C

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Objective 3:	**Monitor and assess status and trends of the water supply throughout the watershed.**			
WS Action 3-1; High	**Conduct shallow aquifer protection monitoring.** **Metrics**: Collection of monitoring data. **Milestones**: 3-1a: Use NJ Ambient Groundwater Quality Monitoring Network to identify representative sites and install additional monitoring wells in priority areas of concern. 3-1b: Collect groundwater quality and water level data at appropriate intervals. 3-1c: Evaluate data and adjust monitoring as necessary; identify areas of concern in a summary report to further implementation of WS 1-1 (*e.g.*, identify potential groundwater protections and mitigation options, where needed).	**Partners:** NJDEP, USGS **Lead(s):** NJDEP, TBD **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	S L L	$$ $$$ $$
WS Action 3-2; High	**Continue to monitor water use trends.** **Metrics**: Availability of current database of water use trends for the Barnegat Bay watershed. **Milestones**: 3-2a: Maintain or, if necessary, expand upon collection of water use data. 3-2b: Periodically evaluate trends. 3-2c: Publish results to inform water supply planning and conservation programs.	**Partners:** NJDEP, USGS **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	M L L	$$ $$ $$
WS Action 3-3; High	**Continue, and if possible expand, stream flow monitoring throughout the watershed to assess the effects of changing precipitation patterns, water use, and development.** **Metrics:** Number of stream-gauging stations in the Barnegat Bay watershed. **Milestones**: 3-3a: Maintain existing gauging stations. 3-3b: Identify areas where new stations, either temporary or permanent, would provide beneficial data and secure funding for installation and maintenance. 3-3c: Publish gauging station data on USGS website consistent with current practice, including a monthly summary of freshwater flows to the bay.	**Partners:** USGS, NJDEP **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	L M L	$$ $$$ $$$

C

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 3-4; High	**Assess water supply trends and effects of current and projected surface and groundwater withdrawals.** **Metrics**: Number of completed assessment reports on the effects of existing and projected water withdrawals. **Milestones**: 3-4a: Develop current and projected water withdrawal estimates. 3-4b: Identify and address data gaps. 3-4c: Evaluate trends and effects (ecological, social, *etc.*) at appropriate spatial scales, from local to watershed-wide.	**Partners:** NJDEP, USGS **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	 M L L	 $$ $$$ $$
WS Objective 4: Improve scientific understanding of new and emerging issues (including climate change and sea level rise) pertaining to water conservation, advanced potable treatment options, and reuse.				
WS Action 4-1; Medium	**Identify and explore infrastructure, research, and piloting options for the use of advanced treatment at wastewater treatment plants and water reuse, including wastewater and gray water, within the watershed.** **Metrics**: Completed report on advanced wastewater treatment and reuse options. **Milestones**: 4-1a: Identify possible applications of advanced wastewater treatment and water reuse in the watershed, drawing from available literature. 4-1b: Identify and address, where possible, data/information gaps and barriers to implementation. 4-1c: Identify specific sites for pilot/research projects and corresponding infrastructure improvement needs and budgetary cost estimates.	**Partners:** USEPA, USGS, NJDEP, OCUA **Lead(s):** TBD **Funding Sources:** Water Pollution Control Grants; DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	 M M M	 $$ $$$ $$

C

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 4-2; High	**Conduct research on the effects of sea level rise, salt water intrusion, and deicer/ chloride on regional water supply and ecology.** **Metrics**: Completed report(s) documenting threats and mitigation options. **Milestones**: 4-2a: Identify areas of vulnerability and existing or potential water quality impairment. 4-2b: Identify research questions. 4-2c: Secure funding, conduct research, and report findings.	**Partners:** USEPA, USGS, NJDEP, BTMUA, OCUA, BBP **Lead(s):** NJDEP, water purveyors, USEPA **Funding Sources:** Federal (Safe Drinking Water Act); DEP State Revolving Funds, EIT; Pollution Control Grants, Other State and Local Funding Sources TBD	M M L	$$ $ $$
WS Objective 5: Educate consumers regarding water supply issues, including efficient water use, indoor/outdoor water conservation, and reuse.				
WS Action 5-1; Medium	**Promote water reuse demonstration projects for stormwater, graywater, and wastewater.** **Metrics**: Number of demonstration projects completed. **Milestones**: 5-1a: Identify feasible demonstration projects, including projects in communities with environmental justice concerns. 5-1b: Leverage existing programs, or create new ones, to complete demonstrations with appropriate public education and outreach. 5-1c: Periodically update list of what is feasible to incorporate advances in understanding/ technology.	**Partners:** USEPA, NJDEP, Counties, Municipalities, MUAs, PPA, BBP **Lead(s):** BBP **Funding Sources:** Water Pollution Control Grants; DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD	M M L	$$ $$$$ $$

WS Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
WS Action 5-2; High	**Disseminate educational materials related to best practices for water conservation activities**. **Metrics**: Number of materials distributed, people reached, and/or conservation improvements made. **Milestones**: 5-2a: Inventory available education materials and develop new materials, as necessary. 5-2b: Distribute materials to the public, including communities with environmental justice concerns, and incorporate into existing programs. 5-2c: Evaluate effectiveness and revise program, as necessary	**Partners:** USEPA NJDEP, BBP, Utilities **Lead(s):** BBP, PPA **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding Sources TBD; Clean Water Act Section 320	S M M	$ $ $
WS Action 5-3; High	**Develop programs to educate stakeholders on the source and value of their water.** **Metrics**: Completion and implementation of programs. **Milestones**: 5-3a: Inventory available education materials and develop new materials, as necessary. 5-3b: Develop education strategies, including how to improve outreach to communities with environmental justice concerns. 5-3c: Implement programs, evaluate effectiveness, and revise, as necessary.	**Partners:** NJDEP, BBP, Utilities, PPA, USEPA **Lead(s):** BBP, PPA **Funding Sources:** DEP State Revolving Funds, EIT; Other State and Local Funding TBD; Clean Water Act Section 320	M M L	$ $ $
WS Action 5-4; High	**Implement components of the BBP Communication Plan related to water supply protection.** **Metrics**: Water supply protection components being implemented. **Milestones**: 5-4a: Identify components and whether revisions/updates are necessary. 5-4b: Leverage partners to carry out implementation.	**Partners:** BBP, Save Barnegat Bay, NJDEP JC NERR **Lead(s):** BBP **Funding Sources:** Clean Water Act Section 320; DEP State Revolving Funds, EIT; Other State and Local Funding TBD	S M	$ $

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D

APPENDIX D

Objectives and Actions for Living Resources

Goal

To protect, restore, and enhance habitats in the Barnegat Bay and its watershed to ensure healthy and sustainable natural communities of plants and animals now and in the future.

Time Frame

The time frame from adoption of the CCMP in which the action should be completed. Short (S) indicates completion within 1-2 years, Medium (M) actions within 5 years, and Long (L) actions within 10 years. Steps (*e.g.*, 1a, 1b, *etc.*) are listed in chronological order; initial steps are generally shorter-term than later steps, unless noted.

Cost Range

The anticipated costs of action components:

- $ < $100K
- $$ = $100K - $500K
- $$$ = $500K - $1 Million
- $$$$ > $1 Million

Priority

High, Medium, or Low

Climate

CCMP actions likely impacted by one or more climate stressors, potentially inhibiting implementation, are shaded. See Chapter 8 for details.

LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Objective 1:	**Develop and implement Habitat Protection and Restoration Plans for the watershed's characteristic habitats, including ecologically sensitive areas.**			
LR Action 1-1; High	**Compile existing data and maps; determine and collect missing data for ecologically sensitive habitats and associated buffers.** **Metrics:** The number of complete maps of ecologically sensitive areas. **Milestones**: 1-1a: Identify relevant ecologically sensitive areas (*e.g.*, SAV, riparian buffers). 1-1b: Compile existing maps and data; collect additional data, as needed. 1-1c: Update and publish mapping.	**Partners:** NJDEP, NJPC, County Planning Depts. **Lead(s):** BBP **Funding Sources:** CWA Section 320; DEP State Revolving Funds, NJIB.	 S M M	 $ $ $
LR Action 1-2; High	**Develop and implement conservation/restoration plans for ecologically sensitive terrestrial, coastal, and aquatic habitats.** **Metrics**: The acreage of ecologically sensitive areas conserved/restored. See Ecosystem Based Targets for goals. **Milestones**: 1-2a: Develop conservation/restoration plans. 1-2b: Identify funding sources and submit proposals for plan implementation. 1-2c: Implement plans. 1-2d: Assess implementation and conduct adaptive management.	**Partners:** NJDEP, USFWS, BBP STAC, Academic Institutions **Lead(s):** NJDEP, USFWS, BBP STAC **Funding Sources:** CWA Section 320; DEP State Revolving Funds, NJIB; Other federal (NFWF, NOAA, ACFHP).	 S M L L	 $$ $ $$$ $$

D

LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 1-3; Medium	**Create a web-accessible database of habitat protection and restoration activities completed by the BBP and partners.** **Metrics**: A complete, web-accessible database. **Milestones**: 1-3a: Compile existing information from partners and agencies. 1-3b: Develop web-based database. 1-3c: Publish database.	**Partners:** BBP, NJDEP, USFWS, Counties **Lead(s):** BBP **Funding Sources:** CWA Section 319 & 320; DEP State Revolving Funds, NJIB.	 S S S	 $ $ $
LR Action 1-4; Low	**Encourage the protection and management of habitats on a sub-watershed basis through coordination and collaboration across municipal boundaries.** **Metrics:** The acreage of habitat managed across municipal boundaries. **Milestones**: 1-4a: Identify sensitive habitat areas crossing municipal borders (see 1-2). 1-4b: Meet with municipal, county, and state officials/planners/engineers/resource managers. 1-4c: Develop cross-border management plans.	**Partners:** BBP, NJDEP, Counties, Municipalities **Lead(s):** TBD **Funding Sources:** CWA Section 319 & 320; DEP State Revolving Funds, NJIB.	 M M M	 $ $ $
LR Action 1-5; Medium	**Promote management of ecologically sensitive and other target areas.** **Metrics**: The number of acres under active conservation management. **Milestones**: 1-5a: Identify currently owned sensitive areas not actively managed. 1-5b – Develop and implement parcel specific management plans (*e.g.*, large or adjoining public parcels).	**Partners:** USFWS, NJDEP, Ocean County, NJ Marine Trades Association, Pinelands Preservation Alliance, Land Conservancies **Lead(s):** USFWS, NJDEP, Ocean County Planning/Parks & Recreation **Funding Sources:** DEP State Revolving Funds, NJIB; Ocean County NLT/Parks & Recreation	 S L	 $ $$

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Objective 2:	**Restore and maintain sustainable populations of fish and wildlife.**			
LR Action 2-1; Medium	**Develop a bay-wide multi-use management plan that supports sustainable aquaculture, commercial and recreational fish and shellfish harvest, recreation, and habitat and shellfish restoration.** **Metrics**: A bay-wide multi-use management plan for Barnegat Bay resources. **Milestones**: 2-1a: Create a plan development process. 2-1b: Hold stakeholder meetings. 2-1c: Integrate existing data and stakeholder comments. 2-1d: Publish final plan.	**Partners:** NJDEP, BBP, RCE, NJSGC **Lead(s):** TBD **Funding Sources:** DEP State Revolving Funds, NJIB, Other TBD.	 M M M M	 $ $ $$ $
LR Action 2-2; High	**Restore fish passage and other riparian habitats to improve habitat quality and connectivity.** **Metrics:** The number of river miles reconnected; the number of fish passage barriers removed/improved; the acreage of riparian habitats improved/restored. **Milestones**: 2-2a: Identify barriers to fish passage and riparian habitats in need of improvement. 2-2b: Identify funding source(s) for activities; submit proposals/ develop plans for passage/ habitat improvement. 2-2c: Implement improvement projects as per plans.	**Partners:** USEPA, BBP, NOAA NMFS, NJDEP, USFWS, NJDOT **Lead(s):** BBP **Funding Sources:** CWA Section 319 & 320, other federal (USFWS, NOAA NMFS); DEP State Revolving Funds, NJIB.	 M L L	 $$ $$ $$$

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 2-3; Medium	**Participate in the implementation and periodic update of the New Jersey State Wildlife Action Plan.** **Metrics:** The number of SWAP projects/actions completed in the watershed. **Milestones**: 2-3a: Identify applicable projects within the SWAP. 2-3b: Identify resources required for implementation. 2-3c: Implement plans, including monitoring.	**Partners:** NJDEP, BBP **Lead(s):** NJDEP **Funding Sources:** DEP State Revolving Funds, NJIB.	 M M L	 $ $ $$
LR Action 2-4; Medium	**Create and restore wildlife corridors for habitat quality and connectivity.** **Metrics:** Acreage of wildlife corridors created/restored. **Milestones**: 2-4a: Identify potentially suitable areas for acquisition /restoration. 2-4b: Develop restoration/acquisition plans. 2-4c: Implement plans.	**Partners:** NJDEP, USFWS, Ocean and Monmouth Counties **Lead(s):** NJDEP, USFWS, Ocean and Monmouth Counties **Funding Sources:** Federal, State, OCNLT funds, DEP State Revolving Funds, NJIB.	 M L L	 $ $$ $$$$
LR Action 2-5; Medium	**Monitor, manage, and control invasive and nuisance aquatic and terrestrial species through ecologically appropriate methods.** **Metrics**: Reduction in amount of invasive and nuisance species. **Milestones**: 2-5a: Identify invasive/nuisance species (*e.g.*, southern pine beetle, bay nettle, Japanese sedge, spotted laternfly). 2-5b: Prioritize and implement management activities. 2-5c: Assess outcomes and conduct adaptive management.	**Partners:** USEPA, USFWS, NJDEP, NJPC, BBP, Berkeley Underwater Search & Rescue Unit **Lead(s):** NJDEP, NJDA, Other TBD **Funding Sources:** Federal (NOAA, USFWS, USDA); DEP State Revolving Funds, NJIB.	 L L L	 $$ $$$ $$

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Objective 3:	**Monitor and assess status and trends of living resources throughout the watershed.**			
LR Action 3-1; High	**Assess distribution and abundance of SAV through coordinated, regular surveys to evaluate their structure and function.** **Metrics**: Completion of distribution and demographic surveys. **Milestones**: 3-1a: Develop regularly scheduled survey protocol and identify stable funding source. 3-1b: Conduct distribution assessments, including UAV/other surveys. 3-1c: Conduct demographic surveys.	**Partners:** NJDEP, BBP, RSU, RU **Lead(s):** NJDEP, Other TBD **Funding Sources:** NJDEP State Revolving Funds, NJIB.	 M L L	 $ $$ $$
LR Action 3-2; High	**Continue the ongoing Mid Atlantic Coastal Wetlands Assessment (MACWA) program to evaluate the condition and function of wetlands and address priority information gaps for wetlands management.** **Metrics**: Completion of annual MACWA activities. **Milestones**: 3-2a: Develop and submit additional proposals to continue baseline monitoring and related research. 3-2b: Coordinate annual field activities; conduct fieldwork and data analyses. 3-2c: Prepare annual and multi-year reports and presentations regarding wetland conditions, functions, ecology, and management options. 3-2d: Share information with other state, federal, and regional resource managers (*e.g.*, sediment/dredged materials management)	**Partners:** BBP, NJDEP, USEPA, PDE **Lead(s):** BBP, NJDEP, Academic Institutions **Funding Sources:** CWA Section 319, Section 320, & WPDG; NJDEP, Corporate Wetlands Restoration Partnership.	 L L L L	 $ $$$ $ $

LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 3-3; High	**Update and/or complete mapping of riparian and tidal wetlands and their buffers.** **Metrics**: Extent of mapping of riparian and tidal wetlands and their buffers **Milestones**: 3-3a: Evaluate current promulgated mapping to clarify information needs. 3-3b: Utilize existing state mapping and/or or collect new data to address mapping needs. 3-3c: Publish updated mapping.	**Partners:** USEPA, NJDEP **Lead(s):** NJDEP, Rutgers CRSSA **Funding Sources:** DEP State Revolving Funds, NJIB.	S M M	$ $$$ $$$
LR Action 3-4; High	**Continue to monitor and assess the status of commercially, recreationally, and ecologically important aquatic species.** **Metrics**: Population status information available for fish and shellfish species. **Milestones**: 3-4a: Evaluate data collection activities for important species, and modify if necessary. 3-4b: Collect, analyze, and publish data, reports, and presentations (including the BBP SOTB).	**Partners:** NJDEP, NOAA NMFS, BBP, RSU **Lead(s):** NOAA NMFS, NJDEP, BBP **Funding Sources:** NOAA NMFS, NJDEP, CWA Sec. 320, RSU	S L	$ $$$
LR Action 3-5; Medium	**Monitor and assess target animal and plant species, such as pollinator and migratory species, threatened and endangered species, and plant communities of special importance (see Habitat Plan).** **Metrics:** Population status information available for target species **Milestones**: 3-5a: Evaluate data collection activities for important species, and modify if necessary. 3-5b: Collect, analyze, and publish data, reports, and presentations (including the BBP SOTB).	**Partners:** USEPA, NJDEP, NJPC, USFWS **Lead(s):** NJDEP, USFWS, NOAA NMFS **Funding Sources:** NOAA NMFS, USFWS, DEP, CWA Sec. 320	L L	$ $$$

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 3-6; Medium	**Monitor and assess the impact of the closure of the Oyster Creek Nuclear Generating Station (OCNGS) on living resources in the Barnegat Bay.** **Metrics**: A final report on the ecosystem effects of the OCNGS closure. **Milestones**: 3-6a: Develop monitoring and assessment plans. 3-6b: Collect and analyze data. 3-6c: Write final reports and recommendations.	**Partners:** NJDEP, Academic Institutions **Lead(s):** NJDEP, Academic Institutions **Funding Sources:** NJDEP	 S M M	 $ $$ $
LR Objective 4: Conduct studies to improve scientific understanding of living resources and ecologically sensitive habitats.				
LR Action 4-1; Medium	**Conduct studies that identify and document appropriate mechanisms and strategies to support restoration of ecologically sensitive habitats identified in Objective 1.** **Metrics**: The number of completed studies, including recommendations. **Milestones**: 4-1a: Determine area(s) of need and develop study plan(s). 4-1b: Collect and analyze data. 4-1c: Prepare recommendations and distribute to practitioners.	**Partners:** NJDEP, NJSGC, BBP, RSU **Lead(s):** NJDEP, USFWS, NOAA NMFS, BBP **Funding Sources:** Federal (NOAA; NFWF); DEP State Revolving Funds, NJIB.	 M L L	 $ $$$ $
LR Action 4-2; High	**Identify and assess habitat suitability, connectivity, and barriers to fish passage.** **Metrics:** The number of connectivity/passage assessments conducted at potential stream barriers. **Milestones**: 4-2a: Identify potential barriers to fish passage, and prioritize assessment areas based on habitat suitability (*e.g.,* North Atlantic Aquatic Connectivity Collaborative approach). 4-2b: Conduct assessments; collect and analyze data. 4-2c: Complete reports and make recommendations for project implementation.	**Partners:** BBP, NJDEP; USEPA **Lead(s):** BBP, NJDEP **Funding Sources:** CWA Section 320, FEMA, HUD Resilient NJ, ASMFC, MAFMC, WMI, NAACC, DEP State Revolving Funds, NJIB.	 M M M	 $ $$ $

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 4-3; Medium	**Conduct studies that identify and document the life history and/or ecology of priority living resources.** **Metrics**: The number of studies conducted. **Milestones:** 4-3a: Identify potential study subjects. 4-3b: Collect and analyze data. 4-3c: Disseminate findings.	**Partners:** NJDEP, NOAA NMFS, USFWS, NJPC, BBP, JC NERR **Lead(s):** Rutgers University **Funding Sources:** Federal (NOAA NMFS), NJIB, NJDEP State Revolving Funds	 L L L	 $ $$ $
LR Objective 5: Increase education and public outreach related to habitats and living resources.				
LR Action 5-1; High	**Disseminate information to promote an understanding of science-based decision-making in the management of habitats and living resources.** **Metrics**: Number of educational materials and reports (*e.g.*, State of the Bay) distributed; number of science workshops and conferences; pre- and post-program evaluations to measure changes in understanding **Milestones:** 5-1a: Inventory existing materials. 5-1b: Develop and distribute new materials as necessary. 5-1c: Provide science workshops/conferences.	**Partners:** BBP STAC, JCNERR, NJSGC, NJDEP, USFWS, NOAA, CWFNJ **Lead(s):** BBP STAC, JCNERR, NJSGC, NJDEP **Funding Sources:** CWA Section 320, DEP State Revolving Funds, NJIB.	 M M M	 $ $ $

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 5-2; Medium	**Develop educational materials, programs, and online resources to promote restoration of habitats and living resources (*e.g.* living shorelines, shellfish)** **Metrics**: Number of materials/resources developed, number distributed, number of programs and people reached, program evaluations **Milestones:** 5-2a: Inventory existing programs and materials/resources. 5-2b: Identify needs and target audiences, including communities with environmental justice concerns. 5-2c: Develop and distribute new materials/resources as needed. 5-2d: Develop and provide new programs as needed.	**Partners:** ReClam the Bay, NOAA, USEPA, BBP, NJDEP **Lead(s):** BBP **Funding Sources:** CWA Section 320, DEP State Revolving Funds, NJIB.	 M M M M	 $ $ $ $
LR Action 5-3; Medium	**Develop materials, programs, and online resources to educate about the functional role of critical bay habitats, such as seagrass beds and wetlands, and the early life stages of estuarine-dependent species.** **Metrics**: Number of educational materials/resources developed, number distributed, number of programs and people reached, program evaluations. **Milestones:** 5-3a: Inventory existing materials/resources. 5-3b: Identify needs and target audiences including communities with environmental justice concerns. 5-3c: Develop and distribute new materials/resources as needed. 5-3d: Develop and provide new programs as needed.	**Partners:** BBP, JC NERR, USEPA, NJDEP **Lead(s):** BBP, JCNERR **Funding Sources:** CWA Section 320, NOAA, DEP State Revolving Funds, NJIB.	 S S S S	 $ $ $ $

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 5-4; High	**Produce educational materials and online resources about the impacts of climate change on the living resources of the bay.** **Metrics**: Number of educational materials/resources produced, number distributed, number of people reached. **Milestones:** 5-4a: Inventory existing materials/resources. 5-4b: Identify needs and target audiences, including communities with environmental justice concerns. 5-4c: Develop and disseminate new materials/resources as needed.	**Partners:** BBP, JC NERR; USEPA **Lead(s):** BBP, JCNERR **Funding Sources:** CWA Section 320, NOAA, DEP State Revolving Funds, NJIB.	 M M M	 $ $ $
LR Action 5-5; Medium	**Promote an improved understanding of the economic and ecological importance of fisheries through fisheries programs and activities.** **Metrics**: Number of fisheries programs/activities, number of people reached, program evaluations **Milestones:** 5-5a: Inventory existing programs/activities. 5-5b: Identify needs and target audiences, including communities with environmental justice concerns. 5-5c: Develop new programs/activities as needed.	**Partners:** NOAA, NJDEP **Lead(s):** NOAA, NJDEP **Funding Sources:** NOAA, DEP State Revolving Funds, NJIB.	 S S S	 $ $ $

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LR Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LR Action 5-6; High	**Promote education and enforcement of regulations and best practices for responsible use of ecologically sensitive and target areas (*e.g.*, personal watercraft and boating, off-road vehicles).** **Metrics**: Number of educational materials/online resources developed, number distributed, number of programs/people reached, program evaluations. **Milestones:** 5-6a: Inventory existing programs and materials/resources. 5-6b: Identify needs (*e.g.*, shallow water habitat management plan, *e.g.*, mooring (Coastal Systems Intl., 2017) and boating impact (Kruer, 2016) plans, and target audiences (*e.g.*, off-road vehicle drivers). 5-6c: Develop and distribute new materials/resources as needed. 5-6d: Develop and provide new programs as needed.	**Partners:** NJDEP, USEPA, NJSGC, Ocean County Tourism, Parks & Planning Depts, JCNERR, BBP (including committees), Land Conservancies, Marine Trades Association, PPA, Ocean County Sheriff's Office **Lead(s):** NJDEP, BBP, Others TBD. **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, NJIB.	M M M M	$ $ $$ $$

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E APPENDIX E

Objectives and Actions for Land Use

Goal

To improve and sustain collaborative regional approaches to responsible land use planning and open space protection in the watershed that protect and improve water quality, water supply, living resources, soil function, and hydrology.

Time Frame

The time frame from adoption of the CCMP in which the action should be completed. Short (S) indicates completion within 1-2 years, Medium (M) actions within 5 years, and Long (L) actions within 10 years. Steps (*e.g.*, 1a, 1b, etc.) are listed in chronological order; initial steps are generally shorter-term than later steps, unless noted.

Cost Range

The anticipated costs of action components:

- $ < $100K
- $$ = $100K - $500K
- $$$ = $500K - $1 Million
- $$$$ > $1 Million

Priority

High, Medium, or Low

Climate

CCMP actions likely impacted by one or more climate stressors, potentially inhibiting implementation, are shaded. See Chapter 8 for details.

LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Objective 1: Promote and support open space acquisition, planning, and management for people and nature.				
LU Action 1-1; High	**Compile a comprehensive inventory of open space and lands held in permanent and temporary easements.** **Metrics:** Comprehensive inventory completed. **Milestones:** 1-1a: Compile existing data sets into a comprehensive inventory of permanent and temporary open space and easements held in conservation status by 2023. 1-1b: Work with ANJEC and municipal Environmental Commissions to update their Community Natural Resource Inventory – minimum of five communities/year (starting in 2021).	**Partners:** Counties, Municipalities, NJDEP, USFWS, Land Conservancies, BBP, JCNERR, TPL, NJPC **Lead(s):** OC Planning Dept., BBP **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	S M	$ $$
LU Action 1-2; Medium	**Convene a working group to review all existing public and private planning documents (such as Green Acres Inventory, County and Municipal Open Space Inventories, TPL 2020 Plan, All Hazard Mitigation Plans, Conservation Blue Print initiative) and holdings, in order to coordinate future efforts to maximize ecological services of preserved lands.** **Metrics:** Convene workgroup. **Milestones**: 1-2a: Identify participants, invite, and convene working group to format inventory by 2021.	**Partners:** Counties, Municipalities, NJDEP, USFWS, Land Conservancies, BBP, JCNERR, TPL, NJPC **Lead(s):** OCPD, BBP **Funding Sources:** NJDEP, County NLT, DEP State Revolving Funds, EIT.	S	$

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LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 1-3; High	**Promote the acquisition and management of lands to achieve: a) community resilience for flooding and water supply protection (*e.g.*, forested riparian buffers providing multiple ecosystem benefits and floodplains), b) natural resource protection, including sensitive species and their habitats, c) diverse recreational opportunities, and d) promotion and education of cultural heritage.** **Metrics**: Acres of open space preserved. **Milestones**: 1-3a: Identify and prioritize parcels/tracts for preservation. 1-3b: Develop/maintain GIS database of preserved open space and identified tracts. 1-3c: Screen parcels for willing sellers for conservation and prioritize these for acquisition. 1-3d: Update database and maintain periodic outreach to owners.	**Partners:** USFWS, USDOD, NJDEP, Ocean County NLT, Monmouth County Open Space Fund, JCNERR, Municipalities, TPL, Other Land Conservancies **Lead(s):**, OCPD, Monmouth County Planning, USFWS, NJDEP, TPL **Funding Sources:** USFWS, NOAA, USDOD (Readiness and Environmental Protection Integration), NJDEP (Green Acres), OCNLT & MCNLT Funds, Other TBD	S L L L	$$ $$ $$ $$
LU Objective 2:	**Promote and support sustainable land use practices (*e.g.*, soil restoration, low-impact development, shoreline restoration, and dredged material management) to increase resiliency of vulnerable communities.**			
LU Action 2-1; High	**Support and encourage sustainable land use practices that incorporate BMPs including but not limited to: Jersey-Friendly Yards, Low Impact Development (LID) and Sustainable Jersey actions. These practices should: a) promote nature-based infrastructure to minimize loss of natural vegetation, b) optimize opportunities for ground water recharge, and c) minimize soil disturbance and promote soil health and restoration.** **Metrics**: Progress towards adoption of land use practices (including nature-based infrastructure) that incorporate LID, minimize soil disturbance, protect soil integrity, and recharge areas. **Milestones:** 2-1a: Decrease the area of effective impervious cover in the watershed by 10% by 2033 relative to a 2015 baseline. 2-1b: Adoption of new or revised ordinances and policies that will encourage redevelopment and limit loss of vegetative cover.	**Partners:** County Planning Offices, Municipalities, NJDEP, JCNERR, NJPC, Pinelands Preservation Alliance **Lead(s):** BBP, OCSCD, Others TBD **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	L L	$$ $$

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LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 2-2; High	**Promote and support development of shoreline and wetlands restoration strategies and related technologies (*e.g.*, sediment management) to promote community resiliency to storms and flooding.** **Metrics:** The number of communities that are developing specific (adaptation) plans and adopting ordinances or more progressive sea level rise projections to deal with repetitive losses in low-lying communities. **Milestones:** 2-2a: Bay-wide assessment of potential restoration projects/project sites completed by 2023. 2-2b: Number of restorations, enhancement, or adaptation projects implemented.	**Partners:** BBP, NJDEP, USEPA, County Planning Depts., Municipalities, Sustainable Jersey, NGO Partners (ALS, RCB, SBB, NJCF, NJF, TNC) **Lead(s)**: BBP, NJDEP, Academic Institutions **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT, HUD Block Grants, Blue Acres	M L	$ $$$
LU Action 2-3; Medium	Promote land use practices that recognize and prioritize water-dependent uses; ensure that authorized waterfront uses are compatible with supporting commercial and recreational activities. **Metrics:** Increased understanding of the scope and challenges of the marine-dependent coastal economy of Barnegat Bay; community (government) support for policies and decisions that promote investment in and continuation of marine industry and water-dependent activities. **Milestones:** 2-3a: Completion of a report on the distribution of water-dependent industries, economic significance, threats and conversion to other uses. 2-3b: Identify Working Waterfront Preservation models that have been successful in stemming the loss of marine-dependent activities. 2-3c: Outreach and engagement with business owners, neighborhoods, legislators, and municipal finance representatives on implementation of preservation models and opportunities to preserve sustainable working waterfronts and water-dependent activities. 2-3d: Implement a Barnegat Bay-wide Working Waterfront Preservation Element (including ordinances, funding mechanisms) recognizing the historic, cultural, recreational, economic, and environmental contribution and climate impacts of the working waterfront to Barnegat Bay with full adoption as a Municipal Land Use Action Element in the Watershed.	**Partners:** BBP, NJDEP, NJSGC, NJDOT/ Office of Maritime Resources, Counties, Municipalities **Lead(s):** NJDEP, Counties, Municipalities **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	M M M L	$ $ $$ $$

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LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Objective 3:	**Incorporate CCMP goals and objectives into regional, county, municipal, and other policies, plans, and regulations where applicable to support BBP-related priorities.**			
LU Action 3-1; Medium	**Identify regulatory gaps and overlaps and promote planning tools (*e.g.*, draft local and state ordinances, zoning, transfer of development rights) to achieve priority objectives (*e.g.*, long-term comprehensive, localized and/or regional plans for vulnerable, low-lying or repetitive loss neighborhoods, fire-prone neighborhoods, promote compatible commercial, recreational, public access and other waterfront land uses).** **Metrics**: Compilation of current municipal policies, ordinances, model language, and assessment tools by Barnegat Bay municipalities. **Milestones**: 3-1a: Compilation of current municipal, county, and Pinelands land use policies, ordinances, tools. 3-1b: Development of a Barnegat Bay-wide assessment of the above compilation (gaps and overlaps) by municipality. 3-1c: Preparation of resource library of model ordinance, tools, and policies.	**Partners:** NJDEP (Nutrient TMDL, GAP 2.0, Restoration Enhancement Strategy); ANJEC; County and Municipal Planning; NJPC, TBD **Lead(s):** Academics, Sustainable Jersey, ANJEC **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	S M M	$ $$ $$

LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 3-2; Medium	**Align and expand existing municipal incentive programs, and other related planning tools (*e.g.*, Ocean and Monmouth Counties All-Hazards Mitigation Plan, GTR, Sustainable Jersey, Floodplain Management Plans, USEPA/NJDEP Watershed Management Plans and USACE New Jersey Back Bay Study) to achieve priority objectives**. **Metrics:** Active participation by representatives of county, municipal, and state planning agencies. Compilation of policies, ordinances, and planning tools that reflect a comprehensive/regional approach for a Barnegat Bay Land Use Element. **Milestones:** 3-2a: Convene an intergovernmental working group; participation by representatives of all communities and affected county and state agencies (including utilities). 3-2b: Completion of framework document. 3-2c: Preparation of draft of Barnegat Bay-wide comprehensive/regional Land Use Element. 3-2d: Adoption by appropriate county, municipal, and state agencies of Barnegat Bay-wide comprehensive /regional Land Use Element.	**Partners:** County Planning Offices, Municipalities, NJDEP, NJPC **Lead(s):** Academics, Sustainable Jersey, ANJEC **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	S M M L	$ $ $$ $$
LU Action 3-3; Medium	**Coordinate with municipal, county, regional, and state planning representatives to develop one or more Land Use Elements (Working Waterfronts, Regional Resilience, Restoration and Enhancement activities/targets) for inclusion in planning documents to achieve priority objectives (*e.g.*, long-term comprehensive, localized and/or regional plans for vulnerable, low-lying or repetitive loss neighborhoods, fire-prone neighborhoods; promote compatible commercial, recreational, and other waterfront land uses).** **Metrics:** Number of municipalities participating in the process to align and expand existing plans to incorporate CCMP goals; number of municipalities participating in GTR, CRS, SJ. **Milestones:** 3-3a: At least three adjacent or mutually-interested municipalities per year will be engaged.	**Partners:** BBP, NJDEP, County and Local Planning and OEM, NJPC, Sustainable Jersey **Lead(s):** TBD **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT	L	$

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LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Objective 4:	**Assess status and trends in land uses, land cover, and landscapes, especially those directly impacted by climate change and sea level rise (*e.g.*, inundated and regularly flooded lands), and improve understanding of the impacts of land uses and land management practices on the Barnegat Bay and its watershed.**			
LU Action 4-1; High	**Support the development of an updated Land Use/Land Cover Map, which includes changes in LU/LC, impervious surfaces, shoreline hardening, and other priority metrics, in V Datum.** **Metrics:** Update of LU/LC Map. **Milestones:** 4-1a: Work with NJDEP, NOAA, USEPA, and others to update and maintain an updated Land Use/Land Cover Map, LU/LC Change and Shoreline Analysis. Update data every five years – 2015 as baseline.	**Partners:** County Planning Offices, Municipalities, NJDEP, JCNERR, USGS, NOAA, USEPA **Lead(s):** NJDEP, RU CRSSA **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	M	$$
	4-1b: Using the updated map developed in 4-1a above, update the existing build-out analysis and impervious surface analysis.		M	$$
	4-1c: Set a milestone (target) for reducing hardened shoreline throughout the watershed.		L	$$
	4-1d: Work with Federal Partners (NOAA/USGS) to update the V Datum for the estuary.		M	$$
	4-1e: Make above available for planning, project development, project implementation to inform flooding, sea level rise, FEMA FIRMs.		M	$$
	4-1f: Conduct outreach to local government and community to inform them of data and how it may affect them.		L	$$
	4-1g: Work with partners (NOAA, USEPA, NJDEP, and others) to monitor and document actual sea level rise (can use information to compare and adjust local projections). See Milestone 4-2b.		L	$$
	4-1h: Update/improve/promote use of NJDEP CZMP Coastal Atlas.			

LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 4-2; High	**Promote and support new science and monitoring to understand and reduce impacts of land uses and land management practices on the bay/watershed.** **Metrics:** Number of new applied or expanded science and monitoring studies initiated that will inform land use practices. **Milestones:** 4-2a: Identification of needed science to be included in the Monitoring Plan. 4-2b: Conduct science/monitoring studies.	**Partners:** County Planning Offices, Municipalities, NJDEP, JCNERR, BBP, USEPA, NOAA, Universities **Lead(s):** BBP, Academic institutions, NJDEP **Funding Sources:** NJDEP, NJSGC, EPA, NSF, Sustainable Jersey	L L	$ $$$$
LU Action 4-3; Medium	**Identify the social, economic, and environmental impediments, and solutions for implementing sustainable land use practices, including green and gray infrastructure strategies.** **Metrics:** Completion of reports/studies. **Milestones:** 4-3a: Identify priority land use practices and green and gray infrastructure alternatives to address specific problems around the watershed. Use alternatives from existing reference reports/local applications (*e.g.*, USACE Feasibility study, BBP LID). 4-3b: Conduct cost-benefit and willingness-to-pay analyses for those practices and preferred green/gray infrastructure. 4-3c: Using focus groups and other approaches, identify and address barriers to implementation of practices and use of green/gray infrastructure. 4-3d: Integrate above information into reports and educational materials to promote preferred alternatives.	**Partners:** County Planning Offices, Municipalities, NJDEP, JCNERR, BBP, USEPA, NOAA, Universities **Lead(s):** Academics, Sustainable Jersey, ANJEC, NJ Future **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	M M M M	$ $$ $ $-$$

LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Objective 5:	**Increase education and outreach efforts focused on: a) promoting land acquisition, protection, and management; b) implementing sustainable land use practices across both developed and undeveloped landscapes; c) integrating CCMP priorities, including climate change and sea level rise, into regional, state, local, and municipal planning, and d) reducing land use impacts on natural resources throughout the watershed.**			
LU Action 5-1; High	**Promote the understanding of recreational, educational, and social uses; ecosystem services; and economic benefits and values of wetlands and other natural habitats.** **Metrics:** Number of educational materials distributed; number of programs delivered. **Milestones:** 5-1a: Inventory available education materials and develop new materials, as necessary. 5-1b: Development and delivery of programs, including to communities with environmental justice concerns.	**Partners:** NJDEP, BBP, USEPA, JCNERR NJSGC **Lead(s):** BBP, JCNERR, NJDEP, NJSGC **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT	Ongoing S M	 $ $$
LU Action 5-2; Medium	**Promote the understanding of working waterfronts and their historical, social and economic value to their respective communities.** **Metrics:** Number of educational materials distributed; number of programs delivered. **Milestones:** 5-2a: Inventory available education materials and develop new materials, as necessary. 5-2b: Develop and deliver programs, including to communities with environmental justice concerns.	**Partners:** CEC partners; NJDEP, OC Tourism, Parks/Recreation, Planning Depts., EPA, Tuckerton Seaport, Chamber of Commerce, Marine Trades, **Lead(s):** BBP, JCNERR **Funding Sources:** NJDEP, NJSGC, Others TBD	Ongoing S L	 $ $$
LU Action 5-3; High	**Disseminate information and provide workshops that help watershed communities plan and prepare for climate change/sea level rise.** **Metrics**: Number of watershed communities implementing actions to address climate change impacts. **Milestones**: 5-3a: Inventory existing materials and workshops. 5-3b: Develop new materials and workshops for specific audiences, including communities with environmental justice concerns, as needed.	**Partners:** JCNERR, BBP, EPA, Sustainable Jersey, NJSGC **Lead(s):** JCNERR, BBP, NJSGC, RU Climate Alliance, Academic institutions **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	Ongoing S L	 $ $$

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LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 5-4; Medium	**Develop a BBP Recognition Program for municipalities implementing CCMP Actions to reduce land use impacts on natural resources.** **Metrics:** Number of communities participating in and demonstrating a commitment to adopting CCMP goals and objectives through ordinances, planning, and implementation initiatives. **Milestones:** 5-4a: Guidelines for Recognition Program completed by 2022. 5-4b: Recognition(s) provided by 2022. 5-4c: Recognition of all municipalities in watershed for their participation by 2028.	**Partners:** BBP Management Conference **Lead(s):** BBP CEC **Funding Sources:** None needed.	 S S L	 $ $ $
LU Action 5-5; High	**Maintain and expand the Jersey-Friendly Yards website and related programming (*e.g.*, workshops, demonstration projects) as comprehensive sources of information about sustainable landscaping/land-use practices, including soil restoration techniques and low-impact development.** **Metrics:** Number of watershed property owners implementing JFY best management practices. **Milestones:** 5-5a: Development of JFY certification programs for specific target audiences, such as residents, schools, and businesses. 5-5b: Enrollment of individuals or entities in certification programs.	**Partners:** BBP, NJDEP, OCSCD, RCE **Lead(s):** BBP **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	Ongoing S L	 $ $

LU Action ID # and Priority	CCMP Action	Partners, Leads, and Identified Appropriate Funding Sources	Time Frame	Cost Range
LU Action 5-6; High	**Provide landowners with existing information and interactive web-based tools that identify hazard vulnerability, adaptation, and response actions.** **Metrics:** Number of landowners utilizing web-based hazard vulnerability and mitigation tools. **Milestones:** 5-6a: Develop new materials, update website and conduct a social media campaign to educate the public, and conduct workshops for specific audiences, including communities with environmental concerns, as needed.	**Partners:** JCNERR, BBP, Sustainable Jersey, NJSGC **Lead(s):** BBP **Funding Sources:** NJDEP, County NLT funds, DEP State Revolving Funds, EIT.	Ongoing L	$$

F APPENDIX F

Compilation of CCMP Outreach and Comments Received by the BBP Regarding the Draft Revised CCMP.

Public Outreach Prior to Release of Draft CCMP

As the CCMP was being revised, the BBP incorporated CCMP outreach into existing programs, lectures, and events. Audiences ranged from the general public to specific stakeholder groups, including a recreational fishing club, beach club, historical society, municipal officials, realtors, community college students, boaters, and marine trade business owners. At more than 30 outreach events, BBP staff asked participants what concerned them most about the bay, what concerns they had about the potential impacts of climate change and sea level rise, and what they thought was important to include in the long-term plan for protecting and restoring the bay. Participants responded both verbally and in writing on a form provided by the BBP. The comment form was also available on the BBP website and was promoted through the BBP's newsletter, social media posts, and news releases.

The BBP received more than 900 comments through this initial CCMP outreach. Curbing overdevelopment, managing jellyfish populations, reducing stormwater runoff and non-point source pollution, enforcing boating speed limits and other regulations, preserving more open space, providing better public access to the bay and ocean, and teaching both adults and children about the bay and its watershed were the most frequently made comments.

When the first draft of the CCMP became available, the BBP held four "Your Bay, Your Say" public comment events at four Ocean County Library branches (Brick, Toms River, Lacey, and Stafford) in early 2018. Copies of the draft plan were available at the events along with displays summarizing its goals, objectives, and actions. The 42 people who attended offered comments on the same main topics described above: jellyfishes, overdevelopment, pollution reduction, boating regulation enforcement, public access, and education. The BBP staff also continued to incorporate CCMP outreach into regularly scheduled outreach programs.

Public Outreach after Release of Draft CCMP

The draft revised CCMP was released for public comment on July 1, 2019. During the 60-day comment period, the BBP reached out to the public and stakeholder groups in a variety of ways. People could view and download the draft on the BBP website, then submit their comments using an online form. A total of 8 responses were received through the form. Another option for submitting comments was to send them along with any attachments to a designated CCMP email address[1]; 8 responses were received this way. To make the online document more manageable for those with specific interests, it was also divided into separate PDFs by topic.

At three "Your Bay, Your Say" public comment events (held at the Toms River library, JCNERR, and Long Beach Island Foundation of the Arts and Sciences), a total of 32 individuals provided comments. The BBP staff also met

[1] CCMP@ocean.edu

with various stakeholder groups and government entities to discuss the draft plan and listen to comments and concerns. These included the Windjammers Sailing Club, ReClam the Bay, Ocean County Commissioners, Monmouth County Planning Board, Seaside Park Taxpayers Association, municipal officials, and state legislators. The BBP staff recorded all comments made at these meetings.

Summary of Comments on the Draft CCMP

Please note that all comments and questions received from the public are underlined and are immediately followed by the BBP response.

General Comments

One commenter recommended that the BBP employ a watershed approach, involve all stakeholders, and better ID ecosystem services. We agree that these are useful approaches and concepts; we have been using them for roughly two decades; all of these are mentioned throughout the document; ecosystem services were incorporated into the document in some additional places

What is the overlap between the CCMP and regulatory programs? As part of the National Estuary Program, the BBP is not a regulatory program, and its CCMP actions do not comprise federal or state laws. The BBP operates in accordance with federal and state laws, and works to insure its CCMP actions are implemented consistent with federal and state laws. When requested, the BBP provides technical assistance to federal and state elected officials and agencies that may be used to develop new, or revise existing, laws and/or programs.

The CCMP needs to be more specific to identify needs, assessments and recommendations as it relates to costs, social and environmental issues. Using the best available information, we have identified many specific needs, assessments, and recommendations; however, we are unsure what specific topic or issue is being raised.

Water Quality

Many commenters identified the bay nettle as the biggest problem in the bay because the species makes large parts of the upper bay unswimmable. Many commenters ask us to get rid of these species, which some people erroneously attribute to the bay's poor water quality. Some commenters identified the clinging jellyfish as a problem and identified its potential health impacts as a serious concern. In response, the BBP revised the jellyfish information in the CCMP to provide additional information on the biology of jellyfishes, the potential causes of jellyfish blooms, the need for additional science and research on jellyfishes, and two potential "solutions" to jellyfishes in the bay. The text in the jellyfish sections was modified to provide educational information and context.

A significant number of commenters identified nutrient pollution as major problem in the bay; many of these indicated that more action was needed to reduce nutrient pollution. We agree with these comments, added an additional action for septic systems under WQ Objective 1 (*Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution)*, and support more effort and investment by everyone to reduce the bay's nutrient and other pollution loads. Reducing nutrient load to address the bay's eutrophication is the major concern of WQ Objective 1, *Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution.* This objective is further supported directly or indirectly by all other water quality objectives and actions.

A number of comments identified concerns regarding the water quality (*i.e.*, trash and pathogens) at specific places in Barnegat Bay, most notably Tice's Shoals, Trader's Cove, and other places where large numbers of boats gather in summer. The locations were identified as problem hot spots in WQ2-3, *Support the existing beach monitoring program, and evaluate possible monitoring strategies for known public recreational areas of high public use.* The BBP also has added a water quality action specific to reducing trash in the watershed (See WQ Action 1-9), and revised a separate action to address septic and other point source inputs of pollutants (See WQ Action 1-11).

Several comments, especially from boaters, mentioned that more pump-out stations were needed to replace those destroyed by Sandy. The need for additional pump-out stations was identified in WQ1-8, *Identify sources and reduce pollution inputs from marinas and boating activities.*

The waste volume collected by the Ocean County Pump-out Boat Program was in error and should be 1.74 million gallons collected through 2018. The correction was made.

Several comments were made that the operation and/or closure of the Oyster Creek Nuclear Generating Station was a threat to the bay. We remained concerned for a long time about various potential mpacts, including unrecognized impacts (*e.g.*, chloramines on the bay's eutrophication), resulting from the operation of the OCNGS. We do not suspect that the closure represents a threat to the bay, but do recognize that closing the OCNGS may result in some changes in the bay's characteristics (*e.g.*, winter water temperatures may be cooler) and thus result in some changes in the bay's ecology. The NJDEP funded several multi-year studies, which began in 2017 and are continuing, to assess potential effects of the plant's closure on the bay. The OCNGS section was revised to reflect this ongoing assessment.

Comment: The most critical threat facing Barnegat Bay is the increase in impervious cover, which contributes to "flashy stream flows," nuisance flooding, and non-point source pollution to the bay. We agree that impervious cover is a problem and contributes to the listed observations. Reducing runoff from impervious surfaces is variously recognized and addressed within WQ Objective 1, *Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution;* WS Action 2-2, *Identify, implement, and support voluntary and mandated conservation and infiltration practices and regulation to maintain and restore base stream flows and natural hydrology*; and LU Action 2-1, *Support and encourage land use practices that incorporate BMPs such as Low Impact Development (LID) and Sustainable Jersey actions.* One land use action already recommends a 10% reduction in impervious cover by 2033. No specific changes were made to the CCMP as a result of these comments.

Other commenters recommended a number of ways to address nonpoint source pollution, including the following actions: 1) contain water on-site to reduce both commercial and residential stormwater runoff; 2) employ French drains around the house connected to perimeter drains and downspouts; 3) better capture stormwater from roadways; 4) employ (healthy) soils to improve soil functionality, and 5) broadly implement ideas in the BBP's Low-Impact Design publication. We generally support these recommendations and especially agree that functioning soils are important to improving water quality throughout the watershed; soil actions are included under WQ Objective 1, *Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution*, (*e.g.*, WQ Action 4.1.3, *Address Nonpoint Source Pollution Through Soil Restoration and Fertilizer Laws* and WS Objective 1, *Protect, maintain, and enhance existing surface and groundwater flows*). The reviewer's (and other) methods of stormwater source control are captured by several actions under WQ Objective 1, *Reduce sources of nutrients, contaminants, debris, and other pollutant loadings from point and nonpoint source pollution.* No specific changes were made to the document as a result of these comments.

Comment: In regard to the effectiveness of soil health legislation, it is time to implement an evaluation of practices for environmental, social, and economic benefits. We do not know at present the effectiveness of current soil restoration practices or the extent to which they have been implemented throughout the watershed. Several objectives and actions in different priority areas promote broader application, assessment, and education about soil restoration, *e.g.*, WQ Action 1-3, *Fully implement the Soil Restoration Law and associated comprehensive soil restoration procedures for various land use activities*; LU Objective 2, *Promote and support sustainable land use and related practices (e.g., soil restoration, low-impact development, shoreline restoration, dredged material management) to increase resiliency of vulnerable communities and support other BBP CCMP priorities (e.g., water quality and supplies, living resources).*

One commenter made a number of both general and specific comments, criticisms, and recommendations regarding the State's Stormwater Management program (*e.g.*, zero stormwater runoff from any property; no untreated discharges to waterbodies). Because these comments address existing state regulatory programs, the BBP is sharing these comments with the NJDEP and the BBP's Stormwater Workgroup for further consideration and possible action. No specific changes were made to the document as a result of these comments.

Comment: HUD block grants are a potential funding source to municipalities for projects to reduce stormwater flooding and non-point source pollution. Thank you for your comment; this funding source was added to the list of potential funding sources for water quality actions and improvement projects.

Water Supply

One commenter recommended that we reduce offshore discharges of treated effluent through reuse, additional treatment (*i.e.*, advanced wastewater treatment), and discharge of the effluent from the wastewater treatment plants to the aquifer directly. The BBP has promoted advanced wastewater treatment and other options, all of which require an NJPDES permit through the NJDEP. Some options have been used in small-scale treatment plants in other counties in New Jersey; they are included as options in *WS Action 4-1, Identify and explore infrastructure, research, and piloting options for the use of advanced treatment at wastewater treatment plants and water reuse, including wastewater and gray water, within the watershed* and *WS 5-1, Promote water reuse demonstration projects for stormwater, graywater, and wastewater.* The CCMP was revised in both places to explicitly identify this as a potential action.

One commenter recommended that we address the increasing costs of water and several other specific water supply issues: ASR wells, selling water outside the basin, private companies procuring municipal utilities that own water supplies, need for headwater protection. All four of these water supply issues are under various considerations in the Barnegat Bay watershed and elsewhere in New Jersey. The BBP STAC will share this concern with the NJDEP.

Comment: Greater emphasis needs to be included in the plan about how soil management and restoration are directly connected to encouraging replenishment of ground water resources, maintaining base flows and sustaining living resources, first in the watershed and secondly in the bay. Thank you for your comment. The water supply section was revised to reflect this comment.

Living Resources

Several commenters mentioned that wetlands provide numerous ecosystem services and are among the most threatened ecosystems on the planet. Thank you for your comment. We agree that wetlands provide extensive ecosystem services; moreover, together with our partners, we have identified (and in some cases, documented) some of the ecosystem processes (*e.g.*, fish and wildlife habitat, carbon and nutrient sequestration, sediment trapping, flood storage and storm surge protection) provided by Barnegat Bay wetlands. We also agree that wetlands in Barnegat Bay remain threatened directly and indirectly by a number of human activities, including sea level rise, climate change, and continuing development along the coast.

Another commenter noted that some coastal wetlands are vulnerable to sea level rise. Thank you for your comment. We agree that coastal wetlands are vulnerable to SLR. In response, we made a minor change in the text, noting that many wetlands in the Barnegat Bay are "sediment starved" and thus are vulnerable to sea level rise. In addition, we modified LR Action 3-2, *Continue the ongoing Mid Atlantic Coastal Wetlands Assessment program to evaluate the condition and function of wetlands and conduct studies to address management knowledge gaps* (*e.g.*, uses of sediment to enhance coastal wetlands).

Two recommendations were made regarding wetland mitigation: 1) all wetland mitigation should only occur in the same sub-basin as the wetland disturbance; 2) all mitigation wetlands should be monitored for 10 years. Wetland mitigation is governed by federal and state laws, regulations, and various federal and state policies. The BBP generally comments on wetland projects requiring federal/state permits typically via Public Notice but also under other circumstances (*e.g.*, when projects involve trust resources or public funding). We support extended monitoring of all restoration sites, including mitigation projects. These comments will be considered in development of the BBP CCMP Habitat Plan. No changes were made to the BBP CCMP.

More research is needed on thin-layer deposition before using dredged materials on subsiding wetlands because it is important to avoid unintended negative consequences. We agree that more research and monitoring of wetland restoration projects employing thin-layer deposition are needed. Though not covered in much detail, we note under the Habitat Plan Strategy that wetland restoration strategies include nature-based shorelines, hybrid shorelines, wetlands enhancement (*e.g.* thin layer sediment placement), and other approaches. In addition, we modified LR 3-2, *Continue the ongoing Mid Atlantic Coastal Wetlands Assessment program to evaluate the condition and function of wetlands and conduct studies to address management knowledge gaps* (*e.g.*, uses of sediment to enhance coastal wetlands).

What is the number of acres of tidal wetlands in the watershed and what percentage of that number is the ecosystem target of 10 acres? Approximately 22,795 acres of tidal wetlands remain in the watershed. The target acreage is less than 1% of the bay's tidal wetlands; however, this target exceeds the wetlands acres known to have been restored in the Barnegat Bay during the last 20 years.

One commenter stated that the focus on clam restoration should be expanded to include information on oysters and actions/strategies for oyster restoration. Section 6.2 describes the oyster resources of the bay, including BBP's funding of oyster reef restoration projects. While no specific species or habitats are named, within the Living Resources Priority Area oyster restoration would fall under Objectives LR-1, *Develop and implement Habitat Protection and Restoration Plans for the watershed's characteristic habitats, including ecologically sensitive areas;* LR-2, *Restore and maintain sustainable populations of fish and wildlife*; and LR-4, *Conduct studies to improve scientific understanding of living resources and ecologically sensitive habitats*. Thus, oysters are well represented within the CCMP.

The oyster shell recycling program started by Long Beach Township should be expanded to other municipalities. The BBP should be the coordinating agency/facilitator to help other municipalities set up similar programs. The recycled shells can be used for oyster reef building, living shoreline projects, *etc*. We agree with the commenter that an oyster shell recycling program is an important step in an overall oyster reef restoration program. The BBP experimented with its own small-scale program in the past, and has encouraged and supported other partners in their efforts as well. In other regions oyster shell recycling programs are staffed by state agency personnel (North Carolina, Virginia, Maryland) or grant-funded positions (New York). It is our understanding that the LBT program receives municipal funding for staffing and transportation (trucks for shell collection). We would be happy to assist interested partners in developing a plan to obtain consistent funding to support a watershed-wide oyster shell recycling program.

Another commenter stated that ways to meet some of the bay's restoration needs is to have a shellfish hatchery, preferably a year-round facility near the water. Restoration of shellfishes and submerged aquatic vegetation would improve water quality; restoration of fish stocks would help make the bay a better place to live and visit, and also increase real estate values and create permanent jobs. We thank the commenter for his suggestion regarding shellfish restoration in the bay, and concur that the restoration of shellfish and SAV would benefit the bay's water quality. The BBP's Shellfish Working Group has developed a set of recommendations regarding shellfish enhancement and restoration, and identified the development of bay-specific strains of shellfish brood stock as a priority. Several of our partners are currently pursuing this line of research. However, a shellfish hatchery located within the watershed was not identified as a priority at this time given the scope of current restoration efforts, the expenses associated with constructing, operating, and

maintaining a facility, and the ability to tap into existing shellfish aquaculture facilities both within our watershed and in other parts of the state.

One commenter recommended that we limit the use of pesticides, such as herbicides on stone/gravel yards, because of the impact on bee populations. Pesticide application is regulated by state law; we agree that pesticides, even when used in accordance with state law, can have adverse impact on bees, other pollinators, and other beneficial insects. The BBP's Jersey-Friendly Yards website (www.JerseyYards.org) provides resources and tools for landscaping for a healthy environment. Reducing pesticide use by using safer, non-toxic methods when managing pests is one of the eight steps to a Jersey-Friendly Yard. WQ 4-2 addresses the establishment of a Jersey-Friendly Yard certification program to further promote practices that reduce non-point source pollution, including pesticides.

Land Use

One recommendation was made that brownfield sites should not be capped. Brownfield sites are governed by federal and state regulations; few are located within the Barnegat Bay watershed. The BBP typically comments in response to Public Notices on federal/state regulations and projects requiring federal/state permits, and other activities impacting public resources and interests at its discretion. This comment was shared with the BBP's management conference members for their consideration. No change was made to the BBP CCMP.

One commenter made a number of specific recommendations regarding municipal land use laws and regulations pertaining to development and re-development projects (*e.g.*, no parking, except for deliveries, should be free; parking structures should be multi-level). The BBP does comment on municipal land use projects at the request of municipalities or partners, but works to reach consistency with federal/applicable laws and consistency with BBP partners. These recommendations were shared with the BBP's management conference members for their consideration. The BBP CCMP includes LU Objective 2, *Promote and support sustainable land use and related practices to increase resiliency of vulnerable communities and support other BBP CCMP priorities*.

When municipalities periodically revise their master plans, does the BBP review and formally and officially provide comments to them on it? To our knowledge, the BBP has not formally reviewed any municipality's Master Plan, but has reviewed more limited municipal documents (*e.g.*, Natural Resources Inventory, municipal fertilizer and plastic bag ordinances, specific development projects requiring federal or state permits) at the request of municipalities or other partners.

One reviewer noted that development is unevenly distributed throughout the watershed and different parts of the watershed are affected unevenly by various laws (*e.g.*, Pinelands, CAFRA, *etc.*), and recommended that the BBP CCMP should place more emphasis on parts of the watershed where there are fewer regulatory controls. The BBP is not a regulatory program, and does not work by placing "controls" on land use or other activities. The BBP has provided technical assistance to state and other entities about ways to protect water quality, water supplies, and other natural resources that are applicable throughout all parts of the watershed. The BBP also promotes acquisition and management of open space, especially in areas which could be developed, by its many partners: LU Action 1-3, *Promote acquisition and management of lands to achieve: 1) community resilience, 2) natural resource protection, 3) water supply protection, 4) diverse recreational opportunities (including handicapped accessibility), and 5) promotion/ education regarding cultural heritage*; and LU Action 1-5, *Promote acquisition and management of lands towards achieving community and natural resource protection and resilience and a landscape that supports recreation and the cultural heritage of the Barnegat Bay through implementation of watershed-wide open space plans*. Lastly, the CCMP does identify actions that citizens and others can undertake on their own property.

Municipalities and land use planners need to consider the future costs to protecting homes being built in areas at risk for sea level rise and storm flooding. We agree that future costs and future risks should be incorporated into various plans throughout the watershed. LU Actions 2-2, *Support the development of localized and/or regional adaptation plans for vulnerable, low-lying communities (e.g., communities experiencing repetitive losses)*; and 2-3, *Promote innovative zoning and land use management techniques such as transfer of development rights (TDR), rolling easements, acquisition (fee simple and easements), buy-outs, strategic retreat, non-contiguous density transfer, center-based development, and septic density* explicitly identify and address the increased risks of storms and SLR.

The BBP should create a "sediment management plan" for Barnegat Bay addressing how and where to use dredged materials. Thank you for your comment. The BBP agrees that there is a need for a sediment management plan for the bay and/or the Jersey Shore. It is currently identified in the CCMP under LU Objective 2, *Promote and support sustainable land use and related practices (e.g., soil restoration, low-impact development, shoreline restoration, dredged material management) to increase resiliency of vulnerable communities and support other BBP CCMP priorities (e.g., water quality and supplies, living resources).* It is our understanding that there is a joint federal-state workgroup that is developing a sediment management plan for coastal New Jersey (separate from the development of interstate plans for New York Harbor and Delaware Bay individually).

Climate Change/Sea Level Rise

Sea level rise and the future of barrier islands – address the impact of potential loss of barrier islands to the character of Barnegat Bay. Thank you for your comment. Barrier

islands are dynamic components of coastal ecosystems and are shaped by many natural forces, which can be modified by human activities. In response to sea level rise, barrier islands may change in various ways (erosion, thinning); moreover, with higher rates of sea level rise, they are likely to change considerably (*i.e.*, breaching, overwash, permanent inundation, and retreat). While publicly available tools like NJ Floodmapper identify the probability that complete inundation is possible in the future due to sea level rise, it is our immediate focus to promote resiliency efforts (beach and marsh edge erosion) to coastal ecosystems and communities.

Several comments were made about the importance of addressing septic systems. With changing rainfall intensities along with potential rising and extended seasonal high-water tables due to sea level rise, homeowners may experience more frequent services and issues relating to septic systems. Thank you for making us aware of this concern. We are unaware of rising water tables in areas served by septic systems, but are sharing this concern with municipal, county, and state officials to consider this in future wastewater management planning. We have added a comprehensive action regarding septic systems, which are managed under the authority of each county's Wastewater Management Plan (See WQ Action 1-11.).

Education and Outreach

Further efforts should be undertaken regarding the awareness of not just the living resources, but how the ecosystems are interrelated to the social well-being of human life, first within the watershed and second in the bay. This order of efforts asks us as residents, tourists and citizens, not only to familiarize [ourselves with the bay and its problems] but to make an effort as stewards of the watershed. Thank you for your comment. We tried to capture this in our vision statement. Several actions in the Land Use section address these interrelationships, including LU Action 2-5, *Promote land use practices that recognize and prioritize water-dependent uses; Ensure that authorized waterfront uses are compatible with supporting commercial and recreational activities*; and LU Action 4-1, *Identify the social, economic and environmental impediments and solutions for implementing sustainable land use practices on existing and future private developments*.

One commenter wanted the plan to identify existing and future BBP staffing needs and include an action item to seek funding for a Social Scientist position as well as other needed positions. This would augment educational and communication efforts within the Partnership and external outreach with the public. The commenter further recommended reaching out to universities to seek students majoring in social/economic studies and to work with other estuary programs to develop pilot programs for utilizing social scientists and social science programs as needed. As part of the CCMP revision process, a needs assessment was undertaken in the summer of 2018 to identify critical roles, process improvements, and resources (staffing, facilities) needed by the BBP to facilitate the implementation of action items and reach the specific objectives and broader goals in the updated CCMP. The report's recommendations included the addition of several science and communications staff (See the BBP website for the full report.). At present, we are unaware of any NEP that has a social scientist on its staff; however, the BBP and other NEPs have begun working with national marketing and communications firms to develop and strengthen coordinated communication plans and campaigns.

One commenter recommended that strong consideration be given to the creation of a Citizen Advisory Committee (CAC). The original structure of the BBP included a Citizens Advisory Committee, drawn from local citizen leaders, to inform the public and develop strategies to develop education program and conduct public meetings and forums to involve all citizens in the decision-making process; however, the CAC disbanded prior to the program relocating to Ocean County College. The BBP established a Communication and Education Committee (CEC) to take on the core education and outreach functions of the CAC. The BBP has referred this recommendation to the full management conference for its consideration.

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