PART 4

APPENDICES

Geographic Information Systems (GIS) is a combination of computer hardware, software, and data that let us store, create, and analyze spatial data. Any information that is referenced to a location is spatial data. For example, addresses, latitude and longitude, or another coordinate system correlates specific data values to a place on Earth or in space. Any physical and cultural geographic features and their attributes can be displayed on a GIS system if they have this geo-referencing. GIS systems let us layer many different kinds of information together and examine their relationships. In a GIS we can create a digital map of an area using layers describing political boundaries, roads, streets, wetlands, soil types, building footprints and more. Once the map is created we can use the GIS to ask questions such as, "how many wetlands are within 100 feet of the roads"? The ability to create and update geographic information and interact with different elements of a map is what makes GIS such a powerful tool for many different applications. GIS is used in land use planning, transportation planning environmental management, business marketing and health and social services program planning and management and education.

GIS IN THE METROPOLITAN EAST COAST ASSESSMENT

Columbia University Center for International Earth Science Information Network, (CIESIN) has developed and managed a Geographic Information System (GIS) as a component of its partnership in the Metropolitan East Coast (MEC) Climate Change Assessment study. GIS was used in the MEC project in four capacities:

1. To assist researchers in mapping the results of their studies.
2. To create a visual description of the study region as a tool for researchers, stakeholders.
3. To communicate findings to the general public on the Metro East Coast website.[1]
4. As part of an on-line resource for students and educators wishing to use the MEC Assessment data in their classroom studies.

The Metropolitan East Coast GIS has played a valuable role in assisting research participants to analyze and visualize their results. Fundamentally, the GIS provides a detailed description of the physical and social geography of the study region. More importantly, the GIS helps to map the magnitude and spatial distribution of potential threats to the region's infrastructure, public health, water supplies, coastal zones and wetland areas resulting from climate change. Publishing the maps that illustrating these potential threats on the Metropolitan East Coast web site contributes to the project's goal of increasing public awareness about global climate change issues. One of the most interesting applications of the MEC GIS is a special Educator's Package that delivers GIS data layers and a free GIS software program along with a series of lesson plans for teachers and students to use in classroom projects.

Data Set Inventory

The Metropolitan East Coast study region is a 31-county area that constitutes the New York City metropolitan area. We have complied the following data layers for use in the MEC GIS:

- Tiger Files, 1997 US Census Bureau:
  Political Boundaries, Roads, Landmarks, Water Bodies, Streams, and Demographic Information by Census Tract & Block
  Climate Models from the CCS and Hadley Centers on Climate Change
- New York City Department of Environmental Protection, Watershed Layers:
  Watershed Bounds
  Reservoirs
  Streams
  Farms
  Monitoring Sites
  20-foot Contours
  Political Divisions
- Landsat Thematic Mapper image of the New York region
- USGS Digital Elevation Models
- USGS 1:250,000 Land Use Land-Cover Data
- National Wetland Inventory
- New Jersey Department of Environmental Protection, 1:58,000 Land Use Classifications
- Digital Ortho-Photo Quadrangles for New Jersey & Long Island
- NPA Data, Growth Projection Data

General Description Maps

In order to provide an easy way for researchers and stakeholders in the project to express the study area's physical and cultural geographic features, we developed a GIS that

[1] URL for the MEC website is: http://metroeast_climate.ciesin.columbia.edu

would layer census and other data over digital maps of the states and counties of the MEC region. This affords the ability to illustrate layers such as census geography, road and transportation networks, cultural landmarks, major cities, water bodies and streams over the base map.

We have incorporated into the GIS a series of satellite images that depict the vegetation, urban development and landforms that are part of the study region's urban center and the suburban and rural areas that surround it. A unique set of images using satellite data created by Christopher Small of Lamont-Doherty Earth Observatory show thermal patterns in the Metropolitan East Coast area.

Global Climate Model Maps

A fundamental tool in the Metropolitan East Coast Assessment is scenario analysis based on global climate models (GCMs). These computer models project possible changes in global temperature and precipitation. The two models used in the reports that contribute to the National Assessment are from the Hadley Centre for Climate Prediction and Research[2] and the Canadian Centre for Climate Modeling and Analysis.[3]

Datasets from these centers contain point data with an x and y location and variables for temperature and precipitation for specific years in the future. We compiled these data into values to express projections for the time-slices 2020s, 2050s, and 2080s. To view these data as maps we have layered grid cells of the sizes in the climate models (3.75 degrees (long) x 2.5 degrees (lat) in the Hadley Model, 3.75 (long) x 3.71 (lat) in the Canadian Centre model) with thematic maps that express the variable-based climate scenarios for the time-slices. Temperature values are in degrees centigrade and precipitation is defined as percent change.

A series of maps created using these data include:

- Hadley Global Temperature
- Hadley Global Precipitation
- Canadian Global Temperature
- Canadian Global Precipitation
- Hadley v. Canadian Temperature 2020s, 2050s, 2080s
- Hadley v. Canadian Precipitation 2020s, 2050s, 2080s

Demographic Mapping

The US Census Bureau Provides a series of digital geographic information layers known as the Topographically Integrated Geographic Encoded and Referencing (TIGER) files. These files include layers for roads, streams, political boundaries, landmarks and census geography boundaries such as blocks, tracks and metropolitan statistical areas (MSA's). We have compiled the Census tracts for the 31-county area of the Metropolitan East Coast study with the associated demographic variables to create a series of thematic maps to illustrate social patterns throughout the region.

Using these data we created the following demographics thematic maps:

- Population Density
- Average Income
- Poverty: percent of population living below the poverty line
- Average Housing Value
- Buildings built before 1940

On-line creation of thematic maps for any of other the over 220 variables from the 1990 U.S. Census is possible using either CIESIN's DDViewer (demographic data viewer) program at http://www.ciesin.org/interapps.html, or through the Metropolitan East Coast Assessment Educators' Pack, downloadable at http://metroeast_climate.ciesin.columbia.edu/.

Digital Elevation Models

To understand the potential effects of sea level rise we have employed USGS Digital Elevation Models (DEMs). These models, which depict the average elevation over a 30-square meter (323 square feet) grid cell, allow us to see which coastal areas are most susceptible to increases in mean sea-level elevation. The horizontal accuracy of the data sets is between 1.5 and 3 meters (5 and 10 feet). Using ESRI's ArcView Spatial Analyst software we derived an estimated 5-foot (1.5 meter) contour set for the area and through a projection, we are able to overlay this contour with our other data layers.

This DEM along with detailed information on transportation features (roads, bridges, tunnels, shipping ports, and airports), and buildings were compiled to study the potential impacts of climate change on the region's infrastructure. Using this analysis we have developed a series of maps that indicate the areas with 0 to 3 feet (0 to 0.9 meters), which highlights those areas that are vulnerable to flooding. The potential impacts to the area major airports, highways, and other infrastructure elements can easily been seen.

Land Use Coverage Data

Land use data derived from satellites and arial photography contributes to the GIS by adding an improved temporal dimension. We study the historic change in land use and land cover in the region and incorporate these trends into our analysis of the possible impacts of climate change. We compare the change of land use classification

[2] http://www.meto.govt.uk/sec5/sec5pg1.html
[3] http://www.cccma.bc.ec.gc.ca/

percentages by census tract over the past twenty years. For the New Jersey sections of the Metropolitan East Coast region we have studied the changes in land use and land cover over the past ten years using land use classification layers at a scale of 1:58,000 for the years 1986 and 1997 provided by the New Jersey Department of Environmental Protection.

GIS PROJECTS FOR INDIVIDUAL SECTORS

Coastal Sector Maps

For the Coastal Sector, we have developed a series of maps that define the demographic make-up of populations that are at risk to impacts of sea-level rise. Six study areas were chosen to review: Coney Island, Rockaway, the Battery, and Westhampton in New York and Asbury Park and Sea Bright in New Jersey.

To create the maps we layered five-foot contour intervals from 7.5-minute quadrangle Digital Elevation Models with the Census tracts. The Census tract boundaries are not very accurate; for example, tracts that depict coastal areas very often extend well into the ocean. The zero elevation contours were assumed to be the base shoreline. We edited the census tracts in order to bring the tracts into conformity with the shorelines. Three thematic maps were then generated for each of the six sites using the demographic variables from the 1990 Census: Population Per Square Mile, Average Household Income, and Average Housing Values. Contours lines for the 5-, 10- and 15-foot elevations were placed over the classified census tracts. The resulting maps give a sense of the social composition of populations living near the coasts, those most likely to be subjected to sea-level rise and increased frequency and severity of coastal storm events.

Health Sector Maps

For the Public Health sector, we have employed GIS technology to compile data sets on several diseases and map their spatial distribution. Maps for all the following have been created:

- Heart Disease
- Malignant Neoplasms
- Cerebro-Vascular Disease
- Pneumonia/Influenza
- COPD
- HIV
- Asthma

We also use the GIS to map the spatial and temporal correspondence between ground level ozone and asthma rates, a relationship that is of significant concern in terms of climate impacts. Maps will be created to show the potential increases in these diseases based of environmental change as predicted by internationally recognized Global Climate Models.

MEC EDUCATION MODULE

As part of the outreach and education efforts of the Metropolitan East Coast Assessment, we have developed an education module. The modules use the research of the Assessment as a foundation for students to look at climate change at a local level.

The module is composed of three parts: background, skills, and application. In the background section of the module, we use lectures and readings to introduce students to main concepts of the Metropolitan East Coast Assessment:

- Science of Climate Change
- Climate Change Research: Globally to Locally (IPCC, National Assessment, Metropolitan East Coast Assessment)
- The Metropolitan East Coast Region: People, Place and Pulse
- Climate Impacts, Examples from the MEC Assessment
- Adaptation and Mitigation: Social Responses to Climate Change

During the course of the module, the students are taught to use GIS software and data from the Metropolitan East Coast Assessment to develop maps that combine demographic and physical data of the region to express relationships such as vulnerabilities to climate impacts. (See MEC Educator's Pack for examples of the GIS activities).

In preparation for the final component of the module, a public-hearing role-play, the students learn interviewing skills. The students pick or are assigned roles that represent a variety of interests and perspectives in the Metropolitan Region. Some of the roles have been:

STAKEHOLDERS

The Port Authority of New York and New Jersey
New York City Department of Health
Federal Emergency Management Agency (FEMA)
Regional water planners
Environmental Protection Agency, Region 2
New York Power Authority

TECHNICAL SPECIALISTS

Climate Scientist
Ecologist

Hazards Specialist
Energy Specialist
Social Scientist

NON-GOVERNMENTAL ORGANIZATIONS, PROFESSIONAL ORGANIZATIONS, AND OTHER INTERESTS

Regional Plan Association
Environmental Defense
Climate Change Learning and Information Center
American Petroleum Industry
Emissions Trading Firm
General Public

LOCAL AND STATE GOVERNMENT

Office of the Mayor of New York City
New York Congressional Representatives

Because the Metropolitan East Coast Assessment has done extensive outreach within the region, the students are able to contact the representatives of the various "roles" with whom we have worked and thus have direct access to decision- and policy-makers in the region. The students conduct and write-up the interviews in preparation for the culminating activity of the module: the mock public hearing.

In the mock public hearing, the students are expected to present the views and opinions of the particular "role" that they researched and interviewed. Before the day of the hearing, the students are presented with an invitation to the public hearing, which outlines the issue that is up for discussion. The question can be broad, such as "Should New York State develop a Climate Change Action Plan?" or very specific, for example "Should New York City tax money be spent on building a storm wall in Lower Manhattan?" The students discuss the issues that contribute to the decision according to their rules and finally, vote on the given question.

Through the module, several themes emerge:

- Local impacts of global environmental change
- Overlapping impacts that exist within a city with complex systems
- Scientific uncertainty and decision-making
- The role of mitigation versus adaptation in global climate change
- Short-term and long-term thinking

MEC EDUCATOR'S PACK

The GIS-based MEC Educator's Pack is a package of GIS software, datasets and lesson plans designed for educators who are interested in using GIS technology to explore global climate change issues. The package includes a free GIS software program called ArcExplorer created by ESRI, a leading GIS software developer. The datasets available include climate models and the US Census Bureau's TIGER Files, as well as several other datasets from the MEC Assessment. We also provide two lesson plans that use ArcExplorer to view the MEC data and produce a series of maps that illustrate climate change scenarios in the MEC region. The MEC Educator's Pack is available for free from the MEC web page at http://metroeast_climate.ciesin.columbia.edu or on a CD-ROM upon request. For additional information please contact:

Center for International Earth Science Information Network (CIESIN)
Columbia Earth Institute
Lamont-Doherty Earth Observatory
61 Route 9W
Palisades, NY 10964
845-365-8988
http://www.ciesin/org

Contents

The MEC Educator's Pack contains a series of programs and datasets under the flowing directory structure:

ArcExplorer

- aeclient—This is the free GIS software program from Environmental Research Institute (ESRI). Click on this icon on the website to start the install program.
- arcexplorer_user_guide—An introduction to and a tutorial on using ArcExplorer

More information on ArcExplorer and all of ESRI's GIS products and services may be found on their website at http://www.esri.com.

GIS_Data

CLIMATE MODELS

- Canadian—ccs258.xxx—These five files are the shape file of the Canadian Center Model
- Hadley—hsc258.xxx—These five files are the shape file of the Hadley Center Model

GEO_DATA

This directory contains a number of geographic data layers for use in project, including:

File Name	Description
31 County Metro Area.shp	Counties in the MEC Region
5_foot_metro_contours.shp	5 Foot Contours from DEMs for NYC area
airports.shp	Airports

county.shp	US Counties
ghospital.shp	US Government Hospitals
lalndmrk.shp	Landmarks
cities.shp	US Cities

TIGER

This directory contains a file called MEC *tracts.shp* that contains all the census tract boundaries for all the census tracts with in the MEC region with the associated demographic variables.

Lesson_Plans

This directory holds two sample lesson plans that provide step-by-step instructions for using the GIS program and data sets in the classroom. The first lesson gives instructions for creating maps using the climate change scenarios from the Canadian and Hadley climate models. The second lesson entails creating thematic maps using the 1990 Census data for the MEC region.

System Requirements

ArcExplorer will only run on a PC-based platform. Recommended system requirements are a Pentium Chip and at least 16 MB RAM. The entire Educator's Package uncompressed is approximately 60 Megabytes in size.

Lesson Plan for Middle School Science Class

1.) LESSON PLAN ONE—MAPPING CLIMATE CHANGE SCENARIOS WITH ARCEXPLORER

In this lesson, we use the data layers from the Hadley and Canadian climate centers to create thematic maps illustrating temperature and precipitation predictions for the 2020s, 2050s, and 2080s. We will make maps at the global scale and maps that focus on the Metro East Coast region. After completion the maps may be printed out and used in a comparison exercise that looks at the differences between the projections of the two models. This exercise can also be used as a reference for further explorations that investigate the scientific basis that provides the foundation of the models and their resulting projections.

Step One: Setting Up

Create a directory on your hard drive to install the MEC Educator's Pack. Download the MEC Educators Pack into the new directory. Install ArcExplorer by going to the directory *Mec_Educators_Pack/ArcExplorer/* and click on the *aeclient.exe* file. This will start the installation process. Accept all the default values in the installation process.

After the installation is complete, it is necessary to restart the computer. Once the computer is running again, there will be an ArcExplorer icon on the desktop. To start the program, click on the icon.

Step Two: Start a Project

Start a project by moving your cursor to the *File* menu and click on *File/New ArcExplorer.*

Step Three: Adding Data Layers to the Project:

Click on the *Theme* menu and the *add theme* option (or click on the *plus sign icon* at the top of the window) and navigate to where the *country.shp* file is stored (C:/MEC GIS Viewer/GIS_Data/Geo_Data/country.shp). Select the following layers: *hcs.shp*, *ccs.shp*, *country.shp*, *31cnty_geoshp.shp* and click on the *add theme* button.

Step Four: Creating a Thematic Map of the Hadley Climate Model Showing Temperature Predictions for the Year 2020.

1. Make the *hcs258.shp* visible
2. Double click on the layer name *hsc258.shp* to open up the *Theme Properties Dialogue Box.*
3. Under the *Classification Options* on the left side of the box; choose *Class Breaks.*
4. Choose the *classify* option.
5. Next under the *Numeric Field* drop down list choose *T20S.*
6. Set the number of classes to 6.
7. Create a new color ramp by double clicking on the *Start Color.*

From the new color pallet window select a light color blue for your start color and click the *OK* button. Click on the *End color* and choose a bright red color and click *OK.* Then click on the *OK* button on the lower right of the dialogue box.

We now have a layer of cells colored by the one of the values in the database. In this case, the values of the cells are predicted change in temperature in degrees centigrade for the 2020s.

8. To make the country boundaries layers visible, left click on the check box next to the country file to make the theme visible. This enables a better understanding of the cells' locations.
9. Change the fill pattern to transparent so that only the country borders will be seen: Double click on the *Country file* name on the left side of the ArcExplorer window to open the *Theme Dialogue* box. At the center of the box you will see the option to change the color, style, and the size of the symbols. From the style option click on the drop down box and choose the *Transparent* option. If you wish to change the color of the outline select *Other* symbol properties and from the new window that appears change the line color. Click the *OK* button at the button of the *Theme Properties Dialogue* box.
10. Use the pan and zoom tools to explore different regions.
11. When you are ready to print out the map go to the *File* option on the menu bar and choose the *Print* option.

12. Make maps showing temperature changes for the 2050s and 2080s. To do this, reclassify the grid using the T50S and the T80S variables. Print out each of these maps. Next make a series of maps showing predicted precipitation change using the variables P20S, P50S and P80S.
13. Save your project by going to *File/Save Project.*

Step Five: Adding the 31-County Region Boundaries
To get a close look at the projected climate scenarios in the Metropolitan East Coast Region, we add the geoshape file that layers on the county boundaries for the region.
1. Make the theme *31cnty_geoshp.shp* visible.
2. Change the fill pattern to *Transparent.*
3. Classify the theme *hsc258.shp* to the temperature variables T20S.
4. Zoom into the new *31cnty_geoshp.shp* theme.
5. How much does the model predict that the temperature will change?
6. Now classify the 2050s and 2080s, noting the projected changes.
7. Now do the same for the projected precipitation changes.
8. Save your project.
9. Print out some of your maps.

For the Teacher

This lesson is designed to get students familiar with using the ArcExplorer program and the various data sets. Once students are comfortable with using the program, you can expand your explorations. This lesson has students create and compare maps using Hadley and Canadian data sets. Students can do research on the methods and assumptions that serve as foundation for the development of the models; they can begin to explain the reasons for the models' differing scenarios. The students may discuss some of the potential flaws in the models; it is especially relevant to discuss the challenges of applying a global model to a relatively small area such as the 31-county Metropolitan East Coast region. A follow-on exercise involves discussion of and search for additional data layers that would be useful to bring into the project. Many data are available on the internet and can be imported into the projects to create alternative exercises.

LESSON PLAN TWO—DEMOGRAPHIC THEMATIC MAPPING

In this lesson, we use demographic information created by the U.S. Census Bureau and GIS files describing the census tracts for the MEC region. Included in the MEC Educators Pack is a GIS file called *MEC Tracts.shp* that contains all of the census tracts for the MEC region with an attached database containing over 200 demographic variables on age, ethnicity, income, employment and other categories. In this lesson, this file is used to create color-coded maps that display the spatial distribution of these variables. For more information on census geography visit the bureau's web site at (http://www.census.gov/).

Step One: Setting Up
Create a directory on your hard drive to install the MEC Educator's Package. Download the MEC Educators Pack into the new directory. Install ArcExplorer by going to the directory *Mec_Educators_Pack/ArcExplorer/* and click on the *aeclient.exe* file. This will start the installation process. Accept all the default values in the installation process. After the installation is complete, it will be necessary to restart the computer. Once the computer is running again, a new ArcExplorer icon will be on the desktop. Click on the Icon to start the program.

Step Two: Starting the Project
Start a project by moving your cursor to the *File* menu and click on *File/New ArcExplorer.*

Step Three: Adding Layers to the Project
Click on the *Theme* menu and the *add theme* option (or click on the plus sign icon at the top of the window) and navigate to where the *MEC Tracts.shp* file is stored (C:/MEC GIS Viewer/GIS_Data/Geo_Data/TIGER/Mec Tracts.shp). Select the layer and click on the *add theme* button.

Step Four: Mapping Demographic Variables
1. Double click on the layer name *MEC Tracts.shp* to open up the *Theme Properties* dialogue box.
2. Under the *Classification Options* on the left side of the box choose *Class Breaks.*
3. Choose the *classify* option.
4. Under the drop down list you will see the 200+ demographic variables that you can use for your mapping. Choose the variable *AVGHHINC* to map the average house hold income for the MEC region.
5. Set the number of classes to *6.* This creates six classifications in which the data will be divided.
6. Create a new color ramp by double-clicking on the *start color.*
7. From the new color pallet window, select a light yellow for your start color and click the *OK* button. Click on the *end color* and choose a bright red color and click *OK.* Then click on the *OK* button on the lower right of the dialogue box. We now have a layer of cells colored by one of the values in the database
8. Add some of the other layers that are available under the *Geo Data Folder* such as airports, hospitals, landmarks, and cities.
9. Print out your maps using the *print option* from the *File* menu.

For the Teacher

Demographic maps can supplement a great many lessons from social studies to mathematics. Try combining the demographic information with the climate change scenarios. The students can discuss possible hypotheses regarding impacts of climate change in the region. Math teachers can use the data to discuss different ways to classify and display large datasets. The maps that students generate in these exercises can provide a springboard for group discussions on politics, economics, land use planning, and science and public policy.

APPENDIX CLIMATE 1 Metro East Coast Climate Sites

City	State	Latitude	Longitude	Years	Mean Annual Temp (°F)	Mean Annual Precipitation (inches)
Falls Village	CT	41.95	–73.37	1916–1997	46.75	42.65
Groton	CT	41.35	–72.05	1900–1997	49.22	46.71
Stamford	CT	41.13	–73.55	1919–1997	50.14	52.83
Atlantic City	NJ	39.38	–74.43	1900–1997	54.17	39.66
Belvedere	NJ	40.83	–75.08	1900–1997	49.40	43.53
Boonton	NJ	40.90	–74.40	1900–1997	50.03	46.84
Charlotteburg	NJ	41.03	–74.43	1900–1997	48.25	50.08
Flemington	NJ	40.57	–74.88	1900–1997	50.14	46.57
Hightstown	NJ	40.27	–74.57	1900–1997	51.95	47.35
Longbranch Oakhurst	NJ	40.27	–74.00	1913–1997	51.22	46.25
New Brunswick	NJ	40.47	–74.43	1900–1997	51.43	46.92
Plainfield	NJ	40.60	–74.40	1900–1997	51.86	48.23
Tuckerton	NJ	39.60	–74.35	1900–1997	52.77	47.45
Bridgehampton	NY	40.95	–72.30	1930–1997	50.12	48.16
Glenham	NY	41.52	–73.93	1932–1997	50.92	43.68
Mohonk Lake	NY	41.77	–74.15	1900–1997	46.82	47.46
Port Jervis	NY	41.38	–74.68	1900–1997	48.50	42.72
Poughkeepsie	NY	41.63	–73.92	1900–1997	47.60	40.01
Scarsdale	NY	40.98	–73.80	1904–1997	50.55	43.30
Setauket Strong	NY	40.97	–73.10	1900–1997	51.83	44.39
Walden	NY	41.55	–74.17	1925–1997	48.58	44.03
West Point	NY	41.38	–73.97	1900–1997	50.80	48.94
Yorktown Heights	NY	41.27	–73.80	1900–1997	49.03	47.91

Note: Central Park, NYC meteorological station was omitted from the urban heat island correction done for the Metro East Coast Assessment due to poor data quality.

APPENDIX COAST 1 Sea-Level Trends in Eastern North America

Station	**RSLR (1)** ***(mm/yr)***	**SEOT (2)** ***(mm/yr)***	**AVER. (3)** ***(mm/yr)***	**COR. SLR (4)** ***(mm/yr)***
Yarmouth, N.S.	2.26	0.81	2.0	0.26
Charlottetown, PEI	2.69	0.20	1.14	1.55
Halifax, N.S.	3,52	0.13	2.83	0.69
St. John, N.B.	2.72	0.23	1.19	1.53
Eastport, ME	1.54	0.42	1.19	0.35
Bar Harbor, ME	2.21	0.27	1.19	1.02
Portland, ME	1.94	0.13	0.92	1.02
Portsmouth, NH	1.80	0.22	1.49	0.31
Boston, MA	2.68	0.15	1.49	0.31
Cape Cod Canal, MA	2.01	1.03	1.75	0.26
Wood's Hole, MA	2.47	0.18	1.75	0.72
Providence, RI	1.73	0.24	1.35	0.38
Newport, RI	2.44	0.16	1.35	1.09
New London, CT	2.10	0.21	1.35	0.75
Bridgeport, CT	**2.57**	**0.67**	**1.35**	**1.22**
New Rochelle, NY	**2.05**	**1.48**	**1.35**	**0.70**
Montauk, NY	**2.27**	**0.33**	**1.78**	**0.49**
Pt. Jefferson, NY	**2.20**	**0.56**	**1.78**	**0.42**
Willets Point, NY	**2.30**	**0.22**	**1.78**	**0.52**
New York City, NY	**2.73**	**0.07**	**2.17**	**0.56**
Sandy Hook, NJ	**3.85**	**0.21**	**1.87**	**1.98**
Atlantic City, NJ	3.97	0.15	1.87	2.10
Lewes, DE	3.09	0.7	2.35	0.74
Baltimore, MD	3.14	0.11	1.81	1.33
Annapolis, MD	3.46	0.18	1.81	1.24
Washington, DC	3.05	0.26	1.81	1.24
Solomons Is., VA	3.36	0.22	1.81	1.55
Gloucester Pt., VA	3.64	0.38	1.20	2.44
Kitopeake B., VA	3.35	0.36	1.20	2.15
Hampton Roads, VA	4.26	0.20	1.20	3.06
Portsmouth, VA	3.74	0.29	1.20	2.54
Wilmongton, NC	2.04	0.27	1.23	0.81
Charleston, SC	3.27	0.18	1.01	2.26
Savannah, GA	3.01	0.23	0.43	2.58
Fernandina, FL	1.97	0.14	0.57	1.40
Mayport, FL	2.23	0.21	0.57	1.40
Daytona Beach, FL	2.01	0.66	0.57	1.44
Miami Beach, FL	2.29	0.26	0.69	1.60
Key West, FL	2.23	0.11	0.69	1.54
Average (N=39)	2.67 ±0.70	0.32±0.53	1.41	1.26±0.73

(1) **RSLR:** raw tide-gauge data (PSMSL, 1998); (2) **SEOT:** standard error of trend; (3) **Aver.:** average trend ″ 6000 yrs BP, C14 data (Gornitz, 1995b); (4) **COR. SLR:** corrected sea level trend, i.e., (1)–(3); (5) Because the rate of sea-level rise has decreased over the last several thousand years, a linear regression fit to the geologic data tends to overestimate the correction, thus lowering the modern sea-level trend; Gornitz, 1995a..

APPENDIX COAST 2 Tidal Data

Site	MTL-NGVD		MSL-NGVD	
	feet	*cm*	*feet*	*cm*
Battery Park	0.62	18.9	0.70	21.3
Coney Island	0.58	17.7	0.65	19.8
Rockaway Beach	0.57	17.4	0.63	19.2
Long Beach	0.53	16.2	0.58	17.7
Westhampton Beach	0.52	15.8	0.56	17.1
Montauk	0.48	14.6	0.51	15.5
Sandy Hook	0.76	23.2	0.79	24.1

Note: To convert surge or flood levels based on NGVD to MTL, subtract (MTL–NGVD) from the surge (flood) height. Similarly for NGVD to MSL.

A datum is an arbitrary elevation level used as a reference from which heights or depths are measured. A tidal datum is defined in terms of a particular phase of the tide. Commonly used datums are as follows:

MEAN HIGHER HIGH WATER (MHHW)
The arithmetic mean of the higher of two high tides in a tidal day averaged over a specific 19-year Metonic (lunar nodal) cycle (The National Tidal Datum Epoch).

MEAN HIGH WATER (MHW)
The arithmetic mean of of the high water levels taken over a specific 19-year cycle.

MEAN SEA LEVEL (MSL)
The arithmetic mean of hourly water levels measured over a specific 19-year cycle.

MEAN TIDE LEVEL (MTL)
The arithmetic mean of MHW and MLW. This value is very close to, but not identical with mean sea level.

MEAN LOW WATER (MLW)
The arithmetic mean of the low water levels over a specific 19-year cycle.

MEAN LOWER LOW WATER (MLLW)
The arithmetic mean of the lower of two low tides in a tidal day, observed over a specific 19-year cycle.

NATIONAL GEODETIC VERTICAL DATUM (NGVD)
Formerly known as the mean sea level (MSL) of 1929.

APPENDIX COAST 3 Characteristics of Study Sites

	Coney Island	Rockaway Beach	Long Beach	Westhampton Beach	Sea Bright Ocean Town	Asbury Park Manasquan
Length						
mi	2.95	6.4	7.77	4.0	11.8	9.0
km	4.75	10.3	12.5	6.4	19.0	14.5
Initial date	1994–1995	1975–1997	2002–2003	1997	1994–1998	1997–1999
Duration, yr	50	25	50	30	50	50
Renourish cycle, yr	10	3	6	3	6	6
SLR						
in/yr	0.11	0.11	0.10	0.10	0.15	0.15
mm/yr	2.73	2.73	2.58	2.45	3.85	3.85
Berm ht.[a]						
ft	13.0	10.0	10.0	9.5	10.4	10.4
m	3.96	3.05	3.05	2.9	3.17	3.17
Depth of closure[a]						
ft	–17.0	–17.0	–20.0	–22.0	–21.0	–20.0
m	–5.18	–5.18	–6.10	–6.70	–6.40	–6.10

[a] Referenced to NGVD (see Appendix Coast 2)

APPENDIX COAST 4 Projected Sea-Level Rise Scenarios and Subsidence

METRO EAST COAST REGION (cm)

Site	Decade	Current Trend	CCGG	CCGS	HCGG	HCGS	SUBS
NYC	2000	8.2	9.5	9.5	8.6	7.6	4.3
	2010	10.9	15.9	16.4	12.7	11.1	5.7
	2020	13.7	24.1	21.7	16.1	13.9	7.1
	2030	16.4	31.4	25.3	22.1	18.0	8.6
	2040	19.1	44.7	36.7	27.1	23.6	10.0
	2050	21.8	51.1	47.5	32.5	25.8	11.4
	2060	24.6	64.8	54.1	38.9	30.7	12.9
	2070	27.3	82.3	65.4	46.3	36.9	14.3
	2080	30.0	95.5	75.9	54.4	42.6	15.7
	2090	32.8	114.5	98.6	60.0	49.5	17.2
WP	2000	6.9	8.2	8.2	7.3	6.4	3.0
	2010	9.2	14.2	12.2	11.0	9.3	4.0
	2020	11.5	21.9	19.5	14.0	11.7	5.0
	2030	13.8	28.8	22.7	19.5	15.4	6.0
	2040	16.1	41.7	33.7	24.1	20.6	7.0
	2050	18.4	47.7	44.1	29.1	22.4	8.0
	2060	20.7	60.9	50.2	35.0	26.8	9.0
	2070	23.0	78.0	61.1	42.0	32.6	10.0
	2080	25.3	90.8	71.2	49.7	37.9	11.0
	2090	27.6	109.3	93.4	55.5	44.3	12.0
PJ	2000	6.6	7.9	7.9	7.0	6.1	2.7
	2010	8.8	13.8	11.8	10.6	8.9	3.6
	2020	11.0	21.4	19.0	13.5	11.2	4.5
	2030	13.2	28.2	22.1	18.9	14.8	5.4
	2040	15.4	41.0	33.0	23.4	19.9	6.3
	2050	17.6	46.9	43.3	28.3	21.6	7.2
	2060	19.8	60.0	49.3	34.1	25.9	8.1
	2070	22.0	77.0	60.1	41.0	31.6	9.0
	2080	24.2	89.9	70.1	48.6	36.8	9.9
	2090	26.4	108.1	92.2	54.3	43.1	10.8
M	2000	6.8	8.1	8.1	7.2	6.3	2.9
	2010	9.1	14.1	12.1	10.8	9.2	3.9
	2020	11.4	21.8	19.4	13.8	11.6	4.9
	2030	13.6	28.6	22.6	19.3	15.2	5.8
	2040	15.9	41.5	33.5	23.9	30.4	6.8
	2050	19.2	47.5	43.8	28.9	22.1	7.8
	2060	20.4	60.7	50.0	34.7	26.6	8.7
	2070	22.7	77.7	60.8	41.7	32.3	9.7
	2080	25.0	90.5	70.9	49.4	37.6	10.7
	2090	27.2	108.9	93.0	55.1	44.0	11.6

Site	Decade	Current Trend	CCGG	CCGS	HCGG	HCGS	SUBS
SH	2000	11.6	12.9	12.8	11.9	11.0	7.7
	2010	15.4	20.4	18.4	17.2	15.5	10.2
	2020	19.3	29.7	27.3	21.7	19.5	12.8
	2030	23.1	38.1	32.0	28.8	24.7	15.3
	2040	27.0	52.6	44.6	35.0	31.4	17.9
	2050	30.8	60.1	56.5	41.5	34.8	20.4
	2060	34.7	76.7	66.0	50.8	42.6	24.8
	2070	38.5	93.5	76.6	57.5	48.1	25.5
	2080	42.4	107.9	88.3	66.7	55.0	28.1
	2090	46.2	127.9	112.0	74.1	62.9	30.6
LB	2000	8.0	9.3	9.3	8.4	7.4	
	2010	10.6	15.7	15.6	12.4	10.8	
	2020	13.3	23.8	21.4	15.8	13.5	
	2030	16.0	31.1	25.0	21.7	17.6	
	2040	18.6	44.4	36.3	26.7	23.1	
	2050	21.4	50.8	47.1	32.0	25.2	
	2060	23.9	64.5	53.7	38.4	30.1	
	2070	26.6	82.0	65.0	45.7	36.3	
	2080	29.2	95.3	75.5	53.9	41.9	
	2090	31.0	114.3	98.3	60.0	48.8	
WH	2000	7.3	8.6	8.6	7.7	6.8	
	2010	9.7	14.7	13.6	11.5	9.9	
	2020	12.2	22.6	20.2	14.6	12.4	
	2030	14.6	29.6	23.5	20.3	16.2	
	2040	17.0	42.6	34.6	25.0	21.5	
	2050	20.1	48.8	45.1	30.2	23.4	
	2060	29.2	110.9	95.0	57.0	45.9	
	2070	24.3	79.3	62.4	43.3	33.9	
	2080	26.8	92.3	72.7	51.2	39.4	
	2090	29.2	110.9	95.0	57.0	45.9	

Note: All changes are with respect to the 1961–1990 mean.

Tide-gauge stations: **NYC** New York City (the Battery), **WP** Willets Point, **PJ** Port Jefferson, **M** Montauk, **SH** Sandy Hook. Other sites: LB Long Beach, WH Westhampton.

APPENDIX COAST 5 100-Year Flood Levels for Combined Extratropical and Tropical Cyclones

METRO EAST COAST REGION (feet; meters)

SCENARIO	LOCALITY					
			2020s			
	NYC	**CI**	**RB**	**LB**	**WH**	**SB**
Current	10.2 (3.10)	11.2 (3.4)	10.1 (3.08)	10.4 (3.17)	9.9 (3.02)	10.6 (3.23)
CCGG	10.5 (3.20)	11.5 (3.5)	10.4 (3.17)	10.8 (3.29)	10.1 (3.08)	11.0 (3.35)
CCGS	10.4 (3.17)	11.4 (3.5)	10.4 (3.17)	10.7 (3.26)	10.1 (3.08)	10.9 (3.32)
HCGG	10.2 (3.11)	11.2 (3.4)	10.2 (3.11)	10.5 (3.20)	9.9 (3.02)	10.7 (3.26)
HCGS	10.2 (3.11)	11.2 (3.4)	10.1 (3.08)	10.4 (3.17)	9.8 (2.99)	10.6 (3.23)
			2050s			
	NYC	**CI**	**RB**	**LB**	**WH**	**SB**
Current	10.4 (3.17)	11.4 (3.5)	10.4 (3.17)	10.7 (3.26)	10.1 (3.08)	11.0 (3.35)
CCGG	11.4 (3.47)	12.4 (3.8)	11.3 (3.44)	11.7 (3.57)	11.0 (3.35)	12.0 (3.66)
CCGS	11.3 (3.44)	12.3 (3.7)	11.2 (3.41)	11.6 (3.54)	10.9 (3.32)	11.9 (3.63)
HCGG	10.8 (3.29)	11.8 (3.6)	10.7 (3.26)	11.0 (3.35)	10.4 (3.17)	11.4 (3.47)
HCGS	10.6 (3.23)	11.6 (3.5)	10.5 (3.20)	10.8 (3.29)	10.2 (3.11)	11.1 (3.38)
			2080s			
	NYC	**CI**	**RB**	**LB**	**WH**	**SB**
Current	10.7 (3.26)	11.7 (3.6)	10.6 (3.23)	11.0 (3.35)	10.4 (3.17)	11.4 (3.47)
CCGG	12.8 (3.90)	13.8 (4.2)	12.8 (3.90)	13.1 (3.99)	12.4 (3.78)	13.5 (4.11)
CCGS	12.2 (3.72)	13.2 (4.0)	12.1 (3.69)	12.5 (3.81)	11.8 (3.60)	12.9 (3.93)
HCGG	11.5 (3.50)	12.5 (3.8)	11.4 (3.47)	11.8 (3.60)	11.1 (3.38)	12.2 (3.72)
HCGS	11.1 (3.38)	12.1 (3.7)	11.0 (3.35)	11.4 (3.47)	10.7 (3.26)	11.8 (3.60)

The 100-year flood level includes projected global sea level rise, local subsidence, mean high water, and combined extratropical and tropical storm surge.

NYC New York City (the Battery), **CI** Coney Island, **RB** Rockaway Beach, **LB** Long Beach, WH Westhampton Beach, **SB** Sea Bright/Asbury Park.

APPENDIX COAST 6 Shoreline Erosion

METRO EAST COAST REGION (feet/year; meters/year)

SCENARIO	LOCALITY				
	2020s				
	Coney Island	**Rockaway Beach**	**Long Beach**	**Westhampton Beach**	**Seabright/Asbury Park**
Current	1.27 (0.39)	1.69 (0.51)	1.35 (0.41)	1.53 (0.47)	1.61; 1.88 (0.49; 0.57)
CCGG	2.24 (0.68)	2.97 (0.90)	2.42 (0.74)	2.53 (0.77)	2.48; 2.89 (0.76; 0.88)
CCGS	2.02 (0.62)	2.67 (0.81)	2.18 (0.66)	2.26 (0.69)	2.28; 2.65 (0.70; 0.81)
HCGG	1.50 (0.46)	1.98 (0.60)	1.61 (0.49)	1.63 (0.50)	1.81; 2.11 (0.55; 0.64)
HCGS	1.29 (0.39)	1.71 (0.52)	1.38 (0.42)	1.39 (0.42)	1.63; 1.89 (0.50; 0.58)
	2050s				
	Coney Island	**Rockaway Beach**	**Long Beach**	**Westhampton Beach**	**Seabright/Asbury Park**
Current	2.03 (0.62)	2.68 (0.82)	2.18 (0.66)	2.44 (0.74)	2.58; 2.99 (0.79; 0.91)
CCGG	4.75 (1.45)	6.29 (1.92)	5.17 (1.58)	5.46 (1.66)	5.02; 5.84 (1.53; 1.78)
CCGS	4.42 (1.35)	5.84 (1.78)	4.80 (1.46)	5.04 (1.54)	4.72; 5.49 (1.44; 1.67)
HCGG	3.02 (0.92)	4.00 (1.22)	3.26 (0.99)	3.38 (1.03)	3.47; 4.03 (1.06; 1.23)
HCGS	2.40 (0.73)	3.17 (0.97)	2.57 (0.78)	2.62 (0.80)	2.91; 3.38 (0.89; 1.03)
	2080s				
	Coney Island	**Rockaway Beach**	**Long Beach**	**Westhampton Beach**	**Seabright/Asbury Park**
Current	2.79 (0.85)	3.69 (1.13)	2.97 (0.91)	3.36 (1.02)	3.54; 4.12 (1.08; 1.26)
CCGG	8.88 (2.71)	11.75 (3.58)	9.70 (2.96)	10.32 (3.15)	9.01; 10.48 (2.75; 3.19)
CCGS	7.06 (2.15)	9.34 (2.85)	7.69 (2.34)	8.13 (2.48)	7.38; 8.58 (2.25; 2.61)
HCGG	5.06 (1.54)	6.69 (2.04)	5.49 (1.67)	5.73 (1.75)	5.58; 6.48 (1.70; 1.97)
HCGS	3.96 (1.21)	5.24 (1.60)	4.27 (1.30)	4.41 (1.34)	4.60; 5.34 (1.40; 1.63)

APPENDIX INFRASTRUCTURE 1 Basic Elements of Probabilistic Hazard and Risk Assessment

A probabilistic hazard can be expressed in one of several forms, one of which is known as a *Hazard Curve*, expressed as P = P(h*). It typically shows, on the vertical axis, the (logarithm of) annual probability $P(h \geq h^*)$ that the hazard parameter in question (in this case storm surge height *h*) is equal to or larger than a pre-set value *h** ; and on the horizontal axis it shows (the logarithm of) h*, the hazard parameter in question, i.e. the storm surge height (in ft or m) above a reference sea level or other vertical reference datum (in our examples above NGVD = National Geodetic Vertical Datum of 1929).

For small probabilities (P<<1), or large recurrence periods T, the inverse of the annual probability P is the average recurrence period T associated with surge height h*, i.e.:

$$T(h^*) \oplus 1 / P(h^*) \qquad (1)$$

If the storm surges can be assumed to be part of a Poisson process, i.e. an ensemble of independent random events, then an exact relation between probability of occurrence P, average recurrence period T, and exposure time t applies as follows:

$$P = 1 - \exp^{(-t/T)} = 1 - e^{(-t / T)} \qquad (2)$$

Equation (2) can be used to obtain the probability of occurrence P during exposure time t for a random Poisson process with average recurrence period T, with t and T measured in the same time units (years). Note that equation (2) approaches equation (1) for T>>(t=1y). Another interesting special case is P = 1 – 1/e = 0.63 (or 63%) when exposure time t and average recurrence period T are the same, i.e. t/T = 1. In many practical cases where the recurrence period T is long compared to the exposure period t of interest, we can use equation (1). But we may encounter cases during this study where the recurrence periods T become so short that exposure time t and recurrence periods T are comparable; or where exposure time t (of a structure "waiting" to be flooded) may be longer than the average recurrence period T of the flood with height h*. In that case we must use equation (2) to obtain a meaningful probability of occurrence of any single flood, which never can be larger than 100%, i.e. P is always ″1.

ASSETS In this study the value of the infrastructure assets is generally taken to be their current replacement value. This definition limits the resulting risk only to direct losses associated with the physical damage, its repair or replacement, but not the indirect losses associated with loss of operations, revenues and secondary economic losses, which in the case of networked transportation structures can be enormous.

FRAGILITY The storm surge fragility of the transportation infrastructure is poorly or at best incompletely known because during the systems' lifetime only few of the severest events have occurred. Hence fragility is empirically constrained only for low coastal flooding levels, and only for the structures at locations with the lowest elevations. This limitation constraints much of our assessments later on to largely qualitative statements about which facilities may be flooded under what hazard conditions without being able to quantify the expected direct losses, nor the losses resulting from limited or ceased operations. Moreover, in rigorous studies one must consider network fragility that is different from system component fragility. The operational losses from a failed network are much larger then the sum of the point-losses or local damages in the network.

PUTTING IT ALL TOGETHER: RISK Risk is the area-integrated product of hazard, assets, and asset-specific fragility, given the asset-specific hazard. Once the storm surge hazard is quantified probabilistically at any given site, say by a hazard curve P(h*), one normally proceeds to quantify the risk for a given asset or facility by using the following principles: Find the probability P that is associated with a certain surge height h* at the site of a facility with the asset value A. Let us assume that we know the fragility F(h*) of the structure when subjected to the surge height h*, whereby the condition $0<F(h^*)<1$ applies. That is, the fragility is the fractional loss F=L/A. If total loss occurs, L=A and hence F=1. If no loss occurs, L=0 and hence F=0. The expected risk can be expressed as the probability P(h*) for the loss L = AF(h*) to occur. Repeating this procedure for many different surge heights h* will yield an entire Risk Curve of the form

$$P = P(L) = P(L \mid h^*) \qquad (3)$$

where P (L | h*) reads: the probability for an expected loss L, given a surge height h*. Risk curves show on the vertical axis the probability P (of damage L occurring), and on the horizontal axis the damage L. Ignoring for the moment that lifelines are in reality mostly networks of interacting facilities, we assume here that there is one risk curve per facility.

What are the total regional (direct) losses that can be expected from a given storm j with a given probability Pj?

In that case we need to know the surge heights h_{ij} that storm j is expected to produce at all locations i at which the assets Ai are located, each of which has a fragility $F_{ij}(h_{ij})$ producing individual asset losses L_{ij}.

The total estimated loss which storm j produces will then be T_j = Sum Of L_{ij} where the sum Sum Of is over losses L_{ij} at all asset locations i.

Repeating many different storm tracks and different storm strengths (e.g. for hurricanes as measured by the Saffir-Simpson scale), each storm being associated with a probability P_j, yields an entire array of probabilities P_j vs. total losses T_j values. Plotting the P_j vs. T_j values will give a scatter-graph of the probability of losses vs. the magnitude of losses. From this graph one can derive for any chosen probability P* a distribution of expected total losses T* for which one may choose the mean, median or any other percentile level of confidence, assuming either normal or log-normal distributions, which ever fits the "data" best. This "Risk (or Loss) Distribution Curve" can then be used to determine the "probable maximum loss" (PML) in the area at any desired exceedance probability P and for any desired level of confidence. This generalized, probabilistic definition of PML varies from that used ordinarily in deterministic risk assessments where PML simply means the largest loss amongst all scenarios considered possible, but without quantifying the rate of occurrence or annual probability, i.e. some measure of likelihood.

Another option is to "deaggregate" the risk results further into their contributing factors by, for instance, taking the Saffir-Simpson scale, SS, for hurricanes into account. In that case one would plot the probabilities P on the vertical axis over a SS—T plane to search for the combinations of SS (storm category) and T (total loss in $) that-say—exceed a certain probability level (i.e. emerge as mountainous probability islands above a threshold probability sea). Such plots may allow one to choose the probability "mode" of the data set (the most likely occurrence). Or, by rearranging the variables and plotting loss T over the SS—P plane it would allow one to search for the most expensive storms (see PML, above) and at the same time know their probability and the SS category they would be associated with. Such insights can be important for insurance portfolio decisions, emergency relief planning, mitigation cost/benefit planning, and disaster planning whether by large facility or real estate holders or by public decision-makers setting regulatory policies.

To carry out such comprehensive computations and analyses requires extensive computer programs and storm track probability input data, which the Federal Emergency Management Agency (FEMA) has commissioned to be developed for standardized loss assessments on a national scale. They do already exist as HAZUS (1999) programs for computing earthquake losses; however, the wind, flood and storm surge versions, although partly in development, will take still several years to be fully developed and released. In the interim, we must instead choose a simple heuristic approximation to obtain at least some very rough estimates for expected storm losses. The results of this approximate heuristic approach are presented in the main text of this sector report.

APPENDIX INFRASTRUCTURE 2 Storm Surge Heights

Locations at which MNYHTS (1995) provides storm surge heights (ft) for Saffir-Simpson Category 1-4 storms. Latitudes and longitudes are geocoded and approximate.

ID	Location	Area/County/State	Long	Lat	Cat 1	Cat 2	Cat 3	Cat 4
1	Amityville	Great South Bay	–73.4175	40.6789	2.5	8.7	19.7	26.8
2	Asharoken N. Shore	Suffolk	–73.3603	40.9278	5.2	9.3	13.6	18.0
3	Atlantique	Fire Island	–73.1736	40.6394	6.8	11.4	15.4	19.8
4	Battery	Manhattan	–74.0154	40.7026	10.5	16.6	23.9	28.7
5	Bayonne	NJ	–74.1147	40.6686	9.2	12.5	19.3	27.9
6	Bridgeport	Connecticut	–73.2053	41.1669	7.2	7.2	11.1	13.9
7	Center Orches	Moriches Bay	–72.7842	40.7728	5.5	9.7	13.2	19.7
8	Centre Island	Oyster Bay	–73.5208	40.9000	5.7	10.3	15.2	19.8
9	City Island	Bronx	–73.7869	40.8472	6.3	11.5	17.3	22.2
10	Cold Spring Harbor	Oyster Bay	–73.5170	40.8500	5.7	10.3	15.2	19.8
11	Davis Park	Fire Island	–73.0053	40.6839	6.5	11.3	15.9	19.6
12	East Rockaway Inlet	Kings	–73.7506	40.5914	9.0	14.8	20.0	25.2
13	East Rockaway	Hewlett Bay	–73.7506	40.5914	6.1	17.0	22.1	26.9
14	Elizabeth	NJ	–74.2111	40.6639	8.4	10.3	13.6	17.2
15	Floyd Bennett Naval Air Station	Brooklyn	–73.8996	40.6001	6.7	14.0	21.7	28.5
16	Flushing Bay	Flushing, Queens	–73.8500	40.7670	6.6	11.6	16.3	20.9
17	Fort Hamilton	Brooklyn	–74.0336	40.6186	9.3	15.2	20.9	27.0
18	Freeport, South Shore	Nassau	–73.5836	40.6575	7.7	14.9	23.2	29.4
19	Fresh Kills Landfill	Staten Island	–74.1830	40.5500	8.6	10.5	12.8	17.3
20	George Washington Bridge	NYC	–73.9500	40.8500	6.9	14.1	16.8	26.7
21	Gilgo Beach	Suffolk County	–73.3830	40.6170	8.0	13.6	17.3	23.5
22	Glen Cove	Long Is. Sound	–73.6342	40.8622	6.0	10.9	16.0	21.0
23	Goethals Bridge	Arthur Kill	–74.1737	40.6230	8.9	10.7	14.4	17.8
24	Gravesend Bay	Brooklyn	–74.0097	40.5897	9.2	15.2	20.8	27.2
25	Great Kill	Staten Island	–74.1519	40.5550	10.1	15.9	21.2	27.1
26	Greenwich Cove	CT	–73.5750	41.0175	8.4	8.4	11.1	15.1
27	Hell Gate	Wards Island	–73.9139	40.7986	7.9	11.7	14.9	18.1
28	Huguenot	Staten Island	–74.1950	40.5372	10.2	16.6	22.1	27.4
29	Island Park	Long Beach	–73.6558	40.6042	8.3	16.0	21.0	25.7
30	Jamesport	Great Peconic Bay	–72.5819	40.9494	3.8	6.8	10.2	13.8
31	Jones Beach State Park	LI	–73.5153	40.5975	8.4	13.8	19.1	24.1
32	Keansburg	NJ	–74.1303	40.4417	9.7	15.6	20.8	26.2
33	Kennedy International Airport	Queens	–73.7789	40.6398	6.6	15.6	24.5	31.2
34	Keyport Harbor	NJ	–74.1997	40.4444	10.3	16.6	22.4	27.4
35	La Gaurdia Airport	Queens	–73.8725	40.7772	6.4	11.2	15.7	20.8
36	Lawrence	Nassau Co.	–73.7170	40.6000	6.7	15.7	20.4	25.4
37	Liberty Island	NJ	–74.0456	40.6900	10.3	15.7	22.8	28.0
38	Lincoln Tunnel	NYC	–73.9953	40.7692	7.5	17.2	20.5	30.8
39	Linden	NJ	–74.2450	40.6219	9.0	10.6	14.3	17.7
40	Long Beach	Nassau Co.	–73.6664	40.5833	8.7	15.5	20.1	24.8
41	Mamaroneck Harbor	L.I. Sound	–73.7000	40.9330	6.0	11.0	15.9	21.0
42	Manhattan Bridge	NYC	–73.9935	40.7102	10.1	15.8	22.4	25.6
43	Manorhaven	Manhasset Bay	–73.7153	40.8431	6.5	11.7	17.8	22.7
44	Mattituck	North Shore	–72.5347	40.9911	4.3	7.6	11.0	14.6
45	Mecox Bay	South Shore	–72.3170	40.8830	5.7	9.9	14.0	17.9
46	Midland Beach	Staten Island	–74.0830	40.5670	9.4	15.3	20.7	26.8
47	Mill Neck Bayville	Nassau Co.	–73.5558	40.8897	5.7	10.3	15.2	19.8
48	Monmouth Beach	NJ	–73.9670	40.3170	6.2	10.2	13.8	17.4
49	Montauk Point	South Fork	–71.8578	41.0719	4.9	7.9	10.7	13.5

ID	Location	Area/County/State	Long	Lat	Cat 1	Cat 2	Cat 3	Cat 4
50	N.J. Turnpike	Kearny, NJ	–74.1458	40.7683	6.9	7.4	8.5	12.2
51	Napeague Beach	South Shore	–72.0494	40.9931	5.2	8.9	12.6	16.2
52	New Rochelle	Westchester Co.	–73.7670	40.9000	6.1	11.2	16.4	21.5
53	Newark Bay Bridge	Bayonne	–74.1189	40.6953	7.1	9.1	11.8	15.0
54	Newtown Creek	Queens/Kings	–73.9633	40.7361	9.6	14.4	21.0	23.6
55	Northport Bay	Suffolk	–73.3725	40.9217	5.4	9.8	13.7	18.1
56	Norwalk	CT	–73.4083	41.1175	7.1	7.1	10.0	13.3
57	Oakwood Beach	Staten Island	–74.1122	40.5489	9.7	15.7	21.0	27.0
58	Oceanside	Middle Bay	–73.6222	40.6469	6.1	16.7	23.0	28.3
59	Orient	North Fork	–72.3000	41.1330	4.5	7.4	10.4	13.4
60	Ossining	NY	–73.8619	41.1628	2.9	7.6	8.7	14.6
61	Palisades Park	Overpeck CR	–73.9981	40.8481	Dry	Dry	Dry	9.2
62	Passaic River	Harrison N.J.	–74.1186	40.7122	8.5	10.0	13.4	15.9
63	Patchogue	Great South Bay	–73.0000	40.7500	2.4	4.8	9.2	15.1
64	Peekskill/Indian Point	NY	–73.9170	41.2830	2.0	6.6	7.8	13.7
65	Pelham Bay	Bronx	–73.7900	40.8661	6.4	11.6	17.5	22.4
66	Perth Amboy	NJ	–74.2500	40.5000	10.8	18.7	23.8	26.9
67	Port Chester	N.Y. State Line	–73.6661	41.0017	5.8	10.6	15.6	20.5
68	Port Jefferson	North Shore	–73.0697	40.9464	5.0	9.0	13.1	17.3
69	Ridgefield Park	Hackensack R.	–74.0170	40.8500	Dry	Dry	Dry	9.9
70	Rockaway Beach	Queens	–73.8519	40.5714	9.1	14.0	20.4	26.6
71	Hempstead Harbor	Roslyn	–73.6514	40.7997	6.2	11.3	16.5	21.8
72	Sands Point	Long Island Sound	–73.7170	40.8500	6.1	11.1	16.3	21.5
73	Sandy Hook	NJ	–73.9903	40.4431	7.7	12.3	16.5	21.7
74	Sayreville	NJ	–74.3614	40.4592	8.2	11.6	17.1	27.8
75	Seagate	Coney Island	–74.0097	40.5758	9.1	15.0	20.5	26.4
76	Sheepshead Bay	Brooklyn	–73.9400	40.5819	7.8	15.1	21.0	27.4
77	Shelter Island	Gardiners Bay	–72.3333	41.0644	5.1	8.5	12.0	15.5
78	Shippan Point	CT	–73.5242	41.0278	8.1	8.1	10.6	14.9
79	Shoreham	Long Island Sound	–72.9081	40.9572	4.6	8.1	11.8	15.5
80	Smith Pt./Moriches	Great South Bay	–72.8747	40.7372	6.2	10.6	14.8	18.2
81	South Beach	Staten Island	–74.0653	40.5892	9.1	15.0	20.4	26.4
82	St. George	Staten Island	–74.0670	40.6330	10.0	16.0	22.0	26.7
83	Stapleton	Staten Island	–74.0786	40.6239	9.9	15.4	21.1	26.0
84	Stramford	CT	–73.5330	41.0500	8.0	8.0	10.2	14.4
85	Stratford	CT	–73.1336	41.1844	7.6	7.6	11.6	14.3
86	Tappan Z. Bridge	NY	–73.9000	41.0170	4.6	9.5	10.5	17.5
87	Tottenville	Staten Island	–74.2497	40.5111	10.4	20.0	23.2	26.9
88	Travis	Staten Island	–74.1883	40.5931	9.0	10.5	14.3	17.7
89	US 1 at Passiac River	Newark	–74.1728	40.7356	7.4	9.2	11.9	14.0
90	Victory Bridge	Raritan R.	–74.2919	40.5078	10.7	18.0	19.7	24.9
91	Ward Point	Staten Island	–74.2500	40.4830	10.7	17.5	23.2	27.6
92	West 96th Street	Manhattan	–73.9706	40.7940	8.2	15.0	17.7	28.1
93	West Hampton	Moriches Bay	–72.7158	40.7758	6.0	10.4	14.1	18.1
94	West Islip	Great South Bay	–73.3067	40.7061	3.2	8.4	15.9	22.6
95	WestPoint	NY	–73.9500	41.3830	6.9	6.9	10.0	13.2
96	Whitestone	Bronx	–73.8303	40.8017	6.5	11.3	16.6	22.2
97	Willets Point	Queens	–73.7670	40.7830	6.3	11.4	18.3	23.0
98	Wood Bridge	NJ	–74.2830	40.5500	10.0	12.5	19.3	21.9

APPENDIX ENERGY 1 Estimate of Future Growth in Daily Peak Electricity Demand

The results calculated with the New York Power Pool Zone Forecasting Model exhibit a nearly linear relationship between daily electricity peak and temperature for a given level of relative humidity. This makes it possible to extrapolate beyond the 101°F limit of the model to estimate future daily peaks when temperatures are expected to be higher. The scenarios of the Hadley Centre and Canadian Centre global climate models provide the basis for this extrapolation. The rise in daily peak at a given level of relative humidity increases very nearly linearly with temperature. With equal increments in relative humidity, the increase in daily peak decreases at higher humidity. At higher temperatures, these increments become smaller.

These same twenty points can be represented using multiple linear regression analysis by the equation

Peak load (mw) = 31.75*(Relative humidity %) + 271.32*(Temperature °F) – 8269.5

with a correlation coefficient of 0.99. For the same levels of relative humidity, the daily peaks are parallel and equally spaced for successive increments in relative humidity. For the purpose of extrapolating to higher temperature levels, however, they appear satisfactory, particularly in the middle range of relative humidity of 60 to 80%.

Future changes in temperature and humidity due to increased carbon dioxide in the atmosphere are represented in the results of the Hadley Centre and Canadian Centre global climate models as anomalies, i.e., differences from the temperature and humidity in the 1961–1990 time period appearing in the same model scenario. For daily peaks, it was assumed that the same differences in temperature and humidity existed with respect to the 1999 daily peak calculated by the NYPP model.

The change in peak load is calculated using only the first two terms in the equation for daily peak; the constant drops out in comparing two sets of conditions. The percent change is calculated by dividing the change in peak load by the peak load calculated with the NYPP model for the year 1999: 18,622 mw.

In the Canadian Centre GCM, the values for relative humidity are not given. Therefore they are not included in the calculation. For numerical values of temperature and relative humidity that are comparable in size, the contribution of relative humidity is about one-tenth the total calculated for the two by the regression equation. For temperatures in the 90s and relative humidity in the 60s, the contribution of relative humidity would be less. Since this is a small value, the Canadian Centre results are shown despite the absence of relative humidity in the calculation.

CALCULATION OF MAXIMUM PERCENT INCREASE IN DAILY PEAK ELECTRICITY DEMAND

	Change in 2020s			
	Relative humidity	*Temperature*	*Peak load*	*% increase*
HCGG	0.16	1.78	19,999	7.2
HCGS	1.09	2.02	20,085	7.6
CCGG	0	5.38	20,971	12.4
CCGS	0	2.16	20,097	7.7
	Change in 2050s			
	Relative humidity	*Temperature*	*Peak load*	*% increase*
HCGG	–1.13	4.14	20,599	10.4
HCGS	2.27	2.29	20,187	8.2
CCGG	0	7.02	21,416	14.8
CCGS	0	6.35	21,234	13.8
	Change in 2080s			
	Relative humidity	*Temperature*	*Peak load*	*% increase*
HCGG	0.69	6.64	21,329	14.3
HCGS	2.23	4.32	20,736	11.1
CCGG	0	8.62	21,850	17.1
CCGS	0	5.27	20,941	12.2

APPENDIX DECISION-MAKING 1 Key Institutions and Organizations

COASTS AND WETLANDS

Management/Planning/Economic Development

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Land Use	Statewide planning agencies	Statewide	Provide population, economic and land use forecasts; occasional development of statewide development or growth plans; provide planning assistance to local governments.
	NJ OSP, Plan Development and Implementation Committee, State Planning Commission	NJ	NJ State Development and Redevelopment Plan (1992), under revision (expected adoption 2000).
	NYS DOS	NY	
	CT OPM, Policy Development and Planning Div.	CT	Conservation and Development Policies Plan for CT, 1998-2003.
	NYC DCP	NYC	Prepares annual capital program plans at the community board level; zoning; prepares the coastal zone management plan.
	County and Municipal Planning Agencies	CT, NJ, NY	
	Regional Plan Association (RPA)	31-county tri-state region	Produce the regional land use, economic development, and transportation plan and associated studies for the 31-county region.
Economic Development	NYC EDC	NYC	Influence state and local economic development under state statute.
	CT Dept. of Economic Development	CT	
	NJ DECD	NJ	
	NYS Department of Economic Development/Empire State Development	NY	
Coastal Zone Planning	NYS DOS Division of Coastal Resources	NY	Prepare coastal zone management plans.
	NJ OSP, NJ DCA	NJ	In addition to state agency responsibilities, the federal government is involved in The Long Island Sound Study and Plan and its Comprehensive Conservation and Management Plan (CCMP). It specifies coastal land use and environmental objectives for the protection of the waters of the Sound and encompasses Long Island Sound, the southern coast of CT, and portions of NYC bordering the Upper East River.
	CT DEP, LI Sound office, Planning & Standards Section	CT	

COASTS AND WETLANDS

Regulation Oversight

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Land Use; Environment	NYC Office of Environmental Review	NYC	Has authority over the environmental review of facilities regulated under SEQRA/CEQR, including large housing developments and infrastructure facilities.
	NYC DCP	NYC	Approves development plans for housing, commercial, and institutional structures and infrastructure under the Uniform Land Use Review Procedure (ULURP).
Coastal Zone Regulation	CT DEP, Office of Long Island Sound	CT	Responsible for issuance of permits for regulation of development in environmentally sensitive areas, such as wetlands, coastal areas and floodplains.
	NJ DEP, Environmental Protection & Energy, Land Use Mgmt. & Compliance Divisions, Land Use Regulation	NJ	CT: Coastal Management Act, Tidal Wetlands, Structures, Dredging and Fill. NJ: Waterfront Development Law, the Coastal Area Facility Review Act or the Wetlands Act of 1970, Flood Hazard Area Control Act, and the Tidelands Act.
	NYS DEC	NY	NY: Environmental Conservation Law Permits-Protection of Waters, Tidal Wetlands, State Water Quality Certification.
	USACE—NY District State environmental agencies	NY and NJ*	Directly regulates wetlands development through permits; Issues dredge and fill permits (Rivers and Harbors Act) and wetlands permits (Clean Water Act).

INFRASTRUCTURE: TRANSPORTATION

Planning (includes needs assessment)

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Transportation Planning (including Transportation Improvement Programs under Clean Air and federal transportation legislation)	CT DOT	CT	CT Master Transportation Plan (General Statutes, Sec. 13b-15). CT Transportation Improvement Program.
	Greater Bridgeport and Valley Metropolitan Planning Organization	Ansonia, Bridgeport, Derby, Easton, Fairfield, Monroe, Seymour, Shelton, Stratford, Trumbull	CT TIP for Bridgeport Region prepared in conjunction with the CT DOT, regional planning agencies and transit districts.
	NJ DOT	NJ	NJ State Transportation Improvement Program.
	North Jersey Transportation Planning Authority, Inc.	13 counties (bounded by Hunterdon, Somerset, Middlesex, Monmouth); Jersey City and Newark	Northern NJ Transportation Improvement Program.
	NYS DOT	NY	NYS Transportation Improvement Program.
	NYMTC	NYC, Putnam, Nassau, Suffolk, Westchester, Rockland	NY TIP for the downstate area.
	NYC DCP, Transportation Division	NYC	NYC DCP conducts studies and creates transportation plans.
Port and Harbor Planning	NYC EDC	NYC	Strategic Plan for the Redevelopment of the Port of NY (forecasts and investments for the port).

INFRASTRUCTURE: TRANSPORTATION

Operations and Development (as well as planning)

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Harbor	USACE, NY District	NY and NJ*	Maintains/deepens harbor ship channels through dredging; Prepares dredged material management plans.
Trains, Ports, Bridges, Airports	PANYNJ	Portions of NY and NJ	Develops, operates and maintains Port Authority bridges, tunnels, the PATH system, port facilities, ferries and airports.
Roads, Bridges	NYC DOT NYC DDC NYC OMB NYS DOT	NYC NYS	Operates and maintains city-owned roads and bridges. Construction of large facilities and design-related decisions. Value engineering reviews of capital projects; Determines City's operating budget. Operates and maintains state-owned roads and bridges.
Subways, Buses, Rail	MTA	NYS (with NYC focus, some holdings in other states, e.g., New Haven RR)	Owns, manages, operates and maintains the NYC subway system, selected rail facilities, and maintenance yards.
Buses, Rail	NJ Transit	Portions of NJ	Owns, manages, operates and maintains buses and rail in NE NJ with routes between NJ and NY.
Transportation, Water Infrastructure	NJ OSP	NJ	Infrastructure Needs Assessment: 2000-2020.

INFRASTRUCTURE: WASTEWATER TREATMENT

Planning

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Water Quality Planning	State environmental agencies; designated localities	Statewide	Water quality planning occurs at areawide and facility levels and has been ongoing at least since the federal Clean Water Act of 1972.

INFRASTRUCTURE: WASTEWATER TREATMENT

Operations and Construction

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Wastewater Treatment and Collection	NYC DEP NYC DDC, NYC OMB State and municipal agencies and authorities	Five boroughs of NYC and upstate watershed areas State and municipal watersheds	Owns, manages, operates and maintains wastewater treatment plants, sewers and associated facilities (pumps, regulators), etc. in both surface and subsurface locations, under state and federal statutes.

INFRASTRUCTURE: WASTEWATER TREATMENT

Regulation/Oversight

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Environment; Environmental facilities	NYS DEC	NYS	Regulatory authority over the design and operation (permits/compliance) for wastewater treatment facilities, air emissions, and solid and hazardous waste transport, storage and disposal facilities and for construction in waterfront, coastal and environmentally sensitive areas such as wetlands and floodplains.
	NJ DEP	NJ	
	CT DEP	CT	
	U.S. EPA—Region 2	NY and NJ*	Exercises oversight authority over the design and operation (permits/compliance) for wastewater treatment facilities, air emissions, and solid and hazardous waste transport, storage and disposal facilities; NY/NJ Harbor Estuary Project; REMAP.
	Interstate Environmental Commission (IEC)	Portions of NY, NJ, CT	Exercises oversight of sources of air and water discharges, including infrastructure.

WATER SUPPLY

Planning

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Water Resources Planning	State and local environmental agencies	NYS, NJ, CT	Plan development for the disposition of wastewater outfalls and land use development for the specification of wastewater discharge capacity; regulates wastewater treatment facility permit conditions.
	Federal, state, and local agencies	Long Island Sound NY-NJ Harbor Estuary Program	Estuary plans for estuaries under the National Estuary Program specifying sources and restrictions on pollutants into regions waterways; CCMP.

WATER SUPPLY

Operations

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Water Supply	NYC DEP NYC DDC NYC OMB	NYC, selected upstate towns	Owns, manages, operates and maintains water supplies, transmission, storage and distribution.
	Suez Lyonnaise des Eaux: United Water NY United Water NJ; PVWC, Jersey City, Newark, North Jersey District	Rockland county, NY NE NJ, portions of NYS west of Hudson	Manages, operates and maintains water systems under contract to municipalities.
	Delaware River Basin Commission (DRBC)	Delaware River Basin	Manages, operates and maintains water systems.

PUBLIC HEALTH

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Funding; Research/ Surveillance	U.S. Department of Health and Human Services (DHHS)—Region II; CDC	NYS and NJ* and national	Financial support for health programs, monitoring and assessment of health patterns and trends, mortality, morbidity statistics.
Service Provision	Hospital and health service organizations	Various	Manage and carry out health support services.
	NYC Health and Hospitals Corp. (HHC)	NYC	Manages and operates NYC hospitals.
Health Oversight	NYC DOH NYS DOH NJDOH	NYC NYS NJ	Responsible for health of populations, enforcing the public health code, overseeing water supply systems; monitoring of health condition; and related functions.

ENERGY DEMAND
Planning

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Energy Planning and Policy	CT Energy Advisory Board	CT	State Energy Policy Report.
	NJ OSP, NJ BPU, Bureau of Planning & Research	NJ	Energy Master Plan—a portion of the NJ State Development and Redevelopment Plan.
	NYS Energy Planning Board	NYS	NYS Energy Plan and Final EIS; research and development.
	NYSERDA		
	NYC EDC, Energy Division	NYC	Research and development.

ENERGY DEMAND
Operations

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change)
Electric Utilities	Con Edison	NYC	Own, manage, operate and maintain electrical production and distribution systems.
	Orange & Rockland Utilities	Orange and Rockland counties	
	NYS Electric & Gas Corp.	Westchester and Putnam (part)	
	Central Hudson Gas and Electric Co.	Parts of Putnam, Orange, Dutchess, Ulster, Greene NY	
	Rockland Electric Company	NE NJ at the NY/NJ border	
	Long Island Power Authority (LIPA)	Nassau and Suffolk counties, NY	
	NY Power Authority		
	General Public Utilities	S. NJ—Monmouth County, NJ south and NW NJ; NE NJ	
	Public Service Electric and Gas (PSE&G)	CT	
	The Connecticut Light and Power Company (subsidiary of Northeast Utilities)		
	The United Illuminating company		
	The Connecticut Municipal Energy Electric Cooperative		

ENERGY DEMAND

Regulation

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change
Rate-setting, etc.	CT DPUC	CT	Regulatory authority over distribution companies and licensing authority for suppliers; rate management functions.
	NJ BPU Energy Division	NJ	
	NYS PSC	NY	

CROSS-CUTTING RESPONSIBILITIES

Emergency Response

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change
Disaster Assistance and Analysis	FEMA, Region II	NYS and NJ*	Research and response capabilities for natural and manmade disasters; National Flood Insurance Program (NFIP)
Response	NYC OEM county offices	NYC, applicable counties	Response capabilities for natural and manmade disasters.
	NYS EMO	Statewide	
	NJ OEM	NJ	
	CT OEM	CT	

CROSS-CUTTING RESPONSIBILITIES

Finance

Function/ Authority	Key organizations	Jurisdiction in MEC region only*	Existing mandate (applicable to global climate change
Utility Rate-setting	CT DPUC	CT	Approve electric power rates.
	NJ BPU, Energy Division	NH	
	NYS PSC	NY	
	NYS EFC		Set water supply rates for City and adjacent county users, where applicable.
	Water Finance Authority		Rate bonds for city and county facilities (including infrastructure) based on economic condition and other criteria.
	NYC Water Board	NYC	
Bond Rating	Moody's	National	
	Standard & Poor	National	
Investment	Investment Banks (numerous)		Provide capital for public and private development.

Notes:

There are numerous professional organizations that provide the standards for planning, designing, operating, maintaining and constructing the built environment in the region, such as American Society for Civil Engineering (ASCE), American Society for Testing and Materials (ASTM), American Water Works Association (AWWA), American Public Works Association (APWA), Institute of Electrical and Electronics Engineers (IEEE), American Institute of Architects (AIA), Water Environment Federation (WEF), etc. In addition, while the academic institutions and consortia and public and private organizations in the region and elsewhere that can provide a research base for climate change decision-making have not been documented here, their input will be a key part of the institutional analysis.

*Some jurisdictions extend beyond the region. For example, U.S. EPA Region II's jurisdiction extends to Puerto Rico and the Virgin Islands.

Selected Abbreviations: BPU—Board of Public Utilities (NJ), CCMP-Comprehensive Conservation and Management Plan, CDC—Centers for Disease Control (U.S.), DCA—Department of Community Affairs, DCED-Department of Commerce and Economic Development (NJ), DCP—Department of City Planning (NYC), DDC—Department of Design and Construction (NYC), DEC—Department of Environmental Conservation (NYS), DECD—Department of Economic and Community Development (CT), DEP—Department of Environmental Protection (NJ), DHHS—Department of Health and Human Services (U.S.), DOH—Department of Health, DOS—Department of Sanitation/Department of State, DOT—Department of Transportation, DPUC—Department of Public Utility Control (CT), DRBC—Delaware River Basin Commission, EDC—Economic Development Corporation (NYC), EDF—Environmental Defense Fund, EFC—Environmental Facilities Corporation (NYS), EMO—Emergency Management Office, ESD—Empire State Development (NYS), FEMA—Federal Emergency Management Agency, HHC—Health and Hospitals Corporation (NYC), IEC—Interstate Environmental Commission (formerly the Interstate Sanitation Commission), MTA—Metropolitan Transportation Authority, NRDC—National Resources Defense Council, NYMTC—New York Metropolitan Transportation Council, NYSERDA—NYS Energy Research and Development Administration, OEM—Office of Emergency Management, OMB—Office of Management and Budget, OPM—Office of Policy and Management (CT), OSP—Office of State Planning (NJ), PANYNJ—Port Authority of New York and New Jersey, PSC—Public Service Commission, PVWC—Passaic Valley Water Commission, REMAP—Regional Environmental Monitoring and Assessment Program, RPA—Regional Plan Association, USACE—U.S. Army Corps of Engineers, USEPA—U.S. Environmental Protection Agency.

APPENDIX DECISION-MAKING 2 Planning Programs

Program	Organization
Coasts and Wetlands	
Coastal Zone Management Act—CZMA Plans	NYS Department of State, NYC DCP
Statewide Comprehensive Outdoor Recreation Plans (SCORP)	State environmental and parks agencies
The New Waterfront Revitalization Program—a Proposed 197a Plan (11/99)	NYC DCP
Economic development planning	
Strategic Plan for the Redevelopment of the Port of NY (2/99)	NYC EDC
Bight Restoration Plan, as part of the National Estuary Program, NY-NJ Harbor Estuary Program, Comprehensive Conservation & Management Plan (3/96)	U.S. EPA, NYS DEC, NJDEP, Hudson River Foundation
National Economic Development (NED) Plan—Jurisdiction is the USACE "Principles and Guidelines"	U.S. Army Corps of Engineers (USACE)
NY & NJ Harbor Navigation Study (9/99); Dredged Material Management Plan for the Port of NY/NJ (9/14/98)	
Emergency Management Plans	FEMA; CT, NJ, NY emergency management offices
New Jersey State Development and Redevelopment Plan (1999 Interim Plan)	NJ OSP
Conserving Open Space in New York State 1998, State Open Space Conservation Plan.	NYS DEC & the Office of Parks, Recreation and Historic Preservation
New Jersey Common Ground—1994–1999 New Jersey Open Space and Outdoor Recreation Plan.	NJ DEP, Green Acres Bureau of Recreation and Open Space Planning
Conservation and Development Policies Plan for Connecticut, 1998–2003	CT Office of Policy and Management, Policy Development and Planning Division
Long Island Sound Study (LISS) and Plan and Comprehensive Conservation and Management Plan	CT DEP, Long Island Sound Office
Infrastructure	
NYC Solid Waste Management Plan - Enclosed Barge Unloading Facilities (EBUFs)	NYC DOS
Clean Air Act State Implementation Plan (SIP) - Transportation Element	U.S. EPA, NYS DEC, NYC DEP; similar agencies in NJ and CT
ISTEA/TEA2/NEXTEA Transportation Improvement Program	U.S. DOT, NYS DOT, NYMTC
Statewide transportation master plans	CT, NJ, NY DOTs
Five Year Capital Plan for Transit	MTA
New Jersey Infrastructure Needs Assessment 2000-2020	NJ OSP
Water Supply	
Regional and statewide plans for water supply	CT, NJ, NY environmental agencies
Energy	
NYS Energy Plan - Action Plan for Global Warming	NYSERDA; NYS Energy Planning Board
Public Health	
West Nile Virus Response Plan (5/00)	NYS DOH, NYC DOH

GLOSSARY

ACOE Army Corps of Engineers
AIA American Institute of Architects
APWA American Public Works Association
ASC American Society for Civil Engineers
ASTM American Society for Testing and Materials
AWWA American Water Works Association
BAL Bronchoalveolar lavage
BFE Base Flood Elevation
BIDS Business Improvement Districts
BMP Best Management Practice
BOC Bureau of Census
CAA Clean Air Act
CBRA Coastal Barriers Resource Act
CCCMA Canadian Centre for Climate Modeling and Analysis
CCMP Comprehensive Conservation and Management
CDC Centers for Disease Control and Prevention
CEQR City Environmental Quality Review
CIESIN Center for International Earth Science Information Systems
CNG Consolidated Natural Gas
COPD Chronic Obstructive Pulmonary Disease
CZMA Coastal Zone Management Act
CZM Coastal Zone Management
CZMP Coastal Zone Management Plan
DEC Department of Environmental Conservation
DEP Department of Environmental Protection
DEP Diesel Exhaust Particles
DHHS Department of Health and Human Services
DOH Department of Health
DOI Department of the Interior
DPH Department of Public Health
DRBC Delaware River Basin Commission
DSM Demand-Side Management
EBUFs Enclosed Barge Unloading Facilities
ECL Environmental Conservation Law
EDC Economic Development Corporation
EDF Environmental Defense Fund
EFC Environmental Facilities Corporation
EIS Environmental Impact Statement
EMO Emergency Management Office
ENR Engineering News Record
ENSO El Niño-Southern Oscillation
EPA Environmental Protection Agency
EPRI Electric Power Research Institute
ESD Empire State Development
FEMA Federal Emergency Management Agency
FERC Federal Regulatory Commission
FHWA Federal Highway Administration
GCC Global Climate Change
GCM Global Climate Model
GDP Gross Domestic Product
GHG Greenhouse gas
GIS Geographic Information System
GISS Goddard Institute for Space Studies
GNRA Gateway National Recreation Area
GRI Gas Research Institute
GRP Gross Regional Product
HAZNY HAZOS New York
HAZUS Federal Emergency Management Agency natural hazard loss estimation method
HIV Human Immunodeficiency Virus
HMGP Hazard Mitigation Grant Program
HVAC Heating, Ventilating, and Air Conditioning
IBA Important Bird Area
IEEE Institute of Electrical and Electronics Engineers
IPCC Intergovernmental Panel on Climate Change
ISC Interstate Sanitation Commission
ISTEA Intermodal Surface Transportation Efficiency Act
KWH Kilowatt-hour
LBL Lawrence Berkeley National Laboratory
LIPA Long Island Power Authority
LWRP Local Waterfront Revitalization Program
MAR Mid-Atlantic Region
MEC Metropolitan East Coast
MHW Mean High Water
MNYHTS Metro New York Hurricane Transportation Study, produced jointly by the U.S. Army Corps of Engineers, Federal Emergency Management Agency, the National Weather Service, and other state and local agencies in 1995
MPO Metropolitan Planning Organization
MTA Metropolitan Transportation Authority
NAAQS National Ambient Air Quality Standards
NAO North Atlantic Oscillation
NAS National Academy of Sciences
NCDC National Climatic Data Center
NED National Economic Development
NEMS National Energy Modeling System
NEPA ACTS National Environmental Policy Act
NEXTEA, NEXTEA2 National Economic Crossroads Transportation Efficiency Acts
NFIP National Flood Insurance Program
NGVD National Geodetic Vertical Datum
NICE National Industrial Competitiveness for Energy, Environment and Economy
NJDEP New Jersey Department of Environmental Protection
NOAA National Oceanic and Atmospheric Administration

NO_x Nitrogen oxides
NPDES National Pollutant Discharge Elimination System
NPS National Park Service
NRC National Research Council
NRDC Natural Resources Defense Council
NSPS New Source Performance Standards
NWP Nationwide Permit
NWS National Weather Service
NYC CPD New York City City Planning Department
NYC DOH New York City Department of Health
NYC New York City
NYISO New York Independent System Operator
NYMTC New York Metropolitan Transportation Council
NYSDEC New York State Department of Environmental Conservation
NYSDOS New York State Department of State
NYSDOT New York State Department of Transportation
NYSERDA New York State Energy Research and Development Authority
OEM Office of Emergency Management
PANYNJ Port Authority of New York and New Jersey
PATH TRAINS Port Authority Trans-Hudson (rapid transit trains)
PDSI Palmer Drought Severity Index
PERT Pilot Emission Reduction Trading
PET Potential Evapotransipration
PML Probable Maximum Loss
PSC Public Service Commission
PSE&G Public Service Electric and Gas
PURPA Public Utilities Regulatory Act of 1978
PVSC Passaic Valley Sewerage Commission
PVWC Passaic Valley Water Company
REEPs Residential End-Use Energy Planning System
REMAP Regional Environmental Monitoring and Assessment Program
RPA Regional Plan Association
RSA MODEL Reservoir System Analysis simulation model
RSLR Relative Sea-Level Rise
SENYIWSAC Southeastern New York Intergovernmental Water Supply Advisory Council
SEQRA State Environmental Quality Review Act
SES Socio-economic status
SIP State Implementation Plan
SLR Sea-Level Rise
SON Statement of Needs
SPDES State Pollutant Discharge Elimination System
SS Safir Simpson; the scale on which hurricane severity is measured
TIP Transportation Improvement Plan
TWS Tidal Wetlands Boundary
TWTA Tidal Wetlands Trends Analysis
ULURP Uniform Land Use Review Procedure
USACE United States Army Corps of Engineers
USHCN United States Historical Climate Network
WEF Water Environment Federation
WES Waterways Experiment Station
WIFM Waterways Implicit Flood Model
WPA Work Projects Administration
WRI World Resources Institute