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DRAFT
MEPA CLIMATE CHANGE ADAPTATION AND RESILIENCY POLICY

Effective Date:

GOALS AND OBJECTIVES

The Massachusetts Environmental Policy Act (MEPA) Climate Change Adaptation and Resiliency Policy (hereinafter "the Policy") is proposed to fulfill MEPA's statutory obligations under the Global Warming Solutions Act of 2008 (Chapter 298 of the Acts of 2008) and the MEPA statute (M.G.L. c. 30, §§61-62I). Among other components, including a mandate to reduce greenhouse gas (GHG) emissions, the Global Warming Solutions Act (GWSA) contains a section focused on meeting the threats and challenges posed by climate change. The MEPA Office is required to:

> (1) consider the reasonably foreseeable climate change impacts and GHG emissions of projects subject to MEPA review (and effects such as predicted sea level rise); and (2) ensure that projects subject to MEPA take all feasible measures to avoid, minimize, or mitigate "Damage to the Environment" (as defined in the MEPA statute), including GHG emissions.

Section 7 of the GWSA also amended Section 61 of Chapter 30 of the General Laws by inserting,

> *"In considering and issuing permits, licenses and other administrative approvals and decisions, the respective agency, department, board, commission or authority shall also consider reasonably foreseeable climate change impacts, including additional greenhouse gas emissions, and effects, such as predicted sea level rise."*

It is widely accepted by the scientific community that the increased emissions of greenhouse gases are contributing to a changing climate. Massachusetts, due to its latitude and extensive coastline, is likely to experience a greater extent of impacts than many other parts of the world. Changes to climate are already causing, and will continue to cause, significant local impacts.

Observed effects of climate change in the US and the Northeast include increased atmospheric and ocean temperatures, heat waves, increased evapotranspiration and precipitation, and a greater intensity of storms, and floods. In addition, thermal expansion of a warmer ocean and the melting of glaciers are contributing to a rise in sea level. In the future, annual average temperature is predicted to increase, and is expected to be coupled with a greater number of extreme heat days; precipitation changes by season, intensity and type will occur; and, acceleration of sea level rise[1] in combination with land subsidence, will continue to re-shape our coastline.

MEPA's primary purpose is to evaluate alternatives that avoid, minimize and mitigate the environmental impacts of projects and identify enforceable mitigation commitments. This Policy is intended to facilitate assessment of the risk and vulnerabilities of a project or action under reasonably foreseeable scenarios and conditions associated with climate change to inform the identification and evaluation of measures to mitigate these risks and vulnerabilities to the extent feasible and appropriate.

This Policy builds on the research and strategies included in the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA) Climate Change Adaptation Report (September 2011) and the Office of Coastal Zone Management's (CZM) StormSmart Coasts programs. It complements the MEPA Greenhouse Gas Emissions Policy and Protocol which requires analysis of a project's contribution to GHG emissions and commitments to increase energy efficiency and reduce GHG emissions.

This Policy supports the Commonwealth's Climate Preparedness Initiative, through which State Agencies are implementing projects and strategies to promote climate change resilience and adaptation. One example is the Department of Public Health's (DPH) Building Resilience Against Climate Effects (BRACE). The DPH is implementing a framework developed by the U.S. Centers for Disease Control and Prevention (CDC) for enhancing the integration of health into climate change adaptation planning. It includes the use of existing data to conduct vulnerability assessments that identify populations, systems and areas most vulnerable to climate effects (e.g. heat stress related visits to emergency rooms and heat-related mortality), identify disease burdens and assess public options to address priority health impacts influenced by climate change. It provides the ability to quantify the health benefits of adaptation strategies and track community health patterns. Broader efforts to address adaptation and resiliency of critical infrastructure and systems in a comprehensive manner by the Commonwealth, municipalities, and other property owners will strengthen the effectiveness of the Policy.

It is anticipated that this Policy may be revised to meet the goals of the Commonwealth and the requirements of 301 CMR 11.00 in response to advancements in scientific research, changes to environmental permitting requirements, advancements in adaptation and resiliency mitigation opportunities, and/or climate change adaptation initiatives undertaken by the Commonwealth or the Federal government.

[1] For the purposes of the Policy, the term sea level rise may refer to either Global sea level rise or Relative sea level rise. Global sea level rise is the average increase in the level of the world's oceans from thermal expansion and melting ice sheets and glaciers. Relative sea level rise refers to the change in sea level relative to the adjacent land due to natural or human-induced subsidence or uplift.

APPLICABILITY AND PROCEDURES FOR FILING

This Policy applies to projects that are subject to an Environmental Impact Report (EIR) in accordance with MEPA, (M.G.L. c.30 ss.61-62I) and its implementing regulations at 301 CMR 11.00. The Policy will be applied to individual projects or planning efforts subject to MEPA review (e.g. Institutional Master Plans). This includes projects that receive a Waiver from the requirement to prepare an EIR in accordance with 301 CMR 11.11 (as described further below).

This Policy applies to new projects requiring an EIR. A project will be considered a new project if it files an Environmental Notification Form (ENF) initiating MEPA review on or after the effective date of this Policy. The Secretary of EEA will review Notices of Project Change (NPC) filed pursuant to 301 CMR 11.10 for projects that filed an ENF prior to the effective date of the Policy to determine whether the project will be required to comply with the Policy. The Secretary will make a determination on a case-by-case basis and will consider factors such as, but not limited to, the project purpose, whether the project change is a moderate or significant expansion of the original project, and whether adequate climate change adaptation and resiliency measures are incorporated.

In response to the submission of an ENF for a project that is subject to the Policy pursuant to the paragraph above (i.e., it requires either a mandatory EIR or the Secretary requires a discretionary EIR), the Secretary's Certificate on the ENF will include a scope item requiring assessment of the impacts of climate change and adaptation and resiliency measures. Proponents are not required to include an assessment in the ENF, but are encouraged to do so.

If a Proponent is seeking a Single EIR pursuant to 301 CMR 11.06(8) or a full Waiver pursuant to 301 CMR 11.11, the Expanded Environmental Notification Form (EENF) should include a climate change impact assessment and identify mitigation in accordance with 301 CMR 11.05(7). The Secretary will make determinations regarding Single EIR or Waiver requests based, in part, on the adequacy of this analysis. If the Proponent is seeking a Phase One Waiver pursuant to 301 CMR 11.11(4), the EENF should contain a climate change impact assessment for the portion of the project subject to the Phase One Waiver request.

EXEMPTIONS

The MEPA Office acknowledges that some projects that require an EIR may not be impacted by, nor contribute to, certain aspects of climate change; and this Policy (all or in part) shall not be applied to such projects. For any project that exceeds mandatory EIR thresholds at 301 CMR 11.03, the Proponent may request an exemption in the ENF (or EENF). The review document should clearly identify why an exemption is warranted and provide supporting narrative or data to support this assertion. The Certificate on the ENF and/or Record of Decision will indicate whether the project requires a climate impact assessment.

CONSULTATION WITH THE MEPA OFFICE

The Policy provides general guidance for the preparation of a climate change vulnerability and impact assessment to satisfy MEPA requirements. It is strongly recommended that Proponents

consult with the MEPA Office, and relevant State Agencies as necessary, prior to submission of an EIR or a request for Waiver to discuss methodology and potential mitigation for an individual project. The MEPA Office can provide specific guidance and may provide additional direction based upon previous project assessments and best practices.

This Policy does not in any way supersede or alter the Secretary's discretion to require analysis in any particular scoping Certificate. The Secretary may deviate from the procedures set forth in this Policy based on specific project characteristics, site specific conditions and/or input from State Agencies.

CLIMATE IMPACT ASSESSMENT

The Policy addresses impacts associated with sea level rise, the amount, frequency and timing of precipitation, and increases in average temperature and the frequency of extreme temperature events. The purpose of the assessment is twofold: 1) to evaluate potential impacts; and, 2) to evaluate the effectiveness and feasibility of measures to avoid or reduce hazards and increase resiliency of the built and natural environment to climate change. Resilience is the ability of a system to return to its initial state and function in spite of a major disruption.[2] In other words, it is the extent to which the built or natural environment can respond, recover, and adapt to consequences.

Impacts Associated with Sea-Level Rise, Coastal Flooding and Storm Surge

Massachusetts' coastal cities and towns are home to one third of the State's population and its coastal counties have more than three-quarters of the State's population. As relative sea level rises, high water elevations will move landward, areas of coastal shorelines will retreat, and low-lying areas will be increasingly exposed to erosion, tidal inundation, and flooding. Current rates of sea level rise, storm surge and projections for accelerated trends present significant threats to the coastal communities and natural systems, including the following:

- Increased heights and extent of storm surges and associated coastal flooding frequencies, will affect developed areas and infrastructure, both public and private.
- Increased erosion rates will affect barrier beach and dune systems and developed areas located behind these barrier spits and islands. Barrier beaches will be more susceptible to erosion and overwash, and in some cases, breaching.
- Large areas of critical coastal and estuarine habitat will be unable to adapt and migrate.
- Salt water intrusion into productive aquifers could affect public drinking water supplies, and has been identified as a particular concern on Cape Cod.

The CZM Report, *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning* (December 2013), provides the best information available for Massachusetts regarding reasonably foreseeable scenarios. Four scenarios were developed based

[2] U.S. Climate Change Science Program, Synthesis and Assessment Product 4.4, *Adaptation Options for Climate-Sensitive Ecosystems and Resources,* June 2008.

on the U.S. National Climate Assessment[3], evaluated by CZM, and underwent a peer review process.

Impacts Associated with Changes in Precipitation

According to the most recent National Climate Assessment (Melillo et al, 2014), coastal and inland flooding, and intense precipitation events will increase stresses on Massachusetts' infrastructure, ecosystems, fisheries and agriculture. Potential impacts include: decreased snow cover resulting in lower peak spring flows; impacts to groundwater recharge; and, increases in stormwater runoff and water quality. Assessment of these impacts to vulnerable areas is necessary to protect natural resources and public and private investments.

The National Weather Service has published draft precipitation frequency updates for Massachusetts (Atlas 14 Volume 10)[4], with an expected publication date of September 2015, which will inform future scenarios. These data will also support the analysis of peak rates of runoff and design of effective stormwater management systems, including appropriate sizing of stormwater best management practices (BMPs) and culverts. Many of the Federal Emergency Management Association (FEMA) Federal Insurance Rate Maps (FIRMs) have been updated and revised or will be updated in the near future. Because the majority of FIRMs for Massachusetts communities had not been updated for over 20 years, updated FIRMs will provide a more accurate estimate of the extent of floodplains and flood hazards.

Impacts Associated with Changes in Temperature

Increases in temperature can impact natural and built systems, as well as public health. According to the National Climate Assessment, increases in temperature and heat waves will pose a challenge to Massachusetts and our infrastructure, ecosystems, fisheries and agriculture. The urban heat island effect will be especially magnified in the highly populated and developed Northeast. Extreme heat is most dangerous in urban areas because of a combination of large concentrations of vulnerable populations and large expanses of heat-absorbing pavement and buildings, which cause daytime and nighttime temperatures to be markedly higher than in suburban or rural areas. Overall, increases in temperature could worsen air quality, aggravate asthma, and have other health effects on vulnerable populations such as the elderly and children.

Preparation of a Climate Impact Assessment

The assessment should draw on information included within the Massachusetts Climate Change Adaptation Report, the 2014 U.S. National Climate Assessment, and other scientific research (see appendices for additional resources) to evaluate how a project may be impacted by climate change related events and how the project itself may contribute to, or reduce, climate change impacts. Specific guidance in the development of the analysis and evaluation of mitigation

[3] *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris et al., 2014).
[4] Volume 10 of NOAA Atlas 14: Precipitation Frequency Atlas of the United States - Draft. http://hdsc.nws.noaa.gov/hdsc/pfds/peer_review/

measures will be identified by the Secretary in the scope for an EIR, informed by comments received by State Agencies, municipalities and the public.

1 - Provide a detailed description of the site and the proposed project.

The site description should include existing conditions, elevations (including identification of high and low points), resource areas, adjacent land uses, existing infrastructure, and existing flooding and/or erosion. It should include a detailed project description that identifies the type of project (i.e. master plan, new construction, expansion) and potential phasing, indicates the number of buildings and/or structures, identifies existing and proposed infrastructure (on site and within proposed buildings), and identifies below grade spaces (basement, parking, etc). As appropriate, it should identify any sensitive populations or critical infrastructure (elderly, schools, hospitals, etc.).

2 - Evaluate how effects of climate change may impact the project site and proposed infrastructure.

The assessment should identify potential project vulnerabilities under certain future climate conditions consistent with the anticipated lifespan of the project. It should consider the project purpose and operations, and, as relevant to the project site, impacts of sea level rise, precipitation and/or increases in temperatures on the site. The assessment should address all project elements including, but not limited to:

1. Existing or proposed structures;
2. Coastal or inland water infrastructure (e.g., revetments, docks, piers, dams, culverts, etc.);
3. Public or private roadways and parking areas;
4. Public or private utilities including stormwater management infrastructure;
5. Transportation facilities (e.g., transit stations, bus stops, rail lines);
6. Open space, including public walkways or easements;
7. Wetland and other coastal natural resource areas; and
8. Other vulnerable resources.

The assessment should identify any impacts the project, or associated changes to the site, could have on adjacent land uses, including exacerbating flooding, erosion, or urban heat island effect.

Projects located in the coastal zone should include consideration of the impacts of sea level rise. Projects located in the coastal zone, floodplains, or riverfront areas should include consideration of the potential impacts of more frequent and severe storm events over the life expectancy of the project components. These projects should also include consideration of uncertainties associated with mapping flood zones. Floodplain maps are generally based on historic observations and often do not take into account recent changes in topography, erosion, sea level rise or climate changes that occur after the flood study has been completed. Reliance on FIRMs or historic precipitation data for assessing impacts of increased precipitation may be appropriate for some projects but, for others, FIRM maps may not sufficiently represent future conditions or may not yet be finalized due to appeals. Proponents should familiarize themselves with other best available information sources in their project area, which may include local and state led vulnerability assessments that provide updated assessments at the community level.

Appendix C includes additional information on modeling approaches and tools associated with sea level rise, storms and flooding including the benefits and drawbacks of various approaches. Depending upon the location and project type, a Proponent may select (or may be directed as appropriate by a Secretary's Certificate) a robust modeling approach to identify impacts associated with storm surge or a more dynamic model that can reflect several factors including type of storm, tidal cycle, storm surge, and wind effects.

For the majority of projects, assessment of increases in temperatures or temperature extremes will be focused on consideration of impacts on energy demand and impacts associated with impervious surfaces, which will overlap with the typical analysis required of GHG emissions, stormwater, and mitigation. Site design that reduces impervious surfaces, create low-albedo surfaces and/or incorporate storwmater LID techniques will also reduce a project's contribution to urban heat island effect. A small subset of projects, such as energy generating facilities, manufacturing facilities, and housing or facilities that serve vulnerable populations, may require additional analysis. For instance, energy generating facilities may be required to demonstrate what impact temperature changes would have on emissions of air pollutants or the effectiveness of air pollution control systems. Hospitals or housing for the elderly may consider design elements necessary to protect people during heat waves and/or power outages.

3 – Evaluate Mitigation Alternatives and Measures and Identify Commitments

As part of the alternatives analysis performed in conjunction with MEPA review, the Proponent should consider climate change impacts when determining project layout, design elements, infrastructure connections and locations, or other relevant project components. The alternatives analysis and selection of a preferred alternative should be informed by the tolerable risk of outcomes associated with the project purpose, identified scenarios and the longevity of the project. Suggested mitigation, resiliency and adaptation measures are listed in Appendix A to this Policy.

Proponents are encouraged to identify cross-cutting measures and strategies that reduce GHG emissions or comply with State permitting requirements and also serve as effective climate change adaptation measures (e.g. preserve large tracts of land, provide generous buffers from wetland resource areas, incorporate LID features, low albedo or green roofs). Sustainable and energy efficient design reduce the environmental and energy footprint and can reduce a building's contribution to the urban heat island effect. Energy efficient buildings reduce loads on infrastructure and avoid peak load outages. The assessment should address the dual benefit of these overlapping project features.

Building codes typically establish the minimum acceptable standards to regulate the design, construction and maintenance of buildings for health, safety and welfare. Codes are designed to protect the structural integrity of a building during hazard events, such as hurricanes and nor'easters. Constructing beyond the code minimums may serve to reduce risk, property damage or provide other benefits to a property owner. The State Building Code and the National Flood Insurance Program (NFIP) regulations require that the lowest structural member of the building

must be located above the Base Flood Elevation (BFE). Given potential flooding hazards and, in particular, coastal hazards such as wave velocity, wave action and debris impacts, and the potential impacts of climate change on sea level and storm intensity/frequency during the lifetime of the structure, the selection of a BFE and elevation of structures, as well as uses on the lowest floor, should be carefully considered.

Selection of feasible mitigation measures will be site and project specific and should consider a variety of measures that may be implemented upon construction, and in the future to adapt to changing conditions. Mitigation measures proposed by other public or private parties that may affect the resiliency of the project should be identified. The Proponent should specify those measures to be implemented during the project's initial construction and occupancy phases and those that may be implemented in the future as an adaptation measure. The Assessment should describe thresholds that may influence when and how adaptation measures are implemented. It should discuss how project construction and design will support and facilitate future implementation of adaptation measures.

The Proponent should consider how the proposed project may facilitate or impede potential climate change adaptation measures on-site and/or on adjacent properties or public facilities (i.e., harbor walks, public park access, etc.) as well as environmental impacts associated with the mitigation measure itself. For example, replacement of a revetment with sufficient height to function effectively in a future scenario based on sea level rise and storm surge may increase impacts to wetland resource areas and habitat. Widening of a river to address site-specific flooding could create impacts downstream. The Proponent should identify and discuss the benefits and drawbacks of certain mitigation measures.

Working with Uncertainty, Risk and Adaptive Capacity

For specific analyses where modeling of future scenarios is proposed or required, models should be developed based upon consideration of the project's lifespan, costs, consequences of disruption or damage, sensitivity of the project to impacts, the Proponent's level of risk aversion, and guidance provided by State Agencies and other commenters during the EIR scoping process or MEPA pre-filing meeting. The use of particular scenarios should be supported with discussion of assumptions regarding the project's design life and projected lifespan, potential disruption or damage to humans and the environment, and risk associated with selection of the preferred project alternative.

Many resources are available to assist Proponents in evaluating potential impacts, including those listed in Appendix B and information on modeling is provided in Appendix C. It is important to consider the benefits and drawbacks of particular resources and tools. Outputs of coarse resolution global climate models may require downscaling and bias removal for use in regional or local impact studies. Floodplain maps are generally based on historic observations and often do not take into account recent changes in topography, land use, erosion, sea level rise or climate changes that occur after the flood study has been completed. Reliance on FIRMs or historical precipitation data for assessing impacts of increased precipitation may be appropriate for some projects but, for others, FIRM maps may not sufficiently represent future conditions and may not yet be finalized due to appeals. Proponents should familiarize themselves with

other best available information sources in their project area, which may include local and state led vulnerability assessments that provide updated assessments at the community level.

In addition, for projects subject to storm surge and/or flooding, it is important to consider that the highest water level during a hurricane or coastal storm does not necessarily capture the potential impacts associated with the duration of inundation.

Some projects subject to the Policy may experience a lower risk of impact. For instance, they may not include habitable structures (open space, playgrounds, multi-use paths or parking areas) or greater resiliency is incorporated into the basic project design (docks, piers, etc.) and the risk of impact to the public and/or public interests is comparatively lower. An environmental restoration project may be considered to be low risk because it is designed to increase natural buffers around developed areas to storms and, while increases in precipitation or storm surge could reduce their overall benefit, they would not outweigh the overriding project purpose or exacerbate existing issues. In some instances, projects may be designed to provide relief from the effects of flooding (flood control or municipal stormwater management projects). In general, lower-risk categories may not warrant examination of scenarios based on the highest level of potential impact or detailed modeling.

Other types of development are critical to maintain the health and safety of the general population. For these types of projects, particularly those with a long design life, storm and flood-related impacts may have significant impacts on the public and/or public interests, including potentially catastrophic outcomes. For these projects, consideration of a broader range of scenarios over a longer timeframe may be warranted. These types of projects may include, but are not limited to:

- Power generating and distribution facilities;
- Water and wastewater treatment facilities;
- Transportation infrastructure (e.g., bridges, subway stations, railways, roadways);
- Coastal infrastructure associated with public facilities or with a large geographic scope/population;
- Housing for vulnerable populations such as the elderly, disabled, or low-income;
- Hospitals;
- Schools;
- Buildings identified as community shelters during natural disasters; and,
- Facilities owned or operated by the Commonwealth of Massachusetts.

When considering mitigation measures, the Proponent should consider that the cost of designing and constructing a project with consideration of future scenarios may be less costly and disruptive than retrofitting, rebuilding or moving infrastructure at a later date once effects are occurring. Another consideration is the cost, or ability to secure, insurance for facilities and structures. For some projects, consideration of long-term scenarios may result in the incidental benefit of limiting impacts from smaller events over a longer time period.

PROJECT CHANGES

If changes to the project are proposed after the issuance of a Certificate on a Final EIR or Final Record of Decision, including changes to proposed adaptation and resiliency mitigation measures, the Proponent may be required to file an NPC pursuant to 301 CMR 11.10. The Proponent should consult with the MEPA Office to determine whether an NPC would be required for a particular project change.

OFF-SITE MITIGATION

The MEPA Office recognizes that under certain circumstances, it may not be feasible to implement all of the alternatives described in the EIR. While it is the policy of the MEPA Office to encourage Proponents to avoid or minimize impacts on-site, MEPA will also be receptive to proposals to mitigate climate change impacts through off-site measures when on-site avoidance or minimization strategies are not feasible. However, on-site mitigation should be prioritized over off-site measures because of the local nature of flooding, precipitation and extreme heat. Off-site measures should prioritize benefits to adjacent sites or local benefits over regional projects. For instance, extension of stormwater management to an adjacent site or dam removal within the same floodplain or watershed, may be appropriate off-site measures. The MEPA Office will seek the assistance of local and State agencies or permitting authorities to determine whether off-site mitigation is appropriate. If a Proponent proposes monetary contributions for mitigation, the Proponent will be required to verify that the funds are directly responsible for climate change adaptation and resiliency mitigation.

SELF-CERTIFICATION OF MITIGATION COMMITMENTS AND SECTION 61 FINDINGS

Consistent with 301 CMR 11.12(5), after conducting the climate change adaptation and resiliency analysis in accordance with the protocol specified above (or as modified by the Secretary's Certificate), the draft Section 61 Findings in the EIR (or request for Waiver) should specifically and clearly identify which adaptation and resiliency mitigation measures will be adopted by the Proponent. For those projects proposed to be constructed in phases over time, the Proponent should identify which measures will be adopted in connection with each development phase.

To ensure that climate change adaptation and resiliency mitigation measures adopted by the Proponent as part of the preferred project alternative are actually constructed or performed, the Secretary will require Proponents to provide a self-certification to the MEPA Office indicating that all the required mitigation measures, or their equivalent, have been completed. The draft Section 61 Findings for any State Agencies that will take Agency Action on the project should contain the requirement that the Proponent submit the self-certification described below to the MEPA Office upon completion of the project (or in accordance with a project-specific phasing plan).

Specifically, the Secretary will require, as a condition of a Certificate approving a Final or Single EIR or a Final Record of Decision granting a Waiver, that the Proponent provide a certification

to the MEPA Office signed by an appropriate professional (i.e., engineer, architect, traffic engineer, general contractor) indicating that adaptation and resiliency mitigation measures adopted by the Proponent as the preferred alternative have been incorporated into the project. This self-certification should include supporting plans and a narrative identifying the status of climate change mitigation implementation.

It is possible that between the conclusion of MEPA review and completion of construction that project elements may be modified or designed in a manner different than those identified in the draft Section 61 Findings or MEPA review documents. In such a case, the Proponent will be required to demonstrate during the self-certification process that modified or substituted design elements and operational measures provide an equivalent level of mitigation.

EFFECTIVE DATE

The Secretary will require compliance with the provisions of this Policy for all projects that are subject to the Policy for which ENFs and EENFs are submitted after _____ (and noticed for public review in the _____ edition of the *Environmental Monitor*). Projects that filed an ENF or EENF prior to that date will be subject to the particular provisions of the Scoping Certificate issued for the project. The Secretary will review NPCs filed pursuant to 301 CMR 11.10 for projects that filed an ENF or EENF prior to the effective date of this Policy on an individual basis to determine whether the project will required to comply with the Policy.

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APPENDIX A: Potential Adaptation and Resiliency Mitigation Measures

Please note: the following mitigation measures are provided to assist in the evaluation of how a project may avoid, minimize, or mitigate the impacts of climate change in accordance with this policy. This list is not intended to be exhaustive, nor does it contain suggestions that may be applicable or code compliant for every type of project.

Coastal Projects

- Provide additional freeboard (i.e., elevate the lowest structural member of the building above the Base Floor Elevation (BFE)) above the minimum applicable code requirements. This should be considered for all structures undergoing improvements or repairs, not just new construction.
- Consider applying V-Zone requirements to projects in the Coastal A Zone and the entire Special Flood Hazard Area identified by the National Flood Insurance Program (NFIP).
- Construct structures to withstand direct and indirect impacts of high winds (if not already required by code) through the improved design, use of wind-resistant materials and connections (i.e., clips and braces), and use of impact resistant materials, windows and shutters.
- Implement measures to effectively wet floodproof the structure.
- Implement measures to effectively dry floodproof a structure to seal a structure from floodwater intrusion (not appropriate for anything below BFE in V and Coastal A Zones).
- Design and construct or rebuild roads and bridges at higher elevations to incorporate future sea-level rise (where practical).
- Locate utility connections above projected flood elevations.
- Design wastewater systems (septic or closed pipe) to accommodate projected sea-level rise and/or associated elevations of groundwater. Or, at a minimum, evaluate how the location and elevation of these facilities will need to be modified in the future to respond to climate change impacts.
- Provide alternative means of egress located landward of the proposed structure.
- Create wetlands or off-channel drainage storage basins to reduce erosion during high-flow periods.
- Plan and allow for inland migration of wetland resource areas through preservation of adjacent low gradient slopes.
- Reduce impacts within hazard prone areas through demolition or relocation of existing structures or avoidance and/or limitation of new development.
- In coastal and estuarine or tidally influenced creeks, streams and rivers, consider constructing or enhancing a “living shoreline” to mitigate coastal erosion and preserve natural habitat.

- Establish shoreline setbacks and buffer zones and locate structures as far away from flood and erosion prone areas as practicable. Consider historic and future erosion rates when establishing a setback area.
- Establish conservation restrictions or other development limitations in hazard prone areas.
- Facilitate and implement ecosystem restoration, creation or enhancement projects designed to withstand the impacts of climate change.
- Elevate land through dune restoration, enhancement and management, and beach nourishment.
- Elevate land by filling in upland areas outside of a floodplain.
- Maintain existing shoreline armoring structures such as breakwaters, groins, seawalls, bulkheads, revetments, dikes, and storm surge barriers. In some cases, structures may be an alternative subject to local, State and Federal regulations. Such structures should be designed and constructed to minimize adverse impacts at the site of the structure, the adjacent properties and infrastructure, and the broader coastal system and allow for modifications in response to projected climate change impacts. Avoid fill, landscaping walls, and curbing that interferes with the free passage of coastal flood waters beneath buildings or causes changes in flow direction during coastal storms that could result in damage to buildings or infrastructure.
- Incorporate low impact design (LID) stormwater Best Management Practices (BMPs) into project design to the maximum extent practicable to promote stormwater capture, infiltration, and reuse.
- Use diverse types of drought-tolerant, native plant varieties in landscaping.
- Actively remove invasive species to enhance habitat for key native species.
- Connect landscapes with corridors to facilitate wildlife migration and overall habitat biodiversity.
- Design new or rebuild existing drainage systems with larger pipes or provide reserve areas to expand retention, detention and/or infiltration areas in response to sea-level rise or increased storm intensity.
- Design drainage outlet pipe elevations in response to projected sea-level rise or increased storm intensity, or, at a minimum, evaluate how these elevations will be modified in the future to respond to climate change impacts.
- Maximize on-site stormwater infiltration to reduce flow and capacity burden on closed pipe drainage systems.
- Manage overland runoff to avoid increasing erosion of coastal landforms.
- Use bridges or wetland spans in lieu of culverts to accommodate higher stormwater runoff volumes.

Development Within and Adjacent to Floodplains, Riverfront or Areas Affected by Droughts

- Provide additional freeboard (i.e., elevate the lowest structural member of the building above the Base Floor Elevation (BFE)) above the minimum applicable code requirements. This should be considered for all structures undergoing improvements or repairs, not just new construction.
- Implement measures to effectively wet floodproof the structure
- Implement measures to effectively dry floodproof a structure to seal a structure from floodwater intrusion.
- Design wastewater systems (septic or closed pipe) to accommodate projected flood levels and/or associated groundwater elevations. Or, at a minimum, evaluate how the location and elevation of these facilities will need to be modified in the future to respond to climate change impacts.
- Maximize on-site stormwater infiltration to reduce flow and capacity burden on closed pipe drainage systems.
- Provide alternative means of egress for use during flooded conditions.
- Identify access and egress points (vehicular and pedestrian) in relation to elevations and floodplains.
- Manage overland runoff to avoid erosion of wetland resource areas.
- Consider backflow preventers for wastewater and stormwater.
- Install watertight utility conduits.
- Locate utility connections above projected flood elevations.
- Design and construct or rebuild roads and bridges at higher elevations to incorporate future inland flooding elevations (where practical).
- Use bridges or wetland spans in lieu of culverts to accommodate higher stormwater runoff volumes and enhance habitat.
- Plan and allow for migration of floodplains and wetland resource areas through preservation of adjacent low gradient slopes.
- Reduce impacts within hazard prone areas through demolition or relocation of existing structures or avoidance and/or limitation of new development.
- Elevate land by filling in upland areas outside of a floodplain.
- Avoid fill, landscaping walls, and curbing that interferes with the free passage of floodwaters beneath buildings or could result in damage to buildings or infrastructure.
- Incorporate low impact design (LID) stormwater Best Management Practices (BMPs) into project design to the maximum extent practicable to promote stormwater capture, infiltration, and reuse.
- Design new or rebuild existing drainage systems with larger pipes or provide reserve areas to expand retention, detention and/or infiltration areas in response to increased storm intensity.

- Design drainage outlet pipe elevations in response to increased flooding or storm intensity, or, at a minimum, evaluate how these elevations will be modified in the future to respond to climate change impacts.
- Adopt water conservation and reuse measures on-site.
- Use diverse types of drought-tolerant, native plant varieties in landscaping.
- Actively remove invasive species to enhance habitat for key native species.
- Connect landscapes with corridors to facilitate wildlife migration and overall habitat biodiversity
- Establish conservation restrictions or other development limitations in hazard prone areas.
- Facilitate and implement ecosystem restoration, creation or enhancement projects designed to withstand the impacts of climate change.

Projects Affected by Increases in Temperature and Frequency of High Heat Days (90 degrees or more)

- Limit clearing of the site; maintain existing vegetative cover to the maximum extent practicable.
- Re-vegetate site and incorporate tree planting and/or Complete Streets design elements.
- Reduce impervious areas by minimizing building footprints, paved areas, etc.
- Minimize energy use through proper building orientation and use of appropriate landscaping (e.g. trees for shading parking lots or southern facing facades)
- Use high-albedo paving surfaces where paving is necessary.
- Provide shade for parking lots through the incorporation of trees or canopies.
- Improve building envelope through higher R-value insulation in walls, roof, and if appropriate, basement walls and ceilings.
- Maximize the thermal mass of walls, roofs and floor to provide thermal damping
- Install lower U-value windows to improve envelope performance and incorporate window glazing to balance and optimize daylighting, heat loss and solar heat gain performance.
- Construct green roofs to reduce heat load on roof, further insulate, and retain/filter rainwater.
- Evaluate use of high-albedo roofing materials to reduce heat absorption

Miscellaneous

- Construct structures to withstand direct and indirect impacts of high winds (if not already required by code) through the improved design, use of wind-resistant materials and connections (i.e., clips and braces), and use of impact resistant materials, windows and shutters.
- Increase energy resiliency through incorporation of appropriate on-site renewable energy systems into project including solar PV (both first and third-party ownership models

should be evaluated), solar thermal, wind, low-impact hydro, geothermal, biomass (including pellets), and bio-gas strategies.

- Increase energy resiliency through incorporation of combined heat and power (CHP) technologies where sufficient year-round thermal demand exists.
- Consider black start CHP and ability to island.
- Incorporate climate change resiliency measures into tenant lease agreements for tenants who choose fit-out materials.
- Incorporate operable windows, emergency generators for water/wastewater pumps (in high-rise buildings), and other measures to allow safe operations of facilities during extended periods of power and or heating/cooling loss.
- Establish plans for alternative parking locations for tenant vehicles in structured or surface parking areas subject to flooding during extreme events.

Appendix B: Helpful Links

State Reports

Massachusetts Climate Change Adaptation Report (September 2011)
http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf

Massachusetts Global Warming Solutions Act webpage:
http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/

Massachusetts Office of Coastal Zone Management, *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning*, December 2013.
http://www.mass.gov/eea/docs/czm/stormsmart/slr-guidance-2013.pdf

Massachusetts Office of Coastal Zone Management, StormSmart Properties Fact Sheets, December 2103.
http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/stormsmart-properties/

Massachusetts Environmental Public Health Tracking Database:
https://matracking.ehs.state.ma.us/Environmental-Data/Climate-Change/index.html

Local Reports

The Boston Harbor Association's "Preparing for the Rising Tide"
http://www.tbha.org/preparing-rising-tide-report

City of Boston Climate Action Plan
http://www.cityofboston.gov/climate/bostonsplan/

City of Cambridge Climate Action Plan
http://www.cambridgema.gov/CDD/climateandenergy/climatechangeplanning/climateactionplanreports.aspx

National Reports

United States Global Change Research Program *Scenarios for Climate Assessment and Adaptation* Northeast Region webpage:
http://scenarios.globalchange.gov/regions/northeast

United States National Climate Assessment (2014)
http://nca2014.globalchange.gov/

International Panel on Climate Change Reports:

IPCC Fifth Assessment, Summary for Policy Makers – Climate Change 2013: The Physical Basis
http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

Entire Report by Chapter: http://www.ipcc.ch/report/ar5/wg1/

IPCC Fifth Assessment, Summary for Policy Makers – Climate Change 2014: Impacts, Adaptation and Vulnerability
http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf

Entire Report by Chapter: http://www.ipcc.ch/report/ar5/wg2/

IPCC Fifth Assessment, Summary for Policy Makers – Climate Change 2014: Mitigation of Climate Change
http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf

Entire Report by Chapter: http://www.ipcc.ch/report/ar5/wg3/

Appendix C: Modeling Tools and Data Sources for Coastal Projects

Coastal inundation mapping is a key component in assessing vulnerability and planning for sea level rise. Mapping potential future high tide or storm surge - wind generated waves that produce water levels above the highest high tides - requires high-resolution elevation data (e.g., Light Detection and Ranging [LIDAR] data) and a water surface based on a single value or range of model outputs and uncertainties. The capability to map and visualize the potential inland extent and depth of coastal flooding with sea level rise is important for identifying, understanding, and communicating potential impacts and consequences.

Different methods for modeling and mapping coastal inundation are summarized below. These include coarse methods that may be appropriate for general assessments and dynamic models which are more complex and incorporate the effects of storm surge.

Still-water ("bathtub") Models: These models are coarse approaches that use water level and topographical data and apply sea level rise scenarios at constant elevations but do not include other factors such as storm surge, wave dynamics, or landform responses. Maps generated from these models provide the basis for applying the sea level rise scenarios to assess potential extent and severity of flooding. While they have many limitations and should not be used for site-specific analysis, bathtub models are useful for visualizing potential extents of future high water levels to support first-order assessments.

> FIRM maps: A coarse assessment of potential impacts to a site can be developed by adding elevation associated with SLR scenarios to floodplain elevations from FIRMs. For some project sites, FIRM maps may offer the best available information.
>
> The Boston Harbor Association Rising Tide methodology – This report examined Boston's vulnerability to coastal flooding at two sea levels: five feet above current average high tide (MHHW+5) and 7.5 feet above current average high tide (MHHW+7.5), corresponding to, respectively, the current 100-year storm surge, and the estimated 100-year storm surge, possibly as soon as just after 2050. Flood impacts were limited to an analysis of "flooded" or "not flooded" for each parcel, based on the 2009 digital elevation model (DEM) developed by the Boston Redevelopment Authority (BRA). Properties were considered to be "flooded" only if the geographic center of the building(s) on the parcel was flooded.

Dynamic Models: are more complex and include the effects of storm surge. While dynamic models are more resource intensive (i.e., greater data input requirements and more expensive to run), the addition of important parameters, such as wind speed and direction, forward speed of the storm, shape of the coastline, and the depth and shape of the seafloor (or bathymetry), greatly improves their predictive capacity for identifying areas that may be impacted by coastal storms.

> The National Weather Service (NWS) **S**ea, **L**ake and **O**verland **S**urges from **H**urricanes (SLOSH) model was developed to estimate potential storm surge for Category 1-4 hurricanes. Statistical models are based on historical and hypothetical hurricanes. The Massachusetts Emergency Management Agency (MEMA) recommends that, for public

safety, people prepare for the impacts of one category higher hurricane than the storm's official strength.

Boston Harbor Flood Risk Model (BH FRM) developed for MassDOT – This model is under development to support the assessment of the vulnerability of the Central Artery and Tunnel (CA/T) system to sea level rise and extreme weather events. It is being developed and used to determine inundation risks and flooding pathways; and to stimulate the dynamic nature of flooding in the City of Boston that serve as floodpaths affecting the CA/T. It simulates the effect of tides, storm surge, wind, waves, wave setup, river discharge, SLR and climate change scenarios.

The model will provide flood-risk results for the City of Boston and the City of Cambridge. The model provides information for other locations in Massachusetts, but will not be able to identify risk associated with specific assets for locations outside of the focus area, although it could be extended to these areas in the future.

The quality of both static and dynamic modeling efforts depends on the accuracy of the elevation surfaces used to depict the sea level rise scenarios. It is important to note that these models do not account for coastal landform response, such as erosion, breaching, or migration. Efforts to develop improved decision support models that better consider dynamic landform responses to sea level rise are underway. Appropriate technical expertise to conduct coastal inundation mapping is strongly recommended.

This information was summarized from the following reports:

CZM Report - *Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning*
The Boston Harbor Association - *Preparing for the Rising Tide*
Massachusetts Department of Transportation (MassDOT) *Boston Harbor Flood Risk Model*

Appendix D

Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning

http://www.mass.gov/eea/docs/czm/stormsmart/slr-guidance-2013.pdf