6

Sustainability and Climate Change

This Chapter provides an overview of the sustainable design elements proposed as part of the Project to demonstrate that the Project will meet the requirements of Article 37 of the Boston Zoning Code relative to the City's Green Building policies and procedures. It builds upon and updates the information provided in the ENF/EPNF, which included the proposed U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating goal of LEED v4.0 Gold certifiable, building-specific strategies for each LEED category, and how key credits will be achieved. Information about the building energy model, energy conservation, a renewable and alternative energy evaluation, and a zero-carbon building assessment can be found in Chapter 8, Section 8.3.1.

This chapter also discusses the approach to preparing for changes in climate change, in accordance with the BPDA Climate Change Resiliency and Preparedness Policy. The required Climate Change Resiliency and Preparedness Checklist is provided in Appendix B, *Updated BPDA Checklists*.

6.1 Key Findings

The key findings related to sustainability and climate resilience include the following:

- The Project aims to achieve aggressive energy efficiency goals, including PHIUS+ Core Passive House Certification, and seeks to lead by example in proving an achievable path to successfully contributing to the City of Boston's goal of making Boston carbon neutral by 2050;
- The Project will have superior ventilation in order to provide healthier indoor air quality for the occupants, including a Passive House quality Energy Recovery Ventilator, premium air filtration (MERV 13), and outside air supplied directly to each bedroom;
- Construction quality control procedures will ensure that the high-performance design details are properly implemented in the field, including air sealing, insulation installation, ventilation balancing, and mechanical system commissioning.
- The Project will be designed to be LEED v4.0 Gold certifiable;

- The Project is targeting a 40 percent reduction in indoor water use compared to the baseline;
- The Project will help mitigate the heat island effect by integrating tree canopy cover, providing ample connected open space, and using cool paving materials;
- As a result of building to Passive House standards, all Project buildings will have a high-performance building enclosure, significantly lowering their heating and cooling needs and reducing reliance on mechanical systems to maintain interior thermal comfort;
- As part of Governor Baker's new initiative to understand the impact of building material on carbon emissions, the Project will be a pilot participant in a Whole Building Lifecycle Assessment conducted by Life Cycle Analysis, a third-party provider;
- As design progresses, the design team will review anticipated 2100 storm events to look for opportunities to mitigate effects from those greater future storm events.
- The Proponent will work with the City and other organizations to explore potential district-scale flood protection measures that would protect the larger neighborhood;
- The first floor elevations of residential buildings and critical infrastructure will be set at or above 21.5 feet BCB as recommended by the BPDA; and
- The Project will mitigate secondary and cascading impacts by decreasing reliance on electricity for heating and cooling by constructing the Project to Passive House standards; eliminating reliance on gas (except for domestic hot water); and designing the Project for decreased dependence on motorized vehicles.

6.2 Phase 1 Impacts

Consistent with the Master Plan Project, both Phase 1 buildings will be PHIUS+ Core Passive House certified and LEED v4.0 Gold certifiable (see Section 6.4 below).

Phase 1, particularly Building M, is vulnerable to the projected impacts of flooding due to climate change in the year 2070 with 36 inches of sea level rise (see Section 6.5.1). The recommended base flood elevation for residential buildings on portions of the Site vulnerable to future flooding is 21.5 feet BCB. To improve resilience to flooding, the first floor elevation (FFE) of the residential units and critical infrastructure such as electrical switch gear will be set at or above 21.5 feet BCB. Sloped walkways or ramps will be integrated into the landscape design to connect to existing elevations where feasible. Where existing grades and limitations of building frontage zones preclude external ramps, internal stairs and elevators will be used to provide accessibility to residential floors.

6.3 Regulatory Context

The regulatory context related to sustainability and climate resiliency is described in the sections below.

6.3.1 Sustainability

Rather than being driven by current energy reduction regulations, such as the Massachusetts Stretch Code, or the BPDA's policy of requiring projects to be LEED certifiable, the Project Proponent has set its own aggressive energy efficiency goals, including PHIUS+ Core Passive House Certification. The Project will lead by example in proving an achievable path to successfully contributing to the City of Boston's goal of making Boston carbon neutral by 2050.

The Project will far exceed today's requirements under the Stretch Energy Code and is positioned to meet or exceed proposed net zero energy provisions that are being advocated for by the Massachusetts Climate Action Network (MCAN) and investigated by the Board of Building Regulations and Standards' (BBRS). Meeting Passive House goals will contribute to the Project to be LEED certifiable at the Gold level, which demonstrates that the Project's sustainability features are not limited to energy efficiency. In accordance with Article 37 of the Boston Zoning Code, the Project Team has completed a LEED v4.0 BD+C New Construction checklist for the residential buildings and for the community center. Section 6.4 below provides a summary of the current strategies associated with the LEED checklist.

6.3.2 Climate Resiliency

Climate resiliency guidance is provided by the Draft MEPA Climate Adaptation and Resiliency Policy and the Boston Planning and Development Agency's Climate Change Preparedness and Resiliency Policy and related materials. MEPA requires that state agencies study the environmental consequences of their actions, and that they take all feasible measures to avoid, minimize, or mitigate damage to the environment. In order to address climate change adaptation (as opposed to just mitigation), in late 2014, the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) released the Draft MEPA Climate Change Adaptation and Resiliency Policy. It describes how projects should assess and mitigate the risks and vulnerabilities that are likely to result from climate change impacts and provides a basis for a resiliency strategy for the Master Plan Project.

The BPDA requires projects subject to Boston Zoning Article 80 Large Project Review to comply with the BPDA's Climate Change Preparedness and Resiliency which requires project proponents use the best available science to identify changes in the climate and environment and ascertain how such changes will impact the project's survivability, integrity and safety of its buildings and inhabitants. The BPDA has also published guidance that calls for all projects to consider present and future climate conditions in assessing project environmental impacts, including carbon emissions, extreme precipitation, extreme heat, and sea level rise (SLR), and to identify building strategies that would eliminate, reduce, and/or mitigate adverse impacts including those due to changing climate conditions.

Compliance requires completion of the Climate Change Preparedness and Resiliency Checklist, which provides a framework and specific resiliency targets for assessing project vulnerabilities and adverse impacts. Projects must identify initial strategies for reducing vulnerabilities and adverse impacts, as well as future adaptation strategies for meeting or exceeding resiliency targets and further reducing vulnerabilities and adverse impacts due to future climate conditions. The required checklist has been completed for the Project and is provided in Appendix B.

6.4 Sustainability Rating Systems

The Project Proponent has set its own aggressive energy efficiency goals by committing to the PHIUS+ Core Passive House Certification process. The Project also investigated both LEED v4.0 BD+C New Construction and LEED v4.0 BD+C Multifamily Midrise as possible frameworks for organizing the Project's sustainability goals, ultimately choosing the LEED NC checklist. The Project's integrative design process, as well as its strategies for compliance with the selected Passive House and LEED rating systems is described below.

6.4.1 Integrative Design Process

This Project employed a non-traditional team organization structure in an effort to eliminate inefficiencies in the typical project delivery approach and to develop a cost effective and highly sustainable design. The construction manager was one of the first team members brought onto the Project. The design consultants, who are typically contracted through the architect, instead work directly for the Proponent, who is serving as the overall Project manager, a role traditionally served by the architect. As a result, the consultants, especially the MEP engineer and the sustainability consultant, have been more impactful in helping to develop the design than is typical. The Proponent has also been able to bring in a variety of consultants with very specific expertise.

The Proponent involved all members of the design team in developing early energy and water use reduction goals. The Proponent also conducted a series of stakeholder meetings for residents, community representatives and area not-for-profits to identify goals for the Project. The Integrative Process is not yet complete, as refinement will continue until the design development is solidified, but one important outcome of the process is that the Project will pursue PHIUS+ Core Passive House certification. Uniquely, this process also will result in a number of agreements with area not-for-profits to provide services to the future community both in, and around, the new Project.

6.4.2 Passive House

Passive House is a performance-based certification program that provides a comprehensive approach to energy modeling, design, and construction for projects to attain an extremely high level of energy efficiency. In addition to energy efficiency, buildings built to the Passive House standard provide several other long-term benefits, including comfort, superior indoor air quality, moisture risk mitigation, resiliency, and a path to net zero energy/carbon by minimizing the loads renewable energy systems are required to offset.

In the design phase, the Passive House program requires careful energy modeling under specific guidelines that have been developed based on decades of energy modelling and comparisons to real-world experience. The WUFI Passive energy model balances a comprehensive set of factors that includes internal heat gains (people and appliances) to optimize efficiency, while also providing a comfortable and consistent indoor temperature throughout both the heating and cooling seasons.

PHIUS+ Core Passive House certification requires a WUFI passive energy model that confirms compliance with the following heating and cooling energy targets. These targets are defined by the location of the project, as well as the enclosure area, floor area, and occupant density. For Building D, the following target metrics set the certification criteria and are representative for the whole project:

- Annual Heating Demand ≤ 3.8 kBtu/ft^{2}yr – Site Energy use for heating
- Annual Cooling Demand ≤ 5.1 kBtu/ft^{2}yr – Site Energy use for cooling
- Peak Heating Load ≤ 3.7 Btu/ft^{2}yr
- Peak Cooling Load ≤ 3.0 Btu/ft^{2}yr
- Net Source Energy Demand ≤ 5,500 kWh/yr/person

The total energy limit is based on source energy because source energy best represents the greenhouse gas (GHG) impact of a building's operation. This bottom metric is the most challenging of the five metrics for this project. Sample WUFI Passive reports, including the building's passing results compared against these five metrics are provided in Appendix A.

The Passive House program leverages the following five design principles to achieve ultra-high energy efficiency:

- Continuous insulation throughout the entire enclosure without any thermal bridging;
- An extremely airtight building enclosure to limit air infiltration and the loss of conditioned air;
- High-performance windows and doors that manage solar gain and harness the sun's energy for heating purposes in the heating season, while minimizing overheating during the cooling season;
- High efficiency, balanced heat and moisture recovery ventilation; and
- Minimal space conditioning mechanical systems.

The Passive House program holistically integrates these design principles to optimize the system. For example, superinsulation and airtight construction allow the heating/cooling systems to be downsized, which saves money, but also reduces the energy consequences if a system operates suboptimal. Another example of the Passive House design principles working in concert is that energy models have traditionally under-estimated the negative energy impacts of thermal bridging and air leakage. The Passive House program has removed the challenge of accounting for these impacts, while also avoiding two frequent causes of comfort complaints, by eliminating thermal bridging and requiring a stringent airtightness metric.

Focus on developing good design details early is critical, but good design holds little value if it is not implemented correctly in the field. The construction phase commissioning requirements of the Passive House program ensure that the high-performance details are installed correctly in the field and delivers confidence that the system will work as designed.

The Bunker Hill Housing project has embraced all five of the Passive House design principles and has a strategy for construction. The approach to each of which is described below:

Continuous insulation without thermal bridging

The wall assembly for this project has evolved significantly over time. The goal from day one was for this "project to be able to be heated with a candle" and so the wall assembly started with a very high R-value wall of 8" of closed cell foam in a double stud wall cavity. For a variety of reasons, including the recognition that this strategy still contained a number of thermal deficiencies for structure and window/slider support, the wall detail evolved to 3" of mineral wool with a thermally broken attachment system to the exterior of the sheathing. We found this assembly to best balance all the competing requirements, including NFPA 285 (fire propagation), moisture control, cost, constructability, and efficiency. Although the R-14 insulation value for this wall assembly may not sound overly impressive, the value of this assembly is in the details, which delivers a high-performance wall assembly with minimal thermal bridging and air leakage, resulting in Passive House level energy efficiency.

The insulation detail for the podium will be installed in a way to minimize thermal bridging at this critical location. R-10 will be installed at the base for the slab on grade buildings and the roof is modeled as R-32.

Passive House's strong focus on thermal bridging is not solely driven by the goal of reducing energy loss, there is an occupant health and building durability value as well. Controlling thermal bridging helps avoid mold growth by limiting the number of surfaces where condensation may occur. Passive House requires an additional surface mold risk analysis based on ISO 13788 protocols for any major thermal bridges in order to confirm that the interior air that comes in contact with a cold surface has less than 80 percent relative humidity, which indicates that condensation should not occur. At this point in the design, the team has yet to identify a specific detail where this additional modeling is required but is prepared to do so if necessary. The Design Team is focused heavily on minimizing all potential thermal bridges, especially at the slab to framing transition, the roof to wall transition, and the window punch openings, to ensure they are mitigated and meet the Passive House moisture design criteria.

Airtightness

The Passive House standard currently has two different airtightness metrics depending on the height of the building. This project has buildings above and below the height demarcation, but in the interest of consistency across the project, the more stringent metric is targeted for all buildings. At the completion of construction, each building will receive a whole-building blower door test and demonstrate an air tightness less than or equal to 0.060 cfm50/ft^2 of gross envelope area (or 0.080 cfm75/ft^2). For comparison, the energy code has an optional air barrier compliance pathway that requires less than or equal to 0.40 cfm75/ft^2 – five times higher than Passive House. Full building blower door testing may sound challenging, but given the stringency of this airtightness metric, only a few blower door fans are required to achieve the required pressure differential. In order to ensure the project is on track to meet these aggressive goals, mockup airtightness testing will be conducted early on during construction to ensure compliance is achieved.

The project will also ensure there is a continuous air barrier located at each individual unit by focusing on common issues at plumbing penetrations, vertical duct shafts, and interior demising walls. The project will also conduct individual unit blower door testing on a sample number of units to confirm compliance with the Passive House unit compartmentalization airtightness requirements, which is less than or equal to 0.3 cfm50/ft^2 of unit shell area.

High-performance windows and doors

The same condensation concerns that are centered around thermal bridges, also apply to windows. The project will avoid condensation concerns by complying with the results of PHIUS' Window Comfort & Condensation Risk Assessment Calculator. Based on the current size of the windows for BHH, the Calculator requires the project to have windows with a U-value of 0.27 or less. The Design Team has identified several manufacturers that can provide windows at this level of efficiency that also meet the other needs of the project. BHH plans to take advantage of the scale of the project to solicit price competitive, high-performance windows for this Project. A hope is that such a large sale will also help open opportunities for other projects in the Boston market.

Energy Recovery Ventilation (ERV)

As required by Passive House, the design for BHH calls for ventilation air to be routed directly to each individual bedroom. The ventilation ductwork for BHH is separately run from the heating/cooling ductwork. The ventilation ductwork will branch out at each floor after running vertically from high efficiency ERVs located on the roof. For all buildings there will be multiple ERVs strategically located on the roof to minimize the amount of ductwork that is located above the roof insulation.

Like with windows, the Passive House program has a much more stringent approach to quantifying the performance of a ventilation unit than is standard practice in the US. The WUFI Passive modeling software requires several product metrics that manufacturers typically do not report, such as separate thermal and electrical performance numbers and sperate latent performance metrics for heating and cooling seasons. Therefore, the specific ERV unit will meet the Passive House performance criteria to ensure compliance with the necessary metrics. The ventilation for BHH will also be a balanced system with the supply and exhaust flow rates measured to be within 10 percent of each other. The ventilation system will employ MERV 13 filters, which will be a critical feature give the proximity of the project to Route 1 and the traffic on the Tobin Bridge. The end result of this focused attention on ventilation will be a healthier living space for the occupants.

Small mechanical systems

The heating and cooling for the building will be provided by simultaneous variable refrigerant flow (VRF) Air Source Heat Pumps. This selection will allow the system to be sized appropriately to meet the minimized residential loads thanks to the Passive House design. If occupants leave their windows open during the winter, the mechanical system is not large enough to compensate for the additional load and the temperature set point will not be achieved. As a result, it will be colder in the unit and the occupant will be motivated to keep the windows closed, conserving energy and improving comfort.

There will be no fireplaces in the units and the only fossil fuel combustion in the building will be from the central, sealed combustion, direct vent boilers used to generate domestic hot water.

Quality Control

Construction quality control is a critically important aspect of the Passive House program that ensure the design is successfully implemented. The offsite construction of many of the assemblies for this project will provide a solid underpinning for consistent quality with the insulation and the air barrier. The second and more challenging step will be to ensure the joints between the panels are addressed in a manner that maintains the continuity of both the insulation and the air barrier. BHH has focused on these details and visual inspections and performance testing will ensure these details are properly implemented. Inspections will be conducted by a third-party PHIUS+ Verifier to confirm compliance with all the mandatory prescriptive design elements listed in the PHIUS+ Quality Control Workbook for Multifamily Projects. As required by Passive House, BHH will also complete the inspection checklists required by the EPA ENERGY STAR Multifamily New Construction Program and the DOE Zero Energy Ready Homes Program, although these certifications programs will not necessarily be pursued, including: the MFNC Rater Design Review and Field Checklists, the HVAC Design Report and Functional Testing Checklist, and the MFNC Water Management System Requirements.

6.4.3 Leadership in Energy and Environmental Design

The selection of which LEED track - New Construction versus Multifamily- was driven by several factors, including the team’s understanding that, once it is balloted and approved, LEED v4.0 Residential: Multifamily will be more similarly structured to LEED NC. A summary of the Project’s approach to achieving specific LEED credits is outlined below and in the LEED Checklists included in Appendix B. Based on the current assessment of the Project documentation, location attributes, and information from project partners, the LEED v4.0 checklist is tracking 60 points and Gold certification for both the residential buildings and the two-story, 14,000 square foot Community building, although with a slightly different mix of credits, as described below. Gold requires a point total of 60-79 points and each checklist has double digit "maybe credits," providing a buffer to achieve Gold certification.

Location and Linkages

The Project is not pursuing *LEED for Neighborhood Development* but will instead pursue credits individually in this category. As a previously developed site, the Project automatically scores one point for LTC2: *Sensitive Land Protection*. The Project is located in census tract 408, and according to HUD is designated as a "Difficult Development Area," with 32.1 percent of the population at or below the poverty rate. As such, the Project is located on a *High Priority Site (LTC3),* gaining one point. In consideration of credit LTC4, *Surrounding Density and Diverse Uses*, the Project will increase the density on the Site (and within 0.25 miles of the Project per LEED requirement), for three points, with an average combined density of 104,000 sf/acre. Due to the Project's proximity to diverse amenities, it will garner an additional two points for diverse uses. The Project Site is within 0.25 miles of multiple stops along the Route 93 MBTA line, which provides 73 round trips weekdays and 69 on weekend days, but only achieves one of five possible points under *Access to Quality Transit,* as there are few other transit options that meet the requirements. For example, the nearest transit station is 0.6 miles away from Building F, which is outside of the LEED radius for public transportation, but other buildings on the Site will fall within this radius. A goal of the Project is to assign a transportation coordinator to focus on increasing access to public transportation for the Charlestown area as a whole. The Project will work with institutional partners to expand transportation options for the community, potentially including more frequent buses and shuttles. The Project also plans for real time transit information to be shared in the lobbies of all the buildings. All of these initiatives would mean that under future conditions, the Project could earn additional points, if not all five points, for *Access to Quality Transit*.

For LTC6, *Bicycle Facilities*, the Project will provide long-term bike storage for each unit, and additional short-term storage for visitors to the Project Site. To meet the criteria for LTC8, *Green Vehicles*, and earn one point, the Project will designate five percent of the structured parking spaces for low emitting vehicles, proportionately distributed for residents and guests, and will provide signage indicating these spaces and vehicle qualifications. Additionally, 25 percent of all structured parking spaces will be equipped with electric vehicle supply equipment (EVSE), to provide vehicle charging for residents and guests.

Sustainable Sites

As required by the LEED prerequisite, and local and state standards, the construction manager will follow all necessary permit and documentation criteria to protect the Site and surrounding areas from soil erosion, waterway sedimentation and airborne dust. A site survey, as required by SSC1, *Site Assessment (one point)*, has been conducted to inform the Project Team of unique site conditions that can impact design, and to serve as the basis for optimizing redevelopment of the Site. While thoughtful consideration will be given to the public spaces outside the buildings to create opportunities for residents and guests to gather, play, and experience nature, the Project will not be able to meet the threshold for SSC2: *Protect or Restore Habitat*. SSC3: *Open Space* is currently considered a "maybe" credit because although the project is in the ballpark of the 30 percent open space requirement with 25 percent of that open space vegetated without turf grass, the design still needs to be finalized.

Rainwater runoff will be managed for the 90th percentile storm event, 1.25 inches, via low impact development and green infrastructure strategies. However, the 95th percentile storm event, 1.6 inches, which is required in order to achieve the two points under SSC4: Rainwater Management, will most likely not be achieved by the Project. An additional two points are planned under SSC5: *Heat Island Reduction*, as more than 75 percent of parking will be under cover (either below buildings or in a separate parking garage) and products with high Solar Reflective Indexes will be used for both hardscapes and the roofs. Working with the lighting design team, the Project is looking into the uplight and light trespass requirements using the backlight-uplight-glare (BUG) method for one point for SSC6: *Light Pollution Reduction*. Although the current acorn streetlights at the site do not appear to have up-light cutoffs, based on a discussion with Boston's City Lighting program, it is their understanding that thousands of newer streetlights in Boston are "dark-sky friendly," which means that 95 percent of the light shoots down instead of up into the sky.

Water Efficiency

As required, the Project will not have permanent irrigation beyond the two-year period required to establish vegetation or meet the 30 percent reduction from the peak watering month baseline. Plant species will be selected for their tolerance to drought conditions, and green rainwater management strategies will help maintain rainwater on-site long enough for infiltration and/or store it for irrigation purposes if such a system is warranted. The Project is targeting an Indoor Water Use Reduction of 40 percent, exceeding the 20 percent minimum requirement and garnering four points plus a Regional Priority credit. Appliances in the units, including dishwashers, will be ENERGY STAR rated, and clothing washer and dryers will also carry the ENERGY STAR label. Tenants in the commercial spaces will be required to install these rated fixtures to ensure their consumption is in line with the estimated reduction.

Credits that the Project will pursue include: two points for no irrigation under WEC1: *Outdoor Water Use Reduction,* although the Project could also approach the credit by calculating a reduction to baseline water use if irrigation via stormwater reuse is employed. As amended through the Pilot Alternative Compliance Path, the Project will document that there is no cooling tower, as the building cooling will rely on heat pumps, thus garnering two points. Finally, for Water Metering, the Project will install two separate submeters located at the incoming hot and cold water lines at each residential unit.

Energy and Atmosphere

The Project will comply with the required and enhanced commissioning requirements (for five points) of LEED per *EA Prerequisite: Fundamental Commissioning and Verification* and *EAC1 for Enhanced Commissioning* for both mechanical systems and the enclosure. Through the

Passive House certification program there will be additional enclosure commissioning beyond that required by LEED, including unit compartmentalization air barrier inspections and blower door testing.

For the *EA Prerequisite: Minimum Energy Performance*, rather than creating an ASHRAE 90.1-2010 Appendix G energy model, the Project MEP engineer has generated multiple iterations of the WUFI Passive energy model. Use of WUFI Passive is approved under LEED Interpretation #10486 (https://www.usgbc.org/leedaddenda/10486).

Based on the Project's compliance with The PHIUS Passive House standards, it exceeds the minimum energy performance prerequisite and may claim 12 points under *EAC1: Optimized Energy Performance* as the USGBC has ruled that Passive House certification equates to 30 percent better than the LEED baseline, ASHRAE 90.1-2010 Appendix G energy modeling protocols. The design team believes this allowance is extremely conservative. In comparing the WUFI Passive results to baseline multifamily housing projects for the City of Boston's Article 37 GHG calculations, the Project engineer forecasts a 48 percent reduction compared to the MA State Stretch Energy Code and a greater than 50 percent reduction compared to ASHRAE 90.1-2013, which would equate to 18 points (the maximum) under this LEED NC credit.

For *EA Prerequisite: Building-Level Energy Metering* the Project will install the energy submetering capabilities necessary to meet this prerequisite. The electric meter information will be collected at the building and residential unit level. The natural gas consumption will be tracked at the DHW boilers. All 15 residential buildings will participate in Boston's Building Energy Reporting and Disclosure Ordinance (BERDO) program and will provide the required metrics, including: EUI, ENERGY STAR Score, total site energy use, electricity + gas intensity, GHG total and intensity, water use intensity, tax parcel, and contextual information. The Project is still determining the feasibility of *EAC3: Advanced Energy Metering*, as each individual ERV would require sub-metering for the residential buildings. Sub-metering is also an option under consideration for the community building, although the draws may be so low that it will have limited value.

In accordance with *EA Prerequisite: Fundamental Refrigerant Management* the Project will not employ CFC based refrigerants. For EAC4, *Demand Response*, the owner would not pursue this credit, as the only sizable electrical draw external to the residential units is the operation of the ventilation system and the Project is not interested in compromising indoor air quality by ramping down the ERVs in order to curtail electricity demand. Furthermore, it is not desirable to control electricity draws within the units. For EAC5, *Renewable Energy Production*, a solar feasibility study developed for the Project shows that it could be eligible for between two and three points, varying by specific building. The current strategy is to evaluate the installation of PV panels for each building as it nears completion based on the market opportunities and incentives available at that time. For this reason, the Project is not able to definitively claim any of these credits. For EAC6, *Enhanced Refrigerant Management*, the VRF system will most likely employ R410a as the refrigerant, which has a GWP of 2,088 and an ODP of 0 and is therefore not eligible for this credit given the lengths of refrigerant lines and number of interior heads that will be required for this building type.

Finally, EAC7 *Green Power and Carbon Offsets* is not part of this Project's LEED strategy, but the owner does foresee purchasing green power, carbon offsets, or renewable energy certificates (RECs) as strategies for achieving net zero carbon in the future.

Materials and Resources

As required by LEED, the Project will provide *Storage and Collection of Recyclables* for residents including mixed paper, corrugated cardboard, glass, plastics and metals. The Proponent will also provide collection and safe recycling/disposal for batteries and electronic waste. The construction manager will be required to meet the goals for construction and demolition waste using best practices and adhering to local requirements. Diversion goals will be established for both existing building demolition, and construction of the new structure, and the construction manager will identify diversion targets for at least five specific materials (e.g gypsum board, wood). The selected waste hauling contractor will determine if waste is commingled or separated on-site and will retain transfer tickets documenting diversion throughout the Project. All construction diversion activities will be documented in a final report. The contract will call for the construction manager to divert 75 percent of waste to landfill and address at least four material streams including gypsum board, carpeting, glass and concrete (or as defined by contractor) to achieve two points for Construction and Demolition Waste Management, MRC5.

As part of Governor Baker's new initiative to understand the impact of building material on carbon emissions, the Project will be a pilot participant in a Whole Building Lifecycle Assessment conducted by Life Cycle Analysis, a third-party provider (three points for MRC1, *Building Life-Cycle Impact Reduction*). The Project will specify as many products with *Environmental Product Declarations* as practicable as the Basis of Design in order to meet the requirements of MRC2, with a conservative estimate of one point for this category, and possible two points as the EPD market continues to expand. Points for MRC3, which concerns the *Sourcing of Raw Materials*, are not currently feasible, as a review of repository sites such as Mindful Materials and UL Spot shows that the necessary documentation for this credit is still lacking. The Project anticipates earning one point for *MRC4, Building Product Disclosure and Optimization—Material Ingredients*, as the number of labels that address optimized material chemistry is widely available through Declare, C2C, and HPDs. Specifications will include many products with these labels to ensure the Project contains products optimized for human health.

Indoor Air Quality

One of the Project's primary goals is to provide a heathier indoor environment than is typical. The prerequisites for *Minimum Air Quality Performance* will be exceeded to optimize indoor air quality and ventilation rates. Residential units will not have in-unit combustion; will include premium ventilation with exhaust at the bathrooms and kitchens; and will supply outside air delivered directly to the bedrooms. *Environmental Tobacco Smoke Control* will be met, as the buildings will be a "no smoking" establishment, with smoking only allowed in designated areas outside the building that are clearly marked and separate from building entrances, windows, and play spaces. For EQC1, *Enhanced Indoor Air Quality Strategies*, the Project will: install entryway systems to capture dirt and particulates and prevent them from entering the building on peoples' shoes and maintain them to ensure their optimal performance; sufficiently exhaust each space where hazardous gases are present, to create negative pressure with respect to adjacent spaces; and will install MERV 13 filtration for all outdoor air. To improve indoor air quality, the Project will seek *Low Emitting Materials* with optimized chemistry (per MRC4) and emissions testing, as well as products that meet the standard VOC content criteria. The Project will specify four product categories (e.g. interior paints and coatings, flooring, composite wood, and insulation) that will meet both VOC content and emissions criteria. However, the current checklist is conservative in the estimate of two points due to the uncertainty of being able to procure products that meet the high threshold for both VOC content and emissions. To achieve one point for EQC3, the construction manager will be required to follow a *Construction Indoor Air Quality Management Plan*, but the Project will not conduct a flush out or air quality tests per the *Indoor Air Quality Assessment* credit.

Thermal Comfort for building occupants will be achieved by employing thermal comfort design and providing thermal comfort control (EQC5, 1 point). Due to the cost associated with modeling or measuring compliance with the credit criteria, the Project is not likely to document EQC7 *Daylight* (three points), although the goal of designing each unit's floorplan is to maximize daylight in as many of the occupied spaces as possible, while minimizing solar heat gain. EQC8 *Views*, one point, may be achieved, as the goal of 75 percent of all regularly occupied floor area having views is feasible, but providing two of four types of views makes compliance less certain. Finally, it is the goal of the Project to design a building and systems that meet the criteria of EQC8, *Acoustic Performance*, and to earn the point associated with the credit.

For the Community Center, at least one point under Interior Lighting (EQC6) will be pursued as light quality and adjustability will be considered in the final design for this building.

Innovation and Design

The Project will pursue four ID credits, in addition to one credit for the inclusion of a LEED accredited professional as a consultant. A Pilot credit for *Passive Survivability (thermal safety) During Disruptions* will be claimed under path #3 for the Passive House certification in combination with the operable windows. The Proponent is committed to maintaining safe thermal conditions in the event of an extended power outage, see the project engineer's Indoor Temperature Resiliency Study in Appendix E and discussed in more detail in Section 6.6.2. and the project will automatically achieve one credit under this innovation credit. Currently, the project is not claiming the second, additional credit, which requires backup power beyond life safety, although the opportunity is under investigation.

An additional innovation credit will be claimed for *Community Outreach and Involvement*. This credit entails predesign and preliminary design meetings with impacted community members (i.e. those who live or work in the community) in order to solicit their input and incorporate their recommendations into the design. The Project has worked and will continue to work with the community to advertise and organize meetings, feedback has been documented, and design changes were made in accordance with the communities' thoughts.

The Project will also claim a credit by developing and administering an *Occupant Comfort Survey*. The Proponent will partner with one of the community organizations, community college, or other independent group, to conduct a survey to assess occupant feelings about acoustics, building cleanliness, indoor air quality, lighting thermal comfort, and other attributes to be determined by those who construct the survey. The group will work with the owner to ensure that at least 30 percent (per credit requirements) of the occupants participate. Survey results will be documented, and a corrective action plan will be addressed for any issues where more than 20 percent are dissatisfied. At least one survey will be performed with corrective action as necessary, and at least one more survey will be conducted two years after the initial survey.

A final Innovation credit will be claimed because at least 22% of the units within each residential building will be priced for households earning less than 60% of the area median income.

Regional Priority Credits

These credits are determined by the local USGBC Chapter, and based on credit thresholds achieved throughout the credit categories. As such, the Project stands to achieve at least two additional points. These points are attributed to the following base credit achievements: The Project exceeds the 8-point threshold for *Optimized Energy Performance* (earning 12 in that credit) and the Project is aiming to achieve a 40 percent reduction in Indoor Water Use.

6.5 Climate Change Impacts

The Project Site's vulnerability to anticipated climate change impacts related to projected extreme temperatures, precipitation, and sea level rise (SLR) was initially evaluated in the ENF/PNF. The main data source for that evaluation was the Boston Research Advisory Group's *Climate Change and Sea Level Rise Projections for Boston* (June 2016). Since that time, revised projections and additional information have become available, including the *Climate Ready Boston Report* (Dec 2016), the BPDA's current *Resiliency Policy* (Oct 2017), the *BPDA's Resiliency Checklist* (Oct 2017), and the online *Sea Level Rise Flood Mapping* and *Climate Ready Boston Map Explorer* tools. This section incorporates this more recent information and also examines the Project's consistency with the 2018 C*oastal Resilience Solutions for East Boston and Charlestown* report.

6.5.1 Vulnerability Assessment

Extreme Temperatures

According to the 2016 *Climate Ready Boston Report* and the BPDA's *Climate Resiliency Guidance* document, the annual average temperature in Boston increased by about 2°F in the past hundred years and will continue to rise due to climate change. By the end of the century the average annual temperature could increase to 56°F (compared to the current average of 46°F) and the number of days with temperatures above 90°F could rise to 90 days per year (compared to the current count of approximately 10 days per year). The Project Site will be subject to the impacts of extreme heat, as well as other anticipated variations in temperature patterns.

Precipitation

From 1958 to 2010 there was a 70 percent increase in the amount of precipitation that fell on the days with the heaviest precipitation in the Northeastern United States. Currently, the 10-year, 24-hour design storm precipitation level is 5.25 inches. There is a significant probability that this will increase to at least 6.0 inches by the end of the century. Larger but less frequent storms are likely to occur, along with more frequent droughts. According to the *Climate Ready Boston Map Explorer*, portions of the Site adjacent to Bunker Hill Street, Tufts Street, Corey Street, Moulton Street, Samuel Morse Way, Walford Way, and Medford Street may be subject to stormwater flooding by 2030 with 9 inches of sea level rise (SLR).[1]

Sea Level Rise

The effective FEMA Flood Insurance Rate Map (FIRM) indicates that the Project Site is not currently susceptible to flooding during either the 1% or 0.2% chance annual coastal flood. However, sea level in Boston has been rising and will continue to rise throughout the century, with 4.0 to 8.0 inches of SLR above 2000 sea levels by 2030; 7.0 inches to 1.5 feet by 2050; 1.3 to 3.1 feet by 2070; and 2.4 to 7.4 feet (with a maximum possible of 10.5 feet) by 2100. The implications of these scenarios are represented on the BPDA Sea Level Rise – Flood Hazard Area (SLR-FHA) map as a modeled one percent annual chance flood event with 40 inches of SLR by 2070. According to both the BPDA Sea Level Rise Viewer and the *Climate Ready Boston Map Explorer*, portions of Buildings E1, E2, F, L, M, and N, as well as the open spaces adjacent to buildings M and N, are projected to be impacted by the 1% annual chance flood by 2070 with 36 inches of sea level rise up to a base flood elevation of 19.5 feet BCB (Figure 6.1). According to these sources, the Site is not likely to be impacted by either the 1- or the 10% annual chance flood prior to the 2070/36 inches-of-SLR scenario.

6.5.2 Planning for Climate Change Adaptation

BPDA's Climate Resiliency Guidance

The BPDA's Climate Resiliency Guidance document states that projects within the FEMA Special Flood Hazard Area (SFHA) or the BPDA SLR – FHA should use its recommended Sea Level Rise – Design Flood Elevation (SLR – DFE) for the year 2070 as the minimum performance target for assessing SLR impacts and for reducing or eliminating flood risk, potential damage, and related adverse impacts. The projected SLR – DFEs are comprised of two components: the SLR-BFE and

[1] Source: Boston Water Sewer Commission Wastewater Facilities Study via Climat Ready Boston Map Explorer, Accessed 12/18/19. Elevation data is not available for this dataset

freeboard. The SLR-BFE is based on the Boston Harbor Flood Risk Model (BH-FRM) results, which include 40-inches of SLR, 2.5 inches of local subsidence, and the one percent annual chance coastal flood event in 2070. Freeboard, an added measure of protection, is achieved by raising the first floor an additional amount above the BPDA SLR-BFE. The BPDA recommends setting the SLR – DFE using 12-inches of freeboard for non-critical, non-residential uses and 24-inches for critical buildings, infrastructure and ground floor residential. The BFE at the Project Site for 2070 is 19.5 feet BCB, resulting in an SLR – DFE of 20.5 feet BCB for non-residential uses and 21.5 feet BCB for residential uses. As described below, this information was incorporated into the Proposed Project's design to the maximum extent practicable.

Coastal Resilience Solutions for East Boston and Charlestown

In 2017 the City of Boston published its *Coastal Resilience Solutions for East Boston and Charlestown* report. It explains that the Sullivan Square waterfront is the most important and earliest point of flood entry in Charlestown, the vulnerability of which is being studied in detail as part of MassDOT's Rutherford Avenue and Sullivan Square Redesign Project. Because impacts to the Bunker Hill Housing Redevelopment Project Site are not anticipated until later in the century, the report does not make any specific recommendations for the Project Site. However, the report's recommendations are replicable and flexible and could be applied to other parts of Charlestown and other neighborhoods. Recommended measures mainly include elevating roadways, parks, and pathways to block potential coastal floodwaters.

6.6 Project Adaptation and Resilience Measures

The Proponent has considered a variety of site- and building-based adaptation and resilience measures to limit the potential impacts of extreme temperatures, stormwater flooding and coastal flooding, which are described below.

6.6.1 Project Site Adaptation Measures

Extreme Temperatures

The Project's landscape areas will be strategically designed to mitigate the events of extreme temperature events and urban heat island effect. Impervious land cover will be kept to a minimum in favor of green space, which will be densely vegetated wherever possible. Planting beds will be layered with hardy native and adapted tree canopies, shrubs, and perennial plantings in order to increase biomass, which will in turn allow for more efficient cooling of the air through evapotranspiration. Planting soils will be specified with this goal of high biomass in mind, and beds will be sited strategically to capture stormwater, bolstering the transpiration process while also helping to address stormwater flooding.

Where impervious cover is necessary, materials with less heat absorbing capacity and a high Solar Reflective Index will be specified in an effort to help offset extreme heat events. Street trees, trees in planting beds, and standalone shade trees will all be utilized in order to maximize the shading of paved areas. The placement of trees along the south edges of these areas will be prioritized in order to ensure shade at peak summer hours.

Stormwater Flooding

The Master Plan Project will include a stormwater management system designed to meet or reduce the rates and volumes of stormwater runoff from the Site compared to existing conditions for the 2-, 10-, 25- and 100-year, 24-hour storms. These storms events are 3.23-inches, 5.10-inches, 6.27-inches, 8.08-inches, respectively, based on NOAA Atlas 14 rainfall data. Runoff rate and volume reductions will be achieved by providing storage, promoting infiltration, reducing impervious cover, including green infrastructure, and designing outlets that control discharge in different events. The BWSC recommends designing for the 6-inch storm-event (representing the 2100 10-year storm depth) and the 8.8-inch storm event (representing the 2100 100-year storm depth under the medium emissions scenario). The anticipated 2100 storm events will be reviewed as the designs progress to look for opportunities to mitigate effects from those greater future storm events.

Flood resilience will be a consideration in the design of all open spaces and streetscapes, and in particular Tufts Street, Corey Street, and blocks F, M, and N, which lie in the region identified in Climate Ready Boston as susceptible to future flooding. The open spaces and streetscapes will be thoughtfully designed to withstand flooding, locating flexible, floodable, vegetated program elements such as multi-use lawns and nature play in the lowest-lying areas whenever possible. Nature-based solutions will also be strategically located in low-lying areas in order to intercept and filter stormwater, buffering areas of higher use and lower resilience, like critical circulation paths. Highly durable materials and furnishings will be selected to both actively reduce stormwater runoff, such as permeable pavements where appropriate, and to withstand its effects.

Coastal Flooding

As described above in Section 6.5.1 and shown in Figure 6.1, a portion of the Site lies within the BPDA SLR-FHA, which has a BFE of 19.5’ BCB. Table 6.1 lists the lowest elevations of the roadways that are within the BPDA SLR-FHA. Due to Project phasing, the proposed building/block locations, and the existing off-site buildings, raising existing roadways to the recommended DFE would be extremely difficult.

TABLE 6.1 STREET ELEVATIONS WITHIN BPDA SLR-FHA (FUTURE FLOODPLAIN)

Street	Lowest Elevation within BPDA SLR-FHA (BCB datum)	Location of Lowest Elevation
Medford Street	16.86	Tufts Street
Walford Way	16.42	Tufts Street
Samuel Morse Way	17.65	Corey Street
Moulton Street	16.20	Vine Street

Street	Lowest Elevation within BPDA SLR-FHA (BCB datum)	Location of Lowest Elevation
Tufts Street	16.45	Walford Way
Corey Street	16.59	Moulton Street
Decatur Street	15.34	Vine Street

In addition, it would be preferable to block flood pathways closer to their sources, including the Little Mystic Channel and the Charlestown Navy Yard waterfront, in order to protect larger areas. The Proponent will work with the City and other organizations to explore district-scale flood protection measures in the future. For these reasons, flood protection will primarily be addressed using the building-level strategies discussed in Section 6.6.2 below.

6.6.2 Building Adaptation Measures

Extreme Temperatures

As a result of a building to Passive House standards, all Project buildings will have a high-performance building enclosure, significantly lowering their heating and cooling needs and reducing reliance on mechanical systems to maintain interior thermal comfort.

The Project's MEP engineer conducted an analysis that calculated worst case indoor temperatures during winter and summer power outages for a Passive House residential unit and a MA Stretch Code built residential unit (an Indoor Temperature Resiliency Study is included in Appendix E). The study found that the interior temperatures in the Passive House unit stayed above 55 degrees for twice as long as the comparable code-built unit during a worst-case winter power outage. The Passive House unit was even found to provide more comfortable living conditions when facing north, in which case there is no solar gain, than a code-built unit facing south, which has a heat source in the form of solar gains. These calculations are conservative, and it is likely that the occupants would be able to remain in their homes for longer than the calculated two days for north facing units and four days for south facing units during a winter power outage.

The Indoor Temperature Resiliency Study also analyzed a worst-case summertime power outage and investigated if the high-performance enclosure would trap heat from solar or internal gains, resulting in significant overheating. The analysis predicts that although the Passive House unit is warmer than the code-built unit, it is not significantly hotter, and by Day 6, it is still only four degrees warmer. The operable windows in the Project will allow occupants to modulate indoor temperatures during a summer power outage, while also providing fresh air.

Flooding

To reduce the risk of impacts from future flooding the FFE of the residential units located within the Project's vulnerable buildings will be set at a minimum elevation of 21.5 Ft BCB, which is approximately 2.0 feet above the projected future base flood elevation. The lobby of Building E will be set to match the existing grades on Tufts Street at approximately 17.00 BCB.

Interior elevators and stairs will be used to provide accessibility to the residential units on the first floor, which will be set at 21.5 BCB. In Building F, the FFE of the residential units will be set at 26.0 BCB. Sloped ramps or walkways will be integrated into the landscape design to connect to existing elevations.

In addition, equipment that is critical to the operation of the building, such as transformers, switchgear rooms, telecommunications, and mechanical rooms, will be raised to a minimum of 21.5 feet BCB. Domestic hot water tanks and the standby generator will be located on either the top floor or the roof of the building.

The Proponent will explore incorporating storm response actions and resiliency measures into leasing agreements or Tenant Manuals and be considered as part of guidance related to tenant fit out of commercial space.

6.6.3 Resilience to Secondary and Cascading Impacts

In addition to the direct impacts of flooding and extreme temperatures, the Project will be exposed to secondary and cascading impacts including more frequent and longer interruptions of utility services including electrical, gas, and telecommunication systems, and disruptions of transportation systems and networks. The Project will mitigate these impacts by:

- Decreasing reliance on electricity for heating and cooling by constructing the Project to Passive House standards (see below);
- Eliminating reliance on gas (except for domestic hot water); and
- Enhancing the Project’s walkable footprint and improving pedestrian and bicycle facilities, allowing residents to access the benefits of the surrounding densely developed urban environment without dependence on motorized vehicles.

To achieve Passive House certification, the Project must demonstrate compliance with aggressive energy metrics via energy modeling and ensure those high-performance details are implemented in the field by undergoing a stringent quality control verification protocol. The result is a more resilient building because it is less reliant on mechanical systems to maintain interior thermal comfort, allowing occupants to shelter in place in the event of a power outage.

While on-site solar PV systems will help offset the need for grid supplied electricity and produce carbon-free electricity and offset GHG emissions, as a standalone system, they are not a resiliency strategy. This is because utility companies require that PV system disconnect at the inverter if there is an electricity grid outage, thereby shutting down the building’s electrical system. Solar PV systems are most effective and practical as a resiliency strategy when combined with an energy storage (e.g. battery) system. The stored electricity is then available to be dispatched at any time of day should there be an electricity outage. Should battery storage systems become a practicable alternative, the Proponent will consider designing PV systems to be islandable to improve the Project’s resilience during power outages.

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Chapter from Final Environmental Impact Report dated 7-31-20

3

Climate Change Mitigation and Adaptation

This chapter addresses comments related to solar heat gain mitigation, central air source heat pumps, stormwater management, emergency power, heat island mitigation, and sea level rise resilience.

3.1 Solar Heat Gain Mitigation

A study was conducted to evaluate the effect of whole-window solar heat gain coefficient (SHGC) and external shading on a typical one-bedroom apartment. Key findings are summarized as follows:

- Reducing solar gains reduces cooling demand and total energy usage for all apartment orientations;
- Lower SHGC consistently resulted in less energy usage across all facades;
- It is recommended to apply the same low SHGC to all windows;
- A whole-window SHGC of 0.32 is a good target value; and
- External solar shading was shown to have minimal impact on energy usage.

Boston's climate is typically thought of as heating-dominated, with respect to traditional buildings. However, for multifamily Passive Houses, the combination of air sealing, insulation, efficient ventilation, and high internal gains typical of multifamily housing substantially reduce heating demand. Insulation and internal gains also increase cooling demand. Cooling demand is therefore a driving design factor for multifamily Passive Houses in this climate, which is consistent with the results of this study.

3.1.1 Methodology

A typical one-bedroom, 720-square foot, apartment was modeled using Carrier HAP DOE-2 software program to evaluate the effects of whole-window SHGC and external solar shading on annual heating, ventilation, and air conditioning (HVAC) electricity usage. Since each apartment constitutes a thermal zone, it is appropriate to perform this analysis at the individual apartment level, rather than on the entire building envelope. The modeled apartment has one exterior wall and is bounded on all other sides by conditioned space. The window-to-wall ratio is 23 percent.

3.1.2 Results & Discussion

Previous analysis showed that energy for HVAC comprises roughly 20 percent of the total energy usage for the Project. The other roughly 80 percent includes domestic hot water, lighting, plug loads, and appliances. SHGC and external shading primarily affect HVAC energy usage. Results are presented in terms of annual HVAC electricity usage for the typical apartment. This representation allows for better visualization of the impact that each of these measures has on energy usage. It is important to keep in mind that energy for HVAC only accounts for roughly 20 percent of the total building energy use for this Passive House Project. Results are presented in terms of electricity used on Site, and do not include a site-to-source conversion factor.

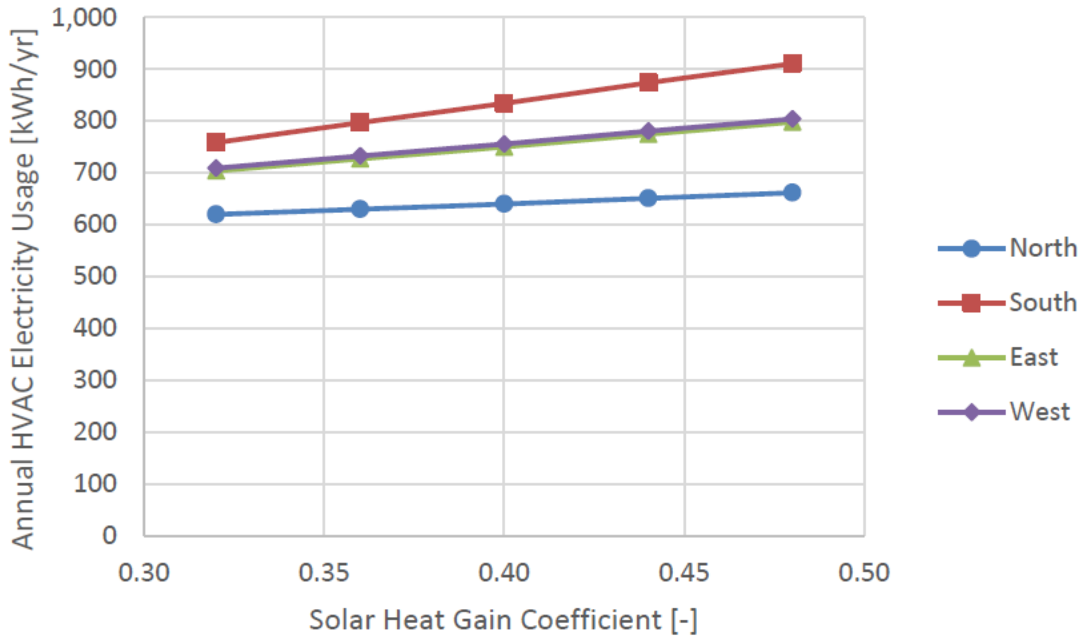
Solar Heat Gain Coefficient (SHGC) Study

The effect of SHGC on annual HVAC electricity usage for a representative 1-bedroom apartment is presented in Chart 3-1 below for whole-window SHGCs ranging from 0.32 to 0.48. This range of SHGC is typical for Boston. Results are presented for north, south, east, and west-facing apartment orientations. Note that the energy usage presented is only the energy used for heating, cooling, and ventilation, and does not include other building energy uses.

For all four orientations, as SHGC decreases, energy use decreases. South-facing apartments have the greatest energy use, whereas north-facing apartment have the least. The effect of lowering SHGC is most pronounced for south-facing apartments and least pronounced for north-facing apartments. East and west-facing apartments have similar energy usage. The effect of SHGC on energy usage is also similar for east and west-facing apartments.

Reducing solar gains reduces cooling demand and total energy usage for all apartment orientations. The percent reduction in HVAC electricity usage, corresponding to a reduction in SHGC from 0.48 to 0.32, ranges from 6 percent for north-facing apartments to 16 percent for south-facing apartments. It is therefore recommended to use low SHGC windows on all building facades. A whole-window SHGC of 0.32 is a good target value that may be applied consistently across all facades. The results of the SHGC study are consistent with cooling demand being a driving factor in the design of multifamily Passive Houses in this climate.

Chart 3-1 Effect of SHGC on HVAC electricity usage for four orientations of a typical one-bedroom apartment.



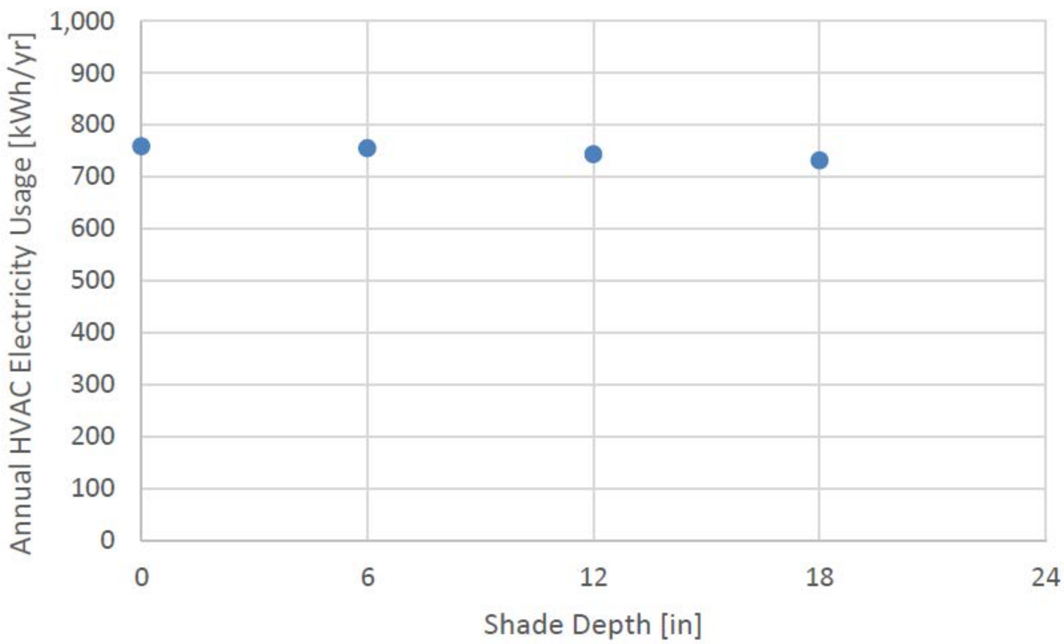
External Shading Study

The effect of external solar shading on south-facing windows was evaluated. The modeled external shading devices were rectangular overhangs that spanned the width of each window. Three depths of shade were considered (6-, 12- and 18-inches) as well as the unshaded case (0-inches). Analysis was conducted for windows with a whole-window SHGC of 0.32.

The effect of external solar shading on HVAC electricity usage for a south-facing apartment is presented in Chart 3-2. External shading reduces apartment HVAC electricity use by about 4 percent. External shading was also evaluated for windows with higher SHGC, and similar energy savings percentages were achieved.

Considering that for this Passive House building, HVAC electricity use accounts for roughly 20 percent of the building energy use, external shading has a nominal impact on total building energy use. Additionally, the effect of shading on energy use is significantly less than the effect of lowering SHGC.

Chart 3-2 Effect of external shading devices on HVAC electricity usage for a typical one-bedroom south-facing apartment (whole-window SHGC = 0.32)



3.2 Central Air Source Heat Pump

Currently, options for central air-source heat pumps for domestic hot water (DHW) generation are limited, expensive and complex at the scale that would be required for this Project. Mitsubishi plans to have central DHW air-source heat pump equipment available in Summer 2021, and we expect that other heat pump manufacturers will offer similar equipment soon thereafter. The Project team will re-evaluate the potential to use central DHW air-source heat pumps after this equipment becomes available (likely after Phase 1).

When available, the central DHW heat pump system will be evaluated either as a replacement for the gas-fired DHW plant or as the primary source of DHW with the gas-fired plant as a secondary/back-up source. In all buildings, the intent is to locate the DHW plant at the top of the building and size the mechanical rooms and the electrical services to allow for a central DHW air-source heat pump system (either as the basis of design or added in the future).

The Project team has reached out to Mass Clean Energy Center and Mass Save® to inquire about incentives to pilot a central DHW heat pump system. There are no standard rebates currently available, but the Project Team is working with ICF to set up a meeting for all interested parties.

3.3 Stormwater Management

In order to understand the ability of the proposed drainage system to accommodate future precipitation conditions, a drainage analysis was performed using HydroCAD to estimate rates and volumes of runoff from each of the Site's sub-watersheds and for the full Project build-out for both existing and proposed conditions. To consider more frequent and severe storm events, the analysis included current and BWSC's projected 2070 rainfall events for the 10-, 25-, and 100-year, 24-hour storms, as listed in Table 3-1 below.

Table 3-1 Analyzed Rainfall Depths (inches)

Storm Event	Current 24-Hour Rainfall[a]	Projected 2070 24-Hour Rainfall[b]
10-year	5.1	6.4
25-year	6.3	8.2
100-year	8.1	11.7

a. Source: NOAA Atlas 14
b. Source: BWSC 2015 Capital Asset Management Plan

It should be noted that BWSC's climate change projections and design criteria were developed to guide the planning and design of BWSC's own infrastructure. BWSC does not require that private developments design their stormwater management systems based on this information. The engineering standard used in Massachusetts to assess the Site rainfall-runoff response continues to be the rainfall volumes published in the National Oceanic & Atmospheric Administration (NOAA) Atlas 14.

The post-development analysis included infiltration systems sized for the 1.25-inch storage requirements for groundwater recharge mentioned above. The analysis demonstrated that the rates and volumes of runoff would be less under proposed conditions than under existing conditions. Since Site runoff was analyzed without the inclusion of the proposed storage areas within the public ways (i.e. street trees and permeable pavers), the proposed stormwater management system is more robust than required for current conditions. It provides enough capacity to manage projected storm events, resulting in a more resilient system than currently exists.

Although the Site is not in the FEMA Floodplain, a low-lying portion of the Site is within the BPDA's Sea Level Rise Flood Hazard Area (SLR-FHA), and may be susceptible to flooding due to future coastal storm events and sea level rise. The proposed design will also aim to raise ground floor elevations of the new buildings within the BPDA's Flood Hazard Area to Elevation 21.5' BCB, two-feet above the Base Flood Elevation of 19.5', which may allow for opportunities to raise stormwater management and minimize inundation during larger events due to flooding. In addition, backflow preventers will also be installed within those buildings to minimize risk of systems backing up and flooding the Site.

3.4 Emergency Power

All buildings over four stories are anticipated to include a generator intended to power egress lighting, the fire alarm system, and the elevator(s) during power outages. The generator may also serve specific common spaces that may serve as gathering area in a storm event. All generators will utilize on-site fuel to operate per National Electrical Code.

3.5 Heat Island Mitigation

As indicated in DEIR Chapter 6, Section 6.6.1, several site design measures will be implemented to reduce the heat island effect. The Project's landscape areas will be strategically designed to mitigate the events of extreme temperature events and urban heat island effect. Impervious land cover will be kept to a minimum in favor of green space, which will be densely vegetated wherever possible. Planting beds will be layered with hardy native and adapted tree canopies, shrubs, and perennial plantings in order to increase biomass, which will in turn allow for more efficient cooling of the air through evapotranspiration. Planting soils will be specified with this goal of high biomass in mind, and beds will be sited strategically to capture stormwater, bolstering the transpiration process while also helping to address stormwater flooding.

Where impervious cover is necessary, materials with less heat absorbing capacity and a high Solar Reflective Index, including light colored concrete pavement and paving materials for sidewalks, will be specified in an effort to help offset extreme heat events. Street trees, trees in planting beds, and standalone shade trees will all be utilized in order to maximize the shading of paved areas. The placement of trees along the south edges of these areas will be prioritized in order to ensure shade at peak summer hours.

3.6 Sea Level Rise Resilience

The future flooding analysis provided in the DEIR was based guidance from the BPDA, which in turn is based on *Climate Ready Boston: Climate Change and Sea Level Rise Projections for Boston* (2016), authored by the Boston Research Advisory Group (BRAG). That report was created to provide a set of agreed-upon climate projections to use for planning purposes throughout the City of Boston. To develop projections for future sea level rise (SLR), BRAG used state of-the-art process modeling, expert assessment, and expert elicitation to produce a continuum of Boston-specific probability distributions. BRAG's projections for SLR are based on three emissions scenarios developed by the Intergovernmental Panel on Climate Change:

- A *High-Emissions Scenario*, often characterized as a continuation of "*Business as Usual*";
- A *Medium-Emission Scenario*, in which emissions remain around their current levels through 2050 and then are slowly reduced in the second half of the century through *Moderate Emissions Reductions*; and
- A *Low-Emission Scenario*, in which net global emissions are reduced to less than a third of their current levels by 2050 and are brought to zero by about 2080 through *Major Emissions Reductions*.

The climate change impacts that are actually experienced are dependent on humanity's choices and behaviors. Table 3-2 shows the likelihood that the indicated sea levels in Boston Harbor would be exceeded under the High emissions scenario, reported in feet above the mean sea level (MSL) in the year 2000.[1]

[1] All climate scenarios include an assumed Relative Sea Level Rise rate due to subsidence of 0.8 +/- 0.3 mm/yr.4.9

Table 3-2 BRAG Relative Sea Level Projections for Boston, MA (feet above MSL 2000)

Likelihood of Exceedance	2030	2050	2070	2100
99%	-0.1	0.1	0.6	1.2
95%	0.1	0.4	1.0	2.4
83%	0.3	0.7	1.5	3.2
50%	0.5	1.1	2.2	4.9
17%	0.7	1.5	3.1	7.4
5%	0.9	1.8	3.7	8.6
1%	1.0	2.1	4.3	9.5
0.5%	1.1	2.2	4.5	9.8
0.1%	1.2	2.4	4.8	10.5

Source: Climate Ready Boston: Climate Projections Consensus Executive Summary, May 2016.

The BPDA has identified the scenarios that the City believes represent reasonable SLR risk thresholds for evaluating impacts to new development. The BPDA used the Boston Harbor Flood Risk Model (BH-FRM) to create its Sea Level Rise – Flood Hazard Area (SLR-FHA) map,[2] which depicts the one-percent annual chance flood event with 40 inches (3.3 feet) of SLR,[3] with an assumption that this will occur around the year 2070. This represents a combination of the mean SLR (3.2 feet above 2013 MSL, which is roughly equivalent to 3.3 feet above 2000 MSL) plus 2.5 inches of local subsidence (also projected to occur by 2070). Put into the context of the BRAG report, the likelihood of mean sea level (MSL) being greater than or equal to 3.4 NAVD88 by 2070 is between 5 and 17 percent. Put another way, there is an 83- to 95-percent chance that the MSL elevation will be less than 3.4 NAVD88 by 2070. A MSL of 3.4 NAVD88 becomes much more likely as the end of the century approaches: Under the high emission scenario there is a 50- to 83-percent chance that a MSL of 3.4 NAVD88 will be equaled or exceeded by the year 2100.

Therefore, DEIR Figure 6.1, which depicts the area with an approximately one- to five-percent chance of being impacted by the one-percent annual chance flood by 2070, also depicts the area with a 50- to 83-percent chance of being impacted by the one-percent annual chance flood by 2100. In both cases, portions of Buildings E1, E2, F, L, M, and N, as well as the open spaces adjacent to buildings M and N, are projected to be temporarily impacted.

As described in DEIR Chapter 6, Section 6.6.2, to reduce the risk of impacts from future flooding, the FFE of the residential units located within the Project's vulnerable buildings will be set at a minimum elevation of 21.5 BCB (14.5 NAVD88), which is approximately 2.0 feet above the projected future base flood elevation. The lobby of Building E will be set to match the existing grades on Tufts Street at approximately 17.00 BCB (10.5 NAVD88). Interior elevators and stairs will be used to provide accessibility to the residential units on the first floor, which will be set at 21.5 BCB (15 NAVD88). In Building F, the FFE of the residential units will be set at 26.0 BCB (19.5 NAVD88). Sloped ramps or walkways will be integrated into the

[2] http://maps.bostonredevelopmentauthority.org/zoningviewer/?climate=true

[3] The BPDA reports projections above MSL in 2013, which is estimated at approximately 1.4 inches higher than MSL in 2000 based on NOAA's Published Rate of SLR for the years 1921-2017.

landscape design to connect to existing elevations. Equipment that is critical to the operation of the building, such as transformers, switchgear rooms, telecommunications, and mechanical rooms, will be raised to a minimum of 21.5 feet BCB (15 NAVD88). Domestic hot water tanks and the standby generator will be located on either the top floor or the roof of the building.

Each phase of the Project will be subject to BPDA design review. If new information or guidance is published indicating that there is an increased potential for flooding at the Project Site, the design will be adjusted accordingly. Similarly, if off-site mitigation measures are implemented that reduce the likelihood of flooding the Project Site, that information will also be considered as the Project goes through design review.