7. Climate Change

7.1 Introduction

This chapter presents climate change projections and includes the South Coast Rail (SCR) Project's strategies for increasing resilience and adapting to anticipated climate conditions.

7.1.1 Requirements of Certificate

The Secretary's Certificate on the Notice of Project Change (NPC) requires the Draft Supplemental Environmental Impact Report (DSEIR) to:

- Demonstrate how the design of Phase 1 Project elements will foster resiliency of Phase 1, and the Full Build project, to the effects of climate change, including measures to address potential impacts associated with more frequent and intense precipitation and flooding; and
- Evaluate measures to maintain the operational capability of energy and other systems including elevation of tracks and stations and over-sizing of compensatory flood storage areas and stormwater recharge and treatment areas to address increases in the frequency and level of precipitation (for example, design for peak stream flow).

7.1.2 Regulatory Context

To address climate change adaptation (as opposed to just mitigation), in late 2014, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) released the *Draft MEPA Climate Change Adaptation and Resiliency Policy*. It 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 practicable. In compliance with this draft policy, this chapter provides an evaluation of how the SCR Project may be impacted by changes in precipitation and increases in temperature. The elements of Phase 1 analyzed in this DSEIR are not within coastal areas subject to the impacts of sea level rise, therefore this climate change impact is not reviewed here.

7.2 Adaptation & Resiliency Assessment

The Massachusetts Department of Transportation (MassDOT) recognizes the potential threat posed by climate change to the resiliency of the state's transportation infrastructure over the coming decades and beyond. Preparing transportation assets, including the SCR Project, to adapt to future climate-related hazards will help prevent infrastructure failure, improve reliability, reduce operations and maintenance costs, and improve safety. According to the U.S. Department of Transportation's (DOT) *2014 Climate Adaptation Plan*, "newly constructed infrastructure should be designed and built in recognition of the best current understanding of future environmental risks." In recent years, multiple governmental entities have begun to assess climate change impacts on infrastructure and to develop potential responses. Following this trend, MassDOT has undertaken a vulnerability assessment as part of its *Statewide Climate Change Adaptation Plan* (currently underway*)*. Completed products resulting from this effort at the time of drafting this DSEIR include climate projection maps for the Commonwealth[1] and a report titled *Assessment of Extreme Temperature Impacts on MassDOT Assets* (the "Assessment"),[2] both of which serve as sources of information for this chapter.

7.2.1 Climate Projections

For projects with a long design life, such as transportation infrastructure, storm and flood-related impacts, including potentially catastrophic outcomes, may significantly affect the public and/or public interests. Therefore, consideration of a broad range of climate change scenarios over a longer timeframe is generally warranted. This chapter examines the impacts of climate change up to the year 2100, which encompasses the SCR Project's service life, and for which time period projections are readily available.

As part of MassDOT's Assessment, three sets of climate projection maps were created reflecting three greenhouse gas (GHG) concentration trajectories (Representative Concentration Pathways 4.5, 6.0, and 8.5[3]) for four future periods (2030, 2050, 2070, and 2100). They provide projections for precipitation depth and temperature change that can be used for planning purposes. Table 7-1 below includes baseline conditions as well as future projections specifically for the geographic area of Massachusetts in which Phase 1 infrastructure is situated. The range represents the middle 80% probability of occurrence.

Table 7-1 MassDOT Climate Projections

	Baseline (1986-2005)	RCP[1]	2030	2050	2070	2100
24-hour 100-year return interval precipitation depth (inches)	6-8	RCP 4.5	6-10	6-10	6-10	6-10
		RCP 6.0	6-10	6-10	6-10	6-10
		RCP 8.5	6-10	6-10	6-10	6-12
Annual maximum number of consecutive days > 95°F	0-5	RCP 4.5	5-10	5-10	5-10	5-10
		RCP 6.0	0-10	0-10	5-10	5-10
		RCP 8.5	5-10	5-10	5-10	5-20

Source: MassDOT Climate Projection Viewer http://gis.massdot.state.ma.us/cpws/, accessed 8/30/17
1 Representative Concentration Pathway

1 MassDOT. *Future Projections for a Changing Climate*. http://gis.massdot.state.ma.us/cpws/ accessed 11/9/17

2 MassDOT. March 17, 2017. *Assessment of Extreme Temperature Impacts on MassDOT Assets*. http://www.massdot.state.ma.us/Portals/17/docs/Sustainable/AssessmentExtremeTempImpacts_Final03172017.pdf

3 Representative Concentration Pathways (RCPs) are four greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014.The pathways are used for climate modeling and research, and describe four possible climate futures, all of which are considered possible depending on how greenhouse gas concentrations change in the years to come.

Additional projected rainfall data for the region (from Taunton to Newburyport) can be found in the Boston Water and Sewer Commission's (BWSC) 2015 *Wastewater and Storm Drainage System Facilities Plan*, which analyzed climate change scenarios related to increased precipitation, river flooding, sea level rise and storm surge. BWSC describes how recent trends in regional rainfall data indicate that average annual rainfall and daily maximum rainfalls are increasing in volume, and the report provides corresponding design standards. For example, the current 10-year, 24-hour design storm used by the BWSC is forecast to increase to as much as 6.65 inches with a peak hourly intensity of 2.11 inches per hour by the year 2100 with climate change, which is consistent with the projected precipitation data provided by MassDOT. The data and design standards described in BWSC's plan are being taken into consideration as design for the Project's on-site stormwater management systems moves forward, including the design of new culverts.

7.2.2 Impact Analysis

The draft Massachusetts Environmental Policy Act (MEPA) policy identifies precipitation impacts associated with impervious surfaces and temperature impacts on energy demand as the impacts that most projects should consider. These are addressed below.

Precipitation

As indicated in Chapter 8, *Wetlands, Water Quality, and Waterways*, 12 locations within the Phase 1 Study Area are within the 100-year floodplain (Figure 8.5), and could be impacted by projected increases in precipitation volume and intensity. They include inland floodplains primarily associated with the Taunton River adjacent to the Middleborough Secondary track in Middleborough, Lakeville, Raynham, and Taunton. While portions of Freetown Station are within 250 feet of a floodplain with a regulatory floodway associated with Rattlesnake Brook, the station is elevated approximately 20 feet above the base flood elevation (BFE) of the 1% annual chance flood, and not likely to be subject to flooding under the foreseeable scenarios. In addition, while Fall River Depot Station is near a coastal floodplain, it lies at an elevation that is 13 feet higher than the BFE, and is also not likely to be subject to flooding. Other low-lying areas, or areas with poor drainage, within the Project may also be prone to temporary flooding due to changes in precipitation.

Temperature

According to MassDOT's Assessment, the most serious threat for transportation systems comes from extended periods of extreme temperatures. Extreme heat has a wide range of potential impacts on the transportation system. Design-related impacts may include:

- Instability of materials exposed to high temperatures over longer periods of time (such as causing pavement or track buckling) can result in increased failures;
- Ground conditions and less water saturation (due to drought conditions) could alter the design factors for foundations and retaining walls; and

- Encased equipment such as signal control systems for rail service might fail due to higher temperatures inside the enclosures.

With respect to rail, the Massachusetts Bay Transportation Authority (MBTA) uses a rail neutral temperature of 95 degrees Fahrenheit. Rail neutral temperature does not actually measure the temperature of the rail, but rather refers to the temperature of the uninstalled rail before it is affixed to the railroad ties. Immediately after any rail is installed, it becomes susceptible to changes in temperature and reacts by attempting to expand and/or contract along its length. For this reason, prior to installation, rail is mechanically or thermally altered to achieve a measured length equivalent to a stress-free temperature of 95°F before it is clipped down, which ensures that at a temperature of 95°F there will be no thermal forces, either compressive or contractive, in the rail. This process of stressing rail greatly reduces the risk of fracturing or buckling at the temperature extremes.

Given expected high temperatures in the next several decades, the current MBTA approach to rail track should provide sufficient buffer to the effects of higher temperatures. MassDOT's Assessment found that although exposure to consecutive high temperature days could cause discomfort and inconvenience to users of the Commonwealth's transportation system (due to higher temperatures and delays due to increased maintenance), the projected levels do not constitute a serious challenge to infrastructure design and materials specification.[4]

7.3 Mitigation and Adaptation

MassDOT is committed to using Best Practices to help determine how climate change may impact the SCR Project, and how to construct the SCR Project to be more resilient to climate change impacts. The MBTA has already taken steps to consider climate change more systematically in project designs. For example, the MBTA's contract template for Design and Engineering Services has been modified to require climate change analysis at the 30% project design level (such as, assess vulnerability) and to identify potential adaptation measures. For Phase 1, project designers are analyzing all project components in terms of their vulnerability to the climate change impacts associated with heat and flooding based on the following procedure:

1. Refer to projected future climate conditions scenario;
2. Identify exposure to climate change impacts;
3. Identify sensitivity to changing climate conditions;
4. Consider the component's adaptive capacity based on the component's useful life; and
5. Choose appropriate design solution(s).

4 MassDOT. *Assessment of Extreme Temperature Impacts on MassDOT Assets*. March 17, 2017, p.13.

7.3.1 Mitigating and Adapting to Potential Flooding Impacts

Table 7-2 below identifies potential design solutions for various precipitation and flooding-related impacts to stations, tracks, and electrical systems that will be considered as design progresses.

Table 7-2 Potential Design Solutions to Mitigate Projected Increased Flooding

Flooding Impacts	Potential Design Solutions
Stations	
At stations, earthen support (soil, berms) for structures may erode due to gradual inundation or storm-related inundation, reducing the foundation's stability.	Prevent localized flooding by reducing runoff from parking lots, station structures, and other impervious surfaces. For parking lots, this can be accomplished with vegetated filter strips; vegetated or bioretention swales; and/or bioretention or infiltration basins. For structures, this can be accomplished through the use of vegetated green roofs and rain barrels or cisterns.
Temporary flooding and/or ponding may occur in parking lots that do not drain sufficiently.	Size drainage structures for future conditions.
Track	
Track in the 1% or 0.2% annual chance flood hazard area[5] and other flood-prone areas is at risk of damage due to washout.	Many washouts can be prevented by planting and/or maintaining vegetation whose roots hold the soil and/or slow the flow of surface and underground water. Consider designing space to allow for the erection of barriers or retaining walls that can protect lines that run parallel to rivers and or are near/within flood hazard areas that may become subject to flooding. Larger culvert openings at stream crossings may also prevent washout.
Immersion of wood ties (often standard, rather than concrete ties) in water due to local inundation softens/expands the wood, weakening its ability to support tracks.	Use materials that can withstand inundation, taking into consideration the water source (fresh or salt).
Erosion of supporting systems (such as ballast and other nearby ground) can threaten track stability.	Reinforce slopes where erosion is likely to occur.
Loss of embankment support due to gradual or sudden inundation-related erosion is a risk.	Monitor vulnerable locations and reinforce embankment support when necessary.
Bridges	
All rail infrastructure in the 0.2% annual chance flood hazard area and other flood-prone areas is at risk of damage due to washout. Underlying earthen support may erode, or manmade infrastructure may break down from forces beyond design specifications.	MassDOT has designed bridges to withstand the 0.2% annual chance flood event. Consider designing to reduce bridge scour by strengthening protections around piers.

5 The 1% and 0.2% annual chance flood hazard areas are colloquially known as the 100-year and 500-year flood hazard areas (or floodplains), respectively.

Table 7-2 Potential Design Solutions to Mitigate Projected Increased Flooding (Continued)

Heavy precipitation events can increase the flow velocity and flow depth of a stream or river, which affect local scour depth. During flood conditions, if the stream elevation reaches the low chord bridge elevation, the local scour depths could increase.	MassDOT has designed bridges to withstand the 0.2% annual chance flood event. Consider designing to reduce bridge scour by strengthening protections around piers.
Flooding can pile debris on bridge decks.	Set the elevation of the lower chord of the bridge to a minimum of 3 feet above normal freeboard for the 100-year flood for streams carrying a large amount of debris to reduce damage.
Electrical Systems	
Heavy precipitation or any flooding can ruin electrical equipment caused by shorting of circuitry. Inundation can cause rail sensor failure, as well as other electrical failures (switches, gates, signals).	Waterproof vulnerable housing for electrical components. Raise electrical components above future flood elevations.

7.3.2 Mitigating and Adapting to Potential Temperature Increases

Table 7-3 below identifies potential design solutions for various temperature-related impacts to stations, tracks, and electrical systems that will be considered as design progresses.

Table 7-3 Potential Design Solutions to Projected Temperature Increase

Temperature Impacts	Potential Design Solutions
Stations	
High heat can affect passengers waiting at station shelters or platforms.	Specify reflective roofs on shelters to reduce heat gain. Design pavements to absorb less heat by increasing albedo (greater reflectivity) and other material and structure choices. Design shelter facilities to provide shading for passenger comfort and safety. Include landscaping near shelters and along pedestrian corridors leading to them to create microclimates with temperatures that are cooler than surrounding areas.

Table 7-3 Potential Design Solutions to Projected Temperature Increase (Continued)

Temperature Impacts	Potential Design Solutions
Track[6]	
Extreme heat can cause track buckling, which occurs when the metal in the track expands beyond the capacity of the supporting infrastructure.	Prevent buckling from rail expansion at high temperatures by setting and maintaining high "rail-neutral temperatures" (95-110°F).
Buckling more often affects track with rock ballast than concrete slab track with a paved right-of-way, as the concrete slab provides stronger support.	Consider designing expansion joints to provide space for rail expansion to prevent buckling.
Continuous welded rail (CWR) is particularly susceptible to temperature-related buckling.	Consider the use of concrete slab in select locations rather than stone ballast under track areas, as concrete slabs provide more stability and are not generally prone to buckling.
Electrical Systems	
Electric utility blackouts and brownouts can affect signals, lighting and communication systems.	Reduce dependency on centralized power for lighting, signals and communication equipment by installing off-grid solar and wind power for back-up power generation.
Electrical equipment is susceptible to overheating and malfunction. Overheating may lead to melting electronics or temporary shutdown in cases where temperature thresholds result in an automatic shutdown. Possible malfunctions of track sensors and signal sensors are possible above threshold temperatures.	Design substations, signal rooms, and electrical boxes with improved ventilation or air conditioning systems for future climate conditions.
Temperature-driven expansion of metal can damage wiring and housing of electrical equipment.	This potential impact has not yet been widely studied. MBTA will continue to monitor this issue.

7.3.3 Resiliency through Redundancy

Another way to increase the rail system's flexibility and adaptive capacity is to establish redundant routes. For instance, the Full Build Project will cross the Taunton River in three locations, and is therefore vulnerable to flooding in extreme storms. If a particular rail segment becomes impassable, the availability of an alternate route would allow travel between destinations. When the Full Build is reached, the Middleborough Secondary will revert to freight usage. However, in emergencies such as flooding, power outages, or track damage, it can become available for commuter rail use to maintain the connection between the South Coast and Metro Boston, significantly improving resiliency of the SCR Project.

6 As noted in Section 7.2.2, given expected high temperatures in the next several decades, the current MBTA approach to rail track should provide sufficient buffer to the effects of higher temperatures. However, later in century when the number of consecutive days of 95 degrees becomes larger, the MBTA might need to re-examine temperature related specifications to its rail design.

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