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GHG Reduction Measure 1: Pedestrian & Bike Roadway Safety Improvements

SRPEDD will administer funding to design, permit and construct the top priority safety improvement projects identified in both RI and southeastern MA.

Measure-Specific Documentation:

GHG Reduction Estimate Method:

The GHG reduction will occur by constructing street safety improvements that reduce delay and idle time of vehicles at signalized intersections. Through discussion with SRPEDD and municipal transportation and traffic staff, the primary carbon reduction method will be improving the left turn phase that causes delay at intersections with traffic signals.

Models/Tools Used:

The only model used will be the Federal Highway Administration (FHWA) Congestion Mitigation and Air Quality Emissions Calculator (CMAQ) toolkit. FHWA CMAQ emissions calculator toolkit provides projections of emissions reductions association with various types of transportation projects, including pedestrian improvements, electric vehicle and alternative fueling infrastructure, managed lanes, and adaptive traffic control. The CMAQ toolkit uses Microsoft Excel spreadsheets and emissions data sources such as the EPAìs motor vehicle emission simulator (MOVES) as well as other data sources to calculate emissions benefits by project type.

CMAQ Intersection Improvements Module of the Traffic Flow Improvements Tool estimates both performance metrics and emissions benefits for a single intersection for a project that:

- Installs a new traffic signal where a previous two-way stop or four-way stop existed before, or
- Adds or modifies a signalìs turn phase (i.e., dedicated left-turn or right-turn signal), or
- Effects on emissions are calculated by estimating the reduction in idling emissions from proposed effects on delay at the intersection and comparing to the existing/no-build delay. Emissions effects are calculated for peak- and off-peak hours on a typical weekday.

The methodology for calculating emission reductions is derived from the calculation of delay reduction at the intersection as a result of intersection improvements. The Highway Capacity Manual (2010) provides an equation for calculating uniform delay at a signalized intersection, calculated from traffic survey data. The delay reduction is calculated by taking the difference of the calculated intersection delay from existing delay for a single vehicle approaching the intersection on that roadway. Idling emission rates (kg/hr) for the analysis year and area type are multiplied by the delay reduction for that roadway and then summed with the product from the other roadway to obtain total emission reductions for a given pollutant for the entire intersection.

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Measure Implementation Assumptions:

Up to 35 total safety improvement projects are anticipated across Southeastern MA and Providence, RI, comprised of a variety of different safety measures. Additionally, traffic signal timing efficiencies will be implemented across all 193 intersections in the City of Providence. The only measure for which a known methodology exists for reliably calculating the estimated GHG reductions is the reduced traffic delays associated with increasing efficiency of land hand turn signals at intersections. Based on existing intersection data at the time of application, it is assumed that up to 30%, or 50, of Providenceìs 193 intersections for the signaling improvements will include this type of measure and that is the basis of the below calculations.

GHG Reduction Estimate Assumptions:

GHG reduction estimates will use data for a representative intersection at which improvements in turn delay resulting in reduction in idling will be applied. The inputs to CMAQ for the representative intersection are provided in the table below.

CMAQ Parameter	Representative Intersection Value
Annual Average Daily Traffic volume (vehicles per day)	20,000
Peak-hour Volume (vehicles)	1,700
Total Peak Hours per Day (hours)	3
Number of Lanes	2
Truck Percentage (%)	6
Existing Delay per Vehicle (seconds)	30
Existing Left-Turn Phase	Yes

Reference Case Scenario (GHG Emissions or Activity Level):

The reference case scenario will be the CMAQ calculated emissions from the representative intersection values in the table above. This means the reference case is not altered for each potential intersection.

GHG Emissions Reduced:

Approximately 50 intersections will be expected to be improved for pedestrian and bicycle safety at which either a new traffic signal where a previous four-way stop existed before or an existing signalìs turn phase is modified.

The CMAQ calculated delay reduction is 19 seconds during peak hours only (three hours of the day). This means in order to reduce traffic congestion; the existing delay is predicted to be reduced from 30 seconds to 11 seconds. This results in a daily total of 55 hours of less idle time by vehicles at the intersection.

Pollutant Reduction	Peak Hours kg/day	Off-Peak Hours kg/day	Daily Total kg/day
CO_2e	178.3	0.0	178.3

The total annual reduced GHG emissions for one intersection is 65,079 kg. The cumulative reductions for one intersection for 2025 ó 2030 and 2025 ó 2050 are 0.00033 and 0.001627 MMT CO_2e, respectively.

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Carbon Reduction Measure 2: Urban Tree Planting

The subrecipients will coordinate and engage municipal and non-profit practitioners and stakeholders in the Providence-Warwick MSA and provide capacity building and workforce training to plant and steward trees in high priority îtree equity zonesï across the region.

Carbon Reduction Measure 2A: Implementation of the Providence Tree Plan

Implementation of the PVD Tree Plan will result in 1,300 trees planted per year during 2025 ó 2029 for a total of 6,500 new trees.

Measure-Specific Documentation:

GHG Reduction Estimate Method:

The GHG reduction will occur by planting trees. The GHG reduction estimate method for implementation of the PVD tree plan will be built from the Providence i-Tree Eco System Analysis (February 2014) report. The publicly available i-Tree Design tool will be used to update the baseline Providence urban forest sequestration as well as calculate additional sequestration from Providence tree plan implementation. The baseline estimate of carbon sequestration will be updated from the reportìs 2014 estimate to a 2024 estimate using the default tree growth in the i-Tree Design tool as applied to the species distribution in the Providence i-Tree Eco System Analysis report. The GHG reduction beyond the baseline will be determined using the number and types of new trees expected to be planted as inputs to the i-Tree Design tool. The activity data needed will be the number of trees planted in the year they will be planted and the locations of the tree plantings.

Models/Tools Used:

The only model used will be the i-Tree Design tool. i-Tree is a state- forestry analysis and benefits assessment tools. The U.S. Forest Service, Davey Tree Expert Company, The Arbor Day Foundation, Urban and Community Forestry Society, International Society of Arboriculture, and Casey Trees have entered into a cooperative partnership to further develop, disseminate and provide technical support for the suite. i-Tree tools are freely available.

i-Tree tools may be used on individual trees, parcels, neighborhoods, cities, and entire states. i-Tree Design estimates tree benefits for the current year and up to 99 years in the future. Future benefits are estimated using a forecasting model that calculates tree height for each consecutive year until the user-specified future year. Details are available in the online documentation for i-Tree tools.

The GHG reduction method will use gross carbon sequestration output from i-Tree Design. A measure of the carbon sequestered calculated as the difference in estimates of tree carbon storage between current year (year 0) and the next year (year 1), accumulated until the final user-specified future year. To estimate annual gross carbon sequestration, the tree diameter at breast height is incrementally increased in the computer model based on an estimated annual growth rate. The carbon storage in the current year (year 0) is then contrasted with carbon storage in the next year (year 1) to

estimate the annual sequestration. If a treeìs carbon storage is over 7,500 kg and the tree is alive, carbon sequestration for these large trees is estimated based on the sequestration rate (kg/cm diameter at breast height growth) when the tree reached 7,500 kg C storage. A maximum sequestration rate was set at 40 kg/cm diameter at breast height. growth if the treeìs storage was greater than 7,500 kg. The tree diameter growth rate is based upon equations extracted from peer-reviewed publications and is estimated using a base growth rate, growing season length, species-specific growth rate, tree condition, diameter at breast height, and maximum diameter at breast height.

Measure Implementation Assumptions:

The requested funding is anticipated to cover the cost of planting 1,300 new trees per year (inclusive of necessary site preparation, staff and crew time, stewardship & workforce training and maintenance costs), for a total of 6,500 trees over the five-year project period, each roughly 1.5ï in diameter at time of planting. The estimated survival rate is 92% (though recent data collected by PNPP from previous planning efforts suggests a higher success rate of 94-95%).

GHG Reduction Estimate Assumptions:

GHG reduction estimates will use Providence tree species data as input to i-Tree Design to determine the baseline tree carbon sequestration as well as added sequestration from new tree plantings. The baseline tree sequestration will be computed from an extrapolation of tree growth since the Providence tree survey results in 2014 to the current calendar year, which is 2024. All trees will be assumed to have survived and will be assumed to be in îGoodï condition (the i-Tree Design tree condition categories are Excellent, Good, Fair, Poor, Dead or Dying). Because a comprehensive list of tree species and percentages will not be available for this proposal, the reportìs list of primary tree species will be used, and the remaining trees will be given a representative tree species. The representative species will be a mixture of a large native tree species (Hornbeam) and small native tree species (Serviceberry). The difference in sequestration from the 2014 report and from 2014 calculated by i-Tree Design will inform uncertainty analysis of the tree species assumptions.

The Providence tree canopy in 2014 contained an estimated 415,000 trees covering 23.9% of the urban landscape. The primary species comprised 51% of the population and their tree size at breast height was 6-12ï diameter for 45% of primary species and >12ï for 55% of primary species. The remaining 51% secondary species had tree size at breast height of less than 6ï. Assumptions for tree species, tree size, and species population percentages are summarized in the table below.

Species Name	Reported Diameter at Breast Height (inches)	Population (%)	2024 Predicted Diameter at Breast Height (inches)	2024 Predicted Increase of Sequestration (kg CO_2e yr^{-1})
Norway Maple	>12	10.1	16	2.9
Norway Maple	6-12	8.2	10	2.4
Northern Red Oak	>12	2.4	15	1.8

Northern Red Oak	6-12	1.9	9	0.9
Honeylocust	>12	2.3	16	3.2
Honeylocust	6-12	1.8	10	2.3
Red Maple	>12	2.1	16	3.4
Red Maple	6-12	1.7	10	2.7
Boxelder	>12	2.1	16	2.4
Boxelder	6-12	1.7	12	2.1
Green Ash	>12	2.1	16	3.0
Green Ash	6-12	1.7	10	1.3
Black Locust	>12	1.7	15	3.4
Black Locust	6-12	1.4	10	2.6
American Beech	>12	1.6	14	2.1
American Beech	6-12	1.3	8	0.8
Pin Oak	>12	1.6	16	1.8
Pin Oak	6-12	1.3	10	1.8
Sycamore Maple	>12	1.1	15	1.7
Sycamore Maple	6-12	0.9	9	1.5
Hornbeam	<6	27.2	9	1.2
Serviceberry	<6	27.3	9	1.8

The sequestration across 415,00 trees calculated by i-Tree Design from the tree list in the table above is compared to the estimated sequestration in the Providence 2014 report. The calculated 2014 sequestration compared to reported 2014 sequestration is 3,655 MT CO_2e compared to MT CO_2e, revealing an overestimate of 11% of the simplified tree species categories.

The reasonableness of the assumptions for calculated 2014 sequestration is further considered when compared to the state-level sequestration estimates. It is important to realize the Providence baseline sequestration may be substantially different than the regional baseline sequestration. The regional sequestration is estimated from state-average values as provided by RI Department of Environmental Management (RIDEM) and MA Department of Environmental Protection (MADEP). The state-level estimates are not an aggregate of each individual community measurements and estimates; instead, sampling approaches are applied across the state to obtain state average values of urban tree canopy, urban area, and sequestration rate.

The state average values in 2020 for RI and MA are 0.2816 MMT $CO_2e\ yr^{-1}$ and 2.6791 MMT $CO_2e\ yr^{-1}$, respectively. An estimate for the 27 MA towns is MA sequestration multiplied by the fraction of MA urban area contained in the 27 MA towns (0.2841), which is 0.7613 MMT $CO_2e\ yr^{-1}$. The regional estimate of urban tree carbon sequestration is 1.0429 MMT $CO_2e\ yr^{-1}$. The estimates for Providence in the 2014 report, 2014 i-Tree Design model calculation, and 2024 i-Tree Design model calculation are 0.01341 MMT $CO_2e\ yr^{-1}$, 0.01354 MMT $CO_2e\ yr^{-1}$, and 0.03122 MMT $CO_2e\ yr^{-1}$, respectively. It is reasonable that Providence sequestration is 1-3% of the regional

sequestration. When considered per unit area, the 2014 sequestration rate for Providence, 0.76 MT CO_2e ha^{-1} yr^{-1}, is substantially smaller than sequestration rate in either RI, 1.91 MT CO_2e ha^{-1} yr^{-1}, or MA, 1.88 MT CO_2e ha^{-1} yr^{-1}. It makes sense that the Providence 2014 reported sequestration is smaller than the state-level because the Providence trees have relatively small diameter (72% of trees have <12ï diameter at breast height).

The 11% overestimate of the calculated 2014 compared to reported 2014 sequestration is much smaller than the difference between the state-level and Providence sequestration. The simplified categories will be assumed to be sufficiently accurate for the purpose of extrapolating growth to achieve a 2024 baseline for sequestration.

The new tree plantings will be assumed to be represented by combination of one large fast growing tree species (Red Maple), one large slow growing tree species (London Planetree), one medium species (Yellowwood), and one small species (Thornless Hawthorn). The species population will be distributed evenly for the four representative species. The size of the new tree plants will be 1.5ï diameter at breast height. The condition of the new tree plants will be îGoodï. The mortality assumed will be 8% based upon data collected by Providence Neighborhood Planting Program. A summary of the new plant tree species, size, growth in 2030 and 2050, and carbon sequestration in 2030 and 2050 is provided in the table below.

Species Name	2025 Diameter at Breast Height (inches)	Population (%)	2030 Diameter at Breast Height (inches)	2050 Diameter at Breast Height (inches)	2030 Cumulative CO_2e reduction (kg)	2050 Cumulative CO_2e reduction (kg)
Red Maple	1.5	25	3	12	39	752
London Planetree	1.5	25	3	9	14	239
Yellowwood	1.5	25	3	9	36	603
Thornless Hawthorn	1.5	25	3	9	21	379

Reference Case Scenario (GHG Emissions or Activity Level):

The reference case scenario will be the calculated 2024 baseline Providence tree carbon sequestration. This means the reference case does not increase or decrease tree population or tree size over the period of cumulative carbon reduction (2025 ó 2030 and 2025 ó 2050). The added sequestration from new tree plants is independent of the existing tree population, so that the sequestration increment is the same whether added to a static carbon sequestration baseline or an increasing or decreasing carbon sequestration baseline.

GHG Emissions Reduced:

1,300 trees will be planted each year 2025 ó 2029 to implement the PVD Tree Plan. The table below summarizes the cumulative carbon reduction for the trees planted in each year. The total cumulative carbon reduction for 2025-2030 and 2025-2050 is 0.000087 and 0.002493 MMT CO_2e. The cumulative carbon reduction as a percentage

of the 2024 baseline Providence sequestration is 0.3% for 2025 ó 2030 and 8.0% for 2025 ó 2050.

Year of Planting	2030 Cumulative Reduction (MMT CO_2e)	2050 Cumulative Reduction (MMT CO_2e)
2025	0.000032	0.000590
2026	0.000024	0.000542
2027	0.000002	0.000496
2028	0.000001	0.000453
2029	0.000001	0.000412

Carbon Reduction Measure 2B: Implement Tree Planting in additional communities in MA & RI

Implementation of additional tree planting, following Providence's model, in 2 additional communities in RI and 5 municipalities in MA will result in an additional 1,800 trees planted (200 trees in each of two other municipalities in RI, 150 trees each in New Bedford & Fall River, and 1,100 additional trees distributed elsewhere in MA)

Measure-Specific Documentation:

GHG Reduction Estimate Method:

The GHG reduction will occur by planting trees. The baseline estimate of carbon sequestration will use the state-level estimate in the State of MA GHG Inventory for 2020. The GHG reduction beyond the baseline will be determined using the number and types of new trees expected to be planted as inputs to the i-Tree Design tool. The activity data needed will be the number of trees planted in the year they will be planted and the locations of the tree plantings.

Models/Tools Used:

The only model used will be the i-Tree Design tool. The i-Tree Design tool model description is contained in the technical information for implementation 2A.

Measure Implementation Assumptions:

The requested funding is anticipated to cover the cost of planting (inclusive of necessary site preparation, staff and crew time, stewardship & workforce training and maintenance costs) 1,800 new trees in both MA and RI over the five-year project period, each tree roughly 1.5ï in diameter at time of planting. The estimated survival rate is 92% (though recently collected data from PNPPì planting efforts suggests a higher survival rate of 94-95%). Groundwork RI will plant 200 trees in each of two additional RI municipalities, to be identified (100 in year 2, 200 in year 3 and 100 in year 4, for a total of 400 trees). Groundwork Southcoast will plant 150 each in New Bedford and Fall River (60 trees total per year in years 1-5, for a total of 300 trees). SRPEDD will work with local partners and forestry consultant(s), to be identified, to plant 1,100 trees in additional MA municipalities (roughly 366 trees per year in years 3, 4 and 5).

GHG Reduction Estimate Assumptions:

The MA average urban forest sequestration value in 2020 is 2.6791 MMT CO_2e yr^{-1}. An estimate for representative towns is MA sequestration multiplied by the fraction of MA

urban area contained in a representative town. New Bedford will be considered the representative town, and the fraction of MA urban area due to New Bedford is 0.76%. The 2020 sequestration estimate for New Bedford is 0.0204 MMT CO_2e yr^{-1}.

The new tree plantings will be assumed to be represented by three species on the allowable trees for planting list posted by New Bedford. Two species are selected: Red Maple and Pin Oak. The species population will be distributed evenly for the two representative species. The size of the new tree plants will be 1.5ï diameter at breast height. The condition of the new tree plants will be îGoodï. The mortality assumed will be 15%. A summary of the new plant tree species, size, growth in 2030 and 2050, and carbon sequestration in 2030 and 2050 is provided in the table below.

Species Name	2025 Diameter at Breast Height (inches)	Population (%)	2030 Diameter at Breast Height (inches)	2050 Diameter at Breast Height (inches)	2030 Cumulative CO_2e reduction (kg)	2050 Cumulative CO_2e reduction (kg)
Red Maple	1.5	50	4	15	67	1,548
Pin Oak	1.5	50	4	15	97	1,425

Reference Case Scenario (GHG Emissions or Activity Level):

The reference case scenario will be the estimated New Bedford urban forest sequestration. This means the reference case does not increase or decrease tree population or tree size over the period of cumulative carbon reduction (2025 ó 2030 and 2025 ó 2050). The added sequestration from new tree plants is independent of the existing tree population, so that the sequestration increment is the same whether added to a static carbon sequestration baseline or an increasing or decreasing carbon sequestration baseline.

GHG Emissions Reduced:

60 trees will be planted in year 1, 160 trees in year 2, 360 trees in year 3, 260 trees in year 4 and 160 trees in year 5, resulting in a 5-yr total of 1,000 trees. The table below summarizes the cumulative carbon reduction for the trees planted in each year. The total cumulative carbon reduction for 2025-2030 and 2025-2050 is 0.000107 and 0.003220 MMT CO_2e. The cumulative carbon reduction as a percentage of the 2020 baseline New Bedford sequestration is 0.5% for 2025 ó 2030 and 15.7% for 2025 ó 2050.

Year of Planting	2030 Cumulative Reduction (MMT CO_2e)	2050 Cumulative Reduction (MMT CO_2e)
2025	0.000042	0.000758
2026	0.000030	0.000698
2027	0.000020	0.000641
2028	0.000011	0.000587
2029	0.000006	0.000535

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Carbon Reduction Measure 2C: Maintain existing trees.

Implementation of the PVD Plan will result in scheduled maintenance of 30,000 trees within city right of way, improving their health and survivor rate. Additional programming in MA will result in scheduled maintenance of 600 additional trees, for a grant total of 30,600 trees maintained.

Measure-Specific Documentation:

GHG Reduction Estimate Method:

The GHG reduction will occur by scheduled maintenance of 30,000 trees within city right of way. The GHG reduction estimate method will be the same as described for Carbon Reduction Measure 2A in that i-Tree design will be used to calculate the 2024 Providence baseline urban tree sequestration. The reduction estimate will use i-Tree Design to predict the added sequestration under the assumption the health of trees in maintenance is improved compared to trees not in maintenance. The GHG reduction estimate is the difference between the sequestration predicted for trees with condition input to i-Tree Design of îGoodï and îExcellentï. The Activity data needed will be the number of trees in the maintenance schedule, the log of maintenance activities for each tree, and health status and changes of health status of each tree.

Models/Tools Used:

The only model used will be the i-Tree Design tool. The i-Tree Design tool model description is contained in the technical information for implementation 2A.

Measure Implementation Assumptions:

Funding for the PVD Tree Plan will provide capacity (inclusive of staff and crew time and training) for the maintenance of 6,000 trees per year in the City right-of-way, by both City Forestry staff and local non-profit partners. Funding for Groundwork Southcoast will fund additional maintenance of 150 trees in each New Bedford and Fall River (60 trees total in each year). It is estimated an additional 100 trees will be maintained in each of 3 additional MA communities, to be identified (100 trees total per year in years 3-5).

GHG Reduction Estimate Assumptions:

GHG reduction estimates will use Providence tree species data as input to i-Tree Design to determine the baseline tree carbon sequestration as well as added sequestration from maintenance 15,000 trees. The assumed tree species, tree species population percentage, and tree size will be from the calculated 2024 Providence baseline. See the table summarizing these characteristics in the description for Carbon Reduction Measure 2A.

All 15,000 trees will be assumed to have survived through 2050. The health condition of trees if not included in a maintenance program will be assumed to be îGoodï and if included in a maintenance program will be assumed to be îExcellentï.

Reference Case Scenario (GHG Emissions or Activity Level):

The reference case scenario will be the 15,000 trees not included in maintenance, assumed to have full survivorship through 2050, and predicted sequestration by i-Tree

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Design from the beginning tree species characteristics as determined for the calculated 2024 baseline Providence tree carbon sequestration for 2025 - 2050. This means the reference case does not increase or decrease tree population or tree size over the period of cumulative carbon reduction (2025 ó 2030 and 2025 ó 2050).

GHG Emissions Reduced:

The PVD Tree Plan will be implemented by enrolling 30,000 trees in a tree maintenance program in 2025. The table below summarizes the cumulative carbon reduction for each tree species. The total cumulative carbon reduction for 2025-2030 and 2025-2050 is 0.000249 and 0.001493 MMT CO_2e, respectively. The cumulative carbon reduction as a percentage of the 2024 baseline Providence sequestration is 0.8% for 2025 ó 2030 and 4.8% for 2025 ó 2050.

Species Name	2024 Predicted Diameter at Breast Height (inches)	Population (%)	2030 Cumulative Reduction (kg CO_2e)	2050 Cumulative Reduction (kg CO_2e)
Norway Maple	16	10.1	506	535
Norway Maple	10	8.2	289	306
Northern Red Oak	15	2.4	355	374
Northern Red Oak	9	1.9	179	189
Honeylocust	16	2.3	477	505
Honeylocust	10	1.8	251	266
Red Maple	16	2.1	550	582
Red Maple	10	1.7	297	315
Boxelder	16	2.1	421	445
Boxelder	12	1.7	297	318
Green Ash	16	2.1	272	288
Green Ash	10	1.7	169	179
Black Locust	15	1.7	487	515
Black Locust	10	1.4	280	297
American Beech	14	1.6	257	272
American Beech	8	1.3	105	133
Pin Oak	16	1.6	407	430
Pin Oak	10	1.3	263	279
Sycamore Maple	15	1.1	365	385
Sycamore Maple	9	0.9	196	207
Hornbeam	9	27.2	194	205
Serviceberry	9	27.3	218	231