ATTACHMENT 12

Quantitative Carbon Analysis

Quantitative Carbon Analysis Forest Clearing and Soil Disturbance

Cape Cod Canal Pipeline Relocation Project Carbon Accounting

Bourne, Barnstable County, Massachusetts

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PREPARED FOR

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EXECUTIVE SUMMARY

The proposed Cape Cod Canal Pipeline Relocation Project (hereafter the Project) is designed to accommodate the replacement of the Bourne Bridge and the Sagamore Bridge while continuing to provide uninterrupted natural gas service to the National Grid distribution system on both sides of the Cape Cod Canal.

To accomplish this goal, a total of 44.8 acres of forested land will be clear cut along the pipeline rights-of-way, within the metering and regulating station footprints, and within construction workspaces. Of the 44.8 total acres, 24.4 acres will be allowed to revert to forest after construction activities conclude; 13.0 acres will be maintained as low-growing vegetation (scrub-shrub habitat); and 7.4 acres will be converted to paved or gravel surfaces. An additional 1.4 acres of non-forested land will be disturbed for Project-related trenching.

This analysis was prepared to inform the Massachusetts Environmental Protection Act office of the change in greenhouse gas (GHG) emissions that may be brought about by the Project. Following the Council on Environmental Quality's January 2023 Interim National Environmental Policy Act Guidance on Greenhouse Gas Emissions,[1] this includes an analysis of the net GHG emissions.

From a GHG accounting perspective, the Project is likely to bring about the following changes.

1. Approximately 8,720 metric tons of CO_2e currently sequestered in live forest biomass, forest and non-forest soil, dead wood, and litter may be released due to vegetation clearing and/or soil disturbance.
2. The conversion of wooded habitat to scrub-shrub habitat or paved/gravel surfaces will reduce the rate of future CO_2e sequestration within 18.3 acres of the Project footprint. However, in the 24.4 acres of the Project footprint that will revert to forest, future sequestration rates will increase. The net effect of the Project over all 44.8 acres is to increases future CO_2e sequestration by approximately 965 metric tons over 50 years.

Overall, the Project is expected to increase CO_2e emissions by approximately 7,755 metric tons over its 50-year lifespan. This equates to approximately 155 metric tons CO_2e annually, which is equivalent to the annual emissions associated with about six and a half Massachusetts households (EOEEA 2025; U.S. Census Bureau 2024).

[1] 88 Federal Register 1196. Available at: https://www.federalregister.gov/documents/2023/01/09/2023-00158/national-environmental-policy-act-guidance-on-consideration-of-greenhouse-gas-emissions-and-climate.

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1 PURPOSE AND NEED

The proposed Cape Cod Canal Pipeline Relocation Project (hereafter the Project) is designed to accommodate the replacement of the Bourne Bridge and Sagamore Bridge while continuing to provide uninterrupted natural gas service to the National Grid distribution system on both sides of the Cape Cod Canal.

The Project is located entirely in the Town of Bourne, Barnstable County, Massachusetts and includes two components.

- Algonquin's G-31 pipeline will replace National Grid's existing supply of natural gas that currently crosses over the Cape Cod Canal via a National Grid pipeline that is attached to the Sagamore Bridge. The G-31 pipeline includes the installation of approximately 2.17 miles of 18-inch diameter pipeline that will transport natural gas from the vicinity of an existing valve site located at the junction of Algonquin's multiple G-System pipelines southeast across the Cape Cod Canal to its terminus at the proposed Pave Paws Road Metering and Regulating (M&R) Station.
- Algonquin's G-32 pipeline will replace National Grid's existing supply of natural gas that currently crosses over the Cape Cod Canal via a National Grid pipeline that is attached to the Bourne Bridge. The G-32 pipeline includes the installation of approximately 3.07 miles of 16-inch diameter pipeline. The G-32 pipeline will transport natural gas from the proposed Pave Paws Road M&R Station to the proposed Bourne Rotary M&R Station. The G-32 pipeline will not cross the Cape Cod Canal; instead, the natural gas will be delivered to Bourne Rotary M&R Station via an interconnection with the G-31 pipeline at the Pave Paws Road M&R Station.

A total of 44.8 acres of forested land will be cut along the pipeline rights-of-way, within the M&R station footprints, and within construction workspaces. Of the 44.8 total acres, 24.4 acres will revert to forest once construction activities conclude; 13.0 acres will be maintained as low-growing vegetation (scrub-shrub habitat); and 7.4 acres will be converted to paved or gravel surfaces. An additional 1.4 acres of non-forested land will be disturbed for Project-related trenching.

This analysis was prepared to inform the Massachusetts Environmental Protection Act office of the change in greenhouse gas (GHG) emissions that may be brought about by the Project.

2 METHODOLOGICAL OVERVIEW

This assessment is designed to provide the best practical estimate of the net change in GHG emissions brought about by Project-related tree clearing and soil disturbance. The estimate considers multiple biophysical and behavioral processes that will have a material effect on the actual Project-related change in GHG emissions. In preparing this estimate it is acknowledged that the scientific community has studied some processes extensively and so their effects are characterized with a relatively high degree of precision; other processes have been subject to less study and so are characterized with less precision.

Project-related changes in GHG emissions are estimated as a function of two processes:

1. Some carbon currently sequestered in live forest biomass, forest soil, dead wood, and litter may be released to the atmosphere due to the tree clearing process. Additionally, some carbon currently sequestered in non-forest soil may be released due to trenching to install or remove pipeline segments.

2. When mature trees are cleared and younger trees or scrub/shrub species are allowed to replace them, the rate at which carbon is sequestered in the future will change. When forested acres are converted to paved or gravel surfaces, future carbon sequestration within the acreage is eliminated.

The methods used to quantify the change in GHG emission associated with each process are outlined in Sections 3.1 and 3.2, respectively.

Note that the estimates provided in this assessment are based on a 50-year time horizon because the Project is expected to be operational for 50 years. The selection of a time horizon is important for two reasons.

1. As described in Section 3.1.2, the proportion of carbon that is currently sequestered in the affected forest and will be released to the atmosphere depends on half-life functions: the more time aboveground biomass, belowground biomass, and dead wood are allowed to decay, the more carbon will be released to the atmosphere.
2. As described in Section 3.2.3, a forest's carbon sequestration rate changes as the forest ages. The forest currently in the Project footprint is relatively old and so has a relatively low annual carbon sequestration rate. The forest that regrows within the 24.4 acres that are allowed to revert to forest will, after a few years, have a relatively high annual carbon sequestration rate. If we measure the net change in future carbon sequestration over a 50-year time horizon, the change is positive (i.e., more carbon will be sequestered over the next 50 years with the Project than without).

3 DETAILED CALCULATIONS

3.1 Release of Currently Sequestered Carbon

Table 1 illustrates the calculations used to estimate the amount of currently sequestered carbon potentially released because of the Project. The reasoning behind each input and calculation is described in the remainder of this section.

Table 1. Project-Related Release of Currently Sequestered Carbon

Carbon Pool	Acres	Carbon At Risk of Release (metric tons per acre)	Proportion of At-Risk Carbon Released to the Air over 50 Years Due to the Project	Project-Related Release of Carbon from the Affected Footprint (metric tons)*	Project-Related Release of CO_2e from the Affected Footprint (metric tons)*
Aboveground Live Biomass	44.8	31.3	100%	1,404.3	5,145.7
Belowground Live Biomass	44.8	6.0	73.3%	195.5	716.4
Soil Organic Carbon					
Forested Land	44.8	47.6	8.0%	170.7	625.5
Non-Forested Land	1.4	0.4	100%	0.6	1.8
Dead Wood	44.8	6.7	100%	301.1	1,103.3
Litter	44.8	6.9	100%	307.5	1,126.9
			Total	**2,379.8**	**8,719.7**

* Due to intermediate rounding, these values differ slightly from the products of the reported values.

3.1.1 Carbon At Risk of Release

Living trees and plants absorb carbon dioxide (CO_2) from the air. As part of the photosynthetic process, the oxygen and carbon molecules are separated; the oxygen is released back into the air while the carbon becomes part of the tree or plant itself. In a functioning forest, the carbon removed from the air is stored in one of five pools: 1) aboveground live biomass, 2) belowground live biomass (roots), 3) soil organic carbon, 4) dead wood, or 5) forest litter. When trees are cleared from an area, some of the stored carbon that would otherwise remain sequestered in the five pools may be released back into the atmosphere as carbon dioxide.

The amount of carbon currently sequestered in each carbon pool was estimated using the U.S. Forest Service (USFS) EVALIDator application. EVALIDator produces a variety of population estimates based on current data from the Forest Inventory and Analysis Database (FIADB) (USFS 2024).

EVALIDator allows the user to specify circles on a map and then reports estimates of sequestered carbon in test plots within the circle. For this analysis, data were obtained from one circle with a 4-mile radius. The center of the circle was placed between the proposed Bourne Rotary M&R Station and the propose Pave Paws Road M&R Station.[2] The 4-mile radius includes all proposed tree clearing activities. The EVALIDator estimates for each carbon pool are reported in Table 1 under "Carbon at Risk of Release (metric tons per acre)."

Estimates of the amount of carbon stored in forest soil tend to vary between sources. Catanzaro and D'Amato (2019) cite data from the USFS (2018) in reporting the amount of carbon stored in forest soils for three mature (80- to 100-year-old) New England hardwood forest types: 28 metric tons per acre for northern hardwood, 27 metric tons per acre for oak-pine, and 21 metric tons per acre for oak-hickory. Thompson et al. (2020) reports that an acre of generic forest soil in Massachusetts may contain as much as 112.9 metric tons of soil organic carbon; this is considerably more than the USFS (2018) reports for mature hardwood forests in New England. Indeed, on pages 54 and 55 of their report, Thompson et al. note that the 112.9 estimate "is much higher than most other forest estimates from the region." They go on to site studies at the Harvard Forest in central Massachusetts and at the Hubbard Brook experimental forest in New Hampshire where soil organic content was more in line with USFS reports. Thus, although the value in Table 1, 47.6 metric tons per acre, falls between the two disparate estimates included in the literature, we believe it is more likely to overstate the carbon at risk of release than to understate the carbon at risk of release.

3.1.1.1 CARBON RELEASED FROM NON-FOREST SOIL

Activities that expose sub-surface soil to the air, such as trenching to install or remove pipeline segments, may result in the release of some carbon that would otherwise remain sequestered in the soil. The quantity of soil carbon likely to be released due to the Project's trenching activities is a function of the following bullets.

- The total length of pipeline installation or removal is 7.5 miles. Of the 7.5 miles of pipeline, 1.0 mile will be installed via HDD and will not require trenching. Of the remaining 6.5 miles, 2.7 miles of pipeline will be installed in land that is currently forested. Trenching that will occur on forested land is excluded from this calculation because the release of soil carbon from forested areas is already included in Section 11.4. Therefore, 3.8 miles of trenching will occur to install or remove pipelines from non-forested land.

[2] The center of the circle was placed at 41.7537 degrees north, 70.5587 degrees west.

- The width of a trench depends on the diameter of the pipeline being installed or removed. Pipelines of various diameters will be installed and removed as part of the Project, which include 8 inches (3 foot wide), 16 inches (3 foot wide), with the widest of which has a diameter of 18 inches (3-4 foot wide). This calculation conservatively assumes that all Project trenches will be three feet wide.
    - Based on the two preceding bullets, Project trenching will cover approximately 1.4 acres.
- Digging a trench exposes soil to the atmosphere in a similar manner to agricultural tilling, which has been heavily studied. Srivastava (2025) compared conventional tillage to no-till practices and reported that conventional tillage releases 1.3 metric tons CO_2e per acre more than zero tillage. Dietz et al. (2024) reported that maize grown with conventional tillage reduced soil carbon by approximately 1.2 metric tons CO_2e per acre. This calculation selects 1.3 metric tons CO_2e per acre as an approximation of the rate of soil carbon released due to trenching.

Based on the preceding observations and assumptions, the amount of CO_2e released due to Project-related trenching is calculated as 1.3 metric tons CO_2e per acre × 1.4 acres ≈ 1.8 metric tons CO_2e.

3.1.2 Proportion of At-Risk Carbon Released to the Air over 50 Years

Existing literature was reviewed to estimate the proportion of carbon currently sequestered in each carbon pool likely to be released to the air over the 50-year Project lifespan. These estimates are reported in Table 1, and the basis of each estimate is described in the following bullets.

- Russell et al. (2014) report that hardwood left to decay has a half-life of 10 years. This implies that, over 50 years, 96.9% of the carbon stored in this pool would be released into the air while 3.1% would remain sequestered. Enbridge anticipates that its contractors, in accordance with 310 CMR 16.03(2)(c)7, will employ some combination of on-site chipping of felled trees for use on site or transport of wood to a wood waste reclamation facility. Regardless of the location, the wood will be processed to smaller pieces than the downed woody debris studied by Russel et al. (2014), and that these smaller pieces will decay at a faster rate. Thus, Table 1 conservatively[3] reports that 100% of the carbon at-risk at risk of release that is currently stored as ***aboveground live forest biomass*** will be released to the air because of the Project.
- Not all carbon stored as belowground live biomass will be released over the 50-year project lifespan. Lundholm et al. (2020) reported a weighted average half-life of 17.5 years. This implies that, over 50 years, 86.2% of the carbon stored in this pool will be released while 13.8% remains sequestered. Additionally, only 85% of the carbon released when belowground biomass decays will enter the atmosphere. The remaining 15% is metabolized by heterotrophs in the soil and eventually contributes to soil organic carbon through a biophysical process known as fragmentation (Bond-Lamberty and Gower 2008). Thus, Table 1 reports that 73.3% of the at-risk carbon currently stored as ***belowground live forest biomass*** will be released to the air because of

[3] The term conservatively is used to communicate the belief that our approach is more likely to overstate than understate the net change in carbon released from this pool because of the project. Our belief is based on the fact that this calculation implicitly assumes that all live forest biomass (i.e., wood) will be left to decompose. If any of the wood is brought to market as timber, the carbon in that wood will remain sequestered. If any of the forest biomass is brought to market as pulp, mulch, or fuel, it will offset, to some extent, carbon that would have been released elsewhere in the supply chain via a process called leakage. The Intergovernmental Panel on Climate Change (IPCC) Special Report on Land Use, Land Use Change and Forestry defines leakage as "…the indirect impact that…an activity in a certain place at a certain time has on carbon storage at another place or time" (IPCC 2000, section 2.3.5.2, p. 71). From an economics perspective, leakage occurs when a project causes a shift in market equilibria that results in market participants behaving in a manner that offsets (either partially or in its entirety) a change in GHG emission that would otherwise be brought about by a project. Streck (2022) is an informative primer on leakage.

the project. This is calculated as the product of a 0.862 probability of release and a 0.85 probability that release will be to the air.

- Activities that expose sub-surface soil to the air, such as tree cutting, may result in the release of some carbon that would otherwise remain sequestered in the soil. Thompson et al. (2020), reports that tree cutting associated with commercial forestry is not likely to release carbon from forest soil. Thompson et al. (2020) note that their conclusion is consistent with the observation that, when measured, the carbon content of soils in yards did not differ from the carbon content of soils in forests adjacent to those yards. However, on page 55 of their report, Thompson et al. also note that in assuming commercial tree clearing does not cause any release of carbon stored in forest soils, they may understate the potential for carbon release. This concern was based on a metanalysis by Nave et al. (2010), which studied "harvest impacts on soil carbon in temperate forests worldwide [and] found that, on average, harvesting reduced soil carbon stocks by 8%, though the impacts can be ephemeral." Thus, Table 1 conservatively reports that 8% of the at-risk carbon currently stored in ***forest soils*** will be released to the air because of the Project.
- Dead wood will be handled in the same manner as aboveground live biomass, in accordance with 310 CMR 16.03(2)(c)7. Like aboveground live biomass, 100% of the carbon stored in ***dead wood*** will be released to the air over 50 years.
- Carbon stored in forest the litter pool is constantly being released into the air or soil through decomposition and constantly being replenished as leaves or needles drop. While leaves and needles enter and exit the litter pool frequently, the litter pool for a mature forest can be conceptualized as being at a steady state with approximately 6.9 metric tons C per acre. When a forest is cleared, the carbon stored in the litter pool will be released over the course of a few years. Thus, Table 1 reports that 100% of the at-risk carbon currently stored in ***forest litter*** will be released to the air because of the Project.

3.1.3 Project-Related Release of Carbon and CO_2e from the Affected Footprint

The Project-related release of carbon from the affected footprint is conservatively calculated as the product of two Table 1 inputs: a) *carbon at risk of release denominated as metric tons per acre*; and b) *the proportion of at-risk carbon released to the air over 50 years due to the Project*.

The Project-related release of CO_2e from the affected footprint is calculated *as the Project-related release of carbon from the affected footprint ÷ 0.27292 tons of carbon per ton of* CO_2.

3.2 Habitat Conversion

A forest sequesters carbon at a rate dependent on its age. Young forests tend to have a low standing stock of carbon sequestered; however, they sequester carbon at a relatively high annual rate. In contrast, mature forests are characterized by a relatively high standing stock of carbon but a low annual sequestration rate.

This analysis assumes the approximate age of forests currently within the Project footprint is 100 years.[4] After construction, the forest in the 24.4 acres that are allowed to revert to forest will be 0 years old.

[4] Catanzaro and D'Amato (2019) report that 100-year-old forests in the Northeast generally store between 60 and 80 metric tons carbon per acre. EVALIDator data indicates that forests in the Project vicinity store 98.5 metric tons carbon per acre; however, soil carbon estimates reported by Catanzaro and D'Amato (2019) are typically about 20 metric tons lower than those reported by EVALIDator. Thus, assuming the forests in the Project vicinity are 100 years old is in line with Catanzaro and D'Amato (2019).

We rely on a model developed by Zhou et al. (2015) to estimate a forests annual carbon sequestration rate as a function of the forest's age. The model indicates that the existing forest's carbon sequestration rate is 1.97 metric tons CO_2e per acre per year. If the forest is not cut, over 50 years this rate will slowly decreases to 1.96 metric tons CO_2e per acre per year. The amount of CO_2e that would be sequestered by an acre of forest in the Project's footprint over the next 50 years, assuming the acre is not cut, is presented in Table 2. The Project acreage is separated by habitat conversion type to incorporate into Table 3, below.

Table 2. Estimated Future Carbon Sequestration for a 100-Year-Old Forest.

Habitat Scenario	Acres	CO_2e Sequestered by Forest over 50 Years (metric tons per acre) Assuming No Tree Cutting	Total CO_2e Sequestered by Forest in the Project Footprint over 50 Years (metric tons) Assuming No Tree Cutting[1]
Paved/Gravel Surface Replaces Forest	7.4	100.1	740.6
Scrub-Shrub Replaces Forest	13.0	100.1	1,301.0
Young Forest Replaces Old Forest	24.4	100.1	2,442,0
Total	44.8	**100.1**	**4,483.6**

[1] Calculated as the product of the Acres and CO_2e Sequestered by Forest over 50 Years (metric tons per acre) columns.

When mature trees are cleared, future rates of carbon sequestration will depend on how the acreage develops in the future. The amount of CO_2e sequestered over the next 50 years by the habitat that will replace the forest within the Project footprint is presented in columns 3 and 4 of Table 3. Column 6 of Table 3 reports the net change in future CO_2e sequestration which is calculated as the difference between Column 5 and Column 4.

Table 3. Change in Carbon Sequestration Rates by Habitat Conversion Scenario

Habitat Conversion Scenario	Acres	CO_2e Sequestered by New Habitat over 50 Years (metric tons per acre)	CO_2e Sequestered by New Habitat over 50 Years for Project Footprint (metric tons)[1]	CO_2e Sequestered by Forest in the Project Footprint over 50 Years (metric tons) Assuming No Tree Cutting[2]	Net Change in Future CO_2e Sequestration (metric tons)
Paved/Gravel Surface Replaces Forest	7.4	0.0	0.0	740.6	-740.6
Scrub-Shrub Replaces Forest	13.0	3.0	39.0	1,301.0	-1,262.0
Young Forest Replaces Old Forest	24.4	221.7	5,409.2	2,442.0	2,967.2
Total	44.8		**5,448.2**	**4,483.6**	**964.6**

[1] Calculated as the product of the *Acres* and *CO_2e Sequestered by New Habitat over 50 Years (metric tons per acre)* columns. The value presented for the *Young Forest Replaces Old Forest* row does not equal the product of the previous two columns due to rounding.

[2] Values taken from Table 2.

The reasoning behind each input and calculation in Table 3 is described in the remainder of Section 3.2.

If age is back calculated using EVALIDator carbon pools and the Zhou et al. (2015) model, the forest is estimated to be approximately 115 years old. Carbon sequestration rates for 100- and 115-year-old forests are similar.

3.2.1 Paved or Gravel Surfaces Replace Forest

Areas covered by gravel or pavement do not sequester carbon. Therefore, the Project will reduce the amount of carbon that would have otherwise been sequestered in 7.4 acres of forest when these acres are converted to paved or gravel surfaces. Over 50 years, 740.6 metric tons CO_2e that would have been sequestered but for the Project will remain in the atmosphere.

3.2.2 Scrub-Shrub Replaces Forest

When mature trees and vegetation are removed and replaced with scrub-shrub habitat, the annual rate of future carbon sequestration is reduced from approximately 1.97 metric tons CO_2e per acre to 0.06 metric ton per acre. The carbon sequestration rate of scrub-shrub habitat is not well documented and the 0.06 metric ton CO_2e per acre-year used here was determined based on the following observations.

- Maryland Department of Natural Resources (2017), Gregg et al (2021), and Anderson (2021) estimate sequestration rates for scrub-shrub habitat. Their estimates range from 0.74 to 1.48 metric ton CO_2e per acre-year; however, these estimates may not be applicable to the Project for several reasons. First, carbon sequestration rates vary by region, and none of these studies were conducted in the U.S. Northeast. Second, the Maryland Department of Natural Resources (2017) estimate of 1.48 metric tons CO_2e per acre-year is derived from the USFS Carbon Online Estimator, which is no longer supported. The species composition and time horizon for this estimate are unknown. Third, Gregg et al (2021) and Anderson (2021) estimate carbon sequestration in successional habitats in which forest colonizes pasture or grassland. Their estimates (1.03 and 1.48 metric tons CO_2e per acre-year, respectively) likely overstate carbon sequestration because they include young successional forest, whereas trees within the Project's managed scrub-shrub habitat will be cut. Therefore, the carbon sequestration rates reported in these three studies were not used in this analysis.

- The USFS EVALIDator web application includes carbon stock estimates for forest understory, defined as live seedlings, shrubs, and bushes. EVALIDator understory data is location-specific, has a known time horizon, and does not include tree carbon beyond that in seedlings. Therefore, relative to the three studies discussed in the preceding bullet, EVALIDator data is more applicable to the Project's managed scrub-shrub habitat. The rest of this subsection describes how the EVALIDator understory data was incorporated in this analysis.

Understory carbon stocks (aboveground and belowground) were obtained from EVALIDator. Understory carbon stocks vary by tree density, so only "nonstocked" FAIDB plots were selected to resemble the Project's managed scrub-shrub habitat.[5] Due to the sparsity of nonstocked plots in Massachusetts, this analysis uses statewide estimates from Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, and Vermont. The average aboveground and belowground CO_2e stored in a 50-year-old nonstocked forest understory was 3.07 metric tons per acre. Assuming that the carbon sequestration rate is uniform across time,[6] the annual sequestration rate used in this analysis is determined as 3.07 metric tons CO_2e per acre divided by 50 years, or approximately 0.06 metric tons CO_2e per acre-year.

[5] "Nonstocked" is defined as an area in which trees occupy between 0% and 9% of the land.

[6] Carbon sequestration rates are not uniform across the age of a forest stand. As illustrated in Figure 1, sequestration rates for a forest are greatest when the forest is relatively young (15 to 30 years old). As a forest reaches maturity, the carbon sequestration rate reaches an equilibrium. However, scrub-shrub species are faster-growing than trees, so the carbon sequestration rate for scrub-shrub habitat reaches equilibrium relatively quickly. Although the exact shape of the sequestration curve for scrub-shrub is not known, using the average over 50 years (0.06 metric tons CO_2e per acre-year) does not affect the final estimate.

Scrub-shrub habitat will replace 13.0 acres of forested land after construction. Therefore, over 50 years, 1,262.0 tons CO_2e that would have been sequestered but for the Project will remain in the atmosphere.

3.2.3 Replacing 100-Year-Old Forest with Young Forest

When mature trees and vegetation are removed and young trees are allowed to regrow, the net change in future carbon sequestration will vary over time. Initially, sequestration rates in young forests are very low; however, after about 2 or 3 years the rate of carbon sequestration increases rapidly. Depending on the species composition, sequestration rates generally peak before a forest is 100 years old.

Figure 1 depicts how a forest's sequestration rate changes with age, as modeled by Zhou et al. (2015). The green line represents the slowly decreasing average annual carbon sequestration rate of a forest as it increases in age from 100 to 150 years old. The purple line illustrates rapidly evolving annual carbon sequestration rate associated with a forest as it increases in age from 0 to 50.

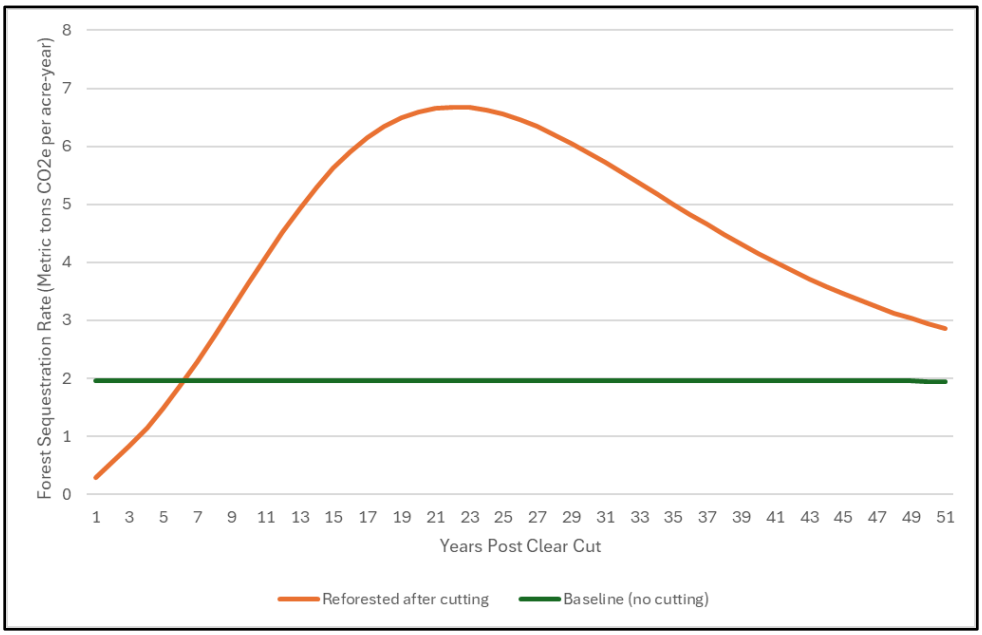


Figure 1. Annual Forest Sequestration Rates

A total of 24.4 acres of forest will be clear cut and allowed to regrow after construction. Without the Project, these 24.4 acres are expected to sequester 2,442.0 metric tons CO_2e over 50 years. When these 24.4 acres are cut and allowed to regrow, 5,409.2 metric tons CO_2e are expected to be sequestered over 50 years. Therefore, for the 50 years following construction, carbon sequestration in these 24.4 acres will increase by 2,967.2 metric tons CO_2e due to the Project.

3.2.4 Project-Related Change in Future Carbon Sequestration

The Project-related change in future carbon sequestration within the affected footprint is 964.6 metric tons CO_2e. This is calculated as the sum of net change in each of the three habitat conversion scenarios (-740.6 metric tons CO_2e in forest converted to paved/gravel surface) + (-1,262.0 metric tons CO_2e in forest converted to scrub-shrub) + (2,967.2 metric tons in areas where young forest replaces older forest) = 964.6 metric tons CO_2e.

4 SUMMARY

The Project is designed to accommodate the replacement of the Bourne Bridge and the Sagamore Bridge while continuing to provide uninterrupted natural gas service to the National Grid distribution system on both sides of the Cape Cod Canal.

To accomplish this goal, a total of 44.8 acres of forested land will be clear cut along the pipeline rights-of-way, within the M&R station footprints, and within construction workspaces. Of the 44.8 total acres, 24.4 acres will revert to forest once construction activities conclude; 13.0 acres will be maintained as low-growing vegetation (scrub-shrub habitat); and 7.4 acres will be converted to paved or gravel surfaces. An additional 1.4 acres of non-forested land will be disturbed for Project-related trenching.

From a GHG accounting perspective, the Project is likely to bring about a change in CO_2e emissions reported in Table 4 and summarized in the following bullets.

1. Up to 8,719.7 metric tons of CO_2e currently sequestered in live biomass, forest and non-forest soil, dead wood, and litter may be released due to vegetation clearing and/or soil disturbance.
2. The conversion of mature forest habitat to young forest (24.4 acres), scrub-shrub (13.0 acres), and paved/gravel surface (7.4 acres) will increase future CO_2e sequestration by approximately 964.6 metric tons over 50 years.

Table 4. Net Change in CO_2e Emissions due to the Project

Project-Related Release of CO_2e from the Affected Footprint (metric tons)	CO_2e Not Sequestered by Forest over 50 Years due to the Project (metric tons)	CO_2e Sequestered by New Habitat over 50 Years for Project Footprint (metric tons)	Net Change in CO_2e Emissions (metric tons)[1]
8,719.7	4,483.6	5,448.2	7,755.1

[1] Calculated as 8,719.7 + 4,483.6 – 5,448.2 = 7,755.1.

As reported in Table 4, the Project is expected to increase CO_2e emissions by approximately 7,755 metric tons over its 50-year lifespan. This equates to approximately 155 metric tons CO_2e annually, which is equivalent to the annual emissions associated with about six and a half Massachusetts households.[7]

[7] The EOEEA (2025) reports that the total gross emissions in Massachusetts were 66,859,515 metric tons CO_2e in 2021 (the most recent year for which they have data). The U.S. Census Bureau (2024) reports that Massachusetts has approximately 2.8 million households. Dividing 66,859,515 metric tons CO_2e gross emissions by 2.8 million households, each Massachusetts household is associated with approximately 23.9 tons of annual CO_2e emissions.

5 LITERATURE CITED

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