SECTION 6-4-5
ENERGY AND CLIMATE CHANGE

This section evaluates the Project's effects on climate change through GHG emissions and energy consumption, and its resilience to climate change effects. As discussed in the New York State Department of Environmental Conservation (NYSDEC) policy,[1] climate change is projected to have broad effects to the environment, including rising sea levels, increases in temperature, and changes in precipitation levels. Although this is occurring on a global scale, the environmental effects of climate change will also be experienced at local scales. New York State has established sustainability initiatives and goals for reducing greenhouse gas (GHG) emissions and for adapting to climate change.

Consistent with the NYSDEC policy*,* GHG emissions associated with the project alternatives were quantified where data inputs were available, with the appropriate level of review to assess the broad-scale effects of GHG emissions to inform decisions, and reasonable measures to lower the level of the potential GHG emissions were considered. Additionally, projected climate conditions were considered synchronous to Project implications.

The approach outlined herein is consistent with NYSDOT guidance and with USDOT and FHWA guidance regarding climate change, including but not limited to USDOT's adaptation plan,[2] FHWA's resilience directive,[3] and USDOT's Climate Change Clearinghouse.[4] Specific data sources and analysis methods and tools are cited within and were selected, as appropriate, from many resources available from the FHWA, NYSDOT, USEPA, NYSDEC, U.S. Department of Energy (DOE), National Oceanic and Atmospheric Administration (NOAA), and Federal Emergency Management Agency (FEMA).

6-4-5.1 REGULATORY CONTEXT

6-4-5.1.1 GREENHOUSE GAS EMISSIONS

Human activity resulting in GHG emissions impacts the Earth's climate, and countries around the world have undertaken efforts to reduce emissions by implementing both global and local measures addressing energy consumption and production, land use, and other sectors.

The USEPA is required to regulate GHGs under the Clean Air Act. In coordination with the National Highway Traffic Safety Administration (NHTSA), USEPA currently regulates GHG emissions from newly manufactured on-road vehicles. In addition, USEPA regulates transportation fuels via the Renewable Fuel Standard program, which will phase in a requirement for the inclusion of renewable fuels, increasing annually up to 36 billion gallons in 2022.

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1 NYSDEC. *DEC Policy: Assessing Energy Use and Climate Change in Environmental Impact Statements*. July 15, 2009.

2 USDOT. U.*S. Department of Transportation Adaptation Plan 2014: Ensuring Transportation Infrastructure and System Resilience*. 2014.

3 FHWA. *Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events. Order 5520*. December 15, 2014.

4 USDOT. www.climate.dot.gov. Accessed October 2016.

There are also regional and State efforts to reduce GHG emissions. In 2009, New York State Governor Paterson issued Executive Order No. 24, establishing a goal of reducing GHG emissions by 80 percent, compared with 1990 levels, by 2050. The 2015 New York State Energy Plan also established interim targets to be achieved by 2030 that include: (1) reducing GHG emissions in New York State by 40 percent, compared with 1990 levels; (2) using renewable energy sources to provide 50 percent of electricity generation in the State; and (3) increasing building energy efficiency gains by 600 trillion British thermal units (Btu).

Under the Regional Greenhouse Gas Initiative (RGGI), the governors of nine northeastern and Mid-Atlantic states have announced plans to reduce GHG emissions from transportation through the use of biofuel, alternative fuel, and efficient vehicles. New York State has also adopted California's GHG vehicle standards (which are at least as strict as the Federal standards).

The Smart Growth Public Infrastructure Policy Act (Smart Growth Act)[5] prohibits New York State agencies from approving, undertaking, supporting, or financing public infrastructure projects, including providing grants, awards, loans or assistance programs unless, to the extent practicable, they are consistent with specific criteria, including the following criteria that directly or indirectly affect GHG emissions:

- Advance projects for the use, maintenance or improvement of existing infrastructure;
- Advance projects located in municipal centers;
- Advance projects in developed areas or areas designated for concentrated infill development in a municipally approved comprehensive land use plan, local waterfront revitalization plan and/or brownfield opportunity area plan;
- Foster mixed land uses and compact development, downtown revitalization, brownfield redevelopment, the enhancement of beauty in public spaces, the diversity and affordability of housing in proximity to places of employment, recreation and commercial development, and the integration of all income and age groups;
- Provide mobility through transportation choices including improved public transportation and reduced automobile dependency; and
- Promote sustainability by strengthening existing and creating new communities which reduce greenhouse gas emissions and do not compromise the needs of future generations, by among other means encouraging broad based public involvement in developing and implementing a community plan and ensuring the governance structure is adequate to sustain its implementation.

Refer to **Appendix D** for more information about the Project's consistency with the Smart Growth Act.

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5 State of New York. *State Smart Growth Public Infrastructure Policy Act.* New York State Environmental Conservation Law, Article 6. May 15, 2009.

6-4-5.1.2 RESILIENCE

The analysis in this document follows current FHWA policy and guidance, including Order 5520,[6] HEC-17,[7] and HEC-25.[8]

New York State's Community Risk and Resiliency Act (CRRA)[9] requires that applicants for certain State programs demonstrate that they have taken into account future physical climate risks from storm surges, sea-level rise, and flooding. CRRA applies to specific State permitting, funding, and regulatory decisions, including smart growth assessments; funding for wastewater treatment plants; siting of hazardous waste facilities; design and construction of petroleum and chemical bulk storage facilities; oil and gas drilling; and State acquisition of open space.

The Smart Growth Act, as amended by CRRA, prohibits state infrastructure agencies from approving, undertaking, supporting, or financing public infrastructure projects, including providing grants, awards, loans, or assistance programs, unless, to the extent practicable, they are consistent with specific criteria. The criteria include mitigating future physical climate risk due to sea level rise, and/or storm surges, and/or flooding, based on available data predicting the likelihood of future extreme weather events, including hazard risk analysis data if applicable.

While implementation guidance for CRRA is not yet available, the following sections review the consistency of the resiliency components of the Project with the Smart Growth Act and the CRRA resiliency criterion.

6-4-5.2 AFFECTED ENVIRONMENT

6-4-5.2.1 POLLUTANTS OF CONCERN

The pollutants included in the GHG analysis for this Project are described in this subsection. Overall, there are seven GHGs, or GHG categories, that could potentially be included in the scope of a GHG analysis: carbon dioxide (CO_2), nitrous oxide (N_2O), methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), and sulfur hexafluoride (SF_6). The analysis for the Project focuses on CO_2, N_2O, and methane. There are no substantial direct or indirect sources of HFCs, PFCs, NF_3, or SF_6 associated with the Project. Although tropospheric ozone is also an important GHG, it does not need to be assessed at the project level since it is a rapidly reacting chemical and efforts are ongoing to reduce ozone concentrations as a criteria pollutant (see **Section 6-4-4, Air Quality**).[10]

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6 FHWA. *Order 5520: Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events.* December 15, 2014.

7 FHWA. *Highways in the River Environment: Floodplains, Extreme Events, Risk, and Resilience.* Hydraulic Engineering Circular No. 17. 2nd Edition. FHWA-HIF-16-018. June 2016.

8 FHWA. *Highways in the Coastal Environment: Assessing Extreme Events.* Hydraulic Engineering Circular No. 25. Vol. 2. FHWA-HIF-14-006. October 2014.

9 *Community Risk and Resiliency Act.* Chapter 355, NY Laws of 2014. April 9, 2013. Signed September 22, 2014.

10 Tropospheric ozone if formed from the chemical transformation of other precursor pollutants. Emissions of ozone precursors were quantified as part of an air quality mesoscale analysis for the project, as documented in Section 6-4-4.

CO_2 is the primary pollutant of concern from anthropogenic sources. Although not the GHG with the strongest effect per molecule, CO_2 is by far the most abundant and, therefore, the most influential GHG. CO_2 is emitted from all combustion processes (both natural and anthropogenic); from some industrial processes such as the manufacture of cement, mineral production, metal production, and the use of petroleum-based products; from volcanic eruptions; and from the decay of organic matter. CO_2 is removed ("sequestered") from the lower atmosphere by natural processes, such as photosynthesis and uptake by the oceans. CO_2 was included in the analysis of GHG emissions.

Methane and N_2O have limited removal processes and a relatively high impact on global climate change as compared with an equal quantity of CO_2. Emissions of these compounds, therefore, were included in GHG emissions analyses.

To present a combined inventory of GHGs, component emissions are added together and presented as carbon dioxide equivalent (CO_2e) emissions—a unit representing the quantity of each GHG weighted by its effectiveness using CO_2 as a reference. This is achieved by multiplying the quantity of each GHG emitted by a factor called global warming potential (GWP). GWPs represent the radiative forcing[11] of each chemical over a period of 100 years relative to CO_2. The GWPs used directly in this analysis are presented in **Table 6-4-5-1**. Note that in some cases, such as the assessment of lifecycle emissions associated with materials, emission factors including GWPs for these and/or other GHGs may be included indirectly.

Table 6-4-5-1
Global Warming Potential (GWP) for Major GHGs

Greenhouse Gas	100-year Horizon GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298

Note: The GWPs presented above are based on the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report of 2007, to maintain consistency in GHG reporting.
Source: USEPA. *Inventory of U.S. Climate Change and Sinks: 1990 – 2014.* 2016.

6-4-5.2.2 CLIMATE CONDITIONS AND PROJECTIONS

The following subsection summarizes projected changes in climate parameters from a report on the Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State (ClimAID).[12] This study has been the basis for many New York State efforts related to climate change, including CRRA. Additional data regarding projected potential increases in short term precipitations were obtained from the New York State Energy Research and Development Authority (NYSERDA) studies.[13] Energy and Greenhouse Gas emissions analysis was conducted for the same analysis years as the Mesoscale Analysis with the same vehicle miles traveled (VMT) as described in **Section 6-4-4,**

11 *Radiative forcing* is a measure of the influence a gas has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the gas as a GHG.

12 NYSERDA. *Climate Change in New York State: Updating the 2011 ClimAID Climate Risk Information Supplement to NYSERDA Report 11-18 (Responding to Climate Change in New York State)*. Report 14-26. September 2014.

13 NYSERDA. *Intensity Duration Frequency Curves for New York State: Future Projections for a Changing Climate.* http://ny-idf-projections.nrcc.cornell.edu. Accessed 10/19/2017.

Air Quality. Estimates are based on projected roadway conditions in the 2026 analysis year as a reasonable representative for the estimated time of completion.

Since the Project is not near coastal areas that would be affected by sea level rise, this subsection does not discuss sea level rise and coastal storms, and an analysis of coastal storms and associated flood levels is not warranted. A summary of other relevant climate variables, including mean temperature and precipitation and extreme temperature and precipitation events, is presented in **Table 6-4-5-2**.

Table 6-4-5-2
Climate Projections for Project Region

Parameter	Baseline (1971-2000)	2020s	2050s	2080s
Mean Annual Air Temperature	45.4°F	+2.8 to +3.9°F	+5.4 to +7.2°F	+7.9 to +11.8°F
Total Annual Precipitation	42.6 inches	+4 to +8 percent	+7 to +13 percent	+9 to +15 percent
Extreme Events				
Heatwaves and Cold Events[1]				
Days per year with maximum temperature exceeding 90°F	3	7 to 10	16 to 26	30 to 57
Number of heat waves per year[2]	0.2	0.8 to 1	2 to 3	4 to 7
Average duration (days)	4	4 to 4	4 to 5	5 to 6
Days per year with minimum temperature at or below 32°F	147	122 to 130	107 to 119	94 to 114
Intense Precipitation				
Days per year with rainfall exceeding—				
1 inch	6	7 to 8	7 to 9	8 to 10
2 inches	0.8	0.8 to 1	0.8 to 1	0.8 to 1
Increase in Short Duration[3] Precipitation ('High' scenario) for Return Period[4]—	Increases presented relative to this period			
1-percent		24%	24%	48%
4-percent		11%	16%	32%
10-percent		11%	13%	26%
20-percent		9%	14%	24%

Notes:

The Project is located in ClimAID Region 6, represented by Watertown in the baseline.

The range presented includes the middle of the Middle Range scenario to the High scenario, representing approximately the 50th percentile of model results through the 90th percentile. Higher and lower values are possible.

1. Decimal places shown for values less than 1, although this does not indicate higher precision/certainty. The high precision and narrow range shown here are because these results are model-based. Due to multiple uncertainties, actual values and ranges are not known to the level of precision shown in this table.
2. Defined as three or more consecutive days with maximum temperature exceeding 90°F.
3. Short duration includes events ranging from 1 to 24 hours. The highest increment for all hours and scenarios is presented, but the relative increase is generally projected to be within a few percent of these values.
4. Return period represents the probability of event in any given year, sometimes referred to as "x-year" event, e.g., a 1 percent event might be called "100-year" event.

Source: ClimAID, 2014. Increase in short duration precipitation based on NYSERDA, 2017.

6-4-5.3 NO BUILD ALTERNATIVE

6-4-5.3.1 GREENHOUSE GAS EMISSIONS

Under the No Build Alternative, the existing roadways would remain with continued, ongoing maintenance and minor repairs. I-81 would remain in its current location with routine maintenance to ensure it is safe for the traveling public. GHGs would continue to be emitted from existing sources including on-road emissions in the Project Area. Construction emissions associated with the Project would not occur, but emissions associated with maintenance of aging roadways would increase. Energy consumption and GHG emissions associated with maintenance of the roadways was not quantified. While maintenance needs and the associated emissions would be larger for the aging roadways under the No Build Alternative than the other build alternatives, overall these emissions would be small relative to other operational and construction emissions.

The direct emissions associated with the operation of the roadways in the study area under the No Build Alternative were calculated using the same data and methodology that were used for the air quality mesoscale analysis (described in **Section 6-4-4, Air Quality** and **Appendix G**). An assessment of emissions from the operation of the existing roadways analyzed in the study area under the No Build Alternative was performed for comparison with the Viaduct and Community Grid Alternatives. The results of this assessment are presented in **Table 6-4-5-3**. Total VMT are presented as well. While total VMT may provide context for the results, note that energy and GHG emissions are calculated based on vehicle type, roadway type, and speed, and are therefore not linearly correlated with total VMT. Well-to-pump emissions are not included explicitly in this analysis since the emissions associated with the consumption of alternative fuels are not relevant to the Project. However, based on the fuel lifecycle model from Argonne National Laboratory, well-to-pump emissions are estimated to add 25 percent to the GHG emissions from gasoline and 27 percent from diesel.

Table 6-4-5-3
Operational Energy and GHG Emissions for the No Build Alternative from Roadways in the Study Area

Analysis Year	Total VMT	CO_2e Emissions (metric tons CO_2e per year)	Energy Use (million Btu per year)
2026	3,796,753,177	1,471,826	19,306,030
2056	3,988,571,639	1,054,382	12,808,948

Climate conditions will continue to change as described in the previous section, with increasing effect on existing infrastructure.

Resilience

In the current existing condition, locations within the Project Area experience flooding during severe rain events. These conditions would continue in the future and would be exacerbated by increased precipitation events.

- Roadway flooding occurs on I-81 in the vicinity of Butternut Street during heavy rainfall events, primarily due to insufficient capacity of the existing combined sewer.
- The portion of northbound I-81 to the eastbound I-690 ramp is also subject to recurrent flooding and roadway ponding due to limitations of the existing drainage structures. Drainage structures

located in the median between the ramp and I-690, especially drainage grates, are subject to obstruction by debris and dirt that collect in the median.

- Low points on West Street near eastbound I-690 are subject to recurrent flooding when existing drainage structures are obstructed with debris. The existing shoulder cross slope is insufficient to ensure that sheet flow is readily directed away from travel lanes.

6-4-5.4 ENVIRONMENTAL CONSEQUENCES OF THE VIADUCT ALTERNATIVE

6-4-5.4.1 PERMANENT/OPERATIONAL EFFECTS

Greenhouse Gas Emissions

The direct GHG emissions associated with the operation of the Viaduct Alternative were calculated using the same data and methodology that were used for the air quality mesoscale analysis (described in **Section 6-4-4, Air Quality** and **Appendix G**). The USEPA's MOVES model, version 2014a, was used for the modeling. Indirect emissions from producing and delivering fuel ("well-to-pump" emissions) also contribute to total GHG emissions. Well-to-pump emissions are not included explicitly in this analysis since the emissions associated with the consumption of alternative fuels are not relevant to the Project. However, based on the fuel lifecycle model from Argonne National Laboratory,[14] well-to-pump emissions are estimated to add 25 percent to the GHG emissions from gasoline and 27 percent from diesel.

Regarding emissions associated with grid power to be used for lighting, message boards, and signals, since the Viaduct Alternative would replace some of these existing roadway components with new, more energy efficient components, it is anticipated that the Viaduct Alternative would reduce electricity use and associated emissions relative to the No Build Alternative. Those changes have not been quantified.

Total vehicle miles traveled (VMT) are presented in **Table 6-4-5-4**; while total VMT may provide context for the results, note that energy and emissions are calculated based on vehicle type, roadway type, and speed, and are therefore not linearly correlated with total VMT. Generally, energy consumption and emissions will increase when VMT increases; however, improved speeds (particularly heavy-duty vehicles) will generally result in lower energy use and emissions. Direct CO_2e emissions and energy use on the roadways analyzed in the Project Area under the Viaduct and No Build Alternatives are shown in **Table 6-4-5-5** and **Table 6-4-5-6**, respectively.

Table 6-4-5-4
Total Operational VMT for the No Build and Viaduct Alternatives
(VMT per year)

Analysis Year	No Build Alternative	Viaduct Alternative	*Increment*
2026	3,796,753,177	3,789,038,105	1,284,928
2056	3,988,571,639	3,997,227,337	8,655,698

14 Based on GREET1_2016 model from Argonne National Laboratory.

Table 6-4-5-5
Operational GHG Emissions for the No Build and Viaduct Alternatives
(metric tons CO_2e per year)

Analysis Year	No Build Alternative	Viaduct Alternative	*Increment*
2026	1,471,826	1,304,892	*-166,934*
2056	1,054,382	929,888	*-124,494*

Table 6-4-5-6
Operational Energy Use for the No Build and Viaduct Alternatives
(million Btu per year)

Analysis Year	No Build Alternative	Viaduct Alternative	*Increment*
2026	19,306,030	17,131,619	*-2,174,411*
2056	12,808,948	12,191,623	*-1,617,325*

Compared with the No Build Alternative, the Viaduct Alternative would result in an estimated decrease in direct GHG emissions ranging from 166,934 metric tons CO_2e in 2026 to 124,494 metric tons CO_2e in 2056, and a decrease in direct energy consumption of 2,174,411 million Btu in 2026 to 1,617,325 million Btu in 2056. The changes in GHG emissions and energy use over the years are driven by two opposing processes: 1) decreases in overall fleet-wide average emissions per vehicle-mile over time as engine technology and efficiency improve, and 2) increases in traffic volumes due to growth. As compared to the No Build Alternative, the Viaduct Alternative would shift some vehicles to different roadway types, resulting in vehicle speed improvements for much of the traffic that would substantially reduce GHG emissions per mile, while the net increase in VMT would increase GHG emissions, resulting in a net decrease in GHG emissions. The effect of these changes varies by year due to changes in engine and fuel technology.

To evaluate total net change in emissions, operational emissions and energy consumption were added to construction emissions and energy consumption by annualizing construction emissions over the lifetime of the Project, estimated at 50 years. Construction would result in an average annual increase of 3,745 metric tons CO_2e and 1,510 million Btu per year over the lifetime of the project. Note that in terms of impact on global climate, emissions that occur in bulk over a few years during construction would have a greater long-term effect than the same amount reduced over 50 years, due to longer dwell time of the pollutants in the atmosphere. However, since the reductions far outweigh the increases, the benefit is still clear. This is also demonstrated by assessing the emissions "payback" period: the total construction emission of 187,258 metric tons CO_2e would be offset by reductions in on-road emissions in approximately the first 14 months of operation. Therefore, the Viaduct Alternative would result in a net decrease of GHG emissions compared to the No Build Alternative over the lifetime of the Project.

Total annualized operational and construction CO_2e emissions and energy use under the Viaduct and No Build Alternatives are shown in **Table 6-4-5-7** and **Table 6-4-5-8**, respectively. For a detailed description of the construction energy and emissions, see the following **Section, 6-4-5.4.2**.

Table 6-4-5-7
Operational and Annualized Construction GHG Emissions for the No Build and Viaduct Alternatives (metric tons CO_2e per year)

Analysis Year	No Build Alternative	Viaduct Alternative	*Increment*
2026	1,471,826	1,308,637	*-163,189*
2056	1,054,382	933,633	*-120,749*

Table 6-4-5-8
Operational and Annualized Construction Energy Use for the No Build and Viaduct Alternatives (million Btu per year)

Analysis Year	No Build Alternative	Viaduct Alternative	*Increment*
2026	19,306,030	17,133,129	*-2,172,901*
2056	12,808,948	12,193,133	*-1,615,815*

The emission projections indicate that the Viaduct Alternative would result in a considerable decrease in GHG emissions relative to the No Build Alternative. According to the NYSDEC guidance and common practice under NEPA, the significance of climate change impacts of a project, as measured by changes in GHG emission, are generally not evaluated directly based on emissions alone because climate change is a cumulative impact of emission sources world-wide. Instead, the evaluation of project impacts is generally undertaken by presenting these results for comparison of alternatives, as one of the many considerations for alternative selection, and by evaluating the efforts otherwise included in a project to reduce any GHG emissions by introducing efficiency in energy and material use, and by using low-carbon materials where practicable. See discussion under **Section 6-4-5.4.5**.

Resilience

Of the notable potential impacts of climate change on transportation identified by USDOT,[15] the following could be relevant for the Viaduct Alternative:

- More frequent/severe flooding of low-lying infrastructure, requiring drainage and possibly pumping, due to more intense precipitation.
- Increased thermal expansion of paved surfaces, potentially causing degradation and reduced service life, due to higher temperatures and increased duration of heat waves.
- Higher maintenance/construction costs for roads and bridges, due to increased temperatures.
- Asphalt degradation and shorter replacement cycles, leading to limited access, congestion, and higher costs, due to higher temperatures.
- Culvert and drainage infrastructure damage, due to changes in precipitation intensity or snow melt timing.
- Decreased driver/operator performance and decision-making skills, due to driver fatigue as a result of adverse weather.

[15] USDOT. Climate Adaptation Plan 2014: Ensuring Transportation Infrastructure and System Resilience. 2014.

- Increased risk of vehicle crashes in severe weather.

While all of these could potentially affect the roadways to be constructed, the impact most relevant to the design of the Viaduct Alternative is increased precipitation and its effect on drainage. In the future condition, it is likely that there will be more days with intense rain events. Furthermore, as described in **Table 6-4-5-2**, the projected increase in short-term precipitation during severe events could considerably increase the amount of runoff from roadway facilities.

NYSDOT is considering options for reducing the discharges to a combined sewer system and also adding discharge capacity. As described above, locations within the Project Area experience flooding during severe rain events. Roadway flooding occurs on I-81 in the vicinity of Butternut Street during heavy rainfall events, primarily due to insufficient capacity of the existing combined sewer. As part of the Viaduct Alternative, a new storm sewer trunk line would be constructed that would provide increased capacity for stormwater and reduce the load on the existing combined sewer system. As part of the new trunk line, a spur is planned to the Butternut Street area to address the existing flooding issue. Additionally, a more intense design storm event ("50-year" rather than the normally required "10-year") is being used as the basis of the trunk line design.

The portion of northbound I-81 to the eastbound I-690 ramp is also subject to recurrent flooding and roadway ponding due to limitations of the existing drainage structures. Drainage structures located in the median between the ramp and I-690, especially drainage grates, are subject to obstruction by debris and dirt that collect in the median. Under the Viaduct Alternative, the eastbound ramp would be reconstructed on a new alignment and all associated drainage facilities would be replaced and designed to meet current standards. In addition, the reconstructed ramp drainage system would connect to the new separated storm sewer trunk line.

Low points on West Street in the vicinity of eastbound I-690 are similarly subject to recurrent flooding when existing drainage structures are obstructed with debris. The existing shoulder cross slope is insufficient to ensure that sheet flow is readily directed away from travel lanes. Currently, West Street is elevated and the ramps to and from I-690 pass over I-690. Under the Viaduct Alternative, West Street would be lowered to surface level and I-690 would be elevated to pass over the West Street ramps. Both I-690 and West Street would be reconstructed in this area and all associated drainage would be replaced and designed to meet current standards. In addition, a new separated storm sewer outlet to Onondaga Creek would be constructed to accommodate the new drainage system.

The design of the drainage systems would apply current NYSDOT design guidelines, which account for current precipitation conditions and do not incorporate FHWA's HEC-17 guidance to apply projected future precipitation levels, which are projected to increase substantially in the future (see **Table 6-4-5-2**). The storm sewer trunk would have a higher-capacity design standard than the minimum required (based on a 50-year return period instead of the minimum 10-year). This increased capacity is intended to address concerns regarding existing problems (see **Chapter 5, Transportation and Engineering Considerations**); the benefits of the additional capacity would diminish over the years as precipitation increases due to continued climate change effects.

Regarding the effect of potential increases in temperature on paved surfaces and the effect of increased heat and severe weather on safety, NYSDOT addresses pavement resilience and safety in design regardless of potential future climate impacts. The potential increase in temperature would further increase the importance of designing pavement for longevity for economic and safety purposes, as well as reducing GHG emissions associated with materials (see **Chapter 5, Transportation and Engineering Considerations**).

6-4-5.4.2 CONSTRUCTION EFFECTS

Greenhouse Gas Emissions

GHG emissions associated with construction of the Viaduct Alternative were estimated based on the specific estimates of construction activity described in **Chapter 4, Construction Means and Methods**. In addition to the on-road sources, calculated as described above for operational impacts and based on projected construction trips, on-site emissions were calculated for non-road construction engines, based on fuel consumption data from USEPA's NONROAD emissions model, conservatively applying fleet-wide average factors for 2018. The construction analysis was based on original projections of construction taking place over six years beginning in 2017. While this schedule has changed, the effect of the calendar year change on emissions estimates is expected to be minor.

The worker automobile trips and construction truck trips for the Viaduct Alternative are estimated to result in 1.7 million and 2.8 million vehicle miles traveled over the course of the construction period, respectively. The mobile-source-related fuel consumption estimates from the Viaduct Alternative were developed using the fleet-wide average fuel efficiency for automobiles and heavy-duty trucks for 2018.[16] GHG emissions were then estimated for both on-site construction activities and mobile sources by multiplying the total fuel consumed by default fuel emission factors.[17] This method accounts for the unknown routes and speeds for these trips by applying appropriate average fuel consumption rates for cars and trucks.

Upstream emissions related to the production of construction materials were estimated based on the expected quantity of iron or steel and cement needed for construction of the Viaduct Alternative based on market-wide estimates. Although other materials would be used, cement and metals have the largest embodied energy and direct GHG emissions associated with their production, and substantial quantities would be used for the Project.

The construction is estimated to require 57,893 metric tons of cement. An emission factor of 0.928 metric tons of CO_2e per metric ton of cement produced was applied to estimate emissions associated with energy consumption (including extraction, processing, and delivery) and chemical process emissions (not related to energy) for cement production.[18]

The construction is estimated to require 106,654 metric tons of steel. An emission factor of 0.6 metric tons of CO_2e per metric ton of steel product produced was applied to estimate emissions associated with production energy consumption (including extraction, processing, and delivery),[19] and an

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16 USEPA. Annual Energy Outlook 2016. September, 2016.

17 The Climate Registry. *Default Emissions Factors 2016*. April, 2016.

18 The Portland Cement Association. Life Cycle Inventory of Portland Cement Manufacture. 2006.

19 Arpad Horvath et al. Pavement Life-cycle Assessment Tool for Environmental and Economic Effects, Consortium on Green Design and Manufacturing. UC Berkeley. 2007.

emission factor of 0.65 metric tons of CO_2e per metric ton of steel product produced was applied to estimate chemical process emissions associated with iron and steel production.[20, 21]

The total GHG emissions and energy use associated with the Viaduct Alternative are presented in **Table 6-4-5-9** and **Table 6-4-5-10**, respectively.

Table 6-4-5-9
Construction GHG Emissions Under the Viaduct Alternative
(metric tons CO_2e per year)

Sector	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	*Total*
Construction Equipment	2	11	11	11	11	11	*56*
On-Road Vehicles	55	98	73	47	169	172	*614*
Materials Embedded	0	0	30,959	24,549	18,138	112,944	*186,589*
Total	**57**	**108**	**31,043**	**24,606**	**18,317**	**113,126**	***187,258***
Note: Totals may vary from sum due to independent rounding.							

Table 6-4-5-10
Construction Energy Use Under the Viaduct Alternative
(million Btu per year)

Sector	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Construction Equipment	2,744	14,455	14,555	14,555	14,555	14,555	75,521
On-Road Vehicles	893,367	849,449	714,606	489,729	868,681	636,435	4,452,267
Materials Embedded	Not Available[1]						
Total (excluding embedded)	**896,111**	**864,004**	**729,161**	**504,284**	**883,237**	**650,990**	**4,527,787**
Notes: Totals may vary from sum due to independent rounding. 1. Energy use embedded in materials is not available since the lifecycle analyses combine energy and non-energy sources of GHG.							

In addition, the construction of the Viaduct Alternative would result in GHG emissions associated with traffic diversions during construction. The total VMT and speeds associated with the diversions and the ensuing emissions have not been determined; however, these emissions would be temporary, occurring only during the construction period.

Resilience

There are no specific climate change-related resilience concerns related to construction of the Viaduct Alternative since construction would occur in the near future with current climate conditions.

6-4-5.4.3 INDIRECT EFFECTS

Upstream GHG emissions are included in the net emissions analysis. Some new development may be attracted to the Northern Neighborhoods Subarea (north of I-690), associated with the Clinton Street

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20 Based on 42.3 teragrams of CO_2e emitted and 65,460 thousand tons produced. Source: USEPA. *Inventory of U.S. Climate Change and Sinks: 1990–2009*. April 15, 2011.

21 Note that the GHG emissions and energy consumption associated with construction material would not occur in the project study area even though they have been counted in the overall project-associated emissions.

improvements, and to the Southwest Neighborhoods Subarea (near Westside and Downtown), due to the removal of the West Street ramps.

There would be no indirect effects related to resilience.

6-4-5.4.4 CUMULATIVE EFFECTS

The traffic data that were used in the operational energy and GHG emissions analysis accounted for all traffic diversions that would be associated with the Viaduct Alternative while accounting for potential traffic associated with known reasonably foreseeable projects. Thus, the results of the GHG operational emissions analysis reflect the traffic effects of the proposed action combined with that of reasonably foreseeable actions. Per NYSDEC guidance, the analysis of GHG emissions and of potential reduction measures is an appropriate mechanism for addressing cumulative climate impacts.

There would be no cumulative effects related to resilience.

6-4-5.4.5 MITIGATION

As part of the construction contracts, NYSDOT would require that the Project be designed to achieve certification at the Silver level under NYSDOT's GreenLITES project design certification program. The program includes various options that reduce energy consumption and GHG emissions from the extraction, manufacturing, and transport of materials, such as selecting lower carbon materials and recycled materials, reducing transport of excavated materials and fill, reusing materials, and selecting local materials.

6-4-5.5 ENVIRONMENTAL CONSEQUENCES OF THE COMMUNITY GRID ALTERNATIVE

6-4-5.5.1 PERMANENT/OPERATIONAL EFFECTS

Greenhouse Gas Emissions

The direct GHG emissions associated with the operation of the Community Grid Alternative were calculated using the same data and methodology that were used for the air quality mesoscale analysis (described in **Section 6-4-4, Air Quality** and **Appendix G**). Indirect emissions from producing and delivering fuel ("well-to-pump") also contribute to total GHG emissions. Well-to-pump emissions are not included explicitly in this analysis since the emissions associated with the consumption of alternative fuels are not relevant to the Project. However, based on the latest fuel lifecycle model from Argonne National Laboratory,[22] well-to-pump emissions are estimated to add 25 percent to the GHG emissions from gasoline and 27 percent from diesel.

Regarding emissions associated with grid power to be used for lighting, message boards, and signals, since the Community Grid Alternative would replace some of these existing roadway components with new, more energy efficient components, it is anticipated that the Community Grid Alternative would reduce electricity use and associated emissions relative to the No Build Alternative. Those changes have not been quantified.

22 Based on GREET1_2016 model from Argonne National Laboratory.

Total vehicle miles traveled (VMT) are presented in **Table 6-4-5-11**; while total VMT may provide context for the results, note that energy and emissions are calculated based on vehicle type, roadway type, and speed, and are therefore not linearly correlated with total VMT. Direct CO_2e emissions and energy use on the roadways analyzed in the Project Area under the Community Grid Alternative as compared with the No Build Alternative are shown in **Table 6-4-5-12** and **Table 6-4-5-13**, respectively.

Table 6-4-5-11
Operational VMT for the No Build and Community Grid Alternatives
(VMT per year)

Analysis Year	No Build Alternative	Community Grid Alternative	*Increment*
2026	3,796,753,177	3,792,590,133	-4,163,044
2056	3,988,571,639	3,982,887,754	-5,683,886

Table 6-4-5-12
Operational GHG Emissions for the No Build and Community Grid Alternatives
(metric tons CO_2e per year)

Analysis Year	No Build Alternative	Community Grid Alternative	*Increment*
2026	1,471,826	1,304,241	*-167,585*
2056	1,054,382	930,980	*-123,402*

Table 6-4-5-13
Operational Energy Use for the No Build and Community Grid Alternatives
(million Btu per year)

Analysis Year	No Build Alternative	Community Grid Alternative	*Increment*
2026	19,306,030	17,122,861	*-2,183,169*
2056	12,808,948	12,205,516	*-1,603,432*

Overall, compared with the No Build Alternative, the Community Grid Alternative would result in an estimated decrease in direct GHG emissions ranging from 167,585 metric tons CO_2e in 2026 to 123,402 metric tons CO_2e in 2056. Similarly, direct energy consumption would decrease by 2,183,169 million Btu in 2026 and 1,603,432 million Btu by 2056. The changes in GHG emissions and energy use over the years are driven by two opposing processes: (1) decreases in overall fleet-wide average emissions per vehicle-mile over time as engine technology and efficiency improve; and (2) increases in traffic volumes due to growth. As compared to the No Build Alternative, the Community Grid Alternative would shift some vehicles to different roadway types resulting in vehicle speed changes and would decrease VMT overall. The net effect would be GHG emission reductions. The effect of these changes varies by year due to changes in engine and fuel technology.

To evaluate the total net change in emissions, the operational emissions were added to the construction emissions by annualizing construction emissions over the lifetime of the Project, estimated at 50 years. Construction would result in an annual increase of 2,103 metric tons CO_2e and 808 million Btu per year over the lifetime of the Project. Note that in terms of impact on global climate, emissions that occur in bulk over a few years during construction would have a greater long-term effect than the same amount reduced over 50 years due to longer dwell time of the pollutants in the atmosphere. However, since the reductions far outweigh the increases, the benefit is still clear. This is also demonstrated by assessing the emissions "payback" period: the total construction emission of 105,164 metric tons CO_2e would be offset by reductions in on-road emissions in less than eight months of operation. Therefore, the Community Grid Alternative would result in a net decrease of GHG emissions when compared to the No Build Alternative over the lifetime of the Project.

Total annualized operational and construction CO_2e emissions and energy use under the Community Grid and No Build Alternatives are shown in **Table 6-4-5-14** and **Table 6-4-5-15**, respectively. For a detailed description of the construction energy and emissions, see the following **Section 6-4-5.5.2**.

Table 6-4-5-14
Operational and Annualized Construction GHG Emissions for the No Build and Community Grid Alternatives (metric tons CO_2e per year)

Analysis Year	No Build Alternative	Community Grid Alternative	*Increment*
2026	1,471,826	1,306,334	*-165,482*
2056	1,054,382	933,083	*-121,299*

Table 6-4-5-15
Operational and Annualized Construction Energy Use for the No Build and Community Grid Alternatives (million Btu per year)

Analysis Year	No Build Alternative	Community Grid Alternative	*Increment*
2026	19,306,030	17,123,669	*-2,182,361*
2056	12,808,948	12,206,324	*-1,602,624*

The emission projections indicate that the Community Grid Alternative would result in a considerable decrease in GHG emissions relative to the No Build Alternative, similar to the Viaduct Alternative. According to the NYSDEC guidance and common practice under NEPA, the significance of climate change impacts of a project, as measured by changes in GHG emission, are generally not evaluated directly based on emissions alone because climate change is a cumulative impact of emission sources world-wide. Instead, the evaluation of project impacts is generally undertaken by presenting these results for comparison of alternatives, as one of the many considerations for alternative selection, and by evaluating the efforts otherwise included in a project to reduce any GHG emissions by introducing efficiency in energy and material use, and by using low-carbon materials where practicable. See discussion under **Section 6-4-5.4.5**.

Resilience

While all of the notable potential impacts of climate change on transportation identified by USDOT[23] (listed above for the Viaduct Alternative) could potentially affect the roadways to be constructed, the impact most relevant to the design of the Community Grid Alternative would be increased precipitation and its effect on drainage. In the future condition, it is likely that there will be more days with intense rain events. Furthermore, as described in **Table 6-4-5-2**, short term precipitation events such as those used for design purposes could increase substantially, thus considerably increasing the

[23] USDOT. Climate Adaptation Plan 2014: Ensuring Transportation Infrastructure and System Resilience. 2014.

amount of runoff from roadway facilities. NYSDOT is considering options for reducing the discharges to a combined sewer system and also adding discharge capacity.

As described above, locations within the Project Area experience flooding during severe rain events. Roadway flooding occurs on I-81 in the vicinity of Butternut Street during heavy rainfall events, primarily due to the insufficient capacity of the existing combined sewer. As part of the Community Grid Alternative, a new storm sewer trunk line would be constructed that would provide increased capacity for stormwater and reduce the load on the existing combined sewer system. As part of the new trunk line, a spur is planned to the Butternut Street area to address the existing flooding issue. Additionally, a more intense design storm event ("50-year" rather than the normally required "10-year") is being used as the basis of the trunk line design.

The portion of northbound I-81 to the eastbound I-690 ramp is also currently subject to recurrent flooding and roadway ponding due to limitations of the existing drainage structures. Drainage structures, especially drainage grates, located in the median between the ramp and I-690 are subject to obstruction by debris and dirt that collect in the median. Under the Community Grid Alternative, the eastbound ramp would be eliminated and would not flood.

Low points on West Street in the vicinity of eastbound I-690 are similarly subject to recurrent flooding when existing drainage structures are obstructed with debris. The existing shoulder cross slope is insufficient to ensure that sheet flow is readily directed away from travel lanes. Under the Community Grid Alternative, the I-690 and West Street interchange would be reconstructed. In addition, a new separated storm sewer outlet to Onondaga Creek would be constructed to accommodate the new drainage system.

The design of the drainage systems would apply current NYSDOT design guidelines, which account for current precipitation conditions, and do not incorporate FHWA's HEC-17 guidance to apply projected future precipitation levels, which are projected to increase substantially in the future (see **Table 6-4-5-2**). The storm sewer trunk would have a higher-capacity design standard than the minimum required (based on a 50-year return period instead of the minimum 10-year). This increased capacity is intended to address concerns regarding existing problems (see **Chapter 5, Transportation and Engineering Considerations**), and the benefits of the additional capacity would diminish over the years as precipitation increases due to continued climate change effects.

Regarding the effect of potential increases in temperature on paved surfaces and the effect of increased heat and severe weather on safety, NYSDOT addresses pavement resilience and safety in design regardless of potential future climate impacts. The potential increase in temperature would further increase the importance of designing pavement for longevity for economic and safety purposes, as well as reducing GHG emissions associated with materials (see **Chapter 5, Transportation and Engineering Considerations**).

6-4-5.5.2 CONSTRUCTION EFFECTS

Greenhouse Gas Emissions

GHG emissions associated with construction of the Community Grid Alternative were estimated based on the specific estimates of construction activity described in **Chapter 4, Construction Means and Methods**. In addition to the on-road sources, calculated as described above for operational impacts and based on projected construction trips, on-site emissions were calculated for non-road construction engines, based on fuel consumption data from USEPA's NONROAD emissions model, conservatively applying fleet-wide average factors for 2018. The construction analysis was based on original projections of construction taking place over six years beginning in 2017. While this schedule has changed, the effect on modeled emissions estimates is expected to be minor.

The worker automobile trips and construction truck trips for the Community Grid Alternative are estimated to result in 1.0 million and 1.7 million vehicle miles traveled over the course of the construction period, respectively. The mobile-source-related GHG emissions from the Community Grid Alternative were developed using the fleet-wide average fuel efficiency for automobiles and heavy duty trucks.[24] GHG emissions were then estimated for both on-site construction activities and mobile sources by multiplying the total fuel consumed by default fuel emission factors.[25] This method accounts for the unknown routes and speeds for these trips by applying appropriate average fuel consumption rates for cars and trucks.

Upstream emissions related to the production of construction materials were estimated based on the expected quantity of iron or steel and cement needed for construction of the Community Grid Alternative, based on market-wide estimates. Although other materials would be used, cement and metals have the largest embodied energy and direct GHG emissions associated with their production, and substantial quantities would be used for the Project.

The construction is estimated to require 36,430 metric tons of cement. An emission factor of 0.928 metric tons of CO_2e per metric ton of cement produced was applied to estimate emissions associated with energy consumption (including extraction, processing, and delivery) and chemical process emissions (not related to energy) for cement production.[26]

The construction is estimated to require 56,982 metric tons of steel. An emission factor of 0.6 metric tons of CO_2e per metric ton of steel product produced was applied to estimate emissions associated with production energy consumption (including extraction, processing, and delivery),[27] and an emission factor of 0.65 metric tons of CO_2e per metric ton of steel product produced was applied to estimate chemical process emissions associated with iron and steel production.[28]

The total GHG emissions and energy use associated with the Community Grid Alternative are presented in detail in **Table 6-4-5-16** and **Table 6-4-5-17**, respectively.

In addition, the construction of the Community Grid Alternative would result in GHG emissions associated with traffic diversions during construction. The total VMT and speeds associated with the diversions and the ensuing emissions have not been determined; however, these emissions would be temporary, occurring only during construction years.

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24 USEPA. Annual Energy Outlook 2016. September, 2016.

25 The Climate Registry. *Default Emissions Factors 2016*. April, 2016.

26 The Portland Cement Association. Life Cycle Inventory of Portland Cement Manufacture. 2006.

27 Arpad Horvath et al. Pavement Life-cycle Assessment Tool for Environmental and Economic Effects, Consortium on Green Design and Manufacturing. UC Berkeley. 2007.

28 Based on 42.3 teragrams of CO_2e emitted and 65,460 thousand tons produced. Source: USEPA. *Inventory of U.S. Climate Change and Sinks: 1990–2009*. April 15, 2011.

Table 6-4-5-16
Construction GHG Emissions Under the Community Grid Alternative
(metric tons CO_2e)

Sector	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	*Total*
Construction Equipment	6	6	6	6	6	0	*30*
On-Road Vehicles	46	47	91	84	768	0	*345*
Materials Embedded	2,790	2,790	15,869	15,606	15,343	52,396	*104,792*
Total	**2,842**	**2,842**	**15,966**	**15,696**	**15,425**	**52,396**	***105,167***

Note: Totals may vary from sum due to independent rounding.

Table 6-4-5-17
Construction Energy Use Under the Community Grid Alternative
(million Btu per year)

Sector	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	*Total*
Construction Equipment	8,078	8,110	8,078	8,078	8,077	0	*40,421*
On-Road Vehicles	614,298	623,566	1,221,458	1,128,613	1,034,408	0	*4,622,342*
Materials Embedded	Not Available[1]						
Total (excluding embedded)	**622,376**	**631,676**	**1,229,535**	**1,136,690**	**1,042,485**	**0**	***4,662,763***

Notes:
Totals may vary from sum due to independent rounding.
1. Energy use embedded in materials is not available since the lifecycle analyses combine energy and non-energy sources of GHG.

Resilience

There are no specific climate change-related resilience concerns related to construction of the Community Grid Alternative since construction would occur in the near future with current climate conditions.

6-4-5.5.3 INDIRECT EFFECTS

Upstream GHG emissions are included in the net emissions analysis. There are some land parcels that could be converted from transportation use to other uses, subject to local land use regulations (see **Section 6-2-1**). Any new development in those areas would likely be relatively small and would likely contribute to GHG emissions due to electricity use, fuel use, and traffic generation. However, the electricity, fuel use, and traffic and the ensuing GHG emissions resulting from these residential and commercial land uses might occur elsewhere if the land uses are not provided at these parcels.

There would be no indirect effects related to resilience.

6-4-5.5.4 CUMULATIVE EFFECTS

The traffic data that were used in the operational energy and GHG emissions analysis accounted for all traffic diversions that would be associated with the Community Grid Alternative while accounting for potential traffic associated with known reasonably foreseeable projects. Thus, the result of the GHG operational emissions analysis reflect the traffic effects of the proposed action combined with that of reasonably foreseeable actions. Per NYSDEC guidance, the analysis of GHG emissions and of potential reduction measures is an appropriate mechanism for addressing cumulative climate impacts.

There would be no cumulative effects related to resilience.

6-4-5.5.5 MITIGATION

As part of the construction contracts, NYSDOT would require that the Project be designed to achieve certification at the Silver level under NYSDOT's GreenLITES project design certification program. The program includes various options that reduce energy consumption and GHG emissions from the extraction, manufacturing, and transport of materials, such as selecting lower carbon materials and recycled materials, reducing transport of excavated materials and fill, reusing materials, and selecting local materials.

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