Applying TEAM in Regional Sketch Planning:

A Case Study in Pittsburgh, Pennsylvania

United States
Environmental Protection
Agency

Office of Transportation and Air Quality
EPA-420-F-20-036
July 2020

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Acknowledgments

The U.S. EPA Office of Transportation and Air Quality would like to thank the Southwestern Pennsylvania Commission for their partnership and support in providing the critical data and thoughtful input required for the successful completion of this project and report.

ICF International provided technical support to the U.S. Environmental Protection Agency in the development of the methodologies and analysis employed for this assessment.

Acronyms and Abbreviations

BAU	business as usual
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CTR	Commute Trip Reduction
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
LRTP	Long Range Transportation Plan
MOVES	Motor Vehicle Emission Simulator (EPA’s motor vehicle emissions model)
MPO	Metropolitan Planning Organization
NOx	nitrogen oxides
PM	particulate matter
SPC	Southwestern Pennsylvania Commission
TAZ	traffic analysis zone
TDM	Transportation Demand Management
TEAM	Travel Efficiency Assessment Method
TE	travel efficiency
TRIMMS	Trip Reduction Impacts of Mobility Management Strategies
VMT	vehicle miles traveled
VOCs	volatile organic compounds

Table of Contents

List of Tables and Figures

1 Introduction

Air quality in the U.S. has improved over the years, as regulations and technologies have affected emissions from all pollution sectors. Yet, even with improvements in vehicle technologies and fuels, the transportation sector continues to be a major source of criteria pollutants and greenhouse gas (GHG) emissions across the country. While emissions per mile traveled have decreased, growth in travel activity has partially offset those reductions, and presents a challenge to achieving and maintaining public health. For air quality and transportation planners interested in reducing transportation emissions in their regions, the ability to estimate the emission reduction potential of a given strategy aimed at reducing travel activity is critical to long range planning and programmatic investment. Over the past several years, the U.S. Environmental Protection Agency (EPA) has supported air quality and transportation planning activities by developing the Travel Efficiency Assessment Method (TEAM) to quantify the potential emission reduction benefits of travel efficiency strategies, and has worked with various state and local agencies to apply TEAM in a series of case studies.[1]

The term "travel efficiency" (TE) strategies refers to a broad range of strategies designed to reduce travel activity, especially single-occupancy travel. TE strategies build on the traditional Transportation Control Measures (TCMs) listed in Section 108(f)(1)(A) of the Clean Air Act such as employer-based transportation management programs and transit improvements by adding smart growth and related land use strategies, road and parking pricing, and other strategies aimed at reducing mobile source emissions by reducing vehicle travel activity. . Over the years, these types of strategies have been promoted by non-governmental organizations, academics, and a variety of government agencies at the local, state, and federal level.

EPA developed TEAM, an approach to quantify the potential emission benefits of travel efficiency strategies without having to run an area's travel demand model, saving time and resources. TEAM uses available travel data and a transportation sketch model analysis to quantify the change in vehicle miles travelled (VMT) resulting from TE strategies. In a TEAM analysis, a future analysis year is chosen. VMT and emissions are estimated in the future "Business as Usual" (BAU) case that does not include the TE strategies. Then VMT and emissions estimated in future TE strategy scenarios are compared against the BAU case. Emission factors are developed using the current version of EPA's MOVES model (the Motor Vehicle Emission Simulator, EPA's emissions model for both onroad and nonroad vehicles). The focus of a TEAM analysis is the effect of strategy primarily on personal passenger vehicles. Therefore, VMT and emissions impacts are estimated for personal passenger vehicles only (i.e., passenger cars, passenger trucks, and motorcycles). Furthermore, potential increases in transit VMT and emissions resulting from transit strategies are not accounted for in the VMT and emission results for this case study.

EPA worked with the Southwestern Pennsylvania Commission (SPC) to apply a TEAM analysis in Pittsburgh to a set of strategies of local interest. SPC is the federally-designated metropolitan planning organization (MPO) for a 10-county region: Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Indiana, Lawrence, Washington, and Westmoreland Counties as well as the City of Pittsburgh. The vision and policy goals set forth in the region's long-range transportation plan (LRTP), *SmartMoves For a Changing Region*, served to guide the TE strategies selected for analysis.[2] SPC consulted with the Port Authority of Allegheny County (PAAC), the organization responsible for providing public transportation

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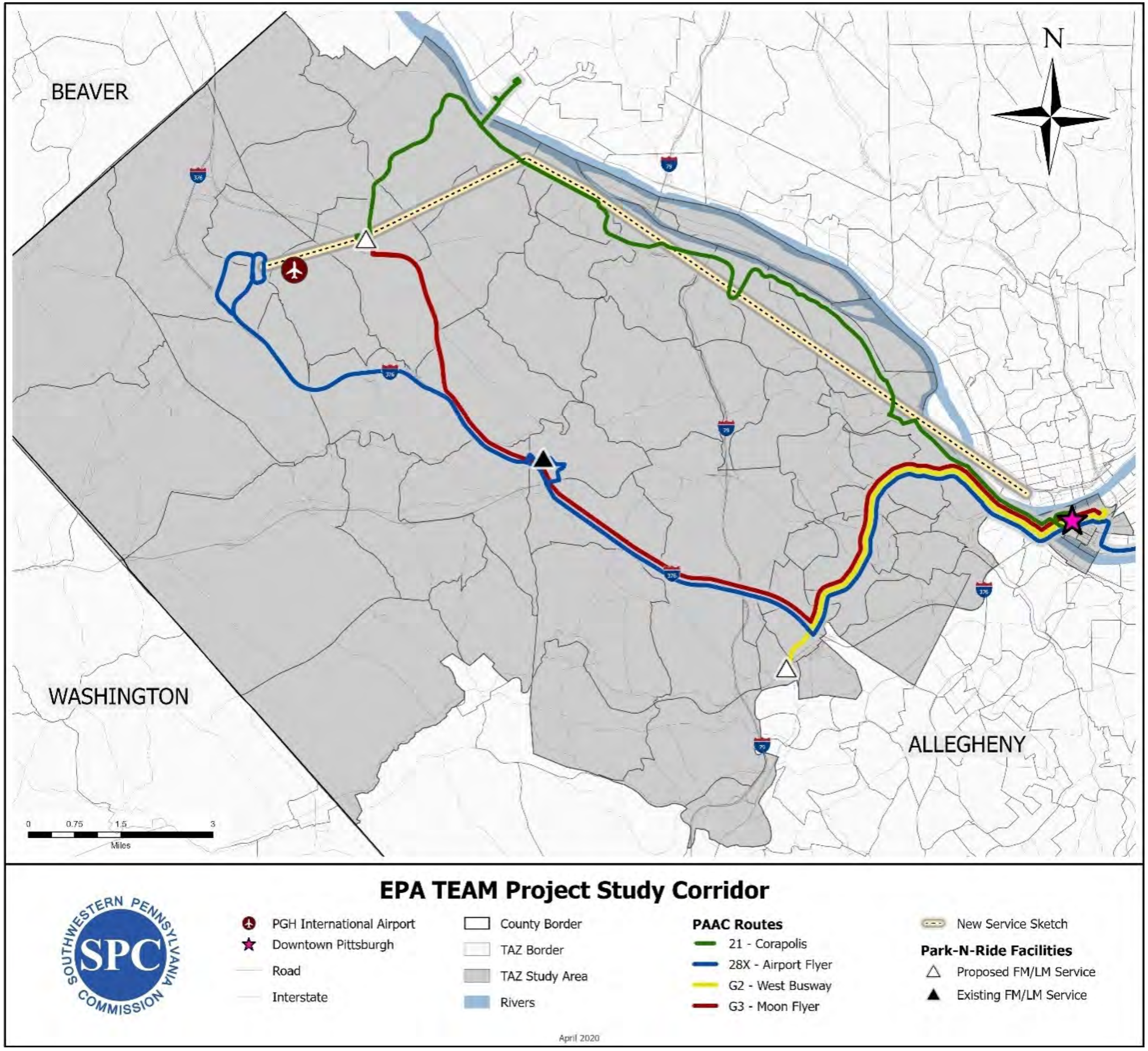
[1] More information on EPA's Travel Efficiency Assessment Method, including past case studies, can be found at www.epa.gov/state-and-local-transportation/estimating-emission-reductions-travel-efficiency-strategies.

[2] Available at: https://spcregion.org/smartmoves.asp.

service throughout Allegheny County, on strategy selection. As shown in Figure 1 below, the geographic scope was focused on a key transportation corridor within Allegheny County between Downtown Pittsburgh (denoted by the red star) and the Pittsburgh International Airport (denoted by the airplane symbol).

Figure 1: SPC TEAM Analysis Geographic Scope



2 TEAM Analysis Tools

A TEAM analysis is performed to determine the potential VMT and emissions reductions of various strategies. The VMT component of the analysis in TEAM uses the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) sketch model developed by the Center for Urban Transportation Research (CUTR) at the University of South Florida. TRIMMS relies on a number of user-supplied parameters, or default parameters if user-supplied inputs are not available, to describe the regional travel and transportation patterns. The parameters include:

- Mode Share - the percentage of travelers currently using a type (mode) of transportation.
- Average Vehicle Occupancy by Mode – the average number of people in each vehicle type.
- Average Trip Length – the average one-way trip length by mode of transportation.
- Demographic and Employment Characteristics – area-wide population and employment information.

At the core of TRIMMS is the capability to estimate mode share changes through scenario analysis. Scenario analysis in TRIMMS estimates impacts on travel patterns from adjusting the direct influences on travel demand, namely trip cost, trip time, etc. Some data inputs need pre-processing before use in TRIMMS. Pre-processing steps are described within the individual scenario discussions below. This analysis was conducted with TRIMMS 4.0, the latest version of this sketch model available at the time the case studies were undertaken.

A key user-supplied TRIMMS input for scenario analysis is the "commuters affected" value. For this input, the user enters the population affected by the policy or scenario under consideration. A policy or scenario may affect the entire regional resident population or a population subset, such as the employees of a certain industry or residents within a defined project radius. While there is some subjectivity when specifying the commuters affected value, it should comprehensively capture the VMT impacts of a given policy or scenario. The commuters affected value is stated in the narratives for each of the scenarios evaluated in this analysis.

The emissions component of the analysis in TEAM uses MOVES2014a to determine regional average emission rates for the study area. MOVES is EPA's state-of-the-science emissions modeling system that estimates emissions for mobile source at the national, county, and project level for criteria pollutants, greenhouse gases, and air toxics. MOVES was run in Inventory mode using inputs provided by SPC to produce activity-weighted composite light-duty emission rates for each pollutant evaluated in this analysis. This process is described further in the Emissions Analysis section of this document. The pollutants evaluated in this analysis include:

- CO2-equivalent (CO2e);
- nitrogen oxides (NOx);
- fine particulate matter ($PM_{2.5}$); and
- volatile organic compounds (VOCs).

3 Scenario Analysis

In a TEAM analysis, data is collected to represent conditions at a defined baseline year and a "business as usual" (BAU) future year. SPC BAU conditions are based on *SmartMoves For a Changing Region*, the current long-range transportation plan for the region. Then future-year TE strategies are selected for evaluation. VMT and emissions are estimated in the future year BAU case that does not include the TE strategies. Next, VMT and emissions are estimated in future TE strategy scenarios and are compared against the baseline and BAU cases. Table 1, below, provides a brief description of the baseline, BAU, and scenarios selected for evaluation.

Table 1: SPC TE Strategy Scenario Overview

Scenario:	Description
Scenario 1: Transportation Pricing	Explore the impact of a hypothetical doubling of the marginal operating cost of automobile vehicle trips within Allegheny County. This would likely be the result of one or more statewide or national initiatives and thus its implementation would likely be at a large geographic scale.
Scenario 2: Incremental transit improvements and enhancements in the corridor	Explores hypothetical transit enhancements to the existing 28X bus route and G3 bus route, and implementation of additional shuttle services between employment centers and major bus stops in the corridor.
Scenario 3: Major transit improvements and enhancements in the corridor	Explore impact of a potential new “high-capacity/high-speed” fixed route transit line offering “frequent/all-day” service on dedicated right-of-way between the Airport and Downtown Pittsburgh, coupled with significant increase in Park-n-Ride capacity in the corridor along the route.

A fourth scenario exploring land use changes was originally selected for analysis, where population and job densities were significantly increased for selected Traffic Analysis Zones (TAZs) within an SPC-specified corridor. However, some data inconsistencies were discovered and were unable to be resolved within the EPA’s limited time and effort constraints for this project.

For this analysis, SPC selected strategies to explore tradeoffs between the strategies and between the alignments of strategies, thus the strategies evaluated are not optimized to reduce VMT and emissions. For example, the alignment of Scenario 3, denoted in Figure 1 as the “New Service Sketch” along the Ohio River, may not necessarily be the ideal location for a new “high-capacity/high-speed” fixed-route facility between Downtown and the Airport. Instead, this analysis provides an opportunity to test the impact of a major service improvement in a corridor that is currently lightly served by transit.

The following section covers the scenarios in greater detail including the primary TEAM analysis inputs.

3.1 Baseline and BAU Details

The data below defines the regional 2020 baseline and regional 2045 BAU modeling parameters used as the basis for the VMT portion of the analysis. For the purposes of this analysis, “regional population” and “regional employment” refer to the numbers of people living or working within the broader analysis area. In this case, the broader analysis area is confined to Allegheny County and does not include the entire 10-county SPC region. The parameters in Table 2 were supplied by SPC unless otherwise noted.

Table 2: Baseline and BAU Regional Parameters

Parameter Description	2020 Baseline	2045 BAU
Regional population	1,229,020	1,400,888
Regional employment	934,510	1,037,234
Mode shares:		
Auto, drive alone	76.00%	76.00%
Auto, rideshare	9.06%	9.06%
Vanpool	0.10%	0.10%
Transit	6.87%	6.87%
Bike	0.14%	0.14%
Walk	3.57%	3.57%
Other[a]	4.26%	4.26%
Average vehicle occupancy:		
Auto, drive alone	1.00	1.00
Auto, rideshare	2.10	2.10
Vanpool	10.00	10.00
Public Transport	8.46	8.46
Other[b]	1.67	1.67
Average vehicle trip lengths (miles):		
Auto, drive alone	13.81	13.81
Auto, rideshare	10.20	10.20
Vanpool	29.70	29.70
Public Transport	5.13	5.13
Bike	2.45	2.45
Walk	0.75	0.75

[a] This value reflects adjustments needed to make mode share sum to 100% and may include modes such as telecommuting.

[b] Denotes TRIMMS default.

3.2 Scenario 1: Transportation Pricing

In this scenario, transportation pricing is a strategy for reducing personal vehicle travel by increasing the cost of vehicle use, without regard to the specific pricing mechanism. This type of strategy is expected to reduce single occupancy vehicle travel and encourage commuters to use other forms of transportation, like public transit and vanpool. Additionally, for this analysis, services such as vanpool and public transit were assumed to not be subject to the pricing strategy. SPC sought to explore the impact of a hypothetical doubling of the marginal operating costs of auto trips (in TRIMMS, “Auto, drive alone” and “Auto, rideshare”), expressed in cost per mile. A $0.18 BAU cost per mile value was selected by SPC. Transportation pricing was applied to the full anticipated regional population in 2045 of 1,400,888, described as “Commuters Affected” in Table 4 . Trip costs for the BAU were calculated by multiplying the VMT cost per mile by the “average trip length” regional parameter for a given mode. Trip costs for the scenario were calculated by doubling the BAU trip cost. The trip cost calculations for both the BAU and scenario are shown in Table 3.

Table 3: Scenario 1 Trip Costs Calculations

Mode	BAU Cost Per Mile ($/mile) (A)	Average trip Length (mi) (B)	BAU Trip Cost ($) = (A) x (B)	Scenario Trip Cost ($) = (A x B) x 2
Auto-Drive Alone	$0.18	13.81	$2.48	$4.97
Auto-Rideshare	$0.18	10.20	$1.84	$3.67

Table 4 provides the analysis inputs for Scenario 1.

Table 4: Scenario 1 Transportation Pricing Analysis Inputs

	BAU	Scenario
Commuters Affected (2045)	1,400,888	
Auto-Drive Alone – Trip Cost ($)	2.48	4.97
Auto-Rideshare – Trip Cost ($)	1.84	3.67

3.3 Scenario 2: Incremental Transit Improvements and Enhancements in the Corridor

Strategy 2 focuses on relatively inexpensive improvements to an existing, well-served busway corridor. This corridor is currently serviced by Route 28X and Route G3 transit lines, denoted in Figure 1 by the blue and red lines respectively. Improving the travel and wait times on these lines were assumed to reduce personal vehicle travel. Specifically, improvements included in this scenario cover the following changes:

1. Add service to the 28X bus route to double the frequency, extend the span of service to early morning and late evening, and allow every other trip to be a direct/non-stop trip from Downtown Pittsburgh to the Airport (by skipping the Robinson Town Centre stop).
2. Double frequency service on the G3 bus route between Downtown Pittsburgh and the University Blvd Park and Ride lot and provide a “first/last” mile shuttle.
3. Reduce bus travel time by 50% between the West Busway ramp at Carson Street and Downtown Pittsburgh by assuming improvements such as bus priority at traffic signals, short sections of queue jump lanes for buses, etc.
4. Provide a new Park and Ride lot at Robinson Town Centre.
5. Implement a new “first/last-mile” shuttle at the West Busway’s Carnegie Station with service parameters similar to the current Shuttle at Robinson Town Centre.

Transit travel time, as defined in this analysis, is the time it takes for a rider, once on-board a transit vehicle, to travel to their destination. Access time is the wait time prior to boarding the transit vehicle. While the typical transit rider does not wait the entire headway between buses, the headway interval is used for the access time input because the headway interval is known by the transit agency. Both the BAU and scenario use the entire headway interval in the calculation of access time. For modeling purposes, the percent difference, in this case doubling frequency and a weighted reduction in travel time, between the BAU and the scenario is the key information. Reducing transit travel and access time has been shown to increase ridership by increasing the convenience of transit relative to other forms of transport, such as single occupancy vehicles. Because two transit routes were considered in this strategy, the calculated access and travel times were weighted by the average number of weekday riders on each route: Route 28X (1,927 riders) and Route G3 (921 riders). The commuters affected value of 289,162 was determined through a spatial mapping and analysis of TAZs along the corridor by SPC. Specifically, this value reflects the jobs in selected TAZs within a ½ mile radius of 28x and G3 transit stops and selected TAZs within 2 miles of locations with proposed “first/last-mile” service. Additionally, TAZs with major Park-n-Ride improvements were assumed to add 10% to the affected TAZ jobs.

Table 5 below shows the resulting access and travel time improvements used in TRIMMS.

Table 5: Scenario 2 Analysis Inputs

	BAU	Scenario
Commuters Affected (2045)	289,162	
Public Transport – Access Time (min)	26.77	13.38
Public Transport – Travel Time (min)	33.97	27.28

3.4 Scenario 3: Major Transit Improvements and Enhancements in the Corridor

Strategy 3 examines a potential major new fixed route, “high capacity/high speed” transit investment, denoted by the “New Service Sketch” legend item in Figure 1. This corridor is currently lightly served by transit via Route 21. As noted, the alignment of Scenario 3 may not necessarily be the ideal location for a new “high-capacity/high-speed” fixed-route facility between Downtown and the Airport but was selected as a possible alternative. This scenario includes “frequent/all-day” service on dedicated right-of-way between Downtown Pittsburgh and the Pittsburgh International Airport and includes a “significant” increase in Park-n-Ride capacity along the new transit line. The commuters affected for this scenario include the populations of TAZs along Route 21 and TAZs selected for potential stations along the new fixed-guideway at McKees Rocks (TAZ 344) and Coraopolis (TAZ 350). For this scenario, increased service frequency and faster travel speeds are captured though access and travel time improvement values that were provided directly by SPC and are shown in Table 6 below.

Table 6: Scenario 3 Analysis Inputs

	BAU	New
Commuters Affected (2045)	308,501	
Public Transport – Access Time (min)	30.00	15.00
Public Transport – Travel Time (min)	40.00	36.00

3.5 Scenario 4: Land Use

Scenario 4 attempted to explore the potential repurposing of an existing strip mall at Robinson Town Centre as a “compact/dense” residential and mixed-use commercial development and to implement new Transit Oriented Developments (TOD) in Carnegie, Robinson Township, and McKees Rocks. Both the Robinson Town Centre and TOD elements were assumed to double the population and number of jobs within a 10-minute walk of transit stops.

It became clear that upon analysis, doubling these values without increasing the geographic scope of the analysis led to illogical results with the current TEAM land use analysis approaches (i.e., the Neighborhood and Multivariate approaches used in previous TEAM case studies). Though analysis results were produced, they were deemed not credible, as discussed below.

The Neighborhood approach relies on the idea that individual neighborhoods can be classified by typical travel habits of their residents, and that land use planning can shift growth patterns away from more driving-intensive neighborhoods towards less driving- intensive ones. For this approach, there must be different neighborhood "regions" identified in which population could shift from one to another. The geographic scope of the SPC analysis was initially confined to a transit corridor which contained relatively homogenous travel characteristics. Therefore, to evaluate the Neighborhood approach, the geographic scope was broadened to the whole of Allegheny County.

VMT and trip tables were then developed to differentiate travel behavior in distinct regions within Allegheny County. These tables included VMT and trip totals occurring within the distinct regions, but obscured origin-destination relationships needed for the Neighborhood approach. As such, VMT from trip "legs" of a round-trip were assigned in the region in which they occurred and not attributed to their origin. For example, the commute of a person living elsewhere in Allegheny County who works in the corridor would have some VMT assigned outside the corridor and some to the corridor. This resulted in a higher VMT per capita occurring within the corridor than the VMT per capita outside the corridor. Based on these results, any shift in population from outside the corridor to within the corridor would increase VMT within the analysis area. This did not appear to be a reasonable result and was inconsistent with results from previous TEAM analyses. If VMT could have been re-tabulated to reflect trip origins or if a VMT per capita outside of the corridor and VMT per capita within the corridor were directly provided, the outcome may have been reversed. However, time constraints prevented further discussion to reconcile this issue.

In contrast, the Multivariate approach is based on research that relates changes in "D" variables to changes in VMT using elasticities, which quantify the percent change in VMT associated with a 1% change in each "D" variable.[3] For this analysis, the following "D" variables were examined for the BAU and scenario cases:

- Density: Household/population density
- Destinations: Job access by auto
- Destinations: Job access by transit
- Distance to Transit: Distance to nearest transit stop
- Diversity: Land use diversity (typically defined as the level of mixing of different land use types such as residential, commercial, and industrial)

To apply this approach, the percent change in each variable between the BAU and strategy is calculated at the level of the traffic analysis zone (TAZ) and then combined as a population-weighted average at the regional level for each "D" variable. Unfortunately, the data needed to conduct a multivariate analysis was not initially obtained for all of the "D" variables needed for the analysis, and the land use analysis was deemed incomplete.

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[3] Ewing and Cervero, "Travel and the Built Environment: A Meta-Analysis," Journal of American Planning Association, 2010. For more detail on how this information is used in TEAM, see www.epa.gov/sites/production/files/2016-07/documents/420r16009.pdf

4 SPC Scenario VMT and Emissions Analysis Results

TEAM results combine VMT analysis from TRIMMS with the emission rates derived from MOVES. Results can be contextualized both in terms of reduction within the affected scenario geography, or population, and in terms of the reduction in VMT on a regional basis. Contextualizing the results in these two ways avoids the possibility of misrepresenting a strategy that may be highly effective within the smaller geographic scale in which they are implemented but which are diluted when considered on the basis of the entire region. For example, transit service improvements can be effective and could significantly affect VMT in a corridor or other sub-geography of a region, however, without additional public investment, may only impact a small sub-population of the entire region.

In TEAM, the focus of the analysis is the effect of a strategy on passenger vehicle travel activity. For the VMT analysis, this activity is captured by strategy as Auto-Drive Alone and Auto-Rideshare modes in TRIMMS. Therefore, VMT and emissions changes are for these vehicle types only. Additionally, potential increases in transit VMT and emission resulting from transit strategies are not accounted for in the VMT and emission results presented below. For transit service improvement strategies (Scenarios 2 and 3), headway and trip time reductions are assumed to be achieved by increasing the number of buses and thus route miles traveled in a given route. For example, halving the headway would require doubling the buses running that route. Additional transit vehicle type, fuel type, and operational details of the transit frequency improvement strategies would be needed to assess the transit VMT and emission impacts of these strategies, which is beyond the scope of this analysis.

4.1 VMT Analysis

TRIMMS runs were used to determine the changes in light-duty VMT (Auto-Drive Alone and Auto-Rideshare) for each scenario. The VMT analysis results are provided both in terms of the percent change in VMT reduction within the affected scenario geography, or population, and in terms of the percent change in regional VMT. As noted above, contextualizing the results this way allows the reader to see the direct effect of a strategy on the affected scenario geography or population and the effect on the region as a whole. Table 7, below, provides the scenario total reduction in daily light-duty VMT, and the percent changes in light-duty VMT at the affected geography or population level and at the regional (Allegheny County) level compared to the 2045 Regional BAU. Since Scenario 1, Transportation Pricing, would apply throughout the region, the percent change affected in those two columns is the same.

Table 7: Changes in VMT by Scenario Within Affected Geography/Population and at Regional Scale

Scenario	Affected Geography or Population	Change in Light-Duty VMT (mi)	% Change in Light-Duty VMT within Affected Geo./Pop.	% Change in Light-Duty VMT within Region
Scenario 1: Transportation Pricing	All VMT in Allegheny County	-892,850	-3.33%	-3.33%
Scenario 2: Incremental transit improvements and enhancements in the corridor	Jobs in Select TAZs within corridor	-36,593	-0.66%	-0.14%
Scenario 3: Major transit improvements and enhancements in the corridor	Jobs in Select TAZs within corridor	-34,170	-0.58%	-0.13%

4.2 Emissions Analysis

In TEAM, the MOVES analysis is focused on generating activity-weighted, regional average emission factors to represent the general conditions of the study region. Fuel efficiency and emission standards are assumed to improve for vehicles over time consistent with assumptions in MOVES, thus emission rates are lower in future years. The SPC defined corridor is entirely within Allegheny County, therefore this analysis used MOVES input databases for Allegheny County for both the 2020 baseline year and 2045 analysis year. The input databases used for this analysis were adapted from input databases submitted by SPC to EPA Region 3 for the 2019 regional transportation conformity demonstration and are consistent with the region's 2019-2022 Transportation Improvement Program (TIP) and 2045 Long Range Transportation Plan (*Smart Moves for a Changing Region*). Activity-weighted emission factors were developed by summing total emissions, by pollutant and associated process, and dividing by the appropriate activity value, whether starts or VMT for the light-duty vehicles included in the analysis (passenger car, and passenger truck, and motorcycles source type). Table 8 provides the activity-weighted emission factors generated for all of Allegheny County by activity type and analysis year for light-duty vehicles.

Table 8: SPC Emission Factors by Process and Analysis Year for Light-Duty Vehicles

	Emissions per mile (g/mi)		**Emissions per start (g/start)**	
Pollutant	**Base Year (2020)**	**Future Year (2045)**	**Base Year (2020)**	**Future Year (2045)**
CO_2e	376.01	229.31	92.22	68.59
NO_x	0.19	0.02	0.70	0.13
$PM_{2.5}$	0.01	0.01	0.01	0.00
VOCs	0.06	0.01	0.99	0.17

MOVES emission factors for 2045 were multiplied by the scenario-level light-duty VMT changes to estimate to estimate emissions reductions for both the scenario affected geography, or population, and at the regional level. Because the corridor served as the primary unit of analysis for most scenarios, the differences reflected in the tables below is due to the different affected sub-populations within the corridor. Table 9, below, provides the daily VMT reductions, in miles, and emission reductions, in kilograms, by scenario.

Table 9: Daily VMT (mi) and Emission (kg) Reductions by Scenario Compared to the 2045 BAU

Scenario	**Light-Duty VMT**	**CO_2e**	**$PM_{2.5}$**	**NOx**	**VOC**
Scenario 1: Transportation Pricing	-892,850	-210,439	-30	-9	-23
Scenario 2: Incremental transit improvements and enhancements in the corridor	-36,593	-8,576	-1	0	-1
Scenario 3: Major transit improvements and enhancements in the corridor	-34,170	-8,008	-1	0	-1

Table 10, below, provides the percent changes compared to the 2045 BAU in light-duty VMT and by pollutant for each scenario for the affected geography, or population, of the scenario. Note, pollutant percent changes generally track closely with VMT percent changes.

Table 10: Affected Scenario Geography or Population Percent Changes in Emissions for the 2045 Scenario Compared to the 2045 BAU

Scenario	Light-Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Transportation Pricing	-3.33%	3.33%	3.33%	3.33%	3.32%
Scenario 2: Incremental transit improvements and enhancements in the corridor	-0.66%	0.66%	0.66%	0.66%	0.66%
Scenario 3: Major transit improvements and enhancements in the corridor	-0.58%	0.58%	0.58%	0.58%	0.58%

Table 11, below, provides the regional percent changes compared to the 2045 BAU in light-duty VMT and by pollutant for each scenario. Note, pollutant percent changes generally track closely with VMT percent changes.

Table 11: Regionally Normalized Percent Changes in Emissions for the 2045 Scenario Compared to the 2045 BAU

Scenario	Light-Duty VMT	CO_2e	$PM_{2.5}$	NOx	VOC
Scenario 1: Transportation Pricing	-3.33%	-3.33%	-3.33%	-3.33%	-3.32%
Scenario 2: Incremental transit improvements and enhancements in the corridor	-0.14%	-0.14%	-0.13%	-0.14%	-0.13%
Scenario 3: Major transit improvements and enhancements in the corridor	-0.13%	-0.13%	-0.12%	-0.13%	-0.12%

4.3 Discussion of Results

The results of this analysis are presented at two distinct geographic scales to illustrate the effectiveness of a strategy on the affected populations or sub-geographies of Allegheny County. This is reflected in the subtle differences in results between the “Affected Scenario Geography or Population Percent Changes” and the “Regionally Normalized Percent Changes” tables in the VMT Analysis and Emission Analysis sections.

Amongst the scenarios selected, *Scenario 1: Transportation Pricing*, which looked at hypothetical regional transportation pricing changes, was the most effective strategy for VMT reduction at the regional level based on how scenarios were operationalized. However, transit service improvements can be effective and could significantly affect VMT. Scenarios 2 and 3 both increased the transit mode share in their respective corridors as shown in Table 12.

Table 12: Transit Mode Shift for Scenario 2 and Scenario 3

Scenario	Transit Mode Share without Strategy	Transit Mode Share with Strategy	Change in Transit Mode Share
Scenario 2: Incremental transit improvements and enhancements in the corridor	6.87%	7.57%	0.70%
Scenario 3: Major transit improvements and enhancements in the corridor	6.87%	7.48%	0.61%

Additionally, Scenarios 2 and 3 were analyzed independent from one another, meaning the changes in VMT, emissions, and mode shift could be additive to some extent. These scenarios combined with other transit enhancements have a strong potential to further impact mode shift within the corridor. Past case studies have indicated that transit subsidies have a strong effect on mode shift and complement operational improvements such as those evaluated in Scenarios 2 and 3. Finally, as noted, the alignment of Scenario 3, denoted in Figure 1 as the “New Service Sketch” along the Ohio River, is not intended to be the only location under consideration for a new “high-capacity/high-speed” fixed-route facility. If further analysis was conducted for optimal siting, a “high-capacity/high-speed” fixed-route facility could potentially reduce VMT more than what is reported in Table 7. TEAM analysis could be used to explore different alignments and identify an optimized siting.