Transportation Demand Management (TDM) Analysis Report

FY 2018 – FY 2020

covering the period July 2017 – June 2020

November 17, 2020

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National Capital Region
Transportation Planning Board
COMMUTER CONNECTIONS PROGRAM

Transportation Demand Management (TDM) Analysis Report

FY 2018 – FY 2020

covering the period July 2017 – June 2020

Prepared for:

Metropolitan Washington Council of Governments
777 North Capitol Street NE, Suite 300
Washington, DC 20002

Prepared by:

LDA Consulting

In association with:

CIC Research, Inc., San Diego, CA
ESTC, San Diego, CA
Center for Urban Transportation Research, Tampa, FL

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ABOUT COMMUTER CONNECTIONS
Commuter Connections, a program of the National Capital Region Transportation Planning Board at the Metropolitan Washington Council of Governments (COG), promotes bicycling to work, ridesharing, and other alternatives to drive alone commuting, provides ridematching for carpools and vanpools, incentive programs for alternative commuting, and offers the free Guaranteed Ride Home program. Commuter Connections is funded by the District of Columbia, Maryland, Virginia and U.S. Department of Transportation.

CREDITS
Prepared by LDA Consulting in association with CIC Research, Inc., ESTC, and the
Center for Urban Transportation Research

Authors:
Nicholas Ramfos, Director, Transportation Operations Programs, COG
Lori Diggins, Principal, LDA Consulting.

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Executive Summary

Background

This report presents the results of an evaluation of four voluntary Transportation Demand Management (TDM) program elements implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG). The objective of these elements is to improve the travel experience of regional commuters and support regional efforts to meet air quality goals and mitigate growth in vehicle miles traveled. The four TDM program elements covered by this analysis report include:

- **Maryland and Virginia Telework Assistance** – The Maryland portion of this element provides information and assistance to Maryland commuters and employers to further in-home and co-working/telecenter-based telework programs. The Virginia portion provides assistance to employers and employees participating in the Telework!VA (TWVA) program.
- **Guaranteed Ride Home** – Eliminates a barrier to use of alternative modes by providing free rides home in the event of an unexpected personal emergency or unscheduled overtime for commuters who use alternative modes.
- **Employer Outreach** – Provides regional outreach services to encourage large, private-sector and non-profit employers voluntarily to implement commuter assistance strategies that will contribute to reducing vehicle trips to worksites. This program element includes the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling component also is part of this analysis.
- **Mass Marketing** – Involves a large-scale, comprehensive media campaign to inform commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various incentive programs and special promotional events also are part of this program element.

COG/TPB's Commuter Connections program is the central administrator of the four program elements noted above. Commuter Connections also operates the Commuter Operations Center (COC), providing direct commute assistance services, such as carpool and vanpool matching, transit information, and other information on travel services through telephone and internet assistance to commuters. The COC supports each of the four program elements.

When the TDM program elements were first implemented, Commuter Connections and COG/TPB staff elected to undertake significant evaluation for each element. The objective of the evaluation process is to provide timely and meaningful information on the performance of each element to decision-makers and other groups, including the TPB and other regional policy makers; COG program funders; Commuter Connections staff; TDM program partners; and employers and commuters who comprise Commuter Connections' clients. This report summarizes the results of the evaluation activities undertaken by Commuter Connections during the evaluation period and presents the transportation and air quality impacts of the individual program elements and the COC.

This evaluation represents a comprehensive evaluation for these programs. It should be noted, however, that the evaluation is conservative in the sense that it includes credit only for impacts that can be reasonably documented with accepted measurement methods and tools. Note that many of the calculations use data from surveys that are subject to some statistical error, at rates common to such surveys.

Additionally, the TDM program elements included in the analysis do not encompass all the TDM activities currently ongoing in the Washington metropolitan region. Many other organizations, such as states and local jurisdictions, transportation management associations, transit agencies, vanpool vendors, other transportation service providers, employers, commercial and residential building operators, and other organizations or companies also offer services that perform similar functions to the TDM program elements implemented by Commuter Connections.

The impacts of these other TDM services are not addressed in this analysis, but certainly are expected to provide travel and air quality benefits to the region and personal benefits to the commuters who use them.

Summary of Program Element Impacts

The objective of the evaluation is to estimate reductions in vehicle trips (VT), vehicle miles traveled (VMT), and tons of vehicle pollutants (Nitrogen Oxides (NOx), Volatile Organic Compounds (VOC), Particulate Matter (PM2.5), Particulate Matter NOx precursors (PM and NOx), and Carbon Dioxide (CO2)) resulting from implementation of each TDM program element and compare the impacts against the goals established for the program element. The impact results for these measures are shown in Table A for each program element individually. Results for all elements collectively and for the Commuter Operations Center (COC) are presented in Table B.

As shown in Table A, the TDM program elements exceeded the collective goal for VMT reduced by 4% and fell just % short of the goal for vehicle trips reduced. The TDM program elements did not reach the emission goals; the impact for NOx was about 53% under the goal and VOC impact was 35% under the goal, but these deficits were due largely to reductions in the emission factors. The program goals were set in 2006, using 2006 emission factors. Goals for some program elements were re-set since the issuance of the FY2012 – 2014 Commuter Connections TERM Analysis Report in 2014, but the emission factors used in the 2020 evaluation were considerably lower than the factors from 2017 and lower still than the factors used in 2014, reflecting a cleaner vehicle fleet.

When the COC results are added to the impacts of the four program elements impacts, as presented in Table B, the combined impact came within 2.7% of the VMT reduction goal. They fell 7% short of the goal for vehicle trips reduced. The combined program element–COC program impact fell 55% short of the NOx goal and was 40% below the VOC goal. Again, the change in the emission factors affected the emission results.

Where shortfalls occurred against the vehicle trip and VMT reduction goals, they appeared more related to lower than expected commuter participation rates, rather than to overly-optimistic factors on the extent of changes commuters would make, for example in their frequency of alternative mode use. COG revised the program element goals following the 2005 TDM analysis to reflect actual behavior changes that commuters make when using Commuter Connections services. COG again revised goals for some elements following the 2014 and 2017 analyses, to account for additions or deletions to activities or services covered by those program elements.

Three program elements, Telework–Maryland Assistance; the Virginia telework component, Telework!VA; and Mass Marketing, easily met their individual goals for participation and travel impact. A fourth program element, Employer Outreach, nearly achieved the travel goals, falling just 5% short of the goal for vehicle trips and 3% under the VMT goal. The Employer Outreach for Bicycling component met the vehicle trip reduction goal. It did not meet the VMT reduction goals, but the absolute deficit was small.

The impacts for the remaining program element, Guaranteed Ride Home, were 17% short of the goals for both vehicle trips and VMT, primarily due to declining registrations, compared with 2017 and previous years. The Commuter Operations Center and the Software Upgrades component also failed to meet their trip and VMT goals.

Additional details on the calculations for each evaluation element are described in individual program sections of this report. These sections also explore factors that affected the achievement of goals. One factor that is noted here, because it likely affected participation in several program elements, was the coronavirus pandemic, which substantially disrupted commute travel in the last four months of the evaluation period. While some essential workers were still required to commute to their usual job locations, a large segment of the commuting population shifted to remote work from home and some workers were furloughed and not working at all.

With travel to work greatly reduced, fewer commuters sought travel assistance services from Commuter Connections. Thus, the participation counts for services such as GRH and the Commuter Operations Center were lower than usual and the 2020 Bike to Work Day event was cancelled. Employer services also might have been affected, although requests for telework assistance from both employers and commuters appeared to grow, as commuters established remote work procedures.

Table A
Daily Impacts for Individual Program Elements (Jul 2017 – Jun 2020) and Comparison to Goals

TDM Program Element	Participation [1]	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance [2]					
2020 Goal	31,854	11,830	241,209	0.1220	0.0720
Impacts (7/17 – 6/20)	46,254	13,636	308,001	0.0664	0.0522
Net Credit or (Deficit)	**14,400**	**1,806**	**66,792**	**(0.0556)**	**(0.0198)**
Virginia Telework Assistance – Telework! VA [2]					
2020 Goal	1,500	500	9,000	0.0027	0.0021
Impacts (7/17 – 6/20)	1,918	537	9,827	0.0022	0.0019
Net Credit or (Deficit)	**418**	**37**	**827**	**(0.0005)**	**(0.0002)**
Guaranteed Ride Home					
2020 Goal	18,496	6,296	177,568	0.0890	0.0480
Impacts (7/17 – 6/20)	12,944	5,200	147,371	0.0253	0.0154
Net Credit or (Deficit)	**(5,552)**	**(1,096)**	**(30,197)**	**(0.0637)**	**(0.0326)**
Employer Outreach – all employers participating [3]					
2020 Goal	2,031	90,776	1,533,161	0.6170	0.3850
Impacts (7/17 – 6/20)	1,962	85,845	1,489,165	0.2995	0.2297
Net Credit or (Deficit)	**(69)**	**(4,931)**	**(43,996)**	**(0.3175)**	**(0.1553)**
Employer Outreach – new / expanded employer services since July 2017 [3]					
2020 Goal	N/A	N/A	N/A	N/A	N/A
Impacts (7/17 – 6/20)	373	11,565	188,153	0.0383	0.0301
Net Credit or (Deficit)	N/A	N/A	N/A	N/A	N/A
Employer Outreach for Bicycling [3]					
2020 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/17 – 6/20)	570	449	1,886	0.0008	0.0012
Net Credit or (Deficit)	**(20)**	**45**	**(535)**	**(0.0008)**	**(0.0003)**
Mass Marketing					
2020 Goal	23,168	10,809	181,932	0.0850	0.0250
Impacts (7/17 – 6/20)	38,273	14,031	277,511	0.0554	0.0415
Net Credit or (Deficit)	**15,105**	**3,222**	**95,579**	**(0.0296)**	**0.0165**
TDM Program Elements (all collectively)					
2020 Goal		120,211	2,142,870	0.9157	0.5321
Impacts (7/17 – 6/20)		119,249	2,231,875	0.4488	0.3407
Net Credit or (Deficit)		**(962)**	**89,005**	**(0.4669)**	**(0.1914)**

1) Participation refers to number of commuters participating, except for the Employer Outreach program element. For this element, participation equals the number of employers participating.

2) Maryland impacts represent portion of regional telework attributable to TW program activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the program element.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2017 and for Employer Outreach for Bicycling.

Table B
Combined Program Element and COC Impacts (July 2017 – Jun 2020) and Comparison to Goals

TDM Program Element	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Program Elements (all collectively)					
2020 Goal		120,211	2,142,870	0.9157	0.5321
Impacts (7/17 – 6/20)		119,249	2,231,875	0.4488	0.3407
Net Credit or (Deficit)		**(962)**	**89,005**	**(0.4669)**	**(0.1914)**
Commuter Operations Center – Basic Services					
2020 Goal	91,609	24,425	512,637	0.2410	0.1150
Impacts (7/17 – 6/20)	75,651	16,281	375,135	0.0731	0.0523
Net Credit or (Deficit)	**(15,958)**	**(8,144)**	**(137,502)**	**(0.1679)**	**(0.0627)**
Commuter Operations Center – Software Upgrades [1]					
2020 Goal	4,681	2,379	66,442	0.0280	0.0110
Impacts (7/17 – 6/20)	3,536	1,363	40,541	0.0071	0.0044
Net Credit or (Deficit)	**(1,145)**	**(1,016)**	**(25,901)**	**(0.0209)**	**(0.0066)**
All Program Elements plus COC					
2020 Goal		147,015	2,721,949	1.1847	0.6581
Impacts (7/17 – 6/20)		136,893	2,647,551	0.5290	0.3974
Net Credit or (Deficit)		**(10,122)**	**(74,398)**	**(0.6557)**	**(0.2607)**

1) Impacts for Commuter Operations Center – software Upgrades are in addition to the impacts for the Commuter Operations Center – Basic Services. This project was previously part of the Integrated Rideshare program element.

Table C, on the following page, presents annual emission reduction results for PM 2.5, PM 2.5 pre-cursor NOx, and CO2 emissions (Greenhouse Gas Emissions - GHG) for each program element and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections program elements. But COG has been measuring the impacts for other pollutants, thus these results are provided.

As shown, the TDM program elements collectively reduce 7.5 annual tons of PM 2.5, 150 annual tons of PM 2.5 pre-cursor NOx, and 218,000 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 8.8 annual tons of PM 2.5, 177 annual tons of PM 2.5 pre-cursor NOx, and more than 258,000 annual tons of CO2 (greenhouse gas emissions).

Table C
Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Impacts for Individual Program Element

TDM Program Element	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
Maryland Telework Assistance [1]	1.100	22.225	31,602.5
Virginia Telework Assistance (TW!VA) [1]	0.025	0.750	1,015.0
Guaranteed Ride Home	0.451	8.485	13,523.9
Employer Outreach – all employers [2]	4.975	100.450	144,665.4
Employer Outreach – new/expanded employers [2]	0.650	12.850	18,242.4
Employer Outreach for Bicycling	0.000	0.275	214.9
Mass Marketing	0.940	18.617	27,104.8
Program Elements (all collectively)	7.491	150.527	217,911.6
Commuter Operations Center – basic services (not including Software Upgrades)	1.232	24.506	36,448.5
Commuter Operations Center – Software Upgrades	0.125	2.400	3,806.5
All Program Elements plus COC	8.848	177.432	258,166.6

1) Maryland impacts represent portion of regional telework attributable to TW program activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the program element.

2) Impacts for new / expanded employer programs and Employer Outreach for Bicycling are included in the Employer Outreach – all employers.

Finally, Table D compares daily reductions in vehicle trips, VMT, NOx, and VOC from the 2020 TDM program element analysis (July 2017 through June 2020) to results of the 2017 analysis (July 2014 through June 2017). As noted before and as described in the footnotes to the table, the emission factors declined between 2017 and 2020, resulting in decreased emission reductions, even though some of the program elements achieved greater vehicle trip and VMT reductions in 2020 than in 2017.

The impacts for the Mass Marketing program element and for TW!VA were higher in 2020 than in 2017. Employer Outreach for Bicycling impacts also were higher in 2020 than in 2017, although the absolute values for the impacts in both years were relatively small, compared with the impacts for other TDM program elements.

The VMT impact for Maryland Telework Assistance was about 15% lower in the 2020 analysis than in 2017. Guaranteed Ride Home and the Commuter Operations Center both had notably lower impacts in 2020 than in 2017.

Table D
Impacts for Individual Program Elements 7/17– 6/20 Compared with 7/14 – 6/17

TDM Program Element	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance				
July 2017 – June 2020	13,636	308,001	0.066	0.052
July 2014 – June 2017	14,839	361,204	0.096	0.070
Change [1)]	(1,203)	(53,203)	(0.029)	(0.018)
Virginia Telework Assistance – Telework! VA				
July 2017 – June 2020	537	9,827	0.002	0.002
July 2014 – June 2017	490	9,359	0.003	0.002
Change	47	468	(0.001)	0.000
Guaranteed Ride Home				
July 2017 – June 2020	5,200	147,371	0.025	0.015
July 2014 – June 2017	6,398	181,335	0.040	0.023
Change [1)]	(1,198)	(33,964)	(0.015)	(0.008)
Employer Outreach – All services except Employer Outreach for Bicycling				
July 2017 – June 2020	85,396	1,487,279	0.299	0.229
July 2014 – June 2017	102,252	1,839,789	0.473	0.349
Change [1)]	(16,856)	(352,510)	(0.174)	(0.120)
Employer Outreach for Bicycling				
July 2017 – June 2020	449	1,886	0.001	0.001
July 2014 – June 2017	373	1,640	0.001	0.001
Change [1)]	76	246	0.000	0.000
Mass Marketing				
July 2017 – June 2020	14,031	277,511	0.055	0.042
July 2014 – June 2017	10,133	163,250	0.042	0.019
Change [1)]	3,898	114,261	0.013	0.023
All TDM Program Elements (Excluding Commuter Operations Center)				
July 2017 – June 2020	119,249	2,231,875	0.449	0.341
July 2014 – June 2017	134,485	2,556,577	0.654	0.464
Change [1)]	(15,236)	(324,702)	(0.206)	(0.123)
Commuter Operations Center (Basic Services + Software Upgrades)				
July 2017 – June 2020	17,644	415,676	0.080	0.057
July 2014 – June 2017	21,728	452,667	0.116	0.085
Change [1)]	(4,084)	(36,991)	(0.036)	(0.029)

1) Change in emissions is due in part to reduction in emission factors from 2017 to 2020.

Societal Benefits of FY 2018 – FY 2020 Travel and Emissions Impacts

Since its inception in 1997, the Commuter Connections TDM analysis has been undertaken primarily to document travel and emissions impacts of each program element and compare the impacts against the goals set for the elements. This remains a central focus of the analysis for the FY 2018 – FY 2020 analysis. But the program elements likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas emissions reductions, greater mobility, improved road safety, and enhanced transportation system performance.

These benefits have joined congestion and air quality as forces shaping the region's transportation policies, making them also relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs. Documenting these contributions also supports the regional response to the federally-mandated performance-based planning and programming (PBPP) process required of states and MPOs. Under this requirement, MWCOG must track a variety of performance indicators related to transportation system performance, such as hours of peak hour excessive roadway delay.

The FY 2018 – FY 2020 TDM analysis includes an analysis component, which was first added to the FY 2015 – FY 2017 analysis, to estimate regional cost savings generated for selected societal benefits of the travel and emissions impacts generated by the TDM program elements. These benefits include:

- Air pollution/emissions reductions in NOx, VOC, PM 2.5 pollutants
- Reduction in Greenhouse gas emissions/CO2
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

The societal cost savings for each of these benefits was calculated by defining a unit of benefit associated with each type of benefit (e.g., tons of CO2 reduced, and hours of delay reduced for reduction in congestion) and multiplying the benefit units by a unit cost factor (e.g., cost per ton of pollutant or cost per hour of delay). The conversion to benefit units and the unit cost factors for most benefits were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS™) model developed by the Center for Urban Transportation Research. TRIMMS™ estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Appendix 9 defines the methodology used for each benefit and the specific sources used to derive unit benefits and unit costs.

Table E presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TDM program elements and the Commuter Operations Center combined. As shown, the combination of the TDM program elements and Commuter Operations Center generate about $686,050 of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of excess fuel used; this benefit is valued at over $401,500 per day, or about 59% of the total daily benefits. Reduction in hours of travel delay accounts for about 21% of the total daily benefit ($142,913). Noise pollution reduction generates about 9% and the air pollution/Greenhouse gas reduction combined benefits and road safety accident reduction benefits each are responsible for about 6% of the total cost saving.

Table E
Daily Societal Benefit Cost Savings Generated by
FY 2018 – FY 2020 TDM Program Elements and Commuter Operations Center Impacts

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.529 T	$1,612	$853
- VOC	Tons VOC removed	0.397 T	$133	$53
- PM 2.5	Tons PM 2.5 removed	0.040 T	$15,107	$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.710 T	$1,612	$1,145
Greenhouse gases	Tons CO2 removed	1,033 T	$36	$37,176
Noise pollution	Total VMT reduced	2,647,551 VMT	$0.0223	$59,040
Congestion	Hours of delay reduced	5,277 hours	$27.08	$142,913
Excess fuel used	Gallons of fuel saved	147,086 gal	$2.73	$401,545
Health/safety [1)]	Accidents avoided/1 M VMT	2.678 acc.	$15,952	$42,721
All benefits				**$686,050**

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

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Section 1 Introduction

This report presents the results of an evaluation of four voluntary Transportation Demand Management (TDM) program elements implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG). The objective of these elements is to improve the travel experience of regional commuters and support regional efforts to meet air quality goals and mitigate growth in vehicle miles traveled. This evaluation documents transportation and air quality impacts for the three-year evaluation period between July 1, 2017 and June 30, 2020 (FY 2017 – FY 2020), for the following TDM program elements:

- **Maryland and Virginia Telework Assistance** – The Maryland portion of this element provides information and assistance to Maryland commuters and employers to further in-home and co-working/telecenter-based telework programs. The Virginia portion provides assistance to employers and employees participating in the Telework!VA (TWVA) program.
- **Guaranteed Ride Home** – Eliminates a barrier to use of alternative modes by providing free rides home in the event of an unexpected personal emergency or unscheduled overtime for commuters who use alternative modes.
- **Employer Outreach** – Provides regional outreach services to encourage large, private-sector and non-profit employers voluntarily to implement commuter assistance strategies that will contribute to reducing vehicle trips to worksites. This program element includes the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling component also is part of this analysis.
- **Mass Marketing** – Involves a large-scale, comprehensive media campaign to inform commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various incentive programs and special promotional events also are part of this program element.

COG/TPB's Commuter Connections program, which operates an ongoing regional commute assistance program, is responsible for implementation of the TDM program elements noted above. Commuter Connections is the central administrator of these elements, but works with partner organizations, such as local jurisdiction commute programs and transportation management associations (TMAs) to implement them.

Commuter Connections also operates the Commuter Operations Center (COC), providing direct commute assistance services, such as carpool and vanpool matching, transit, telework, and Park & Ride information, and other information on travel services that are most cost-effectively provided by a central agency, through telephone and internet assistance to commuters. Other services are offered by local organizations and coordinated regionally by the Commuter Connections Subcommittee, a coordinating body comprised of state and local government agencies in the region, several large federal employers, several public-private Transportation Management Associations (TMAs), and other partner organizations.

When the TDM program elements were first implemented, Commuter Connections and COG/TPB staff elected to undertake significant evaluation for each element. The purpose of the evaluation was to develop timely and meaningful information for regional transportation and air quality decision-makers, COG staff, COG program funders, and state and local commute assistance program managers to guide sound decision-making about the program elements.

This report summarizes the results of the evaluation activities undertaken by Commuter Connections during the evaluation period and presents the transportation and air quality impacts of the individual program elements. The report also documents impacts of the commuter assistance activities of the Commuter Operations Center, which COG operates to provide a basic level of commuter information and ridesharing assistance services throughout the Washington metropolitan region. Results from this report will be used to support the region's transportation and environmental planning activities and the region's congestion management process.

This report represents a comprehensive evaluation for these programs. It should be noted, however, that the results are conservative in the sense that credit is included only for impacts that can be reasonably documented with accepted measurement methods and tools. Many of the calculations use data from surveys that are subject to some statistical error, at rates common to such surveys.

Additionally, the TDM program elements included in the analysis do not encompass all the TDM activities currently ongoing in the Washington metropolitan region. Many other organizations, such as states and local jurisdictions, transportation management associations, transit agencies, vanpool vendors, other transportation service providers, employers, commercial and residential building operators, and other organizations or companies also offer services that perform similar functions to the TDM program elements implemented by Commuter Connections. The impacts of these other TDM services are not addressed in this analysis, but certainly are expected to provide travel and air quality benefits to the region and personal benefits to the commuters who use them.

In June 1997, a consultant team was retained to assist Commuter Connections to define an evaluation methodology. This methodology was used for the first triennial evaluation in 1999. In 2001, 2004, 2007, 2010, 2013, 2016, and 2019, the consultants, along with Commuter Connections, expanded and enhanced the methodologies, data collection tools, and data sources to expand the coverage, corroborate assumptions, and enhance the reliability of the evaluation estimates. Section 3 presents highlights of the changes made to update the framework methodology. Readers who desire additional details on the methodology are directed to the report entitled, "Commuter Connections' Transportation Demand Management Evaluation Project: Transportation Demand Management (TDM) Program Elements Revised Evaluation Framework, FY 2018 – FY 2020." This document (*TDM Evaluation Framework, 2018-2020*) is available on-line at www.commuterconnections.org.

The data collection activities recommended in the Evaluation Framework report were undertaken by COG/TPB staff or by data collection consultants retained by COG. This report summarizes the results of the evaluation activities and analysis. The report also summarizes the transportation and air quality impacts of commuter assistance activities of the Commuter Operations Center. The COC is not an adopted TDM program element but is included in this analysis because its operation supports most all of the regional Commuter Connections program elements.

Organization of the Report

This TDM Analysis Report is divided into nine sections following this Introduction section:

- Section 2 Overall Summary of Results
- Section 3 Highlights of Revised Evaluation Methodology
- Section 4 Maryland and Virginia Telework Assistance
- Section 5 Guaranteed Ride Home
- Section 6 Employer Outreach
- Section 7 Mass Marketing
- Section 8 Commuter Operations Center
- Section 9 Summary of TDM Program Element Impacts

Section 2 summarizes the overall results for each TDM program element individually and for all program elements plus the Commuter Operations Center collectively. Section 3 presents highlights of the revised evaluation methodology developed in 2019 for the FY 2018 – FY 2020 evaluation period. Sections 4 through 7 present for each individual program element, a brief description of the element and its purpose, an overview of the methodology used to estimate the element's impacts and the data used in the analysis, and a comparison of the measured impacts against the goals set for the element. Section 8 presents similar information for the Commuter Operations Center. The final section, Section 9, presents general conclusions from the analysis.

Summaries of the calculations of transportation and air quality impacts of individual program elements also are included in appendices following the body of the report.

Section 2 Summary of TDM Analysis Results

The objective of the evaluation is to estimate reductions in vehicle trips (VT), vehicle miles traveled (VMT), and tons of vehicle pollutants resulting from implementation of each program element between July 2017 and June 2020 and to compare these impacts against the goals established for the TDM program elements. The Revised Evaluation Framework document finalized in March 2019 also recommended that other performance measures be tracked for these TDM program elements to assess levels of program participation, utilization, satisfaction, and cost-effectiveness. These measures are tracked by Commuter Connections on a monthly and annual basis for the program elements and are reported in other documents.

Travel and Emissions Impacts Overall and By Program Element

Tables 1 and 2 present impact results for reductions in the following impacts and comparisons to the goals set for the impact measures:

- Vehicle trips (VT)
- Vehicle miles traveled (VMT)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOC)

As shown in Table 1, the TDM program elements exceeded the collective goal for VMT reduced by 4% and fell just % short of the goal for vehicle trips reduced. The TDM program elements did not reach the emission goals; the impact for NOx was about 53% under the goal and VOC impact was 35% under the goal, but these deficits were due largely to reductions in the emission factors. The program goals were set in 2006, using 2006 emission factors. Goals for some program elements were re-set since the issuance of the FY2012 – 2014 Commuter Connections TERM Analysis Report in 2014, but the emission factors used in the 2020 evaluation were considerably lower than the factors from 2017 and lower still than the factors used in 2014, reflecting a cleaner vehicle fleet.

When the COC results are added to the impacts of the four program elements impacts, as presented in Table 2, the combined impact came within 2.7% of the VMT reduction goal. They fell 7% short of the goal for vehicle trips reduced. The combined program element–COC program impact fell 55% short of the NOx goal and was 40% below the VOC goal. Again, the change in the emission factors affected the emission results.

Where shortfalls occurred against the vehicle trip and VMT reduction goals, they appeared more related to lower than expected commuter participation rates, rather than to overly-optimistic factors on the extent of changes commuters would make, for example in their frequency of alternative mode use. COG revised the program element goals following the 2005 TDM analysis to reflect actual behavior changes that commuters make when using Commuter Connections services. COG again revised goals for some elements following the 2014 and 2017 analyses, to account for additions or deletions to activities or services covered by those program elements.

Three program elements, Telework–Maryland Assistance; the Virginia telework component, Telework!VA; and Mass Marketing, easily met their individual goals for participation and travel impact. A fourth program element, Employer Outreach, nearly achieved the travel goals, falling just 5% short of the goal for vehicle trips and 3% under the VMT goal. The Employer Outreach for Bicycling component met the vehicle trip reduction goal. It did not meet the VMT reduction goals, but the absolute deficit was small.

The impacts for the remaining program element, Guaranteed Ride Home, were 17% short of the goals for both vehicle trips and VMT, primarily due to declining registrations, compared with 2017 and previous years. The Commuter Operations Center and the Software Upgrades component also failed to meet their trip and VMT goals.

Table 1
Daily Impacts for Individual Program Elements (Jul 2017 – Jun 2020) and Comparison to Goals

TDM Program Element	Participation [1]	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance [2]					
2020 Goal	31,854	11,830	241,209	0.1220	0.0720
Impacts (7/17 – 6/20)	46,254	13,636	308,001	0.0664	0.0522
Net Credit or (Deficit)	**14,400**	**1,806**	**66,792**	**(0.0556)**	**(0.0198)**
Virginia Telework Assistance – Telework! VA [2]					
2020 Goal	1,500	500	9,000	0.0027	0.0021
Impacts (7/17 – 6/20)	1,918	537	9,827	0.0022	0.0019
Net Credit or (Deficit)	**418**	**37**	**827**	**(0.0005)**	**(0.0002)**
Guaranteed Ride Home					
2020 Goal	18,496	6,296	177,568	0.0890	0.0480
Impacts (7/17 – 6/20)	12,944	5,200	147,371	0.0253	0.0154
Net Credit or (Deficit)	**(5,552)**	**(1,096)**	**(30,197)**	**(0.0637)**	**(0.0326)**
Employer Outreach – all employers participating [3]					
2020 Goal	2,031	90,776	1,533,161	0.6170	0.3850
Impacts (7/17 – 6/20)	1,962	85,845	1,489,165	0.2995	0.2297
Net Credit or (Deficit)	**(69)**	**(4,931)**	**(43,996)**	**(0.3175)**	**(0.1553)**
Employer Outreach – new / expanded employer services since July 2017 [3]					
2020 Goal	N/A	N/A	N/A	N/A	N/A
Impacts (7/17 – 6/20)	373	11,565	188,153	0.0383	0.0301
Net Credit or (Deficit)	N/A	N/A	N/A	N/A	N/A
Employer Outreach for Bicycling [3]					
2020 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/17 – 6/20)	570	449	1,886	0.0008	0.0012
Net Credit or (Deficit)	**(20)**	**45**	**(535)**	**(0.0008)**	**(0.0003)**
Mass Marketing					
2020 Goal	23,168	10,809	181,932	0.0850	0.0250
Impacts (7/17 – 6/20)	38,273	14,031	277,511	0.0554	0.0415
Net Credit or (Deficit)	**15,105**	**3,222**	**95,579**	**(0.0296)**	**0.0165**
TDM Program Elements (all collectively)					
2020 Goal		120,211	2,142,870	0.9157	0.5321
Impacts (7/17 – 6/20)		119,249	2,231,875	0.4488	0.3407
Net Credit or (Deficit)		**(962)**	**89,005**	**(0.4669)**	**(0.1914)**

1) Participation refers to number of commuters participating, except for the Employer Outreach program element. For this element, participation equals the number of employers participating.

2) Maryland impacts represent portion of regional telework attributable to TW program activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the program element.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2017 and for Employer Outreach for Bicycling.

Table 2
Combined Program Element and COC Impacts (July 2017 – Jun 2020) and Comparison to Goals

TDM Program Element	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Program Elements (all collectively)					
2020 Goal		120,211	2,142,870	0.9157	0.5321
Impacts (7/17 – 6/20)		119,249	2,231,875	0.4488	0.3407
Net Credit or (Deficit)		**(962)**	**89,005**	**(0.4669)**	**(0.1914)**
Commuter Operations Center – Basic Services					
2020 Goal	91,609	24,425	512,637	0.2410	0.1150
Impacts (7/17 – 6/20)	75,651	16,281	375,135	0.0731	0.0523
Net Credit or (Deficit)	**(15,958)**	**(8,144)**	**(137,502)**	**(0.1679)**	**(0.0627)**
Commuter Operations Center – Software Upgrades [1]					
2020 Goal	4,681	2,379	66,442	0.0280	0.0110
Impacts (7/17 – 6/20)	3,536	1,363	40,541	0.0071	0.0044
Net Credit or (Deficit)	**(1,145)**	**(1,016)**	**(25,901)**	**(0.0209)**	**(0.0066)**
All Program Elements plus COC					
2020 Goal		147,015	2,721,949	1.1847	0.6581
Impacts (7/17 – 6/20)		136,893	2,647,551	0.5290	0.3974
Net Credit or (Deficit)		**(10,122)**	**(74,398)**	**(0.6557)**	**(0.2607)**

1) Impacts for Commuter Operations Center – software Upgrades are in addition to the impacts for the Commuter Operations Center – Basic Services. This project was previously part of the Integrated Rideshare program element.

Additional details on the calculations for each evaluation element are described in individual program sections of this report. These sections also explore factors that affected the achievement of goals. One factor that is noted here, because it likely affected participation in several program elements, was the coronavirus pandemic, which substantially disrupted commute travel in the last four months of the evaluation period. While some essential workers were still required to commute to their usual job locations, a large segment of the commuting population shifted to remote work from home and some workers were furloughed and not working at all.

With travel to work greatly reduced, fewer commuters sought travel assistance services from Commuter Connections. Thus, the participation counts for services such as GRH and the Commuter Operations Center were lower than usual and the 2020 Bike to Work Day event was cancelled. Employer services also might have been affected, although requests for telework assistance from both employers and commuters appeared to grow, as commuters established remote work procedures.

Table 3, on the following page, presents annual emission reduction results for PM 2.5, PM 2.5 pre-cursor NOx, and CO2 emissions (Greenhouse Gas Emissions - GHG) for each program element and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections program elements. But COG has been measuring the impacts for other pollutants, thus these results are provided.

As shown, the TDM program elements collectively reduce 7.5 annual tons of PM 2.5, 150 annual tons of PM 2.5 pre-cursor NOx, and 218,000 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 8.8 annual tons of PM 2.5, 177 annual tons of PM 2.5 pre-cursor NOx, and more than 258,000 annual tons of CO2 (greenhouse gas emissions).

Table 3
Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Impacts for Individual Program Element

TDM Program Element	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
Maryland Telework Assistance [1]	1.100	22.225	31,602.5
Virginia Telework Assistance (TW!VA) [1]	0.025	0.750	1,015.0
Guaranteed Ride Home	0.451	8.485	13,523.9
Employer Outreach – all employers [2]	4.975	100.450	144,665.4
Employer Outreach – new/expanded employers [2]	0.650	12.850	18,242.4
Employer Outreach for Bicycling	0.000	0.275	214.9
Mass Marketing	0.940	18.617	27,104.8
Program Elements (all collectively)	7.491	150.527	217,911.6
Commuter Operations Center – basic services (not including Software Upgrades)	1.232	24.506	36,448.5
Commuter Operations Center – Software Upgrades	0.125	2.400	3,806.5
All Program Elements plus COC	8.848	177.432	258,166.6

1) Maryland impacts represent portion of regional telework attributable to TW program activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the program element.

2) Impacts for new / expanded employer programs and Employer Outreach for Bicycling are included in the Employer Outreach – all employers.

FY 2018 – FY 2020 Impacts Compared with Impacts from FY 2015 – FY 2017

Finally, Table 4 compares daily reductions in vehicle trips, VMT, NOx, and VOC from the 2020 TDM program element analysis (July 2017 through June 2020) to results of the 2017 analysis (July 2014 through June 2017). As noted before and as described in the footnotes to the table, the emission factors declined between 2017 and 2020, resulting in decreased emission reductions, even though some of the program elements achieved greater vehicle trip and VMT reductions in 2020 than in 2017.

The impacts for the Mass Marketing program element and for TW!VA were higher in 2020 than in 2017. Employer Outreach for Bicycling impacts also were higher in 2020 than in 2017, although the absolute values for the impacts in both years were relatively small, compared with the impacts for other TDM program elements.

The VMT impact for Maryland Telework Assistance was about 15% lower in the 2020 analysis than in 2017. Guaranteed Ride Home and the Commuter Operations Center both had notably lower impacts in 2020 than in 2017.

Table 4
Impacts for Individual Program Elements 7/17– 6/20 Compared with 7/14 – 6/17

TDM Program Element	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance				
July 2017 – June 2020	13,636	308,001	0.066	0.052
July 2014 – June 2017	14,839	361,204	0.096	0.070
Change [1)]	(1,203)	(53,203)	(0.029)	(0.018)
Virginia Telework Assistance – Telework! VA				
July 2017 – June 2020	537	9,827	0.002	0.002
July 2014 – June 2017	490	9,359	0.003	0.002
Change	47	468	(0.001)	0.000
Guaranteed Ride Home				
July 2017 – June 2020	5,200	147,371	0.025	0.015
July 2014 – June 2017	6,398	181,335	0.040	0.023
Change [1)]	(1,198)	(33,964)	(0.015)	(0.008)
Employer Outreach – All services except Employer Outreach for Bicycling				
July 2017 – June 2020	85,396	1,487,279	0.299	0.229
July 2014 – June 2017	102,252	1,839,789	0.473	0.349
Change [1)]	(16,856)	(352,510)	(0.174)	(0.120)
Employer Outreach for Bicycling				
July 2017 – June 2020	449	1,886	0.001	0.001
July 2014 – June 2017	373	1,640	0.001	0.001
Change [1)]	76	246	0.000	0.000
Mass Marketing				
July 2017 – June 2020	14,031	277,511	0.055	0.042
July 2014 – June 2017	10,133	163,250	0.042	0.019
Change [1)]	3,898	114,261	0.013	0.023
All TDM Program Elements (Excluding Commuter Operations Center)				
July 2017 – June 2020	119,249	2,231,875	0.449	0.341
July 2014 – June 2017	134,485	2,556,577	0.654	0.464
Change [1)]	(15,236)	(324,702)	(0.206)	(0.123)
Commuter Operations Center (Basic Services + Software Upgrades)				
July 2017 – June 2020	17,644	415,676	0.080	0.057
July 2014 – June 2017	21,728	452,667	0.116	0.085
Change [1)]	(4,084)	(36,991)	(0.036)	(0.029)

1) Change in emissions is due in part to reduction in emission factors from 2017 to 2020.

Societal Benefits of FY 2018 – FY 2020 Travel and Emissions Impacts

Since its inception in 1997, the Commuter Connections TDM analysis has been undertaken primarily to document travel and emissions impacts of each program element and compare the impacts against the goals set for the elements. This remains a central focus of the analysis for the FY 2018 – FY 2020 analysis. But the program elements likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas emissions reductions, greater mobility, improved road safety, and enhanced transportation system performance.

These benefits have joined congestion and air quality as forces shaping the region's transportation policies, making them also relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs. Documenting these contributions also supports the regional response to the federally-mandated performance-based planning and programming (PBPP) process required of states and MPOs. Under this requirement, MWCOG must track a variety of performance indicators related to transportation system performance, such as hours of peak hour excessive roadway delay.

The FY 2018 – FY 2020 TDM analysis includes an analysis component, which was first added to the FY 2015 – FY 2017 analysis, to estimate regional cost savings generated for selected societal benefits of the travel and emissions impacts generated by the TDM program elements. These benefits include:

- Air pollution/emissions reductions in NOx, VOC, PM 2.5 pollutants
- Reduction in Greenhouse gas emissions/CO2
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

The societal cost savings for each of these benefits was calculated by defining a unit of benefit associated with each type of benefit (e.g., tons of CO2 reduced, and hours of delay reduced for reduction in congestion) and multiplying the benefit units by a unit cost factor (e.g., cost per ton of pollutant or cost per hour of delay). The conversion to benefit units and the unit cost factors for most benefits were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS™) model developed by the Center for Urban Transportation Research. TRIMMS™ estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Appendix 9 defines the methodology used for each benefit and the specific sources used to derive unit benefits and unit costs.

Table 5 presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TDM program elements and the Commuter Operations Center combined. As shown, the combination of the TDM program elements and Commuter Operations Center generate about $686,050 of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of excess fuel used; this benefit is valued at over $401,000 per day, or about 59% of the total daily benefits. Reduction in hours of travel delay accounts for about 21% of the total daily benefit ($142,913). Noise pollution reduction generates about 9% and air pollution/Greenhouse gas reduction benefits and road safety accident reduction benefits each are responsible for about 6% of the total cost saving.

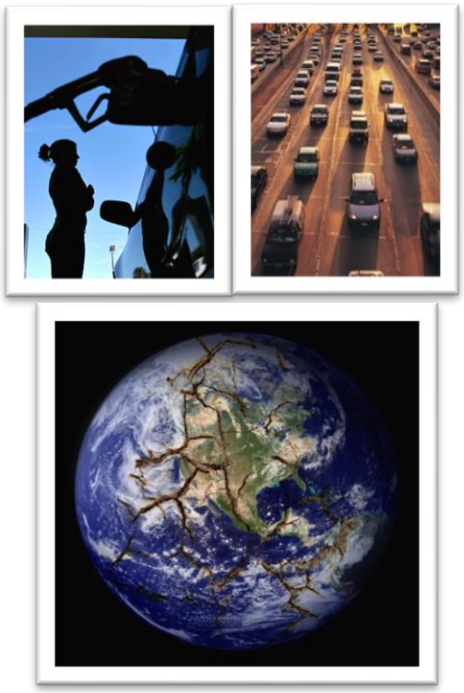
Table 5
Daily Societal Benefit Cost Savings Generated by
FY 2018 – FY 2020 TDM Program Elements and Commuter Operations Center Impacts

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.529 T	$1,612	$853
- VOC	Tons VOC removed	0.397 T	$133	$53
- PM 2.5	Tons PM 2.5 removed	0.040 T	$15,107	$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.710 T	$1,612	$1,145
Greenhouse gases	Tons CO2 removed	1,033 T	$36	$37,176
Noise pollution	Total VMT reduced	2,647,551 VMT	$0.0223	$59,040
Congestion	Hours of delay reduced	5,277 hours	$27.08	$142,913
Excess fuel used	Gallons of fuel saved	147,086 gal	$2.73	$401,545
Health/safety [1)]	Accidents avoided/1 M VMT	2.678 acc.	$15,952	$42,721
All benefits				**$686,050**

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

Section 3 Highlights of Revised Evaluation Methodology

Background



In 1997, consultants selected by COG developed an evaluation framework to guide the collection and analysis of data to estimate travel and air quality impacts of TDM program elements administered by Commuter Connections. This methodology described evaluation objectives, performance measures for each program element, data needs and data collection tools and sources, and analysis and calculation steps to be used to estimate travel, air quality, energy, and consumer cost impacts of the elements. The framework also presented recommendations for the evaluation schedule, responsibilities, and reporting of results to maintain and utilize information produced through the evaluation process.

The methodology was designed to collect sufficient data, using recognized and accepted survey and tracking techniques, to allow COG to measure TDM program elements' performance with confidence, but also in an efficient manner. The first program element analysis, conducted in 1999, reinforced the view that data collection and evaluation for TDM programs can be challenging, especially when the programs are voluntary. Reliable data can be difficult to assemble, assumptions may need to be made using proxy data, and factors outside the program can influence results.

Since that first evaluation, the data collection and analysis methodologies evolved to enhance the accuracy, rigor, coverage, and reliability of the evaluations. A revised methodology was prepared in 2001, reflecting these recommendations. The methodology has been updated triennially, in 2001, 2004, 2007, 2010, 2013, 2016, and 2019, following triennial evaluations, to enhance the analysis results.

This section identifies key enhancements that were made to the methodology since the 2017 TDM Analysis Report was completed and discusses the overall rigor of the evaluation framework as compared to other regions. Overall, the TDM evaluation process employed for this analysis is among the most rigorous and comprehensive in the United States.

Evaluation Methodology Overview

Evaluation Principles

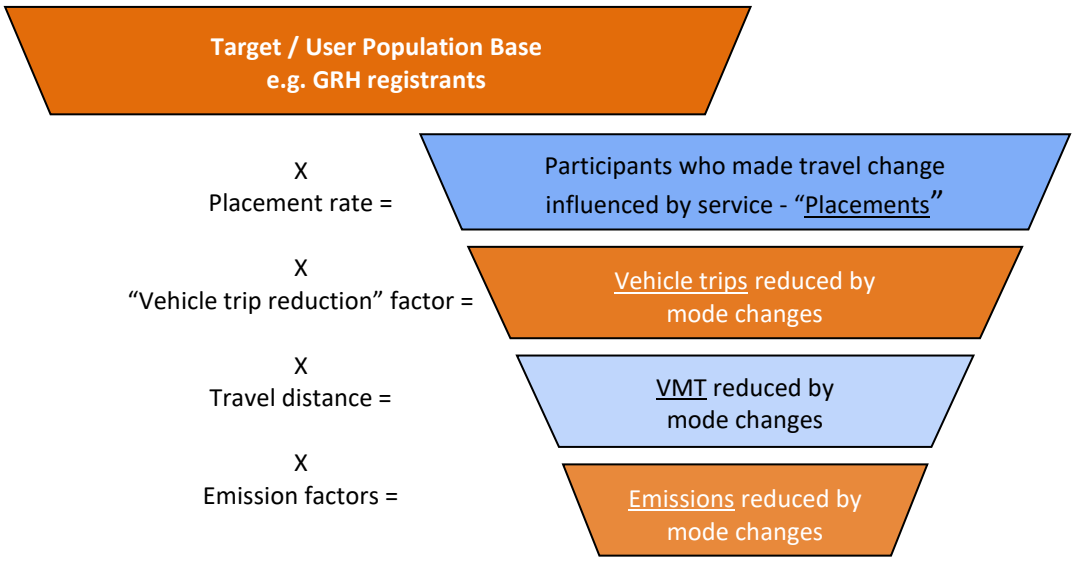
The TDM evaluation process was established on several key evaluation principles that formed the foundation for the Evaluation Framework and that have guided the process since 1997. Some of those principles, which have since been adopted by other regions evaluating TDM programs, include:

- Provide sound, definitive, and useful information about the results of the program
- Assure objective evaluation by using a third-party (other than a funding or implementing agent)
- Avoid double counting by separating out the impacts of individual program elements
- Report only those impacts associated with the program element, and not impacts of commuter services that were in place prior to the adoption of the program elements being evaluated
- Follow accepted and recognized evaluation techniques
- Be rigorous, ongoing, resource efficient, unobtrusive for COG partners, and compatible with regional, state, and national practices

Evaluation Methodology Steps

The calculation of Commuter Connection's program impacts is based on a step-by-step methodology that estimates transportation and air quality benefits generated by the program elements. The methodology calls for a series of "multiplier factors," derived primarily from survey data, to be applied to a known number of commuters who might be influenced or assisted by a program element to make a travel pattern change (population base). The result of these step-by-step calculations is an estimate of the numbers of vehicle trips, VMT, and emissions reduced through commute changes made by commuters after contact with the program element (Figure 1).

Figure 1: Impact Calculation Multipliers Series



For most program elements, the population base is commuters who participate in or use the program service, although in a few cases, the population is all regional commuters. The methodology requires an accurate documentation of the participation in each element and an accurate count of other population bases. This is accomplished primarily by program participant tracking performed by Commuter Connections staff and survey results.

The methodology then applies five primary calculation factors, derived from surveys of the populations of interest, to the population base. Each program element has a unique set of factors, depending on the characteristics of the element and its users, but the basic calculation method is the same for all elements. The calculation factors and the calculation steps are briefly described below.

1. Estimate "placement rate" and "influenced placement rate"
   Placement rate refers to the percentage of the population base "placed" in an alternative mode after receiving a service. Placement rates are typically estimated from survey data of a sample of the population and vary from one service to another, depending on the characteristics of the service and population.

   To collect placement rate data, service users are asked several questions:

   - How do you travel now—what modes do you use and how many days per week do you use them?
   - Did you make any changes in your travel since you received "X" service?
   - How did you travel before you received this service?
   - Did the service encourage or assist you to make this change?

Users who made a travel change are considered "placements." For most elements, two rates were estimated, distinguished by the time the service user used the new mode after shifting. The *Continued* rate represents users who

shifted to a new alternative mode and continued using the new mode. The *Temporary* rate represents users who tried a new alternative mode but returned to original mode within the evaluation period. Temporary changes are credited only for the duration of time the new mode was used.

2. Estimate the number of new alternative mode placements
   Step 2 estimates the number of program element users who were influenced to start or increase use of alternative modes. It was calculated as:

   Total Population base x Placement rate (from Step 1)

3. Estimate the vehicle trip reduction factor for new placements
   Next, the vehicle trip reduction (VTR) factor is estimated for each element. The VTR factor is equal to the average daily vehicle trips reduced per placement, taking into account three types of changes:

   1) Shifts to an alternative mode, either from driving alone or from another alternative mode
   2) Increased use of alternative modes
   3) Increase in the number of riders in an existing carpool or vanpool

   The VTR factor combines the trip reduction results of all placements into an average reduction per placement. Note that shifts from alternative modes to drive alone were not included in the VTR factor, since these changes are typically not caused or motivated by the program element.

4. Estimate vehicle trips reduced
   The number of daily vehicle trips reduced for the program element was estimated by multiplying the number of alternative mode placements by the element's VTR factor:

   Total placements (from Step 2) x VTR factor (from Step 3)

5. Estimate vehicle miles traveled (VMT) reduced
   The daily VMT reduced was calculated by multiplying the number of daily vehicle trips reduced by the average travel distance for program element users who made a travel change.

   Total vehicle trips reduced (from Step 4) x one-way travel distance

6. Adjust vehicle trips and VMT for access mode
   This step adjusts the vehicle trip and VMT reductions to account for commuters who drive alone to where they meet a rideshare partner or board a bus or train. This step eliminates "cold starts" from the emission analysis. The "adjusted" vehicle trips reduced and VMT reduced, rather than the initial totals, were used to calculate emissions reduced.

7. Estimate emissions reduced
   Daily emissions reduced by mode shifts were estimated by multiplying regional emission factors by the number of vehicle trips and VMT reduced. The emissions factors were obtained from Commuter Connections for FY 2020 and were consistent with the regional planning process. The emissions factors account for emissions created from a "cold start," when a vehicle is first started, a "hot soak," that occur when the vehicle is later turned off, and the emissions generated per mile of travel by a warmed-up vehicle. Daily emissions reductions were calculated for NOx and VOC emissions in grams and converted to tons by dividing by 907,185 grams per ton. Annual emissions reductions were calculated for PM 2.5, PM 2.5 pre-cursor NOX, and CO2.

Adjusted vehicle trips reduced (from Step 6) x Trip emission factor
Adjusted VMT reduced (from Step 6) x VMT (running) emission factor

8. Estimate the energy savings
   Energy savings is reported as gallons of gasoline saved and was estimated by multiplying the VMT reduced by an average fuel consumption factor for the regional mix of light duty vehicles.

These steps were established in the evaluation framework developed in 1997 and remained largely unchanged for the subsequent evaluations. They also will be applied to the FY 2018 – FY 2020 evaluation described in this report.

Key Evaluation Issues

Several other issues are noted below, which relate to the high level of rigor build into the evaluation process:

- Avoid Double Counting – The evaluation separates the impacts of individual Commuter Connections TDM program elements and applies discount factors to avoid overestimating benefits when a commuter uses more than one of the program element services. For example, carpools might be formed as a joint result of online ridematching and GRH. These impacts must either be credited to one of the two program elements or divided between the elements in proportion to their respective influences in encouraging the change. Program benefits are not necessarily additive.
- Separate Impacts of Program Elements – Similarly, the evaluation separates the impacts of Commuter Operations Center "basic" services from the impacts of the other TDM program elements. The method for attributing impacts to a specific element or service is discussed in Section 6. This is especially relevant for the Mass Marketing program element, because its impacts can be "direct," meaning the marketing alone motivated an alternative mode shift, or "referred," meaning the marketing influenced commuters to utilize another Commuter Connections program, such as GRH or ridematching. In such cases, the travel and air quality impacts will be assigned to the element or to the Commuter Operations Center, based on their respective influences.
- Account for Commute Mode Prior to Change – Prior mode is an important variable in this evaluation, because a shift to an alternative mode does not always mean a vehicle trip was eliminated. Vehicle trips are reduced only in three cases: 1) the commuter shifts from driving alone to an alternative mode, 2) the commuter increases the frequency of use of an alternative mode, or 3) the commuter shifts to a higher-occupancy mode (e.g., from carpool to vanpool or vanpool to transit). Appendix 1 illustrates the calculation of the vehicle trip reduction (VTR) factor used to convert the number of alternative modes placements into the number of vehicle trips reduced, taking into account various types of before-after alternative mode combinations.
- Account for Access Mode to Transit and Carpool/Vanpool – For emission evaluation purposes, it is necessary to know the access mode of carpoolers, vanpoolers, and transit riders, that is, how commuters who use these modes travel from home to Park & Ride lots, transit stops, or other places where they meet rideshare partners or board a bus or train. Access mode is a minor issue in the evaluation of VMT reduction, because access trips generally account for a very small portion of the total miles between home and work and the alternative mode generally is used for the most congested and longest portion of the trip. However, commuters who drive alone to the meeting point still make a vehicle trip and accumulate some drive-alone VMT, which must be subtracted from the vehicle trips reduced and VMT reduced in the emissions analysis.
- Apply Life-cycle Assessment to Mode Shifts to Capture the Full Duration of Benefits for TDM Impacts – In Commuter Connections' TDM evaluations prior to 2017, mode shifts motivated by TDM program elements during the evaluation period were not carried over to the next evaluation cycle. But numerous surveys conducted for past TDM analyses suggested that mode shifts extended beyond three years, so additional impacts could be retained from one 3-year evaluation cycle to the next. To address this opportunity, in 2016, Commuter Connections conducted a new "Retention Rate" survey to estimate the share of past service users who continued to use alternative modes into the current cycle.

The survey interviewed Commuter Connections online system users and GRH users who last participated in these programs prior to the start of the evaluation period. Users were asked about their current modes, how long they had used their current modes, what Commuter Connections services they received, and if and how those services influenced them to continue to use alternative modes. The survey data were used to develop "retained" placement rates and other factors for the GRH program element and for the Commuter Operations Center and the 2017 TDM analysis calculated "retained" impact credits for these two programs. More details on these factors are provided in the GRH and Commuter Operations Center sections of this report and in the appendices detailing the calculations of those Commuter Connections programs.

FY 2018 – FY 2020 Revised Evaluation Framework

In general, the TDM analysis approaches documented in the FY 2015 – FY 2017 TDM Analysis Report were used as the basis for the evaluation methods applied in the FY 2018 – FY 2020 evaluation. But the Revised Evaluation Framework for FY 2018 – FY 2020 identified a few modifications for the current evaluation period. A brief summary of key methodology issues and approaches is presented below by program element. Further details of each approach are presented in Sections 4 – 7 for each individual program element.

- Maryland and Virginia Telework Assistance – The Telework program element is comprised of resources to help employers, commuters, and program partners initiate and expand telework programs. In evaluating teleworking, several travel changes need to be examined, including telework frequency, the mode on non-telework days, and mode and travel distance to telework locations other than home. The Telework program element includes impacts for two programs, one in Maryland and a second in Virginia.
  - The *Maryland component* of the impacts includes assistance directly to commuters who live and/or work in Maryland and assistance to employers with Maryland worksites. These impacts are estimated, respectively, from the State of the Commute survey and from surveys conducted with Maryland employers that received telework information or assistance from Commuter Connections.
  - The *Virginia component* of the impacts includes extensive telework development consulting provided to selected Virginia employers that participate in the Telework! VA program. Impacts for this Telework component are estimated from baseline and follow-up surveys of employees at participating Virginia worksites.
  - Commuter Connections also continues to provide telework information to commuters who live and/or work outside Maryland and who work for employers that do not participate in TW!VA. Impacts of this assistance are included in the Commuter Operations Center impacts.

- Guaranteed Ride Home (GRH) – The basic methodology for GRH follows the format used for FY 2015 – FY 2017. This includes both new registrations and re-registrations in the program, as well as a "retained" impact component for new alternative mode GRH registrants who ended their participation in GRH prior to the start of the current evaluation period, but who continued to use alternative modes to commute into the FY 2018 – FY 2020 evaluation period. This is accomplished by estimating the number of past GRH participants and applying a "retention" placement rate and other multiplier factors to the past participant count.

- Employer Outreach – Employer Outreach impacts are estimated using the EPA COMMUTER model and worksite TDM program details compiled in the Employer Outreach ACT! database. The model inputs require the starting mode split at the worksite, before TDM services are applied. Because most employers in the program have not conducted a baseline survey, the analysis applies default mode split distributions to these worksites, consistent with the type of employer and transit accessibility conditions at the site. These defaults are derived as the average of mode splits for employers that have conducted baseline surveys.

  In past evaluations, the default values included baseline surveys that dated to 1997. To create default values that more closely represent current infrastructure and travel opportunities, the default values were recalculated, excluding surveys that were conducted prior to 2006. Additionally, more than 100 baseline worksite surveys that had been conducted by local jurisdiction staff after 2005, but which had not been entered into the employer database were incorporated into the default calculation in 2020, expanding the total number

of employers on which the default values were based, and further expanding surveys that reflected more recent local conditions and raising the confidence of the default calculations. Overall, the actual default values changed only slightly, however, suggesting current baseline (pre-TDM) conditions are similar to those applied to past TDM evaluations.

- Mass Marketing – The basic methodology for Mass Marketing follows the format used for FY 2015 – FY 17 and includes the same TDM program activities of commute program/service advertising, two promotional events (Bike to Work Day, Car Free Day), and two incentive programs ('Pool Rewards for carpool and 'Pool Rewards for vanpool). The only change in the methodology for FY 2018 – FY 2020, is that the multiplier factors for Car Free Day (CFD), which were previously imputed from Bike to Work Day survey data, were directly calculated from a new Car Free Day participant follow-up survey after the 2019 CFD event. This change provides enhanced confidence in the results for this event over those estimated in past evaluations.

- Commuter Operations Center (COC) and Integrated Rideshare-Software Upgrades – The basic methodologies for the COC and the Integrated Rideshare-Software Upgrades follows the format used for FY 2015 – FY 2017.

Nature of the Evaluation Approach as Compared with Other Regions

The Commuter Connections TDM evaluation approach used in the Washington DC region to assess program impacts has become recognized as among the most comprehensive and rigorous in the nation. Several regions of a similar size and complexity have adopted similar evaluation approaches.

The key characteristics of the evaluation approach used in metropolitan Washington that have elevated or enhanced the state of the practice in TDM evaluation include:

- The careful avoidance of double counting between program elements
- The derivation of unique placement rates for each program element and mode
- The inclusion of placement duration in the calculation of impacts
- The derivation of empirically-based Vehicle Trip Reduction (VTR) factors to avoid the document mistaken assumption that every new placement reduces a full vehicle trip every day
- The consideration of access mode to a shared ride arrangement to account for cold starts

For these reasons, the users of these evaluative results should feel confident that the reported impacts are as accurate and reliable as is reasonably possible and are based on what is widely accepted as one of the most comprehensive and rigorous evaluation approaches being used today in the US.

Section 4 Maryland and Virginia Telework Assistance

Background

The Metropolitan Washington Telework Resource Center (TRC) was implemented in June 1996. This TDM program element was renamed as Telework Assistance (Telework) in the FY 2012 – FY 2014 TDM analysis when its scope was reduced to focus solely on Maryland employers and on commuters who either lived or worked in Maryland, but its purpose remained the same: to provide information, training, and assistance to individuals and businesses to further in-home and non-home telework programs. Telework activities during the past few years have included assistance to employers to start or expand telework programs, development of employer telework case studies, distribution of telework information included in a telework information kit, and ongoing marketing and initiatives.

In 2016, the Virginia Department of Rail and Public Transportation and the Virginia Department of Transportation requested that the Virginia-based Telework! VA assistance program be added to the FY 2015-17 TDM analysis, to document its results. Telework! VA, which was originally adopted as a separate program element for Northern Virginia, is an online resource to help employers start or expand a formal telework program. In Northern Virginia, the program also offers free expanded technical assistance, in which telework experts provide on-site guidance to company managers and teleworkers tailored to the individual needs and situations of the company. This component of the Commuter Connections Telework element is comprised of impacts generated at Northern Virginia worksites that receive on-site technical assistance.

Evaluation Methodology and Data Sources

The goal of Telework Assistance is to increase the number of telecommuters in the region, whether full-time or part-time telecommuters. For FY 2018 – FY 2020, Telework impacts were evaluated by calculating the number of telecommuters who used or were influenced by Telework Assistance services and estimating the number of vehicle trips and VMT they eliminated by use of telework and the tons of emissions that were reduced by the trip and VMT reductions. Through this method, only impacts that could be traced directly to Telework program element actions were counted in the analysis. In other words, it was recognized that some telework would have occurred even if the Telework program element was not in place. As described below, the Maryland and Virginia components of the Telework program element impacts are analyzed similarly, but using different data.

Three Telework Assistance Populations

Two telework populations were analyzed, one for Maryland and one for Virginia:

- Maryland – Regional telecommuters who live and/or work in Maryland who were directly influenced by Telework services/assistance to begin telecommuting[1]
- Virginia – Telecommuting employees at Virginia worksites that received on-site Telework! VA assistance

[1] In past TDM analyses, the evaluation included a third component, increased telecommuting at Maryland worksites assisted by Commuter Connections. These impacts were calculated by surveying telework coordinators at those worksites about increases in telecommuting following the assistance. The survey also was attempted in 2020, but due to the coronavirus pandemic, none of the assisted employers participated in the survey. Thus, the program impacts could not be calculated for 2020.

Evaluation data for these populations were obtained from several sources, each briefly described below:

State of the Commute Survey (regional commuters) – Data from the SOC survey were analyzed to estimate the:

- Number of regional telecommuters
- Telecommuters' home and work locations (49% lived and/or worked in Maryland and 51% had both home and work outside of Maryland)
- Telecommute locations – the mix between home-based and non-home-based telecommuting
- Average telecommute frequency, telecommuters' travel modes on non-telework days, and commute distance they traveled on non-telecommute days
- Telecommuters' travel patterns to telecommute locations outside the home
- Information sources used to learn about telework (COG/Commuter Connections or other)

Telework! VA Baseline and Follow-up Employee Surveys (new telecommuters at Virginia worksites that received on-site Telework! VA assistance) – These surveys interviewed employees at assisted worksite before Telework! VA assistance was provided (baseline survey) and after assistance was provided (follow-up survey). Fifteen employers, representing 10,041 employees, actively participated in the Telework! VA program during the evaluation period. All of these employers had completed baseline surveys and nine had completed post-assistance surveys. The survey data were analyzed to estimate the:

- Percentage of telecommuters at assisted sites before and after receiving assistance
- Percentage of employees who started or increased teleworking as a result of telework assistance
- Average telecommute frequency, telecommuters' travel modes on non-telework days, and commute distance they traveled on non-telecommute days

Calculation Factors and Impacts

Placement Rates and Placements – Using results from the surveys and Commuter Connections and Telework! VA records on assisted employers, the numbers of new telecommuters who had either direct or indirect (through their employers) contact with the Telework program element during the evaluation period were estimated.

Maryland Telework – As shown below, 46,254 placements were calculated for Maryland Telework, from direct commute assistance. Maryland telecommuters were further divided into "home-based" (91% of total = 42,091) and "non-home-based" (9% of total = 4,163).

Telework! VA –Using data from the baseline and post-assistance surveys, the analysis estimated a placement rate of 19.1% (9.6% new teleworkers and 9.5% employees with increased telework), equating to 1,918 placements. All of these Virginia telecommuters were home-based.

	Population base		Placement Rate		Placements
Maryland Telework					
• Maryland-based commuters	525,618	x	8.8%	=	46,254
Virginia – Telework! VA					
• Assisted Virginia worksites	10,041	x	19.1%	=	1,918

VTR Factors and Vehicle Trips Reduced – The two groups of new/increased telecommute placements were then multiplied by average VTR factors, as identified by the appropriate survey data, to obtain the number of vehicle trips reduced by their telecommuting. Telework element VTR factors accounted for both the average telecommute frequency of the groups as well as their travel modes on non-telecommute days. The VTR factors for non-home-based telecommuters were also adjusted for the modes these commuters used to travel to non-home telecommute locations.

- Maryland home-based telecommuters – The VTR factor was 0.32 daily trips reduced per telecommuter, reflecting the part-time (1.33 days per week average) telework frequency and the elimination of vehicle trips for the 60% of telecommuters who drove alone, carpooled, or vanpooled on non-telecommute days.

- Maryland non-home-based telecommuters – The VTR factor for this group was much lower (0.04) because the majority of these telecommuters drove alone to the non-home telecommute locations. Thus, they did not reduce (and in some cases increased) the number of vehicle trips they made on an average day. However, the benefit of their telecommuting was in the reduction of VMT on telecommute days.
- Telework! VA telecommuters – The VTR factor for Telework! VA telecommuters was 0.28 daily trips reduced per telecommuter. This factor accounted for both the overall telework frequency (1.01 days per week post program vs 0.1 days per week baseline) among teleworkers and the share of telecommuters who drove alone, carpooled, or vanpooled on non-telecommute days (77% post-program vs 83% baseline).

Commute Distance and VMT Reduced – The VMT reduced by telecommuting was calculated by multiplying the daily vehicle trips reduced for each population by the average commute miles reduced per teleworker:

- Maryland home-based telecommuters – Average miles reduced (22.7 miles) equals the one-way commute distance to the main workplace on non-telework days.
- Maryland non-home-based telecommuters – Average miles reduced (13.5 miles) was calculated as the one-way commute distance to main work location minus the distance to the outside telework location (21.6 miles – 8.1 miles).
- Telework! VA telecommuters – Average miles reduced (18.3 miles) equals the one-way commute distance to the main workplace on non-telework days.

Emissions Reduced – Tons of emissions removed were calculated by multiplying vehicle trip and VMT reductions by 2020 emission factors developed by MWCOG staff for the Washington metropolitan region, using the MOVES emission model. Daily emissions were calculated for NOx and for VOC. Annual impacts for PM 2.5, PM 2.5 pre-cursor NOx, and CO2 also were calculated. Appendix 2 details the calculations made to estimate Telework impacts.

Telework Assistance Summary of Goals and Impacts

The results of the calculations for Telework are shown in Table 6 below for all regional telework (6a), for the Maryland component of the Telework program element (6b) and for the Telework! VA program (6c). Tables 6b and 6c also show the goals established for the TW program element. The net credits or deficits, which were equal to the impacts minus goals also are shown.

Table 6
Regional Telework Impacts and
Telework Goals and Estimated Telework Program Element Impacts for Maryland Telework and Telework! VA

Table 6a – Regional Telework	**Regional TW Impacts**
• Number of telecommuters	1,072,690
• Daily vehicle trips reduced	267,422
• Daily VMT reduced	5,067,398
• Daily tons NOx reduced	1.1407 T
• Daily tons VOC reduced	0.9608 T
• Annual tons PM 2.5 reduced	18.350 T
• Annual tons PM 2.5 pre-cursor NOx reduced	382.200 T
• Annual tons CO2 reduced	522,500 T

Table 6-b – Maryland Telework	Telework Goal – MD	Telework Impact – MD
• Number of telecommuters	31,854	46,254
• Daily vehicle trips reduced	11,830	13,636
• Daily VMT reduced	241,209	308,001
• Daily tons NOx reduced	0.1220 T	0.0664 T
• Daily tons VOC reduced	0.0720 T	0.0522 T
• Annual tons PM 2.5 reduced	N/A	1.100 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	22.225 T
• Annual tons CO2 reduced	N/A	31,602.5 T

Impacts vs Goals – Maryland Telework

Participation Benefit (net over or (under) goal): Telecommuters: 14,400

Transportation Benefit (net over or (under) goal): Vehicle Trips: 1,806
VMT: 66,792 miles

Emission Benefit (net over or (under) goal): NOx: (0.0556) tons per day
VOC: (0.0198) tons per day

Table 6-c – Telework! VA Telework	Telework Goal – TW!VA	Telework Impact – TW!VA
• Number of telecommuters	1,500	1,918
• Daily vehicle trips reduced	500	537
• Daily VMT reduced	9,000	9,827
• Daily tons NOx reduced	0.0027 T	0.0022 T
• Daily tons VOC reduced	0.0021 T	0.0019 T
• Annual tons PM 2.5 reduced	N/A	0.025 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	0.750 T
• Annual tons CO2 reduced	N/A	1,015.0 T

Impacts vs Goals – Telework! VA

Participation Benefit (net over or (under) goal): Telecommuters: 418

Transportation Benefit (net over or (under) goal): Vehicle Trips: 37
VMT: 827 miles

Emission Benefit (net over or (under) goal): NOx: (0.0005) tons per day
VOC: (0.0002) tons per day

Regional Telework – In 2019, nearly 1.1 million regional workers teleworked at least occasionally, representing about 34% of the total regional workforce and 35% of all workers who were not self-employed, working only at home (Table 6a). This number of regional telecommuters represented a 21% increase over the 2016 count of 887,000, and more than seven times the 1996 baseline of 150,900 telecommuters.

The substantial and steady growth in regional telework is likely the result of numerous factors, reflecting personal and employer-focused benefits of telework, regional transportation conditions that discourage workers from commuting, and technological advances that make telework viable for a wider range of work types. Telework, which can facilitate a better balance of work and family, can assist employers' efforts to recruit and retain employees, and might lead to greater worker productivity. Increasing traffic congestion in the Washington region and the personal cost of commuting also might have prompted some commuters to work at home to avoid traffic and or the cost of travel. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework, as the coronavirus pandemic has clearly demonstrated. Finally, the greater affordability and sophistication of technology, almost certainly has contributed to the growth in telecommuting.

Maryland Telework – Table 6b shows the expected contribution of the Maryland Telework program component to regional teleworking (Telework Goal – MD) and the impacts for this component (Telework Impacts – MD). The number of Maryland telecommuters estimated for the program element was 45% over the number of telecommuters expected from this element. The element also exceeded the reduction goals for vehicle trips (15%) and VMT (28%).

The Maryland portion of the Telework program element was responsible for about 4.3% of regional telecommuters and about 5% of regional telework impacts. In the 2019 State of the Commute Survey, 8.8% of Maryland telecommuters mentioned Commuter Connections or MWCOG as a source of telework information. These telecommuters were credited to the Telework program element contribution.

One possible area in which the Telework program element's contribution to the regional telework impacts could have been undercounted is that of regional employer outreach. Nearly eight in ten (79%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach program element also promotes telework to employers. Thus, this response likely indicates additional telecommuters who learned about teleworking indirectly from Commuter Connections. Because this cannot be clearly documented, no additional credit is attributed for these employees to the Telework program element. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

Telework! VA – Table 6c presents the impact for the Telework! VA program and the comparison of impacts to goals established for the program. The count of 1,918 employees who started or increased teleworking at assisted sites was 28% above the1,500-teleworker goal set for the program. Telework! VA also exceeded the vehicle trip and VMT goals for the program, by 7% and 9%, respectively. The Telework! VA program missed the goals for reductions in both NOx (-19%) and VOC (-10%) emissions.

Section 5 Guaranteed Ride Home

Background

The regional Guaranteed Ride Home (GRH) program was initiated to eliminate a major barrier to using alternative modes, commuters' fear of being without a personal vehicle in the case of an emergency. The program provides free return transportation by taxi or rental car in the event of an unexpected personal emergency or unscheduled overtime to commuters who carpool, vanpool, use transit, or bike or walk to work at least two times per week on average.

Commuters pre-register for GRH and may use the service up to four times per year. The program also allows "one-time exception" rides provided to non-registered commuters who used an alternative mode on the day a GRH trip was needed. Commuters who wish to use GRH again in the future must then register.

Evaluation Methodology and Data Sources

Transportation and emissions impacts of the GRH program were measured through two surveys, the 2019 GRH Survey and the 2016 Retention Rate survey. The GRH survey, which was conducted in the winter of 2019, assessed commute travel for commuters who participated in the GRH program during the 2020 evaluation period. The Retention Rate survey, which was conducted in spring 2016, examined commute travel for commuters who participated in GRH prior to the 2017 evaluation period. The Retention Rate survey will be administered again in FY 2021.

GRH Survey

The 2019 GRH Survey polled 2,066 commuters who had registered for the Washington Regional GRH Program between March 16, 2016 and March 15, 2019 (FY 2018 - FY 2020). Both commuters who were currently registered at the time of the survey and those who had been registered at some point during the three-year period but whose registrations had expired were eligible to participate in the survey. Additionally, commuters who had not registered for the program, but had taken a "one-time exception trip" were included in the survey sample.

The survey asked detailed questions to define travel behavior changes commuters made immediately before or during their participation in GRH and the influence of GRH on these changes. Information collected from all respondents, included, among other elements:

- Commute patterns: Current mode and previous mode (if commuter made a mode shift), frequency of mode use, travel distance, access mode to rideshare/transit pick-up point, and pool occupancy
- Permanence of mode changes: Whether change was continued (still in effect) or temporary (commuter had stopped using the new mode)
- Motivation: Importance of GRH to decisions to start or continue use of alternative modes

Data from the GRH survey were used to derive the placement rate, VTR factor, and travel distance calculation multipliers for the current/recent GRH participants. Multipliers were estimated for two GRH sub-populations, defined by participants' home and work jurisdictions. The first population included participants who both lived and worked in any of the 15 jurisdictions in the Washington, DC-MD-VA ozone National Ambient Air Quality Standard (NAAQS)

nonattainment area (NAA).[2] The second population included participants who worked in the NAA but lived outside it. This distinction was made because applicants who lived outside the NAA traveled a portion of their VMT outside the NAA. The average VMT for "out of NAA" applicants was discounted to include only the portion of the VMT reduction that occurred within the NAA. Approximately 35% of the total participants lived outside the NAA.

Retention Rate Survey

The 2016 Retention Rate Survey interviewed 989 commuters who participated in GRH or another Commuter Connections program before the FY 2014 - FY 2017 evaluation period (Pre-FY 2015). About 81% of survey respondents had registered for GRH. Data for these respondents was used to derive the GRH retained placement rate.

The objective of the survey was to identify past GRH registrants who made a change to an alternative mode to participate in GRH or while participating in GRH (alternative mode placement) and who had continued using the alternative mode after their GRH participation ended (retained in alternative modes). For this purpose, the survey included questions about, among other elements:

- Current commute pattern: Current modes, frequency of mode use, and commute distance
- Previous commute patterns: Modes used prior to joining GRH and frequency of mode use
- Motivation: Importance of GRH to continue use of alternative modes

Data from the Retention Rate survey were used to derive the retained placement rate, VTR factor, and travel distance multipliers for past GRH participants. The survey did not ask respondents about their home location, so it was not possible to calculate separate Within NAA and Outside NAA factors. Because all commuters traveled part of their commute within the NAA, it was reasonable to use an overall placement rate and an overall VTR factor for all respondents, but it was necessary to adjust the overall travel distance to include only the Within NAA portion of VMT. In past GRH surveys, the Within NAA distance was approximately 75% of the overall distance; this discount factor was applied to the overall distance from the Retention Rate survey to estimate the Within NAA factor.

Calculation Factors and Impacts

Placement Rate and Placements – The placement rate represents the percentage of GRH participant who made a shift to an alternative mode. For FY 2018 - FY 2020 program participants, the GRH placement rate was calculated for Within NAA participants and Outside NAA participants. Numerous past GRH surveys have documented that GRH participants use alternative modes considerably longer than the 36-month evaluation period. Thus, for purposes of the analysis, all GRH placements were considered "continued placements."

The placement rate for Pre-FY 2018 "retained" registrants was calculated from the Retention Rate survey. Because participants must have continued their use of alternative modes to be counted as retained, all of the Pre-FY 2018 placements also would be counted as continued.

To determine the number of commuters placed in alternative modes, the placement rates were multiplied by the numbers of commuters who participated in GRH for the time period and location. A total of 12,944 commuters were current participants between July 2017 and June 2020. The count of past participants, who were registered in the Pre-FY 2018 time period, was estimated to be 18,489. Note that this count reflects the combination of the past registrant count from the Retention Rate survey for the period before July 2014, plus an estimate for GRH users who ended their participation before July 2017 but after the Retention Rate survey was conducted.

[2] The 15 jurisdictions included in the Washington, DC-MD-VA NAAQS nonattainment area (NAA) are: District of Columbia, Calvert County (MD), Charles County (MD), Frederick County (MD), Montgomery County (MD), Prince George's County (MD), Arlington County (VA), Fairfax County (VA), Loudoun County (VA), Prince William County (VA), City of Alexandria (VA), City of Fairfax (VA), City of Falls Church (VA), City of Manassas (VA), and City of Manassas Park (VA).

These calculations resulted in a total of **8,238 placements**, divided as shown below, with 5,983 (73%) new placements from FY 2018 – FY 2020 GRH registrants and 2,243 (27%) retained placements from Pre-FY 2018 GRH registrants:

	Population base		Placement Rate		Placements
FY 2018 – FY 2020					
• Within NAA	8,414	x	43.7%	=	3,677
• Outside NAA	4,530	x	50.9%	=	2,306
Pre-FY 2018					
• Within NAA	12,018	x	12.2%	=	1,466
• Outside NAA	6,471	x	12.2%	=	789

Total Placements = 5,983 new placements + 2,255 retained placements = **8,238**

VTR Factors and Vehicle Trips Reduced – These placement figures were then multiplied by GRH VTR factors derived from the survey data to estimate the number of vehicle trips reduced. The VTR factors for the Within NAA and Outside NAA groups were as follows:

FY 2018 – FY 2020	
• Within NAA	0.83 vehicle trips reduced per placement
• Outside NAA	1.00 vehicle trips reduced per placement
Pre-FY 2018	
• Within NAA	0.31 vehicle trips reduced per placement
• Outside NAA	0.31 vehicle trips reduced per placement

As noted earlier, VTR factors represent the average daily number of vehicle trips reduced by a new alternative mode placement. They combine the vehicle trip reduction contributions of various types of mode changes, such as from transit to rideshare, drive alone to transit, and drive alone to carpool, each of which reduces a different number of vehicle trips per day, into one number. For a program that applies to rideshare, transit, and bicycling, VTR factors of less than 1.0 generally indicate a moderate number of the changes were from one alternative mode to another and/or reflect part-time changes to alternative modes.

The calculation of vehicle trips reduced produced a total of **6,057 vehicle trips reduced**; 5,358 vehicle trips reduced by new (FY 2018 – FY 2020) registrants and 699 from retained (Pre-FY 2018) registrants.

Commute Distance and VMT Reduced – Next, VMT reduction from GRH was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for GRH commuters who made a shift to an alternative mode. For the FY 2018 – FY 2020 registrants, the one-way trip distance for the within NAA respondents was 28.1 miles. The actual one-way distance for the outside NAA respondents was an average of 49.8 miles, but to discount the distance credited to the outside NAA respondents, their one-way travel distance was set equal to that of the distance for the within NAA respondents. For the Pre-FY 2018 retained registrants, the adjusted commute distance was 29.9 miles; this was used for both the Within NAA and Outside NAA groups:

FY 2018 – FY 2020	
• Within NAA/Outside NAA	28.1 miles reduced per trip
Pre-FY 2018	
• Within NAA/Outside NAA	29.9 miles reduced per trip

The calculation of VMT reduced produced a total of **171,461 VMT reduced**, with 150,560 VMT reduced by new FY 2018 – FY 2020 registrants and 20,901 VMT reduced by retained (Pre-FY 2018) registrants.

Emissions Reduced – Estimates of reductions in NOx, VOC, PM 2.5, PM 2.5 pre-cursor NOx, and CO2 for GRH were calculated using regional emission factors, as described for the Telework program element. Details of these calculations are shown in Appendix 3.

GRH Impacts Assigned to Mass Marketing – Note that the GRH results were adjusted to eliminate double counting between GRH and the Mass Marketing program element. About 16% of the FY 2018 – FY 2020 GRH impacts were assigned to the Mass Marketing program element to recognize that some GRH applicants were influenced to contact Commuter Connections and apply for GRH after they heard a Mass Marketing advertisement. The impacts shown in Table 7 account for the adjustment and reflect the net GRH impacts.

GRH Summary of Goals and Impacts

Table 7 presents the transportation and emission impact results for GRH and compares the results against the goals established for the program element.

Table 7
Guaranteed Ride Home Goals and Estimated Impacts

	GRH Goal	Estimated Impacts
• Number of GRH participants FY 2018 – FY 2020*	18,496	12,944
• New applicants during evaluation period	N/A	7,429
• Number of past participants (Pre-FY 2018)	N/A	18,489
• Daily vehicle trips reduced	6,296	5,200
• Daily VMT reduced	177,568	147,371
• Daily tons NOx reduced	0.0890 T	0.0253 T
• Daily tons VOC reduced	0.0480 T	0.0154 T
• Annual tons PM 2.5 reduced	N/A	0.451 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	8.485 T
• Annual tons CO2 reduced	N/A	13,523.9 T

* Number of participants currently enrolled in GRH

Impacts vs Goals

Participation Benefit (net over or (under) goal):	Participants: (5,552)
Transportation Benefit (net over or (under) goal):	Vehicle Trips: (1,096) VMT: (30,197 miles)
Emission Benefit (net over or (under) goal):	NOx: (0.0637 tons per day) VOC: (0.0326 tons per day)

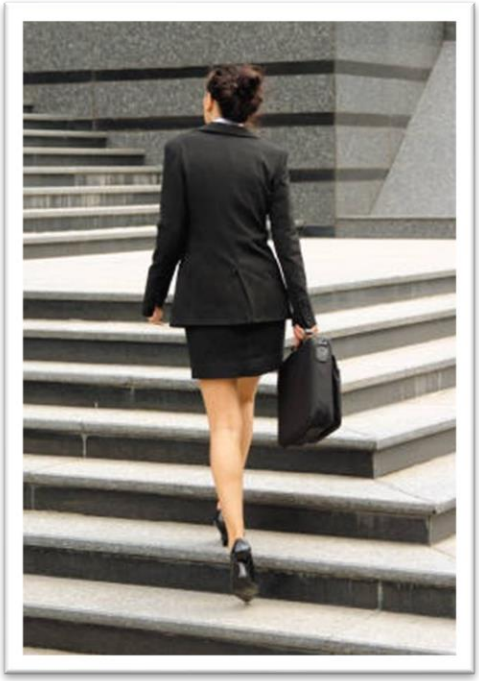
The number of commuters participating in GRH in June 2020 was about 70% of the participant goal. The vehicle trip reduction, VMT, and emissions impacts also fell below the goals, although the retained impact from past registrants who continued to use alternative modes even after leaving the program, substantially offset the shortfall from current registrants. Participation in GRH has dropped steadily over the past 15 years.

Some of the decline could be due to commuters feeling less concerned about being stranded because they have a greater number of travel options, such as transit and ride-hailing, to make their emergency trip home. But some of

the decline also could be related to a decline in regional awareness of the program. While Commuter Connections continues to promote the program through advertising and outreach, the 2019 State of the Commute survey found that only 16% of respondents said they knew a regional GRH program existed, compared to 59% who said they knew about the program in the 2004 SOC survey. Additionally, it is likely applications dropped off in spring 2020, due to fewer commuters requesting travel assistance during the early months of the coronavirus pandemic.

Section 6 Employer Outreach

Background



The Employer Outreach program element is designed to encourage employers to implement new commute assistance programs and to expand the services they offer in existing programs. In this element, jurisdiction-based sales representatives contact employers, educate them about the benefits commuter assistance programs offer to employers, employees, and the region, and assist them to develop, implement, and monitor worksite commuter assistance programs.

A share of the funds received by COG for the Employer Outreach program element is passed-through to the jurisdictions for implementation of the program. Commuter Connections assists the sales force with the following services, designed to enhance regional coordination and consistency:

- Web-based regional employer contact database
- Marketing and information materials
- Employer outreach sales and sales force training
- Annual evaluation program
- Support to Employer Outreach Committee
- Employer satisfaction survey

Evaluation Methodology and Data Sources

Employer Outreach is aimed at increasing the number of private and not-for-profit employers with 100 or more employees that implement worksite commuter assistance programs. But Employer Outreach is ultimately designed to encourage employees of client employers to shift from driving alone to alternative modes.

Two primary evaluation questions are thus important. First, how many employers start or expand commuter assistance programs? And second, how many employees use alternative modes in response to new employer-sponsored services at the worksite? These two variables are strongly linked, as other TDM effectiveness research has shown. Higher levels of employer effort can be expected to offer greater incentive to employees to use alternative modes, leading to reductions in vehicle trips, VMT, and emissions.

The populations of interest for this program element are:

- Employers that participate in Employer Outreach
- Employers that offer bicycle services (Employer Outreach for Bicycling)
- Employees at Employer Outreach worksites
- Employees at worksites that offer bicycle services

Employer Participation in Commute Programs

The employer participation component of the analysis was assessed through data collected by Commuter Connections from sales and outreach contacts with employers. Employer Outreach jurisdiction sales representatives documented the levels of programs implemented by their employer clients in the ACT! contact management database maintained by Commuter Connections. The Employer Outreach program specified services employers offered, for example, transit subsidy, information/promotions, Guaranteed Ride Home, etc.

The Employer Outreach program defined four levels of employer effort: Bronze (Level 1), Silver (Level 2), Gold (Level 3), and Platinum (Level 4), distinguished by the expected increasing trip reduction effectiveness of the services offered and the commitment of the employer, as shown below.[3]

- **Level 1 (Bronze1) programs** offer only commute information and/or electric car charging stations.
- **Level 2 (Silver) programs** offer two or more commute support services, such as: Employee Transportation Coordinator (ETC), preferential parking, carpool/vanpool formation meetings, bike racks or lockers, Capital Bikeshare Corporate Partner, transportation fairs, telework program with 1-20% of employees participating, and compressed work schedule with 1-20% of employees participating.
- **Level 3 (Gold) programs** include, in addition to the Level 2 services, at least one of services such as transit subsidy or parking "cash out," telework program with more than 20% of employees participating, parking fee discount for carpool/vanpools, shuttle to transit stations, comprehensive bicycle/walking program, and company vanpools.
- **Level 4 (Platinum) programs** include two or more of the Level 3 program components, at least two Level 2 strategies, and actively promote the program.

When the Employer Outreach program element was adopted, the TPB established a goal to be achieved by June 2005 and evaluations conducted for periods through June 2005 measured impacts against this goal. Beginning with the 2005-2008 analysis, new Employer Outreach goals were established for the overall program and for new program activity during the evaluation period. Thus, for the FY 2018 - FY 2020 evaluation, impacts were calculated for "maintained" employer programs and "new/expanded" programs.

Maintained impacts included employers that joined EO before July 1, 2017 and made no changes since that date. Expanded impacts included employers that were involved in EO before July 1, 2017 but expanded their commute assistance services after that date. New impacts included employers that joined the EO program on or after July 1, 2017. A final category was defined to calculate the impacts of employers that were included in the FY 2015 – FY 2017 evaluation but dropped out of EO before June 2020. Commuter Connections determined that the impacts that would have been credited for these employers would have to be replaced by new/expanded impacts. Impacts were estimated for the following groups of employers:

- Maintained – June 2017 employer programs continued with no change
- Expanded – June 2017 employer programs expanded since June 2017
- New – Employer programs started since June 2017
- Deleted – June 2017 employer programs deleted between July 2017 and June 2020

The overall benefit of the program is the sum of continued programs plus expanded and new programs. As shown below, in June 2020, the ACT! database included 1,962 employers with programs that met the Level 3 or 4 definitions. These employers accounted for 630,043 employees. Level 1 and 2 employers were not included in the regional impact calculation because their level of impact would be very small due to the absence of financial incentives or other substantial commute support services.

Of the Level 3 and 4 employers, 1,589 joined Employer Outreach prior to July 2017 and made no program changes since then. The expanded category included 80 employers and 293 were listed as "new" since June 2017. The analysis also accounted for the loss of 293 employers that were counted in the 2017 evaluation and that were no longer involved in the program. These employers accounted for 106,764 employees. Had the deleted employers continued in the program, the total employee count would have been 736,807, so they represented a drop of about 14% in total employees in the program. The deleted employee count was slightly higher than the 92,622 employees at new EO worksites, so new employers did not entirely replace the deleted employers. However, employers with expanded programs accounted for an additional 21,359 employees, helping to offset the loss in program credit from deleted employers.

[3] For more details of employer levels, see Appendix 4.

Note that the count of deleted employers reflects an effort by COG/TPB staff and local jurisdiction staff to purge the database of employers that had ceased operations, had moved from the region, and/or were no longer actively involved in the Employer Outreach program. Further, the deleted employers included several very large worksites; 22 of the 293 deleted employers each had 1,000 or more employees. Collectively, these 20 employers accounted for 73% of the total deleted employees.

	Number of Employers			Number of
Employer Status (June 2020)	**Total**	**<100**[1)]	**100+**	**Employees**
- Maintained/unchanged from June 2017	1,589	860	729	516,062
- Expanded after June 2017	80	39	41	21,359
- New programs	293	173	120	92,622
Total	**1,962**	**1,072**	**890**	**630,043**
Deleted from 2017	293	182	111	106,764

1) Actual number of employers with fewer than 100 employees.

Employee Participation in Commute Programs

The second variable in the impact evaluation, employees' response to services offered, was more difficult to obtain. Starting mode split data were available for 673 employers that had conducted a baseline commuter survey prior to implementing the TDM program. But as is typical for voluntary programs, only a few had conducted a follow-up survey by the time the evaluation data were being collected. Because baseline data were available, but post-program survey data were not, the researchers elected to estimate employee behavior changes using the US EPA's COMMUTER Model v 2.0, which estimates worksite mode shifts from inputs on starting mode split and TDM program components. This was the same methodology as was used in the 2017 evaluation.

During the evaluation period, the research team examined several other models to determine if any feasible options existed that would be as reliable and efficient as the COMMUTER model for the EO analysis. This review found that none of the alternative models offered both the capability to analyze the wide range of TDM strategy combinations that were implemented by EO employers as well as the capability to analyze efficiently impacts for individual employers. The research team previously developed a technique to run the COMMUTER model for large numbers of individual employers in "batch" mode, allowing an independent impact analysis for each employer, in a highly efficient process. Without this capability, it would be cumbersome to analyze the large number of employers in the EO analysis. Thus, the COMMUTER model was used for the FY 2017 – FY 2020 EO calculation.

The COMMUTER Model uses time and cost coefficients that are compatible with coefficients used by MWCOG in regional transportation modeling. In 2007, COG and the evaluation team adjusted the cost coefficients used in the model, to correct for the COMMUTER Model's tendency to overestimate the likely impacts of financial incentives on shifts to non-SOV modes. These coefficients were used for the 2008 and 2011 evaluations.

During 2010-2012, MWCOG developed a new regional travel model. MWCOG modeling staff reviewed the COMMUTER Model cost and time coefficients used in the 2011 evaluation and concluded that no further adjustments were needed for 2014 or 2017 to be consistent with the new regional model. MWCOG continues to use this regional model and the model continues to evolve, thus the research team reviewed regional model guidance documents prepared by the MWCOG modeling staff to determine if any changes made to the regional model might indicate a needed change in the COMMUTER model coefficients to remain compatible with the regional approach.

That review found numerous model modifications, but none that would affect the validity of the current coefficients applied in the COMMUTER Model. Most of the regional model changes were made to improve the efficiency and speed of the operation of the model, rather than the model results. And the changes that did alter the model results primarily adjusted assumptions related to bike and walk access to transit, particularly in suburban areas. As these changes were not cost related, the research team concluded that the coefficients used for the EO analysis in 2017 could be carried over to the 2020 evaluation.

Starting Mode Split – The COMMUTER model v 2.0 requires several "scenario" inputs, including the type of employer (primarily office or non-office occupations) and the starting mode split. For employers that had conducted a baseline, "pre-program" survey, the actual mode split from the survey was used as the input. But for employers that had not conducted a survey, a starting mode split was assigned that reflected the average mode split that would be likely for employers with similar location and employee work conditions.

These average mode splits were calculated by aggregating employers in the ACT! database that had conducted baseline surveys into six groups, based on two employer/site variables that are known to influence mode choice: 1) type of employer/work performed, either office or non-office, and 2) availability of transit service: low, moderate, or high. Low transit was defined as limited bus service within ½ mile of the worksite. Moderate transit included a higher level of frequency and route availability. To be designated as a "high transit" employer, the site had to be within ½ mile of a Metrorail station and have access to a significant level of bus service. For each of the six combinations of these two variables, for example, non-office employers with high transit and office employers with moderate transit, an average mode split was calculated from the baseline survey data of employers in that employer group that had conducted commuter surveys.

In past evaluations, the default values included baseline surveys that dated to 1997. To create default values that more closely represent current infrastructure and travel opportunities, the default values were recalculated, excluding surveys that were conducted prior to 2006. Additionally, more than 100 baseline worksite surveys that had been conducted by local jurisdiction staff after 2005, but which had not been entered into the employer database were incorporated into the default calculation in 2020, expanding the total number of employers on which the default values were based, and further expanding surveys that reflected more recent local conditions and raising the confidence of the default calculations. Overall, the actual default values changed only slightly, however, suggesting current baseline (pre-TDM) conditions are similar to those applied to past TDM evaluations.

Program Definition – The TDM analysis also classified employers by the specific commuter program services they offered. The COMMUTER model v 2.0 permits direct analysis of strategies that change the travel cost of a mode (e.g., transit subsidies), and strategies that change the duration of a trip (e.g., express transit service).

The model also has the capability to predict impacts of telework and compressed work schedules (CWS), when certain parameters of the work hour arrangements are known. The ACT! database indicated employers that had a telework program. Some records noted the actual number of employees at the worksite who were teleworking. Employers that offered telework, but for which participation numbers were not available were assumed to have telework rates equal to the regional average calculated from the 2019 State of the Commute survey. The ACT! database also noted employers that offered CWS. When participation counts were missing for these employers, a default percentage calculated from the SOC survey was assigned.

Other commute strategies, such as GRH, flextime, information support, and preferential parking, all are treated by the model as elements in a "support package." They are not modeled separately. Rather the level or extent of the support service package is modeled and the higher the number of these strategies offered, the higher the level of support that is modeled.

The strategy package assigned to an employer was thus comprised of the following potential actions:

- Amount of mode-specific financial incentives (transit, carpool, vanpool, bicycle)
- Amount of parking fee discounts (rideshare parking discount, parking cash out)
- Estimated percentage of telecommuting employees (actual or assumed percentage)
- Estimated percentage of employees working a compressed schedule (actual or assumed percentage)
- Level of alternative mode commuter support (e.g., ridematching, mode information, employee transportation coordinator, Guaranteed Ride Home, preferential parking, flextime, vanpool formation support)
- Availability of bicycle services
- Availability of a shuttle bus to Metrorail or other transit location

The COMMUTER model v 2.0 was run in a batch format that allowed each employer's program components to be modeled separately. The analysis thus calculated for each employer, the final mode split with the program in place. By comparing the starting and ending mode splits, the percentage trip reduction that would be expected following implementation of the program elements was calculated. This trip reduction was then applied to the number of employees at the worksite to estimate the number of vehicle trips reduced for that employer.

Because travel distance was not available for either individual employees or employers in the ACT! database, the number of VMT reduced was estimated by multiplying the vehicle trips reduced for an employer by the average regional one-way trip lengths for each mode, as measured through the 2019 State of the Commute Survey. Emissions reduced were calculated by multiplying trips and VMT reduced by 2020 regional emission factors provided by MWCOG staff. Finally, the individual results for each employer were aggregated to estimate the combined impact of all employers in the program element. Appendix 3 provides details of the calculations of impacts for Employer Outreach.

Employer Outreach Summary of Goals and Impacts

The impacts calculated as described above, were compared against the EO program element goals. The total goals and impacts are shown in Table 8.

Table 8
Employer Outreach Goals and Estimated Impacts

	EO Goal	Estimated Impacts
Employer Outreach (all programs)		
• Employers participating - total	2,031	1,962
– Maintained from 2017	No goal	1,589
– Expanded after 2017	No goal	80
– New in 2020	91	293

• Total employers and employees by jurisdiction and count of new/expanded employers

	Total Employers	Employees	New/Expanded Employers
– Alexandria, VA	146	24,658	20
– Arlington County, VA	354	72,410	73
– District of Columbia	591	163,454	19
– Fairfax County, VA	280	215,044	111
– Frederick County, MD	20	18,227	3
– Loudoun County, VA	19	14,270	7
– Montgomery County, MD	482	79,869	126
– Prince George's County, MD	27	22,144	4
– Prince William County, VA	27	12,698	3
– Tri-County Council, MD	16	7,269	7

- Total employers and employees by size category and count of new/expanded employers

	Total Employers	Employees	New/Expanded Employers
– Sites with 100+ employees	890	588,932	161
– Sites with less than 100 employees	1,072	41,111	212
– "Equivalent 100+" [1)]	411		80

1) For purposes of program tracking, employers with fewer than 100 employees are grouped into "equivalent 100+" employers. The 1,072 employers in this category employ 41,111 employees, thus represent 411 "equivalent 100" employers (41,111 / 100).

Impacts vs Goals

Overall Employer Outreach Program

	EO Goal	Estimated Impacts
Total Program		
• Daily vehicle trips reduced	90,776	85,845
• Daily VMT reduced	1,533,161	1,489,165
• Daily tons NOx reduced	0.6170 T	0.2995
• Daily tons VOC reduced	0.3850 T	0.2297
• Annual tons PM 2.5 reduced	N/A	4.975 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	100.450 T
• Annual tons CO2 reduced	N/A	144,665.4 T

Participating Employers (net over or (under) goal): Employers: (69)

Transportation Benefit (net over or (under) goal): Vehicle Trips: (4,931)
VMT: (43,996) miles

Emission Benefit (net over or (under) goal): NOx: (0.3175) tons per day
VOC: (0.1553) tons per day

New / Expanded Employer Programs

	EO Goal	Estimated Impacts
• New/expanded programs	N/A	373
• Daily vehicle trips reduced	N/A	11,565
• Daily VMT reduced	N/A	188,153
• Daily tons NOx reduced	N/A	0.0383 T
• Daily tons VOC reduced	N/A	0.0301 T
• Annual tons PM 2.5 reduced	N/A	0.650 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	12.850 T
• Annual tons CO2 reduced	N/A	18,242.4 T

Participating Employers (net over or (under) goal):	Employers: No goal for comparison
Transportation Benefit (net over or (under) goal):	Vehicle Trips: No goal for comparison VMT: No goal for comparison
Emission Benefit (net over or (under) goal):	NOx: No goal for comparison VOC: No goal for comparison

As shown, even with the loss of 293 employers that left the EO program since 2017, the overall number of employers participating in the program was just 3% below the participation goal. Further, because the worksite programs were generally quite substantial, the overall EO program came within 3% of the VMT reduction goal and was within 5% of the goal for vehicle trips reduced.

Employer Outreach for Bicycling

A similar exercise was performed to estimate the contribution of bike strategies to Employer Outreach program impacts. This program element provides regional outreach to encourage private sector and non-profit employers to implement worksites strategies that encourage employees to use bicycling for commuting.

A total of 570 employers offered bicycle strategies in their worksite programs in 2020. The impacts for these employers were modeled "with bicycling" and "without bicycling." The difference in vehicle trips reduced between these two cases was assigned as the bike strategies' share of the impacts. It was assigned to the Employer Outreach for Bicycling component of Employer Outreach.

The VMT reduced for bicycling was estimated by multiplying the vehicle trips reduced by an average one-way trip length for bicycle commuters, of 4.2 miles, calculated from the 2019 State of the Commute (SOC) Survey.

The Employer Outreach for Bicycling program element nearly met its goal for the number of employers offering bike strategies and exceeded the vehicle trip reduction goal, but fell short of the VMT and emissions goals established for the program (Table 9).

Table 9
Employer Outreach – Bike Services Goals and Estimated Impacts

	EO Goal	Estimated Impacts
• Employers with bike strategies	590	570
• Daily vehicle trips reduced	404	449
• Daily VMT reduced	2,421	1,886
• Daily tons NOx reduced	0.0016 T	0.0008 T
• Daily tons VOC reduced	0.0015 T	0.0012 T
• Annual tons PM 2.5 reduced	N/A	0.000 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	0.275 T
• Annual tons CO2 reduced	NA	214.9 T

Participating Employers (net over or (under) goal):	Bike Employers: (20)
Transportation Benefit (net over or (under) goal):	Vehicle Trips: 45 VMT: (535) miles
Emission Benefit (net over or (under) goal):	NOx: (0.0008) tons per day VOC: (0.0003) tons per day

Section 7 Mass Marketing

Background

In July 2003, Commuter Connections embarked on an ambitious effort to educate the region about alternatives to stress-filled solo commuting and to raise awareness of commute assistance services available through Commuter Connections and its partners. This effort, captured in the Mass Marketing program element, employs radio, television, direct mail, social media, and other mass media to create a new umbrella level of public awareness and to provide a call to action to entice commuters to switch to alternative modes.

The objectives of the Mass Marketing program element are to:

- Raise regional awareness about the Commuter Connections brand
- Address commuters' frustration with congestion
- Induce commuters to try and adopt alternative commute modes

The FY 2018 – FY 2020 Mass Marketing analysis also includes impacts for two annual commute events: Bike-to-Work Day event and Car Free Day event, and two regional incentive programs: 'Pool Rewards carpool incentive and 'Pool Rewards vanpool incentive. Commuter Connections' role in these events is regional and primarily promotional in nature, so their impacts are most appropriately included in the Mass Marketing program element calculation.

Evaluation Methodology and Data Sources – Umbrella Marketing Campaign

The Mass Marketing program element has six populations of interest:

1) All commuters in the Commuter Connections service area
2) Commuter Connections rideshare applicants who were influenced by the marketing campaign to request Commuter Connections services
3) GRH applicants who were influenced by the marketing campaign to request Commuter Connections services
4) Commuters who participated in the 'Pool Rewards carpool and 'Pool Rewards vanpool incentive programs
5) Commuters who participated in the Bike-to-Work Day event
6) Commuters who participated in the Car-Free Day event

This program element presents two challenges not encountered in most of the other program elements. First, it is more difficult to assess influence on the general commuting public than it is to identify and track program participants. Second, when commuters who changed travel behavior can be identified, it is still necessary to identify what motivated their change. So, the critical issue for this element is attributing changes in attitudes and behavior – to the mass marketing campaign, another program element, or to some other outside influence.

The Mass Marketing advertising evaluation method examines impacts from two types of commute mode changes, which are measured separately. The first, ***"directly"*** influenced mode changes, occur when ads motivate commuters to change mode with no intermediate contact with Commuter Connections. An example of this type of change would be a carpool formed when a commuter hears an ad and asks a co-worker to carpool. Direct influences can only be assessed through a regional survey of commuters that asks about mode changes and the reasons for the changes. If a shift occurred and the shift can be attributed to a Mass Marketing campaign message, the associated

trip, VMT, and emissions reductions can be credited to the campaign. Note that this calculation needs to correct for double counting with commuters who also cite influence of other program elements on their travel change.

The second, "***referred***" mode changes, result when a commuter is influenced by an ad to contact Commuter Connections, such as when a commuter hears a radio ad for GRH and registers for the program. This type of change would include, for example, a commuter who hears the ad, requests a ridematch from Commuter Connections, then forms a new carpool as a result. Under the evaluation method, any mode change the commuter makes in response to GRH would be defined through the GRH assessment, but a portion of the influence for that change would be credited to Mass Marketing, which provided the information about GRH.

Referred influences are best assessed by tracking changes in the volume of web, phone, and other requests for information about GRH, ridematching, events, and other Commuter Connections services. A comparison of the volumes of requests received during periods of media activity to periods without media activity can provide an indication of the mode change result of the ads. A pro-rated share of the impacts of these other program element impacts then can be assigned to Mass Marketing.

Evaluation of Direct Influence

Directly influenced change is measured for this evaluation through the 2019 regional State of the Commute survey, which included questions related to the following:

- Ad awareness – Were commuters aware of commute advertising and the specific messages conveyed and could the source of the ad be reasonably assigned to Commuter Connections?
- Changes made after hearing the ads – How many commuters who recalled Commuter Connections' ad messages shifted to alternative modes after hearing the ads and how were they traveling before the change?
- Reasons for change – Did the ads influence the commuters to make the change?
- Other commute services used – Did the commuters use any commute services provided by Commuter Connections?

Results for these questions were used to estimate the number of regional commuters who were influenced by ads to change mode without contact with Commuter Connections. The survey results were as follows:

Percentage of commuters who:

- Recalled Commuter Connections ad message 14%

Commuters who recalled specific commute messages were asked about actions and influences related to the ads. Among respondents who recalled Commuter Connections messages, the surveyed indicated:

- Shifted to an alternative mode after hearing CC ads 11.5%
- Said the ad influenced their decision to shift 57%
- Did not use any other Commuter Connections or employer service 100%
- **Resulting influence percentage from CC ads 0.918%**

Thus, 0.918% of regional commuters were directly influenced to make a change. This percentage was multiplied by the number of regional commuters (3,044,554) to estimate 27,940 alternative mode placements.

Further analysis of survey respondents who made a change showed that 46% continued using the new mode and 54% were temporary or occasional users. Continued users reduced on average 0.73 vehicle trips per day with their changes and temporary users reduced an average of 1.0 vehicle trips per day. These factors, and the 20.4 mile per trip distance calculated from the State of the Commute data were applied to the total number of new alternative mode placements to obtain the numbers of vehicle trips and VMT reduced by direct influence.

Evaluation of Referred Influence

Indirect influences were estimated through comparison of the volume of requests made to the Commuter Connections by telephone, website contact, and social media response, and the numbers of ridematch and GRH applications received:

- In months between July 2017 and June 2020 when MM ads were aired
- In months between July 2017 and June 2020 when MM ads were NOT aired

As a first step, this analysis calculated the average numbers of inquiries and applications received during "with MM' and "without MM" periods and compared the numbers. An increase in requests observed during the "with MM" periods could be assumed to result from the ads and other marketing efforts performed during the same time periods. Thus, the analysis also calculated volumes of website, phone, and social media information requests (CC inquiries) that were received under "with ad" and "without ad" scenarios.

The analysis suggested that the ads prompted an additional 6% of ridematch applications, but that GRH applications declined during the ad months:

	Increase in Applications		
	CC Inquiries	RS Apps	GRH Apps
• With ads compared to no ads	14%	6%	-2%

But the use of the Commuter Connections inquiries received via the Internet, 800 telephone number, and social media outlets increased by 14% during MM advertising periods. Note that commuters can access numerous commute information services directly from the Internet, without registering or providing contact information. Because these respondents cannot be included in the applicant follow-up surveys that Commuter Connections conducts to estimate impacts from use of the services, any travel changes that they made after using the website are not included in the Commuter Operations Center calculation, so a MM "referred influence" calculation based solely on the number of rideshare applications or GRH applications likely undercounts the impacts of this MM component.

For these reasons, it was decided to base the MM referred influence percentage on the increase in the volume of website uses, rather than on application counts. When taken as a percentage of total website users, these increases translate to about 12.3% of total uses (14/114).

Evaluation Methodology and Data Sources – 'Pool Rewards Program

Impacts for the third component of this program element, 'Pool Rewards carpool and 'Pool Rewards vanpool incentives, were calculated in a manner similar to that used for the GRH TERM. The numbers of carpool and vanpool participants were multiplied by placement rate, VTR factor, and travel distance calculation multipliers specific to the carpool and vanpool programs to estimate the travel impacts. Data to derive the carpool multipliers were collected through three tools: mode tracking required of all participating commuters and two post-program surveys. Data for the vanpool multipliers were estimated from data collected by MWCOG staff on each vanpool for submittal to the National Transit Database (NTD).

'Pool Rewards Carpool Program

Since the program was open only to commuters who were driving alone prior to the program, all 'Pool Rewards carpool participants were placed in a new mode. A survey conducted by Commuter Connections in 2011, following the end of the first participants' enrollment period found that 93% had continued to carpool immediately after the program ended. Two more recent follow-up surveys, conducted in spring 2017 and spring 2020 with 'Pool Rewards participants who had participated during the previous three years, explored retention in alternative modes of this recent participant group. These surveys found that 87% of participants were still using an alternative mode and 13% had returned to driving alone to work. These results were used to derive the long-term carpool retention placement factors: 87% continued placement and 13% temporary placement.

The temporary VTR factor for carpool was derived from mode use logs submitted by participants at the end of their enrollment period. Participants were required to document how many days they carpooled during their enrollment period. The travel during their enrollment period was compared to their pre-program travel (all drive alone) to determine the average daily drive alone trips they reduced (VTR factor), equal to 0.96 daily trips reduced. The 2020 'Pool Rewards carpool participant survey was used to estimate the VTR factor and travel distance for long-term, continued placements. That survey estimated a carpool VTR factor of 1.00 and a one-way travel distance of 28.2 miles.

Between July 2017 and June 2020, 92 commuters had completed the 'Pool Rewards carpool program. When this participation number was multiplied by the placement rates, the calculation resulted in 80 continued carpool placements and 12 temporary placements. Applying the VTR factors and one-way travel distance resulted in 86 daily vehicle trips reduced and 2,425 daily VMT reduced from 'Pool Rewards carpool component.

'Pool Rewards Vanpool Program

The vanpool program also was open only to commuters who had been driving alone prior to the program. Thus, all 'Pool Rewards vanpool participants were classified as new placements. Multiplier factors for this program were derived from NTD data collected by MWCOG staff on the number of vanpools in the program, the number of riders in each van, and the miles traveled by each van with the full complement of riders (revenue miles).

Fifteen vans, with 131 total passengers participated in the program between FY 2018 and FY 2020. These vanpools were first defined as either continued, meaning they were still in operation during FY 2020, or temporary, meaning they had operated in FY 2018 or FY 2019, but had ceased operation prior to FY 2020. This step indicated that 11 vans, carrying 97 total riders, or 74% of the total 131 riders, had continued operation. The remaining four vans, with 34 riders (26%) were defined as temporary.

The continued and temporary VTR factors for vanpool were derived using the average number of riders in continued vanpools (10.2 riders) and temporary vanpools (8.3 riders) and assuming that vanpool riders rode in the van nine of ten work days (per two weeks) and drove to work all work days prior to joining the vanpool.[4] These calculations resulted in VTR factors of 1.72 daily vehicle trips reduced for continued placements and 1.32 daily vehicle trips reduced for temporary placements. The revenue miles data per vanpool were used to derive one-way travel distances for continued placements (39.5 miles) and temporary placements (38.9 miles).

When these factors were applied to the 131 total vanpool riders, the calculation resulted in 97 continued vanpool placements and 34 temporary placements. Applying the VTR factors and one-way travel distance resulted in 190 daily vehicle trips reduced and 7,491 daily VMT reduced from 'Pool Rewards vanpool component.

Evaluation Methodology and Data Sources – Bike to Work Day Event

Impacts for the fourth component of this program element, Bike-to-Work Day (BTWD) Event, were calculated using data obtained from a survey of BTWD participants conducted following the 2019 BTW Day event. Special events are typically short-term. For example, Bike to Work Day is a one-day event. But the influence of the event can be ongoing; its purpose is to introduce commuters to a new travel option, with the goal that some will continue using the new mode after the event ends. Thus, the BTWD survey included questions regarding participants' use of bicycling for commuting before and after the event, and their ongoing level of bicycle commuting.

The impact methodology estimated the trip reduction impacts of new ridership by calculating the number of commuters who started riding to work after the event or increased the days per week they rode to work and the average number of "new" bike days per week. Two time periods were examined: 1) spring through early fall following

[4] Note that data provided by MWCOG indicated that several of the vanpools routinely operated fewer than five days per week. The VMT reduced was prorated for these vans to credit only the vanpool operating days.

the event and 2) early winter following the event. From these data the number of new "seasonal" use and "continued winter" use days were calculated for a year. This number was then converted to a daily figure.

The number of vehicle trips reduced by new bicycling was estimated by multiplying the percentage of participants who drove alone or carpooled on non-bike days (43%) by the number of new daily bicycle trips. VMT reductions were estimated by multiplying the vehicle trip reduction by the average one-way commute distance of these participants (9.0 miles). Emissions reduced were calculated as for other program element.

Evaluation Methodology and Data Sources – Car Free Day Event

The final Mass Marketing component was Car Free Day, an annual event to encourage commuters to leave their cars at home for one day. CFD events were held in the Washington region in the months of September 2017, 2018, and 2019. Commuters who participated in the events made online pledges, indicating the types of transportation they intended to use for that day and the type of transportation they typically would have used for those trips.

Following the 2019 event, Commuter Connections conducted a brief survey of event registrants to examine their use of car-free and car-lite (e.g., carpool and vanpool) travel options during the CFD event and their subsequent continued use of these options for commute travel.

Car Free Day encourages participants to use non-drive alone modes for any type of trip, but the Commuter Connections TDM analysis captures impacts only for commuting travel. Thus, the CFD survey asked participants about the modes they used both for any CFD trip and for CFD trips to and from work. Participants who had used a car-free/car-lite option for a commute trip were asked if the CFD mode was their usual commute mode, and if not, how did they usually get to work on a non-event day. All employed respondents also were asked how many days per week that they used car-free/car-lite options for commuting before CFD and at the time of the survey, several months after the event. Finally, employed respondents were asked the distance from their home to their usual work location.

The survey found that 86% of all respondents had used a car-free or car-lite option for a commute trip on CFD. For 16% of these respondents, the CFD option was a different mode than they usually would have used, and 76% who changed mode would have driven alone or carpooled/vanpooled. Participants had an average commute distance of 14.9 miles one-way. These results were used to calculate the "event day" trip reduction impact.

The survey further indicated that 11% of employed respondents had increased their regular average frequency of car-free/car-lite options, with an average weekly trip reduction of 3.32 trips, equating to a daily trip reduction of 0.66. These factors were applied to the participant population to estimate the on-going CFD impacts. Emissions reduced were calculated as for other TDM program elements.

Mass Marketing Summary of Goals and Impacts

Table 10 presents the results for the Mass Marketing program element, compared to the goals. Individual goals were not established for any of the individual elements that comprised the Mass Marketing components (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, and Car Free Day).

Table 10
Mass Marketing Goals and Estimated Impacts

	MM Goal	Estimated Impacts
Total Mass Marketing		
• Commuter placements	23,168	38,273
• Daily vehicle trips reduced	10,809	14,031
• Daily VMT reduced	181,932	277,511
• Daily tons NOx reduced	0.0850 T	0.0554 T
• Daily tons VOC reduced	0.0250 T	0.0415 T
• Annual tons PM 2.5 reduced	N/A	0.940 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	18.617 T
• Annual tons CO2 reduced	N/A	27,104.8 T

Impacts vs Goals

Participation Benefit (net over or (under) goal): Commuters: 15,105

Transportation Benefit (net over or (under) goal): Vehicle Trips: 3,222
VMT: 95,579

Emission Benefit (net over or (under) goal): NOx: (0.0296) tons per day
VOC: 0.0165 tons per day

The Mass Marketing program element substantially exceeded its goal for commuter placements. MM also generated vehicle trip reduction 30% above the goal and VMT reduction 53% above the goal. Details of the calculation for Mass Marketing are presented in Appendix 5.

Goals were not established for any of the individual elements that comprised the Mass Marketing program element (direct influence, indirect referral influences, 'Pool Rewards, BTW Day, and Car Free Day). But the analysis estimated that direct ad influences accounted for 71% of Mass Marketing vehicle trips reduced. 'Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 20% of the total. The remaining 9% of the credit was generated by GRH and Commuter Operations Center referrals.

Section 8 Commuter Operations Center

Background

Since 1974, COG has offered basic commute information and assistance, such as the regional ridematching database, to commuters living and/or working in the Washington metropolitan region. Prior to 1997, when Commuter Connections was established, these services were provided by COG's RideFinders program. Because these services were available when other TDM program elements were developed, the Center was designated as an ongoing program. It also is part of the region's congestion management process.

The function of the Commuter Operations Center is to increase commuters' awareness of alternative modes, through regional and local marketing and outreach programs and to encourage and assist commuters to form ridesharing arrangements. Encouraging commuters who drive alone to shift to alternative modes is a priority for the COC, but the COC also assists commuters who now use alternative modes to continue to do so, by offering ridematching and transit assistance when carpools break up or commuters' travel patterns change and disrupt existing alternative mode arrangements.

Commuter Connections program services include: carpool and vanpool matchlists, transit route and schedule information, information on Park & Ride lot locations and HOV/Express lanes, telework information, commute program assistance for employers, GRH, commuter incentive programs, and bicycling and walking information. Commuters obtain services and information primarily through the Commuter Connections website, but also can call a toll-free telephone number or contact a local partner assistance program for personal assistance from a commuter services representative.

Evaluation Methodology and Data Sources

In past years, the Commuter Operations Center has enhanced the services it offers to commuters and expanded its marketing of alternative modes to raise public awareness of and interest in alternatives. These efforts were designed to increase the number of commuters placed in alternative modes and generate trip, VMT, and emission reduction benefits for the region. Further, the activities of the COC support the implementation of the other program elements administered by Commuter Connections. Thus, although it pre-dates the development of most Commuter Connections program elements, the COC is included in this evaluation.

Base COC Impacts

The base impacts of the Commuter Operations Center were measured through two surveys, the 2017 Commuter Applicant Placement Survey and the 2016 Retention Rate survey. The 2017 Placement survey, conducted in November 2017, assessed commute travel for commuters who received commute assistance services from Commuter Connections during the 2017 evaluation period. The Retention Rate survey, which was conducted in spring 2016, examined commute travel for commuters who received COC services prior to the 2017 evaluation period. The Retention Rate survey will be administered again in FY 2021.

Placement Survey

The November 2017 Placement Survey polled 706 commuters who received commute assistance services from Commuter Connections between July 1, 2017 and September 30, 2017. The survey asked detailed questions to define travel behavior changes commuters made after they received the commute services. Information collected, included, among other elements:

- Commute patterns: Current mode and previous mode (if commuter made a mode shift), frequency of mode use, travel distance, access mode to rideshare/transit pick-up point, and pool occupancy
- Permanence of mode changes: Whether change was continued (still in effect) or temporary (commuter had reverted to the original mode)
- Motivation: Role of Commuter Connections' assistance in decisions to start or increase alternative mode use

Data from the Placement survey were used to derive the placement rates, VTR factors, and travel distance impact calculation multipliers for the commuters who received Commuter Connections services during the FY 2018 - FY 2020 evaluation period (July 2017 through June 2020). These multipliers were estimated for two applicant sub-populations, defined by participants' home and work jurisdictions. The first population included participants who both lived and worked in any of the 15 jurisdictions in the Washington, DC-MD-VA ozone National Ambient Air Quality Standard (NAAQS) nonattainment area (NAA).[5] The second population included participants who worked in the NAA but lived outside it. This distinction was made because applicants who lived outside the NAA traveled a portion of their VMT outside the NAA. These "out of NAA" applicants were discounted to include only the portion of the VMT reduction that occurred within the NAA. Approximately 37% of the total participants lived outside the NAA.

Retention Rate Survey

The 2016 Retention Rate Survey interviewed 989 commuters who had participated in Commuter Connections services prior to the start of the FY 2018 - FY 2020 evaluation period (Pre-FY 2015). About 81% of the survey respondents had been registered for GRH and 19% had used only a non-GRH service. Impacts for respondents who participated in GRH are counted in the TDM analysis under the GRH program element. Respondents who used only non-GRH services are counted in the analysis under the Commuter Operations Center.

The objective of the Retention survey was to identify past COC applicants who made a change to an alternative mode after receiving commute assistance (alternative mode placement) and who were still using the alternative mode at the time of the survey (retained in alternative modes). For this purpose, the survey included questions about, among other elements:

- Current commute pattern: Current modes, frequency of mode use, and commute distance
- Previous commute patterns: Modes used prior to receiving Commuter Connections services and frequency of mode use
- Motivation: Importance of Commuter Connections services to continue use of alternative modes

Data from the Retention Rate survey were used to derive the placement rate, VTR factor, and travel distance calculation multipliers for past "retained" COC applicants. The survey did not ask respondents about their home location, so it was not possible to calculate separate Within NAA and Outside NAA factors. Because all commuters traveled part of their commute within the NAA, it was reasonable to use an overall placement rate and an overall VTR factor for all respondents, but it was necessary to adjust the overall travel distance to include only the Within NAA portion of VMT. In past placement surveys, the Within NAA distance was approximately 75% of the overall distance; this discount factor was applied to the overall distance from the Retention Rate survey to estimate the Within NAA factor.

[5] The 15 jurisdictions included in the NAAQS nonattainment area (NAA) are: District of Columbia, Calvert County (MD), Charles County (MD), Frederick County (MD), Montgomery County (MD), Prince George's County (MD), Arlington County (VA), Fairfax County (VA), Loudoun County (VA), Prince William County (VA), City of Alexandria (VA), City of Fairfax (VA), City of Falls Church (VA), City of Manassas (VA), and City of Manassas Park (VA).

Calculation Factors and Impacts

Placement Rate and Placements – The first calculation factor used in the TDM analysis is placement rate, equal to the percentage of COC applicants who made a mode shift to an alternative mode. For the FY 2018 – FY 2020 program participants, placement rates were calculated for Within NAA participants and Outside NAA participants. For each geographic sub-population, two rates were calculated, based on the amount of time the respondent had used the new alternative mode. A "continued" rate was estimated for respondents who continued using the new alternative mode until the placement survey was conducted. A "temporary" rate was estimated for respondents who made a switch but returned to their original mode before the survey.

The placement rate for Pre-FY 18 "retained" applicants was calculated from the Retention Rate survey. Because participants must have continued their use of alternative modes to be counted as retained, all the Pre-FY 2018 placements were counted as continued.

To determine the number of commuters placed in alternative modes, the placement rates were multiplied by the numbers of COC applicants for the time period and geographic location. A total of 75,651 commuters received services between July 2017 and June 2020. About 45% of the requests were from new applicants or re-applicants. The COC also provided follow-up assistance, with additional match names for existing carpools and vanpools that needed a new or additional rider to maintain or expand existing ridesharing arrangements.

The count of past applicants for the Pre-FY 2018 time period, was estimated to be 3,290.[6] Note that this count reflects the combination of the past applicant count from the Retention Rate survey for the period before July 2014, plus an estimate for COC users whose last service was before July 2017 but after the Retention Rate survey was conducted.

These calculations resulted in a total of **31,992 placements**, divided as shown below, with 31,446 (98%) new placements from FY 2018 – FY 2020 applicants and 546 (2%) retained placements from Pre-FY 2018 applicants:

	Population base		Placement Rate		Placements
FY 2018 – FY 2020					
• Within NAA - continued	47,660	x	35.5%	=	16,919
• Within NAA - temporary	47,660	x	5.4%	=	2,574
• Outside NAA - continued	27,991	x	37.8%	=	10,581
• Outside NAA - temporary	27,991	x	4.9%	=	1,372
Pre-FY 2018					
• Within NAA - continued	2,058	x	16.6%	=	344
• Outside NAA - continued	1,209	x	16.6%	=	202

Total Placements = 31,446 new placements + 546 retained placements = **31,992**

VTR Factors and Vehicle Trips Reduced – These placement figures were then multiplied by VTR factors derived from the Placement survey (FY 2018 – FY 2020) and Retention Rate survey (Pre-FY 2018) to estimate the number of vehicle trips reduced. The VTR factor for each sub-population is as follows:

FY 2018 – FY 2020

- Within NAA - continued 0.50 vehicle trips reduced per placement
- Within NAA - temporary 0.37 vehicle trips reduced per placement
- Outside NAA - continued 0.53 vehicle trips reduced per placement
- Outside NAA - temporary 0.59 vehicle trips reduced per placement

[6] The 3,267 commuter applicants assigned to the COC for the Pre-FY 2018 time period includes commuters who received ONLY non-GRH services. An additional number of commuters received both non-GRH and GRH services before July 2017. These commuters are counted under the GRH program element.

Pre-FY 2018

- Within NAA - continued 0.73 vehicle trips reduced per placement
- Outside NAA - continued 0.73 vehicle trips reduced per placement

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 8.3 weeks (16% of a year). The calculation of vehicle trips reduced produced a total of **14,747 vehicle trips reduced**; 14,350 vehicle trips reduced by new (FY 2018 – FY 2020) applicants and 397 from retained (Pre-FY 2018) applicants.

Commute Distance and VMT Reduced – Next, VMT reduction from COC applicants was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for commuters who made a shift to an alternative mode. For the FY 2018 – FY 2020 registrants, the one-way trip distance for the within NAA respondents was 29.5 miles for applicants with continued mode changes and 24.4 miles for applicants with temporary changes. The actual one-way distance for the outside NAA respondents was more than 50 miles, but to discount the distance credited to the outside NAA respondents, their one-way travel distance was set equal to that of the distance for the within NAA respondents. For the Pre-FY 2018 retained registrants, the commute distance was 19.7 miles; this was used for both the Within NAA and Outside NAA groups:

FY 2018 - FY 2020

- Within NAA/Outside NAA - continued 29.5 miles reduced per trip
- Within NAA/Outside NAA - temporary 24.4 miles reduced per trip

Pre-FY 2018

- Within NAA/Outside NAA - continued 19.7 miles reduced per trip

The calculation of VMT reduced produced a total of **429,728 VMT reduced**, with 421,887 VMT reduced by new FY 2018 – FY 2020 applicant and 7,841 VMT reduced by retained (Pre-FY 2018) applicants.

Emissions Reduced – Estimates of reductions in NOx, VOC, PM 2.5, PM 2.5 pre-cursor NOx, and CO2 for the COC were calculated using regional emission factors, as described for the Telework and GRH program elements. Details of the COC calculations are presented in Appendix 6. The overall COC results were adjusted to account for overlap with the Software Upgrades (described below), GRH, and Mass Marketing. To avoid double counting of impacts, the COC's contributions to these program elements were subtracted from the COC "basic impacts."

Software Upgrades

Included within the Commuter Operations Center program is the Integrated Rideshare-Software Upgrades Project. When it began, Integrated Rideshare provided improvements to the quality and delivery of alternative mode information. In particular, Commuter Connections added transit, park and ride, telecenter/co-working center, and bicycling information to carpool/vanpool ridematch lists to inform commuters of the range of travel options that were available. Since 2008, when Commuter Connections introduced its updated web-based TDM system, these additional services have been available on a self-service basis through the online information system. But these services represent upgrades to the original ridematching services, so their impacts are captured under the Commuter Operations Center, but are reported separately.[7]

By providing transit and telework information to all commuters who received ridematches, the service is expected to encourage commuters to try transit and park & ride lots, even if they did not have these options in mind when they requested assistance. The Software Upgrade portion of the program element was implemented in October 1998. In the 2008 evaluation, this component was merged into the COC impacts. This arrangement was used also for the 2011, 2014, and 2017 evaluations, but Software Upgrade impacts are calculated separately.

[7] Integrated Rideshare originally had two components; Ridematching Software Upgrades, and Inf-Express Kiosks. The InfoExpress Kiosk project was discontinued during the 2005-2008 evaluation period.

Impacts of the Software Upgrades was assessed using data from the November 2017 Applicant Placement Survey. This survey assessed changes commuters made after receiving a ridematch or other commute service from Commuter Connections. Respondents were asked if they remembered receiving information about transit options, park & ride (P&R) locations, bicycle routes, and/or telework when they received assistance from Commuter Connections. Respondents who recalled any or all these services were asked follow-up questions to determine if they used the information to make any travel changes. Mode changes that were influenced by use of any of these information services were captured in this COC component.

Placement Rate and Placements – The surveys showed that 4.6% of applicants who lived within the NAA and 4.8% of applicants who lived outside the NAA used the transit, P&R, bicycle, and/or telework information to shift to an alternative mode. Most said they continued using the alternative mode. To estimate commuter placements, placement rates were multiplied by the commuters who applied to Commuter Connections or received follow-up assistance from Commuter Connections during the evaluation period. These calculations resulted in a total of **3,536 placements**, divided as shown below:

	Population base		Placement Rate		Placements
• Within NAA - continued	47,660	x	3.1%	=	1,477
• Within NAA - temporary	47,660	x	1.5%	=	715
• Outside NAA - continued	27,991	x	3.6%	=	1,008
• Outside NAA - temporary	27,991	x	1.2%	=	336

VTR Factors and Vehicle Trips Reduced – These placement figures were then multiplied by VTR factors derived from the Placement survey to estimate the number of vehicle trips reduced. The VTR factor for each sub-population is as follows:

- Within NAA - continued 0.53 vehicle trips reduced per placement
- Within NAA - temporary 0.41 vehicle trips reduced per placement
- Outside NAA - continued 0.50 vehicle trips reduced per placement
- Outside NAA - temporary 0.54 vehicle trips reduced per placement

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 8.3 weeks (16% of a year). The calculation of vehicle trips reduced produced a total of **1,363 vehicle trips reduced** by applicants who were assisted or influenced by the Software Upgrades.

Commute Distance and VMT Reduced – VMT reduction was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for commuters who made a shift to an alternative mode:

- Within NAA/Outside NAA - continued 30.0 miles reduced per trip
- Within NAA/Outside NAA - temporary 25.4 miles reduced per trip

As noted in the descriptions for both the GRH program element and the COC, these distances were used for both Within NAA and Outside NAA respondents. The calculation of VMT reduced produced a total of **40,541 VMT reduced**.

Emissions Reduced – Emission reduction was calculated using trip-based and VMT-based regional emission factors. Calculation details for the software upgrade are shown in Appendix 7. To avoid double counting of impacts, the Software Upgrades impacts were subtracted from the COC "basic impacts."

Telework Assistance Outside of Maryland

As noted in Section 4 (Telework Assistance), commuters who received telework assistance from Commuter Connections but who lived and/or worked outside Maryland are not counted in the Telework program element. Instead, their impacts are counted in the COC. The calculation for these impacts follows the method described in Section 4.

Using results from the State of Commute survey, the number of non-Maryland telecommuters who had direct contact with the Telework program element during the evaluation period were estimated and divided into "home-based" and "non-home-based" groups. These numbers of telecommuters were then multiplied by average VTR factors and one-way travel distances, as identified by the appropriate survey data, to obtain the number of vehicle trips and VMT reduced by their telecommuting.

- VTR factor for non-Maryland-based home-based telecommuters was 0.22 daily trips reduced per telecommuter and the average one-way travel distance was 14.9 miles.
- The VTR factor for non-home-based telecommuters was 0.04 and the net VMT reduced per telework day was 13.5 miles.

These calculations resulted in an estimated **33,918 telecommuters, 6,912 daily vehicle trips reduced, and 102,818 daily VMT reduced** by Commuter Connections-assisted telecommuting. These impacts were added to the COC base impacts.

Commuter Operations Center Summary of Goals and Impacts

Shown below are the evaluation results for the COC and the goals established for the Center (Table 11).

Table 11
Commuter Operations Center Regional Goals and Estimated Impacts

	COC Goal	Estimated Impacts
Commuter Operations Center (basic services)		
• Total commuters (new, re-apply, follow-up)	91,609	75,651
• New applicants during evaluation period	N/A	16,126
• Number of past applicants (Pre FY 2018)	N/A	3,290
• Daily vehicle trips reduced	24,425	16,281
• Daily VMT reduced	512,637	375,135
• Daily tons NOx reduced	0.2410 T	0.0731 T
• Daily tons VOC reduced	0.1150 T	0.0523 T
• Annual tons PM 2.5 reduced	N/A	1.232 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	24.506 T
• Annual tons CO2 reduced	N/A	36,448.5 T
Software Upgrades (additional to Basic COC)		
• Daily vehicle trips reduced	2,379	1,363
• Daily VMT reduced	66,442	40,541
• Daily tons NOx reduced	0.0280 T	0.0071 T
• Daily tons VOC reduced	0.0110 T	0.0044 T
• Annual tons PM 2.5 reduced	N/A	0.125 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	2.400 T
• Annual tons CO2 reduced	N/A	3,806.5 T

Impacts vs Goals

Basic COC

Transportation Benefit (net over or (under) goal):	Vehicle Trips: (8,144) VMT: (137,502) miles
Emission Benefit (net over or (under) goal):	NOx: (0.1679) tons per day VOC: (0.0627) tons per day

Software Upgrades

Transportation Benefit (net over or (under) goal):	Vehicle Trips: (1,016) VMT: (25,901) miles
Emission Benefit (net over or (under) goal):	NOx: (0.0209) tons per day VOC: (0.0066) tons per day

The Basic COC services missed the vehicle trip and VMT reduction goals by 33% and 27% respectively. The telework impacts accounted for about 42% of the total COC vehicle trips reduced and one quarter (27%) of the COC's VMT reduction. The COC Base goals were increased following the FY 2012-14 evaluation to represent the addition of non-Maryland telework credit to the Commuter Operations Center. The COC share of impacts generated by applicants was higher in 2020 (VT = 9,368, VMT 272,303) than in 2017 (VT = 6,139, VMT = 173,996), so the COC goal deficit was entirely due to a sizeable decline in the impacts from the non-Maryland telework component. The Software Upgrades component also missed the goals for vehicle trips and VMT reduced, by 43% and 39%, respectively.

In recent years, several external factors have occurred that could have influenced commuters' interest in alternative mode use. One such factor is gasoline prices, which fell significantly in 2010 and which have remained relatively stable, eliminating one of the prime motivations to seek a rideshare arrangement. A second consideration is the expanded availability of private ridematch options, such as Craigslist, Waze Carpool, UberPool, and other informal applications, which could be attracting some commuters who seek commute information.

Finally, it is likely that the COC calculation underrepresents the true impact of both the Software Upgrades and basic COC program. The COC impacts are calculated only on commuters who can be contacted through a follow-up survey to identify travel changes they made after receiving Commuter Connections services. But the Commuter Connections website offers general information on commute options as well as links to Park & Ride lot information and to other resources, which commuters can use without making a formal application to Commuter Connections. Thus, some COC service recipients likely were excluded from the analysis. The extent of the impact undercounting cannot be estimated, but in the 2019 SOC survey, nearly 158,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections website.

The results shown in Table 12 were adjusted to eliminate overlap between the COC and individual program elements. A portion of COC impacts were assigned to Software Upgrades and to GRH. Finally, the impacts for 2.6% of new COC applicants were assigned to Mass Marketing, to reflect the impact of this program element in influencing commuters to contact CC for travel-assistance services.

Table 12
Adjustment of Vehicle Trips and VMT for Overlap between the COC and Program Elements
(excluding telework credit for non-Maryland telecommuters)

Evaluation Measure	Basic COC	Mass Marketing	Software Upgrades	GRH	Net Basic COC
VT reduced	14,748	373	1,363	3,643	9,369
VMT reduced	429,728	10,969	40,541	105,901	272,317

Notes:

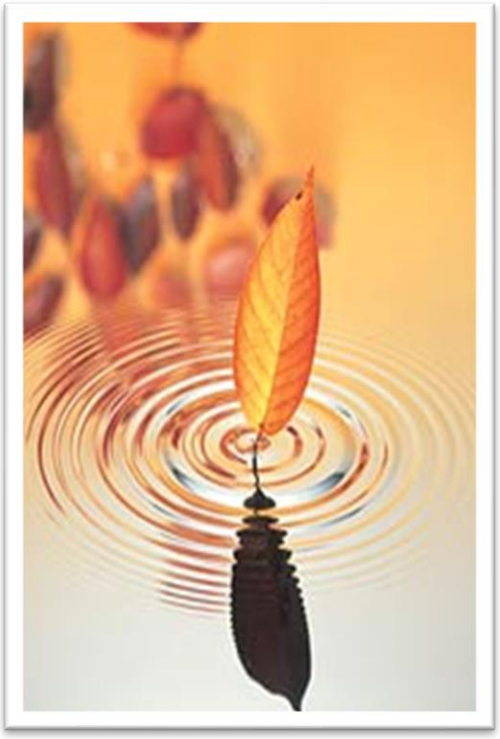
- Mass Marketing – new applicants influenced by ads to contact CC, see Section 6
- Software upgrades – see description in this section
- GRH – 63% of new/reapply applicants who shifted to alternative modes registered for GRH = 30% of Base COC credit was assigned to GRH (63% x 47.4% new/reapply share of total applicants)

Table 13 shows the addition of the net Base COC and telework credit for non-Maryland telecommuters who were assisted by Commuter Connections.

Table 13
Total Commuter Operations Center Credit
(Adjusted Base COC + Non-Maryland Telework)

Evaluation Measure	Net Basic COC	Non-MD Telework	NET COC TOTAL
VT reduced	9,369	6,912	16,281
VMT reduced	272,317	102,818	375,135

Section 9 Summary of TDM Program Element Impacts



The preceding sections of this report documented estimated impacts for four individual TDM program elements and for the Commuter Operations Center. As noted earlier in the report, the four TDM program elements combined met the collective goal for vehicle trips reduced and exceeded the VMT goal by about 6%.

The TDM program elements combined met the collective goal for vehicle trips reduced and exceeded the VMT goal by about 7%. The TDM program elements did not reach the emission goals; the impact for NOx was about 50% under the goal and VOC impact was 38% under the goal, but these deficits were due largely to reductions in the emission factors in the years since the goals were set in 2006. The emission factors used in the 2020 evaluation were considerably lower than the factors from 2017 and lower still than the factors used in 2014, reflecting a cleaner vehicle fleet.

When the COC results are added to the impacts of the four program elements impacts, as presented in Table B, the combined impact came within 0.3% of the VMT reduction goal. They fell 5% short of the goal for vehicle trips reduced. The combined program element–COC program impact fell 54% short of the NOx goal and was 41% below the VOC goal. Again, the change in the emission factors affected the emission results.

Where shortfalls occurred against the vehicle trip and VMT reduction goals, they appeared more related to lower than expected commuter participation rates, rather than to overly-optimistic factors on the extent of changes commuters would make, for example in their frequency of alternative mode use. COG revised the program element goals following the 2005 TDM analysis to reflect actual behavior changes that commuters make when using Commuter Connections services. COG again revised goals for some elements following the 2014 and 2017 analyses, to account for additions or deletions to activities or services covered by those program elements.

Individual sections of this report have discussed factors that affected the achievement of goals. Highlights of those discussions are presented blow for the four program elements and the COC. One additional factor that is noted here, because it likely affected participation in several program elements, was the coronavirus pandemic, which substantially disrupted commute travel in the last four months of the evaluation period. Some essential workers were still required to commute to their usual job locations, however, a large segment of the commuting population shifted to remote work from home and some workers were furloughed and not working at all.

With travel to work greatly reduced, fewer commuters sought travel assistance services from Commuter Connections. Thus, the participation counts for services such as GRH and the Commuter Operations Center were much lower than usual and the 2020 Bike to Work Day event was cancelled. Employer services also might have been affected, although requests for telework assistance from both employers and commuters appeared to grow, as commuters established remote work procedures.

Maryland and Virginia Telework Assistance

The incidence of telework continues to grow in the Washington region. In 1996, about 150,000 regional workers were telecommuting. The 2019 State of Commute Survey estimated the number of telecommuters had grown nearly seven-fold, to 1.07 million, or about 35% of regional commuters.

The substantial and steady growth in regional telework is likely the result of numerous factors. Telework, which can facilitate a better balance of work and family, can assist employers efforts to recruit and retain employees, and might lead to greater worker productivity. Increasing traffic congestion in the Washington region and the personal cost of commuting also might have prompted some commuters to work at home to avoid traffic and or the cost of travel. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework, as the coronavirus pandemic has clearly demonstrated. Finally, the greater affordability and sophistication of technology, almost certainly has contributed to the growth in telecommuting.

The Telework program element includes three components, two for Maryland and one for Virginia:

- Maryland – Regional telecommuters who live and/or work in Maryland who were influenced by Telework services/assistance to begin telecommuting
- Maryland – Telecommuting employees at Maryland worksites that were assisted by Commuter Connections
- Virginia – Telecommuting employees at Virginia worksites that received on-site Telework! VA assistance

Maryland Telework – Overall, about 4.3% of regional telework can be attributed to the efforts of the Telework program element, either directly through information distributed to commuters, through regional advertising to the public-at-large, or through assistance to employers that want to start a telework program. In the 2019 State of the Commute Survey, Maryland telecommuters accounted for approximately 49% of regional telecommuters and nearly 9% of these telecommuters mentioned Commuter Connections or MWCOG as a source of telework information. This represented a slight decline from the 11% estimated in the 2016 SOC survey.

Even with this decline, the program element met its participation and travel impact goals. The number of Maryland telecommuters estimated for the program element was 45% over the number of telecommuters expected from this element. The element also exceeded the reduction goals for vehicle trips (15%) and VMT (28%). Commuter Connections revised the telework goals following the 2014 TDM analysis and the goals now more closely represent the actual telework patterns existing in the region for average telework frequency and mode us on non-telework days. These two factors have a substantial impact on the total trip reduction generated by teleworking.

The 2019 SOC survey indicated a slight decline in the average frequency of regional telework, from 1.4 days per week in 2016 to 1.2 days per week in 2019. This decline was largely offset by the increase in the number of commuters who telecommute. But the drop in frequency might indicate that commuters who are now starting to telecommute can do so only occasionally, either for job-related or personal reasons.

One possible area in which the Telework program element's contribution to the regional telework impacts could have been undercounted is that of regional employer outreach. Nearly eight in ten (79%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach program element also promotes telework to employers. Thus, this response likely indicates additional telecommuters who learned about teleworking indirectly from Commuter Connections. Because this cannot be clearly documented, no additional credit is attributed for these employees to the Telework program element. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

Note also that the Telework program element includes only outreach and assistance efforts to commuters who live or work in Maryland and to a small number of employers that receive telework assistance from Commuter Connections or from Telework! VA. Commuter Connections also provides telework information and assistance to commuters in other parts of the Washington metropolitan region. The impacts of these efforts are counted under the Commuter Operations Center.

Telework! VA – Fifteen employers, representing 10,041 employees, actively participated in the Telework! VA program during the evaluation period. Using data from baseline and post-assistance surveys, the analysis estimated that 19.1% of employees either started teleworking during the assistance period or increased their telework frequency. These new/increased teleworkers equated to 1,918 placements, 28% over the 1,500-teleworker goal set for the program. Telework! VA also exceeded the vehicle trip and VMT goals for the program.

Guaranteed Ride Home

The GRH program element met 83% of the goals for vehicle trips reduced and VMT reduced. The shortfalls primarily resulted because the number of new GRH registrants continues to decline from its high point in 2008. COG adjusted the goals for this program after the 2005 evaluation to reflect the actual travel patterns of typical GRH applicants and the fact that a sizeable share of GRH registrants were ridesharing or using transit prior to registering. These changes resulted in the vehicle trip and VMT calculations more accurately measuring the trip reduction per new GRH registrant, but the lower participation levels resulted in correspondingly lower results for vehicle trip and VMT reduction goals.

Some of the participation decline could indicate that commuters feel less concerned about being stranded because they have a greater number of travel options, such as transit and ride-hailing, to make their emergency trip home. But some of the decline also could be related to a decline in regional awareness of the program. While Commuter Connections continues to promote the program through advertising and outreach, the 2019 State of the Commute survey found that only 16% of respondents said they knew a regional GRH program existed, compared to 59% who said they knew about the program in the 2004 SOC survey.

Despite the drop in program awareness, however, GRH advertising does appear to generate interest and engagement among those who hear the ads. Nearly three in ten GRH applicants said they were influenced to apply for GRH after they heard a Mass Marketing GRH advertisement. To recognize this overlapping influence of the two programs, about 16% of the total GRH impacts were assigned to Mass Marketing. While this boosted the Mass Marketing impact credit, it reduced the GRH impacts reported in this analysis. And note that the 16% share assigned to Mass Marketing in 2020 was higher than the 9% credit that had been reassigned to Mass Marketing in the 2017 TDM analysis. Thus, the GRH shortfall was actually less dramatic than it appears.

Finally, the current GRH participation does not entirely reflect the impact of the GRH program, however. In 2016, COG conducted a "Retention Rate" survey, which asked commuters who participated in GRH and/or other Commuter Connections services prior to the FY 2015 - FY 2017 evaluation period about their current commute travel. The survey estimated that about 14% of past GRH registrants had made shifts to new alternative modes and were continuing to use these new modes during the FY 2015 - FY 2017 evaluation period, even though they were no longer in GRH. Thus, the GRH program impacts extend beyond the 3-year evaluation period. A similar calculation was made in the 2020 TDM analysis and these "retained" alternative mode placements accounted for about 12% of the GRH vehicle trip and VMT reductions for the GRH. Thus, ongoing use of alternative mode by past registrants somewhat mitigates the decline in current participation.

Employer Outreach

In June 2020, the Employer Outreach program counted 1,962 employers with programs that met the Level 3 or 4 definition for a substantial TDM program. These employers accounted for more than 630,000 employees. Level 1 and 2 employers were not included in the regional impact calculation because their level of impact would be very small due to the absence of financial incentives or other substantial commute support services.

Employer Outreach, nearly achieved the travel goals, falling just 5% short of the goal for vehicle trips and 3% under the VMT goal. This program component missed the overall employer participation goal set for the program by about 3%. This reflects, in part, a significant effort by Commuter Connections staff and local jurisdiction staff to purge the database of employers that had ceased operations, had moved from the region, and/or were no longer actively involved in the Employer Outreach program. The 2020 analysis deleted 293 employers, representing more than 106,000 employees, or about 14% of the total employers that could be classified as Level 3 or Level 4.

Although the program did not meet the overall participation goal, 1.589 employers in the program had continued programs from the previous evaluation. An additional 373 employers either newly joined the program (293 employers) or expanded the services they offered to employees (80 employers). These new and expanded activities indicate that the Employer Outreach program continues to attract new employers.

Separate impacts also were calculated for the Employer Outreach for Bicycling component of this program element. This component provides regional outreach to encourage employers to implement worksites strategies that encourage employees to use bicycling for commuting. A total of 570 employers offered bicycle strategies in their worksite programs, slightly below the 590-employer goal for this project. The Employer Outreach for Bicycling component met the vehicle trip reduction goal. It did not meet the VMT reduction goals, but the absolute deficit was small.

Mass Marketing

This program element estimates impacts for six primary groups of commuters:

1) All commuters in the Commuter Connections service area
2) Commuter Connections rideshare applicants who were influenced by the marketing campaign to request Commuter Connections services
3) GRH applicants who were influenced by the marketing campaign to request Commuter Connections services
4) Commuters who participated in the 'Pool Rewards carpool/vanpool incentive program
5) Commuters who participate in the Bike-to-Work Day event
6) Commuters who participate in Car Free Day

Mass Marketing substantially exceeded its goal for commuter placements. This program element also generated vehicle trip reduction 30% above the goal and VMT reduction 53% above the goal.

Goals were not established for any of the individual elements that comprised the Mass Marketing program element (direct influence, indirect referral influences, 'Pool Rewards, BTW Day, and Car Free Day). But the analysis estimated that direct ad influences accounted for 71% of Mass Marketing vehicle trips reduced. 'Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 20% of the total. The remaining 9% of the credit was generated by GRH and Commuter Operations Center referrals.

Commuter Operations Center

The Commuter Operations Center is not a formal TDM program element but was included in this evaluation because it supports the success of the four program elements. The COC received nearly 76,000 applications between July 2017 and June 2020. About 45% of the requests were from new applicants or re-applicants and 55% represented additional follow-up assistance to existing applicants who needed a new or additional rider to maintain or expand existing ridesharing arrangements. Impacts for telework assistance provided by Commuter Connections to commuters who live and work outside Maryland also are included in the COC impacts.

The Basic COC services missed the vehicle trip and VMT reduction goals by 33% and 27% respectively. The telework impacts accounted for about 42% of the total COC vehicle trips reduced and one quarter (27%) of the COC's VMT reduction. The COC Base goals were increased following the FY 2012-14 evaluation to represent the addition of non-Maryland telework credit to the Commuter Operations Center. The COC share of impacts generated by applicants was higher in 2020 (VT = 9,369, VMT 272,317) than in 2017 (VT = 6,139, VMT = 173,996), so the COC goal deficit was entirely due to a sizeable decline in the impacts from the non-Maryland telework component. The Software Upgrades component also missed the goals for vehicle trips and VMT reduced, by 43% and 39%, respectively.

In recent years, several external factors have occurred that could have influenced commuters' interest in alternative mode use. One such factor is gasoline prices, which fell significantly in 2010 and which have remained relatively stable, eliminating one of the prime motivations to seek a rideshare arrangement. A second consideration is the expanded availability of private ridematch options, such as Craigslist, Waze Carpool, UberPool, and other informal applications, which could be attracting some commuters who seek commute information.

Finally, it is likely that the COC calculation underrepresents the true impact of both the Software Upgrades and basic COC program. The COC impacts are calculated only on commuters who can be contacted through a follow-up survey to identify travel changes they made after receiving Commuter Connections services. But the Commuter

Connections website offers general information on commute options as well as links to Park & Ride lot information and to other resources, which commuters can use without making a formal application to Commuter Connections. Thus, some COC service recipients likely were excluded from the analysis. The extent of the impact undercounting cannot be estimated, but in the 2019 SOC survey, nearly 158,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections website.

List of Appendices

Appendix 1 – Basic Calculation of VTR Factor

The vehicle trip reduction (VTR) factor represents the average number of vehicle trips that a commuter "placed" in an alternative mode would reduce per day. The VTR factor combines the trip reduction results of three possible types of travel changes that new commuter placements might make:

1. Drive alone commuters shifting to an alternative mode
2. Commuters who currently use an alternative mode shifting to another alternative mode (e.g., from carpool to bus, train to bus, vanpool to carpool, etc)
3. Commuters who currently use an alternative mode increasing their weekly frequency of alternative mode use (e.g., from carpool one time per week to carpool three times per week).

Shown below is a brief example of how the VTR factor would be calculated for seven commuters who made the following travel changes:

- Placement 1 – shifts from driving alone, 5 days per week, to a two-person carpool, 5 days per week
- Placement 2 – shifts from driving alone, 5 days per week, to transit, 5 days per week
- Placement 3 – shifts from driving alone, 5 days per week, to teleworking, 2 days per week and driving alone 3 days per week
- Placement 4 – shifts from driving alone, 5 days per week, to two-person carpool, 2 days per week and driving alone 3 days per week
- Placement 5 – shifts from a two-person carpool, 5 days per week, to transit, 5 days per week
- Placement 6 – shifts from transit, 5 days per week, to a two-person carpool, 5 days per week
- Placement 7 – increases the frequency of carpool from 1 day per week to 3 days per week, driving alone the other 2 days

The VTR factor is calculated by determining the number of vehicle trips all placements would reduce together and dividing that total by the number of placements. We assume that a commuter makes two trips a day, one from home to work and a second from work to home. Thus, a commuter who drives alone would make 2 vehicle trips each day. A commuter who carpools would make ½ vehicle trip to work and ½ trip back home, for a total of 1 vehicle trip per day. A commuter who uses bus, train, bike, or walk is assumed to make 0 vehicle trips. A commuter who teleworks also makes 0 vehicle trips for telework days.

Shown on the next page are the travel modes and the numbers of vehicle trips each of the seven commuters described above would make for each day of the week before the shift to an alternative mode and after the shift. The third column shows the net vehicle trips (number of trips after the shift minus number of trips before the shift). The final column shows the total weekly trips reduced. Note that commuter #6 actually increases his weekly commute trips, because he shifts from a higher occupancy alternative mode (transit) to a lower occupancy mode (carpool).

Appendix 1, continued

Sample VTR Calculation
Travel Modes Before and After Shifts to Alternative Modes
By Commuter and by Day of the Week

	Vehicle Trips Before Shift					Vehicle Trips After Shift					Vehicle Trips Net Trips					Weekly
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	Change
Placement 1	D	D	D	D	D	C	C	C	C	C						
DA to 2p CP	2	2	2	2	2	1	1	1	1	1	-1	-1	-1	-1	-1	-5 trips
Placement 2	D	D	D	D	D	T	T	T	T	T						
DA to TR	2	2	2	2	2	0	0	0	0	0	-2	-2	-2	-2	-2	-10 trips
Placement 3	D	D	D	D	D	D	D	C	C	C						
DA to TC/DA (part-time)	2	2	2	2	2	2	2	2	0	0	0	0	0	-2	-2	-4 trips
Placement 4	D	D	D	D	D	D	D	C	C	C						
DA to CP/DA (part-time)	2	2	2	2	2	2	2	2	1	1	0	0	0	-1	-1	-2 trips
Placement 5	C	C	C	C	C	T	T	T	T	T						
2p CP to TR	1	1	1	1	1	0	0	0	0	0	-1	-1	-1	-1	-1	-5 trips
Placement 6	T	T	T	T	T	C	C	C	C	C						
TR to 2p CP	0	0	0	0	0	1	1	1	1	1	+1	+1	+1	+1	+1	+5 trips
Placement 7	D	D	D	D	C	D	D	C	C	C						
DA/CP to CP (part-time)	2	2	2	2	1	2	2	1	1	1	0	0	-1	-1	0	-2 trips
Total weekly trips	11	11	11	11	10	8	8	7	4	4	-3	-3	-4	-7	-6	-23 trips

Total placements	= 7 placements (travel for each shown above)
Total trips reduced per week	*= 23 trips per week (all placements together)*
Total trips per day (all placements together)	= 23 trips per week / 5 days per week =4.6 trips per day
Average trips reduced per placement	= 4.6 trips per day / 7 placements = 0.66 trips per placement

The seven commuter placements would reduce a total of 4.6 trips during a single day, thus the average number of trips reduced per day by each of the seven placements would be 0.66. This is the VTR factor.

Appendix 2 – Calculation of Telework Assistance Impacts

3 impact components
- CC Assisted Telework – Maryland
- CC Assisted Telework – Non-Maryland
- Telework! VA

CC Assisted Telework – Maryland and Non-Maryland

Populations of Interest

All regional telecommuters	1,072,690	(from SOC survey)
Teleworkers with MD home or work	525,618	49% (from SOC survey)
Teleworkers not in MD	547,072	51% (from SOC survey)

Commuter Connections TW Placement Rates

Directly assisted TW

• Within Maryland	8.8%	(% of TC assisted by CC, from SOC survey)
• Not in Maryland	6.2%	(% of TC assisted by CC, from SOC survey)

TW Placements (Mixed home and Non-home based)

Maryland (credited to Telework Program Element)

• Directly assisted telecommuters	46,254	(regional TC x directly assisted placement rate)
Total assisted telecommuters - MD	**46,254**	

Not Maryland (to be credited to COC)

• Directly assisted telecommuters	33,918	(regional TC x directly assisted placement rate)
• Telecommuters at TW assisted sites	0	(employees at assisted sites x assisted site placement rate)
Total assisted telecommuters – Not MD	**33,918**	

Placements by Location (home-based and non-home-based)

• % Home-based telecommuters	91%	(from SOC survey)
• % Non-home (NH)-based telecommuters	9%	(from SOC survey)

Maryland (credited to Telework Program Element)

• Home-based telecommuters	42,091	(total assisted TW x % Home-based TW)
• NH-based telecommuters	4,163	(total assisted TW x % NH-based TW)

Not Maryland (credited to COC)

• Home-based telecommuters	30,865	(total assisted TW x % Home-based TW)
• NH-based telecommuters	3,053	(total assisted TW x % NH-based TW)

Appendix 2, continued

Daily Vehicle Trips Reduced

VTR Factors

• Home-based factor – MD	0.32	(from SOC survey)
• Home-based factor – Not MD	0.22	(from SOC survey)
• NH-based factor – MD and Not-MD	0.04	(from SOC survey)

Maryland (credited to Telework Program element)

• Home-based VT reduced	13,469	(HB TW x HB VTR factor)
• NH-based VT reduced	167	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced - MD	**13,636**	

Not Maryland (credited to COC)

• Home-based VT reduced	6,790	(HB TW x HB VTR factor)
• NH-based VT reduced	122	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced – Not MD	**6,912**	

Daily VMT Reduced

Ave one-way trip distance (mi) to main workplace

• Home-based – MD	22.7	(SOC survey)
• Home-based – Not MD	14.9	(SOC survey)

Ave one-way trip distance (mi) for non-home-based TW (MD and Not-MD)

• Non-home based – to main workplace	21.6	(SOC survey)
• Non-home based – to TW location	8.1	(SOC survey)
• Non-home based – net VMT reduced	13.5	(SOC survey)

VMT reductions on TW days

Maryland (credited to Telework Program Element)

• Home-based VMT reduced	305,746	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	2,255	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced - MD	**308,001**	

Not Maryland (credited to COC)

• Home-based VMT reduced	101,171	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	1,647	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced – Not MD	**102,818**	

Appendix 2, continued

Maryland (credited to Telework Program Element)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	13,636	1.0309			14,057	0.0155
• From Running			308,001	0.1498	46,139	0.0509
Total NOx reduced (tons)					**Daily**	**0.0664**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	13,636	2.1358			29,124	0.0321
• From Running			308,001	0.0593	18,264	0.0201
Total VOC reduced (tons)					**Daily**	**0.0522**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	13,636	0.0312			425	0.0005
• From Running			308,001	0.0115	3,542	0.0039
Total PM 2.5 reduced (tons)					**Daily**	**0.0044**
					Annual	**1.100**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	13,636	1.3603			18,549	0.0204
• From Running			308,001	0.2019	62,185	0.0685
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0889**
					Annual	**22.225**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	13,636	212.54			2,898,195	3.19
• From Running			308,001	362.93	111,782,803	123.22
Total CO2 reduced (tons)					**Daily**	**126.41**
					Annual	**31,602.5**

Appendix 2, continued

Non-Maryland (credited to COC)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	6,912	1.0309			7,126	0.0079
• From Running			102,818	0.1498	15,402	0.0170
Total NOx reduced (tons)					**Daily**	**0.0249**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	6,912	2.1358			14,763	0.0163
• From Running			102,818	0.0593	6,097	0.0067
Total VOC reduced (tons)					**Daily**	**0.0230**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	6,912	0.0312			216	0.0002
• From Running			102,818	0.0115	1,182	0.0013
Total PM 2.5 reduced (tons)					**Daily**	**0.0015**
					Annual	**0.375**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	6,912	1.3603			9,402	0.0104
• From Running			102,818	0.2019	20,759	0.0229
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0333**
					Annual	**8.325**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	6,912	212.54			1,469,076	1.62
• From Running			102,818	362.93	37,315,737	41.13
Total CO2 reduced (tons)					**Daily**	**42.75**
					Annual	**10,687.5**

Telework! VA

Populations of Interest

Employees at TW! VA worksites	10,041	(from TW! VA data)

TW! VA Placements

• Placement rate-assisted worksites	19.1%	(from TW baseline/post-assistance surveys)
Total Placements	**1,918**	

Appendix 2, continued

Daily Vehicle Trips Reduced

• Continued VTR factor	0.28	(from TW baseline/post-assistance surveys)
Total Daily Vehicle Trips Reduced	**537**	

Daily VMT Reduced

• Ave one-way trip dist (mi)	18.3	(from TW post-assistance survey)
Total Daily VMT Reduced	**9,827**	

Daily Emissions Reduced – NOx and VOC

NOx	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	537	1.0309			554	0.0006
• From Running			9,827	0.1498	1,472	0.0016
Total NOx reduced (tons)					**Daily**	**0.0022**

VOC	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	537	2.1358			1,147	0.0013
• From Running			9,827	0.0593	583	0.0006
Total VOC reduced (tons)					**Daily**	**0.0019**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	537	0.0312			17	0.0000
• From Running			9,827	0.0115	113	0.0001
Total PM 2.5 reduced (tons)					**Daily**	**0.0001**
					Annual	**0.025**

PM 2.5 Precursor NOx	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	537	1.3603			730	0.0008
• From Running			9,827	0.2019	1,984	0.0022
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0030**
					Annual	**0.750**

CO2	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	537	212.54			114,134	0.13
• From Running			9,827	362.93	3,566,513	3.93
Total CO2 reduced (tons)					**Daily**	**4.06**
					Annual	**1,015.0**

Appendix 3 – Calculation of Guaranteed Ride Home Impacts

Populations of Interest

FY 2018-20 Registrant Base (New credit)

• New GRH registrants (FY 2018-20)	7,429	(GRH database)
• Re-registrants from FY 2018	5,515	(Commuter Connections archive database)
• One-time exceptions (FY 2018-20)	0	(GRH database)
New FY 2018-20 GRH base	**12,944**	

Pre-FY 2018 Registrant Base (Retained credit)

• GRH registrants Pre-FY 2018	29,348	(COC GRH/Online databases)
• Valid contact percentage	63%	(Retention rate survey)
Retained Pre-FY 2018 GRH base	**18,489**	

Distribution of In/Out NAA

FY 2018-20 Registrant Base (New)

Within NAA	65%	8,414
Outside NAA	35%	4,530

Pre-FY 2018 Registrant Base (Retained)

Within NAA	65%	12,018
Outside NAA	35%	6,471

GRH Placement Rates and Placements (continued only) (NAA base x NAA placement rate)

FY 2018-20 Registrants (New)

• Within NAA rate	43.7%	3,677
• Outside NAA rate	50.9%	2,306

Pre-FY 2018 Registrants (Retained)

• Within NAA rate	12.2%	1,466
• Outside NAA rate	12.2%	789
Total Placements		**8,238**

VTR Factors and Daily Vehicle Trips Reduced (continued only) (NAA placement x NAA VTR factor)

FY 2018-20 Registrants (New)

• Within NAA VTR factor	0.83	3,052
• Outside NAA VTR factor	1.00	2,306

Pre-FY 2018 Registrants (Retained)

• Within NAA VTR factor	0.31	454
• Outside NAA VTR factor	0.31	245
Total Daily Vehicle Trips Reduced		**6,057**

Commute Distance and Daily VMT Reduced (NAA VT reduced x NAA distance)

FY 2018-20 Registrants (New)

• Within NAA distance	28.1	85,761	
• Outside NAA distance	28.1	64,799	(discount actual 49.8 miles from GRH survey)

Pre-FY 2018 Registrants (Retained)

• Within NAA distance	29.9	13,575
• Outside NAA distance	29.9	7,326
Total Daily VMT Reduced		**171,461**

Appendix 3, continued

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

Inside NAA

- SOV access percentage 80% (GRH survey)
- SOV access distance (mi) 5.7 (GRH survey)

Outside NAA

- Adjustments are not applicable, because all access VT and VMT occur outside NAA

Adjusted VT Reduction – net of VMT access

- Total VT reduced 6,057
- Within NAA access VT (deduct) - 2,805 (Total VT reduction within NAA x SOV access %)
- Outside NAA access VT 0 No deduction (access trips are outside NAA)

Total VT for AQ analysis 3,252

Adjusted VMT Reduction – net of VMT access

- Total VMT reduced 171,461
- Within NAA access VMT (deduct) - 15,989 (SOV Access VT within NAA x SOV access distance)
- Outside NAA access VMT 0 No deduction (access VMT are outside NAA)

Total VMT for AQ analysis 155,472

Daily Emissions Reduced – NOx and VOC

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	3,252	1.0309			3,352	0.0037
• From Running			155,472	0.1498	23,290	0.0257
Total NOx reduced (tons)					**Daily**	**0.0294**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	3,252	2.1358			6,946	0.0077
• From Running			155,472	0.0593	9,219	0.0102
Total VOC reduced (tons)					**Daily**	**0.0179**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	3,252	0.0312			101	0.0001
• From Running			155,472	0.0115	1,788	0.0020
Total PM 2.5 reduced (tons)					**Daily**	**0.0021**
					Annual	**0.525**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	3,252	1.3603			4,424	0.0049
• From Running			155,472	0.2019	31,390	0.0346
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0395**
					Annual	**9.875**

Appendix 3, continued

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued)

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	3,252	212.54			691,180	0.762
• From Running			155,472	362.93	56,425,453	62.198
Total CO2 reduced (tons)					**Daily**	**62.960**
					Annual	**15,740.1**

Correction for Overlap with Mass Marketing

The GRH results were adjusted to eliminate double counting between GRH and Mass Marketing for new GRH applicants. About 16% of the FY 2018 – FY 2020 GRH impacts were assigned to Mass Marketing to recognize that 31% of new GRH applicants were influenced to apply for GRH after hearing a Mass Marketing advertisement. These new applicants accounted for 57% of the total GRH applicants (Reapply + New). The 12% of total impacts generated through Retained GRH users were excluded from the base. This calculation resulted in 16% of the GRH credit being assigned to Mass Marketing (31% x 57% new apps x 88% non-retained impacts).

Total GRH apps FYs 18, 19, 20	12,944	
New GRH apps FY 18, 19, 20	7,429	57%
Estimated MM share of new GRH	31%	
FY 2018-20 VMT as % of total VMT	88%	(Exclude Retained credit from discount)
Estimated MM share of GRH impact	16%	

Net GRH = GRH Base Total – Mass Marketing credit

	GRH Base Total	GRH Excl Retained	Mass Mkt Credit	Net GRH Credit
Placements	8,238	5,983	957	7,281
Vehicle Trips reduced	6,057	5,358	857	5,200
VMT reduced (mi)	171,461	150,560	24,090	147,371
Daily Emissions Reduced				
NOx (T)	0.0294	0.0259	0.0041	0.0253
VOC (T)	0.0179	0.0158	0.0025	0.0154
Annual Emissions Reduced				
PM 2.5 (T)	0.525	0.4620	0.0739	0.451
PM 2.5 Precursor NOx (T)	9.875	8.6900	1.390	8.485
CO2 (T)	15,740.1	13,851.3	2,214.7	13,523.9

Appendix 4 – Calculation of Employer Outreach Impacts

Populations of Interest

Level 3 or 4 sites (data from ACT! database)

	Employers	Employees
• Programs unchanged since 2017	1,589	516,062
• Expanded programs in 2020	80	21,359
• New programs in 2020	293	92,622
• Deleted programs since 2017	293	106,764

Average Vehicle Occupancy (AVO)

Starting AVO from employee survey data, Final AVO from COMMUTER model

	Starting AVO	Ending AVO
• Programs unchanged since 2017	1.2718	1.3953
• Expanded programs – continued base	1.3412	1.4529
• Expanded programs – new impacts	1.4529	1.5394
• New programs	1.1740	1.2527
• Deleted programs	1.2220	1.3714

Daily person trips

Total employees x 2 one-way trips per day

Starting (pre-program) and ending (with-program)

	Starting	Ending
• Programs unchanged since 2017	1,032,124	1,032,124
• Expanded programs	42,718	43,718
• New programs	185,244	185,244
• Deleted programs	213,528	213,528

Daily vehicle trips

Total employees / starting AVO)

Starting (pre-program) and ending (with-program)

	Starting	Ending	Difference
• Programs unchanged since 2017	811,546	739,715	71,831
• Expanded programs – maintained base	31,851	29,402	2,449
• Expanded programs – new impact	29,402	27,750	1,652
• New programs	157,789	147,876	9,913
• Deleted programs	174,736	155,701	(19,035)

Total Daily Vehicle Trips Reduced

• Maintained impacts from 2017	74,280
• New/expanded impacts	11,565
Net 2020 reduction	**85,845**

Appendix 4, continued

Daily VMT reduced

Results produced by COMMUTER model, assuming travel distance by mode from SOC survey

- Programs unchanged since 2017 1,256,202
- Expanded programs – maintained base 44,810
- Expanded programs – new impact 12,536
- New programs 175,617
- Deleted programs (336,703)

Total Daily VMT Reduced

- Maintained impacts from 2017 1,301,012
- New/expanded impacts 188,153

Net 2020 reduction 1,489,165

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

- Non-SOV access percentage 68% (from 2019 SOC survey)
- SOV access percentage 32% (from 2019 SOC survey)
- SOV access distance (mi) 2.8 (from 2019 SOC survey)

VT Reduction without SOV access – used as base for AQ analysis

(Total VT reduced x non-SOV access %)

- Maintained impacts from 2017 50,510
- New/expanded impacts 7,864

VMT Reduction without SOV access

(Total VMT reduced – (Total daily VT reduced x SOV % x SOV access trip distance))

- Maintained impacts from 2017 1,234,456
- New/expanded impacts 177,790

Emissions Reduced – Maintained from 2017

Daily Emissions Reduced – NOx and VOC

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	50,510	1.0309			52,071	0.0574
• From Running			1,234,456	0.1498	184,922	0.2038
Total NOx reduced (tons)					**Daily**	**0.2612**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	50,510	2.1358			107,879	0.1189
• From Running			1,234,456	0.0593	73,203	0.0807
Total VOC reduced (tons)					**Daily**	**0.1996**

Appendix 4, continued

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	50,510	0.0312			1,576	0.0017
• From Running			1,234,456	0.0115	14,196	0.0156
Total PM 2.5 reduced (tons)					**Daily**	**0.0173**
					Annual	**4.325**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	50,510	1.3603			68,709	0.0757
• From Running			1,234,456	0.2019	249,237	0.2747
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.3504**
					Annual	**87.600**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	50,510	212.54			10,735,395	11.834
• From Running			1,234,456	362.93	448,021,116	493.859
Total CO2 reduced (tons)					**Daily**	**505.692**
					Annual	**126,423.1**

Emissions Reduced - New / Expanded

Daily Emissions Reduced – NOx and VOC

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	7,864	1.0309			8,107	0.0089
• From Running			177,790	0.1498	26,633	0.0294
Total NOx reduced (tons)					**Daily**	**0.0383**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	7,864	2.1358			16,796	0.0185
• From Running			177,790	0.0593	10,543	0.0116
Total VOC reduced (tons)					**Daily**	**0.0301**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	7,864	0.0312			245	0.0003
• From Running			177,790	0.0115	2,045	0.0023
Total PM 2.5 reduced (tons)					**Daily**	**0.0026**
					Annual	**0.650**

Appendix 4, continued

Emissions Reduced - New / Expanded (continued)

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	7,864	1.3603			10,697	0.0118
• From Running			177,790	0.2019	35,896	0.0396
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0514**
					Annual	**12.850**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	7,864	212.54			1,671,415	1.842
• From Running			177,790	362.93	64,525,325	71.127
Total CO2 reduced (tons)					**Daily**	**72.969**
					Annual	**18,242.35**

Distribution of Employer Outreach Impacts to EO Base and EO for Bicycling

	Total EO	EO w/o bike	EO-bike
Vehicle Trips Reduced	85,845	85,396	449
VMT Reduced (miles)	1,489,165	1,487,279	1,886
Daily Emissions Reduced			
NOx (tons)	0.2995	0.2987	0.0008
VOC (tons)	0.2297	0.2285	0.0012
Annual Emissions Reduced			
PM 2.5 (T)	4.975	4.975	0.000
PM 2.5 Precursor NOx (T)	100.450	100.175	0.275
CO2 (T)	144,665.4	144,450.5	214.9

Appendix 4, continued

COMMUTER CONNECTIONS
EMPLOYER SERVICES PARTICIPATION LEVELS
(EFFECTIVE Retroactively to July 1, 2015)
October 20, 2015

SUPPORT STRATEGIES

Likely range of trip reduction 0%

- Expresses Interest and/or distributes/displays information on Ozone Actions Days

LEVEL 1 (BRONZE)

Likely range of trip reduction 0% to 1%

- Expresses interest in telework, transit benefits, Smart Benefits, or other TDM strategy
- Conducts Commuter Survey
- Distributes alternative commute info to employees
- Posts alternative commute information on employee bulletin board(s), intranet sites, newsletter or e-mail
- Installs Electric Car Charging Station(s) at worksite

LEVEL 2 (SILVER) – **Implements two or more of the following strategies**

Likely range of trip reduction 0% to 3% without Telework/Compressed Work Schedules
0% to 9% with Telework/Compressed Work Schedules

- Installs a permanent display case or brochure holders and stock with alternative commute information
- Installs electronic screens or desktop feed of real-time travel information for transit and/or other alternative mode availability.
- Participates in the Capital Bikeshare Program as a Corporate Partner
- Provides preferential parking for carpools and vanpools
- Implements a telework program with 1-20% of employees participating
- Facilitates car/vanpool formation meetings
- Hosts/sponsors an alternative commute day or transportation fair
- Implements flex-time or staggered work schedule
- Implements compressed work week for 1-20% of employees
- Installs bicycle racks or lockers
- Installs shower facilities for bicyclists and walkers
- Establishes an ETC who regularly provides alternative commute information to employees
- Becomes a Commuter Connections member and provides on-site ridematching
- Supplements GRH program with payment for additional trips or own program

Appendix 4, continued

LEVEL 3 (GOLD)

Implements at least one of the following (in addition to the two or more Level 2 strategies):

Likely range of trip reduction **2% to 5% without financial incentive/disincentive, Telework/Compressed Work Schedules**
5% to 20% with financial incentive/disincentive, Telework/Compressed Work Schedules

- Implements a telework program with more than 20% of employees participating
- Implements compressed work week for 21%+ of employees
- Implements a transit/vanpool benefit, Smart Benefits, Federal Bicycle Benefit, or parking "cash out" program
- Implements a carpool/bicycle/walk benefit
- Provides free or significantly reduced fee parking for carpools and vanpools (valid only for companies where employees pay for parking)
- Implements a parking fee (valid only for companies that previously did not charge for parking)
- Provides employee shuttle service to transit stations
- Provides company vanpools for employees' commute to work
- Implements a comprehensive Bicycle/Walking program (includes installation of showers bicycle racks/lockers, and financial incentives for bicycling and/or walking, or a Capital Bikeshare Station)

LEVEL 4 (PLATINUM)

Likely range of trip reduction **2% to 8% without financial incentive, Telework/Compressed Work Schedules**
5% to 30% with financial incentive, Telework/Compressed Work Schedules

- Implements two or more of the Level 3 TDM programs (in addition to the 2 or more Level 2 strategies) and actively promotes these programs and alternative commuting

Appendix 5 – Calculation of Mass Marketing Impacts

6 impact components

- Part 1 – Commuters influenced by ads to change mode – no contact CC (direct influence)
- Part 2 – 'Pool Rewards carpool/vanpool incentive participants
- Part 3 – Car-Free Day event
- Part 4 – Bike to Work Day event
- Part 5 – Commuters influenced by ads to contact CC (referred influence)
- Part 6 – Commuters influenced by ads to join GRH (referred influence)

PART 1 – Direct Ad Influence

Populations of Interest – commuters influenced by ads to change mode – no contact CC

Total commuters in region	3,044,554	(SOC)
• % recall any commute message	45%	(SOC)
• % recall CC/COG commute message	14%	(SOC)
• % chg to alt mode after CC/COG ads	11.5%	(SOC)
• % changers influenced by ad	57%	(SOC)
Placements – no contact with CC	**27,940**	(Commuters x CC recall X change % x influence %)
Placement Rates		
• Continued placement rate	46%	(SOC)
• Temporary placement rate	54%	(SOC)
Placements		
• Continued placements	12,852	(Placements x continued placement rate)
• Temporary placements	15,088	(Placements x temporary placement rate)
Daily Vehicle Trips Reduced		
• Continued VTR factor	0.73	(SOC)
• Temporary VTR factor	1.00	(SOC)
• Continued VT reduced	9,382	(Continued placements x continued VTR factor)
• Temporary VT reduced	604	(Temporary placements x temporary VTR factor x 4% credit for temporary use – Ave use of 2 weeks/50 work weeks)
Total Daily Vehicle Trips Reduced	**9,986**	
Daily VMT Reduced		
• Ave one-way trip distance (mi)	20.4	(SOC)
Total Daily VMT Reduced	**203,714**	

Appendix 5, continued

PART 1 (Direct Ad Influence) (cont.)

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

• SOV access percentage	30%	(from SOC – transit riders)
• SOV access distance (mi)	2.7	(from SOC – transit riders)

Adjusted VT Reduction

• SOV access VT	2,996	(Total VT x SOV access %)
• VT with no SOV access	6,990	(Total VT – SOV access VT)

Adjusted VMT Reduction

• SOV access VMT	8,089	(Total VT x SOV % x 2.7 mi access distance)
• VMT with no SOV access	195,625	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**6,990**
Total VMT for AQ analysis	**195,625**

PART 2 – 'Pool Rewards Carpool/Vanpool Participants

Carpool program participants (FY 2018-20)	92
Vanpool program participants (FY 2018-20)	131

Placement Rates – by retention after program ended

Carpool Component

• Continued placement rate	87%	('Pool Rewards follow-up survey)
• Temporary placement rate	13%	('Pool Rewards follow-up survey)

Vanpool Component

• Continued placement rate	74%	('Pool Rewards NTD vanpool data)
• Temporary placement rate	26%	('Pool Rewards NTD vanpool data)

Placements

Carpool Component

• Continued placements	80	(Participants x continued placement rate)
• Temporary placements	12	(Participants x temporary placement rate)
Carpool placements	**92**	

Vanpool Component

• Continued placements	97	(Participants x continued placement rate)
• Temporary placements	34	(Participants x temporary placement rate)
Vanpool placements	**131**	
Total 'Pool Rewards placements	**223**	

Appendix 5, continued

PART 2 ('Pool Rewards) (cont.)

Daily Vehicle Trips Reduced

Carpool Component		
• Continued VTR factor	1.00	('Pool Rewards follow-up survey)
• Temporary VTR factor	0.96	('Pool Rewards logging data for program period)
• Temporary discount	50%	(assumes 13 weeks of program + 13 weeks after program)
• Continued VT reduced	80	(Continued placements x continued VTR factor)
• Temporary VT reduced	6	(Temporary placements x temporary VTR factor x 50% credit for temporary use)
Carpool VT Reduced	**86**	
Vanpool Component		
• Continued VTR factor	1.72	('Pool Rewards NTD vanpool data)
• Temporary VTR factor	1.32	('Pool Rewards NTD vanpool data)
• Temporary discount	50%	(Ave temporary vanpool duration = 1.5 yr of 3 yr total)
• Continued VT reduced	167	(Continued placements x continued VTR factor)
• Temporary VT reduced	23	(Temporary placements x temporary VTR factor x 50% credit for temporary use)
Vanpool VT Reduced	**190**	
Total Daily Vehicle Trips Reduced	**276**	

Daily VMT Reduced

Carpool Component		
• Ave continued one-way trip dist (mi)	28.2	('Pool Rewards follow-up survey)
• Ave temporary one-way trip dist (mi)	28.2	('Pool Rewards follow-up survey)
• Continued VMT reduced	2,256	(Continued VT reduced x continued trip distance)
• Temporary VMT reduced	169	(Temporary VT reduced x temporary trip distance)
Carpool VMT Reduced	**2,425**	
Vanpool Component		
• Ave continued one-way trip dist (mi)	39.5	('Pool Rewards NTD vanpool data)
• Ave temporary one-way trip dist (mi)	38.9	('Pool Rewards NTD vanpool data)
• Continued VMT reduced	6,596	(Continued VT reduced x continued trip distance)
• Temporary VMT reduced	895	(Temporary VT reduced x temporary trip distance)
Vanpool VMT Reduced	**7,491**	
Total Daily VMT Reduced	**9,916**	

Appendix 5, continued

PART 2 ('Pool Rewards) (cont.)

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

• SOV access percentage (carpool)	69 %	(SOC survey)
• SOV access percentage (vanpool)	86 %	(Placement survey)
• SOV access distance (mi) (carpool)	6.0	(SOC survey)
• SOV access distance (mi) (vanpool)	7.0	(Placement survey)

Adjusted VT Reduction

Carpool Component

• SOV access VT	59	(Total VT x SOV access %)
• **VT with no SOV access**	**27**	(Total VT – SOV access VT)

Vanpool Component

• SOV access VT	163	(Total VT x SOV access %)
• **VT with no SOV access**	**27**	(Total VT – SOV access VT)

Adjusted VMT Reduction

Carpool Component

• SOV access VMT	354	(Total VT x SOV % x 6.0 mi access distance)
• **VMT with no SOV access**	**2,071**	(Total VMT – SOV access VMT)

Vanpool Component

• SOV access VMT	1,141	(Total VT x SOV % x 7.0 mi access distance)
• **VMT with no SOV access**	**6,350**	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**54**
Total VMT for AQ analysis	**8,421**

PART 3 – Car Free Day Event

Pledges (estimate 90% participation of pledges)

Total participants	18,731	(Pledges, 2017, 2018, 2019)
Number of unique participants	14,302	(Pledges, 2017, 2018, 2019 adjusted for participation in more than one event)

Placements (day of event)

• Participated in CFD for work trip	86%	(CFD follow-up survey)
• Used new alt mode for work trip	16%	(CFD follow-up survey)
• Event day commute placement rate	14%	(86% work participation x 16% new mode for work trip)
• Event day placements	2,622	(Participants x placement rate)

Total Event Day Placements	**2,622**

Event Impacts

Daily Vehicle Trips Reduced

• Event day VTR factor	1.43	(CFD follow-up survey)
• Event VT reduced	3,754	(Placements x event VTR factor)
• **Equivalent daily VT**	**5**	(Event VT reduced / 750 days over 3 years)

Appendix 5, continued

PART 3 (Car-Free Day) (cont.)

Event Impacts (continued)

Daily VMT Reduced

• Ave one-way trip distance (mi)	14.9	(CFD follow-up survey)
• Event VMT reduced	55,935	(Event VT reduced x 14.9 trip distance)
• **Equivalent daily VMT**	**75**	(Event VMT reduced / 750 days over 3 years)

Car Free Day Ongoing Impacts (from continued use of new alt modes for commuting after event)

Placements (ongoing following event)

• Number of unique participants	14,302	Calculated above
• Participant employed %	97%	(CFD follow-up survey)
• Cont placement rate (increased alt use)	11%	(CFD follow-up survey)
• Post-event ongoing placements	1,526	(Participants x placement rate)

Total Ongoing Placements	**1,526**

Daily Vehicle Trips Reduced

• Ongoing VTR factor (after CFD)	0.66	(CFD follow-up survey)
• **Ongoing daily VT reduced**	**1,007**	(Ongoing participants x ongoing VTR factor)

Daily VMT Reduced

• Trip distance	14.9	(CFD follow-up survey)
• **Ongoing daily VMT**	**15,004**	(Ongoing daily VT x trip distance)

Total Impacts – Event Day + Ongoing

Total Daily VT Reduced	**1,012**	(Event equivalent daily VT + ongoing daily VT)
Total Daily VMT Reduced	**15,079**	(Event equivalent daily VMT + ongoing daily VMT)

Summary of Travel Impacts for Parts 1, 2, 3

	Total 1, 2, 3	Direct Ads	'Pool Rewards	Car Free Day
Placements (ongoing)	29,689	27,940	223	1,526*
Vehicle Trips Reduced	11,274	9,986	276	1,012
VMT Reduced (miles)	228,709	203,714	9,916	15,079
Air Quality Adjusted VT / VMT				
Vehicle Trips Reduced	8,056	6,990	54	1,012
VMT Reduced (miles)	219,125	195,625	8,421	15,079

* Car Free Day ongoing placements = e.g., commuters who switched to alt mode for continued commuting after event

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Daily Emissions Reduced – NOx and VOC – Parts 1, 2, 3

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,056	1.0309			8,305	0.0092
• From Running			219,125	0.1498	32,825	0.0362
Total NOx reduced (tons)					**Daily**	**0.0454**

Appendix 5, continued

Daily Emissions Reduced – NOx and VOC (continued) – Parts 1, 2, 3

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,056	2.1358			17,206	0.0190
• From Running			219,125	0.0593	12,994	0.0143
Total VOC reduced (tons)					**Daily**	**0.0333**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued) – Parts 1, 2, 3

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,056	0.0312			251	0.0003
• From Running			219,125	0.0115	2,520	0.0028
Total PM 2.5 reduced (tons)					**Daily**	**0.0031**
					Annual	**0.775**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,056	1.3603			10,959	0.0121
• From Running			219,125	0.2019	44,241	0.0488
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0609**
					Annual	**15.225**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,056	212.54			1,712,222	1.887
• From Running			219,125	362.93	79,527,036	87.664
Total CO2 reduced (tons)					**Daily**	**89.551**
					Annual	**22,387.8**

PART 4 - Bike to Work Day Credit

Participants' riding percentage and frequency

Number of riders	25,504	(BTWD registration data, 2017, 2018 and 2019 adjusted for some participation in previous year)
% biking to work before event	87.4%	(BTWD survey)
% new riders	7.4%	(BTWD survey)
Number of new riders	1,887	
% who increase riding days	19.3%	(BTWD survey)
Number of increased riders	4,922	
Total placements	**6,809**	(Total new + increased riders)

Appendix 5, continued

PART 4 (Bike to Work Day) (continued)

Change in Bike Days

Summer Biking

% new riders in summer	6.6%	(BTWD survey)
Weekly new bike days summer	1.6	(BTWD survey)
Weekly new bike days summer	2,693	(total riders x % new ride summer x ave days biking summer)
% increased riders in summer	16.3%	(BTWD survey)
Weekly increased bike days summer	1.7	(BTWD survey)
Weekly increased bike days summer	7,067	(total riders x % inc ride summer x ave days biking summer)

Winter Biking

% new riders biking winter	5.3%	(BTWD survey)
Weekly new bike days winter	1.4	(BTWD survey)
Weekly new bike days winter	1,892	(total riders x % new ride winter x ave days biking winter)
% increased riders biking winter	12.1%	(BTWD survey)
Weekly increased bike days winter	1.9	(BTWD survey)
Weekly increased bike days winter	5,863	(total riders x % incr ride winter x ave days biking winter)

Additional Bike Days (New and Increased Riding)

• NEW/INC bike days summer	9,760	(weekly new and increased bike days summer)
• NEW/INC bike days fall-winter	7,755	(weekly new and increased bike days winter)
• Total additional bike days summer	273,280	(new/inc weekly summer days x 28 weeks – Apr-Oct)
• Total additional bike days winter	170,610	(new/inc weekly winter days x 22 weeks – Nov-Mar)
• Total additional bike days - year	443,890	(summer bike days + winter bike days)
• Additional bike trips - year	887,780	(annual bike days x 2 trips per day)

Additional Bike Trips and Vehicle Trip and VMT Reductions

• Ave new daily bike trips	3,551	(Annual new bike trips / 250)
• % Drive alone/CP/VP on non-bike days	43%	(BTWD survey)
BTWD Daily Vehicle Trips Reduced	**1,527**	(daily new bike trips x DA/CP/VP percentage)

Daily VMT Reduced

• Ave trip distance (mi)	9.0	(BTWD survey)
BTWD Daily VMT Reduced	**13,743**	(vehicle trips reduced x average trip distance)

Daily Emissions Reduced – NOx and VOC – Bike to Work Day

NOx	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,527	1.0309			1,574	0.0017
• From Running			13,743	0.1498	2,059	0.0023
Total NOx reduced (tons)					**Daily**	**0.0040**

VOC	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,527	2.1358			3,261	0.0036
• From Running			13,743	0.0593	815	0.0009
Total VOC reduced (tons)					**Daily**	**0.0045**

Appendix 5, continued

PART 4 (Bike to Work Day) (continued)

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 – Bike to Work Day

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	1,527	0.0312			48	0.0000
• From Running			13,743	0.0115	158	0.0002
Total PM 2.5 reduced (tons)					**Daily**	**0.0002**
					Annual	**0.057**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	1,527	1.3603			2,077	0.0023
• From Running			13,743	0.2019	2,775	0.0031
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0054**
					Annual	**1.350**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	1,527	212.54			324,549	0.358
• From Running			13,743	362.93	4,987,747	5.498
Total CO2 reduced (tons)					**Daily**	**5.856**
					Annual	**1,463.9**

PART 5 – Referred Influence (Commuter Operations Center)

Mass Marketing received a 2.6% portion of the impacts calculated for the Commuter Operation Center. This credit recognized that 12.3% of the commuters who were new COC applicants reported in the Applicant Placement survey that they were influenced to contact Commuter Connections hearing a Mass Marketing advertisement. New applicants accounted for 21.3% of the total COC applicants (Excluding Retained Past applicants). This calculation resulted in 2.3% of the COC credit being assigned to Mass Marketing (21.3% new apps x 12.3% influence).

Populations of Interest – commuters influenced by ads to contact CC

New CC apps (does not include re-apply or follow-up)		
• FY 2018	5,178	(CC database)
• FY 2019	5,497	(CC database)
• FY 2020 (through June 2020)	5,451	(CC database)
Total new applicants	**16,126**	
Total CC applicants	75,651	(includes new, re-apply, and follow-up)
New apps FY 2018-20 as % of total	21.3%	(new apps FY 2018-20 / total CC apps)
% influenced by ads to contact CC	12.3%	(COC applicant analysis; 2017 Applicant placement survey)
% ALL apps influenced by ads	2.6%	(21.3% new apps x 12.3% influenced by ads)

COC Impacts – MM Share (2.6% of total COC base for each impact below – COC base is defined in Appendix 6)

Travel Impacts	MM Share	COC base (2018-2020, excluding retained credit)
• CC placements	818	31,446
• CC Vehicle trips reduced	373	14,350
• C VMT reduced	10,969	421,887

Appendix 5, continued

PART 5 – Referred Influence to COC (continued)

Emissions Impacts	MM Share	COC base (2018-2020, excluding retained credit)	
• NOx reduced (daily tons)	0.0019	0.0745	Daily
• VOC reduced (tons)	0.0012	0.0455	Daily
• PM2.5 reduced (tons)	0.0345	1.3254	Annual
• PM2.5-NOx reduced (tons)	0.6515	25.0593	Annual
• CO2 reduced (tons)	1,036.9	39,881.4	Annual

PART 6 – Referred Influence to GRH – From GRH Analysis

About 16% of the GRH impacts were assigned to Mass Marketing to recognize that 31% of new GRH applicants were influenced to apply for GRH after they heard a Mass Marketing advertisement. These new applicants accounted for 57% of the total GRH applicants (Reapply + New). The 12% of total impacts generated through Retained GRH users were excluded from the base. This calculation resulted in 16% of the GRH credit being assigned to Mass Marketing (31% x 57% new apps x 88% non-retained impacts).

Total GRH apps FYs 18, 19, 20	12,944	
New GRH apps FY 18, 19, 20	7,429	57%
Estimated MM share of new GRH	31%	
FY 2018-20 VMT as % of total VMT	88%	(Exclude Retained credit from discount)
Estimated MM share of GRH impact	16%	(57% of total applicants x 31% MM credit-new applicants x 88% new/reapply)

GRH Impacts – FY 2018-20 (16% of total COC base for each impact below)

Travel Impacts	MM Share	GRH base (2018-2020, excluding retained credit)	
• GRH placements	957	5,983	
• GRH Vehicle trips reduced	857	5,358	
• GRH VMT reduced	24,090	150,560	

Emissions Impacts	MM Share	GRH base (2018-2020, excluding retained credit)	
• NOx reduced (daily tons)	0.0041	0.0259	Daily
• VOC reduced (tons)	0.0025	0.0158	Daily
• PM2.5 reduced (tons)	0.0739	0.4620	Annual
• PM2.5-NOx reduced (tons)	1.3904	8.6900	Annual
• CO2 reduced (tons)	2,216.2	13,851.7	Annual

Mass Marketing – Summary

Total – Sum of PART 1, PART 2, PART 3, PART 4, PART 5, PART 6 (See above for individual calculations)

	Total MM	Direct Ad Infl	'Pool Rewards	Car Free Day	BTW	COC Credit	GRH Credit
Placements	38,273	27,940	223	1,526	6,809	818	957
VT reduced	14,031	9,986	276	1,012	1,527	373	857
Percentage total MM VT		71%	2%	7%	11%	3%	6%
VMT reduced	277,511	203,714	9,916	15,079	13,743	10,969	24,090

Appendix 5, continued

Mass marketing Summary (continued)

	Total MM	Direct Ad Infl	'Pool Rewards	Car Free Day	BTW	COC Credit	GRH Credit
Daily Emissions Reduced							
NOx (T)	0.0554		0.0454		0.0040	0.0019	0.0041
VOC (T)	0.0415		0.0333		0.0045	0.0012	0.0025
Annual Emissions Reduced							
PM 2.5 (T)	0.940		0.7750		0.0567	0.0345	0.0739
PM 2.5 Precursor (T)	18.617		15.2250		1.3500	0.6515	1.3904
CO2 (T)	27,104.8		22,387.8		1,463.9	1,036.9	2,216.2

Appendix 6 – Calculation of Commuter Operations Center Impacts

PART 1 – Commute Information Requests

Populations of Interest – Commuter Connections Rideshare Applicants

FY 2018-20 Applicant Base (New credit) New, Reapply, Transit/other, follow-up requests

• FY 2018	26,348	(CC database)
• FY 2019	24,153	(CC database)
• FY 2020	25,150	(CC database)
New FY 2018-20 assisted commuters	**75,651**	

Pre-FY 2018 Applicant Base (Retained credit)

• Applicants Pre-FY 2018	6,327	(CC database)
• Valid contact percentage	52%	(Retention rate survey)
Retained Pre-FY 2018 applicant base	**3,290**	

Distribution of In/Out NAA

FY 2018-20 Applicant Base (New)			
Within NAA	63%	47,660	(Commuter Connections placement survey)
Outside NAA	37%	27,991	(Commuter Connections placement survey)
Pre-FY 2018 Applicant Base (Retained)			
Within NAA	63%	2,073	
Outside NAA	37%	1,217	

COC Placement Rates and Placements

(NAA applicant base x NAA placement rate; calculated for continued, temporary, and retained cases)

FY 2018-20 Applicants (New)	**Pl Rate**	**Placements**	
• Within NAA – continued rate	35.5%	16,919	(Commuter Connections placement survey)
• Within NAA – temporary rate	5.4%	2,574	(Commuter Connections placement survey)
• Outside NAA – continued rate	37.8%	10,581	(Commuter Connections placement survey)
• Outside NAA – temporary rate	4.9%	1,372	(Commuter Connections placement survey)
Pre-FY 2018 Registrants (Retained)			
• Within NAA – continued rate	16.6%	344	(Retention rate survey)
• Outside NAA – continued rate	16.6%	202	(Retention rate survey)
Total Placements		**31,992**	

VTR Factors and Daily Vehicle Trips Reduced (continued only)

(NAA cont placement x NAA cont VTR factor); (NAA temp placement x NAA temp VTR factor x temp discount)

FY 2018-20 Applicants (New)	**VTR Factor**	**VT Reduced**	
• Temporary discount	16.0%		
• Within NAA – continued VTR factor	0.50	8,460	(Commuter Connections placement survey)
• Within NAA – temporary VTR factor	0.37	152	(Commuter Connections placement survey)
• Outside NAA – continued VTR factor	0.53	5,608	(Commuter Connections placement survey)
• Outside NAA – temporary VTR factor	0.59	130	(Commuter Connections placement survey)
Pre-FY 2018 Applicants (Retained)			
• Within NAA – continued VTR factor	0.73	251	(Retention rate survey)
• Outside NAA – continued VTR factor	0.73	147	(Retention rate survey)
Total Daily Vehicle Trips Reduced		**14,748**	

Appendix 6, continued

PART 1 – Commute Information Requests (continued)

Commute Distance and Daily VMT Reduced
(VMT reduced is calculated as number of vehicle trips reduced x one-way travel distance; individual calculations are performed for continued, temporary, and retained placements and for both Within the NAA and Outside the NAA)

FY 2018-20 Applicants (New)
Distances in miles derived from Commuter Connections placement survey

	O-W Dist	VMT Reduced	
• Within NAA - continued distance	29.5	249,570	
• Within NAA – temporary distance	24.4	3,709	
• Outside NAA – continued distance	29.5	165,436	(Actual outside distance 52.5 miles)
• Outside NAA – temporary distance	24.4	3,172	(Actual outside distance 48.8 miles)

Pre-FY 2018 Applicants (Retained)
Distances in miles derived from Commuter Connections placement survey

• Within NAA – continued distance	19.7	4,945	
• Outside NAA – continued distance	19.7	2,896	

Total Daily VMT Reduced	**429,728**

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

Inside NAA	Cont	Temp	
• SOV access percentage	70%	60%	(Placement survey)
• SOV access distance (mi)	4.6	3.7	(Placement survey)

Outside NAA
- N/A - all access VT and VMT occur outside NAA

Pre-FY 18	Cont	
• SOV access percentage	72%	(Retention survey)
• SOV access distance (mi)	5.5	(Retention survey)

Adjusted VT Reduction – net of drive alone access
(Calculated as Within NAA VTs x SOV access % for continued, temporary, and retained placements)
FY 2018-20 Applicants (New)

• Total VT reduced	14,748	Calculated above
• Within NAA access VT (deduct)	- 6,194	(Total SOV access VTs for cont, temp, retained cases)
• Outside NAA access VT	0	No deduction (access trips are outside NAA)
Total VT (net of SOV access)	**8,554**	

Adjusted VMT Reduction – net of VMT access

• Total VMT reduced	429,728	Calculated above
• Within NAA access VMT (deduct)	- 28,574	(Total SOV access VMTs for cont, temp, retained cases)
• Outside NAA access VMT	0	No deduction (access VMT are outside NAA)
Total VMT (net of SOV access)	**401,154**	

Total VT for AQ analysis	**8,554**
Total VMT for AQ analysis	**401,154**

Appendix 6, continued

Daily Emissions Reduced – NOx and VOC (PART 1 – Commute Information Requests)

NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,554	1.0309			8,818	0.0097
• From Running			401,154	0.1498	60,093	0.0662
Total NOx reduced (tons)					**Daily**	**0.0759**

VOC	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,554	2.1358			18,270	0.0201
• From Running			401,154	0.0593	23,788	0.0262
Total VOC reduced (tons)					**Daily**	**0.0463**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (PART 1 – Commute Information Requests)

PM 2.5	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,554	0.0312			267	0.0003
• From Running			401,154	0.0115	4,613	0.0051
Total PM 2.5 reduced (tons)					**Daily**	**0.005**
					Annual	**1.350**

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,554	1.3603			11,636	0.0128
• From Running			401,154	0.2019	80,993	0.0893
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.1021**
					Annual	**25.525**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	8,554	212.54			1,818,067	2.004
• From Running			401,154	362.93	145,590,821	160.486
Total CO2 reduced (tons)					**Daily**	**162.490**
					Annual	**40,622.6**

Correction for Overlap between COC Base and Integrated Rideshare and GRH

The COC supports several other TDM program elements, including Mass Marketing, Software Upgrades, and GRH and portions of the COC base impact are deducted from the COC and assigned to those program elements. Details of the determination of each credit are presented in the relevant appendices. The "Net COC Base" is calculated as the initial/total COC base – Mass Marketing credit – Software Upgrades credit – GRH credit.

	Initial COC Base	MM	Soft Upg	GRH	Net COC Base
Placements	31,992	818	3,536	7,739	19,899
Vehicle Trips Reduced	14,748	373	1,363	3,643	9,369
VMT Reduced (miles)	429,728	10,969	40,541	105,901	272,317
Daily Emissions Reduced					
NOx Reduced (tons)	0.0759	0.0019	0.0071	0.0187	0.0482
VOC Reduced (tons)	0.0463	0.0012	0.0044	0.0114	0.0293

Appendix 6, continued

Correction for Overlap between COC Base and Integrated Rideshare and GRH (continued)

Annual Emissions Reduced

	Initial COC Base	MM	Soft Upg	GRH	Net COC Base
PM 2.5 (T)	1.3500	0.0345	0.1250	0.3333	0.8572
PM 2.5 Precursor (T)	25.5250	0.6515	2.4000	6.2926	16.1809
CO2 (T)	40,622.6	1,036.9	3,806.5	10,018.2	25,761.0

Notes:
- MM influenced commuters – from MM analysis (see Appendix 5)
- Share of COC assigned to GRH= 28% of COC credit; calculated as the share of COC apps that were new apps/re-apps (47.4%) and who registered for GRH (63%) = (63% x 44.7% = 28%). The GRH credit is not added to the GRH impact; rather it is assumed to be an overlap and is deducted from the COC impact to avoid duplication.
- Software Upgrade component is calculated in Appendix 7.

PART 2 – Telework Credit (Non-Maryland origin / destination)

- Credit for telework assistance provided directly to commuters who do not live or work in Maryland; credit for Maryland residents/workers is assigned to the Telework Assistance program element

NOTE: Calculation details for the Non-Maryland Telework credits below are shown in Appendix 2 (Telework)

Number of regional teleworkers	1,072,690	(State of Commute survey)
% of non-MD teleworkers	51%	(% of regional TWers who live and work outside MD)
Number of teleworkers (non-MD)	547,072	
Share of TW credited to COC	6.2%	(% of TWers learned of TW from Commuter Connections)
Total TW placements credited to COC	33,918	
Vehicle trips reduced	6,912	
VMT reduced	102,818	
Daily NOx reduced (tons)	0.0249	
Daily VOC reduced (tons)	0.0230	
Annual PM2.5 reduced (tons)	0.3750	
Annual PM2.5-NOx reduced (tons)	8.3250	
Annual CO2 reduced (tons)	10,687.5	

Final Commuter Operations Center Credit – Including Base COC and Telework Credit
Net COC = Net COC Base + Non-MD TW

	Net COC Base	Non-MD TW	Net COC
Placements	19,899	33,918	53,817
Vehicle Trips Reduced	9,369	6,912	16,281
VMT Reduced (miles)	272,317	102,818	375,135
Daily Emissions Reduced			
NOx Reduced (tons)	0.0482	0.0249	0.0731
VOC Reduced (tons)	0.0293	0.0230	0.0523
Annual Emissions Reduced			
PM 2.5 (T)	0.8572	0.3750	1.2322
PM 2.5 Precursor (T)	16.1809	8.3250	24.5059
CO2 (T)	25,761.0	10,687.5	36,448.5

Appendix 7 – Calculation of Software Upgrade Impacts

Populations of Interest – Commuter Connections Rideshare Applicants
All data factors (Placement rate, VTR factors, trip distances) derived from Applicant Placement survey

FY 2018-20 Applicant Base (New credit) New, Reapply, Transit/other, follow-up requests

• FY 2018	26,348	(CC database)
• FY 2019	24,153	(CC database)
• FY 2020	25,150	(CC database)
New FY 2018-20 assisted commuters	**75,651**	

Within NAA (63%)	47,660
Outside NAA (37%)	27,991

COC Placement Rates	**In NAA**	**Out NAA**	
• Continued rate	3.1%	3.6%	(CC placement survey)
• Temporary rate	1.5%	1.2%	(CC placement survey)

Placements (Continued and Temporary; In NAA and Outside NAA)

• Continued	1,477	1,008	(Applications x continued rate)
• Temporary	715	336	(Applications x temporary rate)

Total placements	**3,536**

Daily Vehicle Trips Reduced (Continued and Temporary; In NAA and Outside NAA)

VTR Factors	**In NAA**	**Out NAA**	
• Continued	0.53	0.50	(CC placement survey)
• Temporary	0.41	0.54	(CC placement survey)
• Temporary discount	16.0%	16.0%	(CC placement survey)
• Continued trips reduced	783	504	(Placements x cont. VTR factor)
• Temporary trips reduced	47	29	(Placements x temp VTR factor x temp discount)

Total VT reduced	**1,363**

Daily VMT Reduced (Continued and Temporary; In NAA and Outside NAA)

Ave one-way trip distance (mi)	**In NAA**	**Out NAA**	
• Continued	30.0	30.0	(Actual Outside dist. 54.6 miles)
• Temporary	25.4	25.4	(Actual Outside dist. 57.0 miles)
• Continued VMT reduced	**23,490**	**15,120**	(Cont VT x ave trip distance)
• Temporary VMT reduced	**1,194**	**737**	(Temp VT x ave trip distance)

Total VMT Reduced	**40,541**

Appendix 7, continued

Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)

	In NAA	Out NAA	
• SOV access % -Continued	67%	0%	(CC placement survey)
• SOV access dist (mi) – Continued	5.4	0.0	(CC placement survey)
• Non-SOV access % - Temporary	48%	0%	(CC placement survey)
• SOV access dist (mi) – Temporary	5.4	0.0	(CC placement survey)

Outside NAA – not applicable – all access outside NAA

VT Reduction	**In NAA**	**Out NAA**	
• Continued SOV access VT	525	0	(Total cont VT x SOV access)
• Temporary SOV access VT	23	0	(Total temp VT x SOV access)
• Continued VT (without SOV access)	258	420	(Total cont VT – SOV access VT)
• Temporary VT (without SOV access)	24	24	(Total temp VT- SOV access VT)

Total VT (net of SOV access) 815

VMT Reduction	**In NAA**	**Out NAA**	
• Continued SOV access VMT	2,835	0	(Total cont VT x SOV % x access dist)
• Temporary SOV access VMT	124	0	(Total temp VT x SOV % x access dist)
• Continued VMT (without SOV access)	20,655	15,120	(Total cont VMT- SOV access VMT)
• Temporary VMT (without SOV access)	1,070	737	(Total temp VMT- SOV access VMT)

Total VMT (net of SOV access) 37,582

Total VT for AQ analysis 815
Total VMT for AQ analysis 37,582

Daily Emissions Reduced – NOx and VOC

NOx	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	815	1.0309			840	0.0009
• From Running			37,582	0.1498	5,630	0.0062
Total NOx reduced (tons)					**Daily**	**0.0071**

VOC	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	815	2.1358			1,741	0.0019
• From Running			37,582	0.0593	2,229	0.0025
Total VOC reduced (tons)					**Daily**	**0.0044**

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2

PM 2.5	**Trips**	**20 Emission Factor**	**VMT**	**20 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	815	0.0312			25	0.0000
• From Running			37,582	0.0115	432	0.0005
Total PM 2.5 reduced (tons)					**Daily**	**0.0005**
					Annual	**0.125**

Appendix 7, continued

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued)

PM 2.5 Precursor NOx	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	815	1.3603			1,109	0.0012
• From Running			37,582	0.2019	7,588	0.0084
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0100**
					Annual	**2.400**

CO2	Trips	20 Emission Factor	VMT	20 Emission Factor	Tot gm	Tot ton
• From Starts	815	212.54			173,220	0.191
• From Running			37,582	362.93	13,639,635	15.035
Total CO2 reduced (tons)					**Daily**	**15.226**
					Annual	**3,806.5**

Appendix 8 – Reduction in Delay Due to TDM Program-Related VMT Reduction

The TDM Revised Evaluation Framework for FY 2015-17 highlighted the opportunity to develop new performance indicators to document societal benefits, such as mobility, health, safety, livability, and quality of life, that are generated by the Commuter Connections TDM program. Performance-based planning and established goals in the region may take into account the impact of TDM program elements on the performance of the highway system. For this reason, the revised evaluation framework noted "reduction in travel delay" as an emerging metric that seeks to develop a direct relationship between VMT reduction and improved system performance.

As used in this analysis, "travel delay" refers specifically to vehicle hours of delay. Person hours of delay are typically calculated from vehicle hours of delay by applying an assumed or known vehicle occupancy factor. For example, if two people are riding in a vehicle in congestion, both experience the delay, so the person hours of delay would be twice the vehicle hours of delay. However, because this TDM analysis calculates delay reduction from elimination of single-occupant vehicles, each vehicle in the analysis includes only one person, so the hours of delay calculated in this section represents both vehicle hours of delay and person hours of delay.

Ideally, reduction in vehicle hours of delay from use of TDM program elements would be calculated by measuring the travel speed on regional roads with the programs in place, estimating the lower speed that would be experienced if vehicle trips and VMT eliminated by the programs were still on the road, and comparing the conditions with programs to the assumed conditions without programs to estimate an aggregate delay reduction. Practically, this method has multiple issues, such as the need to estimate differential speeds by network links and assign trips reduced to network links to estimate where and when delay is reduced. It also would be necessary to account for non-recurring delay, such as occurs during a roadway incident or regional event.

These issues make the ideal calculation beyond the current scope of the TDM analysis, but the research team designed a substitute method that estimates the average hours of delay for a known number of VMT and applying it to the program element VMT reduction that would have occurred on congested roads. This calculation requires two steps. The first examines overall delay reduction and calculates a VMT to delay factor to convert VMT into hours of delay across the regional system. The second step is to estimate the share of TDM program element VMT reduced that would be traveling on congested roadways if the programs did not exist. This reduced VMT count is used because a mile traveled on a road with no congestion does not create or add to travel delay, so miles on uncongested roadways would be excluded from the benefit calculation.

Step 1 – Estimate overall regional delay reduction

This first step establishes a relationship between TDM impacts and system performance; specifically, between VMT reduced by a TDM program (TDM impact) to delay reduction (easing congestion over levels that likely would have occurred in the absence of the program elements). This relationship will be the form of a conversion factor.

In assessing the economic impacts of system performance, researchers have established the concept of "*marginal added delay."* Marginal added delay results from the presence of one extra vehicle on the road and is measured in added hours of delay per thousands of passenger-car equivalent (pce) VMT. To establish this national conversion factor the evaluation team consulted the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) model developed by the Center for Urban Transportation Research.

TRIMMS 4.0 updated the method used in earlier versions of TRIMMS to estimate the societal cost saving benefits of TDM actions for a range of societal benefits, one of which is change in marginal added delay. The marginal added delay is used to compute changes in added congestions to other vehicles on the roadway. This delay saving results from the reduction in VMT from transit and TDM strategies. The change in marginal added delay (Δ delay) is measured in added minutes of travel time per added VMT using the following formula:

$$\Delta\, Delay\ = Delay_0 \left[\left(\frac{VMT_1}{VMT_0}\right)^{\varepsilon_{d,VMT}} - 1\right]$$

The average delay (minutes/VMT) for the Washington DC MSA is estimated from the Texas Transportation Institute's (TTI) 2015 Urban Mobility Scorecard, which covers 14 years of data (2000-2014) for 101 urban areas. VMT_1 is TRIMMS estimated VMT, VMT_0 is the baseline VMT, and $\varepsilon_{d,\,vmt}$ is the elasticity of delay with respect to VMT. For more information, refer to the TRIMMS User Manual. The TRIMMS calculation estimates a **15.9 hours of delay per 1,000 daily VMT** (Center for Urban Transportation Research , 2018), We use this conversion factor in its evaluation of societal costs and benefits as part of the TDM program element analysis.[8]

Estimate TDM VMT Subject to Congested Conditions

The second step is to estimate the TDM program element VMT reduced that would be traveling in congested conditions if the program element services did not exist. A commuter traveling on a road with no congestion does not create or add to travel delay, so VMT on uncongested roadways are excluded from the calculation of marginal delay. This step requires information on the roads used by commuters who participate in program element services.

Three surveys conducted by COG for the FY 2018 – FY 2020 TDM analysis included questions to examine existing or likely road use by commuters who participated in TDM services. The 2017 Applicant Placement Survey assessed roadways used by commuters who participated in Commuter Connections online commute information and ride-matching services. The 2019 GRH Survey examined roadway use for GRH participants. The 2019 State of Commute Survey identified roadway use for ridesharers and transit riders, on days they traveled in a personal vehicle. Note that commuters who carpooled or vanpooled reported the roads they actually used, while commuters who used only public transit were asked what roads they would expect to use if they were to drive to work.

For all three surveys, the samples of commuters using individual road segments were too small to calculate delay reductions by route. But it was possible from each of the surveys to estimate the percentage of commuters who commuted along Interstate highways and major state routes, roadways that would most likely experience congestion. In short, the survey data could be used to estimate the share of TDM VMT reduction that would have traveled on roads that experience peak period congestion. This adjusted VMT count could then be multiplied by the TRIMMS 15.9 hours of delay per 1000 daily VMT figure to estimate the hours of delay that were eliminated by the TDM-generated VMT reductions.

Table A-1 shows the estimated congested VMT to which the hours of delay per VMT factor was applied. Because each TDM program element involves a specific commuter profile, the calculation was performed first for each element separately. Then the estimated congested VMT by program element were added for a total congested VMT.

The basic calculation involves the following steps:

1 – Define TDM program element base VMT reduction

2 – Estimate percentage of commuters' VMT in congestion on major roads
- Estimate percentage of program element commuters using Interstate highways (from survey data)
- Assume commuters using major roadways travel 85% of their commute miles on major roads
- Estimate 21% share of major roadway miles experience peak period congestion[9]

3 – Multiply TDM base VMT reduction x % congested major roads VMT

[8] The conversion factor of 15.9 hours of delay per 1000 VMT reduced was a significant drop from the conversion value of 62.16 used in the 2017 TERM Analysis Report. This change reflects a modification of the methodology used in the TRIMMS model to estimate delay reduction.

[9] MWCOG periodically produces a National Capital Region Congestion Report, which provides statistics on various aspects of roadway network performance. The 2016 report for 2015 reported that 26% of Interstate roadways miles in the region and 15% of the non-Interstate National Highway System roads were congested during the morning peak period. The evaluation team averaged these two to estimate 21% congested miles for the roadways in the analysis.

Table A-1 – Calculation of Estimated Congested VMT by Individual TDM Program Element

TDM Program Element	% Commuters Using Major Roads	Base VMT Reduction	% Miles on Major Roads	Estimated Major Road-way VMT
Maryland Telework	69%	308,001	12%	36,960
Virginia Telework	69%	9,827	12%	1,179
Guaranteed Ride Home	86%	147,371	16%	23,579
Employer Outreach	67%	1,489,165	12%	178,700
Mass Marketing	67%	277,511	12%	33,301
Commuter Operations Center	76%	415,676	14%	58,195
All Program Elements plus COC				**331,914**

To illustrate, the calculation for the Maryland Telework Assistance is provided below:

Base VMT reduction for the TDM program element = **308,001 VMT**

Commute major road VMT % = % commuters using Interstate highway x % of travel miles on major roads
- 69% of teleworkers use Interstate highway (from 2019 SOC survey)
- Assume commuters using Interstates travel 85% of their commute miles on major roads
- Estimate 21% share of roadway miles experience peak period congestion

- Estimated major road VMT % for Telework program element = 69% x 85% x 21% = **12% major road VMT**

Major road VMT = Base VMT reduction x major road % = 308,001 x 12% = **36,960 major road VMT**

When the calculation provided above is performed for all TDM program elements, the total congested VMT across all program elements equals 331,914, or about 12.5% of the 2,647,551 total VMT reduced by the program elements and the Commuter Operations Center combined. And when the major road VMT total is multiplied by the 15.9 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced equals 5,277 daily hours of delay reduced:

Estimated delay reduction = (331,914 / 1,000) x 15.9 hours per mile = **5,277 daily hours delay reduced**

The calculation shown above uses survey or other measured data on road use to the extent the data are available, but some assumptions are required in the calculation. As noted at the beginning of this appendix, the samples of commuters using individual roads were too small for direct road-by-road analysis of delay impacts. Thus it is not possible at this time to estimate the delay reduction impacts of TDM program elements on specific locations or highway segments. However, by applying the delay reduction calculation only to the share of VMT that would be expected to travel on road segments that experience congestion, the calculation estimates a conservative impact for the delay reduction benefit.

Appendix 9 – Calculation of Societal Benefits Generated by TDM Program Element Impacts

Since its inception in 1997, the Commuter Connections TDM analysis has been undertaken primarily to document travel and emissions impacts of each program element and compare the impacts against the goals set for the elements. This remains a central focus of the analysis for the FY 2018 – FY 2020 analysis. But the program elements likely do offer other benefits to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas emissions reductions, greater mobility, improved road safety, and enhanced transportation system performance.

These benefits have joined congestion and air quality as forces shaping the region's transportation policies, making them also issues relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs. Documenting these contributions also supports the regional response to the federally-mandated, performance-based planning and programming (PBPP) process required of states and MPOs. Under this requirement, MWCOG must track a variety of performance indicators related to transportation system performance, such as hours of peak hour excessive roadway delay.

The FY 2018 – FY 2020 TDM evaluation included an analysis component to estimate regional cost savings generated for selected societal benefits of the TDM program elements' travel and emissions impacts. These benefits include the following:

- Air pollution/emissions reductions in NOx, VOC, PM 2.5 pollutants
- Greenhouse gas emissions (CO2) reduction
- Reduction in congestion (reduced hours of travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

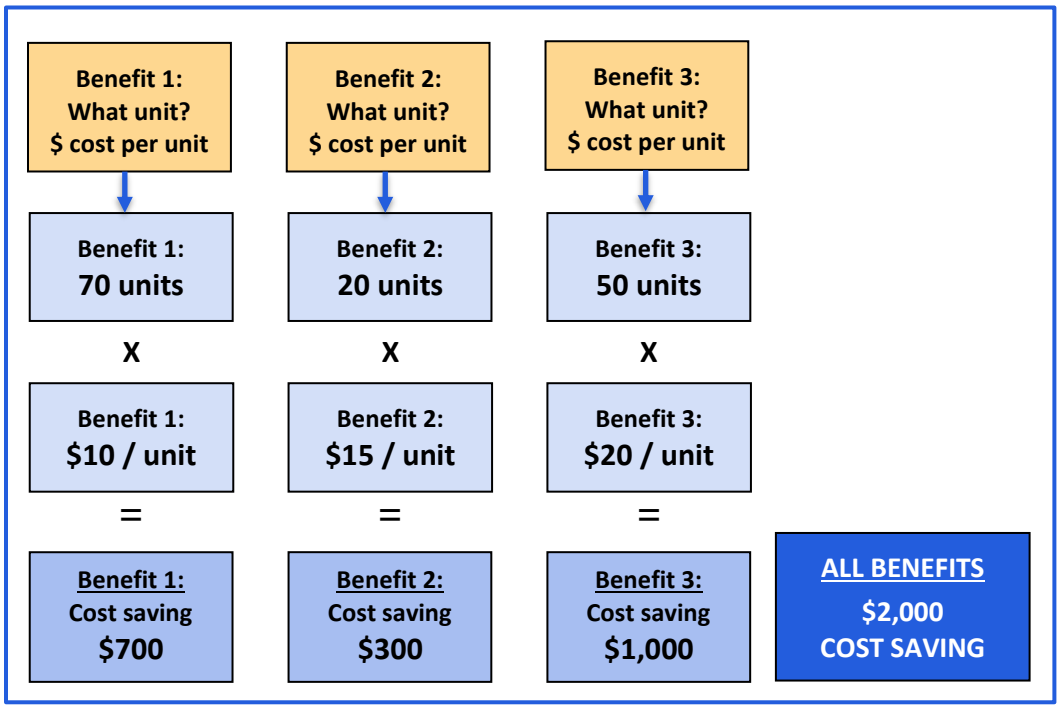
Figure 2 shows the basic method for calculating societal cost savings. The approach requires defining the unit of benefit associated with each type of benefit and cost per unit of benefit. The calculation then multiplies the benefit units by a unit cost factor and sums the individual benefit cost savings for a total across all benefits.

Define Units of Benefits and Cost Saving per Benefit Unit – First, the analysis must define a unit measure that represents performance for each benefit. For example, the benefit unit for traffic congestion reduction is the vehicle hours of peak period travel delay reduced and the unit of benefit for reduction in fuel consumption is gallons of gasoline saved (not used). The analysis also must define for each benefit the financial value, or societal cost saving, that a unit of benefit provides. For travel delay reduction, the unit cost is typically a value of time equal to an hourly wage rate. For fuel consumption saving, the unit cost would be the average cost of a gallon of gasoline.

Calculate Total Benefit Units – After the benefit units have been defined, the analysis calculates the number of units of benefits generated. The method to calculate units of benefit is specific to the benefit, so the methods can vary by benefit, but in this TDM analysis, all are derived from some measure of travel behavior impact, such as reductions in vehicle trips and/or vehicle miles traveled (VMT).

Continuing the example of travel delay reduction, the analysis calculates the number of hours of travel delay that the TDM program element eliminated. As described in Appendix 8, this count was made by estimating the VMT removed from congested roadway segments, then dividing that VMT count by a conversion factor of hours of delay reduced per 1000 daily VMT. Other benefits have similar but unique formulas to convert travel changes into benefit units. These conversion methods are described later in this appendix.

Figure 2 – Example Calculation of Societal Benefits Cost Savings for Three Benefits



Calculate Cost Saving for Each Benefit and Total Cost Saving – The societal cost saving for each benefit is then calculated by multiplying the number of benefit units by the cost saving per unit factor. The cost saving for delay reduction would be calculated by multiplying the hours of travel delay reduced by the average wage rate for workers in the region. Similar calculations are made for the other benefits in the TDM analysis, then the cost savings for individual benefits are summed to calculate the total cost saving for all benefits together.

In all cases, the VMT reduction was the starting point, with conversions made to translate VMT reduction into units of benefit. For most benefits, the method used to derive the units of benefit and the unit cost factors were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS™) 4.0 model developed by the Center for Urban Transportation Research (CUTR). TRIMMS™ estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Following are details of the calculation methodology and calculation results for each TDM program element.

Air Pollution/Emissions Reductions and Greenhouse Gas Reductions

Air pollution has various adverse societal consequences, in particular for human health and for physical impacts on the environment. Health research has documented links between increased levels of pollution and higher levels of respiratory and cardiopulmonary illness, with the greatest risk and incidence occurring among children, the elderly, and people with related diseases. Air pollution also can have negative environmental impacts, through reduced visibility, and damage to agricultural and forest land. Motor vehicles contribute to air pollution through pollutants emitted while vehicles are starting and operating. Thus, TDM program elements that reduce vehicle emissions contribute to less polluted air and offer benefits from reduction in the healthcare costs associated with pollution-related illness and costs incurred to repair environmental damages.

The TDM analysis calculates the societal cost of four primary air quality pollutants: nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter 2.5 microns (PM2.5), and PM2.5 NOx precursors. These four pollutants are strongly associated with the health and environmental damage and with motor vehicle operation.

The TDM analysis also calculates the societal cost for Greenhouse gas emissions, defined as tons of carbon dioxide (CO2). Its environmental role is similar to that for other air pollutants, in that motor vehicle emissions are a primary contributor to the problem, but unlike VOC and NOx emissions, which dissipate relatively quickly, greenhouse gas emissions accumulate over time in the atmosphere, effecting a cumulative increase in the average global temperature. A warming planet presents potentially serious and long-term environmental consequences, including more extreme drought but also more extreme storms, rising sea level that threatens coastal lands, and the loss of arctic sea ice and the ecosystems that rely on it, among other concerns.

The societal cost for emission reduction can be calculated by estimating the tons of pollutant emitted and multiplying by the societal cost of one ton of pollutant. For example, the equation for NOx cost saving would be:

Cost saving for NOx reduction = ((VMT reduced x gm/mi NOx emission factor)
+ (VTrips reduced x gm/trip reduced)) / gm per ton conversion factor
x $ cost per tons NOx reduced

Calculating Benefit Units and Cost per Unit of Benefit – The emission factors are related to the types and ages of vehicles being operated and the speed and other conditions of travel and will vary by metropolitan region. They are most accurately derived through runs of emission models, such as the Environmental Protection Agency's MOVES (Motor Vehicle Emission Simulator) model used by MWCOG, which takes into account the types and ages of vehicles, the speed and operating conditions experienced by travelers, and atmospheric conditions, each of which can affect emission rates.

The dollar costs per ton of pollutant applied in the TDM analysis are taken from CUTR's TRIMMS™ model. As described in the TRIMMS™ User Manual (Version 4.0), TRIMMS™ uses costs associated with damage to health, visibility, and physical impact on the environment. TRIMMS™ "adopted the costs estimates of Delucchi, who estimated costs for several impact categories for urban areas of the U.S. in 1991. Delucchi updated the original values in 2005 to account for changes in information about pollution and its effects. He customizes these estimates by using regional exposure scalars to get from the average exposure basis in U.S. urban areas to the average exposure in each of the metropolitan statistical areas. According to Delucchi, population density is the best simple measure of exposure to air pollution. The original 2005 $/Kg are converted to current dollar values using the consumer price index (CPI). These estimates are scaled to each individual region using the ratio of median household income of each area to the U.S. median household income.[10]

Cost Saving Calculation – TRIMMS™ methodology estimates benefits for various air pollution emissions. The model calculates emissions by multiplying exhaust tailpipe emission rates generated from the EPA Agency Motor Vehicle Emission Simulator (MOVES2010a) in grams per mile to the VMT reduced. But, because the TDM analysis estimates emissions using locally-specific emission factors derived by MWCOG or the regional conformity determination, the evaluation team calculated emission reductions outside of the TRIMMS™ model, but then applied the default daily costs per day by pollutant to the TDM emissions estimates to calculate air pollution societal benefit costs. The relevant emissions calculations are presented in Table A-2.

As shown, the daily benefit cost saving for all air pollutant components combined is $2,655 per day, with a per pollutant range from a low of $53 per day (VOC) to a high of $1,145 (PM 2.5 precursors NOx). The daily cost saving for Greenhouse gas reductions, defined by a benefit unit of tons of CO2 reduced, equals $37,176 saved per day.

[10] TRIMMS™ User Manual, Version 4.0, Center for Urban Transportation Research, USF.

Table A-2 - Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by FY 2018 – FY 2020 TDM Program Elements and Commuter Operations Center Impacts

Societal Benefit	Benefit Unit	Benefit Base Units [1)]	Cost per Unit of Benefit [2)]	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.529 T	$1,612	$853
- VOC	Tons VOC removed	0.397 T	$133	$53
- PM 2.5	Tons PM 2.5 removed	0.040 T	$15,107	$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.710 T	$1,612	$1,145
Total air pollution				**$2,655**
Greenhouse gas	**Tons CO2 removed**	**1,033 T**	**$36**	**$37,176**

1) Daily tons of emissions reduced calculated in TDM analysis using MWCOG emission factors.
2) Cost per tons of emissions reduced obtained from TRIMMS™.

Noise Pollution Reduction

The societal benefit for noise pollution reduction is related to the reduced noise associated with the vehicle travel that has been eliminated from the roadway. Noise costs refer to negative externalities associated with motor vehicle noise emissions such as noise from engine acceleration and vibration, tire contact on road surfaces, and horn usage. Traffic noise is an annoyance, but has real health effects from impaired hearing, increased stress, and sleep disruption, and can contribute to reduction in property values in areas with high or sustained noise levels. An analysis of cost saving from noise pollution reduction estimates how much noise will be reduced and multiplies that reduction by a unit cost factor that represents the cost of abatement for that noise level.

Cost saving for noise reduction = Total VMT reduced
x Noise reduction per VMT reduced
x $ cost per adjusted VMT

Calculating Benefit Units and Cost per Unit of Benefit – The TDM analysis applies the approach and benefit unit and unit cost factors from the TRIMMS™ model. TRIMMS™ applies a unit benefit factor of 1.0 to convert total VMT reduced to a noise reduction component. It then multiplies the adjusted VMT by a noise costs of $0.022692 per mile for auto and vanpool and $0.115205 per mile for transit (derived from a literature review) to estimate the societal cost savings. The composite cost of $0.0223, which includes both health and property value impacts is scaled to account for cost of living differentials between national averages and the Washington metropolitan region.

This calculation estimates a total cost saving for noise pollution reduction of $59,040 per day, as shown below:

Total daily VMT reduced by TDM program elements = 2,647,551

Noise pollution daily cost saving = 2,647,551 x $0.0223 per VMT = **$59,040 per day**

Congestion (Delay) Reduction

A third societal benefit is cost savings from reductions in traffic congestion. Traffic congestion slows the flow of traffic, resulting in slower travel speeds and longer trip times. Longer trips create societal dis-benefit primarily through lower business productivity, reduced access to the workforce, and loss of personal time for travelers who travel in congested conditions. The impact of traffic congestion typically is defined by the additional travel time or travel delay experienced by vehicle operators. When TDM programs remove vehicles and VMT from congested segments of road, travel speeds on those road segments increase, resulting in shorter trip times and less delay.

Because the Commuter Connections TDM analysis assesses benefits related to commuting travel, the benefit unit assigned to traffic congestion in the analysis is reduced vehicle hours of peak period travel delay.

Appendix 8 described the method used in the TDM analysis to estimate vehicle hours of delay reduction. This approach estimates the percentage share of the TDM program elements' total VMT reduced that would have traveled on congested roadways and applies a per VMT delay factor to the reduced VMT to estimate the reduced hours of delay. For example, if 30% of the VMT reduced would have traveled on congested roadways during the peak period, how many additional hours of travel delay would be expected? The hours of delay reduced are then multiplied by a cost per hour of delay to estimate the total cost saving from reduced congestion.

Cost saving for reduced congestion = Congested VMT reduced
x Marginal delay hours per VMT
x $ cost per hour of delay

Calculating Benefit Units and Cost per Unit of Benefit – As shown in Appendix 8, the calculation of "congested VMT" discounted the total VMT reduced to include only miles traveled on Interstate highways and major roadways in the Washington metropolitan region. The method additionally discounted to include only VMT that would have traveled in congested conditions to align with the marginal delay factor used by TRIMMS™ to convert VMT reduced into hours of delay reduction across the regional system. This factor is a national default value of **15.9 hours of marginal delay per 1,000 passenger car equivalent daily VMT**.

The unit cost of an hour of delay, often referred to as the value of travel time savings (VTTS), reflects the opportunity cost of time spent traveling that could be used for other activities. The demand for travel is derived from the benefit of accessing a destination, rather than the travel itself. Thus, time spent traveling has a negative value and a reduction in travel time represents a positive benefit. In its simplest form, the value of travel time saving includes costs to businesses in lost productivity and costs to travelers in lost personal time.

Transportation economic analyses typically value an hour of time saved as a labor wage rate. The VTTS will depend on the traveler, the circumstances of the trips, and the travel alternatives. The U.S. Department of Transportation (USDOT) published Departmental guidance regarding value of time for transportation economic analyses to "assist analysts in developing consistent evaluations of actions that save cost or time in travel."[11] For commuting, when travelers have a defined and non-discretionary trip purpose (getting to/from work), and for TDM strategies, which most often are available to a wide range of commuters, a cost saving analysis can reasonably approximate VTTS over the entire working population, using an average hourly wage rate over all commuters. The USDOT guidance recommends using a VTTS of 100% of the median hourly wage rate, including benefit costs, for "on-the-clock" local business/commercial travel and 50% of the median hourly wage rate, excluding benefits, for personal travel.

However, a consideration that is of great relevance to analysis of the TDM program elements is that the value travelers place on a congested minute appears to be different than the value for non-congested time, as much as 1.5 to 2.5 times the value of time spent in uncongested travel, depending on the extent of congestion. A substantial body of transit and mode choice research has documented differential values of in-vehicle travel time, out-of-vehicle wait time, and transfer times for transit. Travelers experience wait time and transfer time as longer than the actual time and experience travel time as shorter than actual time. For example, the USDOT guidance recommends that personal time spent walking or waiting, as is common for the rideshare, transit, bicycle, and walking trips generated by TDM strategies, also be valued at 100% of wage rate.

The average wage rate for the TDM analysis would be a composite rate comprised primarily of the local personal travel value, which would suggest a value closer to 50% than 100% of the local wage rate. However, as noted above, USDOT applies a 100% value to access/wait time for travel in non-drive alone modes, which are the focus of the TDM program elements. Finally, the role of congestion in commuting can be significant, suggesting the wage

[11] The U.S. Department of Transportation (USDOT), September 28, 2011, Memorandum Subject: Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis. https://www.transportation.gov/sites/dot.dev/files/docs/vot_guidance_092811c.pdf

rate applied should be account be closer to 100% than 50%. For simplicity, the TDM analysis uses a single VTTS of 100% of median hourly wage rate, excluding worker benefits. This number was chosen as an approximation because it is readily available from the U.S. Bureau of Labor Statistics.[12]

Cost Saving Calculation – The adjusted "major roadway" VMT calculation described in Appendix 8 estimated that 331,914, or about 12.5% of the total VMT reduced by the Commuter Connections TDM program would have traveled on major roadways in congested conditions. When this "congested VMT" total is multiplied by the 15.9 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced by the TDM program equals 5,277 daily hours of delay reduced:

Estimated delay reduction = (331,914 mi / 1,000) x 15.9 hours per daily VMT = **5,277 daily hours delay reduced.**

These hours of delay were multiplied by the $27.08 median hourly wage rate for all employees working in the Washington metropolitan region, as reported by the Bureau of Labor Statistics. When this cost is multiplied by the 5,277 daily hours of delay reduced, the total congestion (delay) reduction benefit equals **$142,913 per day**.

Excess Fuel Consumption Reduction

A reduction in vehicle use results in a direct reduction in the amount of fuel consumed for travel. The TDM analysis defines the societal benefit of reducing fuel use as the cost saved when gallons of fuel are not purchased. Reduced vehicle use also results in other vehicle operating savings, such as reduced vehicle maintenance and depreciation, but these costs are excluded from the analysis. The cost saving for reduction in fuel use is calculated by converting the VMT reduction into gallons of fuel saved and multiplying by an average fuel cost per gallon:

Cost saving for reduced fuel consumption = Total VMT reduced
/ Fuel consumption factor (miles per gallon)
x $ cost per gallon of fuel

Calculating Benefit Units and Cost per Unit of Benefit – Fuel consumption has a direct relationship with the number of vehicle miles traveled and is commonly defined by dividing the total VMT by the miles per gallon (mpg) fuel consumption rate. Fuel consumption per mile varies by vehicle type and by travel speed and operating conditions. For example, a large sport utility vehicle (SUV) uses more gasoline per mile or per hour than does a small compact car. And vehicles use different amounts of fuel when traveling as slow speeds than high speeds, with higher speeds generally more efficient use of fuel. TRIMMS™ methodology uses a default value of 18.0 miles per gallon fuel efficiency. This national factor represents the average fuel economy of a typical commuting vehicle in the passenger vehicle fleet, including both large and small vehicles, cars, SUVs, and vans and trucks used as commuting vehicles.

The gallons of fuel saved by reduced VMT is then multiplied by an average cost per gallon of fuel. The U.S. Energy Information Administration publishes average gasoline prices for various parts of the country. In June 2020, the average cost reported for the Mid-Atlantic region was $2.73 per gallon.[13] The result of these calculations is as follows:

Total daily VMT reduced by TDM program elements = 2,647,551

Estimated gallons of fuel saved = 2,647,551 miles / 18.0 miles per gallon = 147,086 gallons

Excess fuel consumption daily cost saving = 147,086 gallons x $2.73 per gallon = **$401,545 per day**

The calculation estimates a fuel saving of 147,086 gallons per day and a cost saving from reduction in fuel use of $401,545 per day.

[12] U.S. Department of Labor, Bureau of Labor Statistics (BLS) wage data May 2016 – median hourly wage rate for all occupations combined; https://www.bls.gov/oes/current/oes_nat.htm
[13] Weekly Retail Gasoline and Diesel Prices, June 2020. U.S. Energy Information Administration. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r1y_m.htm

Improved Road Safety (Accident Reduction)

A reduction in motor vehicle travel generates a benefit of improved road safety by reducing the likelihood of a motor vehicle accident occurring. Quite simply, as vehicles are removed from a roadway, the remaining vehicles have a reduced risk of accidents. The cost saving from reduced vehicle accidents is equal to the reduced risk of a crash multiplied by the economic cost of the average accident.

The TDM analysis applies the road safety/accident reduction approach from the Health and Safety element of the TRIMMS™ methodology. TRIMMS™ applies expected crash rates for accidents of various severities to estimate an overall crash probability per 1 million VMT. In the TDM analysis, this crash risk factor is multiplied by the total VMT reduced by the TDM program elements to estimate the number of likely crashes that would have been avoided by the reduction in vehicle travel. The number of anticipated crashes is then multiplied by the average cost per accident to estimate the total cost saving:

Cost saving for improved road safety = Total VMT reduced
x Expected crashes per 1,000,000 VMT
x $ cost per accident

Calculating Benefit Units and Cost per Unit of Benefit – The value of reduced accidents is calculated by multiplying the estimated number of crashes by crash type by the cost per occurrence of each crash type. TRIMMS™ estimates a composite cost per unit benefit (crash avoided) that includes vehicle crash-related monetary costs for property and personal injury damages caused by collisions, and nonmonetary costs, for pain and loss of productivity. The TRIMMS™ methodology starts with the VMT reduction and applies a multi-level calculation that takes into account the occurrence probability of accidents with varying levels of severity (KABCO Injury Classification Scale)[14] and the average cost per type of accident. Crashes with minor property damage have a higher likelihood of occurring but a lower cost per occurrence. Conversely, crashes with serious or fatal injuries are less likely to occur but have a high societal cost when they do happen. Table A-3 shows crash types, occurrence probabilities and anticipated costs.

Table A-3 – Crash Costs by Injury Severity

KABCO Injury Classification Scale	Probability per 1 M VMT	Cost per Occurrence	Expected Cost per 1 M VMT 1)
No injury (O)	1.00000	$3,650	$3,650
Possible injury (C)	0.00055	$55,768	$31
Non-incapacitating evident injury (B)	0.00011	$2,828	$3
Incapacitating injury (A)	0.00194	$783,341	$1,520
Fatal injury (K)	0.00776	$1,408,533	$10,930
Overall probability and cost	1.01136		$16,134
Weighted cost per 1 M VMT 2)			**$15,952**

1) Expected cost per 1 million VMT = Probability of occurrence in 1 million VMT x average cost per occurrence.
2) Weighted cost per 1 million VMT = Overall cost ÷ Overall probability.

The calculation in Table A-3 produces an average composite risk of 1.01136 vehicle crashes per 1 million VMT and an average weighted cost per crash of $15,952. Note that this crash cost accounts for both the high probability

[14] Federal Highway Administration. (2017, June 30). *KABCO Injury Classification Scale and Definitions.* Retrieved from FHWA Highway Safety Improvement Program - Safety Performance Management : https://safety.fhwa.dot.gov/hsip/docs/fhwasa18001.pdf Table 9 on p30 has comprehensive crash costs in 2017 dollars. Table 39 https://safety.fhwa.dot.gov/hsip/docs/fhwasa17071.pdf shows costs per state.

(1.0000 per 1M VMT) but low cost ($3,650) of a no injury crash and the low probability (0.0076 per 1M VMT) but high cost ($1.4 M) of a fatal injury cost.

The calculation estimates that 2.678 crashes will occur over the 2.647 million VMT reduction. At a per occurrence cost of $15,952, the total cost saving from crash reduction is $42,721 per day.

Total daily VMT reduced by TDM program elements = 2,647,551

Expected crash occurrence = (2,647,551 miles / 1,000) x 1.01136 crash per 1000 VMT = 2.678 crashes

Health and Safety daily cost saving = 2.678 crashes x $15.952 per crash = **$42,721 per day**

Total Societal Benefit Cost Saving

Table A-4 presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the four TDM program elements and the Commuter Operations Center combined.

Table A-4 – Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by TDM Program Elements

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.529 T	$1,612	$853
- VOC	Tons VOC removed	0.397 T	$133	$53
- PM 2.5	Tons PM 2.5 removed	0.040 T	$15,107	$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.710 T	$1,612	$1,145
Greenhouse gases	Tons CO2 removed	1,033 T	$36	$37,176
Noise pollution	Total VMT reduced	2,647,551 VMT	$0.0223	$59,040
Congestion	Hours of delay reduced	5,277 hours	$27.08	$142,913
Excess fuel used	Gallons of fuel saved	147,086 gal	$2.73	$401,545
Health/safety [1)]	Accidents avoided/1 M VMT	2.678 acc.	$15,952	$42,721
All benefits				**$686,050**

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

As shown, the combination of the TDM program elements and Commuter Operations Center generate about $686,050 of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of excess fuel used; this benefit is valued at over $401,500 per day, or about 59% of the total daily benefits. Reduction in hours of travel delay accounts for about 21% of the total daily benefit ($142,913). Noise pollution reduction generates about 9% and the air pollution/Greenhouse gas reduction combined benefits and road safety accident reduction benefits each are responsible for about 6% of the total cost saving.