NATIONAL CAPITAL REGION TRANSPORTATION PLANNING BOARD COMMUTER CONNECTIONS PROGRAM

TRANSPORTATION EMISSION REDUCTION MEASURE (TERM) ANALYSIS REPORT FY 2015-17 Interim – July 2014 – December 2016

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EXECUTIVE SUMMARY

BACKGROUND

This report presents the results of an evaluation of four Transportation Emission Reduction Measures (TERMs), voluntary Transportation Demand Management (TDM) measures implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG) to support the Washington, DC metropolitan region's air quality conformity determination and congestion management process. This evaluation documents transportation and air quality impacts for the three-year evaluation period between July 1, 2014 and June 30, 2017, for the following TERMs:

- Maryland and Virginia Telework – The Maryland portion of this TERM provides information and assistance to Maryland commuters and employers to further in-home and 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 to 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, including the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling TERM also is part of this analysis.
- Mass Marketing – Involves a large-scale, comprehensive media campaign to inform the region's commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various special promotional events also are part of this TERM.

COG's National Capital Transportation Planning Board (TPB), the designated Metropolitan Planning Organization (MPO) for the Washington, DC metropolitan region, adopted and continues to support these TERMs, among others, as part of the regional Transportation Improvement Program (TIP). The purpose of the TERMs is to help the region reach emission reduction targets that would maintain a positive air quality conformity determination for the region and to meet federal requirements for the congestion management process. The Commuter Connections program is considered integral in regional travel demand management and is included in the region's TERMs technical documentation which was updated in October 2015. Travel parameters prior to the year 2010 were captured by the regional travel demand model. Only the effects of the incremental growth of the Commuter Connections program post 2010 will be accounted for in future analysis years.

COG/TPB's Commuter Connections program, which also operates an ongoing regional rideshare program, is the central administrator of the TERMs noted above. Commuter Connections elected to include a vigorous evaluation element in the implementation plan for each of the adopted TERMs to develop information to guide sound decision-making about the TERMs. This report summarizes the results of the TERM evaluation activities and presents the transportation and air quality impacts of the TERMs and the Commuter Operations Center (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.

A primary purpose of this evaluation was to develop meaningful information for regional transportation and air quality decision-makers, COG/TPB staff, COG/TPB program funding agencies, and state and local commute assistance program managers to guide sound decision-making about the TERMs. The results of this evaluation will provide valuable information for regional air quality conformity and the region's congestion management process, to

improve the structure and implementation procedures of the TERMs themselves, and to refine future data collection methodologies and tools.

SUMMARY OF TERM IMPACT RESULTS

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 TERM and compare the impacts against the goals established for the TERMs. The impact results for these measures are shown in Table A for each TERM individually. Results for all TERMs collectively and for the Commuter Operations Center (COC) are presented in Table B.

As shown in Table A, the TERMs combined exceeded the collective goals for vehicle trips reduced by 7% and exceeded the VMT goal by about 9%. The TERMs did not reach the emission goals; the impact for NOx was 35% under the goal and VOC impact was 16% under the goal, but these deficits were due largely to changes in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMs were re-set since that time, but the emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, as presented in Table B, the combined impacts just met the vehicle trip and VMT reduction goals, in this case by 2% and 1%, respectively. The combined TERM – COC program impacts fell 41% short of the NOx goal and were 20% below the VOC goal. Again, the change in the emission factors affected the emission results.

Two TERMs, Telework – Maryland Assistance and Employer Outreach, easily met their individual goals for participation and travel impact. Employer Outreach exceeded vehicle trip and VMT goals by substantial margins. The Employer Outreach for Bicycling TERM component did not meet its goals, but the absolute deficits were small.

The impacts for the other two TERMs were below their goals. Vehicle trip reductions and VMT reductions for the Guaranteed Ride Home TERM were about half of the goals set for these impacts, primarily due to declining registrations, compared with 2014 and previous years. And the Mass Marketing TERM's vehicle trip and VMT reductions were 10% and 17% short of their respective goals. The Commuter Operations Center and the Software Upgrades TERM also were under their goals for vehicle trips and VMT reduced.

Note, however, that the impacts shown in Table A include only data for the first 30-months (July 2014 – December 2016) of the 36-month evaluation period (July 2014 – June 2017). All the TERMs except Telework will generate higher impacts when participation for January – June 2017 is added to the calculation. Impacts for the Commuter Operations Center and Software Upgrades components also will increase, for the same reason. These updated impacts will be documented in the follow-up TERM analysis report to be prepared in the fall of 2017.

Additional details on the calculations for each TERM and for the Commuter Operations Center are described in individual sections of this report. The reasons for the shortfalls from the goals also are discussed in the individual report sections.

Table A
Summary of Daily Impact Results for Individual TERMs (July 2014 – December 2016) and Comparison to Goals

TERM	Participation [1)]	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance [2)]					
2017 Goal	31,854	11,830	241,208	0.122	0.072
Impacts (7/14 – 12/16)	44,350	14,839	361,204	0.096	0.070
Net Credit or (Deficit)	**12,496**	**3,009**	**119,996**	**(0.026)**	**(0.002)**
Virginia Telework Assistance – Telework! VA [2)]					
2017 Goal	TBD	TBD	TBD	TBD	TBD
Impacts (7/14 – 12/16)	TBD	TBD	TBD	TBD	TBD
Net Credit or (Deficit)	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
Guaranteed Ride Home					
2017 Goal	36,992	12,593	355,136	0.177	0.097
Impacts (7/14 – 12/16)	15,245	5,890	166,946	0.037	0.021
Net Credit or (Deficit)	**(21,747)**	**(6,703)**	**(188,190)**	**(0.140)**	**(0.076)**
Employer Outreach – all employers participating [3)]					
2017 Goal	1,844	82,120	1,391,362	0.559	0.318
Impacts (7/14 – 12/16)	1,865	95,582	1,690,401	0.436	0.324
Net Credit or (Deficit)	21	**13,462**	**299,039**	**(0.123)**	**(0.006)**
Employer Outreach – new / expanded employer services since July 2014 [3)]					
2017 Goal	N/A	N/A	N/A	N/A	N/A
Impacts (7/14 – 12/16)	660	20,967	373,553	0.096	0.071
Net Credit or (Deficit)	N/A	N/A	N/A	N/A	N/A
Employer Outreach for Bicycling [3)]					
2017 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/14 – 12/16)	557	356	1,568	0.0008	0.0011
Net Credit or (Deficit)	**(33)**	**(48)**	**(853)**	**0.0008**	**0.0004**
Mass Marketing					
2017 Goal	23,168	10,809	181,932	0.085	0.025
Impacts (7/14 – 12/16)	22,458	9,713	150,832	0.040	0.017
Net Credit or (Deficit)	**(710)**	**(1,096)**	**(31,100)**	**0.045**	**(0.008)**
TERMS (all TERMs collectively)					
2017 Goal		117,352	2,169,638	0.943	0.512
Impacts (7/14 – 12/16)		126,024	2,369,383	0.608	0.432
Net Credit or (Deficit)		**8,672**	**199,745**	**(0.334)**	**(0.080)**

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

2) Maryland impacts represent portion of regional telework attributable to TERM-related 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 TERM.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2014 and for Employer Outreach for Bicycling.

Table B
Summary of TERM and COC Results (July 2014 – December 2016) and Comparison to Goals

TERM	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
TERMS (all TERMs collectively)					
2017 Goal		117,352	2,169,638	0.943	0.512
Impacts (7/14 – 12/16)		126,024	2,369,383	0.608	0.432
Net Credit or (Deficit)		**8,672**	**199,745**	**(0.334)**	**(0.080)**
Commuter Operations Center – Basic Services					
2017 Goal	91,609	24,425	512,637	0.241	0.115
Impacts (7/14 – 12/16)	66,006	18,928	371,971	0.098	0.075
Net Credit or (Deficit)	(25,603)	**(5,497)**	**140,666**	**0.143**	**0.040**
Commuter Operations Center – Software Upgrades [1)]					
2017 Goal	4,681	2,379	66,442	0.028	0.011
Impacts (7/14 – 12/16)	3,552	1,512	43,636	0.009	0.005
Net Credit or (Deficit)	**(1,129)**	**(867)**	**(22,806)**	**(0.019)**	**(0.006)**
All TERMS plus COC					
2017 Goal		144,156	2,748,717	1.212	0.638
Impacts (7/14 – 12/16)		146,464	2,784,990	0.715	0.512
Net Credit or (Deficit)		**2,308**	**36,273**	**(0.497)**	**(0.126)**

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 TERM.

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 TERM and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections TERMs. But COG has been measuring these impacts for other TERMs, thus these results are provided.

As shown, the TERMs collectively reduce 8.1 annual tons of PM 2.5, 163 annual tons of PM 2.5 pre-cursor NOx, and 245,030 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 9.5 annual tons of PM 2.5, 192 annual tons of PM 2.5 pre-cursor NOx, and 288,109 annual tons of CO2 (greenhouse gas emissions).

Table C
Summary of Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Results for Individual TERMs

TERM	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
Maryland Telework Assistance [1)]	1.28	25.68	38,820
Virginia Telework Assistance (TW!VA) [1)]	TBD	TBD	TBD
Guaranteed Ride Home	0.51	9.75	16,266
Employer Outreach – all employers [2)]	5.75	116.70	174,461
Employer Outreach – new/expanded employers [2)]	1.27	25.75	38,558
Employer Outreach for Bicycling	0.01	0.22	187
Mass Marketing	0.52	10.70	15,483
TERMS (all TERMs collectively)	8.06	162.83	245,030
Commuter Operations Center – basic services (not including Software Upgrades)	1.27	26.35	38,845
Commuter Operations Center – Software Upgrades	0.13	2.53	4,234
All TERMs plus Commuter Operations Center	9.46	191.71	288,109

1) Maryland impacts represent portion of regional telework attributable to TERM-related 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 TERM.

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

Finally, Table D shows comparisons of daily reductions in vehicle trips, VMT, NOx, and VOC from the 2017 TERM analysis (July 2014 through December 2016) to results of the 2014 analysis (July 2011 through June 2014). As noted before, the current impacts (July 2014-December 2016) cover only 30-months, while the previous (July 2011-June 2014) impacts cover 36-months. Note also that, as described in the footnotes to the table, the emission factors declined between 2014 and 2017, resulting in decreased emission reductions, even though some of the TERMs achieved greater vehicle trip and VMT reductions in 2017 than in 2014.

The impacts for the Telework TERM and Employer Outreach were substantially higher in 2017 than in 2014. Impacts for GRH and for the Mass Marketing TERMs were lower in the 2017 analysis than in 2014, but when the full 36-month evaluation period is analyzed, the 2017 Mass Marketing impacts likely will meet or exceed the 2014 impacts. The Commuter Operations Center also had lower impacts in 2017 than in 2014, largely due to lower than expected application counts, but these impacts also will be higher when the follow-up 36-month report is completed.

Table D
Summary of Results for Individual TERMs 7/14– 12/16 Compared with 7/11 – 6/14

TERM	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance				
July 2014 – December 2016	14,839	361,204	0.096	0.070
July 2011 – June 2014	9,651	205,511	0.101	0.051
Change [1]	5,188	155,693	(0.005)	0.019
Virginia Telework Assistance – Telework! VA				
July 2014 – December 2016	TBD	TBD	TBD	TBD
July 2011 – June 2014 [2]	N/A	N/A	N/A	N/A
Change	**N/A**	**N/A**	**N/A**	**N/A**
Guaranteed Ride Home				
July 2014 – December 2016	5,890	166,946	0.037	0.021
July 2011 – June 2014	7,711	212,834	0.087	0.033
Change [1]	(1,821)	45,888	(0.051)	(0.012)
Employer Outreach – All services except Employer Outreach for Bicycling				
July 2014 – December 2016	95,226	1,688,833	0.435	0.323
July 2011 – June 2014	78,210	1,325,107	0.533	0.304
Change [1]	17,015	363,726	(0.098)	0.020
Employer Outreach for Bicycling				
July 2014 – December 2016	356	1,568	0.001	0.001
July 2011 – June 2014	323	1,937	0.001	0.001
Change [1]	34	(369)	0.000	0.000
Mass Marketing				
July 2014 – December 2016	9,713	150,832	0.040	0.017
July 2011 – June 2014	10,294	173,269	0.081	0.024
Change [1]	(581)	(22,437)	(0.041)	(0.007)
All TERMs				
July 2014 – December 2016	126,024	2,369,383	0.608	0.432
July 2011 – June 2014	106,189	1,918,658	0.803	0.412
Change [1]	19,836	450,725	(0.195)	(0.020)
Commuter Operations Center (Basic Services + Software Upgrades)				
July 2014 – December 2016	20,440	415,607	0.108	0.080
July 2011 – June 2014	25,641	554,668	0.258	0.121
Change [1]	(5,201)	(139,061)	(0.150)	(0.041)

1) Change in emissions is due in part to reduction in emission factors from 2014 to 2017.
2) Telework! VA was not included in the FY 2012-14 TERM analysis.

SOCIETAL BENEFITS OF FY 2015-17 TRAVEL AND EMISSIONS IMPACTS

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination. Thus, conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. The travel and emissions impact indicators shown in Tables A and B were established for the TERMs by the TPB and the framework established for the FY 2015-17 TERM evaluation did not recommend any official changes to these indicators.

But the TERMs likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as climate change mitigation, greater mobility, improved health/safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

These benefits are joining 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.

The FY 2015-17 TERM evaluation added a new analysis component, estimating regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include:

- Air pollution / emissions reductions (reductions in NOx, VOC, PM 2.5 pollutants)
- Global climate change mitigation (reduction in Greenhouse gases / CO2)
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved health/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 for global climate change mitigation, 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 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.

Table E presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMs and the Commuter Operations Center combined. As shown, the combined TERM/Commuter Operations Center impacts generate about $1.1 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over $568,899 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit ($388,351).Noise pollution reduction generates about65% and air pollution/climate change benefits and health/safety accident reduction benefits each are responsible for about 4% of the total cost saving.

Table E
Daily Societal Benefit Cost Savings Generated by
FY 2015-17 TERM 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	0.716 T	$1,611	$1,154
- VOC	Tons VOC removed	0.512 T	$133	$68
- PM 2.5	Tons PM 2.5 removed	0.038 T	$15,107	$571
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.767 T	$1,612	$1,236
Climate change	Tons CO2 removed	1,152 T	$36	$41,488
Noise pollution	Total VMT reduced	2,784,990 VMT	$0.0223	$62,105
Congestion	Hours of delay reduced	22,638 hr	$25.13	$568,899
Excess fuel used	Gallons of fuel saved	154,722 gal	$2.51	$388,351
Health/safety [1)]	Accidents avoided/1 M	2.817 acc.	$15,952	$44,932
All benefits				**$1,111,835**

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

PURPOSE OF THE REPORT

This report presents the results of an evaluation of four Transportation Emission Reduction Measures (TERMs), voluntary Transportation Demand Management (TDM) measures implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG) to support the Washington, DC metropolitan region's air quality conformity determination and congestion management process. This evaluation documents transportation and air quality impacts for the three-year evaluation period between July 1, 2014 and June 30, 2017 (FY 2015-17), for the following TERMs:

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- Mass Marketing – Involves a large-scale, comprehensive media campaign to inform the region's commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various special promotional events also are part of this TERM.

The TPB, the designated Metropolitan Planning Organization (MPO) for the Washington, DC metropolitan region, adopted these TERMs in the regional Transportation Improvement Program (TIP) to help the region reach emission reduction targets that would maintain a positive air quality conformity determination for the region and to meet federal requirements for the congestion management process.

The United States Environmental Protection Agency has designated the Washington, DC metropolitan region as a "marginal" ozone non-attainment area. No regional mandates have been adopted that require the reduction of nitrogen oxides (NOx) or the implementation of any specific mitigation measure. But the COG/TPB Travel Management Subcommittee developed and analyzed regional TERMs and the TPB adopted these TERMs in annual TIPs.

COG/TPB's Commuter Connections program, which operates an ongoing regional rideshare program, was given responsibility for implementation of the TDM TERMs noted above. Commuter Connections is the central administrator of these TERMs, 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 travel information 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, a number of TMAs, and other partner organizations.

At the early stages of implementation of the TERMs, the Commuter Connections Subcommittee elected to include a vigorous evaluation element in the implementation plan for each of the adopted TERMs. 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 TERMs.

This report summarizes the results of the TERM evaluation activities and presents the transportation and air quality impacts of the TERMs. 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 included in the region's conformity analysis determination and documented in the region's congestion management process.

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 of five TERMs. In 2001, 2004, 2007, 2010, 2013, and 2016, 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 the methodology in this updated framework. Readers who desire additional details on the methodology are directed to the report entitled, "Commuter Connections' Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework, FY 2015 – FY 2017." This document (*TERM Evaluation Framework, 2015-2017*) is available from COG's Information Center or 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 TERM, but is included in this analysis because its operation supports the operation of most of the regional Commuter Connections TERMs.

ORGANIZATION OF THE REPORT

This TERM 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 TERM Impacts

Section 2 summarizes the overall results for each TERM individually and for all TERMs plus the Commuter Operations Center collectively. Section 3 presents highlights of the revised evaluation methodology developed in 2016 for the FY 2015-17 evaluation period. Sections 4 through 7 present for the each individual TERM, a brief description of the TERM and its purpose, an overview of the methodology used to estimate the TERM's impacts and the data used in the analysis, and a comparison of the measured impacts against the goals set for the TERM. 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 TERMs also are included in appendices following the body of the report.

SECTION 2 SUMMARY OF TERM 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 TERM between July 2014 and June 2017 and to compare these impacts against the goals established for the TERMs. The Revised Evaluation Framework document finalized in March 2016 also recommended that other performance measures be tracked for these TERMs 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 TERMs and are reported in other documents.

TRAVEL AND EMISSIONS IMPACTS OVERALL AND BY TERM

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 TERMs combined exceeded the collective goals for vehicle trips reduced by 7% and exceeded the VMT goal by about 9%. The TERMs did not reach the emission goals; the impact for NOx was 35% under the goal and VOC impact was 16% under the goal, but these deficits were due largely to changes in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMs were re-set since that time, but the emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, as presented in Table 2, the combined impacts just met the vehicle trip and VMT reduction goals, in this case by 2% and 1%, respectively. The combined TERM – COC program impacts fell 41% short of the NOx goal and were 20% below the VOC goal. Again, the change in the emission factors affected the emission results.

Two TERMs, Telework – Maryland Assistance and Employer Outreach, easily met their individual goals for participation and travel impact. Employer Outreach exceeded vehicle trip and VMT goals by substantial margins. The Employer Outreach for Bicycling TERM component did not meet its goals, but the absolute deficits were small.

The impacts for the other two TERMs were below their goals. Vehicle trip reductions and VMT reductions for the Guaranteed Ride Home TERM were about half of the goals set for these impacts, primarily due to declining registrations, compared with 2014 and previous years. And the Mass Marketing TERM's vehicle trip and VMT reductions were 10% and 17% short of their respective goals. The Commuter Operations Center and the Software Upgrades TERM also were under their goals for vehicle trips and VMT reduced.

Note, however, that the impacts shown in Table A include only data for the first 30-months (July 2014 – December 2016) of the 36-month evaluation period (July 2014 – June 2017). All the TERMs except Telework will generate higher impacts when participation for January – June 2017 is added to the calculation. Impacts for the Commuter Operations Center and Software Upgrades components also will increase, for the same reason. These updated impacts will be documented in the follow-up TERM analysis report to be prepared in the fall of 2017.

Additional details on the calculations for each TERM and for the Commuter Operations Center are described in individual sections of this report. The reasons for the shortfalls from the goals also are discussed in the individual report sections.

Table 1
Summary of Daily Impact Results for Individual TERMs (July 2014 – December 2016) and Comparison to Goals

TERM	Participation [1)]	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance [2)]					
2017 Goal	31,854	11,830	241,209	0.122	0.072
Impacts (7/14 – 12/16)	44,350	14,839	361,204	0.096	0.070
Net Credit or (Deficit)	**12,496**	**3,009**	**119,995**	**(0.026)**	**(0.002)**
Virginia Telework Assistance – Telework! VA [2)]					
2017 Goal	TBD	TBD	TBD	TBD	TBD
Impacts (7/14 – 12/16)	TBD	TBD	TBD	TBD	TBD
Net Credit or (Deficit)	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
Guaranteed Ride Home					
2017 Goal	36,992	12,593	355,136	0.177	0.097
Impacts (7/14 – 12/16)	15,245	5,890	166,946	0.037	0.021
Net Credit or (Deficit)	**(21,747)**	**(6,703)**	**(188,190)**	**(0.140)**	**(0.076)**
Employer Outreach – all employers participating [3)]					
2017 Goal	1,844	82,120	1,391,362	0.559	0.318
Impacts (7/14 – 12/16)	1,865	95,582	1,690,401	0.436	0.324
Net Credit or (Deficit)	21	**13,462**	**299,039**	**(0.123)**	**(0.006)**
Employer Outreach – new / expanded employer services since July 2014 [3)]					
2017 Goal	N/A	N/A	N/A	N/A	N/A
Impacts (7/14 – 12/16)	660	20,967	373,553	0.096	0.071
Net Credit or (Deficit)	N/A	N/A	N/A	N/A	N/A
Employer Outreach for Bicycling [3)]					
2017 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/14 – 12/16)	557	356	1,568	0.0008	0.0011
Net Credit or (Deficit)	**(33)**	**(48)**	**(853)**	**0.0008**	**0.0004**
Mass Marketing					
2017 Goal	23,168	10,809	181,932	0.085	0.025
Impacts (7/14 – 12/16)	22,458	9,713	150,832	0.040	0.017
Net Credit or (Deficit)	**(710)**	**(1,096)**	**(31,100)**	**0.045**	**(0.008)**
TERMS (all TERMs collectively)					
2017 Goal		117,352	2,169,638	0.943	0.512
Impacts (7/14 – 12/16)		126,024	2,369,383	0.608	0.432
Net Credit or (Deficit)		**8,672**	**199,745**	**(0.334)**	**(0.080)**

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

2) Maryland impacts represent portion of regional telework attributable to TERM-related 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 TERM.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2014 and for Employer Outreach for Bicycling.

Table 2
Summary of TERM and COC Results (July 2014 – December 2016) and Comparison to Goals

TERM	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
TERMS (all TERMs collectively)					
2017 Goal		117,352	2,169,638	0.943	0.512
Impacts (7/14 – 12/16)		126,024	2,369,383	0.608	0.432
Net Credit or (Deficit)		**8,672**	**199,745**	**(0.334)**	**(0.080)**
Commuter Operations Center – Basic Services					
2017 Goal	91,609	24,425	512,637	0.241	0.115
Impacts (7/14 – 12/16)	66,006	18,928	371,971	0.098	0.075
Net Credit or (Deficit)	(25,603)	**(5,497)**	**140,666**	**0.143**	**0.040**
Commuter Operations Center – Software Upgrades [1)]					
2017 Goal	4,681	2,379	66,442	0.028	0.011
Impacts (7/14 – 12/16)	3,552	1,512	43,636	0.009	0.005
Net Credit or (Deficit)	**(1,129)**	**(867)**	**(22,806)**	**(0.019)**	**(0.006)**
All TERMS plus COC					
2017 Goal		144,156	2,748,717	1.212	0.638
Impacts (7/14 – 12/16)		146,464	2,784,990	0.715	0.512
Net Credit or (Deficit)		**2,308**	**36,273**	**(0.497)**	**(0.126)**

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 TERM.

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 TERM and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections TERMs. But COG has been measuring these impacts for other TERMs, thus these results are provided.

As shown, the TERMs collectively reduce 8.1 annual tons of PM 2.5, 163 annual tons of PM 2.5 pre-cursor NOx, and 245,030 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 9.5 annual tons of PM 2.5, 192 annual tons of PM 2.5 pre-cursor NOx, and 288,109 annual tons of CO2 (greenhouse gas emissions).

Table 3
Summary of Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Results for Individual TERMs

TERM	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
Maryland Telework Assistance [1)]	1.28	25.68	38,820
Virginia Telework Assistance (TW!VA) [1)]	TBD	TBD	TBD
Guaranteed Ride Home	0.51	9.75	16,266
Employer Outreach – all employers [2)]	5.75	116.70	174,461
Employer Outreach – new/expanded employers [2)]	1.27	25.75	38,558
Employer Outreach for Bicycling	0.01	0.22	187
Mass Marketing	0.52	10.70	15,483
TERMS (all TERMs collectively)	8.06	162.83	245,030
Commuter Operations Center – basic services (not including Software Upgrades)	1.27	26.35	38,845
Commuter Operations Center – Software Upgrades	0.13	2.53	4,234
All TERMs plus Commuter Operations Center	9.46	191.71	288,109

1) Maryland impacts represent portion of regional telework attributable to TERM-related 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 TERM.

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

FY 2015-17 Impacts Compared with Impacts from FY 2012-14 Analysis

Finally, Table 4 shows comparisons of daily reductions in vehicle trips, VMT, NOx, and VOC from the 2017 TERM analysis (July 2014 through December 2016) to results of the 2014 analysis (July 2011 through June 2014). As noted before, the current impacts (July 2014-December 2016) cover only 30-months, while the previous (July 2011-June 2014) impacts cover 36-months. Note also that, as described in the footnotes to the table, the emission factors declined between 2014 and 2017, resulting in decreased emission reductions, even though some of the TERMs achieved greater vehicle trip and VMT reductions in 2017 than in 2014.

The impacts for the Telework TERM and Employer Outreach were substantially higher in 2017 than in 2014. Impacts for GRH and for Mass Marketing were lower in the 2017 analysis than in 2014, but when the full 36-month evaluation period is analyzed, the 2017 Mass Marketing impacts likely will meet or exceed the 2014 impacts. The Commuter Operations Center also had lower impacts in 2017 than in 2014, largely due to lower than expected application counts, but these impacts also will be higher when the follow-up 36-month report is completed.

Finally, Table 4 shows comparisons of daily reductions in vehicle trips, VMT, NOx, and VOC from the 2017 TERM analysis (July 2014 through December 2016) to results of the 2014 analysis (July 2011 through June 2014). As noted before, the current impacts (July 2014-December 2016) cover only 30-months, while the previous (July 2011-June 2014) impacts cover 36-months. Note also that, as described in the footnotes to the table, the emission factors declined between 2014 and 2017, resulting in decreased emission reductions, even though some of the TERMs achieved greater vehicle trip and VMT reductions in 2017 than in 2014.

Table 4
Summary of Results for Individual TERMs 7/14– 12/16 Compared with 7/11 – 6/14

TERM	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
Maryland Telework Assistance				
July 2014 – December 2016	14,839	361,204	0.096	0.070
July 2011 – June 2014	9,651	205,511	0.101	0.051
Change [1]	5,188	155,693	(0.005)	0.019
Virginia Telework Assistance – Telework! VA				
July 2014 – December 2016	TBD	TBD	TBD	TBD
July 2011 – June 2014 [2]	N/A	N/A	N/A	N/A
Change	**N/A**	**N/A**	**N/A**	**N/A**
Guaranteed Ride Home				
July 2014 – December 2016	5,890	166,946	0.037	0.021
July 2011 – June 2014	7,711	212,834	0.087	0.033
Change [1]	(1,821)	45,888	(0.051)	(0.012)
Employer Outreach – All services except Employer Outreach for Bicycling				
July 2014 – December 2016	95,226	1,688,833	0.435	0.323
July 2011 – June 2014	78,210	1,325,107	0.533	0.304
Change [1]	17,015	363,726	(0.098)	0.020
Employer Outreach for Bicycling				
July 2014 – December 2016	356	1,568	0.001	0.001
July 2011 – June 2014	323	1,937	0.001	0.001
Change [1]	34	(369)	0.000	0.000
Mass Marketing				
July 2014 – December 2016	9,713	150,832	0.040	0.017
July 2011 – June 2014	10,294	173,269	0.081	0.024
Change [1]	(581)	(22,437)	(0.041)	(0.007)
All TERMs				
July 2014 – December 2016	126,024	2,369,383	0.608	0.432
July 2011 – June 2014	106,189	1,918,658	0.803	0.412
Change [1]	19,836	450,725	(0.195)	(0.020)
Commuter Operations Center (Basic Services + Software Upgrades)				
July 2014 – December 2016	20,440	415,607	0.108	0.080
July 2011 – June 2014	25,641	554,668	0.258	0.121
Change [1]	(5,201)	(139,061)	(0.150)	(0.041)

1) Change in emissions is due in part to reduction in emission factors from 2014 to 2017.
2) Telework! VA was not included in the FY 2012-14 TERM analysis.

SOCIETAL BENEFITS OF FY 2015-17 TRAVEL AND EMISSIONS IMPACTS

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination and conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. The travel and emissions impact indicators shown in Tables 1 and 2 were established for the TERMs by the TPB and the framework established for the FY 2015-17 TERM evaluation did not recommend any official changes to these indicators.

But the TERMs likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as climate change mitigation, greater mobility, improved health/safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

These benefits are joining 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.

The FY 2015-17 TERM evaluation added a new analysis component, estimating regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include:

- Air pollution / emissions reductions (reductions in NOx, VOC, PM 2.5 pollutants)
- Global climate change mitigation (reduction in Greenhouse gases / CO2)
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved health/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 for global climate change mitigation, 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 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.

Table 5 presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMs and the Commuter Operations Center combined. As shown, the combined TERM/Commuter Operations Center impacts generate about $1.1 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over $568,899 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit ($388,351).Noise pollution reduction generates about65% and air pollution/climate change benefits and health/safety accident reduction benefits each are responsible for about 4% of the total cost saving. Appendix 9 details the TRIMMS model calculation methodology for each benefit.

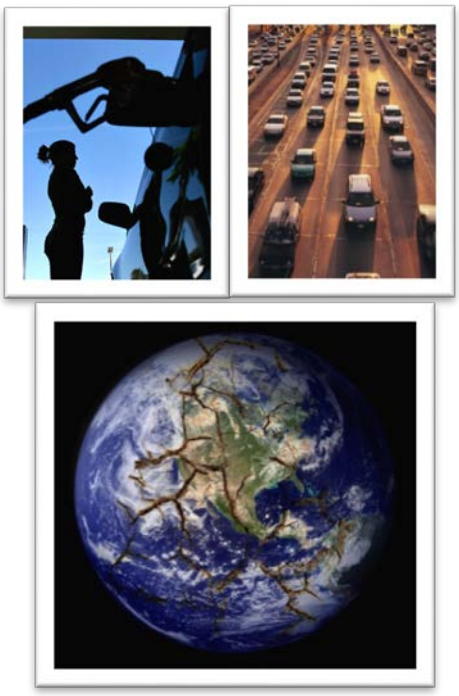
Table 5
Daily Societal Benefit Cost Savings Generated by
FY 2015-17 TERM and Commuter Operations Center Impacts

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.716 T	$1,611	$1,154
- VOC	Tons VOC removed	0.512 T	$133	$68
- PM 2.5	Tons PM 2.5 removed	0.038 T	$15,107	$571
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.767 T	$1,612	$1,236
Climate change	Tons CO2 removed	1,152 T	$36	$41,488
Noise pollution	Total VMT reduced	2,784,990 VMT	$0.0223	$62,105
Congestion	Hours of delay reduced	22,638 hr	$25.13	$568,899
Excess fuel used	Gallons of fuel saved	154,722 gal	$2.51	$388,351
Health/safety [1)]	Accidents avoided/1 M	2.817 acc.	$15,952	$44,932
All benefits				**$1,111,835**

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 TERMs adopted by COG's TPB. This methodology described evaluation objectives, performance measures for each TERM, 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 TERMs. 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 TERM effectiveness with confidence. But it also was designed to be efficient to undertake. The first TERM 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.

The first evaluation made recommendations for several data collection changes that could enhance the accuracy, rigor, coverage, and reliability of future TERM evaluations. A revised methodology was prepared in 2001, reflecting these recommendations. The methodology was updated again, in 2004, 2007, 2010, 2013, and 2016, following subsequent triennial TERM evaluations, to enhance the analysis results for several TERMs.

This section identifies key enhancements that were made to the methodology since the 2014 TERM Analysis Report was completed and discusses the overall rigor of the evaluation framework as compared to other regions. Overall, the Transportation Demand Management evaluation process employed for this analysis is among the most rigorous and comprehensive in the United States.

EVALUATION METHODOLOGY OVERVIEW

Evaluation Principles

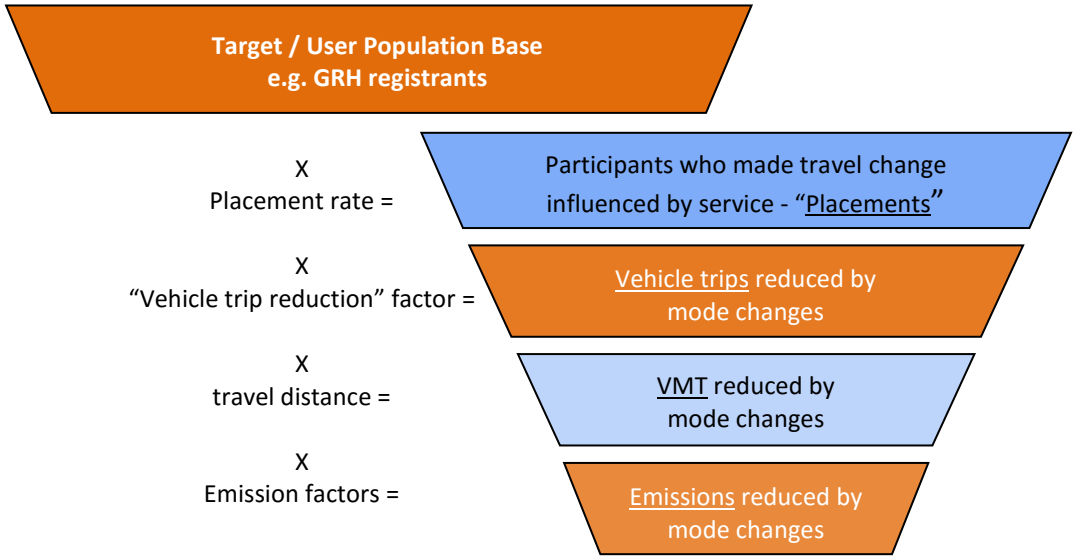
Before discussing the methodology changes in the Revised Evaluation Methodology, it is useful to review several element of the methodology developed in 1997. The TERM evaluation process was founded on several key evaluation principles that formed the foundation for the Evaluation Framework that has guided 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 or TERMs
- Report only those impacts associated with the TERMs, and not the combined impacts of the TERMs and the basic commuter services that were in place prior to the adoption of the TERMs
- 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

As illustrated in Figure 1, the calculation of Commuter Connection's TERM program impacts is based on a step-by-step methodology that applies a series of "multiplier factors" to estimate program impact measures related to transportation and air quality benefits generated by the TERMs. The methodology calls for these multiplier factors, which are derived primarily from survey data, to be applied to a known number of commuters who might be influenced or assisted by the TERM 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 TERM programs or services.

Figure 1: Impact Calculation Multipliers Series



For most TERMs, the population base is commuters who participate in or use the TERM service, although in a few cases, the population is all regional commuters. The methodology requires an accurate documentation of the participation in each TERM program 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 TERM has a unique set of factors, depending on the characteristics of the TERM and users, but the basic calculation method is the same for all TERMs. 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 often 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 TERMs, 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 TERM users who started or increased use of alternative modes as a result of the TERM. 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 TERM. 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 unrelated to the TERM.

4. Estimate vehicle trips reduced

   The number of daily vehicle trips reduced for the TERM was estimated by multiplying the number of alternative mode placements by the TERM'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 TERM 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 2017 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. Annual emissions reductions were calculated for PM 2.5, PM 2.5 pre-cursor NOX, and CO2 emissions.

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 conducted for FY 2000-02, FY 2003-05, FY 2006-08, FY 2009-11, and FY 2012-14. They also will be applied to the FY 2015-17 evaluation described in this report.

Key Evaluation Issues

Several other issues should be noted as background, because they are critical to understanding the high level of rigor build into the evaluation process:

- Avoid Double Counting – The evaluation separates the impacts of individual Commuter Connections programs to avoid double counting benefits. For example, carpools might be formed as a joint result of online ridematching and GRH program benefits. These impacts must either be credited to one of the two TERMs or divided between the TERMs. Program benefits are not necessarily additive.
- Separate Impacts of Program Elements – Similarly, the evaluation separates the baseline impacts of Commuter Operations Center "basic" services from the impacts of the new TERM programs. This is especially important for the Mass Marketing TERM, because its impacts can be "direct," meaning the marketing effort alone motivated use of alternative modes, or "referred," meaning the marketing effort influenced commuters to utilize another Commuter Connections program, such as ridematching. In such cases, the travel and air quality impacts will be assigned to the TERM 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). But some commuters who make shifts within alternative modes increase their vehicle trips, such as if they shift from transit to carpool and these would be valid shifts under the TERM analysis. The calculation of the vehicle trip reduction (VTR) factor converts the number of valid 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 air quality evaluation purposes, it is necessary to know the access mode of carpoolers, vanpoolers, and transit riders. Access mode refers to how carpoolers, vanpoolers, and transit riders travel from home to bus stops, train stations, Park & Ride lots, 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 impacts, because access trips generally account for a very small portion of the total miles traveled 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 air quality analysis.
- Apply Life-cycle Assessment to Mode Shifts to Capture the Full Duration of Benefits for TERM Impacts – In previous TERM evaluations, mode shifts motivated by TERMs during the evaluation period were not carried over to the next evaluation cycle. But numerous surveys conducted for past TERM 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. 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 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 TERM and for the Commuter Operations Center. 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 2015-17 REVISED EVALUATION FRAMEWORK

In general, the TERM analysis approaches documented in the FY 2012-14 TERM Analysis Report were used as the basis for the TERM evaluation methods applied in the FY 2015-17 evaluation. But the Revised Evaluation Framework for FY 2015-17 identified a few enhancements for the current evaluation period. A brief summary of key methodology issues and approaches is presented below for each TERM. More details of each approach are presented in Sections 4 – 7 for each individual TERM.

- The Telework TERM 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 TERM 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 component of the TERM 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 2012-14. However, the FY 2015-17 methodology adds a new "retained" component for registrants who ended their participation in GRH prior to the start of the current evaluation period, made a commute change related to the GRH program, and who continued to use alternative modes to commute into the FY 2015-17 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 – No changes to the methodology for FY 2015-17.

- Mass Marketing – The basic methodology for Mass Marketing follows the format used for FY 2012-14 and includes the same TERM activities of commute program/service advertising, promotional events, and 'Pool Rewards incentive program. One new element in the FY 2015-17 evaluation is the addition of vanpools to the 'Pool Rewards evaluation. In FY 2012, Commuter Connections expanded the program to include newly-formed vanpools that originate in either the District of Columbia or Maryland and are destined for job locations in the Washington metro region non-attainment area. Vanpools that participate in this program are included in the FY 2015-17 TERM analysis.

- 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 2012-14, with two exceptions:
  - The FY 2015-17 methodology adds a "retained" component for COC online applicants whose last contact with Commuter Connections was prior to the start of the current evaluation period, who made a commute change related to their COC assistance, and who continued to use alternative modes to commute into the FY 2015-17 evaluation period. This is accomplished by estimating the number of past COC participants and applying a "retention" placement rate and other multiplier factors to the past participant count.
  - The FY 2015-17 methodology also will count telework impacts generated in Virginia from the Telework! VA program under the Maryland and Virginia Telework TERM; these impacts were counted under the COC in the FY 2012-14 analysis.

NATURE OF THE EVALUATION APPROACH AS COMPARED TO OTHER REGIONS

The evaluation approach used in the Washington DC region to assess the impact of the TERMs implemented by Commuter Connection has become recognized as among the most comprehensive and rigorous in the nation. Several regions of a similar size and complexity have looked to this evaluation as a model and adopted similar approaches. For example:

- The evaluation of voluntary trip reduction strategies in Atlanta is using a similar "bottom-up" approach to measure the impact of various program elements individually and carefully sum the results while avoiding double counting from overlapping program influences. Data are collected and analyzed to evaluate regional ridesharing, transit and vanpool subsidy programs, and marketing campaigns. The TERM analysis served as the basic model for this approach and the data collection and analysis methods used are similar to those used in the MWCOG evaluation.
- A comprehensive evaluation of TDM services in Los Angeles County derived unique placement rates and VTR factors for the programs being evaluated and estimated the cost per person placed and cost per trip reduced of the overall TDM program. This evaluation also explicitly drew from the evaluation experience in Washington DC.
- Triangle J Council of Governments, in the Raleigh-Durham region of North Carolina, also uses an evaluation system that applies placement rates and VTR factors derived from survey data to assess impacts of trip reduction strategies funded by the Department throughout the region. Some elements of this system are based on Commuter Connections' evaluation method.

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 TPB adopted a telework-oriented TERM in the FY 1995-2000 TIP and in June 1996, the Metropolitan Washington Telework Resource Center (TRC) was implemented. This TERM was renamed as Telework Assistance (Telework) in the FY 2012-14 TERM 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 Commuter Connections include the Virginia-based Telework! VA assistance program in the FY 2015-17 TERM analysis, to document its results in Northern Virginia. Telework! VA 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 Telework TERM 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 2015-17, Telework TERM 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 TERM actions were counted in the TERM analysis. In other words, it was recognized that some telework would have occurred even if the Telework TERM was not in place. As described below, the Maryland and Virginia components of the Telework TERM impacts are analyzed similarly, but using different data.

Three Telework Assistance Populations

Three Telework populations were analyzed, two for Maryland and one for Virginia, including:

- 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

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 (45% lived and/or worked in Maryland and 55% had both home and work outside of Maryland)
- Telecommute locations – the mix between home-based and non-home-based
- 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)

Maryland Assisted Employer Telework Survey (new telecommuters at Maryland worksites that received assistance from Commuter Connections) – This survey interviewed assisted employers about telework at their worksites before and after they received assistance and the role assistance played in telework changes at the worksite. The survey data were analyzed to estimate the:

- Percentage of assisted employers with telework programs before and after receiving telework assistance
- Percentage of telecommuters at assisted sites before and after receiving assistance

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). The survey data were analyzed to estimate the:

- Percentage of telecommuters at assisted sites before and after receiving 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 TERM during the evaluation period were estimated. As shown below, 44,350 placements were calculated for Maryland Telework, 44,316 from direct commute assistance and 34 from assisted worksites. Maryland telecommuters were further divided into "home-based" (98% of total = 43,463) and "non-home-based" (2% of total = 887).

At the time this Interim TERM Analysis report was being prepared, the Telework! VA follow-up surveys had not been completed, so the Telework! VA impacts will be added to the TERM calculation when the final TERM analysis is prepared in fall 2017. Virginia telecommuters all will be home-based.

	Population base		Placement Rate		Placements
Maryland Telework					
• Maryland-based commuters	399,241	x	11.1%	=	44,316
• Assisted Maryland worksites	4,219	x	0.8%	=	34
Virginia – Telework! VA					
• Assisted worksites	TBD		TBD		TBD

VTR Factors and Vehicle Trips Reduced – The three groups of telecommuters 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. For this TERM, VTR factors accounted for both the average telecommute frequency of the groups as well as their travel modes on non-telecommute days and the travel modes on telecommute days of commuters who traveled to a telecommute location other than home.

- Maryland home-based telecommuters – The VTR factor was 0.34 daily trips reduced per telecommuter, reflecting the part-time (1.38 days per week average) telework frequency and the elimination of vehicle trips for the 61% 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 (0.07) because the majority of these telecommuters drove alone to the 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 will be calculated when the follow-up survey data are available in late summer 2017.

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 (24.4 miles) equals the one-way commute distance to the main workplace on non-telework days.
- Maryland non-home-based telecommuters – Average miles reduced (10.4 miles) was calculated as the one-way commute distance to main work location minus the distance to the outside telework location (15.1 – 4.7).
- Telework! VA telecommuters – The average miles reduced will be equal to the one-way commute distance to the main workplace on non-telework days. The distance will be calculated when the follow-up survey data are available in summer 2017.

Emissions Reduced – Tons of emissions removed were calculated by multiplying vehicle trip and VMT reductions by 2017 emission factors developed by MWCOG staff for the Washington metropolitan region, using the MOVES emission model. Daily emissions were calculated for the TERMs 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 TERM impacts.

TELEWORK ASSISTANCE SUMMARY OF GOALS AND IMPACTS

The results of the calculations for Telework are shown in Table 5 below for all regional telework (5a), for the Maryland component of the Telework TERM (5b) and for the Telework! VA program (5c). Tables 5b and 5c also show the goals established for the TERM. The net credits or deficits, which were equal to the impacts minus goals, are shown following Table 5.

Table 5
Regional Telework Impacts and
Telework Goals and Estimated Telework TERM Impacts for Maryland Telework and Telework! VA

Table 5a – Regional Telework	**Regional TW Impacts**
• Number of telecommuters	887,202
• Daily vehicle trips reduced	306,493
• Daily VMT reduced	5,970,004
• Daily tons NOx reduced	1.6688 T
• Daily tons VOC reduced	1.3256 T
• Annual tons PM 2.5 reduced	21.55 T
• Annual tons PM 2.5 pre-cursor NOx reduced	447.15 T
• Annual tons CO2 reduced	645,500 T

Table 5 continued

Table 5-b – Maryland Telework	**Telework Goal – MD**	**Telework Impact – MD**
• Number of telecommuters	31,854	44,350
• Daily vehicle trips reduced	11,830	14,839
• Daily VMT reduced	241,208	361,204
• Daily tons NOx reduced	0.1222 T	0.0958 T
• Daily tons VOC reduced	0.0723 T	0.0696 T
• Annual tons PM 2.5 reduced	N/A	1.28 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	25.68 T
• Annual tons CO2 reduced	N/A	38,820 T

Impacts vs Goals – Maryland Telework

Participation Benefit (net over or (under) goal): Telecommuters: 12,496

Transportation Benefit (net over or (under) goal): Vehicle Trips: 3,009
VMT: 119,996 miles

Emission Benefit (net over or (under) goal): NOx: (0.0264) tons per day
VOC: (0.0024) tons per day

Table 5-c – Telework! VA Telework	**Telework Goal – TW!VA**	**Telework Impact – TW!VA**
• Number of telecommuters	TBD	TBD
• Daily vehicle trips reduced	TBD	TBD
• Daily VMT reduced	TBD	TBD
• Daily tons NOx reduced	TBD T	TBD
• Daily tons VOC reduced	TBD T	TBD
• Annual tons PM 2.5 reduced	N/A	TBD
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	TBD
• Annual tons CO2 reduced	N/A	TBD

Impacts vs Goals – Telework! VA

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

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

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

Regional Telework – In 2016, approximately 887,202 regional workers teleworked at least occasionally, representing about 30% of the total regional workforce and 32% of all workers who are not self-employed, working only at home. This number of regional telecommuters represented a 31% increase over the 2013 count of 675,000, 48%% of the 600,000 count in 2010, and nearly six times the 1996 baseline of 150,900 telecommuters.

Telework growth is likely the result of several factors, including the use of telework by employers to recruit and retain employees. Increasing traffic congestion in the Washington region also might have prompted some commuters to work at home to avoid traffic. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework. Finally, the desire of employees for a better balance of work and family, a trend occurring nationally, and greater affordability of sophisticated technology, also might have contributed to the growth in telecommuting.

Maryland Telework TERM – Table 5b shows the expected contribution of the Maryland Telework TERM component to regional teleworking (Telework Goal – MD) and the impacts for this TERM component (Telework TERM Impacts – MD). The number of Maryland telecommuters estimated for the TERM was 39% over the number of telecommuters expected from this TERM activities. The TERM also exceeded the reduction goals for vehicle trips (25%) and VMT (50%). Maryland telecommuters accounted for approximately 45% of regional telecommuters.

The Maryland portion of the Telework TERM was responsible for about 5% of regional telecommuters and telework impacts. In the 2016 State of the Commute Survey, 11% of Maryland telecommuters mentioned Commuter Connections or MWCOG as a source of their telework information. These telecommuters were credited to the Telework TERM contribution.

One possible area in which the Telework TERM's contribution to the regional telework impacts could have been undercounted is in the area of regional employer outreach. More than seven in ten (73%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach TERM also promotes telework to employers. So 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 TERM. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

SECTION 5 GUARANTEED RIDE HOME

BACKGROUND

The regional Guaranteed Ride Home (GRH) program was adopted by the TPB in the Fiscal Year 1995-2000 TIP to eliminate a major barrier to using alternative modes, commuters' fear of being without transportation in the case of an emergency. The program provides up to four free rides home per year in a taxi or rental car in the event of an unexpected personal emergency or unscheduled overtime.

When the program was implemented, it was offered to commuters who used alternative modes three or more times per week and who would register with Commuter Connections for GRH. In January 1999, to encourage additional participation, the program guidelines were changed to require use of alternative modes only two days per week. This rule was in place throughout the entire FY 2015-17 evaluation period.

EVALUATION METHODOLOGY AND DATA SOURCES

Transportation and emissions impacts of the GRH program were measured through two surveys, the 2016 GRH Survey and the 2016 Retention Rate survey, both conducted in 2016. The GRH survey assessed commute travel for commuters who participated in the GRH program during the 2017 evaluation period. The Retention Rate survey examined commute travel for commuters who participated in GRH prior to the 2017 evaluation period.

GRH Survey

The 2016 GRH Survey polled 2,171 commuters who had registered for the Washington Regional GRH Program between March 16, 2013 and March 15, 2016 (FY 2015-17). 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 reverted to the original 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 impact calculation multipliers for the current/recent participants in the GRH TERM; placement rate, VTR factor, and travel distance. These multipliers were estimated for two GRH sub-populations. The first included respondents who both lived and worked in the Washington, DC Metropolitan Statistical Area (MSA); that is within the 11-jurisdiction area covered by the TERM evaluation. The second sub-

population included respondents who worked in the MSA but lived outside it. This distinction was made because applicants who lived outside the MSA traveled a portion of their VMT outside the MSA. The VMT for these "out of MSA" applicants was discounted to include only the portion of the VMT reduction that occurred within the MSA. Approximately 38% of the total participants lived outside the MSA.

Retention Rate Survey

The 2016 Retention Rate Survey interviewed 989 commuters who had participated in GRH or another Commuter Connections program before the start of the FY 2015-17 evaluation period (Pre FY 15). About 81% of the survey respondents had been registered for GRH. Data for these respondents was used to derive the retained placement rate for GRH.

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 calculation multipliers for past GRH participants. The survey did not ask respondents about their home location, so the factors calculated from the survey data were used for both the Within MSA and Outside MSA groups.

Calculation Factors and Impacts

Placement Rate and Placements – The first calculation factor is placement rate, equal to the percentage of GRH participant who made a mode shift to an alternative mode. For the FY 2015-17 program participants, the GRH placement rate was calculated for Within MSA participants and Outside MSA 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," that is they made a shift to an alternative mode and did not return to the previous mode.

The placement rate for Pre FY 15"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 2015 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 15,245 commuters were current participants in the FY 2015-17 time period. The count of past participants, who were registered in the Pre FY 15 time period, was 16,917.

These calculations resulted in a total of **9,274 placements**, divided as shown below, with 6,853 (74%) new placements from FY 2015-17 GRH registrants and 2,421 (26%) retained placements from Pre 2015 GRH registrants.:

	Population base		Placement Rate		Placements
FY 2015-17					
• Within MSA	9,452	x	44.5%	=	4,206
• Outside MSA	5,793	x	45.7%	=	2,647
Pre FY 2015					
• Within MSA	10,488	x	14.3%	=	1,501
• Outside MSA	6,428	x	14.3%	=	920

Total Placements = 6,853 new placements + 2,421 retained placements = **9,274**

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 MSA and Outside MSA groups were as follows:

FY 2015-17
- Within MSA 0.79 vehicle trips reduced per placement
- Outside MSA 0.88 vehicle trips reduced per placement

Pre FY 2015
- Within MSA 0.31 vehicle trips reduced per placement
- Outside MSA 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 **6,402 vehicle trips reduced**; 5,652 vehicle trips reduced by new (FY 2015-17) registrants and 750 from retained (Pre FY 2015) 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 2015-17 registrants, the one-way trip distance for the within MSA respondents was 28.2 miles. The actual one-way distance for the outside MSA respondents was an average of 50.3 miles, but to discount the distance credited to the outside MSA respondents, their one-way travel distance was set equal to that of the distance for the within MSA respondents. For the Pre FY 2015 retained registrants, the commute distance was 29.4 miles; this was used for both the Within MSA and Outside MSA groups:

FY 2015-17
- Within MSA/Outside MSA 28.2 miles reduced per trip

Pre FY 2015
- Within MSA/Outside MSA 29.4 miles reduced per trip

The calculation of VMT reduced produced a total of **181,463 VMT reduced**, with 159,387 VMT reduced by new FY 2015-17 registrants and 22,076 VMT reduced by retained (Pre F2015) 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 TERM. Details of these calculations are shown in Appendix 3.

Note that the GRH results were adjusted to eliminate double counting between GRH and the Mass Marketing TERM. About 8% of the FY 2015-17 GRH impacts were assigned to the Mass Marketing TERM to recognize that some GRH applicants were influenced to contact Commuter Connections and apply for GRH after they heard a Mass Marketing ad. The impacts shown in Table 6 account for the adjustment and reflect the net GRH impacts.

GUARANTEED RIDE HOME SUMMARY OF GOALS AND IMPACTS

Table 6 presents the transportation and emission impact results for GRH and compares the results against the goals established for the TERM.

Table 6
Guaranteed Ride Home Goals and Estimated Impacts

	TERM Goal	Estimated Impacts
• Number of GRH participants FY 2015-17 *	36,992	15,245
• New applicants during evaluation period	N/A	8,786
• Number of past participants (Pre FY 2015)	N/A	16,917
• Daily vehicle trips reduced	12,593	5,890
• Daily VMT reduced	355,136	166,946
• Daily tons NOx reduced	0.1766 T	0.0365 T
• Daily tons VOC reduced	0.0970 T	0.0209 T
• Annual tons PM 2.5 reduced	N/A	0.51 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	9.75 T
• Annual tons CO2 reduced	N/A	16,266 T

* Number of participants currently enrolled in GRH

Impacts vs Goals

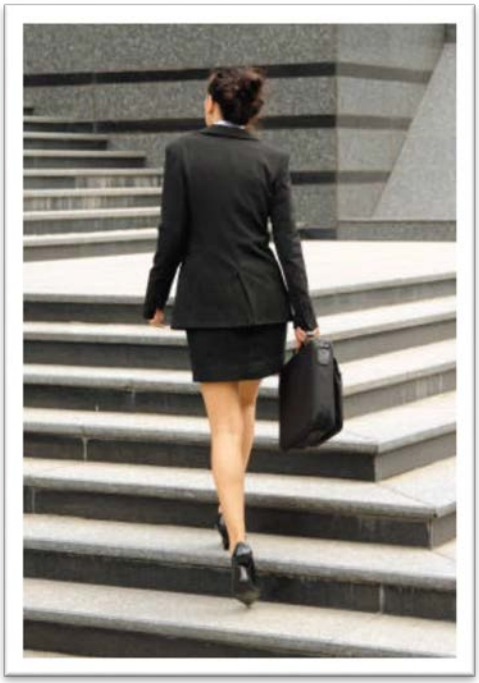
Participation Benefit (net over or (under) goal): Participants: (21,747)

Transportation Benefit (net over or (under) goal): Vehicle Trips: (6,703)
VMT: (188,190 miles)

Emission Benefit (net over or (under) goal): NOx: (0.1401 tons per day)
VOC: (0.0761 tons per day)

The number of commuters participating in GRH in December 2016 was less than half of the participant goal. The vehicle trip reduction, VMT, and emissions impacts were correspondingly short of the goals for these measures. Participation in GRH dropped substantially since 2005, the year the goals were established. Some of the decline could be due to reduced level of Commuter Connections program advertising and outreach focused exclusively on GRH. The 2016 State of the Commute survey found that only 21% 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.

SECTION 6 EMPLOYER OUTREACH



BACKGROUND

The Employer Outreach TERM was adopted by the TPB in FY 1995-2000 TIP. This program provides regional outreach to encourage private sector employers to implement TDM strategies that will contribute to reducing vehicle trips to their worksites. The voluntary program was designed to increase outreach efforts in jurisdictions located in the region. 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:

- Computerized regional employer contact database
- Marketing and information materials
- Employer outreach sales and service force training and support
- Annual evaluation program
- Support to Employer Outreach Committee

EVALUATION METHODOLOGY AND DATA SOURCES

Employer Outreach is aimed at increasing the number of private employers implementing 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 TERM 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.[1]

- **Level 1 (Bronze1) programs** offer only commute information.
- **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, 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 TERM 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 2015-17 evaluation, impacts were calculated for "maintained" employer programs and "new/expanded" programs.

Maintained impacts included employers that joined EO before July 1, 2014 and made no changes since that date. Expanded impacts included employers that were involved in EO before July 1, 2014 but expanded their commute assistance services after that date. New impacts included employers that joined the EO program on or after July 1, 2014. A final category was defined to calculate the impacts of employers that were included in the FY 2012-14 evaluation but dropped out of EO before June 2017. 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 2014 employer programs continued with no change
- Expanded – June 2014 employer programs expanded since June 2014
- New – Employer programs started since June 2014
- Deleted – June 2014 employer programs deleted between July 2014 and June 2017

The overall benefit of the program is the sum of continued programs plus expanded and new programs. As shown below, in June 2017, the ACT! database included 1,865 employers with programs that met the Level 3 or 4 definitions. These employers accounted for 646,502 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, 1,205 joined Employer Outreach prior to July 2014 and made no program changes since that time. The expanded category included 188 employers and 472 were listed as "new" since June 2014. Finally, 285 employers that were counted in the 2014 evaluation were no longer involved in the program. These employers accounted for 115,011 employees. Had the deleted employers continued in the program, the total employee count would have been 761,513, so they represented a drop of about 15% in total employees in the program. The deleted employee count slightly more than the 104,012 employees at new EO worksites, but employers with expanded programs accounted for an additional 110,207 employees; expanded program impacts helped to offset the loss in program credit from deleted employers.

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

Employer Status (June 2017)	Number of Employers Total	<100[1)]	100+	Number of Employees
- Maintained/unchanged from June 2014	1,205	647	558	432,283
- Expanded after June 2014	188	81	107	110,207
- New programs	472	285	187	104,012
Total	**1,865**	**1,013**	**852**	**646,502**
Deleted from 2014	285	145	140	115,011

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 about 500 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 2014 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 employer 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.

Program Definition – The TERM 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 2016 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 2016 State of the Commute Survey. Emissions reduced were calculated by multiplying trips and VMT reduced by 2017 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 TERM. 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 TERM goals. The total goals and impacts are shown in Table 7.

Table 7
Employer Outreach Goals and Estimated Impacts

	EO Goal	Estimated Impacts
Employer Outreach (all programs)		
• Employers participating - total	1,844	1,865
– Maintained from 2014	No goal	1,205
– Expanded after 2014	No goal	188
– New in 2017	No goal	472

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

	Total Employers	Employees	New/Expanded Employers
– Alexandria, VA	137	24,674	45
– Arlington County, VA	307	57,539	137
– District of Columbia	647	228,463	226
– Fairfax County, VA	237	187,772	74
– Frederick County, MD	23	21,853	10
– Loudoun County, VA	15	10,755	5
– Montgomery County, MD	430	78,406	138
– Prince George's County, MD	30	23,121	13
– Prince William County, VA	27	10,970	6
– Tri-County Council, MD	12	2,939	6

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

	Total Employers	Employees	New/Expanded Employers
– Sites with 100+ employees	852	609,219	294
– Sites with less than 100 employees	1,013	37,283	366
– "Equivalent 100+" [1)]	372		144

1) For purposes of program tracking, employers with fewer than 100 employees are grouped into "equivalent 100+" employers. The 1,013 employers in this category employ 37,283 employees, thus represent 372 "equivalent 100" employers (37,283 / 100).

Impacts vs Goals

Overall Employer Outreach Program

	EO Goal	Estimated Impacts
Total Program		
• Daily vehicle trips reduced	82,120	95,582
• Daily VMT reduced	1,391,362	1,690,401
• Daily tons NOx reduced	0.5590 T	0.4359
• Daily tons VOC reduced	0.3180 T	0.3242
• Annual tons PM 2.5 reduced	N/A	5.75 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	116.70 T
• Annual tons CO2 reduced	N/A	174,461 T

Participating Employers (net over or (under) goal): Employers: 21

Transportation Benefit (net over or (under) goal): Vehicle Trips: 13,462
VMT: 299,039 miles

Emission Benefit (net over or (under) goal): NOx: (0.1231) tons per day
VOC: 0.0062 tons per day

New / Expanded Employer Programs

	EO Goal	Estimated Impacts
• New/expanded programs	96	660
• Daily vehicle trips reduced	8,618	20,967
• Daily VMT reduced	140,622	373,553
• Daily tons NOx reduced	0.0724 T	0.0962 T
• Daily tons VOC reduced	0.0455 T	0.0714 T
• Annual tons PM 2.5 reduced	N/A	1.27 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	25.75 T
• Annual tons CO2 reduced	N/A	38,558 T

Participating Employers (net over or (under) goal): Employers: 564

Transportation Benefit (net over or (under) goal): Vehicle Trips: 12,349
VMT: 232,931 miles

Emission Benefit (net over or (under) goal): NOx: 0.0238 tons per day
VOC: 0.259 tons per day

As shown, even with the loss of 285 employers that dropped out since 2014, both the overall number of employers participating in the program and the number of new / expanded employers were well above the goals. The overall TERM results for also substantially exceeded the goals for reductions in vehicle trips (16% over the goal) and VMT (21% over the goal).

Note that Employer Outreach could overlap with the Telework TERM, if Employer Outreach clients also had received Telework Assistance services; the telework portion of these employers' programs would appropriately be counted in the Telework TERM's "assisted employer" category. To assess the level of overlap, the list of the employers that received Telework Assistance was compared against the ACT! client database. Only two employers that offered telework also had received telework assistance from Commuter Connections. To avoid double counting credits, the impacts from the telework components of these employers' program were removed from the Employer Outreach TERM total. Impacts of non-telework strategies offered by these employers were included in the Employer Outreach impact calculation. The results presented in Table 7 show the adjusted impacts with the overlap removed.

Employer Outreach for Bicycling

A similar exercise was performed to estimate the contribution of bike strategies to Employer Outreach program impacts. The Employer Outreach for Bicycling TERM was adopted by the TPB in the Fiscal Year 1997-2002 TIP. This project provides regional outreach to encourage private sector and non-profit employers with 100 or more employees to implement worksites strategies that encourage employees to use bicycling for commuting.

A total of 557 employers offered bicycle strategies in their worksite programs in 2017. The impacts for these employers were modeled "with bicycling" and "without bicycling." The difference in vehicle trips reduced between these two cases was determined to be the bike strategies' share of the impacts. It was assigned to the Employer Outreach for Bicycling TERM 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 4.4 miles, calculated from the 2016 State of the Commute (SOC) Survey.

As shown by the results in Table 8 below, the Employer Outreach for Bicycling TERM fell slightly short of the goals established for the program.

Table 8
Employer Outreach – Bike Services Goals and Estimated Impacts

	EO Goal	Estimated Impacts
• Employers with bike strategies	590	557
• Daily vehicle trips reduced	404	356
• Daily VMT reduced	2,421	1,568
• Daily tons NOx reduced	0.0016 T	0.0008 T
• Daily tons VOC reduced	0.0015 T	0.0011 T
• Annual tons PM 2.5 reduced	N/A	0.008 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	0.221 T
• Annual tons CO2 reduced	NA	187 T

Participating Employers (net over or (under) goal): Bike Employers: (33)

Transportation Benefit (net over or (under) goal): Vehicle Trips: (48)
VMT: (853) miles

Emission Benefit (net over or (under) goal): NOx: (0.0008) tons per day
VOC: (0.0004) 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 TERM, 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 TERM 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 2017 Mass Marketing TERM analysis also includes impacts for the annual Bike-to-Work Day and Car Free Day events and the regional 'Pool Rewards carpool and 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 TERM calculation.

Evaluation Methodology and Data Sources – Umbrella Advertising Campaign

The Mass Marketing TERM 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
1) Commuters who participated in the 'Pool Rewards carpool/vanpool incentive program
4) Commuters who participate in the Bike-to-Work Day event
5) Commuters who participate in Car Free Day event

This TERM presents two challenges not encountered in most of the other TERMs. 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 – the media campaign or another influence.

The Mass Marketing 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 message that is part of the Mass Marketing campaign, the associated trip, VMT, and emissions reductions can be credited to the campaign.

The second, "***referred***" mode changes, result when commuters who are influenced to contact Commuter Connections by the ads make mode changes after receiving Commuter Connections assistance. 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. Referred influences are best measured by tracking changes in the volume of inquiries and applications received for two Commuter Connections' traditional programs: the Commuter Operations Center and GRH. A comparison of the volumes of requests received during periods of media activity to periods without media activity can provide an estimate of the change in requests as a result of the ads. A pro-rated share of the impacts of these other TERM impacts then can be assigned to Mass Marketing.

Evaluation of Direct Influence

Directly influenced change is measured for this evaluation through the 2016 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 21%

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 3.3%
- Said the ad influenced their decision to shift 60%
- Did not use any other Commuter Connections or employer service 100%
- **Resulting influence percentage from CC ads 0.42%**

Thus, 0.42% of regional commuters were directly influenced to make a change. This percentage was multiplied by the number of regional commuters (2,940,524) to estimate 12,227 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 0.8 vehicle trips per day with their changes and temporary users reduced an average of 1.0 vehicle trips per day. These factors, and the 15.4 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' website and the numbers of ridematch and GRH applications received:

- In months between July 2014 and December 2016 when MM ads were aired
- In months between July 2011 and December 2016 when MM ads were NOT aired

As a first step, this analysis calculated the average numbers of 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 16% 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	19%	16%	-9%

But the use of the Commuter Connection inquiries received via the Internet and 800 telephone number increased by 19% 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 16% of total uses (19/119).

Evaluation Methodology and Data Sources – 'Pool Rewards Program

Impacts for the fourth component of this TERM, 'Pool Rewards carpool incentive, were calculated in a manner similar to that used for the GRH TERM. The number of participants was multiplied by placement rate, VTR factor, and travel distance calculation multipliers to estimate the travel impacts. Data to derive these multipliers were collected through three tools: mode tracking required of all participating commuters and two post-program surveys.

Since the program was open only to commuters who were driving alone prior to the program, all 'Pool Rewards 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. A second follow-up survey, conducted in spring 2017 with all past 'Pool Rewards participants, explored longer-term retention in alternative modes. The survey found that 65% of participants were still using an alternative mode and 35% had returned to driving alone to work. These results were used to derive the long-term retention placement factors: 65% continued placement and 35% temporary placement.

The temporary VTR factor 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 0.64 daily trips reduced. The average travel distance of 31.1 miles was estimated from commute travel distance data provided by participants. The 2014 survey was used to estimate the VTR factor and travel distance for long-term, continued placements. That survey estimated a VTR factor of 0.72 and a one-way travel distance of 31.2 miles.

Between July 2014 and December 2016, 131 commuters had completed the program. When this participation number was multiplied by the placement rates, the calculation resulted in 85 continued placements and 46 temporary placements. Applying the VTR factors and one way travel distance resulted in 76 daily vehicle trips reduced and 2,371 daily VMT reduced.

Evaluation Methodology and Data Sources – Bike to Work Day Event

Impacts for the fifth component of this TERM, Bike-to-Work Day (BTWD) Event, were calculated using data obtained from a survey of BTWD participants conducted following the 2016 BTW Day event. The 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 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 translated 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 (46%) by the number of daily bicycle trips. VMT reductions were estimated by multiplying the vehicle trip reduction by the average one-way commute distance of these participants (10.2 miles). Emissions reduced were calculated as for other TERMs.

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 November of 2014, 2015, and 2016. 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.

Data were available from participant pledges to estimate the impacts on the day of the event. The distribution of pledged modes included 40% transit, 45% bike or walk, 7% carpool/vanpool, and 8% telework. Additionally, 31% of participants said they regularly drove alone and the pledge data indicated that the average trip reduced 10.5 miles. These data were used to determine the vehicle trip and VMT reductions for the event days.

Comprehensive survey data regarding long-term continuation of CFD pledges were not available at the time of this evaluation, but the event had many similarities in participants' non-event commute travel to that of BTW Day participants, thus, data from that event were used as proxies for the CFD analysis. As noted, 31% of CF Day participants regularly drove alone to work and 85% of pledges were made for transit, bike, or walk activity.

The BTW Day survey found that about 28% of participants started biking to work or increased their bike commute days after the event and 21% continued biking into the winter months. For the CF Day analysis, a conservative estimate of 10% was assumed as the share of new participants who continued to use the new alternative modes following the event.

The number of vehicle trips and VMT reduced by use of new alternative modes was estimated by multiplying the number of participants by the 10% continuation rate, by a VTR factors that assumed the participant used the new alternative mode two days per week, and by the 10.4 mile average VMT reduction. Emissions reduced were calculated as for other TERMs.

MASS MARKETING SUMMARY OF GOALS AND IMPACTS

Table 9 presents the results for the Mass Marketing TERM, compared to the goals. Individual goals were not established for any of the individual elements that comprised the Mass Marketing TERM (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence). But the analysis determined that direct ad influences accounted for 68% of vehicle trips reduced, 'Pool Rewards and the two events accounted for about 20% of the total, and the ridematch and GRH referrals contributed the remaining 12%.

Table 9
Mass Marketing Goals and Estimated Impacts

	MM Goal	Estimated Impacts
Total Mass Marketing		
• Commuter placements	23,168	22,458
• Daily vehicle trips reduced	10,809	9,713
• Daily VMT reduced	181,932	150,832
• Daily tons NOx reduced	0.0850 T	0.0400 T
• Daily tons VOC reduced	0.0250 T	0.0173 T
• Annual tons PM 2.5 reduced	N/A	0.52 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	10.70 T
• Annual tons CO2 reduced	N/A	15,482 T

Impacts vs Goals

Participation Benefit (net over or (under) goal):	Commuters: (710)
Transportation Benefit (net over or (under) goal):	Vehicle Trips: (1,096) VMT: (31,100)
Emission Benefit (net over or (under) goal):	NOx: (0.0450) tons per day VOC: (0.0077) tons per day

The Mass Marketing TERM nearly met its goals for commuter placements, falling only 3% short. MM generated vehicle trip reduction 10% below its goal and VMT reduction 17% under the goal. Some of this deficit will be erased when commuters who were referred to join GRH and/or request other Commuter Connections services between January and June 2017 are added to the calculation. 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 TERM (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence). But the analysis determined that direct ad influences accounted for 69% of Mass Marketing vehicle trips reduced, 'Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 22% of the total, and the ridematch and GRH referrals contributed the remaining 9%.

SECTION 8 COMMUTER OPERATIONS CENTER

BACKGROUND

Since the 1970's, COG has offered basic commute information and assistance, such as regional ride-matching, 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 Ride-Finders program. Because these services were available when the emissions baseline was developed for regional conformity, the Center was not established as a TERM, but was included in the region's TIP as an ongoing program and is part of the region's congestion management process. But only benefits above the 1997 baseline are included as a TERM.

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 lanes, telework information, commute program assistance for employers, GRH, 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 TERMs administered by Commuter Connections. Thus, although it is not an adopted TERM, the COC is included in this evaluation.

Base COC Impacts

The base impacts of the Commuter Operations Center were measured through two surveys, the 2014 Commuter Applicant Placement Survey, conducted in November 2014, and the 2016 Retention Rate survey, conducted in the spring of 2016. The 2014 Placement survey assessed commute travel for commuters who received commute assistance services from Commuter Connections during the 2017 evaluation period. The Retention Rate survey examined commute travel for commuters who received services prior to the 2017 evaluation period.

Placement Survey

The November 2014 Placement Survey polled 716 commuters who received commute assistance services from Commuter Connections between July 1, 2014 and September 30, 2014. 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 2015-17 evaluation period (July 2014 through June 2017). These multipliers were estimated for two applicant sub-populations. The first included respondents who both lived and worked in the Washington, DC Metropolitan Statistical Area (MSA); that is within the 11-jurisdiction area covered by the TERM evaluation. The second included respondents who worked in the MSA but lived outside it. This distinction was made because applicants who lived outside the MSA traveled a portion of their VMT outside the MSA. These "out of MSA" applicants were discounted to include only the portion of the VMT reduction that occurred within the MSA. Approximately 42% of the total participants lived outside the MSA.

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 2015-17 evaluation period (Pre FY 15). 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 TERM analysis under the GRH TERM. 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 the factors calculated from the survey data were used for both the Within MSA and Outside MSA groups.

Calculation Factors and Impacts

Placement Rate and Placements – The first calculation factor used in the TERM analysis is placement rate, equal to the percentage of COC applicants who made a mode shift to an alternative mode. For the FY 2015-17 program participants, the placement rate was calculated for Within MSA participants and Outside MSA 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 15 "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 of the Pre FY 2015 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 66,006 commuters received services during the FY 2015-17 time period. About 46% 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 Pre FY 2015 applicants, was 3,651. [2]

These calculations resulted in a total of **27,016 placements**, divided as shown below, with 26,306 (97%) new placements from FY 2015-17 applicants and 710 (3%) retained placements from Pre 2015 applicants:

	Population base		Placement Rate		Placements
FY 2015-17					
• Within MSA - continued	38,283	x	32.3%	=	12,365
• Within MSA - temporary	38,283	x	4.7%	=	1,799
• Outside MSA - continued	27,723	x	38.2%	=	10,590
• Outside MSA - temporary	27,723	x	5.6%	=	1,552
Pre FY 2015					
• Within MSA - continued	2,117	x	19.5%	=	412
• Outside MSA - continued	1,533	x	19.5%	=	298

Total Placements = 26,306 new placements + 710 retained placements = **27,016**

VTR Factors and Vehicle Trips Reduced – These placement figures were then multiplied by VTR factors derived from the Placement survey (FY 2015-17) and Retention Rate survey (Pre FY 2015) to estimate the number of vehicle trips reduced. The VTR factor for each sub-population is as follows:

FY 2015-17
- Within MSA - continued 0.40 vehicle trips reduced per placement
- Within MSA - temporary 0.18 vehicle trips reduced per placement
- Outside MSA - continued 0.46 vehicle trips reduced per placement
- Outside MSA - temporary 0.38 vehicle trips reduced per placement

Pre FY 2015
- Within MSA - continued 0.73 vehicle trips reduced per placement
- Outside MSA - continued 0.73 vehicle trips reduced per placement

[2] The 3,651 commuter applicants assigned to the COC for the Pre FY 2015 time period includes commuters who received ONLY non-GRH services. An additional number of commuters received both non-GRH and GRH services before July 2014. These commuters are counted under the GRH TERM.

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 6.7 weeks (13% of a year). The calculation of vehicle trips reduced produced a total of **10,454 vehicle trips reduced**; 9,935 vehicle trips reduced by new (FY 2015-17) applicants and 519 from retained (Pre 2015) 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 2015-17 registrants, the one-way trip distance for the within MSA respondents was 28.9 miles for applicants with continued mode changes and 26.0 miles for applicants with temporary changes. The actual one-way distance for the outside MSA respondents was more than 50 miles, but to discount the distance credited to the outside MSA respondents, their one-way travel distance was set equal to that of the distance for the within MSA respondents. For the Pre FY 2015 retained registrants, the commute distance was 19.9 miles; this was used for both the Within MSA and Outside MSA groups:

FY 2015-17
- Within MSA/Outside MSA - continued 28.9 miles reduced per trip
- Within MSA/Outside MSA - temporary 26.0 miles reduced per trip

Pre FY 2015
- Within MSA/Outside MSA - continued 19.9 miles reduced per trip

The calculation of VMT reduced produced a total of **297,089 VMT reduced**, with 286,779 VMT reduced by new FY 2015-17 applicant and 10,310 VMT reduced by retained (Pre 2015) 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 TERM. Details of these 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 TERMs 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 TERM. 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 TERM 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 0.36 daily trips reduced per telecommuter and the average one-way travel distance was 15.5 miles.
- The VTR factor for non-home-based telecommuters was 0.07 and the net VMT reduced per telework day was 10.4 miles.

These calculations resulted in an estimated **36,109 telecommuters**, 12,789 daily vehicle trips reduced, and 197,975 daily VMT reduced by Commuter Connections-assisted telecommuting. These impacts were added to the COC base impacts.

Software Upgrade

Included within the Commuter Operations Center program is the Integrated Rideshare TERM-Software Upgrades Project. When it began, the Integrated Rideshare TERM provided improvements to the quality and delivery of al-

ternative mode information. In particular, the TERM added transit, park and ride, telecenter, 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 in the regional TERM tracking sheet.[3]

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 TERM 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 and 2014 evaluations, but Software Upgrade impacts are calculated separately.

Impacts of the Software Upgrades was assessed using data from the November 2014 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 of 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 5.8% of applicants who lived within the MSA and 4.8% of applicants who lived outside the MSA 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 **3,552 placements**, divided as shown below:

	Population base		Placement Rate		Placements
• Within MSA - continued	38,283	x	4.1%	=	1,570
• Within MSA - temporary	38,283	x	1.7%	=	651
• Outside MSA - continued	27,723	x	4.4%	=	1,220
• Outside MSA - temporary	27,723	x	0.4%	=	111

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 MSA - continued 0.60 vehicle trips reduced per placement
- Within MSA - temporary 0.19 vehicle trips reduced per placement
- Outside MSA - continued 0.45 vehicle trips reduced per placement
- Outside MSA - temporary 0.38 vehicle trips reduced per placement

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 6.7 weeks (13% of a year). The calculation of vehicle trips reduced produced a total of **1,512 vehicle trips reduced** by applicants who were assisted or influenced by the Software Upgrades.

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

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 MSA/Outside MSA - continued 28.9 miles reduced per trip
- Within MSA/Outside MSA - temporary 26.0 miles reduced per trip

As noted in the descriptions for both the GRH TERM and the COC, these distances were used for both Within MSA and Outside MSA respondents. The calculation of VMT reduced produced a total of **43,636 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."

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 10
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	66,006
• New applicants during evaluation period	N/A	12,446
• Number of past applicants (Pre FY 2015)	N/A	3,651
• Daily vehicle trips reduced	24,425	18,928
• Daily VMT reduced	512,637	371,971
• Daily tons NOx reduced	0.2410 T	0.0984 T
• Daily tons VOC reduced	0.1150 T	0.0750T
• Annual tons PM 2.5 reduced	N/A	1.27 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	26.36 T
• Annual tons CO2 reduced	N/A	38,845 T
Software Upgrades (additional to Basic COC)		
• Daily vehicle trips reduced	2,379	1,512
• Daily VMT reduced	66,442	43,636
• Daily tons NOx reduced	0.0280 T	0.0094 T
• Daily tons VOC reduced	0.0110 T	0.0054 T
• Annual tons PM 2.5 reduced	N/A	0.13 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	2.53 T
• Annual tons CO2 reduced	N/A	4,234 T

Impacts vs Goals

Basic COC

Transportation Benefit (net over or (under) goal):	Vehicle Trips: (5,497) VMT: (140,666) miles
Emission Benefit (net over or (under) goal):	NOx: (0.1426) tons per day VOC: (0.0400) tons per day

Software Upgrades

Transportation Benefit (net over or (under) goal):	Vehicle Trips: (867) VMT: (22,806) miles
Emission Benefit (net over or (under) goal):	NOx: (0.0186) tons per day VOC: (0.0056) tons per day

As shown, the Basic COC services missed the vehicle trip and VMT reduction goals by 23% and 27% respectively. The telework impacts accounted for 68% of the total COC vehicle trips reduced and 53% 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 non-Maryland telework portion of the TERM contributed approximately the same vehicle trip and VMT reductions in the 2017 evaluation as in 2014, so the COC goal deficit was largely due to the drop in commuter applications from 2014. Additionally, a larger share of the COC base was credited to the Guaranteed Ride Home TERM in 2017 (29%) than had been credited in 2014 (23%). This reassignment accounted for overlap between the COC and GRH and the FY 2015-17 data indicated that a larger share of COC applicants had also participated in GRH. Some of the deficit will be made up when the January-June 2017 applicants are added to the evaluation count.

The Software Upgrades component also missed the goals for vehicle trips and VMT reduced, although it is likely that the calculation underrepresents the true impact of both the Software Upgrades and COC base 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 online information system permits commuters to access several services, such as bicycle and transit information, 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.

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 factor could be reductions in employer-provided transit/vanpool financial incentives that are available to employees. In the 2010 State of the Commute survey, 45% of employees said their employers offered a transit/vanpool subsidy. In 2016, only 37% said such a service was available. This likely reduced the attractiveness of transit and vanpooling for many employees. A third consideration is the expanded availability of private ridematch options, such as Craigs List, ZimRide, UberPool, and other informal ridemaching applications, which could be attracting some commuters who seek commute information.

Further, 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 online information system permits commuters to access several services, such as bicycle and transit information, 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 2016 SOC survey, nearly

200,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections web-site in the past year. These commuters represented more than 6% of all commuters region-wide.

The results shown in Table 11, below, were adjusted to eliminate overlap between the COC and individual TERMs. A portion of COC impacts were assigned to Software Upgrades and to GRH. Finally, the impacts for about two percent of new COC applicants were assigned to the Mass Marketing TERM, to reflect the impact of this TERM in influencing commuters to contact CC for travel-assistance services.

Table 11
Adjustment of Vehicle Trips and VMT for Overlap between the COC and TERMs
(excluding telework credit for non-Maryland telecommuters)

Evaluation Measure	Basic COC	Mass Marketing	Software Upgrades	GRH	Net Basic COC
VT reduced	10,454	314	1,512	2,489	6,139
VMT reduced	297,089	8,913	43,636	70,544	173,996

Notes:

- Mass Marketing – new applicants influenced by ads to contact CC, see Section 6
- Software upgrades – see description in this section
- GRH – 59% of new/reapply applicants who shifted to alternative modes registered for GRH = 29% of Base COC credit was assigned to GRH (63% x 46% new/reapply share of total applicants)

Table 12 shows the addition of the net Base COC and telework credit for non-Maryland telecommuters who were assisted by Commuter Connections.

Table 12
Total Commuter Operations Center Credit
(Adjusted Base COC + Non-Maryland Telework)

Evaluation Measure	Net Basic COC	Non-MD Telework	NET COC TOTAL
VT reduced	6,139	12,789	18,928
VMT reduced	173,996	197,975	371,971

SECTION 9 SUMMARY OF TERM IMPACTS

The preceding sections of this report documented estimated impacts for four individual TERMs and for the Commuter Operations Center. As noted earlier in the report, the four TERMs combined exceeded the collective goals for vehicle trips reduced by 7% and exceeded the VMT goal by about 9%.

The TERMs did not reach the emission goals; the impact for NOx was about 35% under the goal and VOC impact was 16% under the goal, but these deficits were due largely to reductions in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMs were re-set since that time, but the emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, the combined impacts just met the vehicle trip and VMT reduction goals, in this case by 2% and 1%, respectively. The combined TERM–COC program impacts fell 41% short of the NOx goal and were 20% below the VOC goal. Again, the change in the emission factors affected the emission results.

Where shortfalls occurred against the travel goals (vehicle trips and VMT reduced), they appeared to be related to lower than expected participation rates, rather than overly-optimistic travel change factors. COG revised the TERM goals following the 2005 analysis to reflect the actual types of behavior changes that commuters make when using TERM services. COG again revised goals for some TERMs following the 2014 analysis, to account for additions or deletions to activities or services covered by those TERMS. Individual sections of this report have discussed factors that affected the achievement of goals. Highlights of those discussions are presented blow for the four TERMs and the COC.

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 2016 State of Commute Survey estimated the number of telecommuters had grown nearly six-fold, to more than 887,200, or about 32% of regional commuters. Telework growth is likely the result of several factors, including the use of telework by employers to recruit and retain employees. Increasing traffic congestion in the Washington region also might have prompted some commuters to work at home to avoid traffic. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework. Finally, the desire of employees for a better balance of work and family, a trend occurring nationally, and greater affordability of sophisticated technology, also might have contributed to the growth in telecommuting.

The Telework TERM 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

At the time this Interim TERM Analysis report was being prepared, the Telework! VA data were not yet available for analysis, so the Telework! VA impacts will be added to the TERM calculation when the final TERM analysis is prepared in fall 2017. The discussion following reflects the Maryland portion of the TERM.

Overall, about 5% of regional telework can be attributed to the efforts of the Telework TERM, 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 2016 State of the Commute Survey, Maryland telecommuters accounted for approximately 45% of regional telecommuters and about 11% of these telecommuters mentioned Commuter Connections or MWCOG as a source of their telework information.

The number of Maryland telecommuters estimated for the TERM was 39% over the number of telecommuters expected from this TERM activities. The Maryland portion of the TERM also exceeded the reduction goals for vehicle trips (25%) and VMT (50%). The Telework goals were revised following the 2014 analysis and now more closely represent the actual telework patterns existing in the region; primarily the average frequency of 1.4 days per week and the 61% drive alone mode share of telecommuters on non-telework days. These two factors have a substantial impact on the total trip reduction generated by teleworking.

One possible area in which the Telework TERM's contribution to the regional telework impacts could have been undercounted is in the area of regional employer outreach. More than seven in ten (73%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach TERM also promotes telework to employers. So 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 to the Telework TERM. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

Note also that the Telework TERM 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 now counted under the Commuter Operations Center.

GUARANTEED RIDE HOME

The GRH TERM did not meet the adopted goals, falling about 53% short in the goals for vehicle trips reduced and VMT reduced. The shortfall primarily resulted because the number of new GRH registrants has dropped substantially since 2008. COG adjusted the goals for this TERM 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 results in correspondingly lower results for vehicle trip and VMT reduction goals.

The number of commuters participating in GRH in June 2017 was about 59% below the participant goal. The vehicle trip reduction, VMT, and emissions impacts were also less than half of the goals for these measures. About 8% of GRH impacts were assigned to the Mass Marketing TERM to recognize that some GRH applicants were influenced to apply for GRH after they heard a Mass Marketing advertisement. But the deficits are due primarily to the substantial drop in GRH participation since 2005, the year the goals were established. Some of the decline could be due to reduced Commuter Connections GRH advertising. The 2016 State of the Commute survey found that only 21% 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.

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 2015-17 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 2015-17 evaluation period, even though they were no longer in GRH. Thus, the GRH program impacts extend beyond the 3-year evaluation period. These "retained" alternative mode placements added about 12% to the vehicle trip and VMT reductions for the GRH.

EMPLOYER OUTREACH

Employer Outreach greatly exceeded the participation goals set for the program, for both overall participation and participation of employers with new or expanded programs. Nearly 1,900 employers were participating in Employer Outreach in June 2017 and about one-third of these employers had either new programs or expanded programs since June 2014. Employer Outreach, the overall program exceeded its vehicle trip and VMT goals by 16% and 21%, respectively. Employer Outreach did not meet the emission goals, but this was due to the change in emission factors described earlier in the report.

Separate impacts also were calculated for the Employer Outreach for Bicycling component of this TERM. This project provides regional outreach to encourage employers to implement worksites strategies that encourage employees to use bicycling for commuting. A total of 557 employers offered bicycle strategies in their worksite programs, just slightly under the 590 employer goal for this project. Employer Outreach for Bicycling also slightly missed the vehicle trip and VMT reduction goals established for the program, but the absolute deficits were small.

MASS MARKETING

This TERM estimates impacts for six primary groups of commuters:

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

The Mass Marketing (MM) TERM generated vehicle trip reduction 10% below its goal and VMT reduction 17% under the goal. Some of this deficit will be erased when commuters who joined GRH and/or requested other Commuter Connections services between January and June 2017. The MM impact includes credit for "referrals" to GRH and the Commuter Operations Center. About 16% of the base impacts for each of these programs was assigned to Mass Marketing in 2017. So additional participation in these programs will supplement the Mass Marketing TERM impact as well.

Goals were not established for any of the individual elements that comprised the Mass Marketing TERM (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence). But the analysis determined that direct ad influences accounted for 69% of Mass Marketing vehicle trips reduced, 'Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 22% of the total, and the ridematch and GRH referrals contributed the remaining 9%.

COMMUTER OPERATIONS CENTER

The Commuter Operations Center is not an adopted TERM, but was included in this evaluation because it supports the success of several TERMs, including GRH, Integrated Rideshare, and Employer Outreach. The COC received more than 66,000 applications between July 2014 and December 2016. About 46% of the requests were from new applicants or re-applicants and 54% 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 23% and 27% respectively. The non-Maryland telework credit accounted for 68% of the total COC vehicle trips reduced and 53% of the COC's VMT reduction. The non-Maryland telework portion of the TERM contributed approximately the same vehicle trip and VMT reductions in the 2017 evaluation as in 2014, so the COC goal deficit was largely due to the drop in commuter

applications from 2014. Additionally, a larger share of the COC base was credited to the Guaranteed Ride Home TERM in 2017 (29%) than had been credited in 2014 (23%). This reassignment accounted for overlap between the COC and GRH and the FY 2015-17 data indicated that a larger share of COC applicants had also participated in GRH. Some of the deficit will be made up when the January-June 2017 applicants are added to the evaluation count. The Software Upgrades component also missed the goals for vehicle trips and VMT reduced.

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 factor could be reductions in employer-provided transit/vanpool financial incentives that are available to employees. In the 2010 State of the Commute survey, 45% of employees said their employers offered a transit/vanpool subsidy. In 2016, only 37% said such a service was available. This likely reduced the attractiveness of transit and vanpooling for many employees. A third consideration is the expanded availability of private ridematch options, such as Craigs List, ZimRide, UberPool, and other informal ridemaching applications, which could be attracting some commuters who seek commute information.

It is likely, however, 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 online information system permits commuters to access several services, such as bicycle and transit information, 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 2016 SOC survey, nearly 200,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections website in the past year. These commuters represented more than 6% of all commuters region-wide.

And, as was described in the GRH section above, the current COC applicant count does not entirely reflect the impact even of counted COC applications. 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 2015-17 evaluation period about their current commute travel. The survey estimated that about 19% of past COC non-GRH applicants had made shifts to new alternative modes and were continuing to use these new modes during the FY 2015-17 evaluation period, well after they received Commuter Connections assistance. These "retained" alternative mode placements added about 5% to the vehicle trip reduction and 3% to the VMT reductions for the COC.

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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. If the commuter carpools, he 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

Populations of Interest

All regional telecommuters	887,202	(from SOC survey)
Teleworkers with MD home or work	399,241	45% (from SOC survey)
Teleworkers not in MD	487,961	55% (from SOC survey)
Employees at TW assisted worksites	4,219	(from TW assistance survey)

Commuter Connections TW Placement Rates

Directly assisted TW

• Within Maryland	11.1%	(% of TC assisted by CC, from SOC survey)
• Not in Maryland	7.4%	(% of TC assisted by CC, from SOC survey)

TW at assisted worksites (MD only

• Within Maryland	0.8%	(% of new TC at sites, from TW assistance survey)
• Not in Maryland	0.0%	Program not in effect outside of Maryland

TW Placements (Mixed home and Non-home based)

Maryland (credited to Telework TERM)

• Directly assisted telecommuters	44,316	(regional TC x directly assisted placement rate)
• Telecommuters at TW assisted sites	34	(employees at assisted sites x assisted site placement rate)
Total assisted telecommuters - MD	**44,350**	

Not Maryland (to be credited to COC)

• Directly assisted telecommuters	36,109	(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	**36,109**	

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

• % Home-based telecommuters	98%	(from SOC survey)
• % Non-home (NH)-based telecommuters	2%	(from SOC survey)

Maryland (credited to Telework TERM)

• Home-based telecommuters	43,463	(total assisted TW x % Home-based TW)
• NH-based telecommuters	887	(total assisted TW x % NH-based TW)

Not Maryland (credited to COC)

• Home-based telecommuters	35,387	(total assisted TW x % Home-based TW)
• NH-based telecommuters	722	(total assisted TW x % NH-based TW)

Appendix 2, continued

Daily Vehicle Trips Reduced

VTR Factors

• Home-based factor - MD	0.34	(from SOC survey)
• Home-based factor – Not MD	0.36	(from SOC survey)
• NH-based factor – MD and Not-MD	0.07	(from SOC survey)

Maryland (credited to Telework TERM)

• Home-based VT reduced	14,777	(HB TW x HB VTR factor)
• NH-based VT reduced	62	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced - MD	**14,839**	

Not Maryland (credited to COC)

• Home-based VT reduced	12,739	(HB TW x HB VTR factor)
• NH-based VT reduced	50	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced – Not MD	**12,789**	

Daily VMT Reduced

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

• Home-based – MD	24.4	(SOC survey)
• Home-based – Not MD	15.5	(SOC survey)

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

• Non-home based – to main workplace	15.1	(SOC survey)
• Non-home based – to TW location	4.7	(SOC survey)
• Non-home based – net VMT reduced	10.4	(SOC survey)

VMT reductions on TW days

Maryland (credited to Telework TERM)

• Home-based VMT reduced	360,559	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	645	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced - MD	**361,204**	

Not Maryland (credited to COC)

• Home-based VMT reduced	197,975	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	520	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced – Not MD	**197,975**	

Appendix 2, continued

Maryland (credited to Telework TERM)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	14,839	1.2435			18,452	0.0203
• From Running			361,204	0.1897	68,520	0.0755
Total NOx reduced (tons)					**Daily**	**0.0958**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	14,839	2.5814			38,305	0.0422
• From Running			361,204	0.0688	24,851	0.0274
Total VOC reduced (tons)					**Daily**	**0.0696**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	14,839	0.0312			463	0.0005
• From Running			361,204	0.0115	4,154	0.0046
Total PM 2.5 reduced (tons)					**Daily**	**0.0051**
					Annual	**1.275**

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	14,839	1.3603			20,185	0.0223
• From Running			361,204	0.2019	72,927	0.0804
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.1027**
					Annual	**25.675**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	14,839	227.06			3,369,343	3.71
• From Running			361,204	380.68	137,503,063	151.57
Total CO2 reduced (tons)					**Daily**	**155.28**
					Annual	**38,820.0**

Appendix 2, continued

Not Maryland (credited to COC)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	12,789	1.2435			15,903	0.0175
• From Running			197,975	0.1897	37,556	0.0414
Total NOx reduced (tons)					**Daily**	**0.0589**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	12,789	2.5814			33,014	0.0364
• From Running			197,975	0.0688	18,621	0.0105
Total VOC reduced (tons)					**Daily**	**0.0514**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	12,789	0.0312			399	0.0004
• From Running			197,975	0.0115	2,277	0.0025
Total PM 2.5 reduced (tons)					**Daily**	**0.0029**
					Annual	**0.725**

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	12,789	1.3603			17,397	0.0192
• From Running			197,975	0.2019	39,971	0.0441
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0633**
					Annual	**15.825**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	12,789	227.06			2,903,870	3.20
• From Running			197,975	380.68	75,365,123	83.08
Total CO2 reduced (tons)					**Daily**	**86.28**
					Annual	**21,570.0**

APPENDIX 3 – CALCULATION OF GUARANTEED RIDE HOME IMPACTS

Populations of Interest

FY 2015-17 Registrant Base (New credit)

• New GRH registrants (FY 2015-17)	8,786	(GRH database)
• Re-registrants from FY 2015	6,401	
• One-time exceptions (FY 2015-17)	58	(GRH database)
New FY 2015-17 GRH base	**15,245**	

Pre FY 2015 Registrant Base (Retained credit)

• GRH registrants Pre FY 2015	24,348	(COC GRH/Online databases)
• Valid contact percentage	69%	(Retention rate survey)
Retained Pre FY 2015 GRH base	**16,917**	

Distribution of In/Out MSA

FY 2015-17 Registrant Base (New)		
Within MSA	62%	9,452
Outside MSA	38%	5,793
Pre FY 2015 Registrant Base (Retained)		
Within MSA	62%	10,488
Outside MSA	38%	6,428

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

FY 2015-17 Registrants (New)		
• Within MSA rate	44.5%	4,206
• Outside MSA rate	45.7%	2,647
Pre FY 2015 Registrants (Retained)		
• Within MSA rate	14.3%	1,501
• Outside MSA rate	14.3%	920
Total Placements		**6,402**

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

FY 2015-17 Registrants (New)		
• Within MSA VTR factor	0.79	3,323
• Outside MSA VTR factor	0.88	2,329
Pre FY 2015 Registrants (Retained)		
• Within MSA VTR factor	0.31	465
• Outside MSA VTR factor	0.31	285
Total Daily Vehicle Trips Reduced		**6,402**

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

FY 2015-17 Registrants (New)			
• Within MSA distance	28.2	93,709	
• Outside MSA distance	28.2	65,678	(discount actual 50.3 miles from GRH survey)
Pre FY 2015 Registrants (Retained)			
• Within MSA distance	29.4	13,687	
• Outside MSA distance	29.4	8,389	
Total Daily VMT Reduced		**181,463**	

Appendix 3, continued

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

Inside MSA

- SOV access percentage 75% (GRH survey)
- SOV access distance (mi) 5.3 (GRH survey)

Outside MSA

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

Adjusted VT Reduction – net of VMT access

- Total VT reduced 6,402 (
- Within MSA access VT (deduct) - 2,841 (VT reduction within MSA x SOV access %)
- Outside MSA access VT 0 No deduction (access trips are outside MSA)

Total VT for AQ analysis 3,561

Adjusted VMT Reduction – net of VMT access

- Total VMT reduced 181,463
- Within MSA access VMT (deduct) - 15,057 (SOV Access VT within MSA x SOV access distance)
- Outside MSA access VMT 0 No deduction (access VMT are outside MSA)

Total VMT for AQ analysis 166,406

Daily Emissions Reduced – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,561	1.2435			4,428	0.0049
• From Running			166,406	0.1897	31,567	0.0348
Total NOx reduced (tons)					**Daily**	**0.0397**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,561	2.5814			9,192	0.0101
• From Running			166,406	0.0688	11,449	0.0126
Total VOC reduced (tons)					**Daily**	**0.0227**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,561	0.0312			111	0.0001
• From Running			166,406	0.0115	1,914	0.0021
Total PM 2.5 reduced (tons)					**Daily**	**0.0022**
					Annual	**0.558**

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,561	1.3603			4,844	0.0053
• From Running			166,406	0.2019	33,597	0.0370
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0424**
					Annual	**10.594**

Appendix 3, continued

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

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,561	227.06			808,561	0..89
• From Running			166,406	380.68	63,347,436	69.83
Total CO2 reduced (tons)					**Daily**	**70.72**
					Annual	**17,679.9**

Correction for Overlap with MM TERM

Total GRH apps FYs 15, 16, 17	15,245	
New GRH apps FY 15, 16, 17	8,786	58%
Estimated MM share of new GRH	16%	
FY 2015-17 VMT as % of total VMT	88%	(Exclude Retained credit from discount)
Estimated MM share of GRH impact	8%	

Net GRH = GRH Base – Mass Marketing credit

	GRH Base	Mass Mkt	Net GRH
Placements	9,274	742	8,532
VMT reduced	6,402	512	5,890
VMT reduced (mi)	181,463	14,517	166,946
Daily Emissions Reduced			
NOx (T)	0.0397	0.0032	0.0365
VOC (T)	0.0227	0.0018	0.0209
Annual Emissions Reduced			
PM 2.5 (T)	0.5580	0.0446	0.5134
PM 2.5 Precursor NOx (T)	10.5936	0.8475	9.7461
CO2 (T)	17,679.9	24,056.5	16,265.5

APPENDIX 4 – CALCULATION OF EMPLOYER OUTREACH

Populations of Interest

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

	Employers	Employees
• 2014 unchanged programs	1,205	432,283
• Expanded programs in 2017	188	110,207
• New programs in 2017	472	104,012
• Deleted programs since 2014	285	115,011

Average Vehicle Occupancy (AVO)

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

	Starting AVO	Ending AVO
• 2014 unchanged programs	1.25	1.36
• Expanded programs – continued base	1.28	1.44
• Expanded programs – new impacts	1.44	1.49
• New programs	1.29	1.43
• Deleted programs	1.23	1.33

Daily person trips

Total employees x 2 one-way trips per day
Starting (pre-program) and ending (with-program)

	Starting	Ending
• 2014 unchanged programs	864,566	864,566
• Expanded programs	220,414	220,414
• New programs	208,024	208,024
• Deleted programs	230,022	230,022

Daily vehicle trips

Total employees / starting AVO)
Starting (pre-program) and ending (with-program)

	Starting	Ending	Difference
• 2014 unchanged programs	692,207	636,647	55,560
• Expanded programs – maintained base	172,333	153,278	19,055
• Expanded programs – new impact	153,278	148,427	4,851
• New programs	161,384	145,268	16,116
• Deleted programs	172,689	187,620	(14,931)

Total Daily Vehicle Trips Reduced

• 2014 maintained impacts	74,615
• New/expanded impacts	20,967
Net 2017 reduction	**95,582**

Appendix 4, continued

Daily VMT reduced

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

• 2014 unchanged programs	980,522
• Expanded programs – maintained base	336,326
• Expanded programs – new impact	86,858
• New programs	286,695
• Deleted programs	(264,477)

Total Daily VMT Reduced

• 2014 continued impacts	1,316,848
• New/expanded impacts	373,553
Net 2011 reduction	**1,690,401**

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

• Non-SOV access percentage	74%	(from 2016 SOC survey)
• SOV access percentage	26%	(from 2016 SOC survey)
• SOV access distance (mi)	2.8	(from 2016 SOC survey)

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

(VT reduced x non-SOV access %)

• 2014 maintained impacts	55,215
• New/expanded impacts	15,516

VMT Reduction without SOV access

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

• 2014 maintained impacts	1,262,528
• New/expanded impacts	358,290

Emissions Reduced – Maintained from 2014

Daily Emissions Reduced – NOx and VOC

NOx	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	55,215	1.2435			68,660	0.0757
• From Running			1,262,528	0.1897	239,502	0.2640
Total NOx reduced (tons)					**Daily**	**0.3397**

VOC	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	55,215	2.5814			142,532	0.1571
• From Running			1,262,528	0.0688	88,862	0.0957
Total VOC reduced (tons)					**Daily**	**0.2528**

Appendix 4, continued

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	55,215	0.0312			1,723	0.0019
• From Running			1,262,528	0.0115	14,519	0.0160
Total PM 2.5 reduced (tons)					**Daily**	**0.0179**
					Annual	**4.476**

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	55,215	1.3603			75,109	0.0828
• From Running			1,262,528	0.2019	254,904	0.2810
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.3638**
					Annual	**90.944**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	55,215	227.06			12,537,118	13.82
• From Running			1,262,528	380.68	480,619,159	529.79
Total CO2 reduced (tons)					**Daily**	**543.61**
					Annual	**135,902.9**

Emissions Reduced - New / Expanded

Daily Emissions Reduced – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	15,516	1.2435			19,294	0.0213
• From Running			358,290	0.1897	67,968	0.0749
Total NOx reduced (tons)					**Daily**	**0.0962**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	15,516	2.5814			40,053	0.0442
• From Running			358,290	0.0688	24,650	0.0272
Total VOC reduced (tons)					**Daily**	**0.0714**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	15,516	0.0312			484	0.0005
• From Running			358,290	0.0115	4,120	0.0045
Total PM 2.5 reduced (tons)					**Daily**	**0.0050**
					Annual	**1.269**

Appendix 4, continued

Emissions Reduced - New / Expanded (cont)

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

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	15,516	1.3603			21,106	0.0233
• From Running			358,290	0.2019	72,339	0.0797
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.1030**
					Annual	**25.752**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	15,516	227.06			3,523,063	3.88
• From Running			358,290	380.68	136,393,837	150.35
Total CO2 reduced (tons)					**Daily**	**154.23**
					Annual	**38,558.0**

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

	Total EO	EO w/o bike	EO-bike
Vehicle Trips Reduced	95,582	95,226	356
VMT Reduced (miles)	1,690,401	1,688,833	1,568
Daily Emissions Reduced			
NOx (tons)	0.4359	0.4351	0.0008
VOC (tons)	0.3242	0.3231	0.0011
Annual Emissions Reduced			
PM 2.5 (T)	5.7447	5.7366	0.0081
PM 2.5 Precursor NOx (T)	116.6959	116.4751	0.2208
CO2 (T)	174,460.9	174,274.2	186.7

Appendix 4, continued

COMMUTER CONNECTIONS
EMPLOYER SERVICES PARTICIPATION LEVELS
(EFFECTIVE July 1, 2013)

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

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 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 – GRH credit

PART 1 – Direct Ad Influence

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

Total commuters in region	2,940,524	(SOC)
• % recall any commute message	54%	(SOC)
• % recall CC/COG commute message	21%	(SOC)
• % chg to alt mode after CC/COG ads	3.3%	(SOC)
• % changers influenced by ad	60%	(SOC)
Placements – no contact with CC	**12,227**	(Commuters x CC recall X change % x influence %)
Placement Rates		
• Continued placement rate	46%	(SOC)
• Temporary placement rate	54%	(SOC)
Placements		
• Continued placements	5,624	(Placements x continued placement rate)
• Temporary placements	6,603	(Placements x temporary placement rate)
Daily Vehicle Trips Reduced		
• Continued VTR factor	0.80	(SOC)
• Temporary VTR factor	1.00	(SOC)
• Continued VT reduced	4,499	(Continued placements x continued VTR factor)
• Temporary VT reduced	2,245	(Temporary placements x temporary VTR factor x 34% credit for temporary use)
Total Daily Vehicle Trips Reduced	**6,744**	
Daily VMT Reduced		
• Ave one-way trip distance (mi)	15.4	(SOC)
Total Daily VMT Reduced	**103,858**	

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	2,023	(VT x SOV access %)
• VT with no SOV access	4,721	(Total VT – SOV access VT)

Adjusted VMT Reduction

• SOV access VMT	5,462	(VT x SOV % x trip distance)
• VMT with no SOV access	98,396	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**4,721**
Total VMT for AQ analysis	**98,396**

PART 2 – 'Pool Rewards Participants

Program participants (FY 2015-17)	131	

Placement Rates – by retention after program ended

• Continued placement rate	65%	('Pool Rewards follow-up survey)
• Temporary placement rate	35%	('Pool Rewards follow-up survey)

Placements

• Continued placements	85	(Placements x continued placement rate)
• Temporary placements	46	(Placements x temporary placement rate)
Total placements	**131**	

Daily Vehicle Trips Reduced

• Continued VTR factor	0.72	('Pool Rewards follow-up survey)
• Temporary VTR factor	0.64	('Pool Rewards logging data for program period)
• Temporary discount	50%	(assumes 13 weeks of program + 13 weeks after program)
• Continued VT reduced	61	(Continued placements x continued VTR factor)
• Temporary VT reduced	29	(Temporary placements x temporary VTR factor x 25% credit for temporary use)
Total Daily Vehicle Trips Reduced	**76**	

Daily VMT Reduced

• Ave one-way trip dist (mi)	31.2	('Pool Rewards follow-up survey)
Total Daily VMT Reduced	**2,371**	

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	72%	
• SOV access distance (mi)	5.5	

Adjusted VT Reduction

• SOV access VT	55	(VT x SOV access %)
• VT with no SOV access	21	(Total VT – SOV access VT)

Adjusted VMT Reduction

• SOV access VMT	303	(VT x SOV % x trip distance)
• VMT with no SOV access	2,068	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**21**
Total VMT for AQ analysis	**2,068**

PART 3 – Car Free Day Event

Pledges (estimate 90% participation of pledges)

Fall 2014 – 4,656	4,190
Fall 2015 – 3,442	2,098
Fall 2016 – 4,497	4,047
Total Placements	**11,335**

Event Impacts

Daily Vehicle Trips Reduced

• % driving alone on non-Car Free days	31%	(Pledge data)
• Event VTR factor	0.62	(Pledge data)
• Event VT reduced	7,058	(Pledges x event VTR factor)
• Equivalent daily VT	9	(Event VT reduced / 750 days over 3 years)

Daily VMT Reduced

• Ave one-way trip distance (mi)	10.5	(Pledge data)
• Event VMT reduced	74,043	(Event VT reduced x distance)
• Equivalent daily VMT	99	(Event VMT reduced / 750 days over 3 years)

Ongoing Impacts

Daily Vehicle Trips Reduced

• Estimate continued use after CFD	10%	
Ongoing placements	**1,134**	(Total participants x continued rate)
• Ongoing VTR factor (after CFD)	0.25	
• Ongoing daily VT reduced	284	(Ongoing participants x ongoing VTR factor)
Total Daily VT Reduced	**293**	(Event equivalent daily VT + ongoing daily VT)

Appendix 5, continued

PART 3 (Car Free Day) (continued)

Ongoing Impacts (cont)

Daily VMT Reduced

• Trip distance	10.5	
• Ongoing daily VT	2,979	(Ongoing daily VT x trip distance)
Total Daily VMT Reduced	**3,078**	(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	13,492	12,227	131	1,134
Vehicle Trips Reduced	7,113	6,744	76	293
VMT Reduced (miles)	109,307	103,858	2,371	3,078
Air Quality Adjusted VT / VMT				
Vehicle Trips Reduced	5,035	4,721	21	293
VMT Reduced (miles)	103,542	98,396	2,068	3,078

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

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	5,053	1.2435			6,261	0.0069
• From Running			103,542	0.1897	19,642	0.0217
Total NOx reduced (tons)					**Daily**	**0.0286**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	5,053	2.5814			12,997	0.0143
• From Running			103,542	0.0688	7,124	0.0079
Total VOC reduced (tons)					**Daily**	**0.0222**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	5,053	0.0312			157	0.0002
• From Running			103,542	0.0115	1,191	0.0013
Total PM 2.5 reduced (tons)					**Daily**	**0.0015**
					Annual	**0.371**

Appendix 5, continued

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

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	5,053	1.3603			6,849	0.0075
• From Running			103,542	0.2019	20,905	0.0230
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0305**
					Annual	**7.649**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	5,053	227.06			1,143,247	1.26
• From Running			103,542	380.68	39,416,369	43.45
Total CO2 reduced (tons)					**Daily**	**44.71**
					Annual	**11,171.4**

PART 4 - Bike to Work Day Credit

Participants' riding percentage and frequency

Number of riders	23,610	(BTWD registration data, 2014, 2015, 2016, adjusted for use by some 2014 participants in 2015 and 2016)
% biking to work before event	86.3%	(BTWD survey)
% new riders	8.5%	(BTWD survey)
Number of new riders	2,007	
% who increase riding days	22.9%	
Number of increased riders	5,407	
Total placements	**7,414**	(Total new + increased riders)

Change in Bike Days

Summer Biking		
% new riders in summer	7.6%	(BTWD survey)
Weekly new bike days summer	1.4	(BTWD survey)
Weekly new bike days summer	2,512	
% increased riders in summer	19.9%	(BTWD survey)
Weekly increased bike days summer	1.7	(BTWD survey)
Weekly increased bike days summer	7,987	
Winter Biking		
% new riders biking winter	6.5%	(BTWD survey)
Weekly new bike days winter	1.3	(BTWD survey)
Weekly new bike days winter	1,995	
% increased riders biking winter	14.6%	(BTWD survey)
Weekly increased bike days winter	1.9	(BTWD survey)
Weekly increased bike days winter	6,549	

Appendix 5, continued

PART 4 (Bike to Work Day) (continued)

Additional Bike Days (New and Increased Riding)

• NEW bike days summer	10,499	(riders x % new after event x ave new days bike after)
• NEW bike days fall-winter	8,544	(riders x % new after event x % still riding late fall x ave new days bike in late fall)
• Total additional bike days summer	293,972	(weekly summer days x 28 weeks – Apr-Oct)
• Total additional bike days winter	187,968	(weekly winter days x 22 weeks – Nov-Mar)
• Total additional bike days - year	481,940	(summer bike days + winter bike days)
• Additional bike trips - year	963,880	(annual bike days x 2 trips per day)

Additional Bike Trips and Vehicle Trip and VMT Reductions

• Ave new daily bike trips	3,856	(Annual new bike trips / 250)
• % Drive alone/CP/VP on non-bike days	46%	(BTWD survey)
BTWD Daily Vehicle Trips Reduced	**1,774**	(daily new bike trips x DA/CP/VP percentage)

Daily VMT Reduced

• Ave trip distance (mi)	10.2	(BTWD survey)
BTWD Daily VMT Reduced	**18,095**	(vehicle trips reduced x average trip distance)

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

NOx	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,774	1.2435			2,206	0.0024
• From Running			18,095	0.1897	3,433	0.0038
Total NOx reduced (tons)					**Daily**	**0.0062**

VOC	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,774	2.5814			4,579	0.0050
• From Running			18,095	0.0688	1,245	0.0014
Total VOC reduced (tons)					**Daily**	**0.0064**

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

PM 2.5	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,774	0.0312			55	0.0001
• From Running			18,095	0.0115	208	0.0002
Total PM 2.5 reduced (tons)					**Daily**	**0.0003**
					Annual	**0.073**

PM 2.5 Precursor NOx	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,774	1.3603			2,413	0.0027
• From Running			18,095	0.2019	3,653	0.0040
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0067**
					Annual	**1.672**

Appendix 5, continued

PART 4 (Bike to Work Day) (continued)

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

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	1,774	227.06			402,804	0.444
• From Running			18,095	380.68	6,888,405	7.593
Total CO2 reduced (tons)					**Daily**	**8.037**
					Annual	**2,009.3**

PART 5 – Referred Influence (Commuter Operations Center)

Populations of Interest – commuters influenced by ads to contact CC

New CC apps (does not include re-apply or follow-up)

• FY 2015	4,754	(CC database)
• FY 2016	4,987	(CC database)
• FY 2017	2,705	(CC database)
Total new applicants	**12,446**	
Total CC applicants	66,006	(includes new, re-apply, and follow-up)
New apps FY 2015-17 as % of total	18.9%	(new apps FY 2015-17 / total CC apps)
% influenced by ads to contact CC	16%	(COC applicant analysis)
% all apps influenced by ads	3.0%	

CC Impacts – FY 2015-17

Travel Impacts	MM Share	COC base	
• CC placements	810	27,016	
• CC Vehicle trips reduced	314	10,454	
• CC VMT reduced	8,913	298,089	
Emissions Impacts	**MM Share**	**COC base**	
• NOx reduced (daily tons)	0.0020	0.0669	Daily
• VOC reduced (tons)	0.0012	0.0398	Daily
• PM2.5 reduced (tons)	0.0280	0.9326	Annual
• PM2.5-NOx reduced (tons)	0.5359	17.8646	Annual
• CO2 reduced (tons)	881.8	29,394.8	Annual

Appendix 5, continued

PART 6 – GRH Credit – From GRH Analysis

Total GRH apps FY 2015-17	15,245	
New GRH apps FY 2015-17	8,786	58% of total applications
Estimated MM share of new GRH	16%	
Estimated MM share of GRH impact	8.0%	

GRH Impacts – FY 2015-17

Travel Impacts	MM Share	GRH base
• GRH placements	742	9,274
• GRH Vehicle trips reduced	512	6,402
• GRH VMT reduced	14,517	181,463

Emissions Impacts	MM Share	GRH base	
• NOx reduced (daily tons)	0.0032	0.0397	Daily
• VOC reduced (tons)	0.0018	0.0277	Daily
• PM2.5 reduced (tons)	0.0446	0.5580	Annual
• PM2.5-NOx reduced (tons)	0.8475	10.5936	Annual
• CO2 reduced (tons)	1,414.4	17,679.9	Annual

Mass Marketing – Summary

Total – Sum of impacts from PART 1, PART 2, PART 3, PART 4, PART 5, PART 6

	Total MM	Direct Ad Infl	'Pool Rewards	Car Free Day	BTW	COC Credit	GRH Credit
Placements	22,458	12,227	131	1,134	7,414	810	742
VT reduced	9,713	6,744	76	293	1,774	314	512
VMT reduced	150,832	103,858	2,371	3,078	18,095	8,913	14,517
		70%	1%	3%	18%	3%	5%

Daily Emissions Reduced	
NOx (T)	0.0400
VOC (T)	0.0173
Annual Emissions Reduced	
PM 2.5 (T)	0.5166
PM 2.5 Precursor (T)	10.704
CO2 (T)	15,482.9

APPENDIX 6 – CALCULATION OF COMMUTER OPERATIONS CENTER IMPACTS

PART 1 – Commute Information Requests

Populations of Interest – Commuter Connections Rideshare Applicants

FY 2015-17 Applicant Base (New credit) New, Reapply, Transit/other, follow-up requests

• FY 2015	27,149	(CC database)
• FY 2016	24,997	(CC database)
• FY 2017 (through Dec 2016)	13,860	(CC database)
New FY 2015-17 assisted commuters	**66,006**	

Pre FY 2015 Applicant Base (Retained credit)

• Applicants Pre FY 2015	5,827	(CC database)
• Valid contact percentage	63%	(Retention rate survey)
Retained Pre FY 2015 applicant base	**3,651**	

Distribution of In/Out MSA

FY 2015-17 Applicant Base (New)		
Within MSA	58%	38,283
Outside MSA	42%	27,723
Pre FY 2015 Applicant Base (Retained)		
Within MSA	58%	2,117
Outside MSA	42%	1,533

COC Placement Rates and Placements (MSA base x MSA placement rate)

FY 2015-17 Registrants (New)		
• Within MSA – continued rate	32.3%	12,365
• Within MSA – temporary rate	4.7%	1,799
• Outside MSA – continued rate	38.2%	10,590
• Outside MSA – temporary rate	5.6%	1,552
Pre FY 2015 Registrants (Retained)		
• Within MSA – continued rate	19.5%	412
• Outside MSA – continued rate	19.5%	298
Total Placements		**27,016**

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

FY 2015-17 Applicants (New)			
• Temporary discount	12.9%		
• Within MSA – continued VTR factor	0.40	4,946	
• Within MSA – temporary VTR factor	0.18	42	(Placements x VTR factor x temp discount)
• Outside MSA – continued VTR factor	0.46	4,871	
• Outside MSA – temporary VTR factor	0.38	76	
Pre FY 2015 Applicants (Retained)			
• Within MSA – continued VTR factor	0.73	301	
• Outside MSA – continued VTR factor	0.73	218	
Total Daily Vehicle Trips Reduced		**10,454**	

Appendix 6, continued

PART 1 – Commute Information Requests (continued)

Commute Distance and Daily VMT Reduced (MSA Vehicle trips reduced x MSA distance)

FY 2015-17 Applicants (New)

• Within MSA - continued distance	28.9	142,939	
• Within MSA – temporary distance	26.0	1,092	
• Outside MSA – continued distance	28.9	140,772	(Actual outside distance 51.1 miles)
• Outside MSA – temporary distance	26.0	1,976	(Actual outside distance 73.6 miles)

Pre FY 2015 Applicants (Retained)

• Within MSA – continued distance	19.9	5,979
• Outside MSA – continued distance	19.9	4,331

Total Daily VMT Reduced	**297,089**

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

Inside MSA	Cont	Temp
• SOV access percentage	72%	45%
• SOV access distance (mi)	5.5	4.2

Outside MSA

- N/A - all access VT and VMT occur outside MSA

Adjusted VT Reduction – net of drive alone access (Within MSA VTs x SOV access %)

FY 2015-17 Applicants (New)

• Total VT reduced	10,454	
• Within MSA access VT (deduct)	- 3,797	(sum within MSA SOV access VTs, continued, temporary)
• Outside MSA access VT	0	No deduction (access trips are outside MSA)
Total VT (net of SOV access)	**6,657**	

Adjusted VMT Reduction – net of VMT access (Within SOV access VT x SOV access distances)

• Total VMT reduced	297,089	
• Within MSA access VMT (deduct)	- 20,860	(sum within MSA SOV access VMT, continued, temporary)
• Outside MSA access VMT	0	No deduction (access VMT are outside MSA)
Total VMT (net of SOV access)	**276,229**	

Total VT for AQ analysis	**6,657**
Total VMT for AQ analysis	**276,229**

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

NOx	**Trips**	**17 Emission Factor**	**VMT**	**17 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	6,657	1.2435			8,278	0.0091
• From Running			276,229	0.1897	52,401	0.0578
Total NOx reduced (tons)					**Daily**	**0.0669**

Appendix 6, continued

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

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	6,657	2.5814			17,184	0.0189
• From Running			276,229	0.0688	19,005	0.0209
Total VOC reduced (tons)					**Daily**	**0.0398**

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

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	6,657	0.0312			208	0.0002
• From Running			276,229	0.0115	3,177	0.0035
Total PM 2.5 reduced (tons)					**Daily**	**0.0037**
					Annual	**0.933**

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	6,657	1.3603			9,056	0.0100
• From Running			276,229	0.2019	55,771	0.0615
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0715**
					Annual	**17.865**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	6,657	227.06			1,511,538	1.67
• From Running			276,229	380.68	105,154,856	115.91
Total CO2 reduced (tons)					**Daily**	**117.58**
					Annual	**29,394.8**

Correction for Overlap between COC Base and Integrated Rideshare and GRH TERMs
Net COC Base = COC Base – Mass Marketing credit – Software Upgrades credit – GRH credit

	COC Base	MM	Soft Upg	GRH	Net COC Base
Placements	27,016	810	3,552	6,535	16,119
Vehicle Trips Reduced	10,454	314	1,512	2,489	6,139
VMT Reduced (miles)	297,089	8,913	43,636	70,544	173,996
Daily Emissions Reduced					
NOx Reduced (tons)	0.0669	0.0020	0.0094	0.0160	0.0395
VOC Reduced (tons)	0.0398	0.0012	0.0054	0.0096	0.0236
Annual Emissions Reduced					
PM 2.5 (T)	0.9326	0.0280	0.1334	0.2225	0.5487
PM 2.5 Precursor (T)	17.8646	0.5359	2.5282	4.2696	10.5309
CO2 (T)	29,394.8	881.8	4234.1	7,003.9	17,275.0

Notes: MM influenced commuters – from MM analysis
GRH – 63% of new apps/reapps who made an alt mode change registered for GRH = 29% of COC credit to GRH (63% x 46% new/reapply share of total apps)

Appendix 6, continued

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 TERM

Calculation details shown on Telework Assistance Worksheets

Number of regional teleworkers	887,202	
% of non-MD teleworkers	55%	
Number of teleworkers (non-MD)	487,961	
Share of TW credited to COC	7.4%	Learned of telework from Commuter Connections
Total TW placements credited to COC	36,109	
Vehicle trips reduced	12,789	
VMT reduced	197,975	
Daily NOx reduced (tons)	0.0589	
Daily VOC reduced (tons)	0.0514	
Annual PM2.5 reduced (tons)	0.7250	
Annual PM2.5-NOx reduced (tons)	15.8250	
Annual CO2 reduced (tons)	21,570.0	

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

	Net COC Base	Non-MD TW	Net COC
Placements	16,119	36,109	52,228
Vehicle Trips Reduced	6,139	12,789	18,928
VMT Reduced (miles)	173,996	197,975	371,971
Daily Emissions Reduced			
NOx Reduced (tons)	0.0395	0.0589	0.0984
VOC Reduced (tons)	0.0236	0.0514	0.0750
Annual Emissions Reduced			
PM 2.5 (T)	0.5487	0.7250	1.2737
PM 2.5 Precursor (T)	10.5309	15.8250	26.3559
CO2 (T)	17,275.0	21,570.0	36,845.0

APPENDIX 7 – CALCULATION OF SOFTWARE UPGRADE IMPACTS

Populations of Interest – Commuter Connections Rideshare Applicants

FY 2015-17 Applicant Base New, Reapply, Transit/other, follow-up requests

• FY 2015	27,149	(CC database)
• FY 2016	24,997	(CC database)
• FY 2017 (through Dec 2016)	13,860	(CC database)
New FY 2015-17 assisted commuters	**66,006**	
Within MSA (58%)	38,283	
Outside MSA (42%)	27,723	

COC Placement Rates	**In MSA**	**Out MSA**	
• Continued rate	4.1%	4.4%	
• Temporary rate	1.7%	0.4%	
Placements			
• Continued	1,570	1,220	(Applications x continued rate)
• Temporary	651	111	(Applications x temporary rate)
Total placements 3,552			

Daily Vehicle Trips Reduced

VTR Factors			
• Continued	0.60	0.45	
• Temporary	0.19	0.38	
• Temporary discount	12.9%	12.9%	
• Continued trips reduced	942	549	(Placements x cont. VTR factor)
• Temporary trips reduced	16	5	(Placements x temp VTR factor)
Total VT reduced 1,512			

Daily VMT Reduced

Ave one-way trip distance (mi)			
• Continued	28.9	28.9	(Actual Outside dist. 51.1 miles)
• Temporary	26.0	26.0	(Actual Outside dist. 61.7 miles)
• Continued VMT reduced	27,224	15,866	(Vehicle trips x ave distance)
• Temporary VMT reduced	416	130	
Total VMT Reduced 43,636			

Appendix 7, continued

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

	In MSA	Out MSA	
• SOV access % -Continued	72%	0%	(CC placement survey)
• SOV access dist (mi) – Continued	5.5	0.0	(CC placement survey)
• Non-SOV access % - Temporary	45%	0%	(CC placement survey)
• SOV access dist (mi) – Temporary	5.5	0.0	(CC placement survey)

Outside MSA – not applicable – all access outside MSA

VT Reduction

• Continued SOV access VT	678	0	(Cont VT x SOV access)
• Temporary SOV access VT	7	0	(Temp VT x SOV access)
• Continued VT (without SOV access)	264	549	(Total Cont VT – SOV access VT)
• Temporary VT (without SOV access)	9	5	(Total Temp VT- SOV access VT)

Total VT (net of SOV access) 827

VMT Reduction

• Continued SOV access VMT	3,729	0	(Cont VT x SOV % x access dist)
• Temporary SOV access VMT	39	0	(Cont VT x SOV % x access dist)
• Continued VMT (without SOV access)	23,495	15,866	(Total Temp VMT- SOV access VMT)
• Temporary VMT (without SOV access)	377	130	(Total Temp VMT- SOV access VMT)

Total VMT (net of SOV access) 39,868

Total VT for AQ analysis 827
Total VMT for AQ analysis 39,868

<u>Daily Emissions Reduced</u> – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	827	1.2435			1,028	0.0011
• From Running			39,868	0.1897	7,563	<u>0.0083</u>
Total NOx reduced (tons)					**Daily**	**0.0094**

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	827	2.5814			2,135	0.0024
• From Running			39,868	0.0688	2,743	<u>0.0030</u>
Total VOC reduced (tons)					**Daily**	**0.0054**

<u>Annual Emissions Reduced</u> – PM 2.5, Precursor NOx, and CO2

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	827	0.0312			26	0.0000
• From Running			39,868	0.0115	458	<u>0.0005</u>
Total PM 2.5 reduced (tons)					**Daily**	**0.0005**
					Annual	**0.133**

Appendix 7, continued

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

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	827	1.3603			1,125	0.0012
• From Running			39,868	0.2019	8,049	0.0089
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0101**
					Annual	**2.528**

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	827	227.06			187,779	0.2070
• From Running			39,868	380.68	15,176,950	16.7297
Total CO2 reduced (tons)					**Daily**	**16.9367**
					Annual	**4,234.1**

APPENDIX 8 – REDUCTION IN DELAY DUE TO TERM VMT REDUCTION

The TERM Revised Evaluation Framework for FY 2015-17 called for the development of additional (beyond conformity) performance indicators to convey the broader impacts of the Commuter Connections TDM program. These benefits included societal benefits such as mobility, health, safety, livability and quality of life. As performance-based planning becomes a reality through federal and regional policy changes, one such benefit of particular interest to stakeholders in the Washington metropolitan region is the impact of TERMs on the performance of the highway system. For this reason, the revised evaluation framework noted "reduced delay" as an emerging metric that seeks to develop a direct relationship between VMT reduction and improved system performance.

Ideally, delay reduction from use of TERMs would be calculated by measuring the travel speed on regional roads now, with TERMs in place, estimating the lower speed that would be experienced if vehicle trips and VMT eliminated by the TERMs were still on the road system, and comparing the current (with TERMs) to the assumed (without TERMs) conditions to estimate an aggregate delay reduction. Practically, however, this method has multiple issues, such as the need to estimate differential speeds by network links and assign TERM-reduced trips to individual network links to estimate where, and perhaps when, reduced delay occurs.

These issues make the ideal calculation beyond the current scope of the TERM analysis, but the TERM evaluation team defined a substitute method that estimates the average hours of delay for a known number of VMT and applying it to the TERM 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 TERM VMT reduced that would be traveling on congested roadways if the TERM services 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 TERM impacts and system performance; specifically between VMT reduced by the TERM (TERM impact) to delay reduction (easing congestion over levels that WOULD HAVE likely occurred in the absence of TERMs). 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 estimates societal cost saving benefits of TDM actions for a range of societal benefits, one of which is congestion mitigation or cost of reduced hours of delay on regional roads. The TRIMMS calculation employs a default value of **61.26 hours of delay per 1,000 pce VMT**, as reported by Sinha and Labi[4], who referred the Highway Economic System Requirements technical documentation.[5] TRIMMS uses this national default conversion factor in its evaluation of societal costs and benefits.

Estimate TERM VMT Subject to Congested Conditions

The second step is to estimate the TERM VMT reduced that would be traveling in congested conditions if the TERM services did not exist. A commuter traveling on a road segment with no congestion does not create or add to travel

[4] Kumares Sinha and Samuel Labi, *Transportation Decision-making: Principles of Program Evaluation and Programming;* John Wiley & Sons, 2007, p. 390.

[5] FHWA, Highway Economic Requirements System-State Version: Technical Report, August 2005.

delay, so miles on uncongested roadways should be excluded from the calculation of marginal delay. This step requires information on the roads used by commuters who participate in TERM services.

Three surveys conducted by COG for the FY 2015-17 TERM analysis included questions to examine existing or likely road use by commuters who participated in TERM services. The 2014 Applicant Placement Survey assessed roadways used by commuters who participated in Commuter Connections online commute information and ridematching services. The 2016 GRH Survey examined roadway use for GRH participants. The 2016 State of Commute Survey identified roadway use on drive alone days for ridesharers and transit riders. In an effort to pinpoint specific road segments used, the SOC survey also asked commuters where they entered and exited individual roadways.

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 TERM VMT reduction that would have traveled on roads that experience peak period congestion. This adjusted VMT count could then be multiplied by the TRIMMS 61.26 hours of delay per 1000 VMT figure to estimate the hours of delay that were eliminated by the TERM-generated VMT reductions.

Table 8A shows the estimated congested VMT to which the hours of delay per VMT factor would be applied. Because each TERM involves a specific commuter profile, the calculation was performed first for each TERM separately. Then the estimated congested VMT counts by TERM were added for a total congested VMT.

The basic calculation involves the following steps:

1 – Define TERM base VMT reduction

2 – Estimate percentage of commuters' VMT in congestion on major roads
- Estimate percentage of TERM commuters using major roadways (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[6]

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

Table 8A – Calculation of Estimated Congested VMT by Individual TERM

[6] MWCOG periodically produces a National Capital Region Congestion Report, which provides statistics on various aspects of roadway network performance. The 2014 report for the 2nd Quarter 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.

TERM	% Commuters Using Major Roads	Base VMT Reduction	% Miles on Major Roads	Estimated Major Road-way VMT
Maryland Telework	72%	361,204	13%	46,956
Virginia Telework	TBD	TBD	TBD	TBD
Guaranteed Ride Home	83%	166,946	15%	25,042
Employer Outreach	70%	1,690,401	13%	219,752
Mass Marketing	71%	150,832	13%	19,608
Commuter Operations Center	79%	415,607	14%	58,185
All TERMs plus COC				**369,544**

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

Base VMT reduction for the TERM = **361,204 VMT**

Commute major road VMT % = % commuters using major road x % of travel miles on major roads
- 72% of teleworkers use major roads (from 2016 SOC survey)
- 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

- Estimated major road VMT % for Telework TERM = 72% x 85% x 21% = **13% major road VMT**

Major road VMT = Base VMT reduction x major road % = 361,204 x 13% = **46,956 major road VMT**

When the calculation provided above is performed for all TERMs, the total congested VMT across all TERMs equals 369,544, or about 13% of the total VMT reduced by the TERM and the Commuter Operations Center combined. And when the major road VMT total is multiplied by the 62.16 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced by the TERMs equals 22,638 daily hours of delay reduced:

Estimated delay reduction = (369,544 / 1,000) x 61.26 hours per mile = **16,581 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. But COG is continuing to collect data on road use by commuters who participate in Commuter Connections TERM services. Over time, the samples for roadways might become large enough for more detailed analyses. This gathering of key geographic information from the same travelers for which VMT impacts are calculated will help estimate where (on which key highways and even road segments) delay reduction occurs.

APPENDIX 9 – CALCULATION OF SOCIETAL BENEFITS GENERATED BY TERM IMPACTS

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination and conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. But the TERMs likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as climate change mitigation, greater mobility, improved health/safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

These benefits are joining 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.

The FY 2015-17 TERM evaluation included a new analysis component, to estimate regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include the following:

- Air pollution / emissions reductions (tons of NOx, VOC, PM 2.5 pollutants)
- Global climate change mitigation (Greenhouse gases / CO2)
- Reduction in congestion (reduced hours of travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved health/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 pollutants reduced or hours of delay reduced) and multiplying the benefit units by a unit cost factor (e.g., cost per ton of pollutant or cost per hour of delay). In all cases, the TERM VMT reduction was the starting point, with conversions made to translate VMT reduction into units of benefit.

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) model developed by the Center for Urban Transportation Research. 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 TERM.

Air Pollution/Emissions Reductions

TRIMMS™ methodology estimates benefits for 17 types of 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. Air pollution costs associated with motor vehicle emissions that have negative effects at local and global levels are then applied to the emission base to estimate the daily emission cost saving.

Because the TERM 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 TERM emissions estimates to calculate air pollution societal benefit costs. The relevant emissions calculations are presented in Table 9A.

As shown, the daily benefit cost saving for all air pollutant components combined is $3,029 per day, with a per pollutant range from a low of $68 per day (VOC) to a high of $1,236 (PM 2.5 precursors NOx). The daily cost saving for global climate change mitigation, defined by a benefit unit of tons of CO2 reduced, equals $41,488 saved per day.

Table 9A - Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by FY 2015-17 TERM 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	0.716 T	$1,611	$1,154
- VOC	Tons VOC removed	0.512 T	$133	$68
- PM 2.5	Tons PM 2.5 removed	0.038 T	$15,107	$571
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.767 T	$1,612	$1,236
Total air pollution				**$3,029**
Climate change	**Tons CO2 removed**	**1,152 T**	**$36**	**$41,488**

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

Noise Pollution Reduction

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. TRIMMS methodology multiplies a noise costs of $0.0223 per mile (derived from a literature review) by the VMT reduction to estimate the reduction in societal costs. These costs are associated with noise because it disrupts sleep, causes stress, and negatively affects property values. These costs are scaled to account for cost of living differentials between national averages and the Washington metropolitan regional.

This calculation estimates a total cost saving for noise pollution reduction of $62,105 per day, as shown below:

Total daily VMT reduced by TERM programs = 2,784,990

Noise pollution daily cost saving = 2,784,990 x $0.0223 per VMT = **$62,105 per day**

Congestion (Delay) Reduction

Benefits generated by reduced congestion are expressed in terms of hours of travel delay generated by reductions in motor vehicle use. Congestion delay is the added delay imposed to all users as an additional vehicle is introduced into the traffic stream. Programs and services that remove a vehicle from the road can potentially produce benefits in reductions in added delay. As explained in TRIMMS final report, "The cost of added delay is the opportunity cost of time spent in a motor vehicle for work or non-work related purposes; time that could be spent on other activities, such as leisure or other more work. This cost is a portion of the overall travel time costs since it only considers the portion of congestion costs generated by added delay to others."[7] ." (Concas & Winters, 2012)

As noted in Appendix 8, TRIMMS methodology uses a national default value of 61.26 hours of marginal delay per 1,000 passenger car equivalent VMT. This estimate of delay reduction benefit was applied to an adjusted estimate of the TERM/COC VMT reduced. The adjustment, detailed in Appendix 8, 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. This adjustment was needed to align with the marginal delay conversion factor used by TRIMMS.

[7] Concas, S., & Winters, P. L. (2012). *Estimating Costs and Benefits of Emissions Reduction Strategies for Transit by Extending the TRIMMS Model.* Tampa, FL: National Center for Transit Research at the University of South Florida.

The adjusted "major roadway" VMT calculation estimated that 369,544, or about 13% of the total VMT reduced by the TERMs/COC would have traveled on major roadways in congested conditions. When this "congested VMT" total is multiplied by the 61.26 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced by the TERMs equals 22,638 daily hours of delay reduced:

Estimated delay reduction = (369,544 / 1,000) x 61.26 hours per mile = **22,638 daily hours delay reduced.**

These hours of delay were multiplied by the $25.13 median hourly wage rate for all employees working in the Washington metropolitan region, as reported by the Bureau of Labor Statistics.[8] When this cost is multiplied by the 262,638 hours of delay reduced, the total congestion (delay) reduction benefit equals **$568,899 per day**.

Excess Fuel Consumption Reduction

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. TRIMMS methodology uses a default value of 18.0 miles per gallon fuel efficiency and an average $4.00 cost per gallon of fuel. For the TERM estimate, the 18.0 mpg factor was used, but a lower per gallon cost was applied. The U.S. Energy Information Administration published average gasoline prices for various parts of the country. In June 2017, the average cost reported for the Mid-Atlantic region was $2.51 per gallon.[9] The result of these calculations is as follows:

Total daily VMT reduced by TERM programs = 2,784,990

Estimated gallons of fuel saved = 2,784,990 miles / 18.0 miles per gallon = 154,722 gallons

Excess fuel consumption daily cost saving = 154,722 gallons x $2.51 per gallon = **$388,351 per day**

The calculation estimates a fuel saving of 154,722 gallons per day and a cost saving from reduction in fuel use of $388,351 per day.

Improved Health and Safety (Accident Reduction)

The Health and Safety element of the TRIMMS methodology estimates vehicle crash costs. It does not include health benefits such as changes in obesity due to more bicycling and walking. Vehicle crash-related costs include monetary costs, such as property and personal injury damages caused by collisions, and nonmonetary costs, such as pain and loss of productivity. The TRIMMS methodology for Health and Safety 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[10] and the average cost per type of accident. Table 9B shows the types of injuries, occurrence probabilities and anticipated costs.

The calculation estimates that 2.817 crashes will occur over the 2.8 million VMT reduction. At a per occurrence cost of $15,952, the total cost saving from crash reduction is $44,932 per day.

Total daily VMT reduced by TERM programs = 2,784,990

Expected crash occurrence = (2,784,990 miles / 1,000) x 1.01136 crash per 1000 VMT = 2.817 crashes

Health and Safety daily cost saving = 2.817 crashes x $15.952 per crash = **$44,932 per day**

[8] 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

[9] Weekly Retail Gasoline and Diesel Prices, June 2017. U.S. Energy Information Administration. https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r1y_m.htm

[10] 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/spm/conversion_tbl/pdfs/kabco_ctable_by_state.pdf

Table 9B – 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.

Total Societal Benefit Cost Saving

Table 9C presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMs and the Commuter Operations Center combined.

Table 9C – Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by FY 2015-17 TERM 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	0.716 T	$1,611	$1,154
- VOC	Tons VOC removed	0.512 T	$133	$68
- PM 2.5	Tons PM 2.5 removed	0.038 T	$15,107	$571
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.767 T	$1,612	$1,236
Climate change	Tons CO2 removed	1,152 T	$36	$41,488
Noise pollution	Total VMT reduced	2,784,990 VMT	$0.0223	$62,105
Congestion	Hours of delay reduced	22,638 hr	$25.13	$568,899
Excess fuel used	Gallons of fuel saved	154,722 gal	$2.51	$388,351
Health/safety [1)]	Accidents avoided/1 M	2.817 acc.	$15,952	$44,932
All benefits				**$1,111,835**

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

As shown, the combined TERM/Commuter Operations Center impacts generate about $1.1 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over $568,899 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit ($388,351).Noise pollution reduction generates about65% and air pollution/climate change benefits and health/safety accident reduction benefits each are responsible for about 4% of the total cost saving.