Appendix A. Technical Appendix

General Method Description and Results

Three distinct Measures were assessed for greenhouse gas (GHG) emissions reductions:

- Measure 1: Improving Regional Transit Service
- Measure 2: Investing in Mobility Infrastructure
- Measure 3: Inspiring Behavior Change

Different GHG reduction calculation methodologies were used for each measure, as described in detail below. In general, emissions reductions were calculated by comparing a baseline case to a proposed project case, as shown in the following equation:

Emissions Reduced = Baseline Case Emissions – Proposed Case Emissions

For the baseline and proposed cases, total emissions were calculated each year from 2025-2050. The annual emissions in the proposed case were subtracted from the annual emissions in the baseline case to calculate the emissions reduced for those specific years. Cumulative emissions reductions were calculated by summing annual emissions reductions from each year.

The following assumptions apply for the three Measures evaluated:

- All Measures begin in 2025 and are fully operational by 2030 (resulting in an implementation rate of 0% in 2025 and 100% in 2030)
- All Measures are in operation, or the behavioral effects of the programs last, until 2050 at minimum
- Daily VMT reductions were annualized using an annualization factor of 180
- VMT reductions were calculated for 2030 and 2050 and then interpolated for all other years
- Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report global warming potentials (GWP) were used to calculate metric tons of carbon dioxide equivalent ($MTCO_2e$)

Cumulative and annual GHG reductions for each Measure type and across Measures are listed in Table 1 and Table 2.

Table 1 – Cumulative GHG Reductions

Year Range	**Cumulative GHG Reductions $MTCO_2e$**
2025-2030	395,188
2025-2050	2,597,588

Table 2 Annual GHG Reductions per Measure

	Annual GHG Reductions $MTCO_2e$			
Year	**Measure 1**	**Measure 2**	**Measure 3**	**TOTAL**
2025	-	-	-	**-**
2026	22,836	372	9,384	**32,591**
2027	44,757	456	11,521	**56,734**
2028	65,813	538	13,583	**79,933**
2029	86,047	617	15,573	**102,237**
2030	105,503	693	17,497	**123,693**
2031	103,828	681	17,624	**122,133**
2032	102,595	672	17,804	**121,071**
2033	101,029	661	17,921	**119,610**
2034	99,876	652	18,090	**118,619**
2035	98,408	642	18,198	**117,247**
2036	96,989	632	18,302	**115,923**
2037	95,619	622	18,402	**114,643**
2038	94,293	613	18,499	**113,405**
2039	92,702	603	18,539	**111,843**
2040	91,469	594	18,630	**110,692**
2041	90,273	586	18,718	**109,577**
2042	88,832	576	18,752	**108,160**
2043	87,440	567	18,785	**106,792**
2044	86,097	558	18,817	**105,472**
2045	85,057	551	18,896	**104,504**
2046	83,544	541	18,877	**102,963**
2047	82,330	534	18,906	**101,770**
2048	81,154	526	18,934	**100,614**
2049	79,786	517	18,916	**99,220**
2050	78,688	510	18,943	**98,141**
TOTAL	**2,144,967**	**14,512**	**438,109**	**2,597,588**

The sections in this appendix describe how the vehicle miles traveled (VMT) reductions for each Measure were developed, and the final section describes how the GHG emissions factors and calculations were completed.

Measure 1: Improving Regional Transit Service

Task 1.1 Expanded CARTS service; 1.2 Improved CapMetro service

Assumptions

The proposed case will increase the frequency of the Capital Area Rural Transportation System (CARTS) and CapMetro service. VMT reductions were estimated by calculating the single occupancy vehicle (SOV) VMT in the bus service area and applying a VMT reduction value to account for increased bus frequency. Additionally, new CARTS and CapMetro VMT associated with increased service frequency were calculated. The emissions from increased transit VMT were subtracted from the Measure's total GHG reductions.

Baseline Case

Baseline case VMT were calculated by estimating the total existing SOV VMT in the service area that is impacted from the project's expansion in CARTS frequency or CapMetro service. The project team assumed that the new bus riders would have commuted in SOVs in the baseline case (i.e., if the CARTS and CapMetro service project were not implemented).

Baseline case assumptions include:

- CapMetro Service Population: 1,096,371 (CapMetro)[1]
- % of CapMetro and CARTS service area where bus frequency is increased: 20% (based on annual average daily traffic [AADT] of Measure service areas and construction timelines)
- 2015 average VMT/person/day: 26 VMT/person/day (CapMetro)[2]
- Annual VMT growth factor: 2.78% (CAMPO)[3]

VMT estimation equations include:

- 2022 baseline daily VMT = 1,096,371 population * 26 VMT/person/day * 20% service area of project
- 2030 and 2050 baseline daily VMT were forecast from 2022 using the annual VMT growth factor

Proposed Case

The proposed case assumes that the baseline SOV commuters fill the additional buses to capacity, which reduces SOV VMT. Additional assumptions used for the proposed case bus emissions include:

- Maximum VMT reduction potential from vehicle travel in the plan/community from increasing transit frequency: 11.3% (CAPCOA)[4]
- Bus capacity: 40 people/bus

VMT estimation equations include:

- Daily SOV VMT reduced = Baseline daily VMT * 11.3% VMT reduction
- Additional daily bus VMT added = SOV daily VMT reduction ÷ 40 people/bus

Task 1.3: Small-scale shuttle service/circulators in construction areas

Assumptions

The proposed case will establish a new shuttle service in areas adjacent to highway construction. VMT reductions were estimated by calculating the daily VMT on highways where construction is occurring, and assuming the shuttle program will reduce a portion of those trips. Additionally, new shuttle VMT was calculated and the associated emissions were subtracted from the Measure's total GHG reductions.

[1] https://www.capmetro.org/facts
[2] https://www.capmetro.org/facts
[3] https://www.campotexas.org/wp-content/uploads/2024/03/2045RTP_03.06.2024.pdf
[4] https://www.airquality.org/ClimateChange/Documents/Handbook%20Public%20Draft_2021-Aug.pdf

Baseline Case

In the baseline case, 2022 daily VMT is estimated by multiplying the annual average daily traffic for each stretch of highway impacted by the project by the length of highway. The daily VMT was forecast to 2050 using an annual VMT growth factor from CAMPO.

Baseline case assumptions include:

I-35 Section	2022 AADT	Miles
North: From SH 45N to US Highway 290 (US 290)	157,848	11.0
Central: From US 290 to State Highway 71 (SH 71)	173,900	8.0
South: From SH 71 to SH 45SE	155,102	8.0

(TXDOT, Mobility35 Capital Express Central Traffic Projections Methodology Memo)[5]

- Annual VMT growth factor: 2.78% (CAMPO)[6]

VMT estimation equations include:

- Daily VMT = AADT * miles
    - Daily VMT was forecast from 2022-2050 using the annual VMT growth factor

Proposed Case

The proposed case assumes that some drivers will switch to transit during construction, and a smaller share will switch back to driving after construction is complete (post-2030). Proposed case assumptions include:

- % of drivers using transit during construction: 26% (University of Minnesota)[7]
- % of transit users switching back to driving after construction: 14% (University of Minnesota)[8]
- Shuttle capacity: 40 people/shuttle

VMT estimation equations include:

- 2030 daily SOV VMT reduced = Baseline daily VMT * 26% VMT reduction
- 2050 daily SOV VMT reduced = Baseline daily VMT * (26%-14% VMT reduction)
- Additional daily shuttle VMT added = SOV daily VMT reduction ÷ 40 people/shuttle

Measure GHG Reduction Uncertainties:

- There is inherent uncertainty with any VMT forecasts as these could be impacts by many different external factors.
- The actual VMT of the additional buses and shuttles services is unknown.

[5] https://my35capex.com/wp-content/uploads/2023/08/APPROVED-FEIS-ROD_Appendix-H-Traffic-Data_2023-08-14.pdf
[6] https://www.campotexas.org/wp-content/uploads/2024/03/2045RTP_03.06.2024.pdf
[7] https://www.lrrb.org/pdf/201313.pdf
[8] https://www.lrrb.org/pdf/201313.pdf

Measure 2: Investing in Mobility Infrastructure

Task 2.1. MetroBike/transit stop mobility hub amenity enhancement at 48 stations

Assumptions

The proposed case will transition all existing pedal MetroBikes to electric bikes. The VMT reduction is estimated by assuming the number of new trips that would be incurred by switching to ebikes are displacing SOV trips.

Baseline Case

The baseline case assumes that there are existing pedal and ebike trips that are already replacing SOV trips. Baseline case assumptions include:

- 2022 Annual MetroBike trips: 276,000 trips/year (MetroBike system data)
- % pedal trips: 20% (MetroBike system data)
- % ebike trips: 80% (MetroBike system data)
- Annual Pedal trips: 55,200 trips/year
- Annual Ebike trips: 220,800 trips/year
- Average trip distance: 2 miles/trip (MetroBike system data)

VMT estimation equations include:

- Baseline daily SOV VMT reduction due to pedal bikes = 55,200 trips/year * 2 miles/trip = 110,400 miles/year
- Baseline daily SOV VMT reduction due to ebike = 220,800 trips/year * 2 miles/trip = 441,600 miles/year

Proposed Case

The proposed case assumes VMT will be reduced by switching from a non-electric bikeshare program to an electric bikeshare program. Based on MetroBike system data, the project team assumes that ebikes cover five-times the distance on a per-trip basis as pedal bikes and assume that all new ebike trips would have otherwise been taken in SOVs. Additional proposed case assumptions include:

- Ebike per trip distance compared to pedal trip distance: 5:1 (MetroBike system data)

VMT estimation equations include:

- Pedal trips switching to ebike = 5 * 55,200 pedal trips/year = 276,000 ebike trips/year
- Total new trips from implementing program = 276,000 ebike trips/year - 55,200 pedal trips/year = 220,800 new trips/year
- Daily SOV VMT reduction due to ebikes = 220,800 new trips/year * 2 miles/trip ÷ 365 days/year = 1,210 miles/day

Task 2.2. Large-scale bicycle storage at 16 mobility hubs (park and rides)

Assumptions

In the proposed case, bike storage facilities will be added to mobility hubs. This will encourage SOV drivers to switch to bicycles when traveling to Park and Ride facilities. VMT reduced are calculated by comparing the baseline SOV VMT to Park and Ride Lots to the proposed SOV VMT after a portion of SOV trips are replaced with bicycle trips.

Baseline Case

The baseline case assumes that all Park and Ride users use SOVs for commuting purposes. Baseline assumptions include:

- Current parking spots at Park and Ride lots: 3,964 parking spots = 3,964 one-way trips/day
- 2022 one-way regional average commuter trip length: 11.8 miles/one-way trip (CAMPO 2045 Transportation Plan)[9]
- 2030 one-way regional average commuter trip length: 13.4 miles/one-way trip (CAMPO 2045 Transportation Plan)[10]
- 2050 one-way regional average commuter trip length: 14.3 miles/one-way trip (CAMPO 2045 Transportation Plan)[11]

VMT estimation equations include:

- Baseline daily VMT = daily commute trips to Park and Ride lots * one-way regional average commuter trip length * 2 multiplier for two-way trips

Proposed Case

The proposed case assumes a portion of Park and Ride SOV trips are replaced with bicycle trips. Proposed case assumptions include:

- % driving trips replaced by new bike trips to Park and Ride lots: 10% (CARB)[12]

VMT estimation equations include:

- Daily VMT reduction = Baseline Daily VMT * 10% reduction in VMT

Task 2.3. Dynamic parking for nearly 4,000 parking spaces

Assumptions

The proposed case will provide dynamic parking sensors on Park and Ride parking spaces. VMT reduction is calculated by comparing the current amount of VMT spent looking for parking against the proposed case VMT after sensors are installed.

Baseline Case

The baseline case assumes that cars spend an average amount of VMT looking for parking each day. Baseline case assumptions include:

- Current parking spots at Park and Ride lots: 3,964 cars/day
- Speed at which motorists look for parking: 8 MPH (University of California, Riverside)[13]
- Time spent looking for parking: 6.36 minutes (University of California, Riverside)[14]

VMT estimation equations include:

[9] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[10] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[11] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[12] https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/bicycle%20facilities_summary_032519.pdf
[13] https://economics.ucr.edu/repec/ucr/wpaper/201611.pdf
[14] https://economics.ucr.edu/repec/ucr/wpaper/201611.pdf

- Baseline daily VMT looking for parking = 8 MPH/car * 1/60 hours/min * 6.36 minutes * 3,964 cars

Proposed Case

The proposed case assumes that parking sensors will reduce VMT looking for parking. Proposed case assumptions include:

- % reduction in VMT due to sensors: 30% (SFMTA)[15]

VMT estimation equations include:

- Daily VMT reduced = Baseline daily VMT looking for parking * 30% reduction in VMT

Task 2.4. Bike and pedestrian counters and Task 2.5. AQI data monitoring infrastructure

VMT reductions were not directly measured for these tasks because they support the bike-related VMT reductions calculated in Tasks 2.1 and 2.2.

Measure GHG Reduction Uncertainties:

- The actual average distance to travel to a Park and Ride lot is unknown, so the average commute distance is used instead.
- The actual amount of SOV VMT replaced by ebike VMT is unknown and is assumed to be a one-to-one replacement for calculation purposes.
- Local VMT/day spent looking for parking is unknown and is instead based on a separate study.

Measure 3: Inspiring Behavior Change

Task 3.1. Provide transportation wallets, subsidies, incentives, and rewards for commuters to take low-GHG trips in place of SOV trips

Assumptions

The proposed case provides alternative commuting incentives for up to 90 days per year for a minimum of 70,700 commuters. VMT reductions are calculated by comparing total SOV commute VMT without an incentive program to SOV commute VMT after an incentive program. This program does not increase transit VMT but incentivizes commuters to use existing transit. Therefore, the calculations do not include adding new transit VMT since the same amount of transit VMT would occur in the baseline and proposed cases. Even though the program only offers the incentives for 90 days per year, it is assumed that there will be continuation rates of up to 70% after the incentive period closes, resulting in long-term emissions reductions due to behavioral change.

Baseline Case

The baseline case assumes commuters would use SOV vehicles without transit incentives. Baseline case assumptions include:

- 2022 % SOV for resident workers in Travis County: 56.6% SOV/commuter (2022 ACS)[16]
- Minimum commuters who will receive cash inventive: 70,700 commuters

[15] https://www.sfmta.com/sites/default/files/reports-and-documents/2018/04/sfpark_eval_summary_2014.pdf
[16] https://data.census.gov/table/ACSST1Y2022.S0801?q=journey%20to%20work&g=050XX00US48453

- 2022 one-way regional average commuter trip length: 11.8 miles/one-way trip (CAMPO 2045 Transportation Plan)[17]
- 2030 one-way regional average commuter trip length: 13.4 miles/one-way trip (CAMPO 2045 Transportation Plan)[18]
- 2050 one-way regional average commuter trip length: 14.3 miles/one-way trip (CAMPO 2045 Transportation Plan)[19]

VMT estimation equations include:

- Daily commute SOV trips for commuters who will receive cash incentive = 70,700 commuters * 56.5% SOV/commuter
- Baseline daily VMT = daily commute SOV trips * one-way regional average commuter trip length * 2 multiplier for two-way trips

Proposed Case

The proposed case assumes a cash incentive will reduce SOV VMT depending on the incentive amount. It also assumes there is 70% annual participation for the 70,700 commuters receiving incentives; incentives are only offered 90 days per year but are expected to create lasting behavior change. Proposed case assumptions include:

- Daily cash incentive: $5 (for up to 90 days per year)
- Participation rate: 70% participation/year (FHWA)[20]
- % VMT reduction due to subsidy: 16% (Victoria Transport Policy Institute)[21]
    - From TDM Encyclopedia Table 2: Transit/HOV Subsidy Vehicle Trip Reduction assuming $2/day ($2/day in 1993 is approximately $4.30 now) for a worksite setting of "Activity Center, mode neutral".

VMT estimation equations include:

- Daily VMT reduction = Baseline Daily VMT * 16% reduction in VMT * 70% participation/year

Task 3.2. Implement grassroots, community-based programming to develop personalized travel planning for hard-to-reach communities impacted by major construction projects; Task 3.3. Implement a coordinated and holistic regional mobility platform for TDM; Task 3.4. Execute a regional multilingual marketing and communications campaign.

Assumptions

These tasks are grouped together as they all involve education, outreach, and travel planning to encourage behavioral change. VMT reductions are calculated by comparing total SOV commute VMT without an education and outreach program to SOV commute VMT after an education and outreach program is implemented. This program does not increase transit VMT but incentivizes commuters to use

[17] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[18] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[19] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[20] https://ops.fhwa.dot.gov/publications/fhwahop12035/chap10.htm
[21] https://www.vtpi.org/tdm/tdm8.htm

existing transit. Therefore, the calculations do not include adding new transit VMT since the same amount of transit VMT would occur in the baseline and proposed cases.

Baseline Case

The baseline case assumes that commuters would take SOVs if there was no education and outreach program in place. Baseline case assumptions include:

- 2022 % SOV for resident workers in Travis County: 56.6% SOV/commuter (2022 ACS)[22]
- Total Austin labor force: 524,495 workers (2022 ACS)[23]
- Total Austin population: 905,757 people (2022 ACS)[24]
- Population for I-35 DEIS study area: 230,541 people (2022 ACS)[25]
- 2022 one-way regional average commuter trip length: 11.8 miles/one-way trip (CAMPO 2045 Transportation Plan)[26]
- 2030 one-way regional average commuter trip length: 13.4 miles/one-way trip (CAMPO 2045 Transportation Plan)[27]
- 2050 one-way regional average commuter trip length: 14.3 miles/one-way trip (CAMPO 2045 Transportation Plan)[28]
- Annual VMT growth factor: 2.78% (CAMPO)[29]

VMT estimation equations include:

- Ratio of Austin labor force to population= 524,495 workers ÷ 905,757 people = 57.9%
- Labor force in I-35 DEIS study area = 230,541 population in study area * 57.9% = 133,499 people
- One-way commute trips/day = Labor force * 57% SOV
    - Commute trips are forecast to 2050 using the annual VMT growth factor
- Baseline daily VMT = daily commute SOV trips * one-way regional average commuter trip length * 2 multiplier for two-way trips

Proposed Case

The proposed case assumes that a portion SOV commuters would switch to transit after and education and outreach program is implemented. Proposed case assumptions include:

- % reduction in VMT: 8% (Victoria Transport Policy Institute)[30]
    - The study concludes that well-managed voluntary travel behavior change programs typically reduce participant's vehicle travel by 5% to 8%

VMT estimation equations include:

[22] https://data.census.gov/table/ACSST1Y2022.S0801?q=journey%20to%20work&g=050XX00US48453
[23] https://data.census.gov/table/ACSST1Y2022.S0801?q=journey%20to%20work&g=050XX00US48453
[24] https://data.census.gov/table/ACSST5Y2022.S0101?q=journey%20to%20work&g=060XX00US4845390165
[25] https://data.census.gov/table/ACSST1Y2022.S0801?q=journey%20to%20work&g=050XX00US48453
[26] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[27] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[28] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[29] https://www.campotexas.org/regional-transportation-plans/2045-plan/
[30] https://www.vtpi.org/tdm/tdm23.htm

- Daily VMT reduction = Baseline Daily VMT * 8% reduction in VMT

Measure GHG Reduction Uncertainties:

- The actual number of commuters receiving incentives given will most likely be higher than what is estimated.
- The amount of people permanently adopting the behavioral change may vary.

GHG Emissions Calculation

Vehicle emission factors are dependent on vehicle and fuel types. The project team assumed that all Measure VMT reductions are from gasoline passenger vehicles and Measure 1 will add diesel bus VMT. However, CapMetro is transitioning its bus fleet to electric vehicles, which will produce less GHG emissions than diesel buses. Therefore, the additional bus emissions included in Measure 1 to reflect the project's increased bus service are likely an overestimate because they assume future diesel bus activity while CapMetro is moving toward electric buses. If CapMetro does use electric buses to provide this increased future service, GHG reductions from this measure would be higher than estimated in this application.

Vehicle CO_2 emission factors are from the EPA Emission Factors Hub.[31] Annual vehicle fuel economy factors for 2025-2050 and CH_4 and N_2O emission factors are based on national values from ICLEI.[32] ICLEI projects passenger car fuel economies by applying CAFE Standard impacts and derives emissions factors from national EPA data. Annual fuel economy and vehicle emissions factors were multiplied by annual VMT values for each measure and summed to calculate cumulative emissions reductions for 2025-2030 and 2025-2050.

GHG Reduction Calculation Uncertainties:

- All commuters may not use gasoline SOVs, which is the assumption for all baseline case VMT reductions.
- MPGs and emission factors will differ depending on the local fleet mix. As the emission factors used in the Measure calculations are based on national fleet information, the MPG and emission factors may differ locally.

Durability of Reductions:

As these Measures rely heavily on behavior change, the permanency of the GHG reductions from these Measures is more certain if the following conditions are met:

- The transit services, alternate transport amenities, and VMT reduction programs are offered until 2050 at a minimum, and;
- Commuters continue with the behavior changes encouraged by these actions (e.g., using transit, bicycles, etc.).

However, travel behaviors may change over time depending on external factors that cannot be addressed by the proposed Measures (e.g., fuel costs, travel times, development patterns, etc.).

[31] https://www.epa.gov/climateleadership/ghg-emission-factors-hub

[32] https://docs.google.com/spreadsheets/d/1KXmtHoxI-mPXz0ujidtj76woUcK-RN9ITMRy-gMoUls/edit#gid=1929834944