Final Project Report

URBAN TRANSPORTATION MODELING

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Contents

List of Abbreviations

CCRPC – Champaign County Regional Planning Commission
CUMTD – Champaign Urbana Mass Transit District
FHWA – Federal Highway Administration
GGE – Gallon Gas Equivalent
GHG – Greenhouse Gas
iCAP – Illinois Climate Action Plan
MT – Million Tons
TAZ – Traffic Analysis Zone
UIUC – University of Illinois at Urbana Champaign
U.S. EPA – United States Environmental Protection Agency
VHT – Vehicle Hours Travelled
VMT – Vehicles Miles Travelled

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Introduction

Objectives & Assumptions

This report discusses the results from the CUAATS Travel Demand Model which aims to understand observed transportation patterns and compare them with two different scenarios. The scenarios for analysis are as follows:

1. 2015 (Baseline)
2. 2040 Traditional Development (Business-as-usual)
3. 2040 Sprawling Development (Scenario 2B).

Scenario 2B also generates additional 5,000 employment in Traffic Analysis Zones (TAZ) near the Willard Airport and 5,000 employment in University Research Park.

The report serves to deliver policy recommendations to the Champaign County Regional Planning Commission (CCRPC), the Champaign-Urbana Mass Transit District (CUMTD), the City of Champaign, and the City of Urbana. The overarching objective is to focus future transportation network design to be efficient and equitable, in synchronization with the state's sustainability goals and the Illinois Climate Action Plan (iCAP).

"To create an efficient, sustainable, and equitable transport network – for all."

Table 1 Scenarios with Population Changes

Scenario	2040 (Business-as-usual)	2B (Sprawling Development)
2010 Population	201,081	201,081
Scenario Population	245,000	267,000
Additional Population	43,919	65,919

TAZ Selection

The first step to select TAZs for scenario 2B. These are to be situated at specific locations as follows:

- Fringe TAZs
- Willard Airport
- TAZs near Willard Airport
- UIUC Research Park

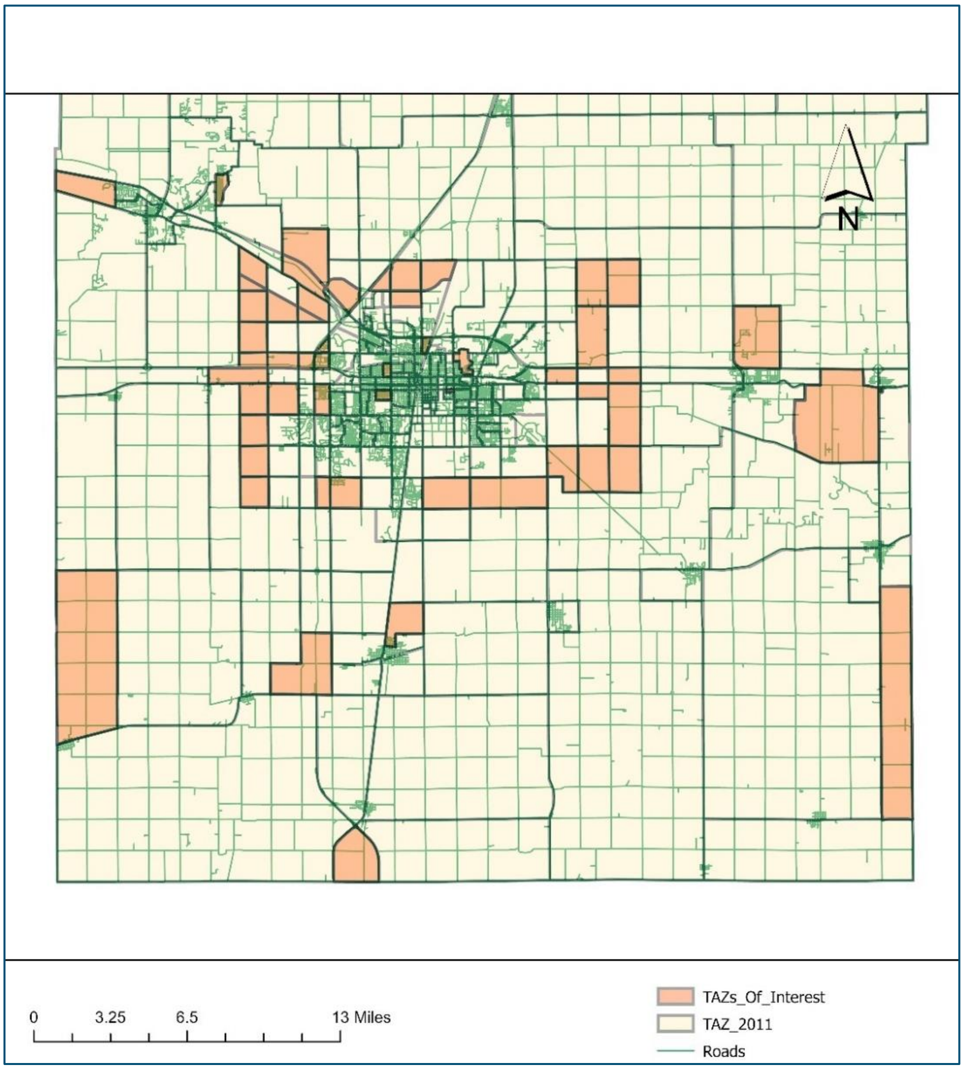

Figure 1 TAZ Selection for Travel Demand Modeling

Distribution across the TAZs is 70:20:10, where most of the additional population (70%) is distributed to the fringe TAZs. The TAZs near Willard Airport and the UIUC Research Park are allocated some of the remaining portion (20%), while the core is assumed to be saturated by 2040 and allows a small increase (10%).

CUAATS TDM

Analysis & Discussion

The CUAATS Travel Demand Model is run for the three scenarios with predefined constraints and specifications. The outputs of the model are discussed in the section below. The inferences from the modelling result form the basis of policy recommendations to achieve the objectives outlined in the report.
The recommendations focus on sustainability, efficiency, and equity as the means to build a better transit network by 2040. The CUAATS Travel Demand Model has certain built-in limitations which were observed during the scenario trials. The model makes several assumptions that run similar across different scenarios which are not representative of the real-world scenario. These limitations result in a constrained result showing smaller differences among the scenarios as compared to what should ideally have been depicted based on practical considerations.

Volume Concentration

In 2010, congestion is observed at points near Neil St. and on Springfield Ave. Higher congestion is observed to be consistent across C-U. The 2040 model traffic volume concentration has increased in some parts of the core region which follows the same patterns as 2010. Congestion persists near Neil St. and Springfield Ave. When the alternative sprawling congestion is considered in the CUUATS Travel Demand Model, it results in less congestion in the Champaign-Urbana city centre. This finding seems realistic given present conditions that are prevalent in Champaign-Urbana. The growth of jobs and people are concentrated further away leaning to less congestion in historically high population densities.

Baseline 2010

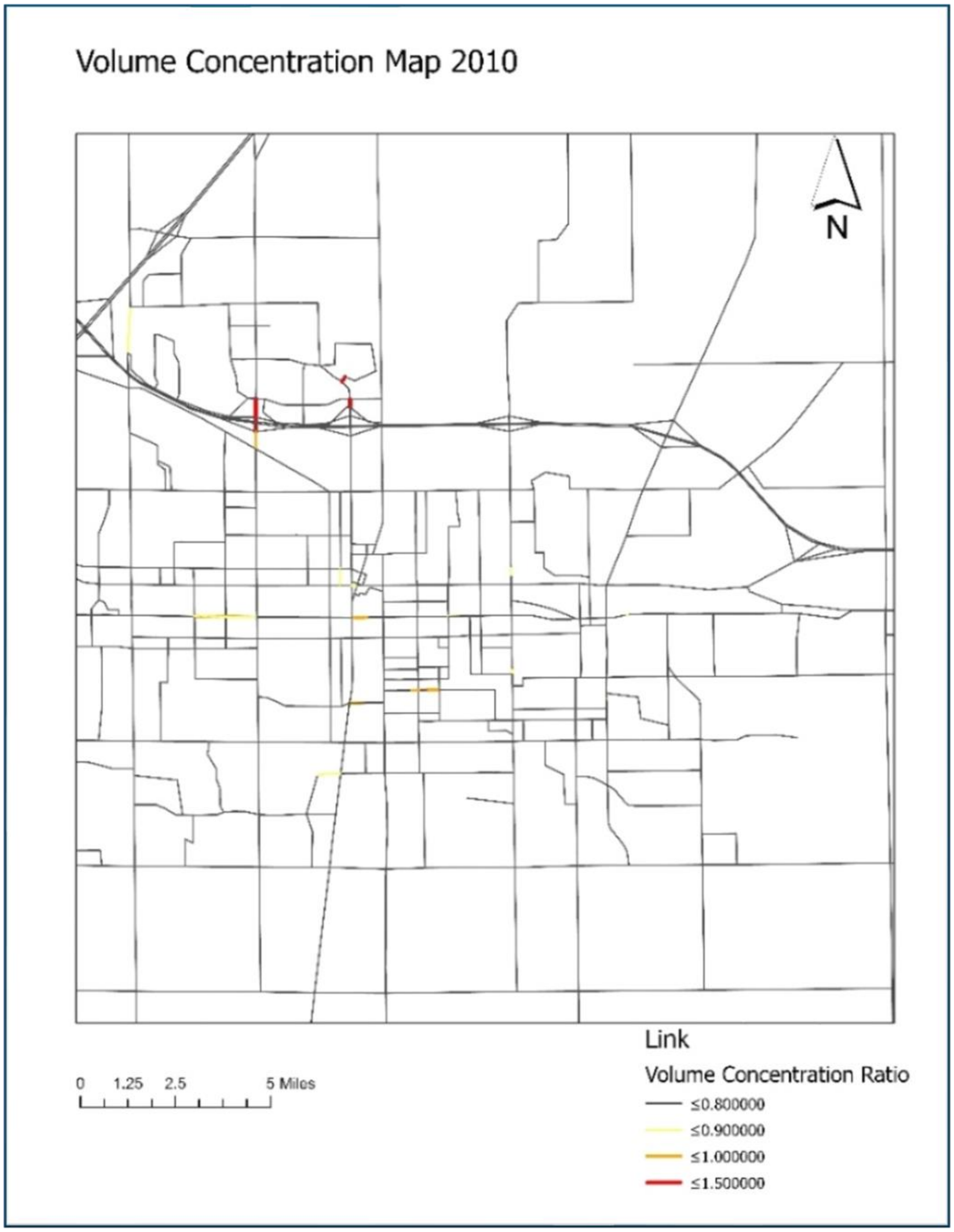

Figure 2 Traffic Volume Concentration Map (2010)

- Volume concentration as modelled for the year 2010.
- Congestion is observed at points near Neil St. and on Springfield Ave.
- Higher congestion is observed to be consistent across C-U.

Traditional Development 2040 (Business-as-usual)

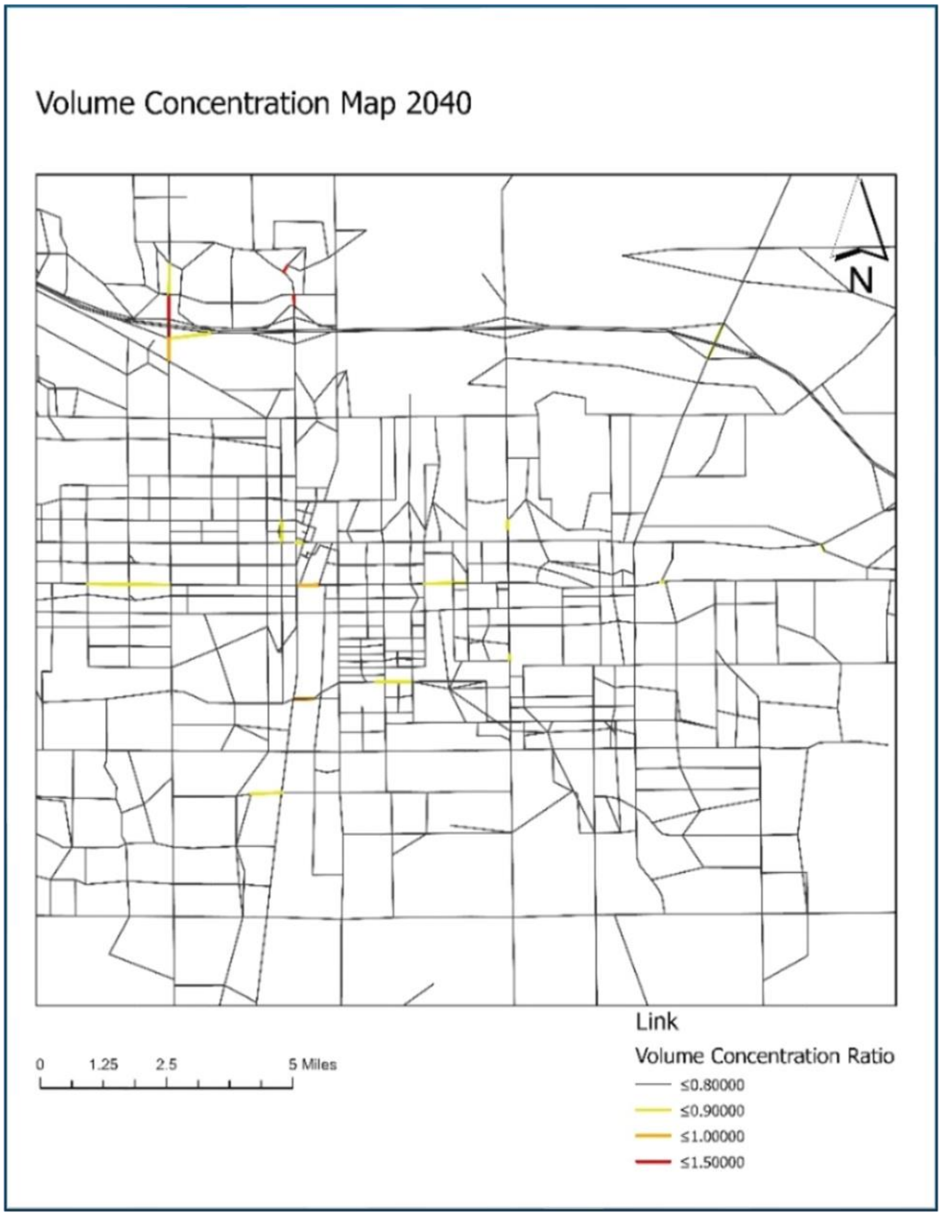

Figure 3 Traffic Volume Concentration Map (2040)

- Traffic volume concentration has increased in some parts of the core region.
- The traditional development scenario follows the same patterns as in 2010.
- Congestion persists near Neil St. and Springfield Ave.

Sprawling Development 2040 (Scenario 2B)

Figure 4 Traffic Volume Concentration Map (2B)

- Sprawling development encourages traffic movement on the peripheries of C-U.
- Traffic concentration is observed to be spread out.
- Two additional points of congestion are added in the northern part of Champaign.

Congested Speeds

In all three scenarios, the congestion speed did not see an overwhelming change. While congestion volumes seemed to decrease in the alternative scenario, the Traditional Development 2040 scenario had the smallest congested speeds overall compared to the other two scenarios. The results show that sprawl may have a significant impact on volume concentration but little to no impact on congestion speed. Another reasoning for the minimal impact could be a lack of sensitivity to sprawling development in the model itself.

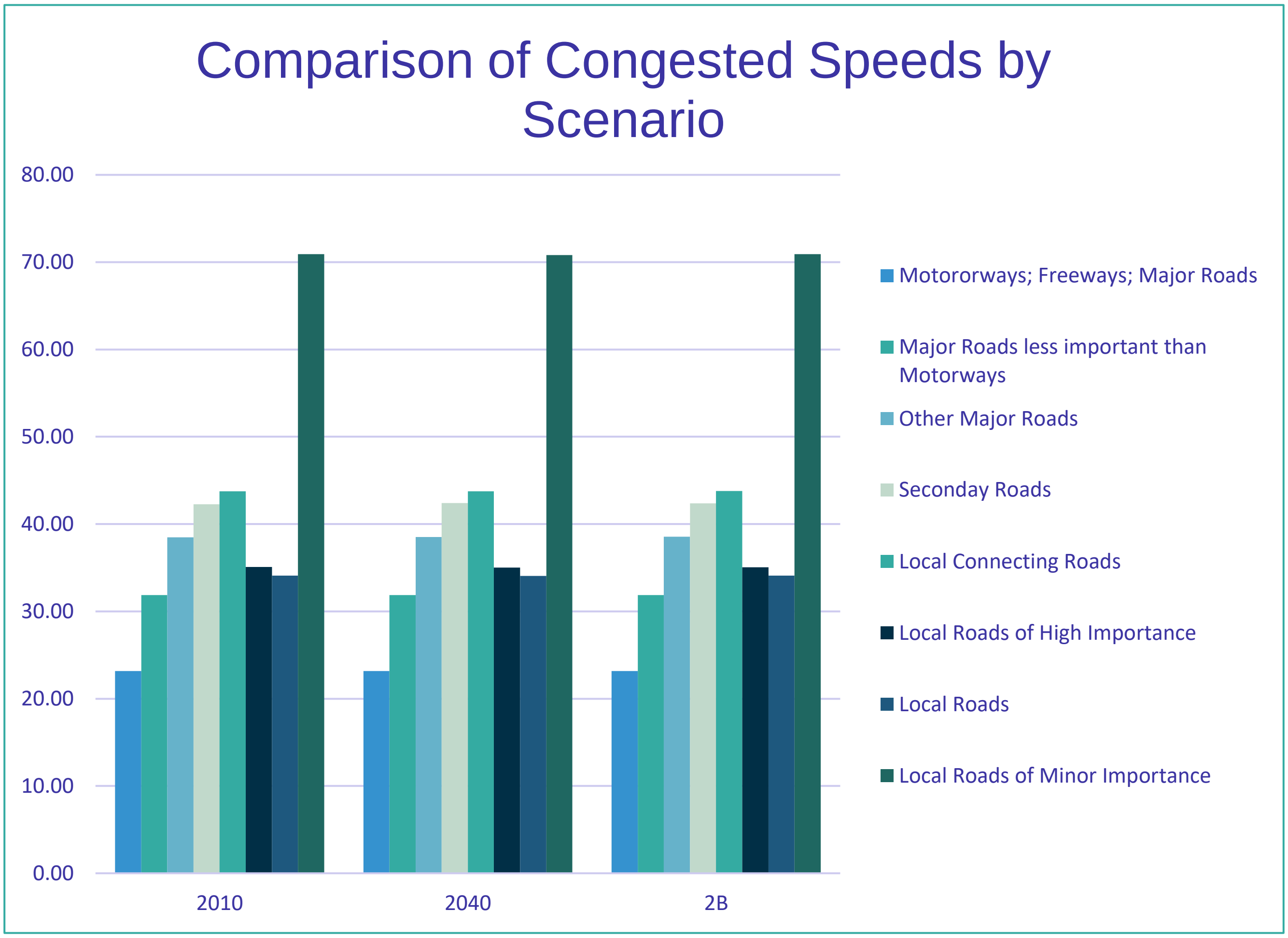

Figure 5 Average Congested Speed for Each Scenario

Vehicle Miles Travelled/Vehicle Hours Travelled

The changes in Vehicle Miles Travelled and Vehicle Hours Travelled are similar for Traditional Development 2040 and Sprawling Development (Scenario 2B) when compared to the Baseline 2010 model. In both cases, traditional growth causes approximately a 33% increase for local roads, a 12% increase for local roads of minor and high importance and a 17% decrease in major roads less important than motorways. While the alternative model saw increases in all local roads except local connecting roads and a decrease in all other categories. Each result was less than a 10% difference. This reinforces previous findings of similarities between the Baseline 2010 model and Scenario 2B.

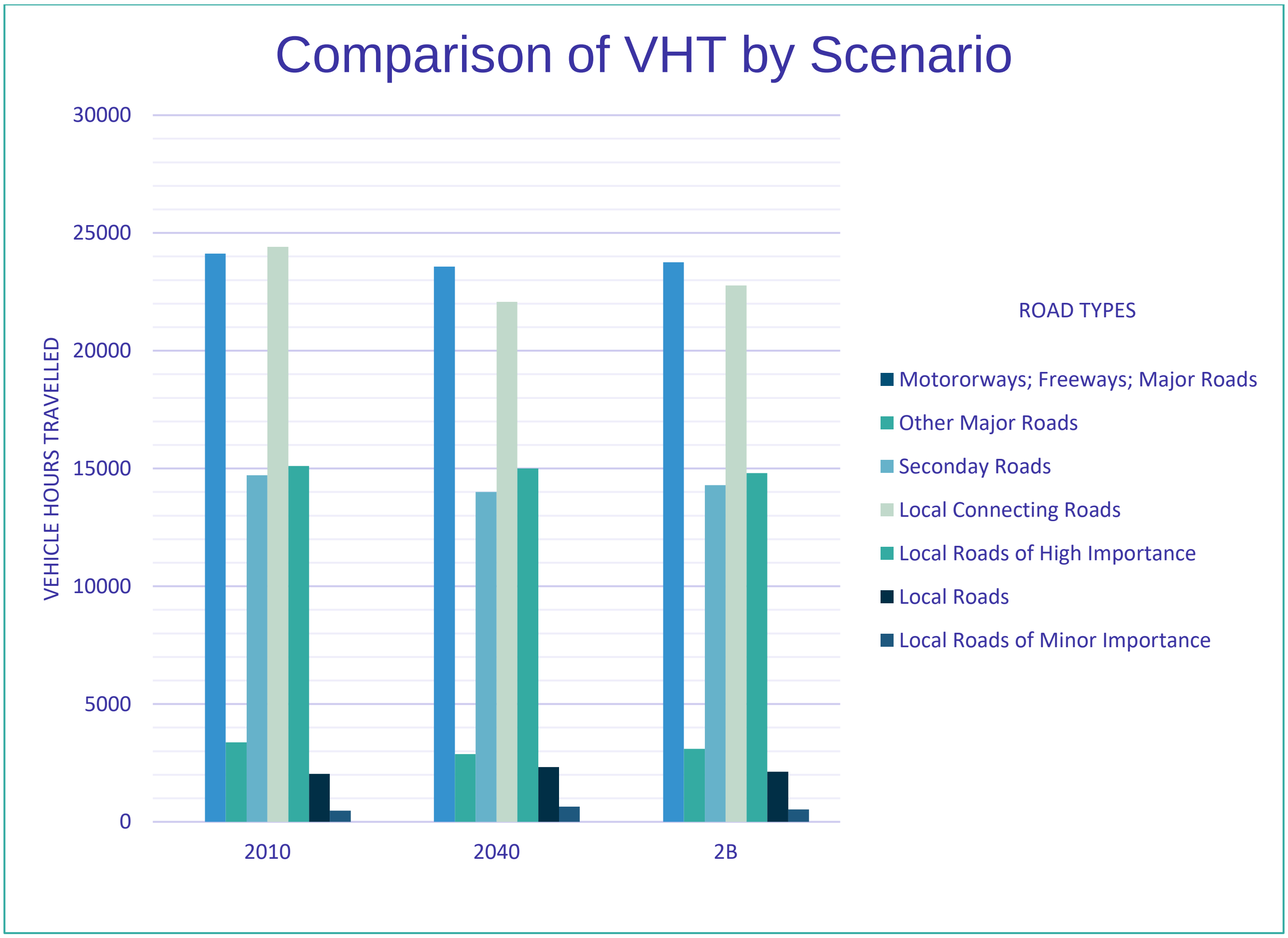

Figure 7 Comparison of VHT by Scenario

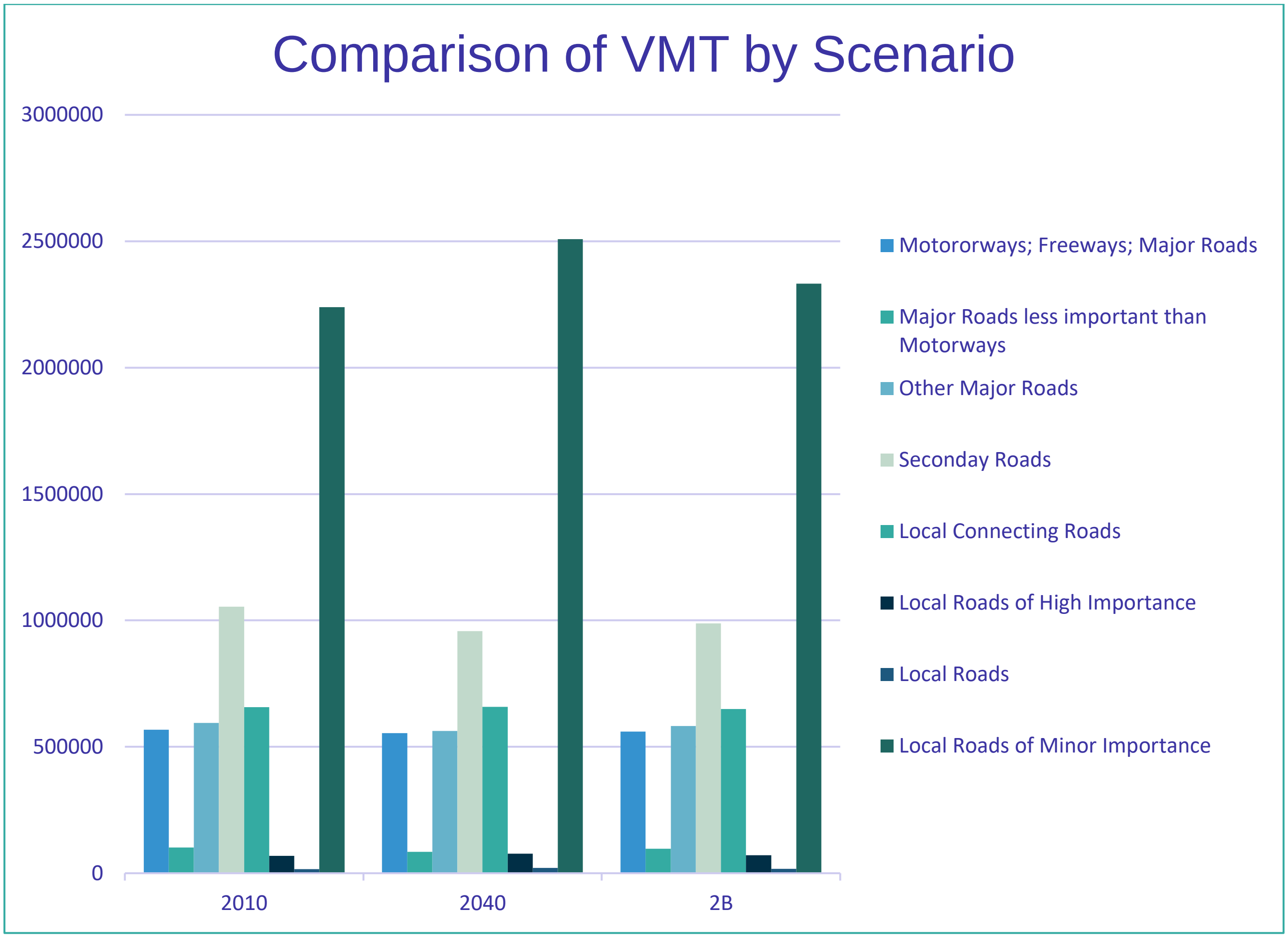

Figure 8 Comparison of VMT by Scenario

The Vehicle Miles Traveled (VMT) for all the scenarios also conformed to the pattern of VHT as observed in *Figure 7* and *Figure 8*. Local roads (Type 7) contribute to the most VMT for all the scenarios. This conformity is expected to be a result of the insignificant changes in travel pattern due to the sprawling development.

Modal Split

The mode choices of the population are similar between the Baseline 2010 model and Traditional Development 2040 as seen in *Figure 9* and *Figure 10* below. All modes resulted in less than an 1% difference.

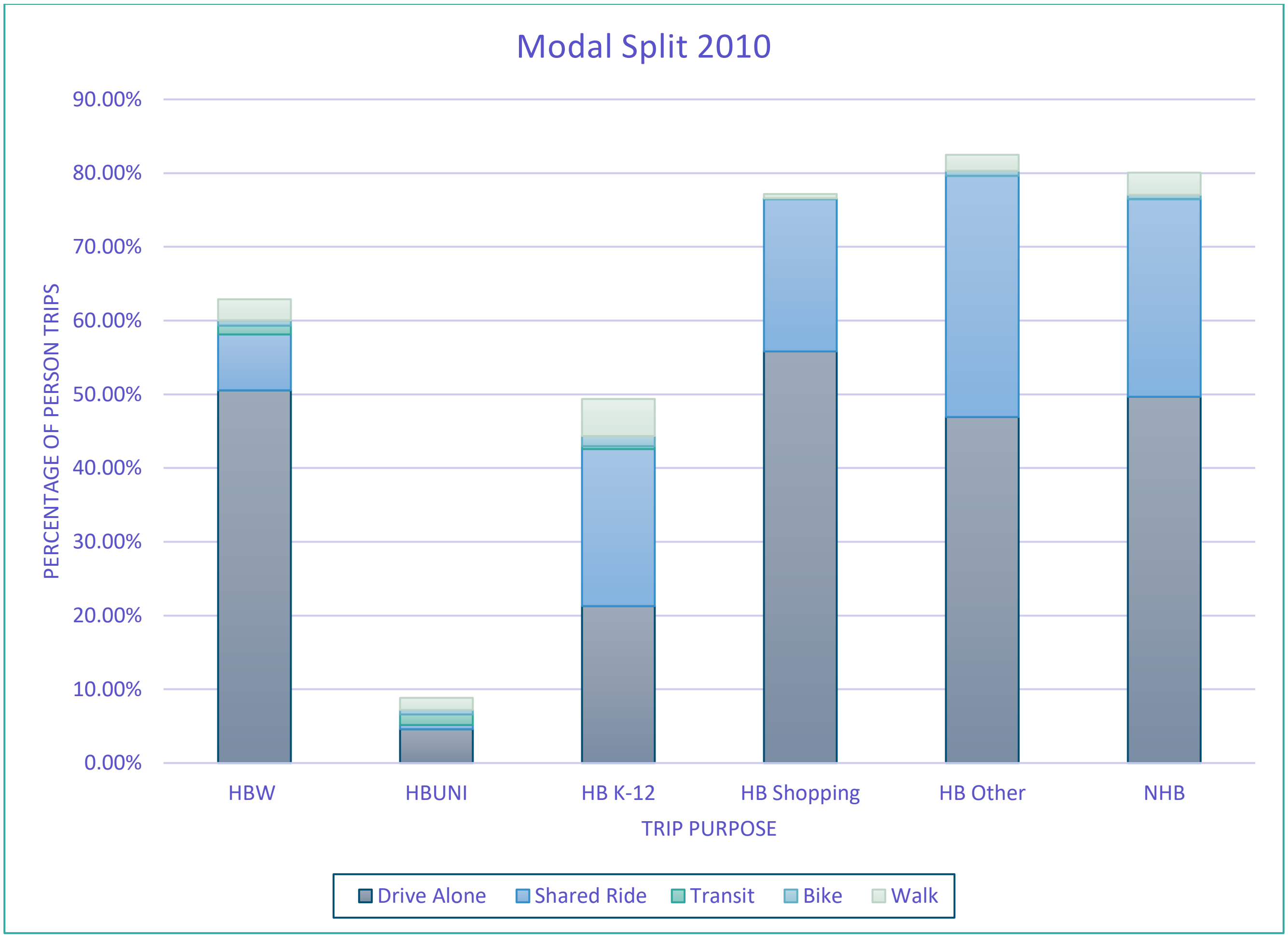

Figure 9 Modal Split 2010

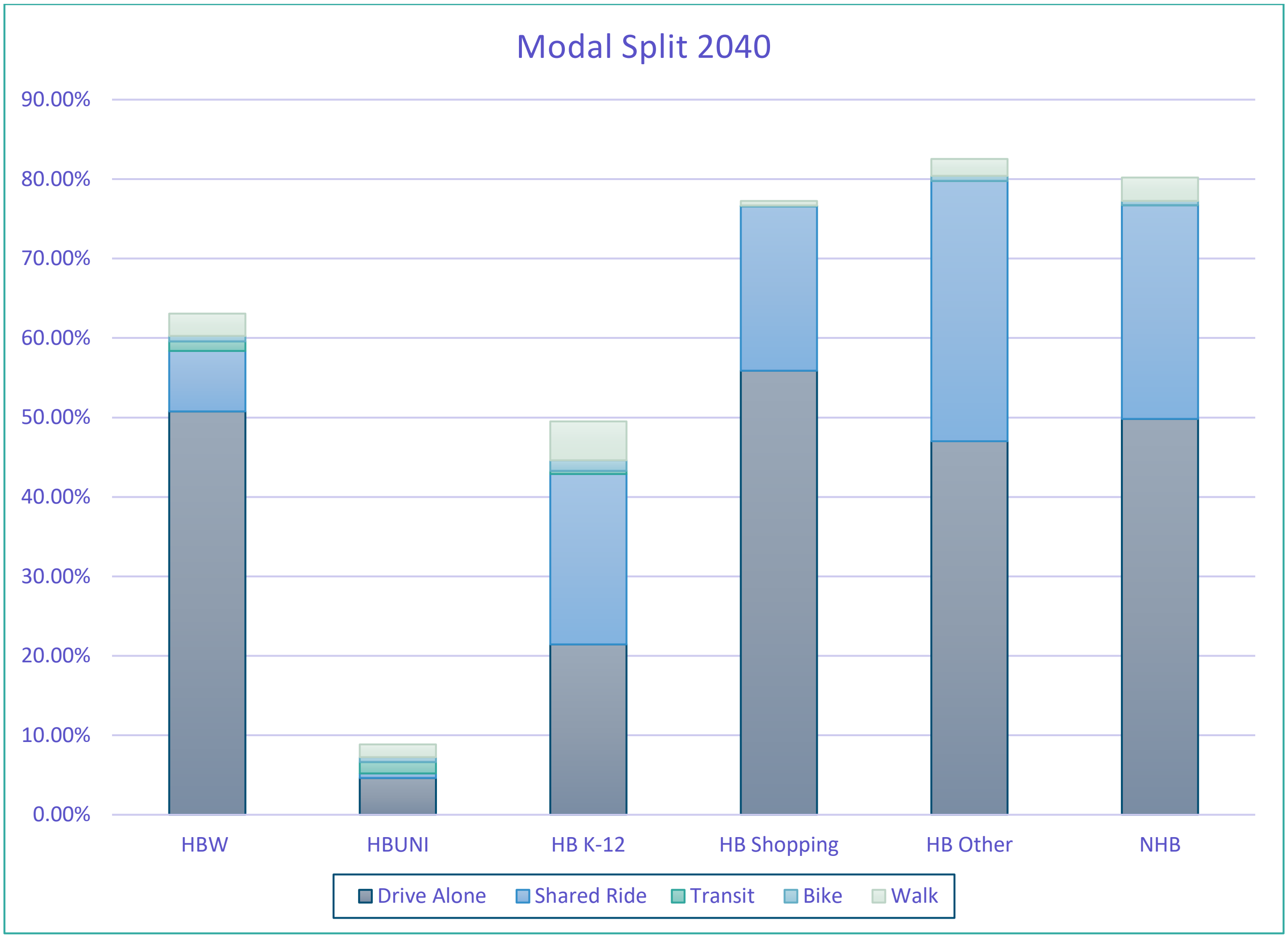

Figure 10 Modal Split 2040

This makes sense given the mode choices historically have been more dependent on drive alone trips. On the other hand, trends cited by CUUATS show that there will be more sprawl in the future. The modal split in 2040 should result in findings that mirror the alternative scenario 2B as shown by *Figure 11*.

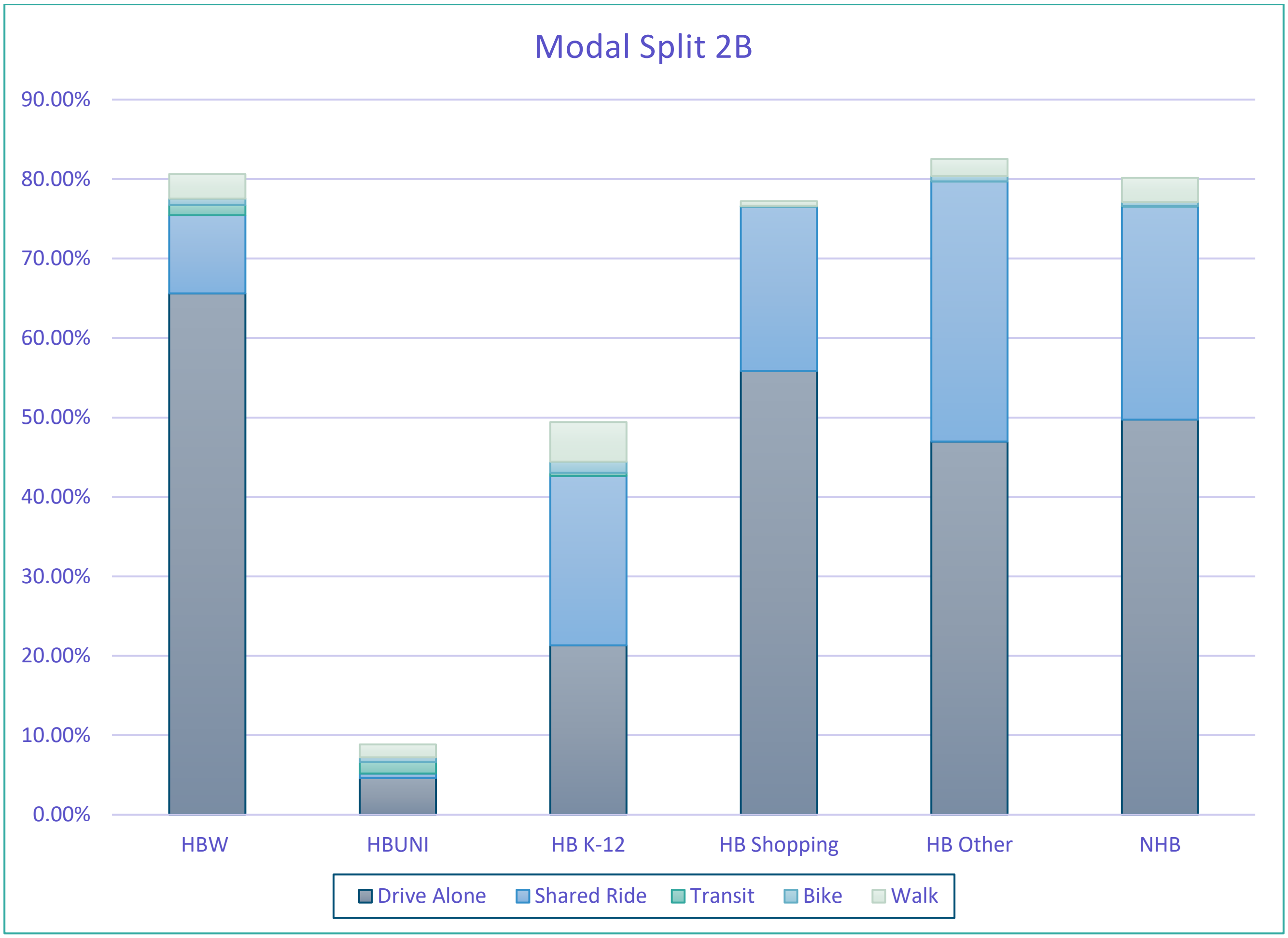

Figure 11 Modal Split 2B

The alternative sprawling model yielded a difference in home-based work drive alone trips. This finding was expected. The concentrated sprawling development would shape an increasingly auto-dependent area surrounding Willard Airport and University Research Park. This finding shows that the model is sensitive to changes in aggressive sprawling patterns but, leaves room to question if the changes are captured in a significant way.

Environmental Impact Assessment

Greenhouse Gas Emissions by Travel Mode

In 2014, U.S. greenhouse gas (GHG) emissions totalled 6,870 million metric tons (15.1 trillion pounds) of carbon dioxide equivalents **(U.S. EPA, 2021)**.
The table below outlines the GHG emission by mode choice for the years 2010, 2040, as well as for Scenario 2B. For complete calculations referenced from the U.S. Department of Energy, refer to *Appendix 1* and *Appendix 2*. The unit of measurement is Carbon Dioxide Equivalent in Metric Tons (CO_2E) of GHG emissions.

Table 2 GHG Emission by Mode Choice (in CO_2E)

Mode Choice	2010 (Baseline Scenario)	2040 Traditional Development (Business-as-usual)	2040 Sprawling Development (Scenario 2B)
Auto	2,825 MT	2,892 MT	2,824 MT
Shared Ride	1,847 MT	1,891 MT	1,846 MT
Transit	8,532 MT	8,734 MT	8,529 MT

FHWA states the mean state-level bus occupancy rate is 20.29, while the occupancy rate of ride-sharing pertaining to four-seater cars is 1.67 **(Federal Highway Administration, 2018)**. The occupancy rates for the different mode choices are incorporated into *Table 2* to obtain GHG emissions per capita for the specific scenarios as shown in *Table 3*.

Table 3 GHG Emission per Capita (CO_2E)

Mode Choice	Occupancy Factor	2010 (Baseline Scenario)	2040 Traditional Development (Business-as-usual)	2040 Sprawling Development (Scenario 2B)
Auto	1	2825	2892	2824
Shared Ride	1.67	1106	1132	1105
Transit	20.29	421	430	420

Table 3 shows that the per capita GHG emission by transit users is 420 to 430 CO_2E MT. This is remarkably lower than the per capita emission by auto (single-occupancy) commuters which is approximately 2800 CO_2E MT.

Conclusion

Policy Recommendations & Limitations

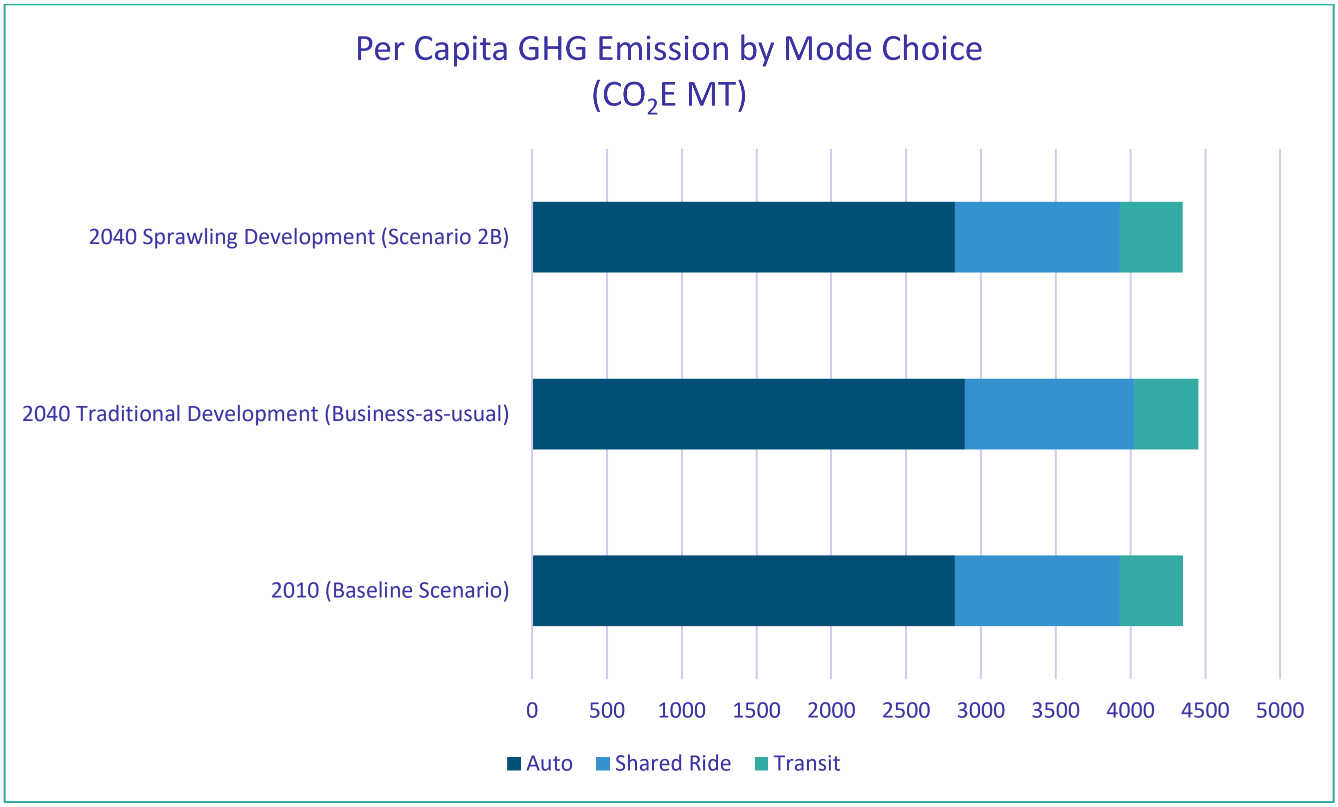

Figure 12 Per Capita GHG Emission by Mode Choice (CO_2E MT)

The CUAATS Travel Demand Model results show that sprawling development in the case of Scenario 2B would not have any significant effect on traffic congestion as shown in the traffic volume concentration maps (*Figure 3* and *Figure 4*).

This finding can be misleading as it would give a false sense of security in terms of development direction and it would also discourage diversity of choice in transit mode. Sprawling development and the associated decrease in traffic congestion would encourage private vehicle usage and consequently result in externalities detrimental to the environment.

The GHG emission analysis described in this report highlight this issue; *Figure 12* shows that while transit has more vehicle miles travelled, the per capita emission of greenhouse gases is 15% of the GHG contribution from single-occupancy private vehicle usage.

This report recommends the following to CCRPC, CUMTD, and the City Councils of Champaign and Urbana:

1. Promote public transit usage as a more **sustainable** mode of transit through public information notices showing data on dollar cost savings, reduction in GHG emissions, and time-cost efficacy.
2. Implement a strategy to reduce overall vehicle miles travelled for transit vehicles by optimizing factors that affect **efficiency**.
   - Identify service lines with minimal footfall.
   - Reduce the operating frequency of these lines by increasing the headways between buses/shuttles.
   - Add additional stops to more busy routes to increase serviceability.
3. Refocus priorities to shift from auto-dependency and towards public transit through infrastructural advancements that promote **equity** and accessibility.
   - Construct more bus shelters with heating facilities to increase footfall during the winter.
   - Add surveillance cameras and adequate lighting at bus stops to ensure safety.
   - Ensure equitable access to and from buses for the disabled and the senior population in the community by installing tactile pavements, movement supports, guardrails, and notices/schedules in braille.

References

Federal Highway Administration. (2018, April). *https://www.fhwa.dot.gov/tpm/guidance/avo_factors.pdf.* Retrieved from U.S. Department of Transportation FHWA Website: https://www.fhwa.dot.gov/tpm/guidance/avo_factors.pdf

U.S. Department of Energy. (2020, February). *Alternative Fuels Data Center.* Retrieved from U.S. Department of Energy Website: https://afdc.energy.gov/data/10310

U.S. EPA. (2021, April 9). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2019*. Retrieved from U.S. EPA Website: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Appendix

Appendix 1 Average Miles Per Gallon Gas Equivalent by Mode Choice

<table>
<tr><th>Mode Choice</th><th>Mode Group</th><th>Miles Per Gallon Gas Equivalent (GGE)</th><th>Average Miles Per GGE</th></tr>
<tr><td>Motorcycle</td><td rowspan="6">Auto</td><td>44</td><td rowspan="6">16.67</td></tr>
<tr><td>Car</td><td>24.2</td></tr>
<tr><td>Light Truck/Van</td><td>17.5</td></tr>
<tr><td>Delivery Truck</td><td>6.5</td></tr>
<tr><td>Class 8 Truck</td><td>5.29</td></tr>
<tr><td>Refuse Truck</td><td>2.53</td></tr>
<tr><td>Ride-sourcing</td><td>Shared Ride</td><td>25.5</td><td>25.5</td></tr>
<tr><td>Paratransit Shuttle</td><td rowspan="3">Transit</td><td>7.1</td><td rowspan="3">5.52</td></tr>
<tr><td>School Bus</td><td>6.2</td></tr>
<tr><td>Transit Bus</td><td>3.26</td></tr>
<tr><td colspan="4">Source: Alternative Fuels Data Center (U.S. Department of Energy, 2020)</td></tr>
</table>

Appendix 2 GHG Emissions by Mode Choice

2010 (Baseline Scenario)				2040 Traditional Development (Business-as-usual)				2040 Sprawling Development (Scenario 2B)			
Mode Choice	Road Type	GGE Consumption	GHG Emission (MT)	Mode Choice	Road Type	GGE Consumption	GHG Emission (MT)	Mode Choice	Road Type	GGE Consumption	GHG Emission (MT)
Auto	0	34,020		*Auto*	0	33,281		*Auto*	0	33,610	
	1	6,137			1	5,110			1	5,831	
	2	35,683			2	33,758			2	34,904	
	3	63,262			3	57,441			3	59,289	
	4	39,392			4	39,485			4	38,949	
	5	4,127			5	4,609			5	4,259	
	6	953			6	1,267			6	1,050	
	7	134,318			7	150,477			7	139,920	
	Total	317,893	**2,825**		Total	325,428	**2,892**		Total	317,811	**2,824**
Shared Ride	0	22,240		*Shared Ride*	0	21,756		*Shared Ride*	0	21,972	
	1	4,012			1	3,340			1	3,812	
	2	23,327			2	22,069			2	22,818	
	3	41,356			3	37,550			3	38,759	
	4	25,752			4	25,813			4	25,462	
	5	2,698			5	3,013			5	2,784	
	6	623			6	828			6	686	
	7	87,807			7	98,371			7	91,469	
	Total	207,815	**1,847**		Total	212,741	**1,891**		Total	207,761	**1,846**
Transit	0	102,738		*Transit*	0	100,505		*Transit*	0	101,499	
	1	18,535			1	15,431			1	17,608	
	2	107,759			2	101,948			2	105,409	
	3	191,047			3	173,466			3	179,048	
	4	118,962			4	119,243			4	117,624	
	5	12,463			5	13,919			5	12,861	
	6	2,879			6	3,826			6	3,170	
	7	405,630			7	454,431			7	422,549	
	Total	960,014	**8,532**		Total	982,769	**8,734**		Total	959,767	**8,529**

Appendix 3 Vehicle Miles Travelled (Miles)

Road Type	2010	2040	2B	% Change (2010 to 2040)	% Change (2010 & 2B)
Motorways; Freeways; Major Roads	567111	554789	560273	-2%	-1%
Major Roads less important than Motorways	102311	85178	97196	-17%	-5%
Other Major Roads	594832	562752	581855	-5%	-2%
Secondary Roads	1054582	957535	988344	-9%	-6%
Local Connecting Roads	656672	658222	649286	0%	-1%
Local Roads of High Importance	68798	76835	70991	12%	3%
Local Roads	15894	21118	17499	33%	10%
Local Roads of Minor Importance	2239077	2508458	2332470	12%	4%

Appendix 4 Vehicle Hours Travelled (Miles)

Road Type	2010	2040	2B	% Change (2010 to 2040)	% Change (2010 to 2B)
Motorways; Freeways; Major Roads	24121	23570	23751	-2%	-2%
Major Roads less important than Motorways	3371	2874	3103	-15%	-8%
Other Major Roads	14718	14005	14291	-5%	-3%
Secondary Roads	24419	22072	22771	-10%	-7%
Local Connecting Roads	15102	15006	14806	-1%	-2%
Local Roads of High Importance	2041	2320	2122	14%	4%
Local Roads	478	645	531	35%	11%
Local Roads of Minor Importance	33130	36883	34386	11%	4%

Appendix 5 Average Congested Speeds (MPH)

Road Type	2010	2040	2B	Difference between 2010 & 2040	Difference between 2010 & 2B
Motorways; Freeways; Major Roads	23	23	23	0.0%	0.0%
Major Roads less important than Motorways	32	32	32	0.1%	0.1%
Other Major Roads	38	39	39	0.1%	0.1%
Secondary Roads	42	42	42	0.3%	0.3%
Local Connecting Roads	44	44	44	0.0%	0.1%
Local Roads of High Importance	35	35	35	-0.2%	-0.1%
Local Roads	34	34	34	0.0%	0.0%
Local Roads of Minor Importance	71	71	71	-0.2%	0.0%

Appendix 6 Mode Choice by Trip Purpose

Base 2010						
	HBW	HBUNI	HB K-12	HB Shopping	HB Other	NHB
Drive Alone	50.55%	4.60%	21.29%	55.82%	46.94%	49.68%
Shared Ride	7.58%	0.57%	21.29%	20.66%	32.70%	26.81%
Transit	1.19%	1.43%	0.39%	0.02%	0.01%	0.02%
Bike	0.72%	0.62%	1.39%	0.09%	0.67%	0.55%
Walk	2.86%	1.63%	5.01%	0.58%	2.17%	3.01%
Traditional Development 2040						
	HBW	HBUNI	HB K-12	HB Shopping	HB Other	NHB
Drive Alone	50.76%	4.63%	21.44%	55.89%	47.01%	49.82%
Shared Ride	7.61%	0.57%	21.44%	20.69%	32.75%	26.89%
Transit	1.20%	1.44%	0.39%	0.02%	0.01%	0.02%
Bike	0.70%	0.61%	1.33%	0.08%	0.63%	0.53%
Walk	2.80%	1.60%	4.89%	0.56%	2.12%	2.94%
Scenario 2B						
	HBW	HBUNI	HB K-12	HB Shopping	HB Other	NHB
Drive Alone	65.62%	4.61%	21.32%	55.86%	46.97%	49.73%
Shared Ride	9.84%	0.57%	21.33%	20.66%	32.73%	26.84%
Transit	1.28%	1.43%	0.39%	0.02%	0.01%	0.03%
Bike	0.81%	0.61%	1.39%	0.09%	0.66%	0.55%
Walk	3.09%	1.62%	4.99%	0.58%	2.17%	3.01%